

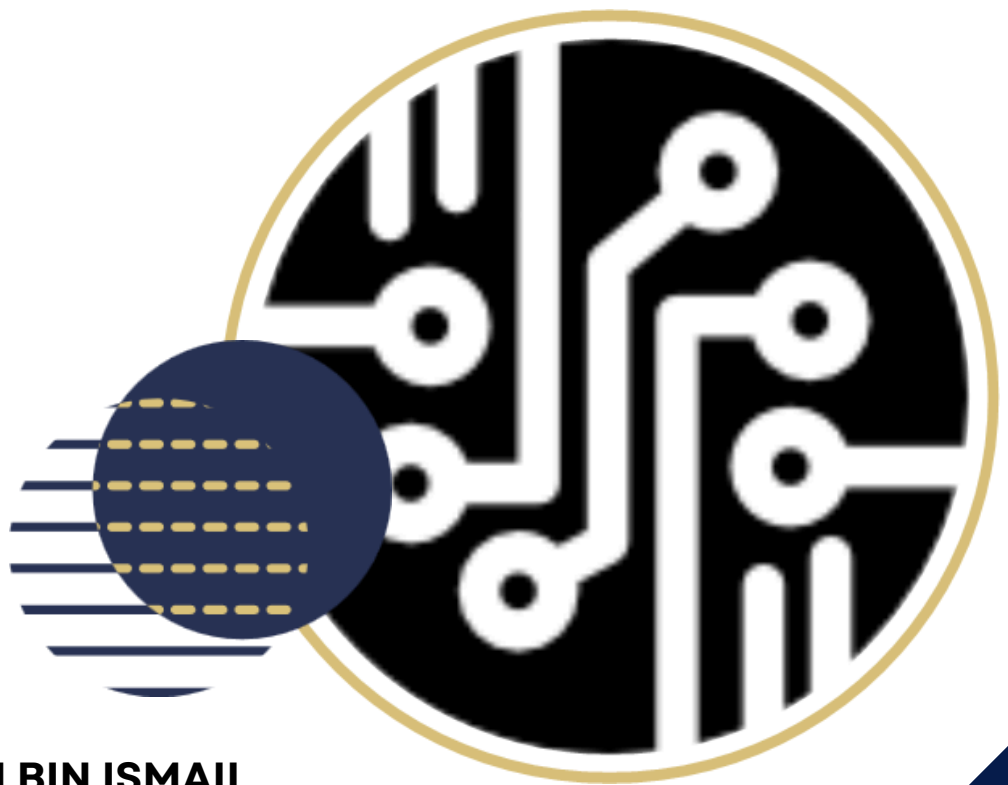
ELECTRONIC CIRCUITS

GUIDED NOTES &

TUTORIALS

POWER SUPPLY – OSCILLATOR - OPERATIONAL AMPLIFIER

SIRI 1



MOHD FARIZUL IRNI BIN ISMAIL
ROHAILA BINTI MOHD RADI
MASNORA BTE HJ. SEPIKUN



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First Edition

September 2024

@ Perpustakaan Negara Malaysia, 2024

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PUBLISHED BY:

Jabatan Kejuruteraan Elektrik

Politeknik Port Dickson

KM 14 Jalan Pantai, 71050 Si Rusa

Negeri Sembilan



06-662 2023 (Librarian)

06-662 2048 (Counter)



suzilawati@polipd.edu.my



Cataloguing-in-Publication Data

Perpustakaan Negara Malaysia

A catalogue record for this book is available
from the National Library of Malaysia

eISBN 978-629-7643-37-3

ACKNOWLEDGEMENT

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Tuan Haji Hasan bin Mohd Sharif
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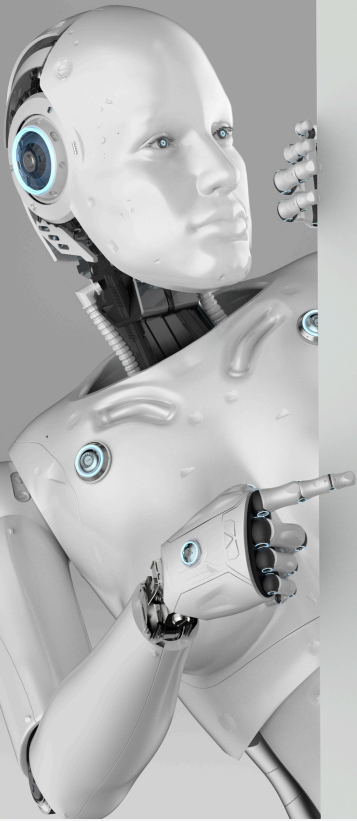
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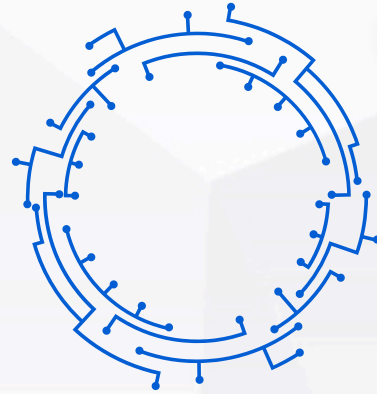
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Mohd Farizul Irni bin Ismail
Rohaila binti Mohd Radi
Masnora bte Hj. Sepikun

We would like to convey our utmost gratitude to the Department of Polytechnics and Community College Education (DPCCE), particularly the E-Learning and Instructional Division for funding our e-book project. We hereby declare that this module is our original work. To the best of our knowledge, it contains no materials previously written or published by another person. However, if there is any, due acknowledgement and credit are mentioned accordingly in the e-book.

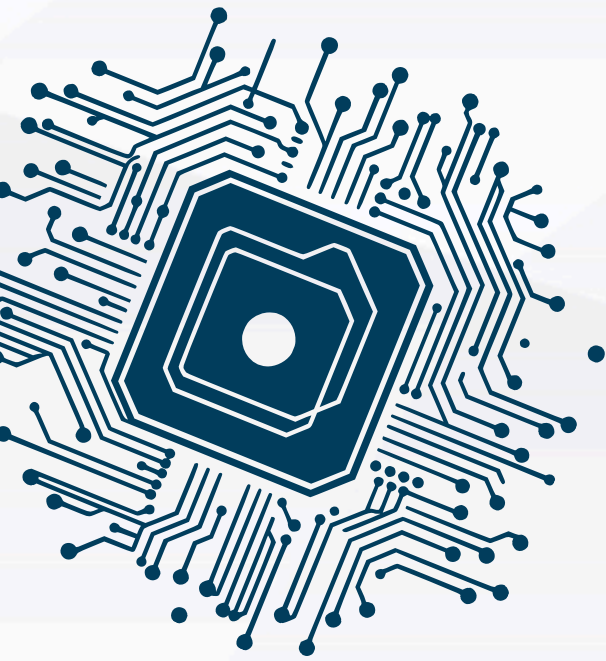


PREFACE



An electronic circuit book is a comprehensive resource designed to facilitate the study of topics such as Power Supply, Oscillators and Operational Amplifiers.

It includes a range of exercises and tutorials for each subject area, aimed at enhancing the reader's understanding of the concepts and foundational principles covered in the course. Moreover, the book is presented in a more engaging writing style to enrich the educational experience.

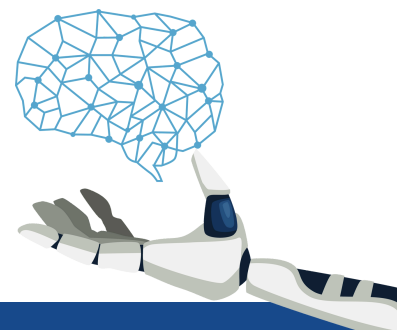




ELECTRONIC CIRCUITS

Table of Contents

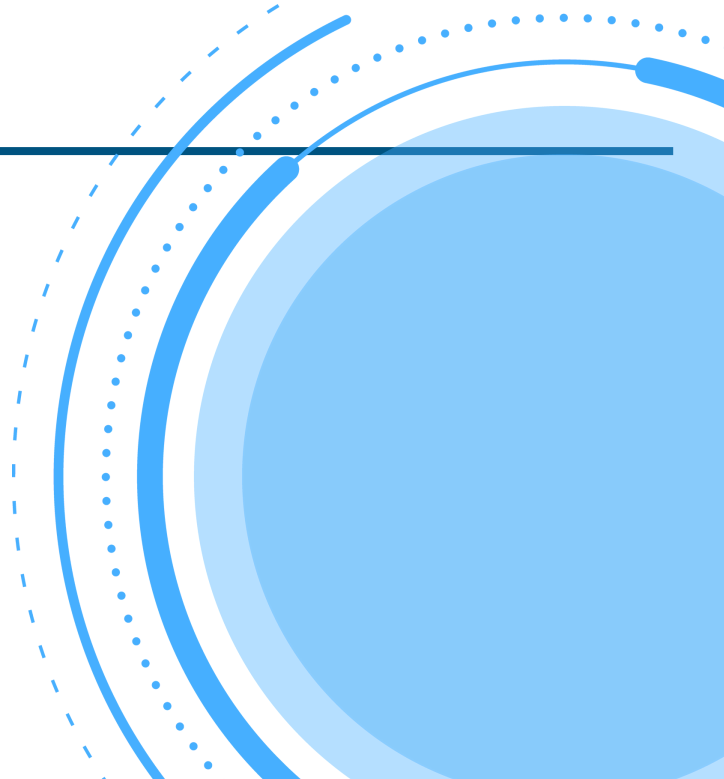
<u>01</u>	TOPIC 1 POWER SUPPLY	»	1
<u>02</u>	TOPIC 2 OSCILLATOR	»	31
<u>03</u>	TOPIC 3 OPERATIONAL AMPLIFIER (OP-AMP)	»	57
<u>04</u>	EXERCISES	»	86



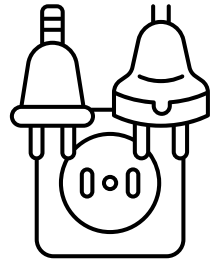


TOPIC 1

POWER SUPPLY

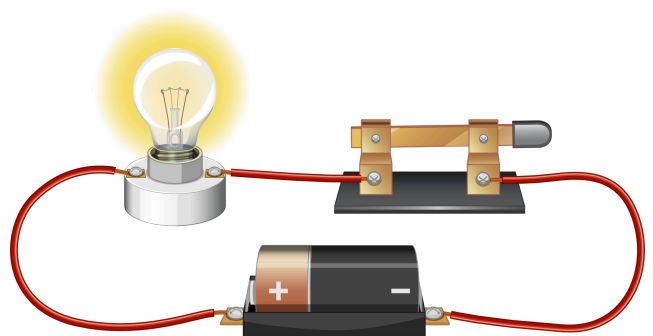
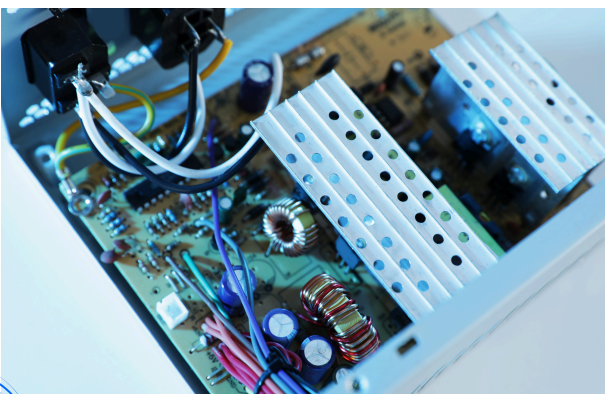


WHAT IS POWER SUPPLY



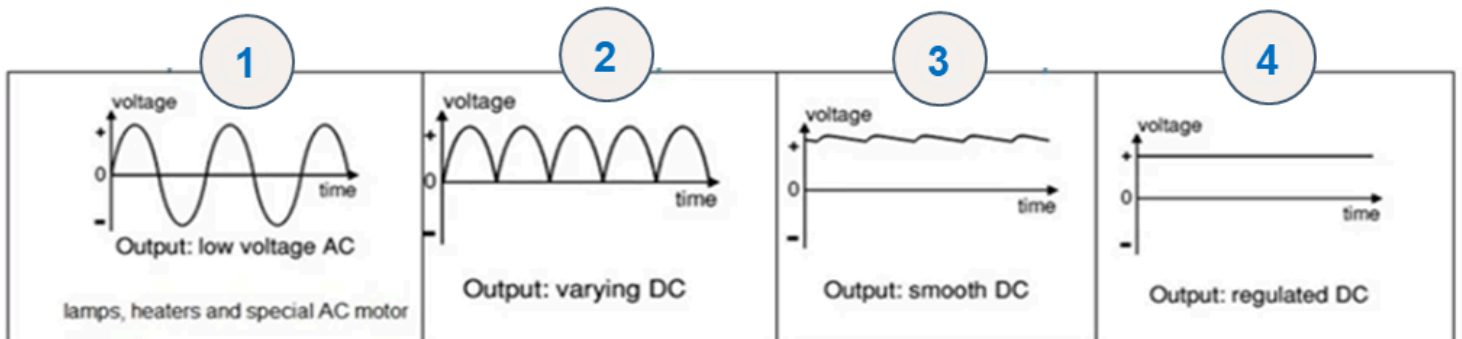
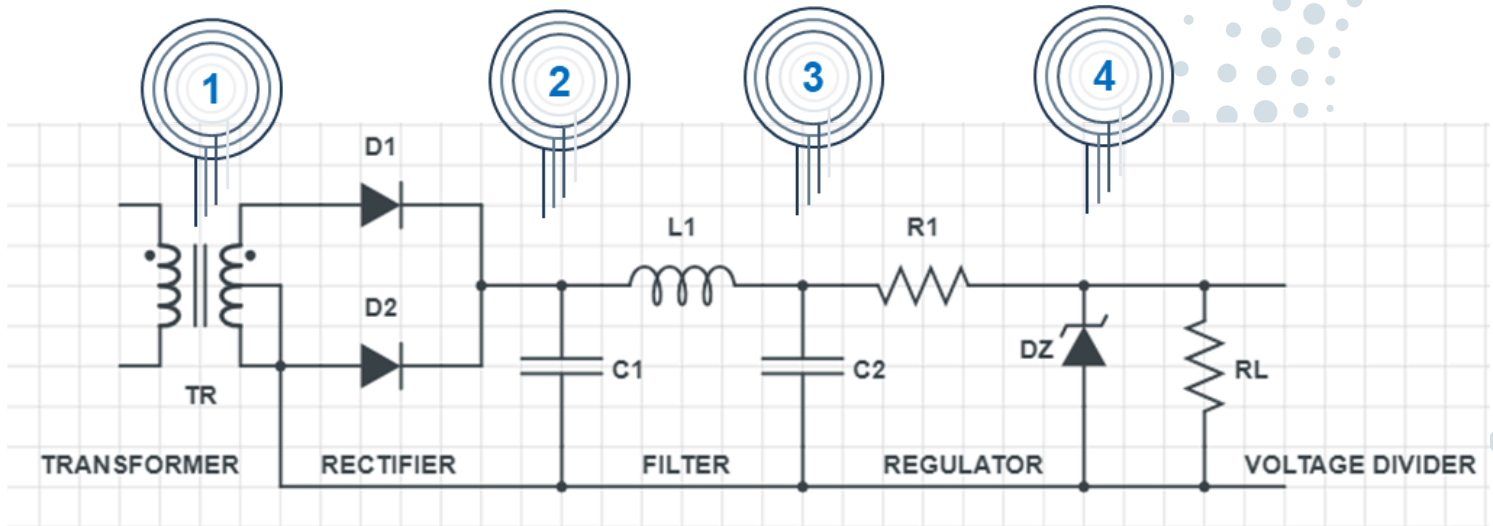
An electrical device that converts AC to DC

It should be constructed in an unbroken loop



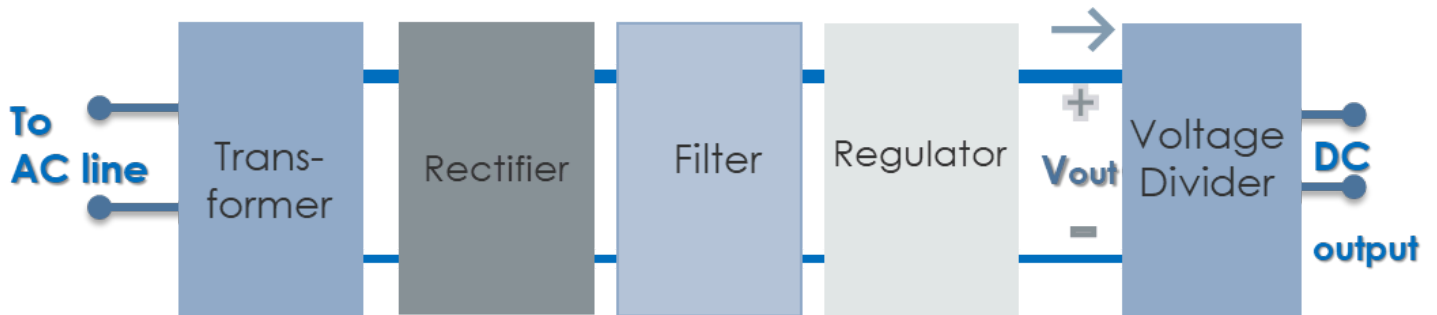


"Schematic Diagrams of a Basic Power Supply Unit"





"BLOCK DIAGRAM"



1

The Transformer

Reduce the input AC voltage to the AC voltage appropriate. 240VAC to 12VAC.

2

Rectifier circuit

Convert AC input signal to the form DC pulse output signal.

3

Filter circuit

Filter DC pulse output signal to form a ripple voltage.

4

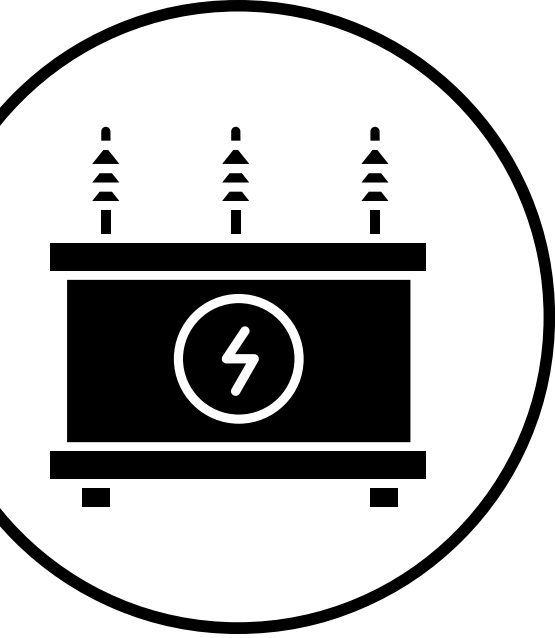
Regulator circuit

Use to stabilize the voltage (reduce the ripple voltage signal).

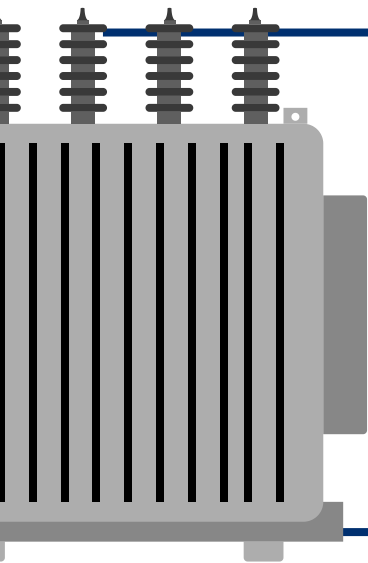
5

Voltage Divider

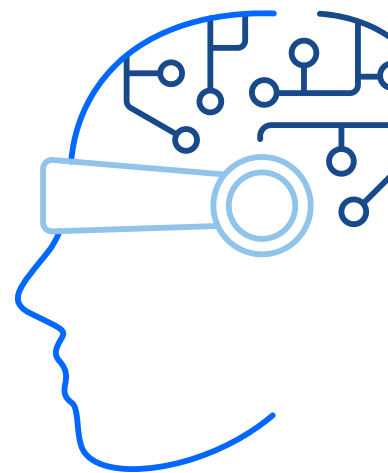
Divide that voltage following the circuit necessity.

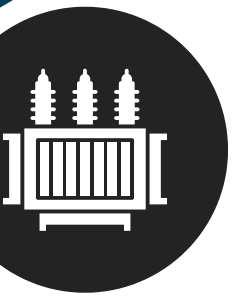


TOPIC 01



TRANSFORMER

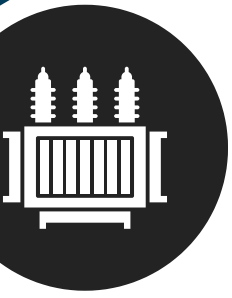




THE PURPOSE OF TRANSFORMERS IS TO...

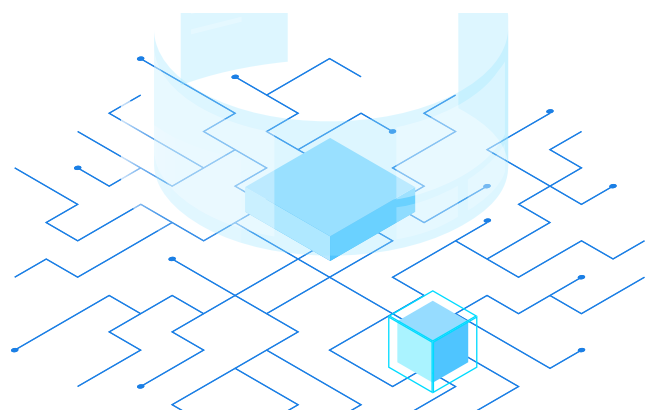
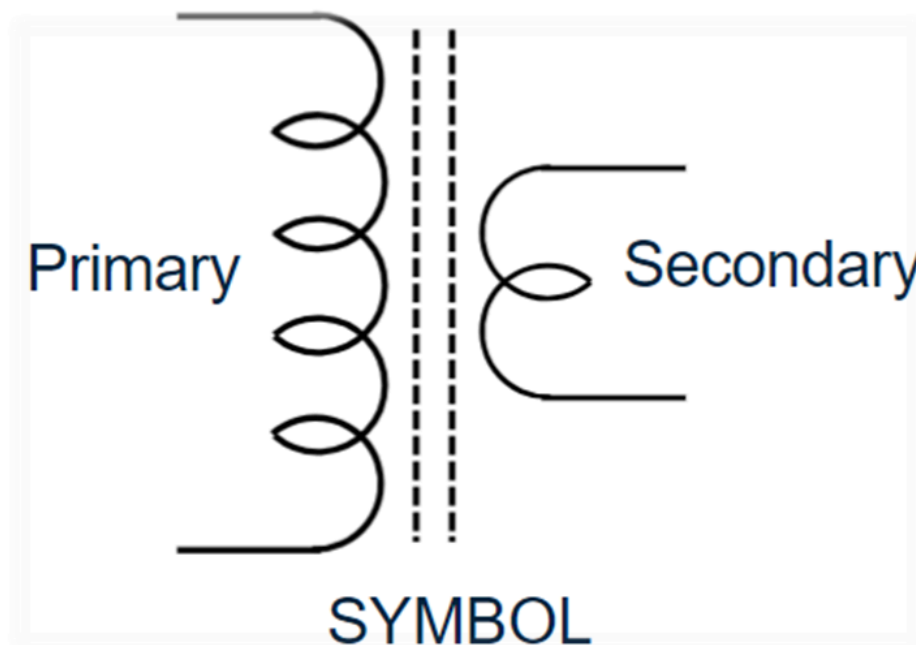


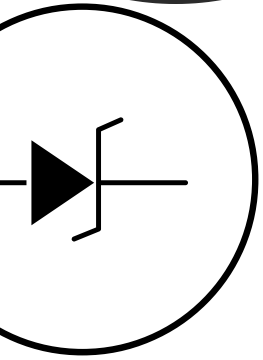
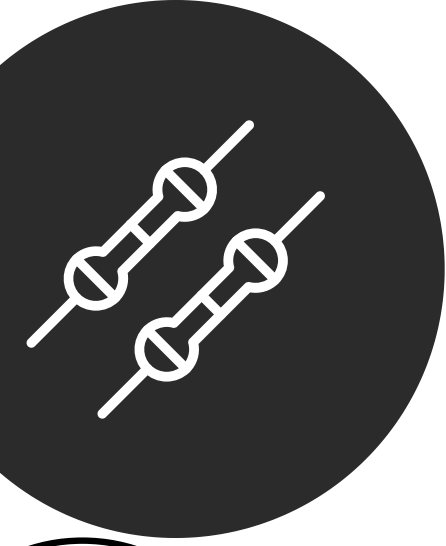
	<p>Voltage Reduction Step-down transformers reduce high voltage to a lower, more manageable voltage level.</p>
	<p>Electrical Safety By lowering the voltage, step-down transformers help enhance electrical safety. Lower voltage levels are safer for household appliances, electronic devices, and other equipment, reducing the risk of electrical shock and fire hazards.</p>
	<p>Compatibility with Devices Many electronic devices and appliances are designed to operate at specific voltage levels.</p>
	<p>Isolation Step-down transformers can provide electrical isolation between circuits. This isolation can protect sensitive equipment from voltage spikes, noise, and other electrical disturbances.</p>



STEP-DOWN TRANSFORMER

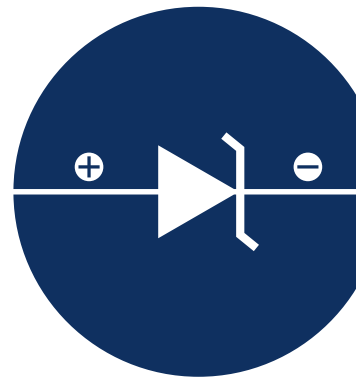
A Step-Down Transformer is a device which converts high primary AC voltage to a low secondary AC voltage.

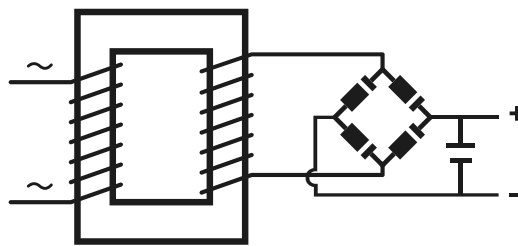
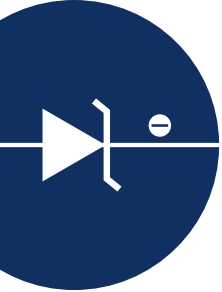




TOPIC 01

RECTIFIER





RECTIFIER

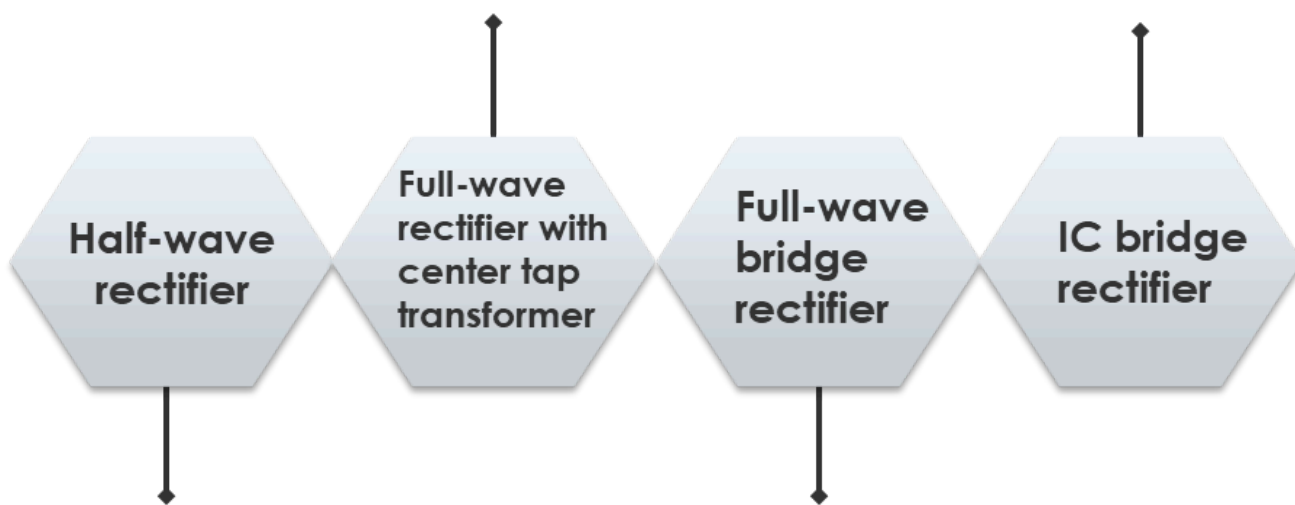
DEE30043



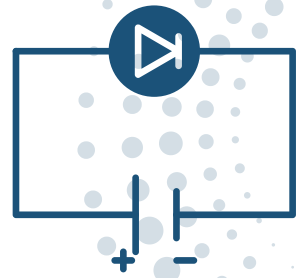
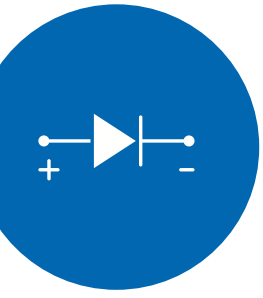
Converts the **AC** input signal to a **direct current** output signal using a diode or multiple diodes.



