SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
An Autonomous Institution

Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A++' Grade (III Cycle)
Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

23ECB202 – LINEAR INTEGRATED CIRCUITS

II YEAR/ IV SEMESTER

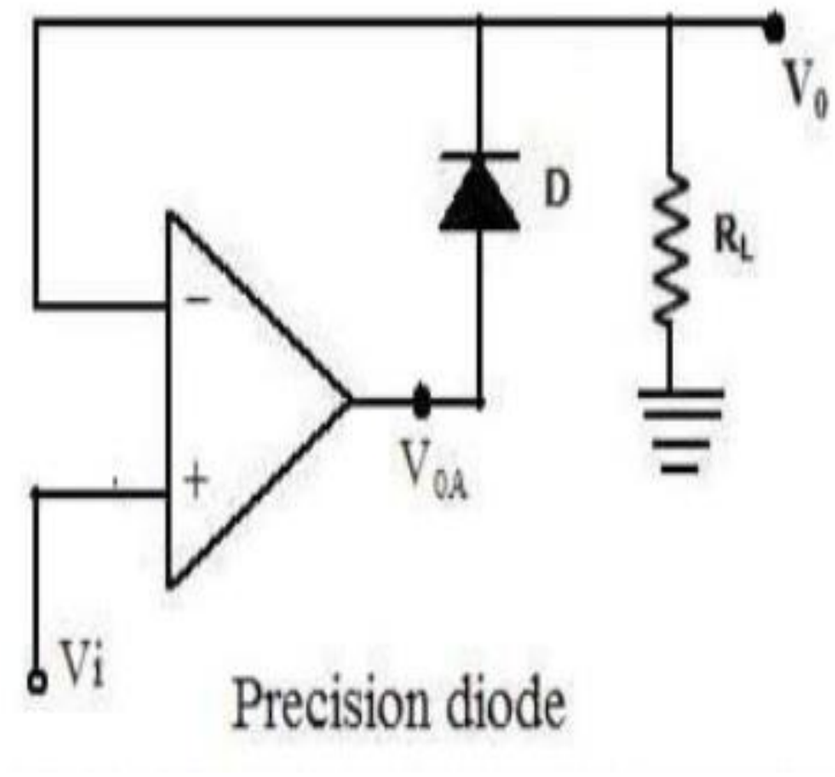
UNIT 2 – **APPLICATIONS OF OPERATIONAL AMPLIFIERS**

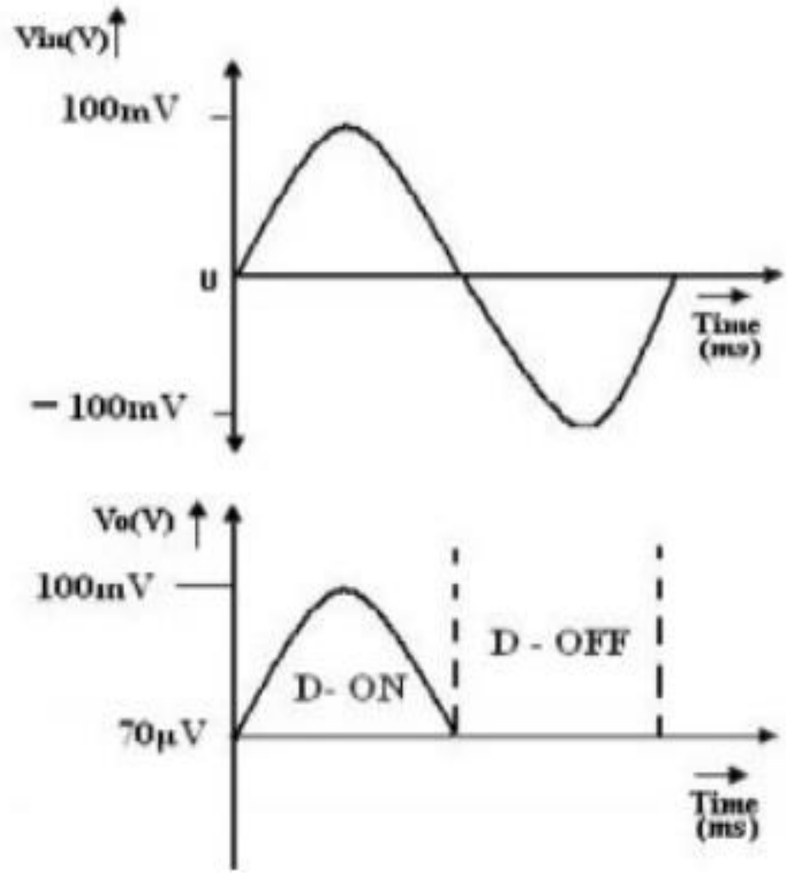
TOPIC – Precision Rectifier

Precision Diode

- The ordinary diodes cannot rectify voltages below the cut-in -voltage of the diode.
- A circuit which can act as an ideal diode or precision signal – processing rectifier circuit for