DRIVES

Development and Research on Innovative Vocational Education Skills

SENSOR FUSION EXPERT

SFE.U1.E2 CIRCUIT DESIGN AND ANALYSIS

Electronics and Electricity Principles

JUNE 2021, Version 1

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The student is able to …

SFE.U1.E2.PC1	The student knows the notations and symbolic representation of the different elements of a circuit.
SFE.U1.E2.PC2	The student is able to distinguish and perceive series and parallel circuits.
SFE.U1.E2.PC3	The student is able to list and understand the main laws and theorems in circuit analysis and is able to apply the fundamental theorems and laws to analyse series and parallel circuits.
SFE.U1.E2.PC4	The student understands the concept of Impedance, Phasors and Complex Numbers.
SFE.U1.E2.PC5	The student is able to associate phasors to the time domain representation of electrical quantities (voltages and currents) of sinusoidal wave form.
SFE.U1.E2.PC6	The student knows how to calculate electric power in alternating current.
SFE.U1.E2.PC7	The student critically analyses resistor-capacitor (RC) and resistor-inductor (RL) circuits.
SFE.U1.E2.PC8	The student is able to design, integrate and manipulate electric circuits.

SYMBOLIC REPRESENTATION AND NOTATIONS OF THE DIFFERENT ELEMENTS OF A CIRCUIT

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To understand how an electronic circuit should be designed, it is necessary to have a notion of what can be included in its design, especially when talking about integrated circuits.

In this sense, some symbols and notations that can be applied in electronic circuits are presented.

SYMBOLIC REPRESENTATION AND NOTATIONS OF THE DIFFERENT ELEMENTS OF A CIRCUIT

The notations on electrical circuits are divided into the following groups:

- Wire and connection
- Power Supply
- Output Device
- Switch
- resistor
- Capacitor
- Diode
- Transistor
- Audio and Radio
- Meters and Oscilloscope
- Sensors (input devices)

SYMBOLIC REPRESENTATION AND NOTATIONS OF THE DIFFERENT ELEMENTS OF A CIRCUIT

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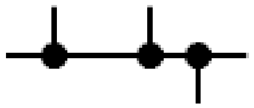
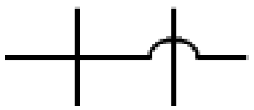
Wire and connection

Wire

Wires joined



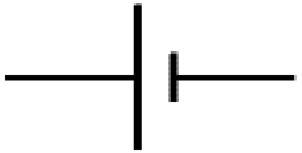
Wires not joined



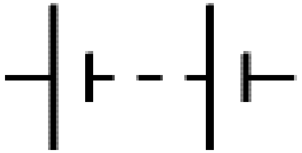
SYMBOLIC REPRESENTATION AND NOTATIONS OF THE DIFFERENT ELEMENTS OF A CIRCUIT

Power supply

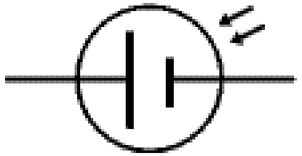
Cell



Battery



Solar Cell

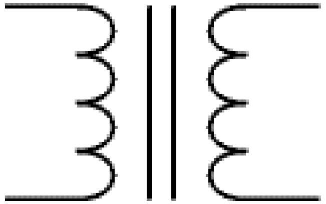


DC Supply

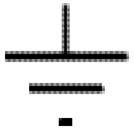
AC Supply

Fuse

Transformer



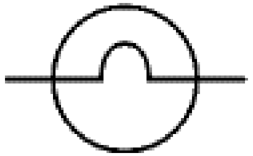
Ground



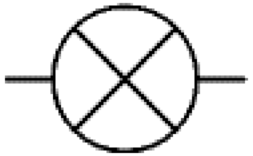
DC – Direct Current
AC – Alternated Current

Output device

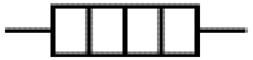
Lamp (lighting)



Lamp (Indicator)

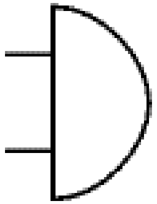


Heater

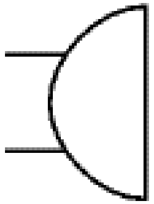


Motor

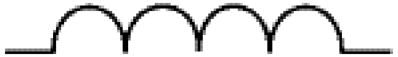
Bell



Buzzer



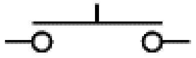
Inductor, Coil, Solenoid



SYMBOLIC REPRESENTATION AND NOTATIONS OF THE DIFFERENT ELEMENTS OF A CIRCUIT

Switch

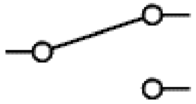
Push-to-make switch



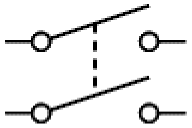
Push-to-break switch

SPST, on-off switch

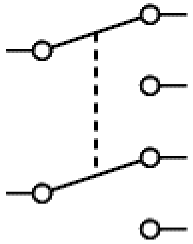
SPDT, 2-way switch



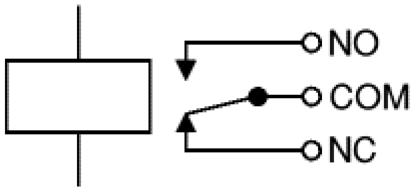
DPST switch



DPDT switch



Relay



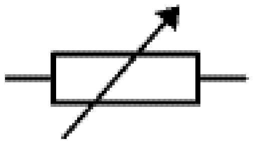
SPST - Single Pole, Single Throw
SPDT - Single Pole, Double Throw
DPST - Double Pole, Single Throw
DPDT - Double Pole, Double Throw

SYMBOLIC REPRESENTATION AND NOTATIONS OF THE DIFFERENT ELEMENTS OF A CIRCUIT

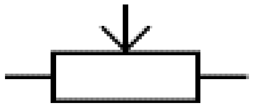
Resistor

Resistor

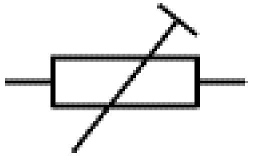
Rheostat variable resistor



Potentiometer variable resistor



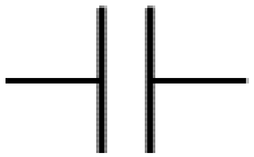
Preset variable resistor



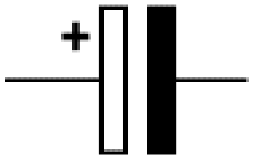
SYMBOLIC REPRESENTATION AND NOTATIONS OF THE DIFFERENT ELEMENTS OF A CIRCUIT

Capacitor

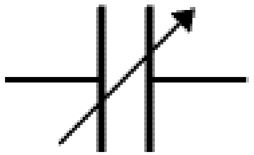
Capacitor unpolarised



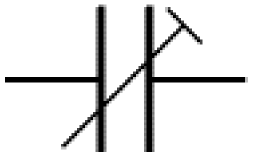
Capacitor polarised



Variable capacitor



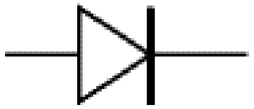
Trimmer variable capacitor



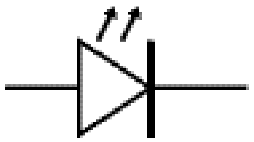
SYMBOLIC REPRESENTATION AND NOTATIONS OF THE DIFFERENT ELEMENTS OF A CIRCUIT

Diode

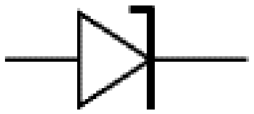
Diode



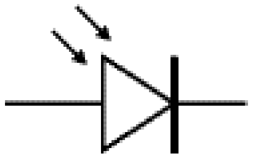
Light Emitting Diode



Zener diode

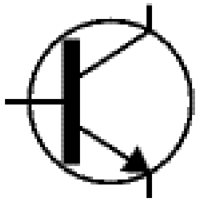


Photodiode

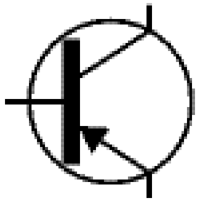


Transistor

Transistor NPN



Transistor PNP

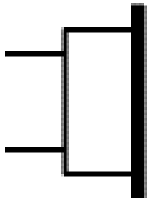


SYMBOLIC REPRESENTATION AND NOTATIONS OF THE DIFFERENT ELEMENTS OF A CIRCUIT

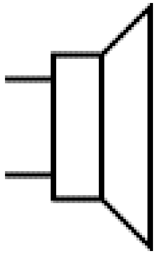
Audio and Radio

Microphone

Earphone

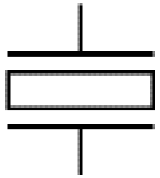


Loudspeaker



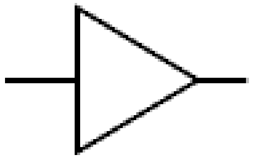
Piezo

Transducer



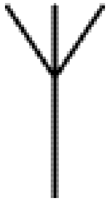
Amplifier

(general symbol



Aerial

(Antenna)



SYMBOLIC REPRESENTATION AND NOTATIONS OF THE DIFFERENT ELEMENTS OF A CIRCUIT

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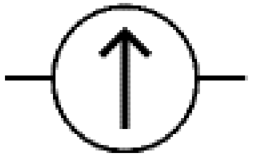
Meters and Oscilloscope

Voltmeter

Ammeter

Galvanometer



Ohmmeter

Oscilloscope

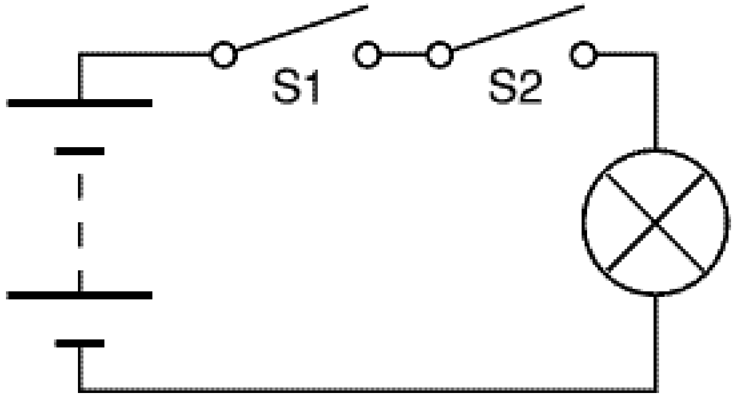
There are two types of electronic circuits:

- Series Circuits
- Parallel Circuits

Definition

It can be said that a series circuit is that the loads have only one point in common between them.

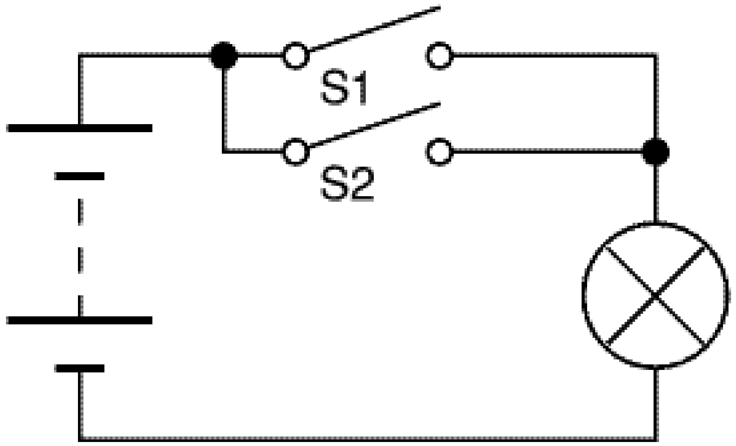
There is only one way for the passage of electric current.



Definition

It can be said that a parallel circuit is one in which the loads have a branch point between them.

There are at least two paths for the passage of electrical current.



For the creation and analysis of an electrical circuit, there are several laws and theorems that whoever wants to design a circuit will have to understand in order to implement them more effectively.

Here are the theorems and necessary laws:

- Ohm’s Law.
- Kirchhoff’s Laws
- Thevenin’s Theorem
- Superposition Theorem
- Reciprocity Theorem
- Compensation Theorem
- Millman’s Theorem
- Joule’s Law
- Maximum Power Transfer Theorem

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Ohms Law

- Ohm's law determines that the difference in potential between the two points of a resistance is equal to the electrical current that is established in it.

$$U = r.i$$

Tension or Electric Potential

Resistor

Electric Current

Kirchhoff’s Laws

- As for Kirchhoff's laws, there are two and they serve to conserve the charge both in the grids and in the nodes of the electrical circuits. The laws in question are:

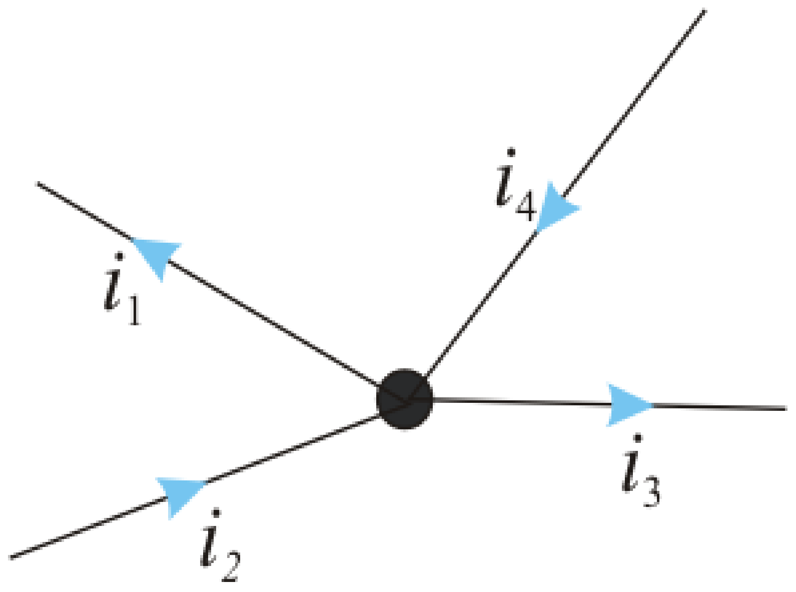
Law of Knots

Law of Knits

Kirchhoff’s Laws – Law of Knots

- The law of knots holds that the sum of all currents arriving at a given node and the sum of all currents leaving that node must be equal.

- Here is the resolution for the example shown in the figure:
- $-i_1+i_2-i_3+i_4=0$



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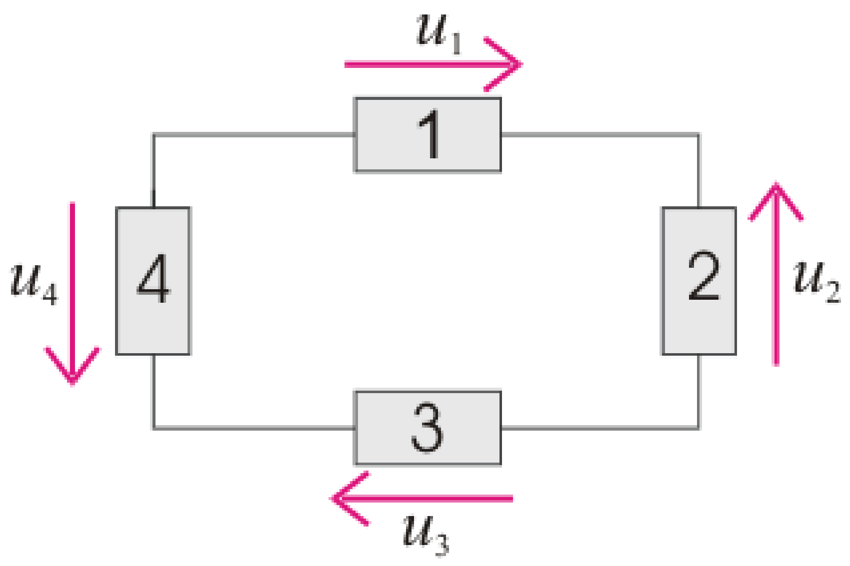
Kirchhoff's Laws – Law of Knits

- The law of grids states that the sum of electrical potentials along a grid is zero.
- Here is the resolution for the example shown in the figure:
- $-u_1-u_2+u_3-u_4=0$



Thevenin's Theorem

- Thevenin defends in his theorem that any linear circuit, that is, with two terminals, can be replaced by a circuit with the same voltage and resistance.

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Superposition Theorem

- This theorem holds that the electrical current in a bilateral circuit is equal to the sum of all currents from each source. However, these must be included individually in the circuit.

- This law essentially works for circuits that have multiple input sources or multiple circuits.

Reciprocity Theorem

- This theorem is used in bilateral circuits, that is, they have only one energy source.

- He argues that in a linear circuit with a voltage source, if you know the current measurement on some side of the circuit, you can change the voltage source to another point in this circuit, and the value will be the same.

Compensation Theorem

- This theorem holds that any cession in a circuit can be replaced by a voltage source. However, that source must have resistance = 0 and a voltage equal to the drop of the replacement resistance, derived from the current that was running on it.

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Millman’s Theorem

- This theorem argues that in a circuit with several voltages in parallel, these can be reduced by just one.

- The advantage of this theory is that it allows to know what is the current or voltage in one or several terminals without the need to apply other theorems.

