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Bredhurst Receiving and Transmitting Society

**Advanced
Radio Amateur
Licence Exam**



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Bredhurst Receiving and Transmitting Society

Advanced
Radio Amateur
Licence Exam

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after

1 July 2004

Introduction Syllabus**Access requirements**

To be able to sit the Advanced examination you must have passed the Foundation and Intermediate examinations but you do not need to hold a licence at either the Foundation nor Intermediate level.

Examination Dates

Advanced Licence Exam £25, 2hrs starting at various times. The list below is believed to be correct but please check with RSGB for any up dates since this page was updated 22/2/2005.

Advanced Examinations Dates	Closing Dates
Tuesday 17 May , 18:30 start	Tuesday 3 May
Monday, 13 June date changed assumed 18:30 start to be confirmed	
Saturday 9 July , 14:30 start	Monday 27 June
Monday 22 August , 18:30 start	Monday 8 August
Sunday 9 October , 10:30 start	Monday 26 September
December 2005/January 2006 tba	

Closing dates are understood to be at least 10 days notice unless otherwise indicated above.

Cost of Exam

- The RSGB charges for the Advanced Radio Communications Examinations Fees is set at £25 (subject to change without notice on this site).

Full Licence Holder / Advanced Licence Holder

For exam purposes and in general conversation the terms Full Licence Holder / Advanced Licence Holder mean exactly the same and are completely interchangeable.

Introduction.

The first point to understand is that **you do not have to attend a course**. Thus if you have the technical knowledge or can learn on your own from the information on the this web site the exam date is really of your choosing, subject to some limitations.

The Advanced Amateur Radio Licence is the final part of a structured suite of three examinations designed to give access to the amateur radio bands. All prospective radio amateurs must demonstrate a suitable level of competence and proficiency as a pre-requisite to holding a licence.

This syllabus sets out the requirements for the top tier in the 3 tier structure. It assumes that candidates have completed the requirements of the Foundation and Intermediate Licence syllabi and passed the associated examinations.

Key Features.

- Part of a progressive system of learning designed to promote an understanding of radio communications science, technology and practice sufficient to allow the licensed operator to work safely on the amateur radio bands.
- Clear presentation of content for easy reference.
- The examination suite as a whole provides a backbone of theoretical knowledge whilst at the same time requiring 'On-air' experience and practical skills.
- A Tutor Guide amplifies syllabus points and assessment procedures.
- A students' workbook is available covering the syllabus and giving a scheme of work for a training course whilst being suitable for self-study if desired.
- Can be used within schools to enrich the Science and Technology curriculum.

The Assessment.

Assessment is by written examination only. This comprises a **62 Question multiple choice examination** each with 4 possible responses. **The examination lasts 2 hours**. Formal certificates of result, which are required to apply for a licence, will be issued by post, normally within 10

days.

Prior Learning and Progression.

A pass in the Intermediate licence examination is an entry requirement for the Advanced Licence examination. Training may commence at any time and students progress to the Full licence at their own pace. Candidates are encouraged to attend a suitable course but there is no obligation to do so.

As this is the top tier of this three tier suite of examinations, there is no formal route within this suite for further progression. However there are many informal and academic opportunities for advancement and progression both in amateur radio and electronics generally. Possession of a Full Amateur Radio Licence is recognised as an advantage for entry into undergraduate training and many careers.

Disabled Candidates.

Arrangements can be made for disabled candidates to sit the examination by whatever means is judged appropriate in consultation with their health professional. This syllabus does not require practical demonstrations and should not, therefore represent any disincentive or barrier to students capable of meeting the academic standard required. Requests for such consideration should be addressed, in the first instance, to the Radio Society of Great Britain who provide the examinations on behalf of the Ofcom.

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Bredhurst Receiving and Transmitting Society

Introduction

Introduction

The Syllabus. Issue no.2 Dec 2004

The term "recall" indicates a need to recall a basic fact and apply it fairly directly to a situation or question; extensive background knowledge and understanding is not expected although, at the advanced level some degree of interpretation may be required.

The term "understand" indicates the need for a wider understanding of the origin and implications of the subject area. Questions will assume such understanding.

Examination Questions.

Examination questions will assume a knowledge and understanding of the basic principles from all parts of the Foundation, Intermediate and Advance syllabuses, although the question itself will be clearly aimed at the relevant syllabus item.

For example, in tackling a question on interference, the candidate may need to demonstrate an appreciation of how unwanted frequencies are produced, their potential to cause interference, how they might enter an affected device and how this might be identified and avoided. This might require knowledge of harmonics, mixing and the susceptible frequencies of the victim device.

It will be assumed that the candidate has some familiarity with amateur operating practices and procedures as outlined in all 3 syllabuses. This will include, for example, a broad understanding of such issues as amateur band plans although examination of specific knowledge will be in line with the syllabus.

Some time spent on-air either as a listener or as an amateur operator at Foundation or Intermediate level will be advantageous in understanding the purpose and context of syllabus items and examination questions.

Formulae

A formula sheet will be provided during the examination. The formula will not be titled or explained and candidates will be expected to recognise which formula is appropriate and may need to transpose it depending on the parameters to be calculated.

The Question heading is our thoughts on the likely spread of questions and is yet to be confirmed so use as a guide only. This also applies to similar number of questions mentioned on individual sections of the training text.

Syllabus

Nature of Amateur Radio

1a.1 Nothing examinable at this level.

Question 1

Licensing Conditions

Note: that a full copy of the leaflet BR68 will be provided in the exam

Also, pending reprinting of documents, the titles Radiocommunications Agency and Ofcom will be regarded as synonymous.

2a Types of licence and format of call signs and location

2a.1 Identify the types of UK licence and the format of all call signs in use including regional secondary locators, but NOT including club, special event and contest call signs.

12(2) Licence documents

1(10), 1(11)(a)(b)(c), 1(12), 12(1)(g) Notes (a)(i)(j) Location

7(3), 7(4), 7(5) Notes (v)(w) Identity of Location

Question 2

2b User Services and International disaster

2b.1 1(2), 1(2A), 12(1)(o) User Services

1(3) International disaster communications and frequencies used.

Messages may be passed, internationally, on behalf of non-licensed persons;

Non-amateur station involved in international disaster communications may also be heard on amateur frequencies.

Question 3

2c Supervision of licensed and non-licensed persons.

1(8) Meaning of 'direct supervision', duties of the supervisor and nature of greetings messages.

1(8A) Meaning of a recognised training course as defined in note 'fa' to BR68. Identification of persons qualifying.

2(8)(b) Meaning of 'direct supervision' and identity of persons who may operate.

2(9) Identification of a disqualified person.

2(10) Use and supervision of Club Stations.

7(2) Identification while under supervision.

12(1)(e) Meaning of Authorised club member.

Recall that Foundation and Intermediate licensees are not permitted by their licenses to supervise the operation of an amateur radio station.

Question 4

2d Maritime mobile operation.

1(11) Location of station, including Maritime Mobile.

2(12) Installation and radio silence.

2(13) Know the 3 ITU regions and that the frequencies are given in the ITU Radio Regulations.

7(4) Suffix 'MM' to call sign.

8(3) Close down

12(1)(d) Meaning of "At Sea".

12(1)(l) Meaning of "Tidal Water".

Question 5

2e CEPT Recommendation and reciprocal licensing.

2e.1 Operation in the UK by CEPT visitors

10, 10(1), 10(2), 10(3), 10(5)

2e.2 Operation abroad under the CEPT Recommendations and under reciprocal licences.

11 Operation in CEPT countries by UK licenced amateurs

11(1) Rules for operation in CEPT countries.

11(2) Temporary licences not valid for CEPT operation.

Recall that many countries will offer reciprocal licenses to UK amateurs with a Full licence and that operation is in accordance with the host country's rules.

the word Full used in this section means the licence issued after a successful Advanced

examination

Question 6

2f.1 Messages

1(4), 1(6), 1(7) 1(9) Messages

2(2) Receipt of messages from amateurs on non-UK frequencies

3(3), pecuniary interest and permitted advertising

5(1), 5(2), 5(3), 5(4) recorded and re-transmitted messages.

Notes (c) (d) (e) (h) inappropriate messages

Question 7

2g Unattended operation

2g.1 2(3) NOT including NGR's, 2(4), 2(5), 2(6)

Question 8

2h Logging and Identification

6(1), 6(2), 6(3), 6(4), 6(5) Notes (q)(r)(s) Logs

7(1), 7(1A), 7(6); Notes (s)(t)(u)(v)(w) Identification

Question 9

2i Apparatus, Inspection Closedown and renewal

4(1), 4(2), 4(3), 4(4), 4(5) Notes (k)(l)(m)(n)(o) Apparatus

8(1),8(2),8(4) Notes (l) (m) Inspection and closedown

9(1), 9(2), 9(3), 9(4) Note (a) Renewal

Question 10

2j Schedule

2j.1 Clause 2(1) and apply the Schedule to the licence including the notes to the schedule.

Technical Aspects

Note that any unit prefix from pico to Giga may be used (in multiples of 10^3) in any question or calculation.

Question 11

3a Potential Difference and Electromotive Force

3a.1 Understand the difference between potential difference (p.d.) and electromotive force (e.m.f.).

Understand the concept of source resistance (impedance) and voltage drop due to current flow.

3b Resistance

3b.1 Understand and apply the formulae for calculating the combined values of resistors in series and/or in parallel.

Resistors of different values of may be used in series, parallel or combined series and parallel circuits.

3c Power in DC circuits

3c.1 Understand and apply the formula relating power to potential difference, current and resistance.

3d Potential dividers

3d.1 Understand that two or more resistors can be arranged to act as a potential divider and apply the formula.

Question 12

3e Capacitance

3e.1 Understand the factors influencing the capacitance of a capacitor; area and separation of the plates, permittivity of dielectrics and formula $C=KA/d$.

3e.2 Understand that capacitors have a breakdown voltage and that they need to be used within that voltage.

3e.3 Recall that different dielectrics are used for different purposes, e.g. air, ceramic, mica and polyester; and that with some dielectrics, losses increase with increasing frequency.

3e.4 Understand the charging and discharging of a capacitor in a CR circuit and the meaning of the time constant $T=CR$.

Recall the dangers of stored charges on large or high voltage capacitors.

Recall that large value resistors can be used to provide leakage paths for these stored charges.

3e.5 Recall and apply the formulae for calculating the combined values of capacitors in series and in parallel

Question 13

3f Inductance

3f.1 Understand the term 'self inductance' and recall that a 'back e.m.f.' is produced as current flow changes in an inductor.

3f.2 Recall that the inductance of a coil increases with increasing number of turns, increasing coil diameter and decreasing spacing between turns.

Understand the use of high permeability cores and slug tuning.

3f.3 Understand the rise and fall of current in an LR circuit.

3f.4 Understand and apply the formulae for calculating the combined values of inductors in series and in parallel.

Question 14

3g AC circuits

3g.1 Understand that the root mean square (r.m.s.) value of a sine wave has the same heating effect as a direct current of the same value and that it is equal to 0.707 of its peak value.

3g.2 Recall that the period of a sine wave is equal to $1/f$ and that the frequency of a sine wave is equal to $1/T$ (where f = frequency in Hertz and T = time in seconds).

3g.3 Understand the concept of phase difference, that it is expressed in degrees and that a full cycle is equal to 360 degrees.

Question 15

3h.1 Recall that for a resistor, the p.d. and current are in phase

Recall that current lags potential difference by 90° in an inductor and that current leads by 90° in a capacitor.

Recall that the term 'reactance' describes the opposition to current flow in a purely inductive or capacitive circuit where the phase difference between V and I is 90° .

Understand and apply the equations for inductive and capacitive reactance.

3h.2 Understand that impedance is a combination of resistance and reactance and apply the formula for impedance and current in a series CR or LR circuit.

3h.3 Understand the use of capacitors for coupling (d.c. blocking) and decoupling a.c. signals

(including r.f. bypass) to ground.

Question 16

3i Tuned Circuits

3i.1 Understand that at resonance $X_C = X_L$ and the formula for resonant frequency

Apply the formula to find values of f , L or C from given data.

3i.2 Identify resonance curves for series and parallel tuned circuits.

3i.3 Understand the concept of the magnification factor Q as applied to the voltages and currents in a resonant circuit.

Understand and apply the formula for magnification factor Q as applied to the voltages and currents in a resonant circuit.

Recall the definitions of the half power point and the shape factor of resonance curves

Understand and apply the equation for Q given the resonant frequency and the half power points on the resonance curve.

3i.4 Understand the meaning of dynamic resistance.

Understand and apply the formula for R_D given component values.

Understand the effect of damping resistors in a tuned circuit.

3i.5 Recall the equivalent circuit of a crystal and that it exhibits series and parallel resonance.

3i.6 Recall that voltages and circulating currents in tuned circuits can be very high and understand the implications for component rating.

Question 17

3j Transformers

3j.1 Understand the concept of mutual inductance.

Understand and apply the formula relating transformer primary and secondary turns to primary and secondary potential differences and currents.

3j.2 Understand and apply the formula relating transformer primary and secondary turns to primary and secondary impedances.

3j.3 Understand the cause and effects of eddy currents and the need for laminations (or ferrites) in transformers.

Question 18

3k Filters

3k.1 Identify the circuits of low pass, high pass, band pass and band stop (notch) filters and their response curves. Understand the concept of the cut-off frequency.

Recall that crystals can be used in filter circuits.

Question 19

3l Screening

3l.1 Recall that screening with thin metal sheet is effective in reducing unwanted radiation from equipment and/or between stages within equipment.

3m Temperature effects

3m.1 Recall that temperature has an effect on the value of components; those with negative coefficients will reduce in value as temperature rises whereas those with positive coefficients will increase in value. Understand the effect this will have on tuned circuits and remedial measures.

Question 20

3n Solid state devices

3n.1 Understand that doping of semiconductor material (silicon and germanium) produces p-type (electron deficient) and n-type (electron rich) semiconductors. Understand current flow in terms of electron and hole movement.

Understand how the p-n junction forms a semiconductor diode.

Understand the formation and effect of the depletion layer.

Understand that an applied potential difference can cause electrons to flow across the pn junction (forward bias) or prevent electron flow (reverse bias) depending on polarity.

3n.2 Recall that a Zener diode will conduct when the reverse bias potential is above its designed value and identify its V/I characteristic curve.

3n.3 Understand that the depletion layer in a reverse biased diode forms the dielectric of a capacitor and that the magnitude of the reverse bias affects the width of the layer and the capacitance.

3n.4 Understand the 3 layer model of the transistor (npn and pnp) and the channel model of the FET.

Question 21

3n.5 Understand the basics of biasing bipolar and FET transistors (including dual gate devices).

3n.6 Identify different types of small signal amplifiers (e.g. common emitter (source), emitter follower and common base) and explain their operation in terms of input and output impedances, current gain, voltage gain and phase change.

3n.7 Recall the characteristics and typical circuit diagrams of different classes of amplifiers (i.e. A, B, A/B and C).

3n.8 Understand the concept of the efficiency of an amplifier stage and be able to estimate expected r.f. output power for a given d.c. input power, given the stage's efficiency.

3o Decibels

3o.1 Understand the equations for decibel power and voltage ratios.

Recall (or determine) the power gain or loss of various dB ratios based on (3, 6, 9, 12, 15 and 10, 20, 30dB. (This includes examples such as $25W \rightleftharpoons 20-6=14dBW$.)

Question 22

3p Mains Power Supplies

3p.1 Recall the circuit diagrams and characteristics of different types of rectifier and smoothing circuits (i.e. half wave, full wave and bridge).

3p.2 Understand the need for rectifier diodes to have a sufficient peak inverse voltage (PIV) rating and be able to calculate the PIV in diode/capacitor circuits.

3p.3 Understand the function of stabilising circuits and identify different types of stabilising circuits (i.e. Zener diode/pass transistor and IC)

Note: questions on the characteristics of individual components are covered earlier in this syllabus, e.g. 3n.2. This sub-section is on complete circuits.

Question 23

4a Transmitters and Receivers

4a.1 Understand the block diagram of an s.s.b transmitter employing mixers to generate the final frequency.

Understand the block diagram of an f.m. transmitter employing either frequency multipliers or mixers to generate the final frequency.

4b Oscillators

4b.1 Understand the function of the components in typical VFO and crystal oscillators.

4c Frequency synthesis

4c.1 Recall the block diagram of a frequency synthesiser and the functions of the stages (i.e. oscillator, fixed divider, phase detector, LPF, voltage controlled oscillator and programmable divider).

Recall how sine waves may be produced by direct digital synthesis and the block diagram of a simple synthesiser. Recall that increasing the number of bits in the synthesiser will increase the purity of the signal.

Question 24

4d Frequency multipliers

4d.1 Understand that frequency multipliers use harmonics to generate frequencies above an oscillator's fundamental frequency (e.g. in a microwave transmitter)

4e Mixers

4e.1 Understand that the desired frequency is often produced by mixing together the output from two or more frequency sources, e.g. v.f.o., crystal oscillator or synthesiser.

Understand how unwanted frequencies may also be produced.

Question 25

4f Modulation

4f.1 Recall the meaning of the term peak deviation.

Recall the meanings of narrow band and wide band modulation for frequency modulation

Recall the meaning of depth of modulation for amplitude modulation

4f.2 Understand the operation of a.m., s.s.b, and f.m. modulators.

Recall the bandwidth of such transmissions.

4f.3 Understand, in functional terms, the operation of data modulators for F1B (direct frequency

shift), F2B (frequency shift keyed audio tone on an f.m. transmitter) and J2B (frequency shift keyed audio tone on an s.s.b. transmitter).

Question 26

4g Power Amplifiers

4g.1 Understand the need for linear amplification and identify which forms of modulation require a linear amplifier.

4g.2 Recall the function of the main components; anode/collector load, bias, input circuit, output filter and matching in a PA circuit.

4g.3 Recall the operation of a valve in a power amplifier. Recall the function for the heater, cathode, control grid and anode.

Recall the advantages and disadvantages of valve PA circuits.

4g.4 Understand the implications for PA rating of different types of modulation and the effects of speech processing, with particular regard to peak to average power ratios.

4g.5 Recall the function of automatic level control within the power amplifier and when using an external power amplifier. Recall the function and use of a manual r.f. power control.

Question 27

4h Transmitter Interference

4h.1 Recall the effect and the importance of minimizing drift.

4h.2 Recall the cause and effect of 'chirp' and identify suitable remedies.

Recall the cause and effect of 'key clicks' and the shaping of Morse keying waveforms.

Question 28

4h.3 Understand ways to avoid generating harmonics (e.g. use of push-pull amplifiers, use of inductive coupling between stages, avoiding high drive levels).

Recall that transmitters may radiate unwanted mixer products and identify suitable remedies

Understand the use of low and band pass filters in minimizing the radiation of unwanted harmonics and mixer products.

4h.4 Recall that unwanted emissions may be caused by parasitic oscillation and/or self oscillation and identify suitable remedies

Question 29

4h.5 Understand that over modulation causes harmonics (of the modulating signal) which may result in excessive bandwidth.

4h.6 Understand how frequency synthesizers may not produce the intended frequency. Identify remedial measures (out of lock inhibit).

4i External Power Amplifiers

4i.1 Understand the need to drive external power amplifiers with the minimum power required for full output and how overdriving may cause harmonics and/or spurious intermodulation products.

Question 30

4j Receiver parameters and terminology

4j.1 Understand the term selectivity and 60 dB bandwidth

4j.2 Recall that the dynamic range of a receiver is the difference between the minimum discernible signal and the maximum signal without overload. Recall the dynamic range is expressed in decibels.

4j.3 Recall, in simple terms, the meaning of "signal to noise ratio" as applied to a receiver specification. Recall that the noise generated in the receiver will influence the minimum

discernible signal.

Question 31

4k Receiver architecture

4k.1 Understand the block diagram of superhet and double superhet receivers and the functions of each block.

Question 32

4l RF. Amplifier and pre-amplifier

4l.1 Recall the operation of the r.f. amplifier.

Understand that external r.f. preamplifiers do not always improve overall performance and will reduce dynamic range by an amount equal to the gain of the pre-amp. Understand that overloading will cause intermodulation and spurious signals.

Question 33

4m Mixer and Local Oscillator

4m.1 Understand the function of a mixer, the generation of intermediate frequencies (i.f.) and other mixer products.

Understand that for given r.f. and i.f. frequencies, there is a choice of two local oscillator (l.o.) frequency. Understand the reasons for the choice and calculate the frequencies.

4m.2 Understand the origin of the second channel or image frequency and calculate the frequency from given parameters.

4n IF amplifier

4n.1 Understand the advantages and disadvantages of high and low intermediate frequencies and

the rationale for the double superhet.

4n.2 Understand the operation of an i.f. amplifier and the i.f. transformer.

Understand the concept of two LC tuned circuits utilising transformer coupling. Identify critical and over-coupled response curves.

Understand how the gain of an i.f. amplifier can be varied, how this may cause distortion and how the effects of the distortion are avoided.

Note: the reason to vary the gain (a.g.c.) is covered at item 4p.

Question 34

4o Demodulation

4o.1 Understand the operation of a.m., c.w., s.s.b. and f.m. demodulators.

4p Automatic Gain control

4p.1 Understand the derivation and use of an a.g.c. voltage.

Recall that automatic gain control circuits can also be used to drive S meters

Question 35

4q Down-converters and transverters

4q.1 Understand that VHF and UHF operation can be carried out by using down converters and transverters ahead of HF equipment

4r Transceivers

4r.1 Understand that transceivers normally share oscillators between the transmitter and receiver circuits; and may use common i.f. filters to limit both the transmitter and receiver bandwidths. They also use common change-over circuits.

Question 36

Feeder and Antenna

5a Feeder basics

5a.1 Understand that the velocity factor of a feeder is the ratio of the velocity of radio waves in the feeder to that in free space and that the velocity factor is always less than unity. Be able to calculate physical feeder lengths given the frequency and velocity factor. Recall that the velocity factor for coaxial feeder with a polythene dielectric is approximately 0.67 or 2/3. Recall that feeder loss increases with increasing frequency and that lower loss feeders may be required at VHF, UHF and above

5a.2 Understand that a quarter-wave length of feeder can be used as an impedance transformer. Apply simple examples of the formula $Z_0^2 = Z_{in} \times Z_{out}$.

5a.3 Recall the basic construction and use of waveguides.

5b Baluns

5b.1 Recall the construction and use of typical baluns; transformer, sleeve and choke.

Identify the circuits of 1:1 and 4:1 transformer baluns.

Question 37

5c Antennas

5c.1 Understand the equation for calculating half-wavelengths and be able to apply 'end factor correction' in calculating the approximate physical lengths of dipole elements.

5c.2 Recall that the angle at which the propagated radio wave leaves the antenna is known as the (vertical) angle of radiation and that longer distances require a lower angle of radiation.

Recall the effect of the ground on the angle of radiation.

5c.3 Recall the current and voltage distribution on the dipole and $\lambda/4$ ground plane antennas.

- Recall the feedpoint impedances of half-wave dipoles, quarter-wave and loaded $5\lambda/8$ vertical, folded dipoles, full-wave loops and end fed $\lambda/4$ and $\lambda/2$ antennas.
 - Recall the effect of passive antenna elements on feed point impedance and the use of folded dipoles in Yagi antennas.
-

Question 38

5c.4 Identify folded and trap dipoles and quad antennas in addition to those in earlier syllabuses.

5c.5 Recall that an antenna trap is a parallel tuned circuit and understand how it enables a single antenna to be resonant and have an acceptable feed-point impedance on more than one frequency. Recall that this technique may be extended to multi-element antennas such as Yagis.

Question 39

5d Return Loss and SWR

5d.1 Understand that the standing wave ratio (SWR) is a measure of the signal travelling back down the feeder expressed in terms of the standing waves caused by the reflected signal voltage (or current).

5d.2 Recall that return loss is the ratio of the forward signal power to the return signal power; normally expressed in dB.

Understand that a low SWR equates to a high return loss and a high SWR equates to a low return loss.

5d.3 Understand that the feeder loss will reduce the SWR and increase the return loss at the transmitter.

Recall that Return Loss at transmitter = Return Loss at antenna + $2 \times$ (feeder loss)

Question 40

5e Antenna Matching Units

5e.1 Understand that AMUs (ATUs) can "tune-out" reactive components of the antenna system feed-point impedance (before or after the feeder) and can transform impedances to an acceptable resistive value.

Understand that if the AMU is located at the transmitter, it will have no effect on the feeder SWR.

Identify typical AMU circuits (i.e. T, Pi and L circuits).

Question 41

6a Electromagnetic Radiation

6a.1 Recall that an e-m wave comprises both an (E) and (H) fields in phase, at right angles and at right angles to the direction of travel to each other.

Recall that in circular polarisation, the polarisation of the wave rotates as it propagates, either a right-handed (clockwise from behind) or left handed polarisation.

Recall that this is often used for satellite communications where the orientation of the satellite is indeterminate.

Recall that the transmit and receive antennas should have the same polarisation.

6a.2 Recall that under free space conditions e-m waves travel in straight lines and spread out according to an inverse square law of power flux density and that the field strength, measured in volts/metre, drops linearly with distance.

Numerical calculations required at item 7c1 only.

Question 42

6b Ionosphere

6b.1 Understand that the ionosphere comprises layers of ionised gasses and that the ionisation is caused by solar emissions including ultra-violet radiation and charged solar particles.

Recall the ionospheric layers (D, E, F1 and F2) and approximate heights.

6b.2 Recall that the E layer can refract (reflect) radio waves and that sporadic-E is caused by areas of highly ionised gas that can refract waves in the VHF band. Recall that the E layer supports single hops up to about 2000km.

6b.3 Recall that the F2 layer provides the furthest refractions for HF signals (about 4000km) and that the F layers combine at night.

Recall that multiple hops permit world-wide propagation.

6b.4 Understand how fading occurs and its effect on the received signal.

Question 43

6b.5 Recall that the highest frequency that will be refracted back to the transmitter is known as the Critical Frequency of Vertical Incidence (critical frequency).

Recall that the highest frequency that will be refracted over a given path is known as the 'maximum usable frequency' (MUF) and that this will be higher than the critical frequency.

Recall, in general terms how the MUF varies over the 24 hour cycle and the variation in MUF from summer to winter.

6b.6 Recall that the D layer tends to absorb the lower radio frequencies and that it tends to disappear at night.

Understand that if the D-layer absorption occurs at frequencies higher than the MUF, then no ionospheric propagation can occur.

6b.7 Recall which amateur bands will be "open" to support ionospheric propagation at different times of the day and year.

Questions will be asked on 3.5 and 21MHz propagation over the 24 hour cycle.

6c Ground Wave

6c.1 Recall that the ground wave has a limited range due to absorption of energy in the ground and

that the loss increases with increasing frequency.

Question 44

EMC

7a Routes of entry into TV and Radio

7a.1 Understand that amateur transmissions can be picked up by the intermediate frequency stages of TV and radio receivers and identify related amateur transmissions.

Understand that television receivers and most broadcast radio receivers employ superheterodyne circuits and recall some typical frequencies used in radio and television receivers; i.e. 470-854MHz TV r.f, 33-40MHz TV i.f., video baseband 0-5MHz Radio i.f.'s typically 455-500kHz and 10.7MHz.

Understand the potential for second channel (image frequency) interference.

Question 45

7a.2 Recall that amateur transmissions can enter the r.f. stages and cause cross modulation and/or blocking.

Recall that cross modulation occurs when strong varying transmissions (e.g. a.m., s.s.b. or c.w. signals) impresses its own modulation on the wanted signal.

Recall that blocking (also known as desensitisation) occurs when strong constant transmissions (e.g. f.m. signals) cause the radio or television to be overloaded.

7a.3 Understand that mast-head amplifiers are frequently wide band devices and can suffer from cross-modulation and overload (causing intermodulation and blocking), and may also overload the TV.

Question 46

- 7a.4 Recall that amateur transmissions can enter audio stages via long speaker leads or other interconnections.
 -
 - Understand that any pn junction within an electronic device can rectify unwanted r.f.
 -
 - 7a.5 Recall that passive intermodulation products can be caused by corroded contacts in any metalwork, including transmitting and receiving antennas, supports and guttering.
 -
 - 7a.6 Understand that ghosting is caused by external reflections and does not normally indicate a fault in the TV receiver.
 -
-

Question 47

7b Filters

- 7b.1 Understand the construction and use of a typical mains filter.
 -
 - 7b.2 Identify a typical circuit of a braid-breaking filter and a combined high-pass/braid-breaking filter. Understand their use.
 -
 - Understand why a ferrite ring will attenuate common-mode currents without affecting the differential-mode wanted signal.
 -
-

Question 48

- 7b.3 Recall the use of ferrite beads or rings in internal and external filtering.
 -
 - 7b.4 Understand the use of notch filters including coaxial stubs as notch filters or traps in minimizing an unwanted signal.
 -
 - 7b.5 Understand the use of high, low and band pass filters in improving the immunity of affected devices.
 -
-

Question 49

7c Field Strength

7c.1 Recall that reducing field strength to the minimum required for effective communication is good radio housekeeping. Recall and apply the formula for field strength given the ERP and distance from the antenna.

Question 50

7d Feeders and Antennas

7d.1 Recall that balanced antenna systems tend to cause fewer EMC problems than unbalanced antennas.

Recall that the feeder (balanced or unbalanced) should leave the antenna at right-angles to minimise coupling.

7e Mobile Installation

7e.1 Understand that EMC problems in motor vehicles can have serious safety implications and be able to identify suitable precautions

Question 51

7f Social Issues

7f.1 Recall the correct procedures for dealing with EMC complaints , whilst understand that although new electronic equipment should meet the EMC standards, some existing equipment may not.

Question 52

Operating Practices and Procedures

8a Packet Radio

8a.1 Recall that Packet radio transmits messages in data format that can be received directly, stored in a mailbox for reception at a later date or forwarded through a network of mailboxes.

Understand the difference between store and forward mailboxes and digipeating.

Question 53

8b Repeaters

8b.1 Recall the purpose and operation of repeaters and the correct procedures in using them.

E.g. offsets on 144 and 433MHz; time-out and reset tone; voice procedures.

Question 54

8c Intermodulation

8c.1 Understand how to identify whether the distant transmitter or the local receiver is producing intermodulation products.

8d Special Events

8d.1 Recall the purpose of special event stations and the format of special event stations.

Question 55

8e Band Plans

8e.1 Recall that band plans are produced by the IARU.

Recall that the band plans state that:

- no s.s.b. operation should take place in the 10MHz 30m band
- no contests should be organised in the 10Mhz (30m), 18Mhz (17m) and 24Mhz (12m) bands

- narrow band modes are at the lower end of most bands
- lower side band operation normally occurs below 10MHz and upper sideband above 10MHz
- transmission on beacon frequencies must be avoided
- transmissions on satellite frequencies should be avoided for terrestrial contacts.

Questions on beacon frequencies and satellite frequencies will be limited to the 14Mhz (20m) and 144MHz (2m) (144MHz) bands and a copy of the Band Plans will be provided.

Question 56

Safety

9a High voltage Equipment

- 9a.1 Understand that all equipment should be controlled by a master switch, the position of which should be known to others in the house or club.
 - 9a.2 Understand that all exposed metal surfaces should be properly earthed.
 - 9a.3 Understand that no work should be undertaken on live equipment unless it is not practicable to do the work dead (disconnected from the power source) and suitable precautions have been taken to avoid shock.
 - 9a.4 Recall that thermionic valve equipment generally uses power supplies with potentials higher than the domestic mains supply.
-

Question 57

9b Portable operation

- 9b.1 Understand that operating in temporary premises and/or outdoors can introduce new hazards (i.e. overhead power lines, inadequate electrical supplies, trailing cables, damp ground, excessive field strengths).
- Recall the additional safety precautions that should be taken whilst operating in temporary premises and/or outdoors (i.e. site survey, cable routing/protection, correct fuming, use of RCDs,

- no live working).

9c Mobile operation

- 9c.1 Understand that operating in vehicles and vessels can introduce new hazards (i.e. insecure equipment, long/flexible antennas, accidental shorts to earth, lack of attention to driving, r.f. induction into vehicle control circuits).

- Recall the additional safety precautions that should be taken whilst operating mobile and/or maritime mobile (i.e. secure equipment, cable routing/protection, correct fuming, use of hands-free equipment, attention to good radio housekeeping).

9d RF

- 9d.1 Recall that the National Radiological Protection Board (NRPB) have published Investigation levels for exposure to r.f. radiation for UK amateur radio.

- Recall that compliance with NRPB investigation levels will ensure that exposures are below the recommended limits and that the lowest investigation level for electric field strength is 28V/m (at 10-146MHz).

- Understand that if the investigation level is exceeded the cause must be investigated and steps taken to reduce the exposure to below the investigation levels.

Question 58

Lightning Protection

- 9e.1 Recall that thunderstorms carry heavy static charges

- Understand that the static charge from thunderclouds can ionise the air to form a low resistance path to ground, enabling a very high current to flow as a lightning strike.

- Understand the risks to human life, domestic property and electronic equipment associated with a direct strike and/or the build up of static charges.

- Understand that there is little that can be done to protect an amateur station from a direct lightning strike but that good static discharge systems can prevent dangerous static charges building up on antenna systems during thunderstorms. Understand that disconnecting antenna feeders from radio

equipment also reduces the risks.

9f Protective multiple earthing

9f.1 Recall that in PME systems the main earth terminal is connected to the neutral of the electricity service at the consumers' premises and that all metalwork within the premises are also connected to the PME bonding point.

Recall that under severe fault conditions PME systems have the potential to cause fatal electric shocks and/or fires in amateur radio stations.

Recall that the RF earth in an amateur station should be connected to the PME bonding point in accordance with IEE Wiring Regulations to maintain safety under fault conditions.

Question 59

Measurements

10 Meters

10a.1 Understand the use of multiplier resistors in analogue voltmeters, shunts in ammeters and the effect of the test meter on the circuit under test.

Question 60

10b Frequency Checking

10b.1 Recall the uses and limitations of absorption wavemeters, heterodyne wavemeters, crystal calibrators, digital frequency counters and standard frequency transmissions.

10b.2 Understand the effect of measurement tolerance, calibration accuracy and time related drift on frequency measurements and the allowances to be made for transmission bandwidths.

Question 61

10c Oscilloscopes

10c.1 Understand the purpose and basic operation of an oscilloscope. Calculate the frequency and voltage of a waveform from given data.

Question 62

10d RF Power measurements

10d.1 Understand that steady r.f. power may be determined by measuring the r.f. potential difference across a dummy load.

Understand the meaning of p.e.p. (peak envelope power) of an s.s.b. transmission and that it may be determined using a peak reading power meter or an oscilloscope and dummy load.

10e SWR. Measurements

10e.1 Identify the circuit of an SWR meter and understand its operation.

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Bredhurst Receiving and Transmitting Society

Advanced
Radio Amateur
Licence Exam

There is nothing examinable at this level

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Maths**Licensing Conditions****Bredhurst Receiving and Transmitting Society****Advanced**
Radio Amateur
Licence Exam**There are 10 questions in the exam on this topic.****BR68 --- Read the following carefully**

In the exam you will be given a copy of BR68 and thus questions will be of a more involved nature than in the Foundation and Intermediate exams. This section for the most part will be a test of how well you know your way around BR68

Ensure that you have seen a copy of BR68 and thus are familiar with its layout and are ready to look up the answers to the question. It will be no good looking at BR68 for the first time in the examination.

As you are given a copy of BR68 exam questions might well have only a slight bearing on this syllabus as the subject has been covered extensively for the FLC and ILC so beware and read the question carefully.

! Some students are not attending to having a full understanding of the sections which will be highlighted by the !.

Syllabus sections:-

1. 2a. Types of licence and format of callsigns and location !
2. 2b. Users Services and International disaster communications !
3. 2c. Supervision of licensed and non-licensed persons !
4. 2d. Maritime mobile operation
5. 2e. CEPT and reciprocal licensing
6. 2f. Messages
7. 2g. Unattended operation

- 8. 2h. Logging and Identification
 - 9. 2i. Apparatus, inspection Closedown and renewal
 - 10. 2j. Schedule to BR68 and notes to the schedule
 - 11. BR68 notes
 - 12. BR68
-

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Radio Amateur
Licence Exam**There are 12 questions in the exam on this topic.**

Due to slight changes in the syllabus issued in Dec 2004 updating of these sections is still required.

NOTE: that any prefix from pico to giga may be used (in multiples of 10^3) in any question or calculation

The **Maths** symbols indicates the parts of the syllabus where maths involved. Please do not be put off by this as the course work will help you to fully understand the maths needed for the exam - if you want to pick up some relatively easy marks !!

Syllabus Sections:-

- Potential difference and electromotive force
- Resistance
- Power in DC circuits **Maths**
- Potential dividers **Maths**
- Capacitance **Maths**
- Inductance **Maths**
- AC circuits **Maths**
- Inductance & Capacitance with AC **Maths**
- Tuned circuits Part A **Maths**
- Tuned circuits Part B **Maths**
- Transformers **Maths**
- Filters
- Screening
- Temperature effects
- Solid state devices
- Decibels **Maths**
- Mains power supplies

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Advanced
Radio Amateur
Licence Exam

There are 13 questions in the exam on this topic.

Due to slight changes in the syllabus issued in Dec 2004 updating of these sections is still required.

Syllabus Sections:-

- Transmitter architecture
- Oscillators
- Frequency synthesis
- Frequency multipliers
- Mixers
- Modulation
- Power Amplifiers
- Transmitter interference
- External power amplifier
- Receiver parameters and terminology
- Receiver architecture
- RF. amplifier and pre-amplifier
- Mixer and Local Oscillator
- IF Amplifier
- Demodulation
- Automatic Gain control
- Down-converters
- Transceivers

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Bredhurst Receiving and Transmitting Society**Next****Syllabus Sections:-****4. Transmitters and Receivers****Transmitter architecture**

4a.1 Understand the block diagram of an s.s.b transmitter employing mixers to generate the final frequency.

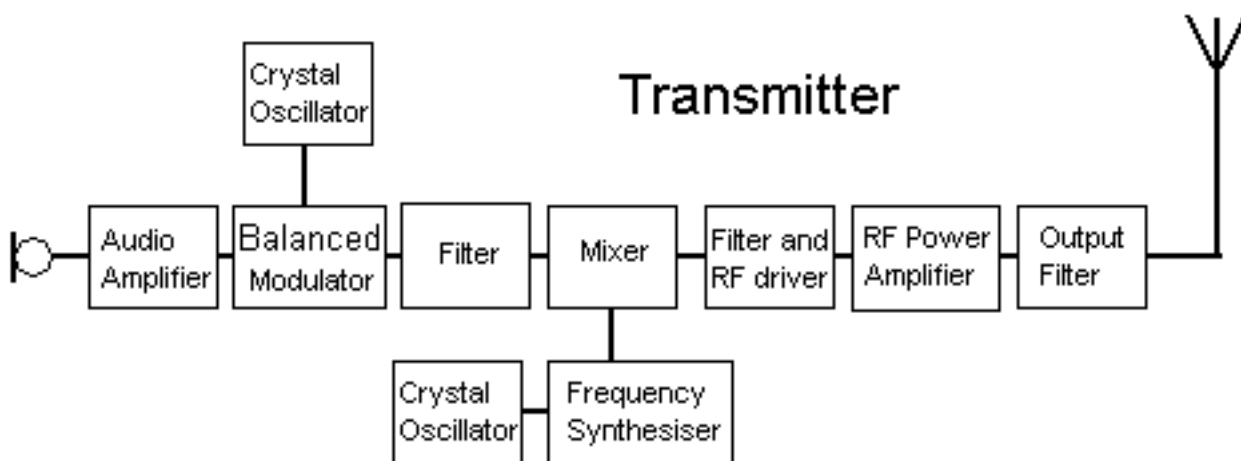


Fig. 1

A general over view

When considering a transmitter it is probably best to think what it is trying to do. So what is it trying to do ?

- Create an RF signal inside the amateur band
- For the signal to be nice and clean
- For the signal to be stable
- For the signal to have minimum band width for the type of transmission
- For the signal to have the correct power output
- for the transmitter to have minimum output on other frequencies

Understand the block diagram of an f.m. transmitter employing either frequency multipliers or mixers to generate the final frequency.

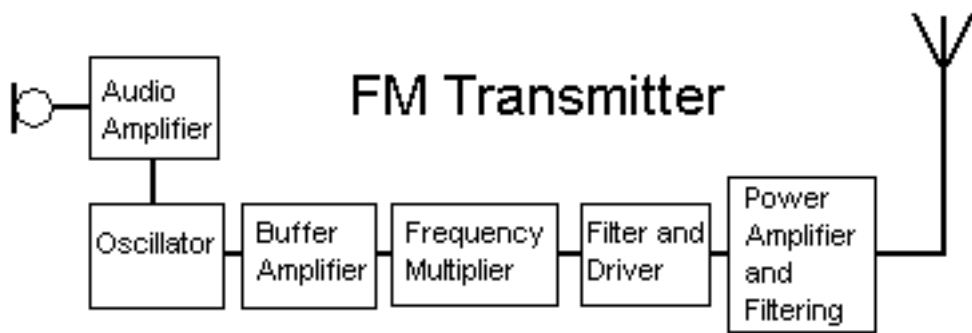


Fig. 2

frequency multipliers

This FM version is using frequency multipliers. The Audio signal is acting directly onto the frequency oscillator which then passes the signal to a buffer amplifier to make it suitable to go into the frequency multiplier stage. When it has been multiplied up sufficiently to the output frequency it is filtered and the driver prepares the correct level of signal for the RF amplifier, which is followed by filtering to present the signal to the aerial.

However this arrangement has for the most part been overtaken by the general transmitter diagram fig 1 which can also be used for FM - when suitable modulators are employed.

So what else is there to know ?

This general over view has shown you what happens to the signal from mic to aerial. The other sections, which follow below will give a more detailed account as to the activity of individual parts.

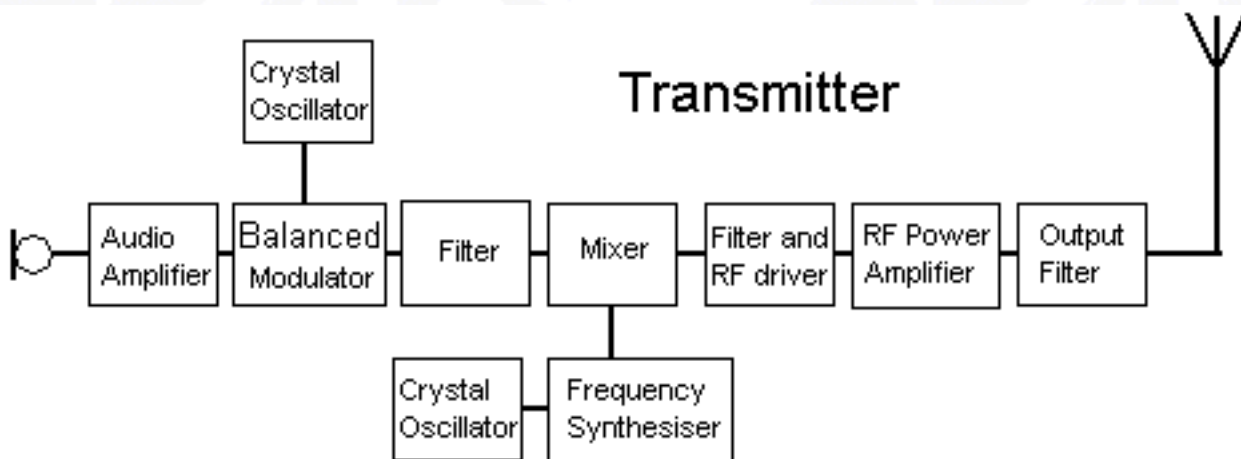


Fig. 1

Crystal oscillator

The start of this process is with the crystal oscillators. These have to create :-

- Stable
- Accurate
- Known

frequency suitable for the part of the circuit in which they are employed.

The reason for the stability is so that they do not "drift" off frequency and possibly put the transmissions outside the amateur bands but almost certainly a drift in frequency would take you into another QSO!! (Drift is a slight and gradual, yet unwanted change of frequency.)

The reason for the accuracy is that you must know for absolute certainty that you are inside the amateur bands. It is desirable to ensure that you use the appropriate frequency for the mode you are using - SSB, FM, CW or data ETC.

There are several ways to achieve the above:-

Crystal oscillator

The old way was to use a crystal oscillator and to change the crystal to change frequency very stable and frequencies accurately known but limited to the number of crystals you have and they were and still are expensive!

VARIABLE Frequency Oscillator

Another old way was to use a VARIABLE Frequency Oscillator. This gave you an infinite number of frequencies in a section of the amateur band.

Changing bands involved using a harmonic (multiple) of the same oscillator and returning later stages of the transmitter suit. The draw back was that such units were affected by heat, impact, when, say, you tapped your rig (microphonics) and thus did drift off frequency, and could give additional modulation to the wanted mode.

Frequency synthesiser

The modern way is to use a crystal oscillator which gives a stable frequency and link this to a frequency synthesiser which then gives you an accurate range of frequencies.

In all the methods mentioned above a stable voltage is needed which is in addition to the voltage power source for the power amplifier -again this is to ensure stability.

The synthesiser has two variants the PLL or Phase Locked Loop and the DDS or Direct Digital Synthesis (the DDS is not covered here as not part of the syllabus).

HOWEVER there is one draw back in using a synthesiser rather than a crystal oscillator or VFO and that is what is called "noise level" - this is the back ground level of noise sidebands present in higher quantities than crystal or VFO oscillators.

WHY 2 Crystal oscillators?

These are in two different parts of the circuits and thus are performing quite separate operations (Note: some designs can use more than two crystal oscillators).

So what happens from microphone to aerial ?

The audio amplifier is linked to the modulator. Once the appropriate modulation has been applied, we now have a modulated signal which may be appropriately filtered but it is not on the correct frequency. This signal is then mixed with the output from the synthesiser to produce the desired output frequency, this then passes into the RF power amplifier and then is filtered again before it goes into the aerial.

So the transmitter has achieved

- Create an RF signal inside the amateur band - **All oscillators correctly chosen and working properly.**
- For the signal to be nice and clean - **Appropriate design and filtering.**
- For the signal to be stable - **crystal oscillator.**
- For the signal to have minimum band width for the type of transmission - **filters and the use of linear amplification for SSB or other amplitude modulation modes.**
- For the signal to have the correct power output - **correct use of RF power amplifier**
- for the signal to have minimum output on other frequencies - **Band pass and harmonic filtering.**

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Bredhurst Receiving and Transmitting Society**Technical Aspects**

Syllabus Sections:-

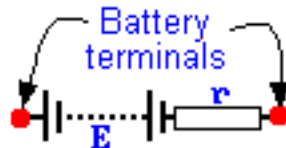
3. Technical Aspects

Potential Difference and Electromotive Force.

3a.1 Understand the difference between potential difference (p.d.) and electromotive force (e.m.f.).

Potential Difference and Electromotive Force

Potential Difference and Electromotive Force is a complex idea to grasp so let us first introduce you to a battery.



Up to now in both the Foundation and Intermediate licence courses you have only considered a battery, in its simplest form, as a source of electrons. The battery as a source of electrons does not change but the concept of the battery does.

Take a look at the diagram above. There is the usual circuit diagram for a battery but attached to it is a resistor and then the terminals have been shown outside these two circuit diagrams items. A battery is therefore in reality a combination of the source of electrons and a resistor.

Note on the battery diagram above the letter E. This stands for electro motive force. No don't panic at this new concept just follow it through.

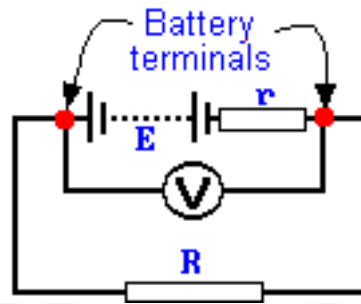
In the Intermediate licence course you were told that you can measure the potential difference of a battery by connecting a voltmeter across its terminals. This measured potential difference is the same as the emf of the battery BUT only when it is not connected to a circuit.

So what is the significance of all of this.

Note carefully the words above "only when it is not connected to a circuit" as when the battery is connected to a circuit the potential difference measured by the voltmeter will be lower than the emf because of the internal resistance of the battery.

Understand the concept of source resistance (impedance) and voltage drop due to current flow.

So now you can see why we have had to introduce you to this new concept and some of the energy used in the circuit will be used in this internal resistance (source resistance or impedance) -the resistance within the battery itself.



So looking at the circuit above you will observe that we have a single resistor connected across a battery.

"r" is shown as the internal resistance of the battery with emf E, connected to a circuit with resistance R. The voltmeter whilst it is connected to the battery terminals is measuring the potential difference across R and not the emf of the battery which is equivalent to the potential difference across $(R + r)$.

So there will be a voltage drop on the voltmeter when in circuit due to the current flow through the internal resistance.

So to sum up :-

1. the electromotive force (EMF) is therefore the maximum potential difference between the terminals of a power source that is a battery.
2. that there will be a current drop due to the current flow through the circuit and through the battery
3. the internal resistance is also known as the source resistance (or source impedance)

Still mystified well look at this another way :-

A car battery is a good source of emf. In an ideal source of emf it will maintain a constant potential difference between its terminals, independent of the current, I , through it or the resistance, R , across it.

The formula for an ideal source of emf is $V = I \times R$, which is known as Ohm's Law which you were introduced to in the Foundation licence as a magic triangle.

The potential difference across a real source in a circuit, however, is not equal to the ideal emf. The reason is that the flow of electrons passing through the materials of the battery encounters **an internal resistance r** and experiences a drop in potential difference equal to $I \times r$.

Thus the equation for a source with internal resistance is $V = (\text{emf} - I \times r)$ and this potential is called the terminal voltage.

Therefore the voltage in a car battery can be less than 12 V (depending on its state of charge or internal resistance) while it is producing a current.

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Bredhurst Receiving and Transmitting Society**Technical Aspects****Syllabus Sections:-****Resistance.**

3b.1 Understand and apply the formulae for calculating the combined values of resistors in series and/or in parallel.

Resistors of different values of may be used in series, parallel or combined series and parallel circuits.

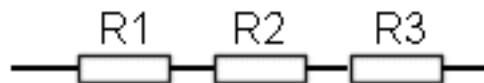
Resistors

Resistors and what they are was introduced to you in the foundation Licence course and developed on that in the Intermediate course

There are two quite difference and for some challenging formulae associated with resistor combinations whether they are in series or in parallel

Resistors in Series

The diagram below shows resistors connected in series.

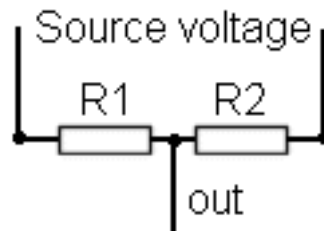


For a calculation any number of resistors, (from as few as two) may be connected as shown above.

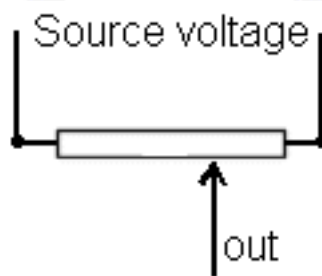
The effective resistance of the combination of R1 R2 and R3 is given by

$$R(\text{total}) = R1 + R2 + R3$$

- BUT you can of course add together as many resistors as you need to and calculate the total effective resistance of all the resistors.
- When a connection is taken from the junction between two resistors in series this is know as as fixed potentiometer or potential divider.



With the two resistors in this configuration a voltage somewhere between the maximum and minimum would be measured at the point marked "out" depending upon the values of the resistors. This fixed combination is usually replaced by a single resistor in which the output can be changed by moving a slider along the track.

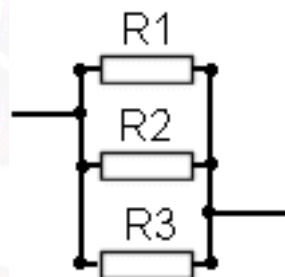


The output could be taken from anywhere along the resistor.

Without necessarily knowing it you have all used such potentiometer on the audio gain control on your transceiver / receiver !!!

Resistors in Parallel

The diagram below shows resistors connected in parallel.



Note that all the resistors are linked to each other by the wire that is across the end of of them all so it does not matter where the other connecting wires into the circuit actually connect the result would be the same.

For a calculation any number of resistors, (from as few as two) may also be connected as shown above.

The effective resistance of the combination of R1 R2 and R3 is given by

$$\frac{1}{R(\text{total})} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}$$

which can also be written as :- $\frac{1}{R(\text{total})} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}$

BUT as with the earlier example you can of course add together as many resistors as you need to and calculate the total effective resistance of all the resistors.

Let's put in some values. R1 = 100 ohms R2 = 150ohms R3 =270ohms

Thus $\frac{1}{R(\text{total})} = \frac{1}{100} + \frac{1}{150} + \frac{1}{270}$

so $\frac{1}{R(\text{total})} = 0.01 + 0.0066 + 0.0037$

so $\frac{1}{R(\text{total})} = 0.0203$

so $R(\text{total}) = 1/0.0203$

so $R(\text{total}) = 49.26$

So the total resistance of R1, R2 and R3 in parallel is about 49 ohms

Note:- that the resulting resistance is always less than the lowest resistor value in the group.

For the exam do the calculation as shown and then compare you answer to that in the question and you will see what figure is like yours and pick that as the correct answer.

If you are weak on maths then ask your lead instructor for some extra work on this to help you learn it.

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Maths**Bredhurst Receiving and Transmitting Society****Technical Aspects****Syllabus Sections:-****Power in DC circuits**

3c.1 Understand and apply the formula relating power to potential difference, current and resistance.

The formulae are :- $P = V \times I$, $V = I \times R$, $P = V^2 / R$, $P = I^2 \times R$

which can also be written using the mathematical notation of placing two letter together meaning multiply them together as:-

The formulae are :- $P = VI$, $V = IR$, $P = V^2 / R$, $P = I^2 R$

In the Foundation Licence course you were introduced to two magic triangles one relating to power, potential difference and current $P = V \times I$, and another one relating to potential difference, current and resistance $V = I \times R$. The triangles were again used in the intermediate Licence course.

Now we are going to develop your knowledge further and see what can be done with the two formula and a little bit of mathematics which either you may have forgotten from school or may not even have learned yet.

If you look at the two formula you will note that there is some similarity in that both have V and I.

We can therefore mathematically substitute the V in $P = V \times I$ by the $V = I \times R$ and we would get :-

So from this $P = V \times I$

which with from $V = I \times R$ we substituted the V by the $I \times R$ and the result is

$$P = I \times R \times I$$

$I \times I = I^2$ in english that is I times I which equals I squared I^2

$$\text{thus } P = I^2 \times R$$

which was the last formula in the syllabus section so what about the other one?

well from $V = I \times R$ also we manipulate the formula to give $V / R = I$

With the I is substituted by V / R in $P = V \times I$

$$\text{we get } P = V \times V / R$$

thus $P = V^2 / R$ which is the other equation mentioned in the syllabus.

So you do not have to actually have to learn

$$P = V^2 / R \quad \& \quad P = I^2 \times R$$

assuming that you can what is called derive them from the two basic formulae of

$$P = V \times I \quad \& \quad V = I \times R$$

and at least now you know where they come from !!!

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3d.1 Understand that two or more resistors can be arranged to act as a potential divider and apply the formula

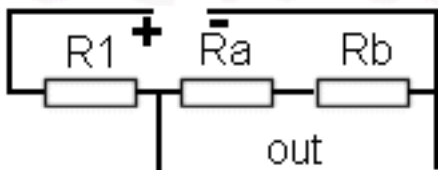
The formula is :- $V_{\text{out}} = V_{\text{in}} \times \frac{R_2}{R_1 + R_2}$

Potential divider formula

In an [earlier section](#) of this course discussion was given regarding two resistors acting as a potential divider, well in fact it can be two or more resistors but whatever number it is the resultant formula would be

$V_{\text{out}} = V_{\text{in}} \times \frac{R_2}{R_1 + R_2}$ as we would have to do separate calculation to end up with two resistors.

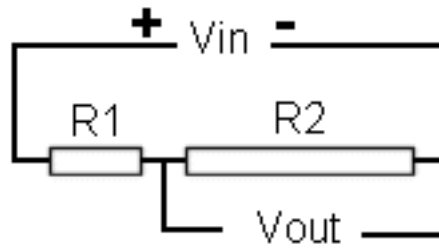
So looking at the diagram below:-



we have the output between R1 and Ra. As Ra and Rb are in

series we can simply add together their values and come up with R2 which we can use in the

formula $V_{\text{out}} = V_{\text{in}} \times \frac{R_2}{R_1 + R_2}$ simple eh ??



The V_{out} is thus dependent upon :-

- V_{in}
- $R1$
- $R2$

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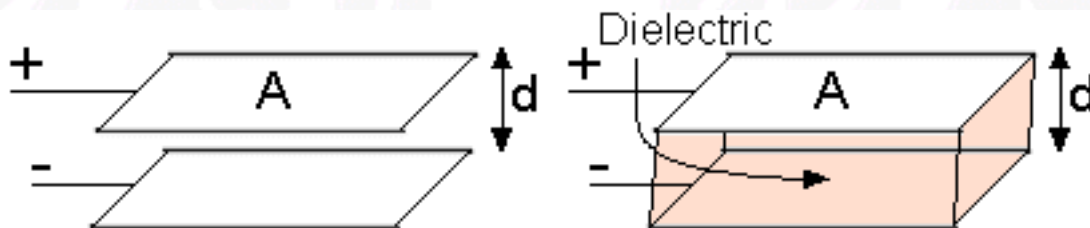
Syllabus Sections:-

Capacitance

3e.1 Understand the factors influencing the capacitance of a capacitor; area and separation of the plates, permittivity of dielectrics and formula $C = K A / d$.

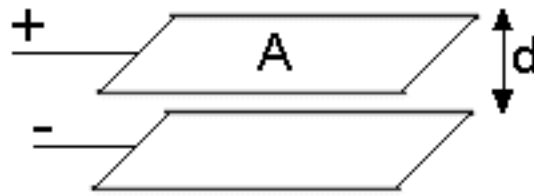
In the Intermediate Licence course you learned that a capacitor consists of two metal plates separated by an insulating material.

In its simplest form is two metal plates set parallel to each other with a separation gap of insulating material. This material is called a dielectric.



The capacitance is the word used to describe the ability of the two plates to store an electrical charge. The capacitance is proportional to the area of the plates (marked A in the diagram) and inversely proportional to the distance between the plates (marked d in the diagram) and also on the properties of the dielectric between the plates. The dielectric can be as simple as air but other materials used are paper, rubber, polythene mica and ceramics.

Thus the bigger the area the bigger the charge the capacitor can hold but the bigger the gap the smaller the charge that can be held. So the ideal high value capacitor will have large plates and a very small gap between them.



For a large value capacitor :-
Large Plates and **Small Gap**

The Dielectric

The property of the dielectric is called permittivity or the dielectric constant.

It is the dielectric material which determines :-

- the losses (as heat) which increase as the frequency gets higher(see more below)
- The variation in the value of the capacitor with a rise in temperature or due to aging
- the maximum voltage the capacitor may be used at as known as the working voltage
- the voltage at which the capacitor would be destroyed also known as the breakdown voltage (see more in the next section).

The formula $C = K \times A / d$ relates the Capacitance (C) to the Dielectric constant (K) to the overlapped area of the plates (A in sq inches) and the distance between the plates (d in inches) and gives the answer in farads.

3e.2 Understand that capacitors have a breakdown voltage and that they need to be used within that voltage.

Capacitors are rated for the maximum continuous voltage that should be applied. Note that the voltage applied will differ as to whether it is DC or AC.

The effect of applying too much PD is to destroy the capacitor and that might occur in spectacular fashion with a small explosion !!!

What actually happens is that the charge on the plates flashes over or makes a hole in the plates. Depending upon the capacity of the capacitor will determine how devastating the destruction will be !!!

3e.3 Recall that different dielectrics are used for different purposes, e.g. air, ceramic, mica and

polyester; and that with some dielectrics, losses increase with increasing frequency.

In addition to ceramic, mica, polyester, and air spaced as the dielectric in capacitors the electrolytic capacitors have a dielectric of a semi liquid conducting compound between their plates which can be of aluminium or tantalum foil. This dielectric is often impregnated paper as a very thin insulating layer.

Losses increase with increasing frequency

As has been mentioned before the maximum frequency that a capacitor can operate at is determined by the dielectric material. As a general rule losses in energy increase with increasing frequency.

Dielectric material	Use	Breakdown voltage	Stability	Frequency
Air	Mainly used for variable tuning capacitors capacitance values up to say 1000pf	High	Good	up to say 300MHz
Electrolytic semi liquid compound	Used for very high capacitors in Power supplies for smoothing	High	Good	up to 1Mhz
Paper	Used in high voltage capacitors	High	Good	up to 20MHz
Mica	This is the best dielectric but is expensive	Good	Good	up to and higher than 200MHz
Polyester	The usual type of capacitor when critical values are not required such as audio coupling and decoupling. tolerance typically 20%	Medium	Fair	up to about 100 kHz
Ceramics	High dielectric constant and has good temperature stability	Medium	Poor	up to 150 - 200MHz

3e.4 Understand the charging and discharging of a capacitor in a CR circuit and the meaning of the time constant $T=CR$.

Capacitance

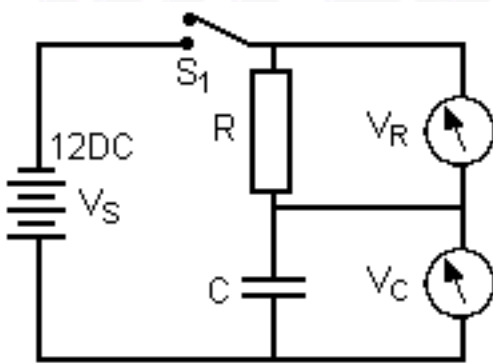
Charge and discharge of Capacitors in CR circuits

CR circuits mean a capacitor and a resistor linked in series.

In the section we are going to use the maths notation that if two items need to be multiplied together then they are written together without the times (x) symbol. Thus $V = I \times R$ would be written as $V = IR$

1. Charge Q on a capacitor

Consider the circuit arrangement shown below



and the following equations:-

Equation A

$Q = CV$ The charge Q on a capacitor is equal to the voltage across the capacitor times its capacitance in FARADS.

Equation B

$Q = \text{Amps} \times \text{Seconds}$ The charge in Coulombs, is equal to the current in amps times the time that the current has flowed in SECONDS.

2. Looking at the diagram above before S_1 is closed, $V_R = \text{zero}$, $V_C = \text{zero}$

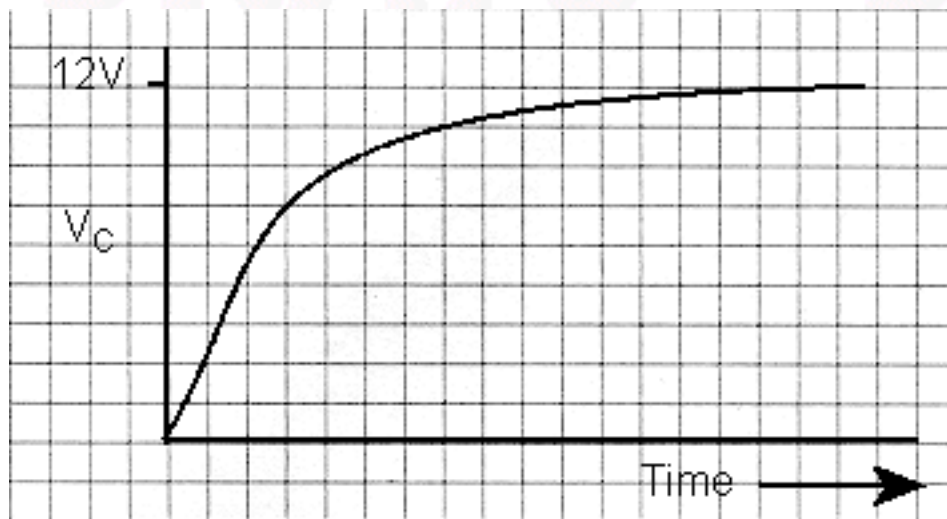
3. At the instant S1 is closed, no current has flowed into the capacitor, therefore there is no charge Q and $V_C = \text{zero}$.

$V_R = 12\text{V}$ and by Ohm's law I starts to flow and $I = V_S / R$ Amps at that instant.

4. A short time after S1 is closed current is flowing, therefore C is charging, V_R must be falling because $V_C = V_R = 12\text{V}$ V_R is now $V_S - V_C$.

If V_R is less I_R is less and the rate of charge of the capacitor falls, until eventually the capacitor is charged to 12V and no current flows then $V_R = \text{zero}$.

5. The graph of V_C with respect to time is shown and is known as an **EXPONENTIAL CURVE**



Time Constant

6. You will need to have a basic mathematical appreciation of the foregoing paragraphs 1 to 4, in order to be able to understand existing circuits involving C and R , and to be able to select values to give correct function in your own circuits.

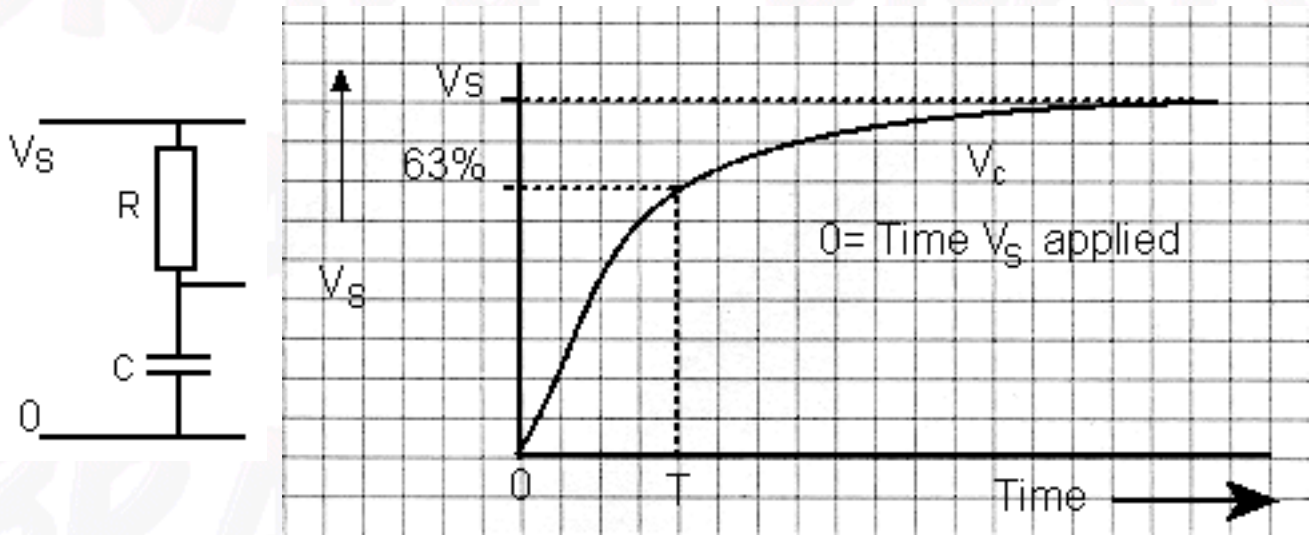
7. With $Q = \text{Amps} \times \text{Seconds}$ and $Q = CV$ then

$$IT = CV \text{ thus } T = CV/I, \text{ from ohm's law } R = V/I \text{ so } T = CR$$

So the equation is simply :-

$$T \text{ (in seconds)} = C \text{ (in farads)} \times R \text{ (in ohms)}$$

where T is the time taken for a capacitor to charge to 63% of the applied voltage V_S



8. T is called the Time Constant, and equally applies to discharge of a charged capacitor via a resistor where discharge by 63% of V_S occurs in Time $T = CR$

Example:

How long will it take to charge a capacitor of one microfarad to 63% of the applied voltage, via a resistor of 2 megohms ?

$$T = CR$$

Using the exponential notation

$$T = 1 \times 10^{-6} \times 2 \times 10^6$$

the 10^{-6} and 10^6 cancel each other out and the answer is

$$1 \times 2 = 2 \text{ Seconds}$$

9. $T = CR$ applies to timer circuits like the well known NE555 timer, PSU smoothing circuits, decoupling circuits, delay and de-bounce circuits.

Recall the dangers of stored charges on large or high voltage capacitors.

Large value and high voltage capacitors have some dangers to be considered when carrying out repairs or constructing equipment.

Low voltage and large value capacitor - high current flow if shorted

The ability to store a great deal of electrical energy is just what you required when building say a low voltage power supply but that same energy even at say 18 volts could destroy a small screw driver if dropped across the terminals or even if it were not destroyed it could heat up to such an extent that it caused a fire.

High voltage and small or large value capacitor - danger of electric shock

When we come to high voltage those are considered to be anything above 50v. In a linear amplifier power supply the volts is likely to be of the order of 2000v. If energy of this voltage level was stored in a capacitor when the equipment was turned off lethal voltage in an electric shock would exist without even taking into account the amount of current that could be available!

Recall that large value resistors can be used to provide leakage paths for these stored charges on high voltage capacitors.

So what so we do to make these large value or high voltage capacitors safe?

Leakage paths resistor

They are fitted with a large value resistor say 1k ohms and this will provide a "leakage" path to take away the charge in the form of heat when the current flows through the resistor when the equipment is turned off. It may take several minutes to discharge down to a safe level so do not be in a rush to delve inside equipment.

In the Foundation Licence course you learned that a resistor restricts the flow of current. You also learned in the Intermediate Licence course that a capacitor can store charges and that these charges can be released into the circuit when needed.

So what happens when the circuit that was using this charge is turned off. The capacitor remains charged to the voltage it reached when it was being used in circuit. If the stored voltage was high say 240V then that would be the same level of voltage as the mains supply and thus equally dangerous.

Here is where the humble resistors comes into play. If a large value resistor say 100K then by ohm's law

$$240 / 100,000 = 0.0024 \text{ or}$$

a current of only 2.4mA would flow and thus over time the voltage would be leaked away to a safe level in the form of heat in the resistor. Such a small level of current flowing whilst the capacitor is "in circuit" would have no effect on the operation of the circuit as the capacitor might be supplying several amps for short intervals.

3e.5 Recall and apply the formulae for calculating the combined values of capacitors in series and in parallel

$$C_T = C_1 + C_2 + \dots \quad C_T = \frac{C_1 \times C_2}{C_1 + C_2} \quad \frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \dots$$

When capacitors are linked in series the total value can be calculated from the formula:-

$$\frac{1}{C_{\text{total}}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \dots\dots$$

The special case is when there are two capacitors linked in series then the simplified formula can

be used :-
$$C_T = \frac{C_1 \times C_2}{C_1 + C_2}$$

When capacitors are linked in parallel the total value can be calculated from the formula:-

$$C_{\text{total}} = C_1 + C_2 + C_3 \dots\dots$$

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3f.1 Understand the term 'self inductance' and recall that a 'back EMF' is produced as current flow changes in an inductor.

Self inductance

If there is a steady current flowing in a coil then there is a steady magnetic field produced by that current. If there is a current change then the field strength will also change, which will then produce a back emf to oppose the change being made.

BACK EMF in an inductor

The slow rise of current through a large inductor when a voltage is connected across it, is caused by the existence of a back EMF (electromotive force) which is a voltage generated by the magnetic field of the inductor working in opposition to the applied voltage. The back emf is particularly large when the the rate of change (frequency) of current flow is rapid, (as occurs when a circuit is switched off).

3f.2 Recall that the inductance of a coil increases with increasing number of turns, increasing coil diameter and decreasing spacing between turns. Understand the use of high permeability cores and slug tuning.

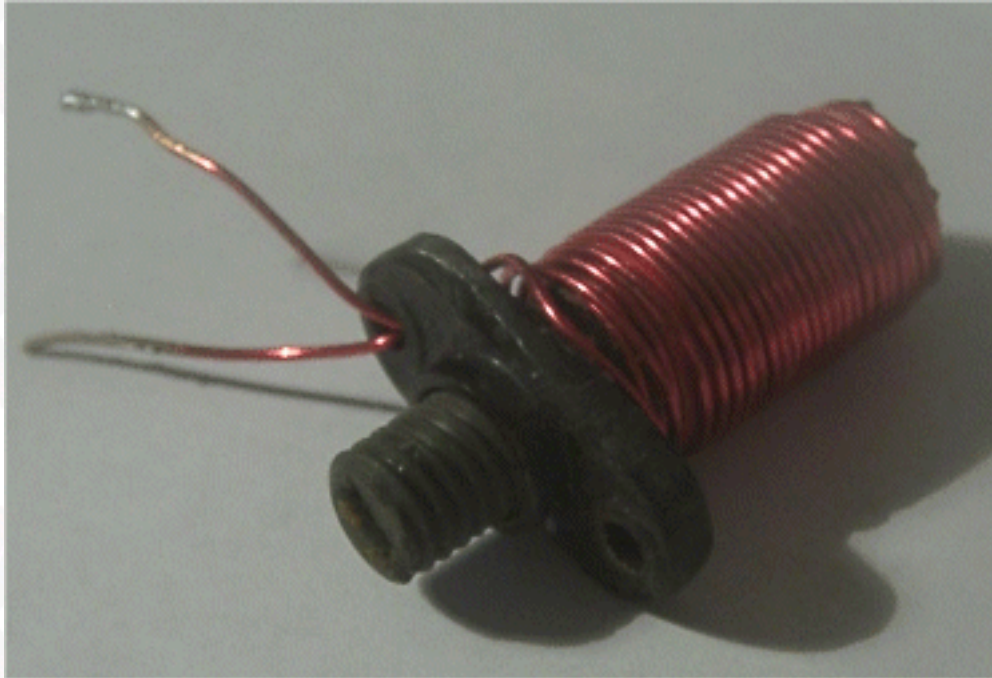
From straight piece of wire to coil

In the ILC you were introduced to the concept of inductance in relation to not only a single piece of straight wire but also when that wire was made into a coil the inductance increased, and that increasing number of turns, increasing coil diameter and putting the turns closer together the inductance increased.

- The inductance can be further increased by the use of a high permeability core.

high permeability cores

So what is a high permeability core. When you have an inductor wound on a former as part of a tuned circuit in order that the circuit can be "tuned" to a specific frequency it is fitted with a high permeability core (also called a tuning slug). The core is threaded so that by the use of a non ferrous tool the core can be moved up or down the former tuning the coil (slug tuning) to the point where it resonates. Sometimes the slug might be partially out of the core.



Coil with tuning slug

Should the inductance of the coil need to be reduced that this can be achieved by the use of a "brass" slug

The use of the core saves the need to change the size or number of turns on the coil as it increases the effective inductance.

3f.3 Understand the rise and fall of current in an LR circuit.

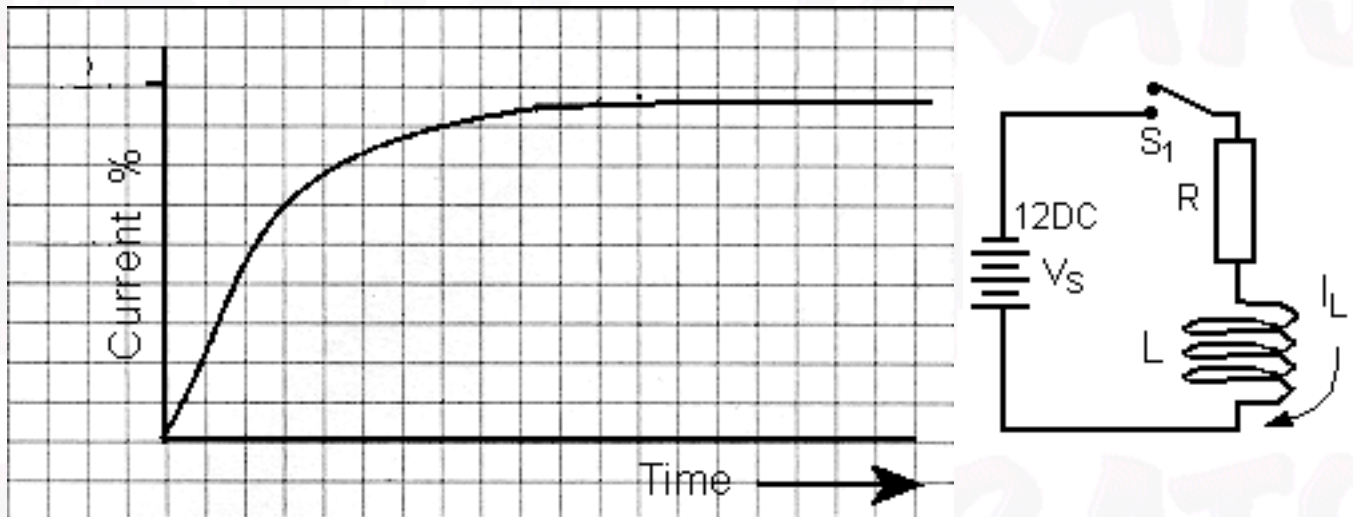
Earlier you were exploring the RC in [3e.4 click here to check back](#) and now we are going to look at an LR circuit.

Insert drawing of an LR circuit

Initially in the DC circuit the inductor L will have effectively no resistance and for the moment have a resistor value of zero.

The effect of closing the switch allow current to flow in the complete circuit and there is an instantaneous change from no current to finite current. and a back EMF is developed by the self inductance in L . This back EMF is almost equal and opposite to the EMF supplied to the circuit.

The back EMF is dependent upon a change in current and if the current does not change the back EMF stops. With no resistance from ohms' law $V = I \times R$ the resulting current would be infinite.



There is an equation which indicates the time for the current I_L to reach 63% of the maximum I , (I^2/R amps) after S_1 is closed

$$T_{(\text{inductive})} = L/R \text{ seconds}$$

This time for the current to reach 63% is called the LR Time Constant.

3f.4 Understand and apply the formulae for calculating the combined values of inductors in series and in parallel.

The formula is :- $L_{\text{total}} = L_1 + L_2 + L_3 \dots\dots$

When inductors are linked in series or in parallel then the total equivalent value is similar in

calculation to that of resistors.

Thus total value of several inductors linked in series can be calculated from the formula:-

$$L_{\text{total}} = L_1 + L_2 + L_3 \dots\dots$$

Can you deduce the other formula for inductors in parallel ?? If not then discuss with your tutor.

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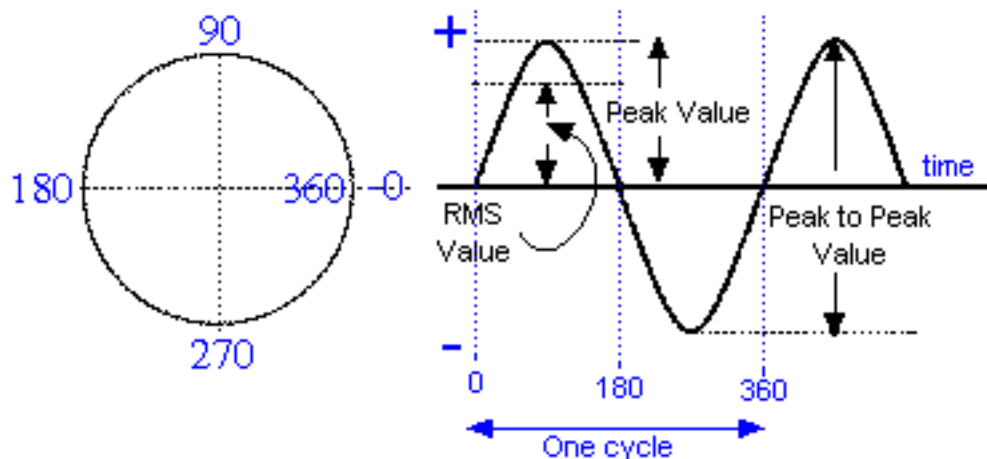
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3g.1 Understand that the root mean square (r.m.s.) value of a sine wave has the same heating effect as a direct current of the same value and that it is equal to 0.707 of its peak value.

Let's take a look at the sine wave that you were first introduced to in the Foundation Licence course, but several new items are added in this course.



Up to now you have only been considering that part of the sine wave marked 0 to 360 but you have learned that the sign wave in fact does continue on indefinitely until the equipment is turned off.

Looking at the diagram you can see Peak Value. This is the maximum voltage of the sine wave. Knowledge of this is needed to understand RMS.

Looking at the diagram you can see RMS Value. This stands for Root Mean Square value. The RMS has the same heating effect as a direct current of the same numeric value. The RMS is numerically equal to 0.707 of its peak value. Thus if the peak value was 240V AC the RMS would be $240 \times 0.707 = 169$. So if you had a DC you would only need to have a voltage of 169 volts to give the same heating as 240V AC.

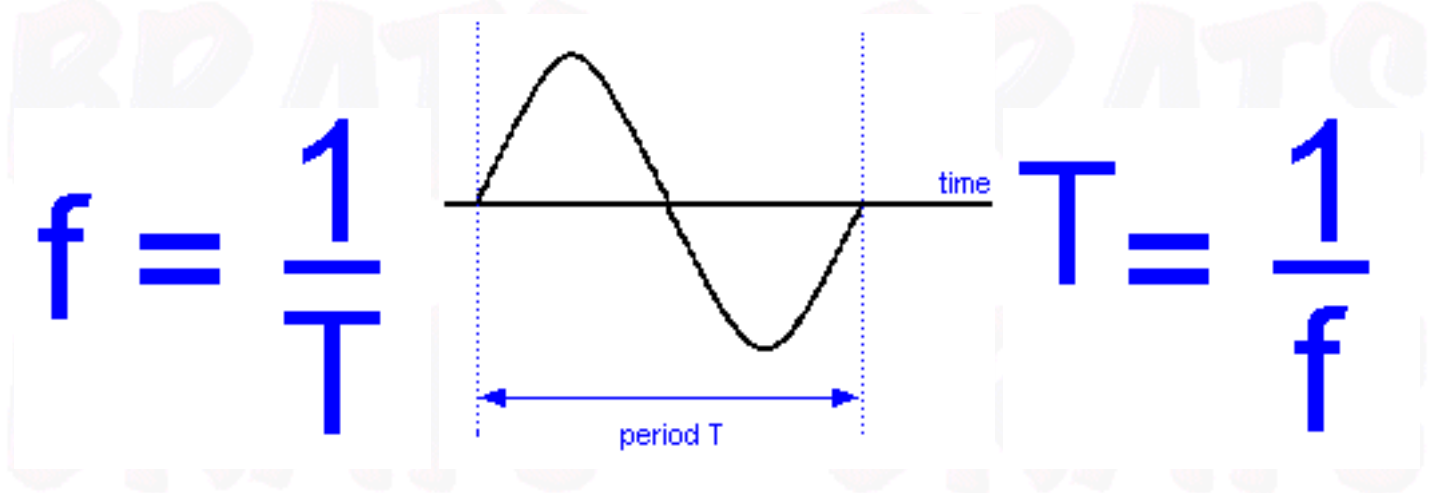
Also the average value of the AC sine wave is numerically equal to 0.636 of its peak value.

Also observe that the measurement between one peak and the next is called the Peak to Peak value.

Finally the horizontal axis through the centre is the time axis and is measured in seconds. The vertical axis is the + and - volts.

3g.2 Recall that the period of a sine wave is equal to $1/f$ and that the frequency of a sine wave is equal to $1/T$ (where f = frequency in Hertz and T = time in seconds).

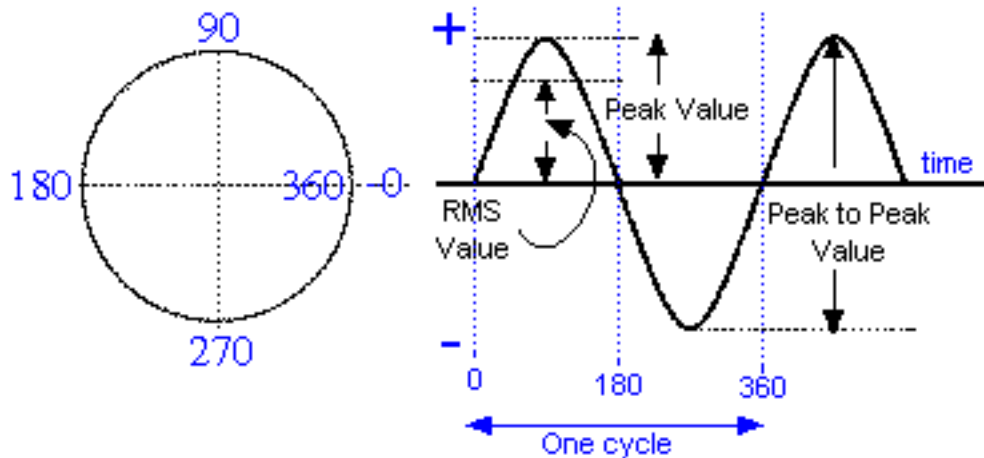
There is more about the sine wave that you need to know.



1. One complete cycle as is shown above is completed in a **time period of T in seconds**
2. The number of cycles completed in one second is the **frequency f and the unit is Hz (Hertz)**
3. Thus $T = 1 / f$ or time to do one complete cycle is one divided by the frequency in Hz
4. And $f = 1 / T$ or the frequency in Hz is given by one divided by the time T to do one cycle.

3g.3 Understand the concept of phase difference, that it is expressed in degrees and that a full cycle is equal to 360 degrees.

As well as measuring time in seconds it is also referred to as so many degrees. Have a look at the diagram below.



You can see that there are markings at the bottom of 0 - 180 - 360 which are measurements in degrees. There are 360 degrees in a circle (see diagram above) just as there are in one cycle of the sine wave.

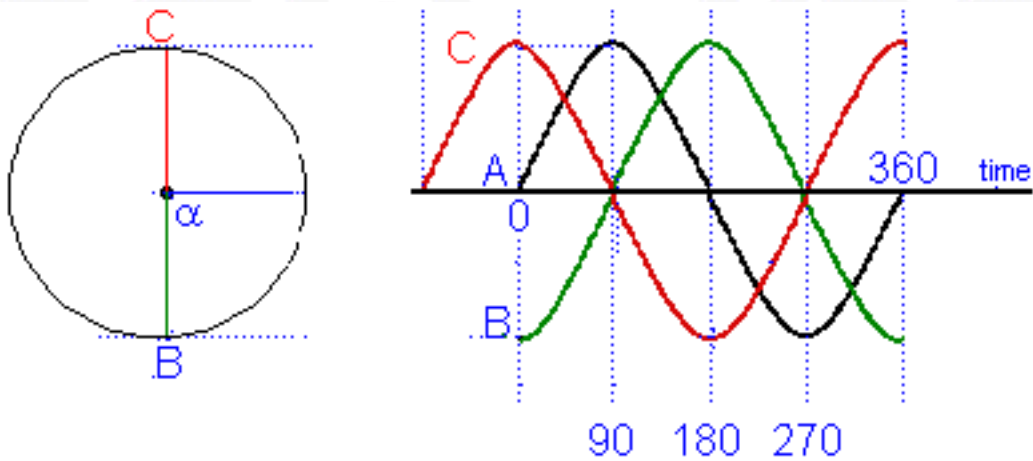
Phase

The word **phase** is used in the context of the waveform to mean an amount of time. The amount of time to do one complete cycle is 360 degrees and half a cycle 180 and so on.

Phase angle

Thus if two sine waves are on the same diagram but start and finish at different places the time difference between them can be expressed conveniently as a **phase angle**.

Out of phase



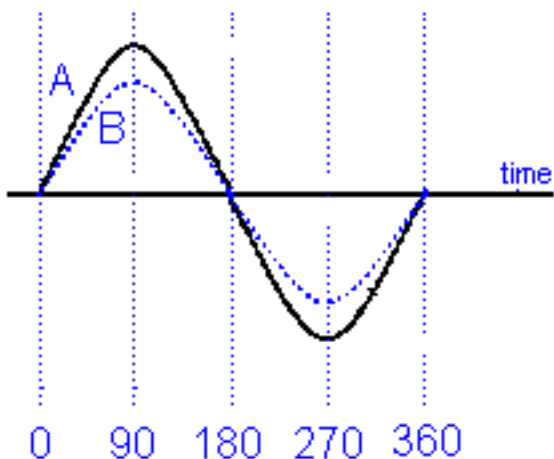
The amount that a curve lags or leads is given in degrees according to where the same point on the first curve the second one is. In the diagram above you can see that the angle $\alpha = 90^\circ$ so by using the circle you could assess the amount of lead or lag in degrees.

From the point of view of the sine wave "A" at point 0, the wave form "C" is leading wave "A" by 90 degrees. If you look at the diagram above "C" as it was at the same point on the time line 90 degree earlier than "A".

Where as wave "B" lags wave "A" by 90 degrees as it has not yet reached the point on the time line where "A" is at 0.

All the waves "A", "B" and "C" are said to be **out of phase**.

In phase



If two curves start and finish at the same time even though they have different magnitudes they are

said to be **in phase**.

All of the above are difficult concepts so make sure you understand them before pressing on.

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Syllabus Sections:-

A.C. circuits Part 2

3h.1 Recall that for a resistor the p.d. and current are in phase

This is the simple part that in an AC circuit of a source and a resistor unlike a capacitor or an inductor the p.d. and the current through the resistors are in phase.

Recall that current lags potential difference by 90° in an inductor and that current leads by 90° in a capacitor.

Re-writing the syllabus to make it easier to understand

Recall that potential difference leads current by 90° in an inductor and that current leads potential difference by 90° in a capacitor.

Memory aid: This section is quite difficult to grasp for some students so an old hand at Amateur Radio, at a recent BRATS club meeting, suggested the following was added to the course note.

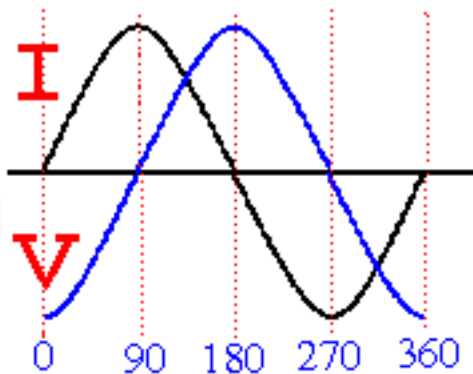
C I V I L**C I V V I L**

with a Capacitor the current leads the voltage the I leads the V in CIV

and with a Inductor voltage leads the current the V leads the I in VIL

With that in mind continue with the topic.

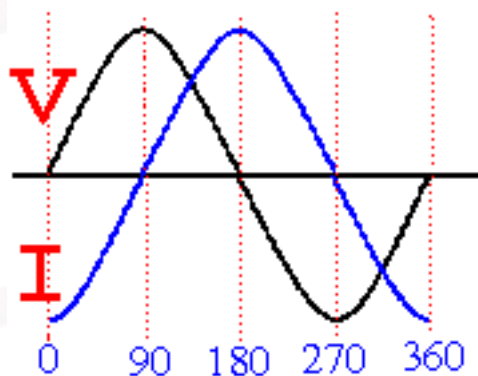
Capacitor - Current leads Potential Difference (C I V)



If the black curve now represents the current through a capacitor then the blue curve represents the potential difference across a capacitor. The current leads the the potential difference by 90° .

This **capacitive reactance** can be calculated by the formula $X_C = 1/2\pi fC$

f is in Hertz with C in Farads



Inductor - Potential difference leads the Current (V I L)

If the black curve represents the potential difference across an inductor then the blue curve represents the current across an inductor. The potential difference leads the current by 90° .

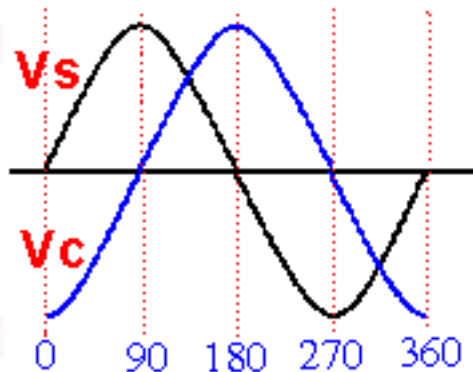
So let us explain further. When the Black curve is at position 0 the blue curve has not yet reached the same 0 position thus the black cure is said to lead the blue curve.

This **inductive reactance** can be calculated by the formula $X_L = 2\pi fL$

f is in Hertz with L in Henrys

PD (voltage Wave forms)

Taking this further at the point of supply of AC the wave forms of PD potential difference (voltage) and Current are in phase but when it encounters a capacitor then from above the current leads the PD (voltage) CIV thus in fact across the capacitor the PD or voltage wave will lag behind the supply waveform.



Had it been an Inductor then the PD (voltage) leads the current V_{IL} thus in fact across the Inductor the PD or voltage wave will lead the supply waveform.

Can you draw the appropriate wave forms ??

Recall that the term 'reactance' describes the opposition to current flow in a purely inductive or capacitive circuit where the phase difference between V and I is 90° .

Understand and apply the equations for inductive and capacitive reactance.

The equations are :- $X_L = 2\pi fL$ $X_C = \frac{1}{2\pi fC}$

Reactance

Reactance is the opposition to current flow in an AC circuit and can be loosely thought of as **AC resistance**. This "**AC resistance**" is not actually resistance and it must be remembered that a capacitor stores energy electrostatically and an inductor stores energy magnetically.

Taking the case of the capacitor it can be loosely thought of as a very small rechargeable battery which accepts a charge and can then accept no more. On the next half cycle the capacitor then gives up that charge back to the supply and charges in the opposite direction. For this reason a "perfect capacitor" (one with no losses) does not get hot. It will be appreciated that the capacitor

will charge and once charged can pass no more electricity hence it then apparently acts as an open circuit.

To differentiate from "normal" resistance we call that caused by the capacitor **Capacitance Reactance** and that by an inductor **Inductive Reactance**.

X_C represents capacitive reactance in an AC circuit.

X_L represents inductive reactance in an AC circuit.

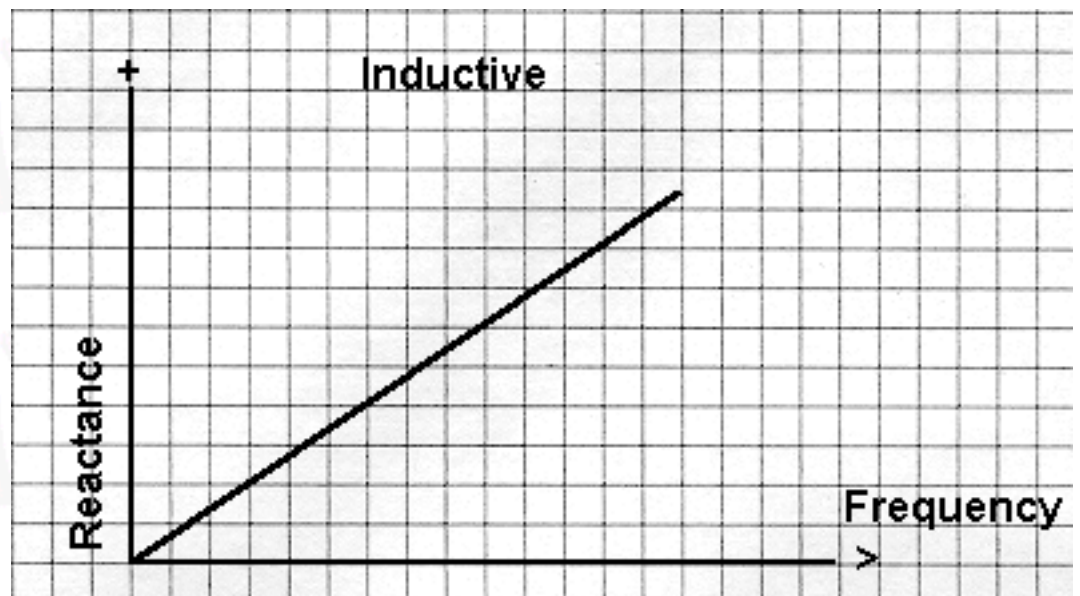
In the formulae that follow they use certain symbols :-

f = frequency in Hz **L** = inductance in henries **C** = capacitance in Farads

$$\pi = 3.142$$

Inductive Reactance

If we draw a graph of inductive reactance $X_L = 2\pi fL$, against Frequency, we get :-

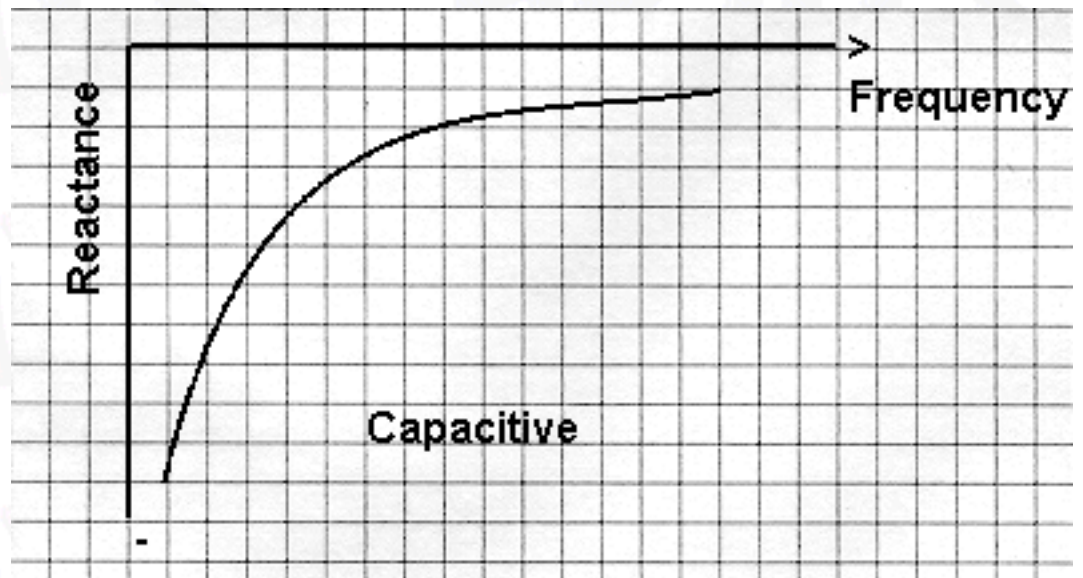


Note: Inductive reactance is considered to be positive.

Capacitive Reactance

If we draw a similar graph for capacitive reactance $X_C = \frac{1}{2\pi fC}$, against frequency we get:-

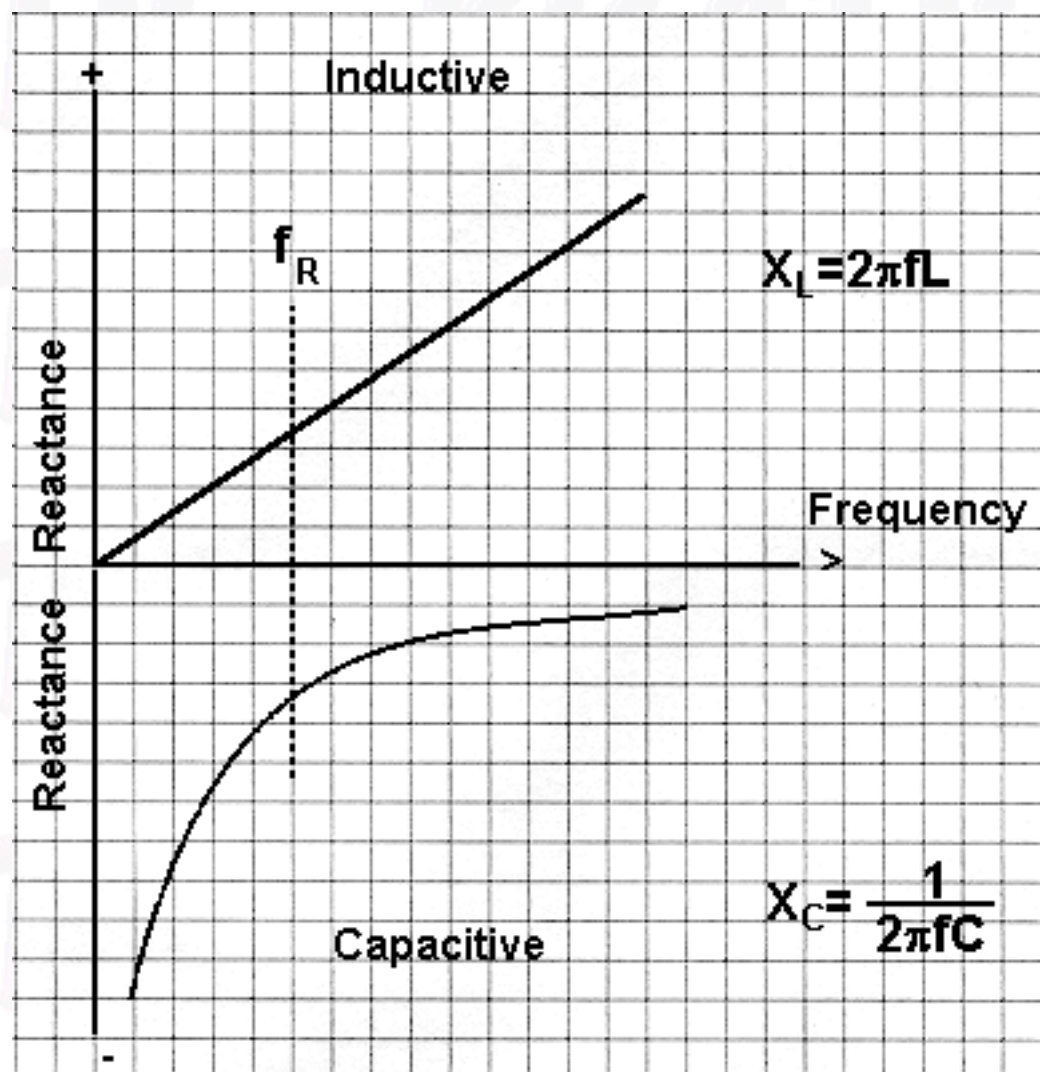
Note: capacitive reactance is considered to be negative.



Resonance

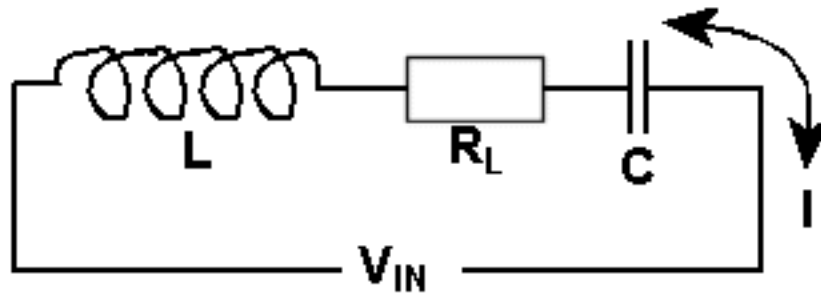
Now, if we have an LC circuit and draw both graphs on a common frequency line we get :-

Examination will show that only at one particular frequency are the reactances equal and opposite -> the **resonance frequency** (see the dotted line).



Series Resonance

We have spoken about the reactance of the coil (inductor) which is like resistance but the coil still has "normal" resistance and for these calculations we call this R_L and identify it in the circuit diagram as a resistor.



Let $X_L = X_C = 10k$ and $R_L = 10R$

V_{IN} 10mV RMS at the resonant frequency.

as X_L and X_C cancel each other out, so $I = \frac{V_{IN}}{R}$

$$\text{Thus } I = \frac{10 \times 10^{-3}}{10}$$

$$\text{Thus } I = \frac{10 \times 10^{-3}}{10} = 1 \text{ mA}$$

Voltage across L or $C = I \times X_L$ or X_C

$$\text{Thus Voltage across } L \text{ or } C = 1 \times 10^{-3} \times 10^4$$

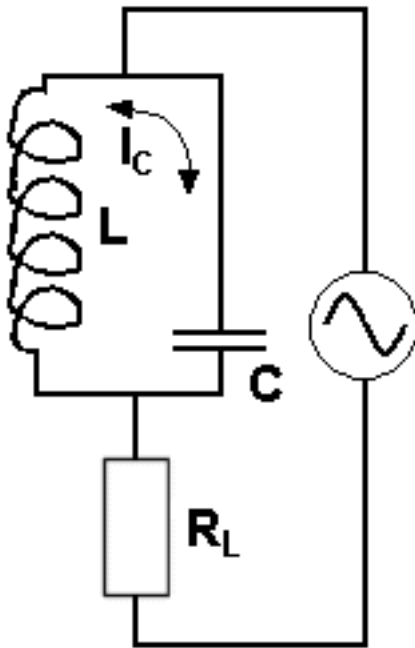
Thus Voltage across L or $C = 10$ volts

Gain

The "gain" between the input and the output is known as **magnification factor** which in this case = 1000 (10mV rising to 10V = 1000 times) and thus the

$$\text{magnification factor at resonance} = \frac{X_L}{R} \text{ or } \frac{X_C}{R}$$

Parallel Resonance



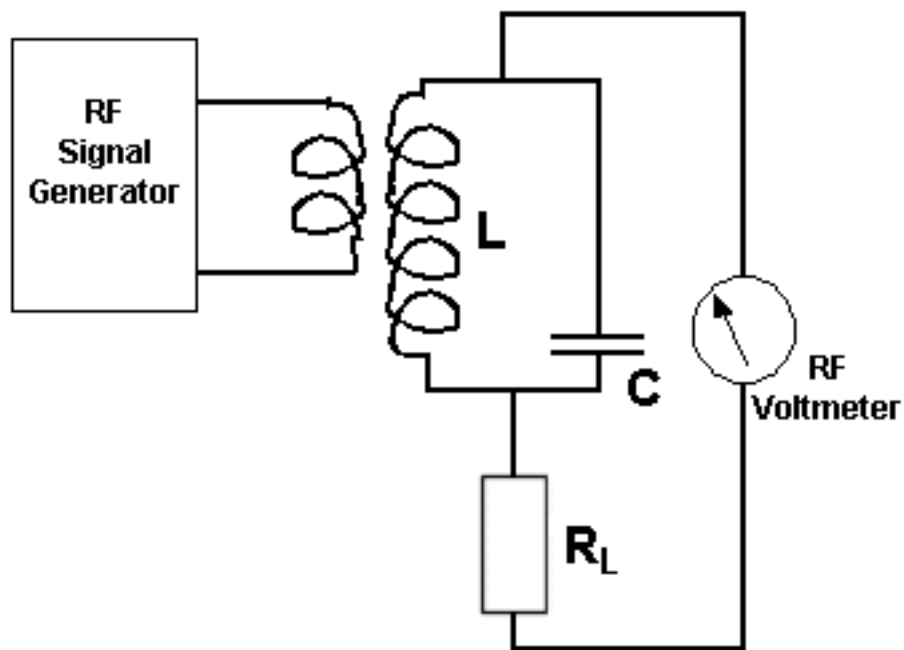
By varying the frequency of the input current, the point where $X_L = X_C$ approaches and a circulating current I_C increases to a maximum in the parallel loop limited only by R_L . The voltage across the circuit $V_C = I_C \times X_C$.

At the same time the overall resistance to the input current rises to a maximum and the through current is a minimum.

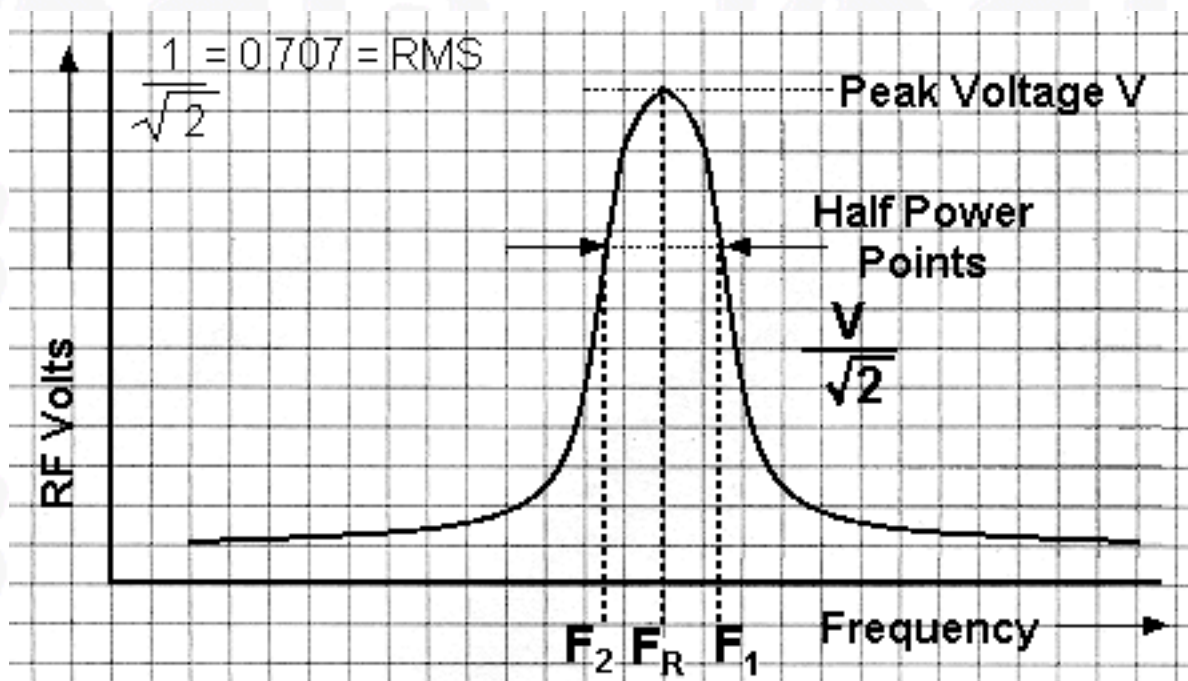
At resonance this circuit is called a rejector circuit.

Resonance Curves

Assuming that we loosely couple a signal generator into the inductor of a parallel LC circuit and measure the voltage across with an RF voltmeter



Now let us sweep the input frequency and draw graph of the resulting voltage changes.



F_R is the resonant frequency giving a peak voltage, V .

The points either side are generally accepted as limits of usable frequency - This range F_2 to F_1 is the bandwidth [eg. 12kHz for speech] for a parallel LC circuit, which could be the load in a power valve RF amplifier.

Q Meter

This measurement, requiring only a voltmeter, is used in a common form of Q meter. Q meters

give a measure of "Goodness" of a component or circuit.

$$\text{In this case } Q = \frac{F_R}{F_1 - F_2}$$

ie the Bandwidth compared to the resonant frequency = **SELECTIVITY**

Q will be discussed further in due course

Longwave Coils (for interest only)

If we build a receiver for say 120kHz, the RF stage (if we still require 12kHz speech bandwidth) will have a measured "MAX"

$$Q = \frac{F_R}{F_1 - F_2} = \frac{120\text{kHz}}{12\text{kHz}} \quad Q = 10$$

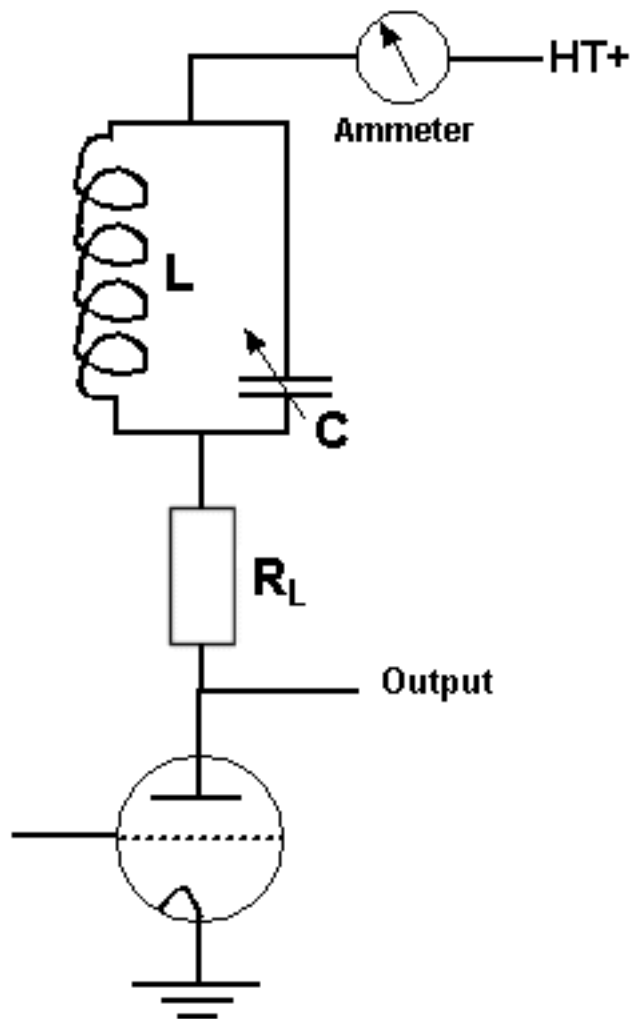
NOTE: a **Q** of **10** is very low !!

Q (Quality Factor)

Providing **Q** is greater than a single figure the following basic statements are true with small and negligible errors.

$$Q = M, \text{ the MAGNIFICATION FACTOR is } Q = \frac{X_L}{R}$$

The parallel resistance of a tuned circuit at resonance is **Q** x **X_L**. This is known as the **DYNAMIC resistance**



An example of this is shown, a parallel tuned circuit in the "ANODE" of a RF amplifier.

Let $X_L = 1000$ Ohms

and $Q = 100$

To tune to resonance we adjust C until the DYNAMIC RESISTANCE is HIGHEST, ie for a max dip on the ammeter.

The coupling resistance to the next stage (Dynamic Resistance) is $Q \times X_L = 100,000$ Ohms

The series RF resistance of the coil

$$= \frac{X_L}{Q} = 10 \text{ Ohms}$$

The general expression for Dynamic Resistance is :-

$$R_D = \frac{L}{C \times R} \text{ which does not include any frequency component.}$$

It is obvious from this that the larger L compared to C , the higher will be the Dynamic Resistance and Q .

3h.2 Understand that impedance is a combination of resistance and reactance and apply the formula for impedance and current in a series CR or LR circuit.

The formulae are :- $Z = \sqrt{R^2 + X^2}$ $I = V/Z$

If there is a resistor and an inductor (and or a resistor and capacitor or even a resistor inductor and

a capacitor) linked together in series in an AC circuit then the total opposition to the flow of current is known as impedance symbol **Z**.

Resistance and reactance CANNOT just be added together

The impedance is made up of both resistance R and reactance X, both are measured in ohms but cannot be added together (as you can do for resistor in series) but have to be added together like vectors :-

$$Z = \sqrt{R^2 + X^2}$$

Ohms law can now be applied to the circuit and the current determined by the formula:-

$$I=V/Z$$

3h.3 Understand the use of capacitors for coupling (d.c. blocking) and decoupling a.c. signals (including r.f. bypass) to ground.

It should be clear to you that from the construction of a capacitor (two separate plates with no link between them) provided no path for DC to pass. Thus it can be said that capacitors block DC and thus can be used for blocking DC in a circuit.

On the other hand in an AC circuit current appears to pass because of the build up and decay of the charge on one plate and then the other AC changes direction of its flow of electrons.

If therefore there is the possibility of an AC signal (and this include RF which is also AC) in a DC circuit then this can be channeled to ground via a capacitor and as such this is called decoupling hence the term "decoupling capacitor".

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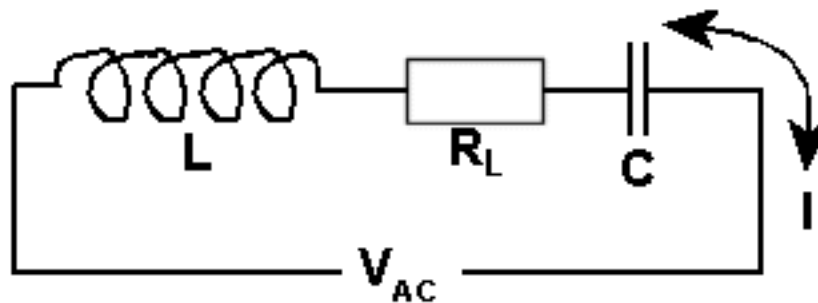
Maths**Bredhurst Receiving and Transmitting Society****Technical Aspects**

Before we get into the explanation of the syllabus here is some introduction to the topic.

Resonance

1. What is Resonance and where can it be found ?
2. What is Capacitive Reactance ?
3. What is Inductive Reactance ?

If we have a simple circuit of an inductor, capacitor and resistor linked in series and apply an AC voltage not only is there resistance due to the resistor but also due to the capacitor and the inductor.



Reactance is the opposition to current flow in an AC circuit, so it can be thought of as **AC resistance**. This resistance however is caused by capacitors and inductors so to differentiate from "normal" resistance we call that caused by the capacitor **Capacitive Reactance** and that by an inductor **Inductive Reactance**.

Now with a LOW frequency being applied at V_{AC} the Capacitive Reactance will be much larger than the resistance of R_L and the Inductive Reactance will be much smaller when compared to both the Capacitive Reactance and R_L .

When the frequency being applied at V_{AC} is made much higher, the Capacitive Reactance will be much smaller than the resistance of R_L and the Inductive Reactance will be much larger.

Frequency	Reactance	
Low	Capacitive HIGH	Inductive LOW
HIGH	Inductive HIGH	Capacitive LOW

It should therefore be apparent to you that at some frequency between these two extremes of low and high that the Capacitive Reactance and the Inductive Reactance will equal each other. Further because the voltage drop across the inductor and the capacitor are not only equal but 180° out of phase they cancel each other out.

At the point of Capacitive Reactance and the Inductive Reactance cancelling each other out, the only opposition to the current flow in the circuit will only be the resistor.

Let's have a look at what we have just said in graph form.

If we draw the graphs of Capacitive Reactance and the Inductive Reactance on a common frequency line we get :-

We mentioned above that at some frequency between these two extremes of low and high that the Capacitive Reactance and the Inductive Reactance will equal each other.

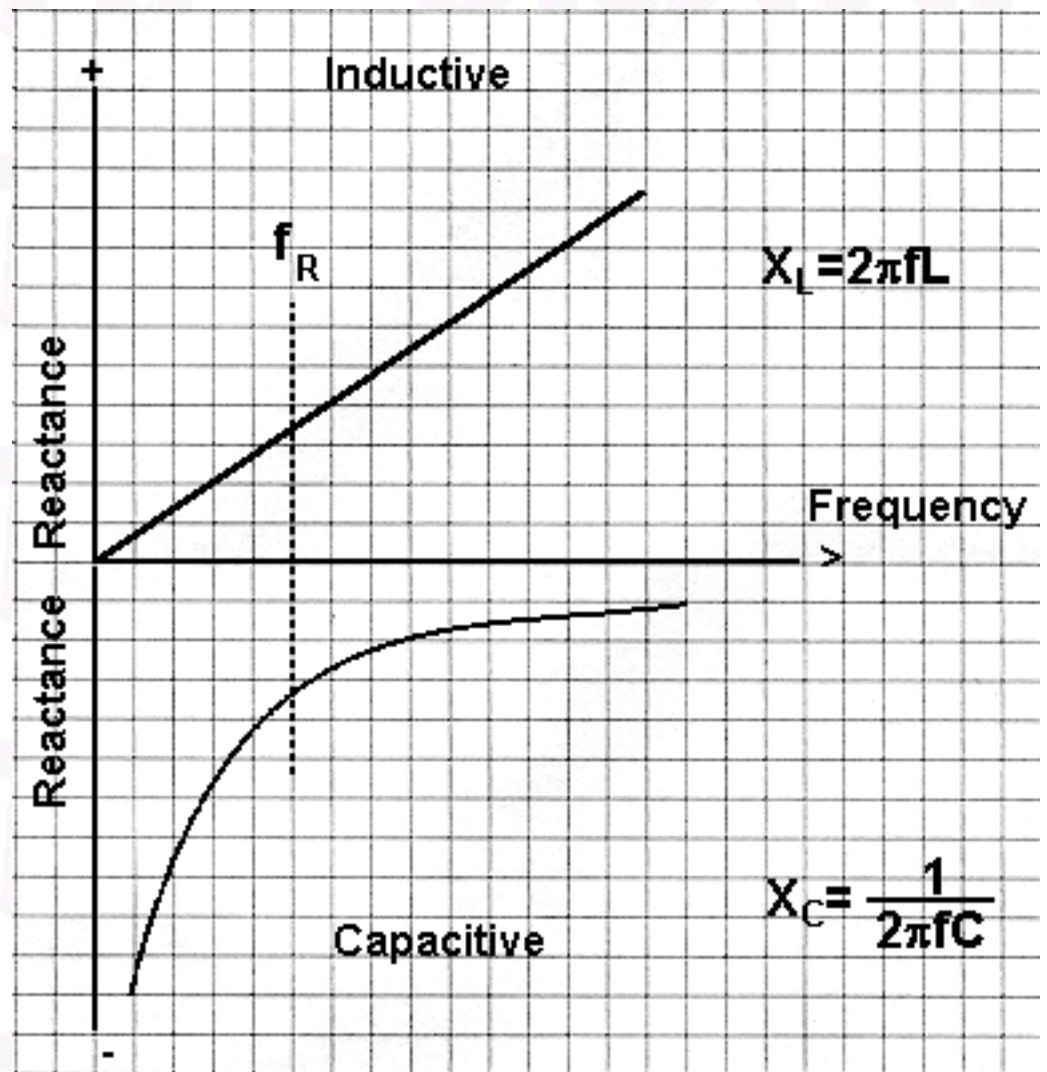
If you examine the graphs you will see that 5 units along the frequency axis and then 3 1/2 units along the resonance axis that the Inductive reactance at 3 1/5 is positive and the Capacitive reactance is 3 1/5 negative.

Only at this one particular frequency do the reactances have equal

value BUT are opposite in sign and this is called

the Resonant Frequency

see the dotted line on the graph



Conclusion

We can now answer the question posed at the top of the page :-

What is Resonance and where can it be found ?

Resonance is that moment when the changing frequency of an oscillator reaches a frequency when applied to a tuned circuit the Capacitive Reactance and the Inductive Reactance are equal. It can be found easily from plotting a graph as shown above at a frequency of f_R and at no other point.

Drinks break time !!!

I hope you are ok so far, as this is very heavy going relative to the Foundation and to the Intermediate Licence courses, so if I were you I would take a break here have some of your favourite drink, or something, and then come back to it again refreshed.

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Technical Aspects

From the [previous page](#) you should now have an understanding of :

Resonance

1. What is Resonance and where can it be found ?
2. What is Capacitive Reactance ?
3. What is Inductive Reactance ?

Now to keep writing Capacitive Reactance and Inductive Reactance is rather long winded so we can adopt two symbols :-

Capacitive Reactance in an AC circuit is represented by X_C

Inductive Reactance in an AC circuits represented by X_L

In the formulae that follow they use certain symbols :-

f= frequency in Hz **L** = Inductance in Henries **C** = Capacitance in Farads **π** = 3.142

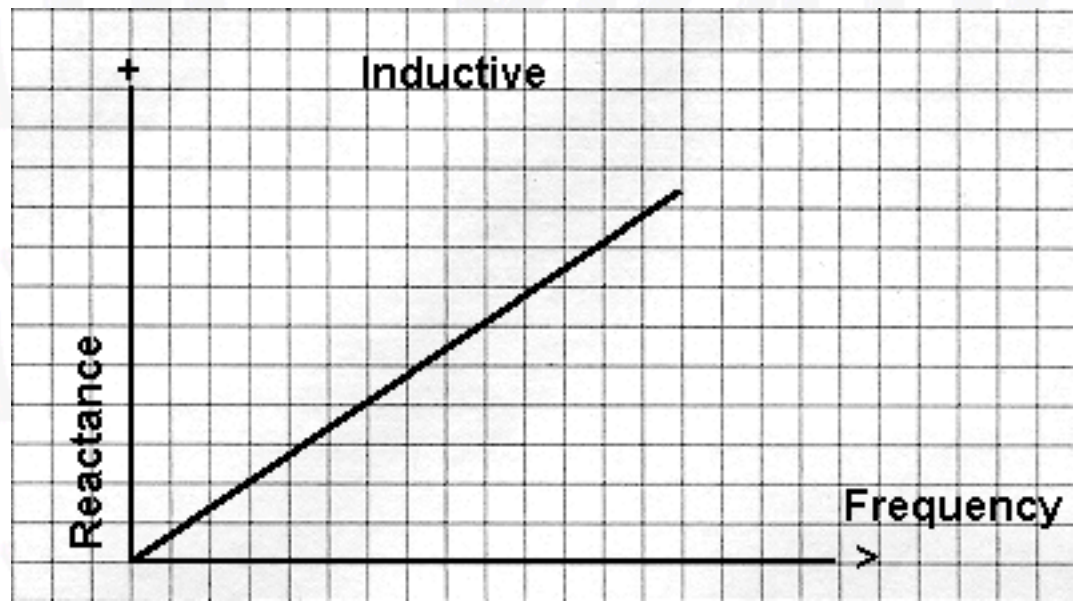
There is much more maths coming up, so be warned, and take it nice and easily. If you find there is something you do not understand then email us telling us where you do not understand and we will try to make the text simpler and more understandable.



Inductive Reactance

If we draw a graph of inductive reactance $X_L = 2\pi fL$, against Frequency, we get :-

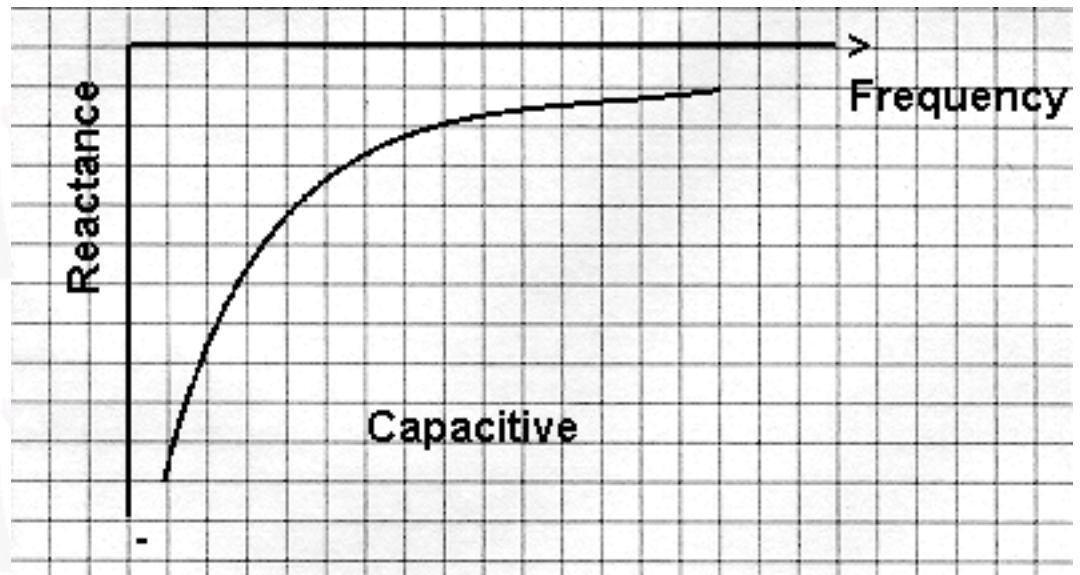
Note: Inductive reactance is considered to be positive.



Capacitive Reactance

If we draw a similar graph for capacitive reactance $X_C = \frac{1}{2\pi fC}$, against frequency we get:-

Note: capacitive reactance is considered to be negative.



Syllabus Sections:-

Tuned Circuits

3i.1 Understand that at resonance $X_C = X_L$ and the formula for resonant frequency.

The formula is :-
$$f = \frac{1}{2\pi\sqrt{LC}}$$

You need to be familiar with the equation $f = \frac{1}{2\pi\sqrt{LC}}$ but where does it come from ??

We know that at resonance in a tuned circuit the reactance of the capacitor is equal to the reactance of the inductor and the two equation associated with reactance are:-

$$X_C = \frac{1}{2\pi f C} \quad X_L = 2\pi f L$$

The π is necessary to maintain standard notation, for each Hz there are 2π radians (= 360° Degrees)

Now $X_L = X_C$ so

$$2\pi f L = \frac{1}{2\pi f C}$$

so now divide both sides by $2\pi L$

thus
$$f = \frac{1}{(2\pi)^2 f L C}$$

and now multiply each side by f

thus
$$f^2 = \frac{1}{(2\pi)^2 L C}$$

this time take the square root of both sides

thus
$$f = \frac{1}{2\pi\sqrt{LC}}$$

the equation at the top of this section.

We will add an example here soon.

Apply the formula to find values of f , L or C from given data.

At resonance $X_C = X_L$ that means that the capacitive and inductive impedance are equal we can use the following equation

$$f = \frac{1}{2\pi\sqrt{LC}}$$

Manipulating an equation can be quite daunting for some so this part will be further explained even more fully in the [maths section](#).

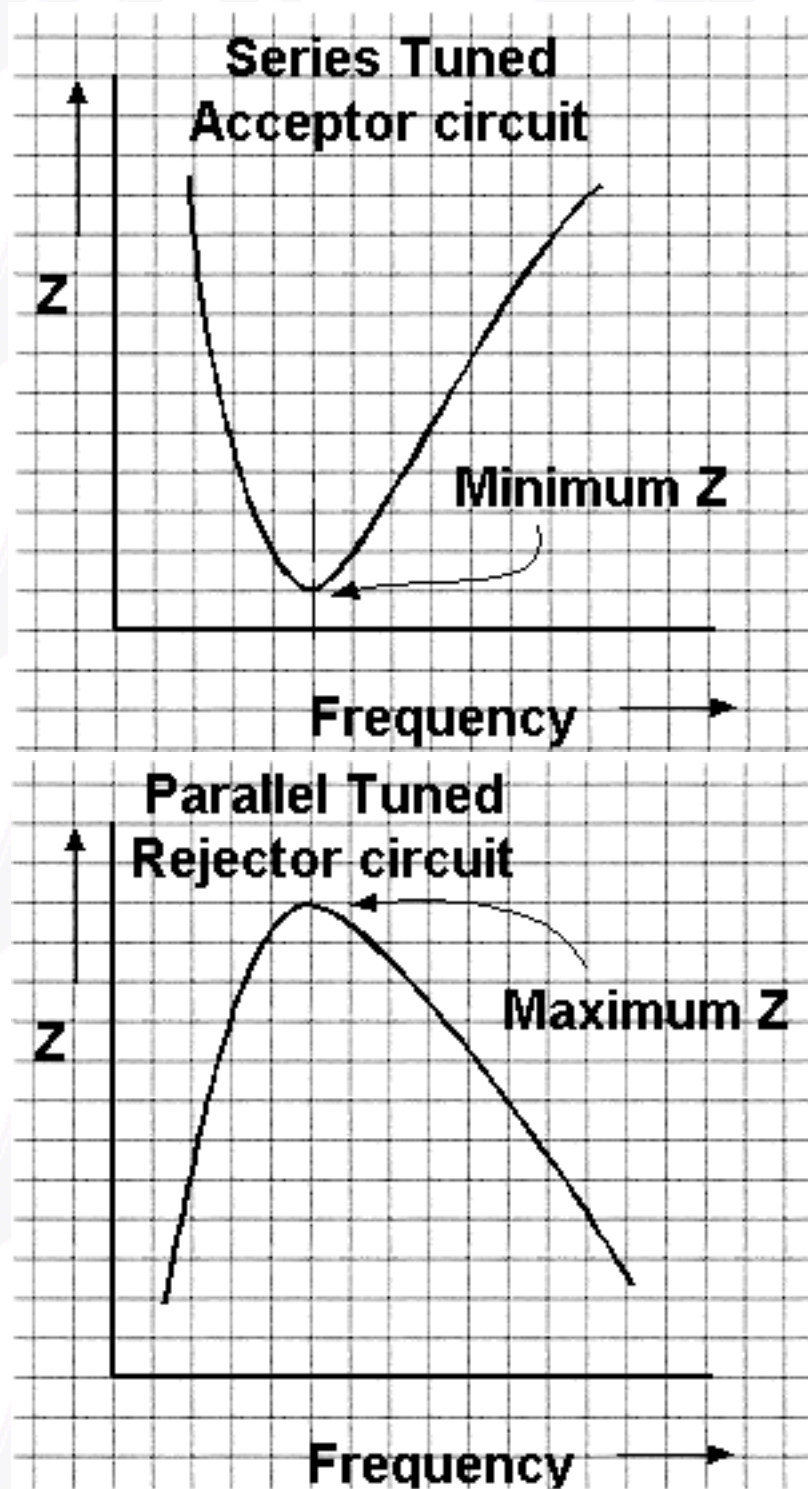
From $f = \frac{1}{2\pi\sqrt{LC}}$ To find C this is what you have to do multiply both side by $2\pi\sqrt{LC}$
 giving $2\pi\sqrt{LC} f = 1$ then divide both sides by $2\pi f$
 giving $\sqrt{LC} = \frac{1}{2\pi f}$ now we need to "square" both sides to remove the "square root on the left hand side
 giving $LC = \left(\frac{1}{2\pi f}\right)^2$ which also equals $LC = \frac{1}{(2\pi f)^2}$

From $LC = \frac{1}{(2\pi f)^2}$ to find L divide both sides by C
 giving $L = \frac{1}{C(2\pi f)^2}$ which we can also look at as $L = \frac{1}{4\pi^2 f^2 C}$
 so we can now use the calculator to work out the answer.

From $LC = \frac{1}{(2\pi f)^2}$ Then to find C divide both sides by L
 giving $C = \frac{1}{L(2\pi f)^2}$ which we can also look at as $C = \frac{1}{4\pi^2 f^2 L}$ so we can now use the calculator to work out the answer.

But see also how a [scientific calculator](#) can help you. 

3i.2 Identify resonance curves for series and parallel tuned circuits



For this part of the syllabus all you need to remember is the shape of the resonance curves for series and parallel tuned circuits.

Series tuned circuit

A series tuned circuit has its lowest impedance at resonance hence the term **acceptor circuit**.

Parallel tuned circuit

A parallel tuned circuit has its highest impedance at resonance hence the term **rejector circuit**. This high impedance at resonance is used for instance for "traps" in aerials to electrically shorten a dipole aerial making it operational in two bands - see section on [antenna and feeders](#) for more information.

3i.3 Understand the concept of the magnification factor Q as applied to the voltages and currents in a resonant circuit.

The concept of Q is not easy to understand, but do not be put off by the name " Q " it is not a 007 special agent.

Let's liken Q to something that you can understand. If you deposited £100 in a bank and a week later returned to withdraw the money and received £200 you would say that the bank was rather good and that your money had been magnified by 2

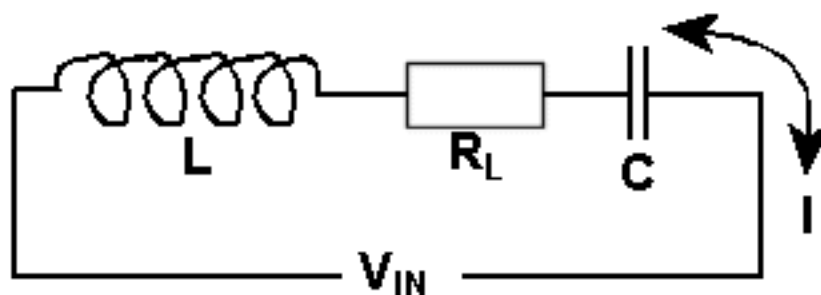
Now if you went back to the bank you received £1000 you would first think that the bank was fantastic and then may be that your money had been magnified by 10 or had a magnification factor of 10

This magnification factor is also known as Q so we could say that the Q factor of the bank was 10.

So let's go back into the world of amateur radio and consider Q and resonance.

Series Resonance

We have spoken about the reactance of the coil (inductor) which is like resistance but the coil still has "normal" resistance and for these calculations we call this R_L and identify it in the circuit diagram as a resistor.



In this example let $X_L = X_C = 10k$ $R_L = 10R$ and with $V_{IN} = 10mV$ RMS at the resonant frequency.

as X_L and X_C cancel each other out, so from Ohm's law $I = \frac{V_{IN}}{R}$

We are now going to use a maths notation 10^{-3} if you do not understand this then [click here](#).

From the figures and the equation given above we have :-

$$I = \frac{10 \times 10^{-3}}{10}$$

$$\text{Thus } I = \frac{10 \times 10^{-3}}{10} = 1 \text{ mA}$$

$$\text{Voltage across } L \text{ or } C = I \times X_L \text{ or } X_C$$

$$\text{Thus Voltage across } L \text{ or } C = 1 \times 10^{-3} \times 10^4$$

Thus Voltage across L or $C = 10$ volts with only an input voltage of $10mV$ thus there is an apparent "GAIN" in output volts.

Gain

This "gain" between the input and the output is known as **magnification factor** which in this case = 1000 ($10mV$ rising to $10V = 1000$ times) and thus the

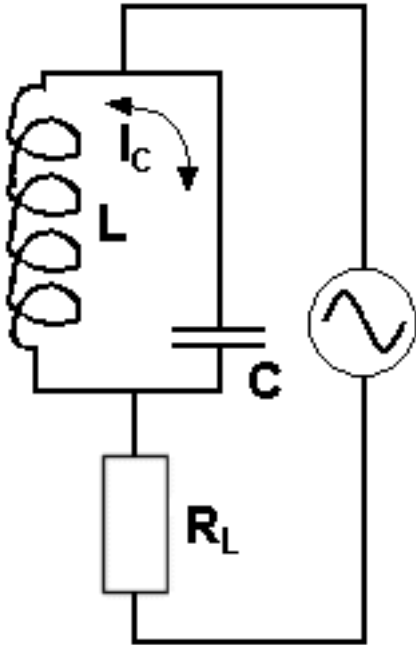
$$\text{magnification factor at resonance} = \frac{X_L}{R} \text{ or } \frac{X_C}{R} \text{ in this case } 10k / 10 = 1000$$

This **magnification factor** is given the name **Q**

$$\text{Thus } Q = \frac{X_L}{R} \text{ or } Q = \frac{X_C}{R}$$

Q (Quality Factor)

Parallel Resonance



By varying the frequency of the input current, the point where $X_L = X_C$ approaches and a circulating current I_C increases to a maximum in the parallel loop limited only by R_L . The voltage across the circuit $V_C = I_C \times X_C$.

At the same time the overall resistance to the input current rises to a maximum and whilst the current through is at a minimum.

At resonance this parallel tuned circuit is called a rejector circuit. Take another look at the graph above.

Understand and apply the formula for Q factor given circuit components values

The formula is :- $Q = \frac{2\pi fL}{R}$ and $Q = \frac{1}{2\pi fCR}$

From the above $Q = \frac{X_L}{R}$ and we know that $X_L = 2\pi fL$ thus $Q = \frac{2\pi fL}{R}$

Also from above $Q = \frac{X_C}{R}$ and we know that $X_C = \frac{1}{2\pi fC}$ thus $Q = \frac{1}{2\pi fCR}$

In all the formulae the following is true:-

f = frequency in Hz **L** = inductance in henries **C** = capacitance in Farads **π** = 3.142

so for a questions in the exam it is now just a matter of applying the formula to the variable given making sure that the correct multiplication factors are use as it is unlikely that you will be given

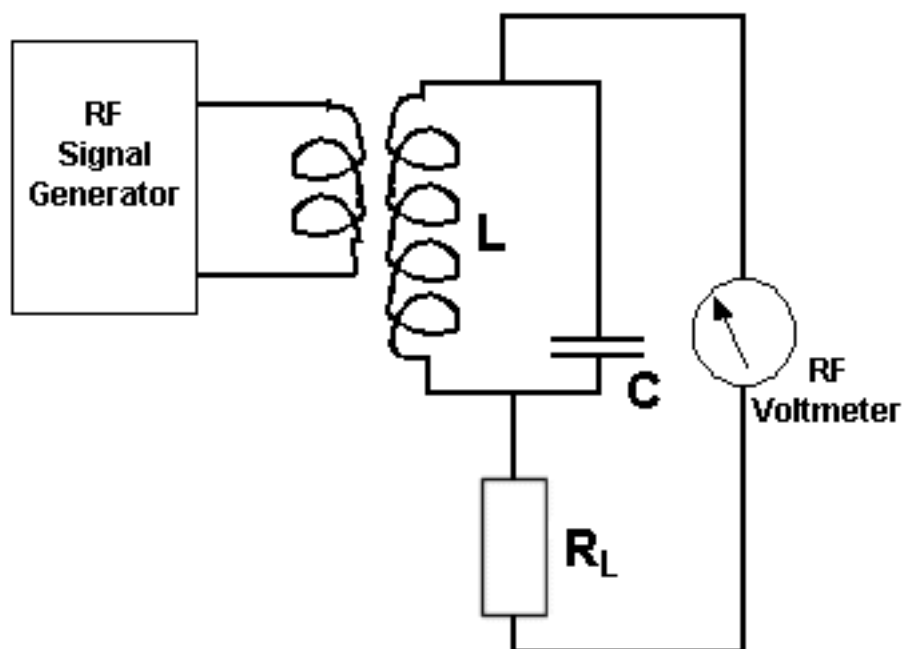
the values of the variables as above but as milli henries and kHz or MHz and with the capacitors microfarads, so be prepared to do some manipulation.

Recall the definitions of the half power point and the shape factor of resonance curves.

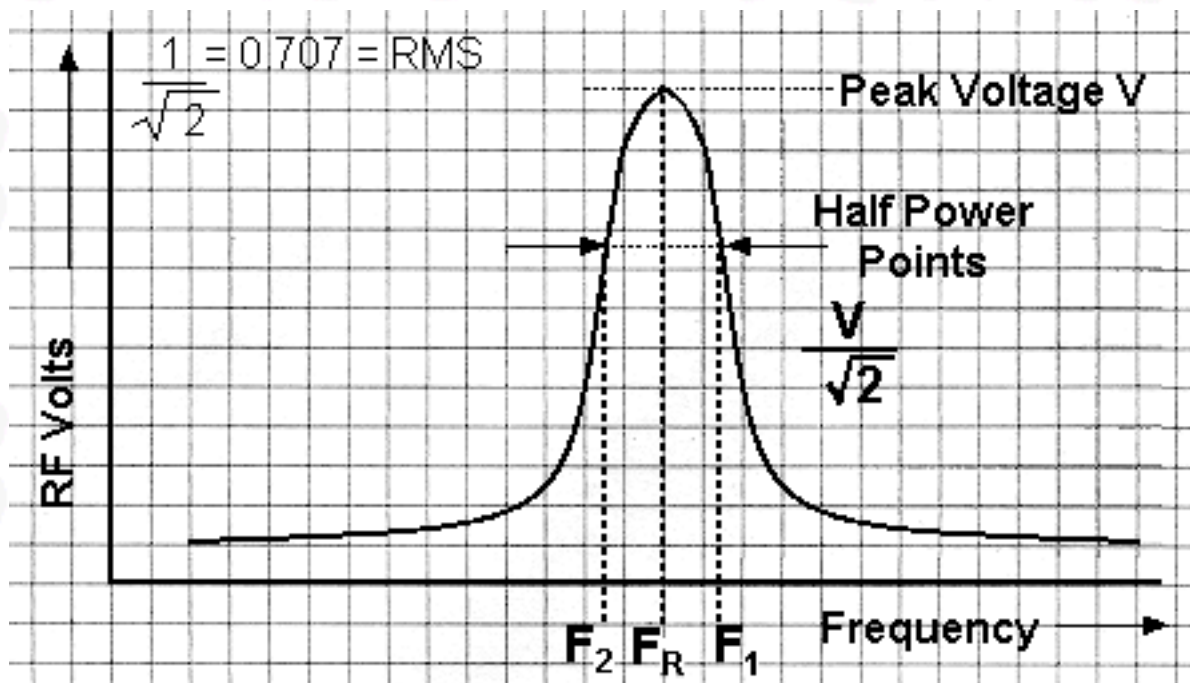
The **half power point** is where the level of the response has fallen to $\frac{1}{\sqrt{2}}$ (0.707 or 70.7%) of the maximum response or the -3dB level.

The **shape factor** is the ratio of the bandwidth at -60dB and -6dB

Assuming that we loosely couple a signal generator into the inductor of a parallel LC circuit and measure the voltage across with an RF voltmeter



Now let us sweep the input frequency and draw graph of the resulting voltage changes.



F_R is the resonant frequency giving a peak voltage, V .

The points either side are generally accepted as limits of usable frequency - This range F_2 to F_1 is the bandwidth [eg. 12kHz for speech] for a parallel LC circuit, which could be the load in a power valve RF amplifier.

Recall and apply the equation for Q given the resonant frequency and the half power points on the resonance curve.

The circuit above shows a parallel tuned circuit with an RF voltmeter, such as is used in a common form of Q meter. Q meters give a measure of "Goodness" of a component or circuit. From the above resonance chart we have

The equation for the resonant frequency and half power points is :-

$$Q = \frac{F_R}{F_1 - F_2}$$

which is also

the Bandwidth F_1 & F_2 compared to the resonant frequency F_R = SELECTIVITY

If we build a receiver for say 120kHz, the RF stage (if we still require 12kHz speech bandwidth)

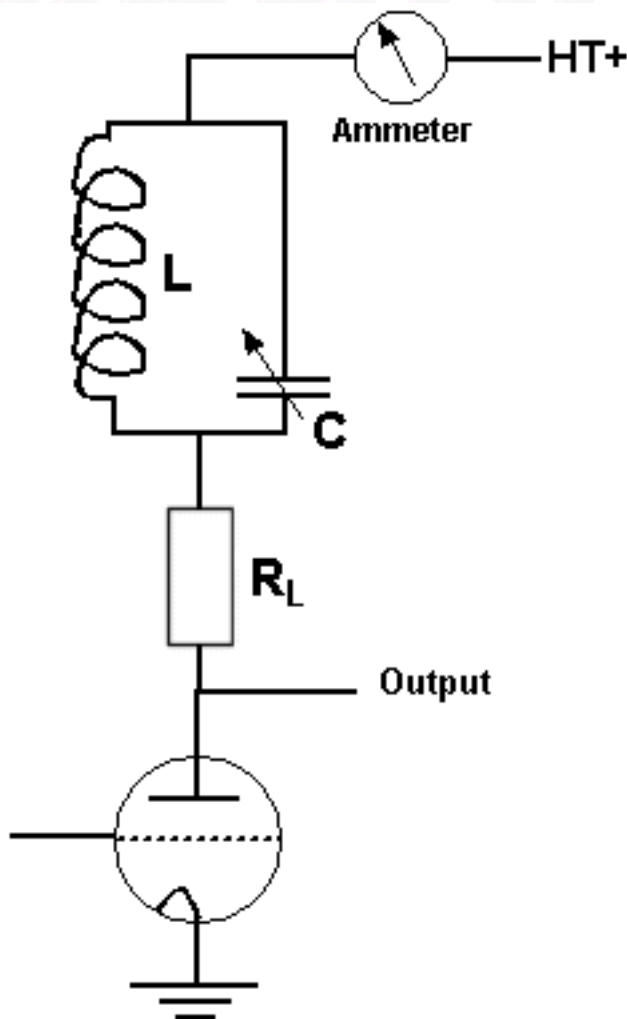
will have a measured "MAX" $Q = \frac{F_R}{F_1 - F_2} = \frac{120\text{kHz}}{12\text{kHz}} Q = 10$

NOTE: a Q of 10 is very low !!

3i.4 Understand the meaning of dynamic resistance.

This expression dynamic resistance is used in parallel tuned circuits of inductor, resistor and capacitor. When such a circuit is at its resonant frequency the tuned circuit can be represented entirely by by resistance. This resistance is called dynamic impedance or **dynamic resistance**. This is an apparent resistance but exist with alternating current of the resonant frequency.

The parallel resistance of a tuned circuit at resonance is $Q \times X_L$. This is known as the **DYNAMIC resistance**



An example of this is shown, a parallel tuned circuit in the "ANODE" of a RF amplifier.

Let $X_L = 1000 \text{ Ohms}$

and $Q = 100$

To tune to resonance we adjust C until the DYNAMIC RESISTANCE is HIGHEST, ie for a max dip on the ammeter.

The coupling resistance to the next stage (Dynamic Resistance) is $Q \times X_L = 100,000 \text{ Ohms}$

The series RF resistance of the coil

$$= \frac{X_L}{Q} = 10\text{Ohms}$$

Understand and apply the formula for R_D given component values

The formula is :- $R_D = \frac{L}{CR}$

Thus at resonance in a parallel tuned circuit of L C & R, the dynamic resistance R_D can be calculate from the formula $R_D = \frac{L}{CR}$ where L (the inductance) is in Henries, C (the capacitance) is in Farads and R (the resistance) is in ohms.

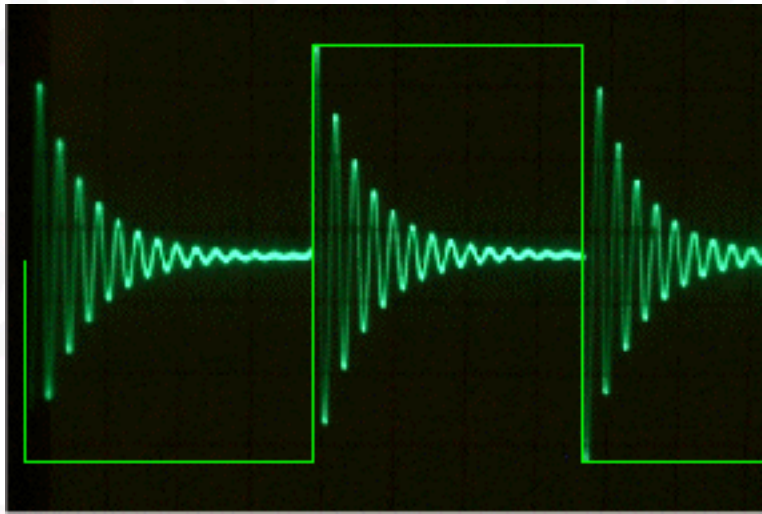
The general expression for Dynamic Resistance is :-

$R_D = \frac{L}{C \times R}$ which does not include any frequency component.

It is obvious from this that the larger **L** compared to **C**, the higher will be the Dynamic Resistance and **Q**.

Understand the effect of damping resistors in a tuned circuit.

If we set a perfect tuned circuit into oscillation and then removed the source of the initial oscillation, it will carry on oscillating indefinitely. If then, we introduce some resistance into the circuit a little power is dissipated each cycle and the oscillation will die off exponentially. This loss of oscillation occurs whether the resistance is in parallel or in series with the tuned circuit. The resistance we have introduced is called DAMPING by damping resistor.



The picture above is of a actual oscilloscope race where a tuned circuit is set in oscillation by a square wave which is superimposed on the trace just to show you where the square wave triggers the oscillation. Each sharp edge of the square wave causes the tuned circuit to oscillate and the damping effect of the imperfect tuned circuit is well shown. Note the shape of the curve of the reducing amplitude, the percentage of amplitude lost is the same for each per cycle hence the exponential curve.

NOTE: There is no such thing as a perfect tuned circuit so all circuits have some inherent damping which eventually stops their oscillation and such is the case with the tuned circuit pictured on the oscilloscope trace as it is the inherent damping of the inductor that caused the damping of the oscillations.

There are equations to calculate the equivalent series resistance caused by a parallel one but these are not required at this level.

Let's look at the real world situation an RF amplifier.

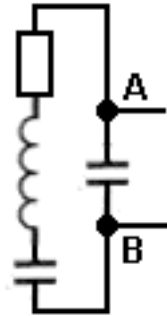
If we use a near perfect tuned circuit in an RF amplifier, once is excited it s oscillations would die out very slowly and any modulation at the amplifier input would be lost in the tuned circuit, so we "DAMP" it to the point where the oscillation dies out much faster than any modulation waveform. This damping, by the way, reduces the Q.

Another definition of Q is the ratio of Energy stored / energy lost (per cycle)

$$Q = \text{Energy stored} / \text{energy lost (per cycle)}$$

3i.5 Recall the equivalent circuit of a crystal and that it exhibits series and parallel resonance.

A piece of uncut Quartz crystal



The equivalent circuit of a crystal, which is a thin slice of quartz held in a holder is shown immediately to the left. Points A and B are representing the crystal holder.

A crystal resonator (or crystal for short) consists of a piece of "quartz" set between two conducting plates. If a voltage is applied to the plates the resultant electric field causes stresses in the crystal to occur such that it vibrates at a certain frequency that is in built due to the size and cut of the quartz.

The equivalent circuit of a crystal with discrete components is a resistor inductor and capacitor in series and another capacitor in parallel as shown in the diagram with the point "A" and "B" each side of the parallel capacitor.

The crystal has two modes of resonance :-

- Accept a frequency - or low impedance as a series tuned circuit used to pass a frequency in a receiver

- Block at another frequency very close frequency or hi impedance or parallel tuned circuit used in an oscillator in a transmitter.

When obtaining crystals the frequency is quoted for 32pf capacity parallel resonance.

If that same crystal is used in the series resonance mode the frequency will be slightly different.

3i.6 Recall that voltages and circulating currents in tuned circuits can be very high and understand the implications for component rating.

Currents flowing in tuned circuits can be greater than the input current due to what is called the "magnification factor" which is also known as "Q" and discussed above.

Similarly voltage too can be higher than the input voltage.

Electronic components have what is called a "rating" and it is especially important that the rating is not exceeded else catastrophic failure of the component could occur and a domino effect occur which causes more damage than to the individually component.

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Maths**Bredhurst Receiving and Transmitting Society****Technical Aspects****Syllabus Sections:-****Transformers****3j.1 Understand the concept of mutual inductance.**

If two coils with their axes aligned on the same line then the current passing through one of the coils creates a magnetic field around itself and also around the second coil which has the mutual effect of INDUCING an EMF in this second coil.

However the current passing in the first coil only induces an EMF in the second coil when the field strength of the magnetic field is changing and this is from an AC source only.

Thus the MUTUAL EFFECT of the magnetic field passing around both coils results in MUTUAL INDUCTANCE and causes the EMF in the second coil.

When all the magnetic field, or magnetic flux as it is sometimes called set up by the first coil cuts all the turns of wire in the second coil the mutual inductance reaches its maximum possible amount.

The amount of coupling is related to the distance between the coils. If the coils are some distance apart then the coils are said to be loosely coupled. The maximum coupling is achieved when the two coils are wound one on top of the other. The minimum coupling is when they are placed far apart or at right angles to each other.

Understand and apply the formula relating transformer primary and secondary turns to primary and secondary potential differences and currents.

$$\text{The formulae are :- } V_s = V_p \times \frac{N_s}{N_p} \quad I_p = I_s \times \frac{N_s}{N_p}$$

Here we are dealing with AC as we are considering transformers!

Transformers and potential differences

In the formulae :-

V_p = Volts in the primary coil (or the driven coil)

V_s = Volts in the secondary coil

N_p = Number of turns in the primary coil

N_s = Number of turns in the secondary coil

I_p = current passing in the primary coil

I_s = Current passing in the secondary coil

Re-arranging the formula $V_s = V_p \times \frac{N_s}{N_p}$ to $\frac{V_s}{V_p} = \frac{N_s}{N_p}$ it is a little easier to see that the

ratio of the input voltage \div output voltage is equal to

the ratio of the input turns \div divided by the output turns

This is a simple comparison of input and output.

From the above it is possible to calculate the transformation of voltage from the primary to the secondary such as you would need to do if building a power supply.

$V_s = V_p \times \frac{N_s}{N_p}$ the part N_s / N_p is called the turns ratio and was introduced to you in the

[Intermediate Licence course](#) click to check back.

Example: A transformer has 200 turns on the primary and 100 on the secondary and an input voltage of 50 volts. What is the calculated output voltage ?

applying the figures to the formula $V_s = 50 \times 100/200$

answer 25 volts.

Transformers and currents

Re-arranging the formula $I_p = I_s \times \frac{N_s}{N_p}$ to $\frac{I_p}{I_s} = \frac{N_s}{N_p}$ it is a little easier to see that the ratio of the input current \div output current is equal to the ratio of the output turns \div divided by the input turns.

This is not quite so straight forward but is based on the Power equation $P = V \times I$.

Thus what is put in as power on one side ($V_{in} \times I_{in}$), assuming no losses will come out as power on the other ($V_{out} \times I_{out}$). this does lead to the equation $\frac{I_p}{I_s} = \frac{N_s}{N_p}$

The equation says that the current in the primary \div the current in the secondary is dependent upon ratio of secondary turns \div primary turns.

Putting some figures to this is there is 240 volts on the primary of 100 turns and 24 volts at 10 amps on the secondary - there would be a need of less current at 240 Volts in the primary to provide the necessary current in the secondary in the secondary at 24 volts. With this in mind let's work it out.

From the equation $\frac{V_s}{V_p} = \frac{N_s}{N_p}$ then $24 / 240 = N_s / 100$

From the equation $\frac{I_p}{I_s} = \frac{N_s}{N_p}$ then $N_s = 24 \times 100 / 240$ answer = 10 turns N_s

so $I_p / 10 = 10 / 100$

thus $I_p = 10 \times 10 / 100$ answer 1 amp

If you were given the current that can be supplied from the primary you can find out what current can be taken from the secondary such as you would need to do if building a power supply if you know the turns ratio.

So now using this formula $I_p = I_s \times \frac{N_s}{N_p}$

Example: A transformer can allow a secondary coil current of a maximum of 20 amps and it has 400 turns on the primary and 100 on the secondary what is the required input current capability ?

Applying the figures to the formula $I_p = 20 \times 100 / 400$

answer 5 amps.

3j.2 Understand and apply the formula relating transformer primary and secondary turns to primary and secondary impedances

The formula is :- $Z_p = Z_s \left(\frac{N_p}{N_s} \right)^2$

Matching input and output impedances

In a perfect situation -one without reactance losses or leakages the above equation would hold true where:-

- Z_p is the impedance looking into the the primary turns on the coil from the power source
- Z_s is the impedance of the load connected to the secondary
- N_p/N_s is the turns ratio N_p primary and N_s secondary.

The primary terminal impedance is determined by the equation being dependent only upon the load resistance and the turns ratio.

Where would this be used. Say a AF amplifier required a load of 200ohms to operate properly and you are driving an 8ohm speaker then you could, assuming the perfect world, design an impedance transformer to ensure the criteria was met.

$Z_p = Z_s \left(\frac{N_p}{N_s} \right)^2$ by dividing both side by Z_s we get

$$\frac{Z_p}{Z_s} = \left(\frac{N_p}{N_s} \right)^2$$

by taking the square root of both sides we get

$$\sqrt{\frac{Z_p}{Z_s}} = \frac{N_p}{N_s} = \sqrt{\frac{200}{8}} = 5$$

So the primary turns must be 5 times as many as the secondary.

This impedance matching means altering the "load" impedance by the transformer to the required output level.

3j.3 Understand the cause and effects of eddy currents and the need for laminations (or ferrites) in transformers.

Eddy Currents

When an AC supply passes through a coil a magnetic field is generated. The size or density of the magnetic field can be increased by the use of an iron core such as is used in transformers. The iron being a conductor the magnetic field causes an electric current to flow in the core. The current flow is called "EDDY CURRENTS".

Effect of the eddy currents

The effect of the eddy currents is a lost power as flowing through the resistance of the core they create heat. As you are aware from the Foundation Course if there is not a complete circuit a current could not flow.

Use of Laminations

So what can be done to stop the eddy currents in the iron core of the coil. The solution is to make the core of thin strips of insulated iron material called "laminations" and for the lamination not to form a continuous loop around the coil. So a break in the lamination is formed and this small air gap is the necessary break in the circuit and the eddy currents cannot now flow.

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Technical Aspects

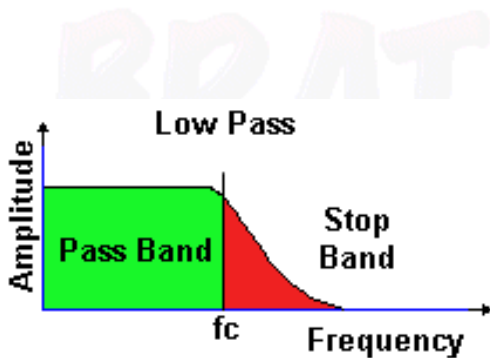
Syllabus Sections:-

Filters

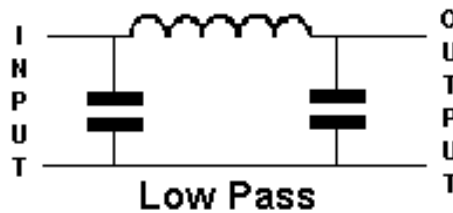
3k.1 Identify the circuits of low pass, high pass, band pass and band stop (notch) filters and their response curves.

The following are the diagrams of the filters as far as you have seen in the Intermediate course.

Response curves



Filters components

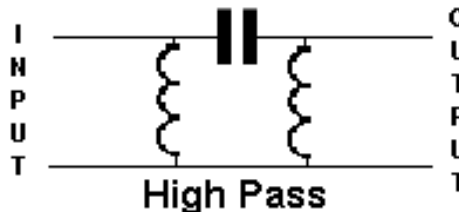
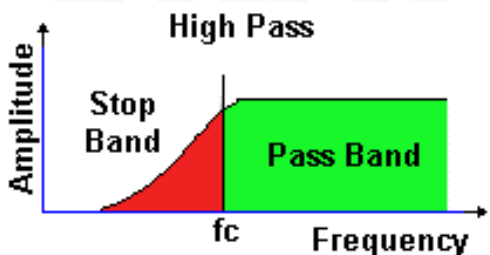


Passes all frequencies below the cut off frequency

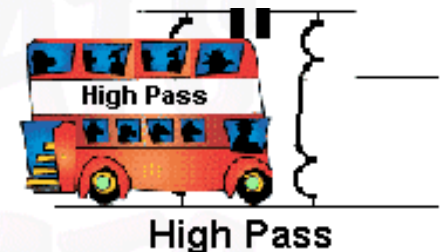
This PI output filter when connected to a transmitter, is the classic low pass filter

Remember the differences!

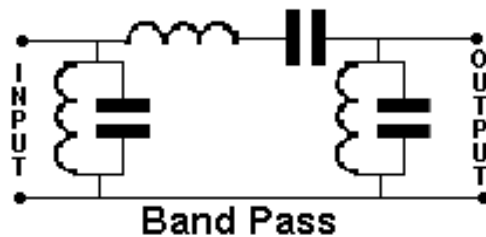
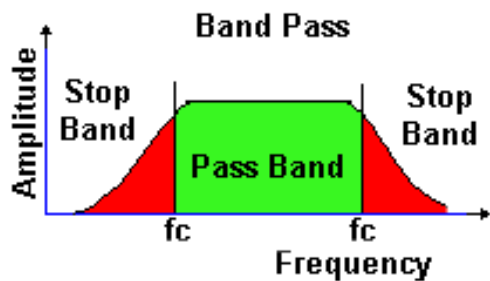
The capacitor's symbols could be thought of as bricks in a wall that cannot alter and thus stay low hence you can remember the configuration of the low pass filter.



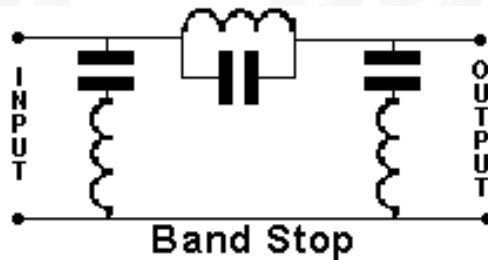
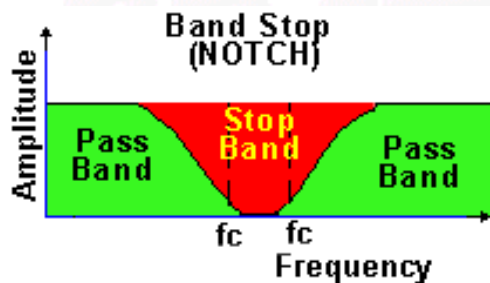
Passes all frequencies above the cut off frequency



This is not intended to indicate what frequencies are passed but only the fact that the inductor look like springs and a bus is high hence this may help you to remember the configuration of the HIGH pass filter.



Band pass filter passes all frequencies in the pass band



Band Stop filter passes all frequencies outside the stop band. Depending upon the design of the filter the "notch" could be very sharp and narrow or as shown broader and thus wider.

Whilst the input and outputs have been marked on some of the filters, with these simple filters the connection can be reversed but in complex filters this is not always the case.

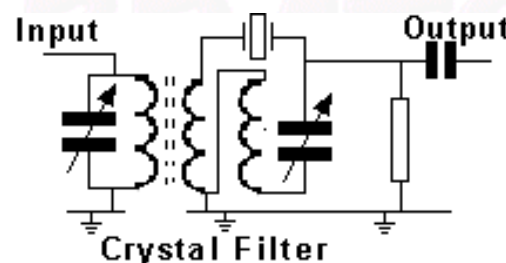
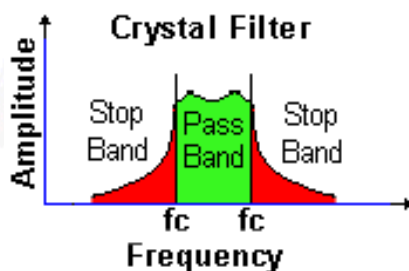
Understand the concept of the cut-off frequency.

The cut off frequency of a filter is determined as the frequency where the response is 3dB down (ie half) of the pass band.

Recall that crystals can be used in filter circuits.

The crystal filter:

Crystals can be used in filters and the diagram below gives an example of its use. Such filters are commonly used at intermediate frequencies above 500kHz.



Note the use of the Xtal in the diagram and that the core of the transformer has dotted lines to indicate that it is a iron dust core

The crystal filter uses a piece of quartz crystal exactly like a typical crystal used for stable frequency generation. The crystal is usually combined in a circuit with inductors and capacitors to give an impedance match between the stages

of amplification that the filtering is applied to.

In practice, because a single crystal is a very high "Q" device (and hence possesses a very narrow bandwidth), it is usual to build a crystal filter that incorporates several crystals. These crystals are all carefully chosen such that they are not all on the same frequency, but spread on, and around the centre frequency of the filter.

In this way, a wider bandwidth for the filter may be obtained, whilst still maintaining the very steep "sides" of the filter characteristic.

Unlike a conventional inductor/capacitor filter, where energy is stored magnetically in the inductor, and electrostatically in the capacitor, the crystal filter actually mechanically vibrates at the marked frequency. It works very much in the same way as a tuning fork, except that the frequency of operation is very much higher. As an example, if the filter is designed for 10.7 Mhz, then the crystal elements within the filter are actually vibrating mechanically at 10,700,000 times every second!

An alternative to the crystal filter is the mechanical filter. These are not usually designed to operate much beyond 0.5Mhz, and their mode of operation is very similar indeed to the crystal filter. These filters possess an even sharper skirt, and where cost is not an issue, and design limitations allow, prove to be a superior choice.

For budget applications, a ceramic filter is a low cost alternative. Performance of this type is not as good as the crystal filter, but it does allow a very useful filter to be constructed for the lower frequencies, whilst being suitable for miniaturisation.

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Syllabus Sections:-**Screening**

31.1 Recall that screening with thin metal sheet is effective in reducing unwanted radiation from equipment and/or between stages within equipment.

It is often necessary to keep an RF away from parts of a circuit or to prevent coupling of one part of the circuit with another. This is often the case when dealing with tuned circuits. The part of the circuit that needs protection is placed in a thin metal enclosure which is connected to the earth of the circuit.

When used with tuned circuits the "screening can", as the enclosure is sometime called, must be more than 1 1/2 times the diameter of the coil otherwise the Q of the coil will be degraded.

Also a screen may be needed to prevent a strong signal feeding back from one part of the circuit to an earlier stage.

Aluminium, copper or tin are suitable materials at RF.

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Bredhurst Receiving and Transmitting Society**Technical Aspects****Syllabus Sections:-****Temperature Effects**

3m.1 Recall that temperature has an effect on the value of components; those with negative coefficients will reduce in value as temperature rises whereas those with positive coefficients will increase in value. Understand the effect this will have on tuned circuits and remedial measures.

All components that are passing current have an associated heating problem. How great or small the problem is dependent upon the being component designed to operate at the level of heat being generated by itself or nearby components.

Coefficients of heating

Components with a **negative coefficients** will **reduce in value** as temperature rises whereas those with **positive coefficients** will **increase in value**. The design of the associated circuit will have to take into account these changes.

If the component is designed to operate at a higher than ambient temperature (ie the normal temperature of its surrounding) then few problems should occur.

Tuned circuits

The tuned circuit is a critical area where changes in values can give a dramatic effect as they can cause changes in the received or transmitted frequency. The values can and do change as the result of temperature changes.

The remedial methods include :-

- using properly rated components
- maintaining the temperature of the tuned circuit by the use of thermostatically controlled heaters - since a crystal can be treated as a tuned circuit and also is affected by temperature changes high stability equipment will commonly employ a "crystal oven" to maintain the

- crystal at a constant temperature above ambient.
- isolating the tuned circuit from other components that might cause local heating - for example DO NOT mount the tuned circuit near the voltage regulator (because the regulator get hot !!).

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Bredhurst Receiving and Transmitting Society**Technical Aspects****Syllabus Sections:-****Solid State Devices**

3n.1 Understand that doping of semiconductor material (silicon and germanium) produces p-type (electron deficient) and n-type (electron rich) semiconductors.

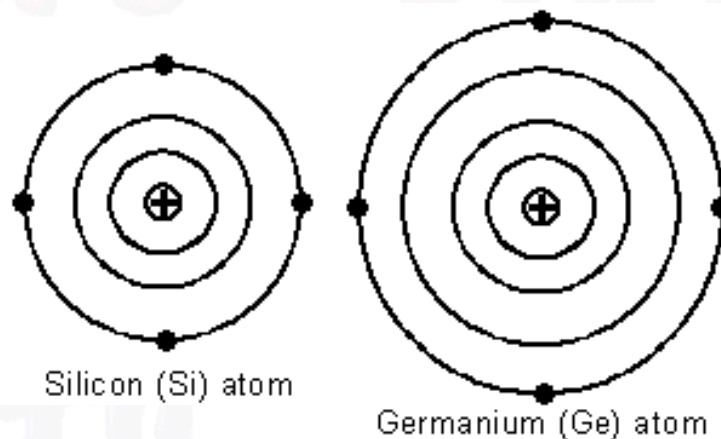
In modern electronic equipment today there are many components that are in the "family" called "semiconductor".

The name "semiconductor" correctly implies that the material is neither a conductor nor an insulator. An insulator has high resistance to the passage of electron and a conductor has low resistance to the passage of electrons. The resistance of the "semiconductor" lies between those two extremes.

The two materials in general use that form semiconductors are SILICON and GERMANIUM.

Molecular structure

Just for a moment we have to split the atom of silicon and germanium. These atoms of these two elements have a nucleus and respectively 3 and 4 rings of electrons. It is the outer rings that we are concerned with as these both have 4 electrons. Both of these outer rings have the capability of joining with an adjacent atom to form a crystal lattice.



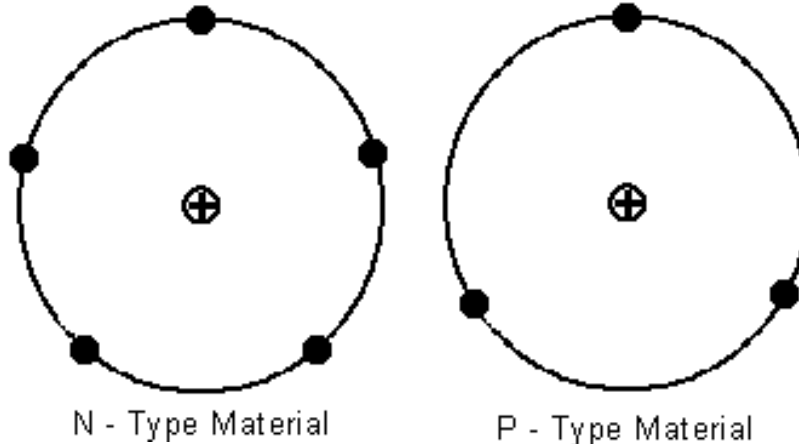
What happens in the other rings is of no consequence with regards to this course. It is important that you understand that each atom has 4 electrons in the outer ring and that those in the silicon outer ring being nearer to the nucleus which has a positive charge have a greater hold onto them than those in the outer ring of the germanium atom simply because they are that little bit further away from the nucleus and thus the attraction between them is

less.

This distance from the nucleus is important as in silicon the outer electrons are NOT FREE to move from the lattice when they have combined with other atoms of silicon (and are thus an insulator) whereas those in the germanium being further away can become detached (and so they have a tendency to being a conductor).

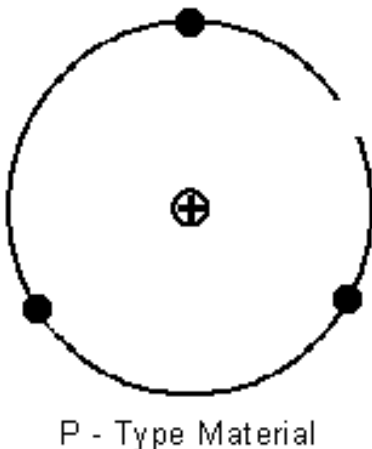
Making semiconductor material

This complex process takes both silicon and germanium (separately) and refines them to high standards of purity and then after all that hard work makes them impure again but in very controlled conditions called "doping".



This "doping" process introduces atoms which have either 5 or 3 electrons in this outer ring. The material where there are 5 electrons in the outer ring is given the name N - Type Material as it is and it appears to be **NEGATIVELY** charged due to the "extra" electron (**electron rich**) whereas if there is 3 electrons in the outer ring the material is given the name **P - Type Material** and appears to be positively charged due to an apparent absence of electrons (**electron deficient**).

Both Silicon and germanium can be doped N or P type material.



P - Type Material appears to be positively charged

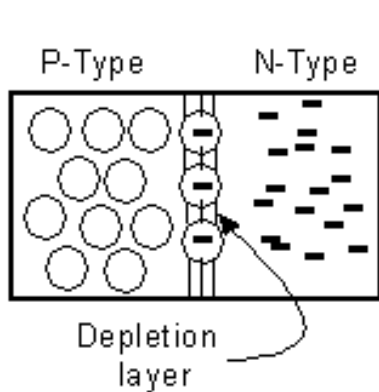
This absence of electrons in P - Type material is a space in the outer ring that can be filled by another electron and is as such called a **"hole"**.

Individually as N and P type material they are electrical neutral

Understand current flow in terms of electron and hole movement. Understand the formation and effect of the depletion layer.

We will take these two parts of the syllabus together.

Let us look at the situation where we have a two pieces of semiconductor material, one piece N-Type and the other P-Type that are fused together. Now we have the situation, just like a party where free spirited boys and girls arrive in different cars from different directions and enter the hall via different door but they all have one aim look for partners.



"depletion layer"

Thus we have the holes of the P-type free to move towards the electrons of the N-Type and the electrons are free to move towards the holes. So, just like the boys and girls sorting themselves out, a melly occurs until pairing has taken place, the Holes and the Electrons move about in an action called "diffusion" across the material junction ,which forms an area, just like the party hall, called the **"depletion layer"** where the free electrons have jumped into the migrated holes and eventually the holes in this area are filled which stops any further migration (diffusion).

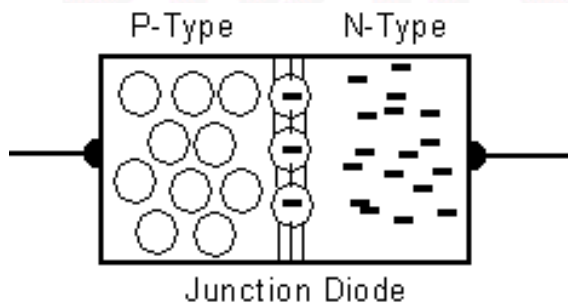
You have learned in the ILC that a flow of electrons is a current thus as there is a movement of electrons and holes there is in essence a current flow but it is not sustained.

Summary:

- Silicon and Germanium are the most common materials that make up semiconductors and each can be N-Type or P-Type semiconductors.
- The N-Type material has a surplus of electrons and thus appears negatively charged.
- The P-Type material has one too few electrons - a HOLE - and thus appears positively charged.
- when P and N type material are fused together diffusion of holes and electrons occurs forming a "depletion layer" which stabilizes the junction between the two materials as holes are filled by electrons preventing further diffusion.
- the movement of holes and electrons is in essence a current flow until holes are filled by electrons.

Understand how the p-n junction forms a semiconductor diode.

P-N JUNCTION

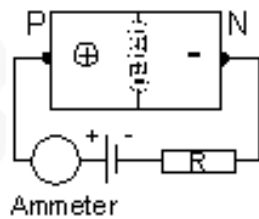


If we take our fused N and P type material mentioned above and now attach wires to each of the P and N type material we have a **JUNCTION DIODE** or semiconductor diode. The material will have already formed its depletion layer and is wanting to do something useful. It is wanting for energy to be applied from an external source such as a cell or battery.

Understand that an applied potential difference can cause electrons to flow across the PN junction (forward bias) or prevent electron flow (reverse bias) depending on polarity.

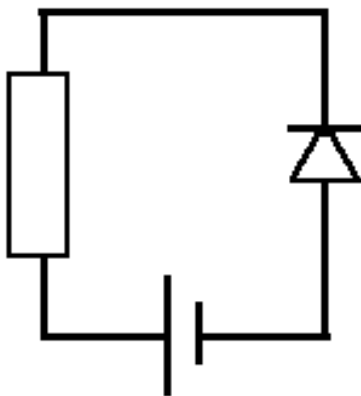
ELECTRON FLOW

forward bias

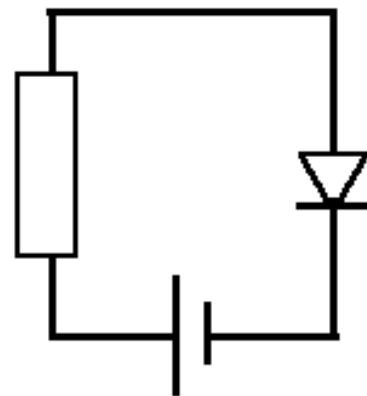


If we connect up a circuit such as shown at the left the electrons from the N will be attracted by the battery's positive terminal and this attraction will be great enough to overcome the depletion layer which previously stops any further activity between the electrons and holes and eventually the electrons will find their way into the connecting wire and to the positive terminal.

At the same time this will leave holes in the N material which will be filled by more electrons entering the circuit from the negative terminal. A flow of electrons will then continue with the rate of the flow restricted by the resistor in the circuit. This circuit is said to be **forward bias** the diode. It was said earlier that there needed to be energy applied to the circuit for current to flow and it is found that no current flows until a pressure (voltage) of about 0.6V for silicon and 0.3V for germanium diodes had been applied. This voltage is called the "barrier voltage" and is the energy that needs to be applied to help the electrons through the depletion layer.



Circuit A



Circuit B

You may recall the diagrams above from your ILC course. Circuit A represents a reverse biased diode whilst Circuit B represents a forward biased diode.

Reverse bias

If the diode is reversed biased, (as in circuit "A" above) no (or negligible) current flow will occur and electrons will build up at the battery end of the N material and Holes at the Battery end of the P material. This condition is called **reverse bias** and as a generalization other than "leakage current" no current flows.

Peak Inverse Voltage PIV

Diodes when used in home construction must be rated properly for the use to which they are to be put.

You must consider :-

1. Peak Reverse Voltage and
2. Maximum Average Current.

Peak Inverse Voltage (or Peak Reverse Voltage) is the maximum voltage that a diode can withstand in the reverse direction without failing and starting to conduct. If you exceed the PIV the diode may be destroyed. Thus the diodes must have a PIV rating that is higher than the maximum voltage that will be applied to them when reverse biased.

In a DC only circuits, diodes should have a Peak Inverse Voltage rating greater than the highest voltage to which diode will be exposed.

In an AC circuits, such as power supplies, diodes should have a Peak Inverse Voltage rating up to 2.8 times the maximum RMS voltage (RMS is 0.707 of the peak voltage) of the transformer's secondary winding (depending upon the rectifier design).

Maximum Average Forward Current is the average forward current that a diode can conduct without being damaged.

In DC only circuits the Maximum Average Current is considered to be the current that the diode will continuously conduct.

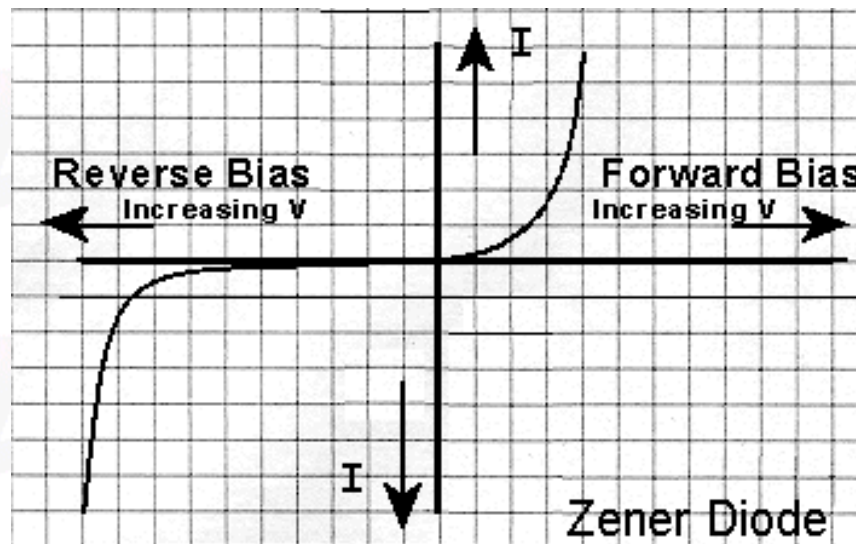
In AC circuits such as power supplies the Maximum Average Current Rating of a diode should be twice the DC current that the supply will deliver at full load. For example; If a power supply can deliver 1 amp the rectifier diodes should have a 5 amp current rating.

3n.2 Recall that a Zener diode will conduct when the reverse bias potential is above its designed value and identify its V/I characteristic curve.

ZENER DIODE

In the standard diode we have established that only a negligible current flow when the diode is reverse biased the "leakage current", but if the voltage is increased then it can reach a value when the diode just cannot prevent a flow of current and the diode can fail dramatically.

With the ZENER diode, as the reverse bias voltage is increased from zero it acts the same as any other diode and resists the passage of all but leakage current. Then when the voltage rises **above its designed value**, the depletion layer allows current to flow and the voltage remains at a stable level. So long as the current passing through the device does not exceed its rated handling capability the ZENER continues to function. This is achieved "somewhere" in the circuit with a current limiting resistor. However if the current passing is too great then the zener will suffer from failure.

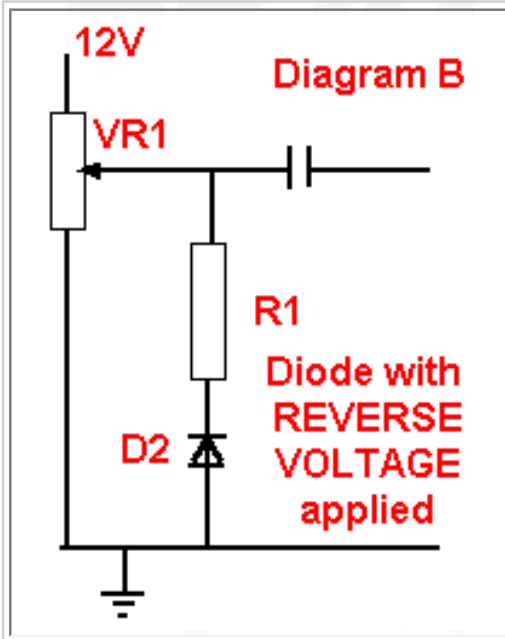


3n.3 Understand that the depletion layer in a reverse biased diode forms the dielectric of a capacitor and that the magnitude of the reverse bias affects the width of the layer and the capacitance.

"varicap diode"

This part of the syllabus is referring to a type of diode called the **Variable Capacitance diode** of "varicap diode".

All diodes to a greater or lesser extent exhibit the phenomenon of an increasing width of the depletion layer when a reverse bias is applied. However Diodes that are made to be especially susceptible to the widening of the depletion layer, which in turn varies the capacitance associated with the diode.



Diode D2 in the diagram B is acting as a varactor diode.

More voltage less capacitance

As the reverse bias (voltage) is **increased** so the depletion layer widens and the capacitance **decreases**

The depletion layer can be thought of as the plates of a capacitor, and just like a capacitor by widening the gap between the plates the capacitance drops. With the Varactor diode as the reverse bias is increased so the depletion layer widens and the capacitance decreases and by reducing this applied reverse bias the capacitance then increases.

The depletion layer in the diode is acting as not only the plates of a capacitor but also **the dielectric of a capacitor**.

3n.4 Understand the 3 layer model of the transistor (npn and pnp) and the channel model of the FET.

Some students might like to look at the SUMMARY which is at the end of this piece as a reminder here at the beginning as an over view else skip all the is in red below.

Bipolar transistors

- Bipolar transistors consist of three regions - EMITTER, BASE, COLLECTOR, - with 2 junctions.
- Current flows between collector and emitter only when current flows between base and emitter.
- A transistor has GAIN when collector current divided by base current is greater than 1.
- Connecting transistors in different ways changes gain and input or output impedances.

FIELD EFFECT TRANSISTORS.

To be strictly correct, the so-called FIELD EFFECT TRANSISTOR is not a transistor at all, as the word TRANSISTOR is derived from TRANSFER RESISTOR and the FET doesn't work like that at all. The FET relies upon the presence and the effects of an electric field.

There are 2 types of FET - The JUNCTION FET and the METAL OXIDE SILICON FET or MOSFET.

Both work by controlling the flow of current carriers in a narrow channel of silicon. The main difference between

them lies in the way the flow is controlled.

Firstly the JUNCTION FET. A tiny bar of N or P type silicon has a junction formed at near one end. Connections are formed at either end of the silicon bar (see drawing) and also to the junction material (P type for N type FET).

The P type connection is called the GATE, the end of the bar nearest the gate is called the SOURCE, and the connection at the other end is called the DRAIN.

A junction FET is normally used with the junction reverse biased (has a negative voltage on it for an N channel as opposed to what you might expect a positive one) so that a few moving carriers are around the junction (keeping it turned off) making the bar of silicon itself a poor conductor.

With less reverse bias (or less negative volts) on the junction the silicon bar will conduct better, and so on as the amount of reverse bias on the junction decreases the FET conducts better.

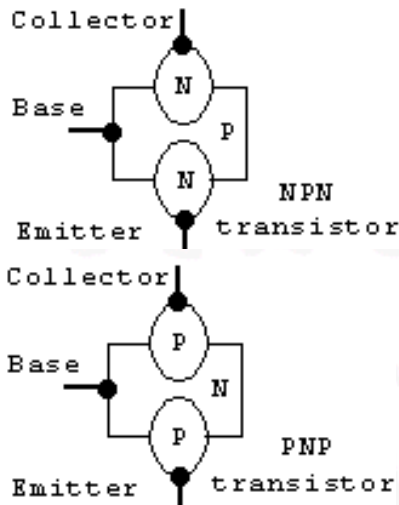
When a VOLTAGE is connected across the SOURCE and DRAIN the amount of current flowing between them depends on the amount of reverse bias (or negative volts) on the GATE and the ratio

SOURCE - DRAIN CURRENT, GATE VOLTAGE is called the

MUTUAL CONDUCTANCE the symbol for which is G_m , this quantity is a measure of the effectiveness of the FET as an amplifier of current flow.

Because the GATE is REVERSE BIASED, practically NO GATE CURRENT FLOWS, so that the RESISTANCE between GATE and SOURCE is VERY HIGH, much HIGHER than the BASE EMITTER junction of a BIPOLAR transistor. This uncommonly high resistance is put to good use. For instance in voltage measuring circuits, NO LOAD is put on the circuit being measured.

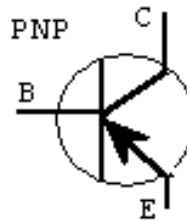
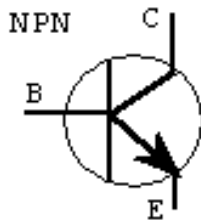
The 3 layer model of the transistor



Bipolar transistors each have 2 junctions and 3 separate connections. The NPN transistor has a thin layer of P type material sandwiched between 2 thicker N type layers. In fact in the manufacture there are not separate layers, as such, just area of the N and P doping making depletion layers at each of the two N / P boundaries.

The PNP transistor has a thin layer of N type material sandwiched between 2 thicker P type Layers. As with the NPN the N and P doping makes the depletion layers at each of the two N / P boundaries.

As the drawings show the layer which forms the middle of the sandwich is called the BASE, the others are called EMITTER and COLLECTOR respectively.

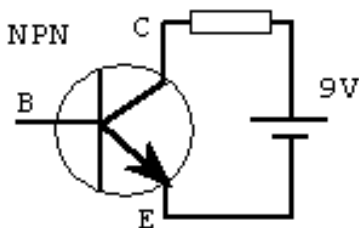


The arrowhead on the emitter symbol distinguishes the transistor as being either NPN or PNP.

The arrowhead also points in the **conventional direction of current flow**.

Bipolar transistors are constructed such that the junctions are so close together that electrons flowing across the base/emitter junction will control the flow of electrons in the collector/emitter junction. The result being that a small amount of current flowing in the base/emitter junction will control a much larger current flowing in the collector/emitter junction.

When we were discussing the diode a junction is said to be forward biased when the P type material is connected to the positive supply and the N type material is connected to the negative supply.



Look at the drawing of an NPN transistor connected across a 9V battery with no BIAS voltage or nothing connected to its base connection, no current can flow between the collector / emitter junction because it is reverse biased (or turned off) (Positive battery connection to the N-Type material).

No current can flow between the collector/base junction because it too is reversed biased (or turned off) the transistor behaves as if it were 2 diodes connected back to back.

When the transistor is forward biased or turned on (0.6V for silicon, 0.3V for germanium), current flows across the base/emitter junction, but because the collector/emitter junction is physically so close, current flows across this junction also. With both junctions conducting most of the current flows across the collector/emitter junction since this is the path of least resistance, hence the base current is less than the collector/emitter current.

The transistor now no longer behaves like 2 diodes because the base current makes the collector current flow despite being reverse biased. The current flowing between the collector/emitter is much greater than the current flowing through the base/emitter. (Typically 25 to 800 times greater) and standards are improving all the time.

☺ Testing NPN and PNP Transistors.

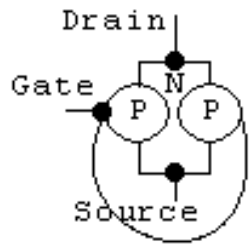
Understand the channel model of the FET.

The FET (Field Effect Transistor)

The FET is another family of transistors and is available in a number of different forms.

As with the NPN and PNP N and P channel type exist but we will consider the N type as shown to the left.

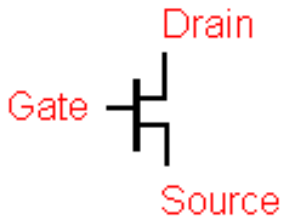
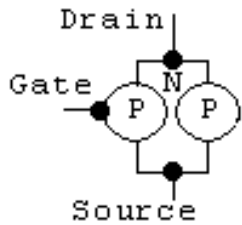
The P doping creates a GATE by encircling the N type material and causing an increase in the depletion layer thereby shutting off any flow of electrons Drain to Source. T



NOTE: The "looped" connection shown in the diagram is there only to indicate a coupling between the two cross-sectional areas of P doped material.

In the real world the connections are as shown to the left. The main current flow is drain to source with a voltage being applied to the gate to control the drain to source flow of current.

The FET is a voltage controlled device whereas the NPN and PNP transistors are current control devices. Bias voltages are applied to BOTH GATE and SUBSTRATE to control the flow of current between SOURCE and DRAIN.



A POSITIVE voltage applied to the gate has the effect of attracting more electrons into the channel, and so increasing its conductivity. A NEGATIVE voltage applied to the gate would repel electrons from the channel, so reducing it's conductivity.

Both N and P type devices can be made. When the voltage applied at the gate has the effect of cutting down the current flow in the channel, the operation is said to be IN THE DEPLETION MODE

The gate is therefore normally forward biased with respect to the source. The increased gate voltage is used to increase current flow, the operation of the FET is said to be IN ENHANCEMENT MODE.

In most cases, ENHANCEMENT MODE devices are made without the conducting channel.

With gate to substrate voltage equal to zero, the device is then CUT OFF.

When a voltage which is positive with respect to the substrate is applied an electrical field is set up that ATTRACTS ELECTRONS to the OXIDE LAYER. These now form an induced channel to support a current flow. Increasing gate voltage increases the drain to source current.

All semiconductors are sensitive to static electricity and appropriate handling precautions must be taken. MOSFETS are especially sensitive and extra precautions are recommended:

1. Always keep new mosfet's in their conductive foam around their leads until soldered in place.
2. Always short the leads of a mosfet together before un-soldering it.
3. Never touch the mosfet leads with your fingers
4. Never plug a mosfet into a holder when the circuit is switched on.

FET'S can be used in circuits similar to bipolar transistors but they give LOW VOLTAGE GAIN, and are only used when their peculiar advantages are required.

FET Advantages

1. FET'S have a very high input resistance
2. FET'S perform very well as switches, with channel resistances switching between a few hundred ohms to several Megohms as the gate voltage is varied.
3. If a graph is drawn of channel current I_{ds} (current drain source) against V_{gs} (Voltage gate source). The graph is noticeably curved in a shape called a square law. This type of characteristic is particularly useful for signal mixers in superhet receivers.

Dual gate mosfets are used as mixers and RF amplifiers in FM receivers. The shape of their characteristic also gives less distortion in power amplifiers, and HIGH POWER FET'S are now commonly used in HI FI and also find application in the power output stages of transmitters.

FET SUMMARY

FET's are devices that depend on a junction action different to that of bipolar transistors.

JUNCTION FET'S are usually operated with their single junction Reverse biased.

MOSFET'S have almost infinite gate resistance, and the leads should not be touched unless first shorted.

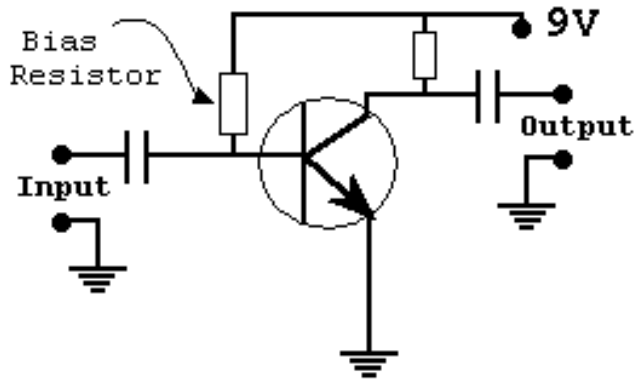
FET'S are used in applications where their high input resistance, good switching characteristics and low noise factor outweigh their poor voltage gain.

3n.5 Understand the basics of biasing bipolar and FET transistors (including dual gate devices).

BIASING OF TRANSISTORS.

There are commonly 3 types of bias systems for transistors they are: -

1. SIMPLE



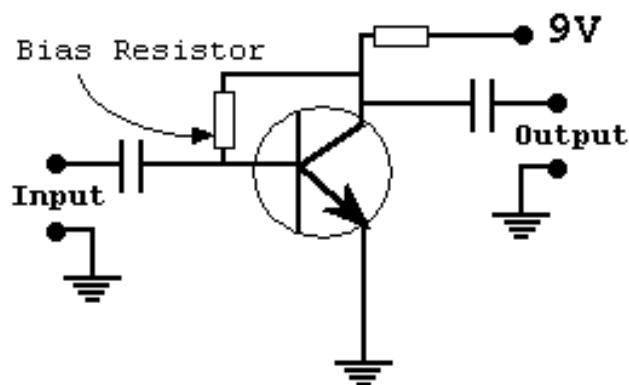
Common Emitter

So called as you can see that the Emitter is **common to both input and output**

Firstly, the SIMPLEST uses a single resistor connected between the supply rail (+ for NPN - for PNP) and the base of the bipolar transistor. This type of bias is seldom used for linear amplification these days, because it is difficult to find a suitable value of bias resistor. In this simple system the value of resistor depends on the value of current gain or H_{fe} of the transistor so that a bias resistor suitable for one transistor will not work properly with another, even if its the same type and number, as the values of H_{fe} are wide and varied. Also the value of resistor maybe critical so that one preferred value of resistor maybe too high, the next one down, too low.

The simple system is unsuitable if the transistor is to work in varying degrees of temperature, because the voltage needed between the base and emitter for a given collector current, decreases as the transistor warms up. As the simple system cannot compensate for this, so the transistor turns harder on, so increasing the collector current further still, unless the current is limited by a collector load resistor, thermal runaway occurs and the transistor is destroyed.

2. CURRENT FEEDBACK TYPE



Common Emitter

THE CURRENT FEEDBACK bias system represents a considerable improvement over the simple system, because the bias resistor is returned to the collector of the transistor rather than the supply rail. This small change makes the bias to some extent self-adjusting, so stabilising the bias.

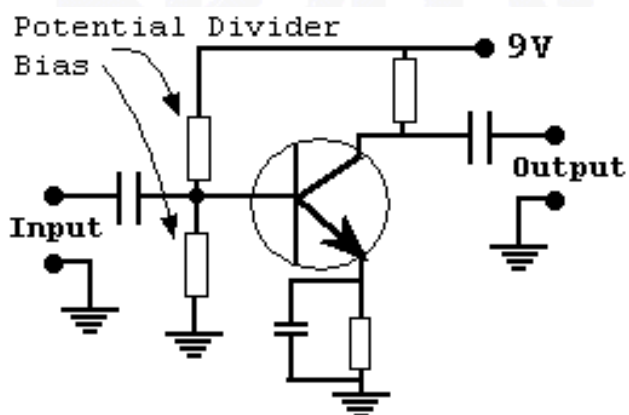
The connection of the bias resistor causes DC feedback, which means that the level of DC voltage at the COLLECTOR affects the amount of DC BIAS CURRENT at the BASE of the transistor.

Let's see what happens. A change in either the transistor itself or the load, which causes the collector current to increase will, because of the presence of the collector resistor, cause the collector voltage to drop, because the voltage is less where the base resistor is connected, the voltage and current at the base is less, this drop off in base current will return the collector current to somewhere near to its original value.

Alternatively a change causing the collector current to drop will cause the base current to rise, so re-instating the collector current. All NEGATIVE FEEDBACK SYSTEMS work in a similar way, keeping conditions unchanged despite other variations (AC feedback which has the effect of reducing stage gain will be considered later).

The disadvantage of this arrangement is that the AC feedback that results reduces the stage gain.

3. FIXED VOLTAGE TYPE



Common Emitter

The FIXED VOLTAGE bias system is the most commonly used of all. A pair of resistors forms a potential divider across the supply to set the voltage at the base terminal, and a resistor placed in series with the emitter controls emitter current flow by DC NEGATIVE FEEDBACK.

If the transistor has a higher gain, then it tends to pass more collector current, which in turn results in more emitter current. This increases the voltage drop across the emitter resistor, and raises the emitter voltage.

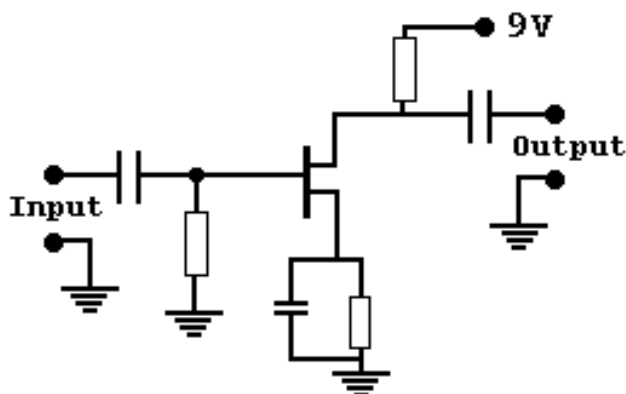
As the base voltage is fixed and the emitter voltage rises, there is less voltage across the base-emitter junction, which then tends to turn the transistor off. It meets equilibrium at the (designed) operating point.

AC feedback does not occur because of the emitter capacitor which bypasses AC components to earth, not allowing any signal voltages at the emitter to oppose the signal at the base. Note that removing this capacitor and all the gain disappears !!

In this type of circuit the replacement by one transistor with another, has little effect on the level of steady bias voltage at the collector or base. This biasing arrangement is therefore ideal for mass produced circuits which must behave correctly even when fitted with substitute transistors.

FET BIASING.

(Drawing of a FET in depletion mode with biasing)



FET amplifier biasing

Biasing of an FET is slightly less complex than for BIPOLAR transistors

Gate must be negatively biased with respect to the source

For correct bias of an FET, the voltage at the gate must be negative with respect to the source voltage - or to put it another way, the source voltage must be positive with respect to the gate voltage. In the circuit drawn the positive voltage is derived from the voltage drop across the resistor in series with source. The gate voltage is kept at zero volts or ground level by the resistor connected from the gate to the negative rail.

SUMMARY.

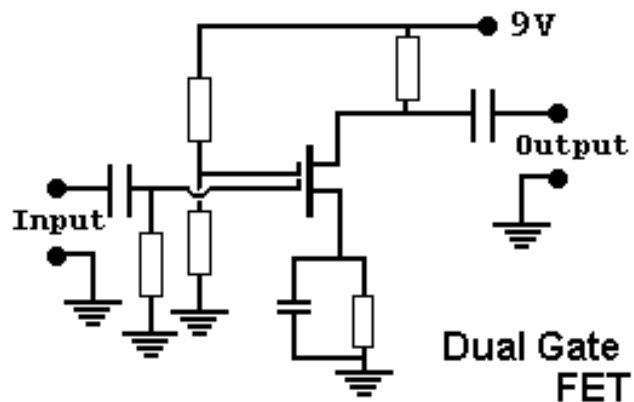
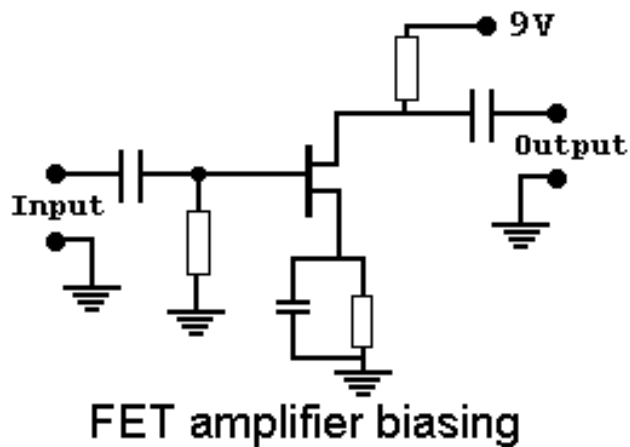
The purpose of biasing a transistor is to set its output current to a value which permits the best use of its transfer characteristic.

For a linear amplifier having a resistive load, the most useful bias setting is when the collector voltage is close to half the supply, (Class A).

The biasing method chosen must be stable, and thermal runaway must not occur.

Bias failure can be caused by either a short circuit or open circuit bias components. Either will greatly affect the working of the transistor as an amplifier.

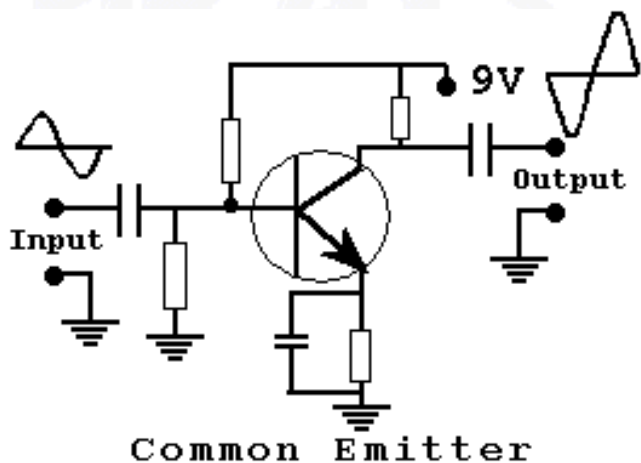
DUAL GATE FET



The FET can also be made as a dual gate device. The original diagram of the FET is shown above (left) and the Dual Gate FET shown above (right). Note in the dual gate that the signal is on one gate and the main bias is on the other gate.

- 3n.6 Identify different types of small signal amplifiers (e.g. common emitter (source), emitter follower and common base) and explain their operation in terms of input and output impedances, current gain, voltage gain and phase change.

The diagrams below you must be able to identify in the exam - so look for the differences.



General information

Impedances / Gain

As mentioned above the Common Emitter is so called as the emitter is common to both the input and the output in that with regard to signals, it is coupled to ground via a capacitor and both input and output have a grounded connection. The emitter resistor does have some involvement in connecting the emitter to ground, but it's main function is to set the correct DC operating conditions. The output signal is an inverted, larger copy of the original.

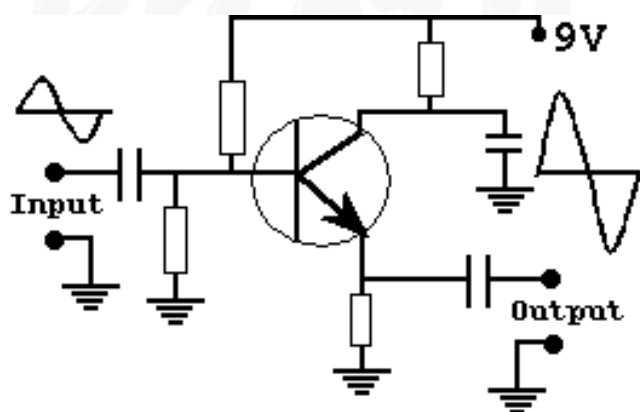
Phase change There is a phase change between input and output as shown in the drawing it being 180° out of phase.

Voltage gain
High (about 100)

Current gain
High (50 - 800)

Input resistance
Medium
(about 5kΩ)

Output resistance
High (about 40kΩ)



Emitter Follower

The Emitter follower is so called as the signal that comes from the emitter is a copy of the input signal. Although there is no voltage gain, (a very small LOSS may be experienced), there is a considerable current gain. Circuits such as this one have an application where a very small load should be applied to the preceding stage, whilst allowing a good drive signal to the following stage. A typical use is for a buffer amplifier for an oscillator, where the oscillator must be loaded very little by the stage it is driving to avoid frequency changes.

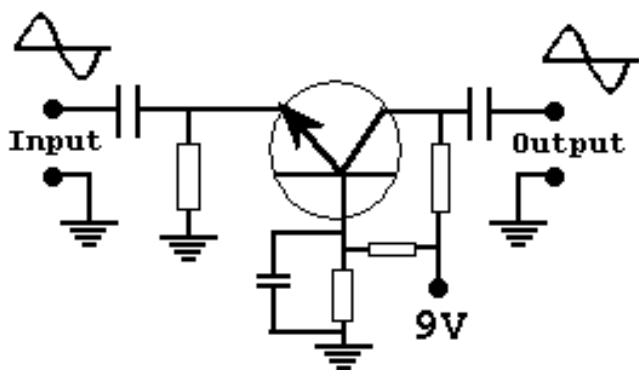
Phase change There is NO phase change between input and out put as shown in the drawing.

Voltages gain
Unity (1)

Current gain
High (50 - 800)

Input
resistance
High (several
tens of $k\Omega$)

Output
resistance
Low



Common Base

The Common Base is so called as the base is common to both the input and the output in that with regard to signals, it is taken to ground via a capacitor and both input and output have a grounded connections. The output signal is a larger copy of the original.

Phase change There is NO phase change between input and out put as shown in the drawing.

Voltages gain
Medium (10 - 50)

Current gain
Unity (1)

Input
resistance
Low (about
 50Ω)

Output
resistance
High (about
 $1M\Omega$)

CURRENT GAIN h_{fe} (previously is was β)

- The amount of current flowing between the collector and the emitter of a BIPOLAR transistor is much greater than the current flowing between the base and the emitter, but the amount of current flowing in the collector is controlled by the base current. The ratio COLLECTOR CURRENT TO BASE CURRENT varies according to the collector current flowing. (An undesirable characteristic!) All comments regarding h_{fe} in the remainder of this section must be understood in relation to this unwanted effect!

The constant is commonly known as current gain and the symbol used to indicate current gain is **hfe** (previously is was β). A low gain transistor might have a gain of around 20 - 50, Power transistors sometimes have a gain of only 10, a high gain transistor might have a gain of 300 - 800 or even more.