rectifying voltages which are below the level of cut-in voltage of the diode can be designed by placing the diode in the feedback loop of an op-amp.
- Cut-in Voltage is divided by open loop gain of op-amp. So cut-in voltage is virtually eliminated.

Precision Diode





- When $Vi > V_\gamma/A_{OL}$ Diode conducts – acts as voltage follower.
- When $V < V_\gamma/A_{OL}$ Diode is off – no conduction takes place.

RECTIFIER

- An electronic circuit, which produces either DC signal or a pulsated DC signal, when an AC signal is applied to it is called as a **rectifier**

Types of Rectifiers

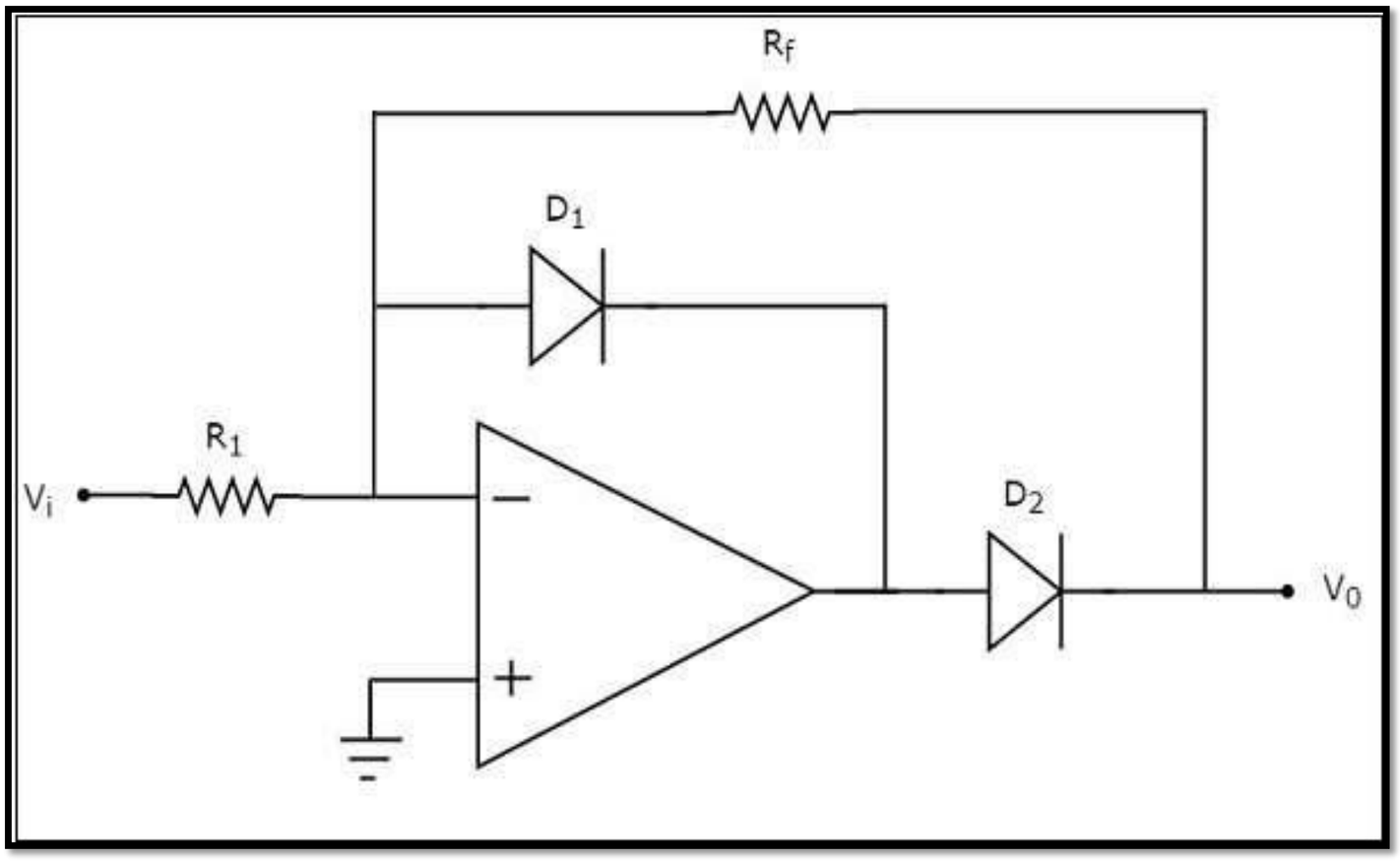
Two types:

