Analog & Digital Electronics

Course No: PH-218

Lec 3: Rectifier and Clipper circuits

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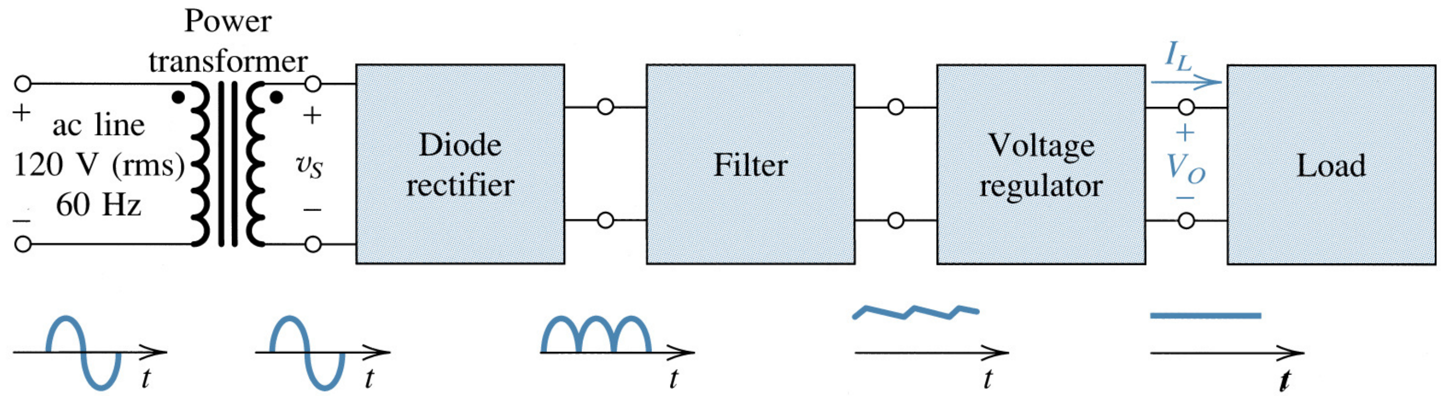
Rectifier Circuits: AC to DC conversion



Role of different circuit components

➢ **Transformer:**

❖ Step down AC voltage amplitude to the desired DC voltage (by selecting an appropriate turn ratio N_1/N_2 for the transformer)

❖ Isolate equipment from power-line

➢ **Rectifier:**

❖ converts an ac input to a unipolar output

➢ **Filter:**

❖ convert the pulsating input to a nearly constant dc output

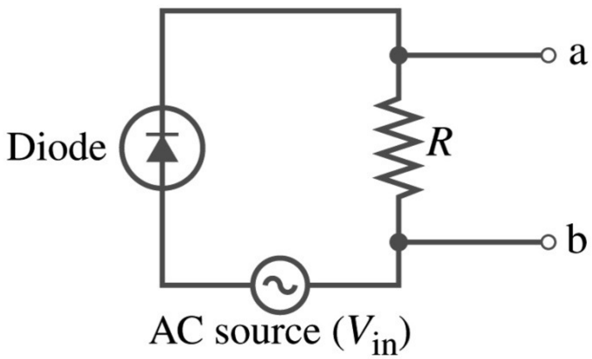
➢ **Regulator:**

❖ Reduce the ***ripple of the dc voltage***

Semiconductor diode: Few Applications

Rectifiers

- **Since a diode p-n junction conducts in one direction but not in the reverse direction, diodes can be used to convert ac voltages into dc voltages.**



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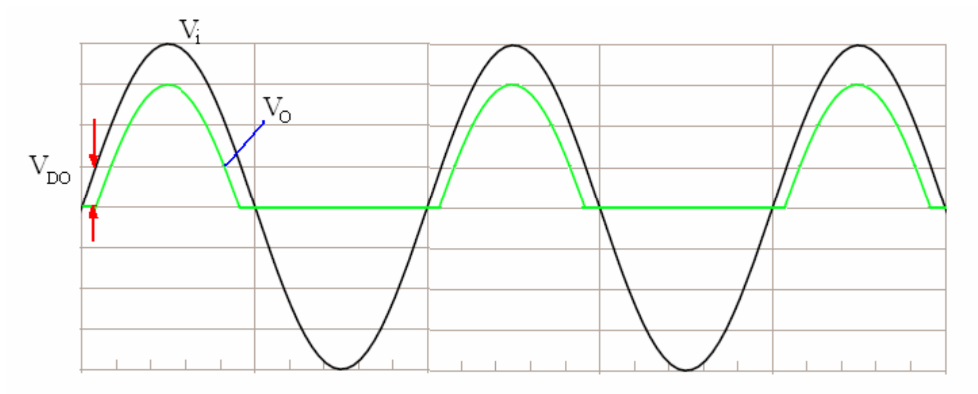
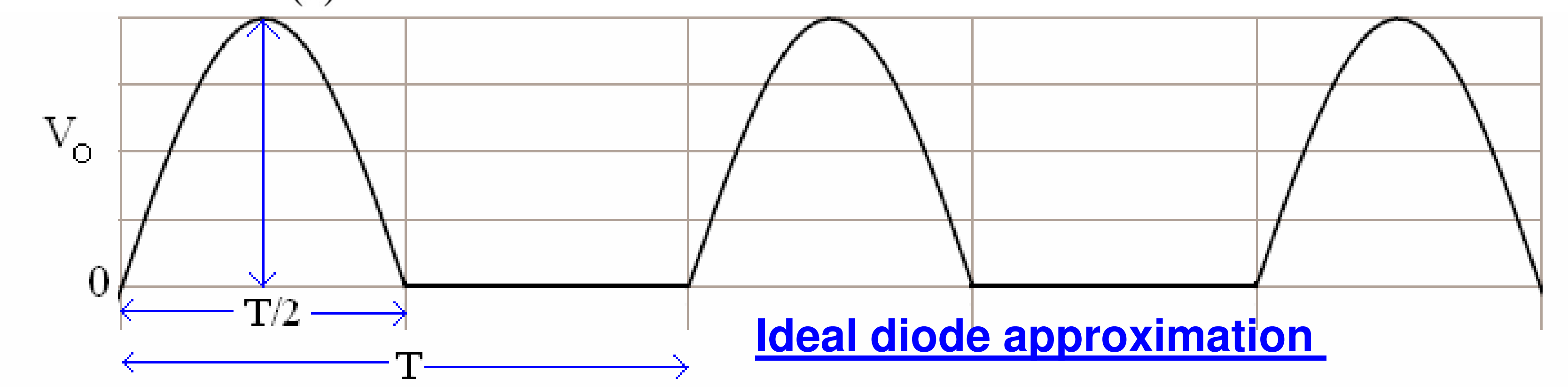
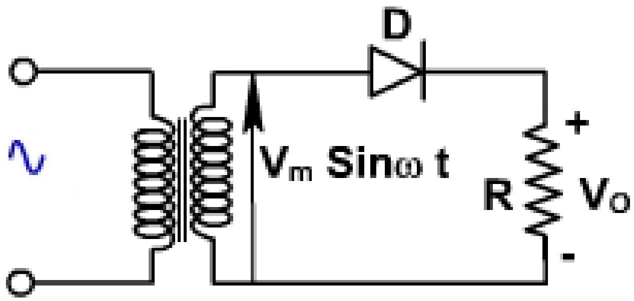
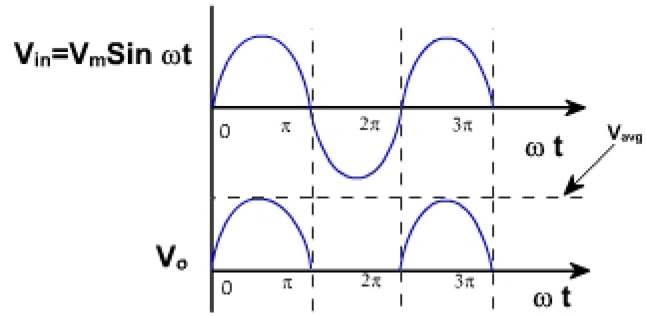




Ideal diode approximation

Half wave Rectifier:





➢In positive half cycle, D is forward biased and conducts. Thus the output voltage is same as the input voltage. In the negative half cycle, D is reverse biased, and therefore output voltage is zero

Efficiency of half wave rectifier:

The ratio of dc power output to the applied input a.c power is known as rectifier efficiency, denoted by η.

