## Diploma of Audio Production        Name_______________

## Analogue Fundamentals

## Module 6

## Resistors as components in a circuit

### Topic 1: Resistor colour codes
### Topic 2: A resistor in circuit
### Topic 3: Series resistor circuits

We know that in any electronic circuit we have 3 main elements;

1. The source of energy that is trying to force an electric current through our circuit.
2. We have the resistance, which is opposing the flow of the current.
3. And we have the current itself, which is proportional to the applied “voltage” and inversely proportional to the resistance in the circuit. This basically means that more resistance, less current.

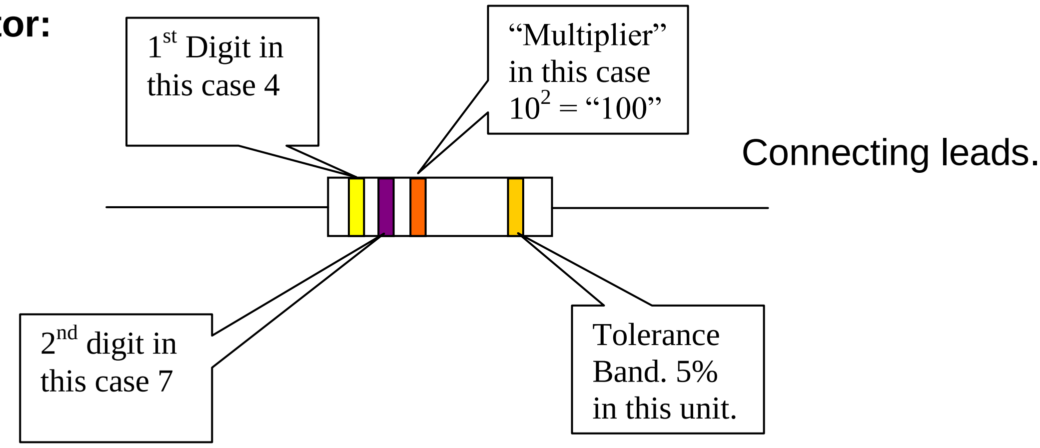
Resistors are “purpose built” components that are used to restrict or limit the amount of current in an electric circuit. They also may be used to “attenuate” audio or other signals in a system to give us control over how loud a system will sound. Resistors are manufactured using controlled quantities of carbon or metal oxide film applied to an insulating surface, or resistive wire, depending on the application.
Resistors are normally sold with a particular power rating. Examples are 1/8$^{th}$ watt, ¼ watt, ½ watt, one watt, five watts etc with quarter watt types being the most common in modern circuits. These resistors can be quite tiny with the ¼ watt varieties only being around 1 Centimetre long and around 2mm’s thick. Most modern manufactured circuit boards have “surface mount” resistors which are ceramic types, are even smaller, and are soldered by “wave soldering” machines. These can still be soldered by hand however. With “surface mount” circuit boards, the components do not have leads that poke through the board to the other side.

All “carbon” resistors are available with a wide range of resistance values from fractions of OHMS (Ω) to millions of OHMS.

To identify the value of a resistor in ohms, we use colour codes, for conventional types. Surface mount resistors have their value printed on e.g. “10K”

Lets have a look at what we are talking about. Colours = yellow, violet, red with a gold band.

**The resistor:**




So this resistor is 4700Ω 5%  or 4.7KΩ 5% Actual size is about 10mm x 2mm. ie.

## The Colour Code.

To allow us to us to identify the actual ohmic value of the resistor we should become familiar with the colour code for resistors and how to apply it.

| 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 |

## The 4th band or the "Tolerance" band

It is very rare that a resistor is the exact value as per its markings. We cannot produce them with this sort of accuracy but the manufactures will guarantee that the indicated value is within a certain percentage of the indicated value as dictated on the Tolerance band.

Tolerance band colours;

Brown  =  1%
Red    =   2%

Gold = 5%
Silver = 10%

This means that a 5% 1KΩ Resistor can vary between 950Ω and 1050Ω. The tolerance percentage has been devised so as a positive tolerance will overlap the negative tolerance of the next higher value resistor. 10% 0n the E12 range of resistors and 5% on the E24 range of resistors.

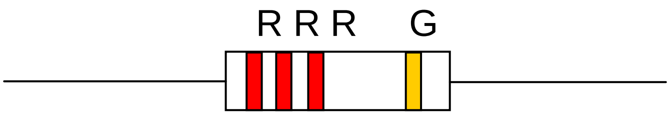
What's all this E12 and E24 stuff?

Well E12 range means that there are 12 values of resistors between 1 and 99 ohms or multiples thereof and with the E24 range means there are 24 values.
The extra values fit in between the E12 values.
As an example 68Ω and 82Ω are two of the values in the E12 range and E24 adds a 75Ω in between.
So here is the complete list:

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **E12** | **1.0** | **1.2** | **1.5** | **1.8** | **2.2** | **2.7** | **3.3** | **3.9** | **4.7** | **5.6** | **6.8** | **8.2** |
| **E24 Adds** | **1.1** | **1.3** | **1.6** | **2.0** | **2.4** | **3.0** | **3.6** | **4.3** | **5.1** | **6.2** | **7.5** | **9.1** |

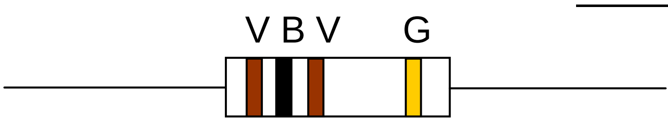
Well at this stage we should have a go at identifying a few resistor values from the following examples. (Don't forget the tolerance)

1/.



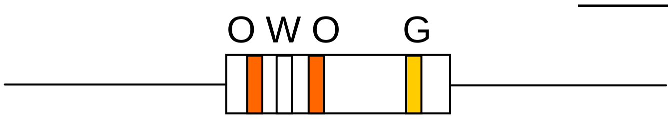

Value________________

2/.



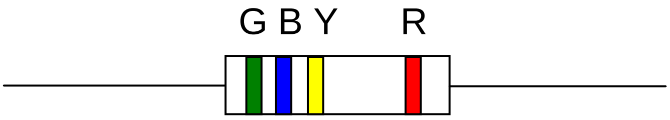

Value________________

3/.



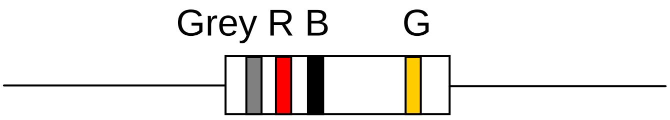

Value________________

4/.




Value________________

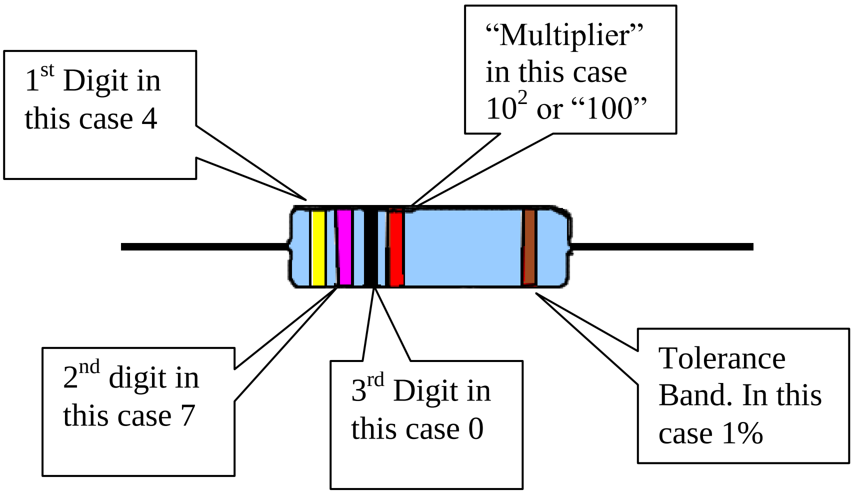
5/.




Value________________

## 5 Band Resistors.

Resistors in the 1% and 2% range usually have 4 bands to indicate their value with the 5th band being the tolerance and will be brown or red.
These resistors have 3 bands for the digits and one for the multiplier.
Colours are identical to the 4 band types.
An example will make this all clear.




So this resistor is a 470 x $10^2$ (100) = 47,000Ω = 47KΩ @ 1% tolerance.
Time for some practical work.

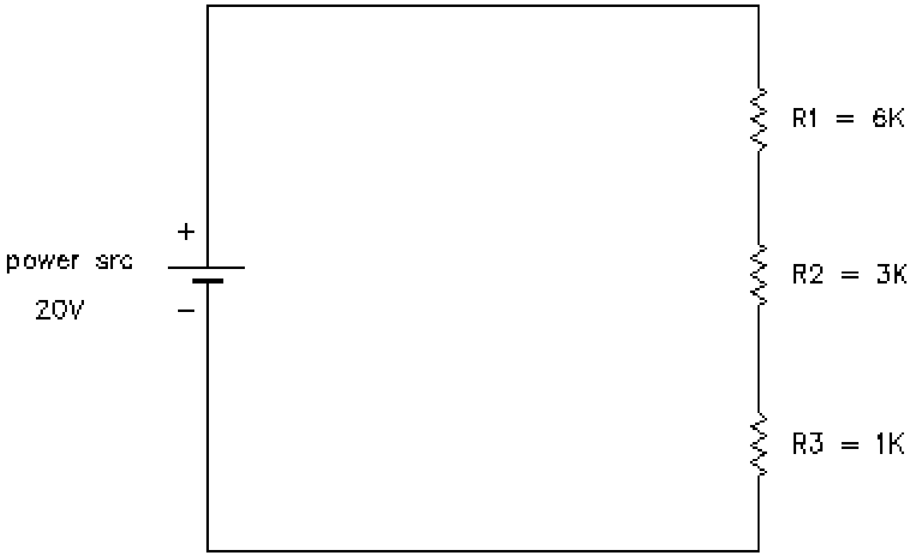
### So here's Prac. No.1

Aim: 1/. Given some resistors Identify and record their values in the table below.
2/. Using a DMM on the resistance range, check your results.

| Resistor number | Colours | Visual Value as per the colours | Measured Value as per the DMM |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| 8 | | | |

## Topic 2: A resistor in circuit

**Let's analyse the following circuit;**




We can assume that the total resistance of the series resistances is equal to the sum of the resistors. Therefore $R_{total}$ = R1 + R2 + R3 which = 10K (10,000Ω)
It follows that the circuit current, according to Ohms Law will **$I = V / R_{total}$**
In a series circuit the current will *be the same in every part of the circuit*. Using Ohms Law rearranged as **$V = I \times R_{total}$ which = 20/10,000 = 0.002A or 2mA.**
If we rearrange Ohms Law again to say **V = I x R**, it follows that the voltage which 'appears' over each resistor = the value of each individual resistor in **Ω** multiplied by the current. The results would be:

**Voltage over R1 = 12V**
**VR2 = 6V**
**VR3 = 2V.**

Further more, if you add up the total voltages dropped over reach resistor, the result will be equal to the supply voltage, in this case 20V. Essentially, this is what resistors are mostly used for in electronic circuits; to divide the voltage according to needs.

In conclusion we can say that the resistor with the highest value in a series circuit has the highest voltage across it.

## Power Dissipation:

The power law states that Power (in watts) = Voltage x Current (in amps) in any circuit. Thus, the power being dissipated in an individual resistor will equal the voltage being "dropped" over that resistor x the current (I) through it. Just to refresh, from the previous lesson on power:

**P = V x I**

As before, we can express this different ways by substituting (for example) I. We know that I = V/R therefore we can say:

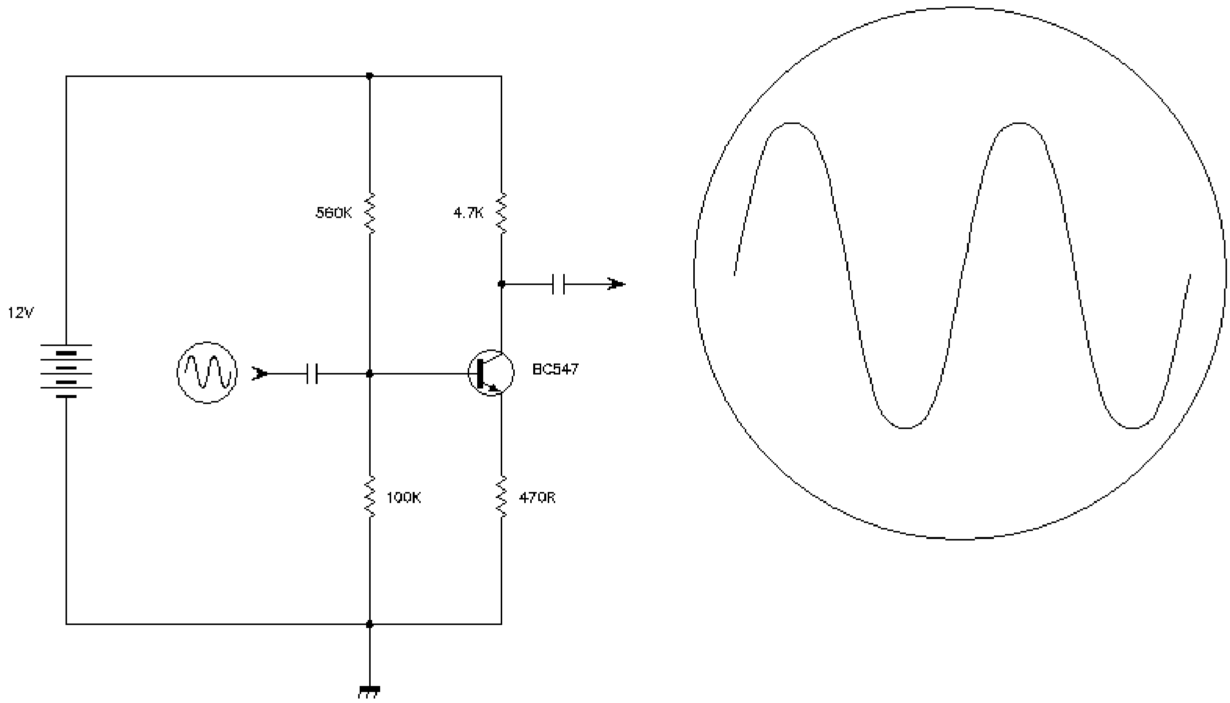
$$P = V \times \frac{V}{R}$$

which =

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

From this we can see that in any circuit, the power dissipated over a resistance will be determined by the voltage which appears over it. The power will also be proportional to the square of any change in this voltage.

However, in most modern electronic circuits, the power dissipated in the resistors will be very small, and indeed kept as low as possible, because this increases the efficiency of the device. Most of the heat in circuits is dissipated in the semiconductor devices.




Above is a very simple circuit of a class ‘A’, single transistor amplifier circuit that will increase the input voltage by about 10 times (20dB). You can build it yourself if you want! It’ll cost about 3 cents. It is quite high fidelity, and will not tarnish the sound of the signal with any ‘nasties’, being class ‘A’. As a circuit, it’s not very efficient because class ‘A’ operation requires the device (BC547 transistor) to operate very much ‘ON’ all the time. However, if you calculate the maximum power dissipation of the resistors in the circuit, it won't be much in the real world. It's only a 'small signal' circuit, and would use about 1½ milliamps from the battery.