

**Systems Engineering
Teach Yourself Series**

Topic 8: Electrotechnological components and their operation
Units 1, 2, 3 & 4

Contents

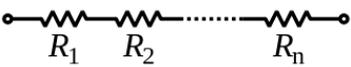
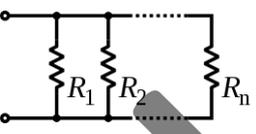
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Electrotechnological Components and their operation

Resistors

As it appears in Units 1 – 4

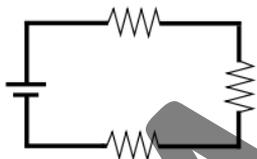
Resistors resist the flow of current. Resistance in series adds up and but when connected parallelly the effective resistance reduces below the value of the lowest resistor which is calculated using the formula

<p>Resistors in series</p>  <p>$R_{total} = R_s = R_1 + R_2 + \dots + R_n$</p>	<p>Resistors in parallel</p>  <p>$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_n}$</p>
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https://en.wikipedia.org/wiki/Series_and_parallel_circuits

Review Questions

1. Calculate the effective resistance, considering that the connecting wires have zero resistance if all resistances are valued at 10K each. Also, ignore the internal resistance of the cell.



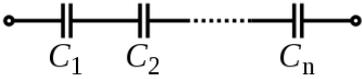
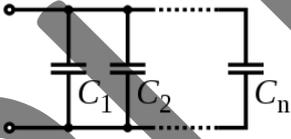
https://simple.wikipedia.org/wiki/Series_and_parallel_circuits

Capacitors

As it appears in Units 1 – 4

Capacitors are used for storage of electricity or for filtration. An application of the storage of electricity is in the reduction of the ripple effect of pulsating direct current (DC) which is usually obtained after stepping down the alternating current (AC) and then using diodes to convert it into pulsating DC. The capacitors of high value (e.g., 1000 micro farad) are used to reduce the ripple effect by supplying the voltage when the voltage drops in the ripple thus keeping the output almost constant. Capacitors are also used to filter frequencies and one application of this can be seen in construction of the digital musical instruments like synthesisers.

Capacitors in parallel adds up and but when connected in series, the effective capacitance reduces below the value of the lowest capacitor which is calculated using the formula $1/C = 1/C_1 + 1/C_2 + 1/C_3$

<p>Capacitors in series</p>  $\frac{1}{C_{\text{total}}} = \frac{1}{C_1} + \frac{1}{C_2} + \dots + \frac{1}{C_n}$	<p>Capacitors in parallel</p>  $C_{\text{total}} = C_1 + C_2 + \dots + C_n$
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https://en.wikipedia.org/wiki/Series_and_parallel_circuits

Review Questions

2. A power adapter used to supply power to an amplifier circuit running at 12 volts is causing a humming sound. An expert suggested to increase the filtration capacitor value by adding another capacitor of 1000 microfarad, rated at 16 volts. Suggest if this capacitor should be connected in series or parallel. Justify.

Semiconductors

As it appears in Units 1 – 4

Semiconductors are elements or compounds whose electrical conductivity lies between conductors and insulators. Semiconductors poor conductors at low temperatures but become good conductors at higher temperatures. Silicon is the most used semiconductor to fabricate electronic circuits. The second most used semiconductor is gallium arsenide which is used in the manufacture of laser diodes and solar cells.

A pure semiconductor is not useful to make electronic components. A semiconductor like silicon (element from group IV in the periodic table) is doped with either an element from group V to create a N type (abundant in free electrons) semiconductor or an element from group III to create a P type (lacking electrons) semiconductor.

Diode

As it appears in Units 1 – 4

Diode is a combination of a P type and N type semiconductor and is hence also called PN junction diode. Diodes allow the flow of current only in one direction. Current flows when diode is connected in forward bias. When connected in reverse bias they will stop the flow of current until the breakdown voltage is reached. Zener diodes use this property to control the voltage levels. Light emitting diodes (LED) are special diodes which produce light when current flows through them. The colour of the light is determined by the energy required by the electrons to crossover the band gap. The corresponding energy is released once this electron combines with the hole in the P type section.

A few different types of diodes that are useful for systems Engineering curriculum are:

Type of diode	Symbol	Function
Normal diode	 https://en.wikipedia.org/wiki/Diode#/media/File:Diode_symbol.svg	The most basic function of a diode is to allow current to flow in one direction
LED (Light emitting diode)	 https://en.wikipedia.org/wiki/Diode#/media/File:LED_symbol.svg	Emits light
Photo diode	 https://en.wikipedia.org/wiki/Diode#/media/File:Photodiode_symbol.svg	Allows current flow when light falls on it
Zener diode	 https://en.wikipedia.org/wiki/Diode#/media/File:Zener_diode_symbol.svg	They allow current to flow backwards when a certain voltage is reached hence, they can be used as voltage regulators.