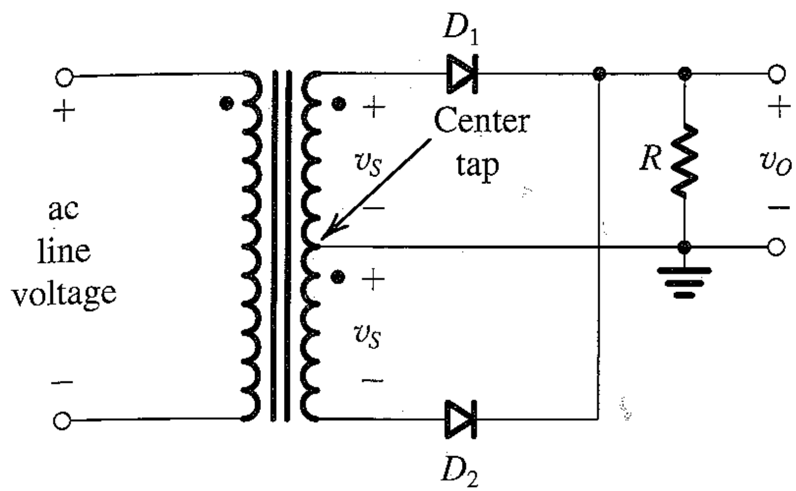
$$\eta = \frac{0.406 R_L}{r_f + R_L}$$

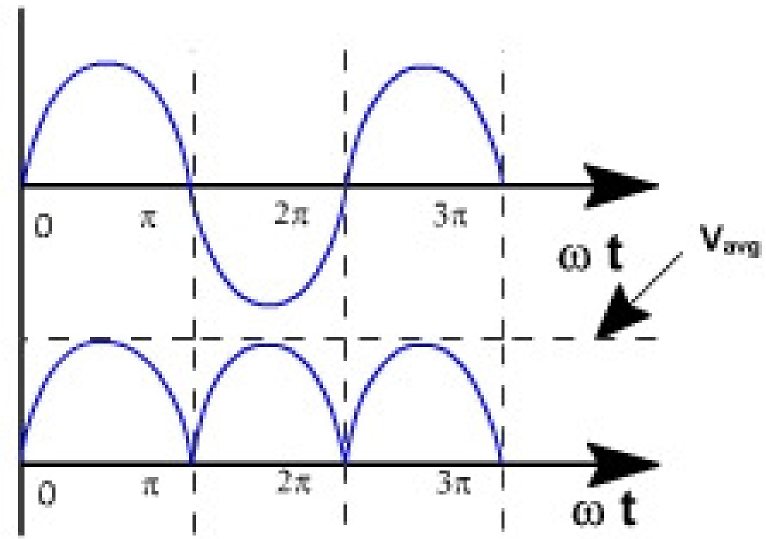
Max efficiency = 40.6%

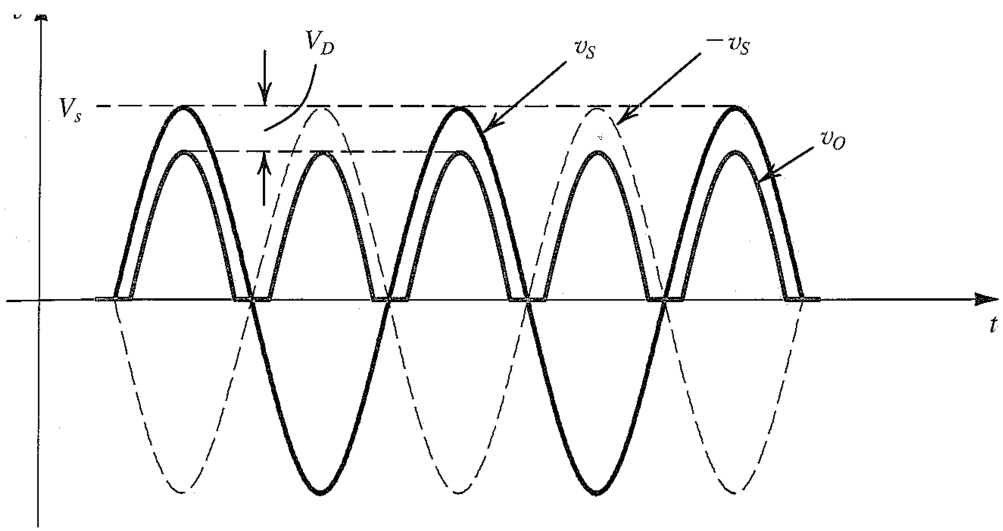
PIV= V_s

Tutorial Problem1: Prove the expression for a half wave rectifier efficiency and explain What happened to the remaining 60% .

Full Wave Rectifier:







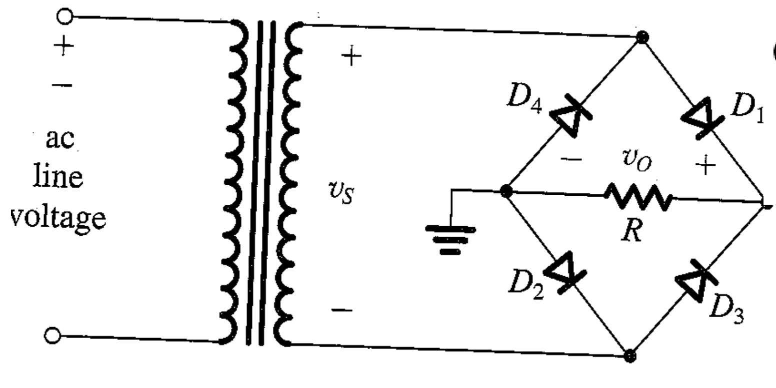
➢ In the first half cycle D_1 is forward biased and conducts. But D_2 is reverse biased and does not conduct. In the second half cycle D_2 is forward biased, and conducts and D_1 is reverse biased.

PIV= $2V_s$-V_D

$$\eta = \frac{0.812 R_L}{r_f + R_L}$$

➢ Disadvantage: 1. Difficult to locate the centre tap on the secondary winding.
2. The dc output is small as each diode utilise only half of the secondary voltage.

Full Wave Bridge Rectifier:



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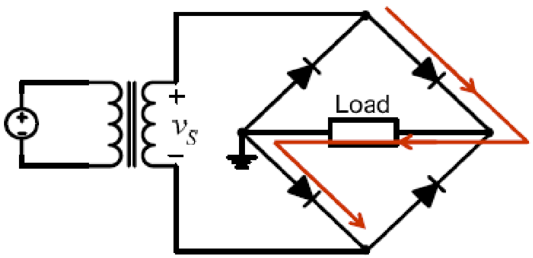
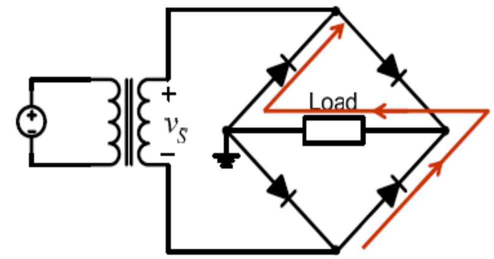
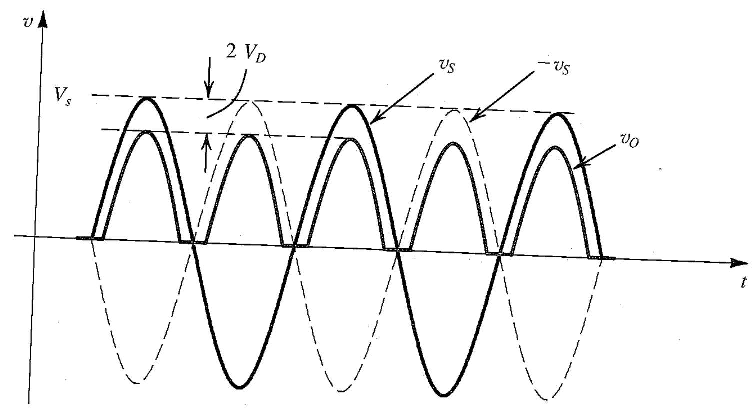


Positive V_s:



Negative V_s:



➢ Current always flows in one direction through the load resistance R, regardless of whether v_S is positive or negative.

➢ In the positive half cycle, D_1 & D_2 are forward biased and D_3 & D_4 are reverse biased. In the negative half cycle, D_3 & D_3 are forward biased, and D_1 & D_2 are reverse biased.

Full Wave Bridge Rectifier:

$$\text{PIV} = V_s - 2V_D + V_D = V_s - V_D$$

➢ Disadvantage:

➢The main disadvantage is that it requires four diodes. When low dc voltage is required then secondary voltage is low and diodes drop (1.4V) becomes significant. Therefore, for low dc output, 2-pulse center tap rectifier is used because only one diode drop is there.

➢ Advantages:

❖ The need for the centre tapped transformer is eliminated.

❖PIV is about half the value for full wave rectifier with a center tapped transformer so diodes with lower breakdown voltage can be used hence cheaper .

❖ The output is twice that of the centre tap circuit for the same secondary voltage.

Ripple factor of diode rectifier:

- The effectiveness of a rectifier depends upon the magnitude of ac component in the output; smaller the ac component, the more effective is the rectifier.

- **Ripple factor is a measure of effectiveness of a rectifier circuit and defined as a ratio of rms value of ac component to the dc component in the rectifier output.**

$$Ripple factor = \frac{I_{ac}}{I_{dc}} \qquad I_{rms} = \sqrt{I_{dc}^2 + I_{ac}^2} \qquad \frac{I_{ac}}{I_{dc}} = \sqrt{\frac{I_{rms}^2}{I_{dc}^2} - 1}$$

For half wave rectifier: $I_{rms} = \frac{I_m}{2}$ $\quad I_{dc} = \frac{I_m}{\Pi}$ **Ripple factor = 1.21**

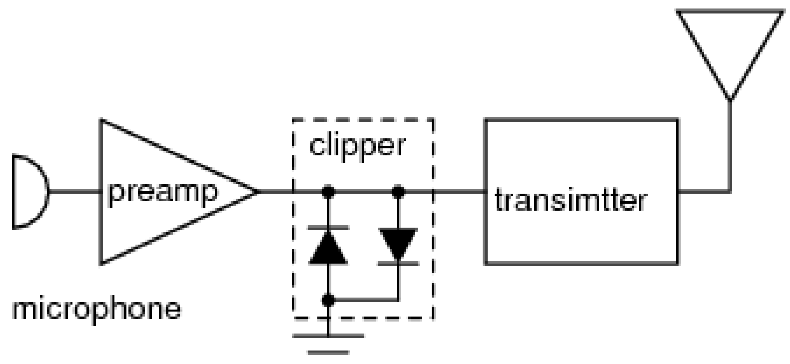
For full wave rectifier: $I_{rms} = \frac{I_m}{\sqrt{2}}$ $\quad I_{dc} = \frac{2I_m}{\Pi}$ **Ripple factor = 0.48**

Clippers:

➢ Clippers are the circuit that employ diodes to remove a portion of an input signal without distorting the remaining part of the applied waveform.

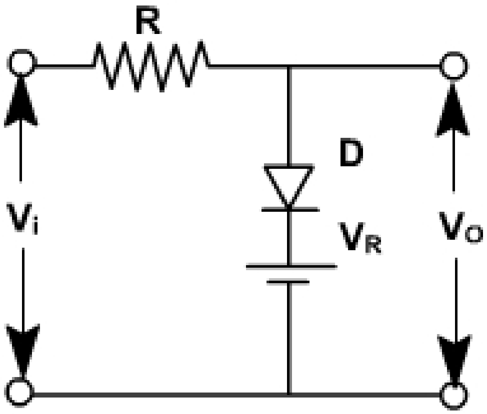
➢ A clipper can serve as a protective measure, preventing a signal from exceeding the clip limits.

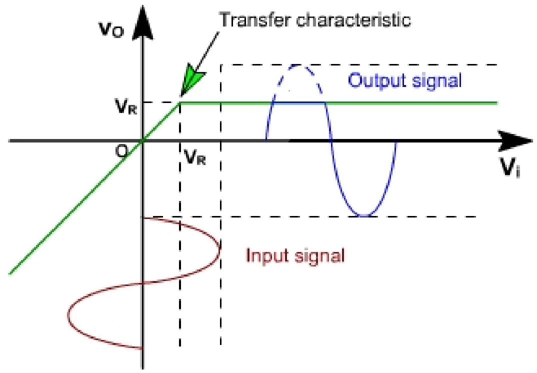
➢ A practical application of a clipper is to prevent an amplified speech signal from overdriving a radio transmitter. Over driving the transmitter generates spurious radio signals which causes interference with other stations. The clipper is a protective measure.



