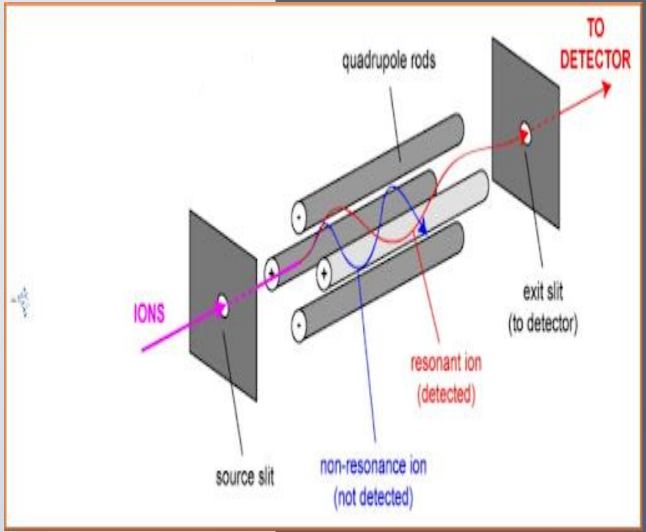
Quadripoles(two-Pole Networks)



DR. GUECHI Nassima

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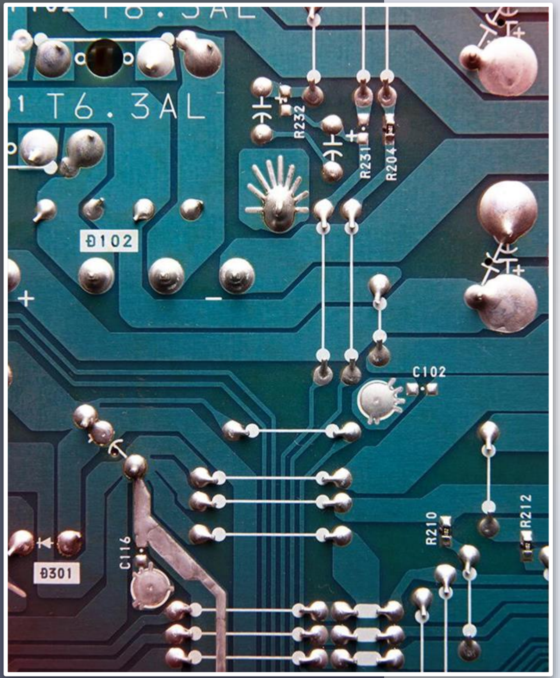


01

Introduction

Introduction to Quadripoles (two-Pole Network)

What is a Quadripole?

A quadripole, or two-pole network, is an electrical circuit with two pairs of terminals one pair for the input and another for the output. It is a fundamental concept used in circuit analysis to study the relationship between voltages and currents at these terminals.

Applications in Electronics

Quadripoles are widely used to represent components like amplifiers, filters, and transmission lines. They help simplify complex circuits by breaking them down into smaller,easier-to understand parts, which helps with analysis and design.

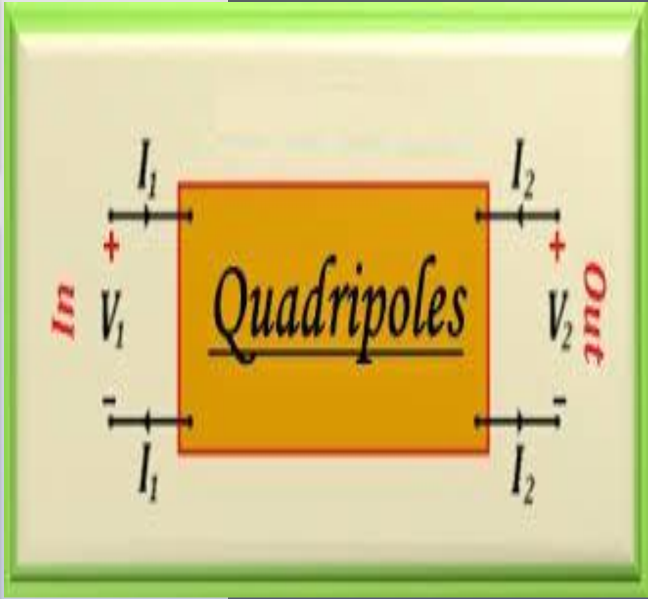
Why Study Quadripoles?

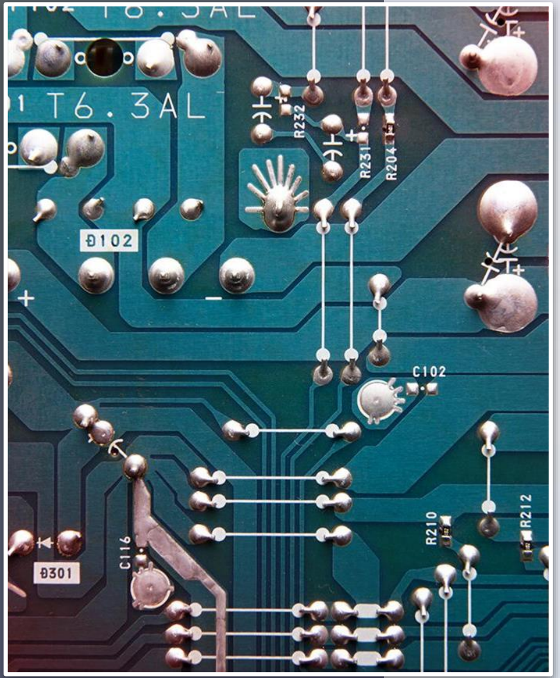
Understanding quadripoles is important for creating effective electronic systems. They give a simple way to study how different parts of a circuit work and make sure that all the parts function well together.

Quadripole

A quadripole is an electrical circuit made up of a number of passive and active elements, with four terminals, which is why it gets its name. It has two input terminals and two output terminals.

The quadripole is characterized by four electrical parameters: input voltage V_1 and input current I_1, as well as output voltage V_2 and output current I_2. Two of these variables are independent, while the others are related to them through the quadripole's parameters. Under normal operating conditions, the quadripole (Q) is driven at the input by a voltage source e and has an internal impedance Z_{in}, while the output is connected to a load with an impedance Z_{out}.





02

Passive-Active Quadripole

Passive-Active Quadripole

Passive Quadripole

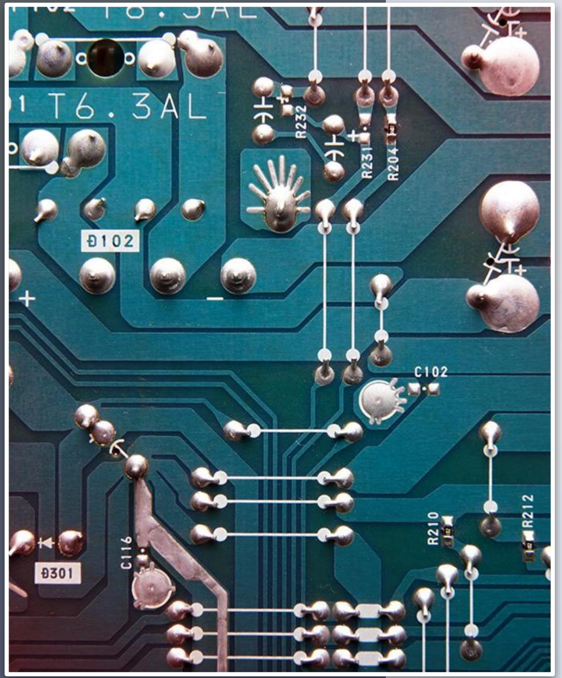
A passive quadripole is a two-pole network that consists of only passive components, such as resistors, capacitors, and inductors. These networks do not require an external power source to operate and are characterized by their ability to modify the amplitude and phase of the input signal.

Active Quadripole

An active quadripole, on the other hand, includes active components like amplifiers, voltage sources, or current sources. These networks can provide gain, filtering, or impedance transformation abilities, and they require an external power source to operate.

Hybrid Quadripole

Sometimes, a quadripole can use both passive and active parts, creating a mixed quadripole. These systems use the advantages of both types of parts to perform more complicated tasks and achieve better results.

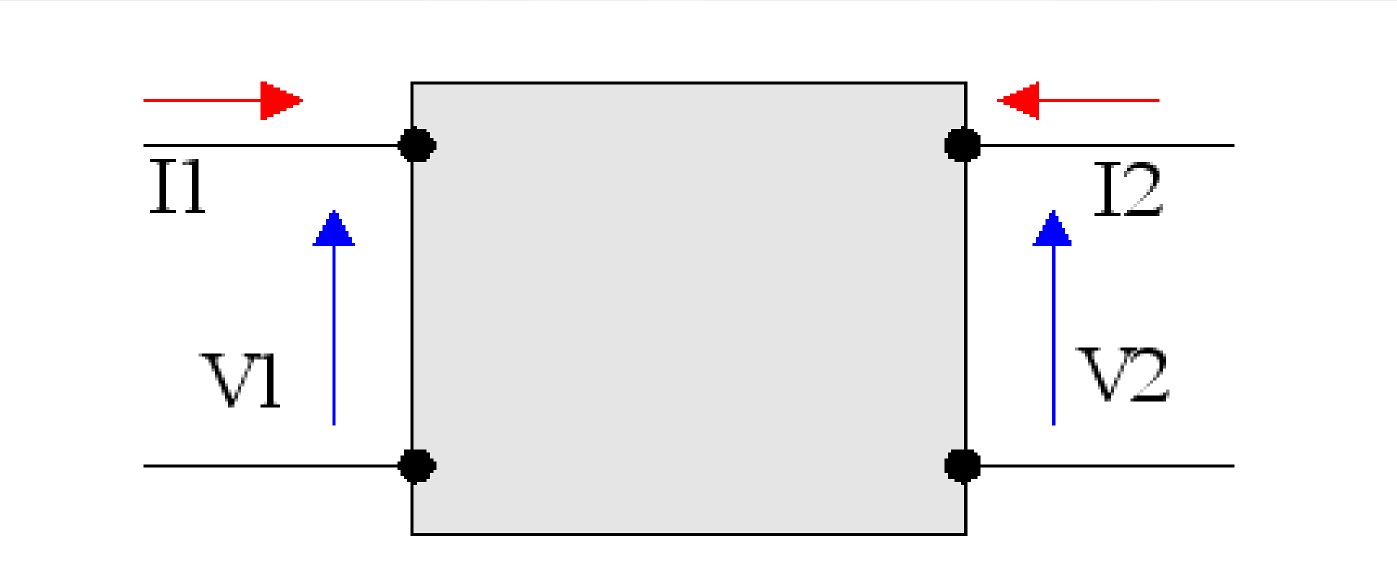


03

Matrix of a Quadripole

Matrix of a Quadripole

The behavior of a quadripole can be explained using a matrix, which connects the input and output values like voltages and currents. The numbers in this matrix give a simple and organized method to study and design electrical systems



Impedance Matrix [Z]

Definition:

"The input and output voltages are expressed in terms of the input and output currents. The matrix elements represent impedances. We express the voltages based on the currents, and the matrix elements have the dimensions of impedances (resistors)."

Mathematical Representation:

The impedance matrix $[Z]$ relates the input and output voltages to the currents in a two-port network. It is defined as:

$$\begin{pmatrix} V_1 \\ V_2 \end{pmatrix} = \begin{pmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{pmatrix} \begin{pmatrix} I_1 \\ I_2 \end{pmatrix}$$

Where:

- V_1 and V_2 are the voltages at ports 1 and 2.
- I_1 and I_2 are the currents entering ports 1 and 2.
- Z_{ij} are the elements of the impedance matrix.

Admittance Matrix [Y]

Definition:

The admittance matrix $[Y]$ relates the input and output currents and voltages in a quadripole (four-terminal network). Each element Y_{ij} of the matrix shows how the current at port i responds to the voltage at port j when all other ports are short-circuited.

Mathematical Representation:

The admittance matrix $[Y]$ relates the currents to the voltages in a two-port network. It is defined as:

$$\begin{pmatrix} I_1 \\ I_2 \end{pmatrix} = \begin{pmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{pmatrix} \begin{pmatrix} V_1 \\ V_2 \end{pmatrix}$$

Where:

- I_1 and I_2 are the currents entering ports 1 and 2.
- V_1 and V_2 are the voltages at ports 1 and 2.
- Y_{ij} are the elements of the admittance matrix.

Hybrid Matrix [H]

Definition:

"We express the output current and the input voltage in terms of the input current and the output voltage. This is a representation commonly used for the study of transistors."

Mathematical Representation:

The hybrid matrix $[H]$ relates the input and output voltages and currents in a two-port network. It is defined as:

$$\begin{pmatrix} V_1 \\ I_2 \end{pmatrix} = \begin{pmatrix} H_{11} & H_{12} \\ H_{21} & H_{22} \end{pmatrix} \begin{pmatrix} I_1 \\ V_2 \end{pmatrix}$$

Where:

- V_1 is the input voltage at port 1.
- I_2 is the output current at port 2.
- I_1 is the input current at port 1.
- V_2 is the output voltage at port 2.
- H_{ij} are the elements of the hybrid matrix.

Transfer Matrix [T]

Definition:

The transfer matrix $[T]$ is a mathematical representation used in the analysis of multi-port networks (including two-port and four-port networks). It describes the relationship between the input and output voltages and currents at the ports of the network.

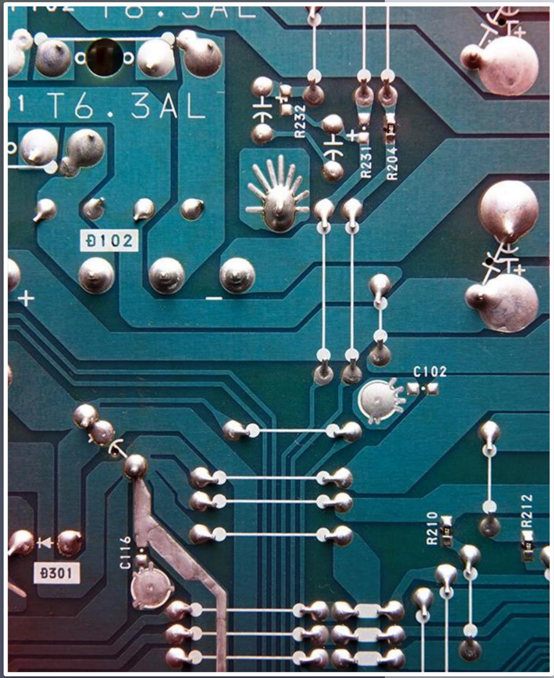
Mathematical Representation:

The transfer matrix $[T]$ describes how the output voltages and currents are related to the input voltages and currents in a two-port network. It is defined as:

$$\begin{pmatrix} V_1 \\ I_2 \end{pmatrix} = \begin{pmatrix} T_{11} & T_{12} \\ T_{21} & T_{22} \end{pmatrix} \begin{pmatrix} V_2 \\ I_1 \end{pmatrix}$$

Where:

- V_1 is the output voltage at port 1.
- I_2 is the output current at port 2.
- I_1 is the input current at port 1.
- V_2 is the input voltage at port 2.
- T_{ij} are the elements of the transfer matrix.

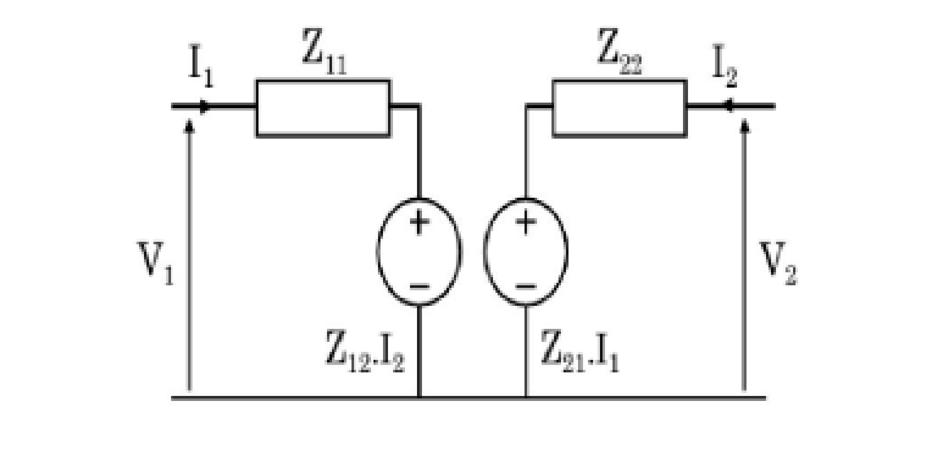


04

Representation of quadripoles in equivalent circuit form

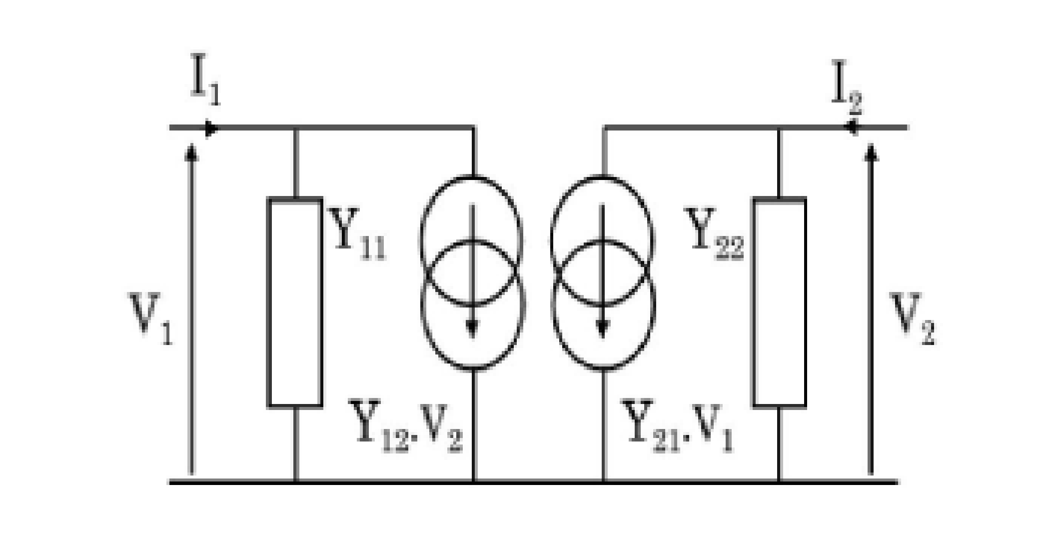
Impedance representation

It is sometimes convenient to replace the studied quadripole with its equivalent circuit, represented by the quadripole matrix. Knowing this equivalent circuit is particularly useful when the actual network is not known, and the determination of the parameters results from measurements.



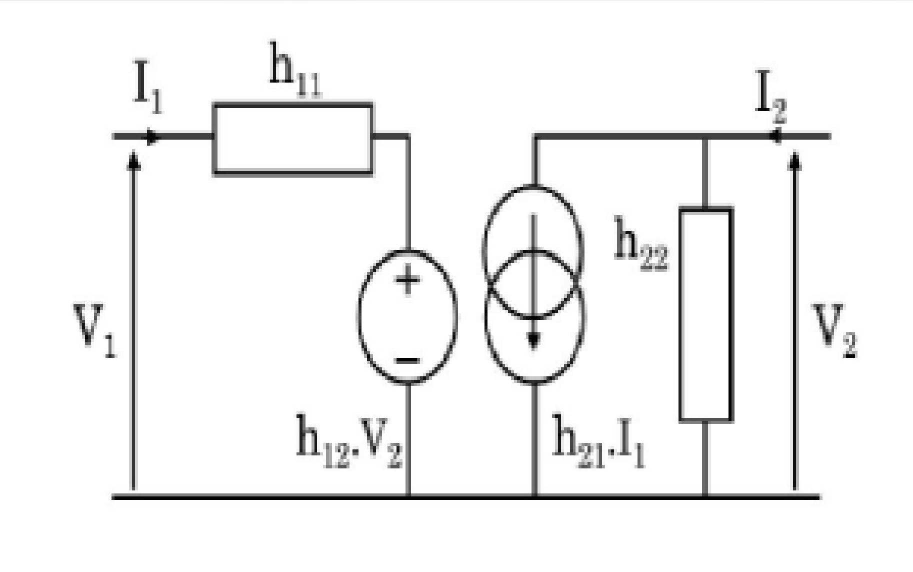
Admittance representation

Equivalent circuit with admittances and current sources.



Hybrid representation

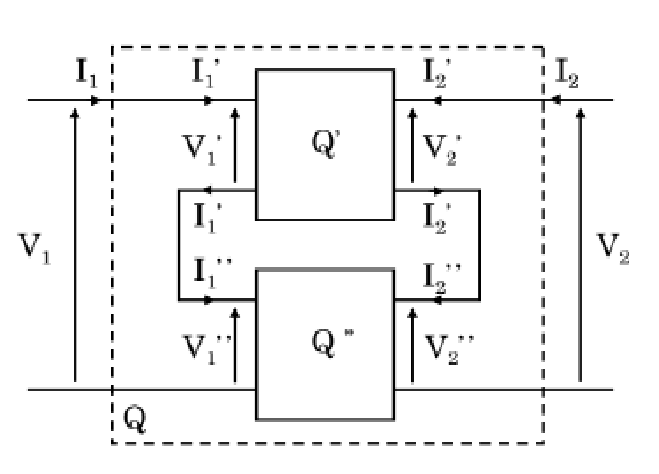
The equivalent circuit consists of an impedance (h11), an admittance (h22), a voltage source (h12·V2), and a current source (h21·I1).



Associations of quadripoles

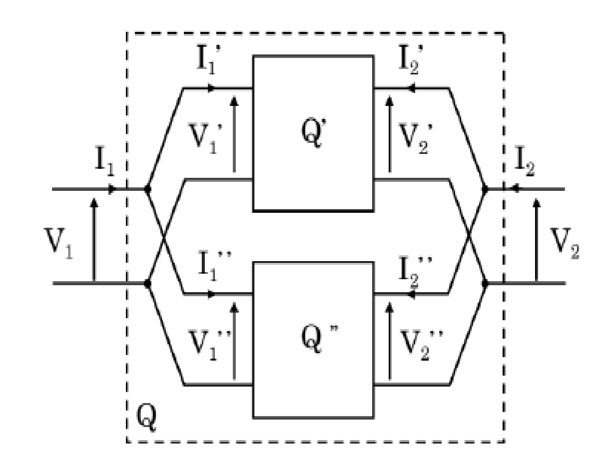
Series-series association

Let the two quadripoles Q′ and Q″ have impedance matrices [Z′] and [Z″], respectively, and they are connected in a series-series configuration as shown in the figure below.



Association parallel-parallel

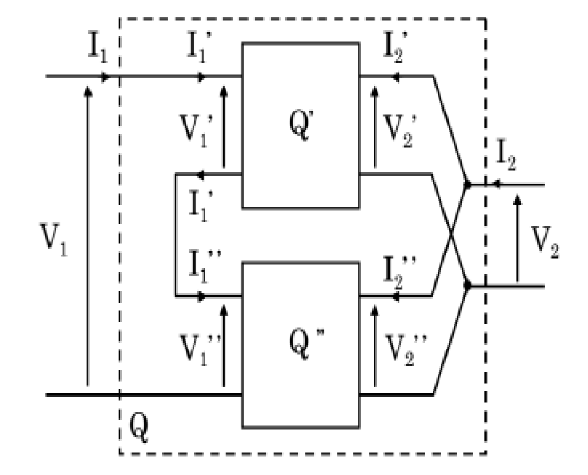
Let the two quadripoles Q′ and Q″ have admittance matrices [Y′]and [Y″], respectively, and they are connected in a parallel-parallel configuration as shown in the figure below.



Associations of quadripoles

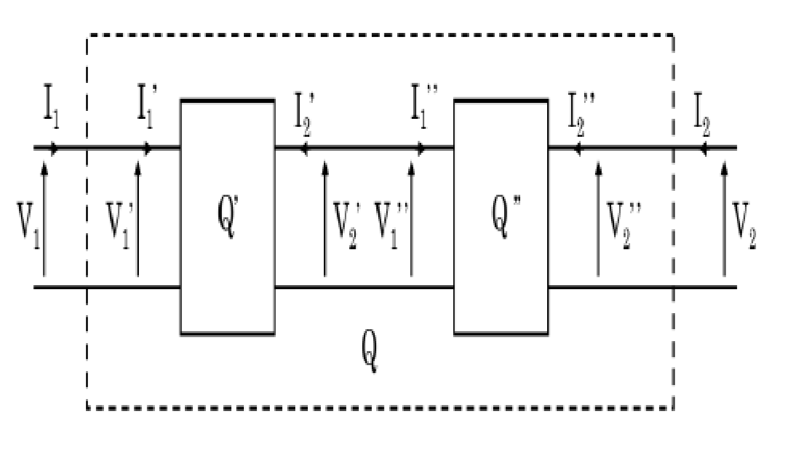
Series-parallel association

Let the two quadripoles Q′ and Q″ have hybrid matrices [H′] and [H″], respectively, and they are connected in a series-parallel configuration as shown in the figure below.



Cascade Association

Let the two quadripoles Q′and Q″ have transfer matrices [T′]and [T″], respectively, and they are connected in a cascade configuration as shown in the figure below.



Examples of quadripoles (two-port networks) in personal computers (PCs) include:

Power Supply Units (PSUs): The PSU can be modeled as a quadripole to analyze the relationship between input voltage/current and output voltage/current for various components.

Motherboard Circuits: Different circuits on the motherboard, such as signal conditioning circuits, can be treated as quadripoles to study their behavior in terms of input and output signals.

Network Interface Cards (NICs): NICs can be modeled as quadripoles to understand how data signals are transmitted and received over the network.

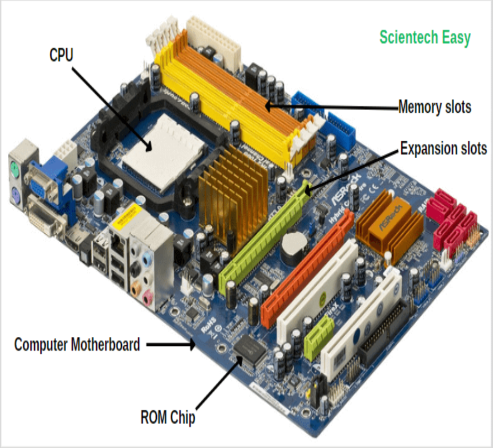
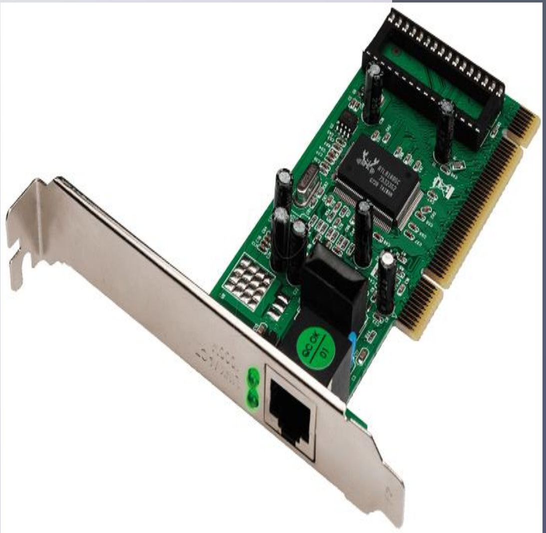
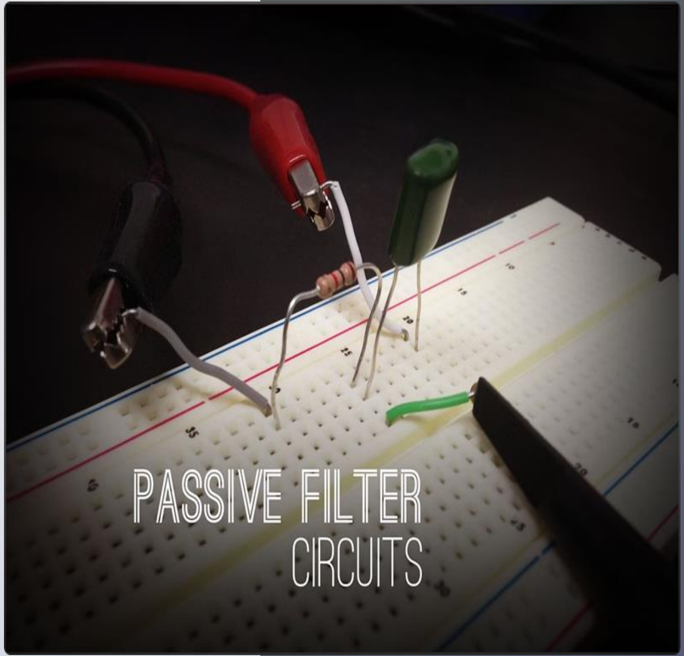


Fig: A typical Motherboard in a computer system



Passive Filters: The Invisible Heroes of Electronics



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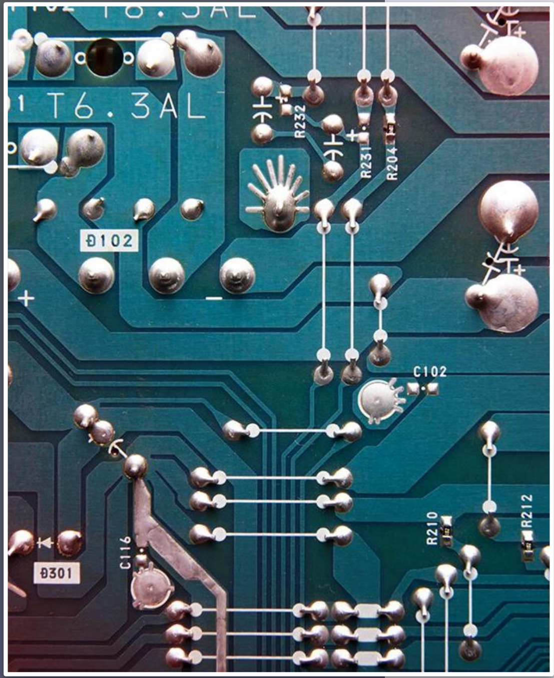


01

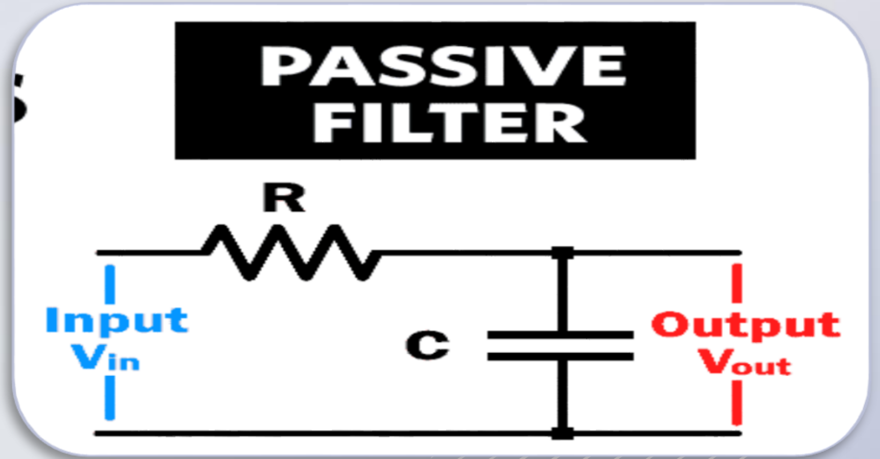
Introduction

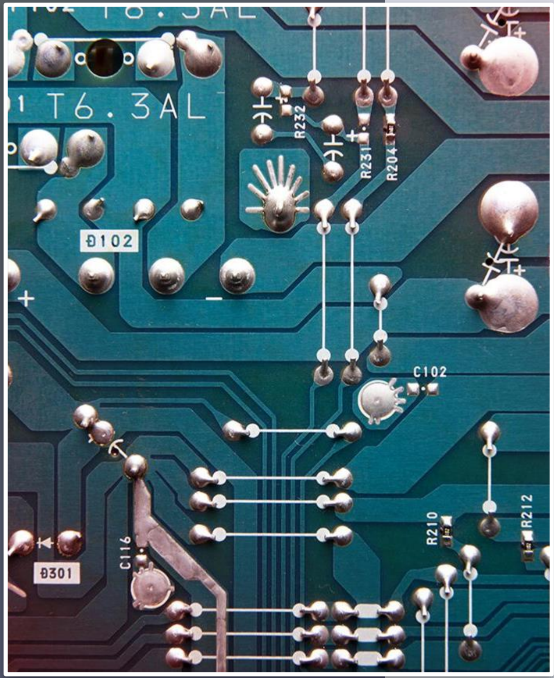
Introduction to Passive Filters

In the world of electronics, passive filters play a crucial role in shaping signals and refining performance across a wide range of applications. Whether in audio systems, telecommunications, or signal processing, these filters work silently behind the scenes, enhancing sound quality, isolating specific signals, and ensuring efficient data transmission. Their impact on signal clarity and noise reduction makes them invaluable components, contributing significantly to the seamless operation and reliability of electronic devices.

Definition

A passive filter is an electronic circuit made up of passive components like resistors, capacitors, and inductors. Its purpose is to allow specific frequency ranges to pass through while blocking others, without requiring any external power source. Passive filters are commonly used to improve signal quality by filtering out unwanted noise and enhancing the desired signal in audio, radio, and signal processing applications.





02

Types of Passive Filters

Types of Passive Filters

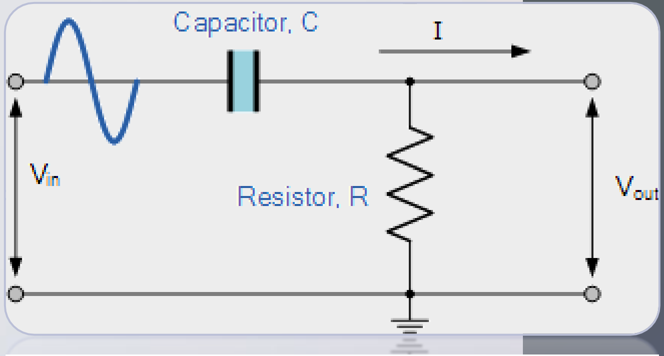
Passive filters come in different types, each designed to control how frequencies are transmitted or blocked in electronic circuits. By selectively allowing certain frequencies to pass through while filtering out others, these filters enhance signal quality and are essential for a wide range of applications. Here's an overview of the main types of passive filters and their functions.

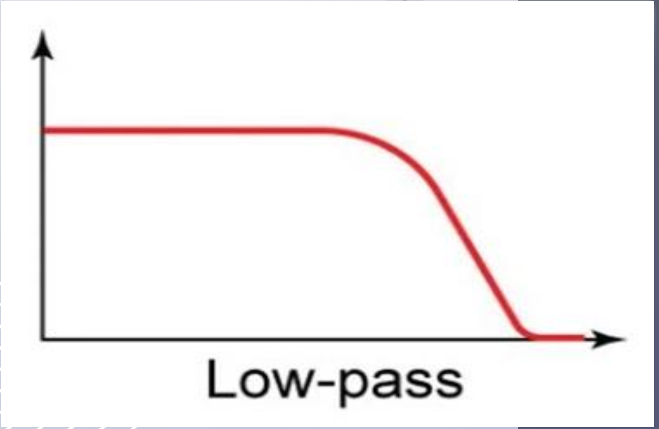
According to the main function of filters, which is to allow or block certain frequencies, filters are divided into four types:

- **Low-Pass Filters:** allow only low frequencies to pass;
- **High-Pass Filters**: allow only high frequencies to pass;
- **Band-Pass Filters**: allow only a specific range of frequencies to pass;
- **Band-Stop Filters**: block a specific range of frequencies.

Low–Pass Filters

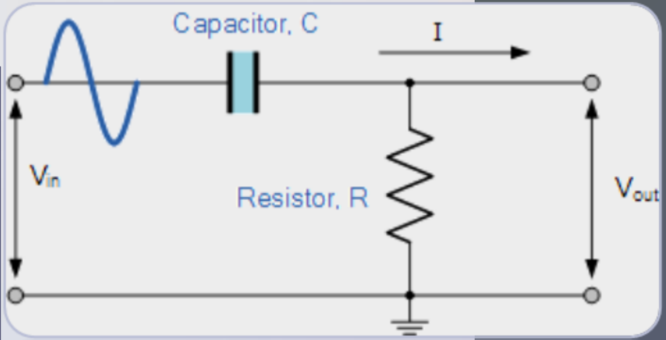
- Low-pass filters allow signals below a certain cutoff frequency to pass through unimpeded.
- They effectively block high-frequency noise, smoothing and shaping the waveform for cleaner output.
- Design parameters like resistor and capacitor values determine the specific cutoff frequency.
- Low-pass filters are commonly used in audio systems, power supplies, and sensor circuits.

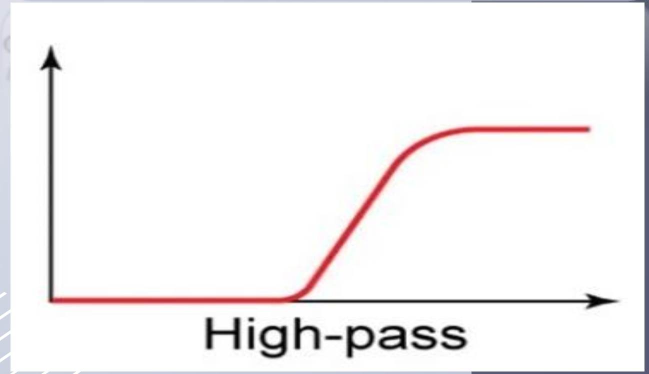




High-Pass Filters

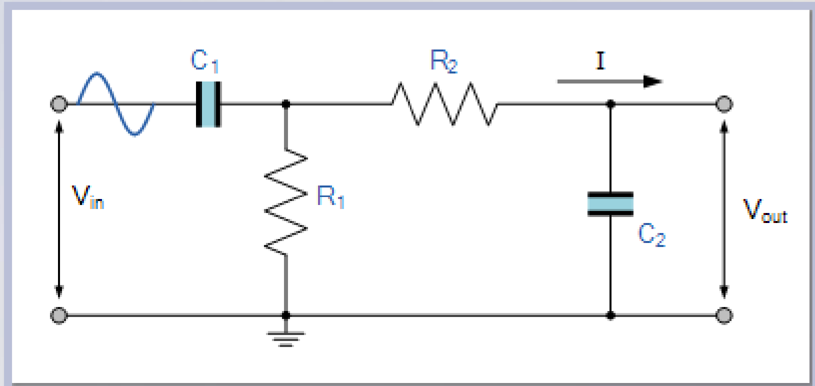
- High-pass filters allow signals above a specific cutoff frequency to pass through unimpeded.
- Cutoff frequency is determined by the values of capacitors and resistors in the circuit.
- They effectively block low-frequency components, sharpening edges and enhancing high-frequency details.
- High-pass filters find applications in audio systems, instrumentation, and communication networks.

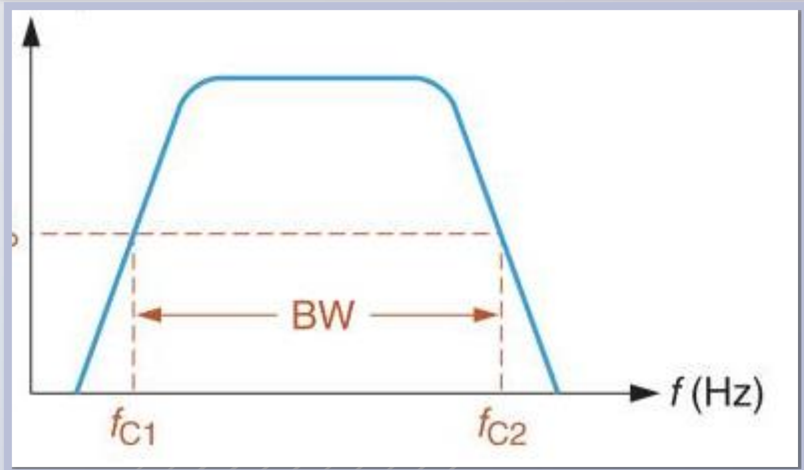




Band-Pass Filters

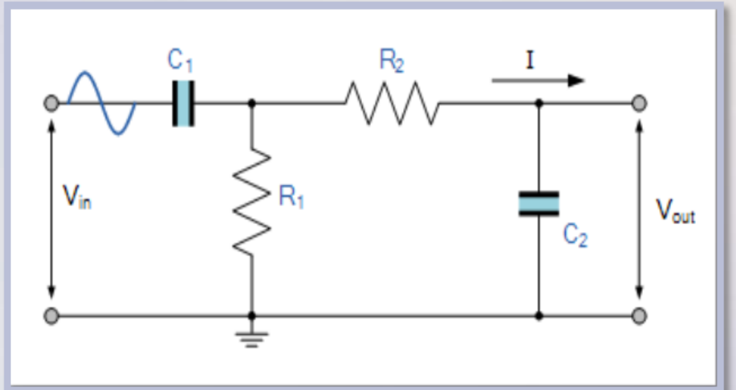
- Band-pass filters allow a specific range of frequencies to pass through while blocking frequencies outside that range.
- By combining low-pass and high-pass filter stages, band-pass filters isolate target signals and suppress unwanted noise.

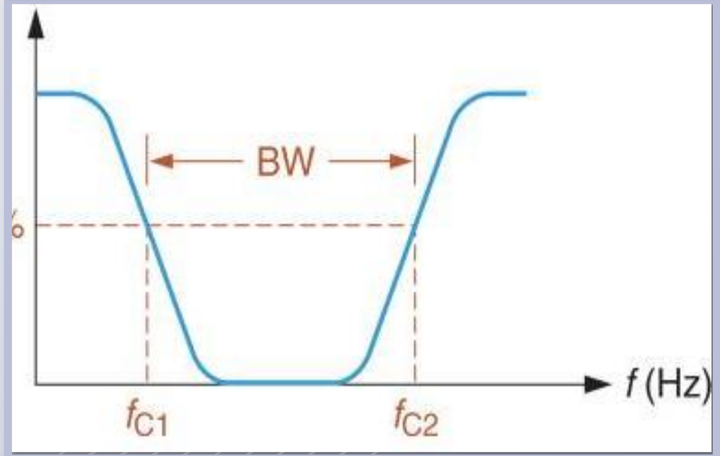


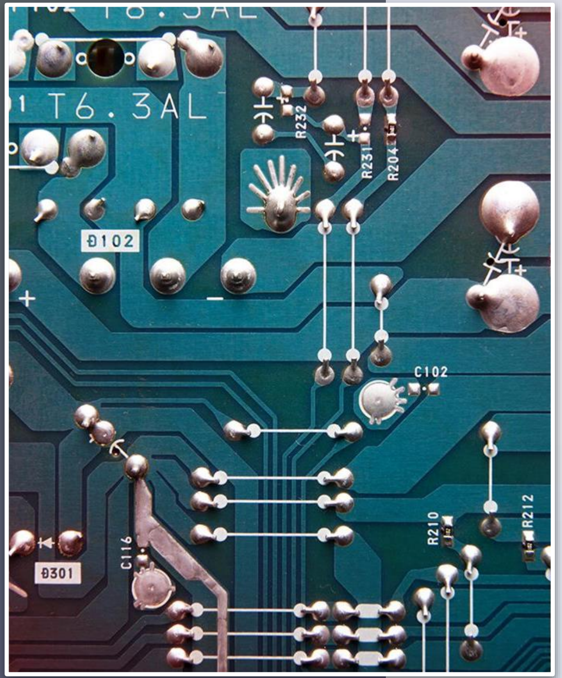


Band-Stop Filters

- Band-stop filters block a specific range of frequencies while allowing all other frequencies to pass through.
- These filters are useful for removing unwanted signals, such as power line hum, from audio or instrumentation systems.







03

Applications of Passive Filters

Applications of Passive Filters

Passive filters are widely utilized across various fields of electronics, making them integral to numerous applications. They help ensure signal integrity by selectively allowing certain frequencies to pass while blocking others, thereby enhancing overall performance. From improving audio quality to supporting communication systems, passive filters serve essential roles in modern technology. Let's explore some of the key applications of these versatile components.

Audio Systems

1

Passive filters shape frequency response, remove noise, and enhance audio quality.

2

Power Supplies

Passive filters help regulate and stabilize power, protecting sensitive electronics.