The equation for the calculation of gain is $I_C = h_{fe} I_B$ $I_C = \beta I_B$

The current flowing in the collector = the hfe (gain) times the current flowing in the base.

Tolerance values of hfe are very large, so that transistors of the same type or even the same batch may have widely different **hfe**'s. Published figures of transistor gains are only typical values. If an exact gain is wanted then the transistor will have to be tested. The secret is not to design a circuit where the maximum gain is required from a transistor, but to design such that many different devices can be used for the same circuit.

MEASURING GAINS OF TRANSISTORS.APPLICATIONS OF BIPOLAR TRANSISTORS.

TRANSISTOR FAILURE.

SUMMARY.

Bipolar transistors

- Bipolar transistors consist of three regions - EMITTER, BASE, COLLECTOR, - with 2 junctions.
- Current flows between collector and emitter only when current flows between base and emitter.
- A transistor has GAIN when collector current divided by the base current is greater than 1.
- Connecting transistors in different ways changes gain and input/output impedances.

FIELD EFFECT TRANSISTORS.

To be strictly correct, the so-called FIELD EFFECT TRANSISTOR is not a transistor at all, as the word TRANSISTOR is derived from TRANSFER RESISTOR and the FET doesn't work like that at all. The FET relies upon the presence and the effects of an electric field.

There are 2 types of FET - The JUNCTION FET and the METAL OXIDE SILICON FET or MOSFET.

Both work by controlling the flow of current carriers in a narrow channel of silicon. The main difference between them lies in the way the flow is controlled.

Firstly the JUNCTION FET. A tiny bar of N or P type silicon has a junction formed at near one end. Connections are formed at either end of the silicon bar (see drawing) and also to the junction material (p type for N type FET).

The P type connection is called the GATE, the end of the bar nearest the gate is called the SOURCE, and the connection at the other end is called the DRAIN.

A junction FET is normally used with the junction reverse biased (got a negative voltage on it for an N channel as opposed to what you might expect a positive one) so that a few moving carriers are around the junction (keeping it

turned off) making the bar of silicon itself a poor conductor.

With less reverse bias (or less negative volts) on the junction the silicon bar will conduct better, and so on as the amount of reverse bias on the junction decreases the FET conducts better.

When a VOLTAGE is connected across the SOURCE and DRAIN the amount of current flowing between them depends on the amount of reverse bias (or negative volts) on the GATE and the ratio SOURCE - DRAIN CURRENT/GATE VOLTAGE is called the MUTUAL CONDUCTANCE the symbol for which is G_m . This quantity is a measure of the effectiveness of the FET as an amplifier of current flow.

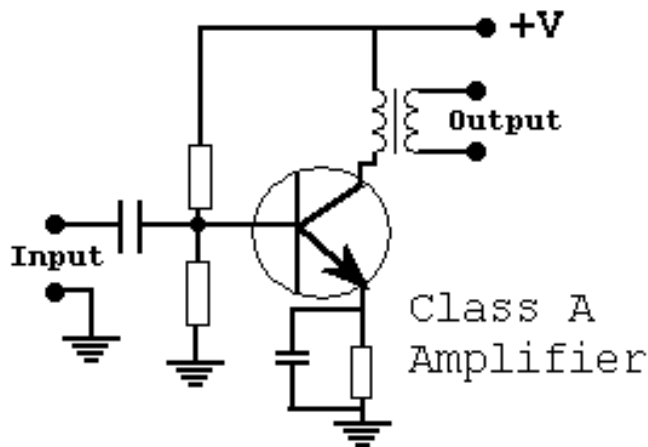
Because the GATE is REVERSE BIASED, practically NO GATE CURRENT FLOWS, so that the RESISTANCE between GATE and SOURCE is VERY HIGH, much HIGHER than a BASE EMITTER junction of a BIPOLAR transistor, This uncommonly high resistance is put to good use, for instance in voltage measuring circuits NO LOAD is put on the circuit being measured.

3n.7 Recall the characteristics and typical circuit diagrams of different classes of amplifiers (i.e. A, B, A/B and C).

Classes of amplification

Several methods exist for biasing transistors; typically class A, B, C.

Class A

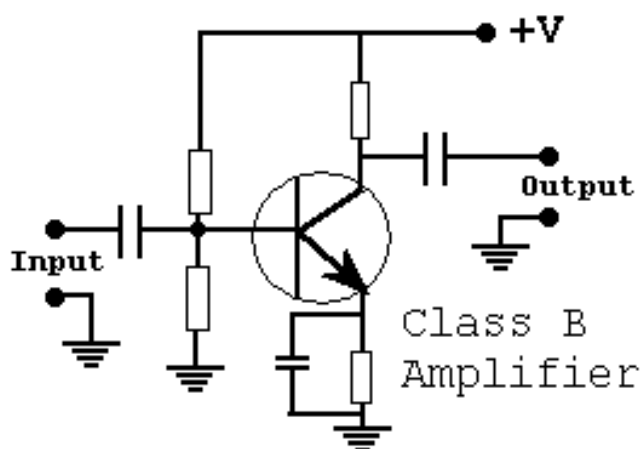


Class A. is biased so that the collector voltage never bottoms, nor is the current flow cut off. Output current flows during the whole AC cycle; it is this bias that is used for linear voltage amplification in low power stages.

Class A suffers from 2 disadvantages.

1. Current flows in the transistor at all times, so the transistor needs to dissipate heat. (Power stages will get VERY hot!).
2. This loss of power in the transistor inevitably means less power is available for dissipation into the load. Even under ideal conditions with everything matched, efficiency is only 33%

CLASS B



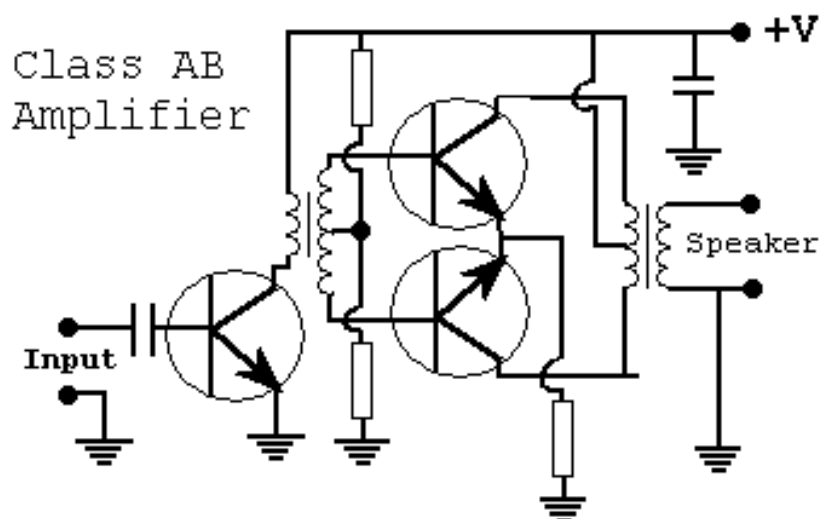
The bias of a class B amp is so set that only half of the AC cycle is amplified. The bias is such that with no input signal, the transistor is biased, but at a level insufficient to turn it on.

Application of the input signal (on positive half cycles) drives the transistor base into conduction, causing an amplified flow of collector current.

For RF applications a tuned circuit as the collector load would be used, which stores energy and releases it to replace the other half of the cycle.

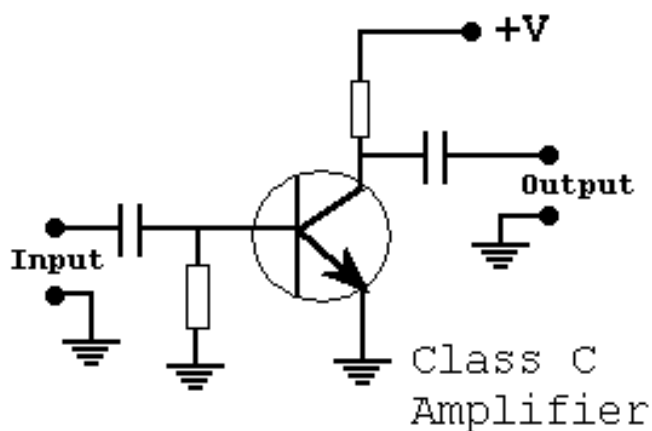
The efficiency of this type of circuit is approximately 50%.

CLASS AB



For audio applications the other half of the cycle is amplified by a second transistor, and transformers are used to split the incoming signal to each transistor, and recombines the amplified results. To avoid audio distortion, some forward bias is applied to the transistors, such that a small current flows in the absence of drive signal. As this results in operation that is neither true class A or B, it is known as class "AB".

CLASS C



Class C amplifiers amplify less than half the AC cycle. With no bias resistor from the positive rail only one to the negative rail. This resistor keeps the transistor turned off until the positive going signal voltage overcomes the negative bias and amplification takes place. Commonly, in medium to high power RF stages, this resistor will be replaced by an RF choke.

Efficiency of a Class C amplifier is quite good and typically, a stage efficiency of 66% may be obtained.

Once again as with Class B, for RF service the

collector load resistor is replaced with a tuned circuit, the stored energy in it replaces the missing half cycle. The Class C amplifier is rich in harmonics; the tuned circuit in the collector selects the desired frequency. Note that such is the level of harmonics that further filtering would be required before this signal were applied to an antenna.

3n.8 Understand the concept of the efficiency of an amplifier stage and be able to estimate expected r.f. output power for a given d.c. input power, given the stage's efficiency.

When dealing with a power amplifier stage it is possible to estimate the expected output RF power from the DC input power given the stage's efficiency.

If the DC input power is 100 watts with a known efficiency of 60%, then 60% of 100 will be the RF output power (60 watts of output).

The remainder of the input power is converted into heat, which must be safely removed from the output device by a heatsink (for transistors) or air flow (for thermionic valves).



THYRISTORS

Thyristors or to put it another way, SILICON CONTROLLED RECTIFIERS are like a diode in that they have an anode and cathode or positive and negative end. They only conduct when a pulse is received at the gate, and do not stop conducting until the current flowing through them is zero. They have many uses in electronics, typically power supply protection and motor speed control circuits.

Next

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INDEX**Introduction****Amateur Radio****Licensing Conditions****Technical Aspects****Transmitter & Receiver****Feeder & Antenna****Propagation****E M C****Operating Practices****Safety****Measurements****Maths****Bredhurst Receiving and Transmitting Society****Technical Aspects****Syllabus Sections:-****Decibels****30.1 Understand the equations for decibel power and voltage ratios.**

The equations are :-

$$\text{Gain(Loss)} = 10 \log_{10} \left(\frac{P_1}{P_2} \right) = 10 \log_{10} \frac{\text{power out}}{\text{power in}} \text{ dB}$$

$$\text{Gain(Loss)} = 20 \log_{10} \left(\frac{V_1}{V_2} \right) = 20 \log_{10} \frac{\text{voltage out}}{\text{voltage in}} \text{ dB}$$

When assessing the sound level strength of an audio signal this is how loud it seems to be when heard by the human ear. If someone thinks that a sound level has doubled when power from an audio amplifier is raised from 5 to 10 watts that same person should also consider that a signal would also be twice as loud if the power increased from 200 to 400 watts. The human ear has what is called a "logarithmic" response to changes in audio levels. It is this basis that is used for the "relative" power level given the name of "the decibel" (dB). One decibel is 1/10th of a bel the unit of sound coined by Alexandra Graham Bell.

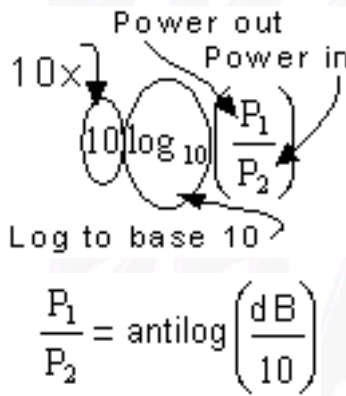
The number of decibels in relation to the ratio of power levels is given by :-

$$\text{Gain(Loss)} = 10 \log_{10} \left(\frac{P_1}{P_2} \right) = 10 \log_{10} \frac{\text{power out}}{\text{power in}} \text{ dB}$$

$$\text{Gain(Loss)} = 20 \log_{10} \left(\frac{V_1}{V_2} \right) = 20 \log_{10} \frac{\text{voltage out}}{\text{voltage in}} \text{ dB}$$

When using the V_1 / V_2 voltage equation the the impedance must be the same for both voltages, thus a power amplifier cannot be properly assessed if only taken on input and output voltages, unless those voltage have the same value of impedance in the circuit.

These equations look very complex but in the [scientific calculator](#) sections it is shown how the equations can be used when $P_1 = \text{Power}_{\text{Out}}$ $P_2 = \text{Power}_{\text{In}}$ similarly $V_1 = \text{Volts}_{\text{Out}}$ and $V_2 = \text{Volts}_{\text{In}}$



The log to the base 10 is the usual log used by engineers and would be that on the [scientific calculator](#). The 10 in front of "log" means multiply the log of the ratio P_1/P_2 by 10, the resulting answer will be the relative power expressed in dBW or decibel watts.

When the decibel value (dB) and one power value is known then the unknown power can be calculated from the equation at the left.

We are using log to the base 10 as shown by "log₁₀" the 10 to the right of the word log indicate base 10. For clarity we will now omit that 10 and only write "log".

When a question is set and Power_{in} is not shown then assume that it is 1 Watt.

Example: What is a measured power of 400W expressed in dBW ?

$$\text{dBW} = 10 \log(\text{power in watts})$$

$$\text{dBW} = 10 \log(400) = 26\text{dBW} \quad \text{Click here to see the calculator key strokes}$$

Example: What is a measured power of 12dBW expressed in Watts ?

$$\text{Power(Watts)} = \text{antilog dBW}/10$$

$$\text{Power(Watts)} = \text{antilog } 12/10 = 16 \text{ Watts} \quad \text{Click here to see the calculator key strokes}$$

Recall (or determine) the power gain or loss of various dB ratios based on $\pm 3, 6, 9, 12, 15$ and $10, 20, 30\text{dB}$. (This includes examples such as $25\text{W} \equiv 20 - 6 = 14\text{dBW}$.)

dB	Calculation	Gain (Rounded figures)	dB	Calculation	Loss (Rounded figures)
+3	antilog 3/10	x 2	-3	antilog 3/10	$\div 2$
+6	antilog 6/10	x 4	-6	antilog 6/10	$\div 4$

+9	antilog 9/10	x 7.94	-9	antilog 9/10	÷ 7.94
+10	antilog 10/10	x 10	-10	antilog 10/10	÷ 10
+12	antilog 12/10	x 15.8	-12	antilog 12/10	÷ 15.8
+15	antilog 15/10	x 31.6	-15	antilog 15/10	÷ 31.6
+20	antilog 20/10	x 100	-20	antilog 20/10	÷ 100
+30	antilog 30/10	x 1000	-30	antilog 30/10	÷ 1000

The sort of question you might be asked is:-

Your transmitter has a power output of 20dBW and the feeder has a loss of 3dB, the antenna has a forward gain of 9dB. What is your ERP in watts (effective radiated power) ?

Solution $20\text{dBW} - 3 + 9 = 26\text{dBW}$

Now we know that $\text{Power(Watts)} = \text{antilog dBW}/10$

so $\text{Power(Watts)} = \text{antilog } 26/10 = 398\text{W}$ rounded up = 400W [Click here to see the calculator key strokes](#)

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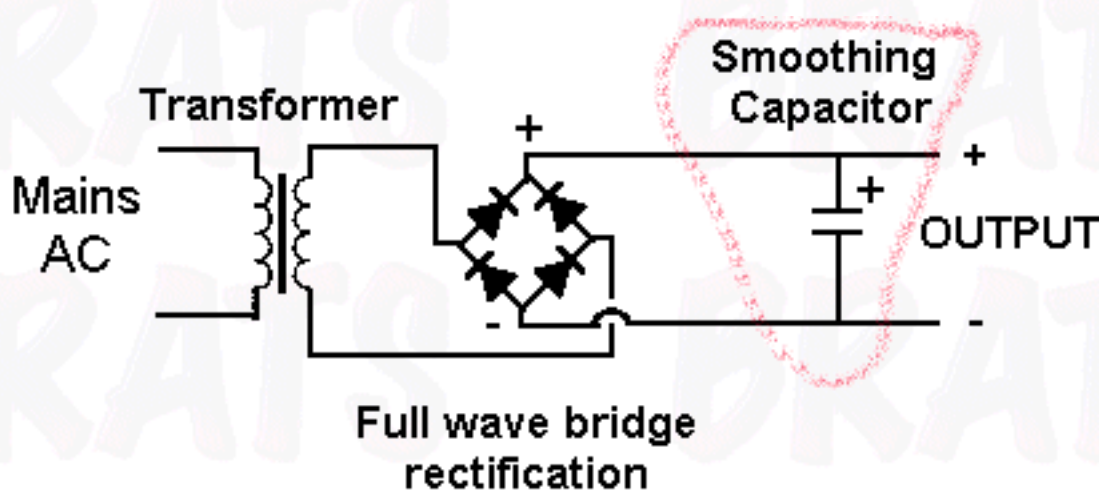
Measurements

Bredhurst Receiving and Transmitting Society**Technical Aspects****Syllabus Sections:-****Mains Power Supplies**

3p.1 Recall the circuit diagrams and characteristics of different types of rectifier and smoothing circuits (i.e. half wave, full wave and bridge).

When considering a "basic" power supply there are several sections into which it breaks down.

- Transformer
- Rectification and
- Smoothing



The transformer must be able to

- supply the correct AC output voltage to allow for rectification and smoothing
- be able to supply sufficient current to the output

The rectification must be able to

- change the AC into DC

- have sufficient current carrying capability to give the output required

The smoothing must be able to

supply as steady voltage with little or no ripple (variation in the output voltage) when a load is applied. If the capacitor is too small there will be ripple on the output.

As for this part of the course as you are not actually having to build a power supply some of the details will be left out.

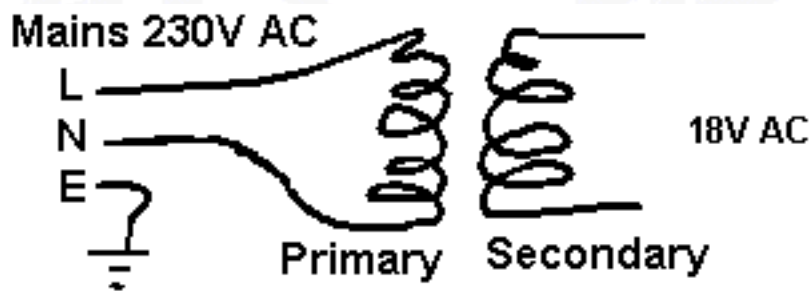
Unless you are powering your equipment from a battery then you will need a method to convert the AC supply from the mains at 230V (approx) to a suitable stabilised DC supply.

The following will explain the various parts of a basic power supply but in no way must this be used to construct a unit as it is only in a very basic form.

There are dangers of death when using mains supply.

TRANSFORMER

The first part that a typical 13.8V power supply needs is a transformer. This is used to convert the mains AC voltage of about 230V on the primary coils to about 18V AC on the secondary coil.



TRANSFORMERS

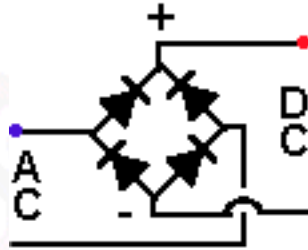
RECTIFICATION

BRIDGE RECTIFICATION

Then we need a means to convert the AC output from the secondary coil to DC. For this we use what is called a BRIDGE RECTIFIER. This is simply 4 diodes set in a certain formation so that

from two input connections at AC there are then two outputs at DC.

A diode only conducts in one direction, and conventionally this is a flow of electrons in the direction of the Arrow head on the circuit diagram. By the clever use of 4 diodes we can arrange them so there is a positive terminal and a negative terminal.



The animation shows that no matter which way the AC arrives there is always a flow from positive to negative on the DC side.

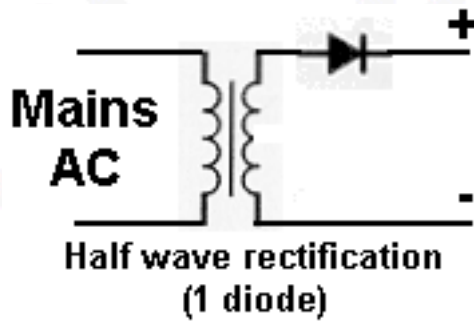
watch the RED dot first and follow its track from the AC input to the DC output then watch the Blue dot as it returned from the circuit to the AC.

You should recall the sine wave diagram which represents the AC flow in the primary.



At certain times the voltage drops to zero (crosses the centre line) and thus the power supply needs some way to maintain an output when there is no AC input.

The 18V AC RMS actually has a peak voltage of about 25V. After rectification this gives a peak voltage of 25V DC but it is anything but smooth meaning if we looked at the DC voltage on an oscilloscope it would still have a waveform.



To try and maintain in the first instance a constant 25V DC output we need the component to fill in the gaps in the wave form or to smooth the output voltage.

Smoothing

Such a component is called a CAPACITOR which can be charged up to the max voltage (25V) and then when the voltage in the DC waveform is dropping off, **the capacitor then "fills" in the gap by discharging**, and then is charged up again as the voltage rises above the level of discharge. If there is no load on the output the capacitor will stay charged between peaks of the DC waveform but if there is a load on the output it will drop down between peaks depending upon the size of the value of the capacitor. This slight dropping back is called the "Ripple Effect". The bigger the value of the capacitor the smaller the ripple.

Also the size of the capacitor will be related to whether the rectification is half wave, full wave or bridge. The capacitor has less work to do in the bridge and full wave as will be seen from the diagram below as there are more peaks of the wave form to charge up the capacitor.



**Blue line
smoothed on load**

So long as the output voltage does not drop below the voltage required when on load then this simple power supply is starting to take shape BUT is it not good enough yet as the output voltage is :-

- with low load much too high and with high loads only a little above what is required, and with considerable ripple.

Such a power supply would not be suitable for a typical transceiver.

To rectify UK mains AC 50Hz (or change it to DC) we use diodes. Diodes can be simply described as one way valves, they pass current in one direction (forward biased) but not in the other direction (reversed biased). So carefully connected diodes can provide a rough DC output.

Various forms of rectification

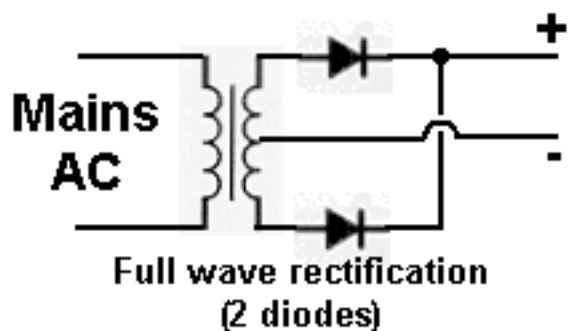
Half wave rectification

Using one diode as a rectifier will pass current only when the sine wave is in the positive or forward half of the cycle, provided that is how it is connected. With the result that the current output, although only flowing in one diode is dc but not smooth dc, which makes it unusable for most electronic circuits. The positive current pulses can be smoothed out by the insertion of a capacitor which we can call the RESERVOIR CAPACITOR. As its name suggests, the capacitor stores some of the charge whilst the diode is conducting, then releases the charge to provide a current flow when the diode is not conducting. The diode needs a voltage to make it conduct, typically 0.6 volt for silicon diodes and 0.2 volt for germanium diodes, so there is always a voltage drop across a diode. The frequency of the ripple is 50hz or mains ripple.

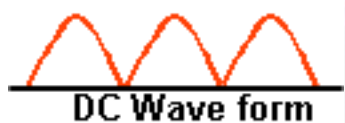
Half wave rectification will give a DC output, but although the voltage off load would be the same, there will be considerable ripple and poor regulation compared to a full wave circuit. If we use 2 diodes with a centre tapped secondary winding on the transformer we can have full wave rectification.

Full wave rectification (using 2 diodes)

If we connect the centre tap of the transformer to the common of the circuit the centre tap will be at zero volts because the voltages at each end of the secondary winding will be equal and opposite, ie when one end is positive the other will be negative, so the centre will always be zero volts.



Note: No smoothing capacitor shown

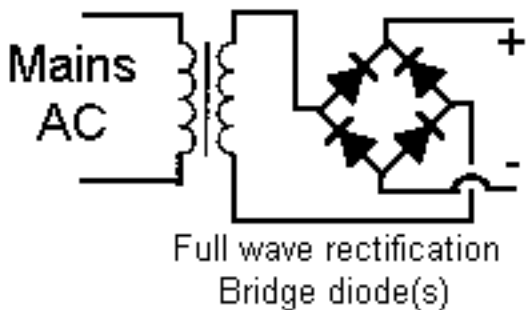


Full wave rectification

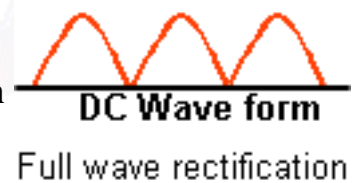
By connecting a diode to each end of the transformer secondary winding, when either end becomes positive then the respective diode will conduct. By commoning the ends together, both halves of the wave in turn are connected to the load. The frequency of the ripple current will be twice or 100hz.

Bridge rectification (also full wave but uses 4 diodes)

Finally the most widely used form of rectification is the full wave bridge rectifier. No centre tapped transformer is needed because the arrangement of the diodes is such that the end of the winding which at any one moment is positive is always connected through the diodes to the same end of the load.



Note: No smoothing capacitor shown



Value of the smoothing capacitor

When a capacitor is used across the output terminals + and - of the Half wave rectification there are more missing parts to the wave form than for the Full wave rectification. Thus there is more work to be done by the smoothing capacitor in Half wave rectification and a larger value capacitor is required.

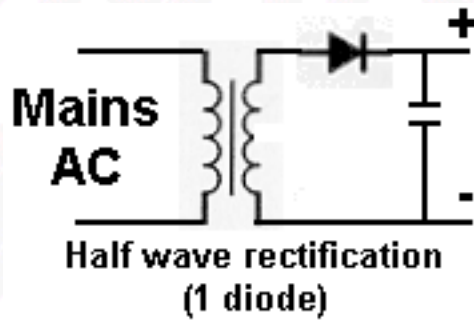
Calculating the actual value of the capacitor needed is not part of the course but it must be of such a size the the wave form ON LOAD is reduced as far as possible at all times to a single straight line of DC voltage. The amount of the deviation from this ideal straight line is called "ripple" and it must be kept to a minimum.

3p.2 Understand the need for rectifier diodes to have a sufficient peak inverse voltage (PIV) rating and be able to calculate the PIV in diode/capacitor circuits.

PEAK INVERSE VOLTAGE

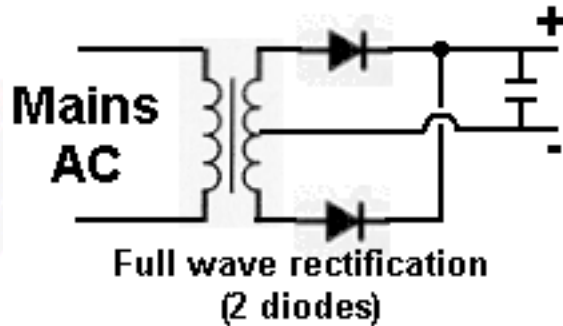
- PEAK INVERSE VOLTAGE (PIV) IS THE MAXIMUM REVERSE VOLTAGE THAT A DIODE CAN STAND AND REVERENCE TO THIS MUST BE STRICTLY

ADHERED TO,

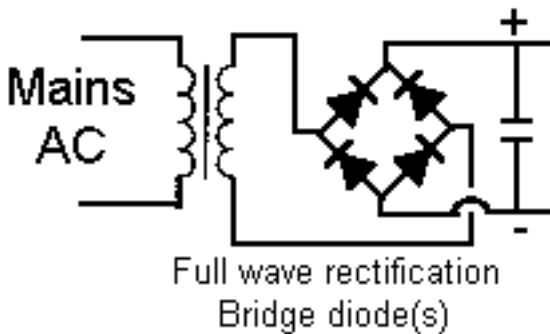


PIV = twice peak voltage + safety margin

REMEMBER the PIV on half wave rectification and full wave using two diode (called bi phase), is twice the peak voltage due to the smoothing capacitor.



All diodes have to be sized for PIV and FORWARD CURRENT capability and need to have an added safety margin (usually x2). With Diodes so cheap go for as large PIV as you like!!



PIV is the peak voltage + margin

With a full wave bridge rectification the PIV is the peak voltage and safety margin .

Also bridge rectifiers are cheap there are advantages in using a single, non-tapped secondary, as the regulation of the transformer will be better. Remember that a bridge circuit will need an 18V winding, whereas the bi-phase (centre tap, two diodes) uses a 36V winding, centre taped, and this has to use thinner wire for a given transformer size. The wire is in fact overloaded on the half cycle it conducts, but gets a rest on the other half cycle - hence it copes.

- Similarly the ripple current is twice the load current for half wave rectification, 1.414 times for full wave (2 diodes) and the same as the load current for full wave bridge rectification. Diodes often have capacitors fitted across them to bypass any high voltage spikes that may damage them. Similarly where diodes are connected in series to increase their overall PIV rating, then balancing resistors are used to even out the reverse voltage across them.

- At zero current you will get a little more than 18v AC but at full load it will be less. It would be obviously desirable to have 18V AC whatever the load but that does not happen. Transformers with good regulation have a little over 18V off load and a little under at full load.
- So you can see some of the advantages of using one method of rectification and disadvantages of using others.



RMS

3p.3 Understand the function of stabilising circuits and identify different types of stabilising circuits (i.e. Zener diode/pass transistor and IC)

Note: Questions on the characteristics of individual components are covered earlier in this section, eg. 3n.2. This sub section is on complete circuits.

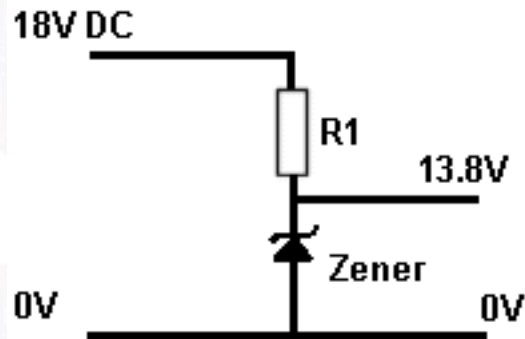
The Regulation must be able :-

- for amateur radio use supply a fixed voltage output usually 13.8V
- output must be able to detect some failure whether it is:-
 - over voltage
 - over current

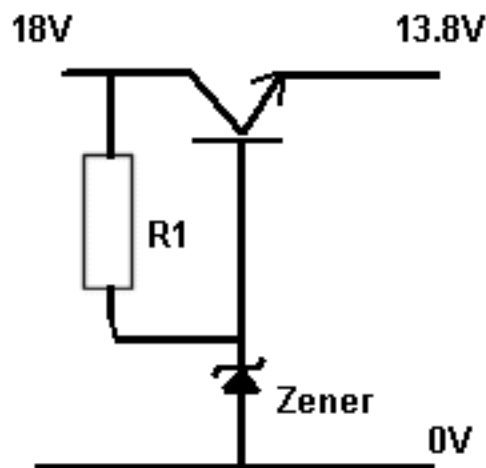
Stabilising circuits / REGULATION

The other part that is needed is some form of REGULATOR to keep the output voltage at say 13.8V all the time without any regard as to the level of current being drawn.

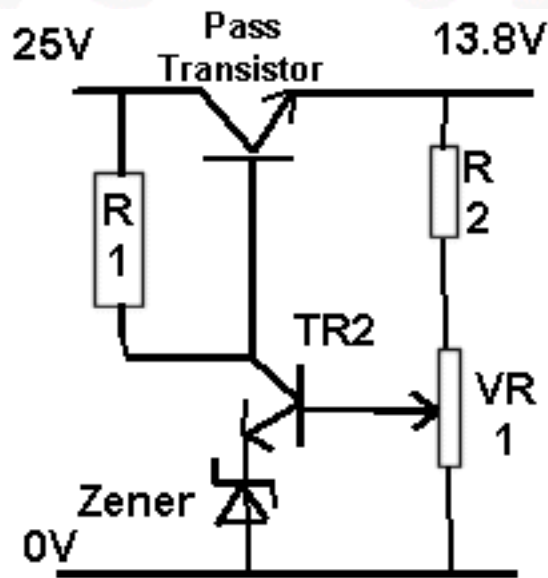
In its simplest form, for low current use, a regulator could be as simple as a Zener diode and a resistor in series across the DC supply. The value of the zener diode determines what the output voltage is.



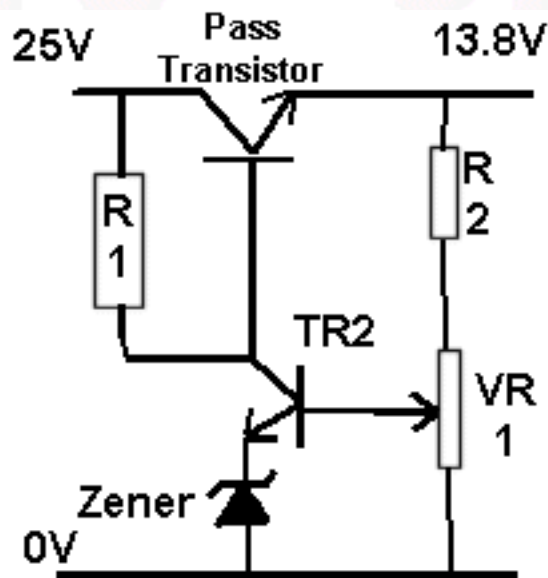
The next stage would be to add a pass transistor as shown below. Here again the zener determines the output voltage.



The next stage in complexity would have a regulator which consists of a few more components as shown in the diagram below as it develops. In this case it is the variable resistor as part of the potential divider chain of resistors that determines the output and thus can be "set" to the output required.



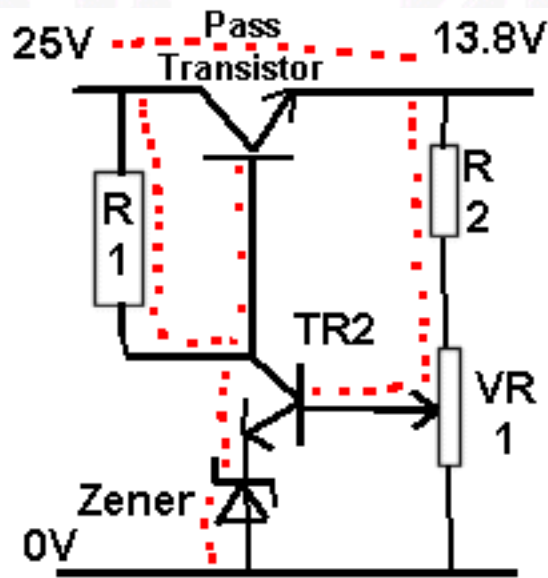
The transistor at the top is called a PASS TRANSISTOR as it is passing all the current going to the output terminal. The lower transistor is part of the regulator circuit. Please note a ZENER diode has been used at a voltage of 5.6V. Such a rated diode perform very well and can control the voltage close to 5.6V without change due to heating.



With the power turned on the preceding part of the circuit will supply 25V to the collector of the pass transistor. R1 will then supply a small current to the base of the pass transistor and current will then flow through the transistor to the output terminal where the diagram is marked 13.8V.

The 13.8V is controlled by the potential divider chain of R2 and VR1 which controls the current flowing into the base of the second transistor. If the 13.8 goes higher then more current flows into the base turning TR2 on harder. This results in there being less current available to the base of the pass transistor, hence the output falls to a point where there is equilibrium in the circuit. The zener is always conducting, providing a reference voltage against which the output voltage is compared.

If the 13.8V goes lower then less current flows into the base and TR2 begins to turn off. This results in there being more current available to the base of the pass transistor, turning it on more, and the output voltage rises to the point where again there is equilibrium in the circuit.



This action continues and thus regulates the output voltage and stabilizes it to 13.8V +/- a very little.

VR1 is used to set the output level at 13.8V initially.

The use of an IC

It is possible to carry out many of the above functions with an IC such as LM723 which is a voltage controlling IC. Discussion in the course is not required other than to be aware that IC's can control voltage circuits of a power a supply when used in conjunction with pass transistors and other components.



REGULATION

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Close page to exit

Power supply unit or PSU

REGULATION

Zener diode

- One of the most simple forms of regulator is the zener diode. When a large reverse voltage is applied across a diode the junction will break down so that current flows. This breakdown can occur at a precise voltage, depending on the type of material and the amount of doping used.
- So therefore the zener diode can be used for stabilization purposes as the reverse voltage will remain constant even though the current may vary quite considerably.



picture of a zener diode regulation circuit or stabilizer.

LIGHT EMITTING DIODES

- Light emitting diodes are made from a transparent semiconductor material which makes visible to the user the light generated when current flows through it.
- So the LED can be used as an indicator of current flow or voltage present. Whilst they may need a higher voltage than ordinary diodes to make them conduct a series resistor is used to limit the current flow through them to prevent destruction of the LED.

THE SERIES REGULATOR



picture

- When a much larger current is required the zener diode provides the base current for a power transistor connected as a shunt or series regulator. The transistor needs 0.6volt on its base to conduct so the collector must be about

0.6volt above the zener voltage. In other words choose the output voltage and make the zener diode value about 0.6 of a volt above that.

- This type of circuit is widely used as it provides reasonable regulation of the PSU and its load.
- Improved versions are available in integrated circuit form, using comparator amplifiers monitoring the load voltage and comparing it to the zener diode reference, so driving the series transistor



picture

INTEGRATED CIRCUIT REGULATORS



PICTURE

- The picture above shows a typical IC regulator circuit in simplified form. The regulator can be installed at fixed or variable output voltage so the circuit can be quite versatile.
- The regulator IC's are not without their problems though, they can become unstable decreasing their efficiency.
- Small value capacitors 0.1 0.01 microfarad type are connected close to the regulator pins to stop HF instability that may impair the regulator efficiency.
- Also a capacitor typically 1 or 2 microfarad fitted after the regulator to remove any HF currents that may be present.

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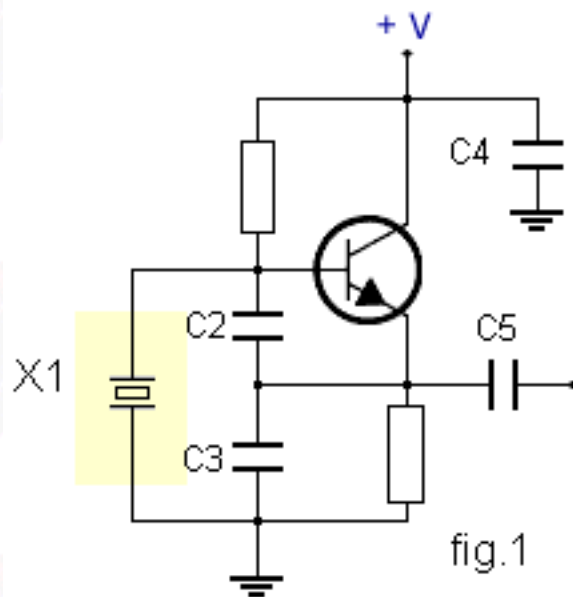
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Transmitter & Receiver

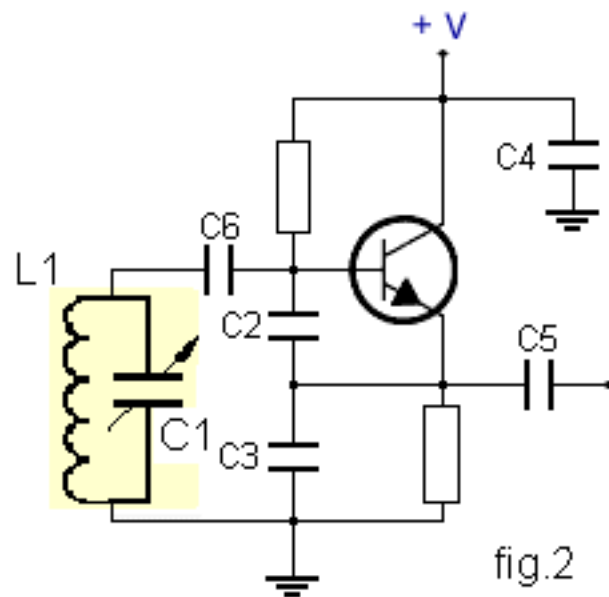
Syllabus Sections:-

Oscillators

4b.1 Understand the function of the components in typical VFO and crystal oscillators.



a crystal oscillator



the variable oscillator

The oscillators shown above in figs 1 & 2 are very similar. In effect, fig 1 shows a crystal oscillator, with the transistor being used as an amplifier with POSITIVE feedback (provided by C2 and C3) at one particular frequency (determined by the frequency for which the crystal has been cut). In Fig 2, the crystal has been replaced with a parallel tuned circuit (consisting of the inductor L1 and C1). This achieves exactly the same result, giving the advantage that either the capacitor or the inductor value may be varied to achieve a change in frequency.

The crystal has a much higher "Q" value than the tuned circuit, and as a result, although the crystal frequency cannot practically be changed, it has the advantage that the output is very stable, being only slightly affected by changes in temperature etc.

Note the use of C6 in the variable oscillator. The function of this is to couple the tuned circuit to

- the transistor, whilst preventing the DC voltage on the base of the transistor being short circuited through the inductor. (The crystal does not pass DC, and hence this capacitor is not required in the crystal oscillator).

- C4 is provided to ensure that:-

1. Any signals appearing on the voltage supply line do not get into the oscillator as they will safely pass to earth through the capacitor.
2. C4 also ensures that signals generated by the oscillator do not get onto the voltage supply line.

C5 couples the oscillator output signal to the next stage, whilst preventing the DC voltage on the emitter of the transistor being passed onward as well.

The resistors in the circuits are used to set the DC operation of the transistor. (i.e. biasing the transistor for use as an amplifier).

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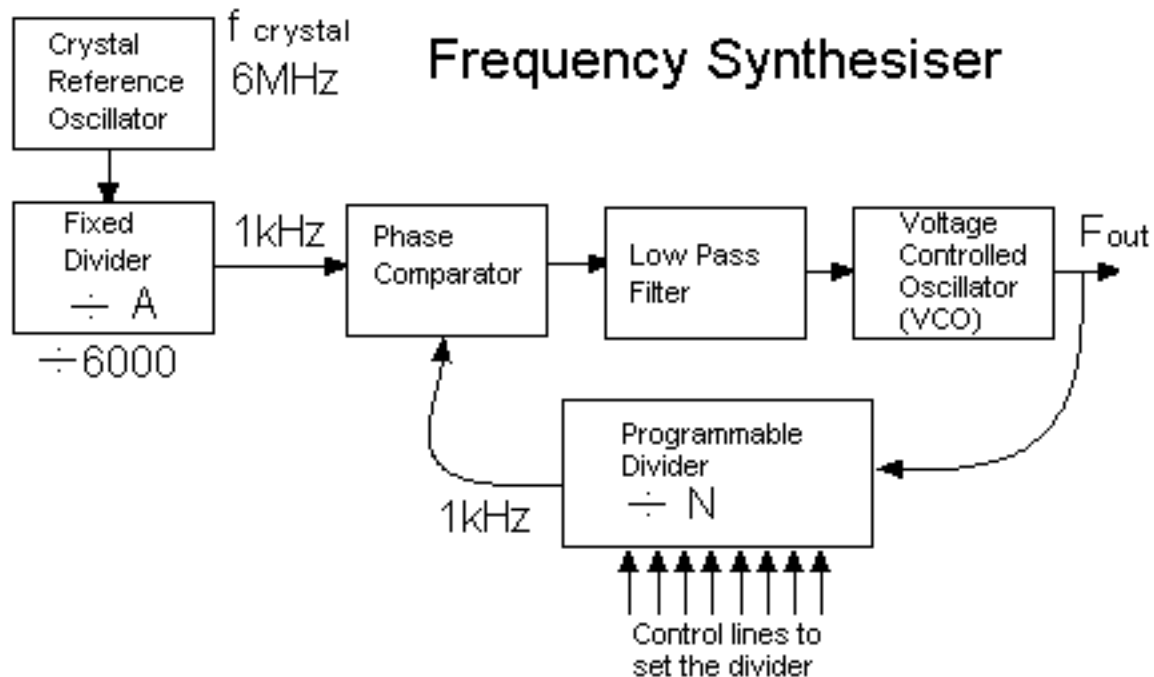
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Transmitter & Receiver

Syllabus Sections:-

Frequency synthesis

4c.1 Recall the block diagram of a frequency synthesiser and the functions of the stages (i.e. oscillator, fixed divider, phase detector, LPF, voltage controlled oscillator and programmable divider).



$$F_{out} = f_{crystal} \frac{N}{A}$$

The frequency out is given by the frequency of the crystal times the divide by N divided by the fixed divider A.

The equation above is a useful one to learn as it is difficult to work out from the diagram above or the text below !!!

The diagram above show a modern Frequency Synthesiser. This is a PLL or Phase locked Loop.

The crystal reference oscillator

The crystal reference oscillator is made to a high standard so that it can provide a good stable output frequency that acts as the heart of the synthesiser.

the fixed divider

The "reference frequency" is then divided down by the fixed divider. This is a solid state digital chip which divides down the original 6MHz to 1kHz and this has the same accuracy as the crystal oscillator because it is derived directly from the crystal oscillator.

Note: The frequencies given, in the diagram above, are examples and many other designs exist.

Voltage controlled oscillator

The VCO is a voltage controlled oscillator whose frequency is controlled by changes in applied voltage. When it starts running it is not stable and said to be "Out of lock". However the pulses are sent to the Programmable divider.

The programmable divider

The programmable divider is set to divide the VCO frequency down so that the output of the programmable divider is also 1kHz.

Phase comparator

A comparison can then be made between the two 1kHz pulses. If the pulse from the programmable divider is slightly low then the pulses will be out of phase with each other and this is detected in the Phase comparator.

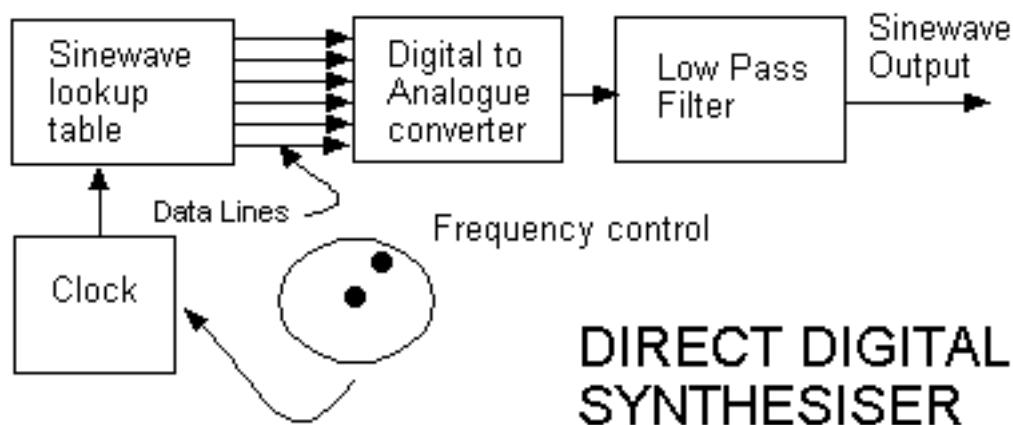
Low pass filter

This error is then passed as a voltage change to the low pass filter to clean it up and then to the VCO. The VCO frequency then changes as a result of the voltage change, and becomes very close to the desired frequency (in effect it is now "LOCKED").

This process continues to make small adjustment to the VCO as required, hence keeping the transceiver on frequency.

When it is desired that a large change of frequency is made, this is achieved by setting the programmable divider by the control lines. Immediately, the synthesiser is "unlocked" or "out of lock" and a large error voltage results. This causes the VCO to change frequency rapidly and "lock" to the new setting. It is very desirable that there is no output from the transmitter whilst the synthesiser is "unlocked" or "out of lock", and it is usual to take a signal from the synthesiser which inhibits the transmitter until "lock" has occurred.

Recall how sine waves may be produced by direct digital synthesis and the block diagram of a simple synthesiser. Recall that increasing the number of bits in the synthesiser will increase the purity of the signal.



The frequency control knob changes the rate clock pulses which are used by the "Sinewave lookup table" to an output on the data lines. This output is then used by the "Digital to analogue converter" to generate the frequency sinewave which is passed to the low pass filter and there on to its output.

Greater the amount of data the greater the purity

The greater the number of Data lines the greater the number of bits of data (or bits resolution) that can be passed and the purity of the signal increased.

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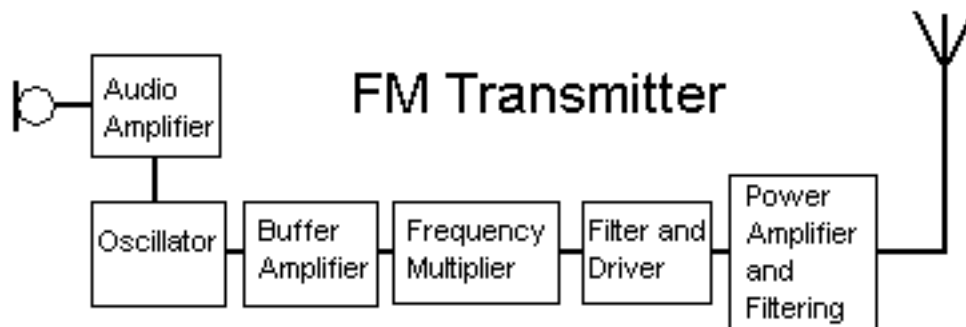
Transmitter & Receiver

Syllabus Sections:-

Frequency multipliers

4d.1 Understand that frequency multipliers use harmonics to generate frequencies above an oscillator's fundamental frequency (e.g. in a microwave transmitter)

Typically you could use an 8MHz crystal multiplied by 18 to achieve an output frequency of 144MHz and higher multiplication to achieve microwave frequency. **There is no local oscillator.**



The concept that is being introduced to you is that a single lower frequency crystal could be multiplied up to a harmonically related frequency and then filtered and amplified prior to feeding to an aerial etc. Which frequency is used as the initial frequency is all down to the circuit designer, with mode and cost being principal considerations.

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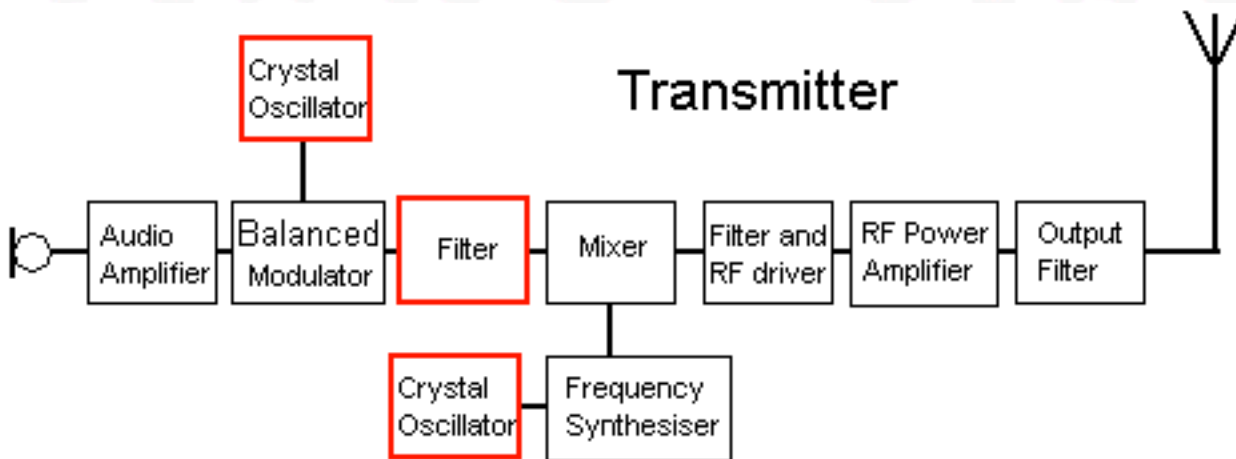
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Transmitter & Receiver

Bredhurst Receiving and Transmitting Society**Next****Syllabus Sections:-****Mixers**

4e.1 Understand that the desired frequency is often produced by mixing together the output from two or more frequency sources, e.g. v.f.o., crystal oscillator or synthesiser.

Understand how unwanted frequencies may also be produced.



You have seen this diagram before right at the start of this section on transmitters and receivers, but in this one the crystal oscillators and mixer have been highlighted.

Note that in the diagram there are two crystal oscillators used which feed via other circuits into the mixer to produce the wanted output frequency.

In the Intermediate Course you saw that when two frequencies are combined in a mixer the output from the mixer has the two new frequencies formed in addition to the original two frequencies, which as far as the Intermediate Course went was all you needed to understand.



Here is a reminder of this basic mixing:-

These new frequencies are equal to the sum of the two original frequencies and the differences of the two original frequencies.

Thus frequency 1 (f_1) + frequency 2 (f_2) = frequency 3 ($f_1 + f_2$)

and frequency 1 (f_1) - frequency 2 (f_2) = frequency 4 ($f_1 - f_2$) (*assuming that f_1 is greater than f_2 otherwise use the frequencies the other way round $f_2 - f_1$).*

This might be easier to understand if we take a look at numeric values.

if we have two frequencies say 15MHz and 5MHz and they are mixed the results would be

$$\text{Sum of:- } 15\text{MHz} + 5\text{MHz} = 20\text{MHz}$$

$$\text{Difference of:- } 15\text{MHz} - 5\text{MHz} = 10\text{ MHz}$$

By filtering, the frequencies that you do not want are removed. However from the earlier section in this course you now know that multiples of the required frequency are also possible and these to also have to be filtered out. The mixed frequencies might also contain other unwanted components which have to be filtered out.

These unwanted frequencies are harmonics of the oscillators and the mixing process.

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Bredhurst Receiving and Transmitting Society

Transmitter & Receiver

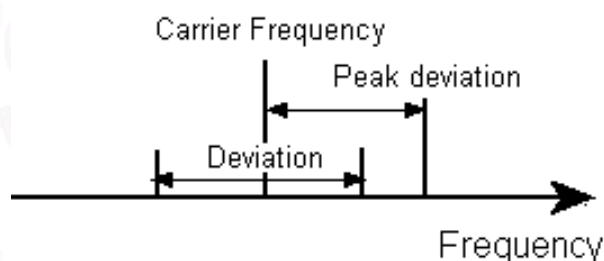
Syllabus Sections:-

Modulation

4f.1 Recall the meaning of the term peak deviation.

When dealing with FM you will come across the term Peak Deviation which means the MAXIMUM amount by which the frequency of the signal may deviate from the carrier frequency.

Deviation is the frequency change from the carrier frequency both above the carrier frequency and below.



Deviation is proportional to the AMPLITUDE of the signal

The amount of the deviation is proportional to the amplitude of the applied signal and NOT the frequency of the applied signal. Thus the louder you speak into the mic the greater the voltage that will be applied to the stage and the greater the deviation.

Greater the applied voltage the greater the deviation

Thus a signal of 3mV at 1kHz will create greater deviation than a signal of 1mV at 3kHz

Recall the meanings of narrow band and wide band modulation for frequency modulation.

The peak deviation is used to assess the Modulation Index.

Modulation Index = Actual deviation divided by Maximum Audio Frequency.

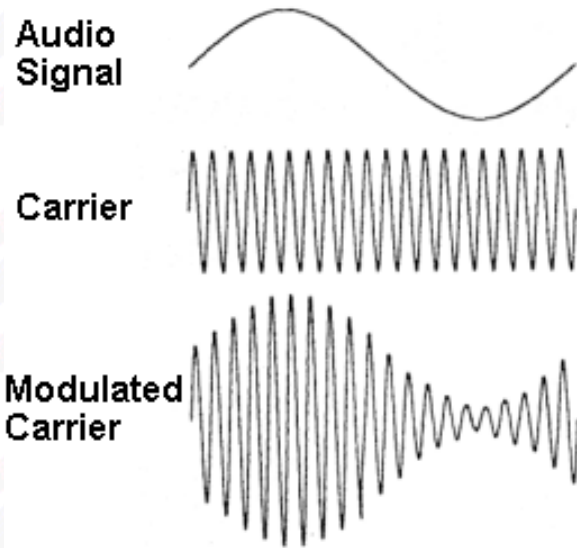
In the world of broadcast radio the Modulation Index is 75kHz divided by 15kHz = 5 and being greater than one is described as **Wide Band** FM or WBFM.

In amateur radio in the 2m band with 12.5kHz channel spacing the peak deviation is usually 2.5kHz with a maximum audio

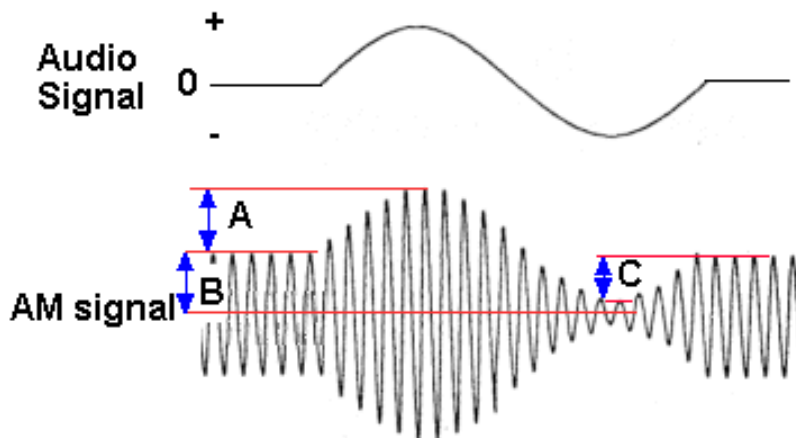
frequency of about 3kHz giving a Modulation Index of 0.83 and being 1 or less is termed **Narrow Band FM** or NBFM.

Recall the meaning of depth of modulation for amplitude modulation.

First let's recall the diagram of wave forms from your Foundation Licence course.



This should need no explanation but let's remind you that the audio signal is that into say the microphone, the carrier is the carrier whether it is AM or FM, the modulated carrier as shown is the AM wave form.



Now the wave forms have been changed a little as we are to explain Depth of modulation.

Notice that at the start of the audio wave for the audio is zero and there is only carrier on the AM signal. Then notice how the audio wave form increases the amplitude of the carrier when the signal is positive and reduces the carrier when the signal is negative.

Thus the audio signal is carried as an exact image of itself on the AM signal, assuming no distortion which there must not be else the received audio would also be distorted.

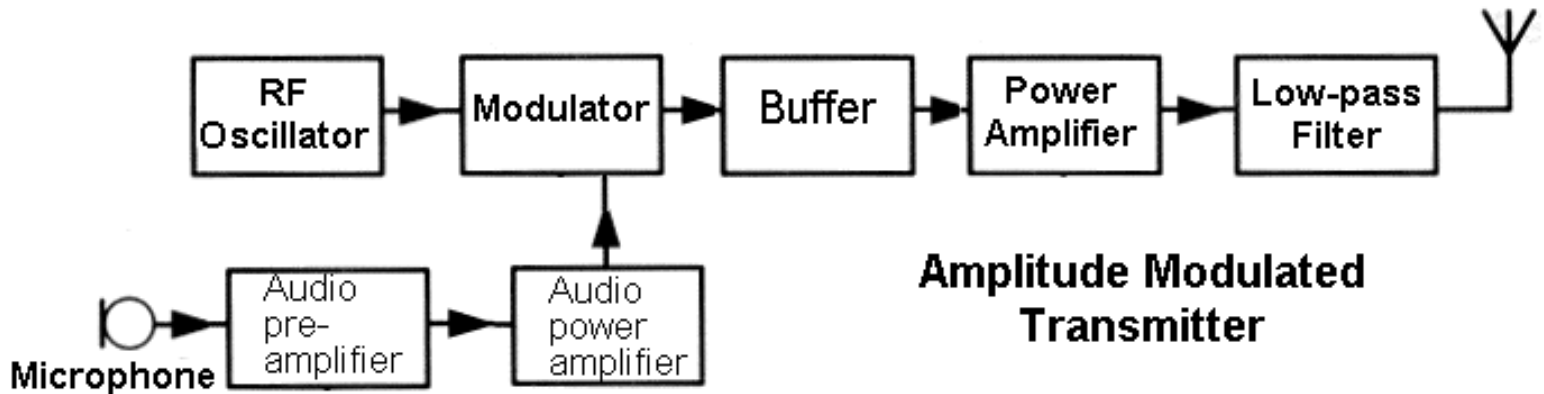
The Depth of Modulation is the amount of change from the level of the carrier without any signal, as shown at the start and finish of AM signal whether this is an increase in carrier amplitude or a decrease in amplitude. Depth of modulation is NOT how low the carrier is forced to its zero point.

When the ratio of A divided by B = 1 then it is said that there is 100% modulation. In the example you can see that C is less than B so the modulation would be less than 100% and would still be acceptable and safe from risk of OVER MODULATION and distortion.

4f.2 Understand the operation of a.m., s.s.b, and f.m. modulators.

Recall the bandwidth of such transmissions.

Let's recap what a transmitter does. The signal from a transmitter is known as the carrier wave whether it is AM FM or SSB - they are all the same. It is what is done to the carrier wave that makes the difference mode AM - SSB - FM.

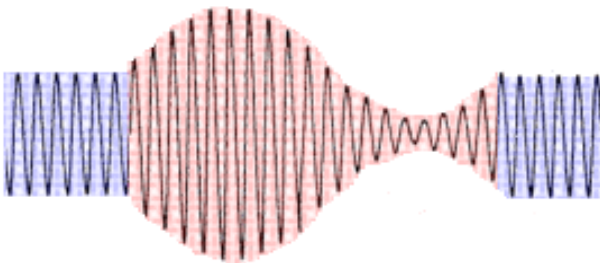


AM MODULATION

The above is a diagram you have seen in the Intermediate Course. The modulation is achieved by varying the amplitude of the carrier, produced by the RF Oscillator, by the applied audio signal carried out in the modulator.

The variation in the modulating signal or put it another way the frequency of the audio, is low by comparison to the carrier wave frequency.

AM signal



From the diagram the carrier is in blue and the black line is the frequency wave form, whilst in the red area the applied audio has impacted upon the carrier but is at a far lower frequency than the carrier which can still be seen as a black wave form.

All modulations using a change in amplitude of the output signal initially have four component parts:-

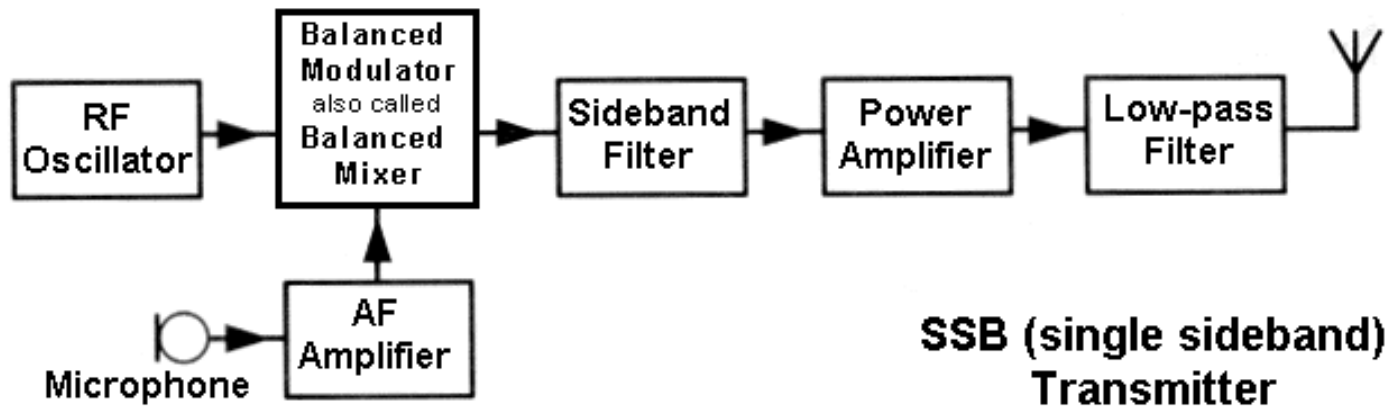
- the carrier frequency
- a range of frequencies above the carrier
- a range of frequencies below the carrier
- original audio frequency unwanted and filtered out

The side frequencies above and below the carrier are the "Side Bands" of frequencies or just side bands.

SSB MODULATION

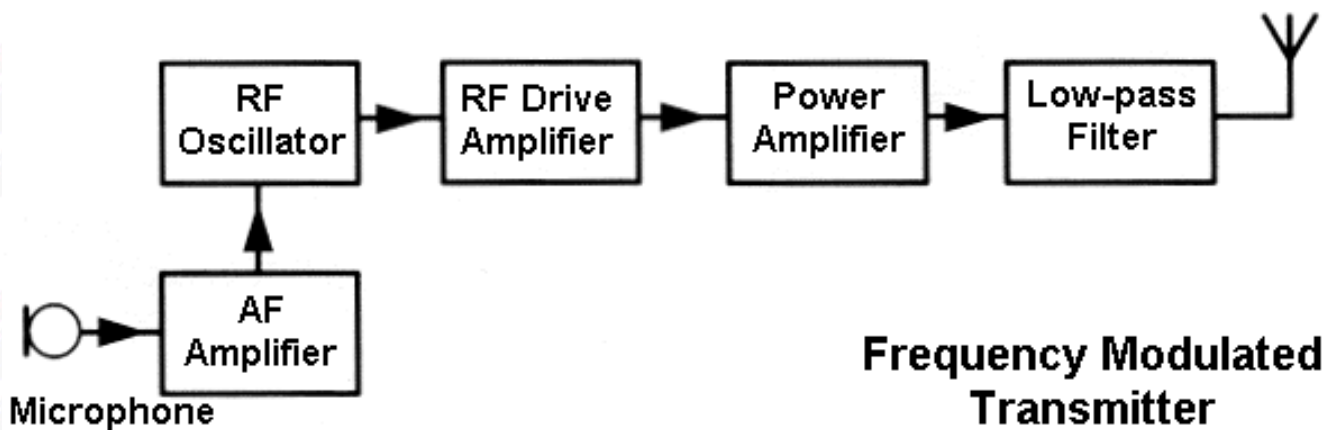
In the SSB modulation whilst it starts off the same as the AM the transmitter then has to carry out two more functions:-

- take out the carrier called "Carrier Suppression"
- remove one of the side bands.



From the Intermediate Course comes again the diagram above and you learned that Modulator or Balance Mixer uses the audio signal from the AF amplifier to produce four frequency components.

There after this is where it differs from the AM transmitter. Only signals equal to the sum and difference of the RF and AF signals are output as sidebands. Neither of the original RF or AF signals are passed by this stage. Then as only one side band is wanted the other is filtered out prior to the signal passing into the power amplifier.



FM MODULATION

For the FM signal the modulation is different. Again the diagram is what you have seen in the Intermediate course but this time notice that the AF Amplifier is feeding its output to the RF oscillator and thus it is directly modifying the frequency of the signal and NOT the amplitude.

Recall the bandwidth of such transmissions. a.m., s.s.b, and f.m.

In communication systems we are not looking for the best possible reproduction of the original input into the microphone but a signal that gives good intelligibility of what was input into the microphone. This can be achieved with a signal about 2.5kHz wide.

AM

With a signal in of 2.5kHz the AM transmitter creates the side bands and it has been found by experimentation over the

years of amateur radio that an AM signals need to have a bandwidth of about 5 to 6 kHz to achieve a good signal at the speaker of the receiver.

SSB

With SSB as one of the side bands is suppressed the bandwidth can be half that of the AM signal so a typical bandwidth is 2.5kHz

FM

In FM it is the frequency that is modulated by the input to the microphone The bandwidth needed for FM is similar to that of AM about 5 to 6 kHz .

4f.3 Understand, in functional terms, the operation of data modulators for F1B (direct frequency shift), F2B (frequency shift keyed audio tone on an f.m. transmitter) and J2B (frequency shift keyed audio tone on an s.s.b. transmitter).

In this section you need to understand what the "code" is for the various modulations. The three codes of interest here are F1B ,F2B and J2B.

The first common element is

- the F which stands for FM.

The next common element is

- the "2" which indicates that there is a data modulating sub carrier.

The last common element is

- the "B" is common element. This is used to indicate that the mode is for automatic data reception in other words you are using a machine / computer to read the data.

The two items only used once each in the examples of the code is:

- the "J" which stands for SSB and
- the "1" which indicates that is NO data modulating sub carrier.

The code therefore just tells :-

- what the modulation is
- whether there is a modulated sub carrier or not
- that in this case it is for automatic reception

In functional terms with the **F1B (direct frequency shift)** it is FM and for automatic reception but the raw data and not audio is fed is directly into the device that determines the output frequency and in modern rig you would have to set the parameters of the tones that the data needs to create at the output.

In functional terms with the **F2B (frequency shift keyed audio tone on an f.m. transmitter)** it is again FM and for automatic reception but this time the audio is fed into an audio "data in" socket of the rig (if it has one) or into the

- microphone socket for it to generate the changes in frequency as for voice.
-
- In functional terms with the **J2B (frequency shift keyed audio tone on an s.s.b. transmitter)** this is an SSB signal
- for automatic reception and like the FM version is generate by the audio which is fed into an audio "data in" socket on the
- rig (if it has one) or into the microphone socket, for it to generate the changes in amplitude of the signal just as for voice.

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Transmitter & Receiver

Syllabus Sections:-**Power Amplifiers**

4g.1 Understand the need for linear amplification and identify which forms of modulation require a linear amplifier.

Firstly what is linear amplification?

Linear amplification takes the input signal and duplicates it exactly and provides an output that many times even hundreds of times larger than the input power.

Which modulations require linear amplification ? AM and SSB

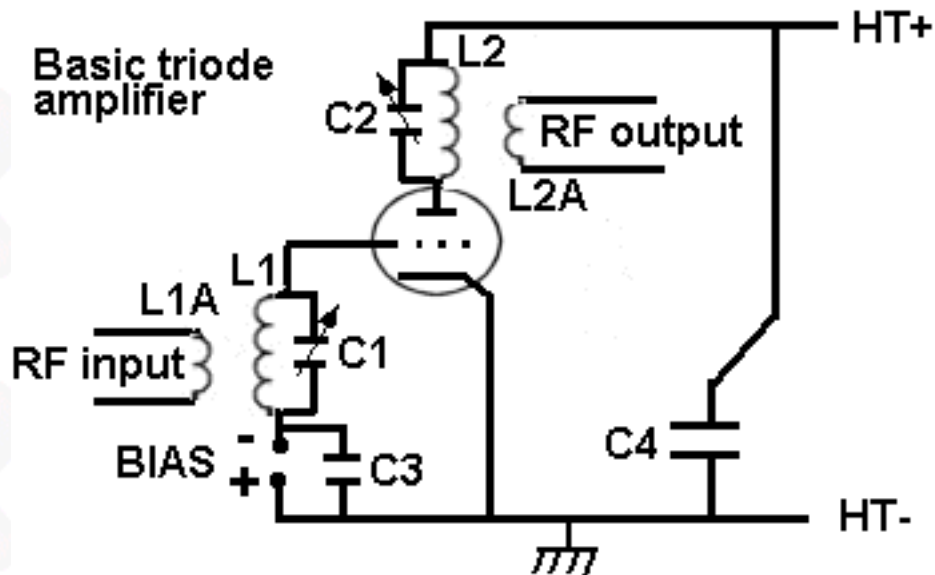
Because of the nature of the wave forms both AM and SSB have the amplitude of the wave form at input directly related to the amplitude of the wave form at the output.

If the wave form is not replicated and thus is distorted so will be the audio signal received by the distant station. The distortion could be so severe that it creates harmonics of the input signal which fall outside the desired band width and could also fall outside the amateur bands causing interference.

Which modulation does NOT require linear amplification ? FM and CW

As the FM signal has no amplitude component part which as shown above can causes distortion, and it is only the FREQUENCY that is changing there is NO NEED for a linear amplifier.

4g.2 Recall the function of the main components; anode/collector load, bias, input circuit, output filter and matching in a PA circuit.



The diagram above shows a typical amplifier circuit.

The circuit shown above is a basic triode amplifier, in actual fact it would not work at RF as being a triode there would be a problem with what is called neutralization. What is really needed is a pentode valve or a tetrode both of which have extra grids between the anode and the control grid.

However all is not lost for as a simple representative circuit this is quite in order.

INPUT CIRCUIT

There is a tuned circuit in the GRID circuit, tuned by L1 and C1 and there is a small link winding and thus we have an impedance transformation between the input and the GRID input to the valve. The valve has a HIGH IMPEDANCE GRID and a HIGH IMPEDANCE ANODE when it is in the grounded cathode configuration. If we put the input RF signal between the GRID and the CATHODE there will be a high impedance between them.

The input filtering is given by link winding on the parallel tuned circuit L1A to C1 L1.

ANODE / COLLECTOR LOAD

The OUTPUT SIGNAL will come from the ANODE and Cathode and this will be high impedance. Let's assume that there is 75 or 50 cable we will need some impedance matching which is why we have a few turns on the RF input link L1 and the output link coil L2A. So that is the reason for two tuned circuits. The tuned circuit L2 and C2 provide an ANODE LOAD for the output signal which is then coupled into the link winding on the RF output.

The mention of COLLECTOR refers to a transistor circuit where the input would be base emitter

and out put from collector emitter.

BIAS

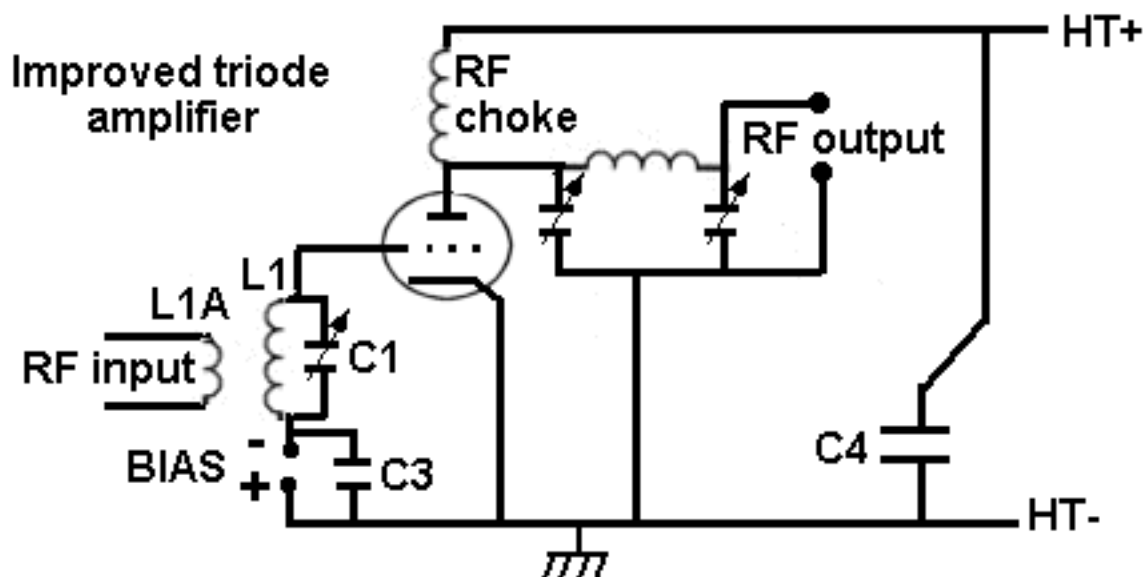
This is the application of a controlling voltage to determine the working conditions of the amplifier. If we want the circuit to work in Class A, Class B, or Class C then we would apply an ever increasing **NEGATIVE VOLTAGE** which will set those working conditions. In valve circuit those classes of amplification give different efficiency levels - very roughly Class A about 30% efficient, Class B about 50% efficient and Class C about 75% + efficient. The connection are as shown above with the positive attached to Chassis / ground and the **NEGATIVE** to the other point marked.

As RF is concerned that lower of the tuned circuit L1 C1 needs to be chassis potential. To achieve this a decoupling capacitor C3 so that point is tied down to chassis.

The HT needs to be decoupled in the same way by C4. In so far as RF is concerned Direct Current (DC) HT+ and HT- are at the same potential.

OUTPUT FILTER

This simple valve circuit needs to have for RF purposes a more effective output circuit and this would be a PI network.



The PI network and the RF choke replaces the output from the previous diagram. The benefit of the PI network is that it give a measure of impedance matching. In the same way that we had in the previous diagram a link coupling on the winding of L2, C2 and L2A which gives us step down impedance the use of the pi network gives a step down between the high impedance anode - so typically this would be 5000Ω to 50Ω impedance.

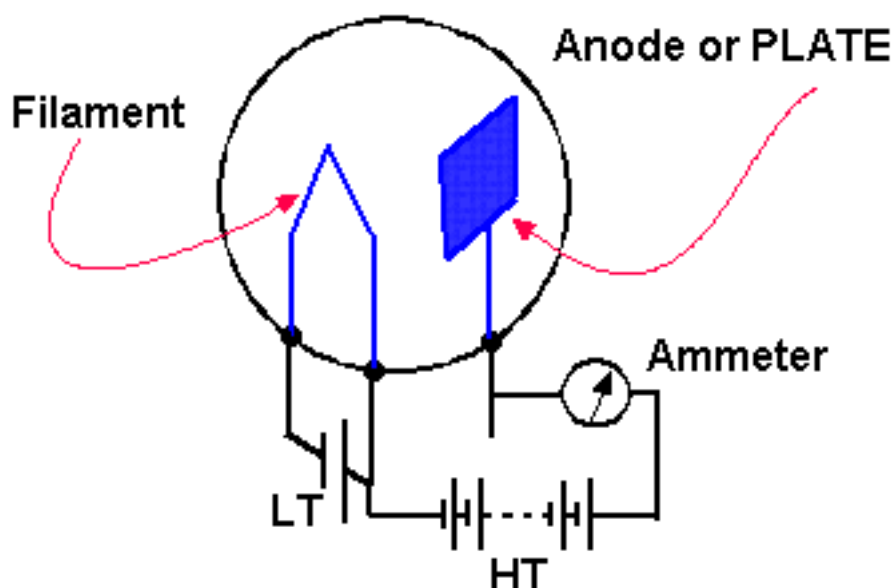
The PI network is also a low pass filter and efficiently give you a degree of filter more than the parallel tuned circuit with the link winding but it also matched the impedance.

Why PA stages are no longer modulated ?

Well many amateur are still modulating their PA stages so more research is being done on this !!!!

4g.3 Recall the operation of a valve in a power amplifier. Recall the function for the heater, cathode, control grid and anode.

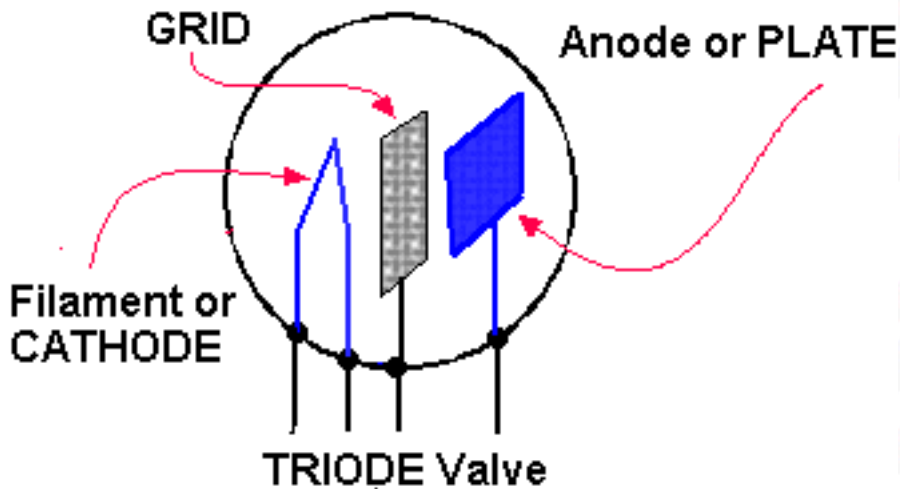
To help you get an understanding of valves let's start at the beginning. The success of radio communication in the early day was due to the introduction of the "thermionic valve" or valve for short.



The earliest valve was the diode having only a filament and an anode also called the plate. These two items were put into an evacuated envelope, the filament was just like that in a light bulb tungsten wire and and could be heated by the low tension source (even a battery) so that it glowed bright red. The plate was a small thin sheet of material. The filament was also given the name of "cathode", and the plate anode.

When the filament is glowing brightly and there is a positive voltage on the anode then a current can be made to flow through the valve. (When the filament is heated, electrons are emitted from it. When these electrons are attracted to the higher voltage on the anode, a current flows through the valve.

If the anode is made negative then the flow of electrons is stopped.

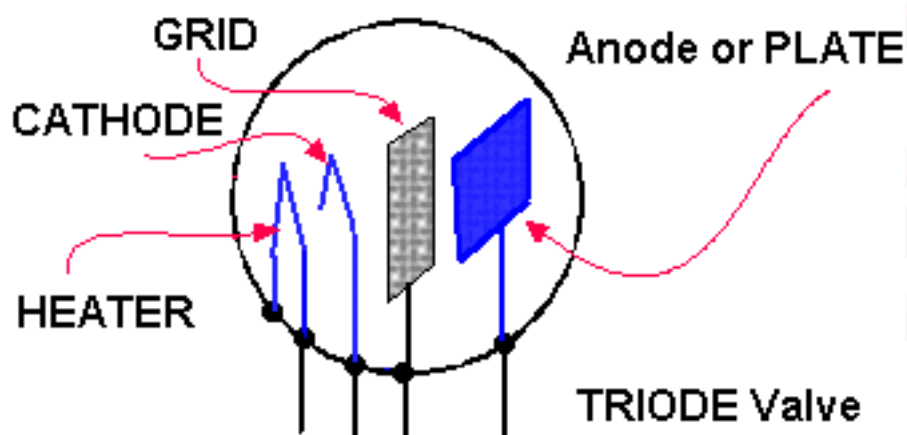


The introduction of the GRID electron between the cathode (filament) and the Anode form the three electron valve called the TRIODE.

The GRID has the ability to control the flow of electrons from the cathode to the anode. As you learned above if the anode was negative it stopped the flow of electrons - the same happens with the GRID. The more the **NEGATIVE** the GRID voltage relative to the Cathode the smaller the cathode to anode current. Hence variations in grid voltage cause a large variation of current through the valve, and achieve amplification.

Here the top drawing depicts a valve in 3 dimension. The diagram below indicate what a circuit diagram of the same valve might be represented.

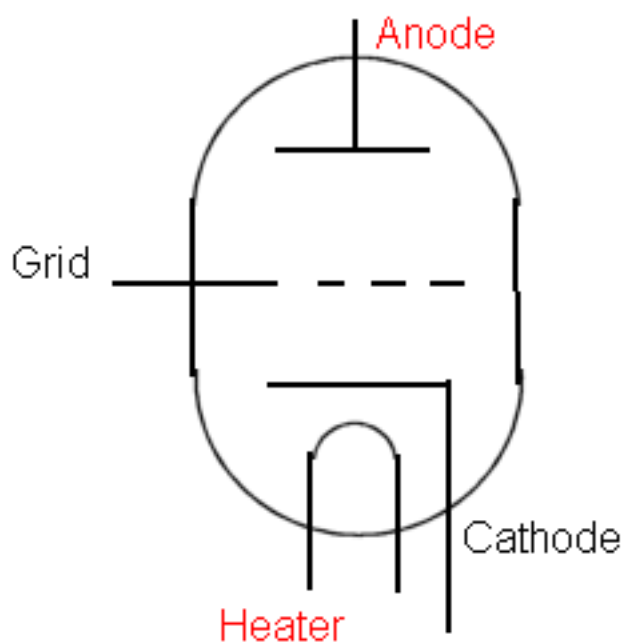
In "real valves" the filament is usually a heating element or "**heater**" that indirectly heats up a



"**cathode**" electrode which provide free electrons that can be attracted to the anode. "Modern" valves have a coating on the cathode that allows sufficient emission at a much lower temperature, allowing the cathode to operate at a "dull red" temperature, hence prolonging valve life.

The "**grid**" controls the flow of electrons.

The "**anode**" when it has a positive voltage attracts electrons from the cathode.



The voltages used in valve circuits are much higher than those used in transistor equivalents, & in most cases are LETHAL so beware.

Recall the advantages and disadvantages of valve PA circuits.

Advantages of a valve PA (Power amplifier)

- Are able to handle higher transmit power output levels
- More able to take short term abuse.
- Higher gain than a transistor amplifier, hence fewer valve stages needed to reach a required output power.

Disadvantage of a valve PA

- Lethal voltages are present in the pa and the power supply which is a HAZARD TO PEOPLE AND REQUIRES CAREFUL ATTENTION TO THE INSULATION USED.
- The valves can be physically fragile by comparison to semi conductor components
- Valves do deteriorate with use.
- Convection cooling is usually insufficient in high power stages and fan assisted cooling is essential in most cases.
- Not as easy to operate at the solid state equivalent which is switch on and go, a valve PA need tuning up.

4g.4 Understand the implications for PA rating of different types of modulation and the effects of speech processing, with particular regard to peak to average power ratios.

Normal speech when looked at on an oscilloscope shows a high peak to average ratio of typically 20 to 1 or 13dB.

With the licence quoting peak envelop power (p.e.p.) the actual average power can be comparatively low on SSB.

Most modern rigs are designed and rated with the presumption that they will be used for SSB. By doing this the power supply and other specification of heatsinks and devices can be lower. However the problem arises when that same rig is used on FM, data such as RTTY, or even high levels of speech processing of SSB, the rig would not perform at it "full" power rating. Under these circumstances it is best to assume a 50% power output level.

4g.5 Recall the function of automatic level control (ALC) within the power amplifier and when using an external power amplifier.

Automatic level control ALC

An automatic level control within a power amplifier makes sure that the level of drive to the amplifier stage does not exceed the point where unacceptable distortion, spurious outputs and harmonics occur.

Having the ALC set correctly is equally important when driving an external power amplifier.

Over driving the amplifier stage causes splatter over nearby frequencies as a result of the intermodulation (distortion) introduced. The signals "spreads" occupying more bandwidth than necessary.

Recall the function and use of a manual rf. power control.

manual rf power control

The manual rf power control sets the initial level of the output power which is then maintained by the ALC control mentioned above.

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Syllabus Sections:-**Transmitter interference****4h.1 Recall the effect and the importance of minimizing drift.**

When any piece of equipment, using an oscillator warms up, the frequency of oscillation changes. In the design stage of the equipment such variation will have been taken into account.

Should the frequency change after the warm up period then the effect of the change in frequency is called "drift".

You can sometime hear this drift of signals on the HF bands when older equipment is being used and to keep track of the frequency you would need to re-tune using the RIT. Then if you were to work the station your TX would go out on the original frequency and you would be working on different frequencies.

Should you own old equipment then you must keep the amount of the "drift" to a minimum less than 3kHz else you could move in frequency out of the pass band of the station that is tuned to your signal. This drift would cause interference to other stations using nearby frequencies and could result in out of band transmissions - hence the reason to **minimize drift**.

4h.2 Recall the cause and effect of 'chirp' and identify suitable remedies. Recall the cause and effect of 'key clicks' and the shaping of Morse keying waveforms.**Chirp and Key clicks are associated with CW or morse code transmissions.**

This topic is associated with CW or morse code which is still much in use on amateur bands - even though it is not now a requirement in UK to pass a "Morse Test" (not to be confused with the Morse Appreciation given to you in the Foundation Licence practical assessment)

Please note that Chirp and Key clicks are two entirely different factors.

CHIRP

"Chirp" is a change in frequency when the transmitter is keyed on (by pressing the morse key) and keyed off (the release of the morse key) when the Morse characters are being formed. - thus the change in frequency would be heard on a receiver at the start and end of each keying stroke.

Chirp Causes

There are three main causes of chirp :-

Poor design of the transmitter

1. DC Instability caused by poor voltage regulation.
2. Pulling

RF Feedback

1. RF Feedback getting back into the frequency determining stage (oscillators)

DC Instability - changes in voltage of the supply rail going to the oscillator of the transmitter when the transmitter is keyed. This particularly happens when the power supply to the oscillator is the same as the power supply to the PA.

REMEDY Use separate power supplies for the oscillator and PA and ensure high level of regulation to that of the oscillator.

Pulling This is where the frequency of other stages changes due to the keying of the transmitter.

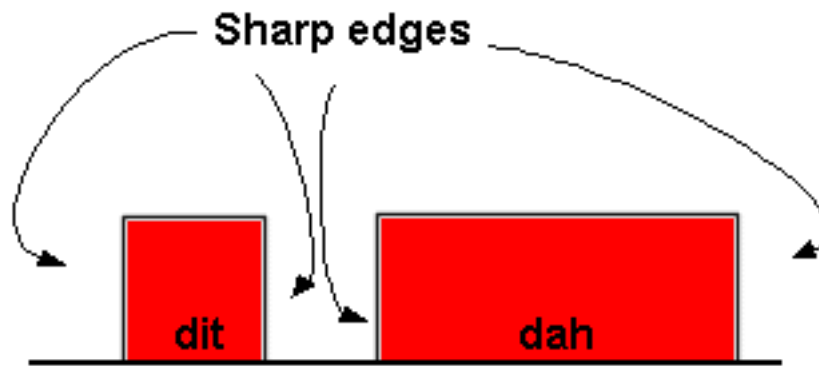
REMEDY Provide better isolation of the oscillator from the other stages .

RF Feedback This is where stray RF signals are finding there way back into earlier stages. Such feed back might be by poor constructional layout.

REMEDY Greater attention to the detail of screening lead carrying RF and keeping leads as short as possible and the use of decoupling capacitors on the power lines.

KEY CLICKS

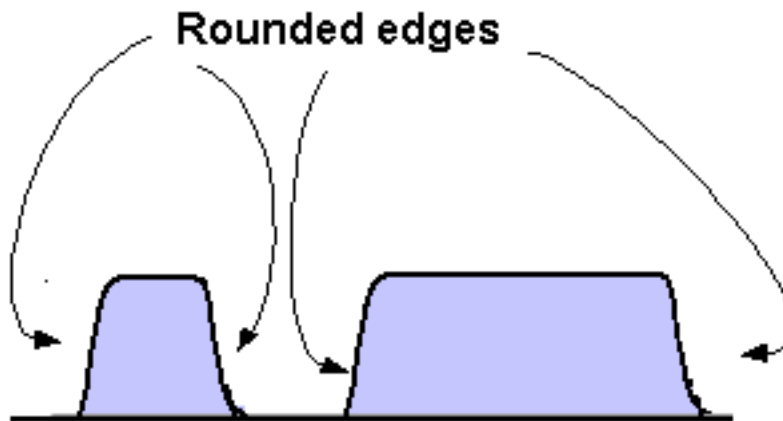
When you key the letter A dit dah you have a very sharp leading and trailing edges to the wave form, if you looked at it on an oscilloscope as shown below (without the annotation !!)



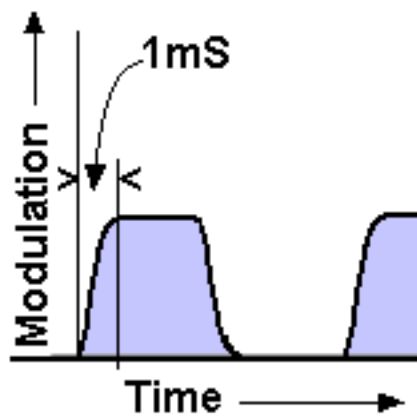
The sharp edge occurs as the carrier goes from zero to maximum in the shortest possible time and is very much like an AM signal that has maximum modulation applied. With the very sharp edge and very short rise time it generates a noise sideband which are the clicks that can be heard.

It is therefore the transition from zero to maximum carrier in the shortest possible time that causes the key clicks.

The way to remove the key clicks is to "soften the keying." This is done by having a less sharp and somewhat more rounded wave form.



The leading and trailing edges are softened / more rounded - if you make it too soft you would lose intelligibility of the Morse character.



A rise and fall time of about 1mS (1 milli second) might be considered a reasonable average but it all depends upon the equipment, as the softening and hardening of characters also depends upon things like decoupling in the bias circuit.

If you wanted to make a transmitter and avoid key click you would need to look at the wave form on an oscilloscope with the scope connectors clipped across a dummy load being fed the the transmitter - on very low power - and you can observe the wave form and then change the keying characteristics but using capacitors or a key click filter of a resistor and capacitor or a choke resistor and capacitor. There are various combinations depending upon the amount of current that you are keying.

BANDWIDTH

The sharper or more rapid the transition from zero to maximum the wider the bandwidth the signal will be as the click is generated.

4h.3 Understand ways to avoid generating harmonics (e.g. use of push-pull amplifiers, use of inductive coupling between stages, avoiding high drive levels).

Recall that transmitters may radiate unwanted mixer products and identify suitable remedies.

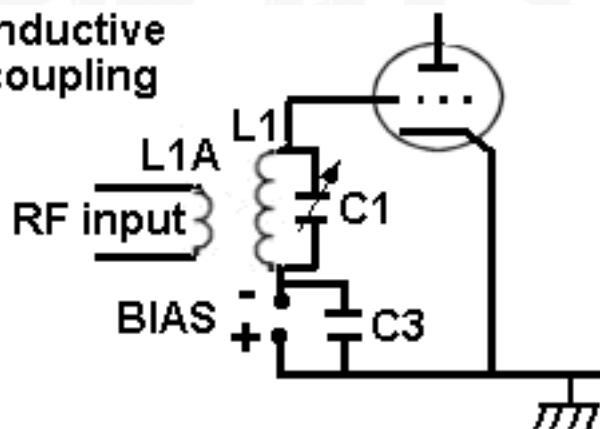
Push-pull

The way to avoid generating harmonics is to use push pull amplifiers. The push-pull amplifier circuit inherently cancels even harmonics.

Inductive coupling

The inductive coupling is as shown on an earlier circuit of the amplifier and an extract is shown below.

Inductive coupling



L1A is the inductive link coupling into the tuned circuit L1 C1.

This provides basic filtering of the wanted wave form and not the harmonic wave form being applied to the amplifier.

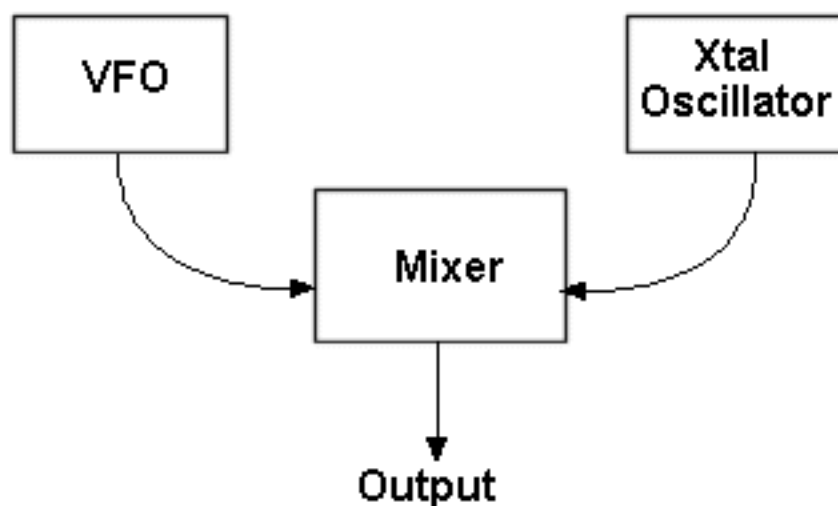
C1 L1 is tuned to the wanted frequency.

Drive Levels

You want to keep the drive levels down. If you "over drive" an amplifier you will destroy its linearity and the non linearity will produce more harmonics.

Design

If you are to design a circuit and you have some VFO and crystal mixer circuit, giving you an output frequency you would have to observe the levels of the VFO input and crystal oscillator input into the mixer and reduce then to such a level to give you just the output of the wanted frequency. If you have either input too high then unwanted harmonics will be present on the output.



Understand the use of low and band pass filters in minimizing the radiation of unwanted harmonics and mixer products.

When using an HF rig it is good practice to use low pass filters in the antenna cable after all other items eg ATU power amplifier etc.

When using a VHF rig, due to interference caused to TV and similar higher frequencies apparatus, the use of a band pass filters so that only the frequencies of the band of operation are transmitted.

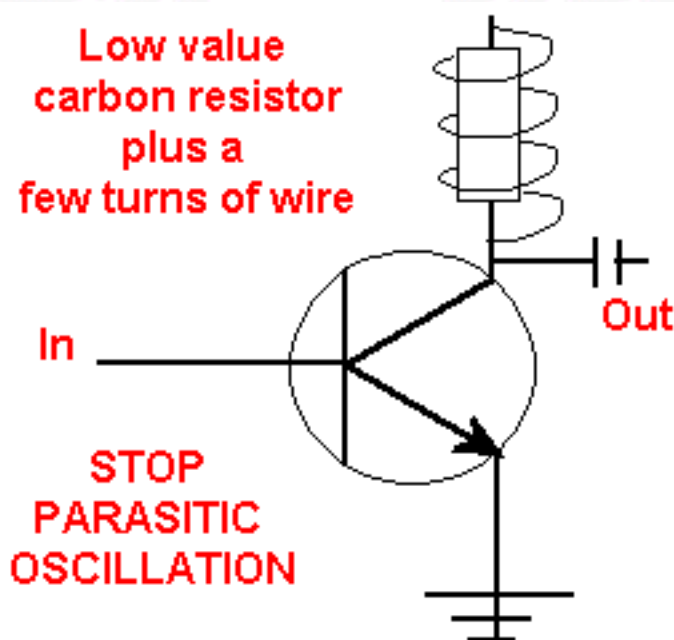
The greatest interference will occur at the 2nd harmonic and this is where it is best to use a notch filter.

Mixers produce the sum and difference frequencies so should always be designed with filters to select the wanted signals and remove the unwanted signals.

4h.4 Recall that unwanted emissions may be caused by parasitic oscillation and/or self oscillation and identify suitable remedies.

Unwanted emissions may be caused by parasitic oscillation and/or self oscillation within equipment being built and these unwanted frequencies must be prevented from being radiated.

Much as a flea is a parasite (unwanted, and unintended) on a cat, a parasitic oscillation must be investigated, and "killed" by suitable circuit design.



Coil wound on the resistor

These unwanted frequencies often occur with badly designed decoupling. Elimination of some of these frequencies can be achieved by the use of low value series resistor and a coil wound on the resistor. (This functions by introducing a slight "loss" in a circuit, preventing sufficient gain to cause oscillation in the first place.)

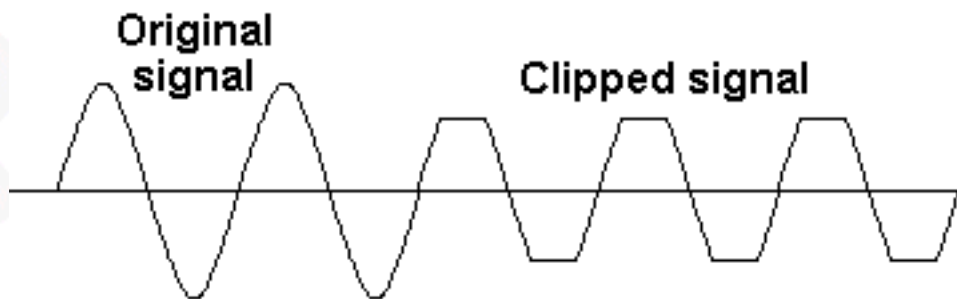
Parasitic STOPPER resistor

A 22ohm resistor connected directly in the collector of a LOW power common Emitter amplifier is a parasitic STOPPER resistor.

4h.5 Understand that over modulation causes harmonics (of the modulating signal) which may result in excessive bandwidth.

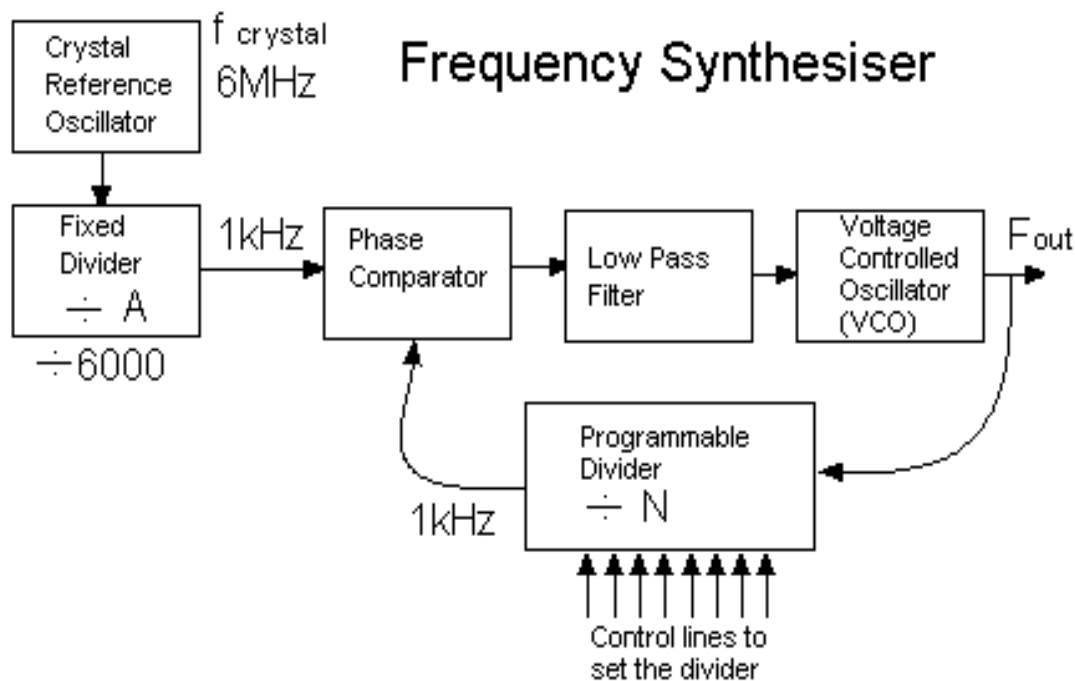
As bandwidth is determined by the modulating frequency, if the modulation overloads a stage to the point of clipping (distortion of the modulation envelope), harmonics of the modulation (the audio signal) are produced. As these are higher in frequency than the intended modulation, the effect is to modulate the signals with higher frequency audio, resulting in a higher, and unnecessary bandwidth being used.

Let's say you are generating a sine wave and this is fed to an amplifier and the amplifier clips the signal you will then get a harmonic problem as the clipped sine wave is now a squarer wave form which is rich in harmonics.



4h.6 Understand how frequency synthesizers may not produce the intended frequency. Identify remedial measures (out of lock inhibit).

If you are not familiar with the diagram below then [please refer back](#) to the text explanation before proceeding.



It is quite possible for the frequency synthesiser not to produce the correct frequency in-band or close to the band edge. Filtering of such frequencies will not help as filtering is normally a broad band approach.

It is very desirable that there is no output from the transmitter whilst the synthesiser is "unlocked", and it is usual to take a signal from the synthesiser which inhibits the transmitter until "lock" has occurred.

It should be realised that the accuracy of a synthesiser depends on the accuracy of the crystals employed and even small inaccuracy could result in inadvertent transmission outside of the band edge, whilst believing you are "just inside".

The synthesiser will be "locked" under these circumstances hence the "lock inhibit" circuit will NOT prevent transmission

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4i.1 Understand the need to drive external power amplifiers with the minimum power required for full output and how overdriving may cause harmonics and/or spurious intermodulation products.

The onset of the generation of unwanted components is relatively sudden.

Driving the amplifier with the minimum required output power results in a "clean" signal. There should be a simple relationship between input and output powers {eg. input is 10 Watts, output 80 Watts, input 20 Watts, output 160 Watts, etc. When the relationship starts to fail (eg. input 40 watts, output 300 watts in stead of 320 watts) you have reached the limits, BACK OFF FROM HERE!}

The price of not doing so is an increase in intermodulation products and harmonics products and harmonics, using unnecessary bandwidth, and possible damage to the amplifier.

Do not to overdrive but operate below maximum ratings.

For those who know a thing or two about power - and that should be all readers - a small reduction in output power level will give a negligible variation to the strength of received signal. A doubling of power is usually needed to raise the "S" meter by half a point (but this does depend upon the calibration of the "S" meter on your rig. So dropping power to 350W from 400W and having a clean signal will lose you only a fraction of an "S" point.

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Transmitter & Receiver

Syllabus Sections:-**Receiver parameters and terminology.****4j.1 Understand the term selectivity and 60 dB bandwidth.****Selectivity**

The selectivity of a receiver is just like you trying to listen to a friend chatting to you in a crowded room with many other conversations going on at the same time. You have to focus your hearing on that one conversation.

Similarly the receiver has to be designed to receive just one signal and ignore the others on adjacent frequencies.

The selectivity is achieved by cutting out the signals of the adjacent frequencies and is usually quoted in dB reduction and a bandwidth.

Bandwidth

Bandwidth is the amount of the band that the receiver is detecting and producing audio in the speaker. If the selectivity is quoted as 2.5kHz at 6dB down then the signal heard on the edges of a band width of 2.5kHz will be only 1/4 of those in the centre. When it says 4.1kHz at 60dB then the reduction of the signals at that width will be very large (you'll only get one millionth of the signal).

4j.2 Recall that the dynamic range of a receiver is the difference between the minimum discernible signal and the maximum signal without overload. Recall the dynamic range is expressed in decibels.

Dynamic range

There will be some signals that your receiver will just not be able to hear and those that are so

- strong that they overload the receiver. This is much like you can hear a conversation from across the room - until someone next to you starts shouting.

- The difference between the weakest and the strongest is called "dynamic range" and is expressed in decibels dB.

- 4j.3 Recall, in simple terms, the meaning of "signal to noise ratio" as applied to a receiver specification. Recall that the noise generated in the receiver will influence the minimum discernible signal.

Signal to noise ratio

Signal

Signal to noise ratio is the ratio of the amplitude of the wanted signal related to the amplitude of the noise signal and so that there is no ambiguity it should be stated as peak signal to peak noise.

Noise signal

Without any signal being received, eg when a dummy load is in the antenna socket there will still be some "noise" coming out of the speaker. It is this noise level that a wanted signal has to be greater than so that the wanted signal can be heard in the speaker.

So whether you can hear a signal all depends on the signal to noise ratio of your receiver. The greater the amount of "noise" generated in the receiver itself the greater the reduction of the ability to discern very low wanted radio signals.

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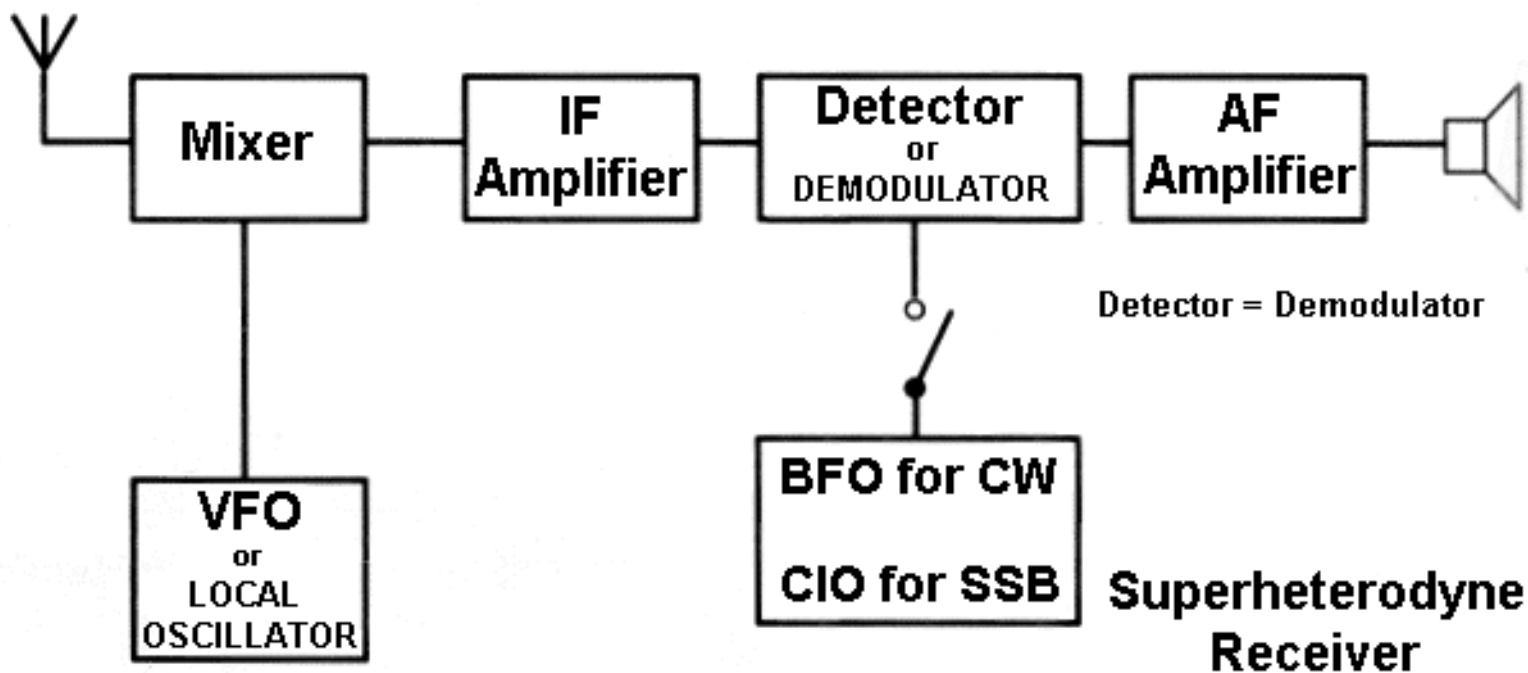
Syllabus Sections:-

Receiver architecture

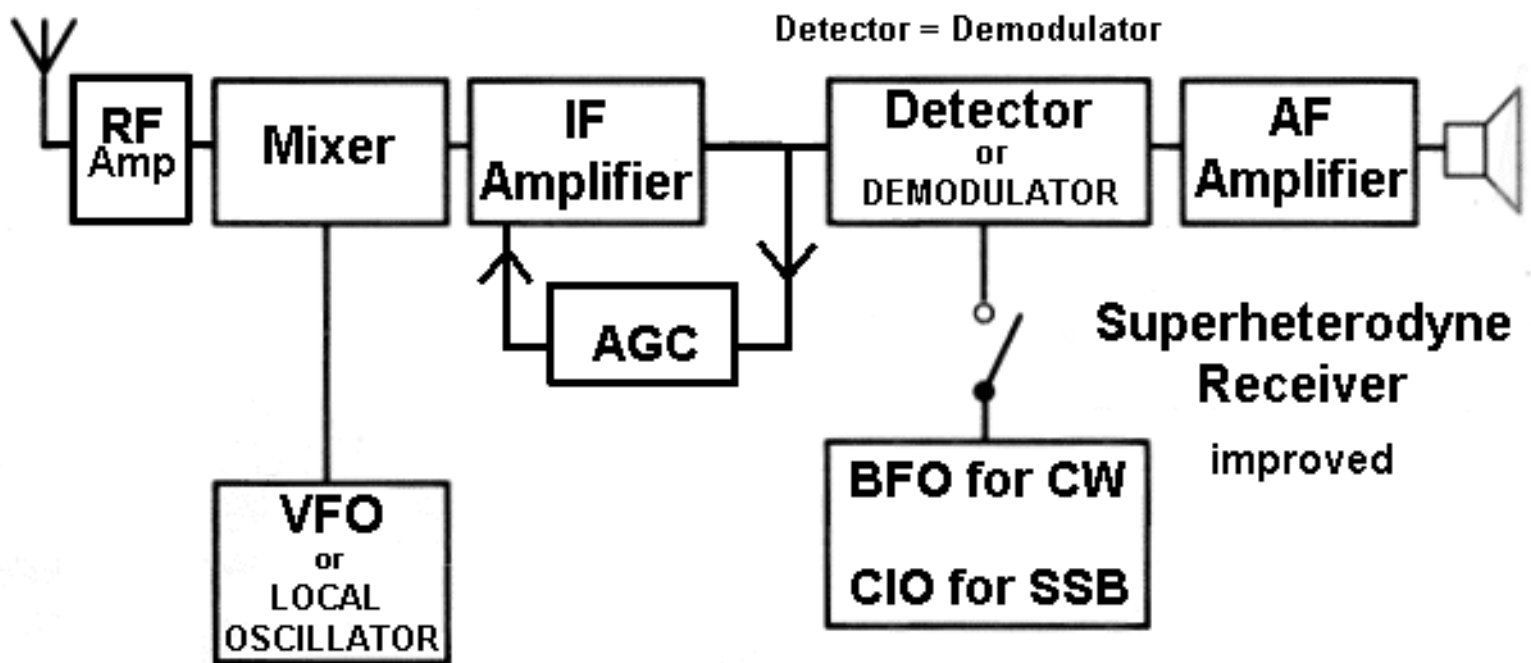
4k.1 Understand the block diagram of superhet and double superhet receivers and the functions of each block.

Superhet receiver

The diagram of the superheterodyne receiver that you have seen in the ILC is as follows.



If you want to check back [click here](#). This is too simple for the advanced course and so let's introduce you to the "next" size up in Superhet.



All that has been added is an AGC control and RF amplifier. Note: Sometimes the AGC is also linked to the RF amplifier.

Most of the text below you have seen in the ILC.

RF Amplifier

- Amplifies the wanted weak signal from the antenna while largely ignoring signals outside of the required range by the use of tuned circuits

Mixer

- The mixer combines the wanted amplified RF signal with the VFO signal (or as it is sometimes stated, with the local oscillator signal) to produce sum and difference frequencies of the RF signal and the LO signal which in fact are modulated identically to the incoming signal.

Local Oscillator (LO)

- The LO is the VFO which generates an RF signal for use by the mixer.

Intermediate Frequency Amplifier (IF)

- Provides the main amplification and includes a filters, which removes adjacent signals and wrong mixing products

AGC (Automatic Gain Control)

- The AGC provides a constant level of signal in the system so that the audio remains about the same level irrespective of the signal strength.

Detector (or Demodulator means the same is interchangeable)

- The demodulator recovers the modulating audio signal

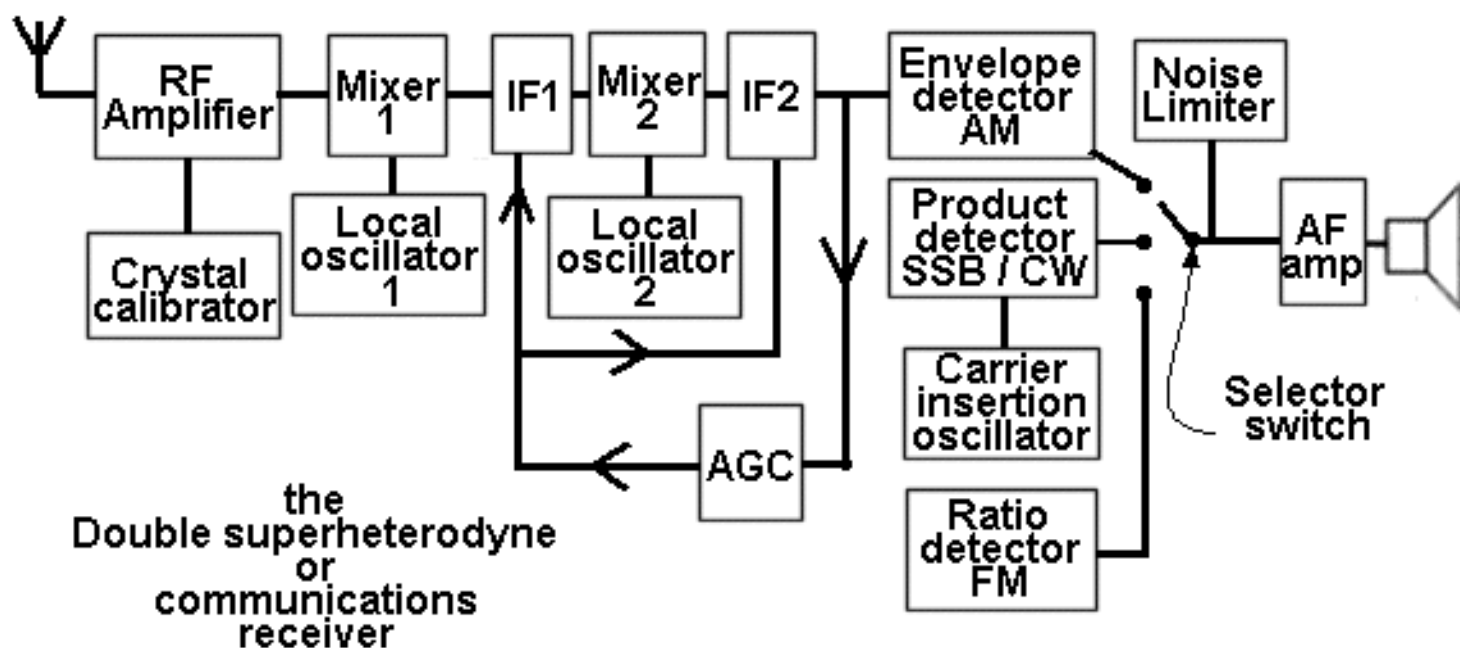
Audio Amplifier (AF amp)

- Amplifies the signal to drive a loudspeaker.

Double superhet receiver or communication receiver.

The double superhet as you would no doubt imagine is a far more complex piece of electronics than the "simple" superhet.

Take a moment to look through the diagram below and before reading through the explanation try to work for your self what parts are doing what.



The AGC can also extend to the RF amplifier.

- The double superhet allows the choice of high frequency 1st IF, which is desirable to reduce problems with image frequency response (an image frequency is another signal that is like a reflection in a mirror in that it is as far from the local oscillator as the wanted image - see section 4m.2 for more explanation). The low 2nd IF allows good filtering and plenty of gain to be easily realised.

By the use of good filters fitted to IF1 and IF2 will be the key to good selectivity.

As three oscillators are used, there is scope for unwanted frequencies within the receiver. Note the use of the detector/demodulators to accommodate the three modes. The noise limiter seeks to reduce the volume of a loud "spike" of interference without affecting the volume of normal signals.

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Syllabus Sections:-**RF. amplifier and pre-amplifier****41.1 Recall the operation of the r.f. amplifier.**

Understand that external r.f. preamplifiers do not always improve overall performance and will reduce dynamic range by an amount equal to the gain of the pre-amp. Understand that overloading will cause intermodulation and spurious signals.

Operation

The operation of the RF amplifier is to increase the RF power of the input signal from a few micro watts to say milli watts.

External r.f. preamplifiers

An external r.f. preamplifiers do not always improve overall performance as they can over drive the RF Amplifier or RF stage - the higher levels signals produce the harmonics and distortion.

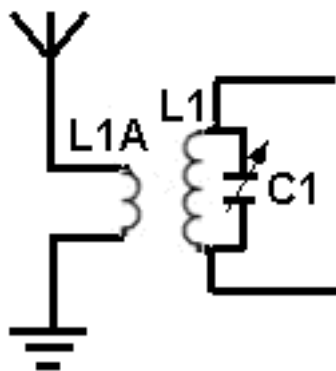
The effect is to reduce the dynamic range equal to the gain of the pre-amp. Thus it is often better to have a mixer and RF preamp stage and keep the dynamic range.

Filters

We will need to have either a band pass or tuned band pass filter such as a parallel tuned circuit in front of the RF amplifier so that only the wanted frequency is passed through.

Overloading by nearby broadcast signals

If you had a link coupling from your aerial into a tuned circuit that then would go onto the first RF amplifier or mixer as shown below.



You could have the wanted Amateur Radio signal and also the local broadcast station present on the link winding and the first tuned circuit.

To limit the broadcast station signal you have to make sure that the coupling is such that its signal is a minimum or you may need a second RF tuned circuit.

Dynamic Range

If you have a dynamic range of 70dB that is the range between the weakest your receiver can handle and the maximum signal - if you add an RF amplifier of 6dB gain then that original dynamic range could be reduced by 6dB and the performance is degraded and this is why you see transceivers with a switch to switch in or out the amplifier.

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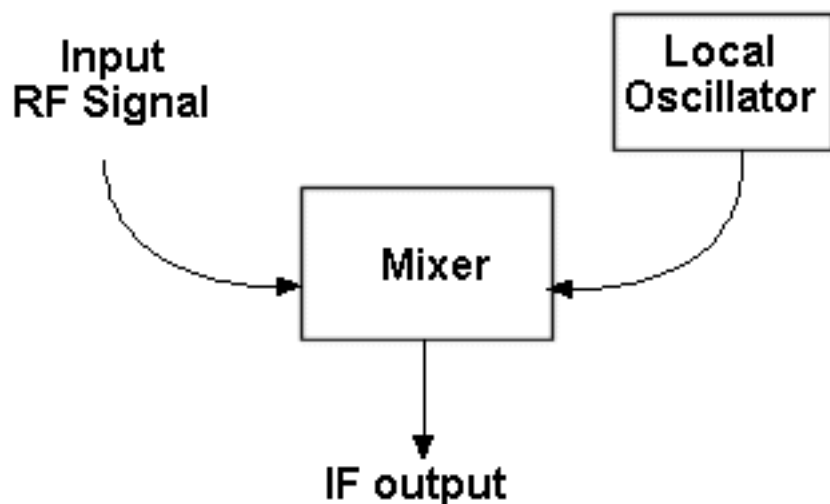
Syllabus Sections:-**Mixer and Local Oscillator**

4m.1 Understand the function of a mixer, the generation of intermediate frequencies (i.f.) and other mixer products.

Understand that for given r.f. and i.f. frequencies, there is a choice of two local oscillator (l.o.) frequency. Understand the reasons for the choice and calculate the frequencies.

If you have a mixer with an incoming RF signal and a local oscillator they mix together and give you an IF output.

You can have what is called oscillator high or oscillator low. Let's look at that in more detail.



If you have an RF signal coming in of 1MHz and an IF out of 0.5MHz to obtain the IF you could have a local oscillator into the mixer of either 1.5MHz or 0.5MHz.

Traditionally we use oscillator high 1.5MHz and this is associated with Image problems discussed below.

Calculation of Frequencies

We know that mixing two frequencies produces :-

1. the RF frequency,
2. The Local oscillator frequency,
3. the SUM of the RF frequency and the Local oscillator frequencies and
4. the difference of the RF frequency and the Local oscillator frequencies

If the RF frequency F_1 , the Local oscillator frequency is F_2 , and we want the output IF frequency = F .

Thus if $F_1 = 1\text{MHz}$ and $F_2 = 1.5\text{MHz}$ the frequencies produced will be from above :-

1. = 1MHz
2. = 1.5MHz
3. = 2.5MHz
4. = 0.5MHz

And if $F_1 = 1\text{MHz}$ and $F_2 = 0.5\text{MHz}$ the frequencies produced will be from above :-

1. = 1MHz
2. = 0.5MHz
3. = 1.5MHz
4. = 0.5MHz

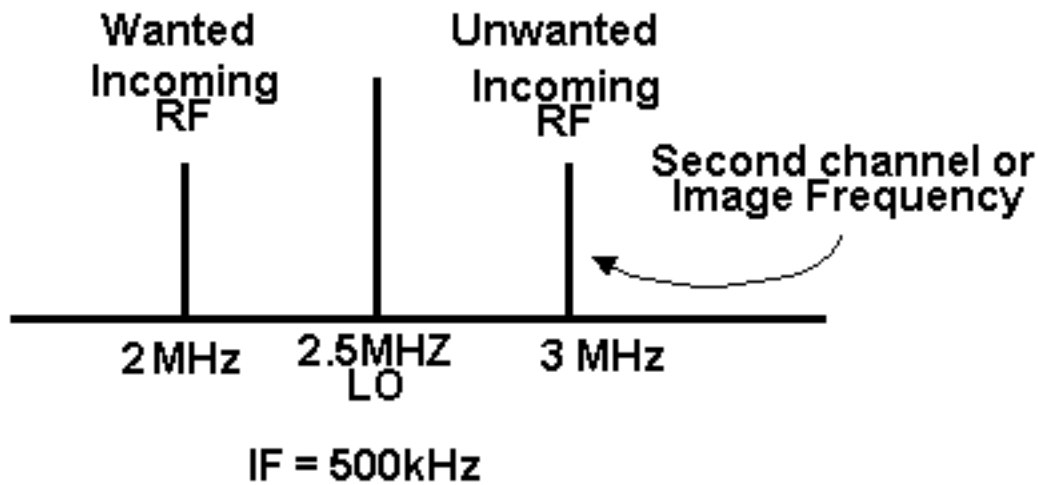
So for two different local oscillator frequencies the same IF frequency can be produced.

So how does one decide whether to use the high or the low frequency. If a low IF is chosen then the filtering is more difficult as it is closer to the wanted frequency so it calls for a high Q tunable filter.

So on balance you might then say that you would choose the high frequency. This would be fine if the signals on the bands were spread well apart but they are not.

Result is the double superhet the high frequency is used first followed by the low frequency.

4m.2 Understand the origin of the second channel or image frequency and calculate the frequency from given parameters.



The image frequency comes about from being either higher or lower frequency than the local oscillator by the value of the intermediate frequency.

In the diagram above there are two signals on the band one at 2 MHz and the other at 3 MHz (numbers chosen purely as examples). Then with the local oscillator at 2.5 MHz the IF is 500 kHz.

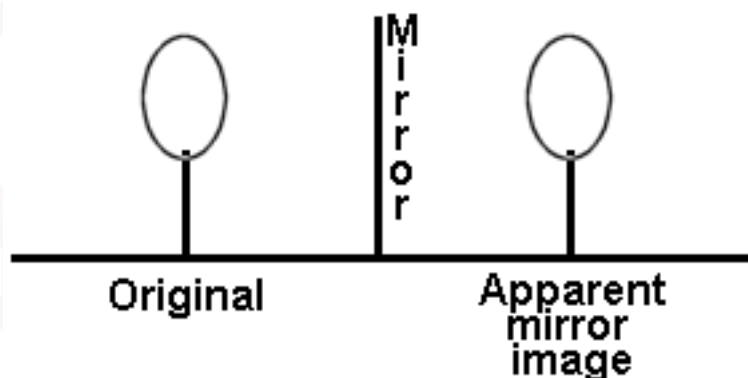
Thus

$$2.5\text{MHz} - 2\text{MHz} = 500\text{kHz} \text{ and}$$

$$3\text{MHz} - 2.5\text{MHz} = 500\text{kHz}$$

So both signals would be at the output speaker and probably neither would be intelligible.

So if the wanted and the unwanted signals are an equal distance away from the LO (local oscillator) they will both appear at the audio output.



When you look in a mirror, your image in the mirror appears to be as far away from you as you are

to the mirror thus apparent mirror image.

So let us look at another example:-

If we have a 28MHz band receiver and an intermediate frequency of 8MHz where would the image frequency be ?

So first you must find the Local oscillator frequency

$$28 - \text{LO} = 8 \quad \text{so } \text{LO} = 28 - 8 = 20\text{MHz}$$

$$\text{or } \text{LO} - 28 = 8 \quad \text{so } \text{LO} \text{ could be } 28 + 8 = 36 \text{ MHz}$$

With the LO at 20MHz and the frequency wanted at 28MHz the image would be at 12MHz

with the LO at 36MHz and the wanted frequency at 28MHz the image would be at 44MHz

another way of looking at this is :-

$$\text{Frequency} + (2 \times \text{IF}) = \text{image frequency}$$

$$\text{thus } 28\text{MHz} + (2 \times 8) = 44\text{MHz}$$

and

$$\text{Frequency} - (2 \times \text{IF}) = \text{image frequency}$$

$$\text{thus } 28\text{MHz} - (2 \times 8) = 12 \text{ MHz}$$

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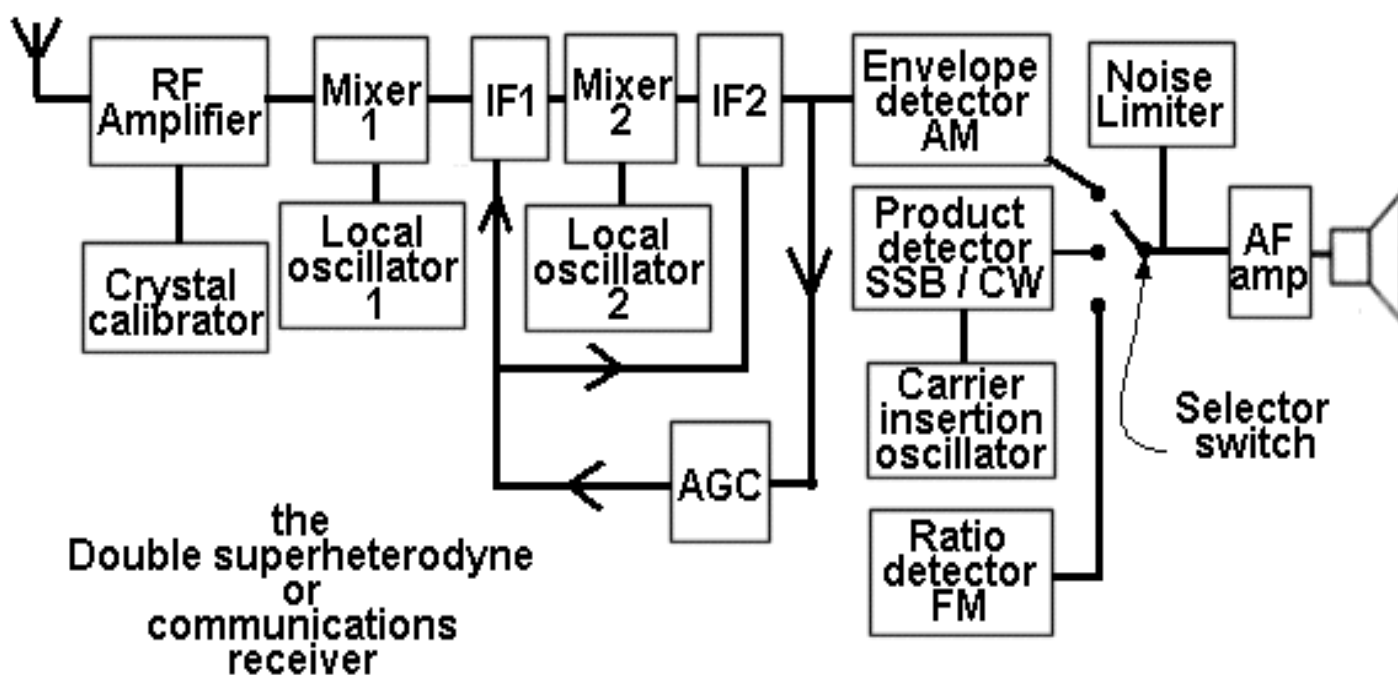
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Syllabus Sections:-

IF amplifier

4n.1 Understand the advantages and disadvantages of high and low intermediate frequencies and the rationale for the double superhet.



High IF gives good image and poor selectivity.

Low IF gives good selectivity and poor image.

You have to decided which to use. For instance if you had very low IF frequency, on a receiver on 28MHz, you may get good selectivity but you may suffer IMAGE that is receiving signals twice removed from the frequency you are interested in. On the other had if you had High IF you would get good image but poor selectivity.

In receiver we tend to have what is called a double superhet. We convert the signal frequency down to a high IF to give good image response and then further convert it to a second IF to give good selectivity.

So in the diagram above the IF1 is the high IF and IF2 is the low frequency.

Q Factor

The Q factor - if you look at a parallel tuned circuit and it has a high Q then the response curve will be very sharp. If the Q is poor we get a low Q circuit where the response is flat and broad.

4n.2 Understand the operation of an i.f. amplifier and the i.f. transformer.

Understand the concept of two LC tuned circuits utilising transformer coupling. Identify critical and over-coupled response curves.

Understand how the gain of an i.f. amplifier can be varied, how this may cause distortion and how the effects of the distortion are avoided.

Note: the reason to vary the gain (a.g.c.) is covered at item 4p.

In a standard IF amplifier, whether it is a valve, transistor, or FET you would have an IF transformers on the input and output. These IF transformers would contain, most of the time, two parallel tuned circuits in the base circuit and two parallel tuned circuits in the collector circuit. There would therefore be four stages of selectivity four tuned circuits at IF.

When the IF transformers are made the spacing between the two coils of the parallel tuned circuits has to be adjusted critically. If the coils are physically too close together we get over coupling situation and gives what is called "double humping" which means you have a very wide response.

If you take the coils further apart then you get a wider coupling and this results in a much sharper response. There is limit as as you move the coils apart the gain of the stage will reduce as the Rf signal has to be coupled between the two. The manufacturer will do their best to provide a good transformer but it might not give you the selectivity you want and you may have to resort to an additional crystal filter.

To remind you the AGC is a controlling voltage to increase or reduce the gain of the IF amplifiers hopefully to keep the audio output in the loud speaker constant. Usually the control trigger for this is taken from the detector.

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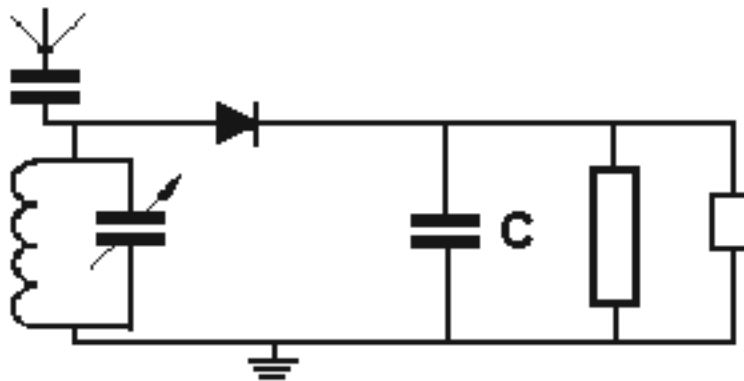
Bredhurst Receiving and Transmitting Society**Next****Syllabus Sections:-****Demodulation**

4o.1 Understand the operation of a.m., c.w., s.s.b. and f.m. demodulators.

AM demodulation

In the Intermediate course notes you were shown how a diode detector recovers an AM signal ([check back here](#)).

The diode allows all the positive signal to pass but rejects all of the negative part of the signal.



The circuit diagram above shows a parallel tuned circuit, which can be tuned to the desired radio station (frequency) by the variable capacitor.

At the resonant frequency, the parallel tuned circuit has a high **impedance** (or opposition to AC / RF currents), the effect of this is to generate a maximum AC / RF potential difference across the tuned circuit.

The potential difference is rectified by the diode and DC is smoothed out by the capacitor C. The end result is that the recovered audio is only the overall shape of the signal which is applied to the

- ear piece / headphones which would have been the same shaped audio signal used to modulate the transmitter hence you hear what was transmitted.

CW demodulator

Now it is possible for the AM simple detector to demodulate a CW signal but you will need a Beat Frequency Oscillator (BFO). This BFO (which is about 700Hz offset from the the IF) mixes with the IF signal which results an audible tone which will be at about 700Hz each time the RF is present which represents the morse key pressed down by the transmitting operator.

SSB demodulator

Also the AM simple detector can demodulate a SSB signal but to do so a Carrier Insertion Oscillator (CIO) is used to replace the carrier removed during the modulation process at the transmitter.

FM demodulator

For the AM simple detector to demodulate a FM signal, a discriminator is used.

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Syllabus Sections:-**Automatic Gain Control**

4p.1 Understand the derivation and use of an a.g.c. voltage.

Recall that automatic gain control circuits can also be used to drive S meters.

The automatic gain control or AGC is a voltage controlled part of the receiver with the voltage coming from the detector stage. The level of the voltage is directly related to the strength of the signal.

The voltage is used to control the gain of the receiver and so enable the receiver to handle a wide range of signal strengths with little or no change in output audio level.

This same voltage can be used to drive a Signal strength meter or "S" meter.

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4q.1 Understand that VHF and UHF operation can be carried out by using down converters and transverters ahead of HF equipment.

The use of down converters and transverters ahead of h.f. equipment was popular until about the late 70's.

Down converter

A down converter take a signal from a a band higher than HF ie higher than 30MHz say 2m and converts it down to an RF signal in the HF band range. This is achieved by mixing the 2m signal with and Intermediate Frequency to give an output on 28-30MHz.

The signal that came in on the 145MHz band is now being heard on a receiver tuned to the 28MHZ band and so long as the HF receiver can receive the mode of the signal is will be heard just as if the receiver could receive 145MHz directly.

The Transverter

Whilst the down convertor only dealt with the converting down of a signal the transverter could not only achieve the conversion down but also the conversion up. This then enable a radio amateur with only an HF rig to transmit and receive 2m.

Where are such equipment used to-day ??

It is not used in the lower frequencies but the microwave frequencies commonly down convert to 2m or 70cms when receiving satellite communications and sometime a transverter is also used.

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Transmitter & Receiver

Syllabus Sections:-

Transceivers

4r.1 Understand that transceivers normally share oscillators between the transmitter and receiver circuits; and may use common i.f. filters to limit both the transmitter and receiver bandwidths. They also use common change-over circuits.

In a transceiver the local oscillator can also be the transmitter VFO.

The IF amplifier and filter used on RX and is used on Tx to generate SSB signals and thereby limit the bandwidths.

The BFO on receive can be the CIO on Transmit

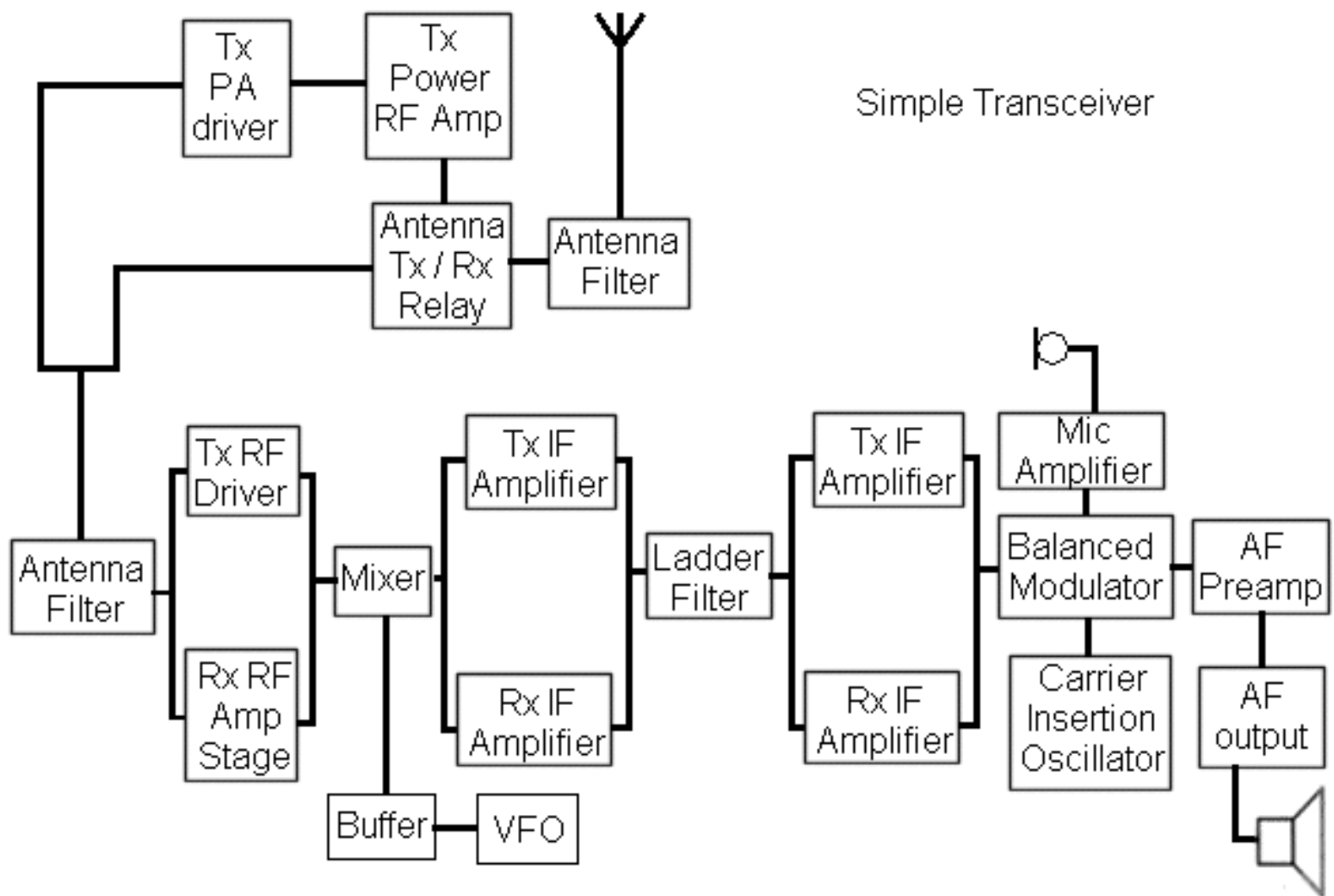
The antenna will need some form of change over relay from Rx to Tx.

Some tuned circuit can be used on Rx and Tx in the low power stage.

In the early days some used a 9MHz IF and a VFO that went from 5MHz to 5.5MHz.

This gives from the mixer frequencies that you can have 14MHz to 14.5MHz and 3.5MHz to 4MHz. So one filter can be used on Rx and Tx and one VFO on Rx and Tx. This was earliest and most often used relationship in a simple transceiver.

To go on other band 7MHz and 21MHz you would need to mix the 5 - 5.5MHz with crystal which then become a crystal mixer VFO to then mix with the 9MHz to give you the other RF frequencies.



This block diagram is based upon the the BITX SSB transceiver see [links page](#).

Recall the function and use of the RIT control

The RIT control allows you to change the receive frequency whilst leaving the transmitter on the original frequency.

The way to use this is when the station with whom you are in QSO moves his TX frequency you adjust your RIT which changes the receive frequency. When you then next transmit you will still TX on the original frequency and with any luck the other station will bring his equipment back on frequency. If you did not do this you would end up chasing each other up or down the band.

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Radio Amateur
Licence Exam

There are 5 questions in the exam on this topic.

The **Maths** symbols indicates the parts of the syllabus where maths involved. Please do not be put off by this as the course work will help you to fully understand the maths needed for the exam.

Syllabus Sections:-

1. Standing wave explanation using *Ohm's Law* **Maths**
2. Feeder basics **Maths**
3. Balun transformers
4. Antennas
5. Return loss **Maths**
6. Antenna matching units

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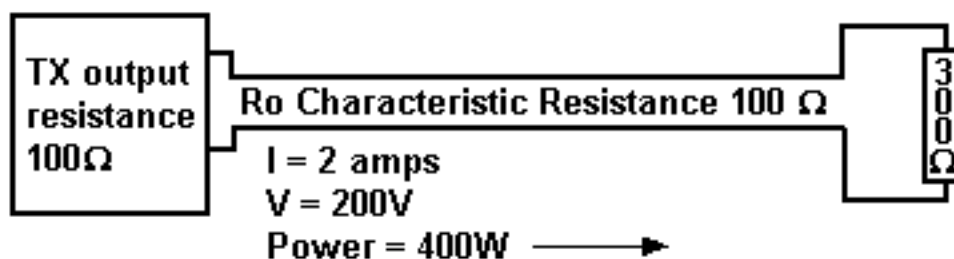
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[Feeder & Antenna](#)

Before we go into the syllabus Standing Wave explanation.

We have added this section so that you can have a grasp of what STANDING WAVES are.



Ohm's Law must be obeyed even though we are dealing with aerial feeders.

Let's look at this from the point of view of the Transmitter (Tx). The Tx does not know what exists at the far end of the transmission line, so 200V/2A signal travels down the transmission line, building up an electromagnetic field, at a velocity close to that of light (for a good transmission line).

The signal then has an awkward situation to overcome when its wave front arrives at the 300Ω load, as there is a gross breach of *Ohm's Law*. 300Ω cannot accept 2A under a pressure of a mere 200V. From *Ohm's Law* we would need $V = 300 \times 2 = 600 \text{ V}$ to satisfy the situation.

The back pressure across the load rises above 200V and starts sending current back into the line, in opposition.

The return current reduces the current flowing into the load, easing the situation.

Looking at the situation from the resistor load towards the Tx - there is the same cable with $R_o = 100\Omega$ so the ratio of the surplus voltage at the load and the return current must still be equal to R_o !

BUT how much current is going back ?

Now for the maths - for those who only want the final resultant equations skip down to after (**Equation 3**).

So for those of you who are still with us here goes.....

Let I_R = Return current, and V_R = Voltage needed to return that current.

So from *Ohm's Law* again $V_R / I_R = R_o$ (R_o in case you had forgotten is the Characteristic Resistance of the feeder cable)

We have the initial Voltage $V = 200$ and initial Current $I = 2$ but as R_o is common to the initial V and I and V_R and I_R then stating it mathematically

$$\frac{V_R}{I_R} = \frac{V}{I} = R_o \quad (\text{Equation 1})$$

$V + V_R$ MUST fulfill *Ohm's Law*

$$\text{so } \frac{V + V_R}{I - I_R} = R \quad (R = \text{the load resistance}) \quad (\text{Equation 2})$$

The equations 1 and 2 are simultaneous and solving them gives us :-

$$\frac{I_R}{I} = \frac{V_R}{V} = \frac{R - R_o}{R + R_o} \quad (\text{Equation 3})$$

We should all be back together now !!!

So back to our example

$$\text{From (equation 3) } \frac{I_R}{I} = \frac{V_R}{V} = \frac{R - R_o}{R + R_o} = \frac{I_R}{2} = \frac{300 - 100}{400} = \frac{1}{2}$$

$$\bullet \bullet \bullet I_R = 1 \text{ amp} \quad (\text{Equation 4})$$

$$\text{again } \frac{V_R}{200} = \frac{1}{2} \text{ thus } V_R = \frac{200}{2}$$

••• $V_R = 100 \text{ V}$ (Equation 5)

So the voltage across the load is $V + V_R = 300\text{V}$

And the current into the load is $I - I_R = 1 \text{ amp}$ so

••• power into load is 300 watts

AND

Power arriving is 2 amps with pressure of 200 volts thus $2 \times 200 = 400 \text{ watts}$

Power returning (which we have just found out is 1 amp with pressure of 100 Volts) $1 \times 100 = 100$

$400 - 100 = 300 \text{ watts}$ *Ohm's Law* is satisfied !!

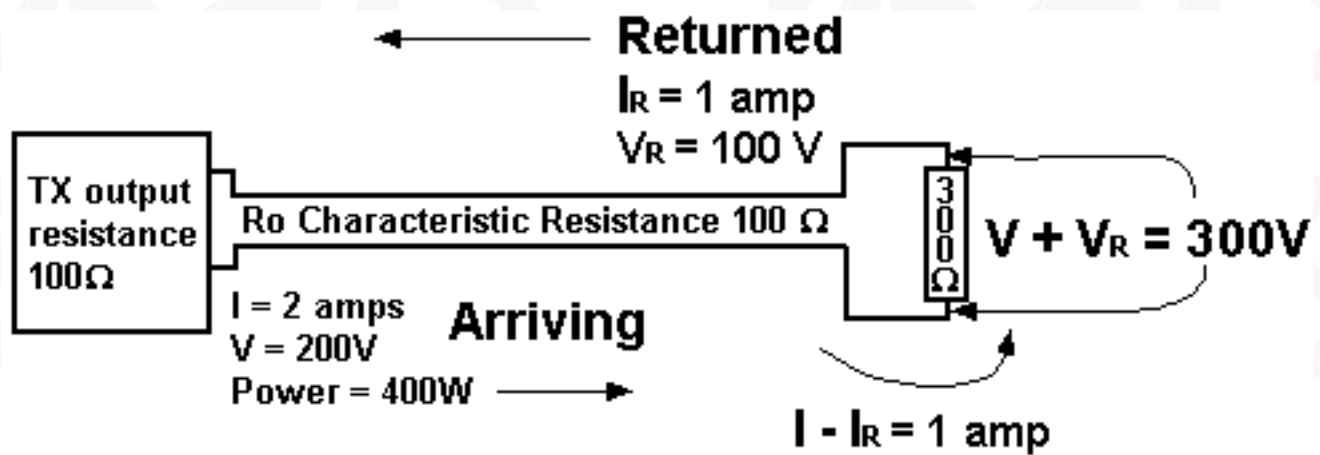
a purely resistive load

For a line with a purely resistive load (i.e. load containing only resistance), $\text{SWR} = R / R_o$ or R_o / R (whichever gives a value of 1 or greater).

The SWR is directly related to the amount of mis-match between the characteristic resistance and the load. The higher the mis-match, the higher the SWR.

For this example $\text{SWR} = R / R_o = 300 / 100 = 3$

Re-drawing the original diagram, with the new information added we have :-



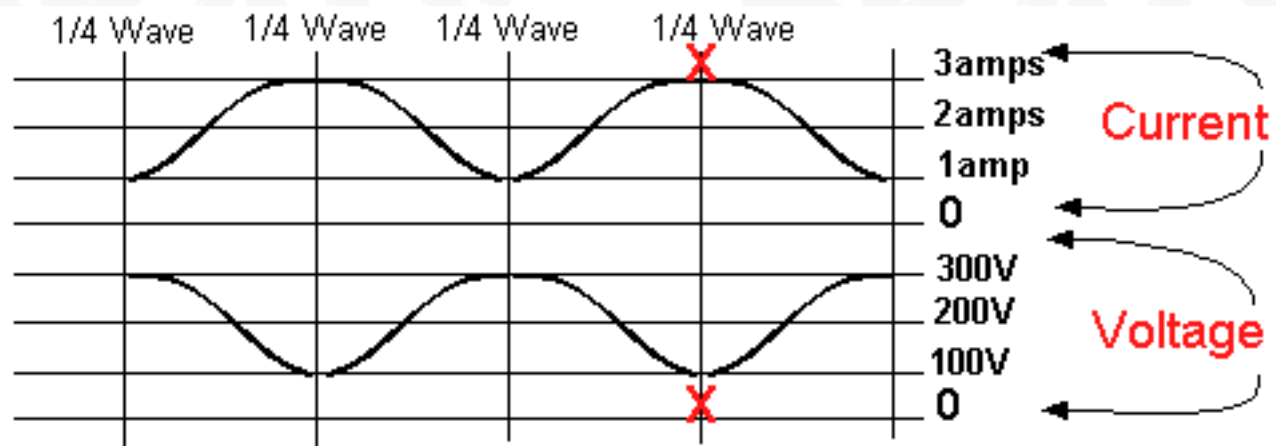
The reflected wave, current and voltage, alternately adds to and subtracts from the 2A/200V travelling from the Tx to the load.

Starting with 1 amp / 300 volts at the load now move back a $1/4$ wave towards the Tx, the original and reflected wave are a half wave apart (total journey to and from the load) and 180° in phase - the two currents are in phase, giving 3 amps and the voltages subtract giving $200\text{V} - 100\text{V} = 100\text{V}$ at a distance of $1/2$ wavelength, phase difference is 360° and we are back to the conditions at the load 1 amp / 300V.

At intermediate points there are different phases so the net current and voltages vary in a wave like manner (not a pure travelling sine wave) see the diagram below.

The net current and voltage varies along the length of the transmission line. The high and low voltage points are in fixed positions. If the transmitter output is a pure sine wave, the forward and reflected waves are pure travelling sine waves. The forward and the reflected waves interact causing a resultant waveform which is a stationary wave called "STANDING WAVE". As mentioned above this standing wave is not pure a sine wave.

So this static wave are not travelling waves like those causing them and can be measured by running a voltmeter along the transmission line. The standing wave ratio is $300:100 = 3:1$ (max volts / min volts).



STATIONARY distribution of Voltage and Current near the end load

NOTE:- At point **XX** a 1/4 wavelength back from the load, the resistance $R = V / I = 100 / 3 = 33.3\Omega$.

If we cut off the load resistance and 1/4 wave length of feeder line, we could fit a 33.3Ω resistor at that new point and the Tx would not know that a change had taken place. The load still looks like 300Ω .

The cable is now acting as a 3:1 transformer as well as a transmission line !!

To complete this section we will deal here with :-

Quarter Wave Transformer

In our example a load resistor of 3 x the characteristic resistance of the transmission lines $3 R_0$ at one end is transformed to $R_0 / 3$ at the other.

In case you had forgotten the Tx in our case was 100Ω and load resistance of 300Ω and characteristic resistance of the line 100Ω

Multiply the end values together $3 R_0 \times R_0 / 3 = R_0^2$

THE SAME RESULT IS OBTAINED FOR ANY LOAD RESISTANCE.

Let the resistance at one end = R to be transformed to R_1 at the other end

$$R_1 \times R = R_0^2 \text{ so required } R_0 = \sqrt{R \times R_1}$$

We use a quarter wavelength of line having a characteristic resistance

equal to $\sqrt{R \times R_1}$

Example. to make a 2000Ω load look like an 80Ω we use a quarter wavelength of line with characteristic resistance $\sqrt{80 \times 2000} = 400\Omega$

A quarter wave transformer always has a standing wave along it.

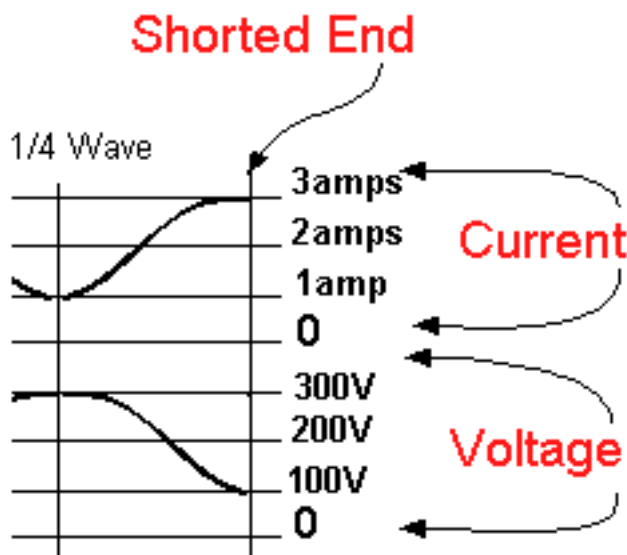
To be correct we should be dealing in impedances as we cannot avoid reactances so the equation becomes :-

$Z_o^2 = Z_{IN} \times Z_{OUT}$ and we will have more on this on another page [click here](#).

Quarter Wave Stubs

If we put what would be a DC short at the end of a Quarter Wavelength of transmission line, and apply the correct frequency to the OPEN end, there will be maximum current and zero volts at the shorted end.

Moving back from the shorted end to the open end when we get to a $1/4$ wave length back, there will be zero current and maximum volts, which indicates A VERY HIGH IMPEDANCE.



We can attach this stub anywhere along a working transmission line, it will have no effect despite the fact that at DC it looks like a short.

This stub is used to support transmission lines (at one frequency only). it can be shown that at lengths between 1/4 wave and the short the stub presents an inductive reactance, decreasing as we move towards the short.

Similarly, an open circuit stub presents a capacitive reactance which decreases as the open end is approached.

The two reactance stubs can be used to cancel out unwanted reactance in a system and are particularly applicable at microwave frequencies.

In the original example, the resistance a 1/4 wavelength back from the load is 33.3 ohms. The 1/4 wavelength transforms the impedance from 300 ohms to 33.3 ohms, but the SWR stays the same.
 $SWR = R_o / R = 100 / 33.3 = 3.$

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Maths**Bredhurst Receiving and Transmitting Society****Feeder & Antenna****Syllabus Sections:-****5a Feeder basics.**

5a.1 Understand that the velocity factor of a feeder is the ratio of the velocity of radio waves in the feeder to that in free space and that the velocity factor is always less than unity. Calculate physical feeder lengths given the frequency and velocity factor. Recall that the velocity factor for coaxial feeder with a polythene dielectric is approximately 0.67 or 2/3.

Velocity factor what is it?

From the syllabus we learn that :-

$$\text{Velocity Factor} = \frac{\text{Velocity of the radio waves in the feeder}}{\text{Velocity of the radio waves in free space}}$$

We know that the velocity of radio wave in free space is the same as the speed of light. From the syllabus statement we learn that the velocity factor is less than unity (which is numerically 1) and for this to be true the velocity of the radio waves in the feeder must be slower.

Whilst we have spoken about velocity factor in relation to feeders the same goes for velocity factor in cables.

Why is this important ?

Well it is because when making up feeder and you want it to be certain multiples of say 1/4 wave length then if you merely cut the feeder without reference to the velocity factor your feeder would be too long.

The same goes for antennas. If you merely cut the half wave dipole to the calculated length it too will be too long.

So the **physical length** of cable or antenna is **always less** than its calculated **electrical length** due to the velocity factor.

So if we have a frequency of say 3.600Mhz what would the length be of a 1/4 wave stub?

You have to be able to remember that the **velocity factor for coaxial feeder with a polythene dielectric is approximately 0.67 or 2/3**

So to calculate the wave length in metres we use the equation from the intermediate course [click here to check back](#)

$$v = f \times \lambda \text{ or } c = f \times \lambda$$

Note that sometimes v is used for the speed of light and at other times c.

The velocity of light = the frequency x wavelength

As we are dealing in MHz we can use the speed of light as 300m/sec

$$\text{so } 300 / 3.6 = \text{wavelength} = 83.33$$

$$\text{so quarter wave} = 83.33 / 4 = 20.83 \text{ metres}$$

$$\text{now apply the velocity factor } 20.83 \times 0.67 = 13.9 \text{ metres}$$

This is simple mathematics and you should be able to easily solve the problems.

Recall that feeder loss increases with increasing frequency and that lower loss feeders may be required at v.h.f., u.h.f. and above.

As the frequency of operation increases feeder losses also increase and thus to have much the same signal coming out of the end as going is at the beginning you have to use better quality feeders - or as it is known lower loss feeders.

5a.2 Understand that a quarter-wave length of feeder can be used as an impedance transformer. Apply simple examples of the formula $Z_0^2 = Z_{in} \times Z_{out}$.

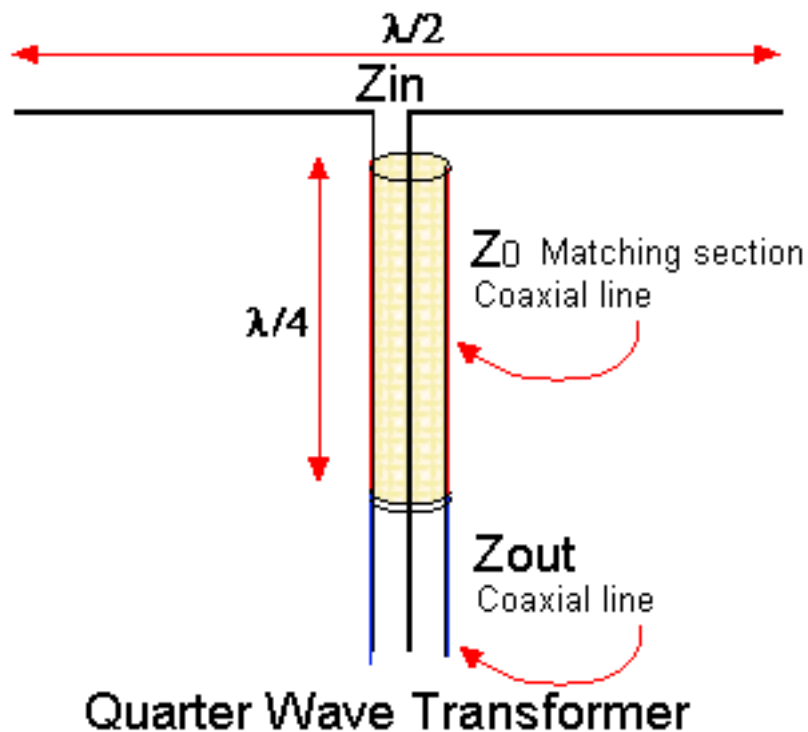
The formulae for calculating the impedance of a matching section will be given to you in the exam, if a question on this topic comes up so the important points to know are what do the mathematical notations represent.

$$Z_0^2 = Z_{in} \times Z_{out}$$

In the formula Z_0 = the impedance of the quarter-wave length of feeder matching line Z_{in} is the impedance of the antenna Z_{out} the impedance of the feed line to which the antenna is to be matched. Note that the Z_0 is "squared" so to find the answer as to the impedance of the matching section you would have to use :-

$$Z_0 = \sqrt{Z_{in} \times Z_{out}}$$

all that we have done is "take the square root" of both sides, so as long as you understand such manipulation the result can be easily found.



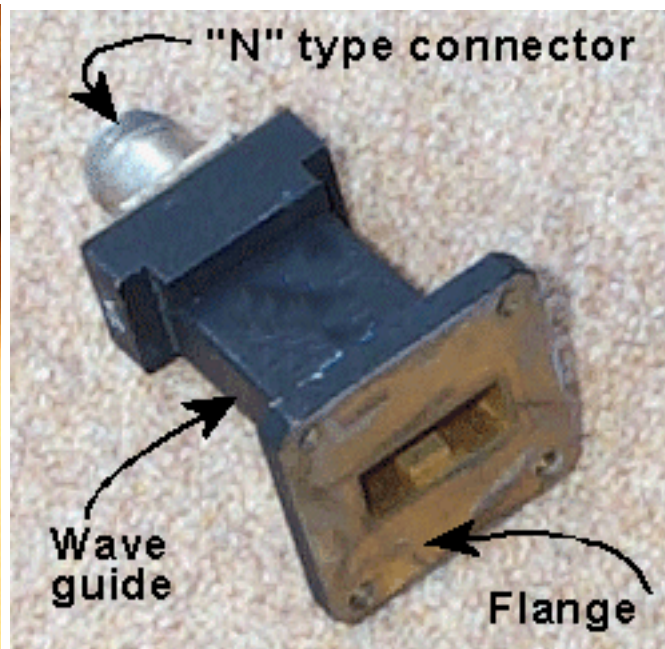
Example:- What would be the matching section's impedance to match a 75 ohms dipole to 50 ohms coax.

$$Z_0 = \text{square root of } (75 \times 50) = 61.3 \text{ ohms.}$$

Now it is not very easy to find such a piece of coaxial feeder so what other feed line could be better used ?

Twin feeder of course, but for the exam you do not have to go into how you would achieve the physical dimensions of the matching section just be able to calculate it - as a diagram of coaxial feeder is easier to remember that it why we have used it.

5a.3 Recall the basic construction and use of waveguides.



The pictures above and below show wave guides. These take the place of other feeders with which you are familiar for HF and VHF and UHF (coaxial and open wire / balanced) when using Microwave frequencies and if properly made with good joint scan be low loss. The guide is usually a rectangular "tube" with flanges attached to join one piece to another and as shown below can be complicated arrangements or as shown above link to coaxial feeder via an "N" type connector.



A very complex wave guide
with two different styles of flanges

[Next](#) [Baluns](#)

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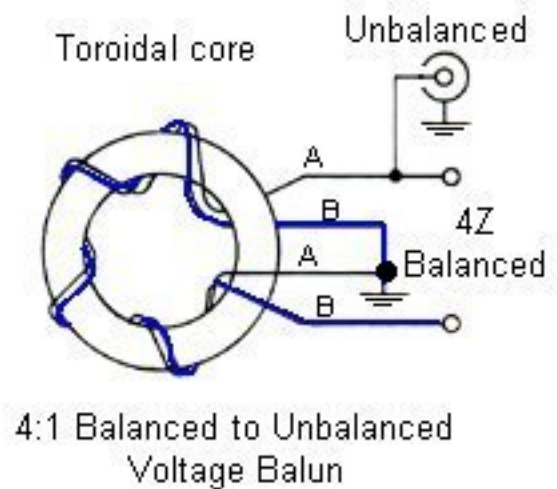
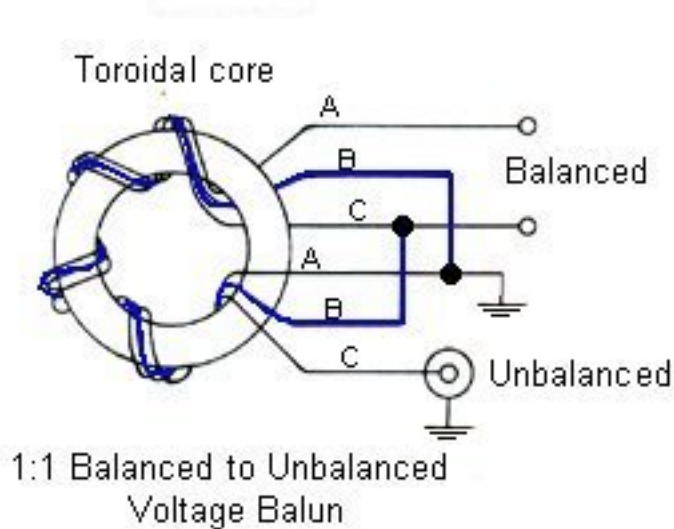
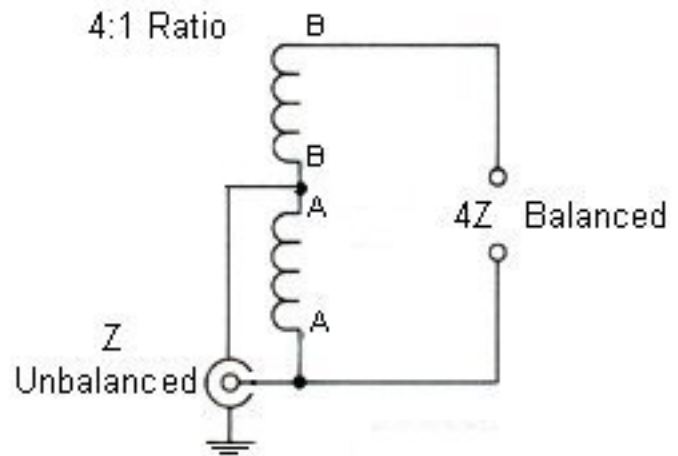
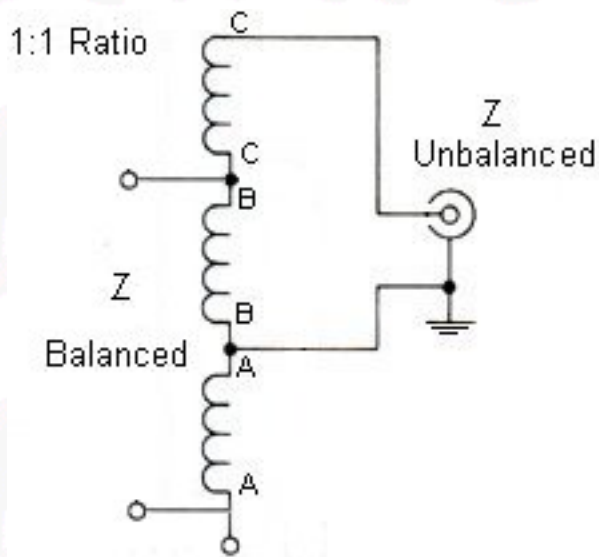
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Bredhurst Receiving and Transmitting Society**Feeder & Antenna****Syllabus Sections:-****5b Baluns**

5b.1 Recall the construction and use of typical baluns; transformer, sleeve and choke. Identify the circuits of 1:1 and 4:1 transformer baluns.

TRANSFORMER

Let's look back at the principle of electromagnetic induction. You will recall that an alternating current flowing in the primary winding creates an alternating magnetic field, which in turn induces current in the secondary winding. Transformers are a major component in electrical and radio circuits, transferring or transforming voltages and currents up or down as required.



The circuits of 1:1 and 4:1 transformer baluns

In a transformer the primary and secondary voltages are relative to one another or a ratio, i.e.- 240v primary & 12v secondary have a ratio of 20:1, the primary voltage is 20 times greater than the secondary voltage. The primary & secondary voltages maybe reversed but the ratio is still 20:1 or 1:20.

The current ratio in a transformer is opposite to the voltage ratio, i.e. if the voltage steps up the current steps down & vice versa.

For example; a transformer has a 240 volt primary @ 1 amp. The secondary voltage is 12volts provided the secondary winding can carry the current it has a potential of 20 amps because the ratio is 20:1 or 1:20.

We have mentioned voltage and current but what about impedance transformation, impedance transformation is similar in that the load or secondary impedance might be 300Ω and the feed or

primary impedance might be 750 the ratio is still 4:1 or 1:4

Let's look at the example.

A transformer has a turns ratio of 1:2, in other words there are twice as many turns on the secondary winding than there is on the primary winding. It doesn't matter how many for the moment, but let's give it a figure of 1000 turns to 2000 turns, the turns ratio is still 1:2.

The transformer has a secondary load of 16000 ohms or 16kohms, what is the primary impedance ???

Using the formula :-

$$Z_p = (N_p / N_s)^2 \times Z_s$$

Where:-

- Z_p = primary impedance
- N_p = primary winding turns,
- N_s = secondary winding turns,
- Z_s = secondary impedance.

we can work out the primary impedance ?

$$Z_p = (1000 / 2000)^2 \times 16000 \text{ ohms}$$

$$Z_p = (0.5)^2 \times 16000 \text{ ohms}$$

$$Z_p = 0.25 \times 16000 = 4000 \text{ or } 4k \text{ ohms}$$

$$Z_p = 1000 \text{ ohms}$$

$$Z_s = 4000 \text{ ohms}$$

Therefore the impedance ratio is 1:4

So as you can see the transformer has a turns ratio of 1:2 but has a impedance ratio of 1:4 or 4:1 depending on which way you're looking.

Try a few examples yourself;

An antenna has a feed impedance of 300ohms, it has a matching transformer connected to it that has a turns ratio of 1:2, if the secondary of the transformer is connected to the antenna feed, what will be the input impedance??

$$Z_p = (N_p / N_s)^2 \times Z_s$$

$$Z_p = (1 / 2)^2 \times 300 \text{ ohms}$$

$$Z_p = 0.25 \times 300 \text{ ohms}$$

$$Z_p = 75 \text{ ohms}$$

Matching transformers or baluns (balanced to unbalanced) are often used as impedance matching devices the turns of wire being wound on a piece of ferrite or ferrite ring, ten double wound turns wound on a ferrite ring, the end of 1 winding joins together to form a centre tapped single winding, such a device gives an impedance transformation of 1:4 or 4:1, ideal for connecting to antenna systems as they will cover a wide range of frequencies.



Examples of materials to make baluns and on the far left hand side examples of two baluns.

By making taps on the balun different impedance transformations can be made.



above is an example of a 4:1 balun. Ten turns of 1.25mm enamelled copper wire twisted together and wound on a t200 amidon ferrite core 2" dia.

Twist together 1 end of 1 winding with the other of the second winding, to make a centre tap (identify which winding is which with a multimeter or put a bit of coloured tape on both ends of 1 winding before attaching to core). Tin the center tap ends together. Tin the other two ends.

The primary (unbalanced) is between the centre tap and one end.

The secondary (balanced) is between end 1 and end 2.

To test connect a 200 ohm carbon resistor load between end 1 and 2 (secondary).

Connect your hf transmitter via an swr bridge to end 1 and the centre tap.

Transmit low power rf and check the swr, it should be 1:1 or thereabouts



Above is a 1:1 balun wound in a similar way to the 4:1 except this time there are 3 windings so winding identification is all important. In the above example a smaller core (1.5") is used with slightly smaller (1mm) diameter enamelled copper wire but still ok 100 watts or so. 1:1 baluns are often used for coupling feeder to antennas a choke balun wound using additional coax feeder can be a cheaper option.(more on that another time).

Mount your balun in a waterproof plastic box (not metal) with suitable coax socket for input and a couple of 4mm insulated terminals for output.

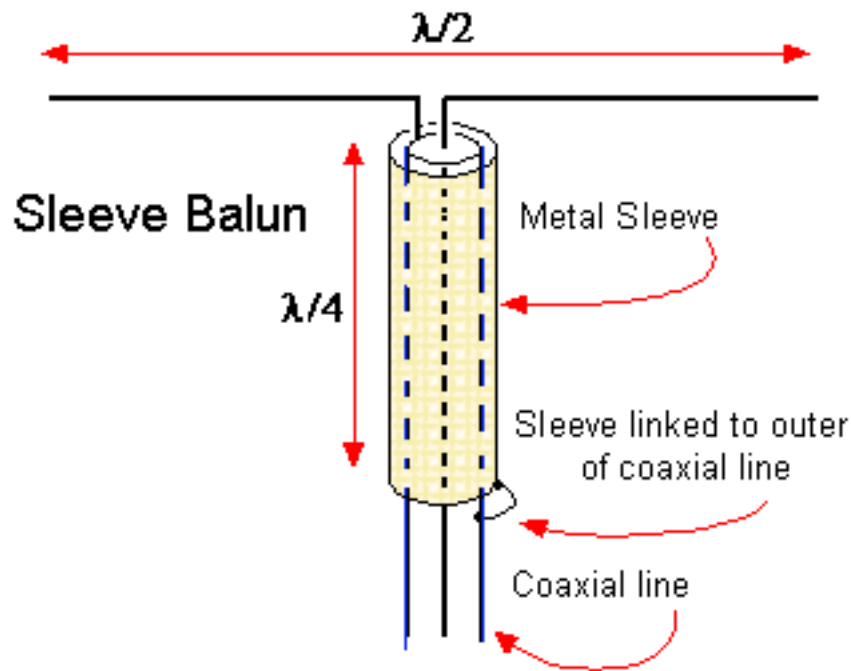
Remember baluns work best with resistive loads, if a reactive load is connected (high swr, antenna too short or long for the band in use) they are not so efficient and can get hot, the heat is the power that is not being radiated.

Other higher power examples

Baluns can also be made using ferrite rod material, just coil the windings in the same way (just wind along the rod) and connect them up the same.



The Sleeve balun also known as the BAZOOKA Balun



This is a $\lambda/4$ metal sleeve over a coaxial feed that is shorted to the outer of the coax and the upper end left open. One half of the dipole is attached to the centre of the coax and the other to the coaxial line outer.

The Choke Balun

The choke balun is where about 10 turns at a diameter of about 150mm coaxial line is formed into a coil at the antenna feed point. This is best used at lower HF frequencies as at higher frequencies it loses its effect of choking of the current flowing down the "OUTSIDE" of the feed line.

Next [Antennas](#)

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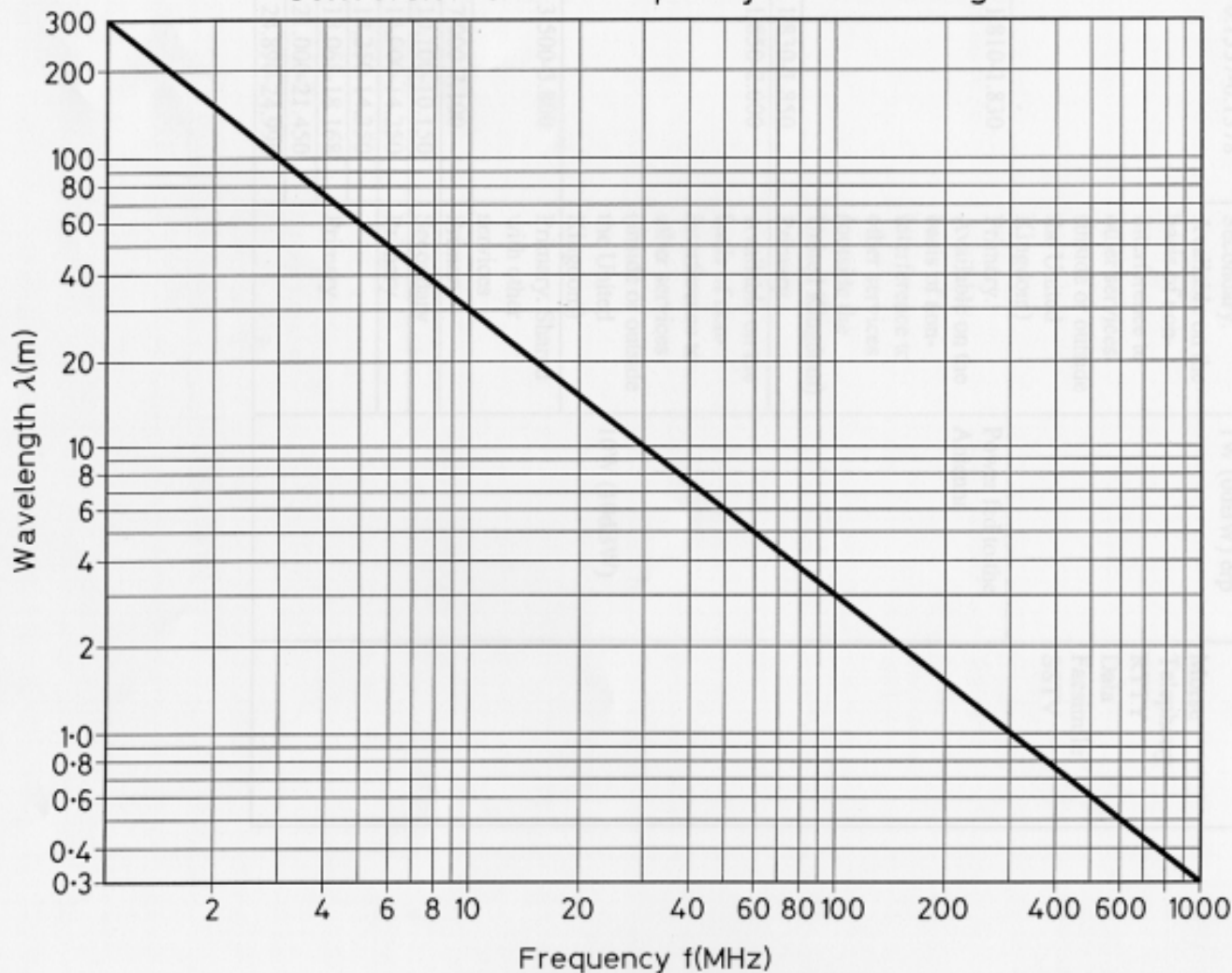
Bredhurst Receiving and Transmitting Society**Feeder & Antenna****Syllabus Sections:-****5c Antennas**

5c.1 Understand the equation for calculating half-wavelengths and be able to apply 'end factor correction' in calculating the approximate physical lengths of dipole elements.

As a memory jogger let's show you some of the information you have learned in previous courses.

From the Foundation Licence Course came the Frequency to wavelength chart [click here to check back](#).

Conversion chart Frequency to Wavelength



From the Intermediate Licence Course came the formula $v = f \times \lambda$ relating speed of light v to frequency f and wavelength λ [click here to check back.](#)

$$v = f \times \lambda$$

The velocity of light = the frequency x wavelength

and you know that the over all length of a dipole is $1/2 \lambda$ long.

$$\text{so } \left(\frac{v}{f} \right) / 2 = \text{half wave length}$$

so the EQUATION for calculating the length of a half wave dipole is derived from the one above and divided by 2 (as it is a $1/2 \lambda$ long):-

$$\left(\frac{300}{f} \right) / 2 = \text{total length in metres}$$

Example. What is the length of a dipole for 3.6MHz ?

$$(300/3.6)/2 = 41.66\text{m}$$

'End factor correction'

But that is not the end of the story as this Advanced syllabus introduces 'end factor correction'.

The equation above would be correct for an aerial in free space, however as we are operating from near to the ground the half wavelength aerial will not be exactly equal to the half wavelength depending upon several factors:-

- the thickness to the wire aerial relative to the wavelength in use.
- capacitance added to the end due to the use of of insulators.

These items are all taken into account in what is called the "**K**" **Factor** which the aerial length calculated above must be multiplied by to give you a "better" approximation as to the length of the aerial.

for wire aerials of wavelengths up to 30MHz **the K factor can be taken as 0.95**

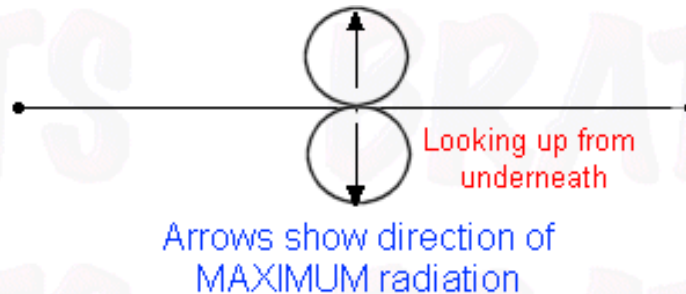
From above length of aerial is 41.66m

Apply the K factor $41.66 \times 0.95 = 39.57\text{m}$ Overall length.

This can then be your starting point to prune the aerial to resonance at the frequency of operation.

So in addition to knowing the formula $v = f \times \lambda$ and rearranging to the aerial calculation as shown above you must know the "K" factor of 0.95 for wire aerials.

- 5c.2 Recall that the angle at which the propagated radio wave leaves the antenna is known as the (vertical) angle of radiation and that longer distances require a lower angle of radiation.
- Recall the effect of the ground on the angle of radiation.
- When a radio signal leaves an antenna, a dipole for instance the radiation takes up a "pattern" as was explained in the Intermediate Course [click to check back](#).



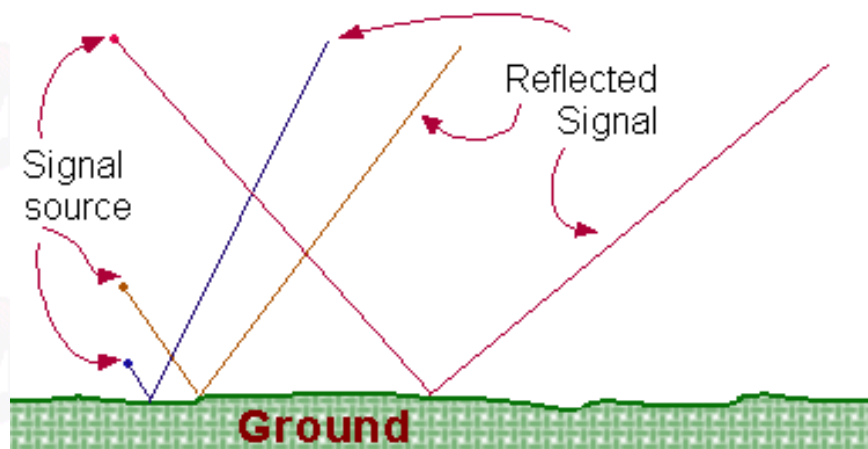
- In the Intermediate Course detailed explanation as to height above ground etc was not explained so this is where the Advanced Course develops your understanding.

Ground Effect

- The dipole whilst not directional in the same sense as a yagi does not radiate off its ends but only off its sides. The ground has an effect (Ground Effect) of re-enforcing the signal from the aerial which is affected by the closeness or otherwise of the radiating element to the ground.

Ground Effect on angle of radiation

- If the antenna is low to the ground then the reflection will be at a higher angle than if the antenna was at a higher position above the ground. Although you cannot have a point source the diagram below shows a single radiation point and considers just a single radiated wave.



Low angle of radiation longer distances

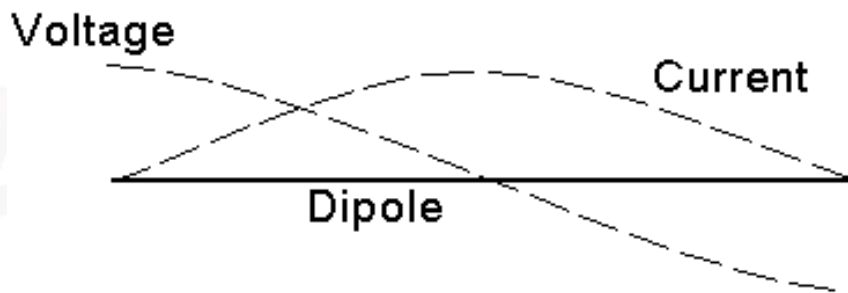
- You can see that the higher the signal source the lower the "VERTICAL ANGLE OF RADIATION". To be able to

to achieve long distance communication the angle of vertical radiation wants to be as low as possible and for general use this means AT LEAST half a wavelength at 14MHz but preferable three-quarter to one wavelength (one wave length @ 14MHz = 21.4 m) above the ground.

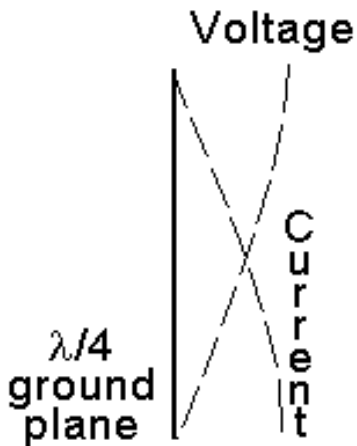
It should be noted that as the ground does not have perfect conductivity that different ground conditions will result in different angles of radiation for the same radiation point above the ground surface.

5c.3 Recall the current and voltage distribution on the dipole and $\lambda/4$ ground wave antennas

When RF energy is passes via the feeder line to an antenna it develop both voltage and current distribution. below if shown that for a dipole.



This indicates that there is high voltage point at the end of the dipole but zero volts at the centre.

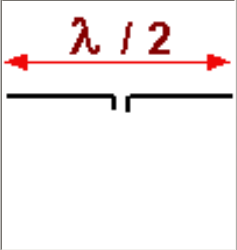
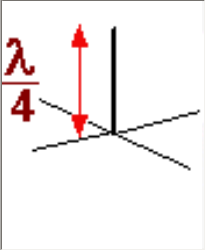
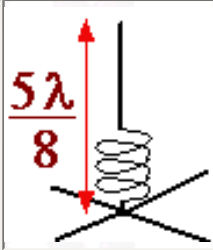
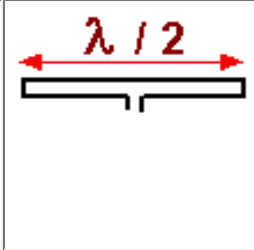
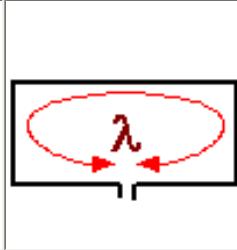
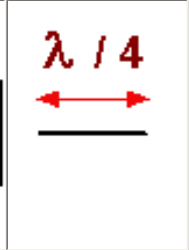
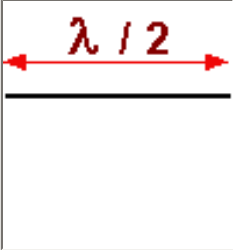


The ground plane antenna is derived from the half the dipole and has the same characteristic distribution of voltage and current from one end of the dipole to the centre.

In the ground plane the centre of the dipole is at the bottom so voltage is zero and current at a maximum.

Recall the feedpoint impedances of half-wave dipoles, quarter-wave and loaded $5\lambda/8$ vertical, folded dipoles, full-wave loops and end fed $\lambda/4$ and $\lambda/2$ antennas.

$\lambda/2$ dipole	$\lambda/4$ vertical	$5\lambda/8$ loaded vertical	folded dipole	full-wave loop	$\lambda/4$ end fed	$\lambda/2$ end fed
-----------------------	-------------------------	------------------------------------	---------------	-------------------	------------------------	------------------------

						
Feed Impedance of the various antennas						
50 to 75 ohms	about 37 - 50 ohms	50 ohms	300 ohms	approx 100 ohms	Low Impedance	High Impedance

Recall the effect of passive antenna elements on feed point impedance and the use of folded dipoles in yagi antennas.

In the yagi only one element is driven the other elements are called passive elements as they only have a passive effect on the performance rather than the active of the driven element.

The addition of the passive elements, directors and reflector, to the driven element, which is usually a dipole, is to lower the feed impedance. To bring the impedance back up to a level where it can be fed with coax a folded dipole is used as the driven element. If you look to the diagram above you can see that the folded dipole has a higher feed impedance than the dipole.

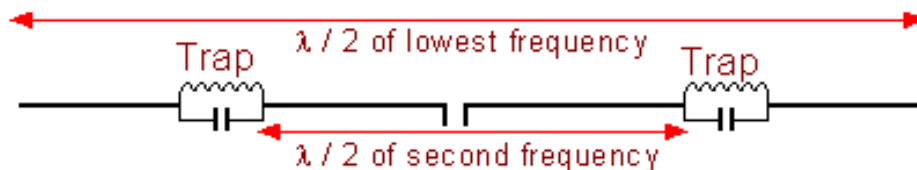
5c.4 Identify folded and trap dipoles and quad antennas in addition to those in earlier syllabuses.

The folded dipole

The folded dipole is a dipole with an additional $\lambda/2$ element along side the original with the ends joined to make a continuous loop. You can see a diagram representation above.

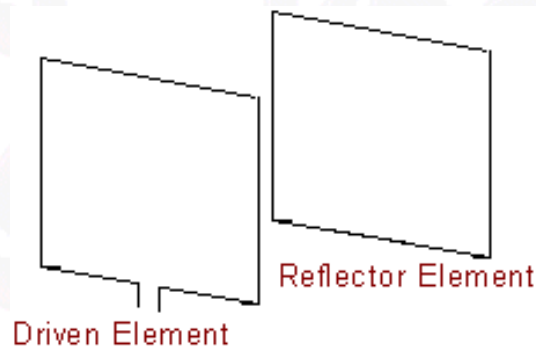
The trap dipole

The trap dipole is a dipole of $\lambda/2$ length of the lowest frequency of operation and then a trap placed in leg at the ends of the $\lambda/2$ length of the higher frequency that the aerial is to work on.

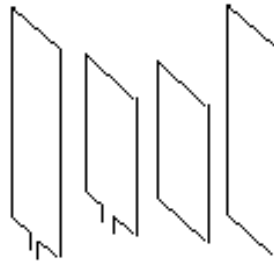


Quad antenna

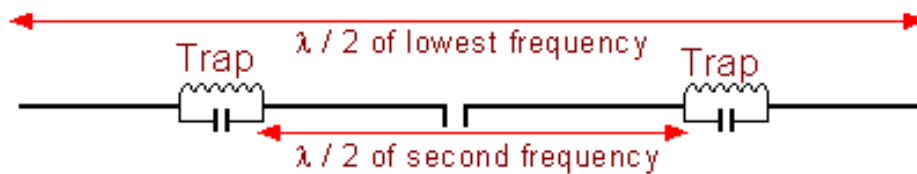
The Quad antenna was originally developed by W9LZX in 1942. It is a simple beam antenna consisting to two elements one driven and one reflector or parasitic reflector as it is known. Each side is $\lambda/4$ long. With the feed point at the bottom the antenna exhibits horizontal polarization (just like a dipole) but if the feed is moved to the side then the antenna exhibits vertical polarization. The quad has a feed impedance of about 75 ohms.



Such antenna can be nested so that higher frequency elements can be positioned their correct distance apart (driven to reflector) and being smaller would sit nicely inside the lowest frequency quad.



5c.5 Recall that an antenna trap is a parallel tuned circuit and understand how it enables a single antenna to be resonant and have an acceptable feed-point impedance on more than one frequency. Recall that this technique may be extended to multi-element antennas such as Yagis.



Trap is a parallel tuned circuit

The trap used in the antenna is a parallel tuned circuit which is resonant at the higher of the two operating frequencies. The trap would not be left exposed but would be covered in a non conducting cover unless that outer covering was the capacitor part of the trap.

So whilst the full length of the antenna is used for the lower frequency and the trap just acts as a small inductance (but otherwise does not have any effect), when the higher frequency is used the trap effectively cut off the antenna at the trap thereby electrically shortening the antenna to the resonance of the higher frequency. By doing this the feed impedance does not change from that of the normal dipole as electrically it is just like having two dipoles and a single feeder is all that connects the antenna to the station system

Multi Band HF Yagi

For HF then same idea is used to make two band and three band YAGI and as such these antennas are called "Dual band" yagi or "Tri band" Yagi. The lowest frequency used in such antennas is usually 14MHz due to the size required to make any lower frequency dipole as the driven element and boom length for the reflector and director for either two or

- three element beams.

- In the same way that traps were used for the dipole traps are also used on the reflector element, driven element, and director element of the beam.

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Maths**Bredhurst Receiving and Transmitting Society****Feeder & Antenna****Syllabus Sections:-****5d Return Loss**

5d.1 Understand that the standing wave ratio (SWR) is a measure of the signal travelling back down the feeder expressed in terms of the standing waves caused by the reflected signal voltage (or current).

The formula is :-
$$SWR = \frac{V_{\max}}{V_{\min}} = \frac{V_{\text{forward}} + V_{\text{reverse}}}{V_{\text{forward}} - V_{\text{reverse}}}$$

When there is a mismatch between feeder and antenna we proved in the earlier section ([click here to check back](#)) that to satisfy *Ohm's Law* some of the transmitted power is reflected, ie returned, to the transmitter. Moving back from the antenna we find that the reflected voltage is alternately in phase or out of phase with the transmitted wave.

When in phase the voltages ADD, when out of phase they subtract.

The highest voltage is $V_{\text{FORWARD}} + V_{\text{REVERSE}}$, and

the lowest voltage is $V_{\text{FORWARD}} - V_{\text{REVERSE}}$

These points of maximum and minimum are at steady positions along the feeder and are called **STANDING WAVES**.

The **STANDING WAVE RATIO** which is a measure of the mismatch is $V_{\text{MAX}} / V_{\text{MIN}}$ which is $(V_{\text{FORWARD}} + V_{\text{REVERSE}}) / (V_{\text{FORWARD}} - V_{\text{REVERSE}})$

$$SWR = \frac{V_{\max}}{V_{\min}} = \frac{V_{\text{forward}} + V_{\text{reverse}}}{V_{\text{forward}} - V_{\text{reverse}}}$$

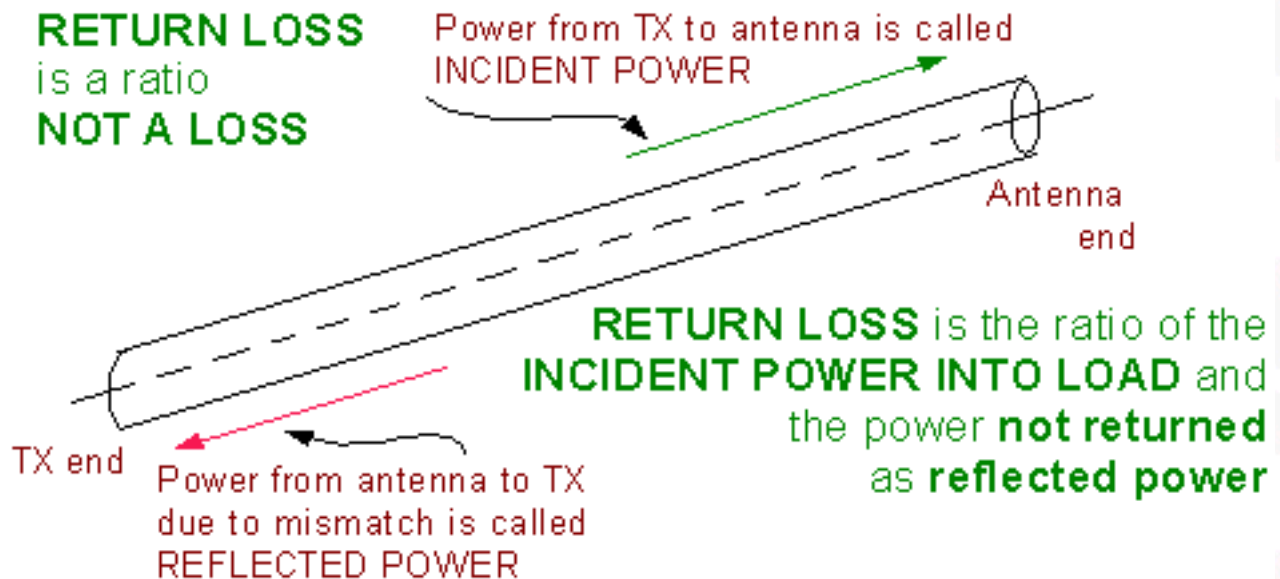
- it is also incidentally equal to ANTENNA RESISTANCE / LINE CHARACTERISTIC RESISTANCE or to be more accurate, the impedances.

Effect of line loss.

Losses along the feeder reduce the voltages of the reflected wave as it travels towards the transmitter, which increases the V_{MIN} and decreases the V_{MAX} , so that the ratio $V_{\text{MAX}} / V_{\text{MIN}}$ falls as it travels back to the transmitter, ie the Standing Wave ratio reduces.

So if you have a long feeder and a great deal of loss, the SWR at the transmitter might well look ok but in fact there could be a major mismatch at the antenna!!!!

5d.2 Recall that return loss is the ratio of the forward signal power to the return signal power; normally expressed in dB.



RETURN LOSS is really nothing more than another way of saying SWR but it is the reverse way round as the word LOSS in RETURN LOSS is misleading as you will probably think that a high RETURN LOSS is a bad thing - infact it is quite the reverse and this is where a question in the exam could catch you out.

So now you know that RETURN LOSS is a rather strange concept let's see if we can unravel it for you.

The higher the return loss the more efficiently the antenna is radiating.

We are considering the REFLECTED POWER with respect to the ARRIVING INCIDENT POWER, to determine how much power is reflected with respect to that which is arriving. Another

way of putting it is to say "How much power is left of the INCIDENT POWER to be reflected after the power has been consumed by the load resistance.

$$\text{RETURN LOSS} = \frac{\text{INCIDENT POWER into load}}{\text{REFLECTED POWER back to the transmitter}}$$

So if we have incident power into the antenna as 100W and reflected power back to the transmitter as 1W the RETURN LOSS is $100/1 = 100$ a HIGH RETURN LOSS.

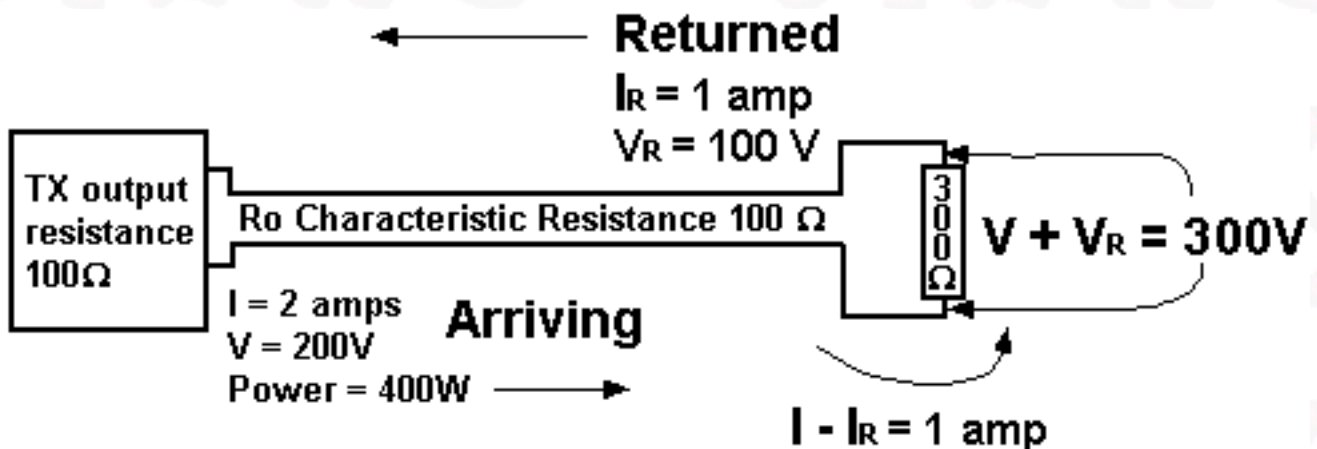
AND if we have incident power into the antenna as 100w and 75 Reflected power back to the transmitter RETURN LOSS = $100/75 = 1.333$ a LOW RETURN LOSS.

Understand that a low SWR equates to a high return loss and a high SWR equates to a low return loss.

You are aware, or should be that a low SWR means very little of your signal is being reflected by a mismatch in the antenna / feeder system and vice versa. So take a look at the following examples.

If the load is replaced by an open circuit, then no power is consumed and 100% of the INCIDENT POWER is reflected, and there is NO RETURN LOSS.

Let's look again at a diagram that you saw earlier in the section on SWR.



Power arriving is $200\text{v} \times 2 \text{ amps} = 400 \text{ Watts}$

Power Reflected is $100\text{V} \times 1 \text{ amp} = 100 \text{ Watts}$

The reduction in the power arriving to the power reflected is $100 / 400 = 25\% = 1/4$ or we can say 6dBs, this is the return loss at SWR of 3:1

If we try Power Reflected / Power arriving as $16 / 400$ we get $1/25$ or 4% and the new RETURN LOSS becomes 14dBs and the SWR works out to be 1.5 :1, a better performance.

So from this you can see that a **HIGH SWR and a LOW RETURN LOSS is BAD** and a **LOW SWR and a HIGH RETURN LOSS is GOOD**. Seems a crazy way of looking at things but that what you have to learn !!!

AND LASTLY on Return loss the answer is normally expressed in dB but as you do not have to do any maths on this point just be aware that answer would be in dB and not as a unit mentioned above !!

So remember the Higher RETURN LOSS in dBs becomes, **the better the performance** of the feeder and aerial system.

SWR return loss and Reflected Coefficient

SWR return loss and Reflected Coefficient are all related functions, RETURN LOSS is much more convenient to use in assessing systems performance, as manipulation in dBs is simple and especially at microwave, power meters are much used.

NOTE: Reflected coefficient is the ratio on INCIDENT WAVE VOLTAGE (or CURRENT) to the REFLECTED WAVE VOLTAGE (or CURRENT).

It can be shown that it is equal to $\frac{R - R_0}{R + R_0}$ in our example above and that it is equal to $\frac{V_R}{V} = 1/2$ (or $(300-100)/(300+100) = 1/2$

5d.3 Understand that the feeder loss will reduce the SWR and increase the return loss at the transmitter.

Recall that Return Loss at transmitter = Return Loss at antenna + 2 x (feeder loss)

If we have a system where there is no feeder loss and the match is perfect then 100W from the TX will be 100W at the antenna.

But nothing is perfect so lets us now assume that we have 26dB from the TX and a mismatch so we have 3dB reflected.

so from this equation :

$$\text{RETURN LOSS} = \frac{\text{INCIDENT POWER into load}}{\text{REFLECTED POWER back to the transmitter}}$$

$$\text{RETURN LOSS} = 26 / 3 = 8.6\text{dB}$$

But if the feeder has a loss of 6dB then :

$$\text{RETURN LOSS at TX} = 8.6 + (2 \times 6) = 17.2\text{dB}$$

Next

[Antenna matching units](#)

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INDEX[Introduction](#)[Amateur Radio](#)[Licensing Conditions](#)[Technical Aspects](#)[Transmitter & Receiver](#)[Feeder & Antenna](#)[Propagation](#)[E M C](#)[Operating Practices](#)[Safety](#)[Measurements](#)**Bredhurst Receiving and Transmitting Society**[Feeder & Antenna](#)**Syllabus Sections:-****5e Antenna Matching Units**

5e.1 Understand that AMUs (ATUs) can "tune-out" reactive components of the antenna system feed-point impedance (before or after the feeder) and can transform impedances to an acceptable resistive value.

The main purpose of an ATU is to present to the Transmitter at its aerial socket with a resistive load of the correct impedance.

The Antenna Matching Unit or antenna Tuning Unit as it was first explained to you in the Foundation Course [Click here to check back](#) and again in the Intermediate Course [Click here to check back](#).

You are aware that an AMU (or ATU same item) does not actually tune the antenna, that can only be achieved by altering the physical dimensions of the antenna.

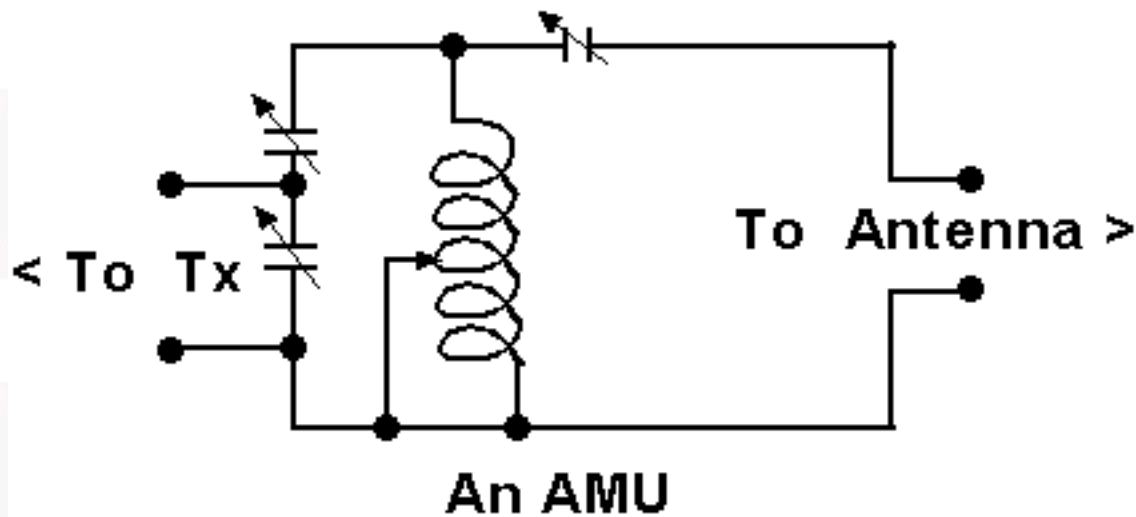
What can an AMU achieve ?

The AMU as this level of amateur radio prefers to use can:

- can "tune-out" reactive components of the antenna system feed-point impedance (before or after the feeder) and
- can transform impedances to an acceptable resistive value

How does it work ?

In side an AMU is generally a large coil or two large coils that can be "tapped" and a variable capacitor of several variable capacitors.



By careful manipulation of the "tuning controls" the inductor(s) (coil(s)) can "tune out" reactive components of the antenna system feed-point impedance and transform impedances to an acceptable resistive value.

As there are parallel tuned circuits in the AMU it can also filter out unwanted harmonics of the wanted frequency. Further parallel tuned circuit can develop high voltages and current passing through the components so care has to be taken in the selection of particularly the capacitors that they will not break down or "flash over" - the wire of the inductor needs to also be of a substantial size.

Can an AMU tune all antennas ?

Quite simply No !! Whilst you do not have to know the ins and out of exactly what are the limitations and how do they come about - you do have to know that the AMU can match a fairly wide range of impedances mismatch to the usual 50Ω output from the transmitter but there are limits to the range.

Understand that if the AMU is located at the transmitter, it will have no effect on the actual SWR on the feeder between the AMU and antenna.

Where can the AMU be used ?

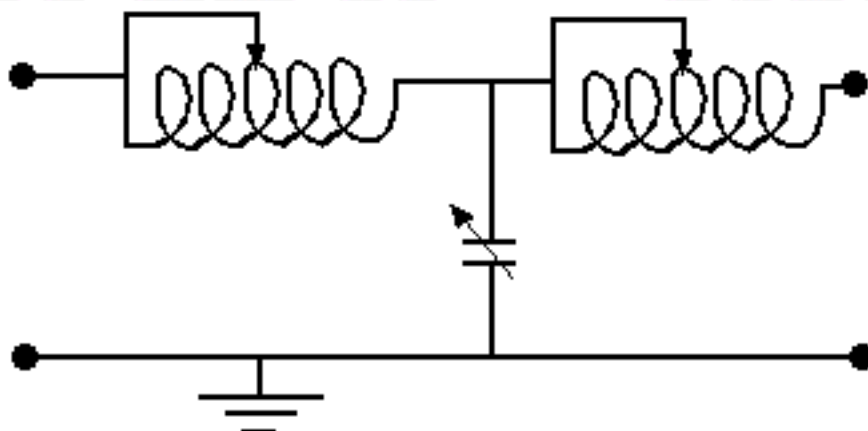
The AMU can be placed near to the antenna or near to the Transceiver.

It should be obvious to you that if it is placed at the Transceiver end of the feeder then the AMU can have no effect on the mismatch all the way down the feeder but will merely present to the transmitter a correct load. Further with a long feeder run and in consequence high SWR in the feeder, the feeder losses will also be greater.

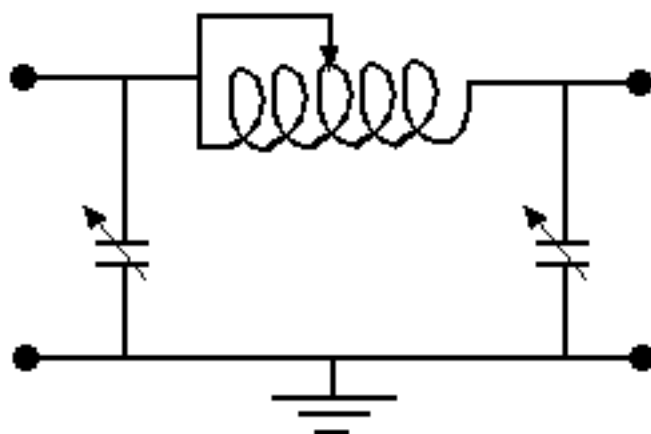
Thus where possible it is best to place the AMU at the load (the antenna) and use a feeder that has an inherent impedance the same as the transmitter.

Identify typical AMU circuits (i.e. T, Pi and L circuits).

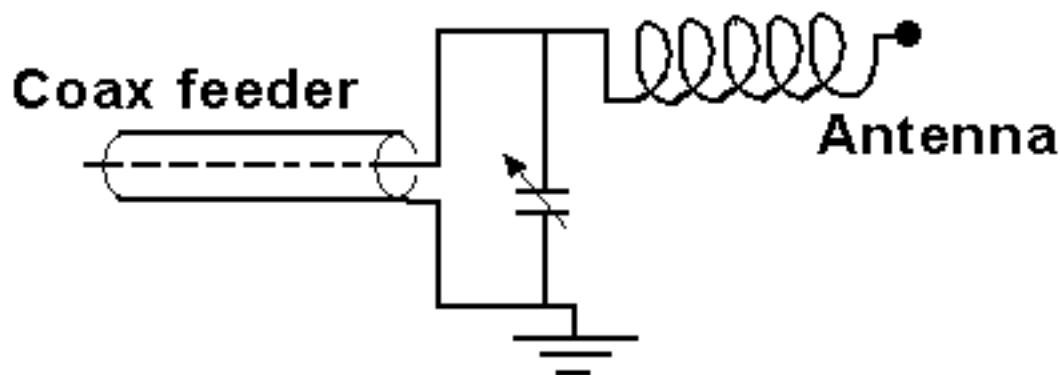
The AMU can come in various forms T, Pi and L styles and you have to be able to identify the types. If you look closely you will note that the "T" type looks like a "T", the "PI" type like the Greek letter " π " and the last one "L" like an inverted "L".



AMU "T"



AMU "PI"
or AMU
" π "



AMU "L"

You have to be able to distinguish between the various circuit diagrams.

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Advanced
Radio Amateur
Licence Exam

There are 3 questions in the exam on this topic.

Syllabus Sections:-

1. [Electromagnetic radiation](#)
2. [Ionosphere](#)
3. [Ground wave](#)

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Bredhurst Receiving and Transmitting Society**Propagation****Syllabus Sections:-****6a Electromagnetic Radiation**

6a.1 Recall that an e-m wave comprises both an (E) and (H) fields in phase, at right angles and at right angles to the direction of travel.to each other.

Recall that in circular polarisation , the polarisation of the wave rotates as it propagates, either a right-handed (clockwise from behind) or left handed polarisation.

This circular patterns of radiation is caused by the style of the antenna. The antenna instead of being a dipole or a vertical is an antenna that is a coil as shown in the animation below.



Let us say the the transmitter is connected to the left hand end. Then the signal makes it way along the antenna and then the diagram shows a break to indicate that the signal is radiated into the atmosphere and then is "collected" by a similar antenna which is coiled in the same direction - proved by looking at the diagram prior to the break appearing.

The polarization is determined by the direction of rotation as viewed from behind. That rotation towards the right is called right hand polarization that towards the left is called left hand polarization.

The concept that the antennas are wound in the same direction you will find is best to understand by winding a piece of wire around a pencil. Wind it on clockwise and then when you look at either end each winding will look in a clockwise direction.

Recall that this is often used for satellite communications where the orientation of the satellite is indeterminate.

This type of antenna is often used in satellite communication when the actual orientation of the satellite's antenna will not be known but it also has a helical antenna.

Recall that the transmit and receive antennas should have the same polarisation.

So whilst the Tx and Rx antennas might both be helical they must both be wound in the same direction else large losses between the TX and Rx signals occur.

6a.2 Recall that under free space conditions e-m waves travel in straight lines and spread out according to an inverse square law of power flux density and that the field strength, measured in volts/metre, drops linearly with distance.

Numerical calculations required at item 7c1 only.

In free space the electric and magnetic waves travel in straight lines and spread out.

This spreading out causes the signal strength to lessen according to an inverse square law of power flux density - which put simply means that the same amount of signal is covering a greater amount of space and thus the Rx'd strength will be less.

This also relates to the field strength dropping with distance and its drop is linear.

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Bredhurst Receiving and Transmitting Society**Propagation****Syllabus Sections:-****6b Ionosphere**

6b.1 Understand that the ionosphere comprises layers of ionised gasses and that the ionisation is caused by solar emissions including ultra-violet radiation and charged solar particles.

Recall the ionospheric layers (D, E, F1 and F2) and approximate heights.

FACT : Ionisation only takes place during the daytime.

Why ? Because that is the time when the sun can be shining !! It is the effect of the sun's radiation which ionises the layers of gasses in the ionosphere.

In the Intermediate Licence Course you saw the following chart. Note that the chart only shows layers D E & F.

Layer	Approx Height
F	400 kms
E	Varies
D	70 kms

For this Advanced course you need to know that the F layer during the daytime divides into two layers F1 and F2 and recombines again at night. Below is an updated chart giving more information than previously shown above.

Layer	Approx Height above earth	Ionisation level	Comment
F2 F1	300 - 400 kms 200kms	Highest	These layers only slowly loose ionisation during the night - used for the long distance communication single hop by F2 reflection is about 4000kms.
E	about 120 kms	Medium, but can be highly ionised due to solar burst of radiation	Quickly disappears after dark and can reflect frequencies up to say 15MHz but when highly ionised provides Sporadic E propagation of 10 - 2m bands.
D	70 kms	Low / weak	Becomes only weakly ionised and absorbs lower frequency below say 4MHz, has less effect in winter due to lower ionisation.

The ability for your radio waves in the frequencies 1 to say 70MHz to reach long distances is due to a single or several reflections from the "ionised" layers and then the earth's surface using the F layer at night and the F1 and F2 layers during the daytime.

The gasses of the F1 and F2 layers is ,during daylight, partially ionised by the sun's rays (radiation), that is that some of the molecules of air are converted into ions and free electrons and at night there is a slow recombination of the ions and electrons which then form the F layer.

Nothing is certain about the amount of ionisation that occurs. The amount of ionisation caused by solar emissions including ultra-violet radiation and charged solar particles has the following variation :-

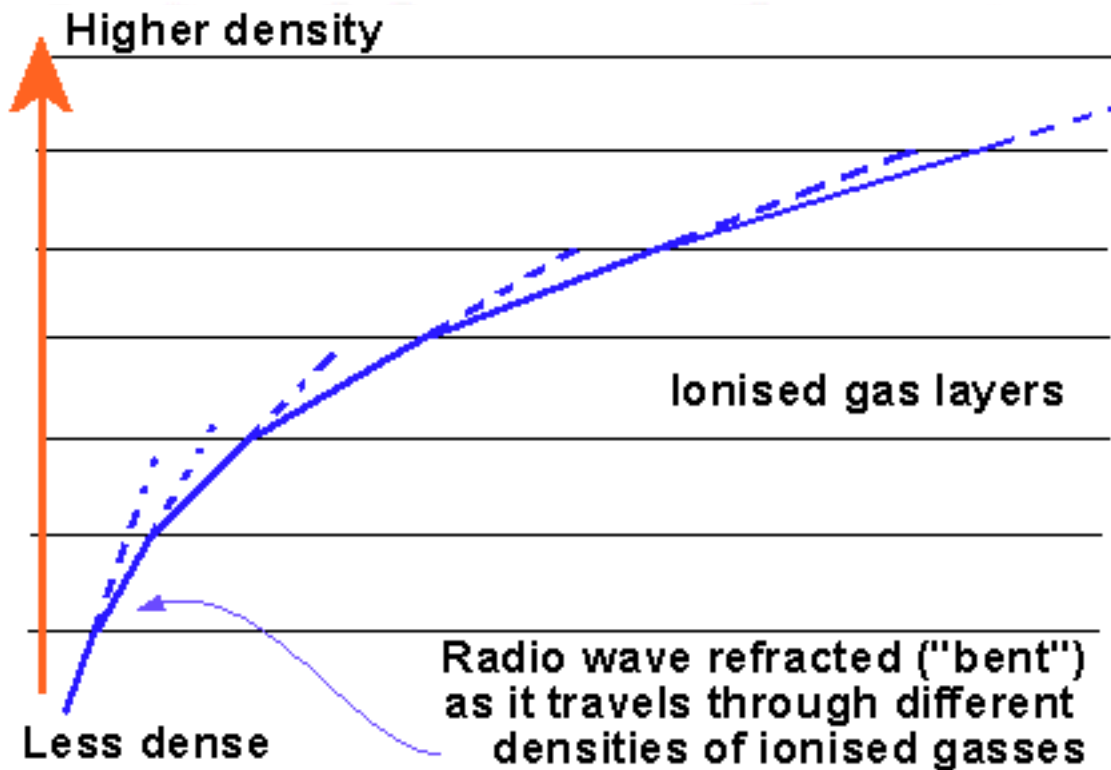
- the height of the layers
- from day to day
- season to season
- amount of sun spot activity.

6b.2 Recall that the E layer can refract (reflect) radio waves and that sporadic-E is caused by areas of highly ionised gas that can refract waves in the VHF band. Recall that the E layer supports single

hops up to about 2000km.

Is it refraction or reflection ?

It is the refraction of the radio waves as they travel through changing densities of ionised gases that cause the radio wave to be bent and this can occur to such an extent that the signals are refracted back to earth. With this amount of refraction it appears as if the wave are reflected. So what appears to be reflection is many refractions or bending the radio waves.



This same bending effect happens at all changes in densities whether it is a glass prism where there is an air to glass layer, or in a pond where there is an air to water layer. The bending effect occurs at the separation layer of densities and this may happen hundreds of times in the ionosphere.

Just like water there will come a time when the signal does not continue through the densities change layer but is in fact reflected and this is called "total internal reflection" and is the point at which the radio wave starts its return journey to earth.

During the summer months regions of intense ionisation of the E layer of the ionosphere, which allows much higher frequencies to be reflected (up to 150 Mhz) which normally pass straight through the ionosphere.

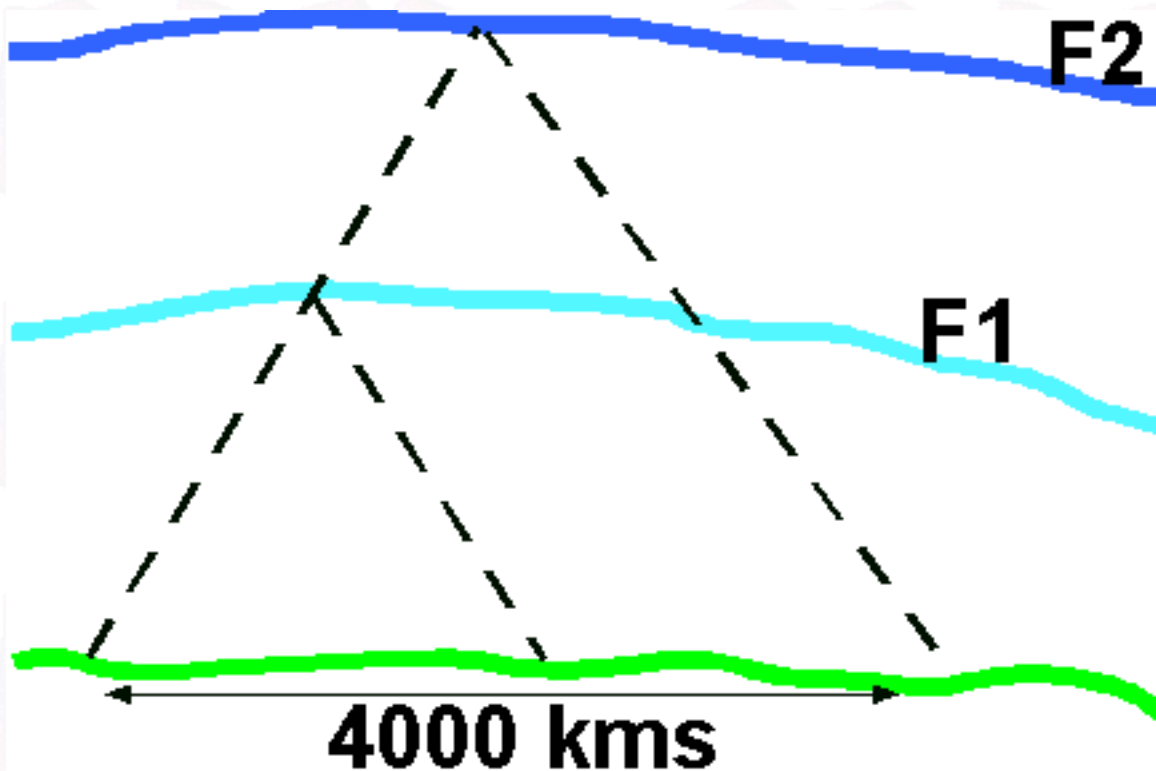
The SPORADIC E season can open up the 50, 70, and 144 Mhz bands to some rare Dx with extremely strong signals but deep fading (QSB) so the length of the QSO must be kept to a minimum.

The sort of distances that E layer propagation can achieve is about 2000 kms.

6b.3 Recall that the F2 layer provides the furthest refractions for HF signals (about 4000km) and that the F layers combine at night.

Recall that multiple hops permit world-wide propagation.

It is the F2 layer that provides the greatest distance at about 4000 kms as it is the highest level of the ionosphere that aids propagation. See the diagram below.



From the diagram you can see that the distance covered by reflection from the lower F1 layer is less than the higher F2 layer for the same radio signal transmission.

It is by multiple hops, reflections between the ionosphere and the ground or sea that enables worldwide communication on the HF bands.

6b.4 Understand how fading occurs and its effect on the received signal.

There are two types of fading that can affect radio signals :-

Fade outs :-

- Sudden Ionospheric Disturbance (sid) and

- Ionospheric Storm condition.

Fading

- Interference fading
- Polarisation fading
- Absorption fading
- Skip fading

Fade outs

Sid (Sudden Ionospheric Disturbance) is apparent from sudden disappearance of signals from a few minutes to several hours DURING DAYLIGHT HOURS ONLY. These occurrences are found to be due to eruptions on the sun. These affect frequencies below 30MHz.

The second type of fade out happens when ionospheric storm takes place. At this time the F layer's ionisation is much reduced and the height above ground varies quite considerably. The ionospheric storm originates at the same time as the faster moving radiation which causes sid and can take two to three days to reach the IONOSPHERE. With them come magnetic storms and this affected the earth's magnetic field. The onset of the ionospheric storm is slow, taking several hours to reach a maximum and the resulting fades outs can last for about two days but diminish in intensity.

Fading

This general fading is apparent when operating with propagation through the ionosphere and through the troposphere.

This type of fading as opposed to the fades out is used to describe the rapid variation in signal strengths received with periods of a few minutes to a few seconds or less.

Interference fading

Interference fading is due to two or more signals from the same transmitter being received that have traveled by differing routes. Thus the signal received is a resultant signals from all the various paths. At times the resultant signal is aided by other signals received but at other times the signal is degraded by another signal which leads to significant changes in received signal strength level.

Polarization fading

Polarization fading is when the radio waves are passing through the ionosphere they are being constantly changes in their polarization especially by the earth's magnetic field. When the signal is of a different polarisation to that of the receiving antenna there will be significant loss of signal strength.

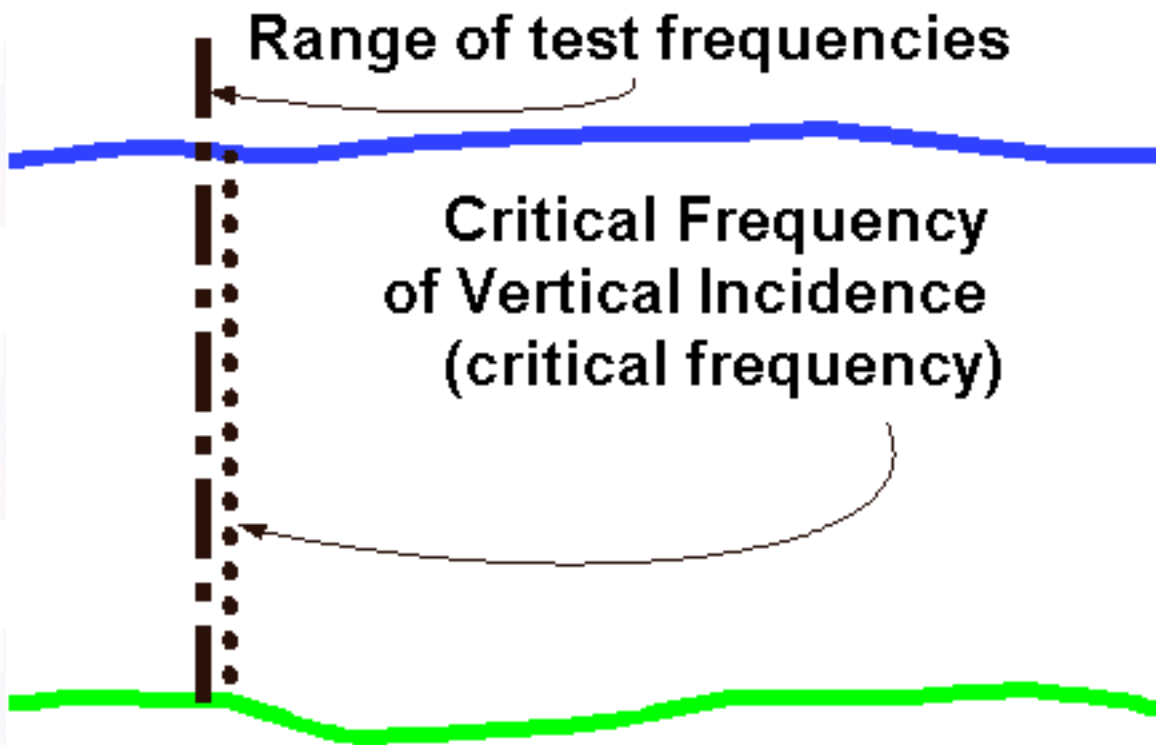
Absorption fading

Absorption fading is due to various amounts of absorption which take place in the ionosphere and troposphere and the period of fading is longer than for interference or polarization fading. A SID (Sudden Ionospheric Disturbance) is an extreme case of absorption fading.

Skip fading

Due to the changing heights of the layers the skip distance will be varying in accordance with the changing levels. If the Receiver is just at the edge of a skip zone the received signal can then rise and fall according to the skip distance. The effect of this type of fading is a very deep and very abrupt fading to a point where the signal will disappear and just as suddenly return to a good signal level.

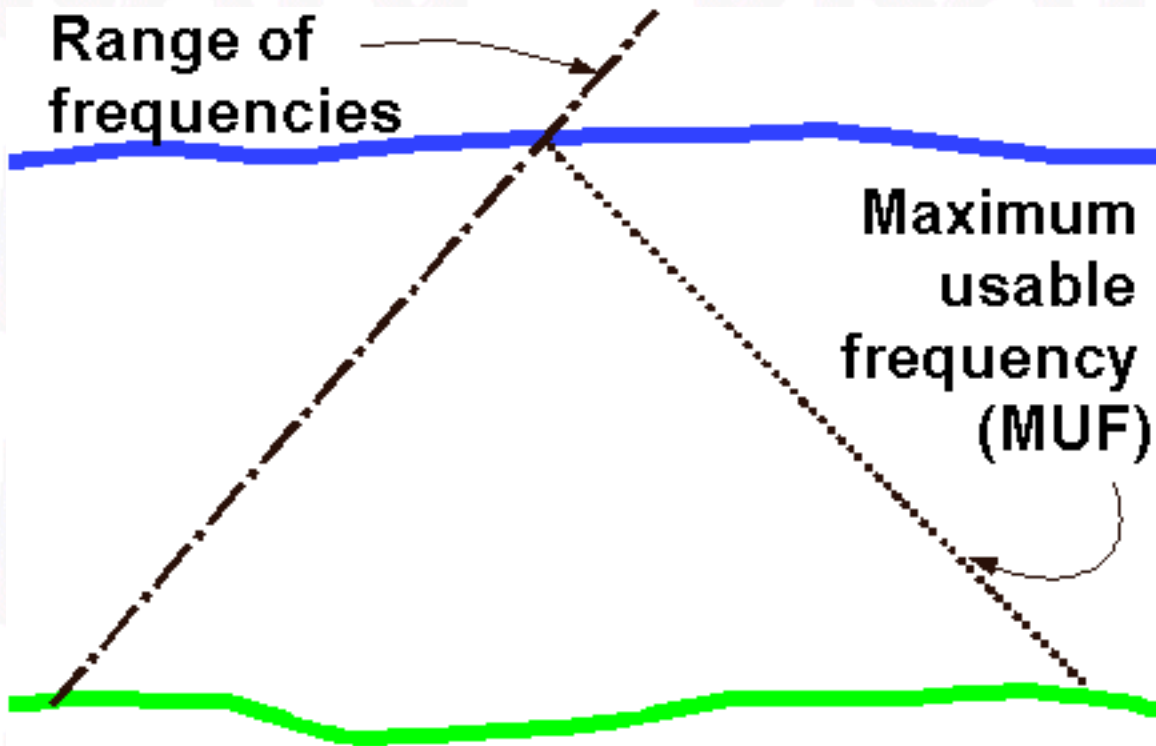
6b.5 Recall that the highest frequency that will be refracted back to the transmitter is known as the Critical Frequency of Vertical Incidence (critical frequency).



If a range of frequencies from say 1MHz to 144MHz are transmitted towards the ionosphere then a frequency will be transmitted where no higher transmitted frequency signal is reflected to be heard on earth.

This maximum frequency is called the Critical Frequency of Vertical Incidence or just Critical frequency.

Recall that the highest frequency that will be refracted over a given path is known as the 'maximum usable frequency' (MUF) and that this will be higher than the critical frequency.

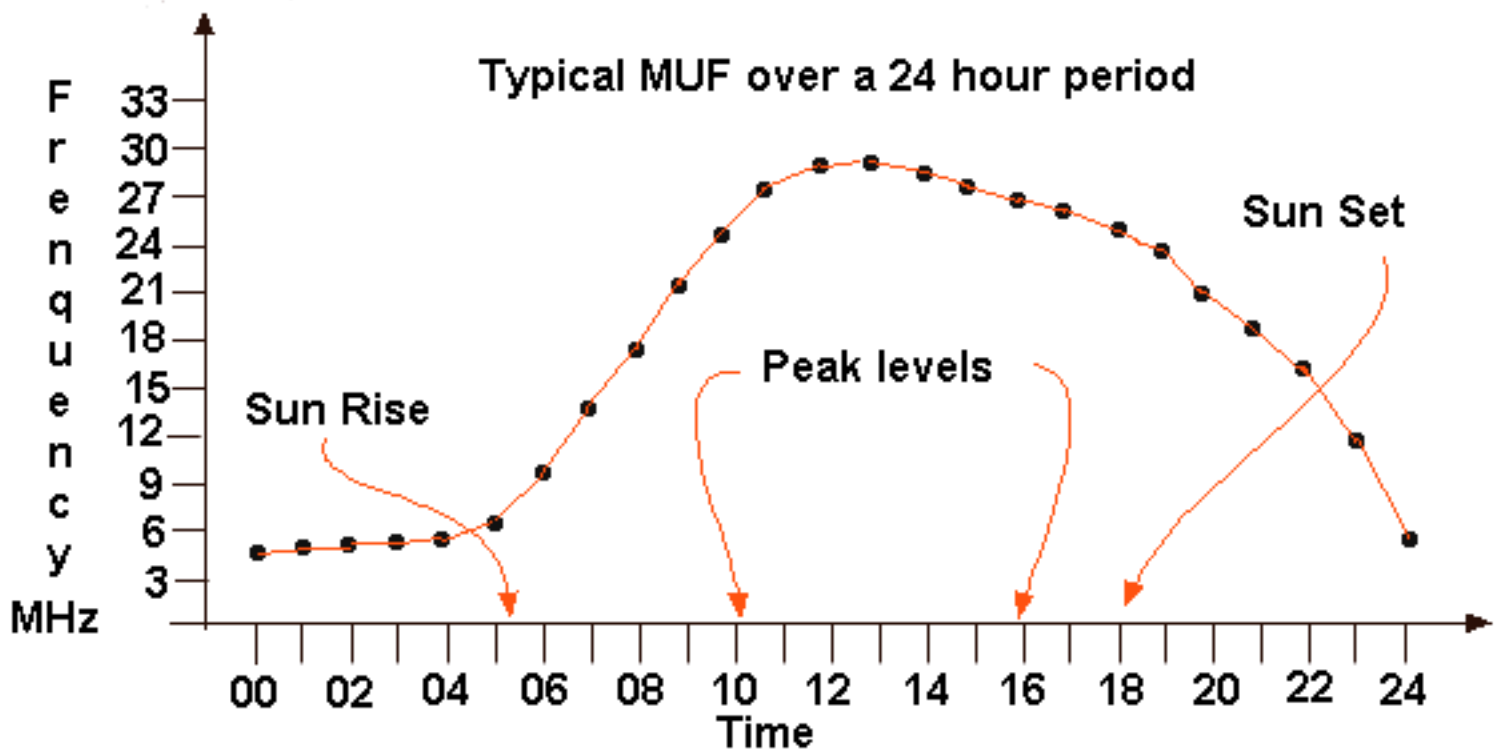


The Maximum usable frequency (MUF) is just what it says it is. It is the maximum frequency that reliable communication can take place over a known given path.

The MUF is in fact a higher frequency than the Critical Frequency due to the fact that the critical frequency is a measure of what can be reflected when it meets the ionosphere at right angle to the layers whereas the MUF is meeting the ionosphere at a lower angle.

Thus higher frequencies than the Critical Frequency will continue to pass into outer space until the angle of at which the signal meets the ionosphere is low enough to reflect the signal. Similarly if there is a known path then the frequency can be raised higher than the Critical Frequency until it is not received at which point the MUF has been reached.

Recall, in general terms how the MUF varies over the 24 hour cycle and the variation in MUF from summer to winter.



The diagram is a most simplified version of what happens to MUF, which are approximate only, over a 24 hour period without consideration of any special sun activity which can lead to enhanced propagation.

The pattern to understand is that the MUF remain low until the sun rises and then there is a relatively steep increase in MUF until midday the highest point of the sun and then the decline in MUF is at a slower rate than in increase until sun set and then the decrease accelerates again until it reaches it lowest level about midnight.

The peak levels of MUF are between 10:00 and 16:00 hrs Summer and Winter but in the Summer the MUF will reach as higher frequencies than in the Winter as the sun's rays are weaker in winter.

6b.6 Recall that the D layer tends to absorb the lower radio frequencies during daylight hours and that it tends to disappear at night.

Understand that if the D-layer absorption occurs at frequencies higher than the MUF, then no ionospheric propagation can occur.

The D layer is the layer that absorbs the lower radio frequencies and is a layer that disappears at night.

The 1.8MHz band is particularly adversely affected by absorption in day light hours by the D layer and thus this band is of primary use at night.

The 3.5MHz band is also adversely affected but not to the extent of the 1.8MHz band with daylight range of signals limited to about 250 miles where as during the night signals can reach half way round the world.

it must be noted that if the D layer is absorbing frequencies lower than the MUF then no ionospheric propagation can occur as the signals cannot reach the upper layers.

6b.7 Recall which amateur bands will be "open" to support ionospheric propagation at different times of the day and year.

Questions will be asked on 3.5 and 21MHz propagation over the 24 hour cycle.

The 3.5MHz band is the night time band for propagation as during the day distance is limited to about 250 miles.

The 21MHz band can be considered under normal propagation as the daylight band as it opens shortly after day break and closes shortly after sun set.

So these two bands effectively mirror each other for propagation purposes.

Next [Ground wave](#)

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6c.1 Recall that the ground wave has a limited range due to absorption of energy in the ground and that the loss increases with increasing frequency.

Ground waves are those radio waves that are merely propagated from the transmitter and do not rely upon any reflection from the ionosphere and are those that just hug the earth. By doing so their range is severely restricted due to the absorption of the radio energy into the ground and the losses increase with increasing frequency.

the ground wave has its uses in what is called Radio Direction Finding where the location of a transmitter is located by reference to the direction of the ground wave signal.

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Radio Amateur
Licence Exam

There are 8 questions in the exam on this topic.

Due to slight changes in the syllabus issued in Dec 2004 updating of these sections is still required.

The **Maths** symbols indicates the parts of the syllabus where maths involved. Please do not be put off by this as the course work will help you to fully understand the maths needed for the exam.

Syllabus Sections:-

1. [Routes of entry into TV and radio sets](#)
2. [Filters](#)
3. [Field strength](#) **Maths**
4. [Feeders and antennas](#)
5. [Mobile installations](#)
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Bredhurst Receiving and Transmitting Society**E M C****Syllabus Sections:-****7a Routes of Entry into TV and Radio Sets**

7a.1 Understand that amateur transmissions can be picked up by the intermediate frequency stages of TV and radio receivers and identify related amateur transmissions.

The IF stage frequency in a TV is often about 36 MHz +/- thus an amateur transmission on the 18MHz band could be doubled in the TV and present patterning on the TV screen or some other visual interference.

In an FM broadcast radio receiver the IF frequency is about 10.7MHz. This could then be susceptible to direct pickup from the 10MHz band and the third harmonic of the 3.5MHz band.

Understand that television receivers and most broadcast radio receivers employ superheterodyne circuits and recall some typical frequencies used in radio and television receivers; i.e. 470-854MHz TV r.f. 33-40MHz TV i.f., video baseband 0-5MHz Radio i.f.s typically 455-500kHz and 10.7MHz.

If the intermediate stage is badly screened then you can get amateur radio transmissions break through into TV and radio receivers. Often manufacturers are not making equipment that has sufficient screening to take account of such amateur transmission in fact there can be no screening at all!

If you are operating using AM it is likely that the person using the TV or radio will be able to hear what are saying. If you are using CW then the breakthrough will be minimum and the person using the equipment would not be able resolve when it is. SSB will be less intelligible than AM.

There can also be pickup in the audio stages of TVs and radios where the first audio amplifier stage acts like a detector and demodulates your transmission.

The IF frequencies that are used in TVs and radios are generally 33 - 40MHz and whilst we do not have any transmission on those frequencies allocated of the amateur bands it could be that the sheer weight of RF could break through into the IF stage.

The UHF radio frequencies used for the for the channels 21 to 68 are between 470 to 854MHz. Whilst again there are no amateur transmissions in those bands but high powered RF can "shock excite" the first RF amplifier in the TV tuner and cause cross modulation but virtue of sheer breakthrough so we need to keep out any signals above and below the TV bands but the use of high and low pass filters.

Further in a TV set all the video frequencies that come out of the video demodulator will lie in the range 0 to 5MHz and this means that lower amateur bands eg 1.8MHz and 3.5MHz signals could again break into the video amplifiers and that would cause coloured herring bone effect on the screen.

THE CURE for TVs

Keep the RF signals out of the TV for all of those problems.

You would therefore suggest to the neighbour that as you work HF bands that they fit a HIGH pass filter at the aerial socket on the TV so that it would allow the high TV frequencies to pass into the UHF tuner. It is difficult to add screening to any TV as you have to go inside the TV and if anything went wrong the neighbour would think that it was your fault.

You cannot re-engineer the TV so you are reliant upon the manufacturers to do a good job in the first place.

You would have of course have checked that it was you signals causing the problem by reducing power to such an extent that the problem went away - then fit the filters and increase power again to a level where no problem occurs with the TV.

THE CURE for radios

On radios break through can occur into the IF can occur - on Medium Wave the IF is 455 to 500kHz and on the FM band it is usually 10.7MHz - BUT thankfully breakthrough is rare and see also below.

[Understand the potential for second channel \(image frequency\) interference.](#)

What is a problem is second channel interference (image frequency) where you get a transmission twice the IF removed from that which the neighbour is listening to, and that would be the offending frequency. It is difficult to remove second channel interference as it means that it is a fault of the receiver and what you would have to do is add further RF filtering - you cannot re-engineer a broadcast receiver all you can do is move frequency so that second channel IF frequency does not break through and interfere with the station that the neighbour wishes to receive.

7a.2 Recall that amateur transmissions can enter the r.f. stages and cause cross modulation and/or blocking.

Recall that cross modulation occurs when strong varying transmissions (e.g. a.m., s.s.b. or c.w. signals) cause the television a.g.c. to vary its gain in sympathy with the modulation.

Recall that blocking (also known as desensitisation) occurs when strong constant transmissions (e.g. f.m. signals) cause the television a.g.c. to reduce the gain.

Crossmodulation in the RF stage of a TV or Broadcast Receiver.

When an RF stage of a broadcast radio is presented with both :-

1. a very strong signal from local amateur transmission together with
2. a Broadcast signal

the amateur signal will very often be higher in amplitude than the broadcast signal the amateur signal modulates the broadcast signal or it can **desensitised (also known as blocking)** the RF stage so that the broadcast signal cannot get through.

If the RF stages are presented with a strong local FM signal there is a constant carrier and the broadcast receiver may be **desensitised (blocked)** as the all the while the FM transmission is there as the FM signal impresses it modulation on the wanted signal and overloads the receiver.

If the RF stages are presented with an AM signal then the modulation may be heard as the gain of the RF amplifier in the receiver will change as the AM carrier changes as the AM signal impresses it modulation on the wanted signal.

If the RF stages are presented with a CW signal then they may hear a "ticking" in the receiver as the Cw signal impresses it modulation on the wanted signal.

The cure ?

Cross modulation can usually be prevented by installing some form of HIGH pass filter to keep the amateur signals away from the TV or radio input if you have and aerial going to the radio but very often it is just a whip aerial.

7a.3 Understand that mast-head amplifiers are frequently wide band devices and can suffer from cross-modulation and overload (causing intermodulation and blocking), and may also overload the TV.

The mast-head amplifiers used by many who receive TV via an antenna are probably one of the most difficult areas of EMC to remedy. The broadband nature of the mast-head amplifier will readily suffer from overloading which in turn can overload the TV.

There can also be cross-modulation where the strong RF signal from your equipment enters the amplifier and then gives the result of varying the "gain" of the TV signal in sympathy with your RF signal.

7a.4 Recall that amateur transmissions can enter audio stages via long speaker leads or other interconnections.

Not only can signals enter equipment from antenna leads but also via speaker leads in fact any interconnecting cable between one part of equipment and another can and sometimes does act as an antenna bringing the unwanted signal from your RF transmission into audio equipment.

In addition to audio equipment an alarm system also has long leads interconnection items and these too can act as an antenna. Both audio and alarm systems are intended to amplify small electrical signals and can therefore contain high gain amplifiers which can be prone to interference from almost any RF source.

Understand that any pn junction within an electronic device can rectify unwanted r.f.

In the Intermediate course you were introduced to the crystal set. [Click here to check back.](#) The crystal set has a simple diode to rectify the RF signal. A diode as is explained in this course ([check here](#)) is a PN junction. Because the PN junction can rectify the RF in a crystal set it can and sometimes does in a TV or radio receiver.

7a.5 Recall that passive intermodulation products can be caused by corroded contacts in any metalwork, including transmitting and receiving antennas and supports and guttering.

The diode effect, also called the "rusty bolt effect" can occur and due to rectification give intermodulation products. This occurs when corroded piece of metal are linked together with rust or corrosion in none ferrous metals between in any metalwork, including transmitting and receiving antennas and supports and guttering.

7a.6 Understand that ghosting is caused by external reflections and does not normally indicate a fault in the TV receiver.

Some effects seen on a TV screen are NOT EMC problems, but your neighbour will still think you are the cause. The effect of a double image or "ghosting" on the TV screen does not normally indicate a TV fault but the TV is receiving two similar signals due to reflection off external items

such as buildings and other large structures for instance gas storage tanks or power station chimneys.

Next [Filters](#)

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At the present time there is no definitive circuit diagram recommended for this part of the course.

The simplest mains filter to fit is the "ferrite ring" where several turns of the mains cable is wound onto a ring or several rings stacked up - with the assembly being placed as close to the chassis of the equipment as possible.

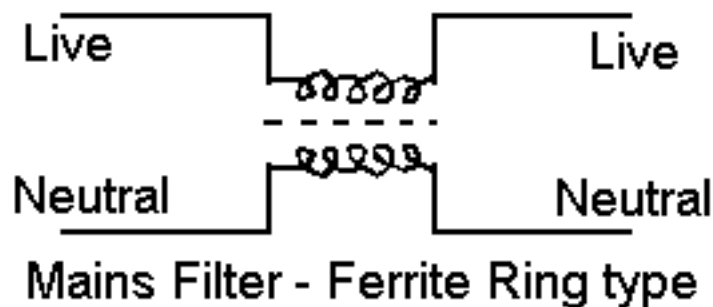
The ends of the cable should be kept apart and the turns on the ferrite only occupy about 2/3 of the diameter.

This filter is known as a ferrite ring choke. You were first introduced to the ferrite ring in the Foundation Licence course - [Click here to check back.](#)





Whilst here it is coaxial cable wound on the ring the principle is the same.



The diagram above is the equivalent circuit of the ferrite ring filter - note the earth core of the cable is not shown as it is only the live and neutral cores that would carry any interference into or away from the equipment.

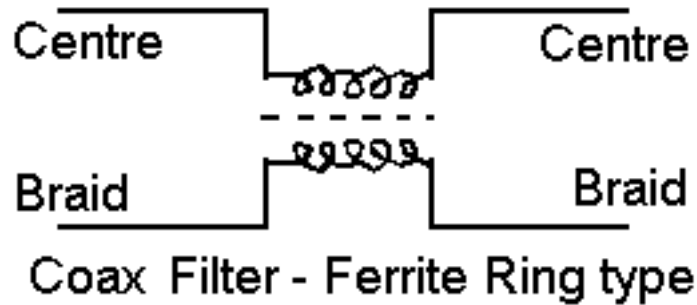
7b.2 Identify a typical circuit of a braid-breaking filter and a combined high-pass/braid-breaking filter. Understand their use.

The section is dealing with filters used on antenna feeds and NOT mains filtering.

Ferrite Ring

The braid breaking filter can also be the simple ferrite ring as shown above and you were first introduced to this ferrite ring in the Foundation Licence course - [Click here to check back.](#)

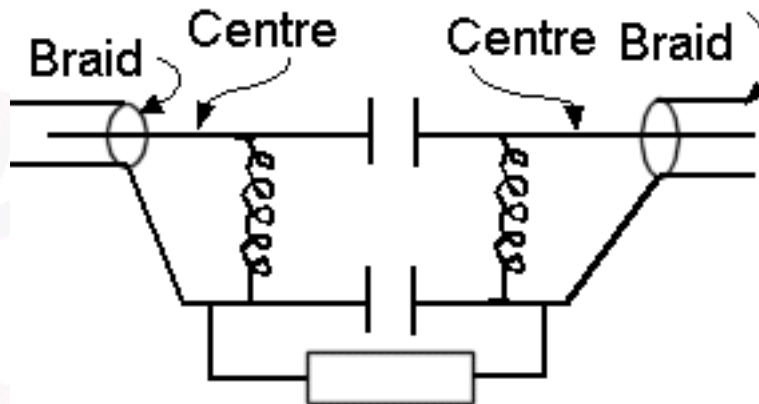
The circuit is similar to that above.



The ferrite ring may be the usual one you can buy at rallies but sometimes the ferrite is not "correct" for the frequency of the interference and a different "mix" of ferrite is required. More information on this, when you need it practically is available from the RSGB.

High pass/ braid breaking filter

The combined high pass/ braid breaking filter is more complex but is basically a high pass filter with a resistor across one of the capacitors to allow a continuous link for the braid through the resistor.



Each of the filters works to stop the unwanted signals and pass the wanted signals. They are placed as close to the chassis of the equipment as possible.

7b.3 Recall the use of ferrite beads in internal filtering.

Sometime the filtering has to be carried out inside the equipment. Here the "tiny" ferrite bead is actually used on a leg of a component or adjacent pcb track is broken and a bead and wire soldered in as a replacement.

The ferrite bead is acting as an RF choke just like it did when using the ferrite ring.

7b.4 Understand the use of notch filters including coaxial stubs as notch filters or traps in minimizing an unwanted signal.

A stub is connected to a feed line. (parallel to it) It can be a length of co-ax, (connected inner to inner, outer to outer when connecting to the feed line) or it can be a length of open wire feeder. ("left wire" of the stub to "left wire" of the feeder, right to right...)

Stubs are usually made to be an ELECTRICAL $1/4$ wavelength at the frequency of interest. $1/2$ and $3/4$ wave stubs can be used, but these are a) longer, and less convenient, b) more lossy, c) less "Q" and hence have a wider bandwidth (Although this may be desirable, and hence is the reason such longer stubs are used).

What happens at the far end of the stub is interesting. For odd $1/4$ wavelength stubs ($1/4$, $3/4$, etc) an OPEN circuit at the end results in (AT THE FREQUENCY OF INTEREST) a short circuit at the end connected on the feed line. And vice versa...

For EVEN wavelengths ($1/2$, 1 , $1 1/2$ etc) what happens at the end of the stub is what happens at the end connected to the feed line. Again, ONLY AT THE FREQUENCY OF INTEREST.

You can now see that it is possible to arrange for a transmitter to have a short circuited $1/4$ wave stub to be connected on its feed line. As it is shorted at the far end, then AT THE FREQUENCY OF INTEREST, the stub produces a very high impedance across the feed line, and has little/no effect. But at different frequencies, the stub can look like a short circuit, and cause a bad VSWR, causing those unwanted frequencies to be reflected back to the transmitter, and dissipated in the output stage. (And not sent to the antenna!).

The application for a receiver is that you have an OPEN end on the stub. This causes signals coming from the antenna (unwanted, strong, interfering signals, on a single frequency) to see a bad VSWR, and return to the antenna, and not be fed to the receiver. Typical application here is an open circuit stub cut for two metres, to stop, say 2M interference to an FM broadcast RX.

You have to be careful, because as I have stated above, stubs also work when $3/4$ wavelength long.

This means that you may find you use a $1/4$ wave stub on a 2M transmitter, hoping to stop the third harmonic on 70cms from being radiated. But that stub is a $3/4$ wave stub on 70 cms :-)

The trick is to cut the stub short, and retune with a trimmer capacitor across the end. The stub in the transmitter feed line then does its job on 2M, allows that through, but is no longer a $3/4$ wavelength on 70cms.

So it does not allow that through.

Practical application of shortening and tuning is to have a 2M 1/4 wave stub on a TV coax to keep 2M out of the TV. This will also stop signals on 720Mhz (5 times 144) as it will be a 5/4 length stub (1 1/4 wave). If this happens to be the TV channel of interest, you shorten the stub, and retune with the trimmer to 2M, and then the "overtone" is no longer on 720Mhz. It will be somewhere, but as long as it is not where the neighbour wants to watch a particular channel, all well and good. Of course, if he is trying to watch a channel on that frequency, you had better have no 5th harmonic from the transmitter anyhow!

Yes. If the bands are not "odd" harmonically related. (i.e. a 20M stub will assist when the nearby TX is on 40M, but see my earlier email for 2M and 70cms as this is an odd harmonic.

A stub is intended to work on one set of frequencies. Hence if it is working at the frequency of interest, it will "kill" or allow. If you are not in this ballpark, the stub will cause the feed line to see either an inductance, or capacitance, and you will get a bad VSWR. So no, you cannot use stubs on a feed line unless they are cut for the frequency involved. This means that you need to have a "T" piece in the coax, and connect the appropriate stub. In the case of a receiver, one stub per band, which will exclude the nearby transmitter on another band, BUT remember the nearby transmitter will be producing unwanted harmonics, which will be where you are trying to receive, so the stub will allow these through :- (Also, if you have a stub on the receiver, at 7Mhz, and the nearby TX is 21Mhz, the stub won't help, as it will pass odd multiples of its design frequency.

You can use more than one stub on a feeder when they are all cut for the same band. You make each an electrical quarter wavelength long and you space them along the feeder an electrical quarter wavelength. This arrangement works on one frequency, as a single stub does, but the attenuation of unwanted products is much higher :-)

You MAY be able to use a 144Mhz stub on an HF feed, but it will cause some VSWR. Remember, it will be short in length compared to the HF frequency, so effectively, you are connecting a capacitor across the HF feed line. A much better arrangement is to have a low pass filter for the HF RX. If a transceiver, you should have a low pass filter anyhow!

Another useful application for an open wire feeder/stub is to make a short circuited version to only allow the frequency of interest to pass. The far end from the feeder is shorted. And can be connected to earth. Useful lightning protection. Will work on 7Mhz and 21Mhz You can't do this with coax.

Stubs have other uses, mainly on open wire feeder. In this case, you can actually design the stub to tune the feed line, as it will add capacity/inductance. The trick there is to know how long it should be, and on what part of the feed line it should be connected!

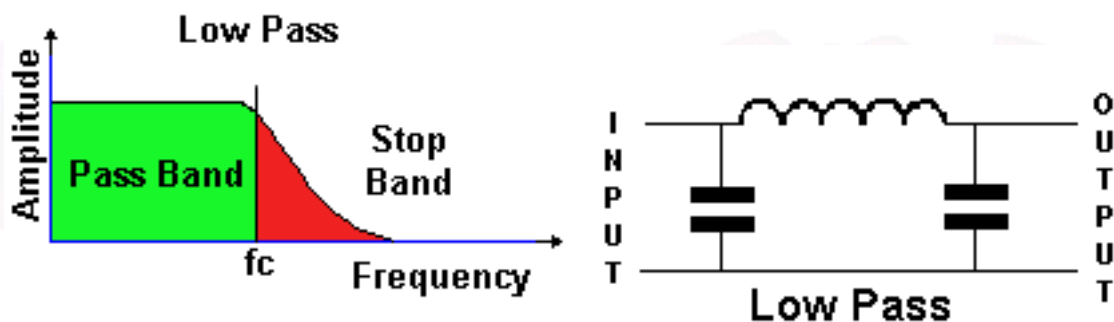
7b.5 Understand the use of high, low and band pass filters in improving the immunity of affected devices.

Filters must be used in equipment at the earliest part of the circuits and this is carried out in the design of the equipment.

You were first introduced to filters in the Intermediate course ([click here to check back](#))

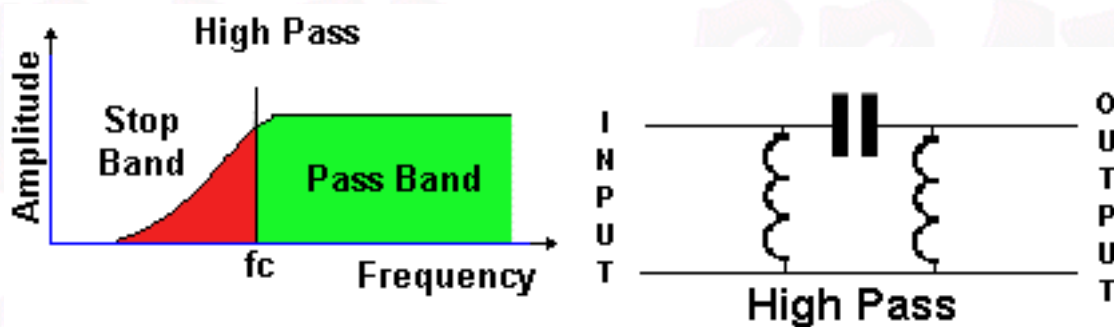
A low pass filter (LPF)

A low pass filter (LPF) is designed so that it passes frequencies that are lower than that of the stop band so in effect signals above the cut-off frequency (f_c) are reduced.



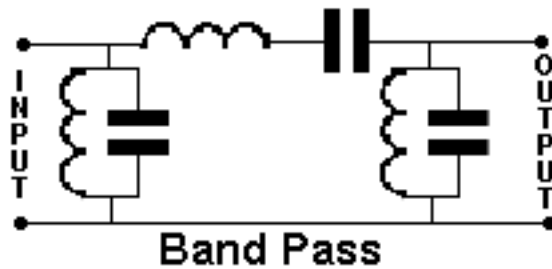
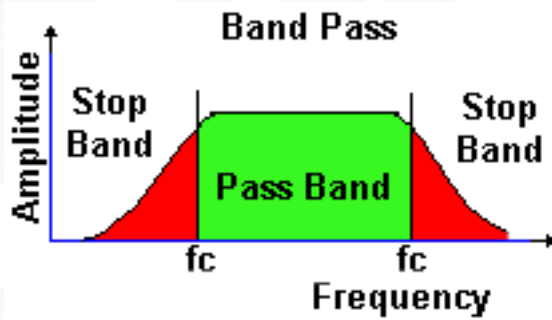
A high pass filter (HPF)

A high pass filter (HPF) is designed so that it passes frequencies that are higher than that of the stop band so in effect signals below the cut-off frequency (f_c) are reduced.



A band pass filter (BPF)

A band pass filter (BPF) is a combination of low pass and high pass filter that will pass a range of frequencies in the pass band, any frequencies above or below this range are reduced. Unlike the LPF and the HPF, the BPF has two stop bands and two cut-off frequencies (f_c) at the meeting points of each of the stop and pass band.



with the use of filters remember that if one type is not sufficient then you can also use another in what is called a "cascade" of filters.

[Field strength](#) [Maths](#)

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7c.1 Recall that reducing field strength to the minimum required for effective communication is good radio housekeeping.

The greater the field strength the greater will be the likelihood of causing electromagnetic radiation that can cause problems to electronic equipment that cannot withstand higher levels of electromagnetic radiation. So working at the lowest power level and thus lowest electromagnetic radiation, compatible with acceptable communication level, **MUST** be the goals of all amateur radio operators what ever mode they are using. At some time you will come across the expression "That operator is an alligator - ALL mouth and no ears"

Recall and apply the formula for field strength given the ERP and distance from the antenna.

$$FS = \frac{7 \times \sqrt{ERP}}{d} \text{ V/m}$$

Diagram illustrating the formula for Field Strength (FS) in Volts per Metre (V/m). The formula is shown as $FS = \frac{7 \times \sqrt{ERP}}{d}$. Labels indicate: "Constant" points to the 7; "Effective Radiated Power" points to ERP; "Volts per Metre" points to the result V/m; "Distance from 'Radiating Source' in metres" points to d. A curved arrow labeled "Field Strength" points from the formula to the variable FS.

Field Strength can be defined as :-

The magnitude of an electric, magnetic, or electromagnetic field at a given point.

Field Strength is not frequency dependent

From the above you can see that the field strength is not frequency dependent but is related only to the ERP (effective radiated power) of the signal in WATTS and the distance in metres.

Example: If your transmitter has a power out of 100W to an antenna with a 2 times gain what will

be your Field strength at 2m in front of the yagi ?

From the equation $7 (\sqrt{2 \times 100}) / 2 = 49.797 \text{ V/m}$ [Click here for calculator key strokes](#)

Example: If your transmitter has a power output of 100W to an antenna with a 2 times gain what will be your Field strength at 2000m in front of the yagi ?

From the equation $7 (\sqrt{2 \times 100}) / 2000 = 0.49 \text{ V/m}$

By manipulation of the formula we can answer the question :-

Example: What ERP would be required to have a Field Strength of 1.5V/m at 25m ?

The rearranged equation is $\left(\frac{FS \ d}{7} \right)^2 = ERP$

Thus $ERP = (1.5 \times 25 / 7)^2 = 28.69 \text{ W (ERP)}$ [Click here for calculator key strokes](#)

THE FIELD STRENGTH METER.

By adding a small pickup rod (like a transistor radio aerial) to the tuned circuit of an absorption wavemeter, the meter may be used as a relative field strength meter, useful when checking antenna gain or directivity.

Next [Feeders and antennas](#)

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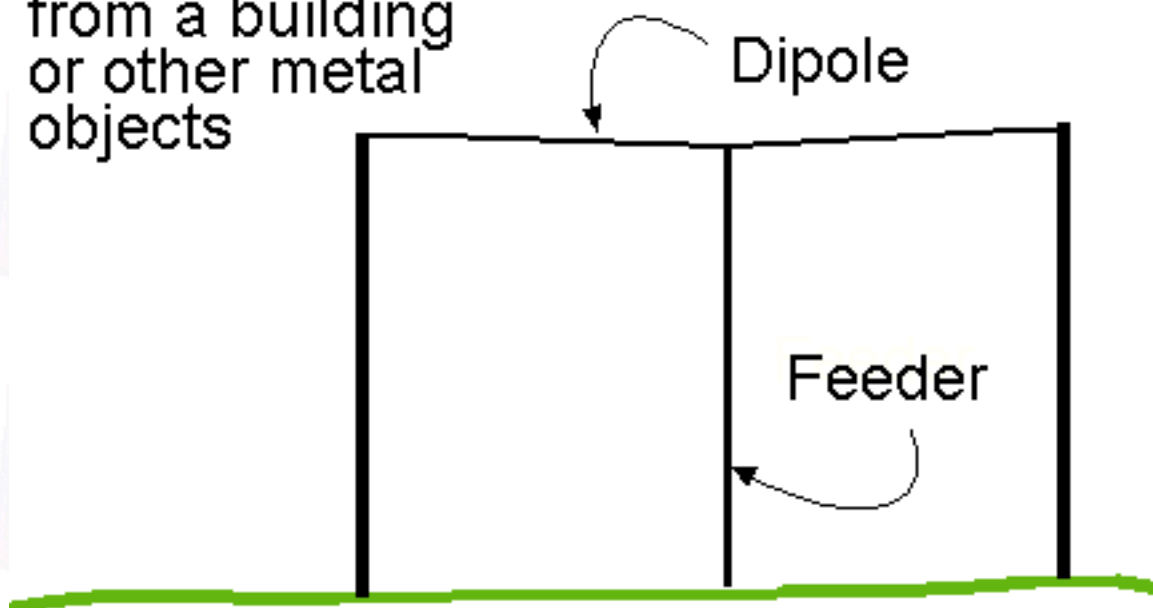
Bredhurst Receiving and Transmitting Society**E M C****Syllabus Sections:-****7d Antenna Tuning Units**

7d.1 Recall that balanced antenna systems tend to cause fewer EMC problems than unbalanced antennas. Recall that the feeder (balanced or unbalanced) should fall away from the antenna at right-angles to minimise coupling.

This part of the syllabus is to highlight the fact that the balanced nature of the dipole tends to minimise feeder radiation when fed with balanced feeder but it is important to note that the feeder **MUST** leave the antenna at right angles to the orientation of the antenna.

Usually the dipole will be supported on two poles or masts one at each end and the feeder will then drop away to the ground.

Keep antenna away
from a building
or other metal
objects



When using the dipole your aim is to maintain as far as possible the balanced nature of the antenna

- and its feeder.

- This sort of antenna arrangement then tends to cause least EMC problems.

- Next [Mobile installations](#)

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7e.1 Understand that EMC problems in motor vehicles can have serious safety implications and be able to identify suitable precautions

What is considered good practise for motor vehicles on roads also applies to motor boats on water.

EMC

Car and other motor vehicles rolling off production lines today are so much more sophisticated than even 5 years ago. Whilst 5 years ago installing a radio transmitter in a car was considered relatively simple that is not the case today. EMC with modern vehicles is an area that must be taken seriously

The modern vehicle has radio controlled systems for locking as just one example - overloading the system with your radio transmissions can cause failure of not only the locking systems but air bags and engine management systems to such an extent that it can cause the vehicle not to function properly or not to function at all.

Before trying to install your radio transceiver in your car can seek advice from the manufacturer.

General safety

There are several points to consider:-

Installation position of transceiver

The transceiver must be installed in such a way that it will not cause injury to persons in the vehicle in the event of an accident or whilst sitting in the vehicle or entering or exiting from the vehicle.

Installation position of cables

Similar to the transceiver but also be properly installed so that it does not interfere with the controls of the car nor be a potential fire hazard. It reduce fire hazard further both the positive and negative leads need to be fused - and for the fuses to be as close to the battery as possible. Fusing in the positive lead protects the car in the event of a short circuit to the chassis (assuming negative chassis) and fusing in the negative lead protect the rig in the event that the earth system of the vehicle is faulty and uses the rig's earth to take the full load of the battery negative.

Do not use the cigarette lighter or as it is now called the auxiliary electrical supply socket as it is only intended for intermittent use and is unlikely to be fused on both positive and negative leads.

Installation position of speaker

Similar to the transceiver but you need to be able to hear the speaker when the car is in motion so consider its location relative to other sounds.

Handsfree operation

Whilst regulation might allow you to talk on a normal microphone it is still dangerous and really operation without a hands free kit is just plain stupid.

Next [Social issues](#)

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7f.1 Recall the correct procedures for dealing with EMC complaints, whilst understand that although new electronic equipment should meet the EMC standards, some existing equipment may not.

Dealing with an alleged interference from your equipment to a neighbour's equipment what ever it is must in the first instance be dealt with sympathetically. That does not mean that you accept responsibility but you must show that you wish to listen to what the interference is that has occurred and show you have every intention to find, with the neighbour, the location of the source of the interference. You must be aware that whilst all new electronic equipment should meet the EMC standards, some existing equipment may not.

With a good start such as inviting discussion you will be well on the way to having a neighbour who understands you want to help rather than the complete opposite.

The first step is to stop transmitting if you were at times when they might be watching the TV especially "the soaps", football matches and any other popular program, as these cause more arguments than any other source of complaint in our experience. Then with the "possible" source stopped at those times of the greatest problems ask if the neighbour has kept any sort of record up to now as to the occurrences of the interference. Offer to show your log book to show that you keep accurate records of all of your transmissions and the "from time to time" tests on interference to your own equipment.

Assuming that the neighbour has not kept a log, and few have, then draw up a simple log sheet for them as suggested below:-

Log of interference to:-				
Please record each occurrence of interference including start and finish time. Thank you.				
<table border="1"> <tr> <td>Start time of</td> <td>Finish time of</td> <td>Description of interference eg.</td> <td>to what</td> </tr> </table>	Start time of	Finish time of	Description of interference eg.	to what
Start time of	Finish time of	Description of interference eg.	to what	

Date....	interference	interference	patterning on TV, sound on tv, sound on radio	equipment
----------	--------------	--------------	---	-----------

Suggest that you both look into the matter again after a few days of keeping the records and see if the neighbour's record correlates with any of your transmissions.

It is a good idea to have available copies of leaflets from the RSGB on EMC which may according to your discussions be worth giving to the neighbour as matters progress.

Suggest to the neighbour if it is apparent that your transmission are the cause that you seek the assistance of another amateur to try to resolve exactly what is happening.

It is in your best interest to keep the relationship with your neighbour as happy as possible without accepting unreasonably all the responsibility.

If the matter gets nasty and the complaint is quite obviously not going to be resolved by you then let the neighbour know that there are formal complaint channels that you will be pleased to tell him about Ofcom.

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Bredhurst Receiving and Transmitting Society**Operating Practices****Syllabus Sections:-****8a Packet Radio**

8a.1 Recall that Packet radio transmits messages in data format that can be received directly, stored in a mailbox for reception at a later date or forwarded through a network of mailboxes. Understand the difference between store and forward mailboxes and digipeating.

Packet is a more up to date version of RTTY in that it is communication via the computer key board and not via speech through the microphone.

Packet received directly

The Packet network has developed since its introduction in about 1982. You can make contact one station to another by the sending of a message that was read immediately on the screen of the other station.

Packet stored in a mailbox

If that station was not available then the TNC (terminal node controller) had a small store facility that the user could set up to receive messages that were put into their own personal mailbox. To do this usually meant that you set up your TNC with another other callsign such as your callsign-1. The -1 indicated that this was your mailbox on your machine. Any message sent to your callsign-1 would then not try to display it but simply stored it in your mail box.

Packet digipeating

Also your TNC, if your were in a prime location could be set up to "digipeating. The effect of this was that others could "route" message through your system and similarly you could route messages through other digipeaters. When your system received a message that was for digipeating it send it onward without storage.

All you needed to know was where the digipeaters was and this you learned from watching the packets on the screen of your computer. The callsign of a digipeaters would, like the mailbox ,be

the callsign-2 for instance. You would send a message such as C M0FSH via G6YLW-2 the C meaning connect and via meaning by using the digipeaters G6YLW-2 .

If the station of M0FSH responded then the reply message would come again automatically via the digipeaters . On your screen you would see "connected to M0FSH". You would then be able to carry on a QSO until you wanted to stop when you sent a message of "DIS" which told your TNC to disconnect you and the link dropped.

This was a very long winded way of sending messages as each time the "via" TNC had to listen to the message and then send it on. When there was a lot of "traffic" messages could get lost and the link often broke down.

So digipeating was on a one to one basis.

Packet Store and forward mailboxes.

It soon became apparent that an improvement to the system was needed and this occurred with the provision of the Store and forward mailboxes.

Rather than direct one to one contact you sent a message to your local mailbox which if the station to whom mail was address used that mailbox then it stayed in the mailbox until that station "connected" and then was told Automatically that mail was waiting. They could then read their mail.

If however the station you wanted to send a message to was in another mail box the system sent the mail onward to the local mailbox that the station could access.

It took some years for the system to develop so that it knew where stations were and soon links to mailboxes outside UK were occurring.

All this happened before the advent of the Internet where now similar sending or message occurs.

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Bredhurst Receiving and Transmitting Society

Operating Practices

Syllabus Sections:-

8b Repeaters

8b.1 Recall the purpose and operation of repeater and the correct procedures in using them, eg. offsets on 144 and 433MHz, "time-out" and reset tone; voice procedures.

Purpose

Initially when repeaters were conceived the idea was to allow mobile stations to make contacts over longer distances / from difficult location where due to being mobile the signal would fluctuate and thus could make a contact with another station directly difficult.

With the repeater located at an advantageous position the mobile station has a better chance of its signal reaching the repeater and being re-radiated to the other station.

Correct voice procedure

To be able to access a repeater you will need to know

where it is,

what is its input frequency, and output frequency set by the offset (more about that later)

what is the CTCSS tone / access tone.

With your transceiver set up properly you will hear the repeater if it is being used by other amateurs. If this is the case then at the end of each over when the transmitting station drops carrier the repeater will give an acknowledgement tone often the letter "K" in morse code - often called the "K" tone. This is the moment for you to put a call into the repeater.

Usually this call would be as simple as "*your callsign* listening by". If the other stations wish you to join the QSO then they will invite you in - which is usual - else you will need to wait until they

have finished their QSO.

Assuming that you are making a fresh start at the end of a previous QSO or when the repeater has been without traffic press the PTT and say "*your callsign* listening through the repeater for any contact". You will then hear the "K" tone when you drop the carrier by releasing the PTT. Should you not hear a "K" tone then you have not made a successful access to the repeater.

This could be for one of three reasons :-

your system is not set up property

you are too far away from the repeater

the repeater is out of action.

So wait on the frequency and after 15 minutes the repeater will give a CW ident. You will then know that the repeater is operational.

Try to access again. If still no "K" tone then assume it is your set up and check it out.

Offset

The UK repeaters on the 144MHz band use an offset from the receive frequency of minus 600kHz

The UK repeaters on the 433MHz band use an offset from the receive frequency of plus 1.6MHz

"time out"

Some of the UK repeaters have what is called a "time out".

 **D'oh** What is a time out ??

It is a device used by the repeater keepers, usually in the software that runs the repeater, that if a contact goes over a certain length of time, say 4 minutes, the repeater automatically shuts down. This is to try ensure that users do not "hog" the air time especially when there are other users waiting to access the repeater.

When a time out has occurred the repeater needs to be "woken" up again using normal access procedure. If the original station is still talking then that station, if they are nearer the repeater than the station that re-accessed, may well end up again talking and possibly timing out again if they do not know about the "time out" device. However other users usually "politely" mention the fact and

hopefully the overs of the culprit will be kept shorter - but that does not always happen.

Reset tone

The re-accessing is achieved by using the 1750Hz tone or a CTCSS tone appropriate for the repeater. These tones are in modern rig and come in automatically when you press the PTT but on older rigs sometime a separate "tone burst" button has to be use in-conjunction with the PTT. The user manual should be consulted which should / will give information as to access to repeater.

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Bredhurst Receiving and Transmitting Society**Operating Practices****Syllabus Sections:-****8c Intermodulation**

8c.1 Understand how to identify whether the distant transmitter or the local receiver is producing intermodulation products.

Intermodulation occurs when a strong signal, on a frequency that the receiver is NOT designed for, gets into the receiver, and is so strong that it alters the DC operating characteristics of one of the stages. The modulation on that strong signal then gets superimposed on the wanted signal.

When the distant transmitter is causing the problem, it is because the signal causing the interference is actually (and wrongly) being produced and radiated. Harmonics, and general spuri, that a transmitter should not have.

Carry out transmitter tests to verify that the transmitter is clean. This will involve the use of a wavemeter (or, if you have shed loads of money, a spectrum analyzer!).

If the transmitter is "dirty", then you have to take steps to rectify that.

When the transmitter is clean, and the obligatory low pass filter is correctly fitted, (AFTER the VSWR meter and before the antenna feeder), the problem will be the distant receiver receiving a very strong signal from you on a frequency that it SHOULD discriminate against, but can't, and it will be suffering from intermodulation.

It is possible to have a clean transmitter, and a receiver that is not suffering from intermodulation, but still experiencing interference.

This can occur because the incoming interference (not that strong) is beating against a harmonic of the receiver local oscillator to produce an IF frequency. Cure? TX move frequency a little. Very similar effect from the incoming beating with the oscillator on it's fundamental frequency, but producing an IF the other side. (i.e if the receiver normally operates with the oscillator HIGHER than the received frequency, the incoming TX ABOVE the oscillator may beat with it to produce an IF)

Again, the "rusty bolt" effect. A clean transmitter excites nearby metalwork where there is an accidental semiconductor junction (The rusty bolt). This then rectifies the strong RF that is flying around the metalwork, produces harmonics, and these get radiated. Difficult to cure!!

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Bredhurst Receiving and Transmitting Society**Operating Practices****Syllabus Sections:-****Special events.****8d.1 Recall the purpose of special event stations.**

The RSGB acts upon behalf Ofcom with regards to authorisation of a special event station and Ofcom requires the society when distributing Notice of Variation allowing radio amateurs to set up special event stations to ensure that the request is for an event which:-

- is of special significance and therefore is generally accepted as one requiring celebration
- and that the event is open to viewing by members of the public.

The station set up cannot be mobile nor maritime mobile .

It is understood that some events which are classed as Special event and for which you obtain a "special Event Licence variation" are charitable events with a major concern being fund raising.

Ofcom has agreed that the nature of the event may be mentioned on air but under no circumstances may donations be requested during the contact nor must the sending of a QSL from the event be dependent / conditional upon a pledge of a donation.

So you cannot ask for money over the air - it is as simple as that !!

However there is nothing to stop the Special Event Station being sponsored in advance. In this case those who are to operate the Station can seek pledges from family members etc for so much money for each contact made or what ever other arrangement you wish to make BUT you may not seek sponsorship "on-air" at any time even prior to the event.

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Bredhurst Receiving and Transmitting Society**Operating Practices****Syllabus Sections:-****Band Plans**

8e.1 Recall that band plans are produced by the IARU.

Recall that the band plans state that:

- no s.s.b. operation should take place in the 10MHz 30m band
- no contests should be organised in the 10MHz (30m), 18Mhz (17m) and 24MHz (12m) bands
- narrow band modes are at the lower end of most bands
- lower sideband operation normally occurs below 10 MHz and upper sideband above 10MHz
- transmission on beacon frequencies must be avoided.
- transmission on satellite frequencies should be avoided for terrestrial contacts.

Questions on beacon and satellite frequencies will be limited to the 14Mhz (20m) and 144MHz (2m) bands and copy of the Band Plans will be provided.

The band plans are an agreed use of the radio spectrum and as such are produced by the IARU.

As no band plans are included in the documentation for the exam you have to be aware that the band plans state that:

- no s.s.b. operation should take place in the 30m band
- no contests should be organised in the 12, 17 and 30m bands (WARC bands WARC = World Administrative Radio Conference)
- narrow band modes are at the lower end of most bands
- lower sideband operation normally occurs below 10 MHz and upper sideband above 10MHz
- transmission on beacon frequencies must be avoided.
- transmission on satellite frequencies should be avoided for terrestrial contacts.

As mentioned above the band plans are not provided in the examination so you have to learn the beacon and satellite frequencies on these two bands.

Frequency MHz	Mode	UK Usage
144.400 - 144.490	Telegraphy, MGM	Beacons only
144.490 - 144.500	Guard Band	
145.200	FM	Space communication eg. ISS
145.800	FM	Space communication eg. ISS
145,806	All modes	Satellite exclusive
<hr/>		
14.000 - 14.250		Amateur Satellite Service - Primary user.
14.099 - 14.101		IBP - reserved exclusively for beacons Note: IBP = International Beacon Project

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There are 3 questions in the exam on this topic.

Due to slight changes in the syllabus issued in Dec 2004 updating of these sections is still required.

Syllabus Sections:-

1. High voltage equipment
2. Operating whilst portable
3. RF
4. Lightning protection
5. Protective multiple earthing

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Bredhurst Receiving and Transmitting Society**Safety****Syllabus Sections:-****9a High Voltage Equipment**

9a.1 Understand that all equipment should be controlled by a master switch, the position of which should be known to others in the house or club

This was first introduced to you in the FLC. It is of such importance that it is repeated here that your station whether at home or elsewhere should, perhaps that ought to be **MUST**, be controlled by a **MASTER SWITCH** so that in the event of an accident it can be readily shut down.

The location and operation of the switch must be known by **ALL** who might have need to use it.

DO YOU HAVE A MASTER SWITCH ??

No - then fit one and let those who need to know its location and regularly test its operation.

9a.2 Understand that all exposed metal surfaces should be properly earthed

When you have any metal surfaces / pipe work etc adjacent to any operating position it must be properly **ELECTRICALLY** earthed to ground. This is often done through the **EARTH** connection of the mains lead but in the situation of field day operation a good earth stake is needed to provide the adequate amount of protection.

9a.3 Understand that no work should be undertaken on live equipment unless it is not practicable to do the work dead (disconnected from the power source) and suitable precautions have been taken to avoid shock.

When considering working on equipment whether it is main operated or from a power supply at lower than mains voltage you must decide :-

Is it necessary to work on the equipment **LIVE** (that is connected to mains power or a power supply **AND** switched **ON** ?

If there is no need to have the power connected then DISCONNECT from the Mains or power supply so that it is totally safe.

If you have to work on the equipment live - because you are trying to trace and intermittent fault ALL necessary care and precautions must be taken to ensure that electric shock cannot occur:-

- Remove watches especially those with metal straps
- Jewellery especially rings and any necklace
- only work with one hand inside the equipment and the other in your pocket to reduce the chance of a shock from one hand to another across your heart
- work on an insulated mat on the work bench
- stand on an insulated mat
- have the work bench clear of any unnecessary items

The above is not intended as an exhaustive list but it is hoped it gives you the general idea about safety.

9a.4 Recall that thermionic valve equipment generally uses power supplies with potentials higher than the domestic mains supply.

This is a statement of fact :-

Thermionic valve equipment generally uses power supplies with potentials higher than the domestic mains supply.

Linear amplifiers often have an HT (High Tension) rail at about 2kV (2000 volts). Whilst it might be the volts that jolt it is the mills (milliamps) that kills and when you have 2000 volts just the fewest milliamps WILL KILL YOU !!!

Next [Operating whilst portable](#)

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Safety

Syllabus Sections:-

9b Operation whilst portable

9b.1 Understand that operating in temporary premises and/or outdoors can introduce new hazards (i.e. overhead power lines, inadequate electrical supplies, trailing cables, damp ground, excessive field strengths). Recall the additional safety precautions that should be taken whilst operating in temporary premises and/or outdoors (i.e. site survey, cable routing/protection, correct fuming, use of RCDs, no live working).

Portable operation could be considered as from any location where the set up of the station is not permanent, the whole station including antennas being set up on a clear site to an operational shack in a matter of hours.

A clear site is ideally what you would like to have to set up a station but there are always bound to be hazards one way or another.

The following are items that should be considered in no particular order and the list is not intended as a final check list before going portable.

So consider the following:-

Prior to the setting up carry out a site survey to :-

- assess the access to the site - no good arriving towing a trailer mast and not being able to turn a narrow right hand corner with the trailer
- assess site for any overhead power line or other cables
- assess the ground condition of the site for holes / manhole covers over drainage system
- assess the site for the liability to flooding - even if only locally
- assess the site for supply of water
- assess the site for security at night
- assess the site for access of the emergency service particularly the Fire and Rescue Service they need at least a 4m wide gate and 4.5m high clear space and would the ground support the weight of the fire engine

- ## Upon arrival at the site arrange

- <http://www.darleys.pwp.blueyonder.co.uk/Radio/advanced/safe2.htm> (2 of 5)26/04/2005 03:50:25

- the cable run from generator to temporary shacks
- the use of RCDs
- the location of the main shut off switch and fused distribution box

What happens if there is an emergency

- Sound the Emergency Alarm
- Action your plan to deal with fire / injury / illness
- if it is a small fire still call the fire service but tackle it if you can - then give the fire crew coffee when they arrive and talk about your successful extinguishing of the fire - they will still want to assess that the fire is safely out and will not think that they have been called out unnecessarily
- ensure everyone is safe or try to find location of anyone trapped and their condition WITHOUT risking life

Hold Site Briefing to discuss :-

- the emergency plan
- the location of the fire points / assembly point
- who takes charge if the originally designated person has to leave site
- who would phone for the emergency services if the originally designated person is off site
- designate a person who would meet the emergency services at the public road entrance having also told any near by property occupiers of the problem and to expect the emergency services
- designate a person who would be responsible for dropping wire aerials that might hinder emergency access
- up date the site plan to be given to the emergency services upon their arrival showing hazards point - fuel - gas cylinders
- ensure that all on present at the site briefing know the location of the fire points / assembly point / fuel dump AND indicate NO SMOKING in the area.
- ensure that all on site know that fueling the generator is the most dangerous time due to fumes and potential sparks so prior to refueling the generator - SHUT OFF the generator - close down ALL operating position even those running low power from battery.
- ensure that all present know that the use of cooking and heating facilities must be used with extreme caution as the fire risk is very high

After initial radio equipment checks consider :-

- field strengths especially if using linear amplifier at full legal limit
- is the generator able to cope with the current requirements of the site
- trip or low slung hazards of power cables
- trip or low slung hazards of antenna feeder cables

- termination of aerials near of the ground and high voltage points
- what you are going to do with waste materials and any related fire hazards

What happens if it rains and /or there are high winds regarding:-

- participants - is there enough dry shelter cover for them
- the generator - what protection has it to keep it functioning even though it is raining
- masts - are they able to withstand high winds or must they be taken down - if so how long would it take to lower the mast(s)
- damp ground - consider faulty mains cables from generator - lightning and closeness to trees
- is there any permanent shelter that could be used even temporarily whilst the storm passed - is there a local pub near by ???

What happens if there is radio equipment failure :-

- is there any reserve equipment
- are there tools including a good soldering iron, test meters
- is there a good safe working area away from the operating area to carry out repairs

THEN

Have a very good field weekend and clear up any rubbish to leave the site as clean or cleaner than when you arrived.



The above photograph is typical of a BRATS' field weekend. If you would like to visit the club on

one of these weekends email us and let us know and we can see what can be arranged.



Next [RF](#)

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Bredhurst Receiving and Transmitting Society**Safety****Syllabus Sections:-****9b RF**

9d.1 Recall that the National Radiological Protection Board (NRPB) have published Investigation levels for exposure to rf radiation for UK amateur radio. Recall that compliance with NRPB investigation levels will ensure that exposures are below the recommended limits and that the lowest investigation level for electric field strength is 50V/m (at 14-146MHz). Understand that if the investigation level is exceeded the cause must be investigated and steps taken to reduce the exposure to below the investigation levels.

Please note the following :-**The National Radiological Protection Board (NRPB) Levels in Amateur Bands Reduced**

The Reference Levels for UK Amateur Radio Bands, published by the National Radiological Protection Board (NRPB), were reduced at the end of July this year. These set the level, above which more detailed calculations and checks should be performed, to ensure safe human exposure limits are not exceeded. The lowest levels applying to HF and VHF bands have reduced from 50V/m to 28V/m.

Be aware that questions in the future have numerical values based upon the above.

It is thus anticipate that the syllabus will be altered in due course.

The text below has been updated accordingly to take account of the above.

You have to be able to recall from memory that :-

- National Radiological Protection Board (NRPB) have published Investigation levels for exposure to rf radiation for UK amateur radio.
- that compliance with NRPB investigation levels will ensure that exposures are below the recommended limits and that the lowest investigation level for electric field strength is 28V/m (at 14-146MHz)

The lowest investigation level

Note particularly the words the lowest investigation level as it comes into the next section. The lowest investigation level means the level above which investigations must take place - or if you are reducing power then when it drops to the maximum allowable field strength of **28V/m (at 14-146MHz)** a figure you must learn!! Note that the reading is frequency dependent.

If you find that the investigation level is exceeded then the cause must be investigated and steps taken to reduce the exposure to below the investigation levels.

What that means is that you have to be able to firstly calculate what levels of field strength you anticipate taking into account the power of the transmitter and the distance from the radiating elements or stray radiation.

Having done a calculation have some way of checking what levels you are experiencing.

A homebrew field strength meter is usually only a relative strength device as calibration is a little difficult if you do not want to have ground effects altering reading and few of us have suite "antenna farms" to carry out tests.

It is however your requirement to understand the problems and dangers.

Next [Lightning protection](#)

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Bredhurst Receiving and Transmitting Society**Safety****Syllabus Sections:-****9c Lightning Protection**

9e.1 Recall that thunderstorms carry heavy static charges. Understand that the static charge from thunderclouds can ionise the air to form a low resistance path to ground, enabling a very high current to flow as a lightning strike. Understand the risks to human life, domestic property and electronic equipment associated with a direct strike and/or the build up of static charges. Understand that there is little that can be done to protect an amateur station from a direct lightning strike but that good static discharge systems can prevent dangerous static charges building up on antenna systems during thunderstorms. Understand that disconnecting antenna feeders from radio equipment also reduces the risks.

heavy static charges

Your radio receiver whilst being selective cannot discern between a radio signal from a distant transmitter and the static build up from a thunderstorm. Cracks and pops can often be heard with other signals.

Consider these :-

- the cracks and pops can be very loud relative to the weak station audio and if you are wearing head phones damage to hearing can be a real possibility
- The sound of the static must alert you to the possibility of a near by lightning strike
- static charges are looking for a route to earth and that could be via your antenna feeder rig and earth line.

lightning

the static charge from thunderclouds can ionise the air to form a low resistance path to ground, enabling a very high current to flow as a lightning strike. This current can be many thousands of amps at high voltages so you have a double wammy to contend with.

There is no real protection from a direct lightning strike

- so there are real risks to human life especially if out doors on damp ground as the whole area can become "live",
- domestic property can be literally blown apart by a direct hit
- electronic equipment can be totally destroyed beyond recognition

Some degree of protection can be gained and can reduce the risks by :-

- having a good static discharge systems to your system, however this can be very expensive but it can prevent dangerous static charges building up on antenna systems during thunderstorms
- **disconnecting antenna feeders from radio equipment**
- provide an earth leakage route for the antennas to ground potential

Keep safe think about protecting your station

Next [Protective multiple earthing](#)

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Bredhurst Receiving and Transmitting Society**Safety****Syllabus Sections:-****9d Protective multiple earthing**

9f.1 Recall that in PME systems the main earth terminal is connected to the neutral of the electricity service at the consumers' premises and that all metal pipes and fittings within the premises are also connected to the PME bonding point.

Recall that under severe fault conditions PME systems have the potential to cause fatal electric shocks and/or fires in amateur radio stations.

What ever is written here is with regard to the examination.

Altering anything associated with Electrical safety such as tampering with your electrical supply to your residence etc. MUST only be carried out by a qualified electrician.

PME

This was introduced to you in the FLC "Recall that details of PME earthing can be obtained from the local electricity supply company and are covered in a separate leaflet."

In a PME systems the main earth terminal is connected to the neutral of the electricity service at the consumers' premises and that all metal pipes and fittings within the premises are also connected to the PME bonding point.

Potential to fault

Under severe fault conditions, such as when the neutral from the power station fails, a PME systems has the potential to cause fatal electric shocks and/or fires in amateur radio stations. How is this you may ask ? Well all the neutral that would normally go back to the power station will now go to earth through your earth bonding. But not only yours but every ones in the street, (as your earth stake is now acting as the neutral) until you power fuse can take no more and blows. The possibility of shock is obvious as all the earth side of your equipment now become live, if

- only even for a short time, and if your cables are small over heating of the cables can occur and a fire develop.

- Recall that the r.f. earth in an amateur station should be connected to the PME bonding point in accordance with IEE Wiring Regulations to maintain safety under fault conditions.

The R.F. earth

The R.F. earth in an amateur station was never intended to take mains current to earth and as such should be connected to the PME bonding point in accordance with IEE Wiring Regulations to maintain as much safety as possible under fault conditions.

For your own piece of mind do some more research on this topic by taking advice from your local qualified electrician and by reading the topic mentioned below.

The RSGB EMC committee publishes leaflet EMC 07. you should also read the information enclosed therein. [Click here to the links page](#) - we have no control over this page please advice if the link breaks.

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There are 4 questions in the exam on this topic.

Due to slight changes in the syllabus issued in Dec 2004 updating of these sections is still required.

Syllabus Sections:-

1. Meters
2. Frequency checking
3. Oscilloscopes A practical experiment (not in the syllabus)
4. RF power measurements
5. SWR measurement

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Syllabus Sections:-

10a

10a.1 Understand the use of multiplier resistors in analogue voltmeters, shunts in ammeters

Meters Analogue and Digital

Despite the popularity of digital voltmeters (DVMs) meters with a numbers display, there is still a requirement for analogue meters with a moving needle display, especially in the Amateur Radio field, where we are often watching voltages/currents which are changing value, and, we may be looking, or "tuning" for, a maximum or minimum value.



Analogue meter with a traditional needle display



Digital meter with a number display

The above operations are very difficult using a DVM as the voltage/current value is sampled at intervals with a hold delay between samples.

Notice the dials on the front of each meter these are used to select the range of the display. For the analogue meter this is particularly important so that the meter needle is not driven hard against the end stop due to the measured voltage being higher than the range.

Meter Multipliers for voltages and Shunts for Current in Analogue meters

The dial on the meter is a multi position switch used to select from a range of voltages or current. These ranges are calibrated for a correct full scale deflection (F.S.D.) by using **multiplier resistors for measuring voltages** and **shunt resistors for measuring currents**.

The values of these resistances are determined by :-

1. I FSD - the current required for FSD of meter movement
2. R coil - the resistance of the meter coil
3. max voltage or current to be read - the particular voltage or current ranges required.

Measuring Voltage on an Analogue meter

Note: Voltage are measured using the meter in parallel with the circuit under consideration.

A 10V FSD VOLT METER

Let's look at a typical example of an analogue multimeter. If we have a basic meter movement which has I FSD = 1 milliamp and R coil = 100 ohms. So what voltage applied to the meter gives the FSD.

From $V = I \times R$ $V = 0.001 \times 100 = 0.1$ volts.

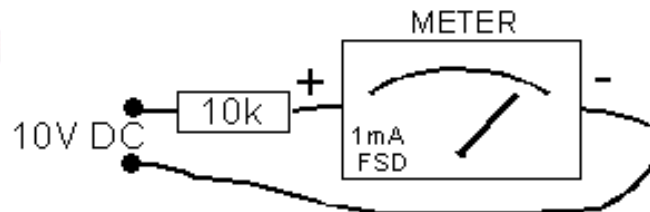
Use of multiplier resistor

Such a low voltage would not be measured very often !! So what can we do to make the meter read 10V FSD on say switch position 1 use a series resistor which is called a "Multiplier".

Then if we apply 10V to the meter it would cause the needle to swing hard over and possibly break the meter. We know that 10V DC must cause a current of 1mA to flow through the meter for FSD, so we need to calculate what resistance will cause a current of 1mA to flow when 10v is applied.

Using ohm's law $V = I \times R$

re-arranged $R = V / I = 10 / 0.001 = 10000$ ohms or 10k



BUT we have not considered the coil's resistance = 100R, and this would cause errors in reading. If we used the 10k we would have a total series resistance is 10,100R and therefore the calculation which gives

$I = V / R = 10 / 10,100 = 0.99\text{mA}$ through the meter and do not achieve the 1mA FSD - there is a 1% error.

The solution is to subtract 100 ohms from 10k - thus $10,000 - 100 = 9900$ ohms.

This 9900 ohms resistor is the "Multiplier".

100V FSD VOLT METER

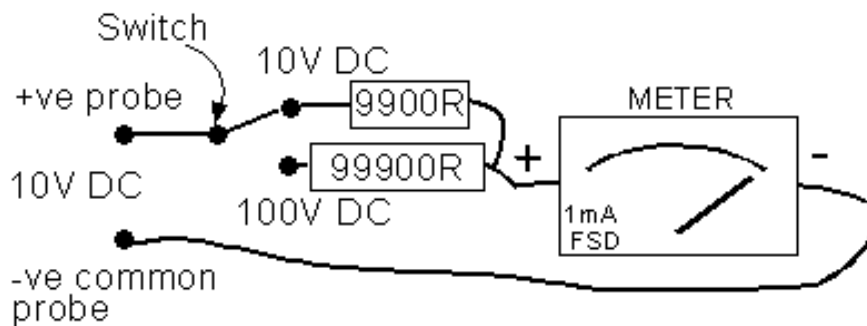
Similarly, if we require a FSD of 100V we must use a series resistance of :-

$$R = V_{(FSD)} / I_{(coil)} \text{ less } 100 \text{ ohms thus } (100 / 0.001) - 100 = 99,900 \text{ ohms}$$

Two points to note are :-

1. The voltage ranges all draw 1 milliamp at FSD. If the source of voltage we are measuring is at high impedance and we use the 10 DC range, the 1mA will cause a volts drop across that impedance, and our "indicated" voltage will be in error (LOW)! BUT if we measure 10V DC using the hundred volt range, the current drawn is 1/10th of a milliamp and the effect on the voltage reading is much less! NB we should **use the highest voltage range** at which we can obtain **a sensible reading**.
2. The resistance values as you can see are unusual and cannot be chosen from preferred values, plus the accuracy will need to be +/- 0.1% or better for a good meter. Specially made resistors or net works of preferred values, measured on a DVM or bridge are used, or for simple meters preferred value resistors plus potentiometers can be used, BUT bear in mind that temperature stability is important too!!!

Our Multimeter so far



Note that the meter need two scales 0 to 10 and 0 to 100 if you want direct reading.

Measuring Current

1 amp range

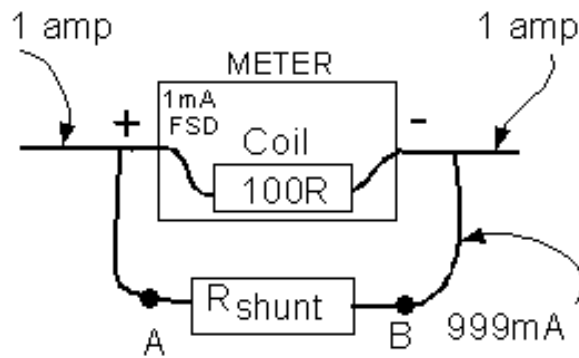
Note: Current passing is measured using the meter in series with the circuit under consideration.

Let's say we want to measure a DC current of 1 amp flowing from a 12V battery to a 12 watt lamp.

We are using the same meter as before so there must still be only 1mA through the meter ANY MORE and we "blow" the movement!!!

Shunt resistor

Thus we must divert 999 milliamps past the meter movement! This time we use a "SHUNT" resistor across the meter movement - in parallel with the meter - BUT of what value ??



What is the voltage between points A and B through the meter coil?

1mA in 100 R, gives $V_{AB} = I \times R = 0.001 \times 100 = 0.1$ volts

Now in R_{shunt} $I = 999\text{mA}$ and the $V = 0.1$ volts (the voltage is the same as the resistors are in PARALLEL).

therefore $R_{shunt} = V / I = 0.1 / 0.999 = 0.1001\text{R}$

NOTE:- The higher the current range, the smaller R_{shunt} becomes. These resistors, which carry HIGH CURRENTS, are normally made from resistance wire like "Constantan", or even copper bus bar (a thick piece of copper) for very high currents.

If you unsure about current value, always start with highest range and switch down the ranges as required.

Meter sensitivity

The quality of a multimeter is usually quoted in "ohms per volt".

If we look at our example above, on the ten volt range we have input resistance of 10k, which we can say is 10k ohms per 10V which equals 1000 ohms per volt.

Similarly, on the 100v range, the input resistance is 100k. 100k for 100v gives the same 1000 ohms per volt. Our meter sensitivity is 1000 ohms per volt, pretty poor, when a good "AVO" is 20,000 ohms per volt.

Our Voltage and Current Multimeter so far

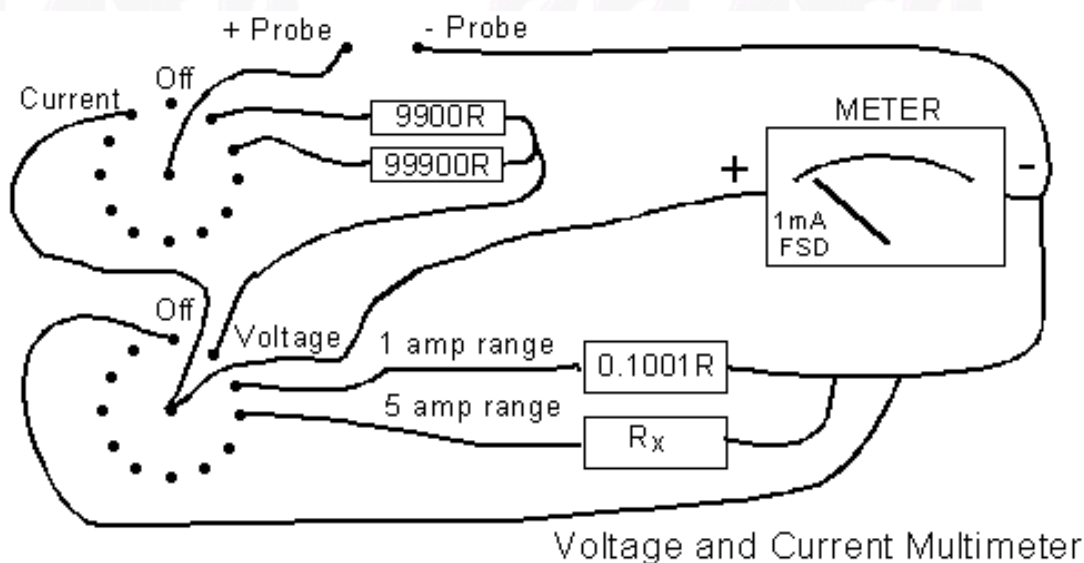
Let's build up our multimeter. So far, we will need a pair multi position switches (which have a current limit of about 5 amps at low voltages), or a rotary wafer switch, (which are expensive but have a higher current carrying capability) with the following positions:-

- 2 for the voltage ranges
- 1 for the current range
- 1 for an off positions

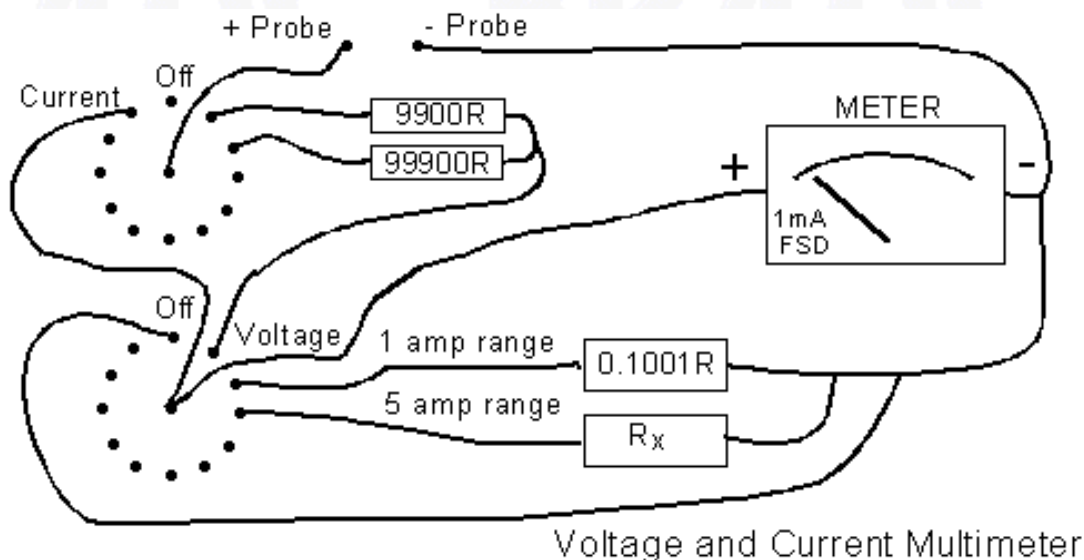
The OFF position is used to place a short across the meter movement. This protects the moving coil movement from shock during movement (shorted motor)

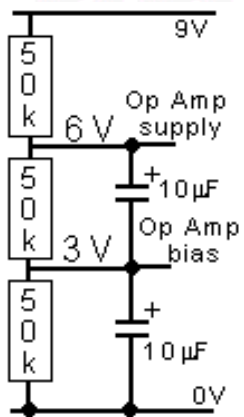
A further position on the switch would be useful to provide a 5 or 10 amp range according to the switch(s) used. This

- additional position is included in the drawing below. We will leave it to you to calculate the value of the shunt resistor R_x

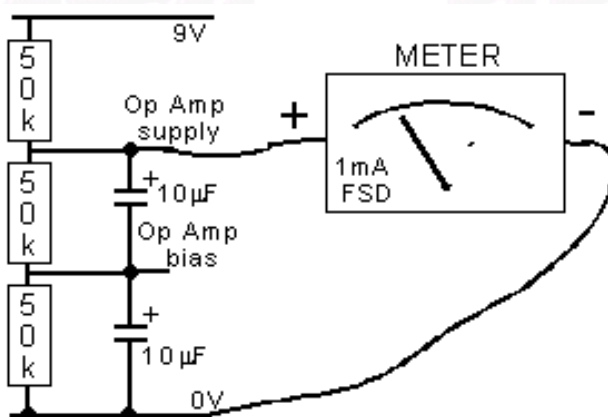


- Here is the last part of the syllabus
- and the effect of the test meter on the circuit under test.
- Looking at "our" multi, and we will attempt to use it to measure DC voltages in a typical circuit. As the HT+ve is 9V in our test circuit we can use the 10V range on our meter and we know that the resistance between the meter leads is 10K ohms (if you are not certain about this look at the top of the page and then come back to here).

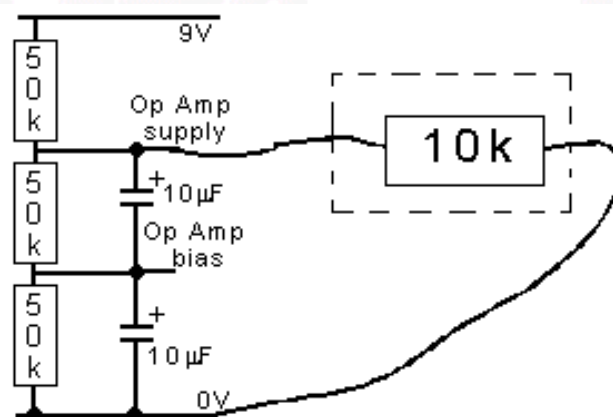




The circuit to test

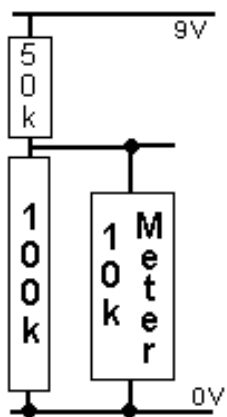


The circuit with Multimeter in place



The equivalent circuit with meter resistance shown (10k)

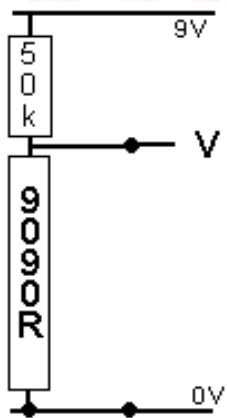
The 10k of the meter will load the circuit, "How ?" You might ask. Like this ---



100k in parallel with 10k is equal to a single resistor of R_T

$$R_T = 100k \times 10K / (100k + 10k) = 9090 \text{ ohms}$$

If you are not happy with the maths convention using brackets then check out the [bottom of this page](#)



Our potential divider is 50K and 9090R

Thus total current passing, from Ohm's Law is $I_{TOTAL} = 9 / 5909 = 0.00015A$

Thus **voltage drop** through the 50k resistor is $V = 0.00015A \times 50000 = 7.165V$

Therefore Voltage at point V is 1.385V.

So we are reading 1.385 volts at a point, normally at +6V !! A better meter would give a near correct reading but there will still be an error, which we should be able to estimate and make a decision that the reading of "OK", if we understand the test meter's limitations.

Conclusion

Meters can load a circuit and give **an apparent error** in the reading!

BUT

We must also be aware that even a "digital" voltmeter and oscilloscopes, etc, present a resistance (or impedance!) to circuits under test.

The average oscilloscope probe has an input resistance of 1 Megohms. Where it is used to examine HIGH IMPEDANCE circuits (oscillators for example) the probe may have a 10:1 multi-plier, raising the I/P resistance to 10 Megohms and reducing the input capacitance.

There two types of this probe:-

PASSIVE. This contains a resistor network which increases the input resistance x 10 and a resultant voltage reduction of

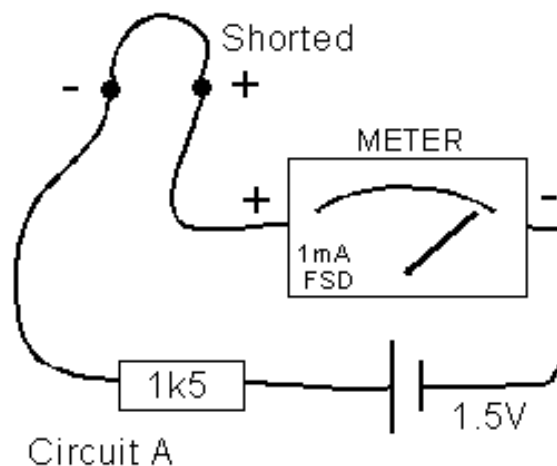
$$\div 10$$

ACTIVE. This includes an amplifier circuit which multiplies the input resistance by say 10 without reducing the input voltage.

Of interest but the following is not in the syllabus

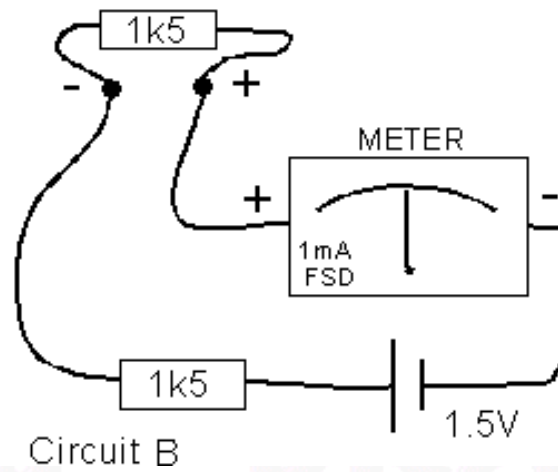
RESISTANCE MEASUREMENT

Whilst not part of the syllabus let's, briefly and ignoring the coil resistance, look at circuit A below.



With the meter terminals shorted as shown the current will be 1mA, giving us a FSD (Full Scale Deflection, which indicates zero ohms and the scale would be marked as such.

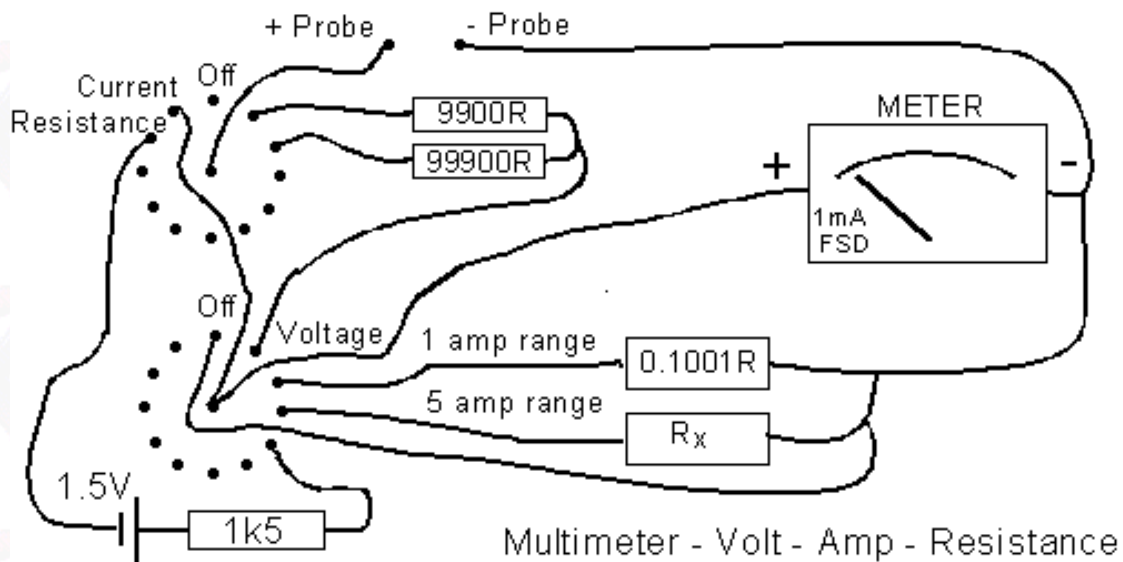
If we now connect a 1k5 resistor across the terminals, as shown in circuit B below.



The total resistance is now 3k which is passing a current of 1/2mA which gives a half scale deflection and would be marked on the scale 1500 ohms. By the use of other resistors you would be able to mark up the scale.

You would find that the scale is non-linear and will be very cramped at the high resistance end of the scale.

Our Voltage, Current and Resistance Multimeter



The meter is based upon the single pole 12 way switches which have limited current carrying capabilities - but as this is for demonstration purposes only high current will not be measured.

Should you decided to build the meter based upon this drawing then you do so at your own risk.

The BRATS club have the intention to build a demonstration multimeter based upon this information to show the practical application

Valve Voltmeter VVM

Valve Voltmeters are analogue meters, generally using a meter such as we have been describing in our multimeter above. The difference is that in the VVM there is a current amplifying circuit between the probe and the meter, giving an input resistance in the megohms range, with, therefore, very little loading on the circuit being measured.

- The amplifier was originally a valve type but may now be a transistor or operational amplifier used. For work on very high
- resistance circuits a bridge circuit is employed which, when balanced, draws no current from the circuit under test. These
- units are often called Voltage Measurement Units (VMUs) with very accurate measurements to $\pm 0.1\%$ or better.

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Examination**Bredhurst Receiving and Transmitting Society**[maths](#) ...[So what is next](#) ...**So is that everything ?**

Eh! well no we have still to consider $1/n$ which means 1 divided by any number and pi -

"reciprocal"

$1/n$ means in mathematical terms the reciprocal. When you have easy numbers like $1/2$ $1/100$ it is easy to use a simple calculator but in the maths you will come across in the advanced course there will be times when it would be nice to have the key on the calculator to do it for you by keying in the number and pressing a single key.

So like the



for square root you will need to see a key like x^{-1} for the reciprocal. Click


[here for more info on a calculator](#)

"pi"

pi pronounced pie and has nothing to do with eating but is what is called a "constant term" (as whilst other number might change it does not) and it will appear in many maths calculations for the course.

Mathematically pi or π is the ratio of the circumference and diameter of a circle and in simple terms is considered as $22/7$ but that is a long number (try it on your calculator) and for short we use 3.14

A complicated manipulation coming up !!

Manipulating $f = \frac{1}{2\pi\sqrt{LC}}$ to be added soon ... 

"Math's Rule" The use of brackets when using + - and X and /

There is a "Math's Rule" which says that you:

Do multiplication and division first UNLESS there are brackets when you do everything in brackets first.

Thus $4 \times 3 + 10 = 22$ and not 52

To have the answer as 52 we would have needed this $4 \times (3 + 10)$ which mathematically would have been written as $4(3 + 10)$ as the 4 prior to the bracket means multiply 4 by what is inside the brackets after you have done that part of the calculation.

Similarly $4 \times 10 - 3 = 37$ and not 28

but $4(10 - 3) = 28$

Note: When using brackets a number before a bracket means multiply it by what is in the brackets unless there is another function shown. This is further explained below.

also when you have opened a set of brackets you must also close them, see the example below where you work out the inner most brackets first then the next set and so on.

Try to work out the answer to this $5(4 \div (45-35))$ Answer 2

Algebraic multiplication

In algebra if we have two variables say C and R for instance and we to multiple these variables together rather than putting $C \times R$ which is correct we can put CR - writing the letters together means multiply them together.

This convention is used on this page [click here](#) and [here](#)

The same would be when using brackets

$A(C-D)$ means from C take D and multiply the result by A

[and now for prefixes](#)



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Bredhurst Receiving and Transmitting Society**Measurements****Syllabus Sections:-****10b Frequency Checking**

10b.1 Recall the uses and limitations of absorption wavemeters, heterodyne wavemeters, crystal calibrators, digital frequency counters and standard frequency transmissions.

What is behind this part of the syllabus ??

It is a requirement that anyone holding an amateur radio licence must be able to prove that the equipment they are using is working correctly and does not interfere with others - this section of the syllabus is to ensure that you know how to assess your frequency of operation.

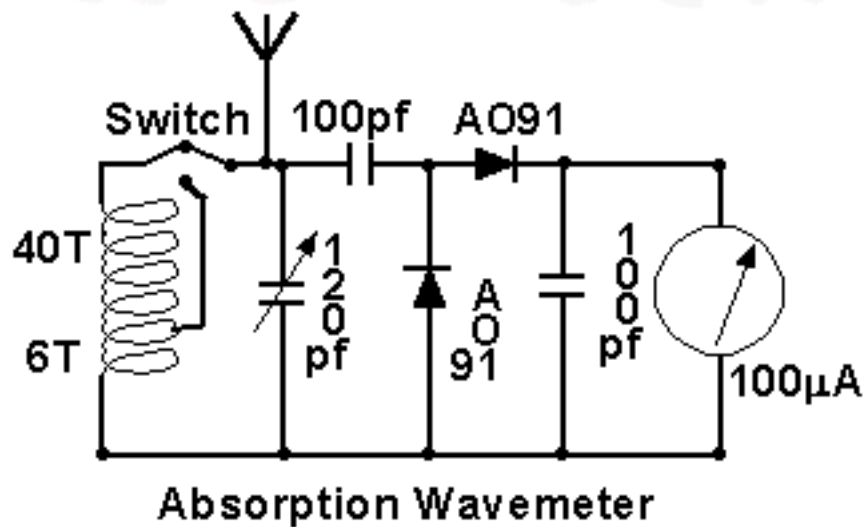
Well that's a pretty all embracing statement, but what does it mean??

It means - that anything you may use in your hobby of amateur radio whether it is used for self training or not, must comply with the terms and conditions of your licence, as detailed in BR68.

You can't make statements like "Well I bought it from a reputable dealer and it's new so therefore it must be ok".

THE ABSORPTION WAVEMETER.

The absorption wavemeter consists of a parallel tuned circuit with the addition of a rectifying diode and a meter used as an indicator of resonance. A version of this type of meter is shown below with approximate values of components.



The variable capacitor of the tuned circuit is adjusted so that many resonant frequencies may be obtained.

The wavemeter absorbs power from a nearby transmitter and shows a maximum reading on the meter when it is tuned to the same frequency.

Calibration of the unit is by setting a known good source of transmissions to different stop frequencies and marking up a scale. The obvious choices would be 1.8MHz and its harmonics so that the meter could also be easily used to check for harmonic output from a transmitter you were building (for instance).

By tuning the variable capacitor across its range and the use of the switch a large range of frequencies can be covered looking for relative harmonic outputs.

Limitation - the wavemeter can only give you an idea as to what frequency you are transmitting on and where there are any harmonics it cannot tell you precise frequencies.

THE HETERODYNE WAVEMETER

This operates in a completely different way. Rather than absorbing the RF from a Tx this gives out RF at very low levels such that the a Receiver may be calibrate by beating against the know frequency.

such an experience was common place say 30 years ago to check your equipment but today few will have ever tried to check out a receiver in this manner. With the Heterodyne wavemeter set to a specific frequency output the receiver is tunes across the band and the signal will be received as a tone. The tone lowers in frequency as you reach the "tuned" position and then at the beat frequency point disappears. As soon as you pass through the null position the signal reappears - assuming you are receiving on AM else on side band only one side of the wavemeters signal is

heard.

The BRATS club has been donated an old heterodyne wavemeter and this will be used at field weekends to demonstrate its operation.

Limitation - A little more accurate than the wavemeter but again accuracy is limited to the components used and at best would be within ± 2 kHz

CRYSTAL CALIBRATORS

The crystal calibrator is again an item used about 30 years ago to ensure that your receiver was on frequency at stop frequencies. The calibrator had a 1 MHz crystal that was so arranged to be rich in harmonics and could then check the frequency up so say the 30th harmonic.

The Heterodyne wavemeter mentioned above also has a crystal calibrator output.

Limitation - The crystal calibrator can only give single frequency output / and harmonically related outputs.

DIGITAL FREQUENCY COUNTERS

Most radio equipment these days is fitted with a digital frequency meter, but the question always arises as to how accurate the meter actually is.

Digital frequency meters sample or count the number of complete sine waves in a given period, ie: 1 second or 1 μ second, and displaying the count on a LED or LIQUID CRYSTAL display.

The digital frequency meter consists of 4 basic parts.

The display, the counter, the clock and the gate.

THE CLOCK produces pulses from a stable oscillator, usually 1 or 10 Mhz, the pulses have a time period ranging from 1 μ sec to 1 sec. The pulses are applied to :-

THE GATE which allows converted sine wave pulses through the gate for a given time period and then shuts.

The pulses are then COUNTED and DISPLAYED as frequency.

Limitation - The accuracy of the frequency counter is dependent upon the accuracy of the clock oscillator, if the gate is on too long then the pulses counted will be wrong for the frequency being

measured.

STANDARD FREQUENCY TONES

A suitable accurate frequency standard has to be found to check the accuracy of any of the above mentioned meters.

Until relatively recently there were world wide transmissions of standard frequency tones on 2.5, 5, 10, 15, and 25 Mhz but now the only ones known to exist are radiated from the USA and China the European standard frequencies were shut down to save costs.

By comparing the received standard with the indicated frequency any error would soon show up.

Limitation - atmospheric conditions may make it impossible to hear a standard frequency tone!!

10b.2 Understand the effect of measurement tolerance, calibration accuracy and time related drift on frequency measurements and the allowances to be made for transmission bandwidths.

Measurement tolerance

Unless you have very accurate and calibrate equipment to check your equipment then the ability to measure frequency accurately is always a matter of how far out your assessment of the frequency measurement you could be. At worst you should not be more that say +/- 3kHz else with speech you could be out side the band edge.

Calibration accuracy

Even with well calibrate equipment over time the frequency calibration can "drift" or change frequency so what you think is calibrate is in fact in error. Further the amount of variation is dependent upon how good the equipment is in its design built in to have a stable frequency generator etc.

Transmission bandwidth

If you take the figure of 3kHz as the basic bench mark and if you equipment is variable by 3kHz then you will not know the band edge position within 6kHz. so it is all a matter of knowing your equipment and its calibration standard.

What is the purpose behind this section?

This is where we stated from at the top of the page - this section of the syllabus is to ensure that

you know how to assess your frequency of operation.

As the frequency counter is probably the more readily accessible and easiest to operate let's look at an example.

Frequency counter example

If your transmitter is operating in the 14Mhz band has a frequency tolerance of 100 parts per million and an AM band width of 6 khz and the digital frequency display is accurate to 10 parts per million, what is the lowest frequency that the licensee can use to ensure that no emission is below 14Mhz ?

- a. 14,004.54 khz
- b. 14,045.4 khz
- c. 14,090.8khz
- d. 14,005.31khz

The tolerance build up is as follows:-

BAND EDGE	14,000,000	14,000.00 kHz
FREQUENCY TOLERANCE (100ppm)	1,400	1.40 khz
FREQ METER TOLERANCE (10 ppm)	140	0.14 khz
HALF OF A3E BANDWIDTH (6khz)	3,000	3.00 khz
TOTAL	14,004,540	14,004.54 kHz

This is the closest to the band edge you would be able to transmit, so know your equipment??

Next

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Syllabus Sections:-**10c Oscilloscopes**

10c.1 Understand the purpose and basic operation of an oscilloscope. Calculate the frequency and voltage of a waveform from given data.

The Oscilloscope

This is a very useful piece of test equipment.

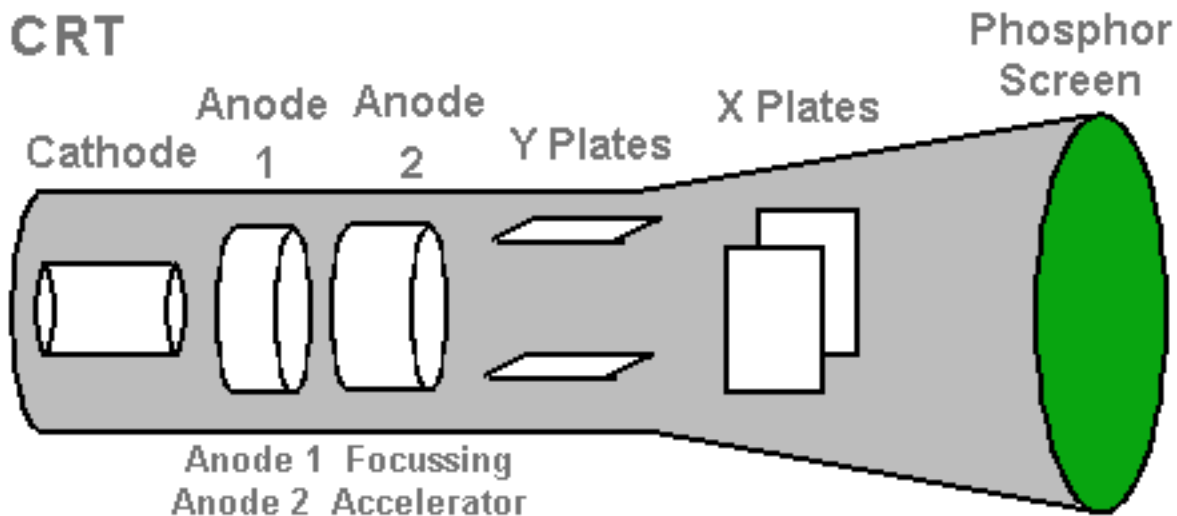
A basic oscilloscope provides a means of measuring **voltages AC and DC**, from a few millivolts to tens of volts, and measurements of **time intervals** from a few microseconds to seconds, **SIMULTANEOUSLY!**

The picture shows a rather old scope by today's standards but

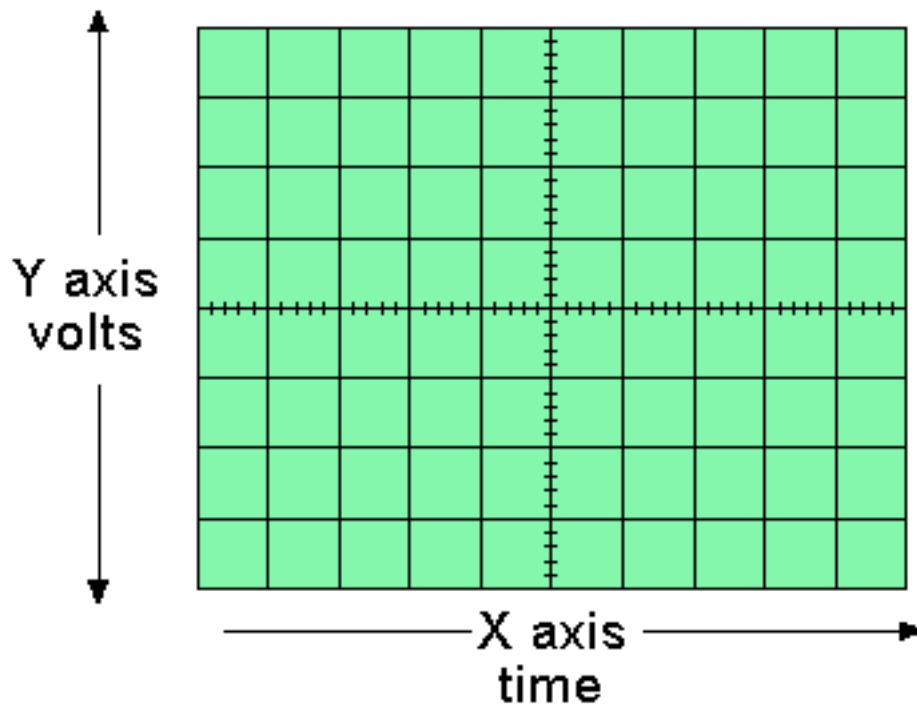


if still works and serves its purpose even though a few of the knobs are missing!!

The information is displayed visually on a cathode ray tube (CRT)

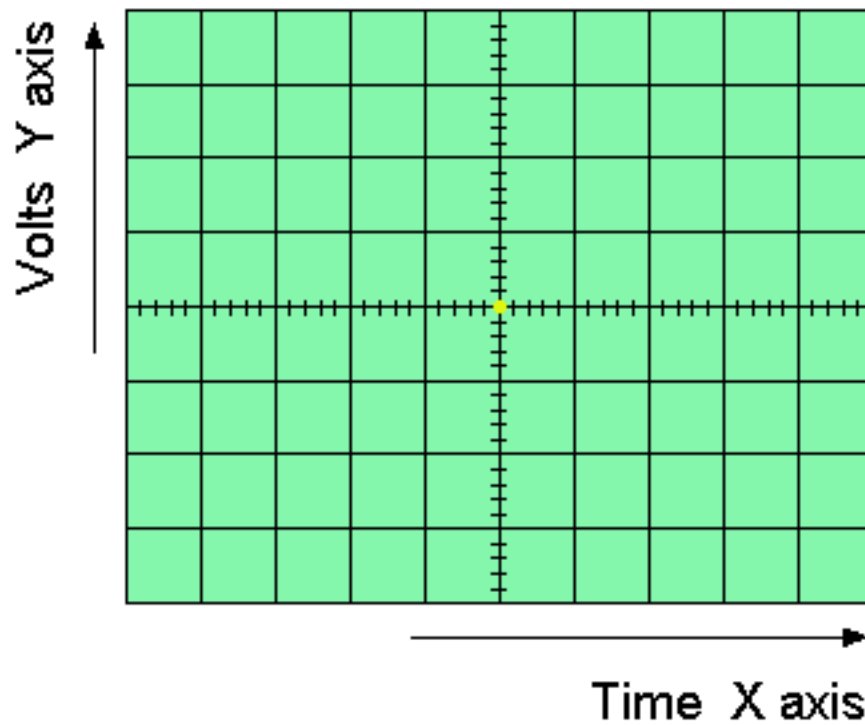


The diagram above shows the typical external and internal structure of a Cathode Ray Tube.



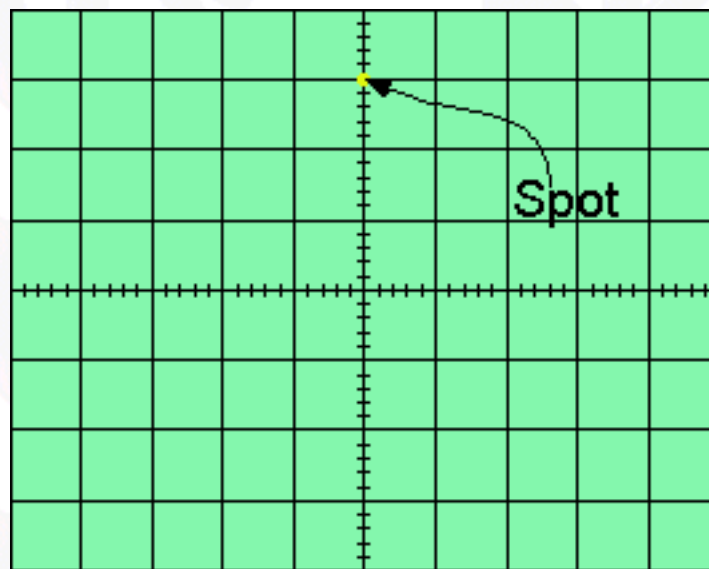
Above is shown the calibration graticule on the tube face.

1. A **CRT is a form of valve**, with a heated cathode, a grid which controls the current flow, and a hollow anode at positive voltage (several kV) to accelerate electrons towards the tube face.
2. Another **Anode focuses the electron beam** to a fine point at the screen which is covered (internally) with a phosphor which glows (green in most cases) when the focussed beam strikes the surface, it produces a bright spot (which should be in the centre with no applied voltage to the probe as shown below).

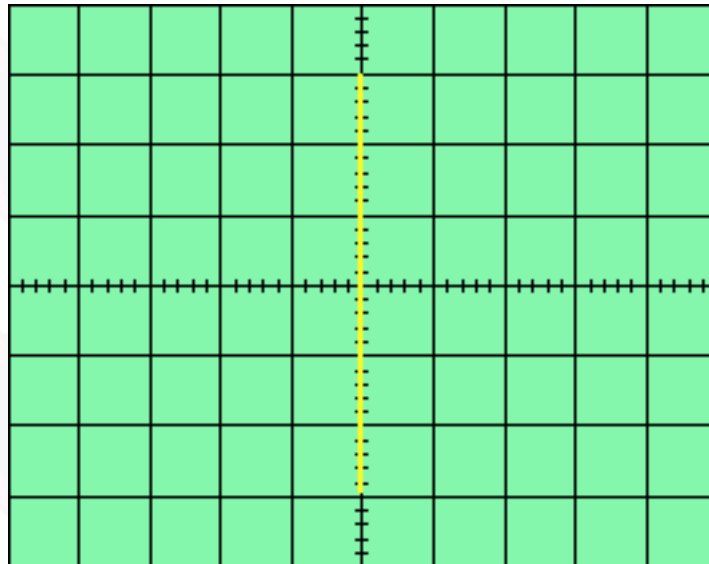


3. A pair of metal plates above and below the beam provides a means of **bending the beam in the vertical plane (Y deflection)**, up if the upper plate is positive and the lower plate is negative and vice versa. The amount of the bend depends upon the potential difference applied.
4. A similar pair of plates, arranged left and right provides beam **bending in the horizontal plane (X deflection)**. By adjusting the potentials on X and Y plates the spot may be positioned anywhere on the CRT display.
5. To provide an **input to the scope**, a coax lead with ground clip (outer) and probe(inner) is connected to an amplifier (Y amp) with the switched gain control, calibrate to move the spot so many cms per volt (so many divisions per volt), often from 10mV/cm to 10V/cm in 10 steps.

So now we have a DC volt meter - if we set the Y amp switch to 1V/cm and apply +3volts to the input lead, the spot will move 3cm up the tube!



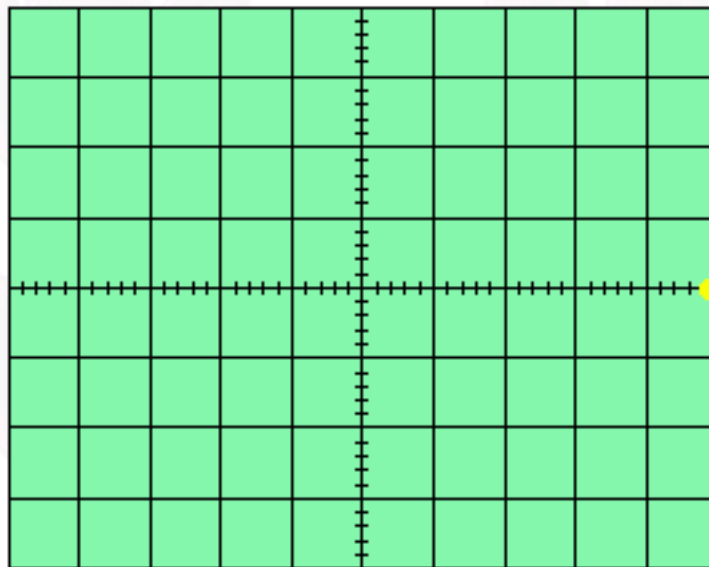
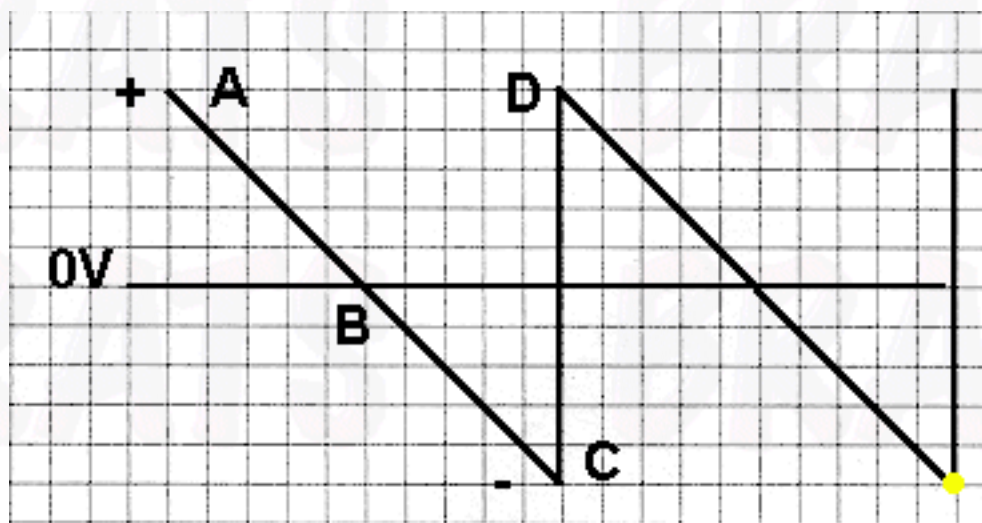
6. What if the input were a **sine wave**, 6V peak to peak? All we would see is a vertical line going 3cm up and 3 cm down not much use.



Let's say that the sine wave is at mains frequency 50Hz. Each cycle will be 1/50th of a second or 20 milliseconds.

7. This is where the **X (horizontal) plates** come into use.

Within the oscilloscope, a variable frequency oscillator generates a SAWTOOTH wave form like that shown below. This is applied to the Left hand horizontal deflection plate.

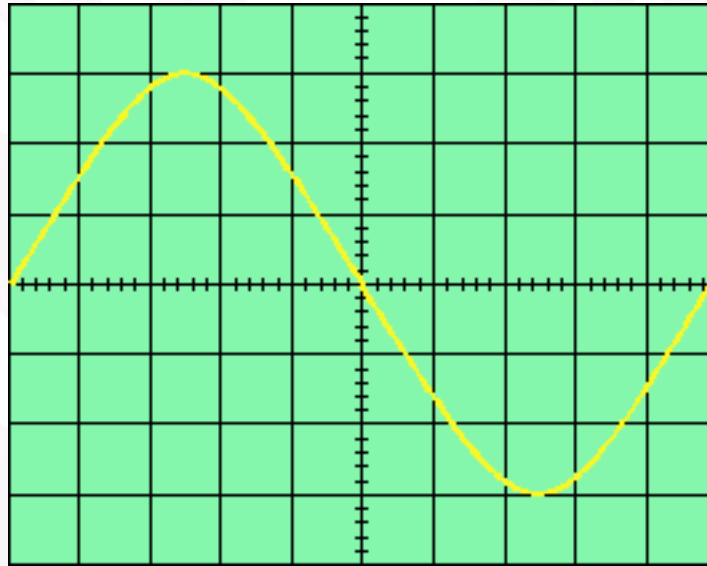


Starting at A the plate is fully positive, the spot will be on the left hand side of the tube and will move in a linear manner towards the right. When at point B the plate is at zero volts, and when fully right at point C the plate is fully negative. At this point the spot on the screen flies back (FLYBACK!) to the left hand side, point A on the tube (almost instantaneously) and the charge on the plate moves to the point D on the sawtooth diagram, and the SWEEP repeats again and again.

8. If we adjust the duration of the **Sweep** (TIMEBASE X plates) to 20 Milliseconds, and the sine wave in para 6 is still applied to the Y plates you will see the diagram below (assuming that the trace will what is called "lock" and not drift across the screen). As with the vertical input the horizontal input also has a gain control.



calibrate to move the spot so many cms per second (so many divisions per second), often from Secs/cm (/per division) through mSsec/cm to μ Sec/cm in steps.



With time base of the scope set to 2 milliseconds per horizontal cm tells us that a whole cycle is $10 \times 2 = 20$ mSec. The peak to peak voltage is still 3V AND we can see the wave form is sinusoidal.

9. Unless the sweep frequency is very accurate, it will **not be synchronized** with the sine wave and it will slowly drift one way or the other across the screen.

By using the input sine wave form to trigger the start of the sweep waveform, the scope allows the sweep to be synchronized (SYNC) and the display will be steady.

A control (**LEVEL**) is provided to **SYNC** the sweep from any point on the negative or positive edge of the input waveform.

10. To avoid seeing the spot flyback at the end of each sweep a **BLANKING** waveform cuts off the CRT current automatically.

11. **SHIFT controls** are provided :-

A: Horizontal - to centre the timebase and align with the graticule

B Vertical - to align the input waveform with the graticule and to take account of AC waveforms with a DC component, e.g ripple on a PSU output.

12. **Input.** A switch allows for DC input, AC input (if we want to see the DC ripple on a power supply without the DC component) and "Ground" to allow Zero TRACE calibration.

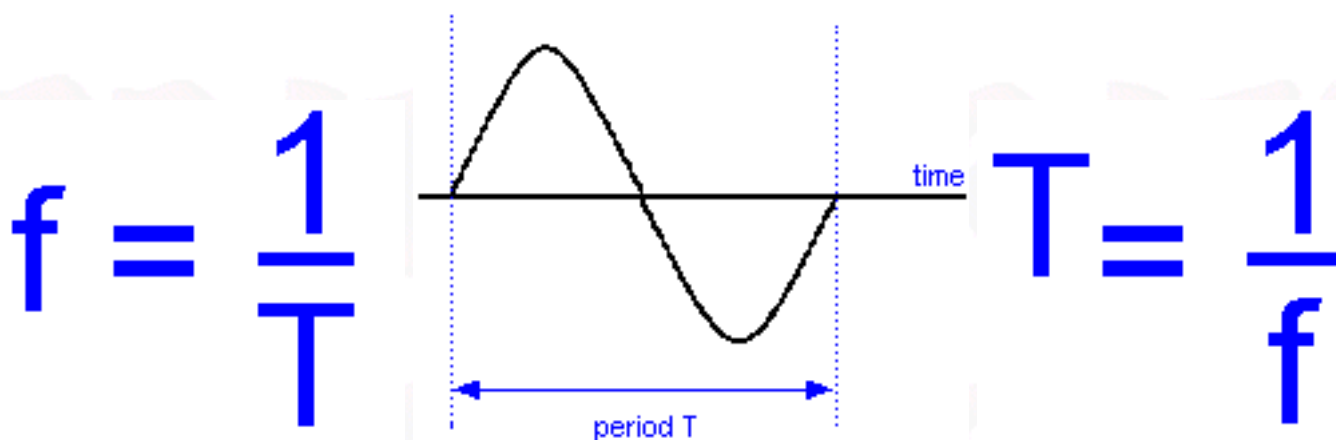
13. **Single shot.** It is necessary to stop the sweep and allow a non-repetitive input to actually trigger the sweep. For example, if we have a pulse or noise burst which occurs once with long regular intervals.

To do this we set the Y timing to something sensible to display the pulse width.

Set the sweep switch to "norm" - there is no trace now the sweep generator is waiting for an input pulse to start, as before we can select + or - trigger and adjust the level for a steady display.

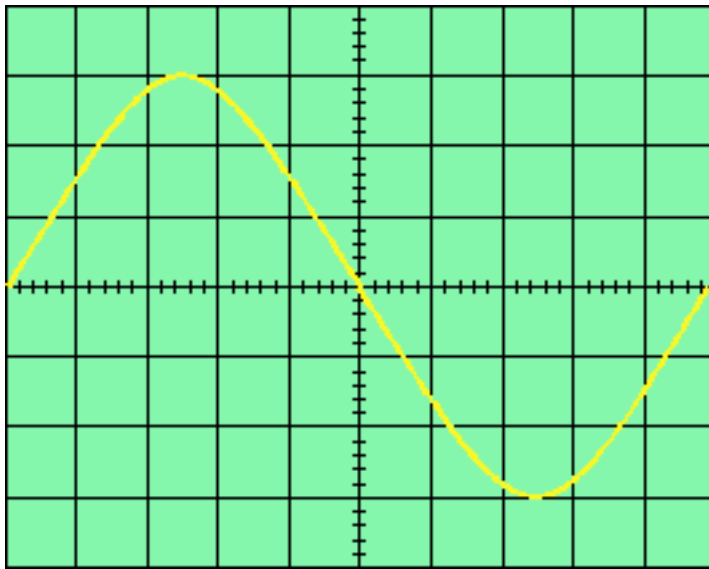
14. **Dual Trace Oscilloscope** Effectively it has two independent traces with all functions previously discuss. It allows for comparison of voltages, waveforms and comparative timing (phases?) only expensive units have dual timebases.

In an earlier part of the course you learned about a sine wave and this is where you will need to apply the knowledge.



1. One complete cycle as is shown above is completed in a time period of T in seconds
2. The number of cycles completed in one second is the frequency f and the unit is Hz (Hertz)
3. Thus $T = 1 / f$ or time to do one complete cycle is one divided by the frequency in Hz
4. And $f = 1 / T$ or the frequency in Hz is given by one divided by the time T to do one cycle.

From the diagram first shown above :-



With time base of the scope set to 2 milliseconds per horizontal cm tells us that a whole cycle is $10 \times 2 = 20$ mSec. The peak to peak voltage is still 3V AND we can see the wave form is sinusoidal.

Question what is the frequency of the wave form ??

We know from above that $f = 1 / T$

We know that $t = 20 \text{ mSECS} = 0.020 \text{ sec}$

$$\therefore f = 1 / 0.02 = 50\text{Hz}$$

Next

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10d.1 Understand that steady r.f. power may be determined by measuring the r.f. potential difference across a dummy load.

Understand the meaning of p.e.p. (peak envelope power) of an s.s.b. transmission and that it may be determined using a peak reading power meter or an oscilloscope and dummy load.

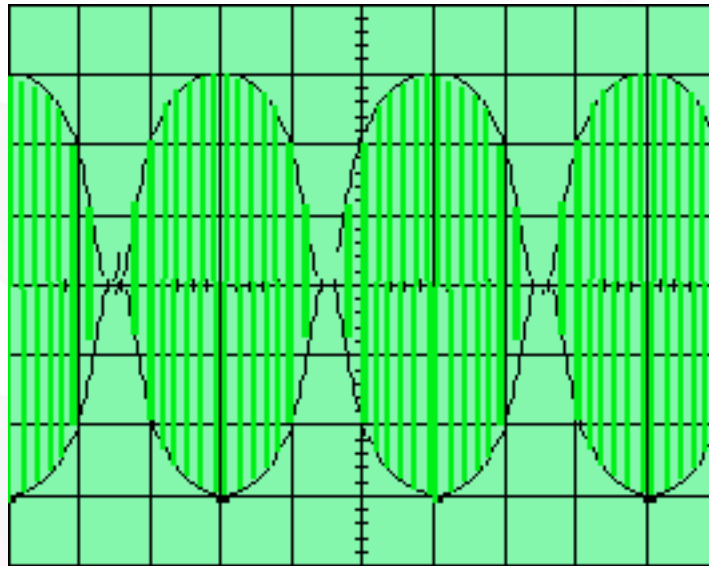
SSB POWER METERS.

Rf power meters need a continuous carrier to read continuously, which presents a problem with ssb as the power is never continuous, varying with speech. With the addition of a suitable capacitor or time constant the capacitor is charged on voice peaks, holding the reading as the human voice goes up and down, if there is no signal present then the meter reading drifts down to zero.

PEP Peak Envelope Power.

Another and perhaps more correct way to measure pep is to use an oscilloscope, dummy load and an audio 2 tone generator.

Set the audio tones to say 600hz and 2khz (not harmonically related) and the same amplitude, connected to the audio input of the ssb tx, set the drive so the calculated power output is 200 watts into a dummy load. The pattern shown on the oscilloscope will be approximately as shown below



the PEP is twice the mean power ie 400watts or 26dbw.

Other power levels may be determined from this

Say 26dbw = 400 watts = 6 cm pk/pk on the scope.

then transmit using voice the peaks are 3 cm pk/pk.

then,

$$400 \times (3)^2/6^2$$

$$=400 \times (3/6)^2$$

$$= 100\text{watts or }26\text{dbw.}$$

The deflection on the oscilloscope is due to proportion of the voltage causing it and for power the proportion is due to the square of the voltage hence the scopes measured deflection is squared.

Not everyone has an oscilloscope or 2 tone generator so the pep reading meter is preferred.

THE DUMMY LOAD.

A dummy load is a resistor or a combination of resistors which is used in place of an antenna for the purpose of testing or tuning. The resistor nominally 50Ω and is of a non inductive material such as carbon.

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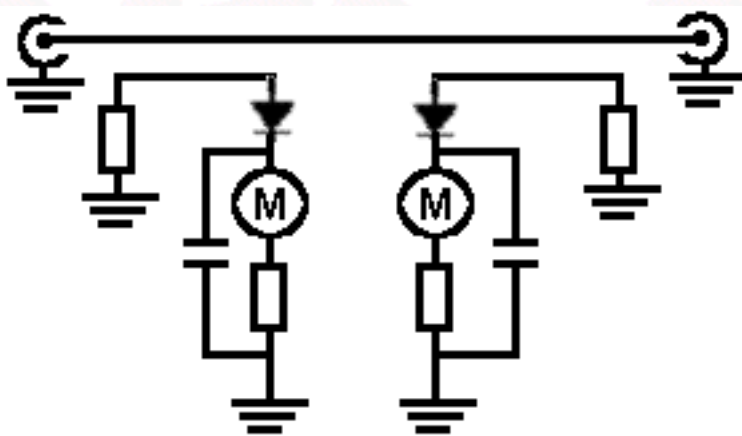
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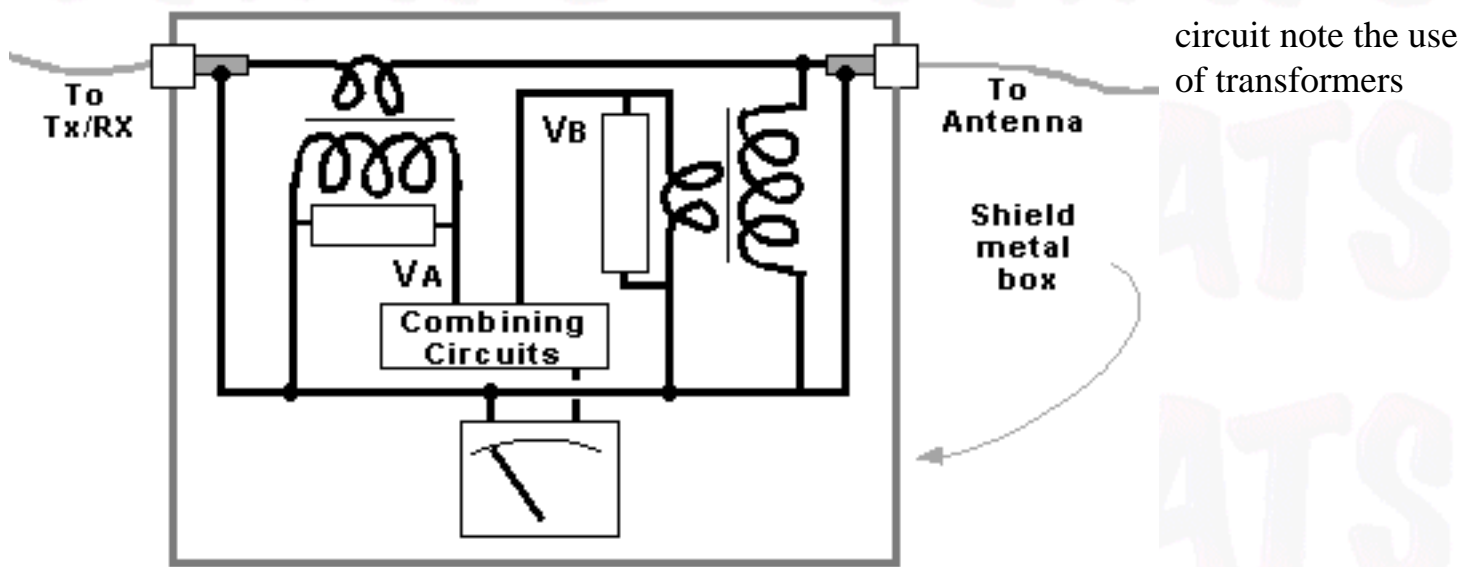
Bredhurst Receiving and Transmitting Society**Measurements****Syllabus Sections:-****10e SWR. measurements****10e.1 Identify the circuit of an SWR meter and understand its operation.****Standing Wave Ratio (SWR) meters**

We have found two different circuits for the SWR unit which at first glance look very different but you should be able to see similarities and thus be able to readily identify an SWR circuit should it turn up in the exam.



This is the first circuit note the diodes and two meters.

This is the second



The SWR meter is fitted in series between the transmitter and the antenna. The meter circuit takes two measurements. One V_A is related to RF CURRENT in the centre conductor of the coax, the second, V_B is related to the RF VOLTAGE between inner and outer conductors.

Let us assume that the antenna cable is connected to a 50 Ohm DUMMY LOAD - A perfect Match - NO STANDING WAVES and current and voltage are in PHASE.

The combining circuit calculates V_B/V_A which is equivalent to V_{RF}/I_{RF} , which will be the cable impedance (50 Ohms) the output meter will be ZERO volts indicating a standing wave ratio of 1:1

If the antenna cable is connected to any impedance other than 50 Ohms, the above relationship V_{RF}/I_{RF} will not resolve to 50 Ohms, due to the standing waves caused by power reflected back from the unmatched load.

The combining circuit will produce an output proportional to the mismatch calibrated as standing wave ratio (SWR).

Under matched conditions, V_B can be processed to indicate power output of transmitter. The combining circuit may also produce an output proportional to reflected power.

For interest, the standing wave ratio can be proven to be :-

$R_{LOAD} / \text{Characteristic Cable Impedance} = R_{LOAD} / 50$ (in our case) where R_{LOAD} is the antenna impedance.

Some more thoughts that might help you

STANDING WAVE NOTE

Standing waves occur when a transmitter feeding a transmission line has a load, or antenna, at the far end, not matched to the line impedance.

The Transmitter Voltage / Current ratio = the Line Impedance.

The unmatched load cannot accept this ratio and some power is reflected back towards the transmitter.

The reflected current and voltage alternately ADD to and SUBTRACT from the out going current and voltage resulting in points of HIGH RF VOLTAGE and points of LOW VOLTAGE along the transmission line which are NOT MOVING! (STANDING WAVES).

If we could run an RF voltmeter along the transmission line we would find points of HIGH Voltage and points of LOW Voltage at regular intervals.

The ratio of high to low voltage is the Standing Wave Ratio.

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maths...

Introduction

In this top tier course there is much more mathematical calculations as possible exam questions than in any of the other two tiers. For some students the math will be complex and initially way beyond their school day maths but it is hoped that by providing this section that ALL students will be able to fully understand the maths in the course.

The following pages have developed and the technical pages have been written so the order of items might seem strange to some readers.

Compendium of all equations that need to be understood for the exam

Note that in the future these equations will be included in the paper work for the exams.

To enter all general topics start here		Choosing and using a calculator	
General information topics		Specific Information topics using calculator (REMEMBER there is usually more than one route to the answer when you use a calculator so if you have been taught a different route USE IT!)	
"whole" numbers	Powers of numbers greater and less than one	Power in DC circuits Maths	Tuned circuits Part B Maths
"fraction" number	Roots of numbers	Circuit theory Maths	Transformers Maths
"decimal" number	Prefixes / Exponential	Capacitance Maths	Decibels Maths
"reciprocal"	Algebraic multiplication	Inductance Maths	Feeder basics Maths

"pi"	formula manipulation	AC circuits Maths	Return loss Maths
"Math's Rule"		Inductance & Capacitance with AC Maths	Field strength Maths

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Compendium of equation used in the course and could be needed in calculations in the exam. It is hoped that we have represented all the equations here that are on the formula sheet.

Note: The sheet that you will be given is not annotated with what the equation is used for but just gives you the equation.

Note : Manipulation of the equation to find the missing item may be needed in any of the following.

The mathematical notation is being used where two letter together means multiplied

eg $P = VI$ is the same as $P = V \times I$

Equation(s)	To calculate ????	Page where equation is discussed
$R(\text{total}) = R1 + R2 + R3$	To find the total resistance in series	Click here
$\frac{1}{R(\text{total})} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}$	To find the total resistance in parallel	Click here
$P = VI, V = IR$	To calculate power, voltage, current, or resistance given any other two. These have been seen in the Foundation or Intermediate level courses	Click here
$P = V^2 / R, P = I^2 R$	As above but this set are new to the Advanced level.	Click here

$V_{\text{out}} = V_{\text{in}} \times \frac{R_2}{R_1 + R_2}$	<p>To calculate the voltage_{out} relative to the voltage_{in} with regards to a potential divider where R₁ and R₂ represent the resistance value either side of the centre.</p>	Click here
$C = K A / d$	<p>To calculate the value of a capacitor from area and separation of the plates, permittivity of dielectrics</p>	Click here
$T = CR$	<p>To calculate the charging and discharging of a capacitor in a CR circuit</p>	Click here
$C_T = C_1 + C_2 + \dots$	<p>To calculate the effective total capacitance of capacitors linked in parallel,</p>	
$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \dots$	<p>To calculate the effective total capacitance of a number capacitors linked in series</p>	Click here
$L_{\text{total}} = L_1 + L_2 + L_3 \dots\dots$	<p>To calculate the effective total inductance of a number inductors linked in series</p>	Click here
$T = 1 / f \text{ and } f = 1 / T$	<p>To calculate the time period of a sine wave at a particular frequency or the frequency knowing the time period.</p>	Click here

$X_L = 2\pi fL$	To calculate the inductive reactance for a known frequency and known inductance.	Click here
$X_C = \frac{1}{2\pi fC}$	To calculate the capacitive reactance for a known frequency and known inductance.	Click here
$Z = \sqrt{R^2 + X^2} \quad I = V/Z$	To calculate the impedance from a combination of resistance and reactance.	Click here
$f = \frac{1}{2\pi\sqrt{LC}}$	To calculate the frequency of resonant a tuned circuit knowing the value of the inductance and capacitance.	Click here
$Q = \frac{2\pi fL}{R} \quad \text{and} \quad Q = \frac{1}{2\pi fCR}$	To calculate the Q factor (quality Factor) knowing the value of the frequency, inductance and capacitance.	Click here
$R_D = \frac{L}{CR}$	To calculate the dynamic resistance R_D knowing the value of the resistance, inductance and capacitance	Click here
$V_S = V_P \times \frac{N_S}{N_P}$	Formulas relating transformer primary N_P and secondary N_S turns to primary	
$I_P = I_S \times \frac{N_S}{N_P}$	and secondary potential differences V_S V_P and currents I_P I_S	Click here

$Z_p = Z_s \left(\frac{N_p}{N_s} \right)^2$	Formula relating transformer primary N_p and secondary N_s turns to primary and secondary impedances $Z_p Z_s$	Click here
$\text{Gain Loss} = 10 \log_{10} \left(\frac{P_1}{P_2} \right) = 10 \log_{10} \frac{\text{power out}}{\text{power in}} \text{ dB}$	The equations relating to decibel power ratios.	Click here
$\text{Gain Loss} = 20 \log_{10} \left(\frac{V_1}{V_2} \right) = 20 \log_{10} \frac{\text{voltage out}}{\text{voltage in}} \text{ dB}$	The equations relating to decibel and voltage ratios.	Click here
$v = f \lambda$ $c = f \lambda$ <p>Please note that sometimes v is used for the speed of light and at other times c.</p>	From the speed of the velocity of light the wavelength can be determined knowing the frequency or the frequency knowing the wavelength. This was first introduced to you in chart form in the Foundation Licence course.	Click here
$c = 3 \times 10^8 \text{ m/s}$	speed of light	Click here
$Z_0^2 = Z_{in} \times Z_{out}$	The formula relating Z_0 = the impedance of the quarter-wave length of feeder matching line to the impedance of the antenna Z_{in} and the impedance of the antenna Z_{out} from the matching line	Click here
$SWR = \frac{V_{\max}}{V_{\min}} = \frac{V_{\text{forward}} + V_{\text{reverse}}}{V_{\text{forward}} - V_{\text{reverse}}}$	The calculation of standing wave ratio (SWR) by reference to V_{FORWARD} and V_{REVERSE}	Click here

$FS = \frac{7 \times \sqrt{ERP}}{d} \quad V/m$	To calculate the field strength given the ERP and distance from the antenna.	Click here
$erp = \text{power} \times \text{gain (linear)}$	To calculate the Effective radiated power from an antenna	Under construction
$\text{Return Loss} = 10 \log_{10} \frac{\text{Reflected power}}{\text{Incident power}}$	To calculate return loss	Under construction
$\text{Gain} = 10 \log_{10} \frac{\text{Power from Yagi}}{\text{Power from Dipole}} \quad \text{dBd}$	To calculate gain of Yagi over a dipole	Under construction
$F_{out} = f_{\text{crystal}} \frac{N}{A}$	To calculate the outgoing frequency from a frequency synthesizer.	Click here
$f_{\text{step}} = \frac{f_{\text{crystal}}}{A}$	To calculate the frequency step from the crystal frequency.	Under construction
$I_c = h_{fe} I_B \quad I_c = \beta I_B$	The two equations mean the same $h_{fe} = \beta$ and is used to calculate the gain or current of a transistor.	Click here

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maths...

"whole" numbers

All maths is based upon addition - subtraction - multiplication and division. If what are called "whole" numbers are used eg 1 2 3 4 100 1000 123560 etc then it is expected that you have no problem especially if using a "simple" calculator to help you check your answers.

It is hope that you are not falling asleep by now as there are some easy marks to be obtained by attempting the maths questions amongst some of the more difficult questions where interpretation and manipulation of formulae is needed.

"fractions" numbers

As well as whole number that are what are called fractions quarter, half, two thirds or as written $\frac{1}{4}$ $\frac{1}{2}$ $\frac{2}{3}$.

Now $\frac{1}{4}$ actually means 1 divided by 4, in the same way $\frac{2}{3}$ means 2 divided by 3. The calculator finds it difficult if not for the most part impossible to display these "fraction" numbers.

The calculation therefore works out the 1 divided by 4 and displays the answer as a "decimal" number.

But what happens it we have to deivide one by a nmbor smaller than one ??

$$\frac{1}{\frac{1}{4}} = \frac{1}{0.25} = 4$$

The result is LARGER than the original number

"decimal" number

The "decimal" number is not a difficult concept to understand. Find yourself a simple calculator one the has addition - subtraction - multiplication and division - you do noy need any more at this

stage but if you need to buy one then take a look at our link on buying a calculator.

If you switch the calculator on and key in 1 then divide then 2 the answer displayed will be 0.5

Try the other examples :-

1 divided by 4 and you will get 0.25

2 divided by 3 and then answer is 0.666666666666 and the 6 is called recurring as it goes on for ever.

Usually we will work to only 2 "**decimal places**" (the number of figures after the decimal point) so the answer would be 0.67 and not 0.66 as we look at the third figure after the decimal point and if that is 5 or greater the second figure after the decimal point is rounded up to the next figure higher in this case 7 --- **NOTE the 0 (zero) before the decimal point (.) of 0.66 This zero should not be omitted else the number could too easily be mistaken for 66 !!**

Conclusion

The maths for the course can be easy is taken at the pace that you want to move and that you must learn the process of **how the maths is done** and not try to do the calculation by learning a procedure and then applying it but no really know ing what you are doing.

Questions to assess your maths level

So that you are not going to be reading items that you already know run through these questions if you have any doubt as to the answers the click onto the explanation page.

Q1. What is the result of $1/2 \times 3/4 \times 5/8$??[Check here](#)

Q2. What is the result of $3/4$ divided by $1/2$??[Check here](#)

Q3. What is the result of $2/3 + 2/3$??[Check here](#)

Q4. What is the result of $2/3 - 1/2$??[Check here](#)

So what is next ??

Ok so you have reached this far and you are now ready to move to the next section.

[Click here](#)

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First do not be ashamed that you have looked at the answer to check if you got it right. Better to learn slowly but fully than get the answer wrong!

Q1. What is the result of $1/2 \times 3/4 \times 5/8$

that equals in fraction terms :-

$$\frac{1 \times 3 \times 5}{2 \times 4 \times 8} = \frac{15}{64} \text{ or in decimal terms } 0.23 \text{ to two places of decimal}$$

If this is not clear to you please speak to your tutor for some additional maths help.

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First do not be ashamed that you have looked at the answer to check if you got it right. Better to learn slowly but fully than get the answer wrong!

Q1. What is the result of $\frac{3}{4}$ divided by $\frac{1}{2}$

$$\frac{3}{4} \div \frac{1}{2} \text{ and in maths terms that is the same as } \frac{3}{4} \times \frac{2}{1}$$

Dividing by $\frac{1}{2}$ is the same as multiplying by $\frac{2}{1}$

$$\frac{3}{4} \times \frac{2}{1} = \frac{6}{4} = 1\frac{2}{4} \text{ divide the 2 into the 4 and you get } = 1\frac{1}{2}$$

that equals in decimal terms :- 1.5

Try it on your calculator and do it in stages

3 divided by 4 = write down the answer(1)

1 divided by 2 = write down the answer(2)

Now enter answer(1) and divide by answer(2) and see what you get !!

It should be 1.5 which is the same as above.

So fractions on a calculator can be reduced to decimals and you can still work out the answer.

However if this is not clear to you please speak to your tutor for some more additional maths help.

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First do not be ashamed that you have looked at the answer to check if you got it right. Better to learn slowly but fully than get the answer wrong!

Q3. What is the result of $\frac{2}{3} + \frac{2}{3}$??

$$\frac{2}{3} + \frac{2}{3} = \frac{2+2}{3} = \frac{4}{3} = 1 \frac{1}{3}$$

that equals in decimal terms :- 1.33 to two decimal places

Try it on your calculator and do it in stages

2 divided by 3 = write down the answer(1)

2 divided by 3 = write down the answer(2)

Now enter answer(1) and add the answer(2) and see what you get !!

It should be 1.33 to two decimal places which is the same as above ([remember the rounding discussion the previous page](#)).

So fractions on a calculator can be reduced to decimals and you can still work out the answer.

However if this is not clear to you please speak to your tutor for some more additional maths help.

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First do not be ashamed that you have looked at the answer to check if you got it right. Better to learn slowly but fully than get the answer wrong!

Q4. What is the result of $\frac{2}{3} - \frac{1}{2}$??

Now this is a bit more tricky as we have to make the numbers below the divide line the same before we can subtract one from the other.

We have a 3 and a 2 below the divide line. So multiply them together = 6

Now we have to convert $\frac{2}{3}$ to something/6

so multiply the top and the bottom by 2 = $\frac{4}{6}$

Now we have to convert $\frac{1}{2}$ to something/6

so multiply the top and the bottom by 3 = $\frac{3}{6}$

then $\frac{4}{6} - \frac{3}{6} = \frac{1}{6}$

Mathematically that would look like this :-

$$\frac{2}{3} - \frac{1}{2}$$

then the result is = $\frac{1}{6}$

$$\begin{array}{r} 4 \\ - 3 \\ \hline 1 \end{array}$$

6

that equals in decimal terms :- 0.166666666

which to two decimal places is 0.17

Try it on your calculator and do it in stages

2 divided by 3 = write down the answer(1)

1 divided by 2 = write down the answer(2)

Now enter answer(1) and subtract answer(2) and see what you get !!

It should be 0.1666666 which is the same as above.

However if this is not clear to you please speak to your tutor for some more additional maths help.

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Advanced Radio Amateur Examination

[maths](#)...So what is next

So what is next ??

There are two more mathematical function as well as addition - subtraction - multiplication and division Powers of numbers and Roots of numbers.

Powers of numbers greater and less than one

Number greater than one

If two numbers are multiplied together it means the same as the number being raised the value by the power of 2.

$3 \times 3 = 9$ but we could have had $3^2 = 9$ then little 2 up a little bit means multiply the number by itself which is also called squared.

What is we have $3 \times 3 \times 3 = 27$

Which could have written that as $3^3 = 27$ which is also called cubed

and we can go on $3 \times 3 \times 3 \times 3 = 81$ which could have written that as $3^4 = 81$

The little number raised above the line is also called the index number and is an especially good way of expressing very large numbers.

What is $1.0 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10$?

$1.0 \times 10 \times 10 = 100 = 1.0 \times 10^2$

$1.0 \times 10 \times 10 \times 10 = 1000 = 1.0 \times 10^3$

$$1.0 \times 10 \times 10 \times 10 \times 10 = 10000 = 1.0 \times 10^4$$

$$1.0 \times 10 \times 10 \times 10 \times 10 \times 10 = 100000 = 1.0 \times 10^5$$

$$1.0 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 = 1000000 = 1.0 \times 10^6$$

Check the original sum and you will see that we had 6 zeros and we have 6 zeros after the 1 in the answer there is a little 6 beside the 10 which you can now understand means move the decimal point 6 places to the right.

In the examples above we showed the figure of 1.0 x to indicate what we were raising to what power. From now on we must understand that the 1.0 x is still there but will now be omitted.

This leads us to multiplying and dividing powers of 10

$$10^2 \times 10^3 = 10 \times 10 \text{ times } 10 \times 10 \times 10 = 100 \text{ times } 1000 = 100000$$

but we could have looked at like this

$$10^2 \times 10^3 = 10^{2+3} = 10^5 = 1 \text{ with 5 zeros} = 10000$$

Then

$$10^3 \div 10^2 = 10^{3-2} = 10^1 = 1 \text{ with 1 zeros} = 10$$

the divide by 10^2 becomes 10^{-2}

try it on your calculator

1000 / 100 and see what you get ???

Numbers less than one

Now above we mentioned 10^{-2}

The use of the -2 means divide one by 10 x 10 which gives 0.01

But let's start at the beginning

$$10^{-1} = 1 \div 10 = 0.1$$

$$10^{-2} = 1 \div 10 \times 10 = 0.01$$

$$10^{-3} = 1 \div 10 \times 10 \times 10 = 0.001$$

This last one is important as it represents $1 \div 1000$ which is the milli.

so 10mA could be written as 10×10^{-3} and in fact this is used in the section on [tuned circuits](#)

What happens if we want to divide indices :-

$$\frac{10^3}{10^{-2}} = \frac{1000}{0.01} = ?$$

We are saying, in a thousand unit, how many 1/100ths are there ?

$$1000 \times 100 = 10^3 \times 10^2 = 100,000$$

We have moved the divisor to above the line and changed the sign. This is a basic Rule or Indices manipulation and can be very useful

So you will find that :-

$\frac{10^3}{10^{-3}} = 10^6$	$\frac{10^{-2}}{10^3} = \frac{1}{10^5}$	$\frac{5 \times 10^4}{8 \times 10^{-3}} = \frac{5}{8} \times 10^7 = \frac{5 \times 10^7}{8}$
-------------------------------	---	--

We are still following the same rule of "Multiply the top and bottom by the same number", which does not change the actual value.

So from above $\frac{10^3}{10^{-3}} = \frac{10^3 \times 10^3}{10^{-3} \times 10^3} = \frac{10^6}{1}$ and $10^{-3} \times 10^3 = 1$

If you want to see more on the use of powers then [click here](#) and go to the section on prefixes

Roots of numbers

An so we move onto the last part of the maths needed for the exam - well understanding the basics of the maths (you will understand more as you get into the site !!).

We have seen that $3 \times 3 = 9$

So if you were asked what number multiplied by itself gives you 9 you would I hope you would say 3 -

You have just taken what is called the square root of 9 - so you are not so dim after all.

So if you were asked what number multiplied by itself gives you 144 you might have to think a bit and might come up with 12 - $12 \times 12 = 144$

BUT if you were asked what number multiplied by itself gives you 9801 you would probably look into you tea or coffee cup and think it was time to make a drink and deal with that later.

Well help is at hand in the form of a calculator which has the square root sign on it.

So we could write "What is the $\sqrt{9801}$?? "

and you would still understand that the wanted answer is a number which when multiplied by itself gives you 9801 --- ok ??

In fact the answer is 99 try on your simple calculator 99×99 and it gives you ???

If you have a calculator with the $\sqrt{\quad}$ enter the number 9801 and press the $\sqrt{\quad}$ key and

the answer 99 will appear !!! I hope !!!

In fact the $\sqrt{\quad}$ symbol is not normally written as large and you would normally see it as

$\sqrt{9801}$ - the bar line over the top of the number indicate that you want the square root of the number below the line.

•

1

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Calculator

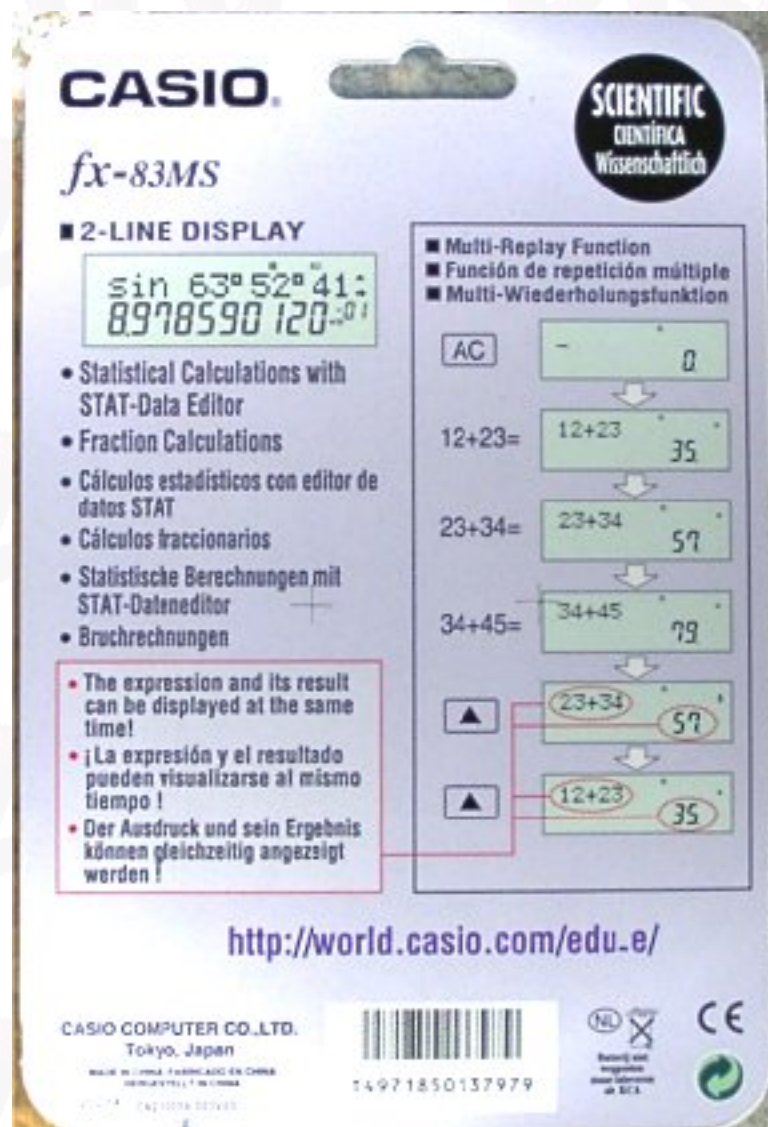
Let it be stated that **"You DO NOT have to buy a calculator"** but if you do want to buy one then consider what is written here and make your own decision. Further if you do decide to buy a calculator then **"You DO NOT have to buy any book(s) on how to use it"**, as this course will show you step-by-step what you need to know about the calculator.

When looking for a calculator it is best to seek one that will meet your needs not only for **amateur radio** but one that is also used in **schools, colleges** and **universities**, then it could meet your needs for years to come (assuming you do not break it !!) - or may be for another member of your family for that matter.

We have found from looking of the web that **Casio fx-83MS (or the Casio fx-85MS solar power version)** is suitable for **schools, colleges, universities** and **amateur radio** calculations and so this is the calculator that we will be using in our pages.

Such a calculator would make an excellent **Birthday or Christmas present** and is available (as at 31st Jan 2004) for about £7.00. Below it is shown in its packaging as in UK.





However if you are a student younger than 11 do not be put off, if you have reached this far in amateur Radio then it should be well within your understanding.

Please note that:- Candidates must accept full responsibility for ensuring that their calculators are in working order for their examination and that the use of material stored in a pre-programmable memory could constitute cheating.

Spare battery

ALWAYS have a spare battery with you and know in advance how to fit it, you will need to have a small screw screwdriver with you! If the calculator will not turn on or if the display becomes dim then a new battery should solve the problem. To continue to use the calculator may result in errors in calculation.



The battery required is a LR44 which is an Alkaline cell of 1.5V - also known as AG13, G13A, LR1154, L1154, RPX675, D76A, V13GA, PX76A, PX675A, GPA76, 1128MP, 1166A, S76, cost about £1.75 - **KEEP a SPARE - DO NOT SHORT out the contacts.**

The Casio *fx-83MS*

Upper keypad



Lower keypad



[NEXT: Using the calculator](#)

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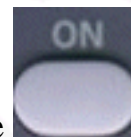
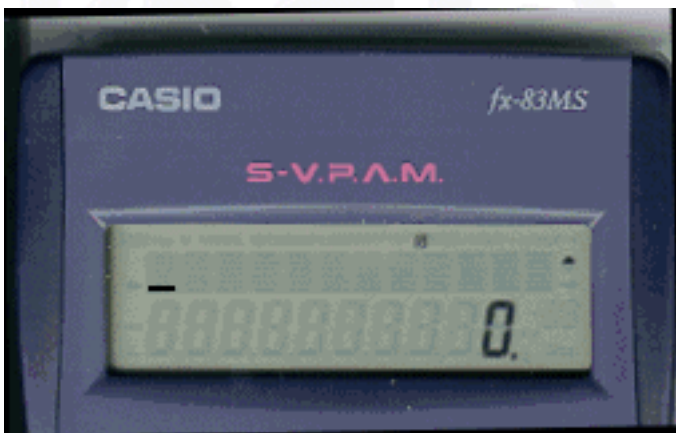
Using the fx-83MS


Using the fx-83MS

The following presentation will familiarise you with the *fx-83MS* calculator, may be even before you have bought one! For some students these steps will be obvious but to others, who have never seen a scientific calculator before, it will be particularly useful.

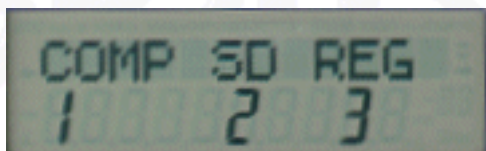
Check that you understand what you are doing and what results you are expecting each step of the way. Learning parrot fashion, without understanding and you could be doomed to disaster!

Switching the calculator on - seems basic but if it does not switch on the battery is probably flat !!

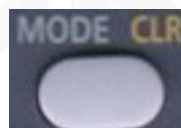


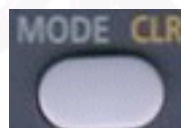
When you first press the  button this is the display you should see.

[Click here](#) to see the switching on and off buttons



Then you must check that you are in the correct mode.

So press the  button

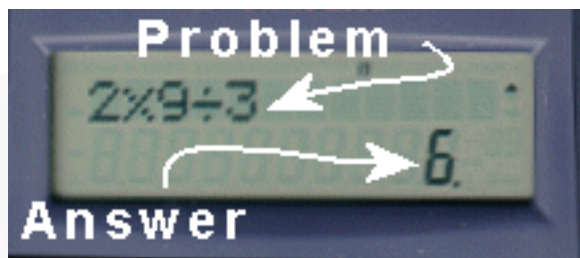







Then press 1 - and the screen will look like this.

This is your starting point for all calculation.

Simple mathematical calculation



Enter 2  9  3 and press the  result 6

You can see the problem shown on the top line as you enter it, with the result after the




button is press on the bottom line.

This use of the two display lines is the same for all calculation.

The other simple mathematical functions of :-



are used in the same way.

To give the reciprocal of a number we used this key  see below

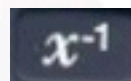
This is the decimal point button



Press the  to CLEAR ALL and you are ready for the next calculation.



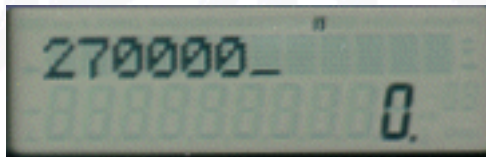
Enter 2 then press



then press  the display is as shown

Now let's introduce the **ENG** button

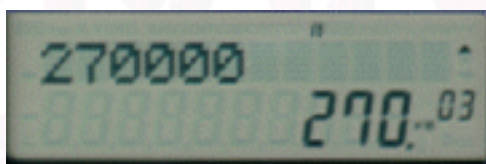
Let's say you want to express 270000 Ω in terms of k Ω



So turn on the calculator and enter **270000**



Press



Press **ENG** the answer is 270×10^3

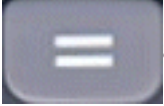
$10^3 = 1000 = k$ thus 270k Ω

The use of the **ENG** key press has made the calculator use its Exponential function and so long as you know which exponential you are seeking you can read off the answer directly.

EXAMPLE

Let's say you want to express 0.001A in terms of mA



So turn on the calculator and enter **.001** Press the  and you will see the display as at the left.



Press **ENG** and the screen stays the same as it is already giving the answer in the correct exponential milli amps 10^{-3} that is $0.001 = 1\text{mA}$ or 1×10^{-3}



Press **ENG** again and the screen is then giving the answer not mA but in micro amps 10^{-6} 1000 μA



Press **ENG** again and the screen is then giving the answer not micro amps but in nano amps 10^{-9} 1000000 nA



Press **ENG** again and the screen is then giving the answer not nano amps but in pico amps 10^{-12} 1000000000 pA

milli 10^{-3}

micro 10^{-6}

nano 10^{-9}

pico 10^{-12}

From this you have learned that each press of the **ENG** button moves the decimal point 3 places

There are more functions to show you but it is hoped that you have taken all the above onboard and it is time to give yourself a coffee / the break !!!

Next [Power in DC circuits](#) Maths

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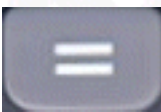




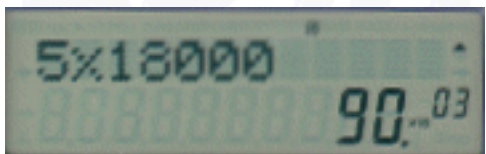
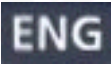
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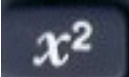

Power in DC circuits Maths

The maths in this topic is in relation to :-

$$P = V \times I, V = I \times R, P = V^2 / R, P = I^2 \times R$$

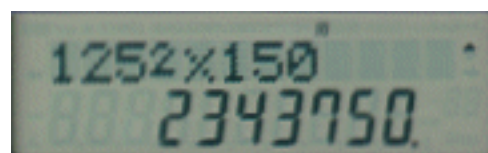
Here we have simple multiplication and division and also raising to the power of two or squaring the number. The course will show you each item. The button to be pressed will be shown but when numerals need to be entered they will be shown as figures the screen result will be shown at the end of in stages depending upon the calculation.

$P = V \times I$	What is the power in watts with 10000V and 5 amps
	 10000  5 
$V = I \times R$	What is the voltage in V if 5 amps passes through a resistance of 18000Ω
	 5  18000 
	Convert 9000V to kV
	From the above press  result 90kV
$P = V^2 / R$	Find the power in watts with 125V and resistance 150Ω

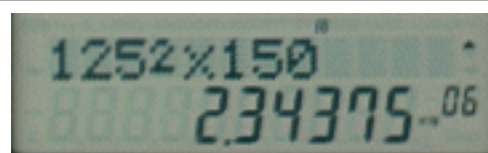
For this calculation we need to introduce another key  try the following :-  5

  result 25.

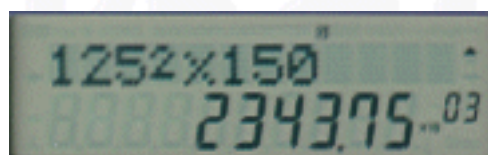
So back to the question in hand :- Find the power in watts with 125V and resistance 150Ω

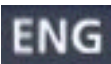



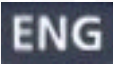
convert to kW



From the above press  note the ⁰⁶ indicating MW

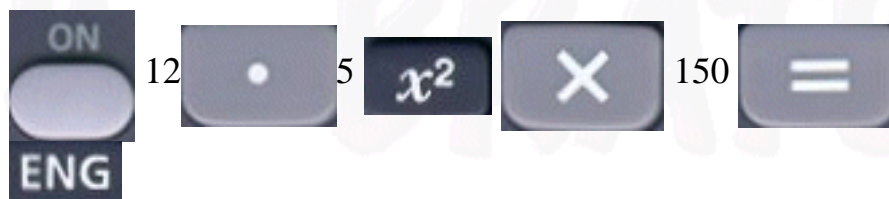
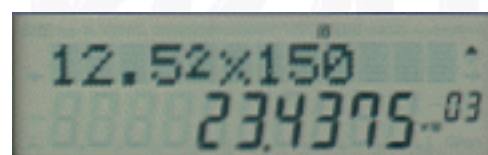


so press the  again and we see the ⁰³ indicating kW - result 2343.75 kW

If we wanted to get back to the ⁰⁶ then press  then  - so this shows that you can go up and down the exponential until you find the correct level.

$$P = I^2 \times R$$

Find the power in kilo watts with 12.5 Amps and resistance 150Ω



Note :-that the conversion to the "engineering" value has to be done after the main calculation. The ⁰³ indicates the kilo value 10³ : Result 23.4375 kW

kilo 10 ³	Mega 10 ⁶	Giga 10 ⁹
----------------------	----------------------	----------------------

So that completes the calculations for this set.

There are more functions to show you but it is hoped that you have taken all the above onboard and it is time to give yourself a coffee / tea break !!!

Next [Circuit theory](#) [Maths](#)

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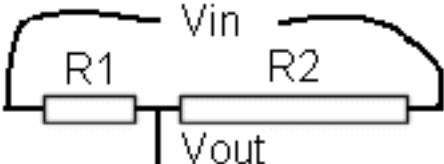
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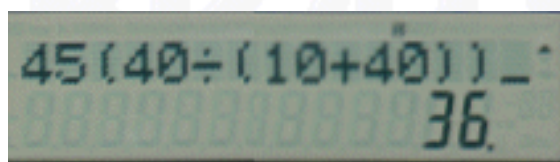
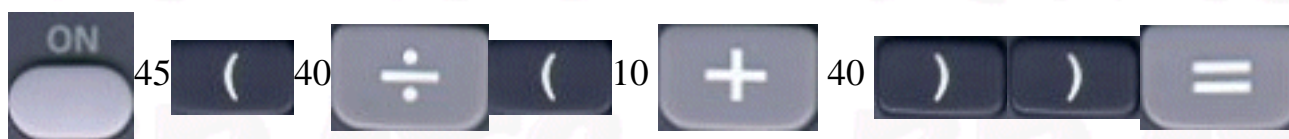
Circuit theory Maths

In this section we come across the formula $V_{out} = V_{in} \times \frac{R_2}{R_1 + R_2}$. Remember we are dealing

here with a potential divider . so how do we use the calculator.

The above equation could be written as $V_{out} = V_{in} \left(R_2 \div (R_1 + R_2) \right)$

Example $R_1 = 10\Omega$ $R_2 = 40\Omega$ $V_{in} 45$ what are the volts_{out}



The picture opposite is infact wider than your calculator screen so that it shows in one go all the key strokes.

With this example we are using the "math's rule" explained earlier where a figure before a bracket mean multiply unless there is another function shown.

Result 36 V_{out}

So that completes the calculations for this set.

There are more functions to show you but it is hoped that you have taken all the above onboard and it is time to give yourself a coffee / tea break !!!

Next [Capacitance](#) [Maths](#)

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Capacitance Maths

In this section we come across the formula

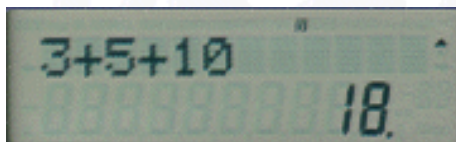
$$C_T = C_1 + C_2 + \dots \quad C_T = \frac{C_1 \times C_2}{C_1 + C_2} \quad \frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \dots$$

Remember we are dealing here with Capacitors in parallel and capacitors in series.

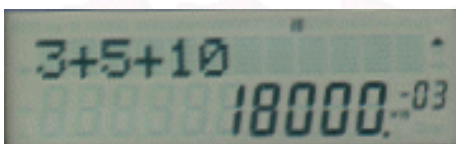
$$C_T = C_1 + C_2 + \dots$$

Capacitors in parallel have their values added together.

Example What is the total capacitance in microfarads for $C_1 = 3\mu\text{F}$ $C_2 = 5\mu\text{F}$ $C_3 = 10\mu\text{F}$?



Result 18



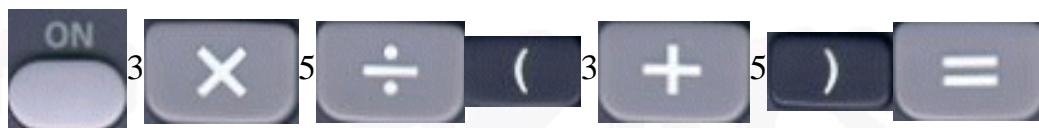
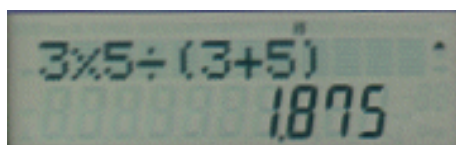
If you had been asked to give the answer in nano farads which is $1/1000$ or 10^{-3} smaller then you would press the **ENG** key until you see $^{-03}$
Result 18000 nanofarads

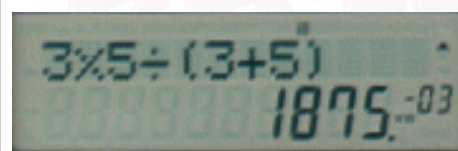
You must know which exponential you are looking for with the **ENG** key otherwise you can still end up with the wrong answer.

$$C_T = \frac{C_1 \times C_2}{C_1 + C_2}$$

This is the formulae for two capacitors in series.

Example What is the total capacitance in microfarads for $C_1 = 3\mu\text{F}$ $C_2 = 5\mu\text{F}$?



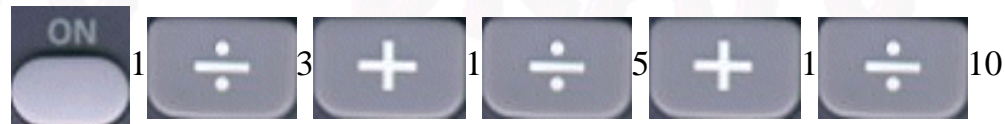
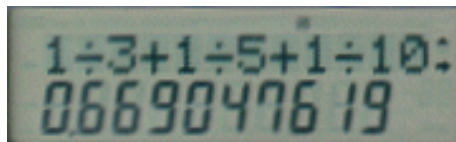


If you had been asked to give the answer in nano farads which is $1/1000$ or 10^{-3} smaller then you would press **ENG** until you see $^{-03}$ and the Result 1875 nanofarads

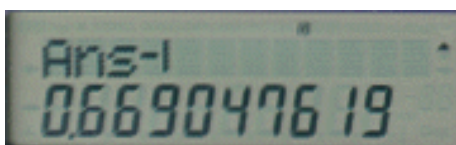
$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \dots$$

This is the formulae for more than two capacitors in series.

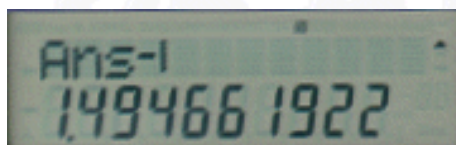
Example What is the total capacitance in nanofarads for $C_1 = 3\mu\text{F}$ $C_2 = 5\mu\text{F}$ $C_3 = 10$ $C_4 = 15$ $C_5 = 28$?



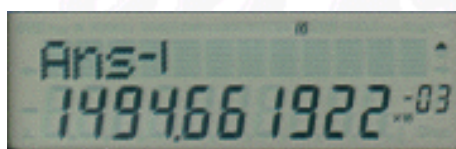
Result 0.669uF when we round to 3 places of decimal.



but this is $\frac{1}{C_T}$ so one last function press **x^{-1}** which give the reciprocal.



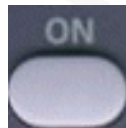
then **=** for the final result, well nearly !!!!



BUT you had been asked to give the answer in nano farads which is $1/1000$ or 10^{-3} smaller so you need to press **ENG** until you see $^{-03}$ and the Result 1494 nanofarads if we forget the figures after the decimal point. In an exam it would be expected that when asked for nanofarads then it wold be a whole number !!

Again this example invokes the "Maths rule" with the division being done first before the addition so no brackets are required.

In this last example the full screen of figures is shown as on the calculator and has not been widened, as by

now you should be familiar with what to expect in the display. From now on leave out the  button

as you know how to use it!

$$T=CR$$

T (in seconds) = C (in farads) x R (in ohms)

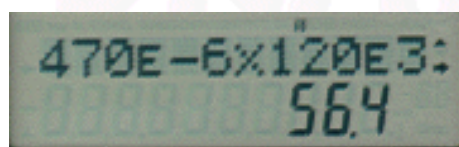
Here as with ALL formula the value of the variables must be considered. It is not often that you will use a capacitor as large as a Farad the microfarad uF being more usual.

Example . How long in seconds will it take for a 470uF capacitor to charge to 63% of the applied voltage V_S 5V through a resistor of 1k2 Ω

In this example because we are using a "wrong" mix of numbers, by that we have components which are not in the prefix correct for the equation we will have to enter the number expressing them in terms of the prefix we need.

To do this we need to introduce you to the exponential key. we know that 470uf can be written as 470×10^{-6} Farads and 120k Ω can be written as 120000 or $120 \times 10^3 \Omega$ so we will be using this in the calculator input. So back to the question.

How long in seconds will it take for a 470uF capacitor to charge to 63% of the applied voltage V_S 5V through a resistor of 120k Ω



Result 56.4 seconds

So by expressing the values given to those required by the formula the answer comes out directly!!

So that completes the calculations for this set and it is hoped that by now the benefit of the use of the calculator is showing through the blur of figures.

There are more functions to show you but it is hoped that you have taken all the above onboard and it is time to give yourself a coffee / tea break !!!

Next [Inductance Maths](#)

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Inductance Maths

In this section we come across the formulae

$L_T = L_1 + L_2 + L_3 + \dots$ for inductors in series and $\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \dots$ for inductors in parallel.

This is similar to the capacitor formulae for series and parallel but so that you are not confused

$C_T = C_1 + C_2 + \dots$ for capacitors in parallel and $\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \dots$ for inductors in series.

So [click here](#) to look back and you should be able to work out how to use the calculator.

Next [AC circuits Maths](#)

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maths...

AC circuits Maths

In this section we come across the formulae

the period of a sine wave is equal to $1/f$, $T = 1/f$ and that the frequency of a sine wave is equal to $1/T$
 $f = 1/T$ (where f = frequency in Hertz and T = time in seconds).

This should be quite straight forward as is it normal division but watch out for the prefixes as

for $f = 1/T$ & $T = 1/f$

f = frequency in Hertz and T = time in seconds

Next [Inductance & Capacitance with AC](#) Maths

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Inductance & Capacitance with AC Maths

In this section we come across the formulae

the equations for inductive and capacitive reactance. $X_L = 2\pi fL$ $X_C = \frac{1}{2\pi fC}$

Next [Tuned circuits Part B](#) Maths

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Tuned circuits Part B Maths

In this section we come across the formula

at resonance $X_C = X_L$ and that $f = \frac{1}{2\pi\sqrt{LC}}$

also the formula for Q, $Q = \frac{2\pi fL}{R}$ and $Q = \frac{1}{2\pi fCR}$

and $Q = \frac{F_R}{F_1 - F_2}$ The equation for the resonant frequency and half power points

and also the formula $R_D = \frac{L}{CR}$

Next [Transformers](#) Maths

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Transformers Maths

In this section we come across the formulae

relating transformer primary and secondary turns to primary and secondary potential differences and currents.

$$V_s = V_p \times \frac{N_s}{N_p} \quad I_p = I_s \times \frac{N_s}{N_p}$$

and the formula relating transformer primary and secondary turns to primary and secondary impedances

$$Z_p = Z_s \left(\frac{N_p}{N_s} \right)^2$$

Next [Decibels](#) **Maths**

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Decibels Maths

In this section we come across the equations for decibel power and voltage ratios.

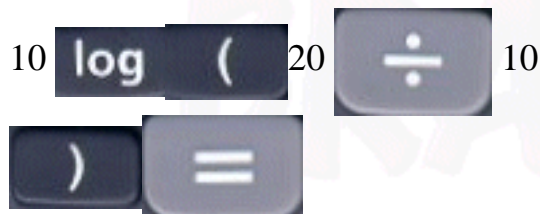
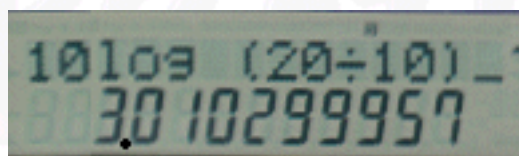
The number of decibels increased or decreased is given by either

$$\text{dB} = 10 \log_{10} \left(\frac{P_1}{P_2} \right) \text{ or } \text{dB} = 20 \log_{10} \left(\frac{V_1}{V_2} \right)$$

$$P_1 = \text{Power}_{\text{Out}} \quad P_2 = \text{Power}_{\text{In}} \text{ similarly } V_1 = \text{Volts}_{\text{Out}} \text{ and } V_2 = \text{Volts}_{\text{In}}$$

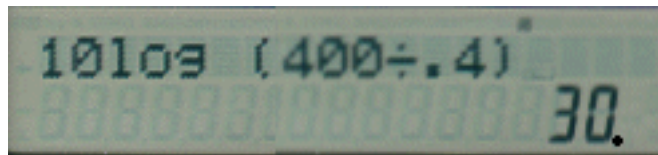
Example: if the power out is 20 watts and the power in is 10 watts what is the increase in power expressed in dB?

You should know that a doubling of power in fact is 3dB increase so let's see what the calculator gives !!



Using a double image of the calculator screen to bring the full input to the calculator you can see the figure comes out at about 3dB what we expected

Example: if the power out is 400 watts and the power in is 0.4 watts what is the increase in power expressed in dB?

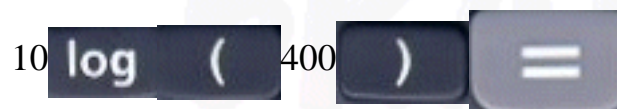
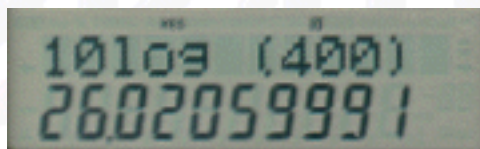


Using a double image of the calculator screen to bring the full input to the calculator you can see the figure comes out at about 30dB what we expected as 30dB represents a 1000 times power increase.

If the question was set using voltages then you should now be able to understand how to do the calculation.

What is a measured power of 400W expressed in dBW ?

Remember $\text{dBW} = 10 \log_{10} (\text{power in watts})$



Example: What is a measured power of 12dBW expressed in Watts ?

For this we have to introduce a secondary key stroke of a previously used key and one you may have forgotten.



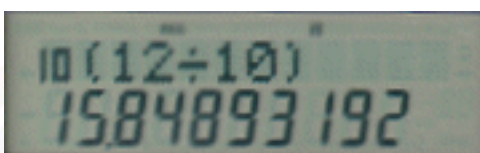
The shift key (use last when turning off the calculator) and the



key which when used "following" (not together with!!) the shift gives "antilog".

So what was the question?

Example: What is a measured power of 12dBW expressed in Watts ?



Remember $\text{Power (Watts)} = \text{antilog} (\text{dBW}/10)$

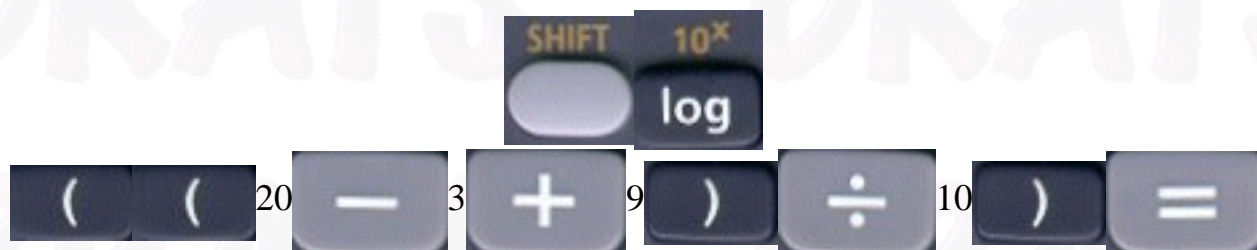
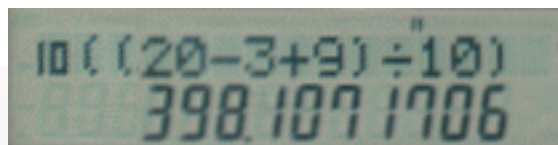


Result 16dBW when rounded up.

Example: Your transmitter have a power output of 20dBW and the feeder has a loss of 3dB, the antenna has a forward gain of 9dB. What is your ERP in watts (effective radiated power) ?

Now we know that $\text{Power(Watts)} = \text{antilog dBW}/10$

so $\text{Power(Watts)} = \text{antilog } ((20-3+9)/10) = 398\text{W rounded up} = 400\text{W}$



Result 398W rounded up = 400W

The brackets are used as they appear in the formula OR AS NEEDED TO KEEP THE MATH'S RULE TRUE and thus it makes keying the calculator straight forward **BUT if you have been taught another way then use it !!**

There are more functions to show you but it is hoped that you have taken all the above onboard and it is time to give yourself a coffee / tea break !!!

Next [Feeder basics](#) [Maths](#)

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Feeder basics **Maths**

In this section we come across the formula $Z_0^2 = Z_{in} \times Z_{out}$

Next [Return loss](#) **Maths**

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Return loss Maths

In this section we come across the formula :-

$$SWR = \frac{V_{\max}}{V_{\min}} = \frac{V_{\text{forward}} + V_{\text{reverse}}}{V_{\text{forward}} - V_{\text{reverse}}}$$

Example: What is the SWR if the V_{forward} is 100V and V_{reverse} is 50V ?

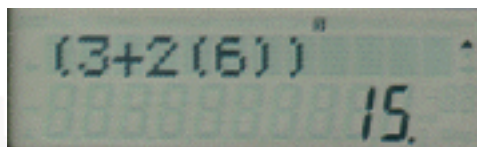
Result 3:1 SWR

Whilst this might be an easy calculation that you could do on a simple calculator using the key strokes including the brackets that you would use for other calculation keeps you thinking along a single procedure using the calculator.

and RETURN LOSS at transmitter = Return Loss at antenna + 2 x (feeder loss)

$$\text{Return Loss}_T = \text{Return Loss}_A + 2(\text{feeder loss})$$

Example: The Return loss at the antenna is 3dB and feeder loss 6dB what is the return loss at the transmitter ?



Result 15dB

Next [Field strength](#) [Maths](#)

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Field strength Maths

In this section we come across the formula for field strength given the ERP and distance from the antenna.

$$FS = \frac{7 \times \sqrt{ERP}}{d} \text{ V/m}$$

Diagram illustrating the formula for Field Strength (FS) in Volts per Metre (V/m). The formula is shown as $FS = \frac{7 \times \sqrt{ERP}}{d}$. Labels indicate: "Constant" for the 7, "Effective Radiated Power" for ERP, "Volts per Metre" for V/m, and "Distance from 'Radiating Source' in metres" for d.

Example: If your transmitter has a power out of 100W to an antenna with a 2 times gain what will be your Field strength at 2m in front of the yagi ?

For this we have to introduce another key on the calculator the square root key



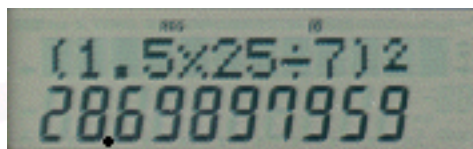
7 (√ (2 × 100)) ÷ 2 = Result 49.497

V/m

NOTE: you have to use the brackets around the square root calculation else it take the square root of 2 and not 200 !!!

Example: What ERP would be required to have a FS of 1.5V/m at 25m ?

The re-arranged equation is $\left(\frac{FS \cdot d}{7} \right)^2 = ERP$



(1.5×25÷7)2
28.69897959



Result 28.69Watts (ERP)

So that completes the calculations for the maths in the Advanced Amateur Radio Syllabus. It is hoped that the benefit of the use of the calculator is now clear to you !!

Now enjoy a coffee / tea break !!! BUT do practise the use of the calculator !!

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Prefixes

You first saw a very similar table to this in the ILC but now there is added an extra column in the scaling which shows you the exponential value.

Prefix	Prefix Name	Scaling			Example	
p	pico	1/1,000,000,000,000	0.000000000001	1.0×10^{-12}	1pF	1 pico farad
n	nano	1/1,000,000,000	0.000000001	1.0×10^{-9}	1nF	1 nano farad
u	micro	1/1,000,000	0.000001	1.0×10^{-6}	0.1uF	1 micro farad
m	milli	1/1,000	0.001	1.0×10^{-3}	1mA	1 milli amp
		1		1.0×10^0		
k	kilo	1000		1.0×10^3	1k Ω	1 kilo ohms
M	Mega	1,000,000		1.0×10^6	1M Ω	1 mega ohms
G	Giga	1,000,000,000		1.0×10^9	1GHz	1 giga hertz

You need to be able to convert between one prefix and another. NOTE: that the interval between the changes is 1,000 10^3 or 10^{-3} whichever way you are going !!!

This was also introduced to you in the ILC

Goal Makers Kick Once Many Underestimate Noise Pollution

Goal = Giga

Makers = Mega

Kick = kilo

Once = 1

Many = milli

Underestimate = u for micro

Noise = nano

Pollution = pico

End of maths for the exam..

Well that really is the end of the basics to the maths in the course. If you still find things difficult then ask your tutor to help you or email the course tutor of this web site and additional information could be placed here to help you and other students.

[Check out our recommendation for a calculator](#)

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Technical Basics Part 4

Frequency allocation table

3c.2 Understand that frequency bands are allocated for particular use, e.g. broadcasting, aeronautical, maritime and amateur.

For this part of the syllabus you have to be able to use the following chart to determine what is the "use" of the part of the radio spectrum asked in the question.

MHz and kHz

Do note that the frequencies given below are ALL in MHz - in the exam be careful to check that you are marking the box with MHz and not kHz.

FREQUENCY ALLOCATION TABLE

FREQUENCY	USE
87.5-108.0 MHz	BROADCASTING
108.0-117.975 MHz	AERONAUTICAL RADIONAVIGATION
117.975-137.0 MHz	AERONAUTICAL MOBILE
137.0-138.0 MHz	SPACE OPERATIONS & SPACE RESEARCH
138.0-144.0 MHz	LAND MOBILE
144.0-146.0 MHz	AMATEUR & AMATEUR SATELLITE
146.0-149.9 MHz	MOBILE except aeronautical mobile
149.9-150.05 MHz	RADIONAVIGATION-SATELLITE
150.05-152.0 MHz	RADIO ASTRONOMY
152.0-156.0 MHz	LAND MOBILE
156.0-158.525 MHz	MARITIME MOBILE
158.525-160.6 MHz	LAND MOBILE
160.6-160.975 MHz	MARITIME MOBILE

So there is nothing to learn - you just have to understand the chart and be able to apply it in the Foundation Licence examination.

The sort of question you might be asked is :-

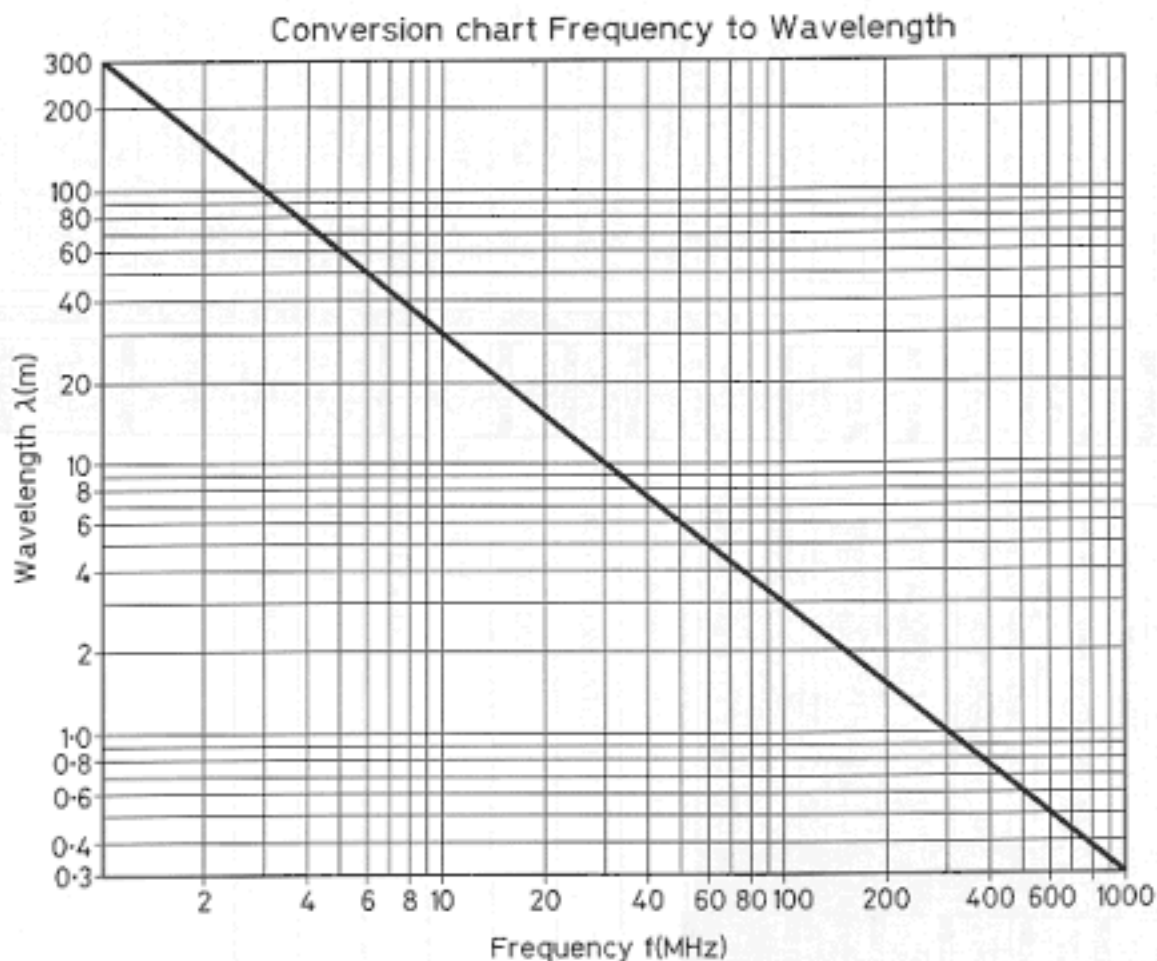
What usage is allocated to 156.125MHz ? Answer from the table above is Maritime mobile.

So this is a look up table which you are provided with in the exam and thus will test your ability to understand information given in tabular form.

Frequency and wavelength conversion

3.10 Understand the relationship between frequency and wavelength. Use a graph to convert from one to the other.

Note: calculations are not required.



This is the chart that you will be given in the written assessment

Wavelength is marked down the left hand side and the Frequency along the bottom.

Now if I asked you :-

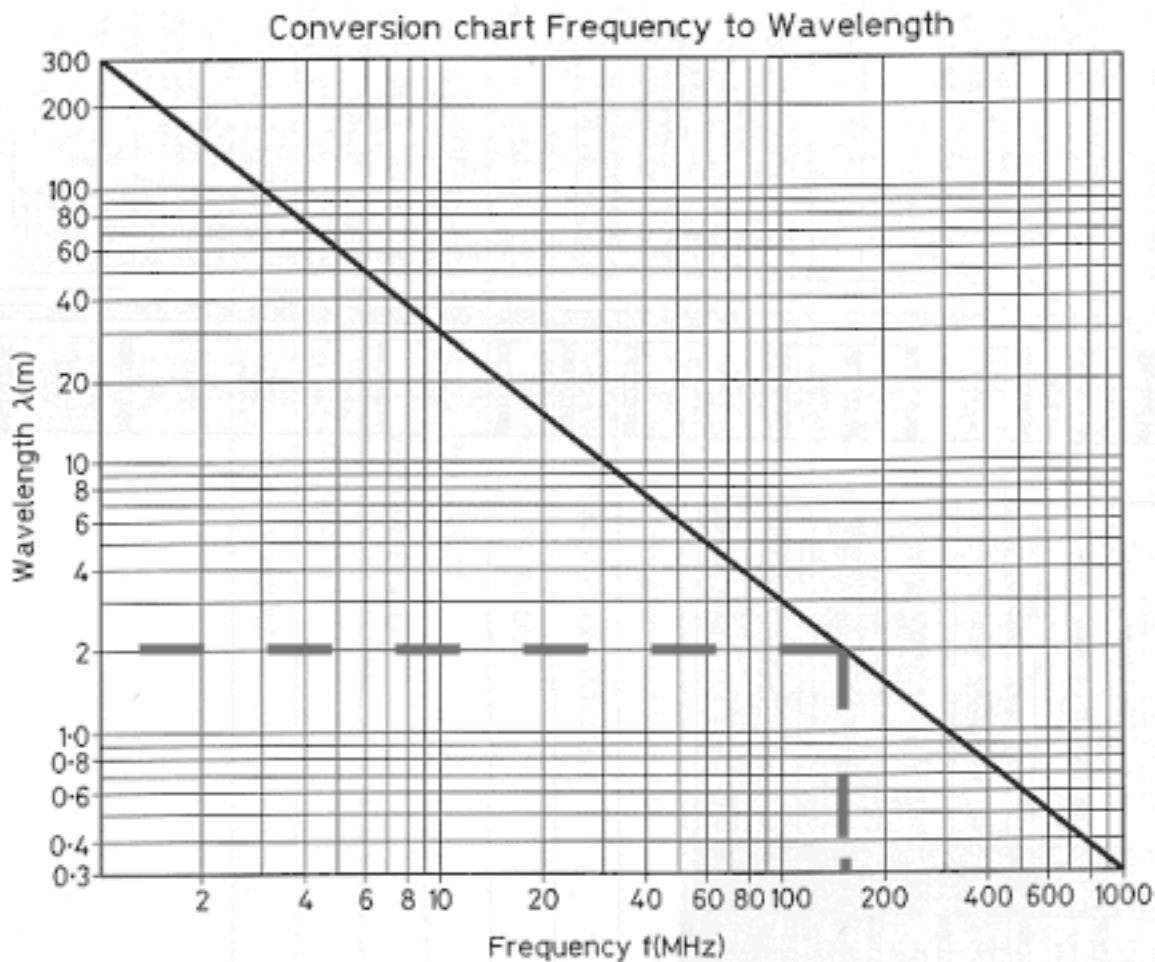
What frequency does 2m equal in wavelength ? How would you go about finding out?

Think for a moment then put your mouse pointer on the chart for a demonstration of how to use the chart.

You are not needed to do calculations just to be able to understand how to use the simple chart

and convert from wavelength to frequency or frequency to wavelength.

If the animation did not work with your browser then you have to draw a straight line from the given information on one axis to the diagonal line and then to the other axis ...see diagram below.



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- Series and parallel
- Circuit Diagram Symbols
- Polarity sensitive
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- Re-Cap

Part 2

- Units
- Resistance
- Formula Relationships
- $V = I \times R$
- $P = V \times I$

Part 3

- Prefixes milli, kilo and Mega.
- Frequency
- 50Hz Mains voltage
- Faster Frequencies
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- Frequency allocation table
- Frequency and wavelength conversion

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- Circuit Diagrams

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6. Propagation


Radio propagation basics

6a.1 Recall the basic structure of the ionosphere: D, E and F layers and their order. Understand that ionisation is caused mainly by ultraviolet rays from the sun.

In the FLC your were introduced to propagation and now we will be taking it several stages further.

You should be aware that HF propagation is predominantly due to ionisation of the ionosphere and that the ionosphere is made up of layers of gases.

We must now consider what these layers of gasses are called. These layers are simply called the D E and F layers there is no A B C layers.

Layer	Approx Height	Diagram
F	400 kms	
E	Varies	
D	70 kms	
Troposphere is below the D Layer		

The D layer is nearest to the earth at about 70kms and the top layer, the F layer is at about 400kms. The E layer sits between the D and the F layers.

It is the ionisation of the gases, caused mainly by ultra violet rays from the sun, that makes them partially conductive and which gives the ability to reflect the HF radio waves back to earth. This "bouncing back and forth can happen several times, for instance to reach Australia with losses in signal strength each time.

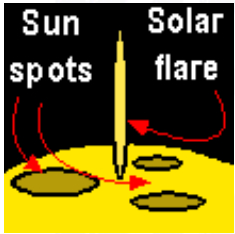
6a.2 Recall that the level of ionisation changes with the time of day, the time of the year, and according to the 11-year sunspot cycle. Understand that the sunspot number is an indicator of solar activity. More sunspots gives better HF propagation as a result

of increased ionisation.

The amount of ionisation that occurs is dependent upon :-

1. **the time of day**
2. **the time of year (season) and**
3. **changes in sun spot activity in its 11 year cycle.**

The sun spot activity is an indicator of solar activity. The more sunspots the better the HF propagation as a result of increased ionisation.



Although radio amateurs talk in terms of SUN SPOTS it is the Solar flares that cause an effect on the ionosphere. The effect of x-ray emissions from a flare is evidenced in the ionosphere as a disturbance and greater ionisation.

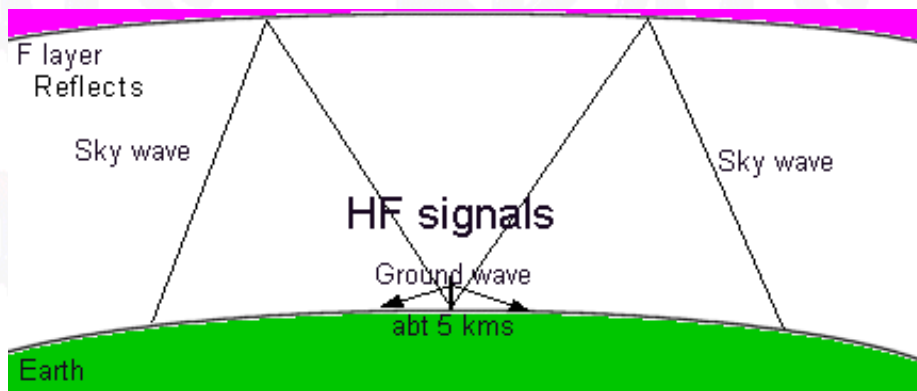
In November 2003 the greatest ever recorded solar flares took place and caused radio black out (amongst other effects) so too much of the sun's activities can worsen rather than improve communication.

6a.3 Recall that reflection from the F layer is the main mode of HF propagation.

Some students just cannot remember but with all these "F's" remember that the word REFLECTS has an "F" in it.