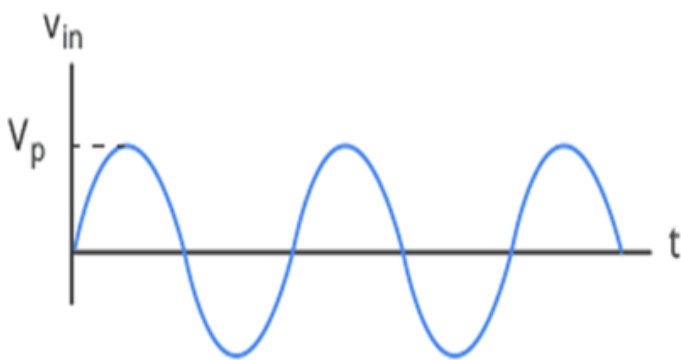
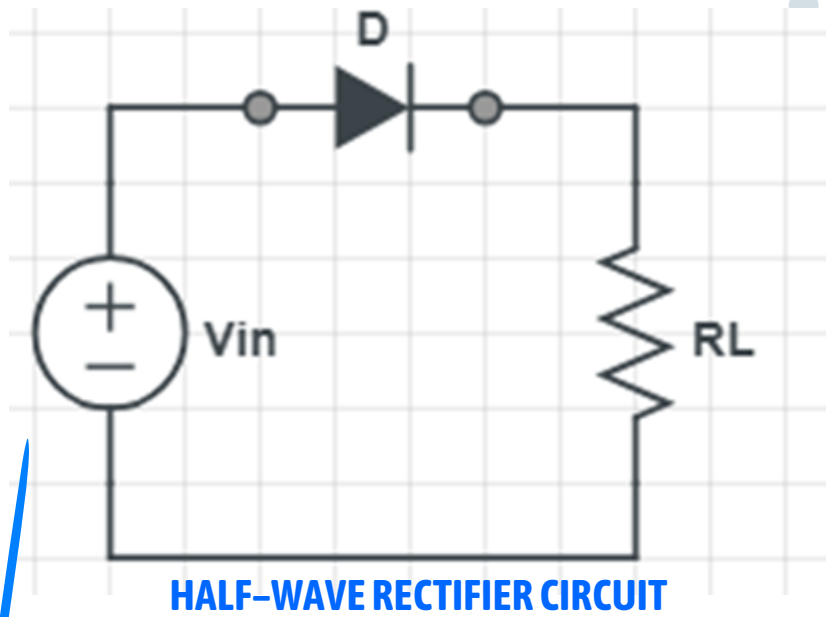
TYPES OF RECTIFIER CIRCUIT



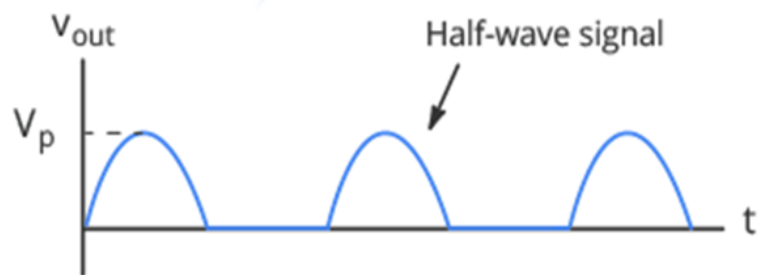
HALF WAVE RECTIFIER



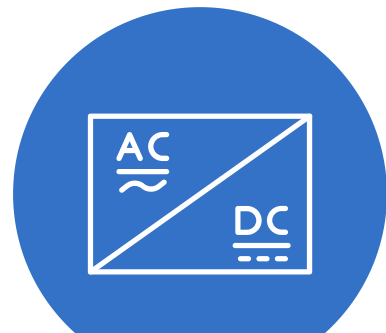
The Half-wave Rectifier passes only one-half of the input sine wave and rejects the other half.

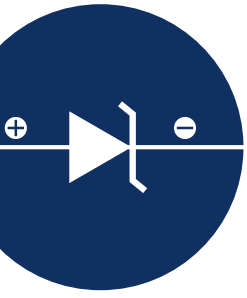


INPUT SIGNAL

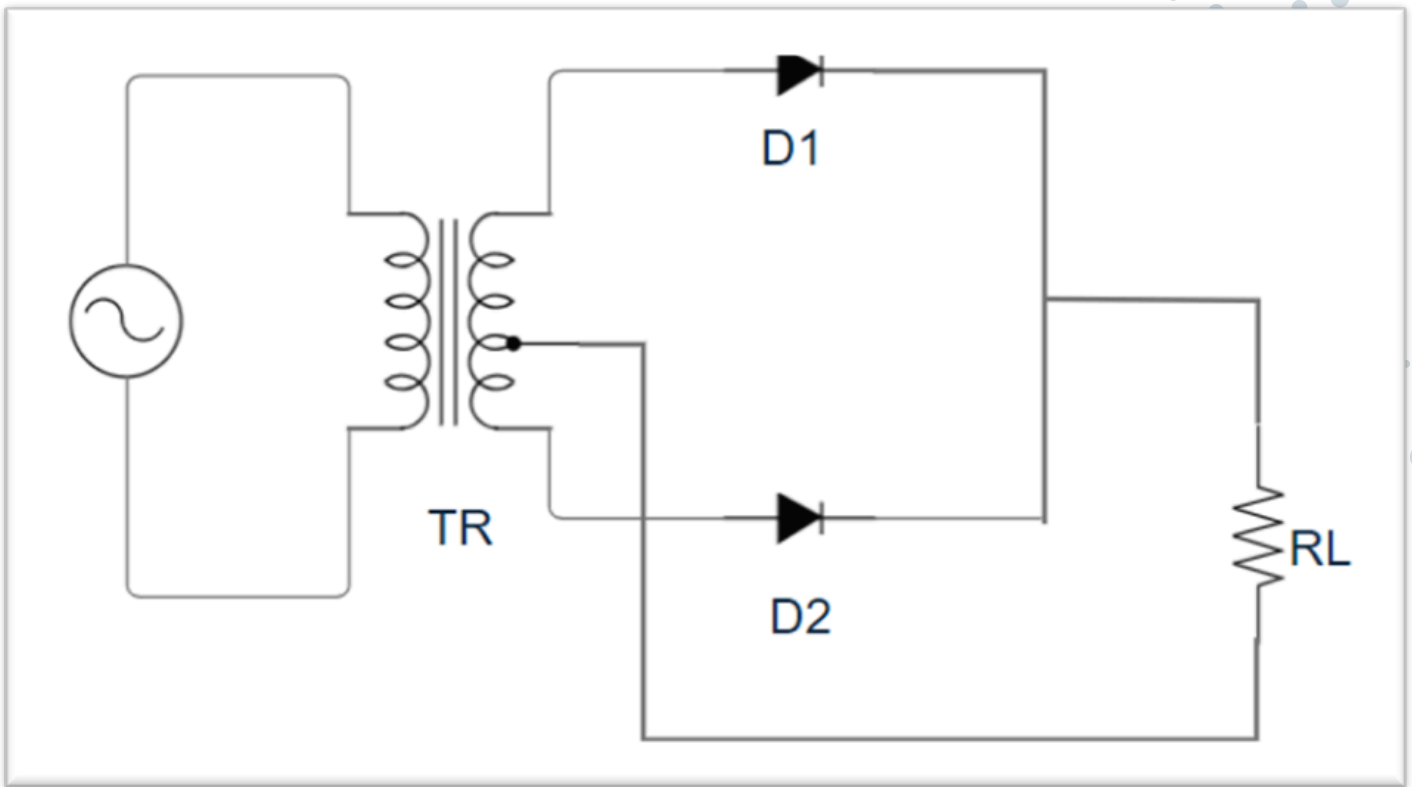


OUTPUT SIGNAL



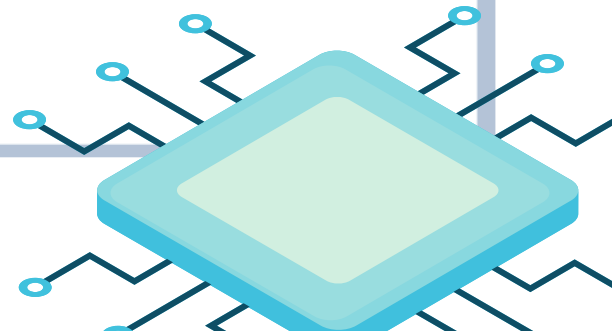
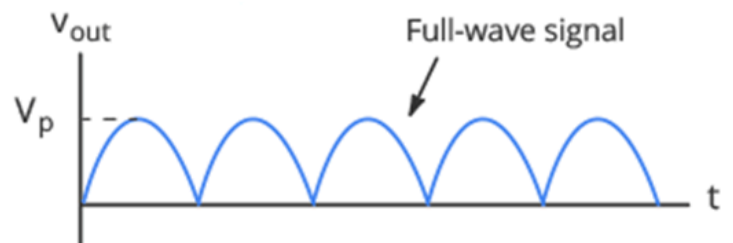


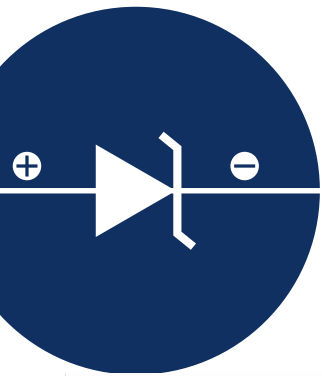
FULL WAVE RECTIFIER WITH CENTER TAP TRANSFORMER



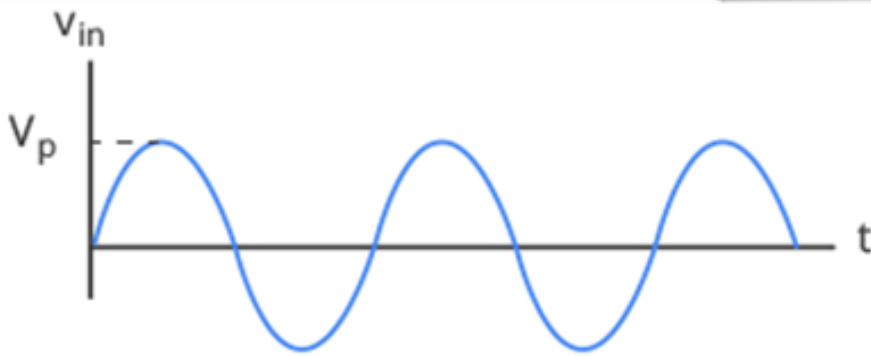
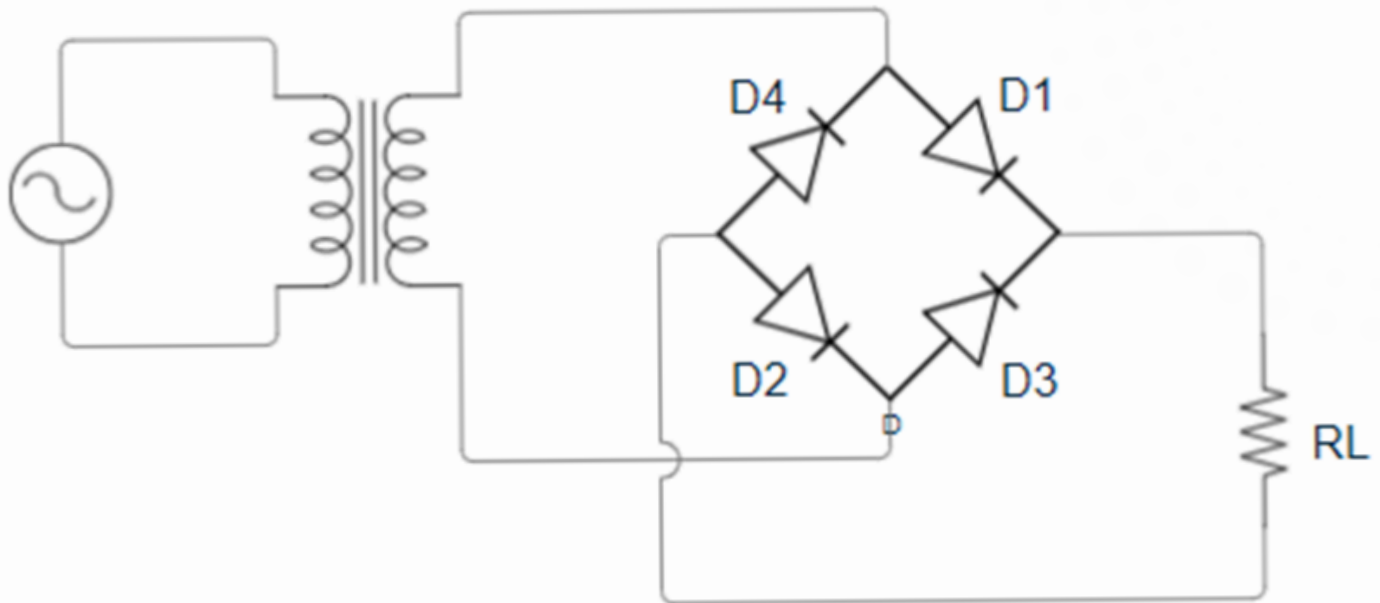
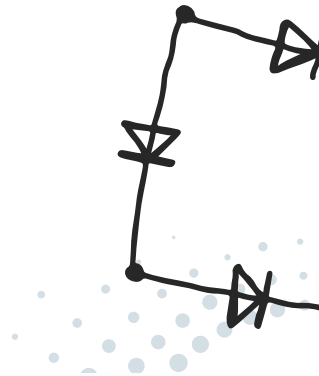
The Full Wave Rectifier With Center Tap Transformer circuit consists of two **diodes** connected to a single load resistance with each diode taking it in turn to supply current to the load.

OUTPUT SIGNAL

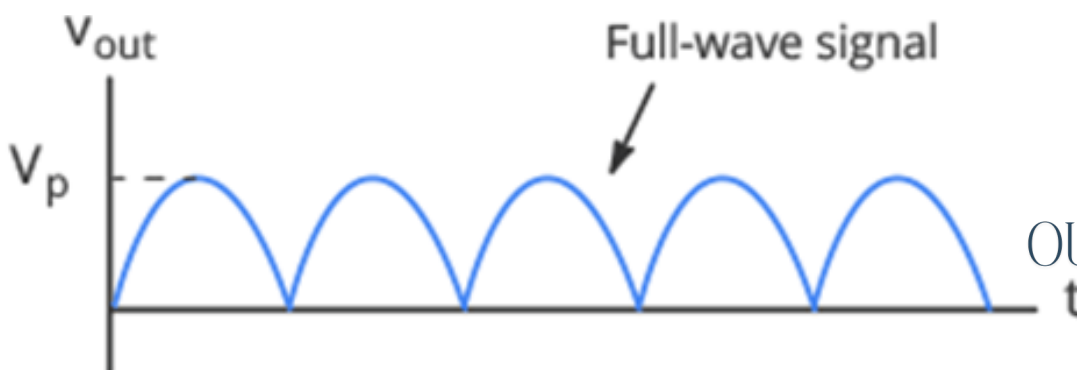




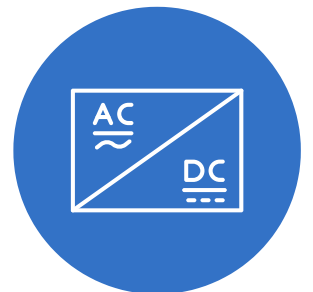
FULL WAVE RECTIFIER BRIDGE

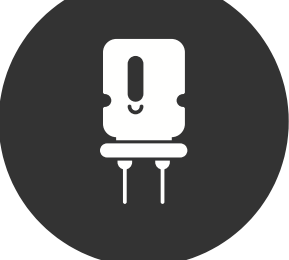


INPUT SIGNAL



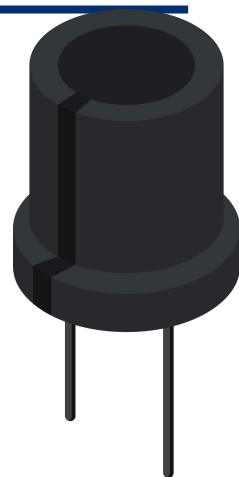
OUTPUT SIGNAL

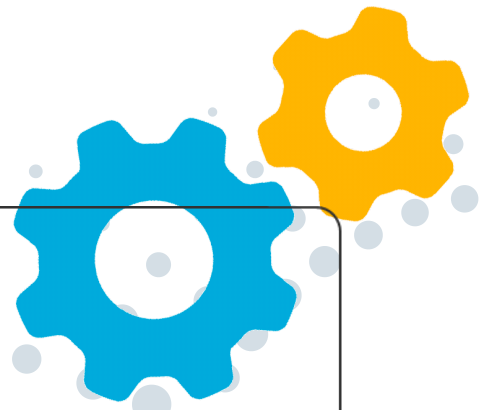




TOPIC 01

FILTER

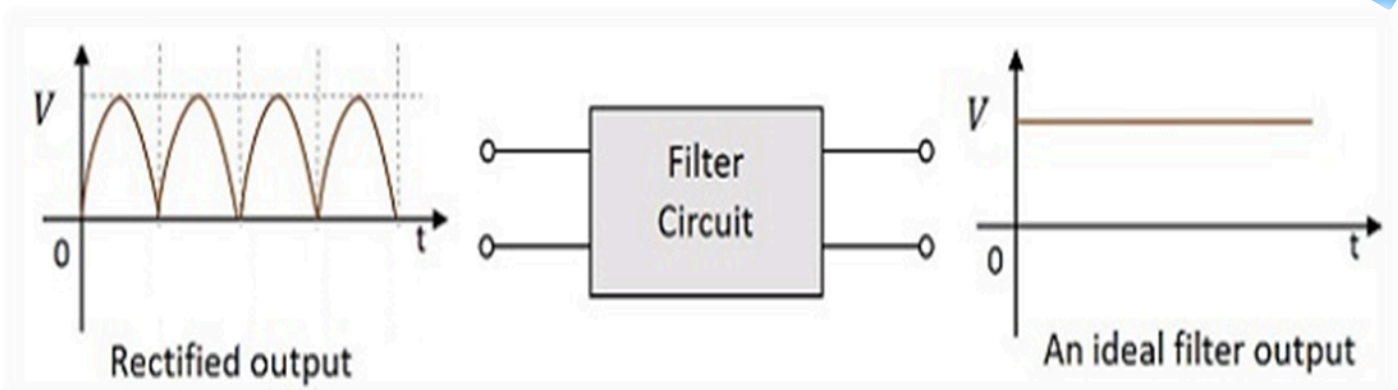
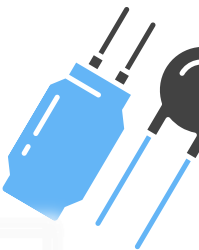




FILTER

**DID
YOU
KNOW?**

A filter circuit is intended to smooth out a DC pulse into a more constant, steady output. The ideal filter output is a direct line.





WHY DO WE NEED FILTERS?

01

Output wave of rectifier is Pulsating DC Voltage.

02

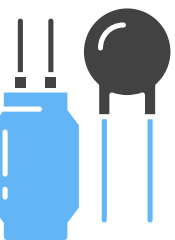
Smooths the pulsating DC to make it more consistent. A filter minimizes or removes ripple voltage from a rectified output by opposing changes in voltage and current.

03

The ripple in the signal denotes the presence of some AC component. This AC component has to be completely removed in order to get pure DC output.

04

A **filter circuit** removes **the AC component in the rectified output** and allows the DC component to reach the load.



RIPPLE VOLTAGE?



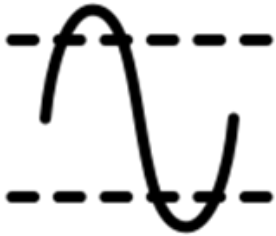
Ripple voltage is the amount of varying voltage present in a DC power supply

The ripple voltage is the voltage drop before the capacitor begins to charge again.

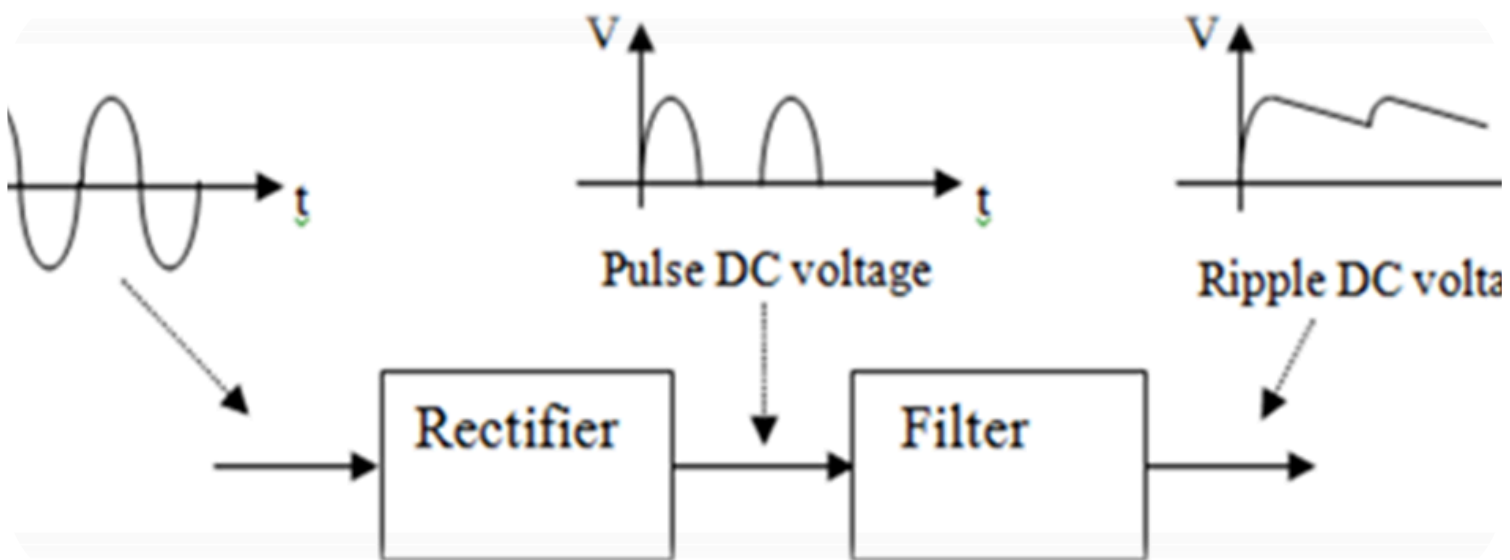


The amount of discharge between voltage peaks is controlled by the resistor-capacitor (RC) time constant of the capacitor and the load resistance.





FILTERING DC PULSE TO SMOOTH WAVE



Output wave of filter called RIPPLE DC VOLTAGE

101101



TYPES OF FILTER



CAPACITOR FILTER



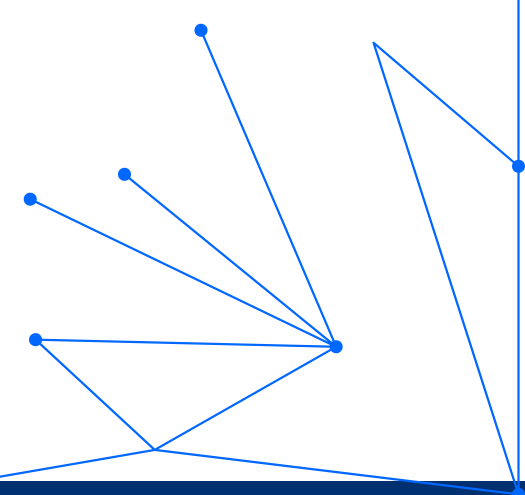
RC FILTER



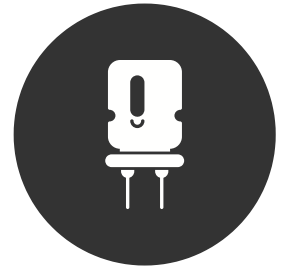
LC FILTER



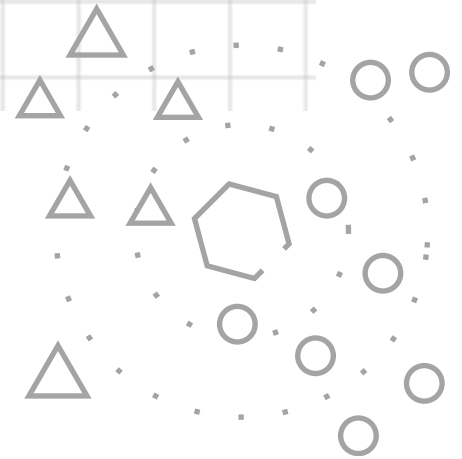
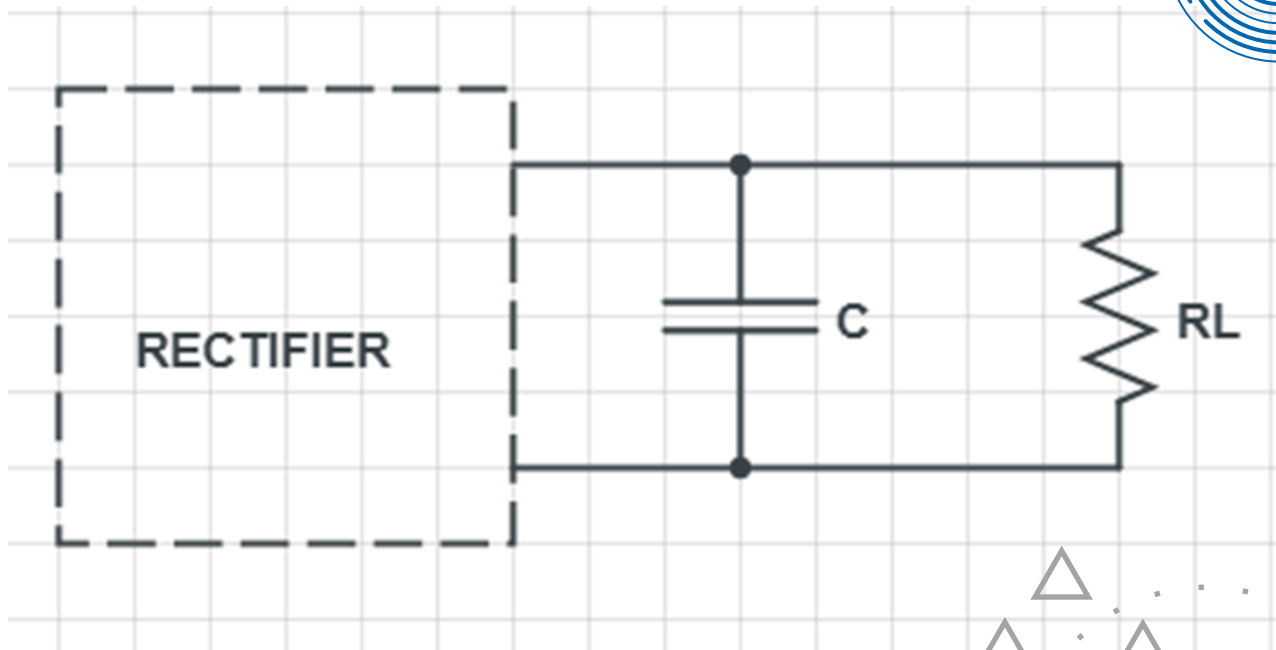
LC FILTER



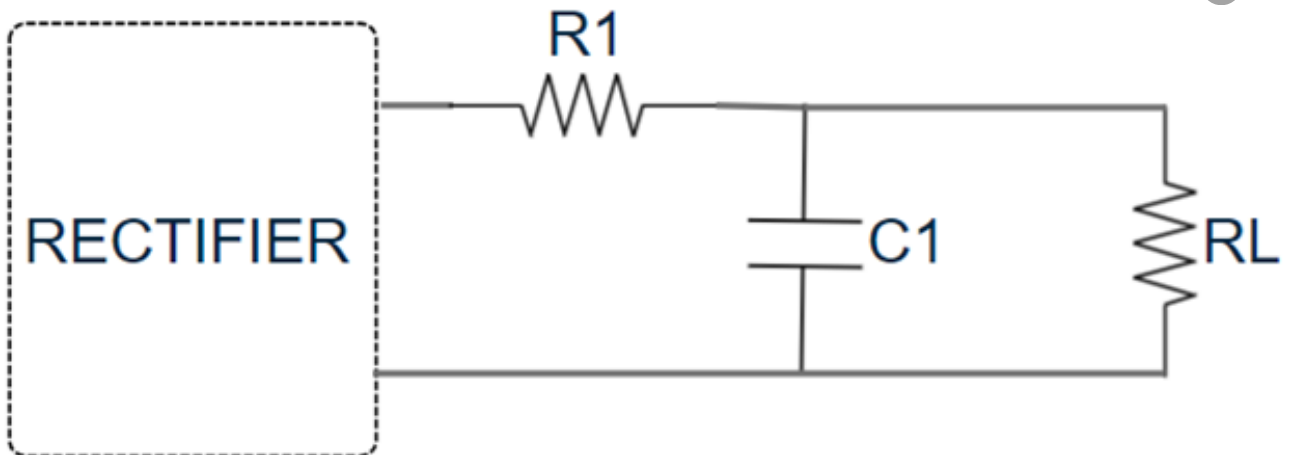
FILTER CIRCUIT



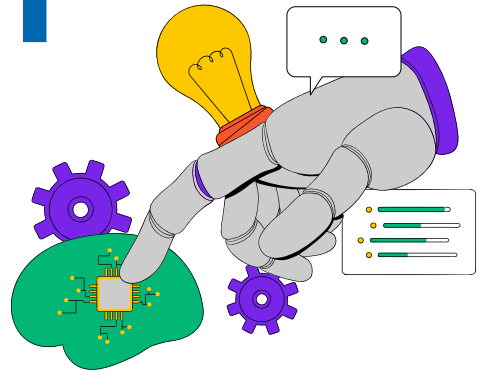
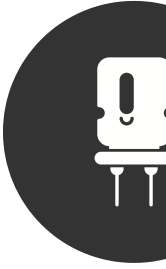
CAPACITOR FILTER



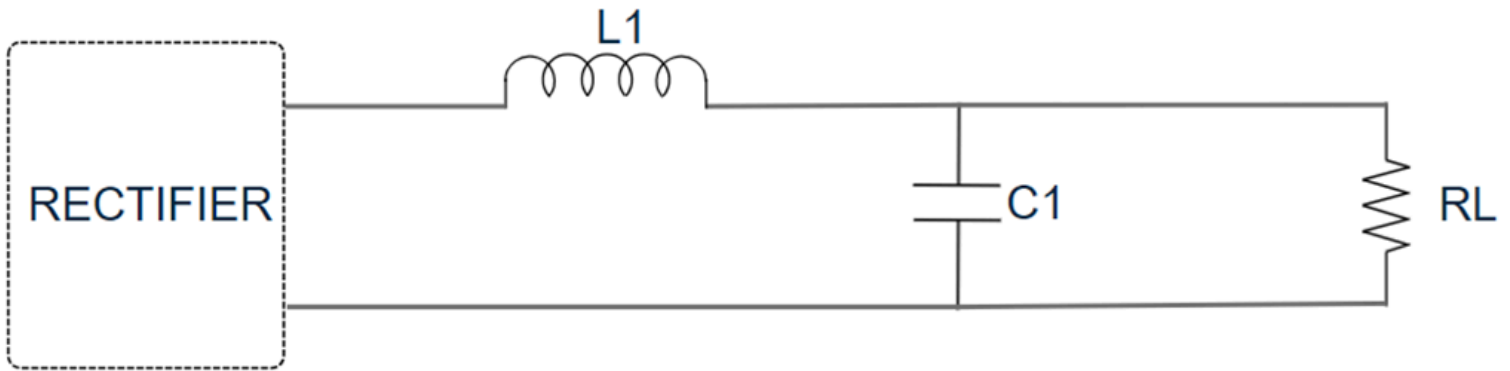
RC FILTER



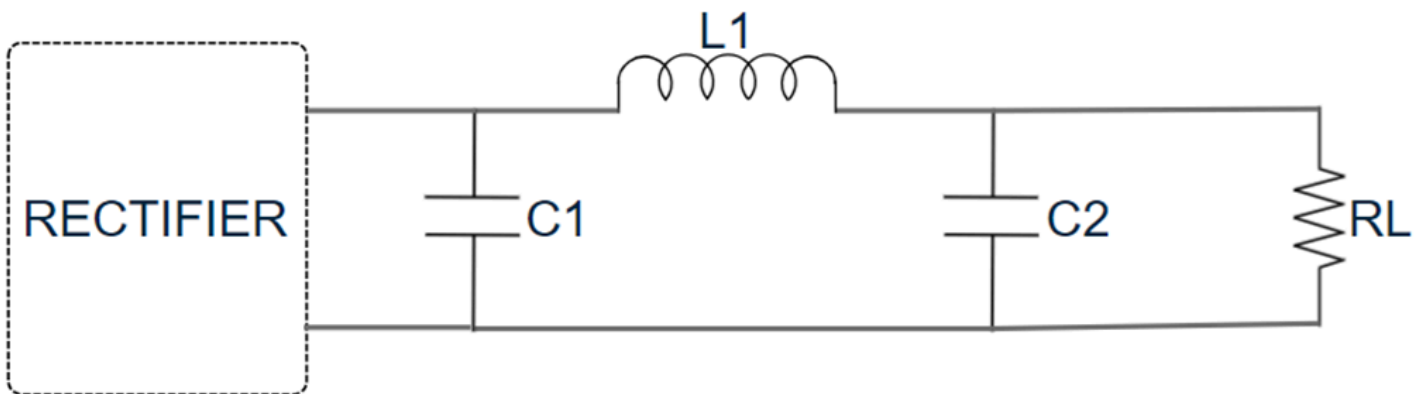
FILTER CIRCUIT



LC FILTER



π LC FILTER

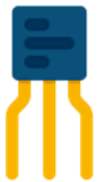




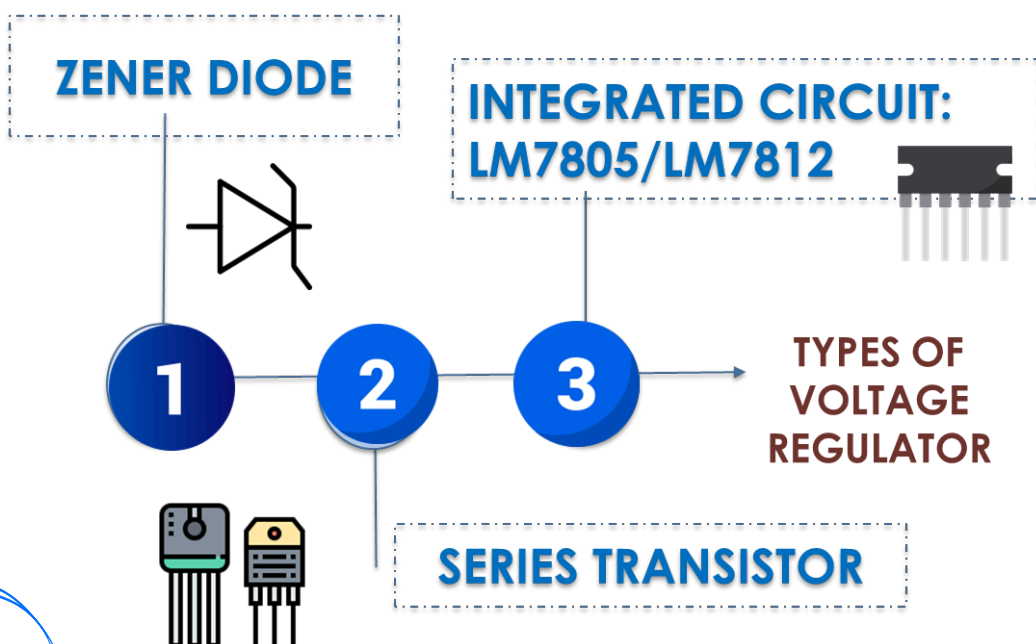
VOLTAGE REGULATOR



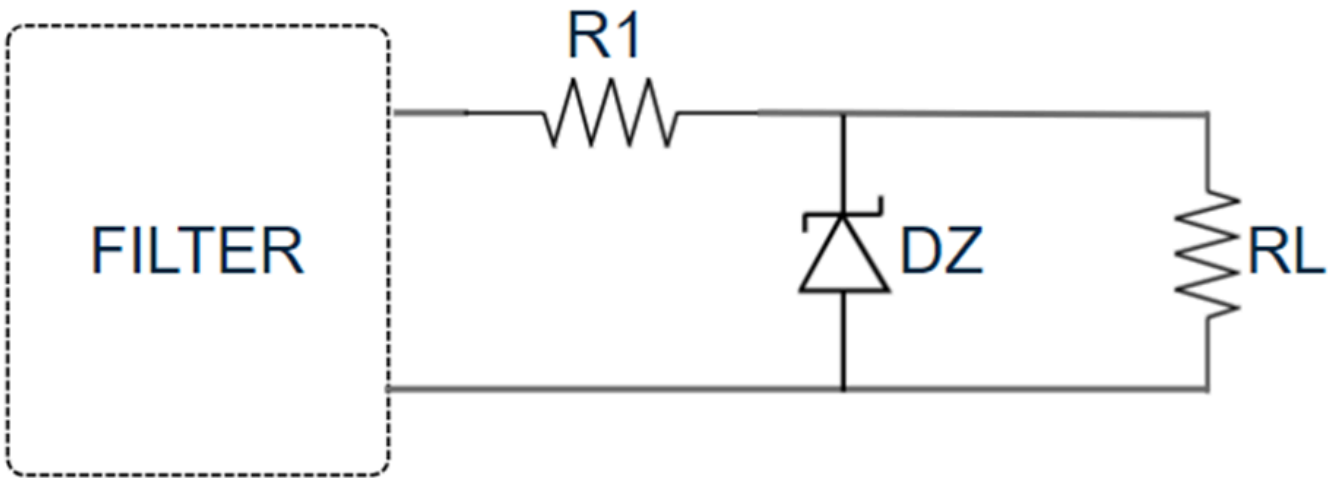
The main purpose of the voltage regulator circuit is to minimize changes to zero or at least to a minimal value



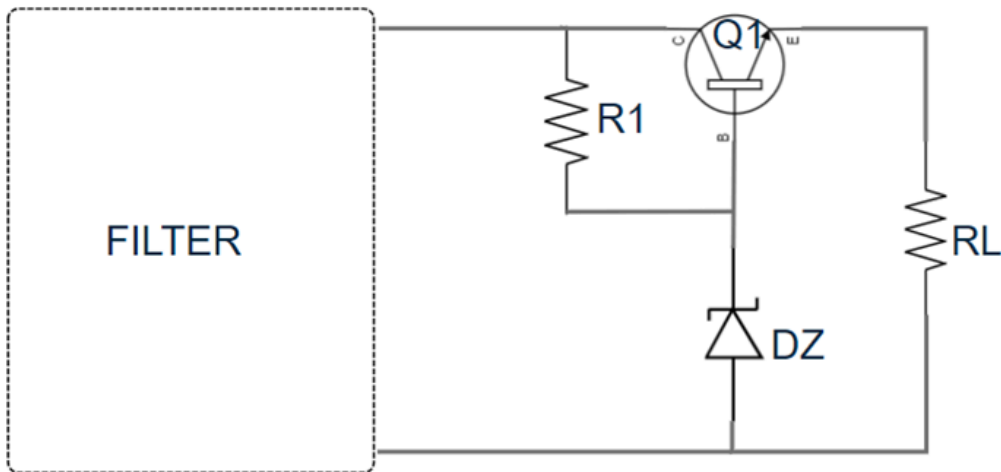
A voltage regulator is an electrical regulator designed to automatically maintain a constant voltage level (stabilize).



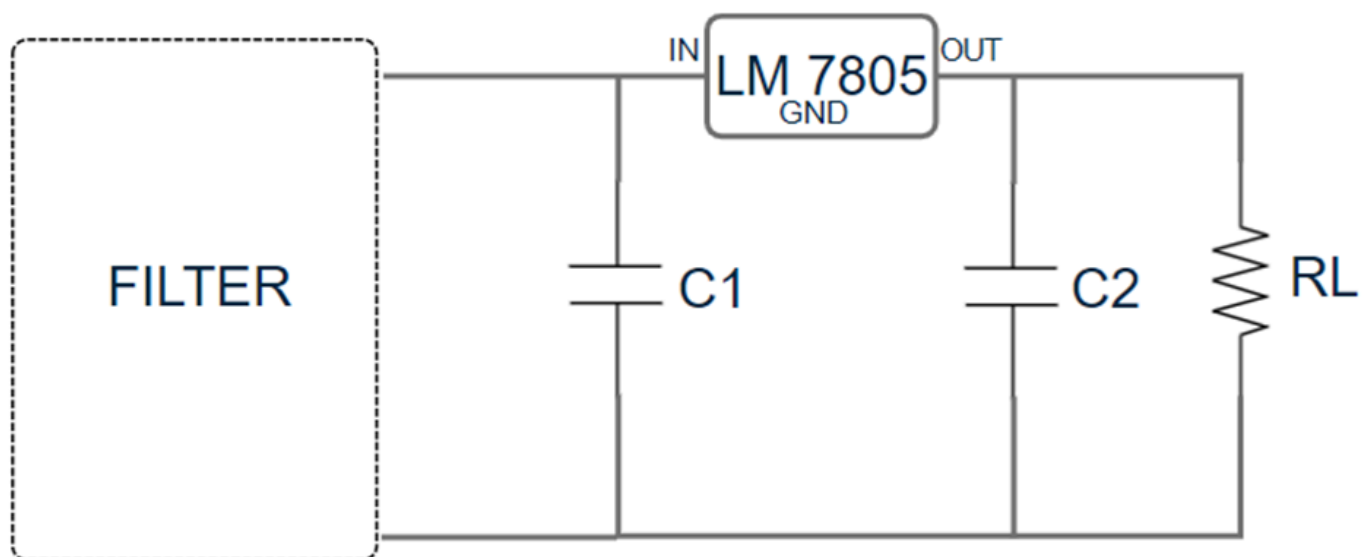
VOLTAGE REGULATOR



Zener Diode Voltage Regulator Circuit



Serial Transistor Voltage Regulator Circuit



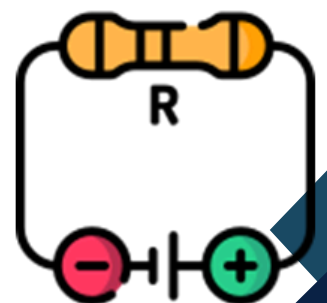
IC Voltage Regulator Circuit



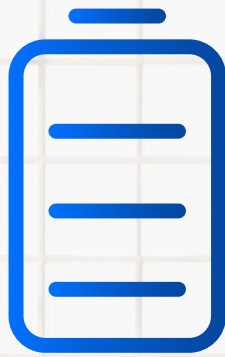
VOLTAGE DIVIDER

A voltage divider is a simple circuit used to reduce a high voltage to a lower voltage.

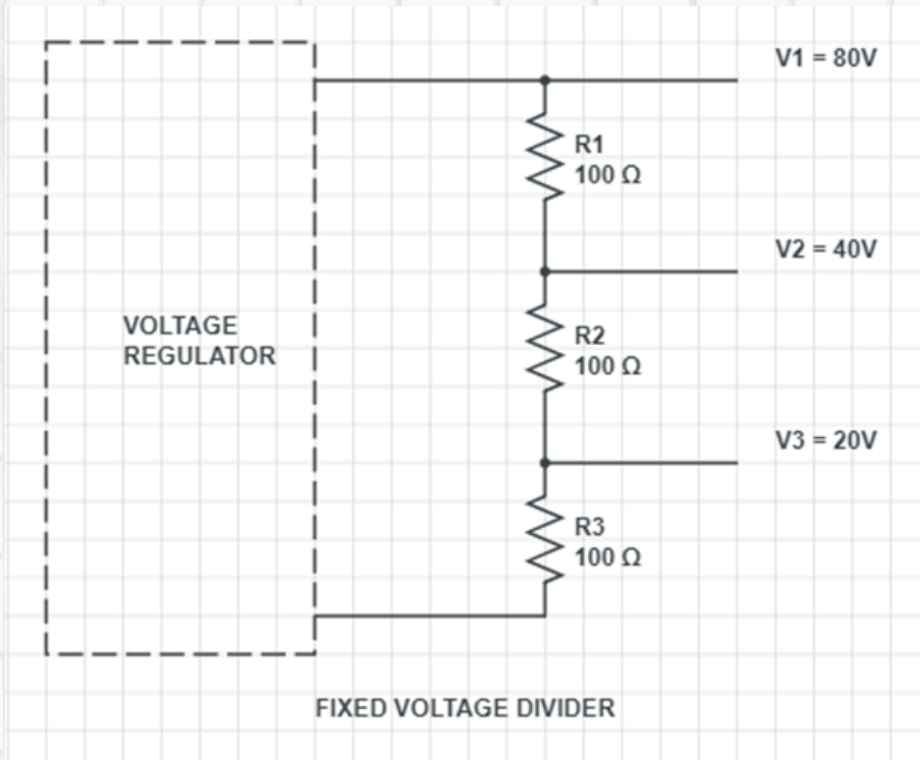
Voltage Divider circuits are used to produce different voltage levels from a common voltage source.



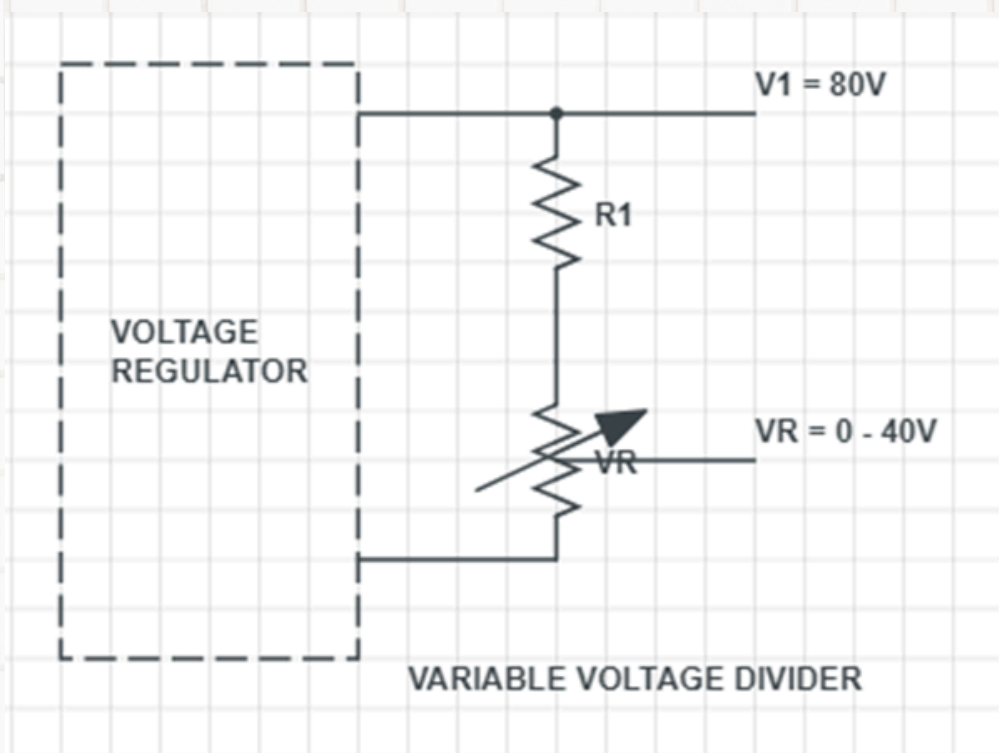
VOLTAGE DIVIDER



FIXED VOLTAGE DIVIDER

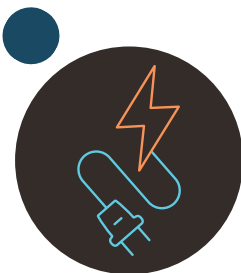


VARIABLE VOLTAGE DIVIDER



TUTORIALS

TOPIC 1



a) Based on Figure 1, name the block for 'P', 'Q', 'R' and 'S'

b) Then, explain the function for each block diagram a simple Direct Current (DC) Power Supply.

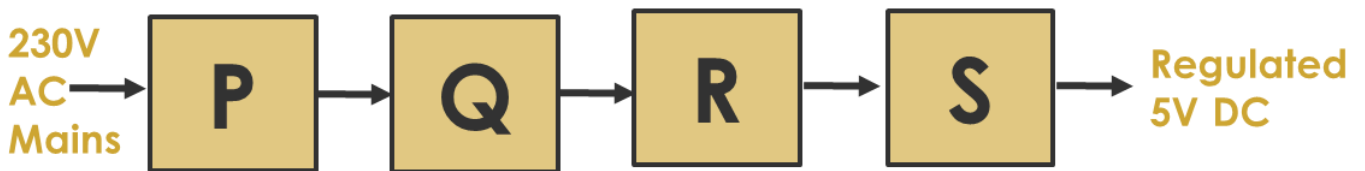
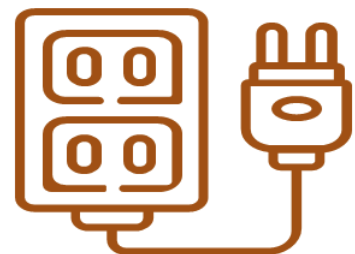


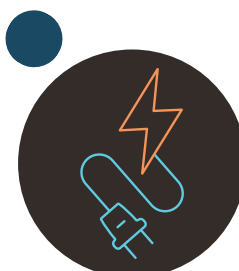
Figure 1: Block Diagram of a Regulated Power Supply System

The four main parts of the system are the Transformer, Full Wave Bridge Rectifier Circuit, Filter Circuit, and Regulator Circuit.

TIPS



Power Supply



Transfer the block diagram in Figure 2 into complete power supply circuit.

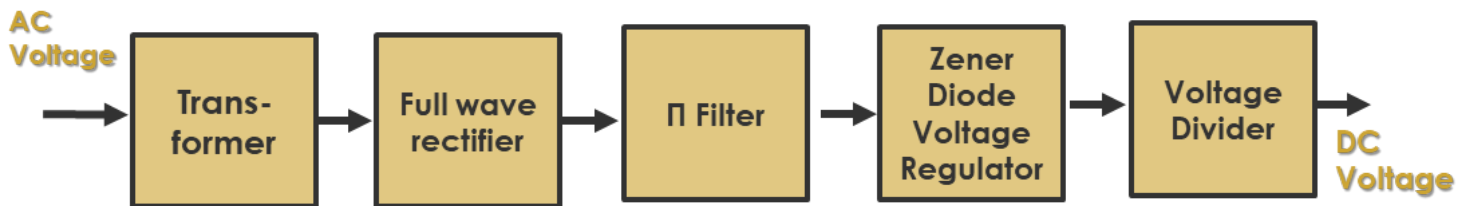
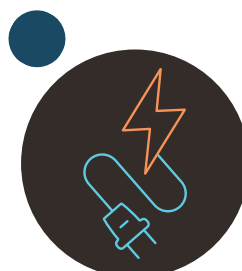
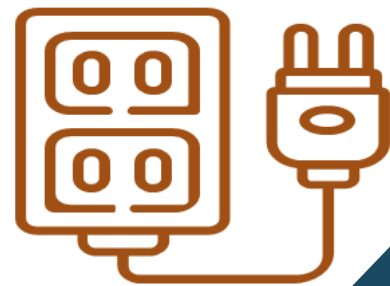


Figure 2

TIPS

A power supply circuit converts AC voltage into DC voltage using components like a transformer, rectifier, filter, and regulator circuits.

Power Supply



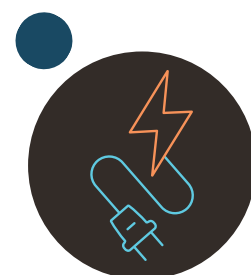
The main function of rectifier in power supply unit is to convert the Alternating Current (AC) to Direct Current (DC) power. List THREE (3) types of rectifier circuit are commonly used in this power supply unit. How many diodes are using in the rectifier circuit, respectively.

TIPS

THERE ARE (4) FOUR TYPES OF RECTIFIER CIRCUIT



RECTIFIER



Referring to the Figure 3, calculate the ripple voltage of the waveform. Then sketch a diagram of π LC filter circuit and explain briefly the operations of the circuit.

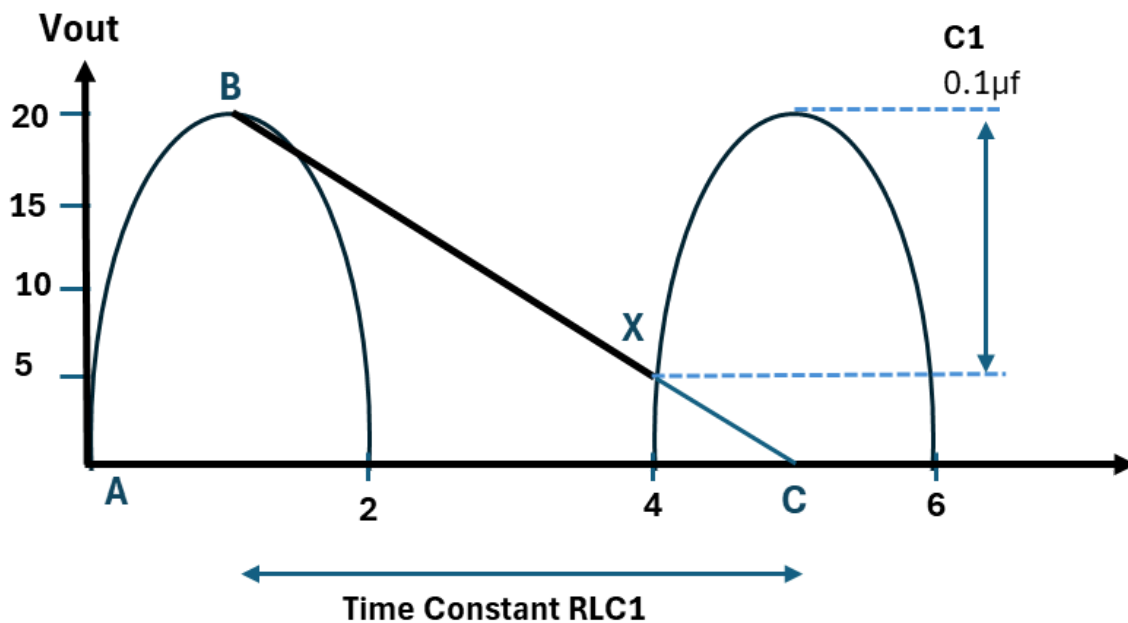
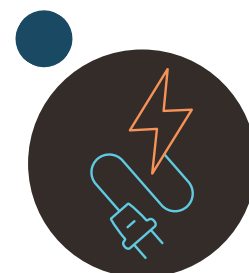
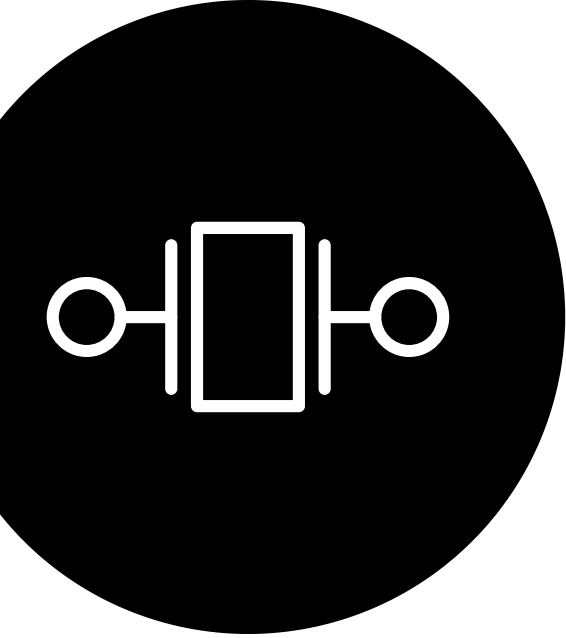


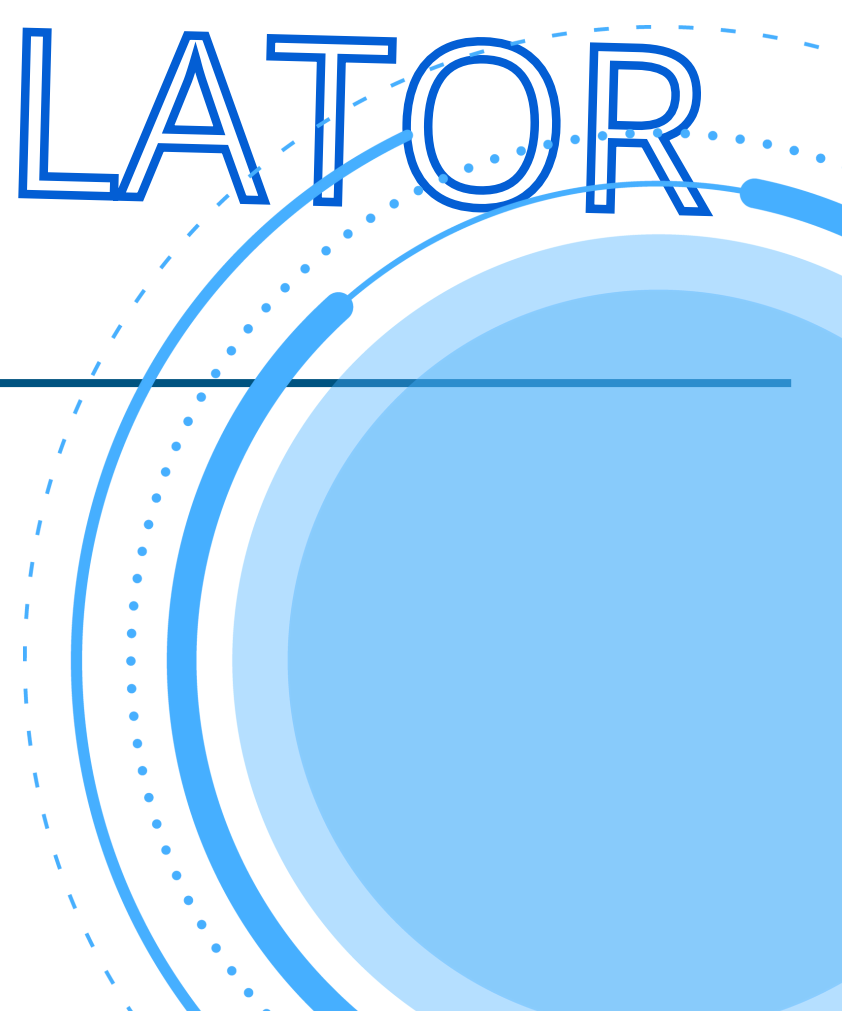
Figure 3



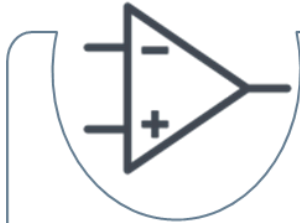


TOPIC 2

OSCILLATOR



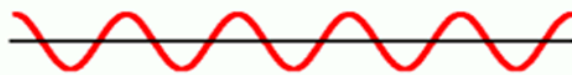
WHAT IS OSCILLATOR ?



Is an electronic circuit that generates a periodic waveform on its output without an external signal source. It is used to convert DC to AC.



Produces a continuous signal of some types without the need of input:-



Sine wave



Square wave



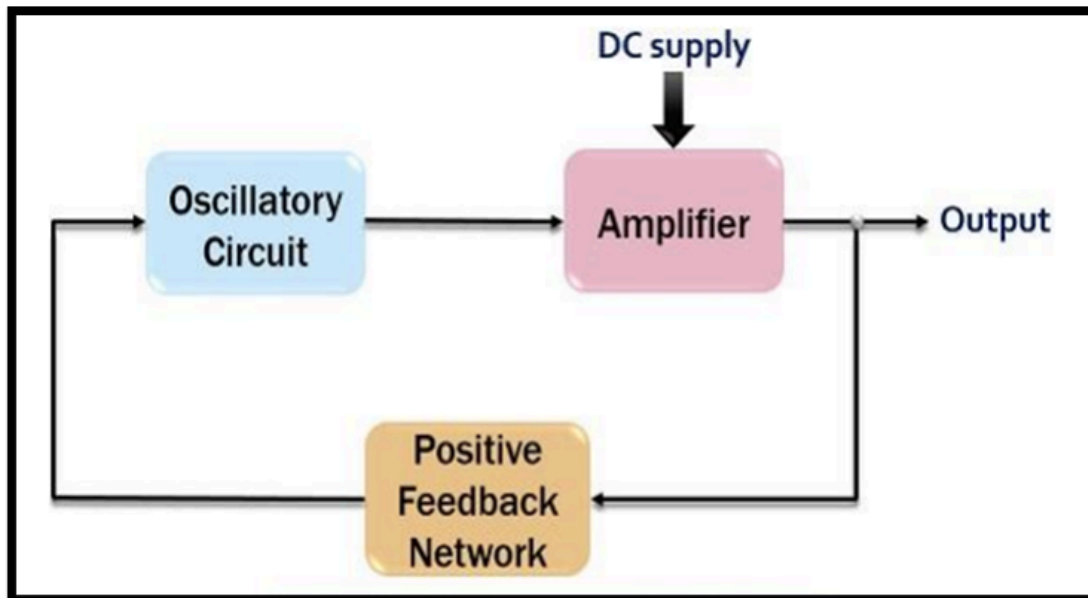
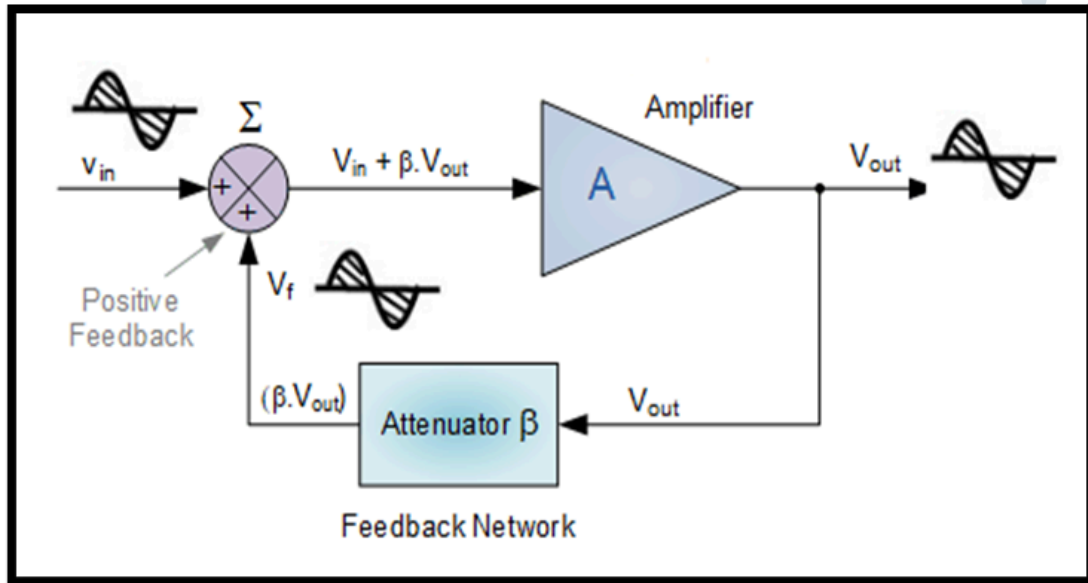
Saw-tooth wave



Triangle wave

BLOCK DIAGRAM

Oscillator



Oscillator



01

Generate an AC output signal without requiring any externally applied input signal.



02

Oscillatory circuit produces oscillations



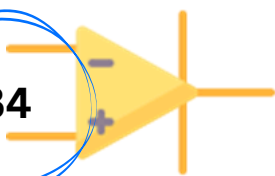
03

An Amplifier for signal gain. Its keep producing an output signal as long the DC power source is connected.

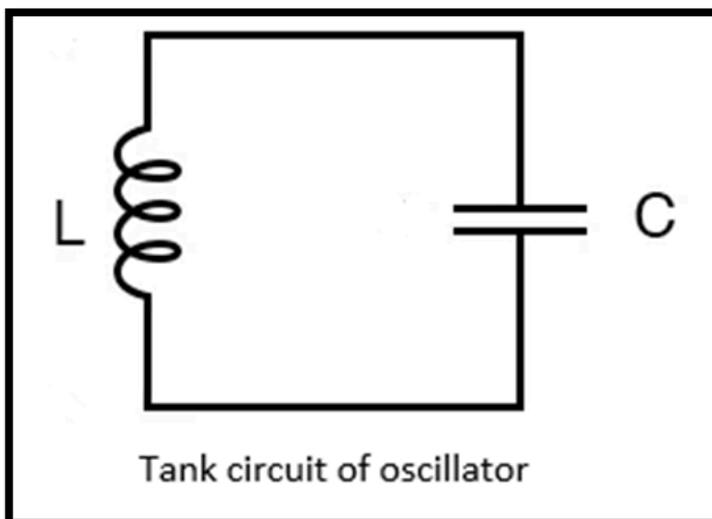
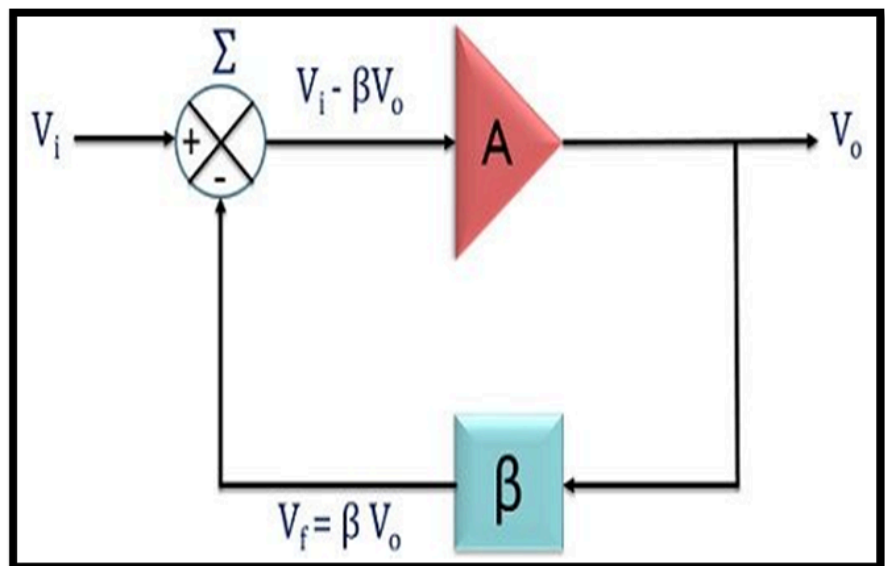
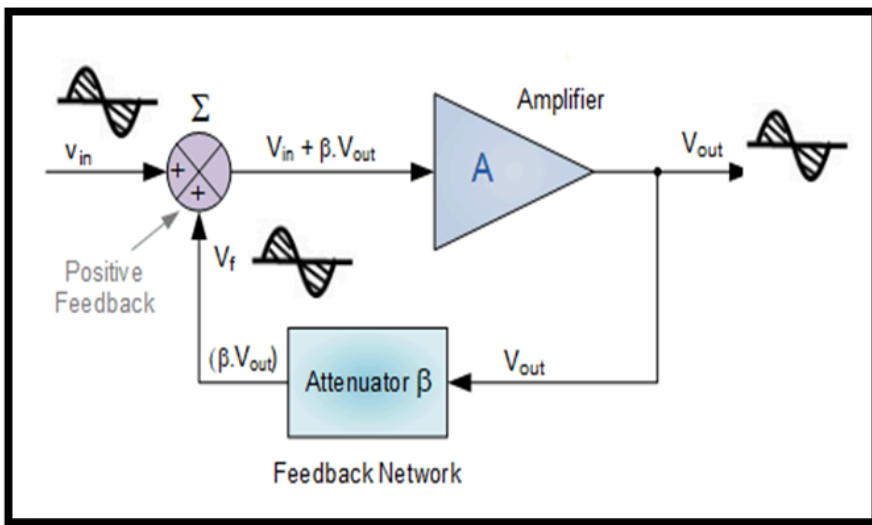


04

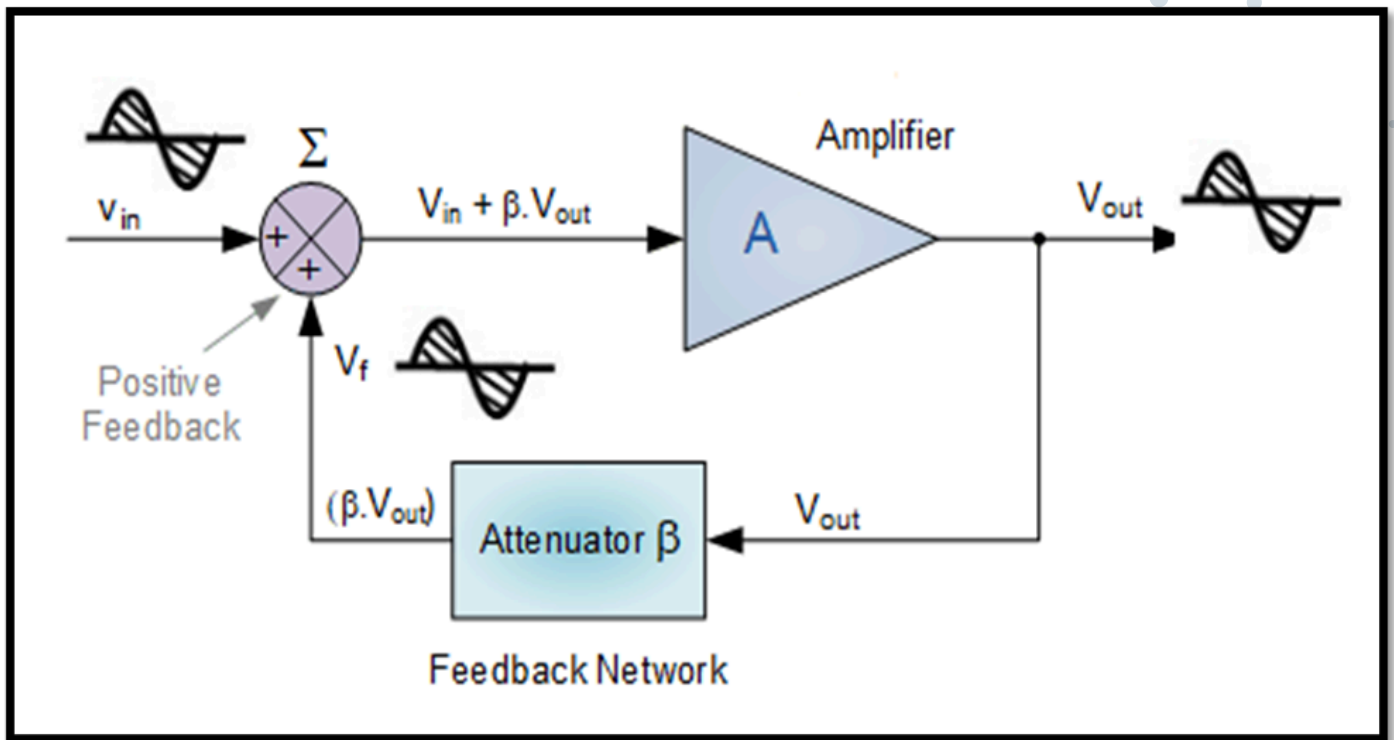
Feedback Network or Positive Feedback Circuit gets a portion of the amplifier output and feeds it the oscillator circuit in correct phase and magnitude to sustain the input. Feedback signal must also be REGENERATIVE (positive).



Oscillator



Terms in Oscillator



TERMS:

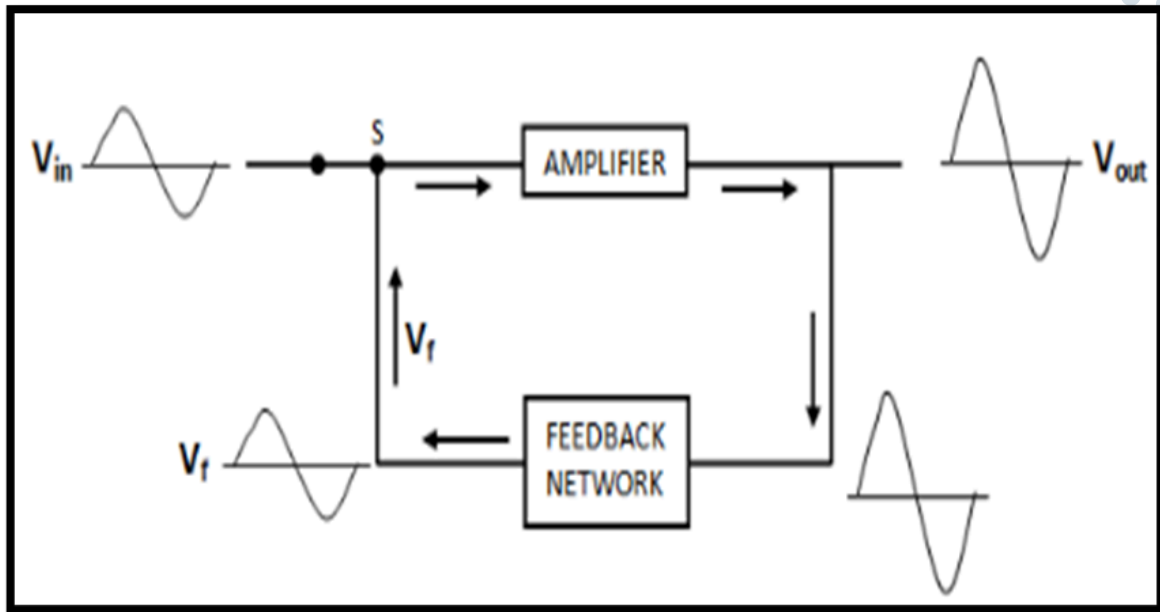
V_{in} is the input from oscillator circuit

A is an amplifier gain

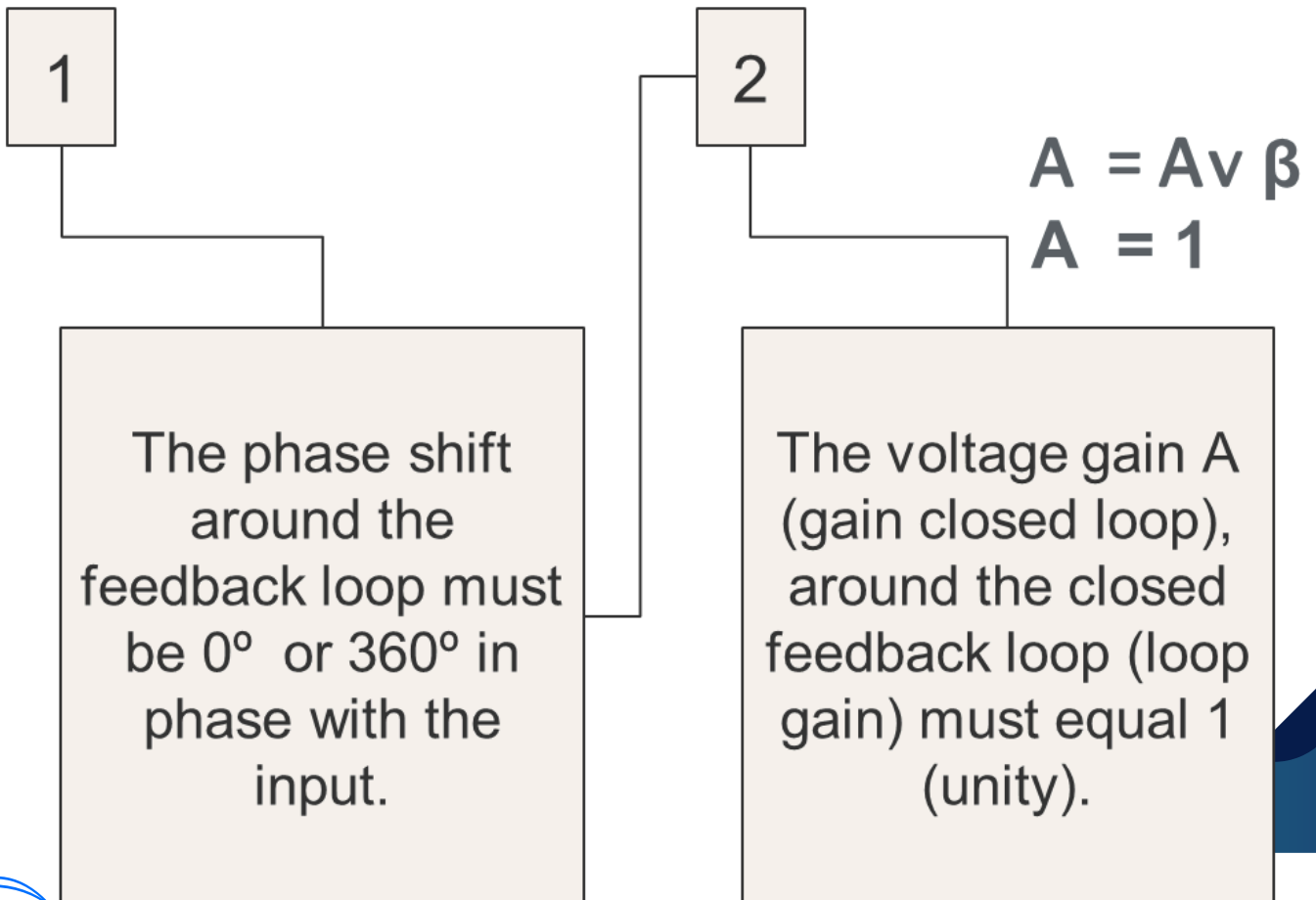
V_{out} is output of the amplifier

β is feedback fraction from feedback network

Requirements of Oscillator Circuits



Two conditions are required for a sustained state of oscillation (**Barkhausen Criterion**):



TYPES OF SINUSOIDAL OSCILLATOR

LC OSCILLATOR

Colpitts's Oscillator
consist of 1 inductor (L1)
and two capacitors (C1,
C2).

Hartley Oscillator
consist of 1 capacitor
(C1) and two inductors
(L1, L2).

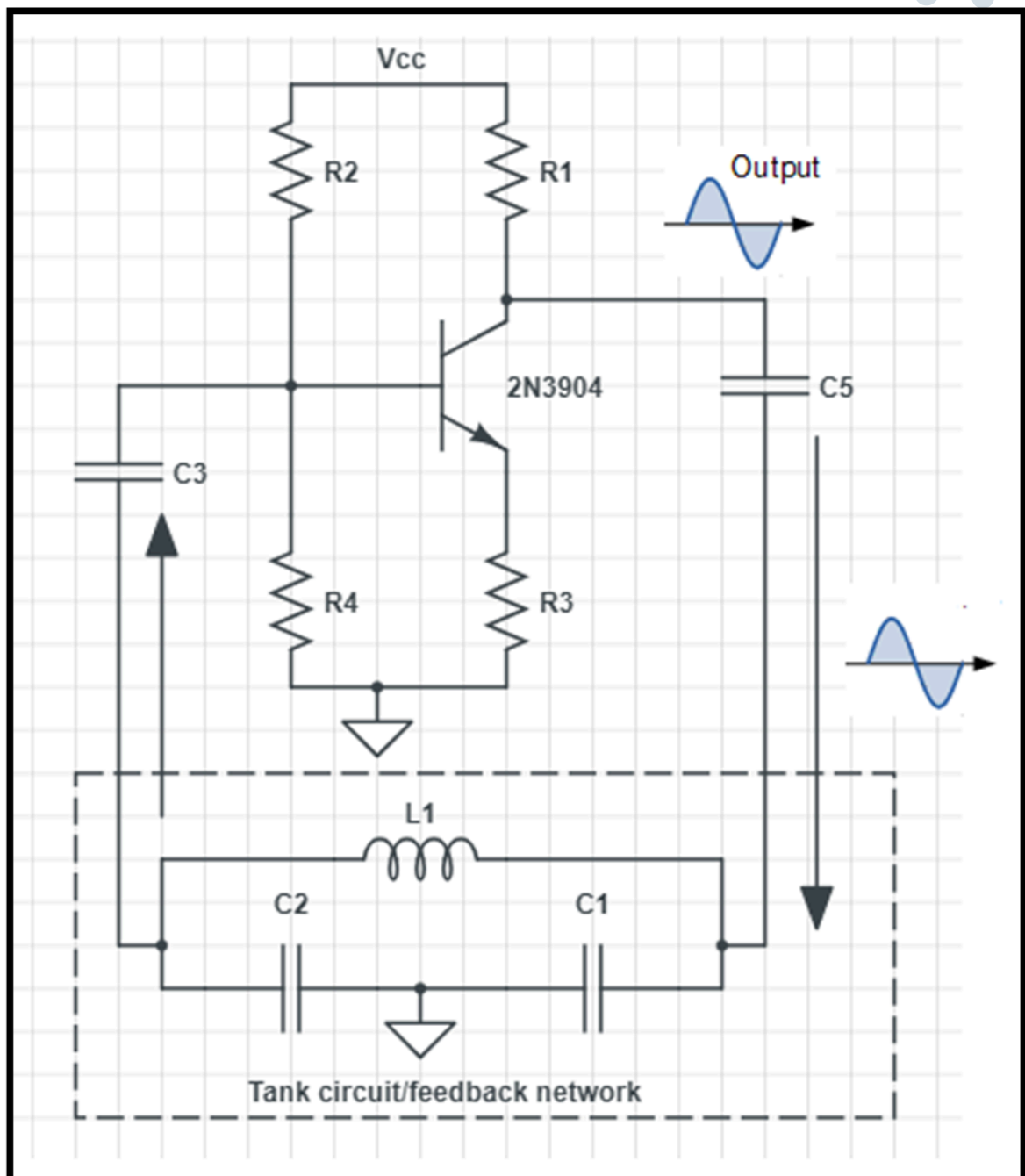
Armstrong Oscillator
consist of transformer
(TR1) and capacitor (C1).

Crystal Oscillator
depend on Equivalent
circuit (in series R1, C1,
L1 and in parallel C2).

RC OSCILLATOR

**Phase Shift (RC)
Oscillator**
consist of resistor-
capacitor (RC Network),
($180^\circ = 3$ RC network)

COLPITT'S OSCILLATOR CIRCUIT



COLPITT'S OSCILLATOR OPERATION

1

Colpitts oscillator consist of tank circuit which is made up of two capacitors connected in series (C1 & C2) and an inductor (L) is connected parallel to this series combination

2

When power supply is switched ON, voltage signal from transistor make the capacitor C1 and C2 starts charging and discharging through the inductor L. Oscillations will be generated.

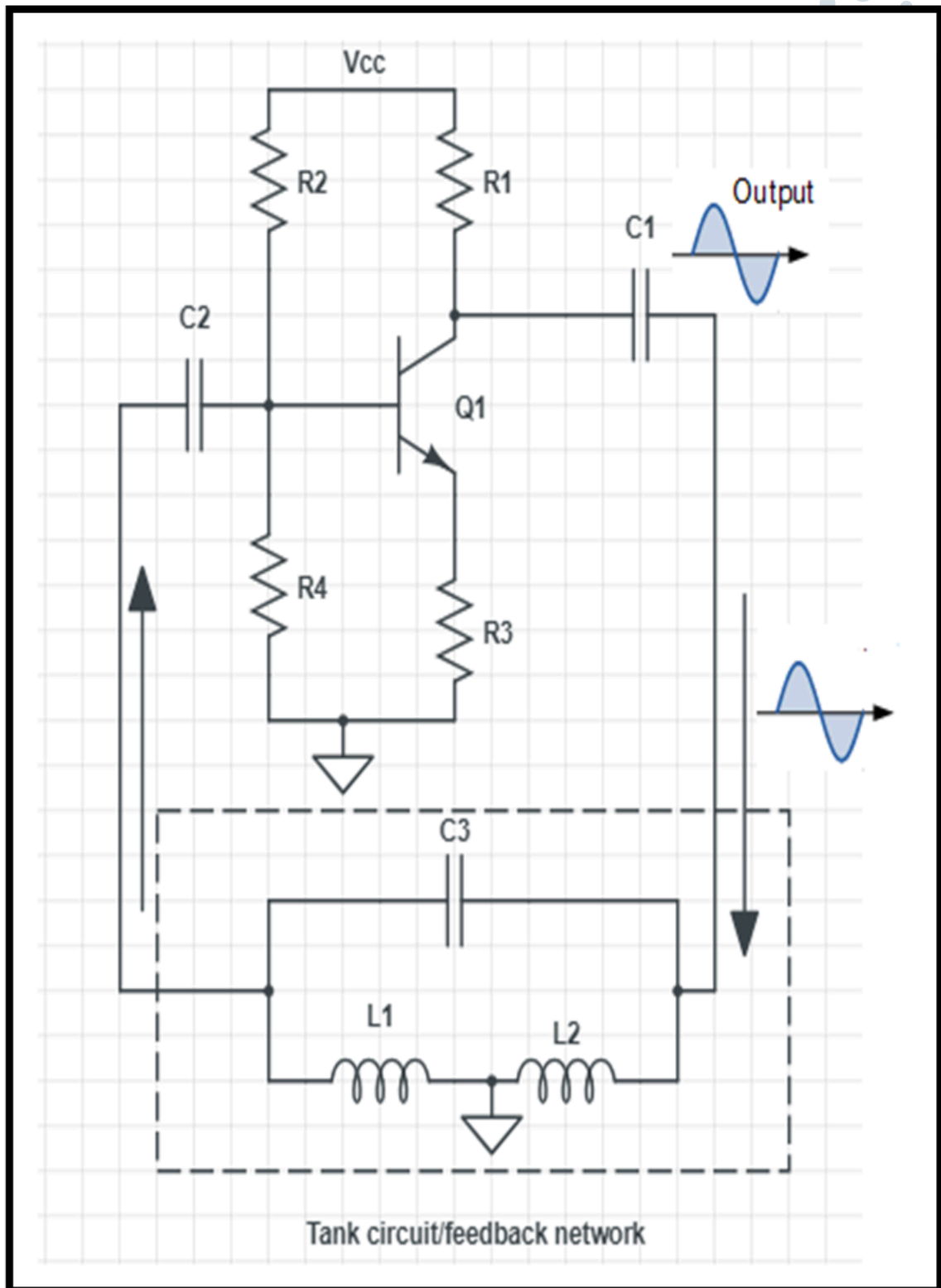
3

Charging and discharging process in tank circuit will produce a phase shift of 180° frequency signal.

4

Transistor produces 180° phase shift between the input and output voltage will result positive feedback signal

HARTLEY OSCILLATOR CIRCUIT



HARTLEY OSCILLATOR OPERATION

1

Hartley oscillator circuit consist **two inductor in series connection** and **parallel with the one capacitor** as a tank circuit

2

When the circuit is turned on, **the capacitor is charged**. When the capacitor is fully charged, **it discharges through inductor L1 and L2**.

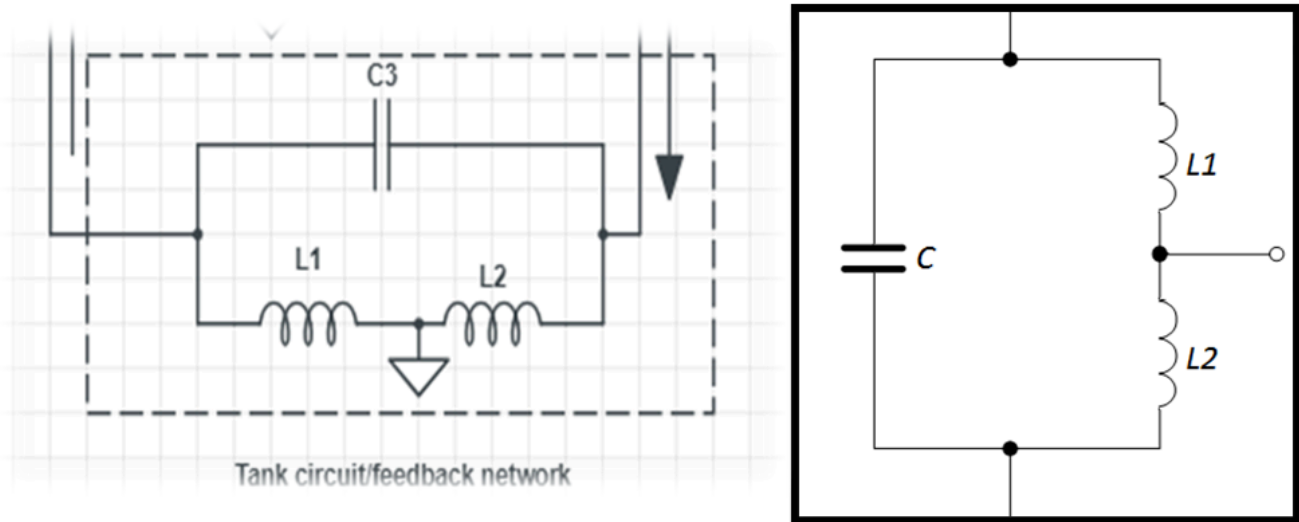
3

This **discharging of the capacitor** results in **charging of the inductor**. This **continuous charging and discharging** will provide a **phase shift of 180° sinusoidal oscillations** at the output.

4

Transistor will provide **different phase of the output signal 180°** . LC circuit will produce a phase shift of 180° . So the **feedback voltage** will be **in phase with the input voltage** of the transistor

HARTLEY OSCILLATOR FREQUENCY



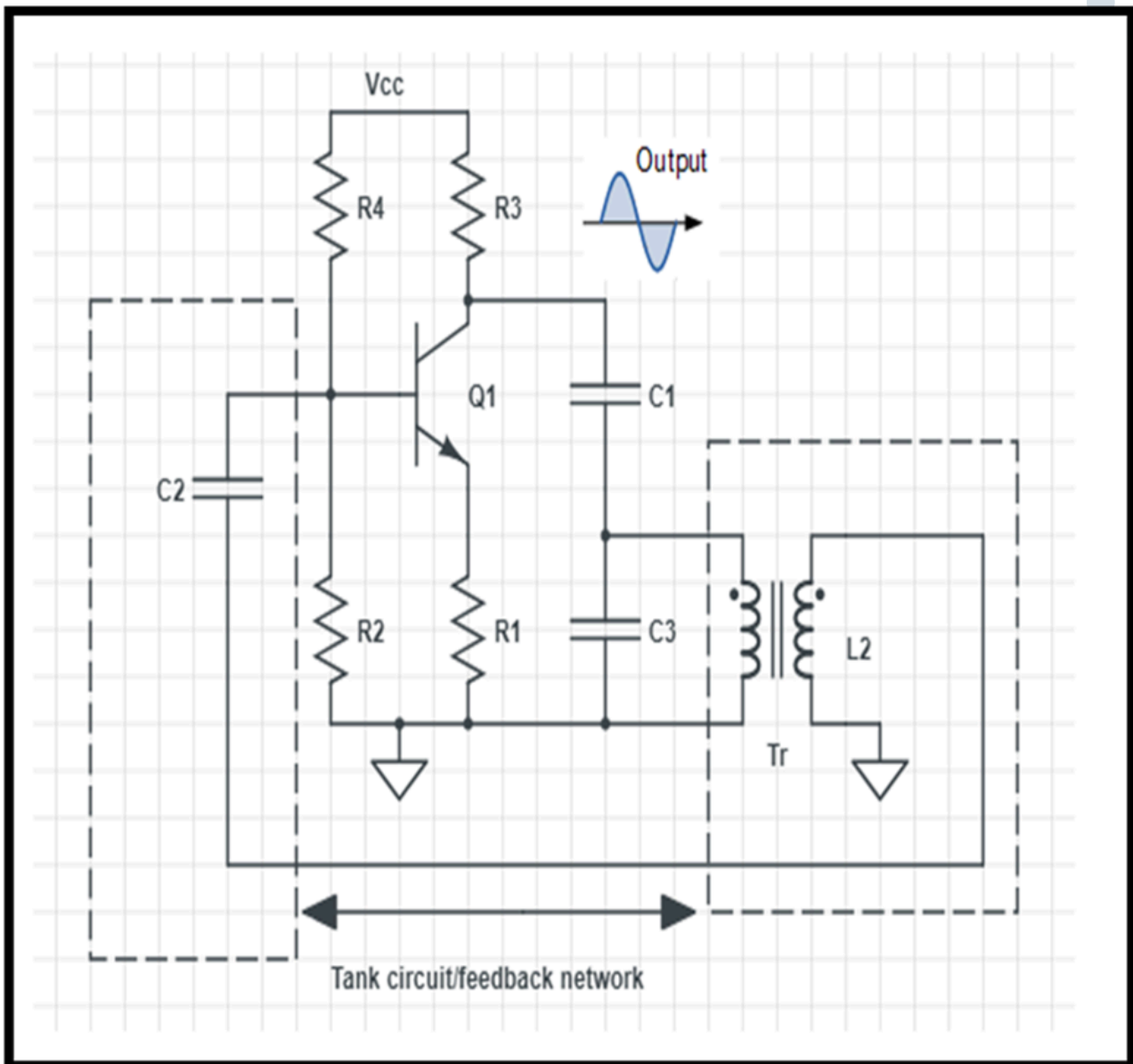
Formulas for the resonance frequency of the circuit are:

$$f = \frac{1}{2\pi\sqrt{CL_T}}$$

Since the inductor in the tank circuit is connected in series, then

$$L_T = L_1 + L_2$$

ARMSTRONG OSCILLATOR CIRCUIT



ARMSTRONG OSCILLATOR

OPERATION

LC

1

Capacitors C1 and C2 are used to block the AC signals

2

Transformer Tr to produce a phase shift of 180° to get a feedback voltage in phase with the input transistors

3

Usually the ratio between the coil windings L1 to L2 coils arranged so that the product of the gain, A, the feedback factor β , equal 1. ($|A\beta| = 1$).

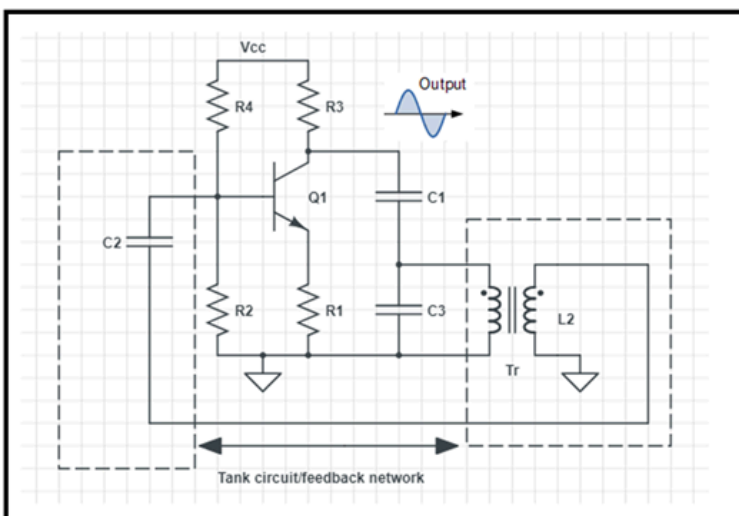
4

Transistor will provide different phase of the output signal 180° .

ARMSTRONG OSCILLATOR FREQUENCY

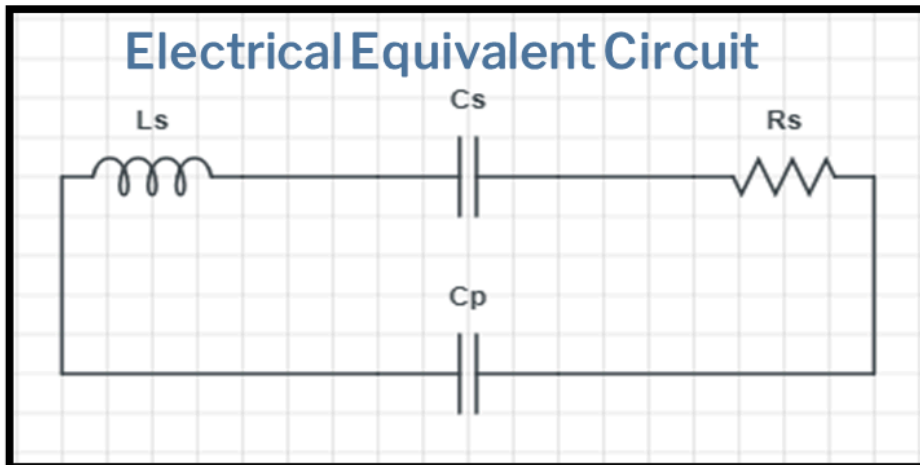
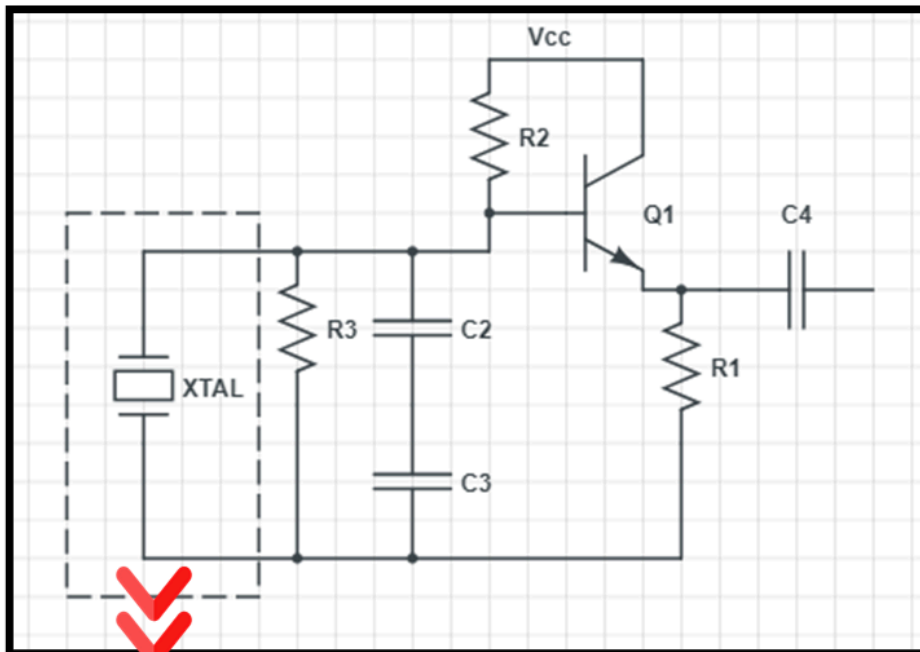
Frequency resonance:

Frequency resonance is determined by the circuit L2, C2 given by :



$$f = \frac{1}{2\pi\sqrt{C_2 L_2}}$$

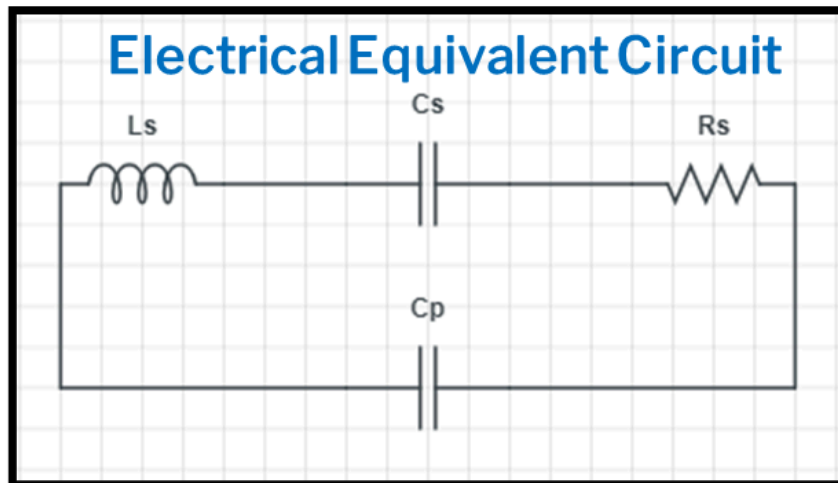
CRYSTAL OSCILLATOR (SERIES & PARALLEL)



Crystal oscillator is the most stable and precisely using a piezoelectric crystal in a feedback circuit. **This circuit is used to stabilize the frequency or to provide constant frequency output.**

CRYSTAL OSCILLATOR (SERIES & PARALLEL)

Parameter of equivalent circuit



L_s , Inductance electrical equivalent of mass represents the crystal.

Capacitance, C_s represents the elasticity of crystals.

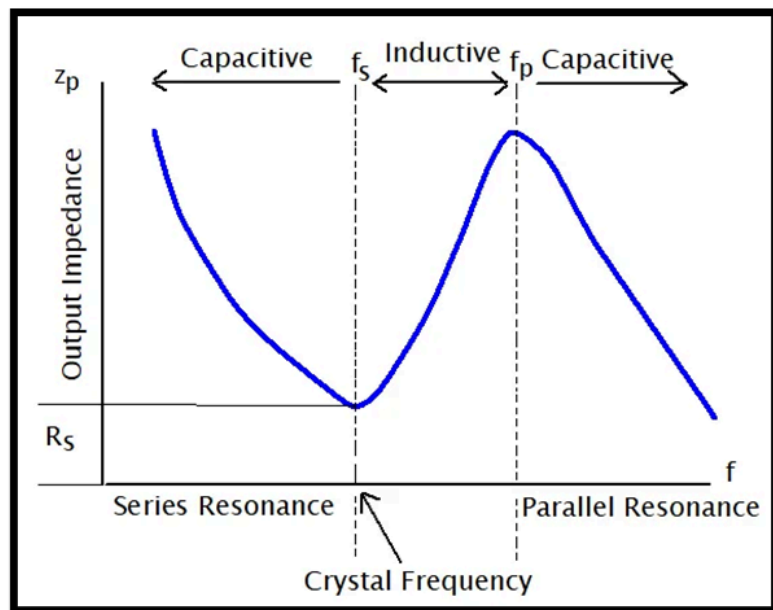
The friction resistance of R_s in the crystal structure.

C_p represents the capacitance capacitor containers loaded crystal.

CRYSTAL OSCILLATOR (SERIES & PARALLEL)

TWO RESONANT FREQUENCIES

Crystal Oscillator has two resonant frequencies. The first frequency generated by the series circuit R_s - L_s - C_s . The second occurs when the frequency components of the same series reactance, C_p .



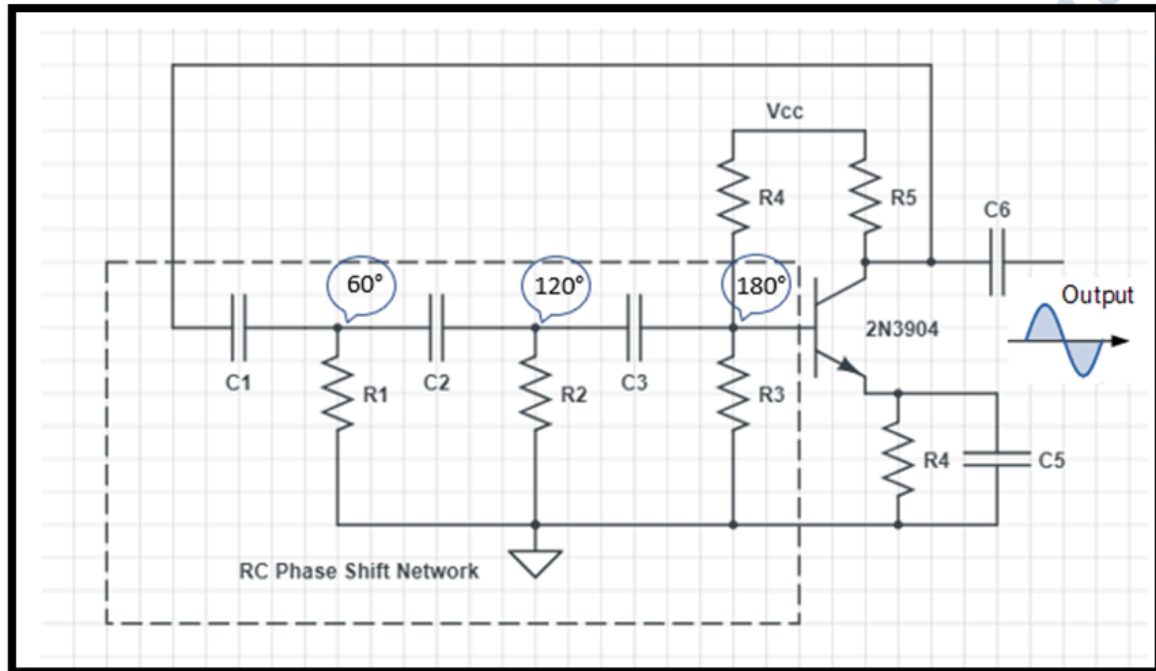
Series Resonance:

$$f_1 = \frac{1}{2\pi\sqrt{L_s C_s}}$$

Parallel Resonance:

$$f_2 = \frac{1}{2\pi\sqrt{L_s C_s}} \quad C = \frac{C_s \times C_p}{C_s + C_p}$$

PHASE SHIFT (RC) OSCILLATOR



01

The output signal from the amplifier phase shift 180° out from the input signal.

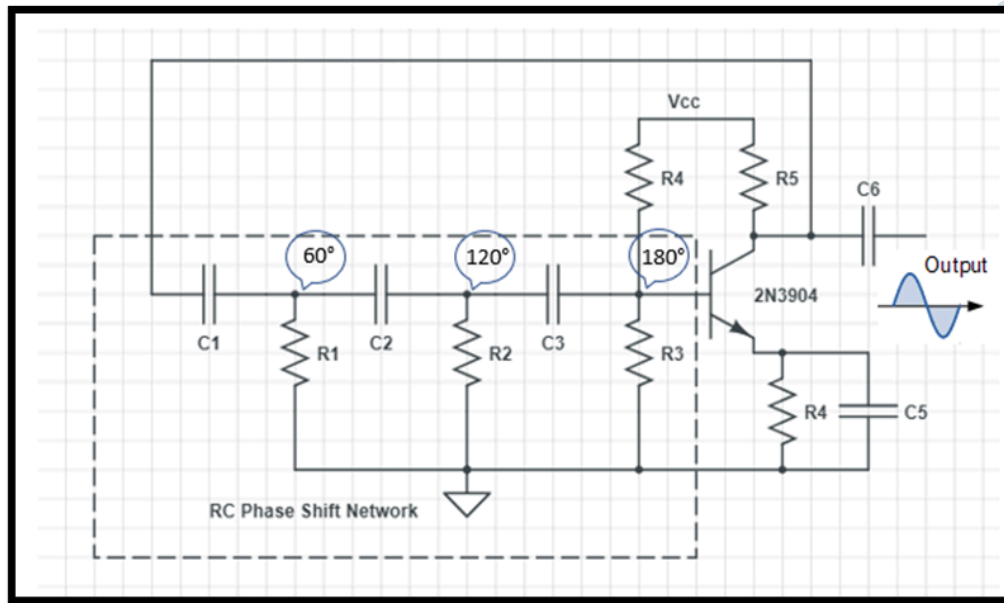
02

To generate a positive feedback signal, the output signal phase shifted by 180° should be in phase with the input.

03

RC network produces a phase shift of 180° which each RC network will shift phase by 60° .

Frequency Resonant for the RC



Frequency resonant for the RC circuit given by equation below:

$$f = \frac{1}{2\pi RC\sqrt{2} \times N}$$

Where:

- f** is the Output Frequency in Hertz
- R** is the Resistance in Ohms
- C** is the Capacitance in Farads
- N** is the number of RC stages
(in our example N = 3)

TUTORIALS

TOPIC 2

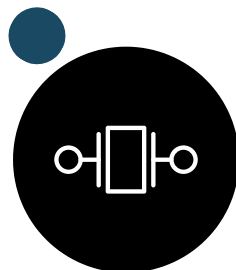
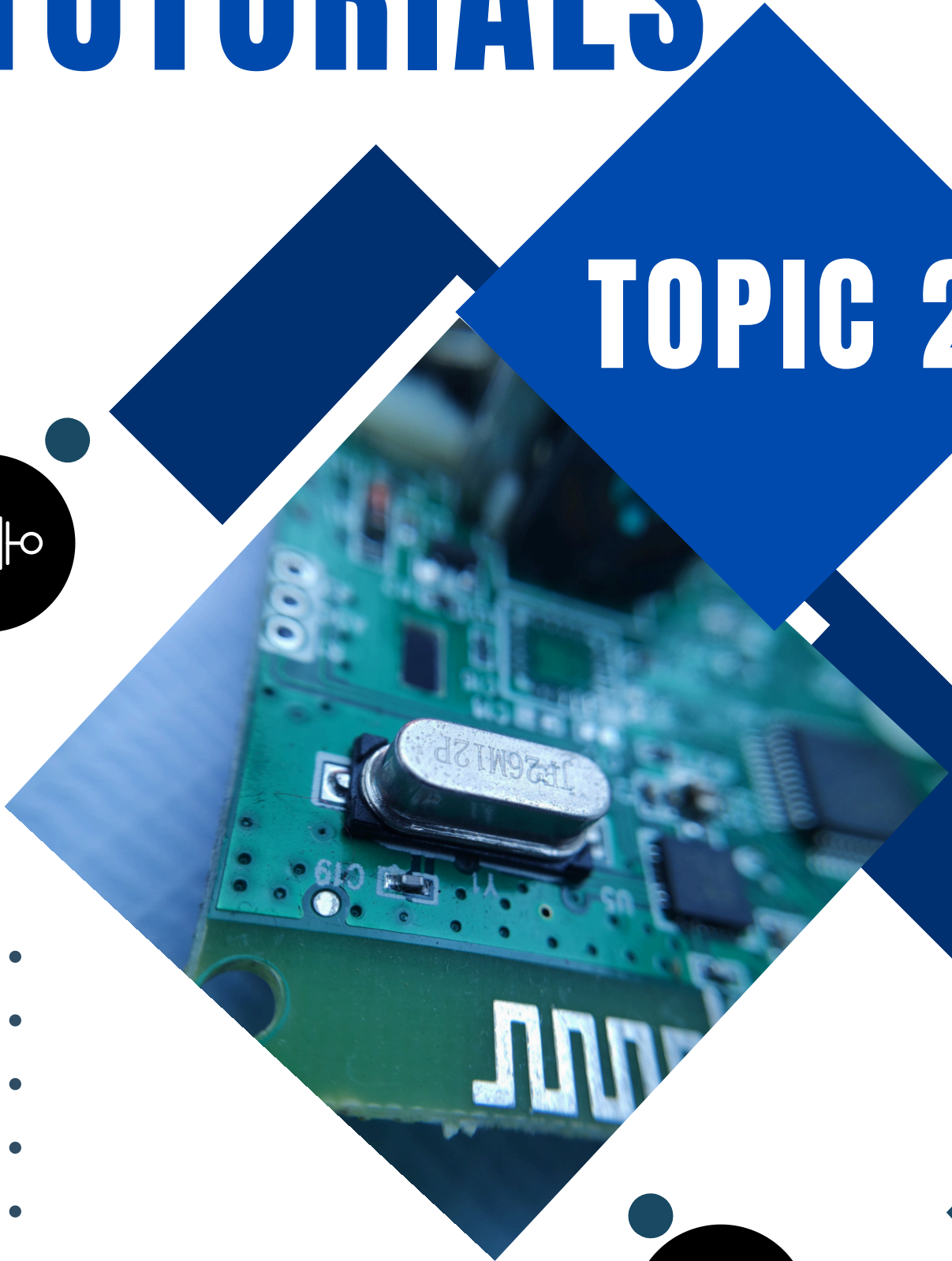
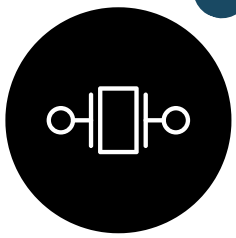


Figure 1 shows the crystal equivalent circuit. If the values of $L = 2\text{H}$, $C_1 = 330\text{pF}$, $R = 2\text{K}\Omega$ and $C_0 = 0.75\text{nF}$.

Calculate the series and parallel resonant frequency of the crystal.

TOPIC 2 - RESONANT FREQUENCY

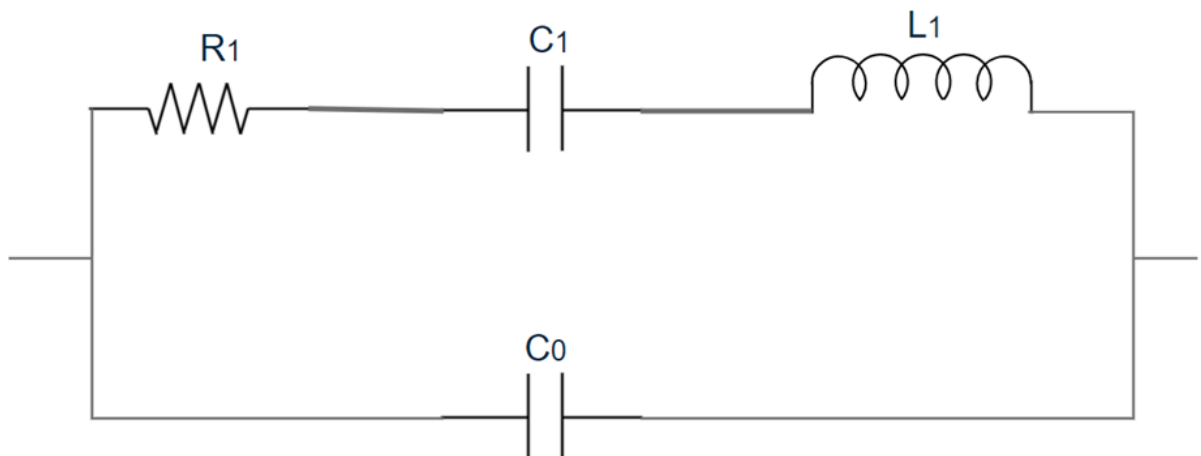
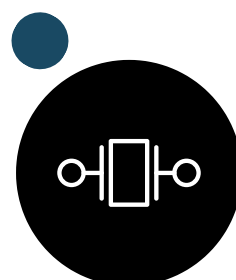


Figure 1



02.

Sketch the Colpitts Oscillator circuit that having two capacitor 10pF and 20pF respectively are connected in parallel with the inductor 3.79mH and calculated operating frequency

Colpitts Oscillator circuit



Hartley oscillator is used to produce a sinewave of desired frequency. Explain the operation of Hartley Oscillator by using a suitable diagram

Hartley oscillator

03

04

Illustrate the tank circuit oscillator that derives its feedback voltage from two series of inductors connected parallel with single capacitor. The oscillator uses amplifier tank circuit feedback. Then, determine the oscillation frequency if the tank circuit use capacitor, $C1 = 15\text{pF}$ with series inductor, $L1 = 20\mu$ and $L2 = 60\mu$.

Colpitts Oscillator circuit

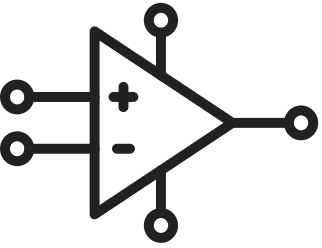
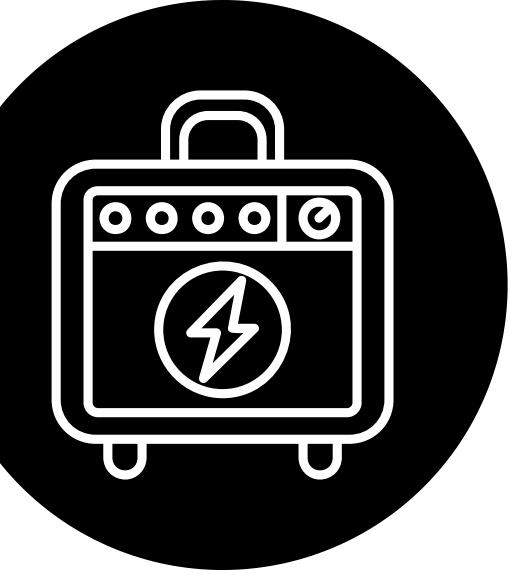


05

A Hartley Oscillator circuit having two inductors of 50mH and 10mH respectively are connected in parallel with a capacitor 200pF. Calculate the resonant frequency, f_0 and draw the Hartley Oscillator circuit by including the transistor, inductor, capacitor and resistor.

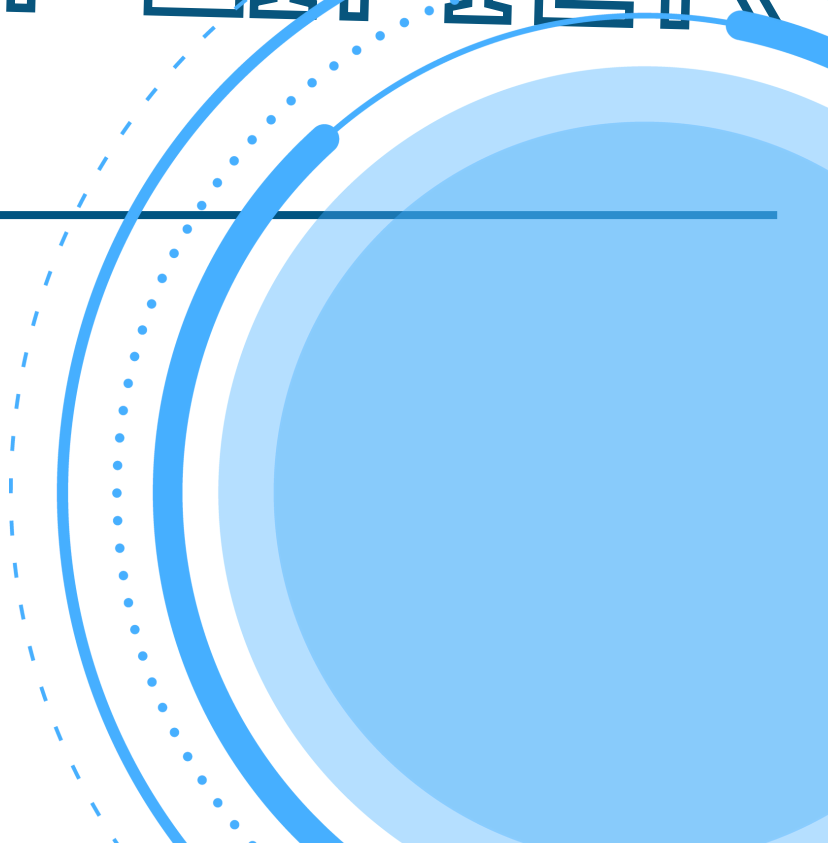
Hartley Oscillator

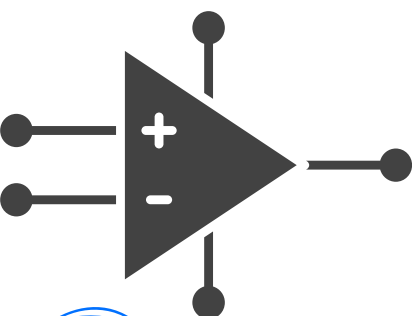
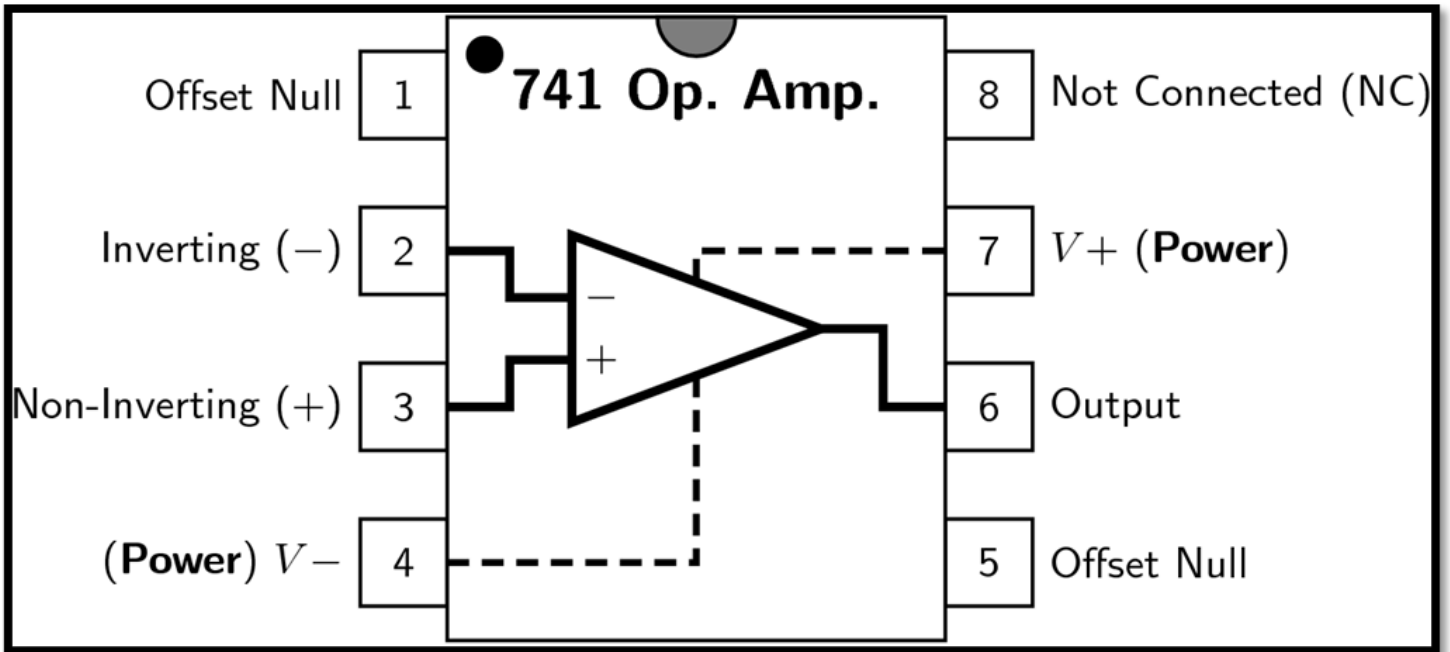
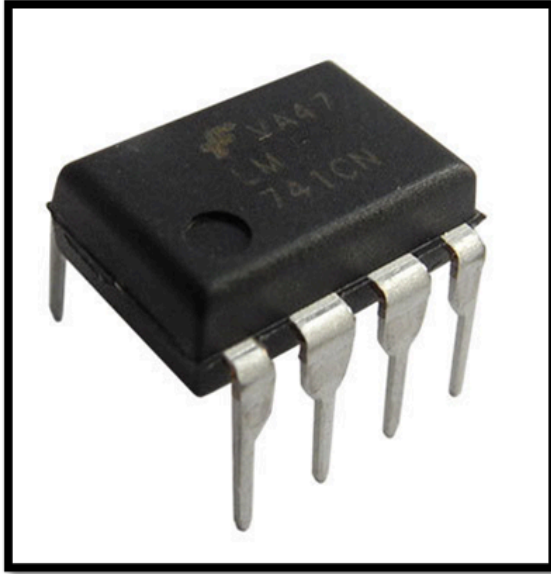


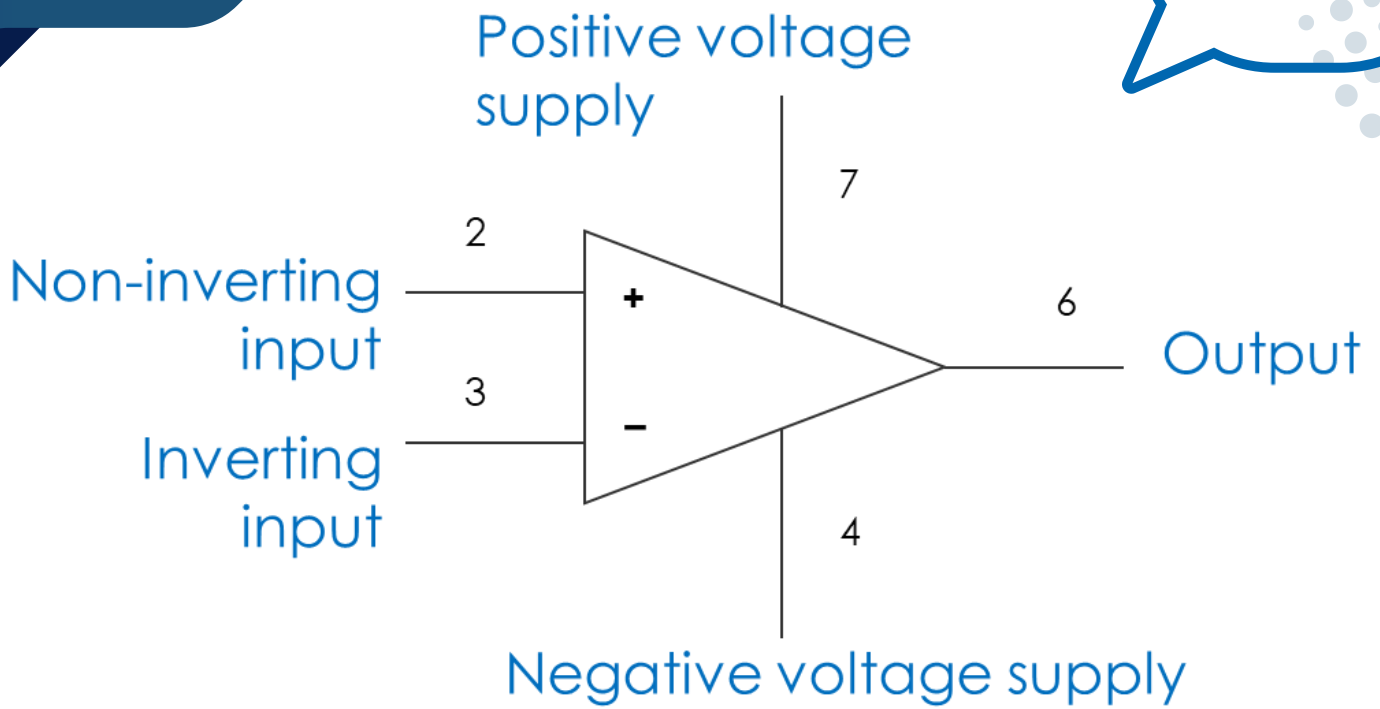


TOPIC 3

OP AMPLIFIER

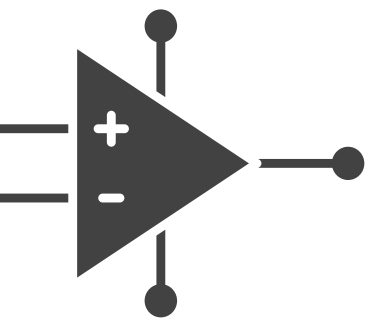






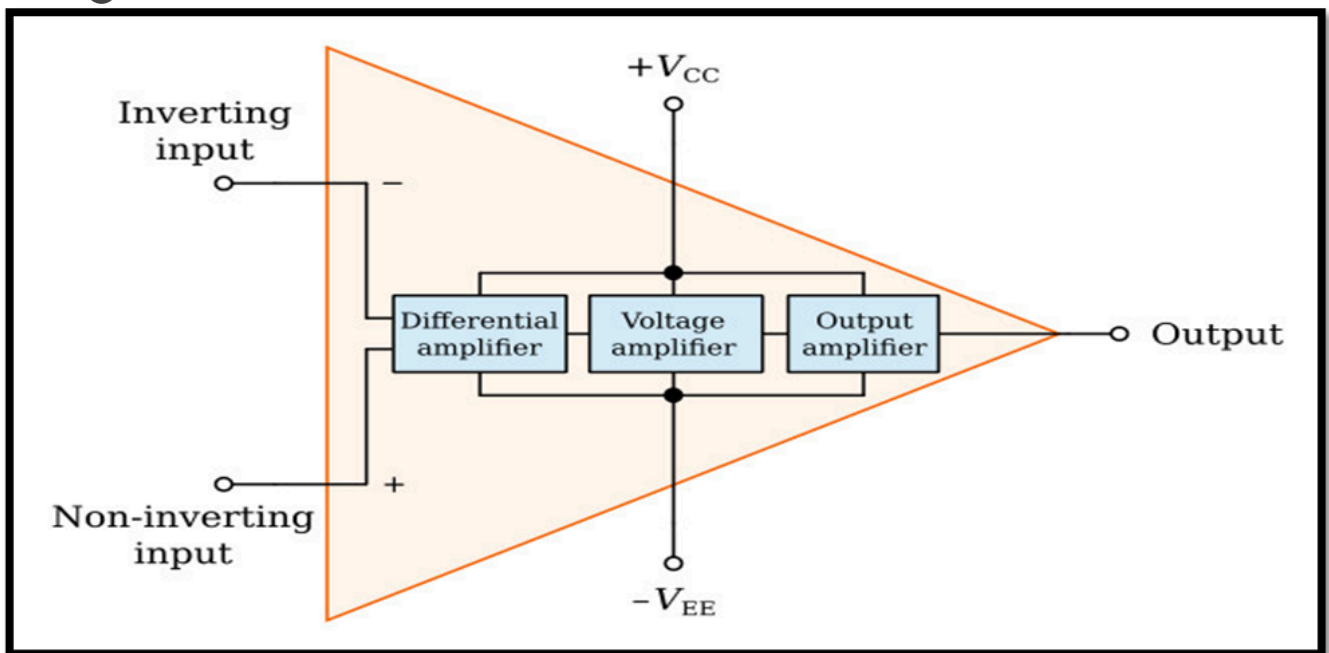
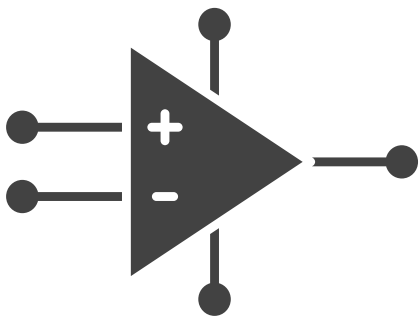
Op Amps have 3 terminals.
2 input and 1 output

An op amp also requires dc power to operate

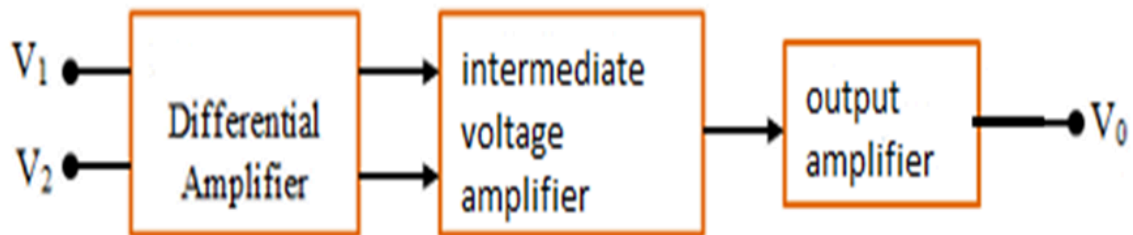


An op amp requires both positive and negative supplies (V_+ and V_-)

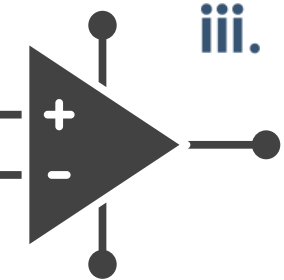
Op Amp Block Diagram



Op Amp Block Diagram



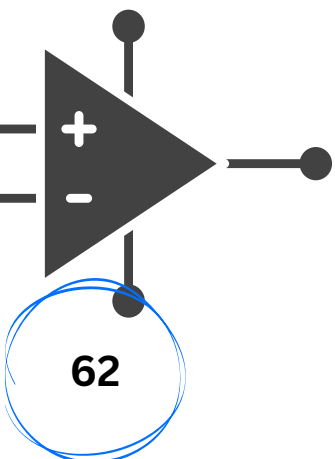
- i. **Differential amplifier (input stage)** – provides low noise amplification, **high input impedance**, usually a differential input.
- ii. **Intermediate voltage amplifier (gain stage)** . Voltage amplifier – provides **high voltage gain**, usually single-ended output.
- iii. **Output amplifier stage** – provides high current driving capability, **low output impedance**, current limiting and short circuit protection circuitry.

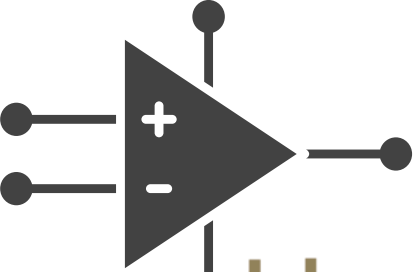




What is an ideal Op- Amp??

An ideal op amp is an op amp that has **perfect conditions** to allow it to function as **an op amp with 100% efficiency.**





Ideal Op Amp Characteristics

An ideal op amp will display the following characteristics:

Input impedance is infinite.
[$Z_{in} = \infty$]

Output impedance is zero
[$Z_{out} = 0$]

Open Loop Gain (AOL) is infinite

Bandwidth is infinite

Offset voltage is zero

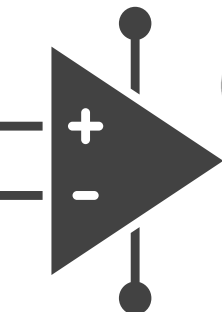
Offset current is zero

Common-Mode Rejection Ratio, CMRR

- The **function** of the **CMRR** is specifically used **to reduce the noise**.

$$CMRR = \left| \frac{A}{A_{cm}} \right|$$

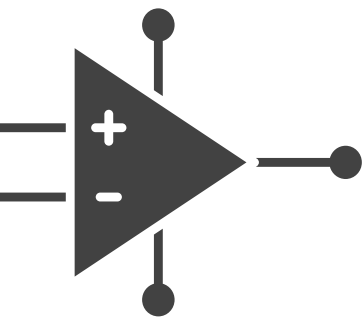
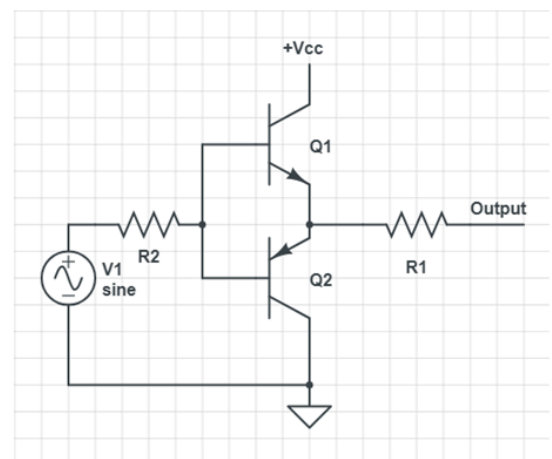
where A is the differential mode gain and A_{cm} is the common mode gain


$$CMRR_{dB} = 20 \log \left| \frac{A}{A_{cm}} \right| dB$$

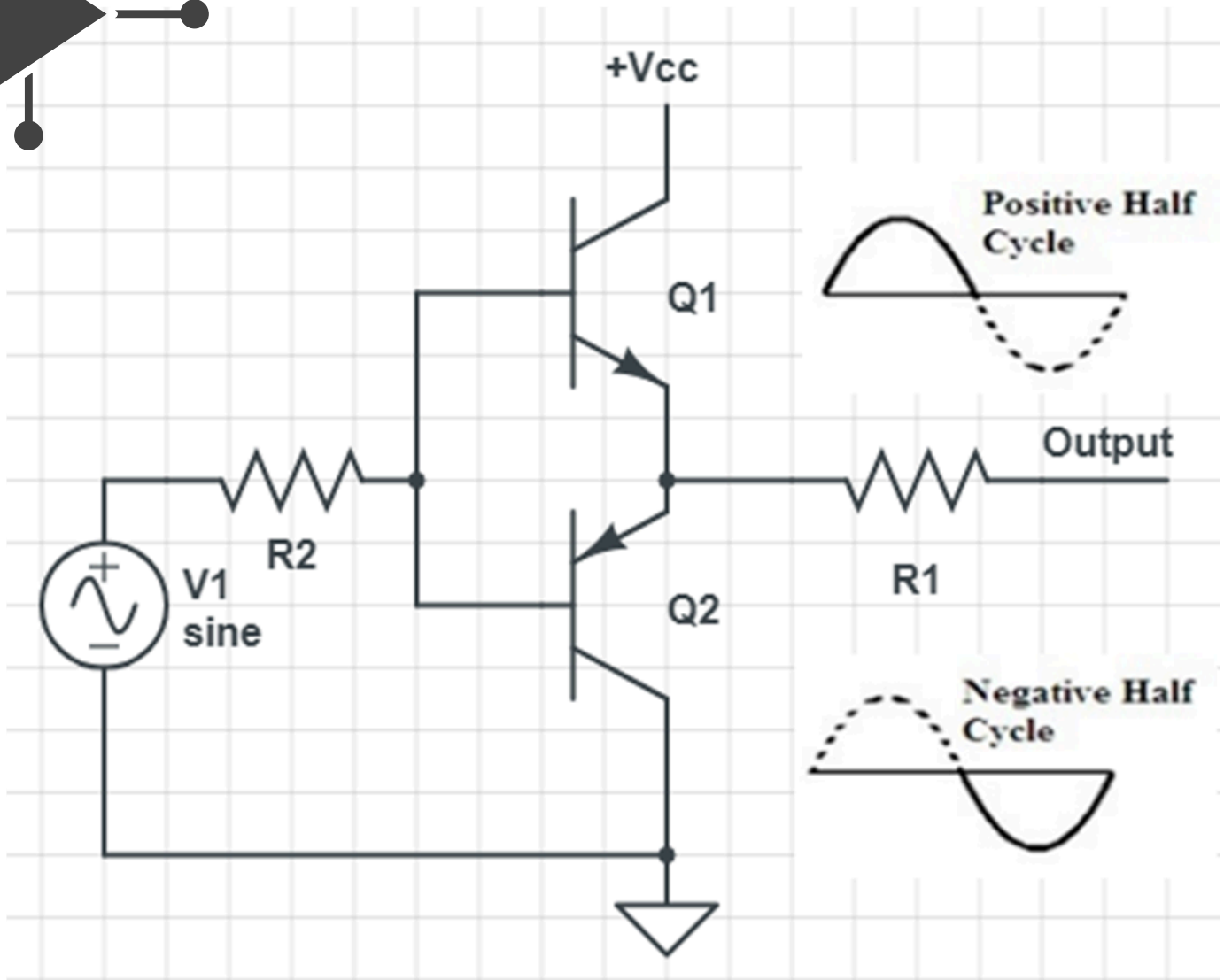
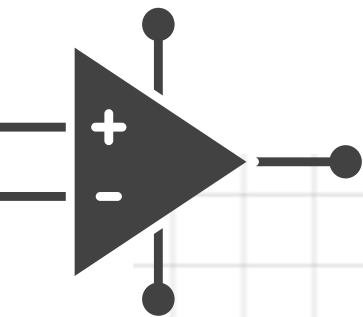
Ideally: $CMRR \rightarrow \infty$ Typically: $60 \text{ dB} \leq CMRR \leq 120 \text{ dB}$

Push-pull Amplifier

- Push-pull Amplifier is a **type of power amplifier.**
- It contains a pair of active devices such as a complementary **pair** of transistors.

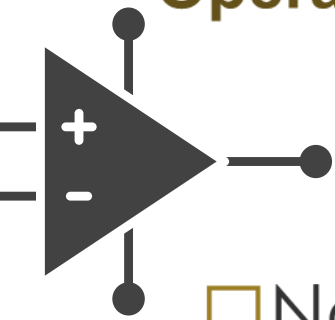


Push Pull Amplifier



Op-Amp Configurations

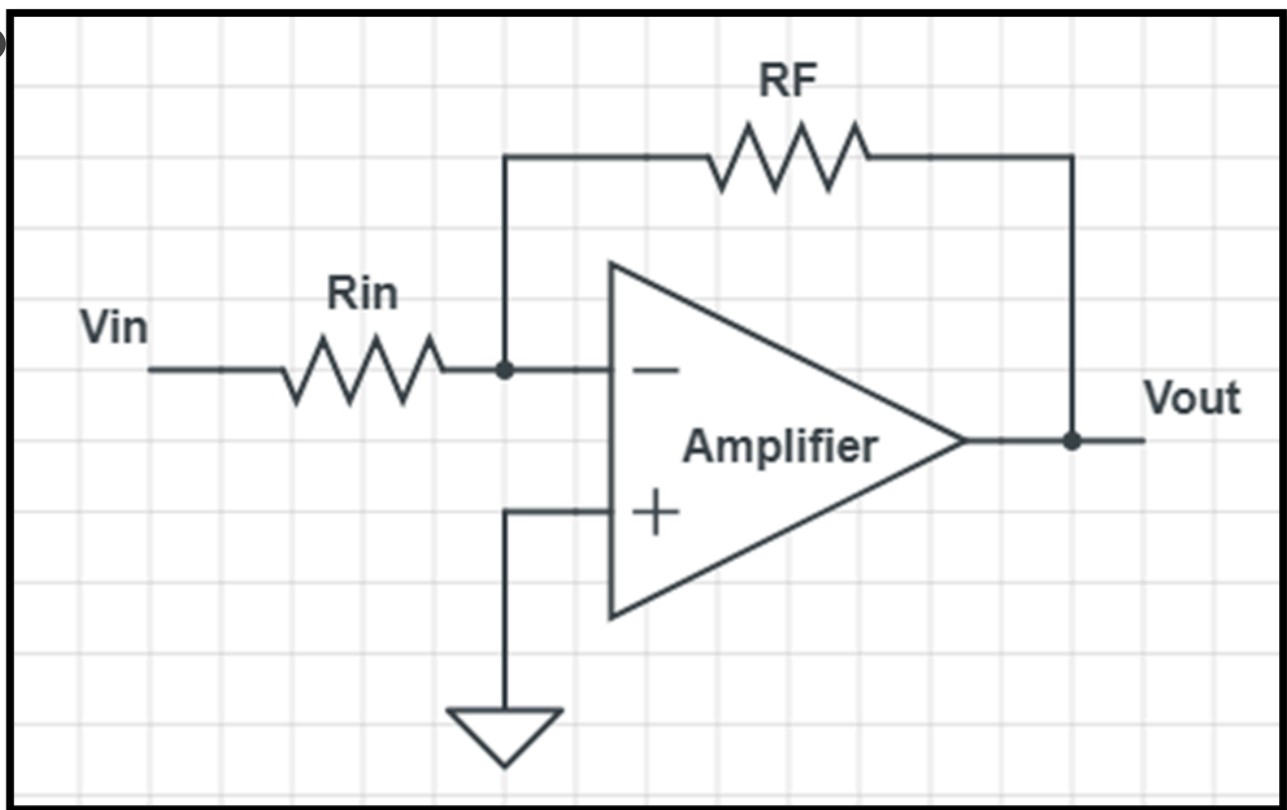
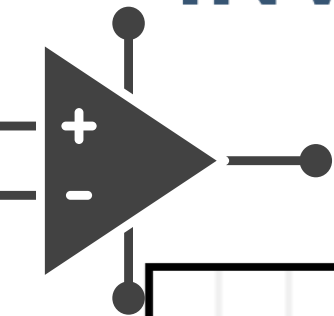
Operation of the Op-Amp configurations:

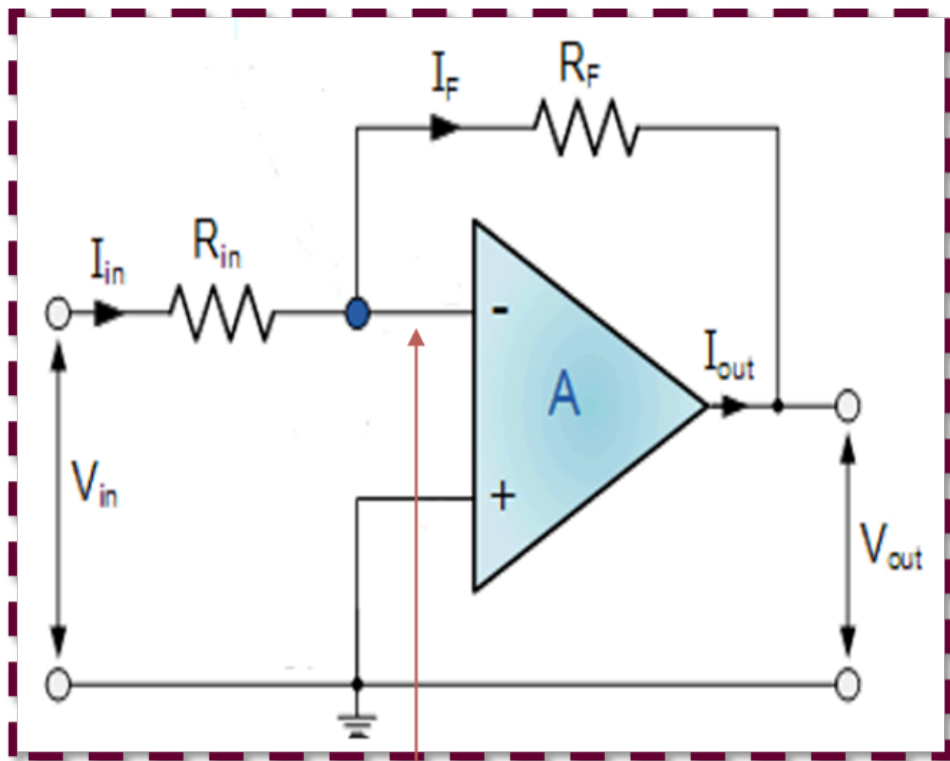
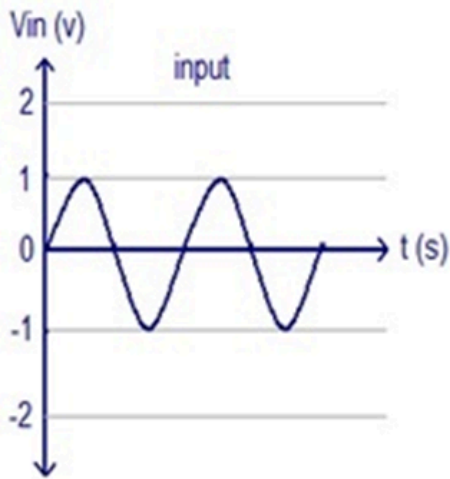


- Non-inverting amplifier (Positive Feedback)
- Inverting amplifier (Negative Feedback)
- Summing amplifier
- Subtractor
- Differentiator
- Integrator
- Comparator

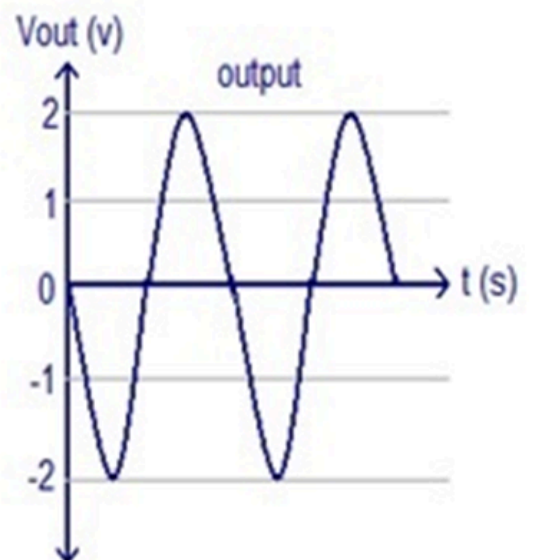
OP-AMP CONFIGURATION

INVERTING AMPLIFIER

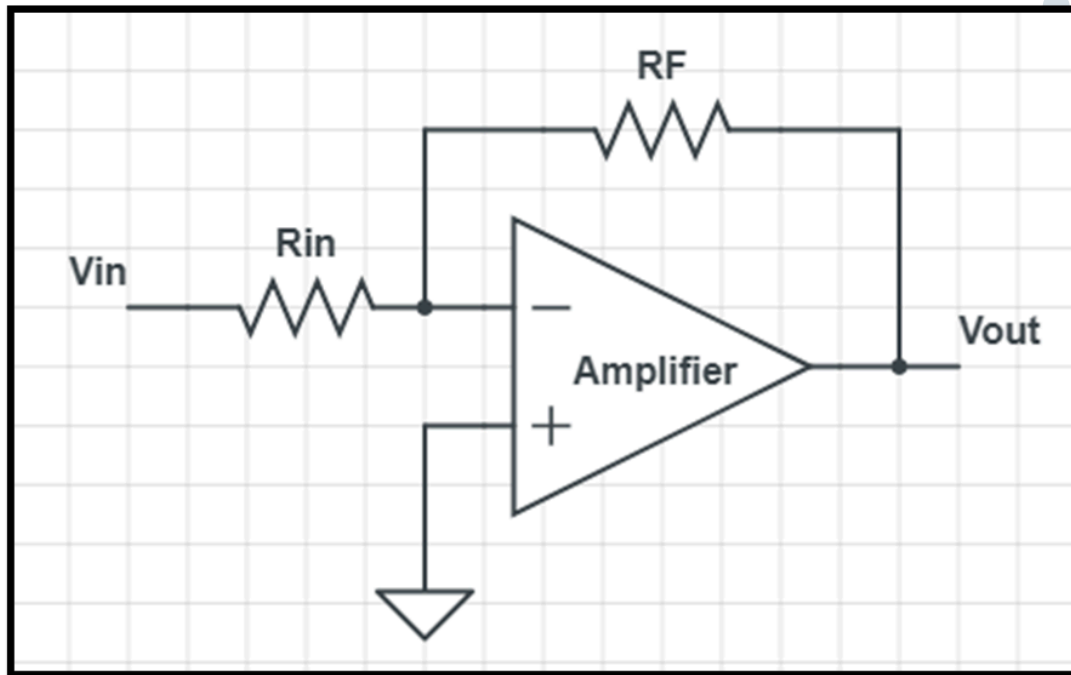




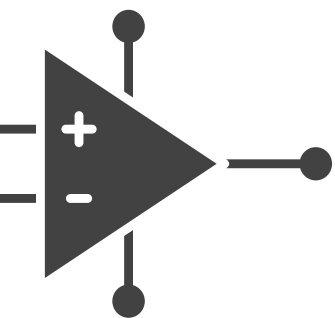
V_{in} at the inverting (-) input



Inverting Amplifier Analysis

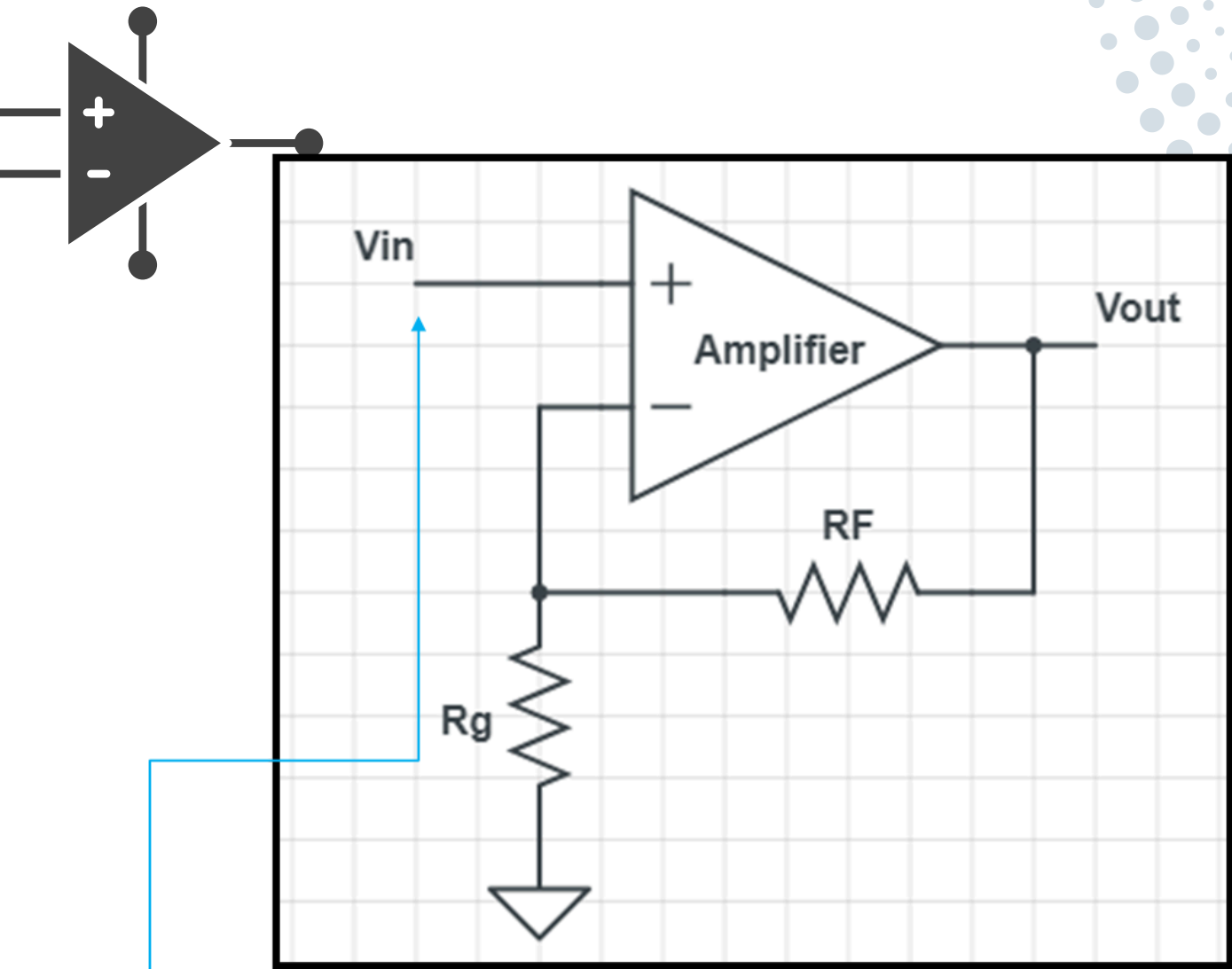


$$\frac{V_{out}}{V_{in}} = -\frac{R_f}{R_{in}}$$

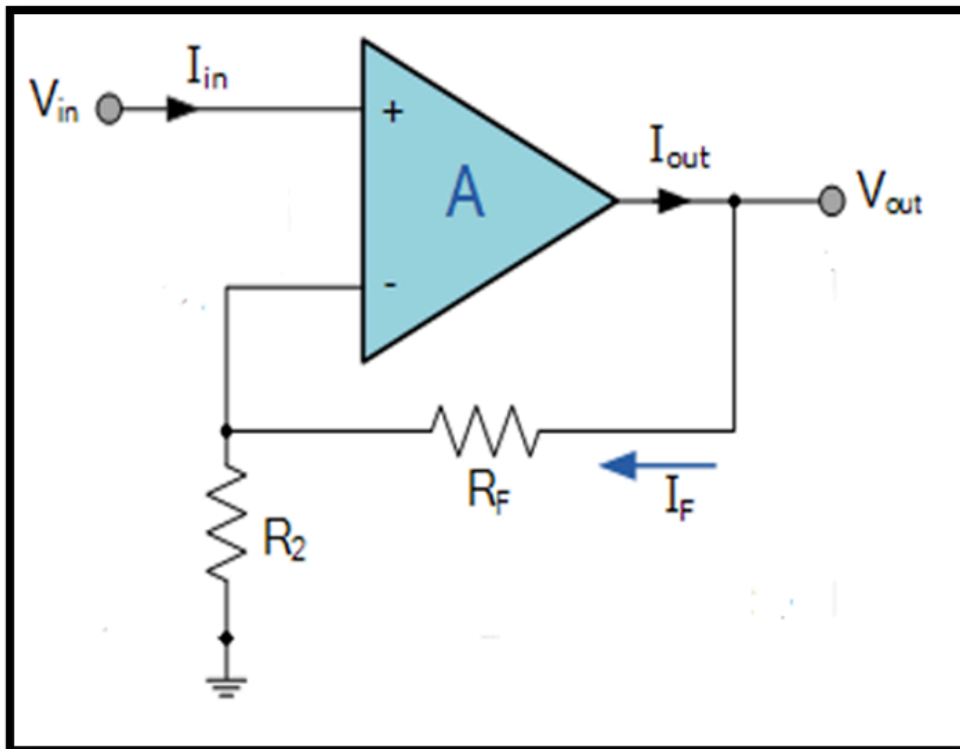
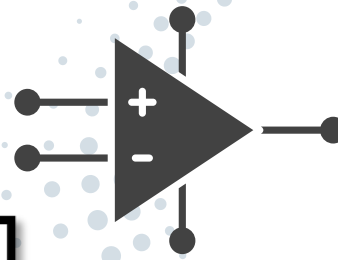


$$A_V = -\frac{R_f}{R_{in}}$$

NON INVERTING AMPLIFIER



V_{in} at the non-inverting (+) input



01

Output signal is “in-phase” with the input signal.

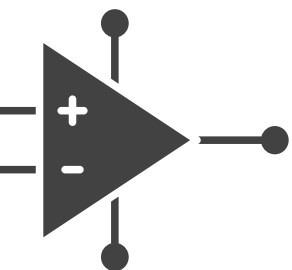
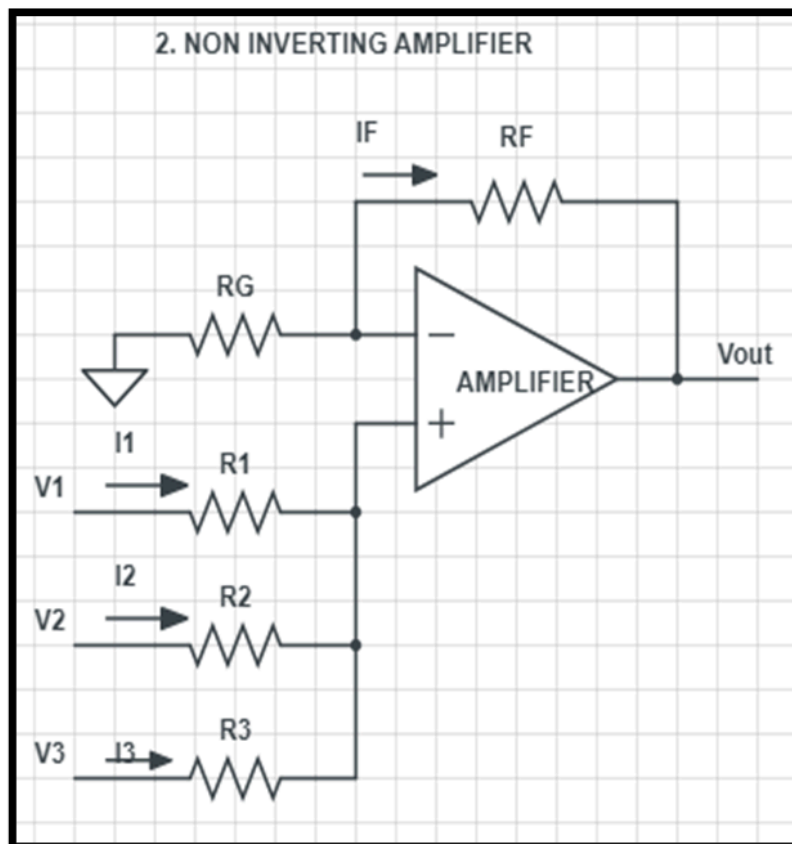
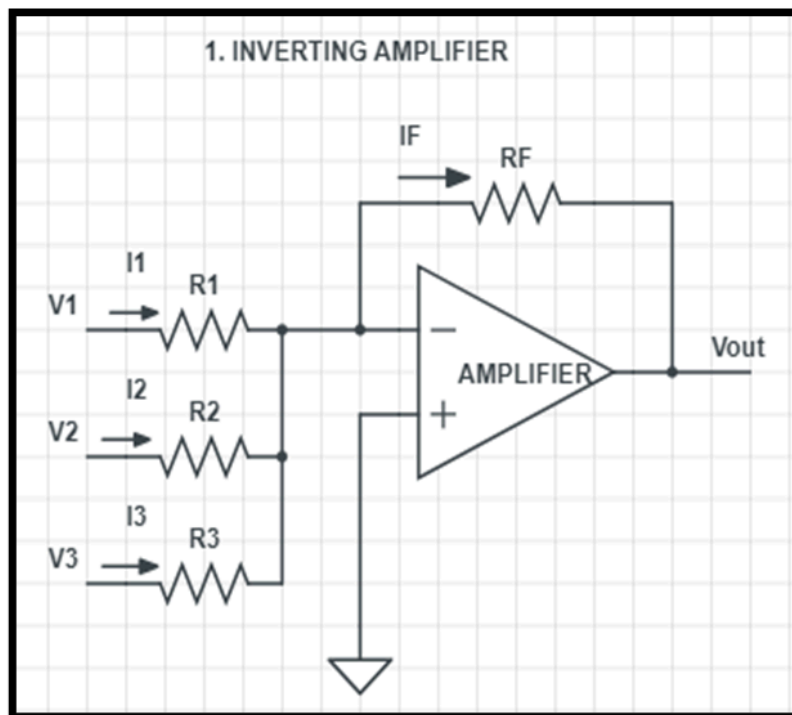
02

Feedback of the output voltage signal back to the inverting (-) input terminal via a $R_f - R_2$ (producing negative feedback).

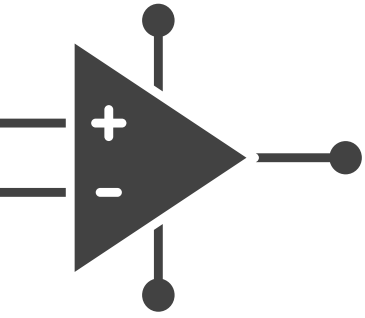
03

Virtual earth node the resistors, R_f and R_2 form a simple potential divider network

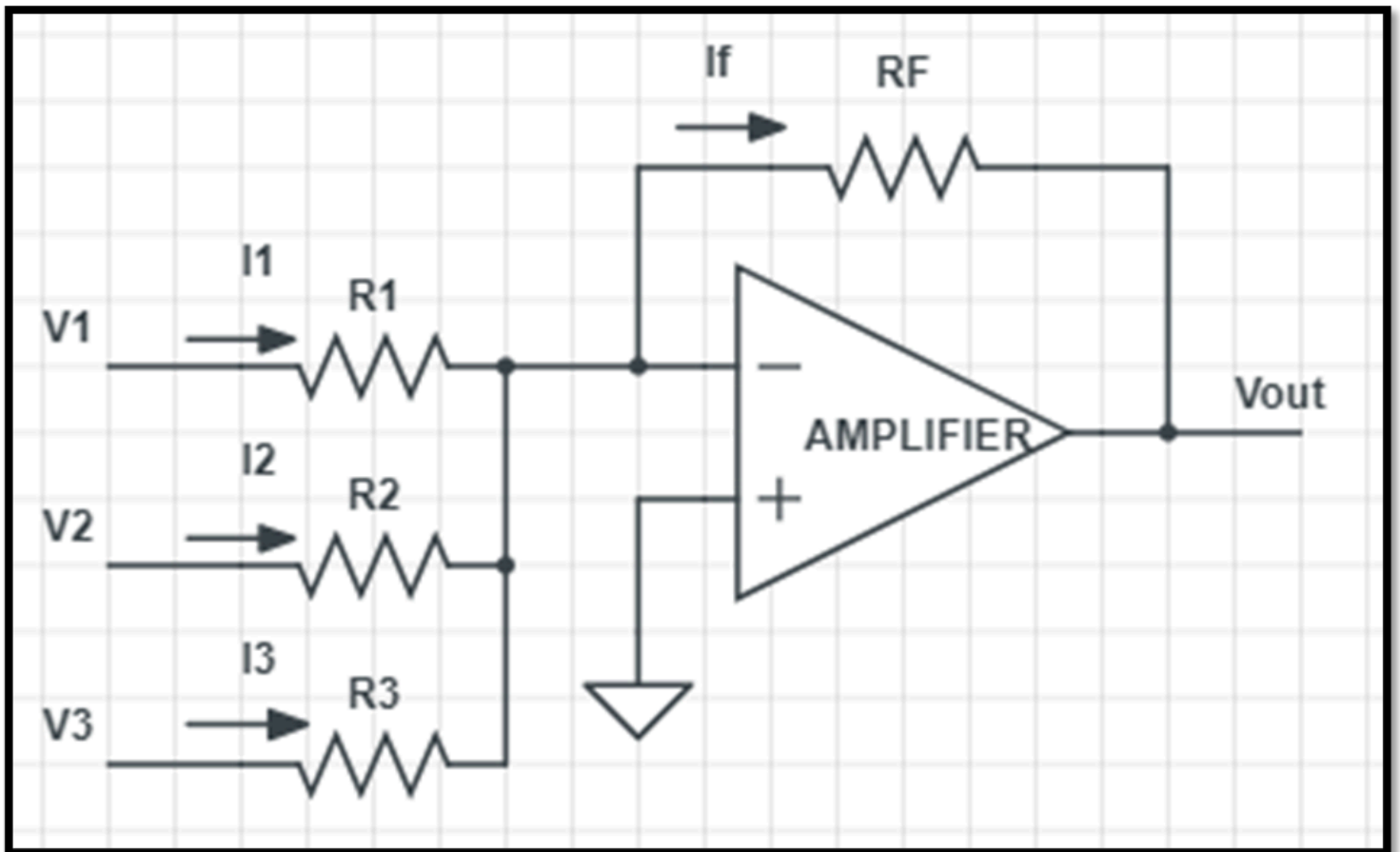
SUMMING AMPLIFIER



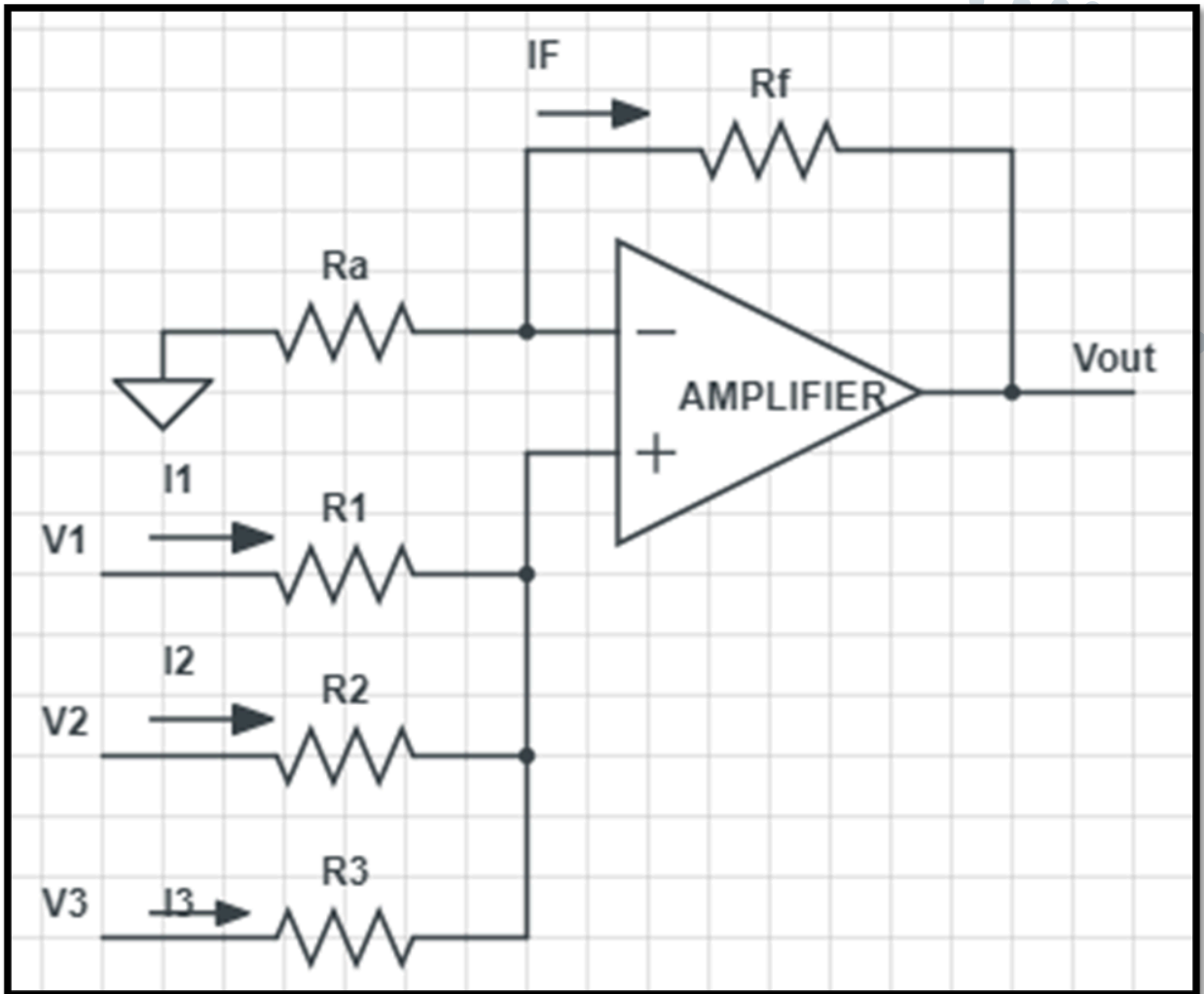
OUTPUT OF INVERTING SUMMING AMPLIFIER



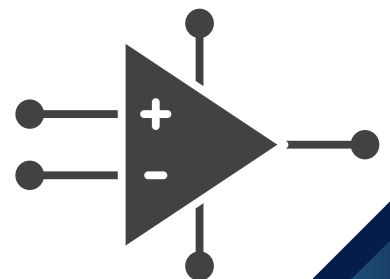
$$V_{out} = - \left(\frac{R_f}{R_1} v_1 + \frac{R_f}{R_2} v_2 + \frac{R_f}{R_3} v_3 \right)$$



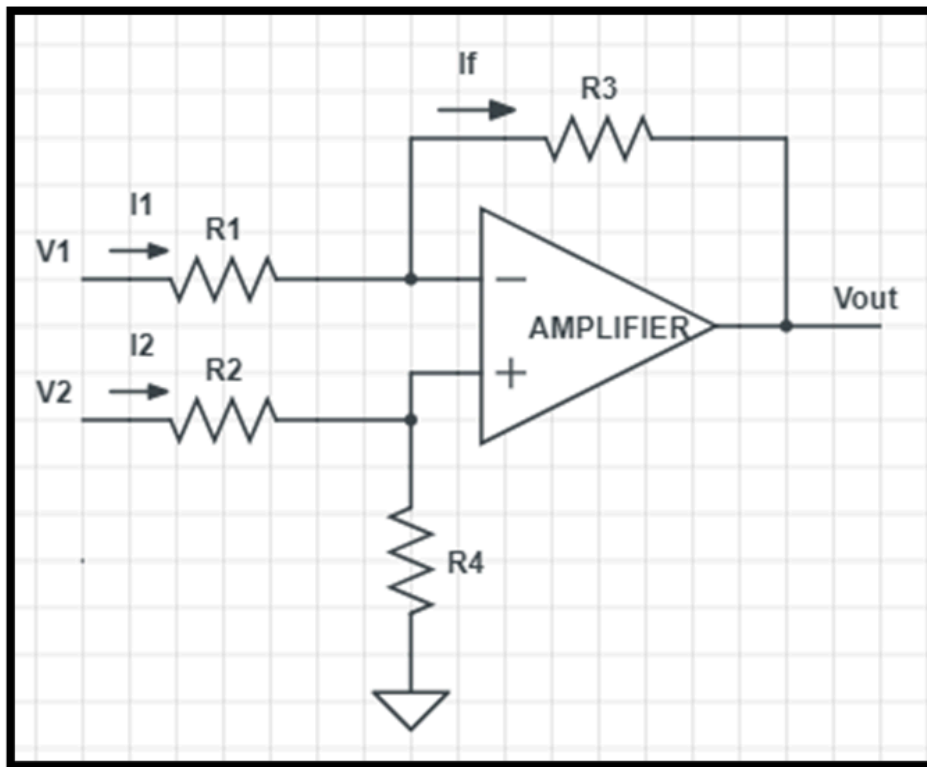
OUTPUT OF NON- INVERTING SUMMING AMPLIFIER



$$V_{out} = \left(1 + \frac{R_f}{R_a} \right) \left(\frac{R_2}{R_1 + R_2} v_1 + \frac{R_1}{R_1 + R_2} v_2 \right)$$



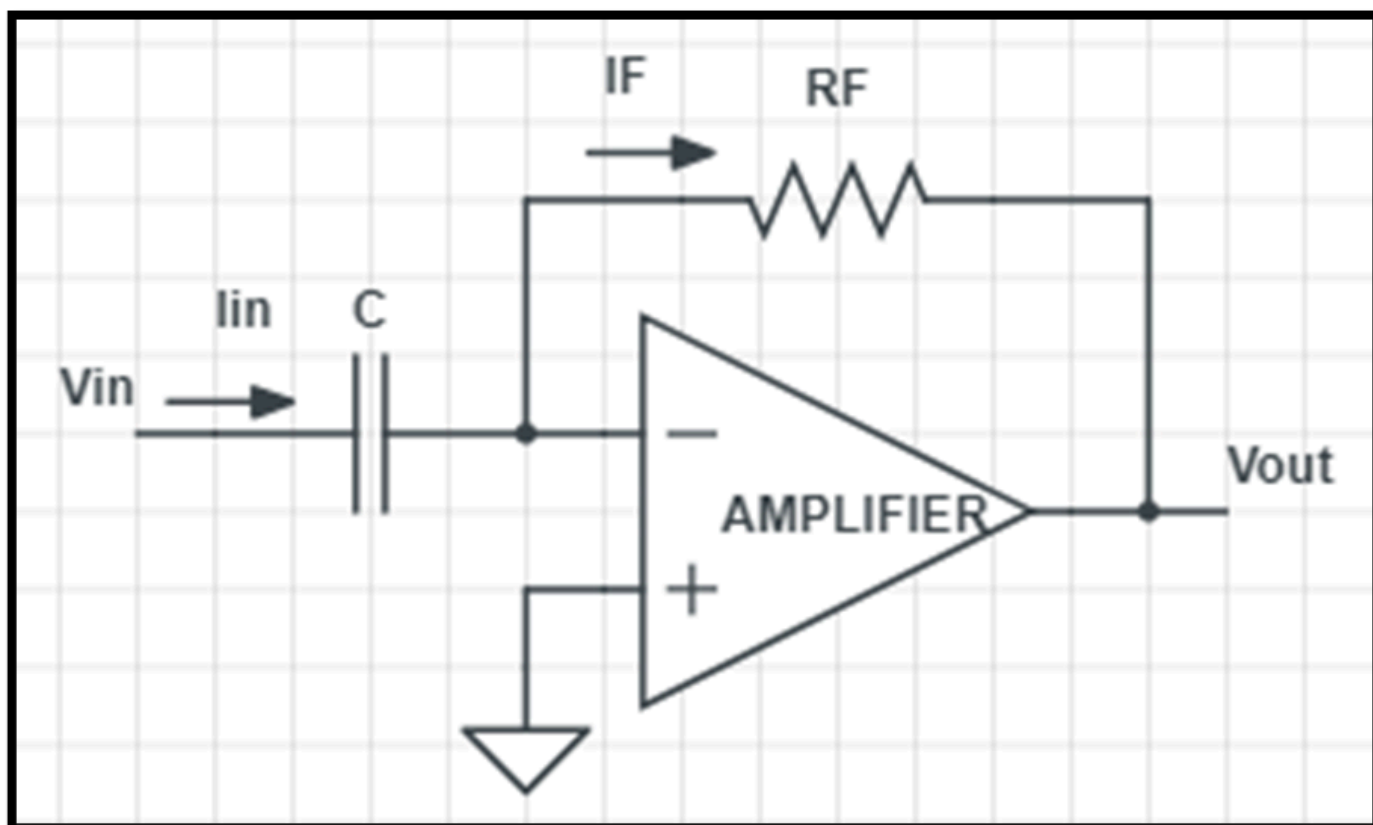
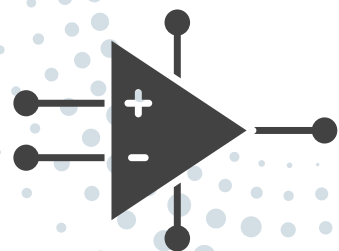
SUBTRACTOR/DIFFERENTIAL AMPLIFIER



Differential amplifiers **amplify the difference between two voltages** making this type of circuit a **Subtractor**.

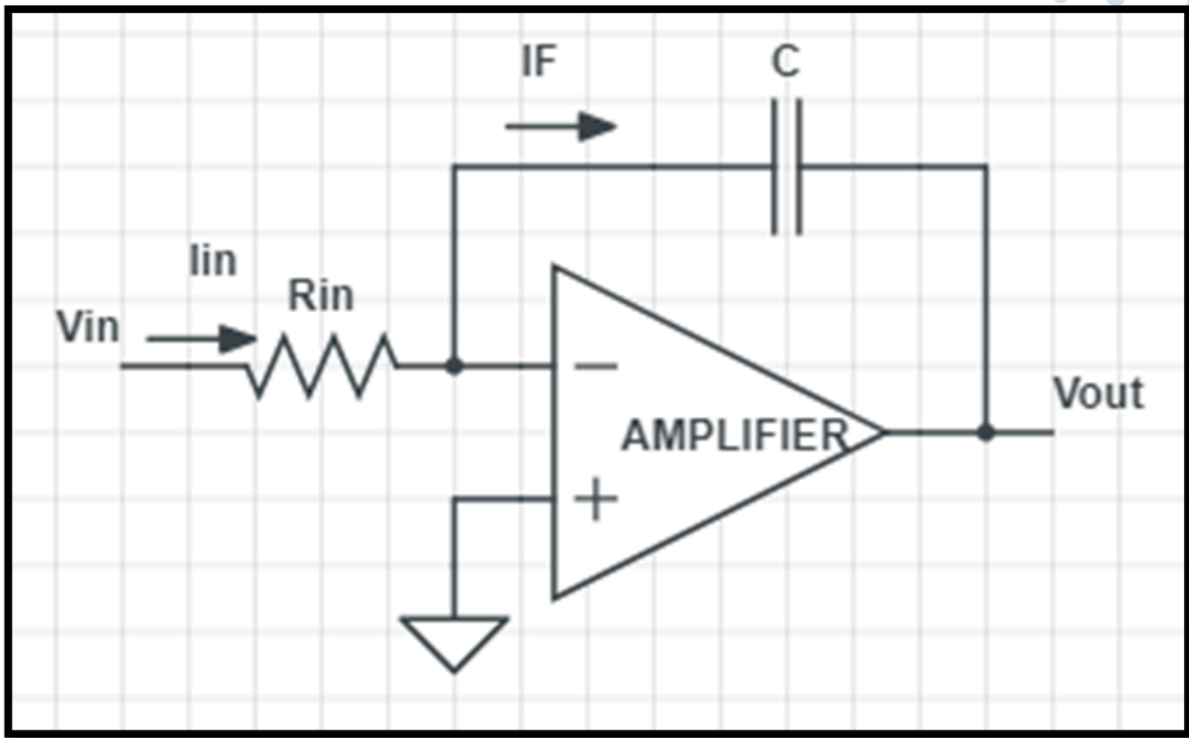
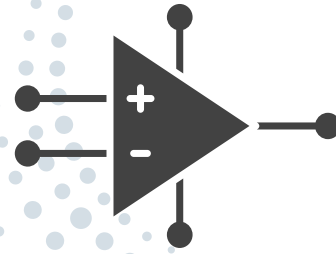
$$V_{\text{out}} = -V_1 \left[\frac{R_3}{R_1} \right] + V_2 \left[\frac{R_4}{R_2 + R_4} \right] \left[1 + \frac{R_3}{R_1} \right]$$

DIFFERENTIATOR AMPLIFIER



$$V_{out} = -R_f C_{in} \frac{dV_{in}}{dt}$$

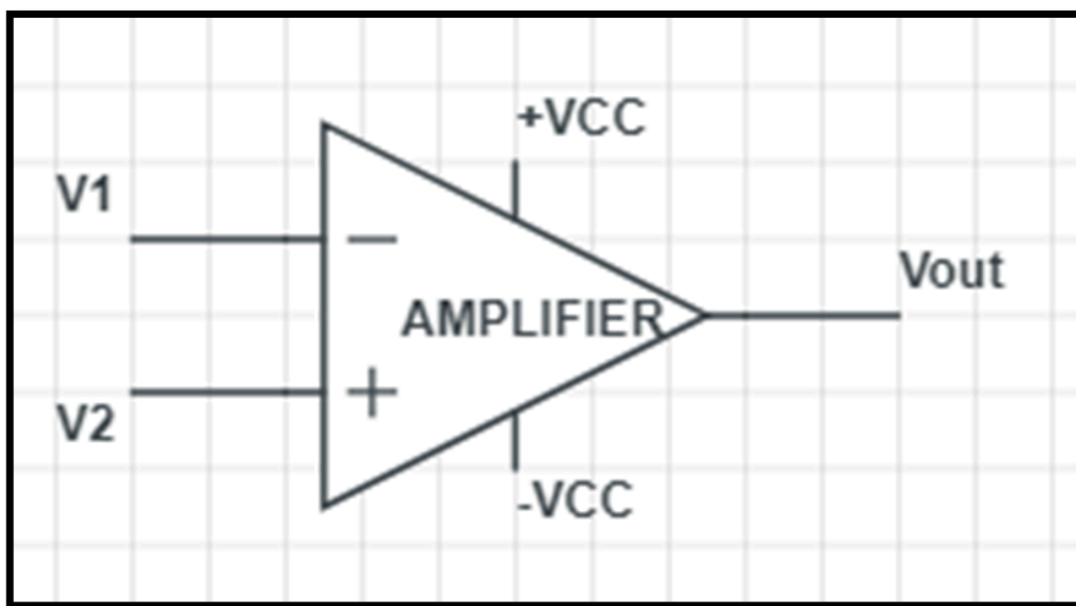
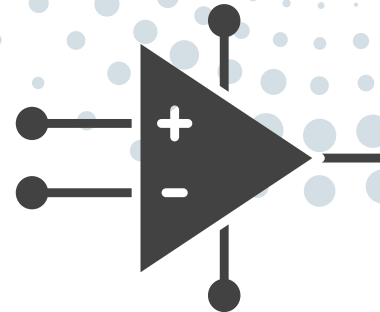
INTEGRATOR AMPLIFIER



$$V_{out} = -\frac{1}{R_{in} C_f} \int V_{in} dt (+V_{DC})$$

The magnitude of the output signal is determined by the **length of time a voltage** is present at its input as the current through the feedback loop charges or discharges the capacitor as the required negative feedback occurs through the capacitor.

COMPARATOR AMPLIFIER



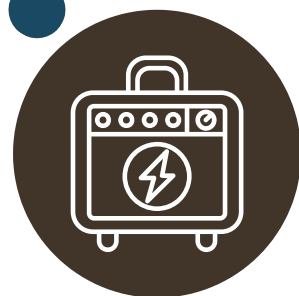
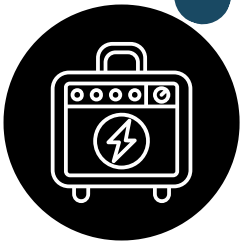
When,

$V2 > V1$ output, V_{out} is equal to **+ VCC (+ Sat)**

$V1 > V2$ output, V_{out} is equal to **- VCC (- Sat)**

TUTORIALS

TOPIC 3

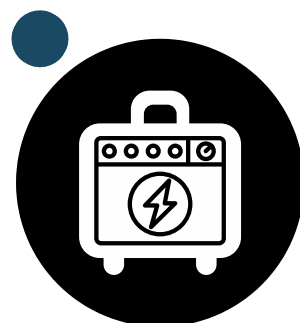


01

Operational amplifier (Op-Amp) is an integrated circuit that contains several levels and a differential amplifier configuration. Draw the block diagram of op-amp and write the function of each stages. Sketch the non-inverting amplifier circuit which has input voltage,

$V_{in} = 0.5\text{mV}$, $R_{in} = 15\text{k}\Omega$ and $R_f = 100\text{k}\Omega$. Calculate the output voltage, V_{out} and draw the waveforms of the input voltage, V_{in} and output voltage, V_{out} .

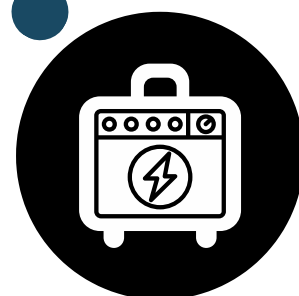
TOPIC 3 - Amplifier Configuration



02.

Compare the **THREE (3)** ideal to the practical characteristics of operational amplifier. Describe the Common Mode Rejection Ratio (CMRR) and calculate CMRR when feedback resistor $R_f = 100\text{K}\Omega$, $R_{in} = 10\text{K}\Omega$ and common gain = 0.001

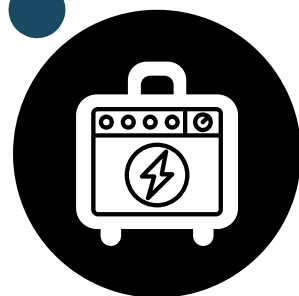
TOPIC 3 - operational amplifier & CMRR



03

An inverting summing amplifier is an op-amp circuit that combines several inputs and produces an output that is weighted sum of the inputs. Carry out the output voltage (V_o) by drawing the inverting summing amplifier which has TWO (2) inputs. Hence, calculate the current input I_1 , I_2 and output voltage if $R_F = 10k\Omega$, $R_1 = 5k\Omega$ and $R_2 = 2.5k\Omega$, input voltage $V_1=2V$ and $V_2=1V$. Draw the waveform of the input and output simultaneously

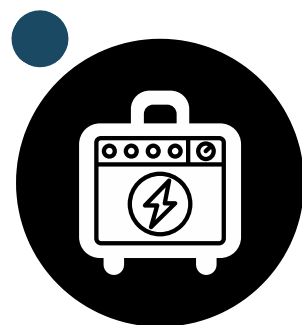
inverting summing amplifier



04.

inverting summing amplifier

Draw the inverting summing amplifier having 3 inputs V_1 , V_2 and V_3 with the resistor R_1 , R_2 , R_3 and feedback resistor R_f respectively. Demonstrate the output voltage equation, V_o . Calculate the output voltage if $R_f=R_1=R_2=R_3=1\text{K}\Omega$ and the input voltage = 1mVp-p



05

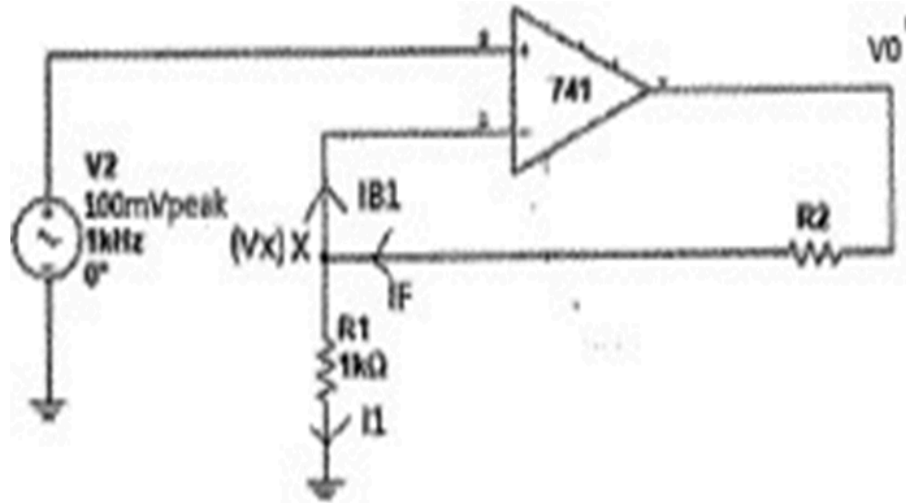
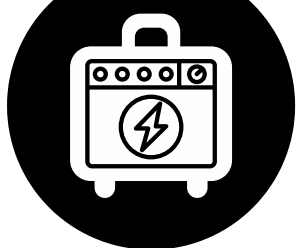


Figure 1

An Operational Amplifier is one of the most used devices in the application of analog circuits. Figure 1 shows one of the application operational amplifiers which has an input voltage value of 100mV and an output voltage of 1.6V. Refer to Figure 1 and the value given, state the name of the amplifier, derive the closed loop gain formula, calculate the voltage gain (AV) and the value of R2. Based on the calculated value, draw the input and output waveform.

operational amplifiers

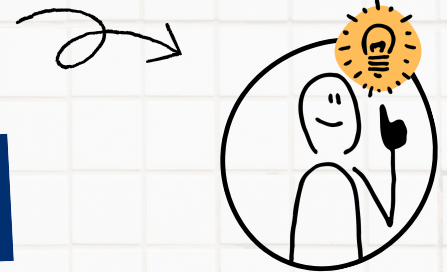


EXERCISES



TOPIC

1



01

(S1 2022/2023)

State four (4) types of the filter in the linear direct current (DC) power supply.

02

(S1 2022/2023)

Write the operation of the half wave rectifier circuit by using aided diagram, complete with the input and output waveform.

03

(S1 2022/2023)

List two (2) types of the rectifier circuit are commonly used in this power supply unit. how many diodes are using in the rectifier circuit respectively.

04

(S2 2022/2023)

The main function of rectifier in power supply is to convert the alternating current (ac) to direct current (dc) power. List two (2) types of rectifier circuit are commonly used in this power supply unit. How many diode are using in the rectifier circuit respectively.

05

(S2 2022/2023)

The power supply tries to provide a smooth, constant direct current (dc) voltage, as required by an electronic device. Sketch a complete 230V ac input power supply circuit and output waveform for each stages that includes center tap transformer, full wave rectifier, RC filter, integrated circuit voltage regulator and variable resistor for voltage divider.

06

(S1 2023/2024)

Sketch a complete power supply circuit that consists of a transformer, full wave rectifier, LC filter, Zener diode regulator and variable resistor voltage divider. Then draw the expected input and output waveform.

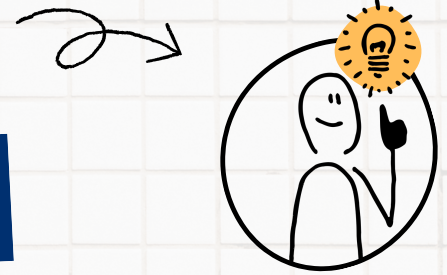
07

(S2 2023/2024)

List four (4) main components needed to develop Dc power supply circuit.

TOPIC

2



01

(S1 2022/2023)

Explain the operation of the Hartley oscillator by using aided diagram.

02

(S1 2022/2023)

List four (4) types of sinusoidal oscillators.

03

(S1 2022/2023)

List two (2) types of sinusoidal oscillator circuit with one (1) example for each types.

04

(S2 2022/2023)

Hartley oscillator is used to produce a sinewave of desire frequency. Explain the operation of Hartley oscillator by using a suitable diagram.

05

(S2 2022/2023)

LC oscillator is used to give the positive feedback for maintaining the oscillation. Name four (4) types of LC feedback oscillator.

06

(S1 2023/2024)

Explain the operation of the Hartley oscillator.

08

(S1 2023/2024)

List two (2) types of a sinusoidal oscillator circuit with one (1) example of each type.

07

(S2 2023/2024)

State two (2) Barkhausen criteria for a circuit to be an oscillator.

10

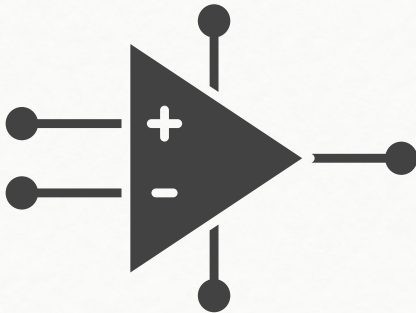
(S2 2023/2024)

Identify the block diagram of an oscillator circuit with complete labeling and State four (4) types of LC oscillator.

09

(S2 2023/2024)

By using a suitable diagram, explain briefly the feedback network of the Colpitts and Hartley Oscillator.



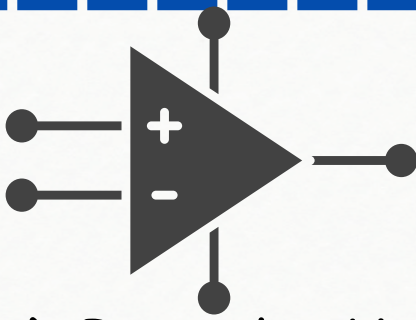
1 Question

Operation amplifier (op-amp) is an integrated circuit that contains several levels and a differential amplifier configuration.

a) Draw the block diagram of op-amp and write the function of each block.

b) Sketch the non-inverting amplifier circuit which has input voltage $V_{in} = 0.5\text{mV}$, $R_{in} = 15\text{k}\Omega$, and $R_f = 100\text{k}\Omega$. Calculate the output voltage, V_{out} and draw the waveform of the input voltage, V_{in} and output voltage, V_{out} .

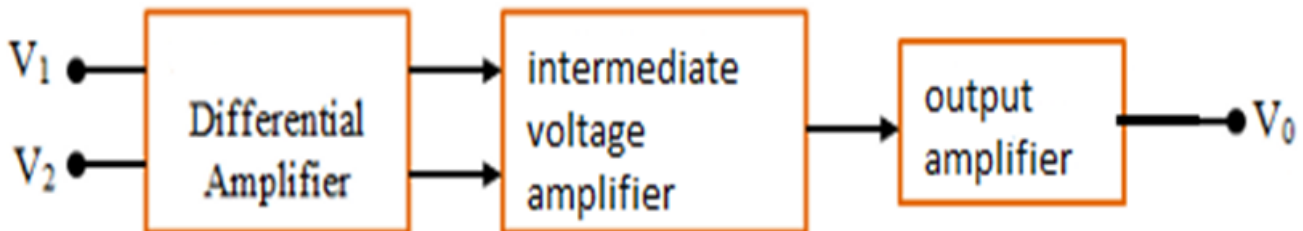
(S1 2022/2023)



1 Solution

a) Draw the block diagram of op-amp and write the function of each block.

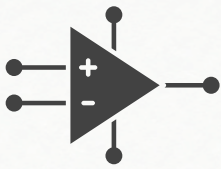
Block diagram and functions:



1. Differential amplifier (input stage) – provides low noise amplification, max voltage gain and high input impedance, usually a differential input.

2. Intermediate voltage amplifier (gain stage). Voltage amplifier – provides high voltage gain, usually single-ended output.

3. Output amplifier stage – provides high current driving capability, low output impedance, current limiting and short circuit protection circuitry.

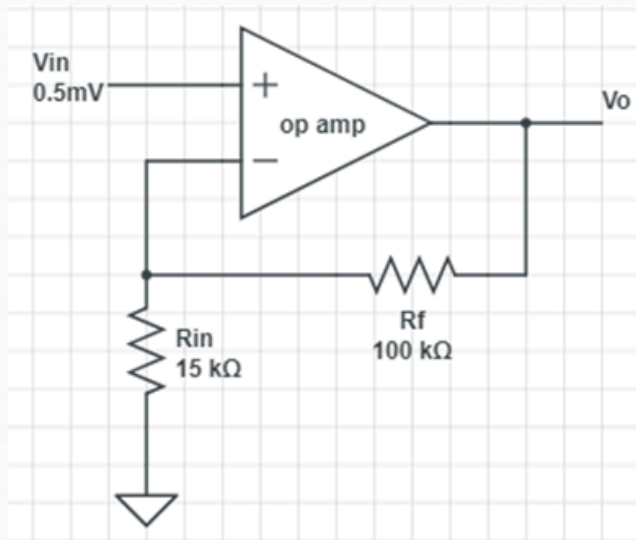


1

Solution

Sketch the non-inverting amplifier circuit

Non-inverting amplifier:



Calculate the output voltage

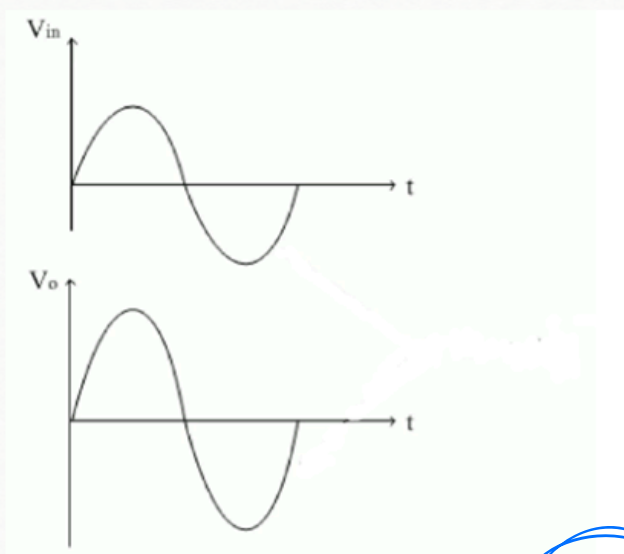
V_{out} :

$$V_{out} = V_{in} \left(1 + \frac{R_f}{R_{in}} \right)$$

$$V_{out} = 0.5mV \left(1 + \frac{100k\Omega}{15k\Omega} \right)$$

$$V_{out} = 3.83mV$$

Draw the waveform of the input voltage (V_{in}) and output voltage (V_o)



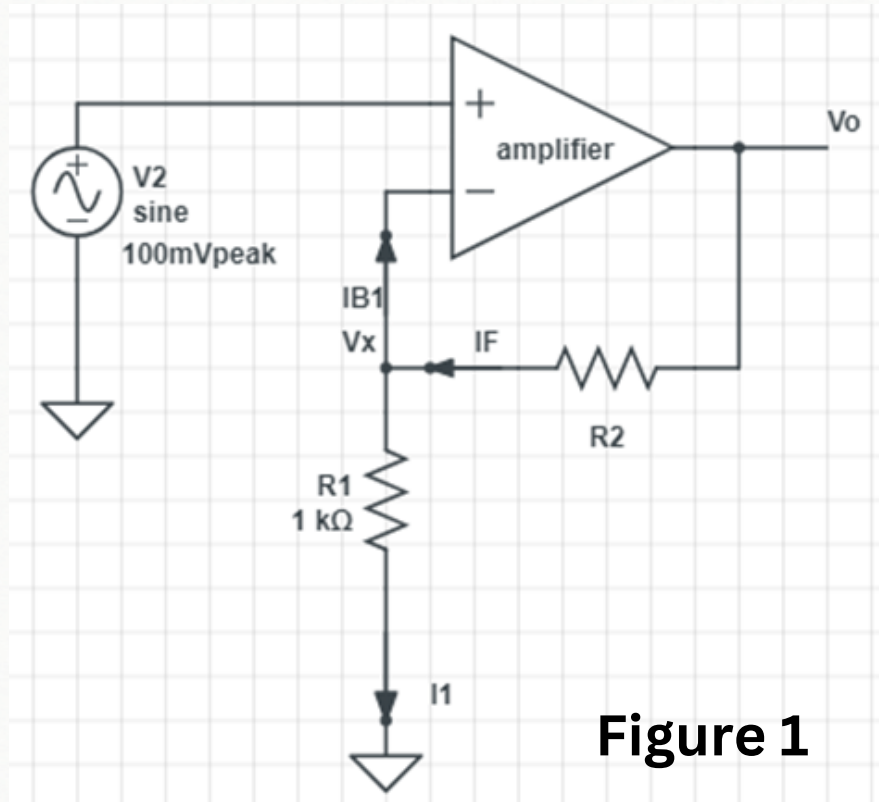
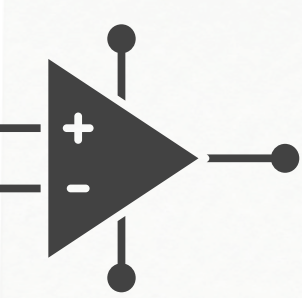
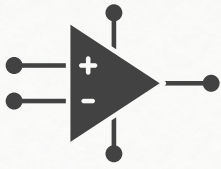


Figure 1

An operation amplifier is one of the most commonly used devices in application of analog circuits. Figure 1 below show the one of the application operational amplifier which an input voltage value of 100mV and an output voltage of 1.6V. State the name of the amplifier, derive the close loop gain formula, calculate the voltage gain, A_v and the value of R_2 . Based on the calculated value, draw the input and output waveform.

(S2 2022/2023)



2

Solution

Non-Inverting amplifier:

$$V_x = V(+)=V(-)=V_{in}$$

$$I_F = I_{B1} + I_1$$

$$\frac{V_o - V_x}{R_2} = 0 + \frac{V_x - 0}{R_1}$$

$$\frac{V_o - V_{in}}{R_2} = 0 + \frac{V_{in} - 0}{R_1}$$

$$(V_o - V_{in})R_1 = V_{in}R_2$$

$$V_oR_1 - V_{in}R_1 = V_{in}R_2$$

$$V_oR_1 = V_{in}R_2 + V_{in}R_1$$

$$V_oR_1 = V_{in} (R_2 + R_1)$$

$$\frac{V_o}{V_{in}} = \frac{R_2 + R_1}{R_1}$$

$$\frac{V_o}{V_{in}} = 1 + \frac{R_2}{R_1}$$

$$A_v = \frac{V_o}{V_{in}} = 1 + \frac{R_2}{R_1}$$

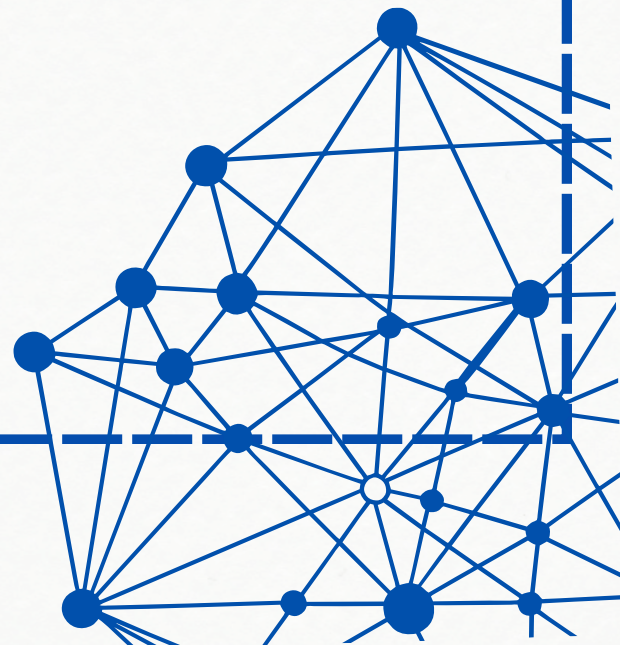
Value of R2:

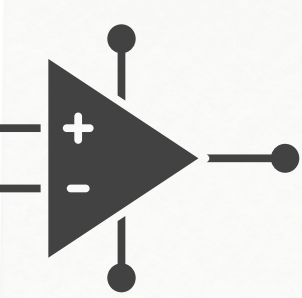
$$A_v = 1 + \frac{R_2}{R_1}$$

$$16 = 1 + \frac{R_2}{1K\Omega}$$

$$15 = \frac{R_2}{1K\Omega}$$

$$15K\Omega = R_2$$

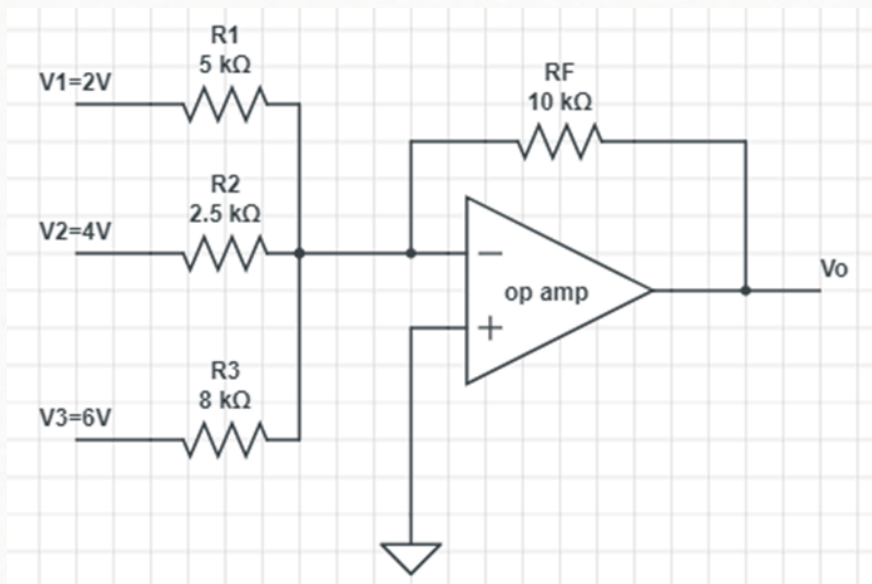
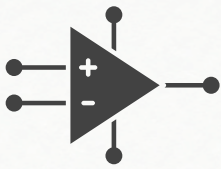




3 Question

An inverting amplifier is an op-amp circuit that combines multiple inputs and generates an output that is the sum of the inputs with inverted polarity. Find the output voltage equation V_o by drawing the inverting summing amplifier which has three (3) inputs. Hence, calculate the current inputs I_1, I_2, I_3 And output voltage if $R_f=10k\Omega$, $R_1=5k\Omega$, $R_2=2.5k\Omega$, $R_3=8k\Omega$ and inputs voltages $V_1=2V$, $V_2=4V$, $V_3=6V$. Draw the input and output signals.

(S1 2023/2024)



Current I_1, I_2 and I_3 :

$$I_1 = \frac{V_1}{R_1} = \frac{2V}{5K\Omega} = 0.4mA$$

$$I_2 = \frac{V_2}{R_2} = \frac{4V}{2.5K\Omega} = 1.6mA$$

$$I_3 = \frac{V_3}{R_3} = \frac{6V}{8K\Omega} = 0.75mA$$

V_{out} :

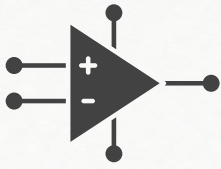
$$V_{out} = -\left(\frac{R_F}{R_1}V_1 + \frac{R_F}{R_2}V_2 + \frac{R_F}{R_3}V_3\right)$$

$$V_{out} = -\left(\frac{10K\Omega}{5K\Omega}2 + \frac{10K\Omega}{2.5K\Omega}4 + \frac{10K\Omega}{8K\Omega}6\right)$$

$$V_{out} = -27.5V$$

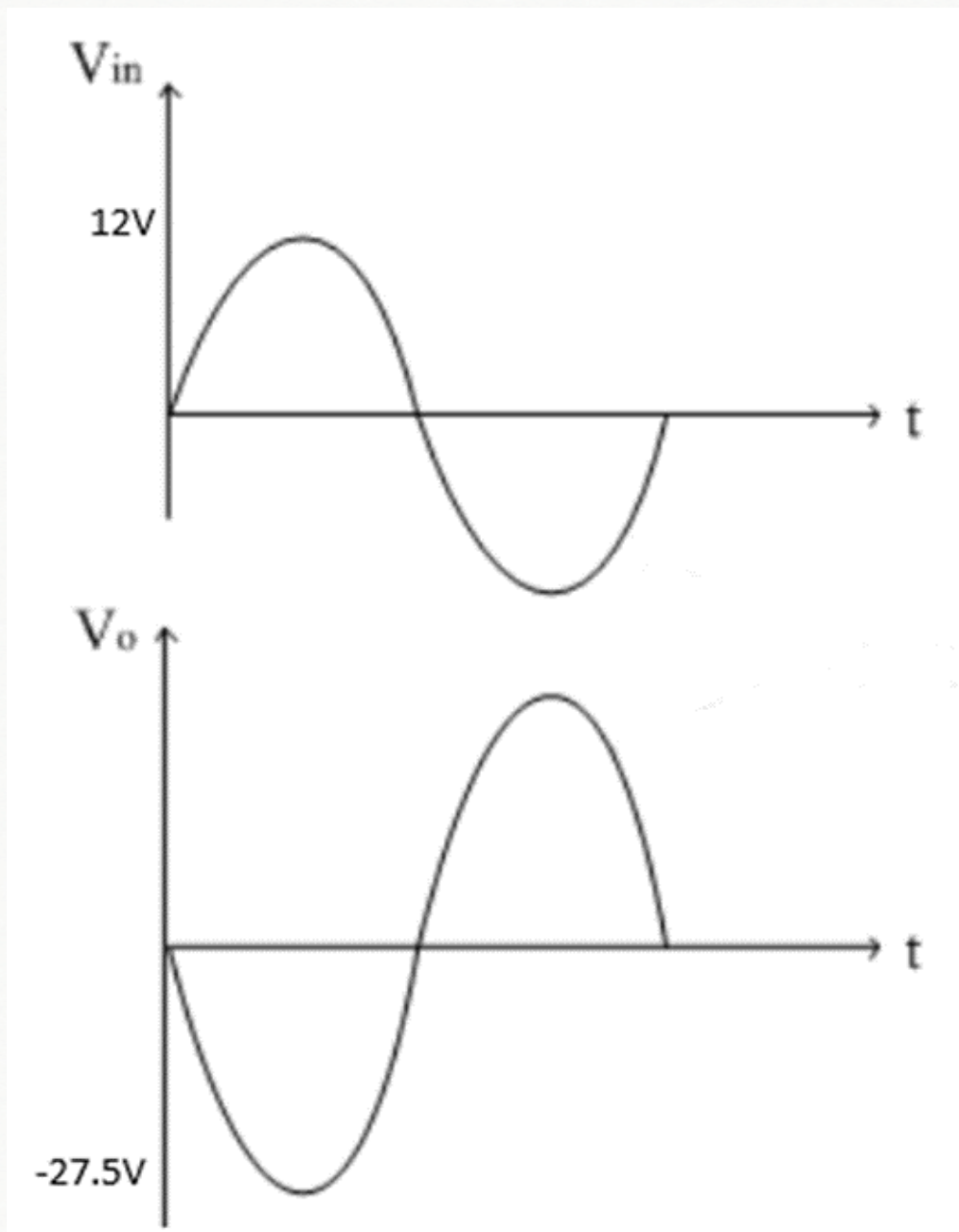
V_{in} :

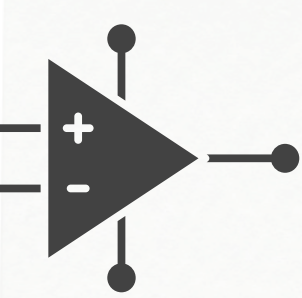
$$V_{in} = V_1 + V_2 + V_3 = 2V + 4V + 6V = 12V$$

**3**

Solution

Draw the input and output waveforms

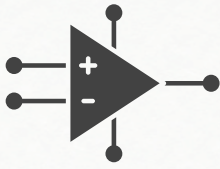




④ Question

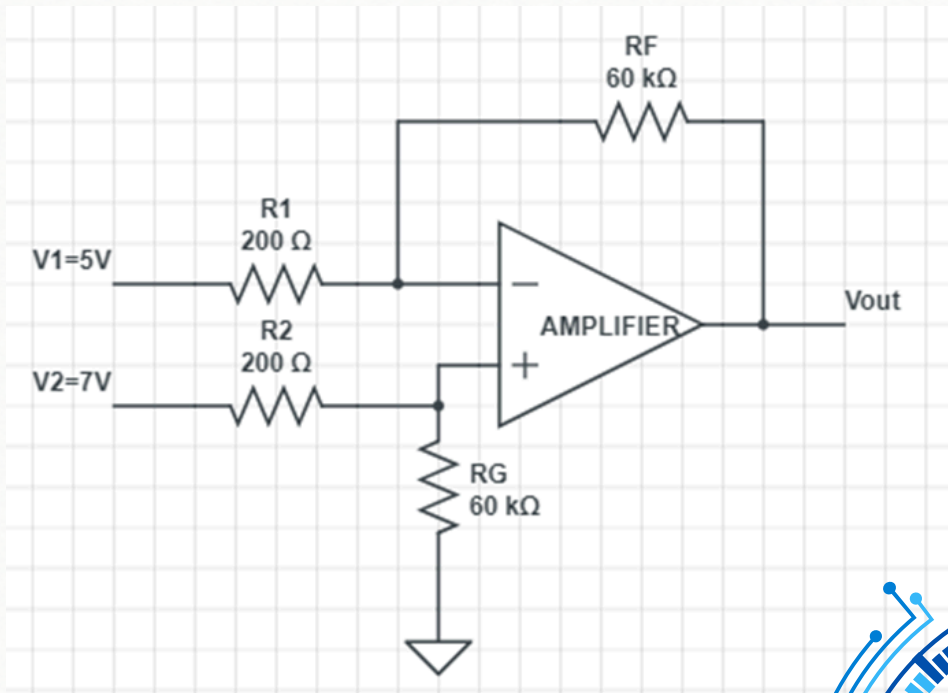
A differential amplifier is an operational amp circuit that combines an inverting amplifier and a non-inverting amplifier. Calculate the value of voltage output, V_{out} by drawing a differential amplifier with the input voltage at the inverting pin. $V_1=5V$ and input voltage 2, $V_2=7V$, input resistor at V_1 , $R_1=$ input resistor at V_2 , $R_2=200\Omega$ and resistor feedback, $R_f=R_g=60k\Omega$. Write the meaning of the Common Mode Gain, A_{cm} and the Common Mode Rejection Ratio, CMRR of an operational amplifier. Then calculate the CMRR of the circuit in dB if the A_{cm} is 0.003.

(S2 2023/2024)



4

Solution



V_{out} :

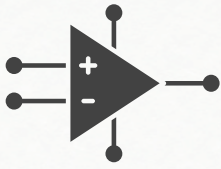
$$V_{out} = \frac{R_F}{R_1} + (V_2 - V_1)$$

$$V_{out} = \frac{60K\Omega}{200K\Omega} + (7V - 5V)$$

$$V_{out} = 600V$$

CMG & CMRR:

1. Common Mode Gain (A_{cm}): When the same input signals are applied to the both inputs: $V_1=V_2$
2. Common Mode Rejection Ratio (CMRR): When the same input signals are applied to the both inputs.



4

Solution

$$CMRR = \frac{A}{A_{cm}}$$

$$CMRR (dB) = 20 \log \frac{A}{A_{cm}}$$

$$CMRR (dB) = 20 \log \frac{A}{0.003}$$

$$A = \frac{V_{out}}{V_{in}}$$

$$A = \frac{V_{out}}{(V_2 - V_1)}$$

$$A = \frac{600V}{(7V - 5V)}$$

$$A = 300V$$

$$CMRR (dB) = 20 \log \frac{A}{0.003}$$

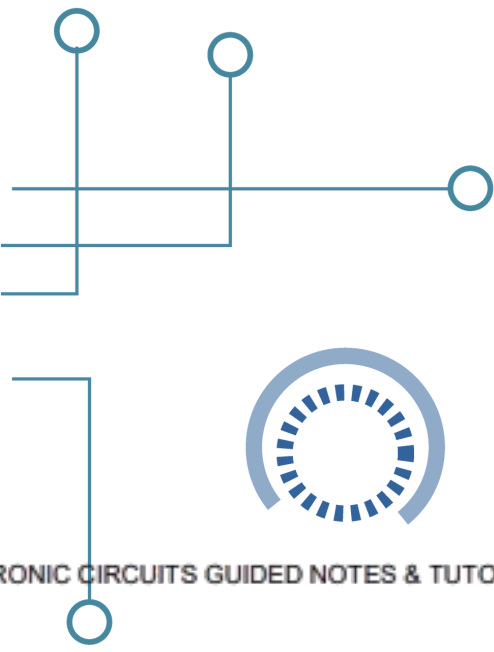
$$CMRR (dB) = 20 \log \frac{300}{0.003}$$

$$CMRR (dB) = 100dB$$



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ELECTRONIC CIRCUITS GUIDED NOTES & TUTORIALS

e ISBN 978-629-7643-37-3



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