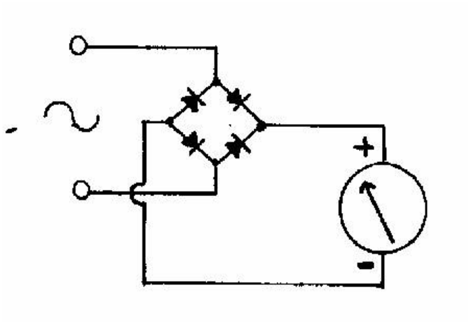
MEASUREMENTS

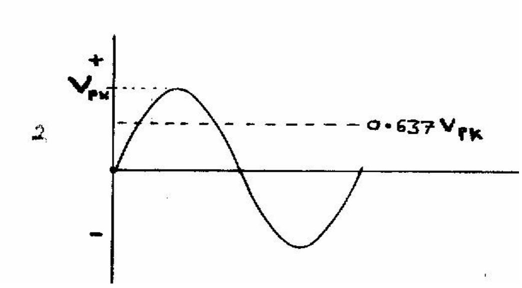
A previous lesson described the moving coil meter. However, such a meter can only be used for direct current or voltages.

LOW FREQUENCIES -Mains or audio

If alternating current passes through the coil of a moving coil meter, the pointer move in one direction during the positive half cycles and in the opposite direction during the negative half cycles.
At other than very low frequencies,(1 or 2Hz) the pointer will be unable to follow the waveform and will just vibrate around the zero mark. Thus it will still read zero when a AC signal is measured...not much use!



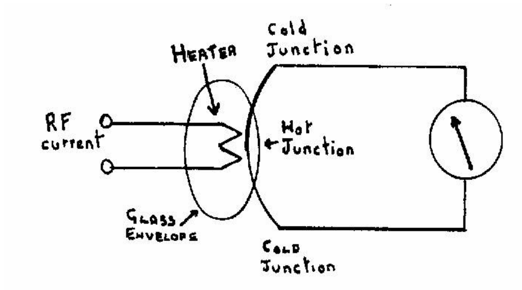
To overcome this problem the current is rectified *before* it passes through the meter coil.
Many meters use a metal oxide full wave bridge rectifier.



Such a meter will the average of the waveform. (In the case of a sinewave this is 0.637 of the peak Voltage (or current).
Meters are usually recalibrated for RMS reading, but this will only be true for sinewave signals.
The usual shunts & multipliers are then added to give various AC ranges.

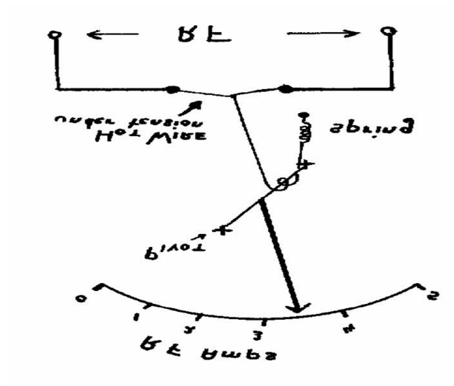
RADIO FREQUENCIES

The diode bridge used to rectify low frequencies would cause problems at higher frequencies. It would have too much "self capacitance". This can be reduced by using special low capacitance diodes.
However, it is better to use one of the following meters that are inherently independent of frequency.



THE THERMO-COUPLE METER

This type of meter uses the fact that a small voltage is generated when two different metals are joined together.
The voltage generated is proportional to the temperature at the joint (or junction).
The Radio Frequency (RF) current to be measured is passed through a heater wire that is close to one junction. When the RF current passes through this heater wire the junction will become warmed.
This will generate a small voltage at the junction.
This voltage will be DC and can therefore be measured using a sensitive moving coil meter
The thermo-couple meter is slow to react but will indicate RMS values, whatever the waveform.

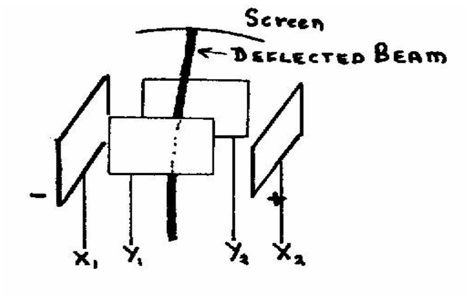


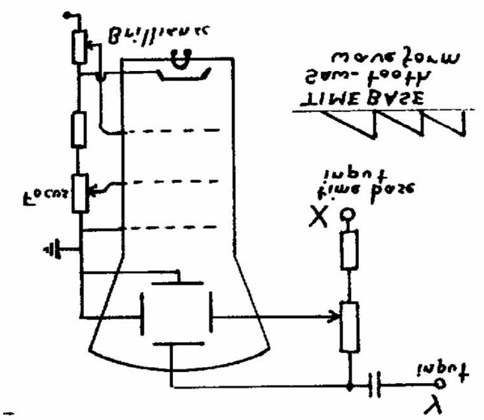
THE HOT WIRE AMMETER

The RF current is passed through a wire that is suspended between two fixed points. The current warms up the wire and causes it to expand.
This expansion is used to mechanically move the pointer of a meter. The wire is kept under tension by a little spring
This type of meter, as it relies on the heating effect, will indicate RMS that is independent of frequency.

OSCILLOSCOPES – to "look at" waveforms

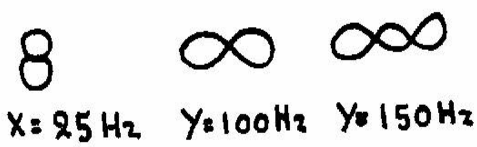
The Cathode Ray Oscilloscope (CRO or "scope") is similar to a thermionic valve.[Lesson12A]
In the CRT the stream of electrons is focused (by focus anode)into a narrow beam that strikes a phosphor coated screen.
The point on the screen "hit" by these electrons gives off light!
Electrons are negative charges and hence they can be deflected if they pass through an electric field. The electric field is set up between the deflection plates. If one of the deflection plates is made positive then the beam will be bent towards that plate.
By fitting two pairs of plates at right angles to eachother it is possible to deflect the beam in both horizontal and vertical directions.
The plates that deflect the beam vertically are called the "Y" plates.
The plates that deflect the beam horizontally are called the "X" plates.
It is usual to connect a timebase sawtooth waveform to the X plates. This is a waveshape that uniformly increases the voltage.
This sweeps the beam at a constant speed across the screen from left to right. The voltage then rapidly reduces to zero . sending the beam quickly back to the start.
This will result in a straight line being traced across the screen.





If the signal to be observed is applied to the Y plates, the beam will trace out its waveform as the time-base moves the beam across the screen.
If the time-base is at the same frequency as the input signal then one whole cycle will be displayed on the screen.

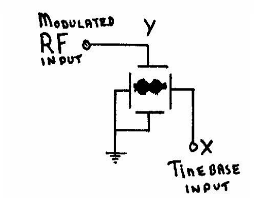
The CRO can be used for frequency comparison by applying a known sinewave freq to the X plates (instead of the time-base) and the other freq to the Y plates. If both frequencies are the same then the display will be a circle.
If one frequency is twice the other a "figure of eight" will be traced out on the screen.

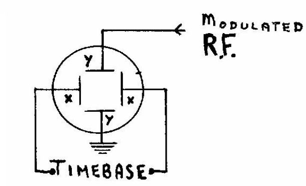


This technique is only of use if the unknown freq is multiple or sub-multiple of the known frequency.
(freq = frequency)

DEPTH OF MODULATION

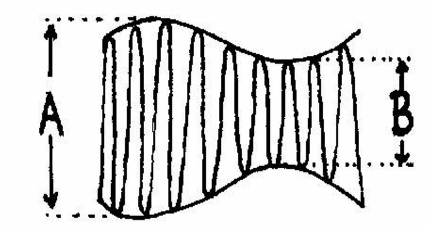
To measure Modulation Depth
Modulate the transmitter with a sinewave.
Connect the transmitter to a suitable dummy load and connect the CRO Y plates across it