The word propagation means to increase the distance that your radio signal travels over and above the distance that it can travel as a Ground Wave.

As you will see from the diagram below that **GROUND WAVE** are the radio waves that hug the earth but quickly become weaker with a range of a few kms at best. Thus at whatever frequency you are operating in the HF bands any distance you achieve is dependent upon bouncing / deflecting off the "F" layer in the ionosphere.



F layer ionisation during daylight enhances propagation

It is the F layer which plays the greatest part in HF propagation. The sun causes the ionisation during periods of daylight with a peak in the early afternoon (local time).

F layer loses much of its ionisation during night particularly at the higher HF frequencies.

Whilst the F layer remains ionised over night it is much weaker than during the day and hence propagation at night dwindles on the higher HF bands.

- **In Winter F layer remains relatively constant at the daylight levels**

- During the winter the ionisation tends to remain higher as the WX is colder.

- **F layer has enhance propagation during sun spot activities**

- During the 11 sun spot cycle the more sun spots there are the higher the ionisation which lead to better reflection and the higher the radio frequency that can be reflected.

- **6a.4 Understand the meaning of ground wave, sky wave, skip distance, and skip zone (dead zone).**

- There are certain terms associated with propagation that are now introduced :-

- **GROUND WAVE = the radio waves that hug the earth** but quickly become weaker with a ranges of a few kms at best.

- **SKY WAVE = the radio waves that are reflected back to earth by the ionosphere.** Even very low powered HF transmitters are capable of having their signals reflected back from the ionosphere as it is not the power of the transmitter that is needed to make the signal reach the ionosphere, the power is only needed to be sufficient for the signal to be heard by the receiving station. QRP operation on less than 5 watts has reached Australia!

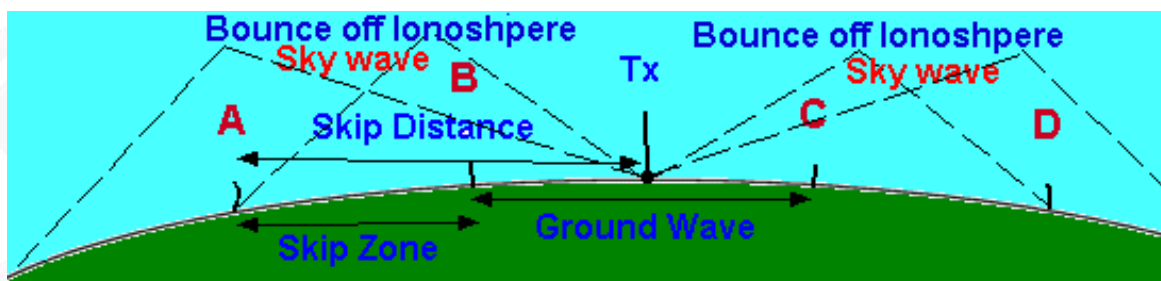
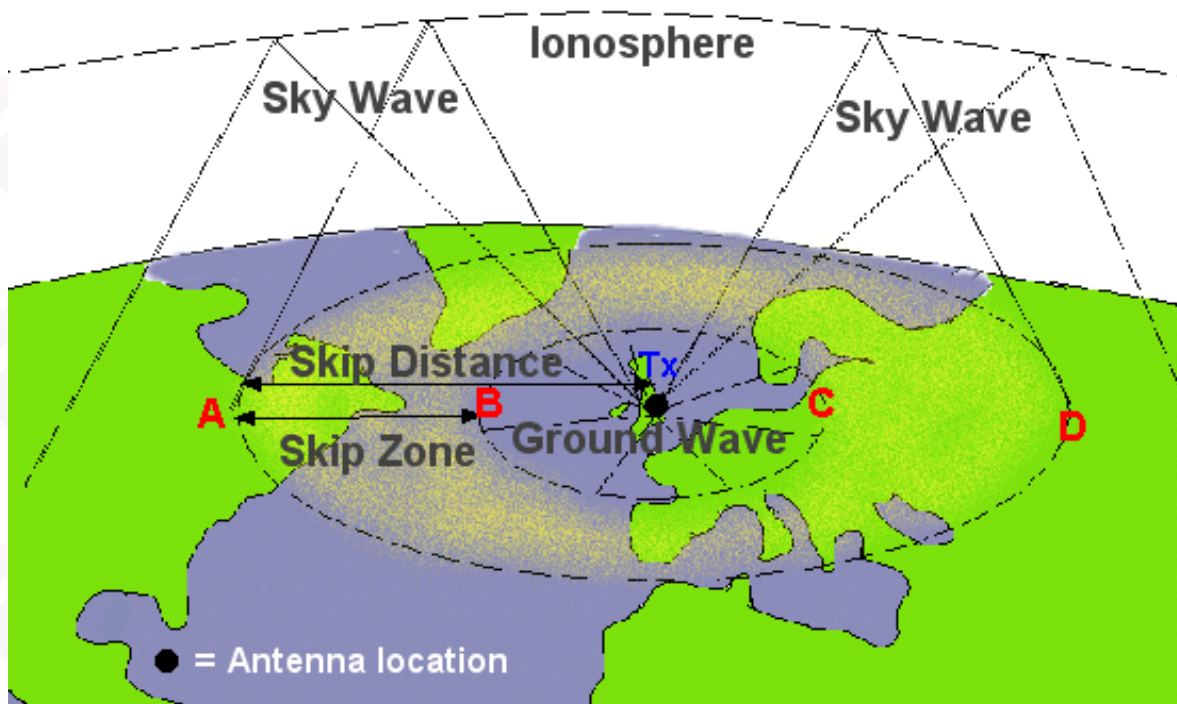
- **SKIP DISTANCE = the distance from the transmitter to the first point at which returning skywave is received back on earth** having been reflected by the ionosphere.

- **SKIP ZONE = The zone is between the end of Ground Wave coverage and the point at which returning skywave is first received back on earth.** Thus the SKIP ZONE (also called the Dead Zone) is signal free as far as communication is concerned as nothing is heard from the transmitting station.

- All the distances change as the ionosphere changes so you cannot state the the Skip Zone is such and such a distance and the same goes for the Skip Distance.

Skip distance minus ground wave distance = the skip zone distance

- **Note:- NO SIGNALS are received in the SKIP ZONE from the transmitting station's antenna location!!!**



- The Tx indicates where the Transmitting station is located. Stations at A, B, C, and D will hear the signals but for different reasons.

Ground Wave

- Stations B and C are near enough to hear the ground wave signal

Sky wave

- Stations A and D are far enough away (outside the Skip Zone or DEAD ZONE) to hear the signals from a bounce off the ionosphere.

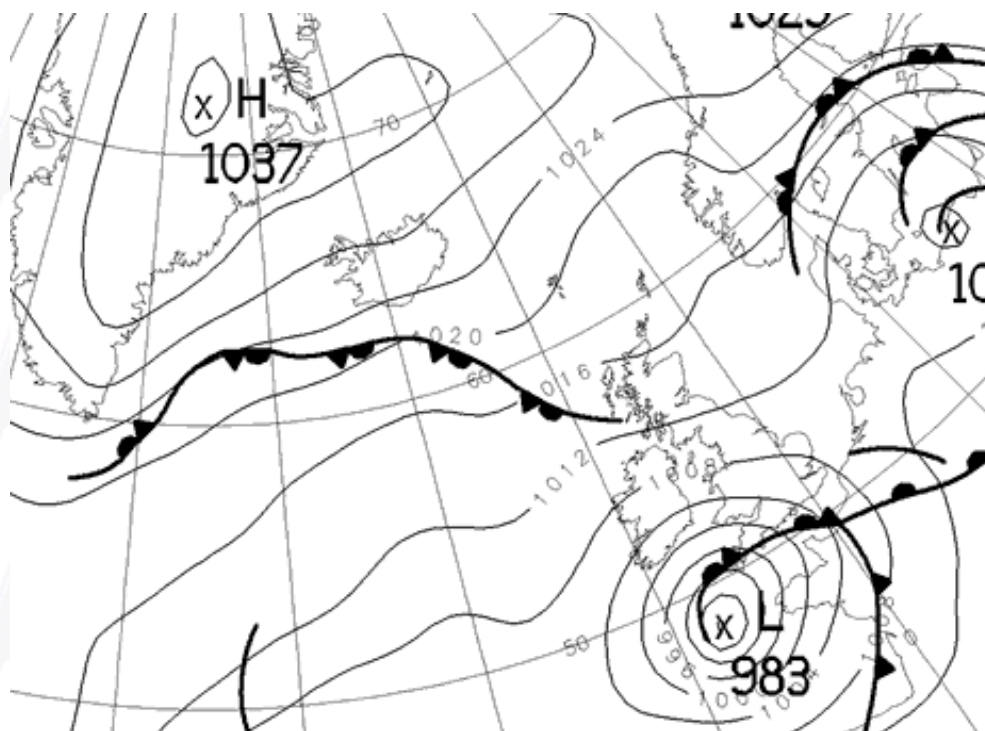
Skip Zone or DEAD ZONE

- The Skip Zone or DEAD ZONE is as it says no signals will be heard from the transmitting station, so anywhere between A and B and C and D will not hear the transmissions.

- 6a.5 Recall that high atmospheric pressure can cause ducting in the troposphere, which increases the range of VHF and UHF signals. Recall that the range of VHF signals can occasionally be significantly increased by reflection from highly ionised areas in the E layer (Sporadic E).

- What is high atmospheric pressure.

If you look at the weather forecast on the TV you will often see a simplified version of what is called a synoptic chart such as is shown below.

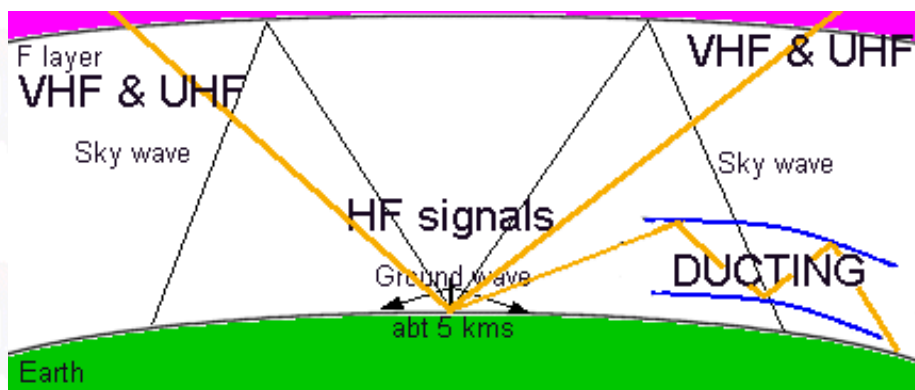


You can see on the chart the letter H and the number 1037 below and L and the number 983 below. The H represents the high pressure area and the L the low pressure area. The numbers relate to what is called a barometric pressure - but you do not need to know any details other than understanding that there is a difference between HIGH and LOW Pressure in the atmosphere.

These HIGH and LOW pressure areas are also called a High pressure system and a Low pressure system. So with that background in mind let's deal with the effect of the High pressure system.

Ducting is the enhancement of VHF and UHF

When there is high atmospheric pressure, as explained above, enhanced VHF and UHF propagation can occur by what is called "Ducting" in the troposphere.



The troposphere is the layers of atmosphere below the ionosphere.

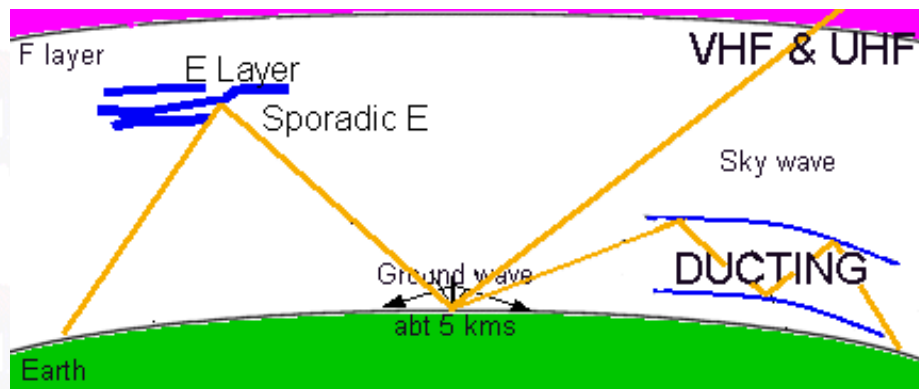
The orange coloured lines represent the VHF and UHF signals which are not reflected / refracted by the F layer but if the signal does get trapped in the troposphere then it "ducting" then enhances the propagation.

The basis of ducting is that the VHF and UHF signals get trapped between two layers of the troposphere or between the ground and a layer of troposphere and then are released in a hole in the ducting at a much further distance than is normally expected of VHF and UHF propagation.

From UK ducting across the North Sea water surface may allow microwaves communication with the Netherlands but the path soon disappears at a cliff face even a modest one where the signal is forced up out of the duct.

E LAYER and Sporadic E enhance VHF and UHF

If you have success with DX communication on VHF and UHF then it will be because of the enhanced propagation due to tropospheric ducting.



VHF and UHF can sometimes get reflected like HF when the "E Layer" becomes highly ionised - and the signals are reflected back to earth. Because the effect is not uniform it can be considered as sporadic - hence "**Sporadic E**" propagation.

6a.6 Recall that VHF and UHF signals normally pass through the ionosphere, and at these frequencies propagation is within the troposphere situated below the ionosphere.

If the signals of VHF and UHF are not trapped in some ducting in the troposphere then when they pass into the ionosphere they continue and pass right through and are lost into space.

6a.7 Recall that snow, ice and heavy rain can attenuate signals at UHF and above.

Snow, ice and heavy rain can attenuate (reduce the signal strength) UHF and higher frequency signals.

6a.8 Recall and be able to manipulate the formula $v = f \times \lambda$. Be able to calculate frequency or wavelength given the other parameter. *For calculations, the velocity of radio waves will be given.*

Some more maths for you to further your understanding of conversion of frequency to wavelength and vice versa.

In the FLC you were able to use a simple table to convert frequency to wavelength and vice versa. That table was a representation of the simple formula which enables you to calculate frequency or wavelength given one or the other.

$$v = f \times \lambda$$

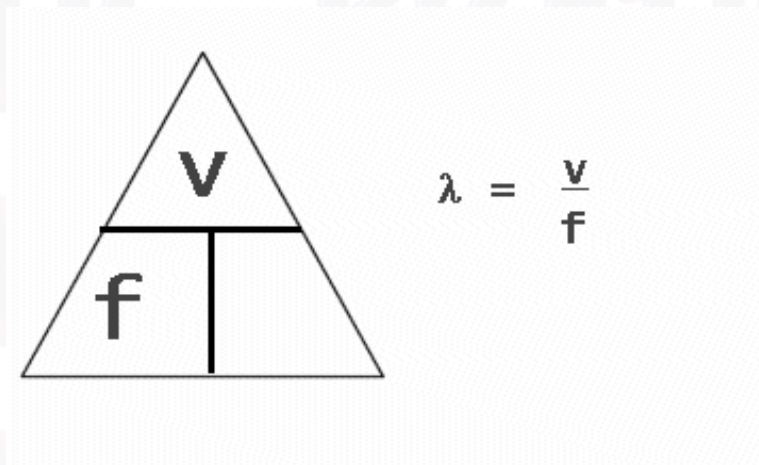
The velocity of light = the frequency x wavelength

Note the uses of a lower case v so that there is no confusion with an upper case V which stand for Voltage.

NOTE: The frequency f is expressed in Hz and the wavelength λ is in meters.

In the exam you will be given the velocity of light at a figure of 300,000,000 m/s.

For those who find manipulation of formulae difficult another magic triangle has been constructed.



and now for a few examples:-

Example 1

If $f = 3\text{MHz}$ what is the wavelength ?

so $3\text{MHz} = 3,000,000 \text{ Hz}$

and wavelength = $300,000,000 / 3,000,000$ (answer in m)

so wavelength = $300 / 3 = 100\text{m}$ REMEMBER use Frequency in Hz and wavelength in meters !

Example 2

if wavelength = 6m what is the frequency

so frequency = $v / \text{wavelength}$

so frequency = $300,000,000 / 6$ (answer in Hz)

so frequency = $50,000,000 \text{ Hz} = 50\text{MHz}$

Example 3

If the frequency is 1 GHz what is the wavelength ?

wavelength = $V / \text{frequency}$

so wavelength = $300,000,000 / 1,000,000,000$ (answer in m)

so wavelength = $300 / 1000 = 3 / 10 = 0.3\text{m}$

NOTE:

- For the exam we are told that the only units that will be used will be 1,2,3 or 6 eg 1Mhz, 20m, 30Mhz, 6m (this means that the
- leading number will only be 1, 2, 3, or 6)

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The BRATS 2003,4,5

INDEX**Nature of Amateur Radio****Licensing Conditions****Technical Basics****Transmitters and Receivers****Feeders and Antenna****Propagation****Operating Practices & procedures****EMC****Construction****Safety****BRATS****Intermediate
Radio Amateur
Licence Exam****Feeders and Antenna****Bredhurst Receiving and Transmitting Society**

Part 2

5. Feeder and Antenna

5f Antennas

The sections of the syllabus have been re-ordered as it is considered that the order shown help you to best understand the principles outlined.

5f.2 Recall that the gain of an antenna is measured in dB, and understand how to calculate the e.r.p. for a known RF power and antenna gain (in multiples of 3 dB).

Maths alert Well here is some more maths for you and it does require some learning. The table below shows the relative comparison between dB and the linear unit. This table needs to be learned and is not provided in the examination. You will see that the table goes up in 3dB jumps and each time the gain is double the previous, except for 10dB which is ten times the original power input figure.

The dB has the same basic values as given for feeder losses and thus you should be able to quickly get you head around the figures for antenna gain.

dB	Linear unit
3dB	times 2

6dB	times 4
9dB	times 8
10dB	times 10
12dB	times 16
15dB	times 32

ERP (effective radiated power) as you learned in the FL course is :-

$$\text{ERP} = \text{Power into antenna} \times \text{gain of the antenna}$$

Example 1

If the power into the antenna is 50 watts and it has a gain of 10dB what is the ERP ?

power in = 50

gain = 10db = x10

therefore ERP = 50 x 10 = 500 watts ERP

Example 2

If the power into the antenna is 10 watts and it has a gain of 9dB what is the ERP ?

power in = 10

gain = 9db = x8

therefore ERP = 10 x 8 = 80 watts ERP

5f.3 Recall that a three-element yagi has a half-wave driven element, a reflector that is slightly longer than the driven element and a director that is slightly shorter than the driven element. Recall that yagi antennas may have more than one director.

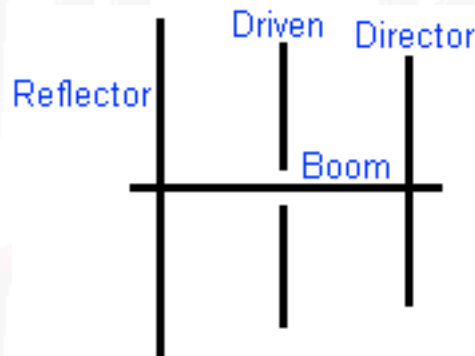
The yagi antenna is a beam antenna which due to its construction concentrates the RF signal generally one direction.

This is achieved in its simplest form by three elements -

the driven element which is a di-pole constructed to be resonant for the frequency of transmission,

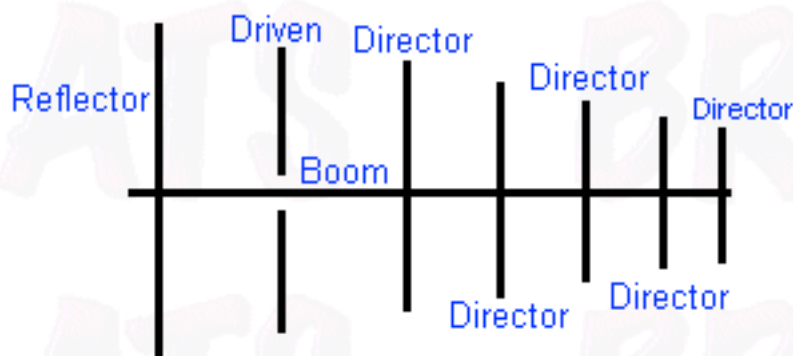
a reflector element which set behind the driven element and is a little **longer than the driven element** and

a director element which is set in front of the driven element and is a little **shorter than the driven element**.



Some students find understanding this section difficult and confusing. Can we suggest that you ask your tutor to show you a yagi antenna and explain what each part does and not just to reply upon this description.

With the construction of the bigger reflector and smaller directors than the driven element the focused direction of most of the radiation from the driven element is towards the director element and onwards.



5f.4 Recall that electromagnetic radiation comprises both an electrical field and a magnetic field. Recall that the two fields are at right-angles to each other and that the direction of propagation is at right-angles to both fields. Recall that it is the electrical field that defines polarisation of the wave.

This part is a new concept to you and has not been touched upon in the FL course.

It was James Clerk Maxwell ideas theories of what he called Electromagnetism to explain the relationship between electricity and magnetism. His theory is based upon the idea of an electromagnetic field.

Let's take one step backwards. It is hoped that you have all at one time or another played with iron filings on a piece of paper and moved around a magnet beneath and have been able to move the iron filings around. The movement was caused by a magnetic field affecting the iron filings and the movement of the magnet causing the magnetic field.

It has been explained elsewhere that if an electric current passed through a wire it too generates a magnetic field. This is what is called a stationary electromagnetic field as it stays bound to item that is causing the field. Examples of stationary fields are: the magnetic field around a wire carrying current or the magnetic field around the magnet.

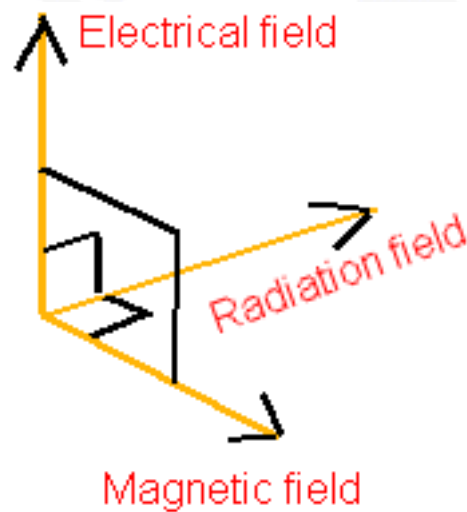
Now if the current through the wire is changing something special happens if the changes are rapid enough.

The changing electromagnetic field propagates away from its origin in the form of a wave. We know these as radio waves.

The electromagnetic radiation has actually two components parts - an electrical field and a magnetic field. The two fields are located at right angles to each other and the direction of radiation is at right angles to both those fields. This is the concept that you have to know. Why they are at right angles to each other and which one goes where is of no consequence to you at this stage.

Vertical electrical field the vertical polarization

It is the **electrical field** which **determines** or defines what is called the **polarisation of the radiation wave**.



5f.5 Recall that VHF and UHF signals will normally be received best when the transmitter and the receiver have the same antenna polarisation. This is less important at HF due the effects of ionospheric reflection.

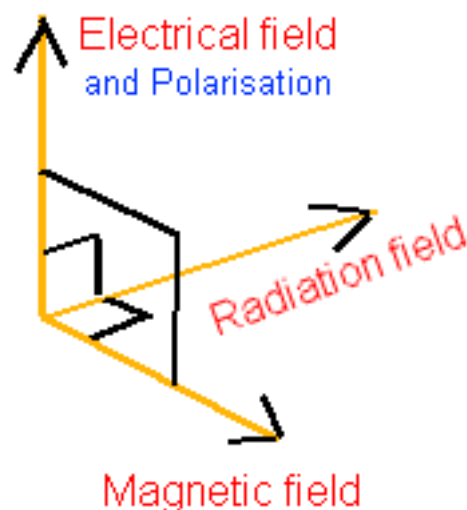
When using VHF and UHF the signals will normally be better received if the same polarisation is used else significant attenuation occurs.

The terms used at this exam level are horizontal and vertical polarization.



If the transmitting antenna is set vertically and the receiving antenna horizontally then the antennas are said to be "cross polarised".

With HF, the signals are themselves twisted due to the effects of the ionospheric reflections that the effect of "cross polarisation" of antennas is less marked.



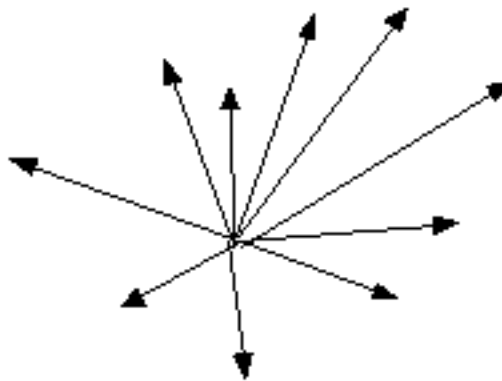
5f.1 Understand the concept of an antenna polar diagram. Be able to recognise the

directions of maximum and minimum radiation. Be able to recognise polar diagrams for the half-wave dipole and yagi antennas.

So what is the concept of a polar diagram. Well it has nothing to do with the north or south pole.

As you are aware antennas radiate, the polar diagram is a representation of the radiation pattern as a simple drawing. The diagram below shows a set of arrows which represents the direction and radiation strength.

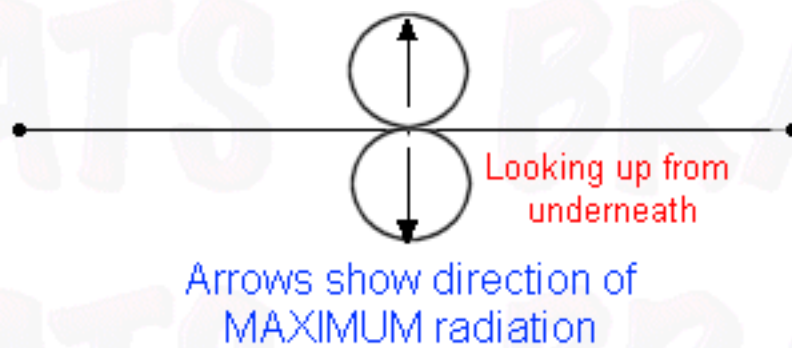
The direction is obvious but the radiation strength is proportional to length of the line - more strength longer line.



The diagram is NOT representative of any particular antenna, it is the principle of the direction of the arrow and length of the arrow (showing strength) establishes the polar outline when the arrow head are linked up.

Dipole

Let's start with the polar diagram of the dipole.



It is hoped that you gather from the animation that wire hanging down in the middle is the feeder and the horizontal wire are the legs of the dipole.

The radiation is then a bit like a doughnut that has been slipped on one end and slid along to the middle.

Thus :-

- The **maximum direction of radiation** is then **always out away from the wire** of the dipole and
- **minimum radiation** is **along the line of the dipoles** there is minimal radiation off the ends of the wire.

Yagi



The yagi diagram develops to show the direction of the maximum radiation in the direction of the arrows. Remember the driven part of the yagi is in fact a dipole and thus the reflector and the directors do a good job of changing the radiation pattern but some of the signal still goes out at the sides and rear of the yagi. The pattern shows the field strength at a particular distance from the antenna and is not intended to show the range of the signal else you would not reach too far if the signal only reached the end to the antenna!!

The **longer the arrow the bigger the radiated signal** so on the yagi the minimum signal is to the rear next less is to the sides.

5g Dummy loads

5g.1 Understand the use of a dummy load and its construction.

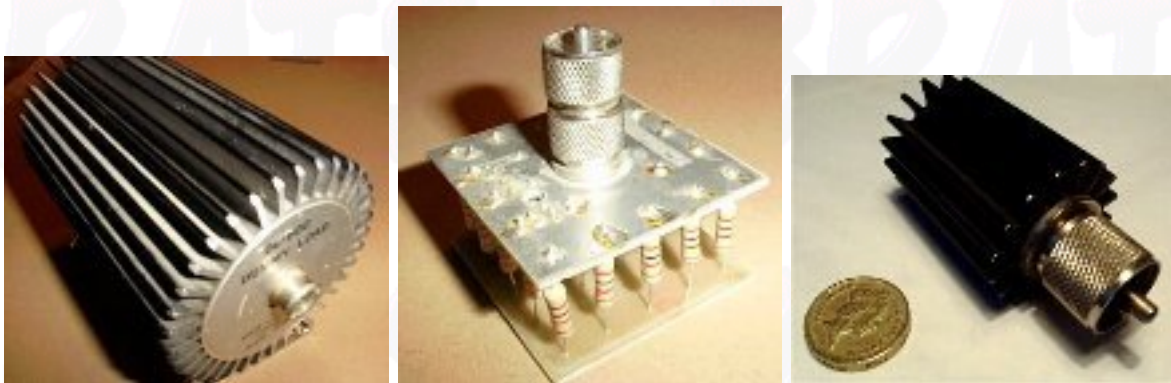
The dummy load is a substitute for an aerial and as such is also called an **artificial antenna** and as far as transmitters or receivers are concerned it electrically resembles an aerial (usually 50 ohms impedance) and thus can stand totally in place of an aerial. The dummy load is a piece of test equipment which all radio amateurs should own.

The dummy load enables a transmitter to be tested without radiating a signal (or at worst a very low radiated signal). When connected to a receiver it does not pick up external RF signals and RF noise.

When testing a transmitter the Dummy Load must be capable of safely dissipating, as heat, the output power of the transmitter.

Carbon Resistor NOT wire wound resistor

The dummy load is a large resistor of usually 50 ohms (or a number of resistors to make up the required wattage dissipation). The resistor is set inside a suitable screening enclosure and has a connector so that it may be linked by a coaxial feeder to the transmitter or receiver or even the end of a coaxial cable run which is under test.



Above are three examples of dummy loads

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Announcement

In the December Radcom 2004 it was announced that

"changes are to be made in the advanced Examination."

"the changes have been made following the current pilot scheme"

"To bring into line with current educational practice, a Formula Sheet will be included in the exam material."

"the number of questions will be reduced to 62 from the current 68, to shift the emphasis more towards operating practices rather than electronic theory."

"The changes will come into effect from the beginning of 2005"

Further **"some amendments in the operation of the Advanced Exam, following comments that the new exam was more technical than the old RAE. Ofcom agreed"**

Changes have now been made to the course notes to take account of the changes in the syllabus issued in Dec 2004.

Further updating of the site will take place from time to time as required and from feed back from students.

Close page to return to index

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Syllabus sections:-

2. Licensing Conditions**Note: that a full copy of the leaflet BR68 will be provided in the exam**

Also, pending reprinting of documents, the titles Radiocommunications Agency and Ofcom will be regarded as synonymous and references to the Secretary of State should be understood as references to Ofcom

Licence document

Understand the clauses in BR68 set out below:

This includes the Notes to the Booklet BR68 where cited in the licence clauses or where they provide additional information.

2a Types of licence and format of call signs and location

2a.1 Identify the types of UK licence and the format of all call signs in use including regional secondary locators, but NOT including club, special event and contest call signs.

Much of this topic has been in the Foundation and Intermediate licence syllabuses but due to the importance to be able to recognise UK licence holders it is also in the syllabus for this Advanced Licence Course.

There are three levels of licence the introductory level being Foundation then the next level up is Intermediate with the Advanced being the highest level.



In addition to the format for call signs for individuals there are also different formats for club, special event and contest call signs, however having knowing call signs other than for individuals is NOT part of the syllabus and thus is excluded from the course work.

Licence level	Licence title	Callsign example in England if main address	Callsign example for the Isle of Man if main address
Third tier	Advanced	M0FSH M1AAA G4VSZ G1DLL & M5ABC NOTE:- All callsigns beginning with a "G" and "M" and figures "1, 0, & 5" are Advanced Licence holders	MD0FSH GD0FSH
Second tier	Intermediate	2E0AAA 2E1JVT Note :- It is the "2" that indicates the Intermediate Licence holder	2D0AAA
First tier	Foundation	M3RND Note:- It is the "3" that indicates the Foundation licence holder	MD3RND

! You must also be able to recall all the secondary identifiers and how they are used with Foundation and Advanced licences and recall that with the Intermediate licence the Secondary Identifier replaces the letter E when the station is not located in England.

As shown in the examples the secondary identifier follows the initial letter in Foundation and Advanced level callsigns:-

M, D, W, I, J & U ,

With all licences there is also:-

/P (when not at your main station address) and

/M (for when you are mobile walking cycling etc).

UK Operation Only in areas coloured Green



Please note that whilst the Advanced Amateur Radio Licence is recognised for reciprocal operation in other countries, recognition of all UK licences is up to the host administration.

As not all countries have "Intermediate" Licences there is no mutual recognition arrangements have been made as at 12th Jan 2004 thus holders of a UK Intermediate Licence **MAY NOT operate a station located OUTSIDE UK.**

HOWEVER in the July 2003 RADCOM (the Bulletin of the RSGB) it is announced that as Gibraltar has introduced its own Foundation Licence scheme that this is a changing situation.

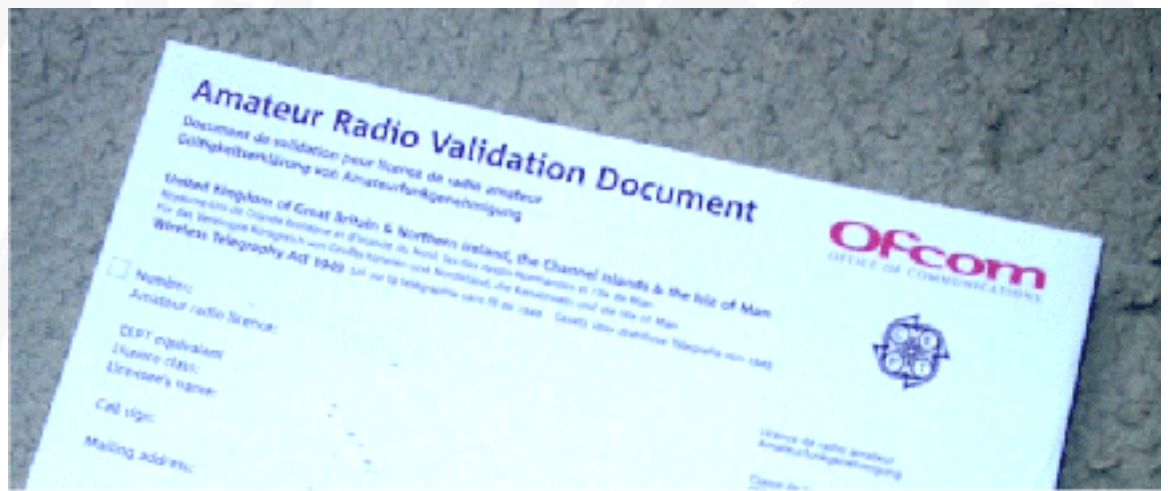
We also have to cover for this section :-

12(2) Licence documents

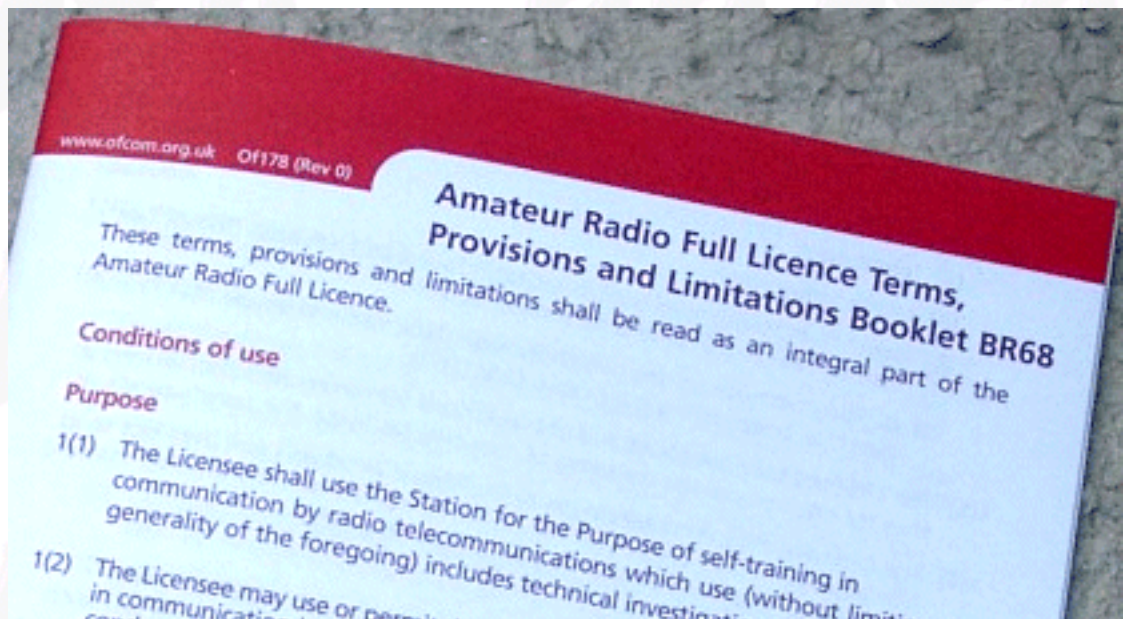
BR68 states :- 12(2) The Licence consists of the Validation Document, Terms, Provisions and Limitations Booklet BR68, the Schedule to the Booklet and the Notes to the Schedule, as any of them may be varied from time to time.

So you must not only be aware of the various part of your licence but also understand them and be able to apply as needed:-

Validation
Document,



Terms, Provisions
and Limitations
Booklet BR68,



the Schedule to the
Booklet and the
Notes to the
Schedule,

The Schedule to Terms, Provisions and Limitations Booklet BR68 (Amateur Radio Full Licence.)

Those licensed under an Amateur Radio Licence (B) may not transmit on those bands between 0.1357 and 29.700 MHz.

1	2	3	4	5
Frequency Bands in MHz	Status of Allocations in the United Kingdom to: The Amateur Service	The Amateur Satellite Service	Maximum Power level in Watts (dB relative to one Watt) PEP	Permitted Types of Transmission
0.1357-0.1378	Secondary. Available on the basis of non-interference to other services (inside or outside the United Kingdom).	(Not allocated)	1W (0dBW) erp	

and to be aware that any part may be altered from time to time.

Further you need to know about

1(10), 1(11)(a)(b)(c), 1(12), 12(1)(g)Notes (a)(i)(j) Location

BR68 States :- 1(10) "Station" means the station of the Licensee at the Main Station Address, a Temporary Location or while Mobile or Maritime Mobile, as the case may be.

1(11) Subject to clause 11, the Licensee shall operate the Station only:

(a) at the Main Station Address ("Main Station Address" means the main station address of the Licensee set forth in the Validation Document);

(b) at a Temporary Location ("Temporary Location" means a location, other than the Main Station Address, in the United Kingdom, and in a fixed position);

(c) while Mobile ("Mobile" means located in the United Kingdom in any vehicle, as a pedestrian or on any Vessel in Inland Waters);

1(12) The Licensee shall give prior written notice to the Secretary of State at the address specified in note (a) to this Booklet of any change in the Main Station Address (or mailing address, if different).

12(1) In this Licence, unless the context otherwise requires:

(g) "Inland Waters" means any canal, river, lake, loch or navigation which is not Tidal Water;

Notes (a) Remittances and correspondence should be sent to the Radio Licensing Centre, P0 Box 885, Bristol B599 SLG. Tel:(0117) 925 8333. Do not send the Licence when making remittances.

(i) If the Station is situated within 1km of the boundary of an aerodrome, then the height of the antenna or any mast or structure supporting it must not exceed 15m above ground level. An antenna which crosses above, or is liable to fall or to be blown onto, any overhead power wire (including electric lighting) or power apparatus must be guarded to the reasonable satisfaction of the owner of the power wire or power apparatus.

(j) This Licence does not absolve the Licensee from obtaining any necessary consent before entering on private or public property (including a public transport vehicle) with any apparatus.

Also you need to know ::

From BR68 :- 7(3), 7(4), 7(5) Notes (v)(w) Identity of Location

7(3) At a Temporary Location, the Licensee shall:

(a) use the suffix "/P" with his call sign and give the location of the Station every 30 minutes to an accuracy of at least 5km by a generally used identifier [for guidance see note (v) to this Booklet], or

(b) give prior written notice of the location to the Operations Manager of the local office of the Radiocommunications Agency in whose area the operation is to take place.

7(4) When Mobile, the Licensee shall use the suffix "/M" and when Maritime Mobile, the suffix "/MM".

7(5) When away from the Main Station Address, the Licensee shall use the appropriate Regional Secondary Locator specified in note (w) to this Booklet.

There is a great deal to understand in this section but most has been seen in the FLC / ILC.

the suffix "/P"

Note (v) states When the Station must be identified in accordance with sub-clause 7(3) (a), it is recommended that one of the following location identifiers be used:

(i) the full postcode,

(ii) latitude and longitude in degrees and minutes,

(iii) National Grid Reference correct to six figures,

(iv) International Amateur Radio Union (IARU) locator, or

(v) the address or other geographical description correct to 1 km.

This has been covered in depth in the Intermediate stage so [check back](#) if you have any doubts.

Notes

(v) The following Regional Secondary Locators should be used immediately after the United

Kingdom prefix "G" or "M" (as specified in the Validation Document) when identifying the Station in accordance with sub-clauses 7(5) or 10(2) of this Booklet:

D Isle of Man	I Northern Ireland	J Jersey
M Scotland	U Guernsey	W Wales
(No secondary locator) England		

If the Station is a club station and operating in accordance with sub-clause 1(8) of this Booklet, then the following club regional locators should be used instead of those above:

T Isle of Man	N Northern Ireland	H Jersey
S Scotland	P Guernsey	C Wales
X England		

(w) When identifying in accordance with clause 7, please observe the following extract from Article S19 of the Radio Regulations (S19.18-S19.22): "Identification signals shall wherever practicable be in one of the following forms:

- (a) speech, using simple amplitude or frequency modulation;
- (b) international Morse code transmitted at manual speed;
- (c) a telegraph code compatible with conventional printing equipment;
- (d) any other form recommended by the Radiocommunication Sector of the ITU."

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Syllabus sections in blue type face **parts of BR68 to which they relate are in RED bold type face :-**

Note: that a full copy of the leaflet BR68 will be provided in the exam

2b User Services and International disaster

2b.1 1(2), 1(2A), 12(1)(o) User Services

1(3) International disaster communications and frequencies used.

Messages may be passed, internationally, on behalf of non-licensed persons;

Non-amateur station involved in international disaster communications may also be heard on amateur frequencies.

In BR68 sections :-

1(2) The Licensee may use or permit the use of the Station, as part of his self-training in communication by radio telecommunications, during any operation conducted by a User Service [defined in sub-clause 12(1) (o)] or during any exercise relating to such an operation for the purpose of sending Messages on behalf of the User Service to other licensed amateur stations. It is recommended that the Licensee follows a formal emergency communications training scheme, details of which are available from the Radiocommunications Agency.

1(2A) The Licensee may use or permit the use of the Station, as part of his self-training in communication by radio, during any community event where the Licensee has been requested in writing by a User Service [defined in sub-clause 12(1) (o)] to provide communication without pecuniary gain for the purpose of sending Messages relating to the event to other licensed amateur stations.

12(1) In this Licence, unless the context otherwise requires:

(o) "User Service" means the British Red Cross Society, the St John Ambulance Brigade, the St Andrew's Ambulance Association, the Chief Emergency Planning Officer ("Chief Emergency Planning Officer" means an Emergency Planning Officer who is not responsible to any higher Emergency Planning Officer, such as a County, Regional or Islands Emergency Planning Officer) or any United Kingdom police force, fire or ambulance service, health authority, government department or public utility;

1(3) Notwithstanding sub-clauses 1(1) and 1(4) (a) of this Licence and subject to the limitations in paragraphs 2, 3, 4, 5, 6 and 8 of Resolution 640 of the Radio Regulations of the International Telecommunication Union, the Licensee may use the following frequency bands to meet the needs of international disaster communications: 3.5 MHz to 3.8 MHz, 7.0 MHz to 7.1 MHz, 10.10 MHz to 10.15 MHz, 14.00 MHz to 14.35 MHz, 18.068 MHz to 18.168 MHz, 21.00 MHz to 21.45 MHz, 24.89 MHz to 24.99 MHz and 144 MHz to 146 MHz.

This item has great importance with regard to disaster communication. Reliance is placed upon the Amateur radio hobby around the world to be available to assist in disaster communications not just in UK under the User Services but Internationally.

There is the distinct possibility that you could hear a NON-amateur calling for help in a disaster situation. Up to now you have been told that to communicate with such persons, who are in effect amateur radio pirates, is not permitted, however the Full Licence permits you to assist and pass messages on behalf of NON -amateurs on the bands mentioned above.

You do not have to learn the bands, mentioned above in red, off by heart as you are given a copy of BR68 but do make sure that you have at least familiarised yourself with which bands they are and are not allowing such communication.

! Thus Disaster Relief is the operation of your communication equipment on certain Internationally Agreed Bands and has nothing to do with CEPT recommendations.

International Disaster Communications Frequency Bands

3.5 -	7.0 -	10.10 -	14.00 -	18.068 -	21.00 -	24.89 -	144 -
3.8MHz	7.1 MHz	10.15 MHz	14.35 MHz	18.168 MHz	21.45 MHz	24.99 MHz	146 MHz

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Syllabus sections in blue type face **parts of BR68 to which they relate are in RED bold type face** :-

Note: that a full copy of the leaflet BR68 will be provided in the exam

2c Supervision of licensed and non-licensed persons.

1(8) Meaning of 'direct supervision', duties of the supervisor and nature of greetings messages.

BR68 states:- **1(8) Having regard to sub-clauses 2(10) and 3(3), greetings messages may be sent by non-licensed persons provided that:**

(a) it is under the direct supervision of the Licensee or other Authorised Club Member (in case of a Licence held on behalf of a club), who must operate the transmitter and identify the station; and

(b) each greetings message does not exceed five minutes; and

(c) greetings messages may be sent and received only within the United Kingdom or to and from stations in the United States of America, the Republic of Maldives, Gibraltar, Malta and Falkland Islands. Greetings messages may also be sent to or from stations in Canada and Pitcairn Islands provided that each greetings message does not exceed two minutes and that each person may only send one such message to each station with which the station is in contact.

This is another new area for you to understand - as a Advanced licence holder you will be allowed to permit "greeting" messages but this is under the "strict" terms set out above which need no further explanation.

Read through carefully (a) (b) and (c) above.

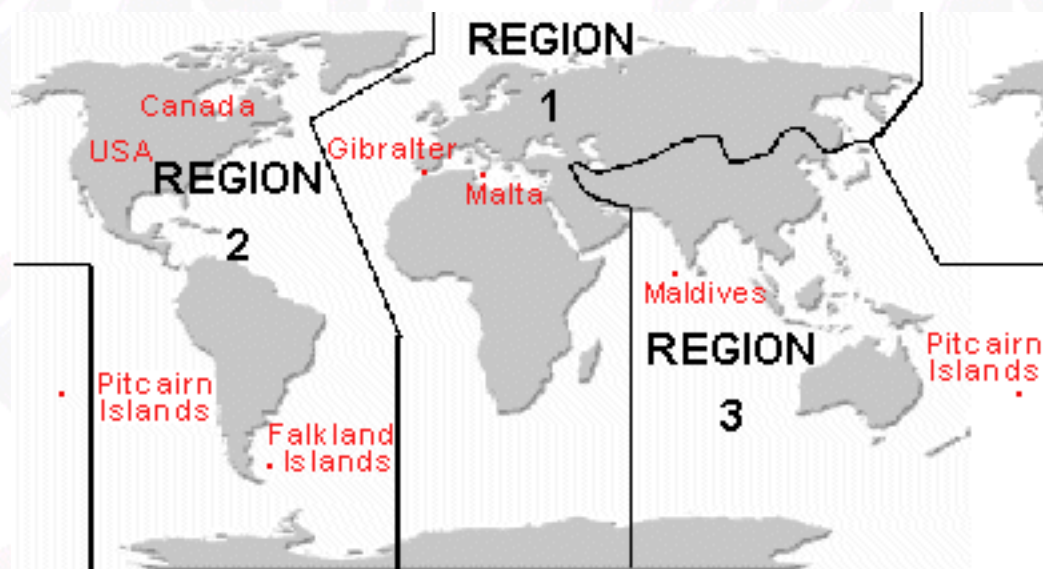
Under the direct supervision and must

1. operate the transmitter
2. identify the station

Greetings message does not exceed five minutes

5 minute messages to :-
United Kingdom
or to and from stations in
the U S A,
the Republic of Maldives,
Gibraltar, Malta
and Falkland Islands

Only one 2 minute message to or from stations in
Canada and Pitcairn Islands



The map above gives an approximate location for the various places to which greetings messages may be made. It is thought that you will be just hoping that one day you could make contact with these places, let alone supervise others to talk into the microphone and send a greeting message !!!

1(8A) Meaning of a recognised training course as defined in note 'fa' to BR68. Identification of persons qualifying.

1(8A) Having regard to sub-clauses 2(10) and 3(3), messages may be sent by non-licensed persons who are on a recognised Foundation or Intermediate training course, provided that such transmission is under the direct supervision of the Licensee, or other authorised club member (in the case of licence held on behalf of a club).

(fa) When operating in accordance with 1(8A) a registered training course is a course

recognised by or on behalf of the Radiocommunications Agency (Ofcom).

With the introduction of the Foundation and Intermediate Licences there was the need for the the trainers to **allow messages to be sent by the students when supervised by those who holds a FULL licence**. This part of BR68 provides the permission to you to do this when you have passed the Advanced exam and obtained your full licence. Further unlike the sending of messages by an unlicensed person, the student may operate the PTT.

A recognised training course is one recognised by or on behalf of the Radiocommunication Agency. Such courses are run by a trainer who is registered with the RSGB and has his / her individual Registration No.

2(8)(b) Meaning of 'direct supervision' and identity of persons who may operate.

2(8) The Licensee shall operate or permit the operation of the Station only under the terms and limitations of this Licence and the Station shall be operated only:

(b) in the presence of and under the direct supervision of the Licensee:

(i) by a person who holds a current United Kingdom Amateur Radio Licence,

(ii) by any person:

(aa) who does not fall within sub-clauses (i), (iii) or (iv);

(db) whom the Licensee has reasonable grounds to believe is not a disqualified person; and

(cc) who either holds a Radio Amateurs' Examination Certificate or a Novice Radio Amateurs' Examination Certificate issued by the City and Guilds of London Institute or an Amateur Radio Certificate issued by the Secretary of State; or

(iii) by any licensed radio amateur from any other country, or

(iv) by a representative of a User Service in accordance with sub-clause 1(2).

The licence holder is totally supervising the operation of the station to ensure that ALL licence conditions are met.

When supervising a station that person must have regards to who may operate a full licence holder's station ensuring particularly that a disqualified person does not operate - in other words do not let a pirate to operate the station!

2(9) Identification of a disqualified person.

2(9) In this clause 2, a "disqualified person" means any person:

- (a) whose United Kingdom Amateur Radio Licence is currently revoked or varied as a result of revocation action;
- (b) whose last application for an Amateur Radio Licence was refused as a result of revocation action; or
- (c) who, in the last six months, has been convicted of an offence under the Wireless Telegraphy Acts.

A rather important section as the onus is all upon the station licence holder to ensure that they are aware as to the person who they are to allow on the air is not disqualified !! Could be a tricky situation ... Best solution is to only allow those on air who hold valid licence documentation or resort to greetings message only as out lined above!!!

2(10) Use and supervision of Club Stations.

2(10) If this Licence is issued to the Licensee for use on behalf of a club, then the Licensee may:

- (a) authorise any club member who holds an Amateur Radio FULL Licence to use and supervise the operation of the Station on his behalf under this Licence.
- (b) permit a non-licensed person to speak into the microphone in accordance with sub-clause 1(8) provided the Station is operated by an Authorised Club Member.

Note that it is only when you have a FULL licence that you can supervise the use of a Club station.

7(2) Identification while under supervision.

7(2) When another person is using the Station under the Licence in accordance with sub-clause 2 (8) (b), the Licensee shall ensure that the callsign specified in the Validation Document is transmitted in accordance with sub-clause 7(1).

7(1) subject to sub-clause (1A) below, which does not apply to operation via repeaters during transmissions, the Licensee shall transmit the callsign specified in the Validation Document:

- (a) during initial calls ("CQ" calls);

- (b) at the beginning and at the end of each period of communication with a licensed amateur and when the period of communication is longer than 15 minutes, at the end of each interval of 15 minutes;
- (c) at the beginning of transmission on a new frequency (whenever the frequency of transmission is changed);
- (d) by the same type of transmission that is being used for the communication;
- (e) on the same carrier frequency that is being used for the communication; and
- (f) by morse telegraphy or telephony, at the end of each 30 minute period during which transmissions are sent from the Station (unless already transmitting in morse telegraphy or telephony). If the Licensee is conducting automatic operations involving digital communications then he shall transmit the callsign under this sub-clause at a maximum speed of 20 words per minute.

12(1)(e) Meaning of Authorised club member.

Recall that Foundation and Intermediate licensees are not permitted by their licenses to supervise the operation of an amateur radio station.

12(1) In this Licence, unless the context otherwise requires:

(e) "Authorised Club Member" means where a licence is held on behalf of a club, a member of that club who is suitably licensed and who is authorised by the licensee to use and supervise the use of the Station;

Until you are an Advanced licence holder you cannot supervise the operation of a station. But also when you are an Advanced licence holder you cannot allow a Foundation Licence Holder nor Intermediate Licence holder to supervise others in the operating of ANY amateur radio station.

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Syllabus sections in blue type face **parts of BR68 to which they relate are in RED bold type face :-**

Note: that a copy of the leaflet BR68 will be provided in the exam

2d Maritime mobile operation.

1(11) Location of station, including Maritime Mobile.

1(11) Subject to clause 11, the Licensee shall operate the Station only:

(d) while Maritime Mobile ("Maritime Mobile" means located on any Vessel At Sea).

With the Advanced licence you will be able to operate Maritime mobile and use the suffix /MM when on a vessel at sea - that means in tidal waters. Note that on inland waters you are /M (mobile)

The other locations remain as for the Foundation and the Intermediate licence.

2(12) Installation and radio silence.

Vessels

2(12) On a Vessel, the Licensee shall:

(a) install, use or make changes to the Station only with the written permission of the Vessel's master; and

(b) observe radio silence on the advice of the Vessel's master.

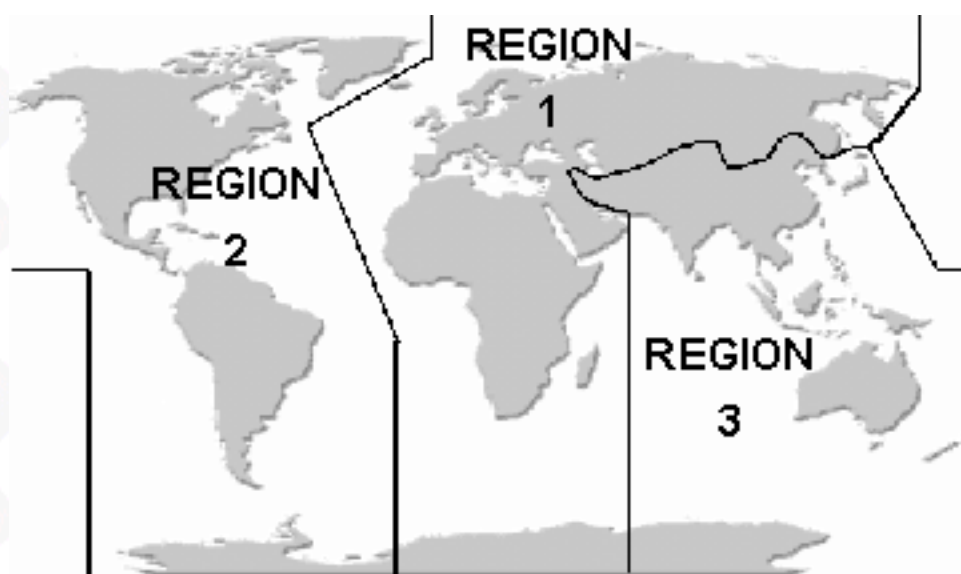
From the interpretation section the following is to be noted:-

"Vessel" includes a **hovercraft** and any other floating structure which is capable of being manned.

If you are to operate on board any sea going ship big or small you must not only have the agreement IN WRITING from the vessel's master but you must also understand that there are times when radio silence must be observed. This is to allow for distress calls to be more easily heard on what ever frequency they are being made.

2(13) Know the 3 ITU regions and that the frequencies are given in the ITU Radio Regulations.

2(13) When on a Vessel in international waters, the Licensee shall use only those frequency bands which, in accordance with the Radio Regulations, have an allocation to the amateur service in the International Telecommunication Union (ITU) region being visited.



The map above shows the approximate boundaries between the 3 ITU regions.

The frequencies that you may use are that are allocated to the amateur service in the International Telecommunication Union (ITU) region being visited.

7(4) Suffix '/MM' to call sign.

7(4) When Mobile, the Licensee shall use the suffix "/M" and when Maritime Mobile, the suffix "/MM".

The /MM indicates maritime mobile in the same way as /M indicate mobile.

8(3) Close down

8(3) When Maritime Mobile, the Licensee shall cease to operate the Station on the demand of the Vessel's master.

Quite obvious this one that if you are told to stop operating then you must cease else you may put at risk the safety of the ship. This could be for a number of reasons :-

- Interference with ship's radio
- Interference with ship's radar
- Interference with ship's electrical / electronic systems
- or just because the master is fed up with you having fun !!!!

12(1)(d) Meaning of "AT Sea".

12(1) In this Licence, unless the context otherwise requires:

(d) "At Sea" means in the Tidal Waters or territorial sea of the United Kingdom or in international waters;

In the Foundation and Intermediate Licence operation on non tidal water is allowed and the important item there is the words "Non Tidal".

In the Advanced licence you are now able to go to sea, which is a tidal location and could be the territorial sea of the UK or in International waters.

12(1)(l) Meaning of "Tidal Water".

(l) "Tidal Water" means any part of the sea or a river within the ebb and flow of the tide at ordinary spring tides;

Here we are getting even more specific as to what tidal waters means. This is both the sea and any part of the river where there are tidal changes. The comment on ordinary spring tide is associated with the highest tides of the year called "spring tides" and these would cover marshes which at other times of the year might be dry. So if for instance you were operating from a platform that could float then you would change from working /P to /MM as the tide came in !!

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2e CEPT Recommendation and reciprocal licensing.

2e.1 Operation in the UK by CEPT visitors

10, 10(1), 10(2), 10(3), 10(5)

Let's be reminded of what CEPT stands for :-

European Conference of Postal and Telecommunications Administrations which was established in 1959 by 19 countries

10(1) CEPT Amateurs may operate in the United Kingdom under a CEPT equivalent licence which is:

(a) valid and in force;

(b) not temporary; and

(c) issued by an administration which

(i) has implemented CEPT Recommendation T/R 61-01, and

(ii) permits persons licensed to use amateur stations under section 1 of the Act to use such stations in its territory (with or without conditions) without making application in that behalf.

10(2) CEPT Amateurs shall transmit their home callsign after:

- (a) the United Kingdom callsign prefix "M";
- (b) followed by the appropriate Regional Secondary Locator (if any); and
- (c) followed by the symbol "/"

[for guidance see note (w) to this Booklet].

10(3) Subject to this clause 10, CEPT Amateurs shall comply with:

- (a) the terms of their CEPT equivalent licence, unless such compliance would result in a breach of the requirements of the United Kingdom;
- (b) this Terms, Provisions and Limitations Booklet BR68 (insofar as its terms and limitations may reasonably be applied); and
- (c) the relevant provisions of CEPT Recommendation T/R 61-01.

10(5) CEPT Amateurs shall operate only:

- (a) a mobile or a portable station (which includes a station powered from the mains electricity at a temporary fixed location such as an hotel); or
- (b) the Station of an amateur licensed under the Act.

Operations by the Licensee in accordance with CEPT Recommendation TIR 61-01

So a visitor to UK can operate a station but must do so under UK regulations.

2e.2 Operation abroad under the CEPT Recommendations and under reciprocal licences.

11 Operation in CEPT countries by UK licenced amateurs

Let's be reminded of what CEPT stands for :-

European Conference of Postal and Telecommunications Administrations which was established in 1959 by 19 countries

11 Subject to sub-clause 11(2), the Licensee may operate in countries which have implemented CEPT Recommendation T/R 61-01 in accordance with the following terms.

11(1) Rules for operation in CEPT countries

11(1) The Licensee shall:

(a) be a temporary visitor and non-resident in the host country;

(b) operate only:

(i) a mobile or a portable station (which includes a station powered from the mains electricity at a temporary fixed location such as an hotel), or

(ii) the station of an amateur licensed by the relevant authority in the host country;

(c) comply with the requirements applicable to the use of wireless telegraphy apparatus at the location of operation in the host country;

(d) present this Licence upon request to the relevant supervisory authorities in the host country;

(e) if he possesses an Amateur Radio Licence (A) or (B), use only those frequencies above 30 MHz authorised for use by licensed amateurs in the host country;

(f) unless instructed otherwise by the host country, use his home callsign after the appropriate host country callsign prefix; and

(g) comply with the relevant provisions of CEPT Recommendation T/R 61-01.

temporary visitor

To be able to operate under the CEPT regulations you must be a temporary visitor and non - resident in the country you are visiting.

non temporary visitor

If you were to permanently reside in a country then your callsign would be one issued by the licensing authority in that country.

operate mobile or as a portable station

Then you must only operate mobile or as a portable station. In UK the idea of a portable station

means one that is not connected to the mains electricity but under these regulations you can be powered by mains and be at a fixed location for instance a hotel but you are using it as a temporary base.

the station of another licenced amateur in the country you are visiting

You can also be at the station of another licenced amateur who is licence in the country you are visiting.

comply with any regulation appropriate to the country

You have to comply with any regulation appropriate to the country you are visiting and this could also be dependent upon where in the country you are operating.

have your licence from UK with you

You would have to have your licence from UK with you as you have to be able to present it to the authorities upon demand !!

How the next part can apply to you as there is now no (A) or (B) licence in UK but there is in other countries. We will look further into but for the moment be aware that some countries still have a morse requirement.

the country prefix and callsign to use

Unless otherwise instructed as to the callsign that you will use, it is the country prefix / your UK callsign and as far as we can understand no suffix. Thus visiting France for instance your call would be F / UK callsign.

provisions of CEPT Recommendation T/R 61-01

We are trying to find out more about the relevant provisions of CEPT Recommendation T/R 61-01 and will update the site as soon as possible.

the word Full used in this section means Advanced the licence

11(2) Temporary Licence not valid for CEPT operation.

11(2) If this Licence is a temporary Licence, then the Licensee shall not operate under this clause 11.

Recall that many countries will offer reciprocal licences to UK amateurs with an Advanced Licence and that operation is in accordance with the host countries rules

You must remember that any form of temporary licence is not valid for CEPT operation but many countries offer reciprocal licences to UK amateurs who hold an ADVANCED LICENCE such as you are studying (the word Full used in this section means Advanced the licence and vice versa) .

When you are in a CEPT country then you operate under their rules !!!!

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2f.1 Messages

1(4), 1(6), 1(7) Messages

BR68 states :-

1(4) The Licensee shall address Messages only to other licensed amateurs or the stations of licensed amateurs and shall send only:

- (a) Messages relating to technical investigations or remarks of a personal character; or**
- (b) Signals (not enciphered) which form part of, or relate to, the transmission of Messages.**

1(6) The Licensee may use codes and abbreviations for communications as long as they do not obscure the meaning of, but only facilitate, the communications.

1(7) The Licensee may send Messages to individual amateurs but shall not send Messages (whether directly or for onwards transmission by another station) for general reception by licensed amateurs other than:

- (a) initial calls; or**
- (b) to groups of licensed amateurs as long as communication is first established separately with at least one licensed amateur in any such group; or**
- (c) to licensed amateurs who participate within a net and subject to the identification**

- **requirements provided for in sub-clause 7 (IS) below; or**

- **(d) messages transmitted via a mailbox or bulletin board for reception by all or any licensed amateurs who have the facility to transmit and receive RTTY or Data Transmissions.**

- **2(2) Receipt of messages from amateurs on non-UK frequencies**

- **2(2) The Licensee may receive Messages from an overseas amateur or from a UK amateur duly authorised by the Secretary of State on a frequency band not specified in the first column of the Schedule as long as the Licensee transmits only in a band specified in the first column of the Schedule which is authorised under sub-clause 2(1) or (2).**

Whilst you could receive a station on a frequency band not allocated to UK amateurs you may only transmit back on a frequency band allocated to UK use. As such you may be working what is called cross band and you would have to announce the band of the other station in your identification so that those listening would know where to hear the other side of the conversation.

- **3(3), 3(4) pecuniary interest and permitted advertising**

- **3(3) The Licensee shall:**

- **(a) have no pecuniary interest (direct or indirect) in any operations conducted under this Licence; and**

- **(b) except as provided by sub-clauses 1(2) and (3) and except in the case of activities on behalf of a non-profit organisation established for the furtherance of amateur radio, not use the Station for business, advertisement or propaganda purposes including (without limiting the generality of the foregoing) the sending of news or messages of, or on behalf of, or for the benefit or information of, any social, political, religious or commercial organisation.**

Note :- There is no section 3(4) in BR68 and this may be an error in the syllabus.

- **5(1), 5(2), 5(3), 5(4) recorded and re-transmitted messages.**

- **5(1) The Licensee may record and retransmit Messages addressed to the Licensee from other licensed amateurs:**

- **(a) with whom the Licensee is in direct communication; or**

- **(b) which are intended for retransmission to a specified licensed amateur.**

5(2) The Licensee may send Messages by (or as part of) the intermediate relaying of the Messages to or from other licensed amateurs.

5(3) When recording and retransmitting the Message of another licensed amateur, if the Licensee also records and retransmits the call sign of the licensed amateur, then the Licensee shall transmit the call sign in such a way that the origin of the Message and the origin of the retransmission are clear.

5(4) Notwithstanding sub-clauses 5(1) and (2), the Licensee shall not operate the station as:

(a) a mailbox or bulletin board (each being a device which stores, in a readable form, complete messages, which are not to or from the Licensee, for re-transmission on behalf of other licensed amateurs); or

(b) a telephony repeater (a facility which receives and simultaneously retransmits Messages by telephony for or on behalf of other licensed amateurs).

Notes (c) (d) (e) (h) inappropriate messages

(c) If any message, the receipt of which is not authorised by this Licence, is received by means of the Station, neither the Licensee nor any person using the Station should make known the contents of any such message, its origin or destination, its existence or the fact of its receipt to any person except an authorised officer of Her Majesty's Government or a competent legal tribunal, or retain any copy or make any use of such message, or allow it to be reproduced, copied or made use of. It is an offence under section 5 of the Act deliberately to receive messages the receipt of which is unauthorised or (except in the special circumstances mentioned in that section of the Act) to disclose any information as to the contents, sender or addressee of any such message.

(d) It is an offence to send certain misleading messages, viz:

"Any person who;

(i) by means of wireless telegraphy, sends or attempts to send, any message which, to his knowledge, is false or misleading and is, to his knowledge, likely to prejudice the efficiency of any safety of life service or endanger the safety of any person or of any vessel, aircraft or vehicle, and, in particular, any message which, to his knowledge, falsely suggests that a vessel or aircraft is in distress or in need of assistance or is not in distress or not in need of assistance;

...shall be guilty of an offence under this Act." (Section 5 WT Act 1949).

(e) This Licence does not authorise the doing of any act which is an infringement of any copyright which may exist in the communication sent or received.

(h) It is an offence under the Wireless Telegraphy (Content of Transmission) Regulations 1988 to send a message, communication or other matter in whatever form that is grossly offensive or of an indecent, obscene or menacing character.

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2g Unattended operation

2g.1 2(3) NOT including NGR's, 2(4), 2(5), 2(6)

Unattended operation

2(3) Subject to sub-clause 2(5), the Licensee may conduct the Unattended Operations ("Unattended Operation" means the operation of the Station which is unattended by the Licensee) only:

(a) of a beacon:

(i) in the frequency bands or sub-bands:

- 70 MHz to 70.5 MHz**
- 1298 MHz to 1299 MHz**
- 2310.0000 MHz to 2310.4125 MHz**
- 2310.4125 MHz to 2355.0000 MHz**
- 2355 MHz to 2365 MHz**
- 2365 MHz to 2392 MHz**
- 2392 MHz to 2450 MHz**
- 3400 MHz to 3420 MHz**
- 3420 MHz to 3430 MHz**
- 3430 MHz to 3450 MHz**
- 3450 MHz to 3455 MHz**
- 3455 MHz to 3475 MHz**
- 5650 MHz to 5670 MHz**

- 5670 MHz to 5680 MHz
- 5755 MHz to 5765 MHz
- 5820 MHz to 5850 MHz
- 10000 MHz to 10125 MHz
- 10400 MHz to 10475 MHz
- 24000 MHz to 24050 MHz
- and with the exception of 47000 MHz to 47200 MHz all bands including and above 47000 MHz specified in the first column of the Schedule, with a maximum power level of 14dBW erp pep, or;

(ii) for the purpose of direction finding competitions, on 1.96 MHz with a bandwidth not exceeding 12.5 kHz and in the frequency bands:

- 28.0 MHz to 29.7 MHz ; or
- 144 MHz to 146 MHz ,
- with a maximum power level of 14 dBW erp pep which is capable of transmitting the call sign of the Licensee periodically (in accordance with clause 7) and capable of being switched off within two hours of a demand to close down given by a person authorised by the Secretary of State;

(b) of a low power device to control apparatus at the Main Station Address or at a Temporary Location by remote control, in the frequency bands or sub-bands:

- 70 MHz to 70.5 MHz
- 432.5000 MHz to 432.5875 MHz
- 1298 MHz to 1299 MHz
- 2310.0000 MHz to 2310.4125 MHz
- 2310.4125 MHz to 2355.0000 MHz
- 2355 MHz to 2365 MHz
- 2392 MHz to 2450 MHz
- 3400 MHz to 3420 MHz
- 3420 MHz to 3430 MHz
- 3430 MHz to 3450 MHz
- 3450 MHz to 3455 MHz
- 3455 MHz to 3475 MHz
- 5650 MHz to 5670 MHz
- 5670 MHz to 5680 MHz
- 5755 MHz to 5765 MHz
- 5820 MHz to 5850 MHz
- 10000 MHz to 10125 MHz
- 10400 MHz to 10475 MHz
- 24000 MHz to 24050 MHz
- and with the exception of 47000 MHz to 47 200 MHz , all bands including and above

47000 MHz, specified in the first column of the Schedule, with a maximum power level of -20 dBW erp pep, under all reasonably foreseeable operational conditions, in such a way that no electromagnetic energy capable of reception by any station or apparatus outside the boundary of the premises in which the Station is situated is emitted from the Station: or

(c) by digital communications at the Main Station Address or at a Temporary Location:

(i) in the frequency band:

- 50 MHz to 51 MHz with a maximum power level of 10 dBW erp pep, or

(ii) on the spot frequencies:

- 70.3125 MHz
- 70.3250 MHz
- 70.4875 MHz
- with a bandwidth not exceeding 25 kHz; or

(iii) in the frequency bands or sub-bands:

- 144 MHz to 146 MHz
- 1299 MHz to 1300 MHz
- 2310.0000 MHz to 2310.4125 MHz
- 2310.4125 MHz to 2355.0000 MHz
- 2355 MHz to 2365 MHz
- 2365 MHz to 2392 MHz
- 2392 MHz to 2450 MHz
- 3400 MHz to 3420 MHz
- 3420 MHz to 3430 MHz
- 3430 MHz to 3450 MHz
- 3450 MHz to 3455 MHz
- 3455 MHz to 3475 MHz
- 5650 MHz to 5670 MHz
- 5670 MHz to 5680 MHz
- 5755 MHz to 5765 MHz
- 5820 MHz to 5850 MHz
- 10000 MHz to 10125 MHz
- 10400 MHz to 10475 MHz
- 24000 MHz to 24050 MHz
- and with the exception of 47000 MHz to 47 200 MHz, all bands including and above 47000 MHz, specified in the first column of the Schedule with a maximum power level

of 14 dBW erp pep.

2(4) With the exception of sub-clause 2(5) the Licensee shall not conduct the Unattended Operation of a beacon or of digital communications unless he has given at least 7 days written notice of the location, period of operation, frequency, power (dBW), identity of other users of wireless telegraphy who share the site and shut down procedures to the Operations Manager of the local office of the Radiocommunications Agency in whose area the operation is to take place. The Operations Manager may, before the commencement of operation, prohibit the Unattended Operation or allow the operation on compliance with the conditions which he may specify.

2(5) The Licensee may transmit on an unattended basis using automatic position reporting software on a spot frequency of 144.800 MHz at any one temporary location not within 50km of NGR TA 012869. The maximum permitted period of unattended operation is 30 minutes and the Licensee must be present to activate and deactivate transmissions. The maximum permitted power level is 14 dBW erp.

With regard to unattended operation you will have to read through the sections in red above and realise that you do not have to learn it detail as you will have the information in the BR68 in the exam, so the best idea is to have a working appreciation of the information and where to find it in BR68 rather than learning it parrot fashion !!!

2(6) The Licensee is not required to log the operation of a low power device under sub-clause 2(4) (b), although he shall log the operation of the Station in accordance with clause 6.

No log of low power devices but the actual operation of the station must be logged.

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2h Logging and Identification

6(1), 6(2), 6(3), 6(4), 6(5) Notes (q)(r)(s) Logs

6(1) Subject to sub-clause 2(6), the Licensee shall keep a permanent record (the "Log") of all wireless telegraphy transmissions at the Main Station Address and all Temporary Locations showing:

(a) dates of transmission;

(b) the times (in Co-ordinated Universal Time (UTC)) during each day of:

(i) the first and last transmissions from the Station (except when using automatic operations involving digital communications), or

(ii) switching the Station on and off for the purpose of enabling transmissions (when using automatic operations involving digital communications), and changing the frequency band, class of emission or power;

(c) frequency band of transmission or, in an Unattended Operation, the specific frequency employed;

(d) class of emission;

(e) power (or power level in dBW);

- (f) initial calls ("CQ" calls) (whether or not they are answered);
-
- (g) except during automatic operations involving digital communications, the callsign of licensed amateurs or licensed amateur stations with which communications have been established (not including those amateurs or stations which form part of the intermediate relay of Messages);
-
- (h) details of tests carried out in accordance with sub-clause 4(4); and
-
- (i) location when the station is operated at a Temporary Location.

6(2) The Log shall be written in a book or maintained on a magnetic tape, disc or other electronic storage medium. If the Log is maintained on an electronic storage medium the means to view the Log and produce a hard copy shall be kept readily available at the Main Station Address.

6(3) Where the Log is maintained:

- (a) in a book, the book shall not be loose-leaf and no gaps shall be left between the entries;
- (b) on a magnetic tape, disc or other electronic storage medium, suitable precautions shall be taken to ensure that the Log is backed up.

6(4) The Licensee shall keep the Log for inspection by a person authorised by the Secretary of State for at least six months from the date of the last entry whether or not this Licence has expired or been revoked.

6(5) When a person authorised by the Secretary of State requires additional matters to be recorded, the Licensee shall record those additional matters in the Log for the period specified by that person.

(q) No Log need be kept in respect of Mobile and Maritime Mobile operations.

Note this one

No Log need be kept in respect of Mobile and Maritime Mobile operations

(r) For the purposes of the Licence, "Co-ordinated Universal Time" may be regarded as equivalent to Greenwich Mean Time (GMT).

(s) Codes for classes of emission

Under the Telecommunication Convention, classes of emission are designated by groups of a

minimum of three characters. The symbols used to designate classes of emission are listed in the Radio Regulations of which the following is a full list.

First symbol - Type of modulation of the main carrier

N Emission of unmodulated carrier

Emission in which the main carrier is amplitude modulated (including cases where sub-carriers are angle modulated):

A Double sideband

H Single sideband, full carrier

R Single sideband, reduced or variable level carrier

J Single sideband, suppressed carrier

B Independent sidebands

C Vestigial sideband

Emission in which the main carrier is angle modulated:

F Frequency modulation

G Phase modulation

D Emission in which the main carrier is amplitude and angle modulated either simultaneously or in a pre-established sequence

Emission of pulses:

P Sequence of unmodulated pulses

A sequence of pulses:

K Modulated in amplitude

L Modulated in width/duration

M Modulated in position/phase

Q In which the carrier is angle modulated during the period of the pulse

V Which is a combination of the foregoing or is produced by other means

NB: Emissions where the main carrier is directly modulated by a signal which has been coded into quantized form (e.g. pulse code modulation) should be designated by A, H, R, J, B, C, F or G as appropriate.

W Cases not covered above, in which an emission consists of the main carrier modulated, either simultaneously or in a pre-established sequence, in a combination of two or more of the following modes: amplitude, angle, pulse

X Cases not otherwise covered

NB: For the purpose of this Licence, modulation used only for short periods and for incidental purposes, such as identification or calling, may be ignored when calculating the emission designator. Double sideband emissions with reduced or suppressed carrier are included in the first character A.

Second symbol - Nature of signal(s) modulating the main carrier

0 No modulating signal

1 A single channel containing quantized or digital information without the use of a modulating subcarrier (excluding time-division multiplex)

2 A single channel containing quantized or digital information with the use of a modulating subcarrier (excluding time-division multiplex)

3 A single channel containing analogue information

7 Two or more channels containing quantized or digital information

8 Two or more channels containing analogue information

9 Composite system with one or more channels containing quantized or digital information, together with one or more channels containing analogue information

X Cases not otherwise covered

Third symbol - Type of information to be transmitted (in this context, the word "information" does not include information of a constant, unvarying nature such as that provided by standard frequency emissions or continuous wave or pulse radars).

N No information transmitted

A Telegraphy - for aural reception

B Telegraphy - for automatic reception

C Facsimile

D Data transmission, telemetry, telecommand

E Telephony

F Television (video)

W Combination of the above

X Cases not otherwise covered

The following examples of classes of emission and their symbols are given for the purpose of guidance only:

Telephony (speech):

J3E Single side band, suppressed carrier (SSB)

F3E Frequency modulation (FM)

G3E Phase modulation (PM)

A3E Amplitude modulation (AM)

Morse:

A1A Hand sent, on/off keying of the carrier

F2A Hand sent, on/off keying of the audio tone (FM transmitter)

A1B Automatic reception, on/off keying of the carrier

RTTY/AMTOR

F1B Direct frequency shift keying of the carrier

F2B Frequency shift keyed audio tone (FM transmitter)

J2B Frequency shift keyed audio tone (SSB transmitter)

Packet/Data:

F1D Direct frequency shift keying of the carrier

F2D Frequency shift keyed audio tone (FM transmitter)

J2D Frequency shift keyed audio tone (SSB transmitter)

Television:

C3F Vestigial sideband (AM transmitter)

J2F Slow scan television (SSB transmitter)

Facsimile:

J2C frequency shift keyed audio tone (SSB transmitter)

7(1), 7(1A), 7(6) Notes (s)(t)(u)(v)(w) Identification (using new lettering as per Nov)

7(1) subject to sub-clause (1A) below, which does not apply to operation via repeaters during transmissions, the Licensee shall transmit the callsign specified in the Validation Document:

(a) during initial calls ("CQ" calls);

(b) at the beginning and at the end of each period of communication with a licensed amateur and when the period of communication is longer than 15 minutes, at the end of each interval of 15 minutes;

(c) at the beginning of transmission on a new frequency (whenever the frequency of transmission

is changed);

(d) by the same type of transmission that is being used for the communication;

(e) on the same carrier frequency that is being used for the communication; and

(f) by morse telegraphy or telephony, at the end of each 30 minute period during which transmissions are sent from the Station (unless already transmitting in morse telegraphy or telephony). If the Licensee is conducting automatic operations involving digital communications then he shall transmit the callsign under this sub-clause at a maximum speed of 20 words per minute.

7(1A) Where the Licensee is intending to operate within a net pursuant to sub-clause 1(7)(c), the Licensee shall observe the following requirements in relation to the transmission of his callsign:

(a) he shall transmit his callsign when he first joins the net and on leaving it;

(b) subject to sub-clause 7(c) below, whilst participating in the net, he shall not be obliged to transmit his callsign when making contact with other participants;

(c) whilst participating in the net, he shall transmit his callsign;

(i) when 15 minutes have elapsed since the last transmission of his callsign; or

(ii) if he has not transmitted speech before 15 minutes have elapsed since such transmission, on the first occasion thereafter on which he transmits speech.

Participation in a net

That is a new area concerning licence conditions.

A net is a group of like minded amateurs who link up on a single frequency to have a natter as a round robin with a net controller. It is usual for the net controller to call in stations to "have and over" and then they comment on the over before passing it on further to the next operator.

To join a net you will press the PTT just as a participate has finished their "over" and just prior to the net controller coming in. However this is not always needed - say for instance if you try this approach and the net controller does not hear you but someone else does.

The licence requires you to announce your callsign when you first join the net and on leaving it, so that would be in your first "over" to whom you might address comments. Where the net controller

cannot hear you, may be you will be called in by another member of the net. who can hear you, as mentioned above. By giving your callsign to this other person you have fulfilled your licence requirement for identification.

Whilst you are participating in a net, you are not obliged to transmit your callsign when making contact with other participants - but it is polite so to do.

15 minutes ruled for nets

Further whilst participating in the net you must transmit your callsign when 15 minutes have passed since the last transmission of your callsign or if you have another "over" sooner than 15 minutes since your last over then you do not have to give your callsign in that "over" but you must give your callsign on the next "over" when you speak.

7(6) When operating a low power device under sub-clause 2(4) (b), this clause 7 shall not apply to the operation of the low power device (although this clause 7 shall continue to apply to the operation of the Station).

Notes :-

(s) Codes for classes of emission

Under the Telecommunication Convention, classes of emission are designated by groups of a minimum of three characters. The symbols used to designate classes of emission are listed in the Radio Regulations of which the following is a full list.

First symbol - Type of modulation of the main carrier

N Emission of unmodulated carrier

Emission in which the main carrier is amplitude modulated (including cases where sub-carriers are angle modulated):

A Double sideband

H Single sideband, full carrier

R Single sideband, reduced or variable level carrier

J Single sideband, suppressed carrier

B Independent sidebands

C Vestigial sideband

Emission in which the main carrier is angle modulated:

F Frequency modulation

G Phase modulation

D Emission in which the main carrier is amplitude and angle modulated either simultaneously or in a pre-established sequence

Emission of pulses:

P Sequence of unmodulated pulses

A sequence of pulses:

K Modulated in amplitude

L Modulated in width/duration

M Modulated in position/phase

Q In which the carrier is angle modulated during the period of the pulse

V Which is a combination of the foregoing or is produced by other means

NB: Emissions where the main carrier is directly modulated by a signal which has been coded into quantized form (e.g. pulse code modulation) should be designated by A, H, R, J, B, C, F or G as appropriate.

W Cases not covered above, in which an emission consists of the main carrier modulated, either simultaneously or in a pre-established sequence, in a combination of two or more of the following modes: amplitude, angle, pulse

X Cases not otherwise covered

NB: For the purpose of this Licence, modulation used only for short periods and for incidental purposes, such as identification or calling, may be ignored when calculating the emission

- designator. Double sideband emissions with reduced or suppressed carrier are included in the first character A.

- Second symbol - Nature of signal(s) modulating the main carrier**

- 0 No modulating signal

- 1 A single channel containing quantized or digital information without the use of a modulating subcarrier (excluding time-division multiplex)

- 2 A single channel containing quantized or digital information with the use of a modulating subcarrier (excluding time-division multiplex)

- 3 A single channel containing analogue information

- 7 Two or more channels containing quantized or digital information

- 8 Two or more channels containing analogue information

- 9 Composite system with one or more channels containing quantized or digital information, together with one or more channels containing analogue information

- X Cases not otherwise covered

- Third symbol - Type of information to be transmitted (in this context, the word "information" does not include information of a constant, unvarying nature such as that provided by standard frequency emissions or continuous wave or pulse radars).**

- N No information transmitted

- A Telegraphy - for aural reception

- B Telegraphy - for automatic reception

- C Facsimile

- D Data transmission, telemetry, telecommand

- E Telephony

- F Television (video)

W Combination of the above

X Cases not otherwise covered

The following examples of classes of emission and their symbols are given for the purpose of guidance only:

Telephony (speech):

J3E Single side band, suppressed carrier (SSB)

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A1A Hand sent, on/off keying of the carrier

F2A Hand sent, on/off keying of the audio tone (FM transmitter)

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RTTY/AMTOR

F1B Direct frequency shift keying of the carrier

F2B Frequency shift keyed audio tone (FM transmitter)

J2B Frequency shift keyed audio tone (SSB transmitter)

Packet/Data:

F1D Direct frequency shift keying of the carrier

F2D Frequency shift keyed audio tone (FM transmitter)

J2D Frequency shift keyed audio tone (SSB transmitter)

Television:

C3F Vestigial sideband (AM transmitter)

J2F Slow scan television (SSB transmitter)

Facsimile:

J2C frequency shift keyed audio tone (SSB transmitter)

(t) When telephony is used, the letters of the callsign may be confirmed by the pronouncement of well-known words of which the initial letters are the same as those in the callsign. The phonetic alphabet contained in Appendix S14 of the Radio Regulations, reproduced below, should be used:

A Alpha	J Juliet	S Sierra
B Bravo	K Kilo	T Tango
C Charlie	L Lima	U Uniform
D Delta	M Mike	V Victor
E Echo	N November	W Whiskey
F Foxtrot	O Oscar	X X-Ray
G Golf	P Papa	Y Yankee
H Hotel	Q Quebec	Z Zulu
I India	R Romeo	

(u) When the Station must be identified in accordance with sub-clause 7(3) (a), it is recommended that one of the following location identifiers be used:

(i) the full postcode,

- (ii) latitude and longitude in degrees and minutes,
- (iii) National Grid Reference correct to six figures,
- (iv) International Amateur Radio Union (IARU) locator, or
- (v) the address or other geographical description correct to 1 km.
- (v) The following Regional Secondary Locators should be used immediately after the United Kingdom prefix "G" or "M" (as specified in the Validation Document) when identifying the Station in accordance with sub-clauses 7(5) or 10(2) of this Booklet:

D Isle of Man	I Northern Ireland	J Jersey
M Scotland	U Guernsey	W Wales
(No secondary locator) England		

If the Station is a club station and operating in accordance with sub-clause 1(8) of this Booklet, then the following club regional locators should be used instead of those above:

T Isle of Man	N Northern Ireland	H Jersey
S Scotland	P Guernsey	C Wales
X England		

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Bredhurst Receiving and Transmitting Society**Licensing Conditions**

Syllabus sections in blue type face **parts of BR68 to which they relate are in RED bold type face** :-

Note: that a full copy of the leaflet BR68 will be provided in the exam

2i Apparatus, Inspection Closedown and renewal

4(1), 4(2), 4(3), 4(4), 4(5) Notes (k)(l)(m)(n)(o) Apparatus

4(1) The Licensee shall ensure that:

(a) the emitted frequency of the apparatus comprised in the Station is as stable and as free from Unwanted Emissions as the state of technical development for amateur radio apparatus reasonably permits; and

(b) whatever class of emission is in use, the bandwidth occupied by the emission is such that not more than 1% of the mean power of the transmission (not including the power contained in spurious emissions) falls outside the frequency band.

4(2) Notwithstanding any other term of this Licence, the Licensee shall ensure that the apparatus comprised in the Station is designed and constructed, and maintained and used, so that its use does not cause any undue interference to any wireless telegraphy.

4(3) If any undue interference to wireless telegraphy is caused by the radiation of Unwanted Emissions or the field strength of electromagnetic energy radiated from the Station, then the Licensee shall suppress the Unwanted Emissions or reduce the level of the field strength to the degree satisfactory to the Secretary of State.

4(4) The Licensee shall conduct tests from time to time to ensure that the requirements of this clause 4 are met.

4(5) The Station shall be capable of receiving Messages on the same frequencies and with the

same classes of emission in use for the transmission of Messages by the Station.

(k) Sub-clause 4(2) of the Licence requires that the apparatus in the station be so designed, constructed, maintained and used that the use of the Station does not cause any undue interference with any wireless telegraphy. In order to prevent interference due to close coupling of antennas, the antenna used for the Station should be sited as far as possible from any existing television or other receiving antennas. This is particularly important in the case of the installation of an indoor transmitting antenna, e.g. in a loft, where transmissions may be conducted through the electricity supply wiring. In some circumstances it might not be possible to use an indoor antenna. In densely populated areas sufficient separation of the amateur equipment from surrounding transmitters, receivers and electronic equipment may not be possible to permit the amateur to operate with high power without the high probability of causing interference. Adjacent transmitters may produce intermodulation products on other frequencies and excessive field strengths may cause breakthrough even in receivers which display an adequate level of immunity to unwanted transmissions. While owners of receivers should take steps to ensure that their apparatus has a reasonable standard of immunity, in some circumstances the amateur may need to modify his transmission practice to minimise a problem to neighbours. If an interference problem arises, this may indicate either that the affected equipment has inadequate immunity or has not been properly installed or maintained or that excessive field strengths are being generated. Each case needs to be considered on its merits, but regard will be had to the harmonised immunity standards introduced for the purposes of Council Directive 89/336/EEC on electromagnetic compatibility. In order to solve the problem, it may be necessary, depending on the circumstances, to take reasonable steps to improve the immunity of the affected receiving installation, to modify transmission practice or to impose restrictions on the licensee.

(l) In the event of a demand by an authorised officer to close down or restrict the operation of the Station under sub-clause 8(2), the Licensee must act in accordance with the demand immediately. He will at that time be given oral reasons for the demand and will have an opportunity to provide reasons why the demand should not be met. If the demand is affirmed, then it will be confirmed in writing to the Licensee as soon as practicable. Written reasons will be given by an Operations Manager of the Radiocommunications Agency and the Licensee will again be invited to comment. The temporary period referred to in sub-clause 8(2) will usually be 28 days, but may be a greater or lesser period as the circumstances warrant. Where appropriate and where circumstances allow the local office of the Radiocommunications Agency will be available to discuss with the Licensee how a breach of Licence might be corrected, however, if the Licensee does not comply with the demand or if the breach resulting in the demand is not rectified within a reasonable period of time to the satisfaction of the Secretary of State, then revocation or variation of Licence procedures may be commenced under sub-section 1(4) of the Act or a prosecution may be initiated (depending on the circumstances of each case).

(m) Sub-section 19(5) of the Act applies for the purposes of this Licence as it applies for the purposes of the Act:

"In considering for any of the purposes of this Act, whether, in any particular case, any interference with any wireless telegraphy causes or likely to be caused by the use of any apparatus, is or is not undue interference, regard shall be had to all the known circumstances of the case and the interference shall not be regarded as undue interference if so to regard it would unreasonably cause hardship to the person using or desiring to use the apparatus."

(n) The bandwidths of emissions should be such as to ensure the most efficient utilisation of the spectrum; in general this requires that bandwidths be kept at the lowest values which technology and the nature of the service permit. Where bandwidth-expansion techniques are used, the minimum spectral power density consistent with efficient spectrum utilisation should be employed.

(o) Under section 1 of the Act, it is an offence to use any station or apparatus otherwise than under and in accordance with a licence granted by the Secretary of State. The Licensee is responsible for ensuring that at all times persons operating under this Licence observe its terms and limitations. Breach of this provision may result in prosecution of the Licensee or operator and the revocation of this Licence.

This is all straight forward about the apparatus that you are using and much has been seen before in the FLC and ILC.

Note particularly section 4(4) that the actual tests are not specified but must be carried out from time to time - the period of the time is an old favourite with examiners !!

In 4(5) it points out that you must be able to receive signals that you are sending. So it is no good working cross band if you do not have a receiver that you could receive your own transmissions and not just the other station on another band.

8(1),8(2),8(4) Notes (l) (m) Inspection and closedown

8(1) The Licensee shall permit a person authorised by the Secretary of State:

(a) to have access to the Station, and

(b) to inspect the Licence and Log and to inspect the apparatus of the Station at any and all reasonable times (or when, in the opinion of a person authorised by the Secretary of State, an urgent situation exists, at any time) for the purpose of verifying compliance with the terms of the Licence.

8(2) When, in the opinion of a person authorised by the Secretary of State:

(a) the Licensee is in breach of the Licence; and

(b) the breach justifies immediate restriction or close down, the Licensee shall restrict the operation of, or close down and cease to operate, the Station (or any apparatus comprised in the Station) forthwith in accordance with the demand of a person authorised by the Secretary of State for the temporary period specified in the demand.

8(4) For the purposes of sub-section 1(4) of the Act, this Licence may be revoked, or its terms, provisions or limitations varied, by a notice in writing of the Secretary of State served on the Licensee, or by a general notice addressed to all holders of an Amateur Radio Licence (A) or Amateur Radio Licence (B) published in the London, Edinburgh and Belfast Gazettes or broadcast nationally by the British Broadcasting Corporation.

(l) In the event of a demand by an authorised officer to close down or restrict the operation of the Station under sub-clause 8(2), the Licensee must act in accordance with the demand immediately. He will at that time be given oral reasons for the demand and will have an opportunity to provide reasons why the demand should not be met. If the demand is affirmed, then it will be confirmed in writing to the Licensee as soon as practicable. Written reasons will be given by an Operations Manager of the Radiocommunications Agency and the Licensee will again be invited to comment. The temporary period referred to in sub-clause 8(2) will usually be 28 days, but may be a greater or lesser period as the circumstances warrant. Where appropriate and where circumstances allow the local office of the Radiocommunications Agency will be available to discuss with the Licensee how a breach of Licence might be corrected, however, if the Licensee does not comply with the demand or if the breach resulting in the demand is not rectified within a reasonable period of time to the satisfaction of the Secretary of State, then revocation or variation of Licence procedures may be commenced under sub-section 1(4) of the Act or a prosecution may be initiated (depending on the circumstances of each case).

(m) Sub-section 19(5) of the Act applies for the purposes of this Licence as it applies for the purposes of the Act:

"In considering for any of the purposes of this Act, whether, in any particular case, any interference with any wireless telegraphy causes or likely to be caused by the use of any apparatus, is or is not undue interference, regard shall be had to all the known circumstances of the case and the interference shall not be regarded as undue interference if so to regard it would unreasonably cause hardship to the person using or desiring to use the apparatus."

9(1), 9(2), 9(3), 9(4) Note (a) Renewal

9(1) Subject to the payment of the fee in the manner indicated in sub-clause 9(2), this Licence shall continue in force from year to year unless revoked by the Secretary of State.

9(2) The Licensee shall pay to the Secretary of State before the anniversary date of the Date of Issue in each year, the fee on renewal prescribed by the Regulations for the time being in force under sub-section 2(1) of the Act, and on the payment of the fee the Secretary of State will issue to the Licensee a document in the form of the title page of this Licence (the "Validation Document") which will indicate the next date for renewal.

9(3) If the Licensee does not pay the fee in the manner described in sub-clause 9(2), then the Licence shall expire at the end of the day before the relevant anniversary date of the Date of Issue.

9(4) The Licensee shall surrender the Validation Document to the Secretary of State forthwith upon the revocation of the Licence. The Secretary of State reserves the right to publish the name and callsign of the Licensee if the Licence is revoked.

(a) Remittances and correspondence should be sent to the Radio Licensing Centre, P0 Box 885, Bristol B599 SLG. Tel:(0117) 925 8333. Do not send the Licence when making remittances.

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Licensing Conditions

Syllabus sections in blue type face **parts of BR68 to which they relate are in RED bold type face** :-

Note: that a full copy of the leaflet BR68 will be provided in the exam

2j Schedule

2j.1 Clause 2(1) and apply the Schedule to the licence including the notes to the schedule.

2(1) Subject to other, more specific, terms in this Licence, the Licensee shall only use:

- (a) the frequency bands specified in the first column of the Schedule to this Licence subject to the limitations set out in the second and third columns of the Schedule;
- (b) a power relating to such frequency bands not exceeding the maximum specified in the fourth column of the Schedule; and
- (c) the types of transmission specified in the fifth column of the Schedule.

See more about this in the next section.

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Syllabus sections:-

Note: that a full copy of the leaflet BR68 will be provided in the exam**2j Schedule**

2j.1 Clause 2(1) and apply the Schedule to the licence including the notes to the schedule.

2(1) Subject to other, more specific, terms in this Licence, the Licensee shall only use:

(a) the frequency bands specified in the first column of the Schedule to this Licence subject to the limitations set out in the second and third columns of the Schedule;

(b) a power relating to such frequency bands not exceeding the maximum specified in the fourth column of the Schedule; and

(c) the types of transmission specified in the fifth column of the Schedule.

Quite simple this part !! You must know how to properly use the information comprised in the schedule and the notes to the schedule. The notes are dealt with on the next page.

Please check for any updates of the schedule on the [Ofcom web site](#).**The Schedule to Terms, Provisions and Limitations Booklet BR68 (Amateur Radio (Full) Licence)**

1	2	3	4	5
Frequency	Status of Allocations in the United Kingdom to:		Maximum Power level in	Mode of

Bands in MHz	The Amateur Service	The Amateur Satellite Service	Watts (dB relative to 1 W) PEP	Transmission
0.1357-0.1378	Secondary. Available on the basis of non-interference to other services (inside or outside the United Kingdom)	(not allocated)	1 W (0 dBW) erp	Morse Telephony RTTY Data Facsimile SSTV
1.810-1.830	Primary. Available on the basis of non-interference to other services (outside the United Kingdom)		400 W (26 dBW)	
1.830-1.850	Primary			
1.850-2.000	Available on the basis of non-interference to other services (inside or outside the United Kingdom)		32 W (15 dBW)	
3.500-3.800	Primary. Shared with other services			
7.000-7.100	Primary	Primary		
10.100-10.150	Secondary	(not allocated)		
14.000-14.250	Primary	Primary		
14.250-14.350		(not allocated)		
18.068-18.168		Primary	400 W (26 dBW)	
21.000-21.450				
24.890-24.990				
28.000-29.700				

50.00-51.00	Primary. Available on the basis of non-interference to other services outside the United Kingdom	(not allocated)		
51.00-52.00	Secondary. Available on the basis of non-interference to other services		100 W (20 dBW)	
70.00-70.50	inside or outside the United Kingdom		160 W (22 dBW)	
144.0-146.0	Primary	Primary	400 W (26 dBW)	
430.0-431.0	Secondary	(not allocated)	40 W (16 dBW) erp	Morse
431.0-432.0	Secondary. Not available for use within a 100 km radius of Charing Cross, London (51°30'30"N, 00°07'24"W)			Telephony
432.0- 435.0				RTTY
435.0-438.0	Secondary	Secondary	400 W (26 dBW)	Data
438.0-440.0		(not allocated)		Facsimile
				SSTV
				FSTV

1	2	3	4	5
Frequency Bands in MHz	Status of Allocations in the United Kingdom to:		Maximum Power level in Watts (dB relative to 1 W) PEP	Mode of Transmission
	The Amateur Service	The Amateur Satellite Service		

1240-1260	Secondary	(not allocated)	400 W (26 dBW)	Morse Telephony RTTY Data Facsimile SSTV FSTV
1260-1270		Secondary. Earth to space only		
1270-1325		(not allocated)		
2310-2400				
2400-2450	Secondary. Users must accept interference from ISM users	Secondary. Users must accept interference from ISM users		
3400-3475	Secondary	(not allocated)		
5650-5670		Secondary. Earth to space only		
5670-5680				
5755-5765	Secondary. Users must accept interference from ISM users	(not allocated)		
5820-5830				
5830-5850		Secondary. Users must accept interference from ISM users. Space to Earth only		
10000-10125	Secondary	(not allocated)		
10225-10450				
10450-10475		Secondary		
10475-10500	(not allocated)			
24000-24050	Primary. Users must accept interference from ISM users	Primary. Users must accept interference from ISM users		

24050-24150	Secondary. May only be used with the written consent of the Secretary of State. Users must accept interference from ISM users	(not allocated)
24150-24250	Secondary	
47000-47200	Primary	Primary
75500-76000	Primary (1)	Primary (1)
76000-77500	Secondary	Secondary
77500-78000	Primary	Primary
78000-79000	Secondary	(not allocated)
79000-81000	Secondary	
122250-123000		
134000-136000	Primary	Primary
136000-141000	Secondary	Secondary
142000-144000	Primary (1)	Primary (1)
241000-248000	Secondary	Secondary
248000 - 250000	Primary	Primary
ISM (Industrial, Scientific and Medical) (1) until 31 December 2006.		

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Notes to Schedule

Syllabus sections:-

Note: that a full copy of the leaflet BR68 will be provided in the exam

2b.15 Apply the Schedule to the licence including the notes to the schedule

Note This schedule has been updated to take account of the Notice of Variation dated 26 July 03Please check for any updates of the schedule on the [Ofcom web site](#).**Notes to Terms, Provisions and Limitations Booklet BR 68**

(a) Remittances and correspondence should be sent to the Radio Licensing Centre, PO Box 885, Bristol B599 SLG. Tel:(0117) 925 8333. Do not send the Licence when making remittances.

(b) A list of the Radiocommunications Agency's local offices (see sub-clauses 2(5) and 7(3)) may be obtained from the address given in note (aa).

(c) If any message, the receipt of which is not authorised by this Licence, is received by means of the Station, neither the Licensee nor any person using the Station should make known the contents of any such message, its origin or destination, its existence or the fact of its receipt to any person except an authorised officer of Her Majesty's Government or a competent legal tribunal, or retain any copy or make any use of such message, or allow it to be reproduced, copied or made use of. It is an offence under section 5 of the Act deliberately to receive messages the receipt of which is unauthorised or (except in the special circumstances mentioned in that section of the Act) to disclose any information as to the contents, sender or addressee of any such message.

- (d) It is an offence to send certain misleading messages, viz:

- "Any person who;

- (i) by means of wireless telegraphy, sends or attempts to send, any message which, to his knowledge, is false or misleading and is, to his knowledge, likely to prejudice the efficiency of any safety of life service or endanger the safety of any person or of any vessel, aircraft or vehicle, and, in particular, any message which, to his knowledge, falsely suggests that a vessel or aircraft is in distress or in need of assistance or is not in distress or not in need of assistance;

- ...shall be guilty of an offence under this Act." (Section 5 WT Act 1949).

- (e) This Licence does not authorise the doing of any act which is an infringement of any copyright which may exist in the communication sent or received.

- (fa) When operating in accordance with 1(8A) a registered training course is a course recognised by or on behalf of the Radiocommunications Agency.

- (f) References to the operation of the Station include references to the speaking into the microphone comprised in the Station.

- (g) Any operation under this Licence must also comply with the "Self-Provision Licence" granted by the Secretary of State under section 7 of the Telecommunications Act 1984. Copies of this Licence are available from the Office of Telecommunications, Export House, 50 Ludgate Hill, London EC4M 7JJ. Except as specifically authorised in writing by the Secretary of State, the Licensee may not permit the automatic reception and or transmission of messages between the amateur radio service operated in accordance with section 1 of the Act and other telecommunications networks.

- (h) It is an offence under the Wireless Telegraphy (Content of Transmission) Regulations 1988 to send a message, communication or other matter in whatever form that is grossly offensive or of an indecent, obscene or menacing character.

- (i) If the Station is situated within 1km of the boundary of an aerodrome, then the height of the antenna or any mast or structure supporting it must not exceed 15m above ground level. An antenna which crosses above, or is liable to fall or to be blown onto, any overhead power wire (including electric lighting) or power apparatus must be guarded to the reasonable satisfaction of the owner of the power wire or power apparatus.

- (j) This Licence does not absolve the Licensee from obtaining any necessary consent before entering on private or public property (including a public transport vehicle) with any apparatus.

(k) Sub-clause 4(2) of the Licence requires that the apparatus in the station be so designed, constructed, maintained and used that the use of the Station does not cause any undue interference with any wireless telegraphy. In order to prevent interference due to close coupling of antennas, the antenna used for the Station should be sited as far as possible from any existing television or other receiving antennas. This is particularly important in the case of the installation of an indoor transmitting antenna, e.g. in a loft, where transmissions may be conducted through the electricity supply wiring. In some circumstances it might not be possible to use an indoor antenna. In densely populated areas sufficient separation of the amateur equipment from surrounding transmitters, receivers and electronic equipment may not be possible to permit the amateur to operate with high power without the high probability of causing interference. Adjacent transmitters may produce intermodulation products on other frequencies and excessive field strengths may cause breakthrough even in receivers which display an adequate level of immunity to unwanted transmissions. While owners of receivers should take steps to ensure that their apparatus has a reasonable standard of immunity, in some circumstances the amateur may need to modify his transmission practice to minimise a problem to neighbours. If an interference problem arises, this may indicate either that the affected equipment has inadequate immunity or has not been properly installed or maintained or that excessive field strengths are being generated. Each case needs to be considered on its merits, but regard will be had to the harmonised immunity standards introduced for the purposes of Council Directive 89/336/EEC on electromagnetic compatibility. In order to solve the problem, it may be necessary, depending on the circumstances, to take reasonable steps to improve the immunity of the affected receiving installation, to modify transmission practice or to impose restrictions on the licensee.

(l) In the event of a demand by an authorised officer to close down or restrict the operation of the Station under sub-clause 8(2), the Licensee must act in accordance with the demand immediately. He will at that time be given oral reasons for the demand and will have an opportunity to provide reasons why the demand should not be met. If the demand is affirmed, then it will be confirmed in writing to the Licensee as soon as practicable. Written reasons will be given by an Operations Manager of the Radiocommunications Agency and the Licensee will again be invited to comment. The temporary period referred to in sub-clause 8(2) will usually be 28 days, but may be a greater or lesser period as the circumstances warrant. Where appropriate and where circumstances allow the local office of the Radiocommunications Agency will be available to discuss with the Licensee how a breach of Licence might be corrected, however, if the Licensee does not comply with the demand or if the breach resulting in the demand is not rectified within a reasonable period of time to the satisfaction of the Secretary of State, then revocation or variation of Licence procedures may be commenced under sub-section 1(4) of the Act or a prosecution may be initiated (depending on the circumstances of each case).

(m) Sub-section 19(5) of the Act applies for the purposes of this Licence as it applies for the purposes of the Act:

"In considering for any of the purposes of this Act, whether, in any particular case, any interference with any wireless telegraphy causes or likely to be caused by the use of any apparatus,

is or is not undue interference, regard shall be had to all the known circumstances of the case and the interference shall not be regarded as undue interference if so to regard it would unreasonably cause hardship to the person using or desiring to use the apparatus."

(n) The bandwidths of emissions should be such as to ensure the most efficient utilisation of the spectrum; in general this requires that bandwidths be kept at the lowest values which technology and the nature of the service permit. Where bandwidth-expansion techniques are used, the minimum spectral power density consistent with efficient spectrum utilisation should be employed.

(o) Under section 1 of the Act, it is an offence to use any station or apparatus otherwise than under and in accordance with a licence granted by the Secretary of State. The Licensee is responsible for ensuring that at all times persons operating under this Licence observe its terms and limitations. Breach of this provision may result in prosecution of the Licensee or operator and the revocation of this Licence.

(p) The Licence is not transferable.

(q) No Log need be kept in respect of Mobile and Maritime Mobile operations.

Note this one

No Log need be kept in respect of Mobile and Maritime Mobile operations

(r) For the purposes of the Licence, "Co-ordinated Universal Time" may be regarded as equivalent to Greenwich Mean Time (GMT).

(s) Codes for classes of emission

Under the Telecommunication Convention, classes of emission are designated by groups of a minimum of three characters. The symbols used to designate classes of emission are listed in the Radio Regulations of which the following is a full list.

First symbol - Type of modulation of the main carrier

N Emission of unmodulated carrier

Emission in which the main carrier is amplitude modulated (including cases where sub-carriers are angle modulated):

A Double sideband

H Single sideband, full carrier

R Single sideband, reduced or variable level carrier

J Single sideband, suppressed carrier

B Independent sidebands

C Vestigial sideband

Emission in which the main carrier is angle modulated:

F Frequency modulation

G Phase modulation

D Emission in which the main carrier is amplitude and angle modulated either simultaneously or in a pre-established sequence

Emission of pulses:

P Sequence of unmodulated pulses

A sequence of pulses:

K Modulated in amplitude

L Modulated in width/duration

M Modulated in position/phase

Q In which the carrier is angle modulated during the period of the pulse

V Which is a combination of the foregoing or is produced by other means

NB: Emissions where the main carrier is directly modulated by a signal which has been coded into quantized form (e.g. pulse code modulation) should be designated by A, H, R, J, B, C, F or G as appropriate.

W Cases not covered above, in which an emission consists of the main carrier modulated, either

- simultaneously or in a pre-established sequence, in a combination of two or more of the following
- modes: amplitude, angle, pulse
-

X Cases not otherwise covered

NB: For the purpose of this Licence, modulation used only for short periods and for incidental purposes, such as identification or calling, may be ignored when calculating the emission designator. Double sideband emissions with reduced or suppressed carrier are included in the first character A.

Second symbol - Nature of signal(s) modulating the main carrier

0 No modulating signal

1 A single channel containing quantized or digital information without the use of a modulating subcarrier (excluding time-division multiplex)

2 A single channel containing quantized or digital information with the use of a modulating subcarrier (excluding time-division multiplex)

3 A single channel containing analogue information

7 Two or more channels containing quantized or digital information

8 Two or more channels containing analogue information

9 Composite system with one or more channels containing quantized or digital information, together with one or more channels containing analogue information

X Cases not otherwise covered

Third symbol - Type of information to be transmitted (in this context, the word "information" does not include information of a constant, unvarying nature such as that provided by standard frequency emissions or continuous wave or pulse radars).

N No information transmitted

A Telegraphy - for aural reception

B Telegraphy - for automatic reception

- C Facsimile
- D Data transmission, telemetry, telecommand
- E Telephony
- F Television (video)
- W Combination of the above
- X Cases not otherwise covered

The following examples of classes of emission and their symbols are given for the purpose of guidance only:

Telephony (speech):

- J3E Single side band, suppressed carrier (SSB)
- F3E Frequency modulation (FM)
- G3E Phase modulation (PM)
- A3E Amplitude modulation (AM)

Morse:

- A1A Hand sent, on/off keying of the carrier
- F2A Hand sent, on/off keying of the audio tone (FM transmitter)
- A1B Automatic reception, on/off keying of the carrier

RTTY/AMTOR

- F1B Direct frequency shift keying of the carrier
- F2B Frequency shift keyed audio tone (FM transmitter)
- J2B Frequency shift keyed audio tone (SSB transmitter)

Packet/Data:

F1D Direct frequency shift keying of the carrier

F2D Frequency shift keyed audio tone (FM transmitter)

J2D Frequency shift keyed audio tone (SSB transmitter)

Television:

C3F Vestigial sideband (AM transmitter)

J2F Slow scan television (SSB transmitter)

Facsimile:

J2C frequency shift keyed audio tone (SSB transmitter)

(t) When telephony is used, the letters of the callsign may be confirmed by the pronouncement of well-known words of which the initial letters are the same as those in the callsign. The phonetic alphabet contained in Appendix S14 of the Radio Regulations, reproduced below, should be used:

A Alpha	J Juliet	S Sierra
B Bravo	K Kilo	T Tango
C Charlie	L Lima	U Uniform
D Delta	M Mike	V Victor
E Echo	N November	W Whiskey
F Foxtrot	O Oscar	X X-Ray
G Golf	P Papa	Y Yankee
H Hotel	Q Quebec	Z Zulu

I India

R Romeo

(u) When the Station must be identified in accordance with sub-clause 7(3) (a), it is recommended that one of the following location identifiers be used:

- (i) the full postcode,
- (ii) latitude and longitude in degrees and minutes,
- (iii) National Grid Reference correct to six figures,
- (iv) International Amateur Radio Union (IARU) locator, or
- (v) the address or other geographical description correct to 1 km.

(v) The following Regional Secondary Locators should be used immediately after the United Kingdom prefix "G" or "M" (as specified in the Validation Document) when identifying the Station in accordance with sub-clauses 7(5) or 10(2) of this Booklet:

D Isle of Man	I Northern Ireland	J Jersey
M Scotland	U Guernsey	W Wales
(No secondary locator) England		

If the Station is a club station and operating in accordance with sub-clause 1(8) of this Booklet, then the following club regional locators should be used instead of those above:

T Isle of Man	N Northern Ireland	H Jersey
S Scotland	P Guernsey	C Wales
X England		

(w) When identifying in accordance with clause 7, please observe the following extract from Article S19 of the Radio Regulations (S19.18-S19.22): "Identification signals shall wherever practicable be in one of the following forms:

- (a) speech, using simple amplitude or frequency modulation;

- (b) international Morse code transmitted at manual speed;
- (c) a telegraph code compatible with conventional printing equipment;
- (d) any other form recommended by the Radiocommunication Sector of the ITU."
- (x) CEPT member countries and non-CEPT member countries which have implemented CEPT Recommendation T/R 61-01 are listed in the Validation Document by abbreviation. These abbreviations are given solely for the purpose of the Validation Document and are not the country prefixes for use when identifying under sub-clause 11(1)(g). CEPT member countries and non-CEPT member countries (as marked with an asterisk) are identified by abbreviations as follows:

Albania AL	Latvia LV	Sweden S
Austria A	Liechtenstein FL	Switzerland CH
Belgium B	Lithuania LT	The Former Yugoslav Republic of Macedonia Bosnia and Herzegovina BH
Bulgaria BR	Luxembourg L	Turkey TR
Canada VE	Malta M	Ukraine
Croatia HR	Moldova MLD	United Kingdom of Great Britain and Northern Ireland GB
Cyprus CY	Monaco MC	United States of America USA
Czech Republic CZ	Netherlands NL	Vatican City SCV
Norway N	New Zealand* ZL	Denmark DK
Estonia EST	Peru* PER	Finland FI
Poland PL	France F	Portugal P
Germany D	Romania RO	Greece GR
Russian Federation	Hungary H	San Marino RSM
Iceland IS	Slovak Republic SK	Ireland IRL
Slovenia SLO	Israel* IL	South Africa ZS
Italy I	Spain E	

(y) CEPT Recommendation T/R 61-01 does not deal with the import or export of amateur apparatus which is subject to the relevant requirements of the countries visited.

(z){ revised as (x) but likely misprint !!!} The Licensee does not have to pay a Licence fee if, at the time of application or renewal, he is under 21 years of age. In order to maintain the accuracy of the Licence records, all Licensees will receive renewal reminders, however, under-21s only have to indicate that they wish to continue as Licensees.

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Bredhurst Receiving and Transmitting Society

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Bredhurst Receiving and Transmitting Society

Licensing Conditions

Note: BR68 has updated in line with the variation notice of 26 July 2003

Please check for any updates of the schedule on the [Ofcom web site](#).

BR68

These terms, provisions and limitations shall be read as an integral part of the Amateur Radio Licence

Conditions of use

Purpose

1(1) The Licensee shall use the Station for the purpose of self-training in communication by radio telecommunications, which use (without limiting the generality of the foregoing) includes technical investigations.

1(2) The Licensee may use or permit the use of the Station, as part of his self-training in communication by radio telecommunications, during any operation conducted by a User Service [defined in sub-clause 12(1) (o)] or during any exercise relating to such an operation for the purpose of sending Messages on behalf of the User Service to other licensed amateur stations. It is recommended that the Licensee follows a formal emergency communications training scheme, details of which are available from the Radiocommunications Agency.

1(2A) The Licensee may use or permit the use of the Station, as part of his self-training in communication by radio, during any community event where the Licensee has been requested in writing by a User Service [defined in sub-clause 12(1) (o)] to provide communication without pecuniary gain for the purpose of sending Messages relating to the event to other licensed amateur stations.

1(3) Notwithstanding sub-clauses 1(1) and 1(4) (a) of this Licence and subject to the limitations in

- paragraphs 2, 3, 4, 5, 6 and 8 of Resolution 640 of the Radio Regulations of the International Telecommunication Union, the Licensee may use the following frequency bands to meet the needs of international disaster communications: 3.5 MHz to 3.8 MHz, 7.0 MHz to 7.1 MHz, 10.10 MHz to 10.15 MHz, 14.00 MHz to 14.35 MHz, 18.068 MHz to 18.168 MHz, 21.00 MHz to 21.45 MHz, 24.89 MHz to 24.99 MHz and 144 MHz to 146 MHz.

Messages

1(4) The Licensee shall address Messages only to other licensed amateurs or the stations of licensed amateurs and shall send only:

- (a) Messages relating to technical investigations or remarks of a personal character; or

- (b) Signals (not enciphered) which form part of, or relate to, the transmission of Messages.

1(5) "Messages" and "Signals" include communication by:

- (a) telephony;

- (b) morse telegraphy;

- (c) visual communications (which include slow scan television (SSTV), fast scan television (FSTV) and facsimile); and

- (d) digital communications (which include data, radio teletype (RTTY) and amateur teleprinting over radio (AMTOR)).

1(6) The Licensee may use codes and abbreviations for communications as long as they do not obscure the meaning of, but only facilitate, the communications.

1(7) The Licensee may send Messages to individual amateurs but shall not send Messages (whether directly or for onwards transmission by another station) for general reception by licensed amateurs other than:

- (a) initial calls; or

- (b) to groups of licensed amateurs as long as communication is first established separately with at least one licensed amateur in any such group; or

- (c) to licensed amateurs who participate within a net and subject to the identification requirements provided for in sub-clause 7 (IA) below; or

(d) messages transmitted via a mailbox or bulletin board for reception by all or any licensed amateurs who have the facility to transmit and receive RTTY or Data Transmissions.

1(8) Having regard to sub-clauses 2(10) and 3(3), greetings messages may be sent by non-licensed persons provided that:

(a) it is under the direct supervision of the Licensee or other Authorised Club Member (in case of a Licence held on behalf of a club), who must operate the transmitter and identify the station; and

(b) each greetings message does not exceed five minutes; and

(c) greetings messages may be sent and received only within the United Kingdom or to and from stations in the United States of America, the Republic of Maldives, Gibraltar, Malta and Falkland Islands. Greetings messages may also be sent to or from stations in Canada and Pitcairn Islands provided that each greetings message does not exceed two minutes and that each person may only send one such message to each station with which the station is in contact.

1(8A) Having regard to sub-clauses 2(10) and 3(3), messages may be sent by non-licensed persons who are on a recognised Foundation or Intermediate training course, provided that such transmission is under the direct supervision of the Licensee, or other authorised club member (in the case of licence held on behalf of a club).

1(9) The Licensee shall not transmit such material as music, public broadcasts or speeches.

Location

1(10) "Station" means the station of the Licensee at the Main Station Address, a Temporary Location or while Mobile or Maritime Mobile, as the case may be.

1(11) Subject to clause 11, the Licensee shall operate the Station only:

(a) at the Main Station Address ("Main Station Address" means the main station address of the Licensee set forth in the Validation Document);

(b) at a Temporary Location ("Temporary Location" means a location, other than the Main Station Address, in the United Kingdom, and in a fixed position);

(c) while Mobile ("Mobile" means located in the United Kingdom in any vehicle, as a pedestrian or on any Vessel in Inland Waters); or

(d) while Maritime Mobile ("Maritime Mobile" means located on any Vessel At Sea).

1(12) The Licensee shall give prior written notice to the Secretary of State at the address specified in note (a) to this Booklet of any change in the Main Station Address (or mailing address, if different).

Standard Frequency Service

1(13) The Licensee may use the Station for the reception of transmissions in the Standard Frequency Service (a radio communication service for scientific, technical and other purposes, providing the transmission of specific frequencies of stated high precision, intended for general reception).

Limitations on use

2(1) Subject to other, more specific, terms in this Licence, the Licensee shall only use:

(a) the frequency bands specified in the first column of the Schedule to this Licence subject to the limitations set out in the second and third columns of the Schedule;

(b) a power relating to such frequency bands not exceeding the maximum specified in the fourth column of the Schedule; and

(c) the types of transmission specified in the fifth column of the Schedule.

2(2) The Licensee may receive Messages from an overseas amateur or from a UK amateur duly authorised by the Secretary of State on a frequency band not specified in the first column of the Schedule as long as the Licensee transmits only in a band specified in the first column of the Schedule which is authorised under sub-clause 2(1) or (2).

Unattended operation

2(3) Subject to sub-clause 2(5), the Licensee may conduct the Unattended Operations ("Unattended Operation" means the operation of the Station which is unattended by the Licensee) only:

(a) of a beacon:

(i) in the frequency bands or sub-bands:

70 MHz to 70.5 MHz

- 1298 MHz to 1299 MHz (not in Northern Ireland and not within 50km of NGR SS 206127 and NGR SE 302577)
- 2310.0000 MHz to 2310.4125 MHz (not within 50km of NGR SS 206127 and NGR SE 302577)
- 2310.4125 MHz to 2355.0000 MHz
- 2355 MHz to 2365 MHz (not within 50km of NGR SS 206127 and NGR SE 302577)
- 2365 MHz to 2392 MHz
- 2392 MHz to 2450 MHz (not within 50km of NGR SS 206127 and NGR SE 302577)
- 3400 MHz to 3420 MHz
- 3420 MHz to 3430 MHz (not within 50km of NGR SO 916223, NGRSS 206127 and NGR SE 302577)
- 3430 MHz to 3450 MHz
- 3450 MHz to 3455 MHz (not within 50km of NGR SO 916223, NGR SS 206127 and NGR SE 302577)
- 3455 MHz to 3475 MHz
- 5650 MHz to 5670 MHz
- 5670 MHz to 5680 MHz (not within 50km of NGR SS 206127 and NGR SE 302577)
- 5755 MHz to 5765 MHz
- 5820 MHz to 5850 MHz
- 1000 MHz to 10125 MHz (not within 50km of NGR SO 916223, NGR SS 206127, NGR SK 985640 and NGR SE 302577)
- 10400 MHz to 10475 MHz
- 24000 MHz to 24050 MHz (not within 50km of NGR SK 985640 and NGR SE 302577)
- and with the exception of 47000 MHz to 47 200 MHz within 50km of NGR SK 985640 and NGR

- SE 302577, all bands including and above 47000 MHz specified in the first column of the
- Schedule, with a maximum power level of 14dBW erp pep, or;
-
- (ii) for the purpose of direction finding competitions, on 1.96 MHz with a bandwidth not
- exceeding 12.5 kHz and in the frequency bands:
-
- 28.0 MHz to 29.7 MHz (not within 50km of NGR SK 985640); or
-
- 144 MHz to 146 MHz (not within 50km of NGR TA 012869),
-
- with a maximum power level of 14 dBW erp pep which is capable of transmitting the call sign of
- the Licensee periodically (in accordance with clause 7) and capable of being switched off within
- two hours of a demand to close down given by a person authorised by the Secretary of State;
-
- (b) of a low power device to control apparatus at the Main Station Address or at a Temporary
- Location by remote control, in the frequency bands or sub-bands:
-
- 70 MHz to 70.5 MHz
-
- 432.5000 MHz to 432.5875 MHz
-
- 1298 MHz to 1299 MHz (not in Northern Ireland and not within 50km of NGR SS 206127 and
- NGR SE 302577)
-
- 2310.0000 MHz to 2310.4125 MHz (not within 50km of NGR SS 206127 and NGR SE 302577)
-
- 2310.4125 MHz to 2355.0000 MHz
-
- 2355 MHz to 2365 MHz (not within 50km of NGR SS 206127 and NGR SE 302577)
-
- 2365 MHz to 2392 MHz
-
- 2392 MHz to 2450 MHz (not within 50km of NGR SS 206127 and NGR SE 302577)
-
- 3400 MHz to 3420 MHz
-
- 3420 MHz to 3430 MHz (not within 50km of NGR SO 916223, NGR SS 206127 and NGR SE
- 302577)
-
- 3430 MHz to 3450 MHz
-
-
-

- 3450 MHz to 3455 MHz (not within 50km of NGR SO 916223, NGR SS 206127 and NGR SE 302577)

- 3455 MHz to 3475 MHz

- 5650 MHz to 5670 MHz

- 5670 MHz to 5680 MHz (not within 50km of NGR SS 206127 and NGR SE 302577)

- 5755 MHz to 5765 MHz

- 5820 MHz to 5850 MHz

- 10000 MHz to 10125 MHz (not within 50km of NGR SO 916223, NGR SS 206127, NGR SK 985640 and NGR SE 302577)

- 10400 MHz to 10475 MHz

- 24000 MHz to 24050 MHz (not within 50km of NGR SK 985640 and NGR SE 302577)

- and with the exception of 47000 MHz to 47 200 MHz within 50km of NGR SK 985640 and NGR SE 302577, all bands including and above 47000 MHz, specified in the first column of the Schedule, with a maximum power level of -20 dBW erp pep, under all reasonably foreseeable operational conditions, in such a way that no electromagnetic energy capable of reception by any station or apparatus outside the boundary of the premises in which the Station is situated is emitted from the Station: or

- (c) by digital communications at the Main Station Address or at a Temporary Location:

- (i) in the frequency band:

- 50 MHz to 51 MHz (not within 50km of NGR SE 302577)

- with a maximum power level of 10 dBW erp pep, or

- (ii) on the spot frequencies:

- 70.3125 MHz

- 70.3250 MHz

70.4875 MHz

with a bandwidth not exceeding 25 kHz; or

(iii) in the frequency bands or sub-bands:

144 MHz to 146 MHz (not within 50km of NGR TA 012869)

1299 MHz to 1300 MHz (not in Northern Ireland and not within 50km of NGR SS 206127 and NGR SE 302577)

2310.0000 MHz to 2310.4125 MHz (not within 50km of NGR SS 206127 and NGR SE 302577)

2310.4125 MHz to 2355.0000 MHz

2355 MHz to 2365 MHz (not within 50km of NGR SS 206127 and NGR SE 302577)

2365 MHz to 2392 MHz

2392 MHz to 2450 MHz (not within 50km of NGR SS 206127 and NGR SE 302577)

3400 MHz to 3420 MHz

3420 MHz to 3430 MHz (not within 50km of NGR SO 916223, NGR SS 206127 and NGR SE 302577)

3430 MHz to 3450 MHz

3450 MHz to 3455 MHz (not within 50km of NGR SO 916223, NGR SS 206127 and NGR SE 302577)

3455 MHz to 3475 MHz

5650 MHz to 5670 MHz

5670 MHz to 5680 MHz (not within 50km of NGR SS 206127 and NGR SE 302577)

5755 MHz to 5765 MHz

5820 MHz to 5850 MHz

10000 MHz to 10125 MHz (not within 50km of NGR SO 916223, NGR SS 206127, NGR SK 985640 and NGR SE 302577)

10400 MHz to 10475 MHz

24000 MHz to 24050 MHz (not within 50km of NGR SK 985640 and NGR SE 302577)

and with the exception of 47000 MHz to 47 200 MHz within 50km of NGR SK 985640 and NGR SE 302577, all bands including and above 47000 MHz, specified in the first column of the Schedule with a maximum power level of 14 dBW erp pep.

2(4) With the exception of sub-clause 2(5A) the Licensee shall not conduct the Unattended Operation of a beacon or of digital communications unless he has given at least 7 days written notice of the location, period of operation, frequency, power (dBW), identity of other users of wireless telegraphy who share the site and shut down procedures to the Operations Manager of the local office of the Radiocommunications Agency in whose area the operation is to take place. The Operations Manager may, before the commencement of operation, prohibit the Unattended Operation or allow the operation on compliance with the conditions which he may specify.

2(5) The Licensee may transmit on an unattended basis using automatic position reporting software on a spot frequency of 144.800 MHz at any one temporary location not within 50km of NGR TA 012869. The maximum permitted period of unattended operation is 30 minutes and the Licensee must be present to activate and deactivate transmissions. The maximum permitted power level is 14 dBW erp.

2(6) The Licensee is not required to log the operation of a low power device under sub-clause 2(4) (b), although he shall log the operation of the Station in accordance with clause 6.

Pulse emissions

2(7) The Licensee shall not use pulse emissions:

(a) on frequency bands below 1000 MHz;

(b) with a peakpower level which exceeds the Peak Envelope Power (PEP) level specified in the fourth column of the Schedule.

Operators

2(8) The Licensee shall operate or permit the operation of the Station only under the terms and limitations of this Licence and the Station shall be operated only:

- (a) by the Licensee personally (except in the case of Unattended Operations under sub-clause 2 (4)); or
- (b) in the presence of and under the direct supervision of the Licensee:
 - (i) by a person who holds a current United Kingdom Amateur Radio Licence,
 - (ii) by any person:
 - (aa) who does not fall within sub-clauses (i), (iii) or (iv);
 - (bb) whom the Licensee has reasonable grounds to believe is not a disqualified person; and
 - (cc) who either holds a Radio Amateurs' Examination Certificate or a Novice Radio Amateurs' Examination Certificate issued by the City and Guilds of London Institute or an Amateur Radio Certificate issued by the Secretary of State; or
 - (iii) by any licensed radio amateur from any other country, or
 - (iv) by a representative of a User Service in accordance with sub-clause 1(2).

2(9) In this clause 2, a "disqualified person" means any person:

- (a) whose United Kingdom Amateur Radio Licence is currently revoked or varied as a result of revocation action;
- (b) whose last application for an Amateur Radio Licence was refused as a result of revocation action; or
- (c) who, in the last six months, has been convicted of an offence under the Wireless Telegraphy Acts.

2(10) If this Licence is issued to the Licensee for use on behalf of a club, then the Licensee may:

- (a) authorise any club member who holds an Amateur Radio FULL Licence to use and supervise the operation of the Station on his behalf under this Licence.
- (b) permit a non-licensed person to speak into the microphone in accordance with sub-clause 1(8) provided the Station is operated by an Authorised Club Member.

2(11) The Licensee may permit any person to type the Message of the Licensee for transmission

by the Licensee from the Station.

Vessels

2(12) On a Vessel, the Licensee shall:

- (a) install, use or make changes to the Station only with the written permission of the Vessel's master; and
- (b) observe radio silence on the advice of the Vessel's master.

2(13) When on a Vessel in international waters, the Licensee shall use only those frequency bands which, in accordance with the Radio Regulations, have an allocation to the amateur service in the International Telecommunication Union (ITU) region being visited.

Aircraft

2(14) The Licensee shall not establish or use the Station in any aircraft or other airborne vehicle.

Other requirements

3(1) The Licensee shall hold:

- (a) a Radio Amateurs' Examination Certificate issued by the City and Guilds of London Institute; or
- a FULL Radio Examination Pass Certificate issued by or on behalf of the Secretary of State; or
- (b) any other qualification recognised by the Secretary of State.

3(2) The Licensee shall comply with:

- (a) the relevant provisions of the Telecommunication Convention and Radio Regulations unless such compliance would result in a breach of the Licence; and
- (b) all relevant statutory enactments including (without limiting the generality of the foregoing) the Act, the Wireless Telegraphy Act 1967 and the Telecommunications Act 1984.

3(3) The Licensee shall:

- (a) have no pecuniary interest (direct or indirect) in any operations conducted under this Licence;

and

(b) except as provided by sub-clauses 1(2) and (3) and except in the case of activities on behalf of a non-profit organisation established for the furtherance of amateur radio, not use the Station for business, advertisement or propaganda purposes including (without limiting the generality of the foregoing) the sending of news or messages of, or on behalf of, or for the benefit or information of, any social, political, religious or commercial organisation.

Apparatus

4(1) The Licensee shall ensure that:

(a) the emitted frequency of the apparatus comprised in the Station is as stable and as free from Unwanted Emissions as the state of technical development for amateur radio apparatus reasonably permits; and

(b) whatever class of emission is in use, the bandwidth occupied by the emission is such that not more than 1% of the mean power of the transmission (not including the power contained in spurious emissions) falls outside the frequency band.

4(2) Notwithstanding any other term of this Licence, the Licensee shall ensure that the apparatus comprised in the Station is designed and constructed, and maintained and used, so that its use does not cause any undue interference to any wireless telegraphy.

4(3) If any undue interference to wireless telegraphy is caused by the radiation of Unwanted Emissions or the field strength of electromagnetic energy radiated from the Station, then the Licensee shall suppress the Unwanted Emissions or reduce the level of the field strength to the degree satisfactory to the Secretary of State.

4(4) The Licensee shall conduct tests from time to time to ensure that the requirements of this clause 4 are met.

4(5) The Station shall be capable of receiving Messages on the same frequencies and with the same classes of emission in use for the transmission of Messages by the Station.

Recorded or retransmitted Messages

5(1) The Licensee may record and retransmit Messages addressed to the Licensee from other licensed amateurs:

(a) with whom the Licensee is in direct communication; or

- (b) which are intended for retransmission to a specified licensed amateur.

- 5(2) The Licensee may send Messages by (or as part of) the intermediate relaying of the Messages to or from other licensed amateurs.

- 5(3) When recording and retransmitting the Message of another licensed amateur, if the Licensee also records and retransmits the call sign of the licensed amateur, then the Licensee shall transmit the call sign in such a way that the origin of the Message and the origin of the retransmission are clear.

- 5(4) Notwithstanding sub-clauses 5(1) and (2), the Licensee shall not operate the station as:

- (a) a mailbox or bulletin board (each being a device which stores, in a readable form, complete messages, which are not to or from the Licensee, for re-transmission on behalf of other licensed amateurs); or

- (b) a telephony repeater (a facility which receives and simultaneously retransmits Messages by telephony for or on behalf of other licensed amateurs).

Log

- 6(1) Subject to sub-clause 2(6), the Licensee shall keep a permanent record (the "Log") of all wireless telegraphy transmissions at the Main Station Address and all Temporary Locations showing:

- (a) dates of transmission;

- (b) the times (in Co-ordinated Universal Time (UTC)) during each day of:

- (i) the first and last transmissions from the Station (except when using automatic operations involving digital communications), or

- (ii) switching the Station on and off for the purpose of enabling transmissions (when using automatic operations involving digital communications), and changing the frequency band, class of emission or power;

- (c) frequency band of transmission or, in an Unattended Operation, the specific frequency employed;

- (d) class of emission;

- (e) power (or power level in dBW);
-
- (f) initial calls ("CQ" calls) (whether or not they are answered);
-
- (g) except during automatic operations involving digital communications, the callsign of licensed amateurs or licensed amateur stations with which communications have been established (not including those amateurs or stations which form part of the intermediate relay of Messages);
-
- (h) details of tests carried out in accordance with sub-clause 4(4); and
-
- (i) location when the station is operated at a Temporary Location.

6(2) The Log shall be written in a book or maintained on a magnetic tape, disc or other electronic storage medium. If the Log is maintained on an electronic storage medium the means to view the Log and produce a hard copy shall be kept readily available at the Main Station Address.

6(3) Where the Log is maintained:

- (a) in a book, the book shall not be loose-leaf and no gaps shall be left between the entries;
- (b) on a magnetic tape, disc or other electronic storage medium, suitable precautions shall be taken to ensure that the Log is backed up.

6(4) The Licensee shall keep the Log for inspection by a person authorised by the Secretary of State for at least six months from the date of the last entry whether or not this Licence has expired or been revoked.

6(5) When a person authorised by the Secretary of State requires additional matters to be recorded, the Licensee shall record those additional matters in the Log for the period specified by that person.

Identification

7(1) subject to sub-clause (1A) below, which does not apply to operation via repeaters during transmissions, the Licensee shall transmit the callsign specified in the Validation Document:

- (a) during initial calls ("CQ" calls);
-
- (b) at the beginning and at the end of each period of communication with a licensed amateur and when the period of communication is longer than 15 minutes, at the end of each interval of 15 minutes;
-
-

- (c) at the beginning of transmission on a new frequency (whenever the frequency of transmission is changed);
- (d) by the same type of transmission that is being used for the communication;
- (e) on the same carrier frequency that is being used for the communication; and
- (f) by morse telegraphy or telephony, at the end of each 30 minute period during which transmissions are sent from the Station (unless already transmitting in morse telegraphy or telephony). If the Licensee is conducting automatic operations involving digital communications then he shall transmit the callsign under this sub-clause at a maximum speed of 20 words per minute.

7(1A) Where the Licensee is intending to operate within a net pursuant to sub-clause 1(7)(c), the Licensee shall observe the following requirements in relation to the transmission of his callsign:

- (a) he shall transmit his callsign when he first joins the net and on leaving it;
- (b) subject to sub-clause 7(c) below, whilst participating in the net, he shall not be obliged to transmit his callsign when making contact with other participants;
- (c) whilst participating in the net, he shall transmit his callsign;
 - (i) when 15 minutes have elapsed since the last transmission of his callsign; or
 - (ii) if he has not transmitted speech before 15 minutes have elapsed since such transmission, on the first occasion thereafter on which he transmits speech.

7(2) When another person is using the Station under the Licence in accordance with sub-clause 2(8) (b), the Licensee shall ensure that the callsign specified in the Validation Document is transmitted in accordance with sub-clause 7(1).

7(3) At a Temporary Location, the Licensee shall:

- (a) use the suffix "/P" with his call sign and give the location of the Station every 30 minutes to an accuracy of at least 5km by a generally used identifier [for guidance see note (v) to this Booklet], or
- (b) give prior written notice of the location to the Operations Manager of the local office of the Radiocommunications Agency in whose area the operation is to take place.

- 7(4) When Mobile, the Licensee shall use the suffix "/M" and when Maritime Mobile, the suffix "/MM".
- 7(5) When away from the Main Station Address, the Licensee shall use the appropriate Regional Secondary Locator specified in note (w) to this Booklet.
- 7(6) When operating a low power device under sub-clause 2(4) (b), this clause 7 shall not apply to the operation of the low power device (although this clause 7 shall continue to apply to the operation of the Station).
- 7(7) If this License is held on behalf of a club, the Licensee shall use the callsign specified in the Validation Document. If the Licensee is operating under sub-clause 1(8), then the club regional secondary locators specified in note (w) to this Booklet must be used.
- 7(8) The Secretary of State reserves the right to release details of the callsign of the Licensee specified in the Validation Document to third parties so that the callsign may be published in call books compiled by third parties, either in written form or in the form of "read only" computer disks.

Inspection and close down

8(1) The Licensee shall permit a person authorised by the Secretary of State:

(a) to have access to the Station, and

(b) to inspect the Licence and Log and to inspect the apparatus of the Station at any and all reasonable times (or when, in the opinion of a person authorised by the Secretary of State, an urgent situation exists, at any time) for the purpose of verifying compliance with the terms of the Licence.

8(2) When, in the opinion of a person authorised by the Secretary of State:

(a) the Licensee is in breach of the Licence; and

(b) the breach justifies immediate restriction or close down, the Licensee shall restrict the operation of, or close down and cease to operate, the Station (or any apparatus comprised in the Station) forthwith in accordance with the demand of a person authorised by the Secretary of State for the temporary period specified in the demand.

8(3) When Maritime Mobile, the Licensee shall cease to operate the Station on the demand of the Vessel's master.

8(4) For the purposes of sub-section 1(4) of the Act, this Licence may be revoked, or its terms, provisions or limitations varied, by a notice in writing of the Secretary of State served on the Licensee, or by a general notice addressed to all holders of an Amateur Radio Licence (A) or Amateur Radio Licence (B) published in the London, Edinburgh and Belfast Gazettes or broadcast nationally by the British Broadcasting Corporation.

Period of Licence and fees due

9(1) Subject to the payment of the fee in the manner indicated in sub-clause 9(2), this Licence shall continue in force from year to year unless revoked by the Secretary of State.

9(2) The Licensee shall pay to the Secretary of State before the anniversary date of the Date of Issue in each year, the fee on renewal prescribed by the Regulations for the time being in force under sub-section 2(1) of the Act, and on the payment of the fee the Secretary of State will issue to the Licensee a document in the form of the title page of this Licence (the "Validation Document") which will indicate the next date for renewal.

9(3) If the Licensee does not pay the fee in the manner described in sub-clause 9(2), then the Licence shall expire at the end of the day before the relevant anniversary date of the Date of Issue.

9(4) The Licensee shall surrender the Validation Document to the Secretary of State forthwith upon the revocation of the Licence. The Secretary of State reserves the right to publish the name and callsign of the Licensee if the Licence is revoked.

9(5) Sub-clauses 9(1), (2) and (3) do not apply to a temporary licence.

Operations by CEPT Amateurs in accordance with

CEPT Recommendation TIR 61-01

10 The following additional provisions apply to licensed non-resident amateurs temporarily visiting and operating wireless telegraphy apparatus in the United Kingdom in accordance with CEPT Recommendation T/R 61-01, as enabled by statutory instrument ("CEPT Amateurs") unless the individual is a disqualified person as defined in sub-clause 2(9) of the Booklet.

10(1) CEPT Amateurs may operate in the United Kingdom under a CEPT equivalent licence which is:

(a) valid and in force;

(b) not temporary; and

(c) issued by an administration which

(i) has implemented CEPT Recommendation T/R 61-01, and

(ii) permits persons licensed to use amateur stations under section 1 of the Act to use such stations in its territory (with or without conditions) without making application in that behalf.

10(2) CEPT Amateurs shall transmit their home callsign after:

(a) the United Kingdom callsign prefix "M";

(b) followed by the appropriate Regional Secondary Locator (if any); and

(c) followed by the symbol "/"

[for guidance see note (w) to this Booklet].

10(3) Subject to this clause 10, CEPT Amateurs shall comply with:

(a) the terms of their CEPT equivalent licence, unless such compliance would result in a breach of the requirements of the United Kingdom;

(b) this Terms, Provisions and Limitations Booklet BR68 (insofar as its terms and limitations may reasonably be applied); and

(c) the relevant provisions of CEPT Recommendation T/R 61-01.

10(5) CEPT Amateurs shall operate only:

(a) a mobile or a portable station (which includes a station powered from the mains electricity at a temporary fixed location such as an hotel); or

(b) the Station of an amateur licensed under the Act.

Operations by the Licensee in accordance with CEPT Recommendation TIR 61-01

11 Subject to sub-clause 11(2), the Licensee may operate in countries which have implemented CEPT Recommendation T/R 61-01 in accordance with the following terms.

11(1) The Licensee shall:

- (a) be a temporary visitor and non-resident in the host country;
- (b) operate only:
 - (i) a mobile or a portable station (which includes a station powered from the mains electricity at a temporary fixed location such as an hotel), or
 - (ii) the station of an amateur licensed by the relevant authority in the host country;
- (c) comply with the requirements applicable to the use of wireless telegraphy apparatus at the location of operation in the host country;
- (d) present this Licence upon request to the relevant supervisory authorities in the host country;
- (e) if he possesses an Amateur Radio Licence (A) or (B), use only those frequencies above 30 MHz authorised for use by licensed amateurs in the host country;
- (f) unless instructed otherwise by the host country, use his home callsign after the appropriate host country callsign prefix; and
- (g) comply with the relevant provisions of CEPT Recommendation T/R 61-01.

11(2) If this Licence is a temporary Licence, then the Licensee shall not operate under this clause 11.

Interpretation

12(1) In this Licence, unless the context otherwise requires:

- (a) The Interpretation Act 1978 shall apply to this Licence as it applies to an Act of Parliament;
- (b) the expression "Co-ordinated Universal Time" has the same meaning as it has in the Radio Regulations [for guidance see note(s) to this Booklet];
- (c) "Act" means the Wireless Telegraphy Act 1949;
- (d) "At Sea" means in the Tidal Waters or territorial sea of the United Kingdom or in international waters;
- (e) "Authorised Club Member" means where a licence is held on behalf of a club, a member of that club who is suitably licensed and who is authorised by the licensee to use and supervise the

use of the Station;

(f) "CEPT" means the European Conference of Postal and Telecommunications Administrations;

(g) "Inland Waters" means any canal, river, lake, loch or navigation which is not Tidal Water;

(h) "Inspect" means examine and test;

(i) "Licensee" means the licensee named in paragraph (a) of the Validation Document or a CEPT Amateur [as defined in clause 10], as the case may be;

(j) "Secretary of State" means the Secretary of State for Trade and Industry;

(k) "Telecommunication Convention" and "Radio Regulations" mean the International Telecommunication Convention and the Radio Regulations thereunder and include any Convention or Regulation which may from time to time be enacted or brought into force in substitution for, in amendment of, or in addition to, the Telecommunication Convention or Radio Regulations;

(l) "Tidal Water" means any part of the sea or a river within the ebb and flow of the tide at ordinary spring tides;

(m) "United Kingdom" means the United Kingdom of Great Britain and Northern Ireland, the Channel Islands and the Isle of Man;

(n) "Unwanted Emissions" means spurious emissions and out-of-band emissions as defined in the Radio Regulations;

(o) "User Service" means the British Red Cross Society, the St John Ambulance Brigade, the St Andrew's Ambulance Association, the Chief Emergency Planning Officer ("Chief Emergency Planning Officer" means an Emergency Planning Officer who is not responsible to any higher Emergency Planning Officer, such as a County, Regional or Islands Emergency Planning Officer) or any United Kingdom police force, fire or ambulance service, health authority, government department or public utility; and

(p) "Vessel" includes a hovercraft and any other floating structure which is capable of being manned.

12(2) The Licence consists of the Validation Document, Terms, Provisions and Limitations Booklet BR68, the Schedule to the Booklet and the Notes to the Schedule, as any of them may be varied from time to time.

12(3) References to a certificate issued by the Secretary of State include references to a certificate issued or granted by the Secretary of State for the Home Department, the Postmaster General or the Minister of Posts and Telecommunications.

12(4) The headings in this Licence are for ease of reference only and shall not affect the interpretation of the Licence.

12(5) To the extent that they do not conflict with or are not inconsistent with any of the clauses herein, the Notes to the Schedule to the Booklet and the Notes to the Booklet shall be complied with by the Licensee.

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Syllabus sections in blue type face **parts of BR68 to which they relate are in RED bold type face :-**

Note: that a full copy of the leaflet BR68 will be provided in the exam

2b.10 Log

Log: clauses 6(1), 6(2), 6(3), 6(4), 6(5)

6(1) Subject to sub-clause 2(6), the Licensee shall keep a permanent record (the "Log") of all wireless telegraphy transmissions at the Main Station Address and all Temporary Locations showing:

(a) dates of transmission;

(b) the times (in Co-ordinated Universal Time (UTC)) during each day of:

(i) the first and last transmissions from the Station (except when using automatic operations involving digital communications), or

(ii) switching the Station on and off for the purpose of enabling transmissions (when using automatic operations involving digital communications), and changing the frequency band, class of emission or power;

(c) frequency band of transmission or, in an Unattended Operation, the specific frequency employed;

(d) class of emission;

(e) power (or power level in dBW);

- (f) initial calls ("CQ" calls) (whether or not they are answered);
-
- (g) except during automatic operations involving digital communications, the call sign of licensed amateurs or licensed amateur stations with which communications have been established (not including those amateurs or stations which form part of the intermediate relay of Messages);
-
- (h) details of tests carried out in accordance with sub-clause 4(4); and
-
- (i) location when the station is operated at a Temporary Location.

6(2) The Log shall be written in a book or maintained on a magnetic tape, disc or other electronic storage medium. If the Log is maintained on an electronic storage medium the means to view the Log and produce a hard copy shall be kept readily available at the Main Station Address.

6(3) Where the Log is maintained:

- (a) in a book, the book shall not be loose-leaf and no gaps shall be left between the entries;
-
- (b) on a magnetic tape, disc or other electronic storage medium, suitable precautions shall be taken to ensure that the Log is backed up.

Sub-clause 4(4) is all about the apparatus [this link takes](#) you back to it if you want to review it again.

6(4) The Licensee shall keep the Log for inspection by a person authorised by the Secretary of State for at least six months from the date of the last entry whether or not this Licence has expired or been revoked.

6(5) When a person authorised by the Secretary of State requires additional matters to be recorded, the Licensee shall record those additional matters in the Log for the period specified by that person.

Most of this information in red you will be familiar with if you have been operating a station through your foundation and Intermediate Licence.

It is a matter of reading through and being familiar with the text so that in an exam there would be no surprises for you.

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2b.11 Identification

Identification: clauses 7(1), 7(1A), 7(2), 7(3), 7(6)

7(1) subject to sub-clause (1A) below, which does not apply to operation via repeaters during transmissions, the Licensee shall transmit the callsign specified in the Validation Document:

(a) during initial calls ("CQ" calls);

(b) at the beginning and at the end of each period of communication with a licensed amateur and when the period of communication is longer than 15 minutes, at the end of each interval of 15 minutes;

(c) at the beginning of transmission on a new frequency (whenever the frequency of transmission is changed);

(d) by the same type of transmission that is being used for the communication;

(e) on the same carrier frequency that is being used for the communication; and

(f) by morse telegraphy or telephony, at the end of each 30 minute period during which transmissions are sent from the Station (unless already transmitting in morse telegraphy or telephony). If the Licensee is conducting automatic operations involving digital communications then he shall transmit the callsign under this sub-clause at a maximum speed of 20 words per minute.

7(1A) Where the Licensee is intending to operate within a net pursuant to sub-clause 1(7)(c), the Licensee shall observe the following requirements in relation to the transmission of his callsign:

- (a) he shall transmit his callsign when he first joins the net and on leaving it;**
- (b) subject to sub-clause 7(c) below, whilst participating in the net, he shall not be obliged to transmit his callsign when making contact with other participants;**
- (c) whilst participating in the net, he shall transmit his callsign;**
 - (i) when 15 minutes have elapsed since the last transmission of his callsign; or**
 - (ii) if he has not transmitted speech before 15 minutes have elapsed since such transmission, on the first occasion thereafter on which he transmits speech.**

7(2) When another person is using the Station under the Licence in accordance with sub-clause 2(8) (b), the Licensee shall ensure that the callsign specified in the Validation Document is transmitted in accordance with sub-clause 7(1).

7(3) At a Temporary Location, the Licensee shall:

- (a) use the suffix "/P" with his call sign and give the location of the Station every 30 minutes to an accuracy of at least 5km by a generally used identifier [for guidance see note (v) to this Booklet], or**
- (b) give prior written notice of the location to the Operations Manager of the local office of the Radiocommunications Agency in whose area the operation is to take place.**

7(6) When operating a low power device under sub-clause 2(4) (b), this clause 7 shall not apply to the operation of the low power device (although this clause 7 shall continue to apply to the operation of the Station).

There is a great deal to understand in this section but most has been seen in the FLC / ILC.

the suffix "/P"

Note (v) states When the Station must be identified in accordance with sub-clause 7(3) (a), it is recommended that one of the following location identifiers be used:

- (i) the full postcode,**

- (ii) latitude and longitude in degrees and minutes,
- (iii) National Grid Reference correct to six figures,
- (iv) International Amateur Radio Union (IARU) locator, or
- (v) the address or other geographical description correct to 1 km.

This has been covered in depth in the Intermediate stage so [check back](#) if you have any doubts.

Participation in a net

That is a new area concerning licence conditions.

A net is a group of like minded amateurs who link up on a single frequency to have a natter as a round robin with a net controller. It is usual for the net controller to call in stations to "have and over" and then they comment on the over before passing it on further to the next operator.

To join a net you will press the PTT just as a participant has finished their "over" and just prior to the net controller coming in. However this is not always needed - say for instance if you try this approach and the net controller does not hear you but someone else does.

The licence requires you to announce your callsign when you first join the net and on leaving it, so that would be in your first "over" to whom you might address comments. Where the net controller cannot hear you, may be you will be called in by another member of the net. who can hear you, as mentioned above. By giving your callsign to this other person you have fulfilled your licence requirement for identification.

Whilst you are participating in a net, you are not be obliged to transmit your callsign when making contact with other participants - but it is polite so to do.

15 minutes ruled for nets

Further whilst participating in the net you must transmit your callsign when 15 minutes have passed since the last transmission of your callsign or if you have another "over" sooner than 15 minutes since your last over then you do not have to give your callsign in that "over" but you must give your callsign on the next "over" when you speak.

NEXT >

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Bredhurst Receiving and Transmitting Society

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BRATS

Intermediate
Radio Amateur
Licence Exam

Licensing Conditions

Bredhurst Receiving and Transmitting Society

Part 1

In this section you may think that you have seen some items before, if so, you would be correct in your flash back, as some topics are included from the Foundation Licence Syllabus, however most of the course does introduce many new licence clauses or new facets on existing clauses. The parts in **blue** are from the **Intermediate syllabus** and those parts in **Bold and blue** are extracts from BR68/I

The section numbering takes account of the syllabus and the numbering given to BR68/I prior to July 2003. This will be updated when the syllabus is updated.

Note:- That the Advanced Licence may still be referred to as the **FULL Licence**.

OPERATORS

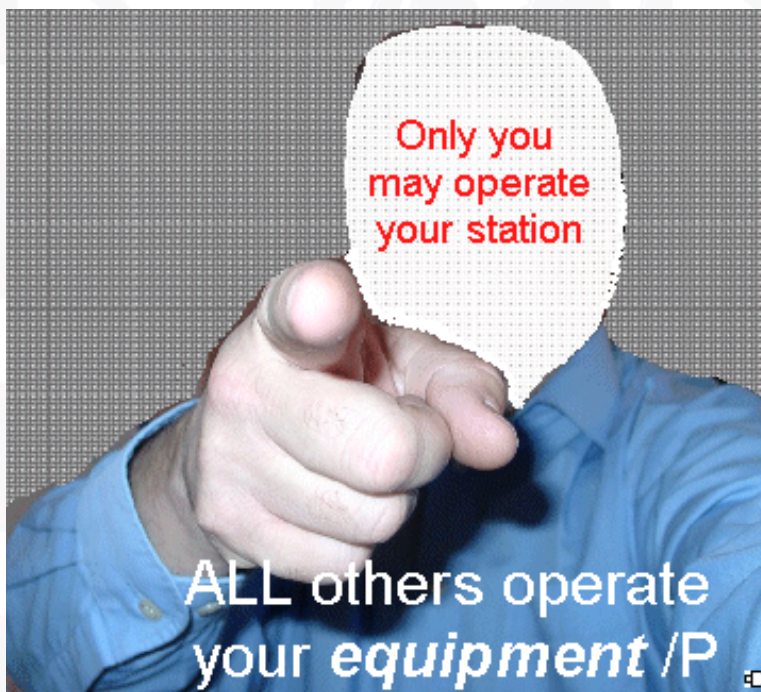
2a.1 Recall that only the licensee personally may use the station.

2(1) The Licensee shall only use: (the station)

2(7) The Station shall be operated only by the Licensee personally (Except in the case of Unattended Operations under sub-clause 2(4)).

**Only the Licensee
personally to
operate the station**

**Another amateur may
use the equipment
under their own
callsign /P**



Visitors to the location of your station can use your "Equipment" but must work under their callsign /P

Just as with the Foundation Licence only you may operate your station.

So if a Foundation Licence holder or an Advanced Licence holder visits your station then that person must work under their own call sign /P and use their own log book. As the station owner it is your duty to protect your Intermediate Licence and ensure that the visitor works /P. You do not sign their log book!!

Only you may operate your station. Your station comprises all the equipment and your log book!

2a.2 Recall that an Intermediate licensee may operate the Station of a Advanced licensee, using the callsign of and under the direct supervision of the Advanced licensee.

The licensee may operate under the supervision of a Higher Grade Licence Holder and use the additional privileges

If you are at the station of a Advanced licence holder then under their supervision you can operate their station using their call sign and under their direct supervision. This of course means that you, under supervision, operate the station using all the benefits of the higher grade licence including higher power and operation through satellites etc etc ...AND don't forget to sign their log book!!

The ability to use the privileges of a higher grade licence holder is not mentioned in BR68/I but is in the BR68 which is appropriate to a Advanced licence and it is that licence holder who must know what a lesser licence holder can and cannot do.

MESSAGES

2b.1 Recall that messages must be limited to matters relating to technical investigations and remarks of a personal nature.

1(2) The Licensee shall address Messages only to other licensed amateurs or the stations of licensed amateurs and shall send only:

a. Messages relating to technical investigations or remarks of a personal character;

The use of the word messages is confusing to some students in that outside Amateur Radio you consider a message is something left for someone else as in leaving a message on an answering machine. In amateur radio and in this section of the course the use of the word message means the text of your communications (what you say of in data modes type) over the air to the other station and nothing to do with leaving a message for someone else.

Even though this is in the Foundation licence some students forget what topics they can discuss and that they can only matters relating to technical investigations and remarks of a personal nature.

This you have seen before. If you have an exam question on this part think clearly that in amateur radio it is best not to talk about some sensitive subjects and thus keep even topics of a personal nature in good taste and something you would not mind the world hearing, as that just might be the case !!!

Chatting about items of a technical nature is usually very worth while and amateurs are usually happy to help each other out. You can often learn a great deal about antennas in qso's.

3(3) Except as provided by sub-clause 3(4), the Licensee shall:

a. have no pecuniary interest (direct or indirect) in any operations conducted under this Licence; and

b. except in the case of activities on behalf of a non-profit organisation established for the furtherance of amateur radio, not use the Station for business, advertisement or propaganda purposes including (without limiting the generality of the foregoing) the sending of news or messages of, or on behalf of, or for the benefit or information of, any social, political, religious or commercial organisation.



You cannot use the amateur band for publicity of any business venture nor to use it to keep in touch with business colleges for as such the amateur radio bands are then benefiting your business and that is just not allowed.

~~**Business**~~
~~**Advertisement**~~

2b.3 Recall that messages may be used to aid User Services and who they are.

1(1B) The Licensee may use or permit the use of the Station, as part of his self-training in communication by radio telecommunications, during any community event where the Licensee has been requested in writing by a User Service (defined in sub-clause 10(1)(1)) to provide communications without pecuniary gain for the purpose of sending Messages relating to the event to other licensed amateur stations.

1(4) Except when conducting emergency communications on behalf of a User Service, the Licensee may use codes and abbreviations for communications as long as they do not obscure the meaning of, but only facilitate, the communications.

10(1)(1) "User Service" means the British Red Cross Society, the St John Ambulance Brigade, the St Andrew Ambulance Association, the Women's Royal Voluntary Service, the Salvation Army, HM Coastguard, the Chief Emergency Planning Officer ("Chief Emergency Planning Officer" means an Emergency Planning Officer who is not responsible to any higher Emergency Planning Officer, such as a County, Regional or Islands Emergency Planning Officer) or any United Kingdom

• **police force, fire or ambulance service, health authority, government department or utility services.**

• This is something completely new that as a Foundation Licence holder you were not able to do. There are what are called USER SERVICES and these you must know and there is a special relationship with the users services that means that you can pass what are called "third party messages". The sort of information that is :-

- Not personal to you
- Not of a technical nature
- BUT is of importance to the users services.

**the British Red Cross Society
the St John Ambulance Brigade
the St Andrew Ambulance Association
the Women's Royal Voluntary Service
the Salvation Army,
HM Coastguard
the Chief Emergency Planning Officer
any United Kingdom:-
police force,
fire or ambulance service
health authority
government department
utility services**

The following are "user services"

Thus under normal operating you would not be able to pass the message as it does not fall into the sections numbered 1 and 2 above but with the user service needing your help you can pass messages on their behalf.

However you must be called out in writing and this is usually through groups such a RAYNET, the radio amateur emergency network.

• **LOCATION and IDENTIFICATION**

• 2c.1 Recall that the licensee must transmit the call sign printed on the Validation Document during CQ calls, at the start and finish of all periods of transmission and every 15 minutes during long periods of transmission.

• **7(1) Subject to sub-clause (IS) below, which does not apply to operation via repeaters during transmissions, the Licensee shall transmit the callsign specified in the Validation Document:**

- **a. during initial calls ("CQ" calls);**
- **b. at the beginning and at the end of each period of communication with a licensed amateur and when the period of communication is longer than 15 minutes, at the end of each interval of 15 minutes;**

When you are using your own station then you must transmit the call sign that is printed on the validation document:-

- during CQ calls, and
- at the start and
- finish of all periods of transmissions.

With regards to the periods of transmission many amateurs consider that you start the period of transmission when you press the PTT and that it ends when you let go of the PTT but others agree on the start but consider that the end of the period of transmission

is when you finish the QSO.

Best operating practise would be to use the call sign at the start and finish of each OVER as the end of an over is the end of a transmission.

When you talk for a long time, as a single over for greater than 15 minutes, then in addition to the forgoing you also have to give your call sign in the QSO every 15 minutes.

2c.2 Recall that the call sign must be sent in either voice or Morse code at least every 30 minutes during periods of transmission using other modes.

f. by morse telegraphy or telephony, at the end of each 30 minute period during which transmissions are sent from the Station (unless already transmitting in morse telegraphy or telephony). If the Licensee is conducting automatic operations involving digital communications then he shall transmit the callsign under this sub-clause at a maximum speed of 20 words per minute.

"Data modes"

In addition to giving ID in the mode of operation you must give ID in

**Morse or
telephony
ID every
30 minutes**

When using modes other than voice and CW then you must also announce in voice or CW your call sign at least every 30 minutes. This item is often forgotten by RTTY, PSK31 and SSTV operators as they often cannot program the software to include the CW ident.

CW to be sent at

Maximum 20 Words per minute

2c.3 Recall the meaning of 'main station address', 'temporary location' and 'mobile'.

1(7) "Station" means the station of the Licensee at the Main Station Address, a Temporary Location or while Mobile, as the case may be.

1(8) The Licensee shall operate the Station only:

a. at the Main Station Address ("Main Station Address" means the main station address of the Licensee set forth in the Validation Document);

b. at a Temporary Location ("Temporary Location" means a location, other than the Main Station Address, in the United Kingdom, and in a fixed position);

c. while Mobile ("Mobile" means located in the United Kingdom in any vehicle, as a pedestrian or on any Vessel in Inland Waters).

'main station address' : The location of your station as listed on your validation document /licence

'temporary location' : A location other than your main location or when you are mobile.

and **'mobile' :** When you are not at your 'main station address' or your 'temporary location' then you must be mobile!!! Mobile is not only in a motor vehicle but is also when you are on a bicycle and also walking (or for the fit ones amongst you running).

2c.4 Recall that the licensee must give the location of the station, to within 5 km, at least every 30 minutes when operating from a temporary location.

7(2) At a Temporary Location, the Licensee shall:

a. use the suffix "/P" with his callsign and give the location of the Station every 30 minutes to an accuracy of at least 5km by a generally used identifier (for guidance see note (v) to this booklet);

When you are in a "temporary location" you must give the location at least every 30 minutes so that those listening know where you are and to an accuracy of at least 5kms.

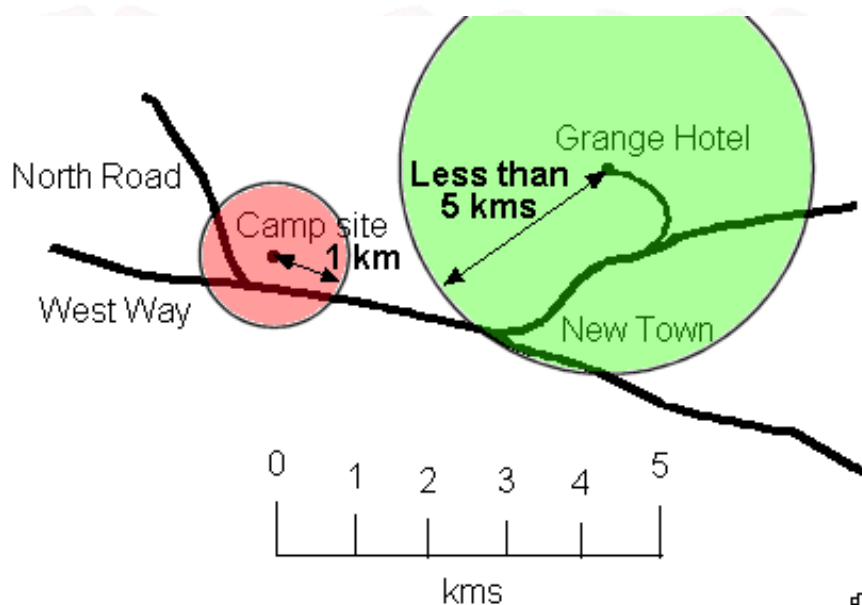
You must use your log book at a /P location and must also note in the log book the location.

Item "v" mentioned above says "When the Station must be identified in accordance with sub clause 7(2) (a), it is recommended that one of the following location identifiers be used:

1. the full post code
2. latitude and longitude in degrees and minutes
3. National Grid Reference correct to six figures
4. International Amateur Radio Union (IARU) locator, or
5. the address or other geographical description correct to 1km"

So is 5kms or 1km ?

The two limits are referring to slightly different things. You MUST pinpoint YOUR location to 5kms, if you choose to do that by a geographical description then the added uncertainties in such a method results in a recommendation that you aim for 1km accuracy. Have a look at the diagram below.



If you were staying in the "Grange Hotel" then as that is within 5kms of "New Town" then you could say that you are "at the "Grange Hotel" just out side of New town - which is less than 5kms so meeting licence conditions.

If you were staying on the campsite then you could say "at the campsite at the junction of West Way and North Road which is east of New Town as the campsite might be a temporary one and thus the accuracy of 1km.

Thus for the exam it is necessary to be careful exactly what is being asked.

The whole point of giving a call sign is so that if interference occurs then it is possible to identify its origin. When you are at home

- in your "main station location" that address is know to the RA but when you are at a "temporary location" unless you specify where you are there would be no way of easy of location you.
-
- When you are mobile there is no need to know your whereabouts even if you were causing interference as you are only passing through and thus any interference would not be for a long period of time.
-
- 2c.5 Recall that the appropriate secondary regional locator (D, I, J, M, U, W, E) must be used when operating away from the main station address.
-
- **7(4) When away from the Main Station Address, the Licensee shall use the appropriate Regional Secondary Locator specified in note (w) to this Booklet.**
-
- **w. The following Regional Secondary Locators should be used immediately after the United Kingdom prefix "2" when identifying the Station in accordance with sub-clause 7(4) of this booklet:**
-

D Isle of Man I Northern Ireland J Jersey M Scotland U Guernsey W Wales E England

! some students are caught out not knowing the use of the Intermediate callsign, the call sign that you are trying hard to gain with your Intermediate exam, where in :-

England the call is 2E1AAA,

Scotland it would be 2M1AAA,

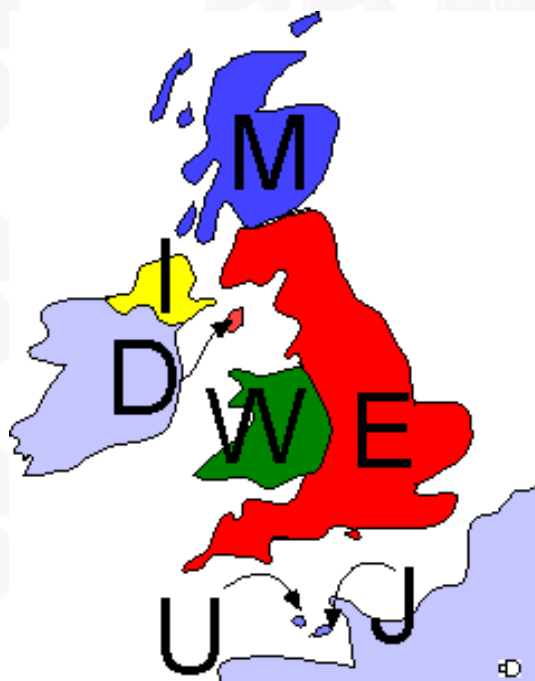
Isle of Man it would be 2D1AAA,

Jersey it would be 2J1AAA,

and so on. If you have any doubt about understand this then write then all out so that it helps you to learn them.

! These secondary identifiers were introduced to you in the Foundation Licence and have to be known so if you have any doubt look back and re-learn. [Click here to check back](#)

check you know the places by reference to the map.



2c.6 Recall that the licence does not permit operation from an aircraft or vessel except on inland waters.

2(10) The Licensee shall not establish or use the Station on any vessel, other than in Inland Waters, or in any aircraft or other airborne vehicle.

k. "Vessel" includes a hovercraft and any other floating structure which is capable of being manned.

Whilst you are rowing a small boat, or hovercraft on INLAND WATERWAYS you can have a QSO.



and NOT from a vessel (SHIP) in tidal waters.

but NOT from any aircraft, balloon.



2c.7 Recall that the Intermediate licence does not permit operation outside the UK.

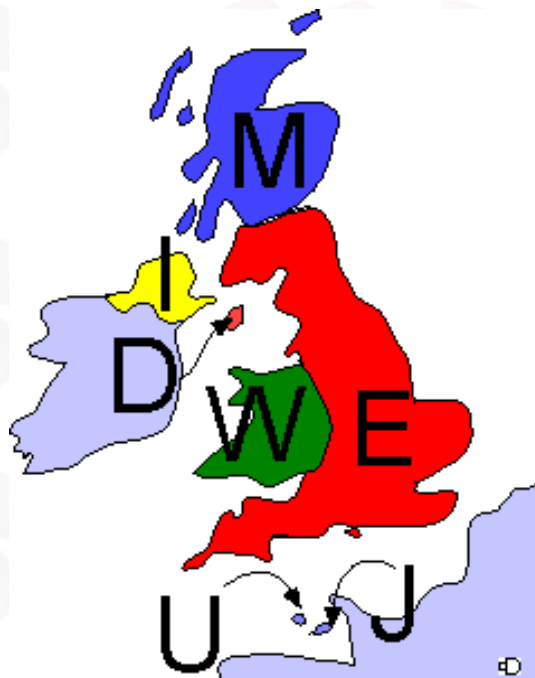
1(8) The Licensee shall operate the Station only:

a. at the Main Station Address ("Main Station Address" means the main station address of the Licensee set forth in the Validation Document);

b. at a Temporary Location ("Temporary Location" means a location, other than the Main Station Address, in the United Kingdom, and in a fixed position);

c. while Mobile ("Mobile" means located in the United Kingdom in any vehicle, as a pedestrian or on any Vessel in Inland Waters).

The Intermediate Licence does not permit you to operate from a country outside UK. In this context UK includes Great Britain (England Scotland and Wales), Northern Island, the Channel Islands and the Isle of Man - these are the same locations as have Secondary Identifiers which you saw above.



Satellite operation permitted

With effect from 26 July 2003, the terms, provisions and limitations of the Intermediate Licence was varied and the biggest change is that the Intermediate Licence does permit through satellite and thus also through the International Space Station (ISS) but be careful that you know what you are doing in these two areas as they are quite specialise operation.

UNATTENDED OPERATION

2d.1 Recall that the licence-holder may conduct unattended operation of a beacon, for the purposes of direction-finding competitions, for remote control of the main station or for digital communications.

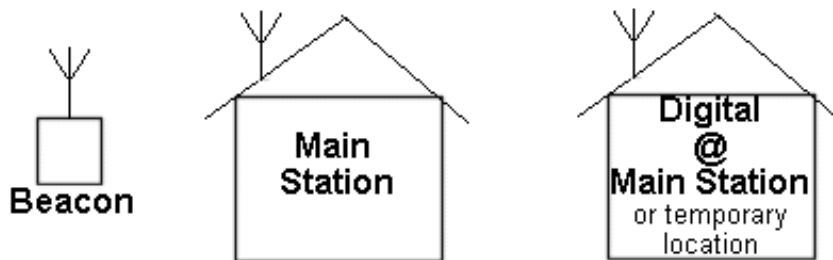
2(3) Subject to sub-clause 2(5), the Licensee may conduct the Unattended Operations ("Unattended Operation" means the operation of the Station when unattended by the Licensee) only:

a. of a beacon:

ii. for the purpose of direction finding competitions,

b. of a low power device to control apparatus at the Main Station Address or a Temporary Location by remote control,

c. by digital communications at the Main Station Address or at a Temporary Location:



Unattended means that you are not in the vicinity of the station. Such a station could be:-

- a low powered beacon for direction-finding competitions (DF hunts) and
- you can also remotely operate your station and
- you when you use digital communications and leave the station unattended.

BUT SEE BELOW

2d.2 Recall that seven days' notice of unattended operations must be given to the local office of the Radiocommunications Agency (which from the 29th December is known as Ofcom).

2(4) The Licensee shall not conduct the Unattended Operation of a beacon or of digital communications unless he has given at least 7 days' written notice of the location, period of operation, frequency, power (Watts), identity of other users of wireless telegraphy who share the site and shut down procedures to the Operations Manager of the local office of the Radiocommunications Agency in whose area the operation is to take place. The Operations Manager may, before the commencement of operation, prohibit the Unattended Operation or allow the operation on compliance with the conditions which he may specify.

Unattended operation of beacon or digital station needs

7 days written notice

giving

location,
period of operation,
frequency,
power (Watts),
identity of other users
who share the site and
shut down procedures

Before you conduct unattended operation of a beacon or digital communication you must give **seven days' written notice of unattended operations** must be given to the local office of Ofcom.

The notice must tell OFCOM the location, period of operation, frequency, power (Watts), identity of other users of wireless telegraphy who share the site and shut down procedures

So do not set up a digital packet station and then go out as you are breaking your licence conditions.

When you leave your home station remember to turn off all your equipment so that there can be no possibility of inadvertent transmissions.

LOG

2e.1 Recall that the log may be written in a book (not loose-leaf), on a magnetic disk or tape or other electronic storage medium.

- **6(2) The Log shall be written in a book or maintained on a magnetic tape, disc or other electronic storage medium. If the Log is maintained on an electronic storage medium the means to view the Log and produce a hard copy shall be kept readily available at the Main Station Address.**

- **6(3) Where the Log is maintained:**

- **a. in a book, the book shall not be loose-leaf and no gaps shall be left between the entries;**
- **b. on a magnetic tape, disc or other electronic storage medium, suitable precautions shall be taken to ensure that the Log is backed up.**

The information about the requirement for a log book was introduced to you in the Foundation Licence.

the log may be :-

- written in a book (not loose-leaf),
- on a magnetic disk or tape or
- other electronic storage medium.

2e.2 Recall that if the log is kept on a computer, the means to view the log and print a copy must be readily available and that suitable precautions must be taken to ensure the Log is backed up.

and again

- **b. on a magnetic tape, disc or other electronic storage medium, suitable precautions shall be taken to ensure that the Log is backed up.**

If you keep the log on a computer then you must be able to :-

- provide the means to view the log and
- you must be able to readily print out a copy of the log and that
- you must ensure that suitable precautions must be taken to backup the Log.

2e.3 Recall that the log must be retained for at least six months after the last entry.

- **6(4) The Licensee shall keep the Log for inspection by a person authorised by the Secretary of State for at least six months from the date of the last entry whether or not this Licence has expired or been revoked.**

**Keep log for
6 months
from
last entry**

This is something new to you. The log must be kept for 6 months after your last entry. In fact it is like a diary of event that you have had and thus keeping it should be no great hardship BUT it is a necessity.

APPARATUS

2f.1 Recall that transmissions from the station must not cause undue interference to other radio users.

- **4(1) The Licensee shall ensure that:**

- **a. the emitted frequency of the apparatus comprised in the Station is as stable and as free from Unwanted Emissions as the**

state of technical development for amateur radio apparatus reasonably permits

4(2) Notwithstanding any other term of this Licence, the Licensee shall ensure that the apparatus comprised in the Station is designed and constructed, and maintained and used, so that its use does not cause any undue interference to any wireless telegraphy.

Having a radio transmitter available to you is a responsibility as you have the ability to cause interference to other radio users. It is a licence requirement that you do not cause undue interference to other radio users whether they are amateur or commercial users.

2f.2 Recall that the licensee must reduce any emissions causing interference, to the satisfaction of an Officer authorised by the Secretary of State.

4(3) If any undue interference to wireless telegraphy is caused by the radiation of Unwanted Emissions or the field strength of electromagnetic energy radiated from the Station, then the Licensee shall suppress the Unwanted Emissions or reduce the level of the field strength to the degree satisfactory to the Secretary of State.

In the early questions in the exam paper it will be dealing with Licence conditions. As such the significance of interference problems are related to the direction of Ofcom with regard to what you can and cannot do if you have been found to be causing interference to other radio users.

Thus should you be foolish enough to cause interference then you will be ordered to reduce any emissions causing interference and this you must do to the satisfaction of an Officer authorised by the Secretary of State.

Should this happen to you don't try to be clever just abide by the rules and all should be well.

2f.3 Recall the licensee must carry out tests from time to time to ensure that the station is not causing undue interference.

4(4) The Licensee shall conduct tests from time to time

and also from 6(2) you have to note

h. details of tests carried out in accordance with sub-clause 4(4)

From time to time

Having a radio transmitter available to you is a responsibility as you have the ability to cause interference to others. This might be to their radio hifi television or what ever. It is a licence requirement that you do not cause undue interference to other radio users.

Tests must be carried out "from time to time". This phrase is an old favourite in exam questions !!

Carrying out test from time to time means that Ofcom are not going to specify when you must do your tests - but you must decide how often you want to check your equipment to ensure that you are not causing interference and that all is operating well.

It would be considered appropriate to check your equipment when ever there has been a break of say "several weeks" in operating and you would do tests to check SWR etc --- so they would be logged.

Also when you carry out any significant changes to your operating station then you would do simple tests to check it all works ok --- so they too would be logged.

However carrying out more exhaustive test every six months might be considered about right, with modern commercial equipment.

Details of the the tests carried out

- Further you have to note in your log book the full **details of the the tests carried out** - of course you would also have to enter the date and times as usual mode power etc

• So what as the tests that you have to carry out ???

• These have not been defined but you have to know that you are not causing or likely to cause interference and to ensure :-

- that your station is not transmitting outside the amateur bands
- that your station is not causing harmonically related radiation of your wanted signal

• These items you can check with the aid of a general coverage receiver and tune up the band and through the harmonically related frequencies. Should you hear you own signal outside the permitted bands stop transmitting. Then reduce the Tx power level move further inside the band and try again. Also remove the aerial to the receiver - but if then no signal can be heard substitute with a short length of wire say 250mm. If all is well and you are again in band return to the frequency that should be in band and test again.

• Log the results of all the tests - a simple "OK" will do if the test was successful.

• If you have a frequency counter then use that to check your transmitter carrier frequency log the result.

• Other tests ?

- All other transmission which are test of your equipment which need you to transmit to carry then out must also be included - as you are radiating power and could be causing interference.

If you transmit for what ever purpose log it !!

• Typical log book entry might be

AMATEUR RADIO STATION LOG

Date	Time (UTC)		Frequency Band	MODE	Power Watts	Station called/worked	Report		QSL		Remarks
	start	end					sent	rec'd	sent	rec'd	
29/2/04	09:00		2m	SSB	50	station tests	with receiver	for out	of band	transmissions	OK
"			"	CW	"	"					OK
"			"	RTTY	"	"					OK
"		10:25	20m	RTTY	"	"					OK

• LICENCE

2g.1 Recall the licensing role of the Radiocommunications Agency (which from the 29th December 2003 is known as Ofcom), on behalf of the Secretary of State.

8(1) The Licensee shall permit a person authorised by the Secretary of State:

a. to have access to the Station; and

- **b. to inspect the Licence and Log and to inspect the apparatus of the Station at any and all reasonable times (or when, in the opinion of a person authorised by the Secretary of State, an urgent situation exists, at any time) for the purpose of verifying compliance with the terms of the Licence.**

• **8(2) When, in the opinion of a person authorised by the Secretary of State:**

• **a. the Licensee is in breach of the Licence; and**

• **b. the breach justifies immediate restriction or close down, the Licensee shall restrict the operation of, or close down and cease to operate, the Station (or any apparatus comprised in the Station) forthwith in accordance with the demand of a person authorised by the Secretary of State for the temporary period specified in the demand.**

• It is Ofcom who act on behalf of the Secretary of State on all matter concerning your amateur radio licence.

• **2g.2 Recall that possession of a current Validation Document is necessary for the station to be used.**

• **Do you know what a validation document looks like ?**

• Well you must - as you have to have one to transmit as an M3 !!!

• **Do you know where your current Validation Document is located ?**

• Go and find it now then you will know what it looks like and that you have a current one!!

• You must be aware that you must have a current Validation Document before using your station and by this it means transmitting from your station.

• **9(2) The Licensee shall pay to the Secretary of State before the anniversary date of the Date of Issue in each year, the fee on renewal prescribed by the Regulations for the time being in force under sub-section 2(1) of the Act, and on the payment of the fee the Secretary of State will issue to the Licensee a document in the form of the title page of this Licence (the "Validation Document") which will indicate the next date for renewal.**

• **Current Validation Document**

• Should you let your licence lapse and thus not have a current Validation Document you cannot use your station - anywhere !!!

• **2g.3 Know that if a licence is not renewed, it expires at the end of the day before the anniversary of the date of issue.**

• **9(3) If the Licensee does not pay any fee due and in the manner described in sub-clause 9(2), then the Licence shall expire at the end of the day before the relevant anniversary date of the Date of Issue.**



• **! Your licence if not renewed expires at MIDNIGHT on the day before the anniversary of issue.**

• Think of **the anniversary of issue** as if it were your birthday and if you do not renew by midnight on the day before your birthday you do not get any presents - then may be you will remember when you need to renew your licence.

• **2g.4 Recall that the licence can be revoked by the Secretary of State.**

8(3) For the purposes of sub-section 1(4) of the Act, this Licence may be revoked, or its terms, provisions or limitations varied, by a notice in writing of the Secretary of State served on the Licensee, or by a general notice addressed to all holders of an Amateur Radio Licence (A) or Amateur Radio Licence (B) published in the London, Edinburgh and Belfast Gazettes or broadcast nationally by the British Broadcasting Corporation.

Your amateur radio licence is a privilege that you have / are earning by studying for the written assessments and doing the practicals. Having been successful to obtain a pass certification you may then apply for your licence.

After your licence has been granted the grant of the licence can be revoked.

2g.5 Recall that the full licence conditions are set out in the Terms, Provisions and Limitations Booklet BR68/I.

When you obtained your Foundation Licence you were supplied with a BR68/F. It is hoped that you have read through it all - many don't - but now you have to know that upon being granted an Intermediate Licence you have to be know that the full licence conditions are set out in the **Terms, Provisions and Limitations Booklet BR68/I**.

Note: Not all the terms and conditions are examined and therefore much is not touched upon in this training course but it will be your responsibility to read through ALL the documentation and understand it and apply it as necessary when you operate under an Intermediate Licence callsign.

LICENCE SCHEDULE

2h.1 Be able to apply the schedule to the Intermediate licence. *A copy of the Schedule will be available during the examination.*

Go into the next page you will see **the schedule**.

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Part 2

BR68/I is shown below as at Jan 2004.

A copy of this schedule will be available in the Written exam.

Note: The schedule is from the update in July 2003 and differs from the one in BR68/I of Jan 2002

Print off a copy to have it ready to discuss it with your tutor.

Right click and save images then print them out [Page 1](#) [Page 2](#) [Page 3](#)

LICENCE SCHEDULE

2h.1 Be able to apply the schedule to the Intermediate licence. A copy of the Schedule will be available during the examination.

Some students are still not using the paper work given to them in the exam which is the schedule as shown below. Make sure that you have a working knowledge of how to use the paper work so that if given a frequency or a ranges of frequencies you would be able to find out from the paper work the answer to the question as to say whether you can use the given frequency on a primary, secondary basis, non interference, or what ever it is. The question will not say look this up but when you are given a frequency or a range of frequencies you must then know to look at the paper work and check it out carefully.

Not to be able to answer a question on this section right would also indicate that you have never looked at the BR68/F with your Foundation Licence as you have to know for the Foundation Licence what you can and cannot do by reference to a similar schedule.

The Schedule to Terms, Provisions and Limitations Booklet BR68/I (Amateur Radio (Intermediate) Licence)

1	2	3	4	5	
Frequency Bands in MHz	Status of Allocations in the United Kingdom to: The Amateur Service		Maximum Power level in Watts (dB relative to 1 W) PEP	Mode of Transmission	
0.1357-0.1378	Secondary. Available on the basis of non-interference to other services (inside or outside the United Kingdom)	(not allocated)	1 W (0 dBW) erp	Morse Telephony RTTY Data Facsimile SSTV	
1.810-1.830	Primary. Available on the basis of non-interference to other services (outside the United Kingdom)		50 W (17 dBW)		
1.830-1.850	Primary				
1.850-2.000	Available on the basis of non-interference to other services (inside or outside the United Kingdom)		32 W (15 dBW)		
3.500-3.800	Primary. Shared with other services				
7.000-7.100	Primary	Primary			
10.100-10.150	Secondary	(not allocated)			
14.000-14.250	Primary	Primary			
14.250-14.350		(not allocated)			
18.068-18.168		Primary	50 W (17 dBW)		
21.000-21.450					
24.890-24.990					
28.000-29.700					
50.00-51.00	Primary. Available on the basis of non-interference to other services outside the United Kingdom	(not allocated)			
51.00-52.00	Secondary. Available on the basis of non-interference to other services inside or outside the United Kingdom				
70.00-70.50					
144.0-146.0	Primary	Primary			
430.0-431.0	Secondary	(not allocated)			Morse Telephony RTTY Data Facsimile SSTV
431.0-432.0	Secondary. Not available for use within a 100 km radius of Charing Cross, London (51°30'30"N, 00°07'24"W)		40 W (16 dBW) erp		
432.0- 435.0					

432.0- 435.0	Secondary		50 W (17 dBW)	Facsimile SSTV FSTV
435.0-438.0		Secondary		
438.0-440.0		(not allocated)		

1	2	3	4	5
Frequency Bands in MHz	Status of Allocations in the United Kingdom to The Amateur Service		Maximum Power level in Watts (dB relative to 1 W) PEP	Mode of Transmission
1240-1260	Secondary	(not allocated)	50 W (17 dBW)	Morse Telephony RTTY Data Facsimile SSTV FSTV
1260-1270		Secondary. Earth to space only		
1270-1325		(not allocated)		
2310-2400				
2400-2450	Secondary. Users must accept interference from ISM users	Secondary. Users must accept interference from ISM users		
3400-3475	Secondary	(not allocated)		
5650-5670		Secondary. Earth to space only		
5670-5680		(not allocated)		
5755-5765	Secondary. Users must accept interference from ISM users			
5820-5830				
5830-5850	Secondary. Users must accept interference from ISM users. Space to Earth only			
10000-10125	Secondary	(not allocated)		
10225-10450				
10450-10475		Secondary		
10475-10500				
24000-24050	Primary. Users must accept interference from ISM users	Primary. Users must accept interference from ISM users		
24050-24150	Secondary. May only be used with the written consent of the Secretary of State. Users must accept interference from ISM users	(not allocated)		
24150-24250	Secondary			
47000-47200	Primary	Primary		
75500-76000	Primary (1)	Primary (1)		
142000-144000	Primary (1)	Primary		

142000-144000	Primary (1)	Primary		
248000-250000	Primary	Primary		

ISM = Industrial, Scientific and Medical.

(1) Until 31 December 2006.

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Licensing Conditions

Syllabus sections in blue type face **parts of BR68 to which they relate are in RED bold type face :-**

Note: that a full copy of the leaflet BR68 will be provided in the exam

2b.12 Inspection and close down

Inspection and close down: clauses 8(1), 8(2), 8(4)

8(1) The Licensee shall permit a person authorised by the Secretary of State:

(a) to have access to the Station, and

(b) to inspect the Licence and Log and to inspect the apparatus of the Station at any and all reasonable times (or when, in the opinion of a person authorised by the Secretary of State, an urgent situation exists, at any time) for the purpose of verifying compliance with the terms of the Licence.

8(2) When, in the opinion of a person authorised by the Secretary of State:

(a) the Licensee is in breach of the Licence; and

(b) the breach justifies immediate restriction or close down, the Licensee shall restrict the operation of, or close down and cease to operate, the Station (or any apparatus comprised in the Station) forthwith in accordance with the demand of a person authorised by the Secretary of State for the temporary period specified in the demand.

8(4) For the purposes of sub-section 1(4) of the Act, this Licence may be revoked, or its terms, provisions or limitations varied, by a notice in writing of the Secretary of State served on the Licensee, or by a general notice addressed to all holders of an Amateur Radio Licence (A) or Amateur Radio Licence (B) published in the London, Edinburgh and Belfast Gazettes or broadcast nationally by the British Broadcasting Corporation.

Let's hope that you never have to have an Inspection and close down of your station.

Note that the mention of (A) and (B) licence holders now does not apply with the demise of the morse requirement.

The use of a broadcast nationally by the British Broadcasting Corporation would be in the event of a national emergency and as far as we are aware was last use prior to WWII but the more normal distribution of notices is by publishing them in the London, Edinburgh and Belfast Gazettes, and of course today they would be available on the Internet but that is not a legitimate method of "legal" publication !!

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Bredhurst Receiving and Transmitting Society**Licensing Conditions**

Syllabus sections in blue type face **parts of BR68 to which they relate are in RED bold type face** :-

Note: that a full copy of the leaflet BR68 will be provided in the exam

2b.13 Period of licence and fees due

Period of licence and fees due: clauses 9(1), 9(2), 9(3), 9(4)

9(1) Subject to the payment of the fee in the manner indicated in sub-clause 9(2), this Licence shall continue in force from year to year unless revoked by the Secretary of State.

9(2) The Licensee shall pay to the Secretary of State before the anniversary date of the Date of Issue in each year, the fee on renewal prescribed by the Regulations for the time being in force under sub-section 2(1) of the Act, and on the payment of the fee the Secretary of State will issue to the Licensee a document in the form of the title page of this Licence (the "Validation Document") which will indicate the next date for renewal.

9(3) If the Licensee does not pay the fee in the manner described in sub-clause 9(2), then the Licence shall expire at the end of the day before the relevant anniversary date of the Date of Issue.

9(4) The Licensee shall surrender the Validation Document to the Secretary of State forthwith upon the revocation of the Licence. The Secretary of State reserves the right to publish the name and callsign of the Licensee if the Licence is revoked.

Quite straight forward all off these points and much has been seen in the FLC / ILC.

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Syllabus sections in blue type face **parts of BR68 to which they relate are in RED bold type face** :-

Note: that a full copy of the leaflet BR68 will be provided in the exam

2b.14 Operation (in the UK) by CEPT amateurs

Operation (in the UK) by CEPT amateurs: clauses 10(1), 10(2), 10(3), 10(4), 10(5) except 10(5) (b)

Let's be reminded of what CEPT stands for :-

European Conference of Postal and Telecommunications Administrations which was established in 1959 by 19 countries

10 The following additional provisions apply to licensed non-resident amateurs temporarily visiting and operating wireless telegraphy apparatus in the United Kingdom in accordance with CEPT Recommendation T/R 61-01, as enabled by statutory instrument ("CEPT Amateurs") unless the individual is a disqualified person as defined in sub-clause 2(9) of the Booklet.

Requirements for CEPT operation in the UK

10(1) CEPT Amateurs may operate in the United Kingdom under a CEPT equivalent licence which is:

(a) valid and in force;

(b) not temporary; and

(c) issued by an administration which

(i) has implemented CEPT Recommendation T/R 61-01, and

(ii) permits persons licensed to use amateur stations under section 1 of the Act to use such stations in its territory (with or without conditions) without making application in that behalf.

Format of call sign including secondary location identifiers

10(2) CEPT Amateurs shall transmit their home callsign after:

(a) the United Kingdom callsign prefix "M";

(b) followed by the appropriate Regional Secondary Locator (if any); and

(c) followed by the symbol "/"

[for guidance see note (w) to this Booklet].

10(3) Subject to this clause 10, CEPT Amateurs shall comply with:

(a) the terms of their CEPT equivalent licence, unless such compliance would result in a breach of the requirements of the United Kingdom;

(b) this Terms, Provisions and Limitations Booklet BR68 (insofar as its terms and limitations may reasonably be applied); and

(c) the relevant provisions of CEPT Recommendation T/R 61-01.

10(4) CEPT Amateurs who possess the equivalent of a CEPT Class 2 licence shall use only those frequencies above 30 MHz specified in the first column of the Schedule.

10(5) CEPT Amateurs shall operate only:

(a) a mobile or a portable station (which includes a station powered from the mains electricity at a temporary fixed location such as an hotel);

Much of this you may think that you have read some where before. In fact it is much the same as for a UK licence holder operating abroad.

However it tells you in more details how the foreign station may operate.

Why do you need to know ? - well it is in case you are entertaining the licence holder and you can then help to ensure that the visitor operate properly.

It is a matter of going through the sections in red and making certain that you are familiar with the requirements remembering that you do not have to learn BR68 as you will be given a copy for the exam.

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Advanced
Radio Amateur
Licence Exam

Mock Written assessment

Bredhurst Receiving and Transmitting Society

This section is under construction but to help students the questions as written are submitted to the web, there may be errors !!

Time allowed for the paper of 62 questions with 2 hours to do it in.

A copy of BR68 will be available during the "real" examination so make sure that you have a copy when you sit the mock exam.

Q1 The station G4VSZ/MM is heard on 20MHz. The station is

- A** ☐ located in Scotland
- B** ☐ located on the Isle of Man
- C** ☐ A special event station
- D** ☐ located on tidal waters

Q2 The term "User Service" does not include which of the following:-

- A** ☐ St Peter's ambulance service
- B** ☐ St John ambulance service
- C** ☐ St Andrew's ambulance service
- D** ☐ St Michael's ambulance service

Q3 If you are away from your home who may operate your station using your callsign?

- A** ☐ Any holder of a Full amateur radio licence.
- B** ☐ Nobody.
- C** ☐ A member of the user services.
- D** ☐ A representative of the Secretary of State.

Q4 When in international waters what frequencies may you use as a Full licence holder?

- A** ☐ The frequencies as in BR68
- B** ☐ Only CW portions of the bands.
- C** ☐ Only SSB portions of the bands.
- D** ☐ Those frequencies appropriate to the ITU area you are located.

Q5 The operation by a Full licence holder of their station in International relief is

- A** ☐ a requirement in countries who have implement CEPT recommendations
- B** ☐ Not permitted outside UK
- C** ☐ only permitted on HF bands
- D** ☐ only permitted on VHF bands

Q6 When may pecuniary interest occur in messages sent over amateur radio

- A** ☐ To advertise items for sale
- B** ☐ To ensure that times and dates of religious service are known.
- C** ☐ To ensure that dates and times of non-profit making organisations are known
- D** ☐ To bring local news to the area.

Q7 On which frequency may a beacon be operated for direction finding competitions

- A[☐] 1.8MHz
 - B[☐] 1.93MHz
 - C[☐] 1.96MHz
 - D[☐] 1.968MHz
-

Q8 If your licence is revoked how long do you have to keep your log book showing the last entry?

- A[☐] 6 months.
 - B[☐] 12 months.
 - C[☐] 24 months.
 - D[☐] You do not have to keep the log.
-

Q9 How much of the mean power of a transmission may fall outside the frequency band.

- A[☐] None.
 - B[☐] 5%
 - C[☐] 2%
 - D[☐] 1%
-

Q10 Which column of the schedule specifies the frequency bands ?

- A[☐] 4
 - B[☐] 3
 - C[☐] 2
 - D[☐] 1
-

Q11 When is potential difference and EMF of a battery the same value ?

- A[☐] All the time
 - B[☐] When the battery is not connected into a circuit
 - C[☐] When the battery is connected into a circuit
 - D[☐] When the current flow is at a maximum for the circuit.
-

Q12 Which of the following is not a dielectric ?

- A[☐] Air
 - B[☐] Mica
 - C[☐] Copper
 - D[☐] Polyester
-

Q13 What is the total value of the inductance of coils connected in series having individual values of 1uH 2uH and 4uH ?

- A[] 1uH
- B[] 7uH
- C[] 8uH
- D[] 3.5uH

Q14 How many degrees represents a full cycle of a sine wave ?

- A[] 0°
- B[] 90°
- C[] 180°
- D[] 360°

Q15 In an AC circuit the current differs from the potential difference by how many degree in an inductor?

- A[] 90° lag
- B[] 90° lead
- C[] 180° lag
- D[] 180° lead

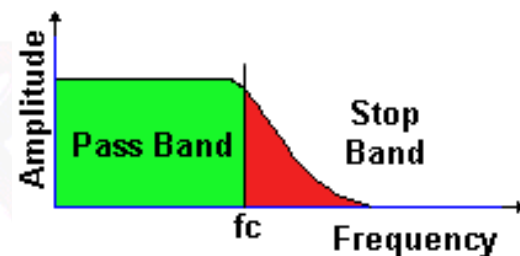
Q16 At resonance ?

- A[] Capacitive reactance equals zero.
- B[] Capacitive reactance equals Inductive Reactance.
- C[] Inductive reactance equals zero .
- D[] Resistance equals zero.

Q17 Mutual inductance is the ability to?

- A[] cause a current to flow in a second coil due to the presence of an DC source in the first coil.
- B[] cause a current to flow in a second coil due to the presence of an AC source in the first coil.
- C[] cause a current to flow in a second coil due to the presence of an AC or DC source in the first coil.

Q18



The diagram above shows a response curve of a ?

D ☐ stop a current to flow in a second coil due to the presence of an AC source in the first coil.

A ☐ A notch filter

B ☐ Band pass filter

C ☐ High pass filter

D ☐ Low Pass filter

Q19 Components with a negative temperature coefficient will ?

A ☐ reduce in value.

B ☐ increase in value.

C ☐ stay at the same value as when manufactured.

D ☐ stay at the same value as when inserted in the circuit.

Q20 Semiconductors have a junction which form between what types of materials ?

A ☐ b - e

B ☐ p - n

C ☐ e - c

D ☐ g - s

Q21 A transistor configuration of common emitter is so called as?

A ☐ the signal flows from the emitter.

B ☐ the signal is connected to the collector.

C ☐ The resistor in the collector is also common to the emitter

D ☐ the emitter is common to both the input and output.

Q22 Half wave rectification uses ?

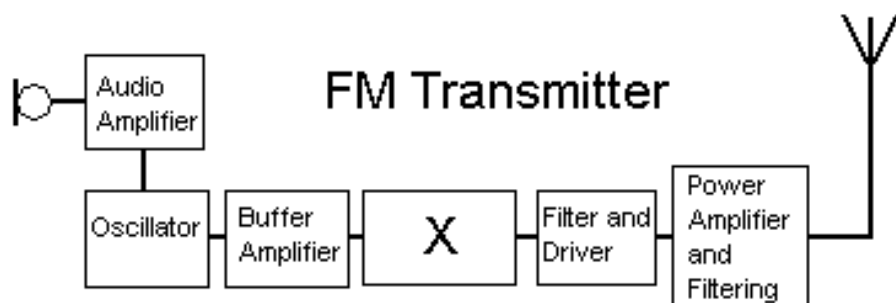
A ☐ 4 diodes

B ☐ 3 diodes

C ☐ 2 diodes

D ☐ 1 diode

Q23 The box marked "X" in the FM transmitter is the



- A[] frequency multiplier.
- B[] frequency deviation control.
- C[] carrier frequency generator.
- D[] AM filter to produce FM.

Q24 How in mixers do unwanted frequencies occur

- A[] due to harmonics of the wanted frequency.
- B[] when a crystal oscillator is not used.
- C[] when a side band filter is used.
- D[] only when using FM

Q25 What is depth of modulation ?

- A[] A measure of how near the modulation reach the zero point on the carrier wave.
- B[] A measure of the modulation from maximum to minimum.
- C[] A measure of the modulation from carrier peak to modulation peak.
- D[] A measure of the modulation from carrier peak to modulation minimum.

Q26 Certain modulation requires linear amplification, which?

- A[] AM
- B[] SSB
- C[] FM
- D[] AM & SSB

Q27 When "chirp" occurs in a CW transmitter the best course of action to reduce it is ?

- A** ☐ Use a better key click filter.
 - B** ☐ Use a chirp filter.
 - C** ☐ Improve the voltage stabilization in the keying stage.
 - D** ☐ Improve the voltage stabilization in the oscillator stage.
-

Q29 If a frequency synthesised transmitter is not producing the intended output frequency what can be done ?

- A** ☐ Proper voltage regulation to the synthesizer.
- B** ☐ Use a band pass filter.
- C** ☐ Use an out of lock inhibitor.
- D** ☐ Reduce the voltage to the transmitter.

Q28 Parasitic oscillation can be prevented by ?

- A** ☐ Proper use of decoupling.
 - B** ☐ Proper use of filters.
 - C** ☐ Proper use of screening.
 - D** ☐ Proper use of the correct sized connecting wire between parts of the transmitter.
-

Q30 What does 60dB bandwidth mean?

- A** ☐ All signals will be boosted by 60dB.
- B** ☐ The signal will be poorly received at the receiver due to poor selectivity.
- C** ☐ A 1kHz signal will be attenuated by 60dB.
- D** ☐ The signal will be well received at the receiver due to good selectivity.

Q31 What is the function of the Intermediate Frequency Amplifier ?

- A** ☐ It generates an RF signal for use by the mixer
- B** ☐ It provides a constant level of signal in the system so that the audio remains about the same level irrespective of the signal strength
- C** ☐ It provides the main amplification and includes filters, which removes adjacent signals and wrong mixing products
- D** ☐ It recovers the modulating audio signal

Q32 What is the operation of the R. F. amplifier

- A** ☐ It acts like a filter so that only the wanted frequency is passed through.
- B** ☐ It removes the sideband.
- C** ☐ It acts as a link coupling from your aerial to the first stage of the receiver.
- D** ☐ Increase the RF power of the input signal from a few micro watts to say milli watts

Q33 In a super heterodyne receiver the function of the first mixer is to

- A** ☐ mix a local oscillator with the RF signal and give you an IF output
- B** ☐ provide the replacement of the carrier frequency in a SSB signal
- C** ☐ convert the RF to audio signals
- D** ☐ select the chosen frequency on the dial of your receiver

Q34 How is the voltage coming from the detector stage related to signal strength

- A** ☐ RMS of the RF.
- B** ☐ 50% of the signal strength.
- C** ☐ Directly.
- D** ☐ 0.707 of the signal strength.

Q35 The purpose of a down converter is to

- A** ☐ allow reception of one frequency on another band
- B** ☐ allow reception and transmission of one frequency on another band
- C** ☐ allow transmission of one frequency on another band
- D** ☐ reduce the audio frequency of the input to the microphone so that it is more intelligible.
-

Q36

- A** ☐
- B** ☐
- C** ☐
- D** ☐
-

Q37

- A** ☐
- B** ☐
- C** ☐
- D** ☐
-

Q38

- A** ☐
- B** ☐
- C** ☐
- D** ☐
-

Q39

- A** ☐
- B** ☐
- C** ☐
- D** ☐
-

Q40

- A** ☐
- B** ☐
- C** ☐
- D** ☐
-

Q41

A[☐]

B[☐]

C[☐]

D[☐]

Q42

A[☐]

B[☐]

C[☐]

D[☐]

Q43

A[☐]

B[☐]

C[☐]

D[☐]

Q44

A[☐]

B[☐]

C[☐]

D[☐]

Q45

A[☐]

B[☐]

C[☐]

D[☐]

Q46

A[☐]

B[☐]

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Q47

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Application for Amateur Radio (Full) Licence and Club

Please refer to the notes overleaf and complete in dark ink in BLOCK CAPITALS

Details of applicant

Name

Title____Initials____Surname _____

Mailing address

Telephone (Please include dialling code)

Postcode _____

Date of birth

Home _____ Work _____

Main station address

(if different from mailing address)

Postcode _____

Current/Previous Licence details (if applicable)

Type of Licence required

☐ Full ☐ Club

Call sign (if held)

If you are applying on behalf of a club, give the club's previous call sign not your own

☐☐☐☐☐☐☐☐

Date of issue

Qualifications (tick those that apply)

(Please send originals as photocopies are not acceptable)

- ☐ Pass in the City & Guilds RAE
- ☐ RSGB Advanced Examination Certificate
(if current Intermediate Licensee)
- ☐ RSGB Intermediate and Advanced Certificate
(if current Foundation Licensee)
- ☐ Foundation, Intermediate and Advanced Examination
Certificates (if not a holder of an Amateur Radio Licence)

Club details

If this application is on behalf of a club please give:

Club name

Licence holder's call sign

☐☐☐☐☐☐☐☐

Call sign

If you would like to request a particular call sign, please provide details below. If you do not want to request a call sign you will be automatically allocated one by the system. (see notes overleaf).

Call sign

☐☐☐☐☐☐☐☐

Call books

Do you wish your name and address to be published? (see notes overleaf)

☐ Yes ☐ No

Renewal payments

In future I wish to pay my renewal fee by:
(see notes overleaf) If you select to pay by Direct Debit a bank payment instruction will be sent to you.

- ☐ Direct debit
- ☐ Cheque/postal order/credit card/debit card

Declaration

If you provide false information you may invalidate your application and be liable for prosecution.

I certify that the information I have given is correct to the best of my knowledge.

Name _____ Signed (Applicant) _____ Date _____

If you are under 18 years of age the signature of your parent or guardian is required

Signed (Parent or Guardian) _____ Date _____

Notes

Conditions

Under the Wireless Telegraphy Act 1949 a licence issued by Ofcom is required before any person may establish or use any station for wireless telegraphy or install or use any apparatus for wireless telegraphy in the UK and UK territorial waters.

To be eligible for an Amateur Radio Licence you must:

- Have passed the City & Guilds Radio Amateurs' Examination (RAE)
- Pass in RSGB Advanced Exam

Club licence application

For a club licence:

- a) the name shown on the application form (at 1) should be that of the officer who will be responsible for the station (the Licence Holder).
- b) the club must have a minimum of three suitability licensed members.
- c) the Chairman, Secretary and Treasurer (or similar officers) of the club must be listed and identified.
- d) the Main Station Address, given overleaf, should be the normal operating address of the club excluding the club title.
- e) when applying for a Club licence you must enclose a list of names and call signs of licensed club members. If the club has a large membership, enclose the name and call signs of ten licensed members.

Publication of name and mailing address

Ofcom permits publication of your name and mailing address in a call book, if you have consented by ticking the appropriate box.

If you have not consented, only your call sign will be published. If this call book is compiled, stored and published by a third party, either in written form or by "read only" computer disks, it will be made clear to the third party that the information will be disclosed to it for the publication of a call book and for no other purpose.

Renewal payments

Please note that Licences are free to the under 21's and to those aged 75 years or older. If you are under 21 or 75 and over at the time of renewal, you only need to sign and return the Remittance Advice Note to indicate that you wish to continue

How to pay

Please enclose a cheque or Postal Order for the fee valid at the time of application made payable to Radio Licensing Centre and crossed "A/C Payee". Please print your name and customer reference number if applicable, on the reverse of your cheque or postal order. Do not send cash. If you wish to pay by credit/debit card please provide the following details:

Please do not send cash. If you wish to pay by credit/debit card please provide the following details:

Type	<input type="text"/>
Card number	<input type="text"/>
Expiry	<input type="text"/>
Card holder	<input type="text"/>
Issue Date of No. (If applicable)	<input type="text"/>
Signature	<input type="text"/>

The following cards are currently accepted: Mastercard, Visa, Switch/Maestro, Visa Delta.

Please do not send your card.

Future renewal payments

For future renewals you have an option of automatic payment made by Direct Debit Instruction with your bank or building society. Paying by Direct Debit means you will not have to amend your instruction whenever there is a change in the licence fee. If you wish to pay by this method please tick the appropriate box on the form.

Foreign Applications

Please enclose a Eurocheque for the valid fee in Sterling made payable to Radio Licensing Centre and crossed "A/C Payee".

Where to send this application

The completed form should be sent to:

Radio Licensing Centre

PO Box 884, Bristol BS99 5LF

Please ensure you enclose:

- Licence fee (see "How to pay" above),
- City & Guilds RAE Record of Achievements or RAE Certificate
- Pass in RSGB Advanced Examination.
(Originals only, photocopies are not acceptable) which will be returned to you.
- the information requested in Club Licence Applications.

Please allow 14 days from posting your application for receipt of your licence.

Helpline

If you have any enquiries regarding your application please contact the Radio Licensing Centre **(0117) 925 8333**.

Our lines are open from 9.00am - 5.00pm Monday - Friday. An answerphone service is available outside office hours. Minicom number **(0117) 921 8393**.

email: radio.licensingcentre@royalmail.com

Website: radiolicensingcentre.co.uk

Fax: **0117 921 8444**

Requesting a call sign

If you would like to request a particular call sign in the current series of call signs, you may do so at the call sign section overleaf. To avoid the disappointment of the call sign you requested not being available you can list a number of call signs in order of preference either on the application form or a separate sheet of paper. Before filling this in, you should telephone RLC to check that the call sign is available. The call sign will only be issued to you once your full application is received by them and call signs are issued on a "first come first served" basis. Please note that if you previously held a call sign, this will be re-issued to you and you will not be able to request another call sign.

For official use only

Call sign	<input type="text"/>
Date issued	<input type="text"/>
Type of licence	<input type="text"/>
Customer reference number	<input type="text"/>
Officer's signature	<input type="text"/>