An Introduction to:

ELECTRIC CURRENT AND OHMS LAW

ELECTRIC CURRENT

In some atoms, notably silver and copper, the outer electrons can be replaced by other electrons and thus move from atom to atom. This constitutes a flow of electric current.

Current is measured in Amperes, after its discoverer, Ampere.

TERMS

Ampere

Milli-ampere = 1 one-thousandth of an ampere
= 1 X 10-3 ampere.

Micro-ampere = 1 one-millionth of an ampere =1 l X 10-5 ampere.

Resistance - In some atoms, the electrons are very difficult to move, so it becomes very hard to pass an electric current. Such atoms or molecules are known as insulators.

The unit of resistance is the Ohm, named after Ohm.

Ohm

Megohm = 1 one million ohms
= 1 $x10^6$ ohms.

Milliohm = 1 one-thousandth of an ohm
=1 x 10^{-3} ohm.

1 ohm is the resistance of a column of mercury at 0°C., having a uniform cross section, a height of 106.3 cm. and weighing 14.452 grams.

E.M.F.—Electromotive Force, also known as electrical pressure or voltage.

It is the electrical force or pressure between two points. It is usually called Volt after Volta.

Volt

Megavolt = one million volts
=1 x 10^6 volts.

Kilovolt =1 thousand volts
=1 x 10^3 volts.

Millivolt =1 one thousandth of a volt
=1 x 10^{-3} volt.

Microvolt =1 one millionth of a volt
=1 x 10^{-6} volt.

MeV - The unit of energy applied to-the radioactive emission of particles or similar radiation. Not to be confused with electro-magnetic radiation.
MeV = about one-millionth of an erg = 1 million electron volts.
1 erg = work done in moving a mass of 1 gram a distance of 1 cm.
The term MeV should not enter the course.

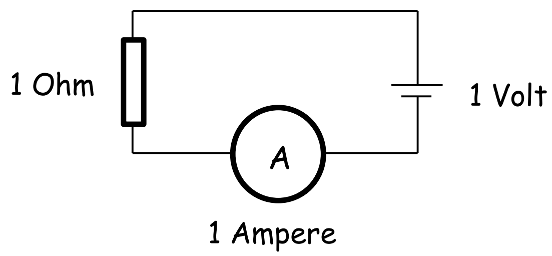
OHMS LAW
This is a fundamental law of electricity and must be completely memorised:
$Current = \frac{E.M.F.}{Resistance}$

This is usually written:
C : E / R, where C is current in amperes (sometimes known as I}.

E = E.M.F. (voltage) or pressure or volts.

R : resistance in ohms.

In A.C. calculation, R is known as Z, the symbol of Impedance.
One ampere is the current which will flow in a resistance of 1 ohm when an E.M.F. of 1 volt is applied.



Transposing:

C = E / R
E = C * R
R = E / C

Power.—This is expressed in the unit Watt.
KW or Kw : 1 kilowatt : 1,000 watts.
MW : 11 megawatt 1 1,000,000 watts
(used mainly in electrical power systems). Do not confuse with radio term of:
mW : 1 milliwatt. 1 one-thousandth of a watt 1 x 10^{-3} watt.

The watt is a unit of power. The watt-hour is a unit of energy.

Suppose a power station can produce 100,000 Kw. and it operates continuously for one year. Then the energy it will have produced:
= 100,000 x 5760 KWH (kilowatt hours), as there are 5760 hours in a normal year.
= 870,000,000 kilowatt hours.
= 870 megawatt hours.

RESISTANCE

When two or more resistances are connected in series, the total resistance is the sum of the individual resistances. However, when two or more resistances are connected in parallel the resultant resistance is less than the smallest, as determined by the formula known as the Reciprocal of the Reciprocals.

$$R\ Total = \frac{1}{1/R1 + 1/R2 + 1/R3 + 1/RN}$$

The following problem will illustrate both the calculations of resistances in series and resistances in parallel (shunt).

Problem

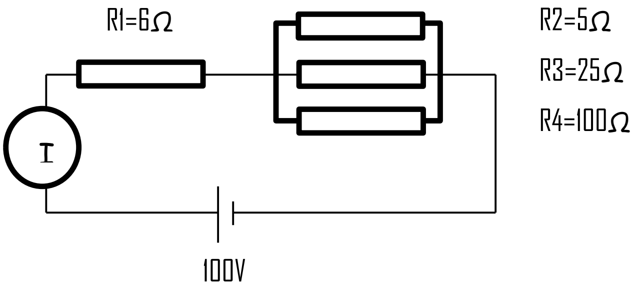
In the following circuit, find:

(1) The voltage drop across each resistance.

(2) Current in each resistance.

(3) Total current in the circuit.

It is assumed that the battery has zero internal resistance.



A. The simplest way to tackle this problem is to find, firstly, the total current, because when this is known all the other answers can be derived from Ohms Law.
B. Ohms Law states C = E / R.
Therefore to find the total, it is necessary to find the total resistance of the circuit, therefore we have to calculate the effective resistance of the three parallel resistances and add this value to the 6 ohms series resistance R1.

$$R\ Parallel = \frac{1}{1/R2 + 1/R3 + 1/R4}$$

$$= \frac{1}{1/5 + 1/25 + 1/100}$$

Find LCD = 100

$$= \frac{1}{\frac{1/5 + 1/25 + 1/100}{100}}$$

$$= \frac{1}{\frac{20 + 4 + 1}{100}}$$

$$= \frac{1}{\frac{25}{100}}$$

B. Remove reciprocal. Invert bottom term.
Therefore R (parallel) = 100/25
= 4 ohms.

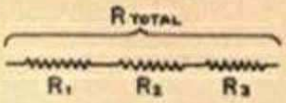
Add the 6 Ohm resistor in series to the above result which then = 10 Ohms.

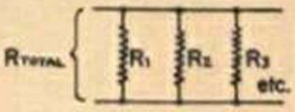
HANDY RADIO FORMULAE

Direct Current Relations

VOLTS =	IR	$\frac{W}{I}$	$\sqrt{RW}$
AMPERES =	$\frac{E}{R}$	$\frac{W}{E}$	$\sqrt{\frac{W}{R}}$
OHMS =	$\frac{E}{I}$	$\frac{W}{I^2}$	$\frac{E^2}{W}$
WATTS =	EI	I^2R	$\frac{E^2}{R}$

Resistance Relations

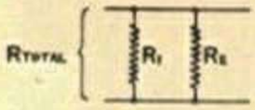


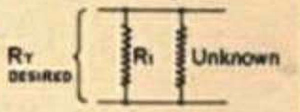


$R_{TOTAL} = R_1 + R_2 + R_3$ etc.

$\frac{1}{R_{TOTAL}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ etc.

Two Resistances Only

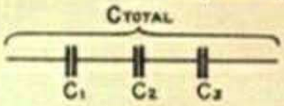


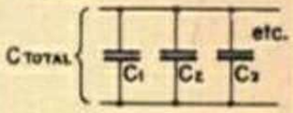


$R_{TOTAL} = \frac{R_1 \times R_2}{R_1 + R_2}$

$\text{Unknown} = \frac{R_T \times R_1}{R_1 - R_T}$

Capacity Relations

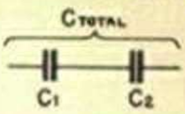


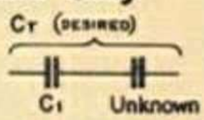


$\frac{1}{C_{TOTAL}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$ etc.

$C_{TOTAL} = C_1 + C_2 + C_3$ etc.

Two Capacities Only

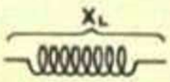


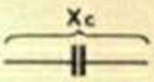


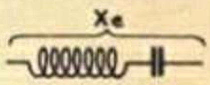
$C_{TOTAL} = \frac{C_1 \times C_2}{C_1 + C_2}$

$\text{Unknown} = \frac{C_1 \times C_T}{C_1 - C_T}$

Simple Reactance





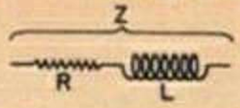


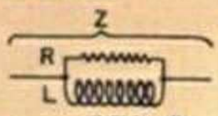
$X_L = 2\pi FL$

$X_C = \frac{1}{2\pi FC}$

$X_e = 2\pi FL - \frac{1}{2\pi FC}$

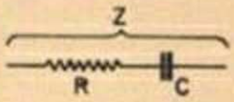
Complex Impedance

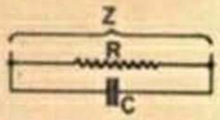




$Z = \sqrt{R^2 + 4\pi^2 L^2 F^2}$

$Z = \frac{2\pi FLR}{\sqrt{R^2 + 4\pi^2 L^2 F^2}}$





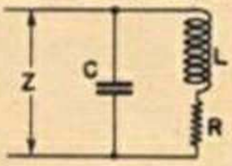
$Z = \sqrt{R^2 + \frac{1}{4\pi^2 F^2 C^2}}$

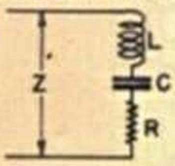
$Z = \frac{R}{\sqrt{4\pi^2 R^2 C^2 F^2 + 1}}$

Resonance Formulae

$F = \frac{1}{2\pi\sqrt{LC}}$ $\quad L = \frac{1}{4\pi^2 F^2 C}$ $\quad C = \frac{1}{4\pi^2 F^2 L}$

Where F is in cycles, L is in henries, and C in Farads





$Z = \frac{2\pi FL}{4\pi^2 F^2 LC - 1}$

At Resonance:

$Z = Q\,2\pi FL$

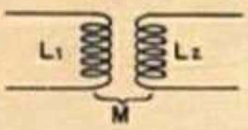
Where $Q = \frac{2\pi FL}{R}$

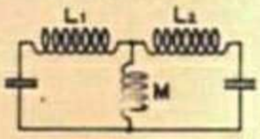
$Z = \sqrt{\left(2\pi FL - \frac{1}{2\pi FC}\right)^2 + R^2}$

At Resonance:

$Z = R$

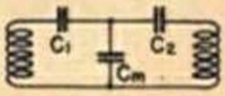
Coupling Coefficient

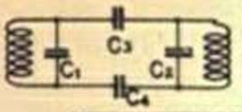




$K = \frac{M}{\sqrt{L_1 \times L_2}}$

$K = \frac{M}{\sqrt{(L_1 + M)(L_2 + M)}}$



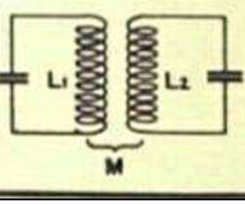


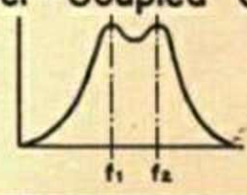
$K = \frac{\sqrt{\frac{C_1 \times C_m}{C_1 + C_m} \times \frac{C_2 \times C_m}{C_2 + C_m}}}{C_m}$

$K = \frac{\sqrt{\frac{C_1 \times C_m}{C_1 + C_m} \times \frac{C_2 \times C_m}{C_2 + C_m}}}{C_m}$

Where $C_m = \frac{C_3 \times C_4}{C_3 + C_4}$

Over-Coupled Circuit Frequencies





$f_1 = \frac{F}{\sqrt{1 + K}}$

$f_2 = \frac{F}{\sqrt{1 - K}}$

Where F is the resonant frequency of each circuit independent of the other and K is the coupling-coefficient