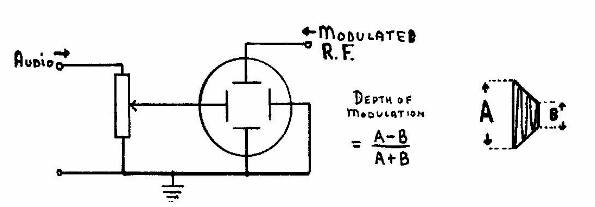


Modulation depth: Method 1

Apply the CRO's own timebase to its X plates.
The modulation envelope will be displayed. This shows a high frequency carrier wave whose amplitude follows the shape of the modulating signal.
This example shows the envelope when a sine-wave voltage is applied to the mike input.
The maximum (A) and the minimum (B) dimensions are them measured.
The CRO display does not need to be calibrated as it is just the ratio of A and B that is used in the depth of modulation calculation.



$$\text{Depth of modulation} = \frac{A-B}{A+B}$$

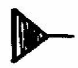


Modulation Depth: Method 2
The time-base is disconnected from the X plates of the CRO and replaced by a proportion of the audio modulating signal.

This will give a trapezium display on the CRO screen.
The formula is the same as before.
Trapezium Examples

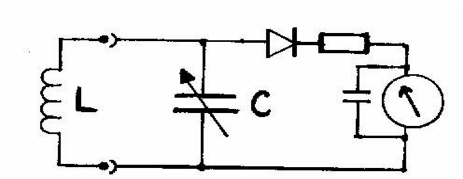
50% modulation

100% modulation



Over-modulation

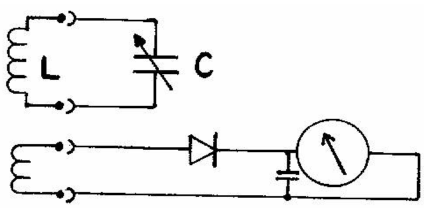
ABSORPTION WAVEMETER
An absorption wavemeter is a very simple device. The circuit is very similar to a crystal set. The earphone, however, is replaced with the meter.



Cct 1

Circuit 1 This has the disadvantage that the tuned circuit (L & C) would have a low Q as they are damped by the diode and meter circuit.

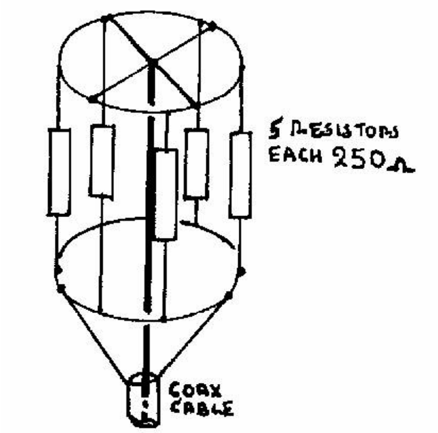
Circuit 2 This circuit overcomes this problem by having a second coil to couple the signal into the meter circuit. The coils act like a step down transformer and matches the high impedance L & C to the low impedance meter circuit.



Cct 2

The wavemeter is usually supplied with several plug-in coils so that a wide range of frequencies are covered.
The dial, fitted to the tuning capacitor, may have all the ranges marked directly or, simply, a 0 to 100 logging scale. the latter would then be used inconjunction with a set of calibration charts or graphs.
A frequency meter of this simple type would often cover 1MHz to 100MHz in several ranges. It would therefore, have several "plug-in" coils.
An absorption wavemeter gives a low accuracy measurement of frequency. However, it is simple to make and use, and it is adequate to ensure that a transmitter is selecting the correct oscillator harmonic.
It is often used when adjusting a transmitter by ensuring that the correct harmonic or mixing product, is selected at each stage.

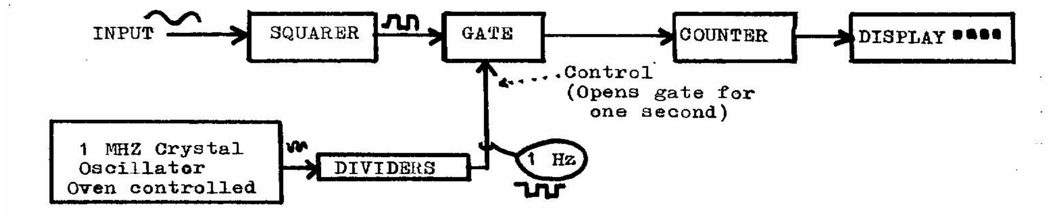
DUMMY LOADS
When setting up (tuning up) or testing a transmitter, it is important that minimum interference is caused to other stations. Thus most of this work should be done with the transmitter not connected to the aerial. But it must not just be disconnected.. The power must be suitably absorbed.
A dummy load is fitted in place of the aerial to absorb the transmitted RF power. The dummy load must be of an impedance to match the transmitter output; usually 50 or 75 Ohms. It should also be completely screened so that no RF power is radiated.



Many transmitters have a RF power output of up to 100W.Thus a dummy load is typically a 50 Ohm resistor capable of handling 100W. Such a resistor is not easily obtainable. A wire-wound resistance is not suitable as it would act like an inductor. In practise it is usual to construct a 50 Ohm dummy load from ten 500 Ohm carbon resistors connected in parallel. Connected in this way each resistor needs only be rated at ten watts.

It is possible to use resistors rated at lower values if they are
immersed in insulating oil.

DIGITAL FREQUENCY METER (DFM)



In this DFM it will be seen that the counter actually counts the number of cycles (of the frequency to be measured) that reach it during the time that the gate is open. (In this case - 1 second)

It is not practical to make a 1Hz oscillator (to control the gate). Therefore, this low frequency is obtained by a crystal oscillator running at a much higher frequency, say 1MHz.
The 1MHz is then passed though a series of "divide by ten circuits". The various ranges of a frequency counter are obtained by selecting (by a switch on the front panel) a different number of divider circuits. Thus the gate could be open for:10 seconds; 1 sec; 0.1sec etc
If the gate is open for 0.1 sec and the display shows 456 then the actual frequency would be 4.56 kHz.

Digital frequency counters can be very accurate. But they are only as accurate as the crystal controlled oscillator! It is very important that its fre quency does not drift. This part of the circuit is usually enclosed in a temperature controlled compartment. DFMs have to be used with care to avoid misleading results.
If the input signal is too low then it will insufficient to trigger the squarer circuit and it will not count or (worse still) give a low count.
If, however, the input is too high the signal may overload the input circuit and the DFM may display the frequency of a harmonic.
A DFM could be used for checking:-

- Oscillator (VFO or crystal)
- Freq output of each stage
- Frequency of the final output of a transmitter, but not if the transmission is SSB or deeply modulated AM.

A frequency counter should **not** be used to check that a transmitter is using the correct multiplication factor! This should first be done with a simple absorption wavemeter.

Before answering the following questions, please read the section in the RAE Manual covering "measurements".

36/1 A thermo –couple meter depends, for its operation, on:
a) the junction between a conductor and an insulator
b) b) two dissimilar metal junctions, both hot.
c) two dissimilar metal junctions, both cold
d) d) two dissimilar metal junctions, one hot and one cold.

37/2 Which of the following is *incorrect* ?
a) $W = I^2R$ b) $W = V^2/R$ c) $W = V^2 \times I$ d) $R = V/I$

38/3 An oscilloscope beam can be deflected by
a) rotations of the tube b) change in weight of the electrons
c) electrostatic or magnetic field d) giroscopic rotations

39/4 If a sky-wave arrives at a receiver aerial at the same time as the ground-wave but is *out of phase*. This results in
a) modulation distortion b) fading of the received signal
c) and overloaded RF stage d) increased amplitude of the modulation

40/5 Normal test meters can not be used at radio frequencies because
a) multipliers are not accurate b) meter movement is not robust
c) diode inductance is too small d) diode capacitance too great

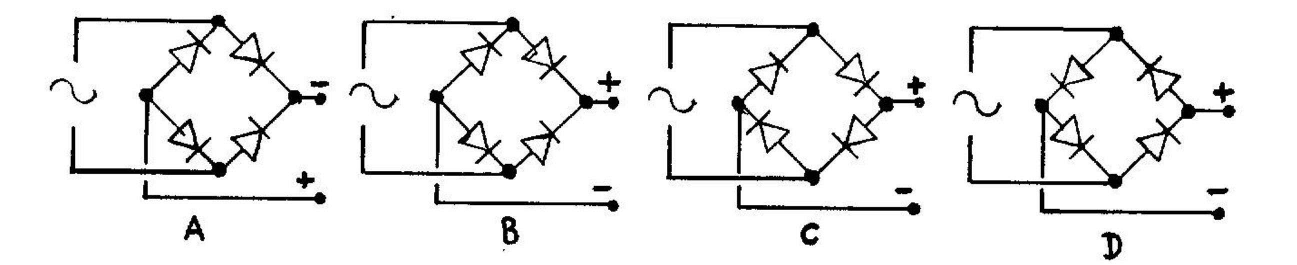
41/6 A digital frequency meter can be used to
a) measure frequency of received signal b) determine presence of harmonics
c) measure VFO frequency d) measure power from FM transmitter

42/7 The relationship between the maximum permitted height of an Amateur aerial or mast and its distance from at airfield is
a) 1.0km and 15 metres b) 5 miles and 200 Metres
c) 1.0 miles and 75ft d) ¼ mile and 60ft

43/8 The hot wire ammeter is used to measure radio frequencies because
a) it is fast acting b) it is independent of frequency
c) it is independent of current d) it can indicate power loss factor

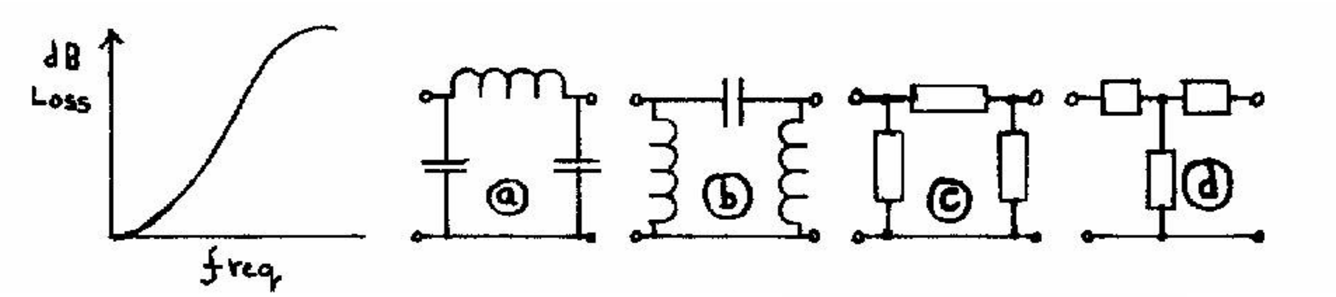
44/9 What is a BALUN?
a) a device to remove SSB carrier b) a matching device
c) non-linear resistor d) a matching device

45/10 Which of these *bridge rectifier circuits* is incorrect ?

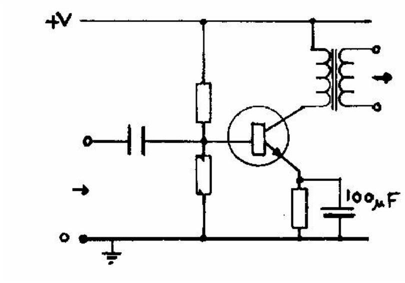


46/11 An amateur licence can be revoked by
a) verbal request by police b) written request by planning officer
c) by general broadcast by the BBC d) automatically at breakout of war

47/12 Which circuit would give this response?



48/13 What type of amplifier is this:



a) RF
b) IF
c) AF
d) VHF

49/14 Which of the following “Q codes” means *please change frequency.*
a) QSK b) QSX c) QRX d) QSY

