ADVANCED

Lesson 3

RESISTORS

ACMA Syllabus February 2024 Chapters 2.1 and 3.1

Contents

Resistor Types

Resistors come in various designs.

Fixed Resistors

Are resistors whose value is predetermined and marked with colour bands.

Variable Resistor (Sometimes called a Potentiometer or Pot)

A potentiometer Is a resistor whose value can be varied through a specified range providing voltage off taps.

Wire Wound Resistors

These are usually special resistors designed to dissipate a lot of heat.

Resistor Sizes (General)

Resistor sizes are not infinite and do not come by 1-ohm increments. For standard compatibility, resistors, capacitors, inductors and Zener diodes are expressed in an international standard called the E series.

There are a number of E series but the most common applicable to resistors is the E12 series. E12 means that every decade, means adding a zero, (0.1-1.0, 1-10, 10-100, 100-1000 etc.) is divided into 12 steps on a logarithmic scale. The size of every step is equal to:

$$10^{\left(\frac{1}{12}\right)} = 1.21$$

Based on this, every value is 21% or 1.21 times higher than the previous value in the series. Each value is rounded to whole numbers. All resistors with a tolerance of 10% should not overlap in this series.

Starting with 1 Ohms, the next value is 1 x 1.21 = 1.21 (Rounded to whole number becomes 1.2 ohms.)

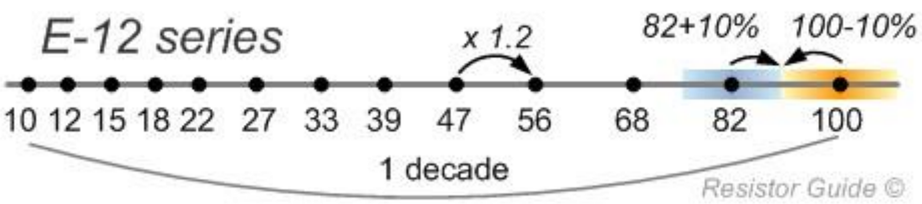
Next 1.2 x 1.21 = 1.452 (Rounded to whole number becomes 1.5.)

Next 1.5 x 1.21 = 1.815 (Rounded to whole number becomes 1.8.)

And so on.

The series looks as follows: 1 – 1.2 – 1.5 – 1.8 – 2.2 – 2.7 – 3.3 – 3.9 – 4.7 – 5.6 – 6.8 – 8.2 – 10.

One decade of the E12 series



The next decade would look like this

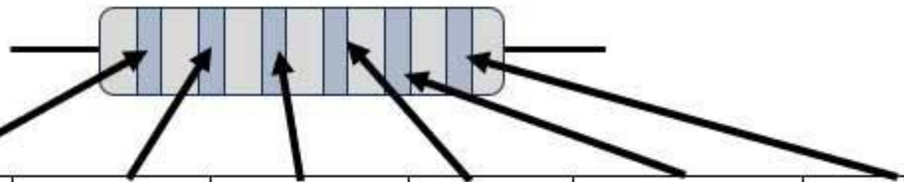
100 – 120 – 150 – 180 – 220 – 270 – 330 – 390 – 470 – 560 - 680 – 820 – 1000

Having resistors limited to standard sizes makes manufacturing easier and equipment design can use standard sizes for ease of maintenance and repair. If a specific size is required, there are applications that can calculate the mixture of resistors required to make up a specific value. Such as connecting resistors in series and or parallel is a way of formulating required resistor sizes.

Example: Two 100-ohm resistors in parallel would make a 50-ohm resistor.

Resistor colour codes

Resistors can be very small, so the value of the resistor is painted in bands around the resistor. There can be 3, 4, 5, or 6 bands and each colour represents a specific value. Surface mounted resistors have a different numbering sequence due to their small size.



Colour	1st Digit	2nd Digit	3rd Digit	Multiplier	Tolerance	Temp Coefficient
Black	0	0	0	1Ω	N/A	N/A
Brown	1	1	1	10Ω	± 1% (F)	100
Red	2	2	2	100Ω	± 2% (G)	50
Orange	3	3	3	1kΩ	± 3%	15
Yellow	4	4	4	10kΩ	± 4%	25
Green	5	5	5	100kΩ	± 0.5% (D)	N/A
Blue	6	6	6	1MΩ	± 0.25% (C)	10
Violet	7	7	7	10MΩ	± 0.10% (B)	5
Grey	8	8	8	100MΩ	± 0.05% (A)	N/A
White	9	9	9	1GΩ	N/A	N/A
Gold				0.1Ω	± 5% (J)	N/A
Silver				0.01Ω	± 10% (K)	100

In a three-band resistor colour codes, there is no tolerance band, so 20% is assumed.

