Diploma of Audio Production Name________________

Analogue Fundamentals

Module 8

Topic 1. Series Voltage Dividers, Attenuators & Decibels

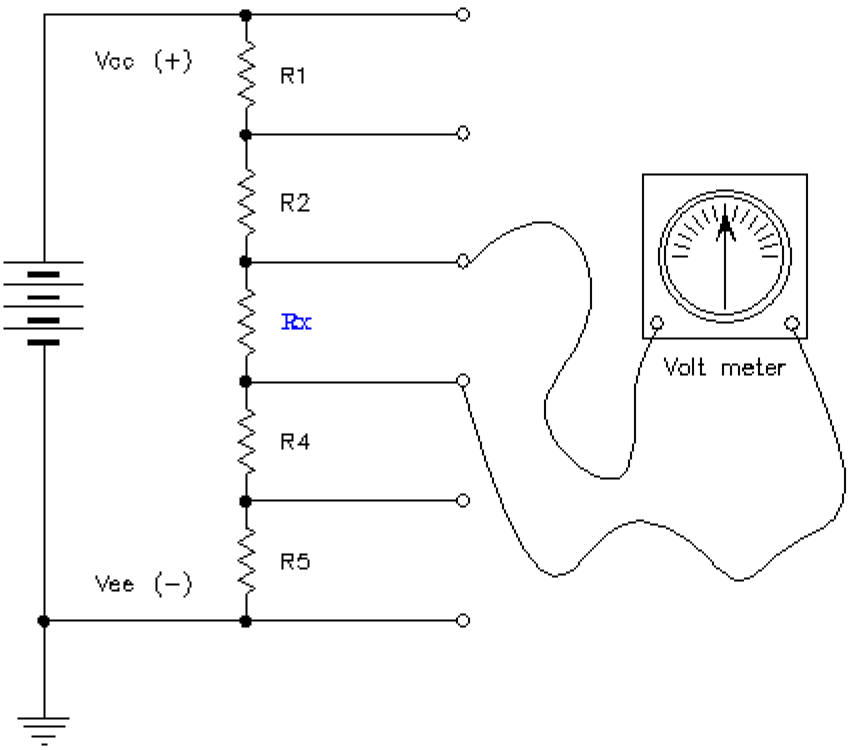
In this session we will look at testing and using voltage dividers and attenuators.

From last weeks lesson we looked at reading voltages with respect to a point and this point is usually the common or ground reference.

Here's a circuit just to put us in the correct frame of mind and what we will do is predict the approximate voltages at each point using common as the reference. Remember the formula:

$$V_{Rx} = V_{ss} \times \frac{R_x}{R_{Total}}$$

… where $\mathbf{V}^{Rx}$ is the voltage over the "resistor of interest" and $\mathbf{V}^{ss}$ is the supply voltage applied to the whole circuit.



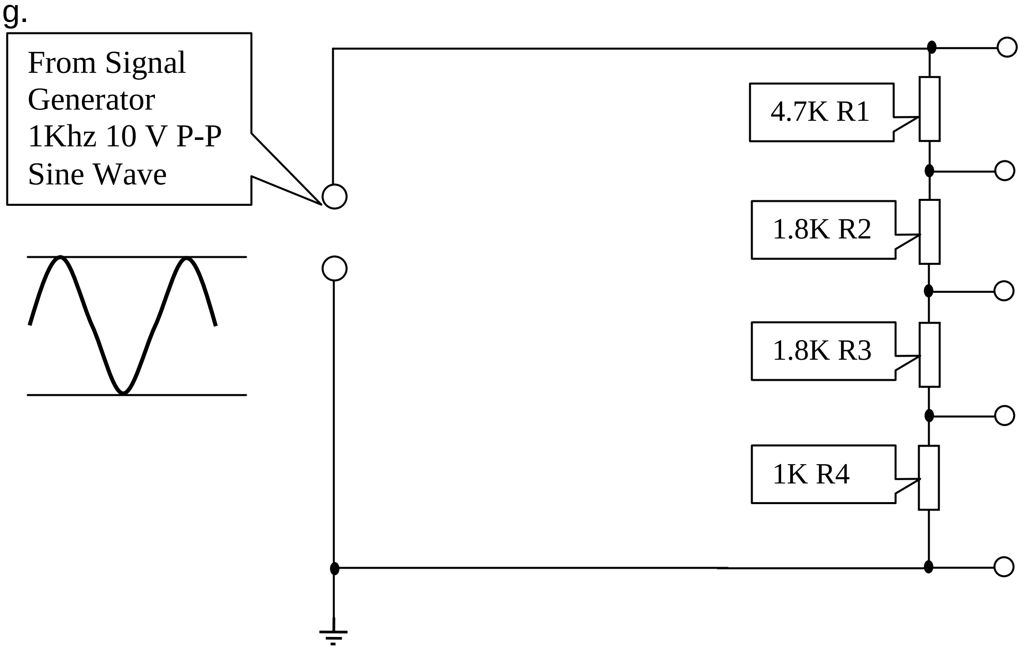
If we replace the DC power supply voltage with a 1 KHz Sine wave, the circuit will "attenuate" the signal by the same amount as it did the DC voltage. At any point on the ladder, the level of attenuation is calculated by considering what the '**R_X**' value in the formula is relative to earth (**W**ith **R**espect **T**o Earth). In other words if we wanted to know what the level would be at the the point just above the 1.8K resistor, we would consider **R_X** to be **R4 + R3**, which is **1K + 1.8K = 2.8K**.

Your predictions:

Voltage at Point 1 ______Volts P-P or ____Volts RMS
Voltage at Point 2 ______Volts P-P or ____Volts RMS
Voltage at Point 3 ______Volts P-P or ____Volts RMS
Voltage at Point 4 ______Volts P-P or ____Volts RMS

So replace the DC power supply voltage on the previous circuit and do some measurements to confirm your predictions.

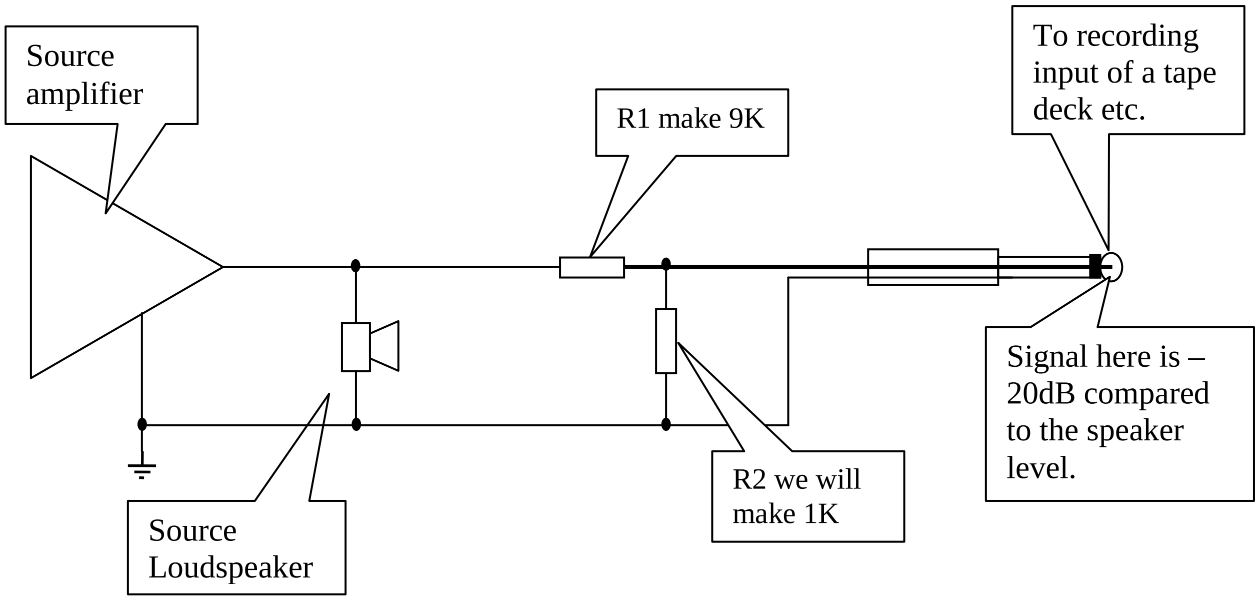
e.g.



This circuit can be used as an audio Attenuator if we run our signal to the amplifier through it. If we replace the sine wave generator with an audio signal from a mixing desk or CD player, the same result will occur.

Suppose we wanted to record a program and we had only access to the speaker output from the source. This level would be far too high for the microphone input or even the line input of our mixer or recording device whether magnetic or CD technology and would result in severe distortion of the recorded signal.
So we would need to drop the level by at least a factor of 10 which is a loss of 20dB..

A picture and demo may help to grasp this concept.



Notice the connections to the standard phone plug or tip and sleeve plug as it is sometimes referred to as.
Note the figure of 20dB ignores the input resistance of the recording device which in any case would be much greater than R2 and therefore can be ignored.

Where did this 20dB figure materialize from?

Well using the following formula we can predict the amount of dB attenuation for any series resistive attenuator.

$$dB_{(att.)} = 20\ Log_{10}\ .\ \frac{R_2}{RT}$$

Some basic rules of "thumb" for decibel changes.

First of all we should state that dB or decibel only refers to a level of power or a change to that power whether it is electrical or acoustic power..

1/. Double or half the voltage is a change of +/- 6dB. That is we change the output power by a factor of 6dB which incidentally is a change in power of 4 Times.

2/. Ten times or one tenth the voltage is a change of 20dB and this is a change in output power of 100 Times..

3/. One third or 3 times the voltage is approximately a change of 10dB and this is a power change of 10 Times..

4/. Also if we double or halve the distance from a sound source the change in acoustic power is 6dB.

Proving all this by calculations..

We can predict the change in the decibel output if we know the change in output voltages in our attenuator. (Note: it also applies to Amplification.)

The Formula $$\text{dB change} = 20 \times \log \frac{V_{out}}{V_{in}}$$

What's this log business?

Well log is short for Logarithms and this is a unique mathematical representation of any number. Stating it another way we can say that the logarithm of a number to any particular base is the index ('exponent") to which that base is raised in order to obtain the number.

To make things simpler we only will use logs to the base 10 and this is the case if you just use the log button on your calculator.

Lets just try a couple of attenuator outputs to see if it works.

$$\text{dB change} = 20 \times \log \frac{V_{out}}{V_{in}}$$

$$= 20 \log \frac{5}{10}$$

$$= 20 \log 0.5$$

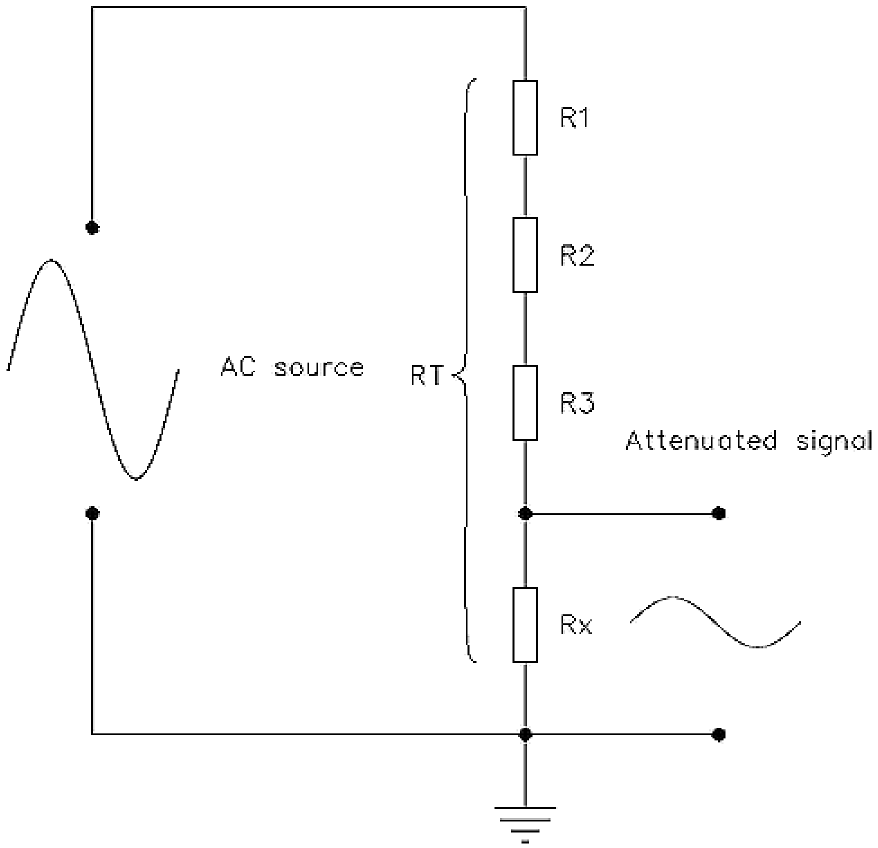
$$= 20 \times -0.3$$

$$= -6\text{dB}$$

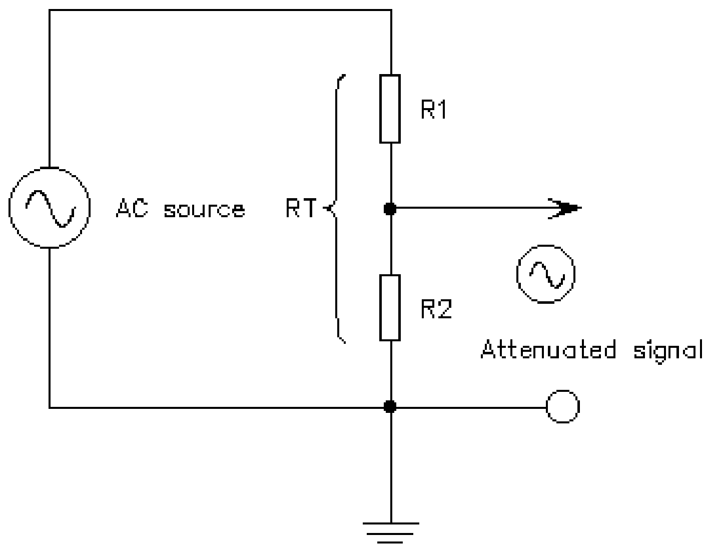
Now as we know that with a series circuit the voltage drop across the resistors is directly proportional to the resistor value itself, we can simply use the Ratio of the resistors to find the dB attenuation.. We don't even require the input or output voltages.

$$\text{dB change} = 20 \log . \frac{R_X}{R_T}$$

Looking at our original circuit:



If we want to we can "reverse engineer" the dB attenuation formula to find what values of R1 & R2 we need by doing this: Starting with the formula before:-



$$\mathbf{dB_{(att.)} = 20\ Log_{10} .\ \frac{R_2}{R_T}}$$

$$\text{t.f. attenuation ratio} = \frac{\textbf{antilog of } (R_2/R_T)}{\mathbf{20}}$$

Remember the “Ratio” formula expressed as: $\mathbf{V^{out} = V^{in} . \frac{R_2}{R_T}}$

$\therefore$ $\mathbf{R_2 . V_{in} = R_T . V_{out}}$

& it follows that $\mathbf{R_2 = \frac{R_T . V_{out}}{V_{in}}}$

... where $\mathbf{V_{out} / V_{in}}$ is the “desired ratio of attenuation”. So if we choose a value of (say) $\mathbf{R_T}$, then we can calculate $\mathbf{R_2}$ (the attenuating resistor) if we know what level of attenuation we desire in **dB**.

$\therefore$ it follows that $\mathbf{R_2 = R_T . antilog . \frac{dB}{20}}$

