


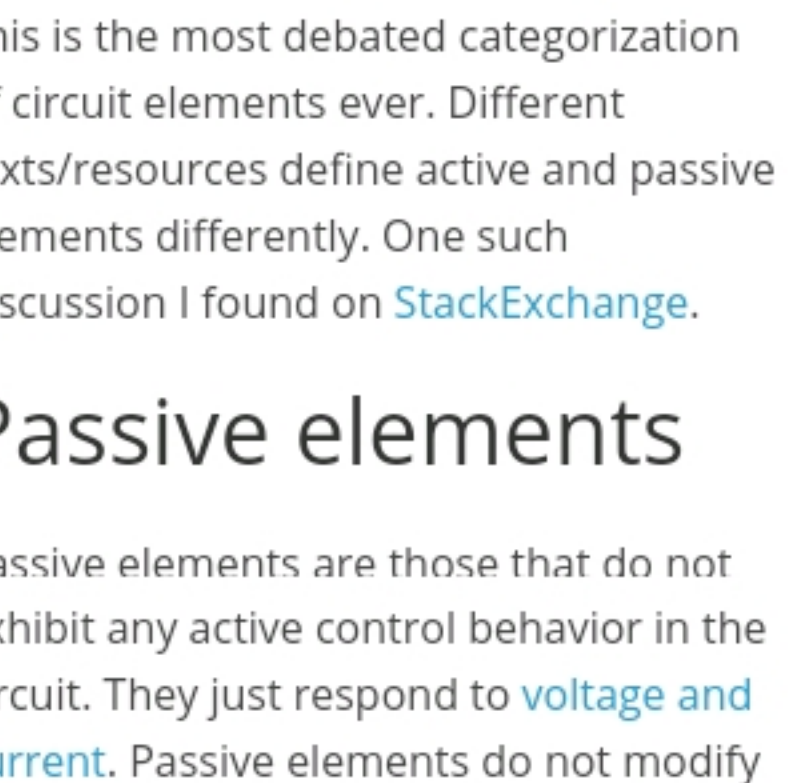


Uncategorized

Basic Circuit Elements – Active, Passive, Linear, Nonlinear

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  0 Comments

An electrical or electronic circuit basically means various **circuit elements** or **circuit components** interconnected by wires. Various circuit components can be connected in a specific manner to perform a specific task. Commonly, circuit elements can be classified in different categories as (i) active and passive elements, (ii) linear and non-linear elements, (iii) unilateral and bilateral elements etc.



Passive elements and active elements

This is the most debated categorization of circuit elements ever. Different texts/resources define active and passive elements differently. One such discussion I found on [StackExchange](#).

Passive elements

Passive elements are those that do not exhibit any active control behavior in the circuit. They just respond to **voltage and current**. Passive elements do not modify or amplify signals. They do not generate or supply energy. They just either dissipate energy (resistors) or store and release energy (capacitors and inductors). Passive components do not require an additional power or external power supply for operation.

Examples of passive elements:
Resistors, Capacitors and Inductors. However, Memristors, often called **fourth passive component**, are seemingly getting a boost in their research.

Active elements

Active elements are those that can actively control the circuit behavior or supply energy to the circuit. Elements that modify signals or amplify signals are also counted as active elements. For example, transistors can control the current of one circuit actively depending upon some other current. Voltage and current sources are also counted as active elements as they supply energy to the circuits.

Examples of active elements: Voltage and current sources, transistors etc.

What about a diode? Many texts/resources include diodes into active elements. For example, *“Practical Electronics: Components and Techniques”* by J. M. Hughes and *“Basic Electronics and Linear Circuits”* by N. N. Bhargava. On the other hand, many references include diodes into passive elements too. Here is a nice discussion on whether a **diode an active device or passive device**.

Linear and non-linear elements

Linear elements exhibit a linear relationship between voltage and current. A linear element primarily has two properties: homogeneity and additivity. For example, a resistor is a linear element since it possesses both properties. According to Ohm’s law, $V = IR$, where V is voltage across the resistor, I = current through it and R = the resistance (constant). It is clear that, here, 10% scaling of the voltage results in 10% scaling of the current. This is called as homogeneity property. Also, if I_1 is resulting current from voltage V_1 , and I_2 is resulting current from voltage V_2 , then applying voltage V_1+V_2 will result in the current equal to I_1+I_2 . This property is called as additive property. Similarly, capacitors and inductors are also linear elements.

Nonlinear elements do not exhibit linear relationship between voltage and current. Also, they do not possess homogeneity and additive properties. For example, diodes, in which current is an exponential function of the voltage. Transistors and most of the other semiconductor components are non-linear.

Unilateral and Bilateral elements


Unilateral elements allow conduction of current in only one direction. For example, rectifier diodes allow current flow in one direction only when they are forward biased. They block current in reverse direction until breakdown occurs. Such elements are called as unilateral elements.

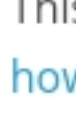
Bilateral elements allow current conduction in both directions. For example, resistors, inductors and capacitors show same resistance to the current no matter in which direction the current is flowing. However, some capacitors, such as electrolytic capacitors, are unilateral since they need to be connected with the correct polarity.

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