Reference: http://www.allaboutcircuits.com/vol_3/chpt_3/6.html

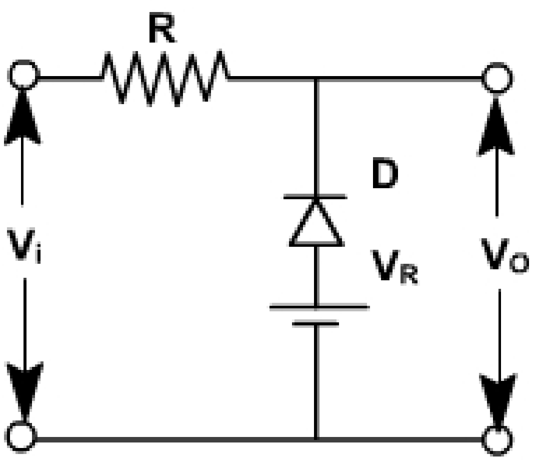
Clipper Circuit - 1:

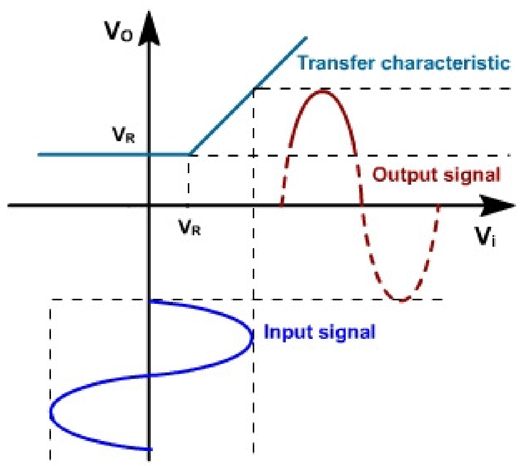




If $v_i < V_R$, diode is reversed biased and does not conduct. Therefore, $v_o = v_i$ and, if $v_i > V_R$, diode is forward biased and thus, $v_o = V_R$.

Clipper Circuit – 2:

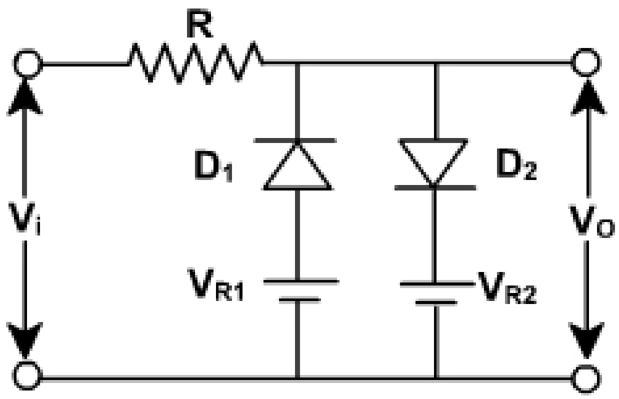


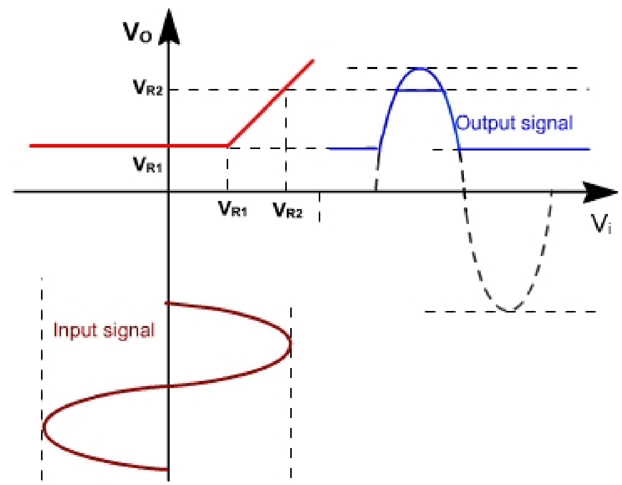


If $v_i > V_R$, diode is reverse biased. $v_o = v_i$

and, If $v_i < V_R$, diode is forward biased. $v_o = V_R$

Clipper Circuit – 3:





Clipper Circuits: