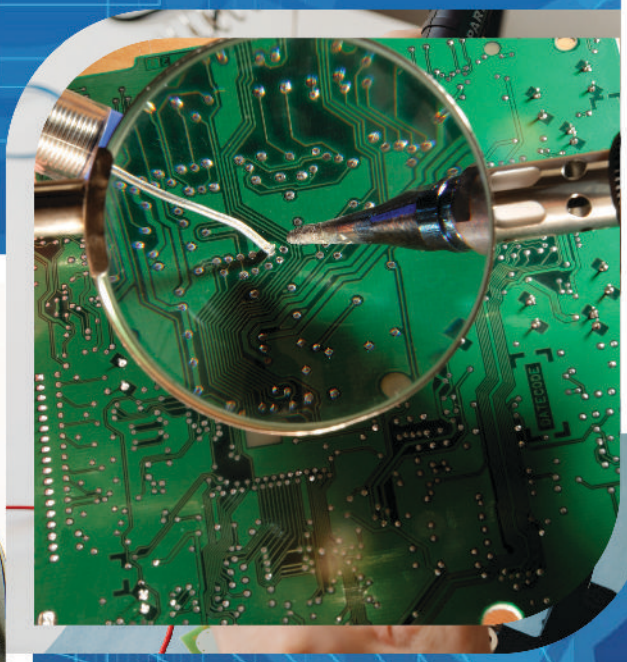
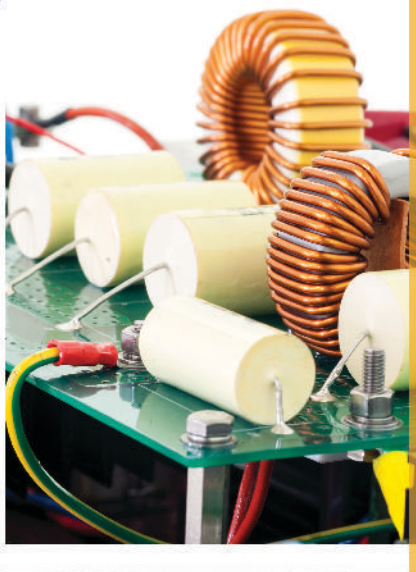
BASIC

DC POWER SUPPLY





Norhafiza binti Sharom
Fauziah binti Aliman
Lian Ai Chen

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Special thanks go to our families and friends for their patience and understanding during the countless hours we dedicated to this project. Your encouragement and belief in us kept us motivated.

Thank you

PREFACE

This e-book on Basic DC Power Supply covers the fundamental principles of designing DC power supply circuits. It is organized into five key components: Transformer, Rectifier, Filter, Regulator, and Voltage Divider. The e-book stands out for its clear and concise text, designed to be easily understood and referenced by students and readers. It includes illustrations that relate directly to the topics discussed, providing a visual context to enhance comprehension.

We hope this e-book proves to be a valuable resource for students and general readers alike, contributing to a deeper understanding of DC power supplies.

Table Of Content

Introduction

DC Power Supply

Introduction to DC Power Supply

WHAT

IS DC
POWER
SUPPLY

Introduction to DC Power Supply

A DC power supply converts alternating current (AC) from the mains into direct current (DC) suitable for powering electronic devices. It typically consists of several key components, including a transformer, rectifier, filter, voltage regulator, and voltage divider.

Scan me for voice

Components of a DC Power Supply

AC Input -> Transformer -> Rectifier -> Filter -> Voltage Regulator -> Voltage Divider ->DC Output

Transformer

Rectifier

Filter

Voltage Regulator

Voltage Divider

Source: Canva

Components of a DC Power Supply

Transformer	Steps down the input AC voltage to a lower level suitable for rectification.
Rectifier	Converts AC to pulsating DC by allowing current to flow in one direction only. Common rectifier types include diode bridges or more complex rectifier circuits.
Filter	Smooths the pulsating DC output from the rectifier, reducing ripple voltage and making the output more stable.
Voltage Regulator	Ensures that the output voltage remains constant despite fluctuations in input voltage or load changes. This can be achieved through various types of voltage regulation circuits, such as linear regulators or switching regulators.
Voltage Divider	Divides DC voltage to several voltages

Tutorial

No. 1

1. What is the function of a DC Power Supply?
2. Identify the function of a voltage regulator in DC Power Supply.
3. Based on Figure 1, name the block of ‘P’ and ‘R’.

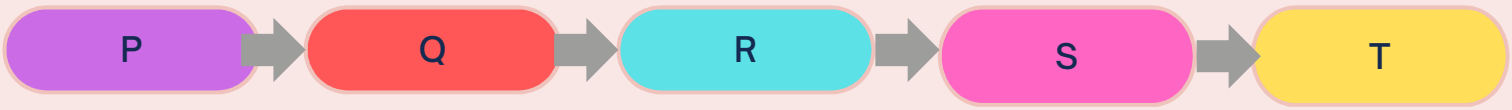

Figure 1

Source: pixabay

Tutorial Answer

1. The function of a DC Power Supply is to convert alternating current (AC) from the mains into direct current (DC)
2. The voltage regulator is used to maintain the DC output voltage.
3. ‘P’ is transformer and ‘R’ is filter.

Source: pixabay

Block 1

Transformer

DC Power Supply

Transformer

A basic transformer is defined as a passive electrical device constructed of two coils of wire (winding) magnetically coupled that transfers electrical energy from one coil to another through the process of electromagnetic induction.

It is most commonly used to increase ('step up') or decrease ('step down') voltage levels between circuits

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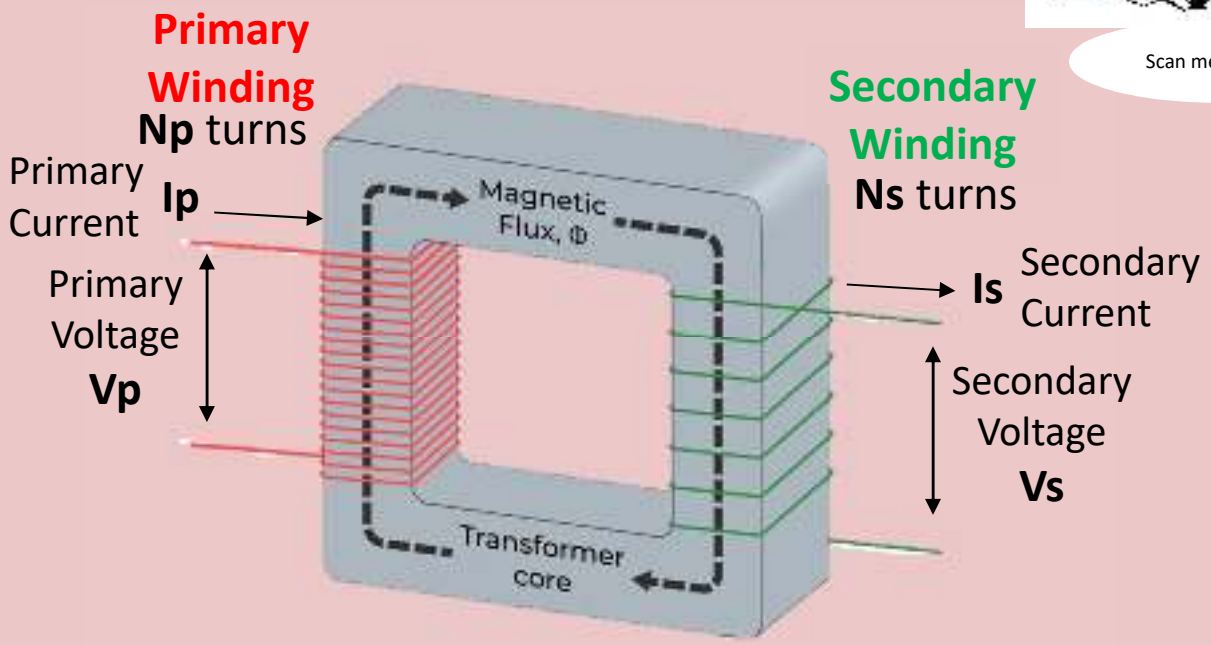
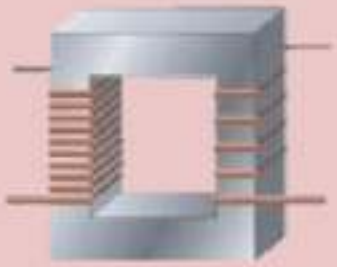


Source: Canva

Transformer

Step-down



Operation

A transformer that decreases voltage between the primary to secondary windings is defined as a step-down transformer.

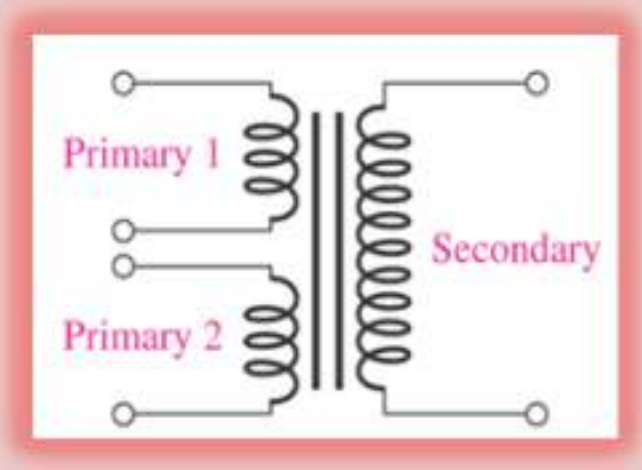
Operation

Step-up

- A transformer that increases voltage between the primary to secondary windings is defined as a step-up transformer.

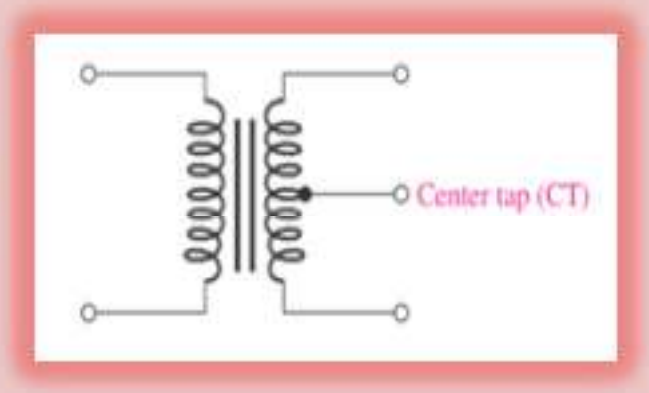
Source: Canva

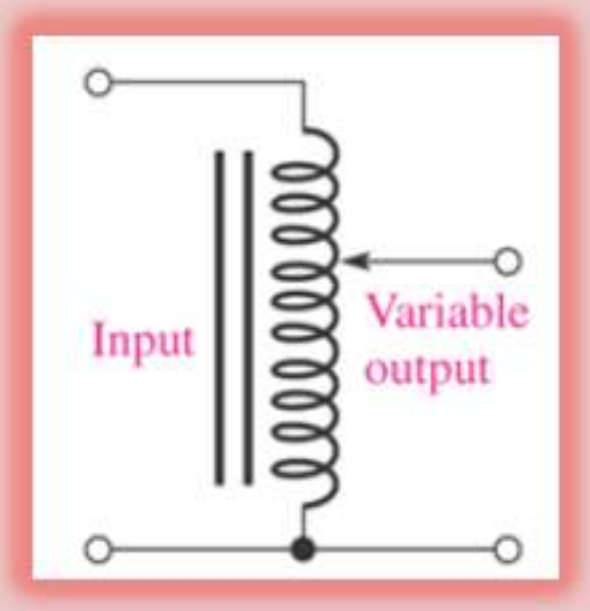
Types of Transformer



Multiple Winding

Center-tap Transformer





Auto Transformer

Ratio Transformer

$$n = \frac{V_P}{V_S} = \frac{I_S}{I_P} = \frac{N_P}{N_S}$$

Source: Pixabay

Function of the Transformer (Step down)

An electrical device that steps down alternating current (AC) voltage or current to a lower AC voltage or current.

Source: Pixabay

Tutorial

No. 2

1. By referring to Figure 1 below, determine the following:

   i. Secondary voltage

   ii. Secondary current

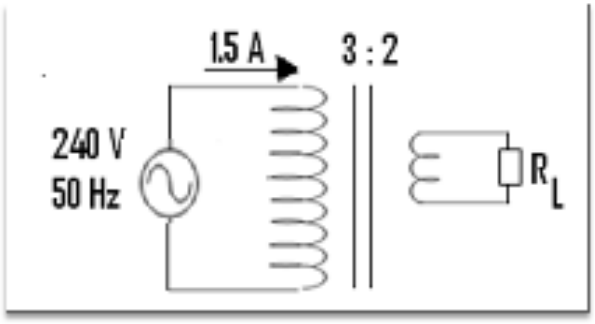


Figure 1

2. List THREE (3) types of transformer.

3. Explain the function of transformer in DC power supply.

4. By using the suitable diagram, sketch the basic transformer.

5. Show the equation of turn ratio using voltage value.

Tutorial Answer

1. Determine the following:

i. $\frac{V_P}{V_S} = \frac{N_P}{N_S}$

$\frac{240}{V_S} = \frac{3}{2}$

$\frac{V_S}{240} = \frac{2}{3}$

$V_S = \frac{2}{3} \times 240$

$= 160\,\text{V}$

ii. $\frac{I_S}{I_P} = \frac{N_P}{N_S}$

$\frac{I_S}{1.5} = \frac{3}{2}$

$I_S = \frac{3}{2} \times 1.5$

$= 2.25\,\text{A}$

2. THREE (3) types of transformer.

i. Auto transformer

ii. Center-tap transformer

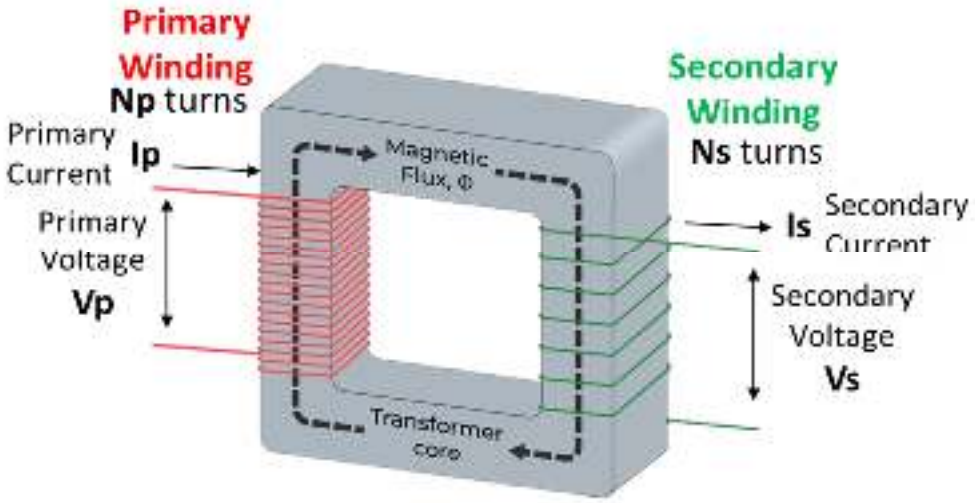
iii. Multiple winding transformer

To get more explanation click here

Tutorial Answer

3. The function of transformer in DC power supply is to step down current or voltage AC to a smaller current or voltage AC.

4. Diagram of the basic transformer.



5. The equation of turn ratio using voltage value.

$$n = \frac{V_P}{V_S}$$

Block 2

Rectifier

DC Power Supply

Introduction to Rectifier

The rectifier is a crucial component in a DC power supply, responsible for converting alternating current (AC) input into pulsating direct current (DC). This conversion is essential because most electronic devices require a steady DC voltage to operate.

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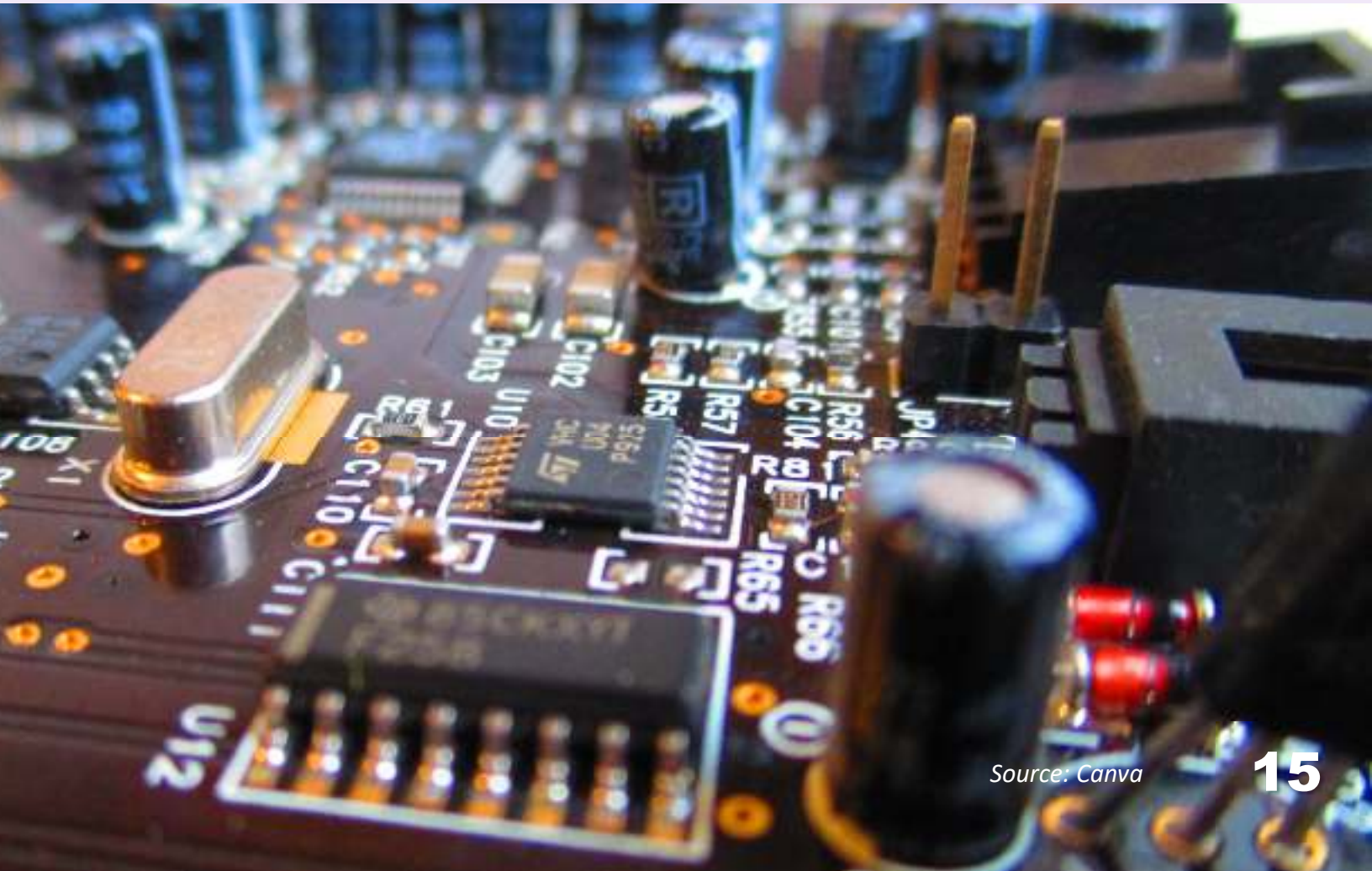


Source: Canva

Function of the Rectifier

The primary function of the rectifier is to change the alternating voltage (AC) from the mains power source into direct voltage (DC). In other words, it converts the alternating current, which changes direction periodically, into a unidirectional current flow.

AC → DC pulsating

Source: pixabay

Types of Rectifiers

Half-Wave Rectifier

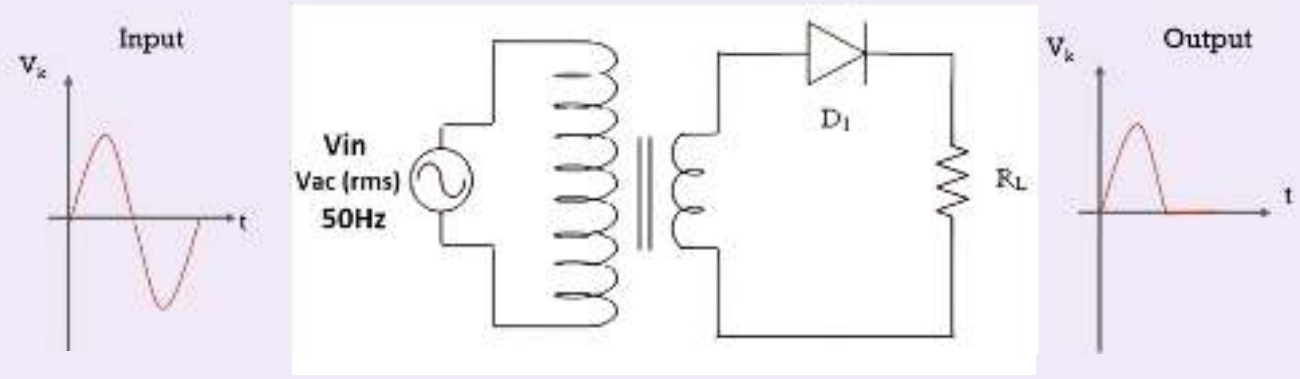
This simple rectifier uses a single diode to allow current flow in only one direction during half of the AC cycle. It's less efficient and produces more ripple compared to full-wave

Full-Wave Rectifier

Full-wave rectifiers use multiple diodes arranged in a bridge configuration (Bridge Rectifier) or center-tapped configuration to allow current flow in the same direction during both halves of the AC cycle. This results in a more efficient conversion with less ripple.

Types of Rectifiers

Half-Wave Rectifier



Operation

When the secondary AC voltage swings positive,

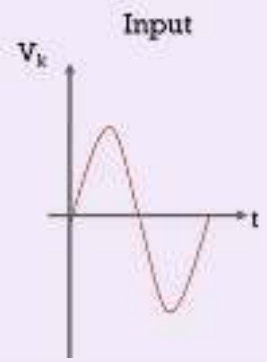
- Diode D1 turns ‘ON’ and the circuit is connected.
- Current flows in the circuit and produces half waveform across the load

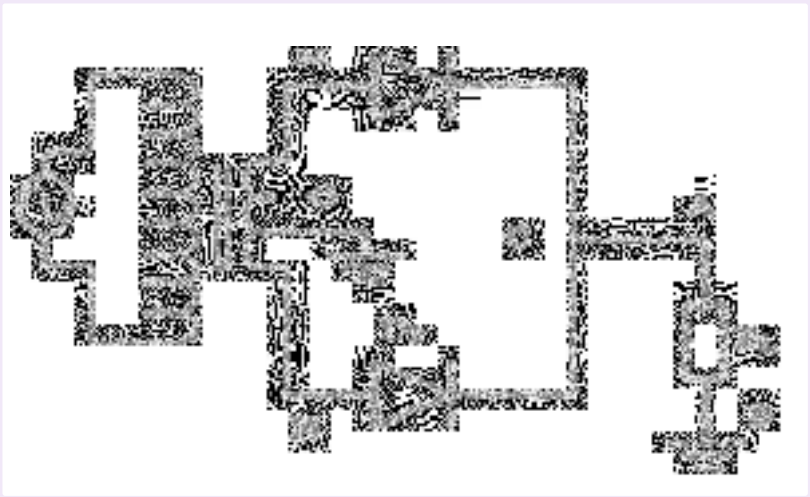
When secondary AC voltage swings negative,

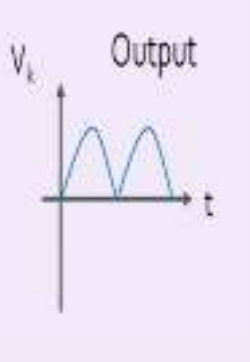
- Diode D1 turns ‘OFF’ and the circuit is opened
- No current flows in the circuit and NO waveform is produced across the load

Types of Rectifiers

Fill-Wave Rectifier : Center-tapped







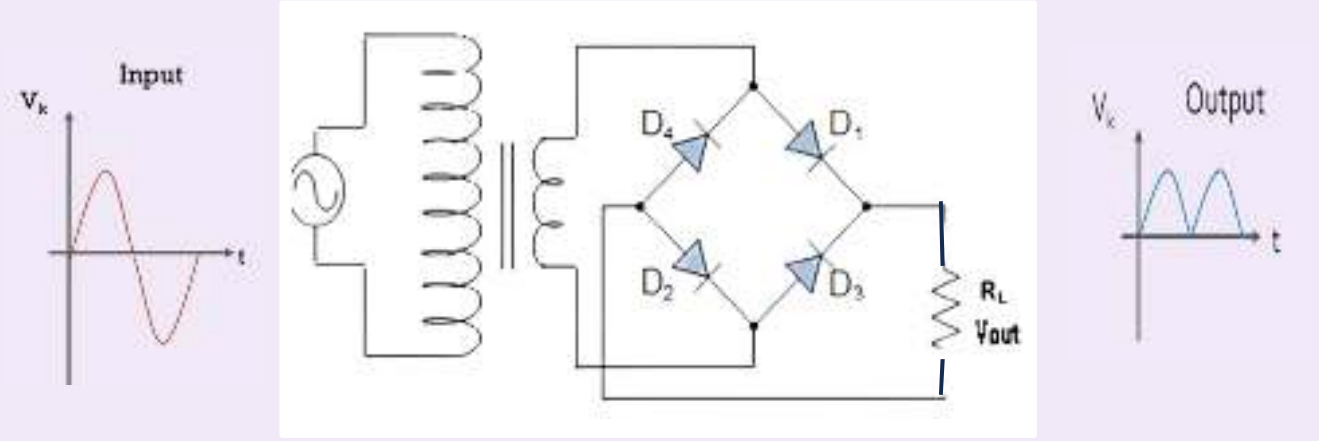
Operation

- When Vin swings positive, a positive voltage is developed on M so D1 is ON while a negative voltage is developed on N so D2 is OFF.
- Electrons flow through the load and develop a positive output half-cycle across the load (Vout).

- When Vin swings negative, a negative voltage is developed on M so D1 is OFF while a positive voltage is developed on N turning ON D2.
- Current flows through the load, developing another positive output half-cycle across the load (Vout)

Types of Rectifiers

Fill-Wave Rectifier :
Bridged Rectifier



Operation

- When the Vin swings positive, a positive potential is applied to the top of the bridge, causing D1 to turn ON, while a negative potential is applied to the bottom of the bridge, causing D2 to turn ON.
- With D1 and D2 ON and D3 and D4 OFF, current will flow up through the load as indicated by the arrow (I), developing a positive output half-cycle across the load (Vout).

- When Vin swings negative, a negative potential is applied to the top of the bridge, causing D4 to turn ON, while a positive potential is applied to the bottom of the bridge, causing D3 to turn ON.
- With D4 and D3 ON and D1 and D2 OFF, electrons will flow up through the load as indicated by the arrow (I), developing another positive output half-cycle across the load (Vout).

Tutorial

No. 3

1. Identify the function of a rectifier.
2. The main function of the rectifier in the power supply unit is to convert the Alternating Current (AC) to Direct Current (DC) power. List TWO (2) types of rectifier circuits that are commonly used in this power supply unit. How many diodes are used in the rectifier circuit respectively?
3. Draw the input and output waveforms of half-wave rectifier.
4. Draw a bridge rectifier circuit and explain its operation.

Source: pixabay

Tutorial Answer

1. The rectifier is used to convert the AC voltage to pulsating DC output voltage.

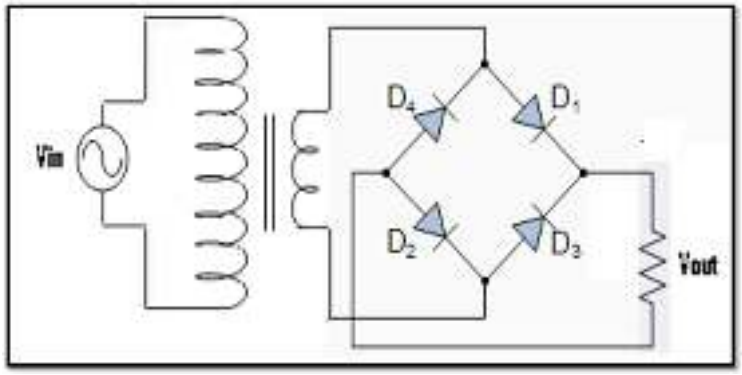
2. TWO (2) types of rectifier circuits and number of diodes are used in the rectifier circuit respectively:
   - Full wave rectifier using center tap transformer – use 2 diodes
   - Full wave rectifier using bridge rectifier – use 4 diodes
   - Half wave rectifier – use 1 diode

3. The input and output waveforms of half-wave rectifier.

Source: pixabay

Tutorial Answer

4. Bridge rectifier circuit



Operation:

- When the Vin swings positive, a positive potential is applied to the top of the bridge, causing D1 to turn ON, while a negative potential is applied to the bottom of the bridge, causing D2 to turn ON.
- With D1 and D2 ON and D3 and D4 OFF, current will flow up through the load as indicated by the arrow (I), developing a positive output half-cycle across the load (Vout).
- When Vin swings negative, a negative potential is applied to the top of the bridge, causing D4 to turn ON, while a positive potential is applied to the bottom of the bridge, causing D3 to turn ON.
- With D4 and D3 ON and D1 and D2 OFF, electrons will flow up through the load as indicated by the arrow (I), developing another positive output half-cycle across the load (Vout).

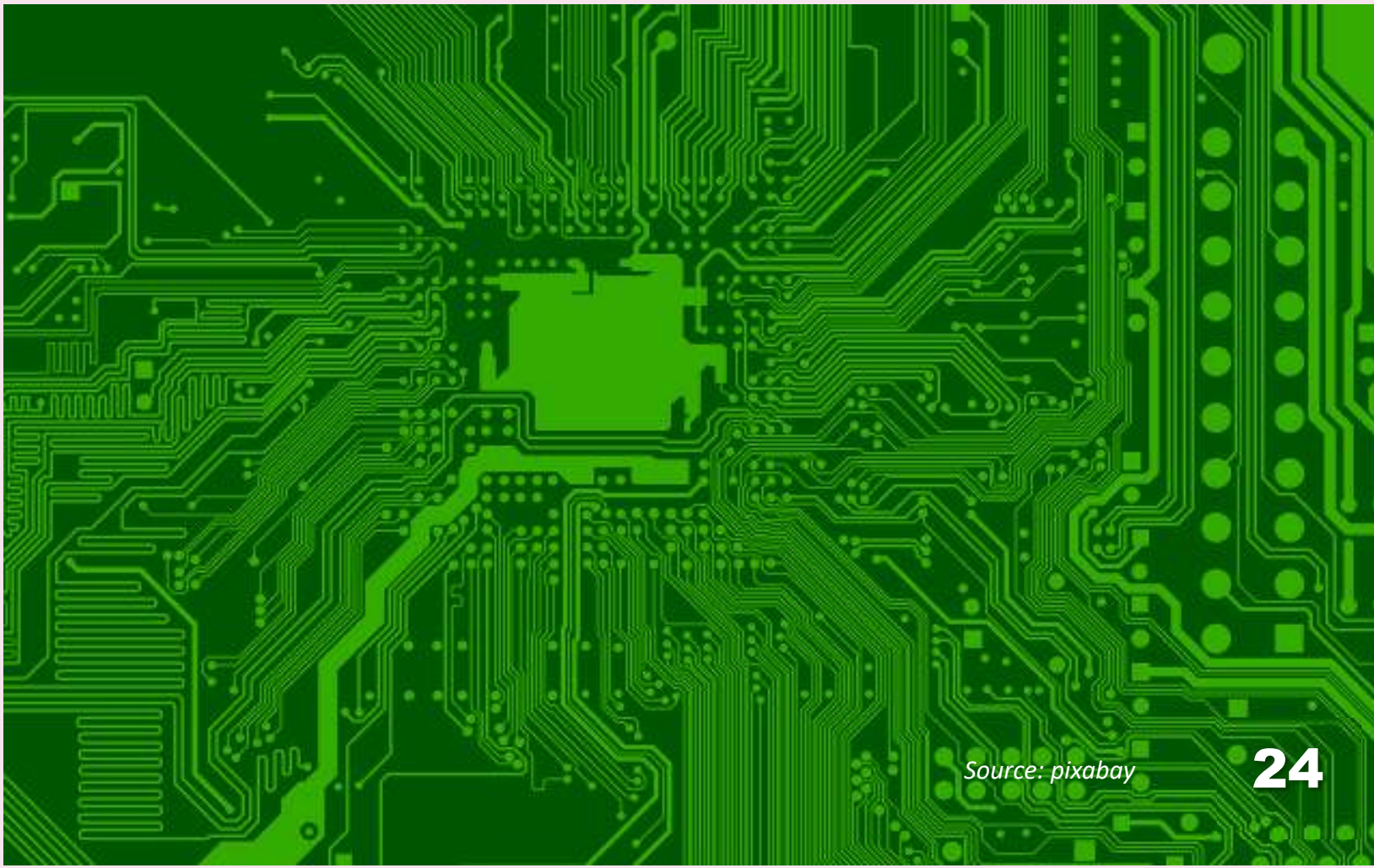
Block 3

Filter

DC Power Supply

Introduction of Filter

Filtering or smoothing the rectified voltage is used to obtain a pure DC from the pulsating DC.



Source: pixabay

Function of the Filter

To get smooth DC voltage from pulsating DC input

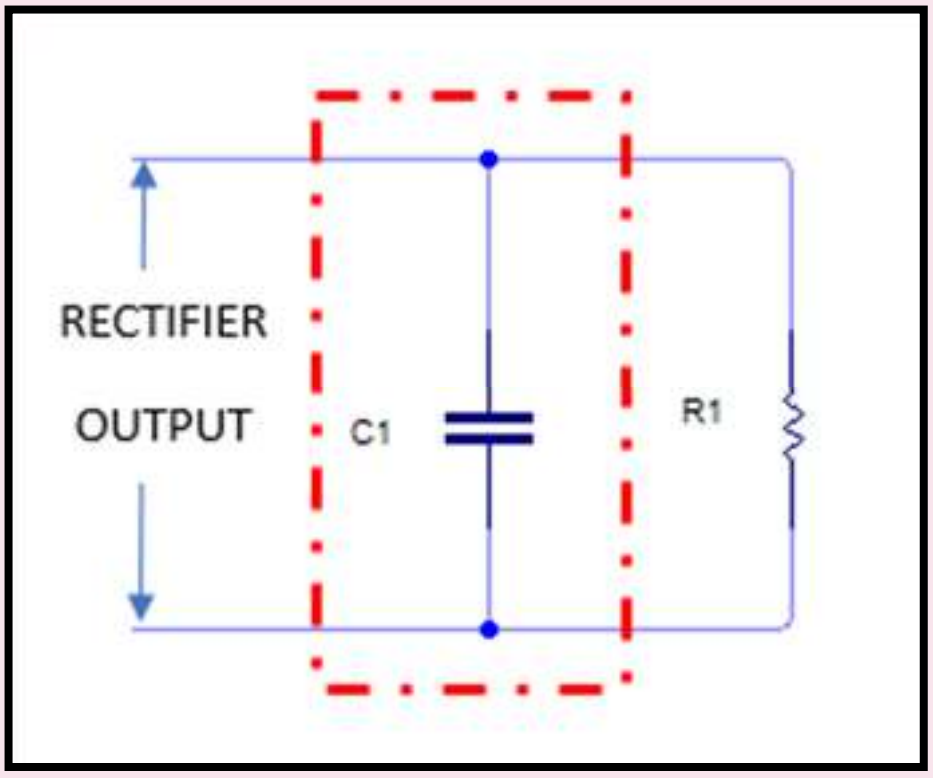
The small amount of fluctuation in the filter output voltage is called ripple.

Removes the ac component from the output of rectifier and produces the pure dc output across the load

Types of Filter

Capacitor Filter

A capacitor, C is connected at the end of rectifier circuit and parallel with the load resistor.



Types of Filter

Capacitor Filter

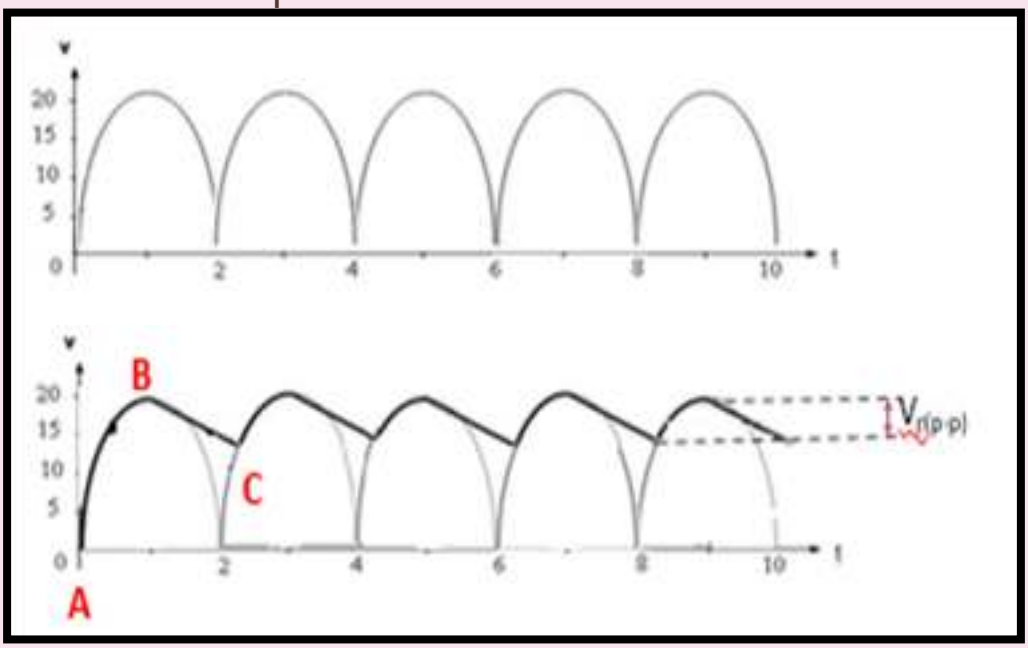
•When the voltage from the rectifier circuit increases, it charges the capacitor until the peak value Vm of the rectifier voltage (A – B).

•After that, the rectifier voltage starts to decrease causing the capacitor to discharge through the load and the voltage across it decreases (B-C).

•The process is repeated. The little ripple is left in the output.

Waveform output full wave rectifier

Waveform output c filter



Types of Filter

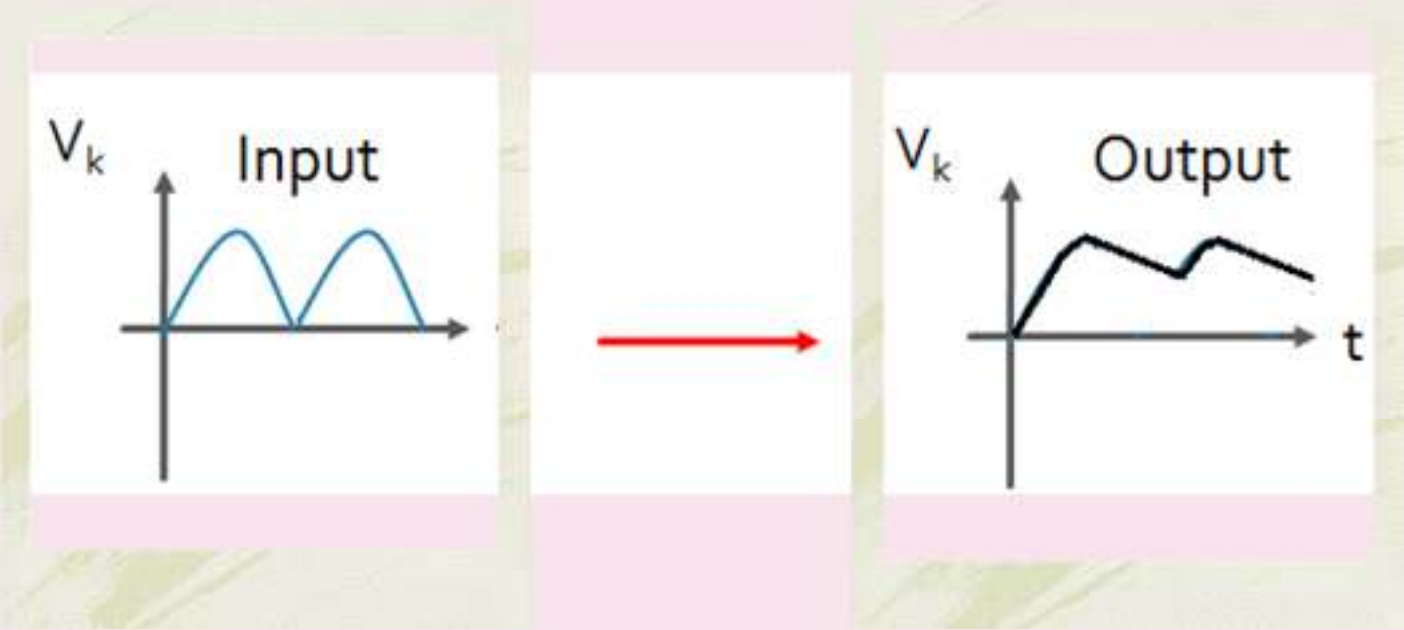
Capacitor Filter

- The larger valued capacitor is used, the ripple voltage becomes lesser.
- Popular because of its low cost, small size, lightweight and good characteristics.
- The disadvantage of this filter is the output voltage is not pure dc and has much less variation (or ripple) than the unfiltered output of the rectifier.

Types of Filter

Capacitor Filter

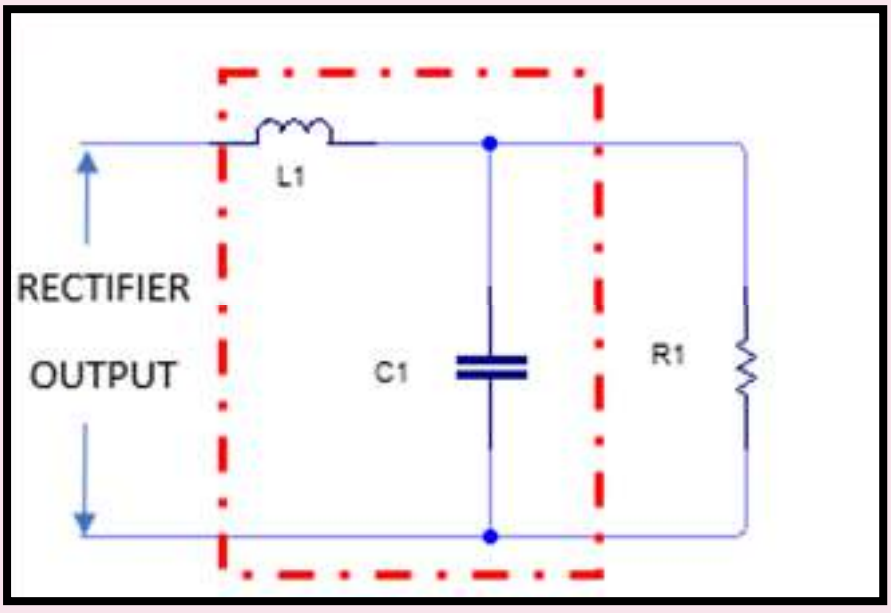
Waveform Input and Output



Types of Filter

Choke Input Filter

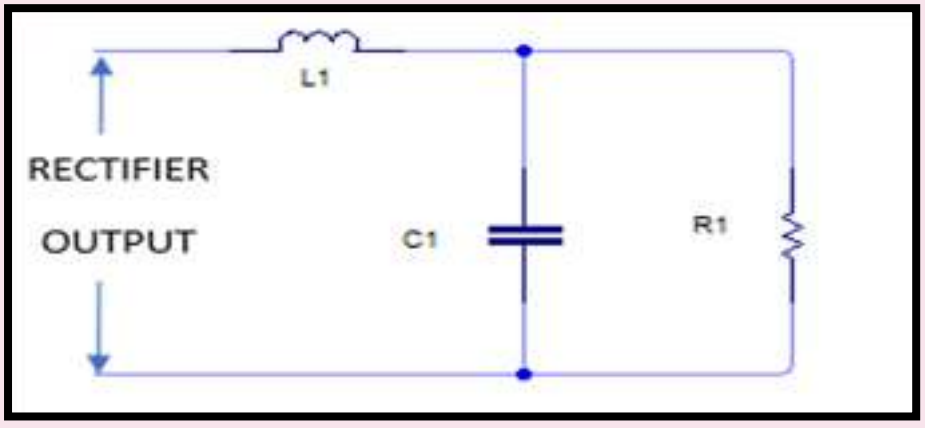
A choke L is connected in series with the rectifier circuit and a Capacitor filter across the load resistor



Types of Filter

Choke Input Filter

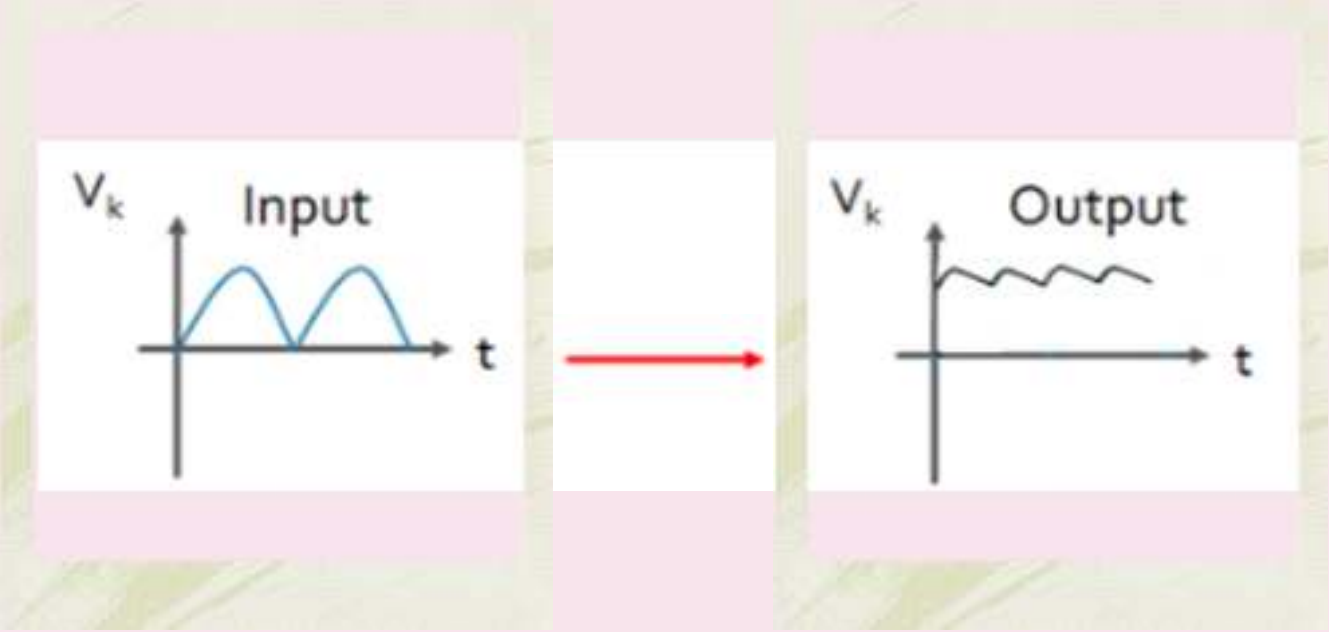
- The pulsating output from the rectifier circuit contains AC and DC components.
- The choke allow high opposition to the passage of AC component but blocking opposition to the DC component.
- The resulting AC component appears across the choke while the DC component passes through the choke to the load.
- It reduced pulsation across the load, R.



Types of Filter

Choke Input Filter

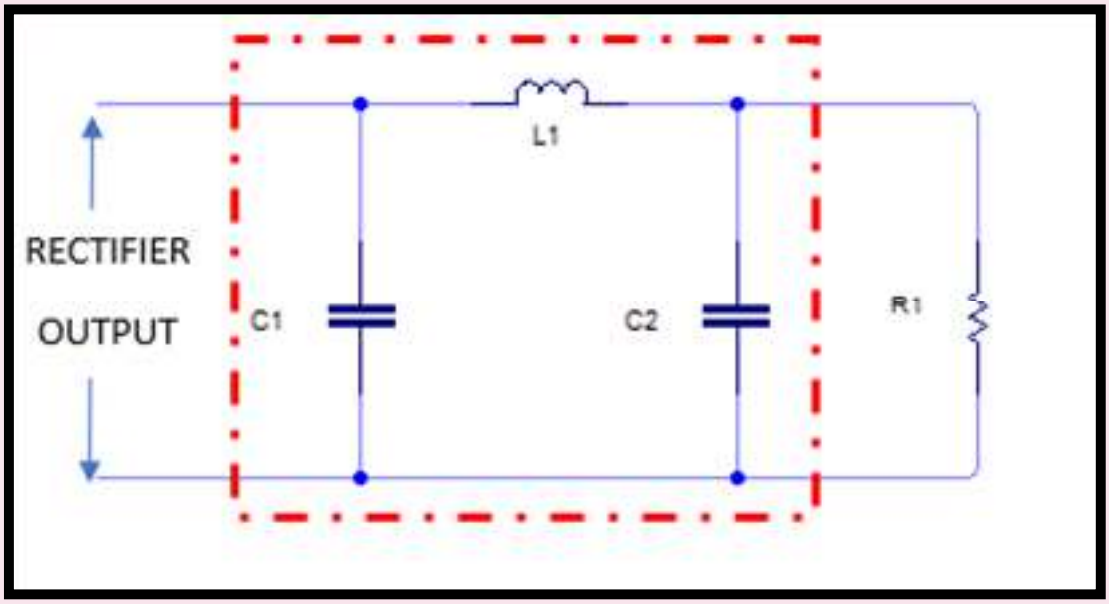
Waveform Input and Output



Types of Filter

Capacitor Input Filter
Or
Pi Filter

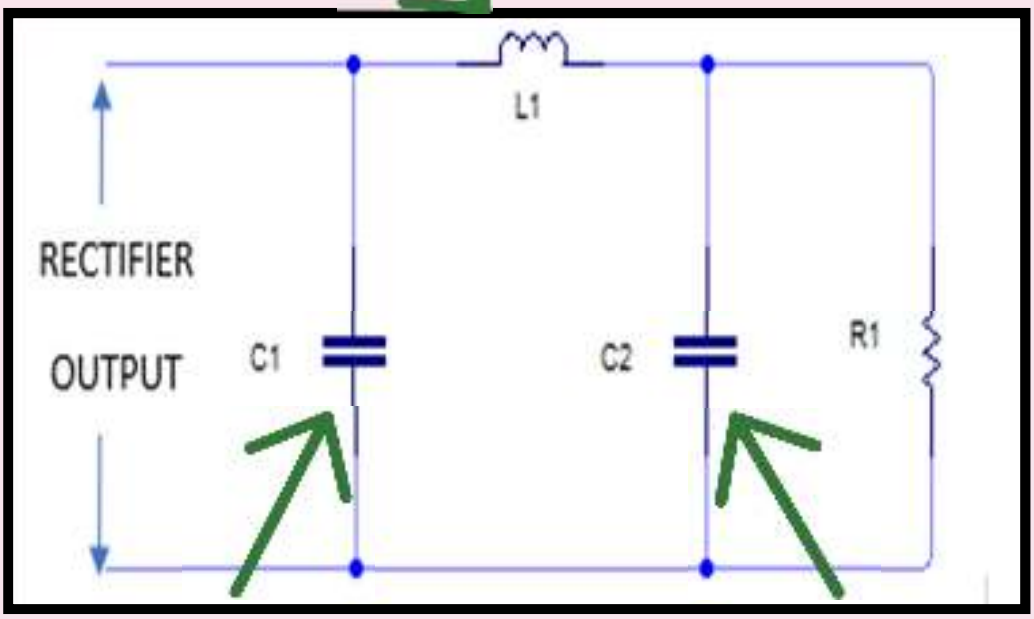
A filter capacitor C1 connected across the rectifier output, a choke L in series and another filter capacitor C2 connected across resistor as load



Types of Filter

Capacitor Input Filter
Or
Pi Filter

- Give high reactance to AC component of rectifier output
- Give zero reactance to DC component



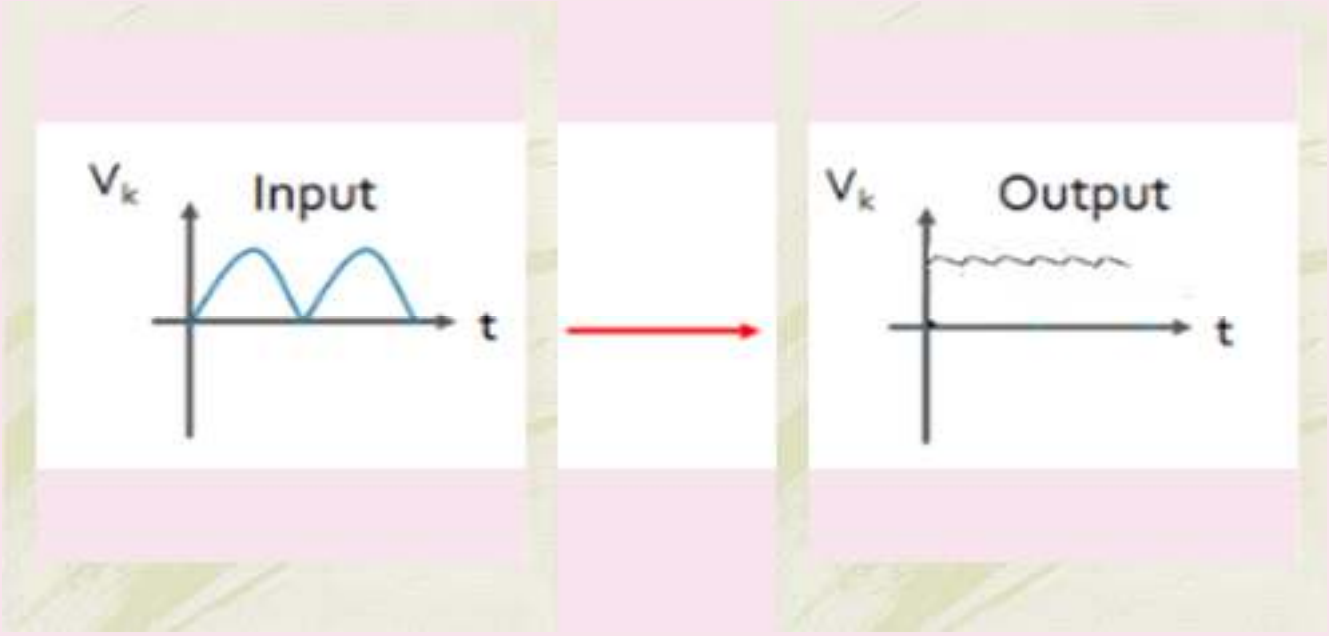
- Give low reactance to AC component of rectifier output.
- Give infinite reactance to DC component

Only DC component appears across the load

Types of Filter

Capacitor Input Filter
Or
Pi Filter

Waveform Input and Output



Tutorial

No. 4

1. List THREE (3) types of filter.
2. By using the diagram, explain the pi filter.
3. Explain the function of filter.
4. Draw the input and output waveforms of filter.
5. Explain the operation of capacitor filter.

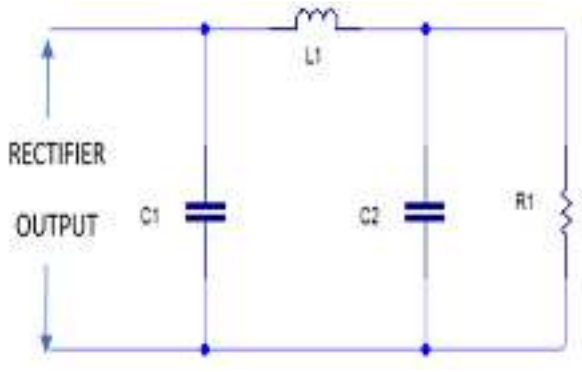
Tutorial Answer

No. 4

1. THREE (3) types of filter.
    a) C filter
    b) **Choke Input Filter**
    c) **C input filter or pi filter**

2. The pi filter

    A filter capacitor C1 connected across the rectifier output, a choke L in series and another filter capacitor C2 connected across resistor as load

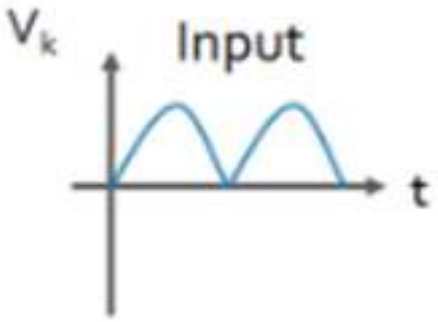


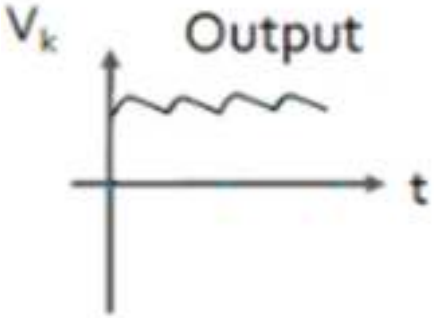
Tutorial Answer

No. 4

3. The function of filter is to get smooth DC voltage called ripple from pulsating DC input

4. The input and output waveforms of filter





Source: pixabay

Tutorial Answer

No. 4

5. The operation of capacitor filter.

When the voltage from rectifier circuit increases, it charges the capacitor until the peak value Vm of the rectifier voltage. After that, the rectifier voltage starts to decrease causing the capacitor to discharge through the load and the voltage across it decreases. The process is repeated. The little ripple is left in the output.

Source: pixabay

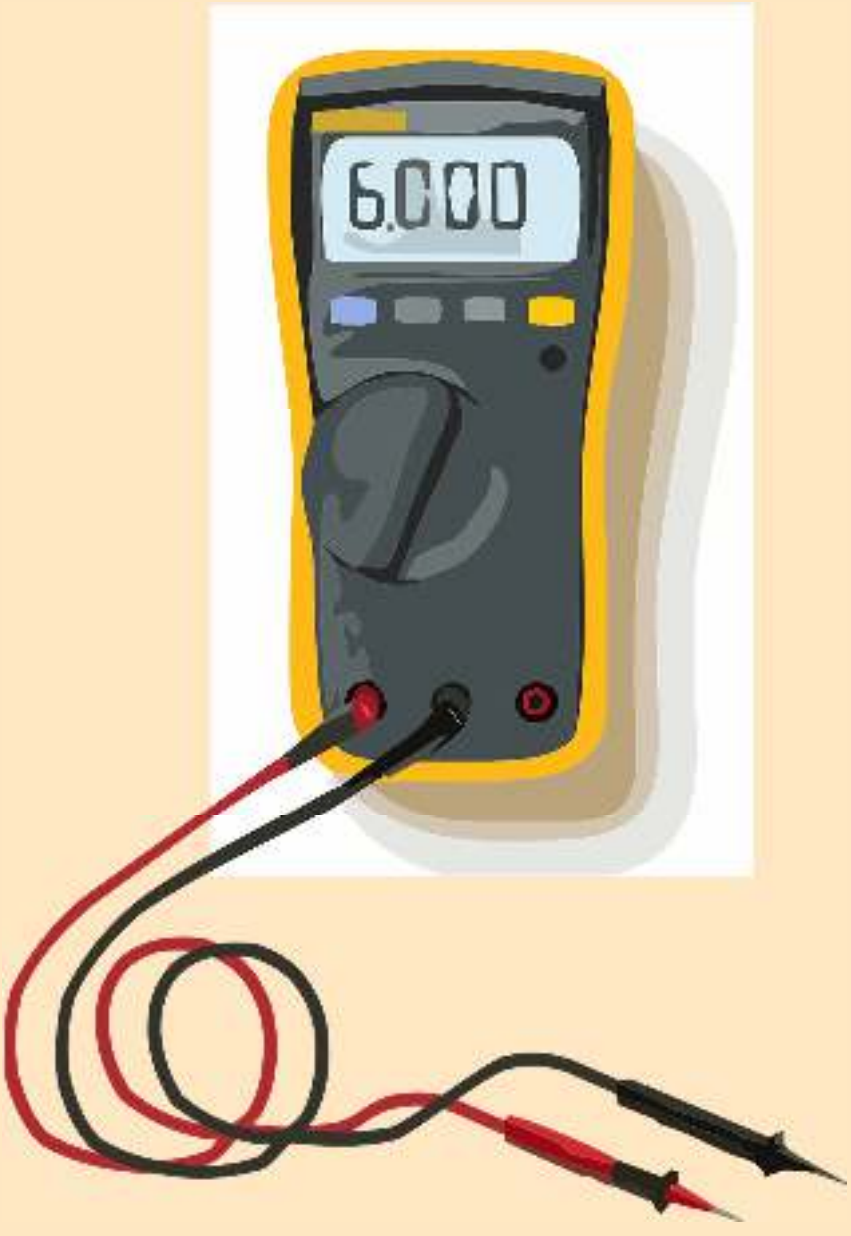
Block 4

Voltage Regulator

DC Power Supply

Introduction of Voltage Regulator

A voltage regulator is **a system designed to automatically maintain a constant voltage.**



Source: pixabay

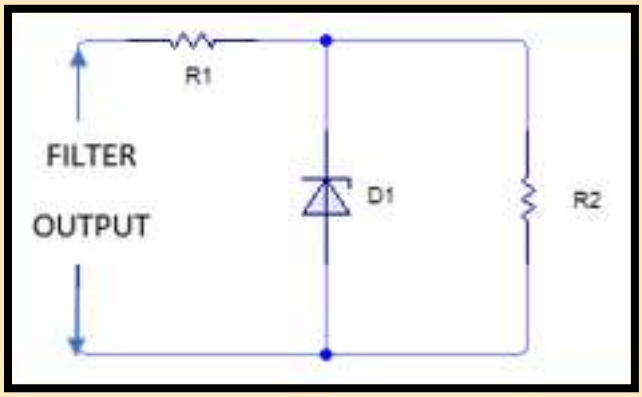
Function of Voltage Regulator

To ensure the output voltage to remain constant whether the current load changes or there are fluctuations in the input AC voltage.

Source: Canva

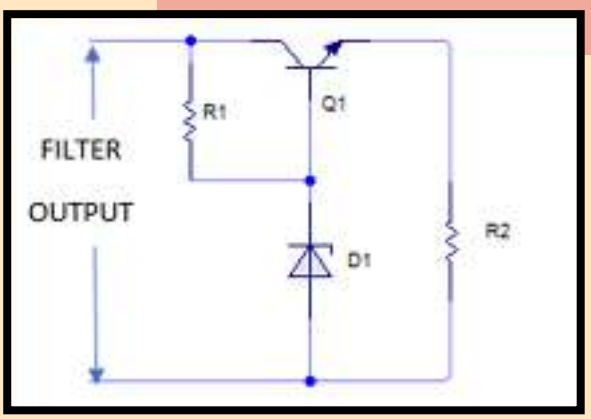
Types of Voltage Divider

Zener Diode Voltage Regulator

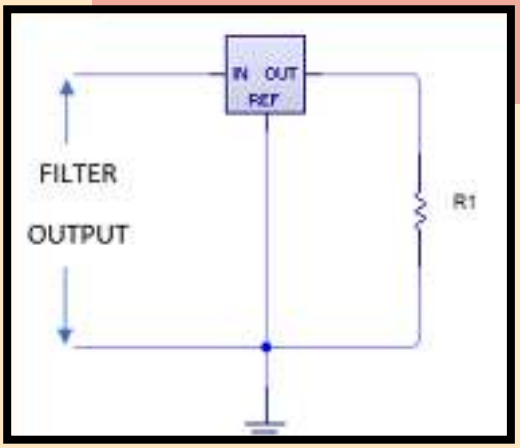


TYPES OF FILTER

Transistor Series Voltage Regulator



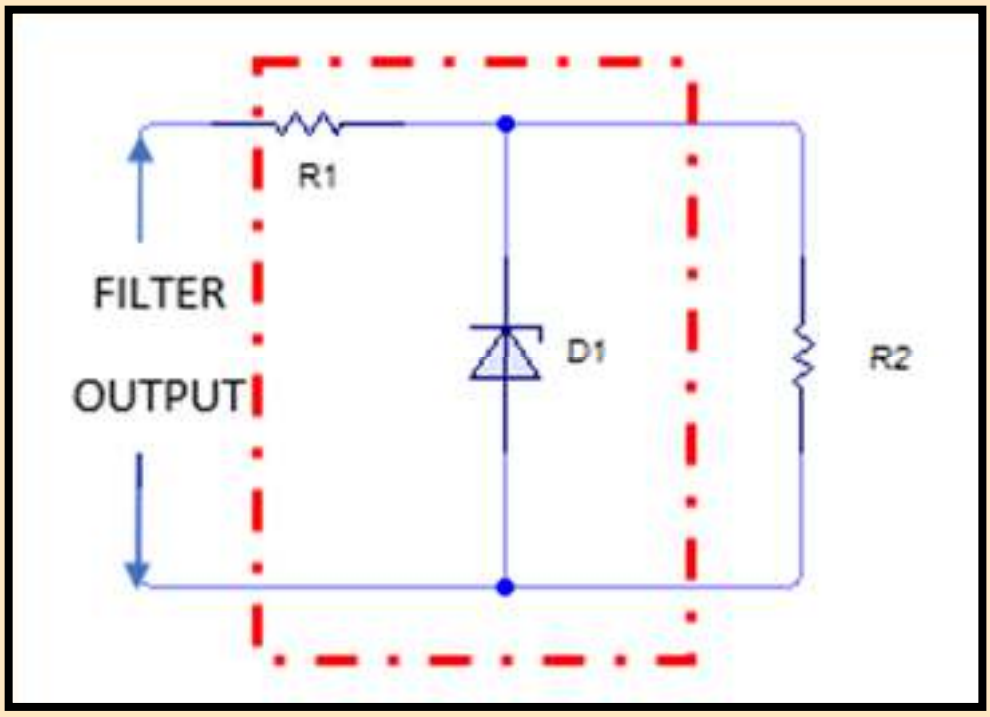
IC Voltage Regulator



Types of Voltage Divider

Zener Diode Voltage Regulator

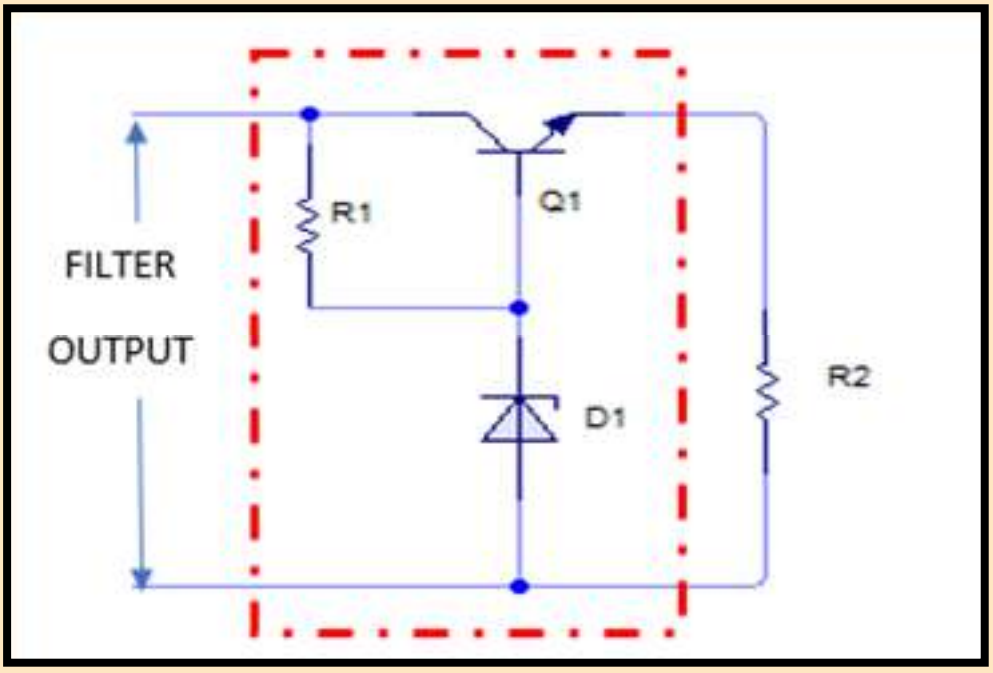
A zener diode is connected parallel with load resistor to make it reverse bias.



Types of Voltage Divider

Transistor Series Voltage Regulator

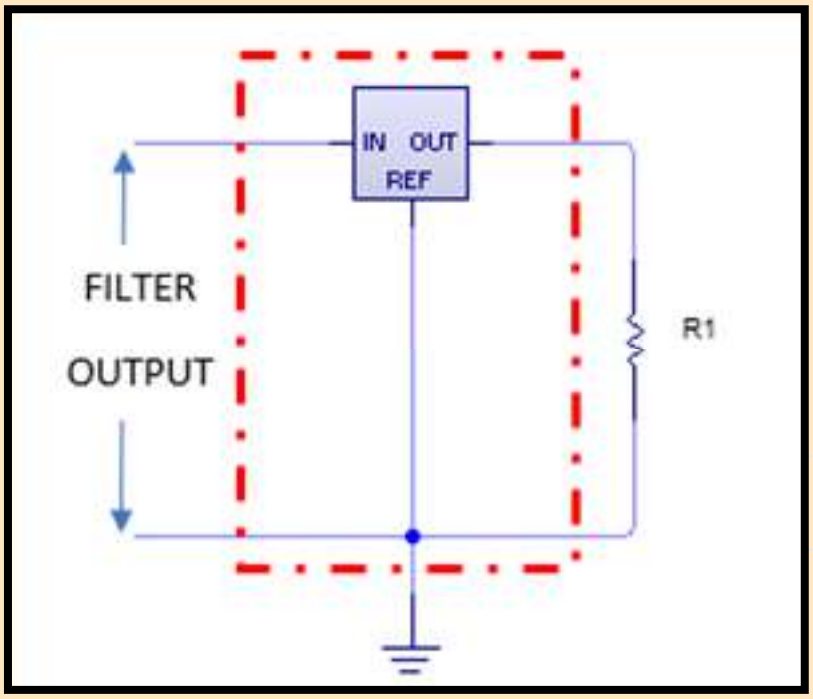
This regulator has a transistor in series with Zener diode and both in parallel to the load.

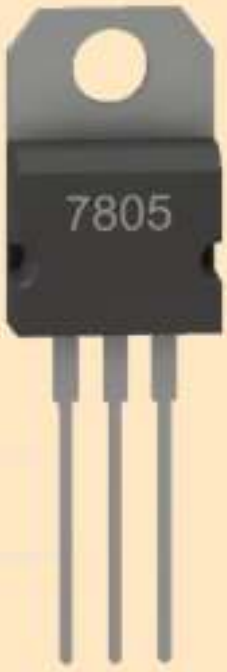


Types of Voltage Divider

Integrated Circuit Voltage Regulator

IC voltage regulators has three-terminal components.





Types of Voltage Divider

Integrated Circuit Voltage Regulator

TYPES

- ✔ Fixed positive voltage regulator
- ✔ Fixed negative voltage regulator

Types of Voltage Divider

Integrated Circuit Voltage Regulator

Fixed positive voltage regulator

78XX

The 78XX series of regulators are used to supply a positive output voltage, with the last two digits specifying the output voltage.

For example :

7805 = +5V

7810 = +10V

Types of Voltage Divider

Integrated Circuit Voltage Regulator

✓ Fixed positive voltage regulator

type number	output voltage (V)	minimum input voltage (V)
7805	+5	+7.3
7806	+6	+8.3
7808	+8	+10.5
7810	+10	+12.5
7812	+12	+14.5
7815	+15	+17.7
7818	+18	+21.0
7824	+24	+27.1

Types of Voltage Divider

Integrated Circuit Voltage Regulator

Fixed negative voltage regulator

79XX

The 79XX series of regulators are used to supply a negative output voltage, with the last two digits specifying the output voltage.

For example :

7905 = -5V

7912 = -12V

Types of Voltage Divider

Integrated Circuit Voltage Regulator

Fixed negative voltage regulator

type number	output voltage (V)	minimum input voltage (V)
7905	-5	-7.3
7906	-6	-8.4
7908	-8	-10.5
7909	-9	-11.5
7912	-12	-14.6
7915	-15	-17.7
7918	-18	-20.8
7924	-24	-27.1

Tutorial

No. 5

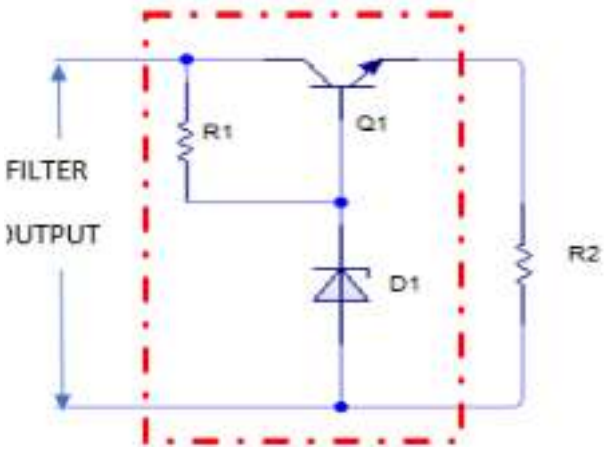
1. List THREE (3) types of voltage regulator.
2. By using the diagram, explain the transistor series regulator.
3. Explain the function of voltage regulator.
4. Draw the input and output waveforms of voltage regulator.
5. Explain the output of LM7912 and LM7809.

Tutorial Answer

No. 5

1. THREE (3) types of voltage regulator is Zener Diode Voltage Regulator, Transistor Series Voltage Regulator and IC voltage regulator
2. The transistor series regulator.

This regulator has a transistor in series with Zener diode and both in parallel to the load.



Source: pixabay

Tutorial Answer

No. 5

3. The function of a voltage regulator is to ensure the output voltage to remain constant whether the current load changes or there are fluctuations in the input AC voltage.

4. The input and output waveforms of a voltage regulator.

5. The output of LM7912 is -12V and LM7809 is +9V

Block 5

Voltage Divider

DC Power Supply

Introduction of Voltage Divider

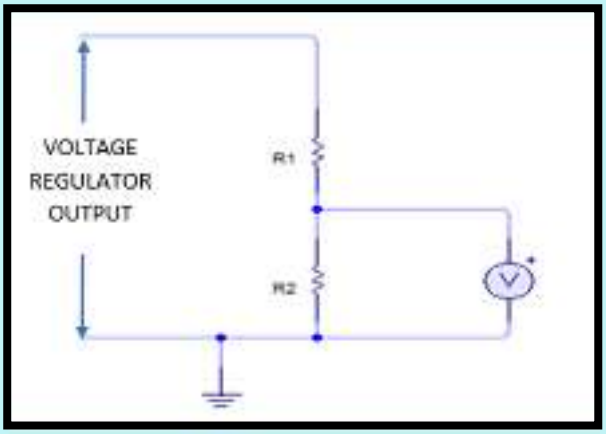
A voltage divider is a simple circuit that can reduce voltage.

Function of Voltage Divider

- To scale down input voltage to a smaller voltage based on the ratio of the 2 resistors.
- Usually consists of resistors that are connected in series

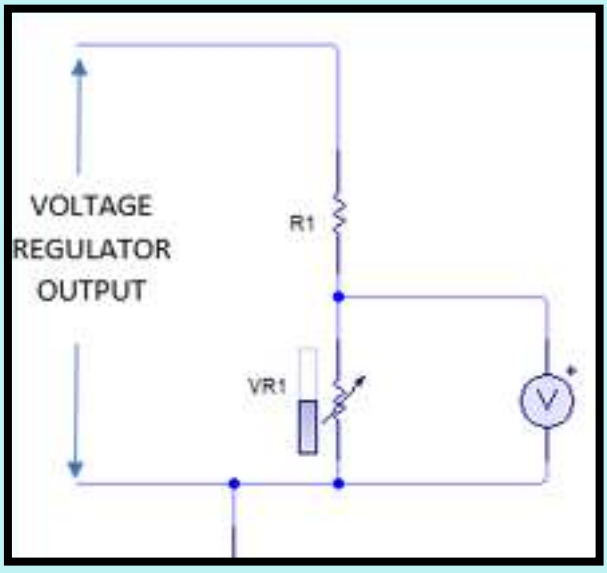
Types of Voltage Divider

Fixed Voltage Divider



TYPES OF VOLTAGE DIVIDER

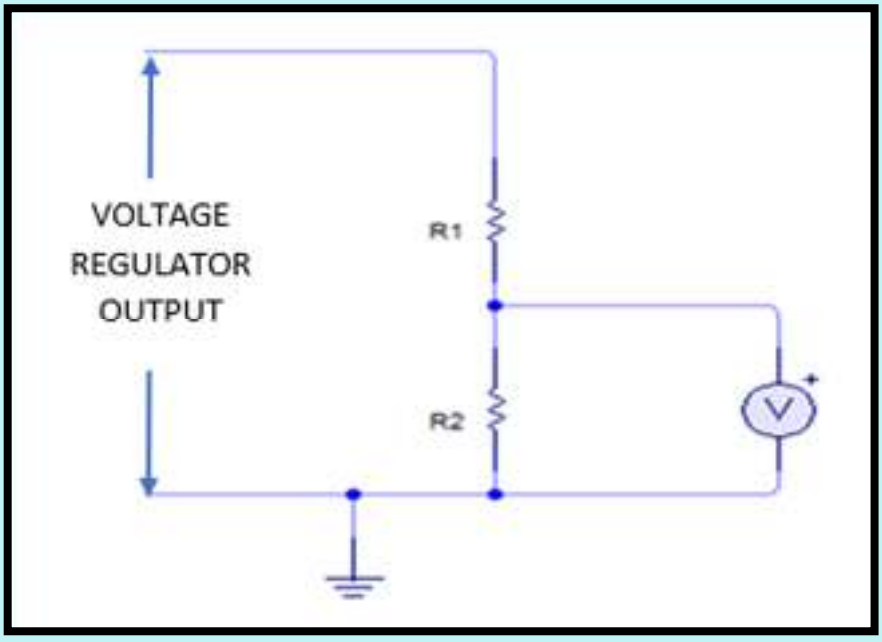
Variable Voltage Divider



Types of Voltage Divider

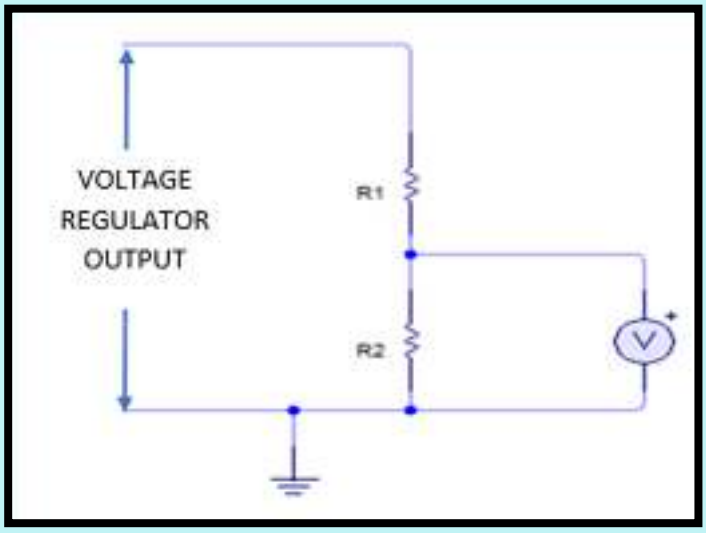
Fixed Voltage Divider

Consists of TWO resistors connected in series.



Types of Voltage Divider

Fixed Voltage Divider



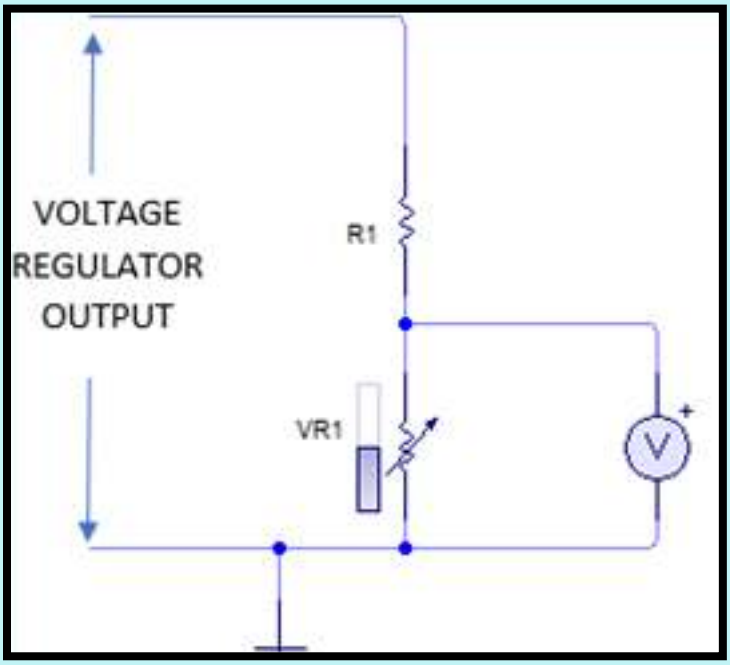
$$V_{R1} = \frac{R_1}{R_1 + R_2} (V_{IN})$$

$$V_{R2} = \frac{R_2}{R_1 + R_2} (V_{IN})$$

Types of Voltage Divider

Variable Voltage Divider

Consists of one resistor and variable resistor connected in series.



QUESTION

Video simulation DC power supply

https://youtu.be/es2YP9aO6xc

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Basic DC Power Supply

Unlock the essentials of DC power supply design with this comprehensive e-book, "Basic DC Power Supply." Structured around five core components—Transformer, Rectifier, Filter, Regulator, and Voltage Divider—this guide demystifies the intricacies of power supply circuits.

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Norhafiza Binti Sharom
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