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Joule’s Law

- When electrical current flows through an electronic circuit, it will react to a thermal effect which heats up.
- Regardless of whether this warming is noticeable or not, it happens. This effect is called the thermal effect or joule effect.
- What the law says is that when electrical current passes through a heat receiver, electrical energy is transformed into thermal energy, which is equal to the value of resistance.

$$W = R.I^2.t$$

Energy *Resistor* *Intensity* *Time*

Maximum Power Transfer Theorem

- This theorem states that for a circuit to obtain the maximum power over a load through a source with internal resistance, the value of the resistance of the internal load must be equal to the value of the internal resistance of the source.

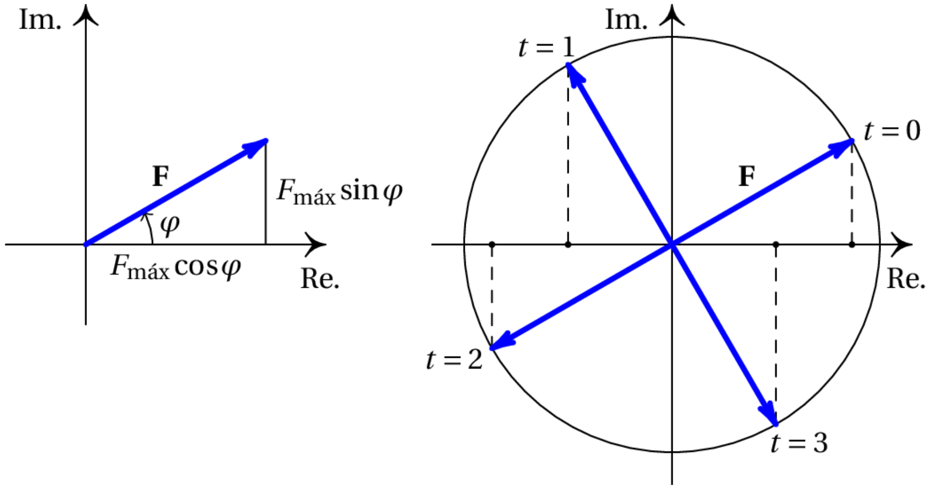
- This theorem is important, for example, if you want to build an audio amplifier and want to know what features a load source must contain in order to deliver the greatest power to the amplifier.

Understanding Impedance

- Impedance is the name given to the phenomenon of when an electrical circuit opposes the passage of electrical current when it is subjected to a voltage source.
- **Simply put, it is the total resistance load in an alternating current circuit.**

Understanding Phasor

- "A phasor is a complex number that represents the magnitude and phase of a sine wave."
- To understand phasors, it is necessary to have knowledge of complex numbers.
- The phasor is obtained by adding the complex numbers or vectors that represent the phasors of the summed functions.



Graphic representation of a F phasor

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- The student is able to associate phasors to the time domain representation of electrical quantities (voltages and currents) of sinusoidal wave form.

SFE.U1.E2.PC5

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Understanding Complex Numbers

- Complex numbers are very useful when analyzing alternating current circuits.
- The expression "complex numbers" began to be used in relation to the numerical set whose representatives are Z = a + bi, with i = √– 1 and with a and b to belong to the sets of real numbers.
- This representation is called the algebraic form of the complex number Z.
- Thus, the complex number z can be written in rectangular form as:

$$z=x+jy$$

How to calculate electric power in alternate current

- Unlike direct current, alternating current has three types of power circuits, which are:
  - Active Power
  - Reactive Power
  - Apparent Power

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How to calculate electric power in alternate current

Active Power

- Must be calculated in watts
- There are three formulas for these to be calculated:

$$P=V.I \qquad P=R.I^2 \qquad P=\frac{V^2}{R}$$

P= Active Power

V= Voltage

I= Electric Power

R= Resistance

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How to calculate electric power in alternate current

Reactive Power

- It is calculated in Volt Ampere reactive (VAr)

$Q = S.Sen\rho$ $\quad\quad$ $Q = \sqrt{S^2 - P^2}$

Q= Reactive Power

S= Apparent Power

Senp = lag constant

P= Active Power

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How to calculate electric power in alternate current

Apparent Power

- Apparent power is calculated in volt amperes (VA).

$$|s| = \dot{V} . \dot{I} \qquad S = \frac{P}{fp} \qquad S = \sqrt{P^2 + Q^2}$$

$|s|$= Apparent Power Module

$\dot{V}$= Complex Electrical Voltage

$\dot{I}$= Complex Electric Current

fp= Power Factor

In the analysis of electrical circuits, we have to know how to analyze the state of the circuit. For this, there are two types of very interesting analyses.

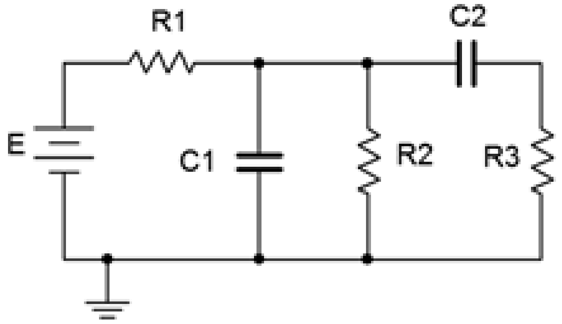
- The Resistor-Capacitor (RC) Circuit
- The Resistor-Inductor Circuit (RL)

The Resistor-Capacitor (RC) Circuit

- In the initial state, the capacitor voltage cannot be changed instantly.
- As a general rule, it should be assumed that the enabler is not initially loaded
  - Voltage=0
- If energy is injected into the circuit and it does not have voltage, it can be said that the behavior is a short-circuit.

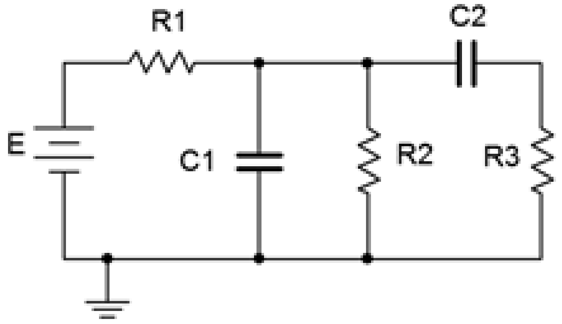
The Resistor-Capacitor (RC) Circuit

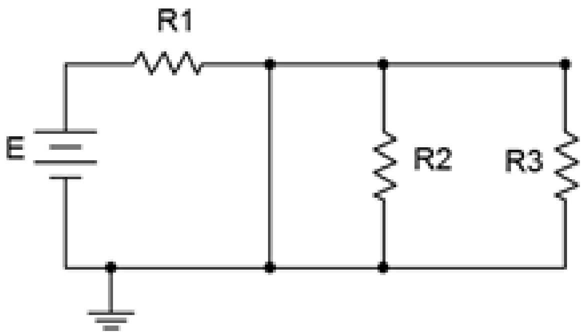
- As mentioned earlier, C1 and C2 have voltage equal to 0.
- So, if power is injected, the capacitors are in short circuit mode.



The Resistor-Capacitor (RC) Circuit

- Redrawing the circuit can obtain a similar one.
- There may be a short on C2 on R2 and R3. There is also short on C1.
- So, only R1 and source E were left, in this case, as the currents are energized, this one will start charging the capacitors.
- At that point, no other current is flowing, and the capacitor can be said to behave like an open one.
- **It is concluded that in steady state the enablers are open.**



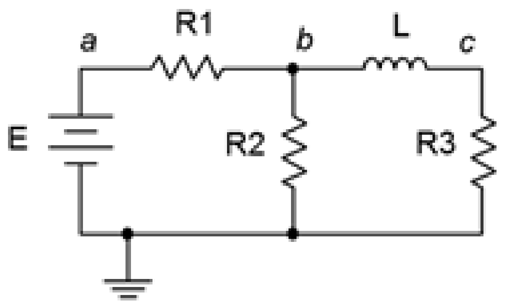


The Resistor-Inductor Circuit (RL)

- Current cannot vary.
- Until it is injected with energy, this circuit is still at a value of zero.
- It can be stated that for the Direct Current analysis the inductors appear as open and in the steady state the inductors appear as short.

The Resistor-Inductor Circuit (RL)

- An example of an RL circuit where L is open can be seen.
- Thereby R1 and R2 are in series with the power source.
- So in steady state and no shorts, with a parallel combination in R2 and R3, all inductors exhibit some Resistance.
- It follows that in most cases it is good to think of the inductor as a real inductance.



Software to Design Circuits

- In order to design and test your circuits, we advise you to use free software, so that you can design your circuits and test your connections.
- easyeda design is free, with advertising, however, it can also be paid for not having ads and more features.
- Try it out at https://easyeda.com/

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DRIVES

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