LESSON 2.

Resistors

Most resistors, that you will come across, are made from carbon. The resistance of the carbon is ' controlled ' during manufacture. In the early days, resistors were made from solid rods of carbon. Nowadays, most resistors comprise a film of carbon or metal oxide over the surface of the non conducting rod. The resistance is dictated by the resistance and thickness of the coating or film.

The value of a resistor is usually dictated by a colour code :
Black = 0, Brown = 1, Red = 2, Orange = 3, Yellow = 4, Green = 5, Blue = 6, Violet = 7, Grey = 8, White = 9.
The colour of the first ring indicates the first digit. The second ring gives the second digit. The third ring gives the number of Zero's. The fourth ring if any, gives the tolerance. (Brown = 1%, Red = 2%, Gold = 5%, Silver = 10%, No Colour = 25%)

The Wattage of a resistor is determined by its physical size and type of construction. Carbon and metal oxide resistors are made in the following power ratings:

    1/8 (0.125) Watt,   1/4 (0.250) Watt,   1/2 (0.500) Watt,   1 (1.00) Watt.

Higher wattage resistors are usually made from wire. The wire is wound on an insulating rod and often covered in vitreous enamel. (1W & 3W). For higher wattage's ceramic resistors are used. The resistance wire is wound on a fibreglass core and protected by a ceramic outer body (4W, 7W, 11W, 17W) such resistors are designed to get very hot. Therefore, care should be taken to avoid damage to other components and your fingers

EVEN HOTTER................

If an even higher power rating is required then several resistors may be connected in parallel. Ten 5 Watt resistors connected in parallel would give a total power rating of 50 Watts. The resulting resistance will, of course, be a tenth of the individual resistors.

DUMMY LOADS

When testing a transmitter the aerial is often replaced by a dummy load. This is designed to ' match ' the output of the transmitter and be capable of absorbing its full power output. The object is to enable the transmitter to be tested or aligned under normal operating conditions with out actually radiating a signal. The resistors are therefore screened by fitting them all into a metal can. In order that the heat is efficiently dissipated, It is usual to immerse the resistors in oil. The oil will conduct the heat but not electricity. It is important to provide a small breathing hole in the can to prevent the build up of pressure as the temperature rises.

Coaxial plug
Screening
Each resistor 500 ohm, 5Watt (only 4 of 10 resistors shown)
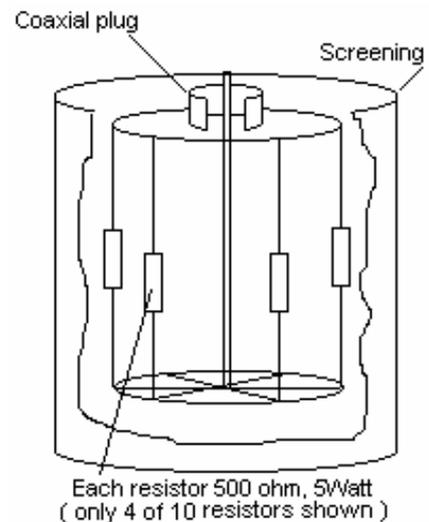
The 50 Ohm dummy load shown here, Has ten resistors connected in parallel. Each resistor is 500 Ohm and is rated at 5 Watts. It would Handle 50 Watts continuously and 500 Watts for short periods.

VARIABLE RESISTORS

It is often necessary to be able to make adjustments to working circuits. This could be done by changing the resistors until the right conditions are met, A more practical solution is the variable resistor (strictly speaking this is a two terminal device).
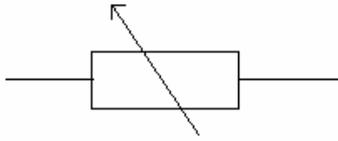
This symbol represents a variable resistor that is adjusted by a knob on the front panel. I.E. This component is adjusted during the normal operation of the equipment

This symbol represents a variable resistor that it mounted within the equipment, Usually on the printed circuit board. It is adjusted by a screwdriver when the equipment is being aligned or maintained.
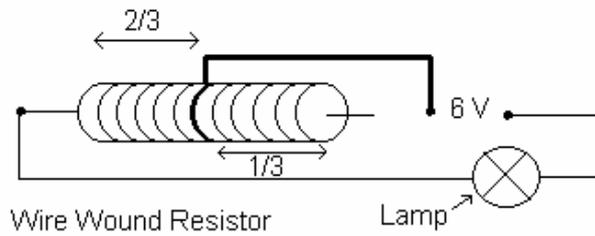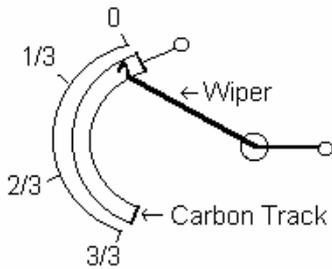
If the total resistance of the carbon track is 30 KΩ then the resistance between the wiper and the top connection would be 10 kΩ. If The wiper is moved to the top and then the bottom the resistance would be 0 Ohms (Short circuit) and 30 KΩ respectively.

The 10 Ωwire wound resistor is shown set to about 6Ω and connected in series with a 6 volt supply and a dial lamp. The circuit would allow the lamp to be set to the required brightness by adjusting the variable resistor.

POTENTIOMETERS

If connections are made to the wiper and both ends of the variable resistor, It is then called a potentiometer (Pot)
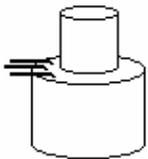
The potentiometer on the left would be fitted on the front panel and operated by the user of the equipment. The one on the right would be mounted on the printed circuit board and is known as a pre-set (during alignment) control.
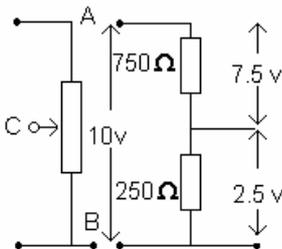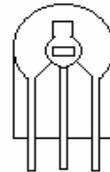
As an example 10 volts is connected across a 1000 Ohm potentiometer. (A & B) The voltage between B & C will be proportional to the position of the wiper. If it is one quarter round the track, starting from the bottom, then potential difference between B & C will be 10 x 1/4 = 2.5 V. An equivalent potential divider could be made with two fixed resistors.
You will note that the voltage across the 750 Ohm section, plus the voltage across the 250 Ohm section, will equal the input voltage.
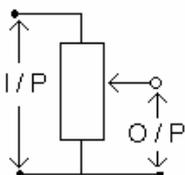
I am sure that you use a potentiometer many times each day....... Think of the volume control on your radio. The sound will be loudest when the wiper is at the top and quietest when it's at the bottom. By convention, the pots are wired so that turning clockwise, moving up or to the right will increase the output.

THE INTERNAL RESISTANCE OF A SUPPLY

In a simple circuit comprising a cell and a resistor the current flowing would be the voltage divided by the resistance. However, in practice, the voltage at the terminal of the cell would drop a little when the current is flowing

The cell, although producing the voltage, is not a perfect conductor, and there will be a volt drop across its own *internal resistance*. In calculations where the internal resistance is known, it is considered to be in series with the cell or other source of voltage.
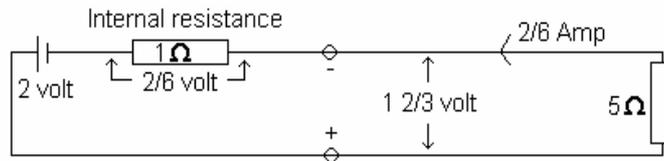
For Example, a 2 volt lead acid cell is connected across a 5 Ohm resistor. The cell has an internal resistance of one Ohm.
What current will flow and what will the voltage of the cell be when supplying this current ?

The total resistance of the circuit is 5 + 1 = 6 Ohms.

Current is Volts divided by resistance = 2/6 = 0.33 amps.

The voltage dropped across the internal resistance of the cell is 2/6 X 1 ($V = IR$) = 2 / 6 volts.

Thus the actual voltage at the terminals of the cell will be 2 - (2/6) = 1 4/6 = 1 2/3 = 1.66 volts.

In the dry cell the internal resistance is quite large and this prevents high currents being drawn from such cells. However the internal resistance of the lead acid secondary cells is very low thus allowing very considerable currents to flow. Generators also have internal resistance - the resistance of the wire in their windings.

Magnetism

A freely suspended magnet will align itself with the earth's magnetic field. The end towards the north pole is known as the north seeking pole and the end towards the south pole is known as the south seeking pole. These are normally abbreviated to north pole and south pole.

Laws of magnetism

LIKE poles REPEL and UNLIKE poles ATTRACT

Magnets are surrounded by their magnetic field - this can be demonstrated with iron filings.
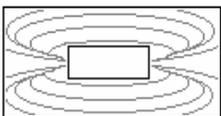
A postcard is placed on the top of a small bar magnet. If you sprinkle iron filings on to the card they will show the pattern of the magnetic field.

Certain materials (e.g. Nickel - Iron) are difficult to magnetise, But once achieved, will retain it almost permanently.

Application: Loud speakers, headphones, cathode ray tube focusing.

Other materials (e.g. soft iron) are very easy to magnetise but lose their magnetism as soon as the magnetising force is removed.

Application: Relays, Electromagnets, Transformers.

ELECTRICITY AND MAGNETISM

A wire carrying an electric current will have a magnetic field around it.
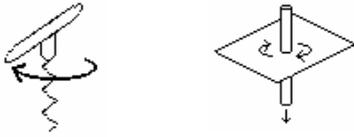
Maxwell's right hand corkscrew rule gives the direction of this field: If a right hand corkscrew moves forward in the direction of the current then its rotation will indicate the direction of the magnetic field.

The strength of a magnetic field is proportional to the current flowing through the wire. But the field around a single wire is very week. However, If the wire is wound into a coil the magnetic field becomes more concentrated. The magnetism becomes even stronger if the coil is wound around a ferrous (iron) core.

The strength of the electromagnetic field will depend on :

> The number of turns in the coil
> The current in the coil
> The core material (if any)

Electromagnetism is the basis of each of the following important items.

THE EARPHONE

The permanent magnet, with its pole pieces, attracts the diaphragm giving a slight concave shape. When a speech carrying current, flows through the coils the magnetic attraction will vary. This will make the diaphragm move in sympathy with the speech.
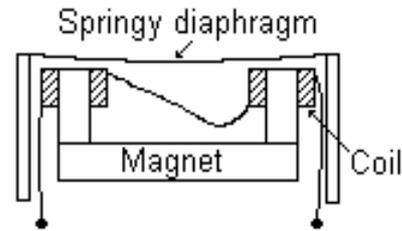
LOUD SPEAKER

A coil is wound on a former that is fixed to the base of the cardboard cone. The coil (and cone) is mounted so that it will move freely in the strong magnetic field produced by the permanent magnet. You will notice that the circular magnet has its north pole in the centre and its south pole round the edge. Current in the speech coil generates a magnetic field that will interact with the fixed magnetic field. The coil and the cone will move in sympathy with the speech currents.
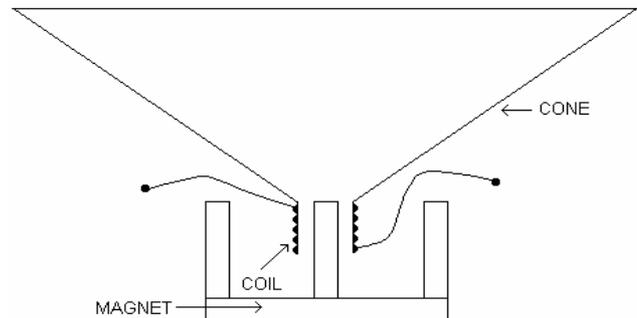
The movement of the diaphragm (or the cone) vibrates the adjacent air. We hear these vibrations and call it sound.

THE ELECTROMAGNETIC RELAY

This is an electromagnetic switch. when a current passes through the coil the magnetic field attracts the armature.
The movement of the armature operates the relay contacts.
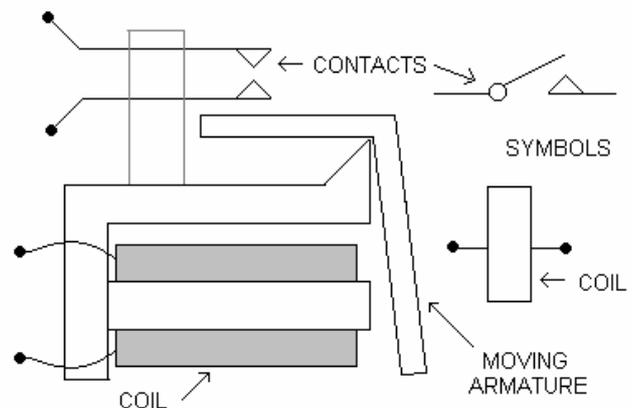
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Before you have a go at the ' End of lesson ' questions, lets work through a problem together.

QUESTION

A 12 KOhm resistor is connected in parallel with a 36 KOhm resistor. What current will flow through the 12 KOhm resistor if a 40 volt supply, with an internal resistance of 1 KOhm, is connected across it ?

ANSWER

Draw the circuit, this will show whether you have understood the question and will help you work out the answer.

It is also useful to put in your own names to the resistors and currents. e.g.   R1 R2 R3 and I Ix etc.
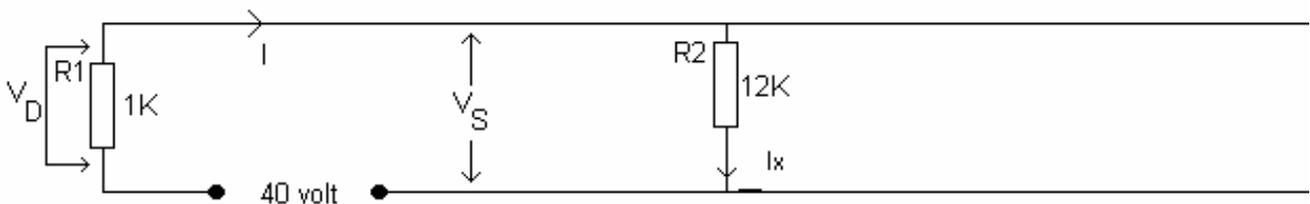
First find the resultant resistance (Rt) of the two resistors in parallel:

$$\frac{1}{Rt} = \frac{1}{R2} + \frac{1}{R3} \quad or \quad \frac{1}{12000} + \frac{1}{36000} = \frac{3+1}{36000} \quad or \quad \frac{4}{36000}$$

So   Rt = 36000 / 4 = 9000 Ohms or 9 KOhms

This 9 KOhms should now be added to the 1 KOhm (internal resistance of the supply voltage) to give the total resistance of the circuit.

$$9 \text{ KOhm} + 1 \text{ KOhm} = 10 \text{ KOhm}$$

The total current from the supply is $\dfrac{\text{Total voltage}}{\text{Total resistance}} = \dfrac{40}{10000} = 4 \text{ mA}$

Remember that this 4 mA is flowing from the supply via its 1000 Ohm internal resistance. Thus the 'Volt lost' in the supply will be Vd.

$$Vd = I \times R = \frac{4}{1000} \times 1000 = 4.0 \text{ Volts}$$

Therefore the voltage across the two parallel resistors is 40 - 4   i.e. 36 Volts. We can now calculate the current through the 12 KOhm resistor.

$$Ix = Vs / R1 = 36 / 12000 = 3 / 1000 \text{ Amps or } 3.0 \text{ mA}$$

NOTE   The voltage across the parallel resistors could have been calculated by remembering that their combined resistance was 9 KOhm and the total current was 4.0 mA. V = 4 / 1000 x 9000 = 36 Volts.

Questions for Lesson 2

Please show all your mathematical working, even in the multiple choice questions.

Question : 2.1   Give three sources of electricity

Question : 2.2   Define the unit of *quantity* of electricity

Question : 2.3   What is meant by the internal resistance of a supply

Question : 2.4   With all the switches set as shown, what current
will flow through the meters X, Y, Z
The resistor by Switch "A" is 12Ω
The resistor by switch "B" is 24Ω

Question : 2.5
What current will flow through meter X with
switch A closed, Switch B open and switch C
closed
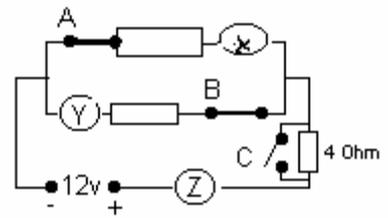
Question : 2.8   A dummy load consists of ten 750 Ohm resistors in parallel. A transmitter, having an
output of 200 Watts is connected to this dummy load. How much heat will be
dissipated by just one of the resistors.

Question : 2.9   What value of resistance would this dummy load present to the transmitter

Question : 2.10   What causes the cone of a loud speaker to move when it is driven by an audio
frequency alternating current

Question : 2.11   A battery, whose open circuit EMF is 6 volts, passes a current of one Amp when
connected to a four Ohm resistor. What is the internal resistance of the battery.

A) 1 Ohm   B) 2 Ohm   C) 0.5 Ohm   D) 4 Ohm

Question : 2.12   In the Morse test, how many errors may be made in the ' received 'section.

A) 2   B) 4   C) 6   D) 8

Question : 2.13   What is the annual fee for an amateur radio licence (Class A)

A) £8.00   B) £other   C) £6.40   D) £10.00

Question : 2.14   In the circuit below, what is the total resistance between point P and point Q

A) 8 KOhms   B) 6 KOhms   C) 32 KOhms   D) 3.2 kOhms

R1 = 1.8   KOhm
R2 = 6.2   KOhm
R3 = 24   KOhm