UNDERSTANDING ELECTRONICS

Resistors

Objectives

After working through this chapter, you should be able to do the following:

1. Define what a resistor is and recognise the circuit symbol.
2. Know what is meant by the term preferred values.
3. Know what is meant by the term tolerance.
4. Be able to use the resistor colour code to identify 4 colour band resistors.
5. Be able to calculate the total resistance of resistors connected in series.
6. Be able to calculate the total resistance of resistors connected in parallel.
7. Be able to calculate power dissipation.
8. Know what a variable resistor is and recognise the circuit symbol.

In electronic circuits there are many occasions where we want to be able to control or restrict the current flowing, or to fix the voltage at a given point. To achieve this we used a **fixed resistor**.

Fig 2.1 Symbol for a Resistor

Resistors are constructed from one of the following materials, carbon film, metal film, metal oxide or are wirewound. They come in a range of values, typically from 4R7 to 1M, although values as low as 0.47R and as high as 10M are available. Resistors also come in a range of power ratings, typically from 0.25W up to 50W. Again lower and higher power ratings are available.

Preferred values

With such a wide range of potential values, it would be very expensive and uneconomic to manufacture every single value. To overcome this a range of **preferred values** has been created. The most common ranges are known as the E12 and E24, although others are available.

E12 range 10R, 12R, 15R, 18R, 22R, 27R, 33R, 39R, 47R, 56R, 68R, 82R and their multiples.

E24 range 10R, 11R, 12R, 13R, 15R, 16R, 18R, 20R, 24R, 27R, 30R, 33R, 36R, 39R, 43R, 47R, 51R, 56R, 62R, 68R, 75R, 82R, 91R and their multiples.

When choosing a resistor we always choose the preferred value that is higher than that calculated. For example if our calculated value for a resistor was 50R, we would use a 56R resistor. (Based on the E12 range)

Exercise 2.1

Using the E12 range chose the nearest resistor to the values below.

1. 30R
2. 110R
3. 620R
4. 4K3
5. 91K
6. 160K
7. 510K

Tolerance

Resistors also come in a range of **tolerances**. Tolerance means how accurate or close the measured resistance would be to the stated value of the resistor. Typical **tolerances** are 5%, 2% and 1%

Colour coding

Due to the small physical size of a resistor, a unique **colour coding** system has been devised. The table on the next page shows the **colour code** for a four band resistor.

Colour	1st Band	2nd Band	3rd Band
Black	O	0	-
Brown	1	1	0
Red	2	2	00
Orange	3	3	000
Yellow	4	4	0000
Green	5	5	00000
Blue	6	6	000000
Violet	7	7	0000000
Grey	8	8	
White	9	9	

To read the **colour code**, begin by identifying the 4th band on the resistor which is coloured Gold. This indicates the tolerance of the resistor. Most of the resistors used in schools are 5%. Once you have done this, keep the 4th band to your right. You can now start on the left hand side with the 1st band and begin to identify the resistor.

Example

1. A resistor is coded orange, orange, brown and gold. What value is this resistor?

Having identified the 4th band as the tolerance band, we will start with the first colour which was orange. Orange represents the number 3. The 2nd colour is also orange, so we have another 3. The third band is the most important. It tells us how many zero's to add. So our third brown means that we need to add a zero.

So our resistor Orange Orange Brown gold is 330 Ohms with a 5% tolerance.

2. This time we need to identify the colours of a 1K resistor to ensure that the one we have taken out of the tray is the correct value.
Firstly convert 1K to ohms

1K = 1000R (kilo = 1000)

Now we cans start to work out the colours. Our first digit is 1, so from the table the colour of the first band is brown. The 2nd digit is 0, so the colour is black. The remaining digits represent the third band, which is the number of zero's. For this resistor we need two zero's so the colour is red.

Exercise 2.2

Using the above examples to guide you, work out the value of the following resistors.

1. Brown, black, orange, gold?
2. Yellow, violet, black, gold?
3. Red, red, red, gold?
4. Green, blue, yellow, gold?
5. Blue, grey, brown, gold?

From the stated value, work out the correct colour code for each resistor. Remember to convert each value into ohms first.

6. 100R
7. 2k2
8. 33k

9. 180k
10. 1M

Resistors in series

Fig 2.2 Resistors in Series

When you start to look at circuits, you will often see resistors connected together one after another as if they were in a continuous chain. We say they are connected in **series**.

When resistors are connected in this way, the overall resistance can be found by

R (total) = **R1** + **R2** +**R3** and so on.

All you have to do is simply add all the resistances together. Note that the use of R1, R2 etc refers to the identification of each resistor, it is not a value.

Example

What is the overall resistance of a circuit if R1 is 22R and R2 is 56R?

R = **R1** + **R2**
R = 22 + 56
R = 78R

You may be wondering why we connect resistors in series. One reason is that sometimes we require a resistor value that is not manufactured or within the preferred range. By combining resistors, we can often obtain the required value. Another use is to drop or reduce voltages in a circuit.

Resistors in parallel

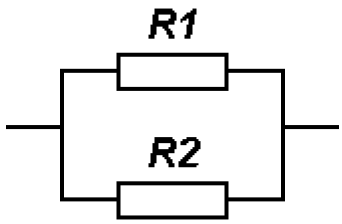

Fig 2.3 Resistors in Parallel

When two or more resistors lay side by side with their ends connected together, we say they are connected in **parallel**.

When resistors are connected in this way, the overall resistance can be found by

R total = R1 x R2 / (R1 + R2)

Or

T total = 1/R1 + 1/R2 + 1/R3

Example

1. Two resistors are connected together in parallel. R1 is 8R and R2 is 8R. What is the total resistance?

R total = R1 x R2 / (R1 +R2)
R total = 8 x 8 / (8 + 8)
R total = 64 / 16
R total = 4R

2. Two resistors are connected together in parallel. R1 is 8R and R2 is 6R. What is the total resistance?

R total = R1 x R2 / (R1 +R2)
R total = 8 x 6 / (8 + 6)
R total = 48 / 14
R total = 3.43R

This can also be written as 3R43. This way is normally used so as to save any confusion with decimal points.

Looking at the two examples you may have noticed a couple of patterns. Firstly with example 1, if both resistors are of equal value then the total resistance will always be exactly half the value of one of the resistors.

In example two where we had two resistors of different values, the total resistance will always be less than the lowest value resistor.

If you apply these two rules when looking at your answer you should never miscalculate the total resistance.

Exercise 2.3

Calculate the total resistance of the following resistors connected in series.

1. When R1 is 100R and R2 is 220R?
2. When R1 is 1K and R2 is 680R?
3. When R1 is 10K and R2 is 330R?

Calculate the total resistance of the following resistors connected in parallel.

4 When R1 is 16R and R2 is 16R?
5 When R1 is 1K and R2 is 1K?
6 When R1 is 100R and R2 is 47R?
7 When R1 is 27R and R2 is 22R?

Power Dissipation

In chapter 1 you came across the term **Power dissipated** or **Power rating**. In restricting the flow of electric current, resistors generate heat. All resistors have a power rating the most common is 0.25W. If you are unsure how to calculate power dissipation, look back at chapter 1.

Variable Resistors

You have already come across **variable resistors** in your home without knowing it. The volume control on your Hi-Fi is a variable resistor as are the tone controls or graphic equaliser. A variable resistor can be adjusted from 0R to its stated value.

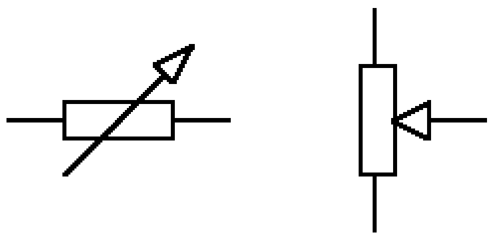

Fig 2.4 Symbols for variable resistors

On circuit boards a smaller variable resistor called a **pre-set** is used. These are variable resistors which once adjusted usually do not need to be adjusted again.

Potential (Voltage) divider

Very often in circuits you will see two resistors connected together as shown below.

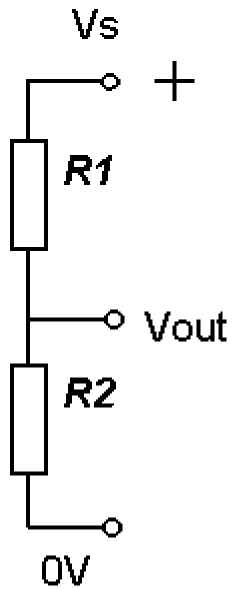

Fig 2.5 Potential divider

Each of the resistors has the same value of current flowing through it. For example if there is 10mA flowing through R1 then there will be 10mA flowing through R2.

However a portion of the supply voltage is dropped across each resistor. For example if each resistor is 100R and the supply voltage Vs is 9V then because each resistor is of the same value they will each drop half the supply voltage i.e. 4.5V. Indeed if you measured the voltage across either of the resistors you would find it was half the supply voltage. But what happens when the two resistors are of different values.

The current through each resistor is the same but to find the voltage at Vo the formula below is used.

Vo = Vs x R2 / (R1 + R2)

For example if R1 is 5R, R2 is 10R and the supply voltage Vs is 9V find the output voltage.

Vo = Vs x R2/ (R1 + R2)

Vo = 9 x 10 / (5 + 10)

Vo = 6V

Exercise 2.4

Find the output voltage Vo if

1. Vs = 9V, R1 = 100R, R2 = 75R
2. Vs = 9V, R1 = 50R, R2 = 75R
3. Vs = 9V, R1 = 25R, R2 = 25R
4. Vs = 9V, R1 = 40R, R2 = 30R

Although we have considered two fixed resistors for our potential divider they could be any two resistive components. For example one of the two resistors could be a preset and the other could be a light or heat sensor. You will meet the potential divider again in the chapter on sensors.