1. In four band resistor colour codes the tolerance band is used.
2. In the case of five band and six band resistor colour codes, the 5th band code is used for tolerance in percentages.
3. The temperature coefficient in parts per million/ Degrees Celsius(ppm/°C) tells the change in the resistance value with temperature.

A mnemonic to remember these numbers is,

Better Be Ready Or Your Great Big Venture Goes West.

Black Brown Red Orange Yellow Green Blue Violet Grey White   Or

Big, Beautiful Roses Occupy Your Gardens, But Violets Grow Wild.
Black, Brown Red Orange Yellow Green Blue Violet Grey White

Resistor Power Rating

The power rating of a resistor is measured in watts, and it's usually between ⅛W (0.125W) and 1W. Resistors with power ratings of more than 1W are usually referred to as power resistors, resistors and specifically for their power dissipating abilities.

Dissipation Types

Carbon Resistor – Composed with carbon dust or graphite paste. Used for low wattage resistors.

Film Resistor – Composed with conductive metal oxide paste. Used for low wattage resistors

Wire-wound Resistor – Mounted on metal bodies to achieve heat dissipation. Very high wattage.

Resistor wattage size is the power (in watts) a resistor can safely dissipate as heat. Common resistor wattage sizes are 1/8W, 1/4W, 1/2W, 1W, 2W, 3W, and 5W. Industrial applications may require higher wattage specialised resistors.

Example: A 12 V supply pushing 0.1 Amperes. What is the wattage and size of the resistor?

R = E / I = 12 / 0.1 = 120 Ohms

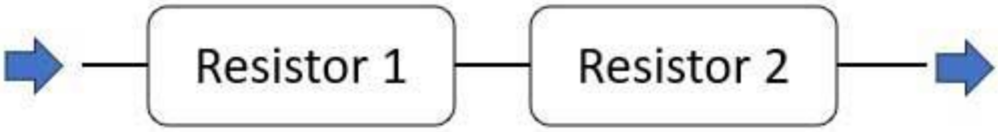
P = I x E = 0.1 x 12 = 1.2 Watts. Go bigger so a 2-watt resistor would be selected

Resistors in Series and parallel

We looked at circuits with one resistor and now we look at combinations of resistors. These configurations will look familiar.

Hint: Series connection. Electrons go through one device then the next.

Parallel connection. Electrons split and go own separate paths.



Series Connection

To calculate resistors in series, you add the resistances together.

Formula: Rt = R1 + R2 + R3 + R4…….n

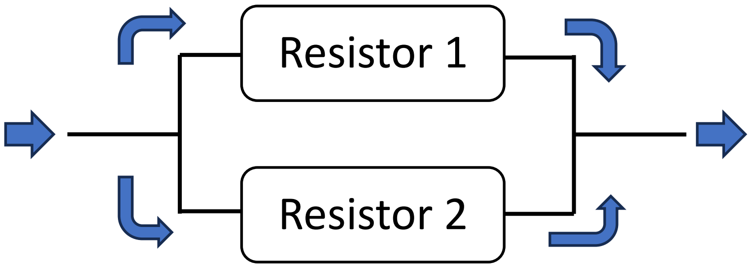
Example: R1, R2, R3 and R4 are 1.5 kΩ and are connected in series. What is the total resistance?

Rt = R1 + R2 + R3 + R4

Rt = 1.5 kΩ + 1.5 kΩ + 1.5 kΩ + 1.5 kΩ

Rt = 6 kΩ

The value of resistors in parallel will result in less than the smallest resistor value.



Parallel Connection

Formula: $\frac{1}{Rt} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3} \ldots n$

Example: R1, R2, R3 and R4 are 1.5 kΩ and are connected in parallel. What is total resistance?

1/Rt = 1/1500 + 1/ 1500 + 1/ 1500 + 1/ 1500

1/Rt = 0.00066 + 0.00066 + 0.00066 + 0.00066

1/ Rt = 0.0026

Now you need to flip Rt.

R = 1/ 0.0026

R = 384.61Ω

Practical Exercise

A practical exercise is included for comprehension of the material. However, the answers to all the questions can be calculated without the aid of test equipment. Go HERE

Next go to Lesson 3 questions.