Half wave rectifier

Full wave rectifier

Half wave Rectifier

- A **half wave rectifier** is a rectifier that produces positive half cycles at the output for one half cycle of the input and zero output for the other half cycle of the input



Half wave Rectifier

- An inverting amplifier, with two diodes D_1 and D_2
- For the **positive half cycle** of the sinusoidal input, the output of the op-amp will be negative.
- Hence, diode D_1 will be forward biased.
- When diode D_1 is in forward bias, output voltage of the op-amp will be -0.7 V
- So, diode D_2 will be reverse biased. Hence, the **output voltage** of the above circuit is **zero** volts

Half wave Rectifier

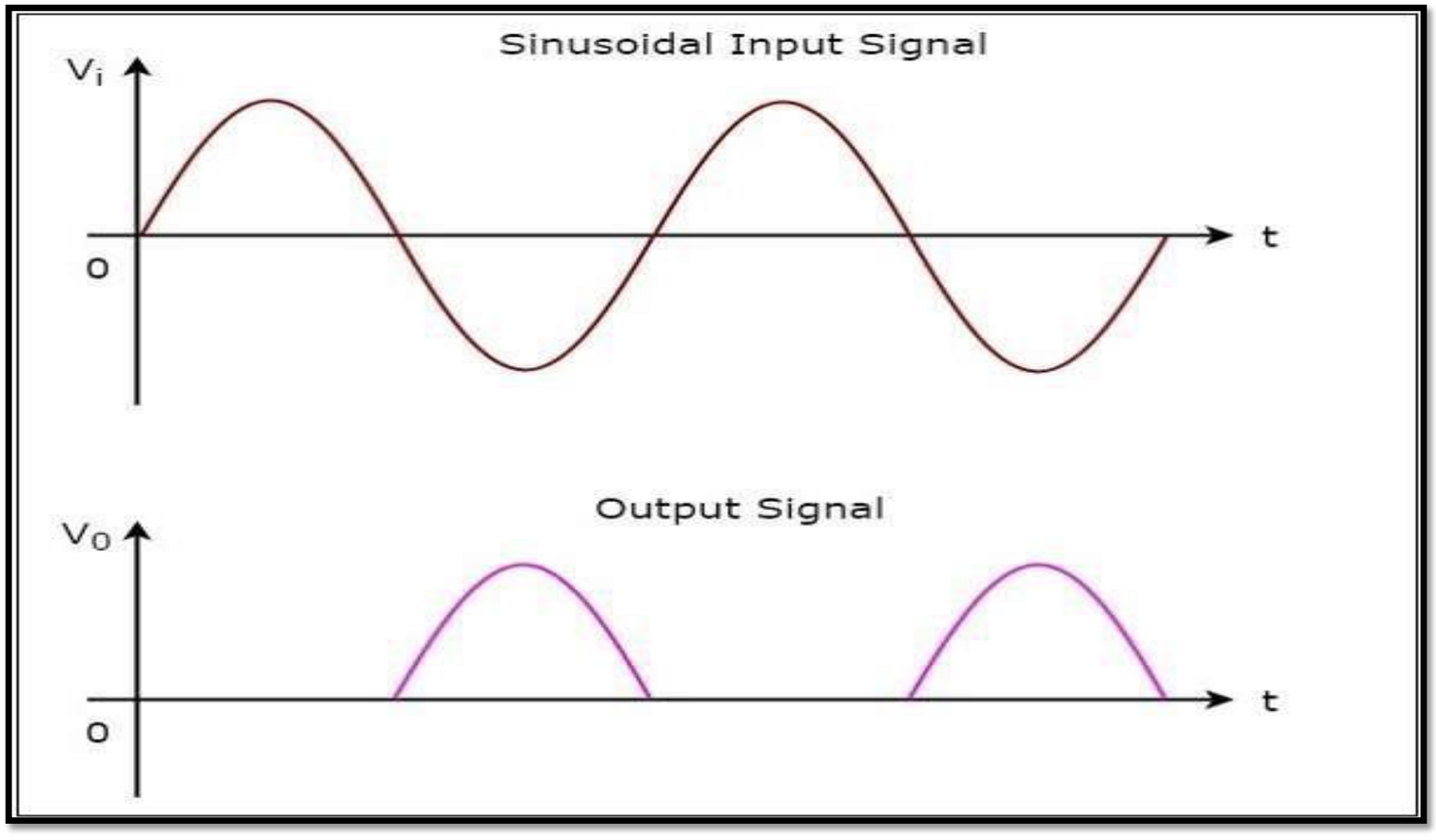
- There is **no (zero) output** of half wave rectifier for the positive half cycle of a sinusoidal input
- For the **negative half cycle** of sinusoidal input, the output of the op-amp will be positive
- Hence, the diodes D_1 and D_2 will be reverse biased and forward biased respectively
- So, the output voltage of above circuit will be

$$V_0 = -(R_f R_1) V_1$$

- Therefore, the output of a half wave rectifier will be a **positive half cycle** for a negative half cycle of the sinusoidal input Wave forms

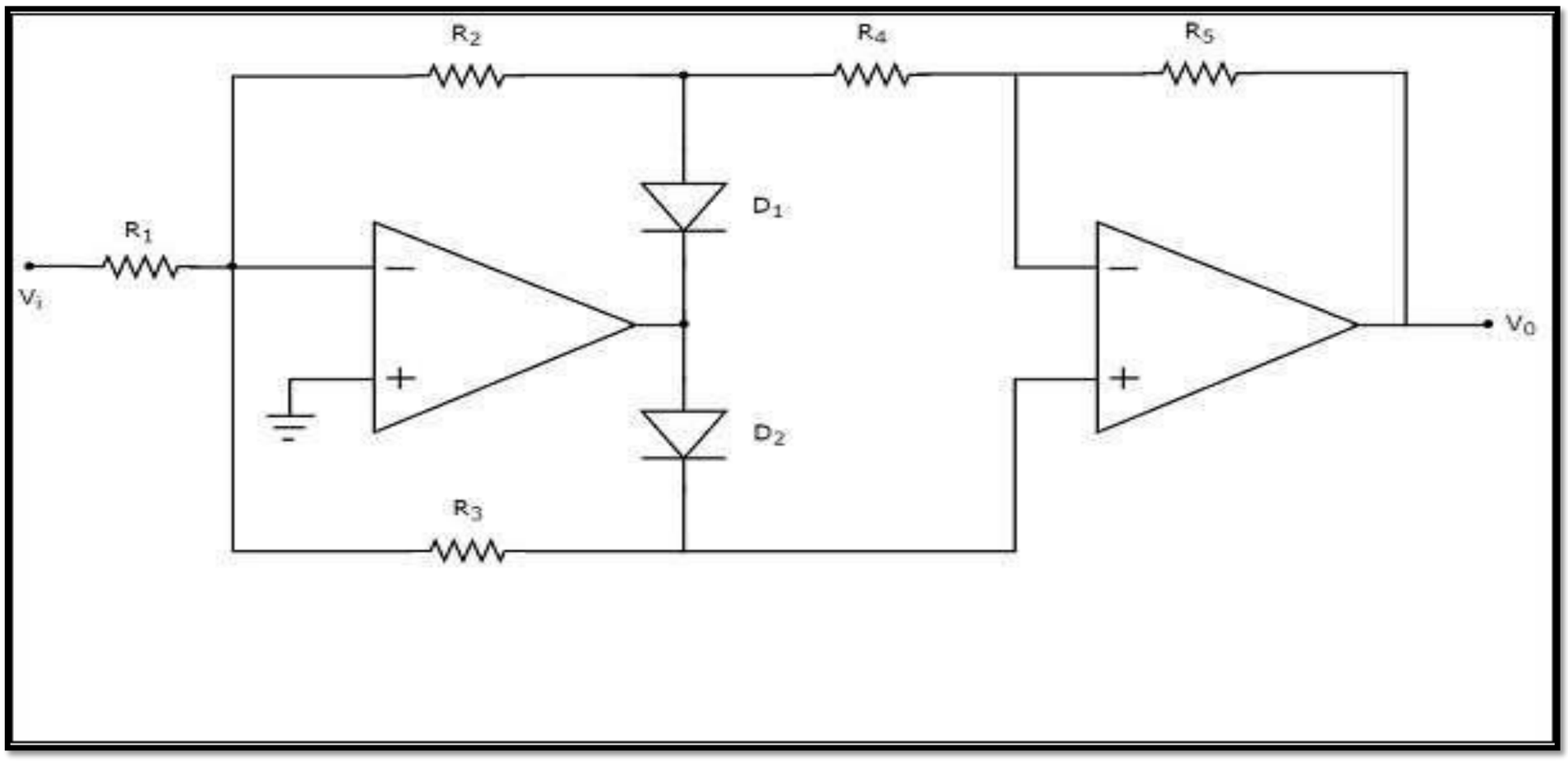
Half wave Rectifier Waveform

The **input** and **output waveforms** of a half wave rectifier are shown in the following figure



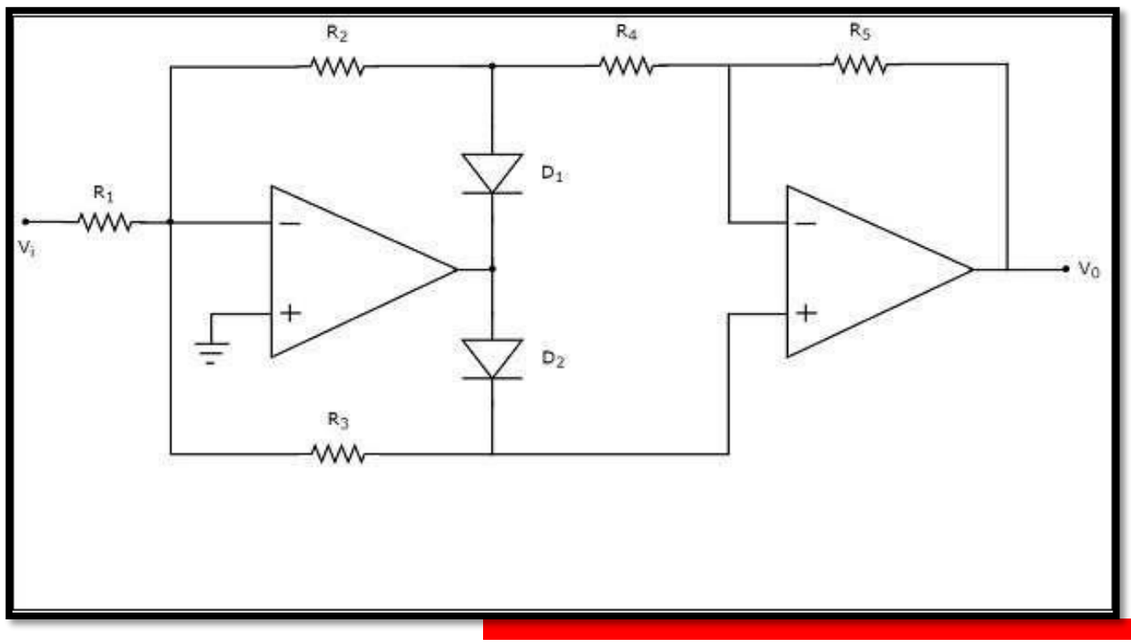
Full wave Rectifier

- A **full wave rectifier** produces positive half cycles at the output for both positive and negative half cycles of the input.
- The **circuit diagram** of a full wave rectifier is shown below



Full wave Rectifier

- It consists of two op-amps, two diodes, D_1 & D_2 and five resistors, R_1 to R_5
- For the **positive half cycle** of a sinusoidal input, the output of the first op-amp will be negative.
- Hence, diodes D_1 and D_2 will be forward biased and reverse biased respectively
- Then, the output voltage of the first op-amp will be



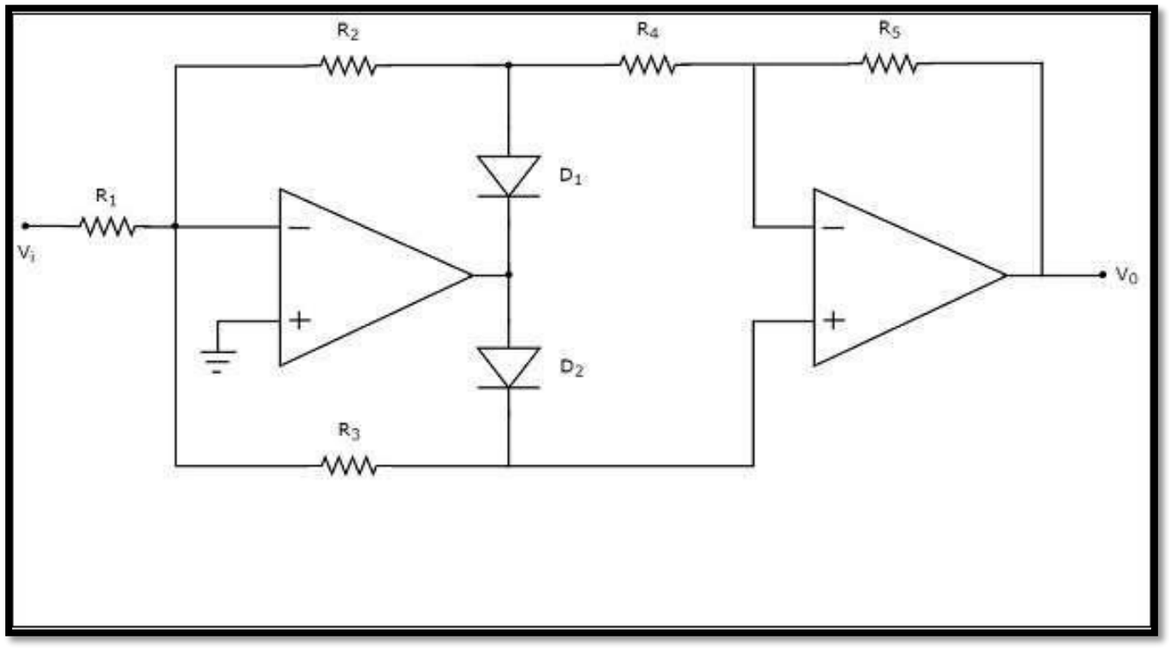
$$V01=-(R2/R1)Vi$$

Full wave Rectifier

- Observe that the output of the first op-amp is connected to a resistor R_4, which is connected to the inverting terminal of the second op-amp.
- The voltage present at the non-inverting terminal of second op-amp is 0 V. So, the second op-amp with resistors, R_4 and R_5 acts as an **inverting amplifier**.

$$V0=-(R5/R4)V01$$

Substituting the value of V_{01} in the above equation, we get



$$=>V0=-(R5/R4)\{-(R2/R1)Vi\}$$
$$=>V0= (R2R5/R1R4)Vi$$

Full wave Rectifier

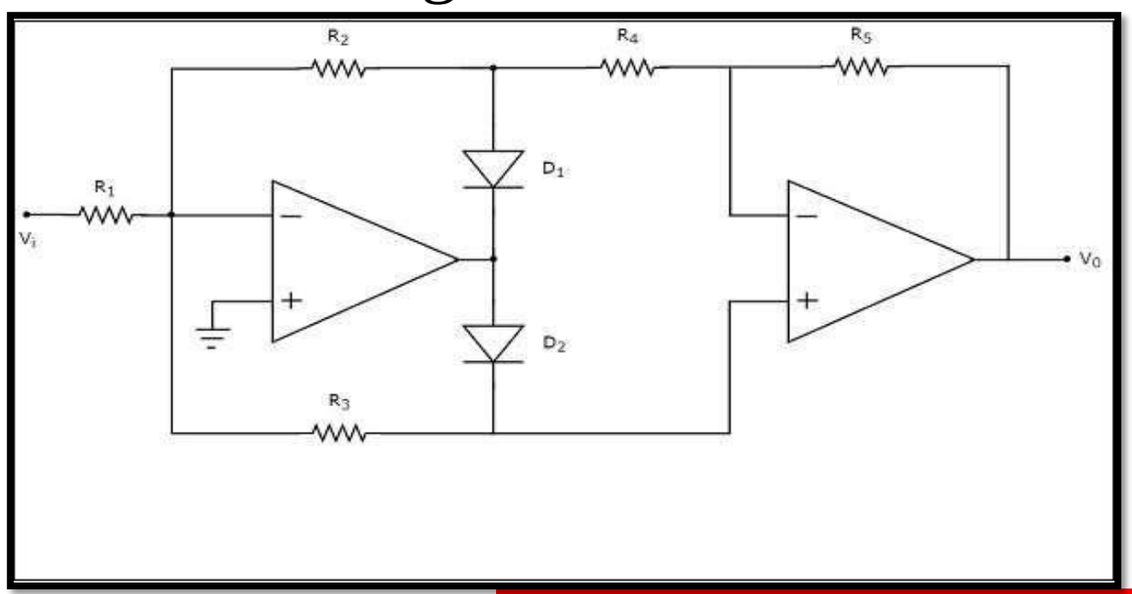
- Therefore, the output of a full wave rectifier will be a positive half cycle for the **positive half cycle** of a sinusoidal input.
- In this case, the gain of the output is R2R5/R1R4
- If we consider R1=R2=R4=R5=R, then the gain of the output will be one
- For the **negative half cycle** of a sinusoidal input, the output of the first op-amp will be positive.
- Hence, diodes D_1 and D_2 will be reverse biased and forward biased respectively.

Full wave Rectifier

- The output voltage of the first op-amp will be

$$V_{01} = -(R3/R1)V_i$$

- The output of the first op-amp is directly connected to the non-inverting terminal of the second op-amp
- R4 and R5 acts as a non-inverting amplifier
- The output voltage of the second op-amp will be $V_0 = (1+R5/R4)V_{01}$
- Substituting the value of V_{01} in the above equation,



$$\Rightarrow V0 = (1+R5/R4)\{-(R3/R1)Vi\}$$
$$\Rightarrow V0 = -(R3/R1)(1+R5/R4)Vi$$

Full wave Rectifier

- The output of a full wave rectifier will be a **positive half cycle** for the negative half cycle of sinusoidal input also

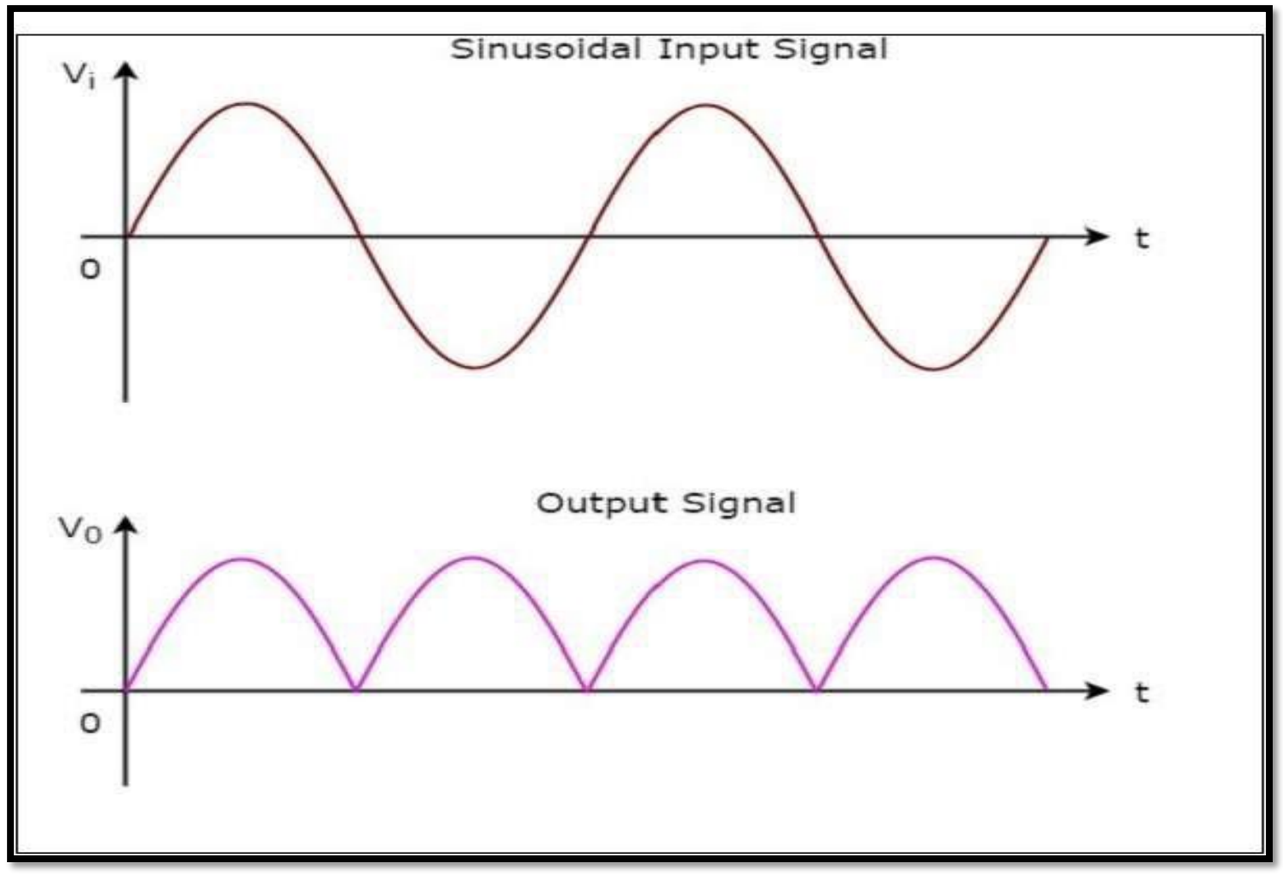
- The magnitude of the gain of the output is

(R3/R1)(1+R5/R4)

- If we consider R1=2R3=R4=R5=RR1=2R3=R4=R5=R then the gain of the output will be **one**.

Full wave Rectifier

The **input** and **output waveforms** of a full wave rectifier



Assessment

1. In a full wave rectifier, the current in each diode flows for
a. whole cycle of the input signal
b. half cycle of the input signal
c. more than half cycle of the input signal
d. none of these

2. In a full wave rectifier, if the input frequency is 50 Hz, then output frequency will be
a. 50 Hz
b. 75 Hz
c. 100 Hz
d. 200 Hz

THANK YOU