Summing-up: Fundamentals of Electricity

The main elements of an electrical circuit.	• The source of energy putting electricity through the circuit; • The resistance which is ***opposing*** the flow of current; • The current itself which is ***inversely*** proportional to the resistance in the circuit.
Effects of an electric current:	• Heat (& light) • Magnetism • Chemical effect • Physiological
Ohms Law	$\mathbf{I = \frac{V}{R}}$ $\mathbf{V = I \times R}$ $\mathbf{R = \frac{V}{I}}$
Power Law	$\mathbf{P = V \times I}$ $\mathbf{P = RI^2}$ $\mathbf{P = \frac{V^2}{R}}$

Resistor Colour codes:	Table below (E12 type)

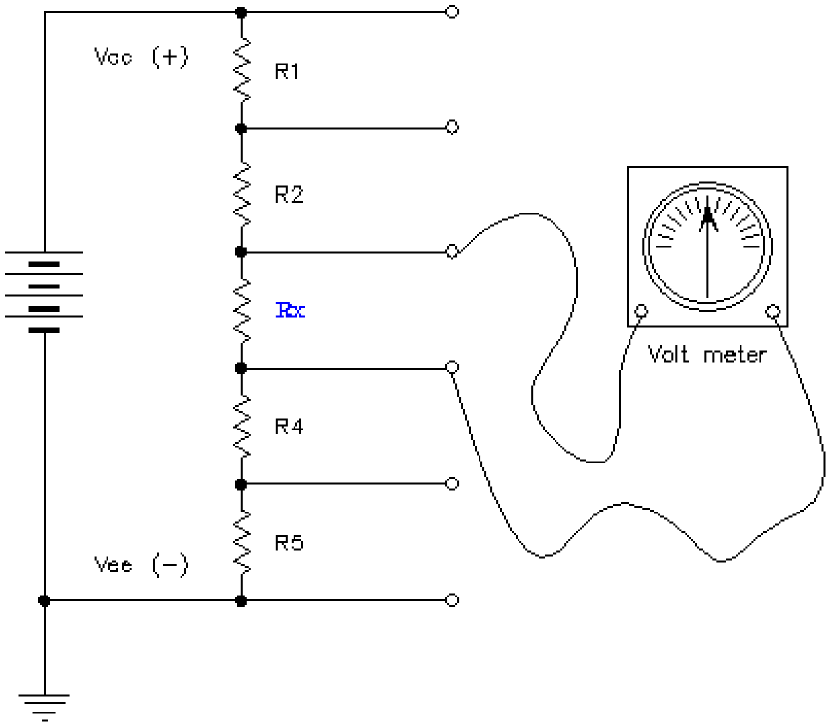
Colour	**1st Digit / 1st Band**	**2 Digit / 2nd Band**	**Multiplier 3rd Band**
Black	Not Used	0	x 1 (10^0)
Brown	1	1	x 10 (10^1)
Red	2	2	x 100 (10^2)
Orange	3	3	x 1000 (10^3)
Yellow	4	4	x 10,000 (10^4)
Green	5	5	x 100,000 (10^5)
Blue	6	6	x 1,000,000 (10^6)
Violet (Purple)	7	7	Not used
Grey (Slate)	8	8	Not used
White	9	9	Not used

Bass numbers: **Units:**	Mega (M) (10^6) Kilo (K) (10^3) and descending order; milli (m) (10^{-3}) micro (µ) (10^{-6}) nano (n) (10^{-9}) pico (p) (10^{-12})

Voltage distribution in series circuits:

$$V_{Total} = V_{R1} + V_{R2} + V_{R3} + V_{R4} + V_{R5} \text{ etc}$$

$$V_{RX} = V_{IN} \cdot \frac{R_X}{R_{Total}} \quad *$$



* We can show how this formula is ***true*** as follows:

Ohms Law states that:

$$I = \frac{V}{R}$$ which transposes to:

$$V = I \times R$$

Therefore the voltage over
$\mathbf{V_{RX} = R^X.I^{cct}}$ (Ohms Law), where $\mathbf{R_X}$ is the "resistance of interest", and I^{cct} is the series current.

Also $\mathbf{I^{cct} = Vin/R_T}$ (Ohms Law again). So we can say that:

$$V_{Rx} = Rx \cdot \frac{V_{in}}{R_T}$$

And this may be stated as:

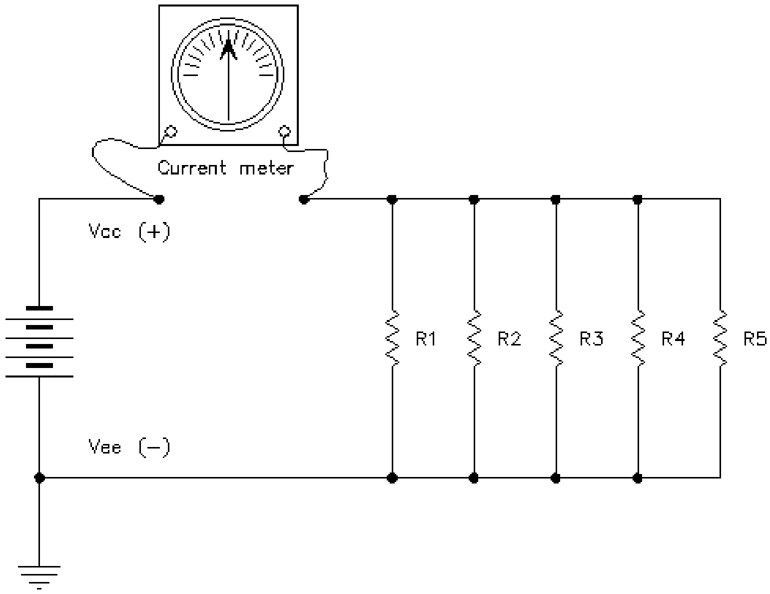
$$V_{Rx} = V_{in} \cdot \frac{Rx}{R_T}$$

Current distribution in parallel circuits:

NOTE: A short cut formula for the total resistance of just <u>two</u> resistors in a parallel circuit is:

$$RT = \frac{R1 \times R2}{R1 + R2}$$

$$I_{Total} = I_{R1} + I_{R2} + I_{R3} + I_{R4} + I_{R5} \text{ etc}$$



$$I_{Total} = \frac{Vss}{R_{Total}}$$

$$\therefore R_{Total} = \frac{Vss}{I_{Total}}$$

$$\text{and } R_{Total} = \frac{Vss}{I_{R1} + I_{R2} + I_{R3} + I_{R4}}$$

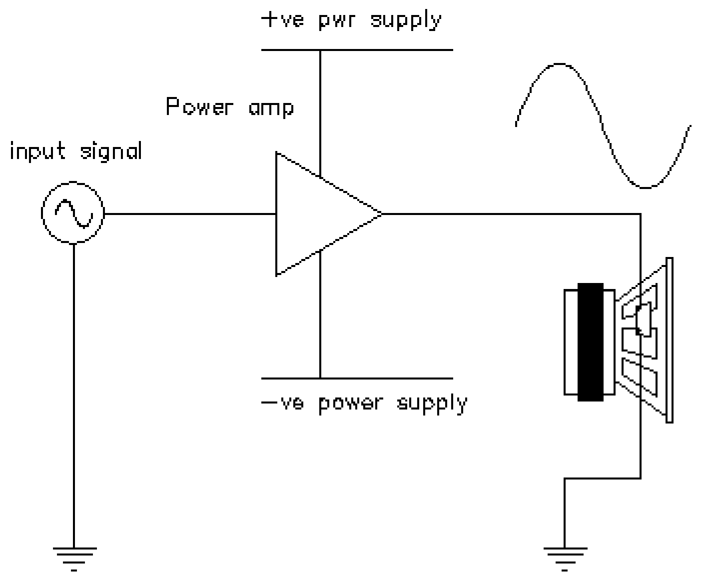
And …… I = V/R (Ohms Law)

$$\therefore R_{Total} = \frac{Vss}{Vss/R_1 + Vss/R_2 + Vss/R_3 + Vss/R_4}$$

…. and the Vss's cancel out to

$$\therefore R_{Total} = \frac{1}{1/R_1 + 1/R_2 + 1/R_3 + 1/R_4}$$

Series resistive circuits and power dissipation:	$I_{cct} = \frac{Vss}{R_{Total}}$ $\quad R_{Total} = R_1 + R_2 + R_3 + R_4 + R_5$ **etc** $P_{Total} = \frac{V_{ss}^2}{R_T}$ <u>or</u> $P_{Total} = I_{cct}^2.R_T$ <u>or</u> $P_{Total} = I_{cct}.V_{ss}$
Parallel resistive circuits and power dissipation:	$I_{Total} = I_{R1} + I_{R2} + I_{R3} + I_{R4} + I_{R5}$ **etc** $P_{Total} = Vss \times I_T$ <u>or</u> $P_T = V.I_{R1} + V.I_{R2} + V.I_{R3}$ **… etc** $P_{Total} = Vss^2/R^T$ <u>or</u> $P_T = V^2/R_1 + V^2/R_2 + V^2/R_3$ **… etc** $P_{Total} = I^{T2} \times R_T$ <u>or</u> $P_T = I^2.R_1 + I^2.R_2 + I^2R_3$ **… etc**

Power calculations in a loudspeaker:	

(In all cases we assume that we are dealing in **RMS** values)

Power to the speaker = $\mathbf{P} = \mathbf{V} \times \mathbf{I}$ or;

$$\mathbf{P} = \frac{\mathbf{V}^2}{\mathbf{R}}$$

or;

$$\mathbf{P} = \mathbf{I}^2\mathbf{R}$$

or;

$\therefore$ if $$\mathbf{P} = \frac{\mathbf{V}^2}{\mathbf{R}}$$

we can say that $\mathbf{V}^2 = \mathbf{P} \times \mathbf{R}$ & it follows that;

$$\mathbf{V} = \sqrt{\mathbf{PR}}$$

Doing the same for current ($\mathbf{I}$) to the speaker:

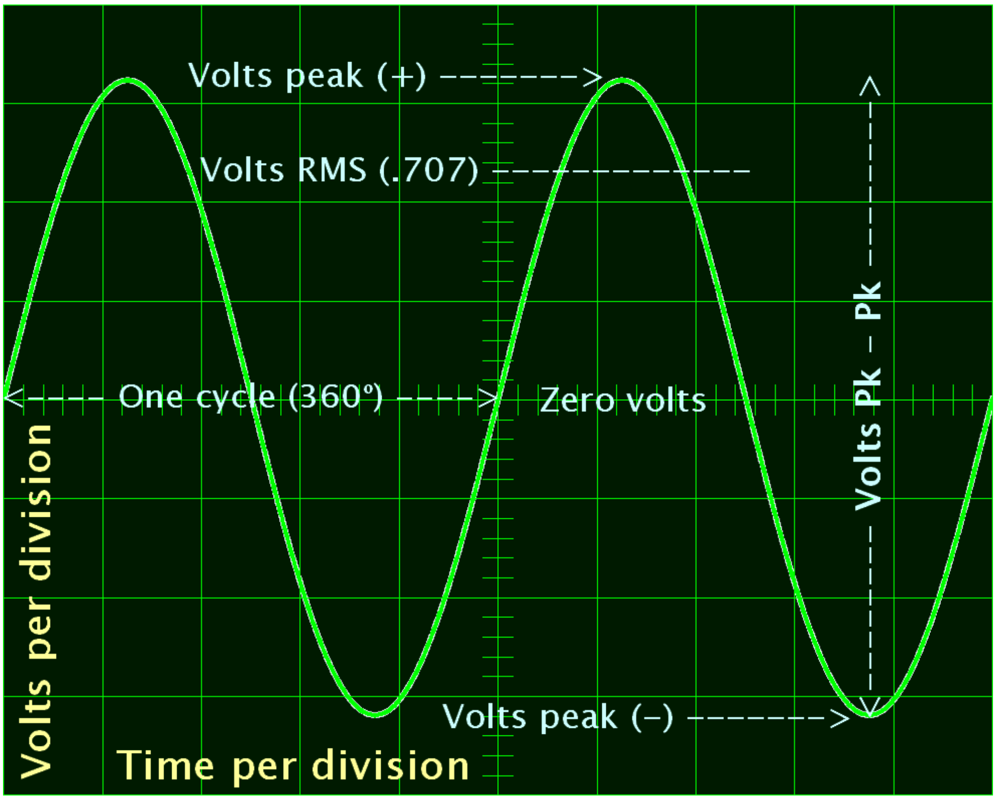
$$\mathbf{P} = \mathbf{R}\mathbf{I}^2$$

$$\therefore \quad \mathbf{I}^2 = \frac{\mathbf{P}}{\mathbf{R}}$$

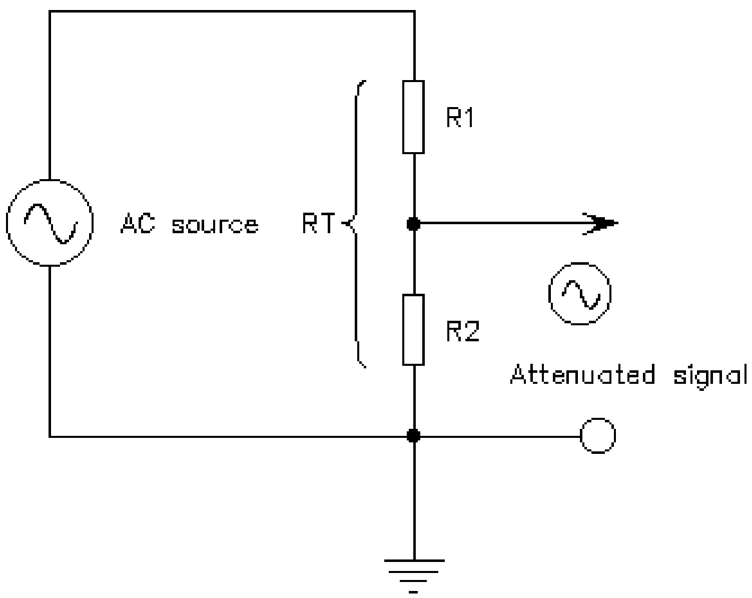
$$\therefore \quad \mathbf{I} = \sqrt{\frac{\mathbf{P}}{\mathbf{R}}}$$

Sine waves; RMS & V ^{pk} etc	$V^{RMS} = V^{Pk} \times 0.707$	$V^{RMS} \ \frac{V^{Pk-Pk}}{2} \times 0.707$
	$V^{Pk} = V^{RMS} \times 1.414$	$V^{Pk-Pk} = V^{RMS} \times 1.414 \times 2$
Or, using √2	$V^{RMS} = V^{Pk} \times \frac{1}{\sqrt{2}}$	$V^{RMS} = \frac{V^{Pk-Pk}}{2} \times \frac{1}{\sqrt{2}}$
	$V^{Pk} = V^{RMS} \times \sqrt{2}$	$V^{Pk-Pk} = V^{RMS} \times \sqrt{2} \times 2$

Sine waves & Volts Peak to Peak	

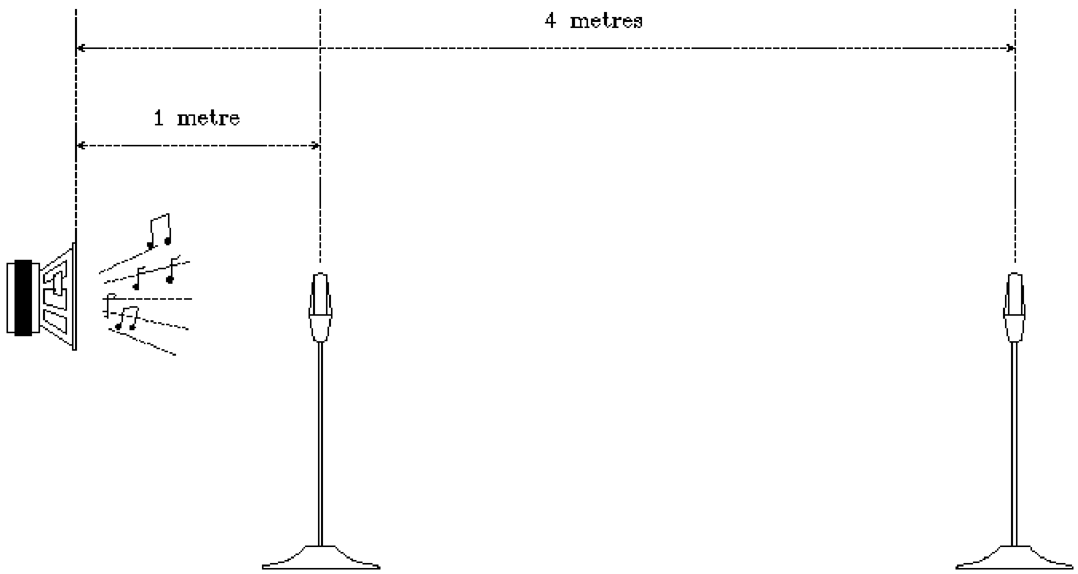


ƒrequency = $\frac{1}{\text{Time}}$	Length (time) of one cycle = 5 divisions (aprox) e.g. if the CRO was set to 1 millisecond per div. this would give 1 x 5 = 5 mS. Therefore the ƒrequency of the observed wave would be 1/.005 = 200 Hertz (cycles per second).

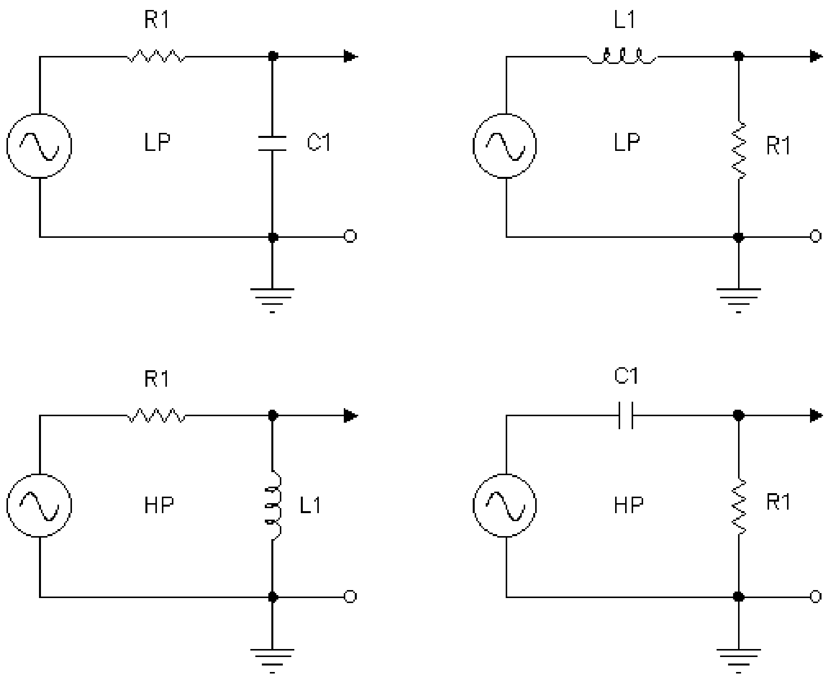
Decibels; voltage and power levels:	When expressing the difference in voltages between signals we say that **dB = 20 x the log** $^{(\text{base } 10)}$ of the ratio of the voltage difference. e.g. with the following attenuation circuit:  $VRx = Vin \times \frac{Rx}{Rtotal}$ **dB attenuation = 20 x log** (R_2/R_T) e.g. if R1 = 82K & R2 = 10KΩ dB = 20 x log (10/(82+10) which = 20 x log (0.0980) = -20.172 dB

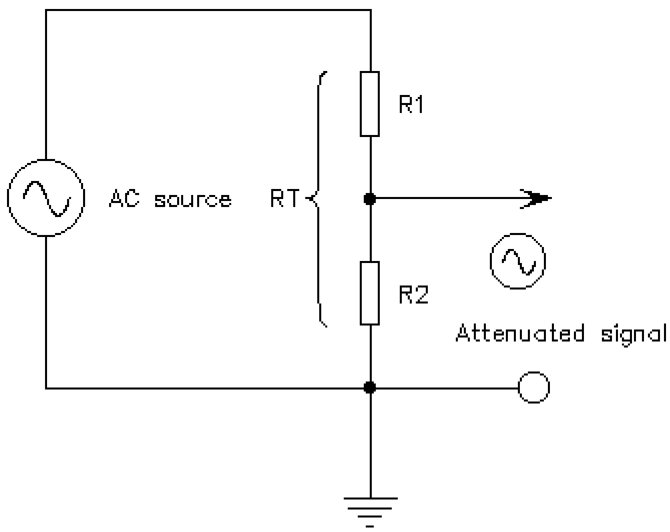
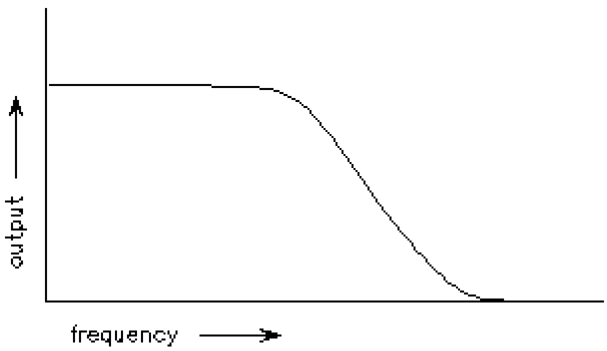
Decibels and power:	When expressing the difference in *powers* between signals we say that dB = 10 x the log (base 10) of the ratio of the voltage difference. e.g. with the following situation: We increase the **power** coming out of an amplifier into a loudspeaker from 10 watts RMS to (say) 80 watts RMS. **dB difference = 10 x log (P_1/P_2)** which = 10 x log (80/10) which = 10 x log 8 = + 9.039 dB

Decibels and distance:	The sound pressure level from a sound source in a non reflective environment decreases as the square of the distance from the source. So if the distance is increased from (say) 1 metre to 4 metres, the sound level *decreases* by a factor of 4^2 = 16. In decibel terms this means that if the distance is quadrupled, the $\text{SPL change} = 20 \times \log^{\text{base } 10}\left(\frac{4}{1}\right)$ which = 12dB or put correctly, **-12.04119dB** or -12dB in round figures.



Decibels, distance and amplifier power:	If we wanted to produce the same sound level at this increased distance of 4 metres, the power required to increase the sound pressure up to what it was (i.e. an increase of 12 dB), we need: **antilog (12.04119dB ÷10) = 16** times as much power into the speaker.

Filter circuits:	 By rearranging where the position of the capacitor or inductor relative to the series resistor or the load resistor, we change the filter characteristics. i.e. in the first diagram, the cap will present a lower resistance to the signal as the frequency goes up. If you look at it as a voltage divider with two resistors, as the *reactive value* of C gets smaller as f goes up, it is like R2 in the diagram below getting smaller and smaller in value, and the output signal is attenuated more and more. Therefore it is called a **L**ow **P**ass **F**ilter, because it *allows the low frequencies to pass through*, and rolls off the highs.

	
A signal passed through a LPF looks like this:	
A signal passed through a HPF looks like this: