ABES ENGINEERING COLLEGE, GHAZIABAD

DEPARTMENT OF ELECTRONICS

&

COMMUNICATION ENGINEERING

COURSE MATERIAL

Subject Name: Emerging Domain in Electronics Engineering

Subject Code: BEC-101/201T

Branch/Semester: All Branches / 1st or 2nd

Session: 2022-23 (Odd & Even-Semester)

Faculty: Dr. Manish Zadoo, Mr. Mudit Saxena, Ms. Pooja Pathak, Ms. Arpita Johri, Mr. Shahbaz Alam, Ms. Kavita Chaudhary & Dr. Shivam Singh

EVALUATION - SCHEME, B.Tech- I YR./ I SEM (AKTU)

Revised Structure B. Tech 1st Year
B.Tech. I Semester
(All branches except Bio Technology and Agriculture Engg.)

S. No.	Course Code	Course Title	Periods			Evaluation Scheme				End Semester		Total	Credits
			L	T	P	CT	TA	Total	PS	TE	PE		
1	KAS101T/ KAS102T	Engineering Physics/ Engineering Chemistry	3	1	0	30	20	50		100		150	4
2	KAS103T	Engineering Mathematics-I	3	1	0	30	20	50		100		150	4
3	KEE101T/ KEC101T	Basic Electrical Engineering/ Emerging Domain in Electronics Engineering	3	0	0	30	20	50		100		150	3
4	KCS101T/ KME101T	Programming for Problem Solving / Fundamentals of Mechanical Engineering & Mechatronics	3	0	0	30	20	50		100		150	3
5	KAS151P/ KAS152P	Engineering Physics Lab/ Engineering Chemistry Lab	0	0	2				25		25	50	1
6	KEE151P/ KEC151P	Basic Electrical Engineering Lab/ Electronics Engineering Lab	0	0	2				25		25	50	1
7	KCS151P/ KAS154P	Programming for Problem Solving / English Language Lab	0	1	2				25		25	50	1
8	KCE151P/ KWS151P	Engineering Graphics & Design Lab/ Mechanical Workshop Lab	0	1	2				50		50	100	1
9	KMC101/ KMC102	AI For Engineering/ Emerging Technology for Engineering	2	0	0	15	10	25		25		50	2
10	**KNC101**	**Soft Skill I**	2	0	0	15	10	25		25			NC
11	MOOCs	(For B.Tech. Hons. Degree)*											
		Total										900	20

EVALUATION - SCHEME, B.Tech- I YR./ II SEM(AKTU)

Revised Structure B. Tech 1st Year

B.Tech. II Semester

(All branches except Bio Technology and Agriculture Engg.)

S. No.	Course Code	Course Title	Periods			Evaluation Scheme				End Semester		Total	Credits
			L	T	P	CT	TA	Total	PS	TE	PE		
1	KAS201T/ KAS202T	Engineering Physics/ Engineering Chemistry	3	1	0	30	20	50		100		150	4
2	KAS203T	Engineering Mathematics-II	3	1	0	30	20	50		100		150	4
3	KEE201T/ KEC201T	Basic Electrical Engineering/ Emerging Domain in Electronics Engineering	3	0	0	30	20	50		100		150	3
4	KCS201T/ KME201T	Programming for Problem Solving / Fundamentals of Mechanical Engineering & Mechatronics	3	0	0	30	20	50		100		150	3
5	KAS251P/ KAS252P	Engineering Physics Lab/ Engineering Chemistry Lab	0	0	2				25		25	50	1
6	KEE251P/ KEC251P	Basic Electrical Engineering Lab/ Electronics Engineering Lab	0	0	2				25		25	50	1
7	KCS251P/ KAS254P	Programming for Problem Solving / English Language Lab	0	1	2				25		25	50	1
8	KCE251P/ KWS251P	Engineering Graphics & Design Lab/ Mechanical Workshop Lab	0	1	2				50		50	100	1
9	KMC201/ KMC202	AI For Engineering/ Emerging Technology for Engineering	2	0	0	15	10	25		25		50	2
10	**KNC201**	**Soft Skill II**	2	0	0	15	10	25		25			NC
	MOOCs	(For B.Tech. Hons. Degree)*											
		Total										900	20

UNIT-1(b) (Applications of General-Purpose Diode)

Contents as per syllabus:

1. Rectifier

1.1. Introduction

1.2. Need to Study Rectifier

1.3. Types of Rectifiers

1.4. Half wave rectifier (HWR)

1.5. Bridge Type Full wave rectifier (BTFWR)

1.6. Centre Tap Transformer Type Full wave rectifier (CTFWR)

1.7. Rectifier Parameters

1.8. Comparisons of rectifiers

1.9. Numerical based on Rectifier

2. Clipper

2.1. Introduction to Clipper

2.2. Need to Study Clipper

2.3. Types of Clippers

2.4. Series Clippers

2.5. Parallel Clippers

2.6. Numerical

3. Clamper

3.1. Introduction to Clamper

3.2. Need to Study Clamper

3.3. Types of Clampers

3.4. Negative Clampers

3.5. Positive Clampers

3.6. Designing of Clamper circuits

3.7. Numerical

4. Voltage Multiplier

4.1. Introduction to Voltage Multiplier

4.2. Need to Study Voltage Multiplier

4.3. Types of Voltage Multipliers

4.4. Voltage doubler

4.5. Tripler/Quadrupler

1. Rectifier

1.1. Introduction to Rectifier

Rectifier is an important element of Regulated DC power Supply as shown in figure 1.1.1 Regulated DC power supply is used to convert the available ac power into the regulated DC power supply in our daily life in terms of Mobile charger, laptop charger, etc.

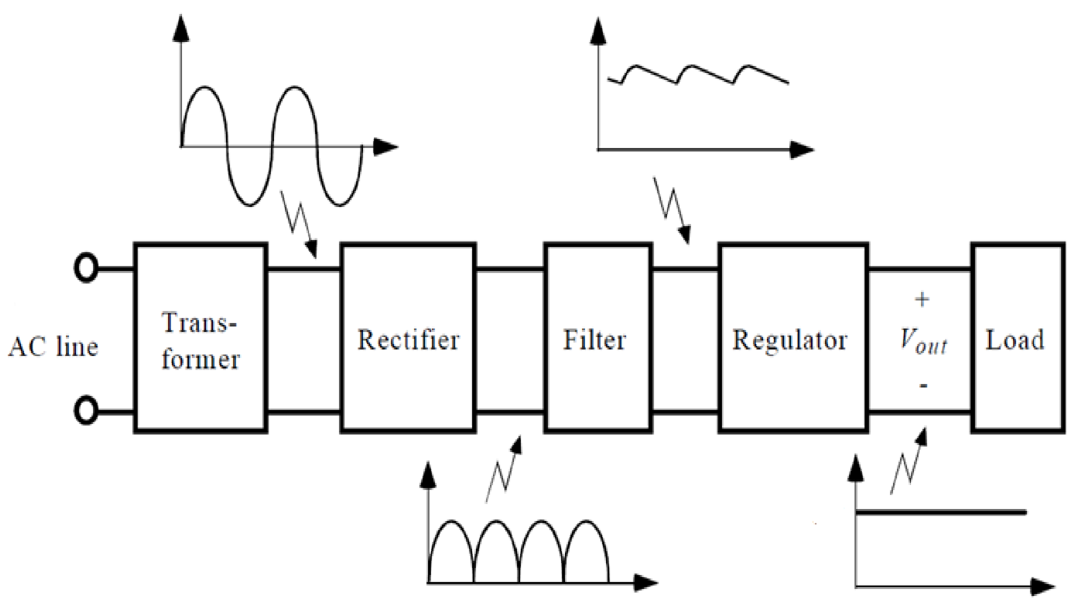


Figure 1.1.1

The Designing of a typical mobile charger is shown below.

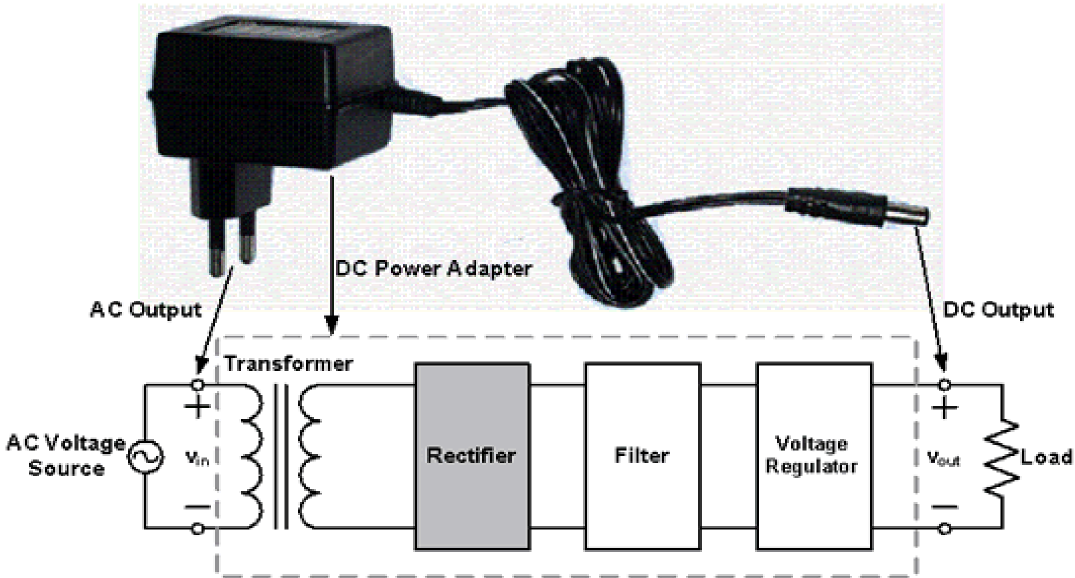
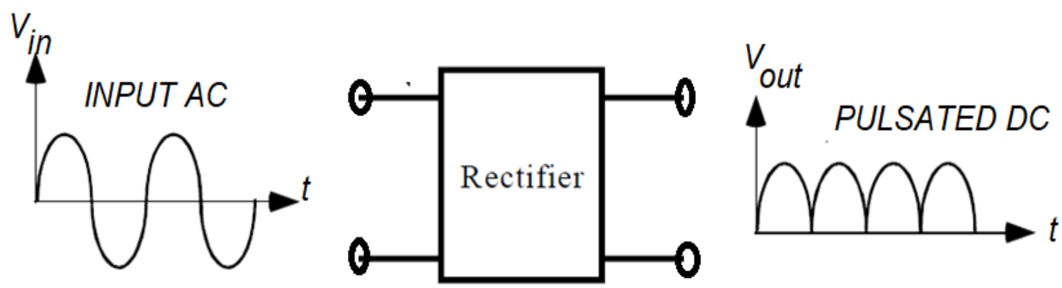


Figure 1.1.2

As shown above it is clear that Rectifier is a crucial element of Regulated power supply which convert the ac power into the Pulsated dc power supply. The process is known as Rectification. The block diagram of rectifier is shown below.

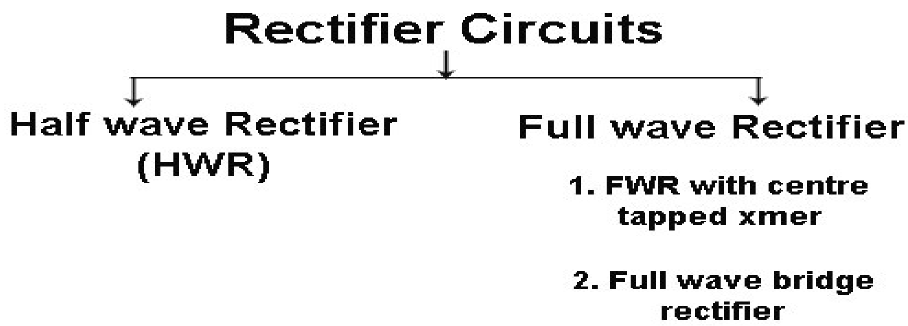


The **input to a rectifier is AC** whereas its **output is unidirectional or Pulsated DC.**

1.2. Need to Study Rectifier

In our daily life we use various types of Electronics equipment, machines like mobile phones, CCTV camera, Laptop, LED TV, various equipment in our laboratories, Hospitals. These electronic equipments need dc power supply to operate. However, we have ac power supply available everywhere. Therefore, study of conversion of ac power into dc power is necessary.

1.3. Types of Rectifier circuits



1.4. Half wave rectifier

1.4.1 Circuit diagram:

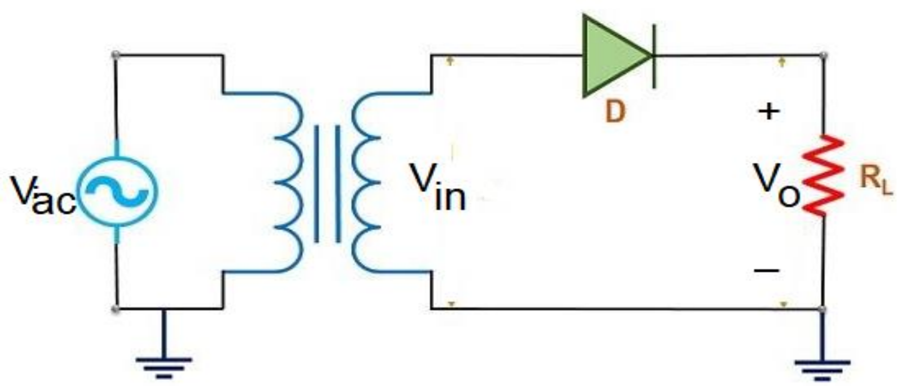


Figure 1.4.1

1.4.1 Working: For positive half cycle diode is in forward bias, current flows in clockwise direction as shown below.

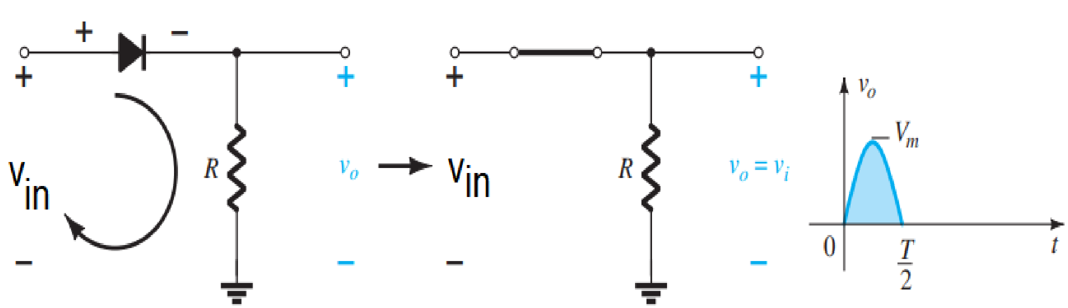


Figure 1.4.2

Apply KVL, we get

$V_{in} - V_o = 0$ (ideally)

Or, $V_o = V_{in}$ or $V_o = V_{in} - 0.7v$ (Practical diode)

1.4.2 For negative half cycle: The diode is in reverse bias (open circuited).

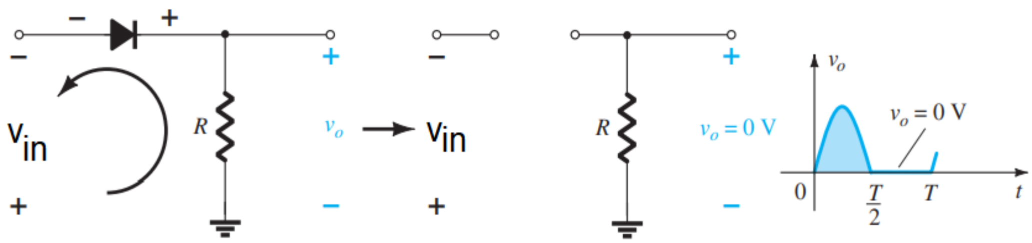


Figure 1.4.3

Here, Vo= 0

1.4.3 Input-Output waveforms:

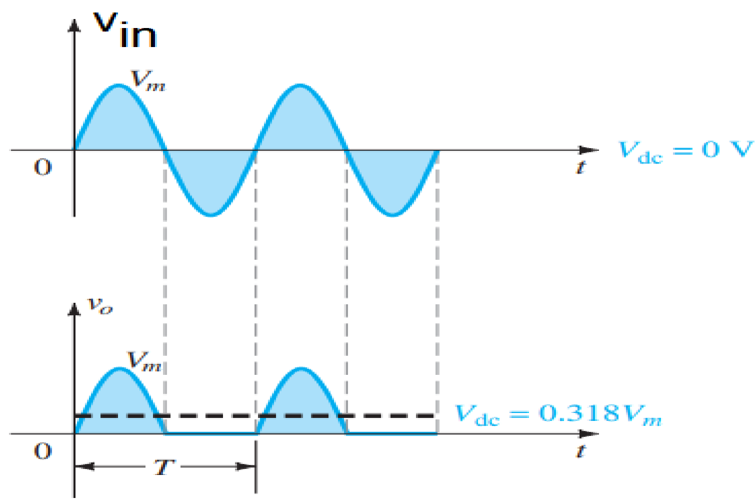


Figure 1.4.4

1.5. Bridge Type full wave rectifier (BTFWR)

Four diodes are used in this rectifier. Use of step down Transformer is optional.

1.5.1 Circuit diagram:

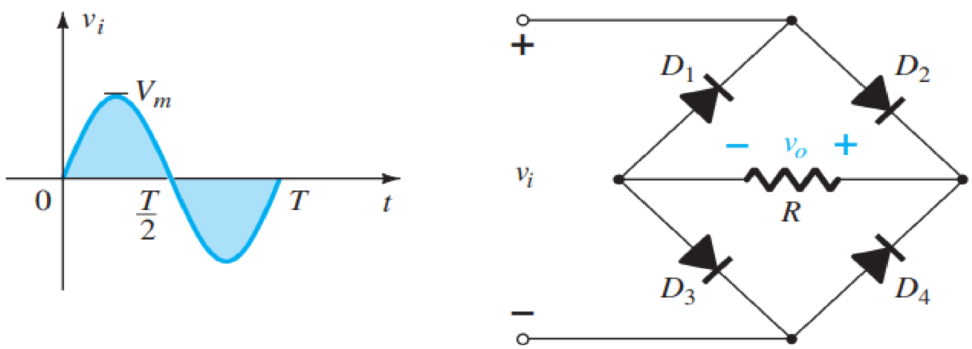


Figure 1.5.1

1.5.2. Working:

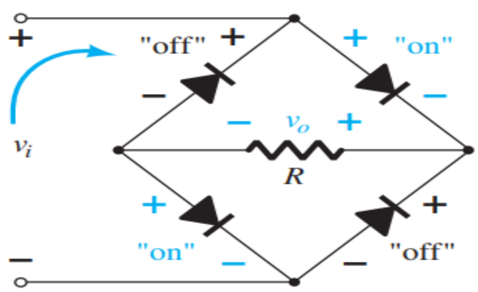


Figure 1.5.2

1.5.2.1. For positive half cycle: D_2 and D_3 are in forward bias on the other hand D_1 and D_4 are in reverse bias.

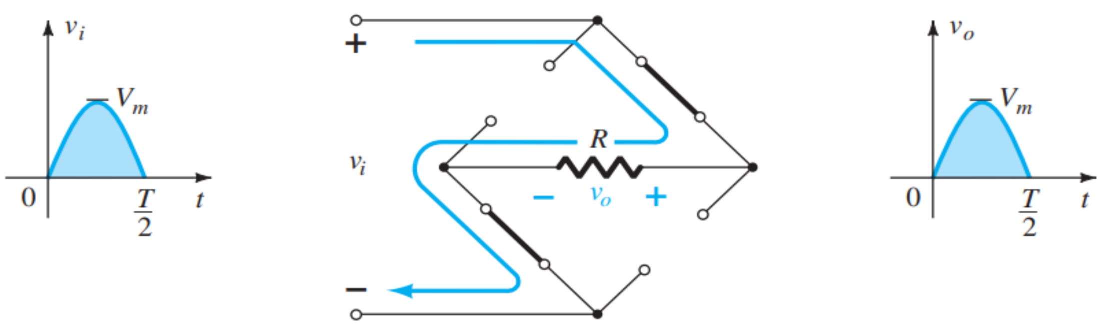


Figure1.5.2.1

Apply KVL, we get $V_i - V_o = 0$ (ideally)

Or, $V_o = V_{in}$ or $V_o = V_{in} - 1.4v$ (Practical diodes)

1.5.2.2. For negative half cycle: D_1 and D_4 are in forward bias on the other hand D_2 and D_3 are in reverse bias.

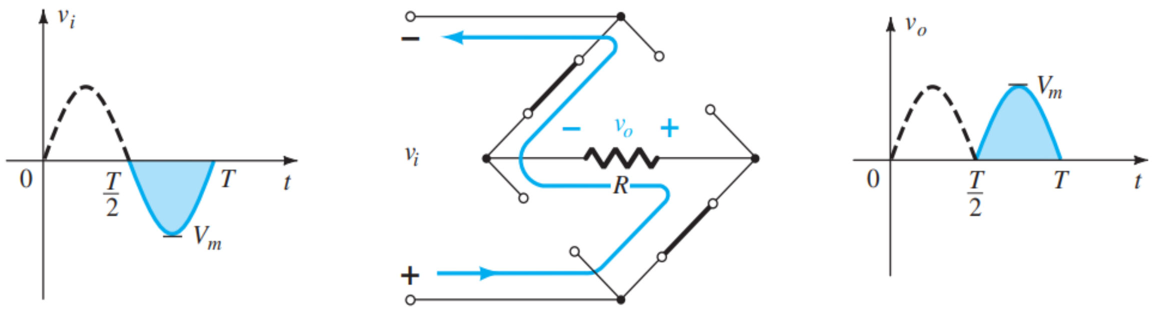


Figure 1.5.2.2

Apply KVL, we get $V_i - V_o = 0$ (ideally)

Or, $V_o = V_{in}$ or $V_o = V_{in}$ - 1.4v (Practical diodes)

1.5.3. Input-Output Waveforms:

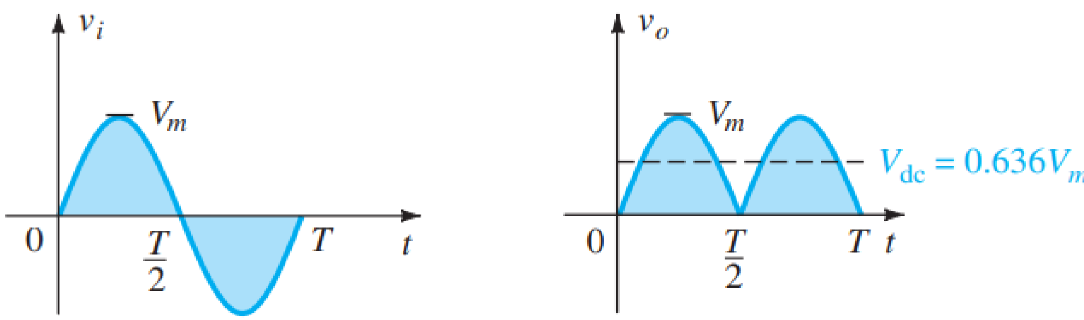


Figure 1.5.3

1.6. Centre Tap Transformer Type Full wave rectifier (CTFWR)

Two diode and one Centre Tap Transformer are used in this rectifier.

1.6.1. Circuit diagram

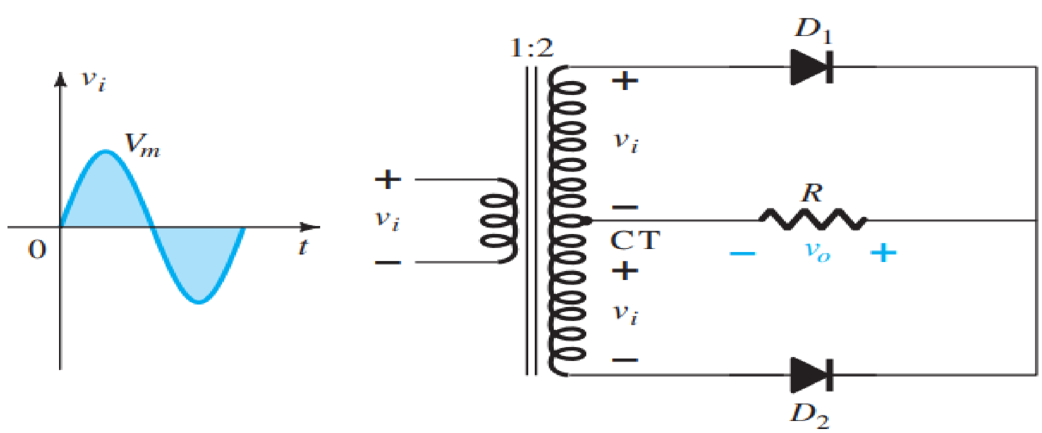


Figure 1.6.1

1.6.2. Working for Positive half cycle: D_1 is in forward bias and D_2 is in reverse bias.

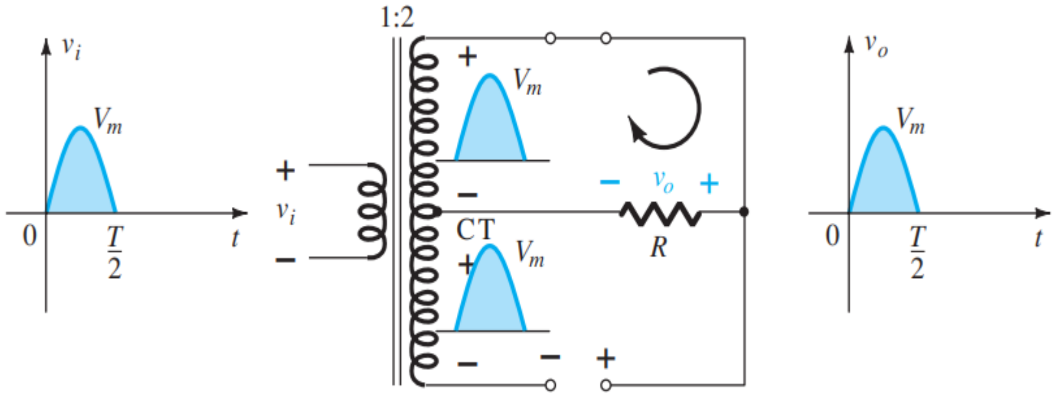


Figure 1.6.2

Apply KVL, we get $V_i - V_o = 0$ (ideally)

Or, $V_o = V_{in}$ or $V_o = V_{in} - 0.7v$ (Practical diodes)

1.6.3. Working for Positive half cycle: D_2 is in forward bias and D_1 is in reverse bias.

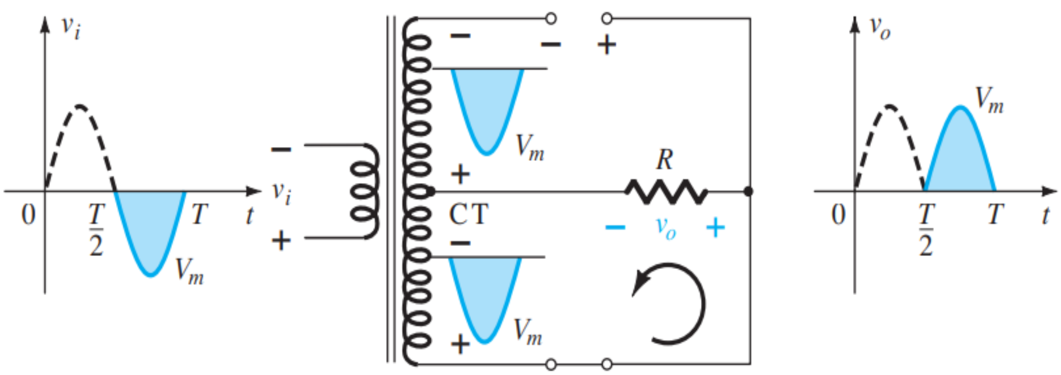


Figure 1.6.3

Apply KVL, we get $V_i - V_o = 0$ (ideally)

Or, $V_o = V_{in}$ or $V_o = V_{in} - 0.7v$ (Practical diodes)

1.6.4. Input output waveforms:

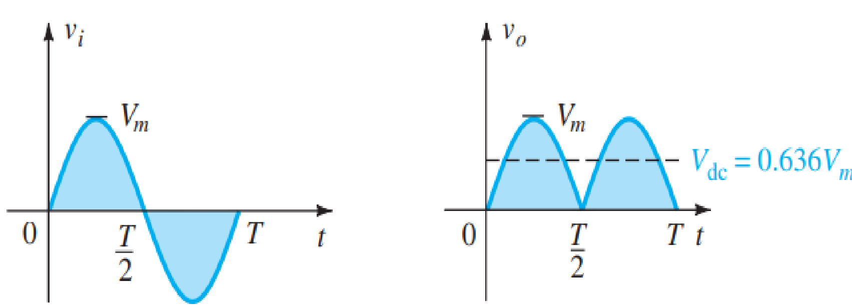


Figure 1.6.4

1.7. Rectifier Parameters

- Average (DC) value
- RMS value
- Ripple Factor
- Efficiency
- Peak Inverse Voltage (PIV)

1.7.1. Average (DC) Value

For half wave rectifier:

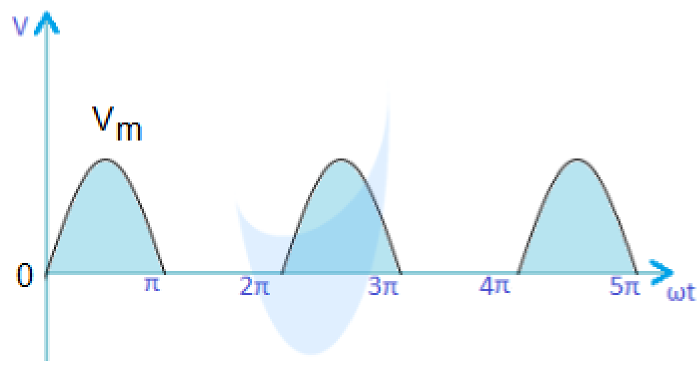


Figure 1.7.1

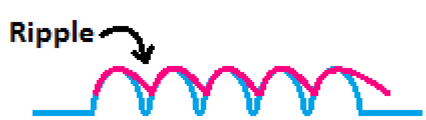
$V_{average} = V_m/\Pi$, $I_{average} = I_m/\Pi$

1.7.2. RMS Value

$V_{rms} = V_m/2$, $I_{rms} = I_m/2$

1.7.3. Ripple Factor

Ripple Factor is defined as the ratio of the rms value of the ac component to the dc component.



$$\text{Ripple Factor}, \gamma = \frac{\text{RMS value of AC component present in Rectifier Output}}{\text{Average Value of Rectifier Output}}$$

$$\gamma = \frac{I'_{rms}}{I_{dc}} = \frac{V'_{rms}}{V_{dc}}$$

$$\textit{Ripple Factor}, \gamma = \frac{\sqrt{(Irms)^2 - (Idc)^2}}{Idc}$$

$$= \frac{\sqrt{(Vrms)^2 - (Vdc)^2}}{Vdc}$$

$$\gamma = \sqrt{\left(\frac{V_{rms}}{V_{dc}}\right)^2 - 1}$$

Ripple factor for HWR= 1.21

Ripple factor for FWR= 0.48

1.7.4. Efficiency

Efficiency of Rectifier is defined as the ratio of Output dc power to the input ac power.

Efficiency= $\frac{Output\ dc\ power}{Input\ ac\ power}$

$$\eta = \frac{P_{dc}}{P_{ac}}$$

For HWR,

$$P_{dc} = I_{dc}^2 R_L = \frac{I_m^2 R_L}{\pi^2}$$

$$P_{ac} = I_{rms}^2 (R_L + R_f) = \frac{I_m^2}{4}(R_L + R_f)$$

$$\eta = \frac{P_{dc}}{P_{ac}} = \frac{I_m^2 R_L}{\pi^2} \times \frac{4}{I_m^2 (R_L + R_f)} = \frac{4}{\pi^2}\left(\frac{R_L}{R_L + R_f}\right)$$

R_f=0, for an ideal diode

$$\eta^{max} = \frac{4}{\pi^2} = 0.405 = 40.5\%$$

For BTFWR,

$$P_{dc} = I_{dc}^2 R_L = \frac{4 I_m^2 R_L}{\pi^2}$$

$$P_{ac} = I_{rms}^2 (R_L + 2R_f) = \frac{I_m^2}{2}(R_L + 2R_f)$$

$$\eta = \frac{P_{dc}}{P_{ac}} = \frac{I_m^2 R_L}{\pi^2} \times \frac{4X2}{I_m^2 (R_L + 2R_f)} = \frac{8}{\pi^2}\left(\frac{R_L}{R_L + 2R_f}\right)$$

$$\eta^{max} = \frac{8}{\pi^2} = 0.81 = 81\%$$

For CTFWR,

$$P_{dc} = I_{dc}^2 R_L = \frac{4 I_m^2 R_L}{\pi^2}$$

$$P_{ac} = I_{rms}^2 (R_L + R_f) = \frac{I_m^2}{2}(R_L + R_f)$$

$$\therefore \eta = \frac{P_{dc}}{P_{ac}} = \frac{4 I_m^2 R_L}{\pi^2} \times \frac{2}{I_m^2 (R_L + R_f)} = \frac{8}{\pi^2}\left(\frac{R_L}{R_L + R_f}\right)$$

$$\eta^{max} = \frac{8}{\pi^2} = 0.81 = 81\%$$

1.7.5. Peak Inverse Voltage (PIV)

The maximum reverse voltage across the diode in any circuit is called PEAK INVERSE VOLTAGE OR PEAK REVERSE VOLTAGE (PIV OR PRV)

PIV (HWR)= V_m

PIV (CTFWR) = $2V_m$ (IDEALLY)
= $2V_m$ - 0.7V (PRACTICALLY)

PIV (BTFWR) = V_m (IDEALLY)
= V_m - 0.7V (PRACTICALLY)

Where V is the Peak value of input voltage

Explanation: For HWR

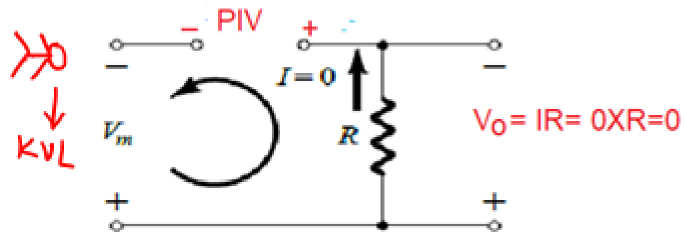


Figure 1.7.2

APPLY KVLIN ANTI CLOCKWISE DIRECTION

V_m- 0 - PIV = 0

OR, PIV = V_m

PIV for CTFWR

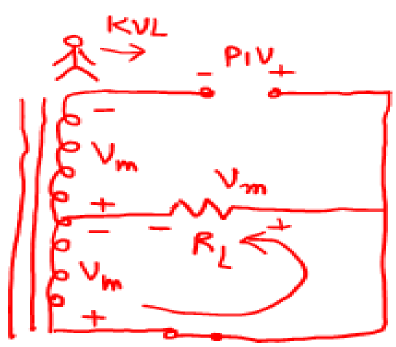


Figure 1.7.3

Apply KVL in clockwise direction, we get

PIV - V_m - V_m = 0 (Ideally)

or, PIV = $2V_m$ Ideal diode

PIV - V_m - 0.7 - V_m = 0 (Practically)

Or, PIV = $2V_m$ - 0.7V Practical diode

PIV for BTFWR:

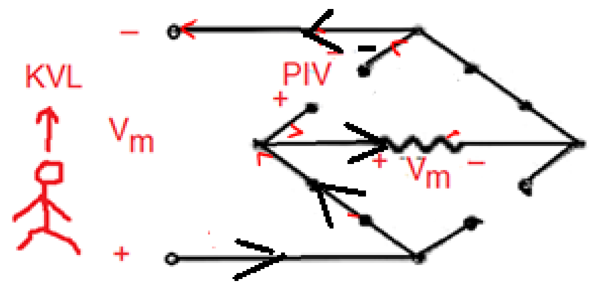


Figure 1.7.5

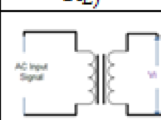
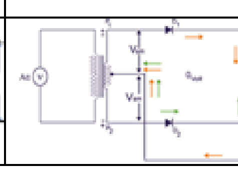
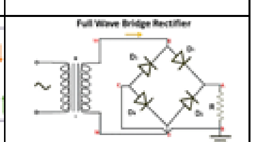
Apply KVL, we get,

$-V_m + PIV + 0.7 = 0$

Or, $PIV = V_m - 0.7v$ (Practical diode)

$PIV = V_m$ (Ideal diode)

1.8. Comparisons of Rectifiers

Sr.no	Parameters	HWR	FWR	Bridge rectifier
1	DC or average load current ($I_{L\,dc}$)	I_m/π	$2I_m/\pi$	$2I_m/\pi$
2	Maximum average load voltage ($V_{L\,dc}$)	V_m/π	$2V_m/\pi$	$2V_m/\pi$
3	RMS load current $I_{L\,rms}$	$I_m/2$	$I_m/\sqrt{2}$	$I_m/\sqrt{2}$
4	RMS load voltage $V_{L\,rms}$	$V_m/2$	$V_m/\sqrt{2}$	$V_m/\sqrt{2}$
5	DC load power P_{dc}	I^2_m/π^2 X RL	$4I^2_mR_L/\pi^2$	$4I^2_mR_L/\pi^2$
6	Maximum rectification efficiency (ή)	40%	81.2%	81.2%
7	TUF	28.7%	69.3%	81.2%
8	Ripple factor	100%	48%	48%
9	Ripple frequency	50Hz	100 Hz	100 Hz
10	Number of diodes	One	Two	Four
11	Centre tap transformer	Not required	Very much required	Not required
12	Transformer core saturation	Possible	Not possible	Not possible
13	PIV	V_m	$2V_m$	V_m
14	Expression for the peak load current	$I_m = V_m/(R_S+R_F+R_L)$	$I_m = V_m/(R_S+R_F+R_L)$	$I_m = V_m/(R_S+2R_F+R_L)$
15	Circuit diagram			

1.9. Numerical

Q1. Draw the output of the circuit given below, also calculate the DC level and required PIV of each diode.

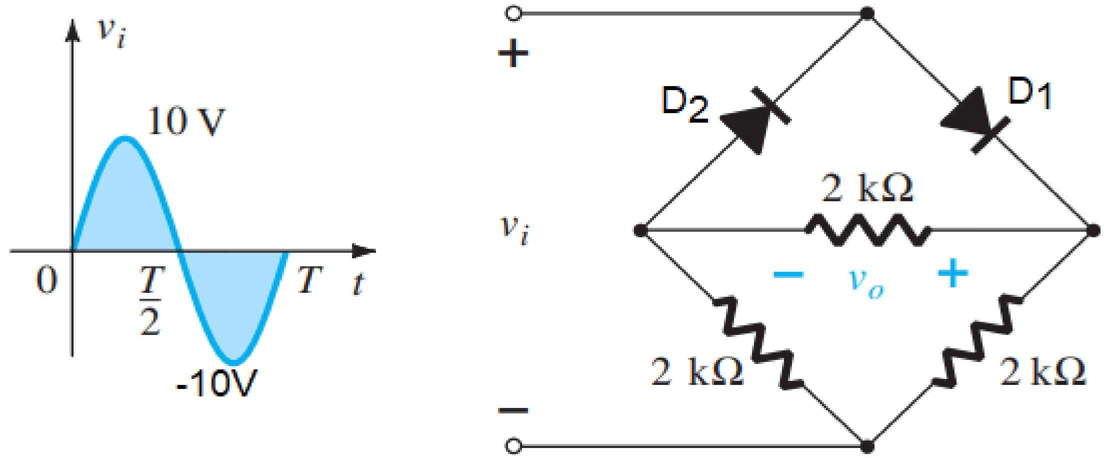


Figure 1.9.1

Solution: For positive half cycle, D1 is in forward bias and D2 is in reverse bias.

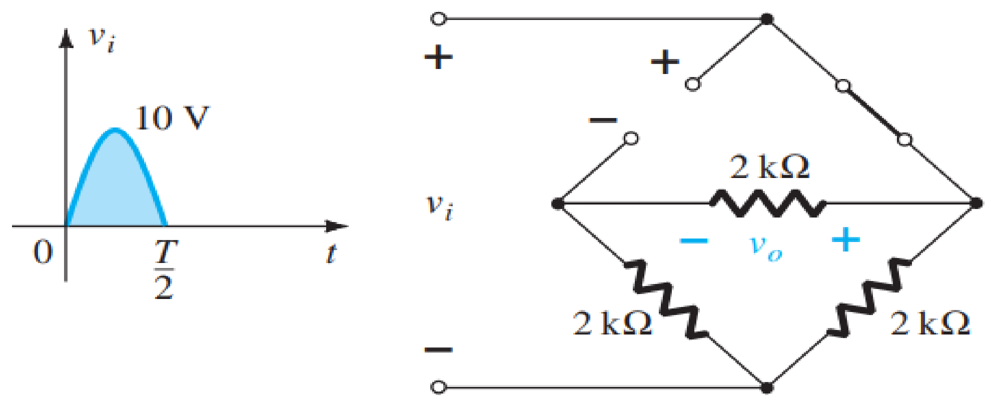


Figure 1.9.2

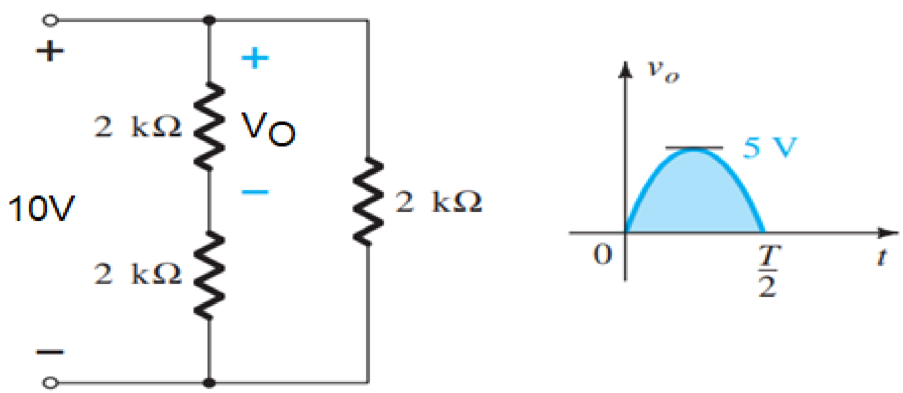


Figure 1.9.3

Using voltage divider rule, V_O= 5V

Similarly for negative half cycle, V_O= 5V

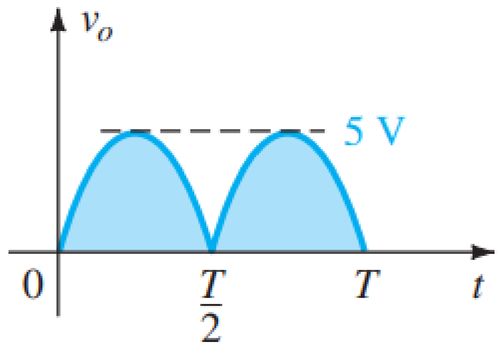


Figure 1.9.4

$$V_{dc} = 0.636(5\text{ V}) = \mathbf{3.18\ V}$$

PIV= 5V

Q2. Sketch output voltage and calculate dc level of output voltage.

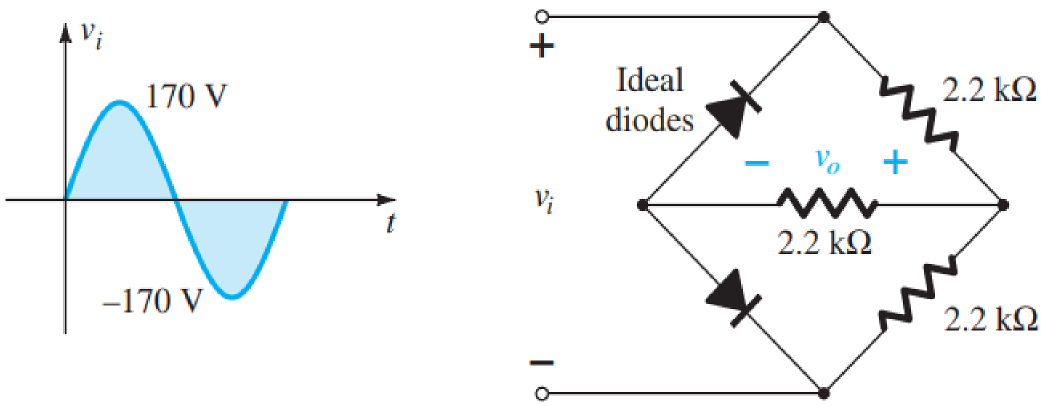


Figure 1.9.5

ANS: Try yourself,

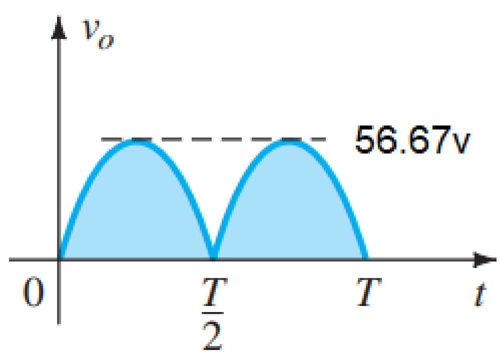


Figure 1.9.6

V_O= 170/3=56.67V

V_{dc}= 0.636(56.67)= 36.04v

2. Clipper

2.1. Introduction to Clipper

Clipper is a circuit which remove the unwanted portion of input signal without distorting the remaining signal, **the process is known as Clipping**.

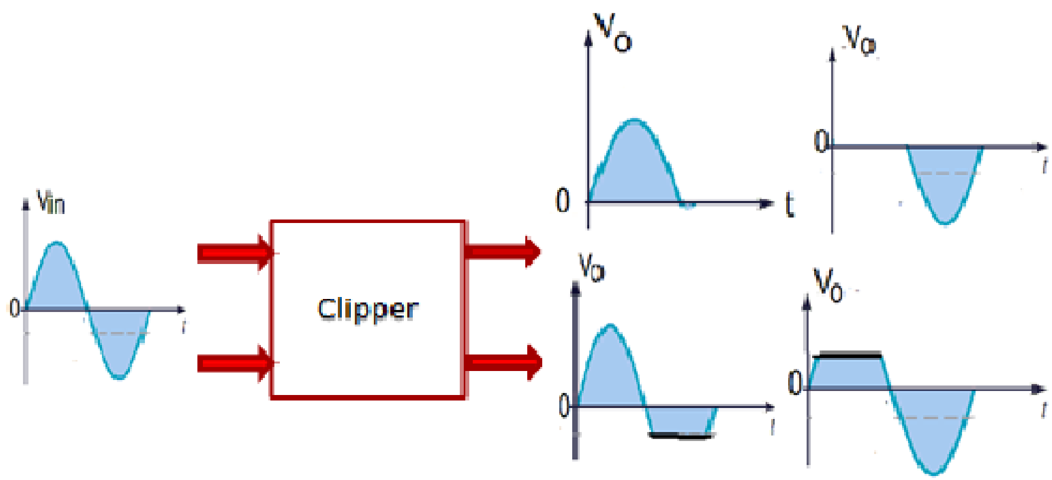


Figure 2.1

2.2. Need to study Clipper

In some applications we need to limit the range of input signal to protect the instruments or to get the desired output signal. So, we need to clip or remove the unwanted portion from the input signal. To get the above requirement we use the diode circuit such that it removes the unwanted portion from the positive half cycle or negative half cycle or may be from both. This circuit is known as clipper. When clipper removes the unwanted portion from both half cycles known as Limiter or Double ended clipper.

2.3. Types of Clippers

On the basis of output waveforms there are three types of clipper circuits, on the other hand there are two types of clipper circuit on the basis of circuit designing (position of diode). If diode is in series with the output, it is known as Series clipper and if diode is in parallel with output, then it is called Parallel clipper. Double ended clipper falls under parallel clipper.

1. Series Clipper
    a. Positive Clipper
    b. Negative Clipper

2. Parallel Clipper

a. Positive Clipper

b. Negative Clipper

c. Double Ended or Bidirectional Clipper/Limiter

2.4. Series Clipper

In series clipper diode is in series with the output terminal.

2.4.1. Unbiased Positive Clipper

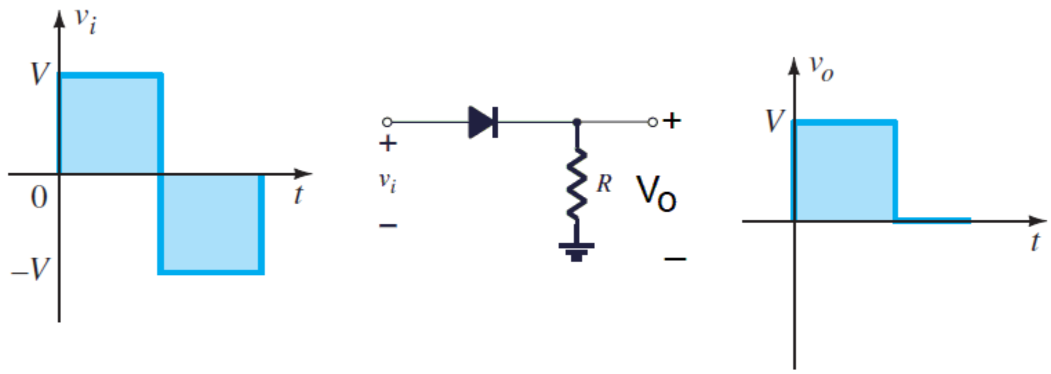


Figure 2.4.1

For positive half cycle, diode is in forward bias,

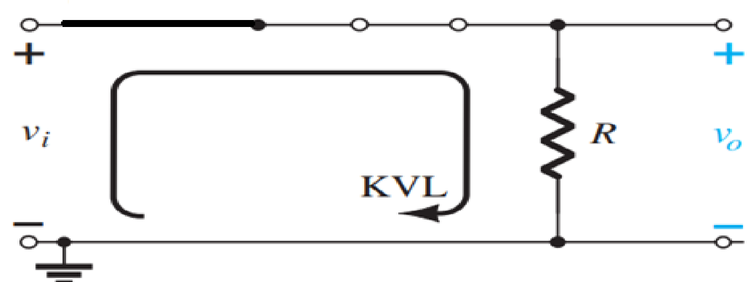


Figure 2.4.2

Apply KVL, we get $V_i - V_o = 0$ (ideally)

Or, $V_o = V_{in}$ or $V_o = V_{in} - 0.7v$ (Practical diodes)

For negative half cycle:

Diode is in reverse bias (open circuited)

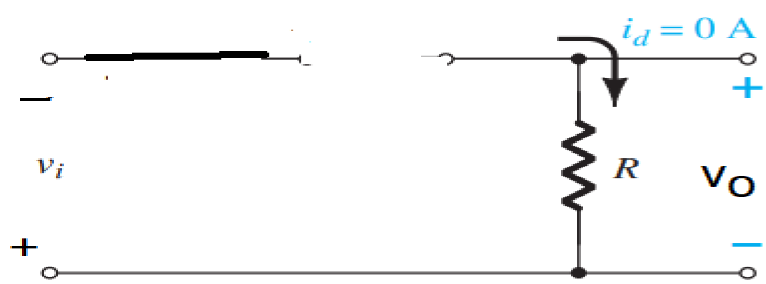


Figure 2.4.3

$V_o = 0$

Waveforms:

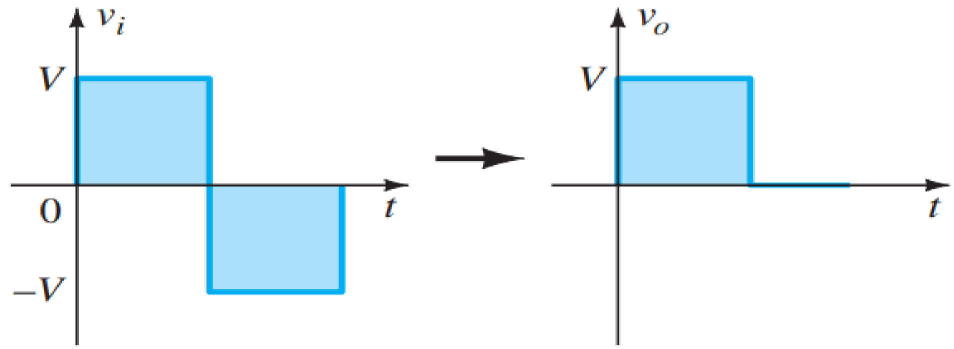


Figure 2.4.4

2.4.2. Series clipper with dc supply (RB)

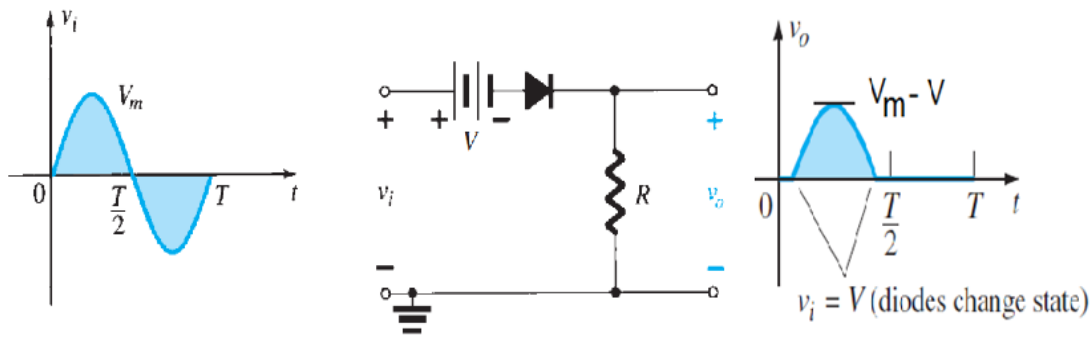


Figure 2.4.5

Working: when $V_{in} \geq v$, diode is in forward bias.

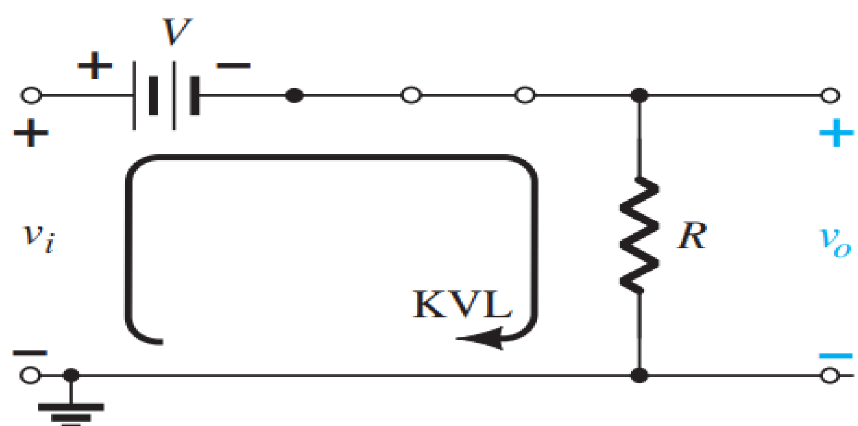


Figure 2.4.5

Apply KVL, we get $V_i - V - V_o = 0$ (ideally)

Or, $V_o = V_i - V$ or $V_o = V_i - V - 0.7v$ (Practical diodes)

when $V_{in} \leq v$, diode is in reverse bias (open circuited).

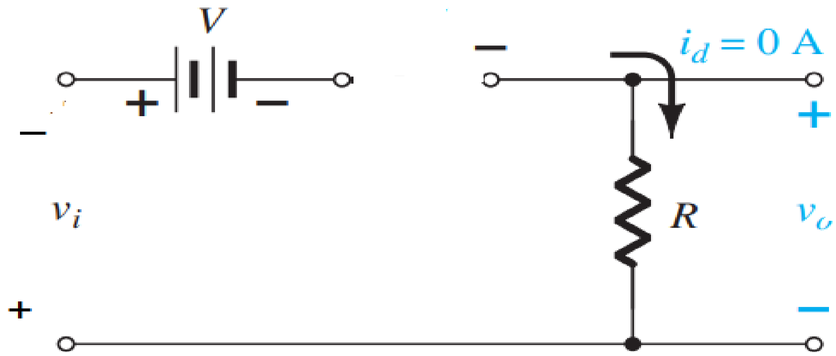


Figure 2.4.6

$V_o = I_R R = 0*R = 0$

Waveforms:

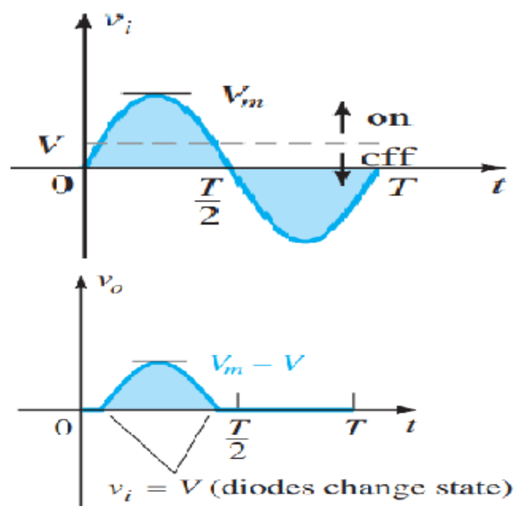


Figure 2.4.7

2.4.3. Series Clipper with dc supply (FB)

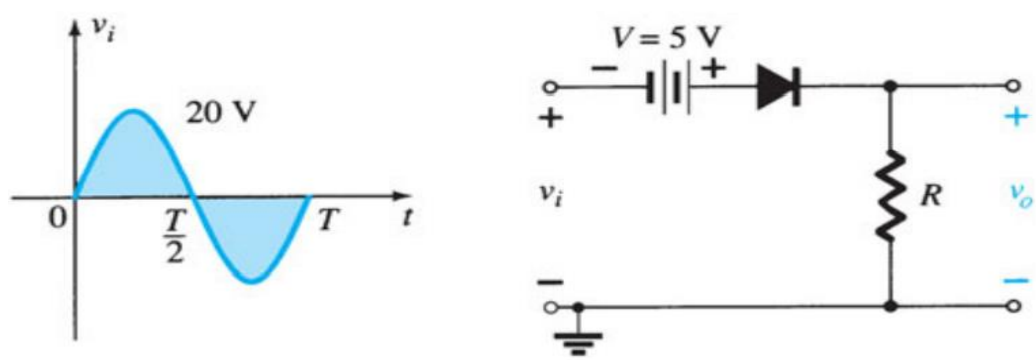


Figure 2.4.8

Working: when $V_{in} \geq$ -5V, diode is in forward bias.

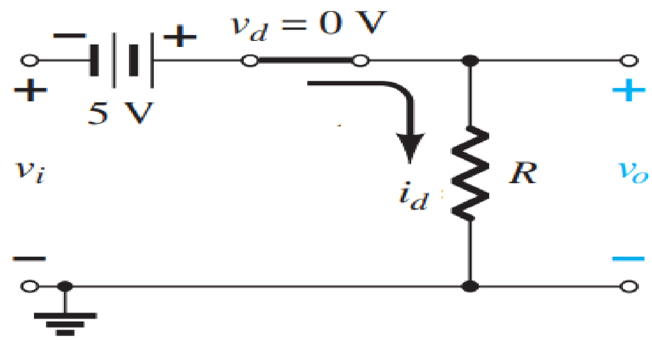


Figure 2.4.9

Apply KVL, we get $V_i + 5 - V_o = 0$ (ideally)

Or, $V_o = V_i + 5$ or $V_o = V_i + 4.7$ (Practical diodes)

when $V_{in} \leq -5V$, diode is in reverse bias.

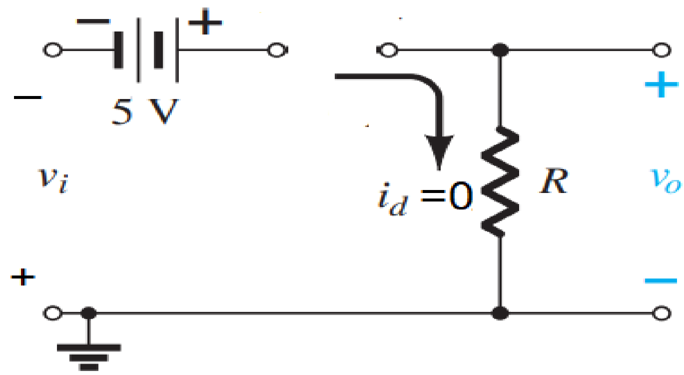


Figure 2.4.10

$V_o = I_R R = 0 * R = 0$

Waveform:

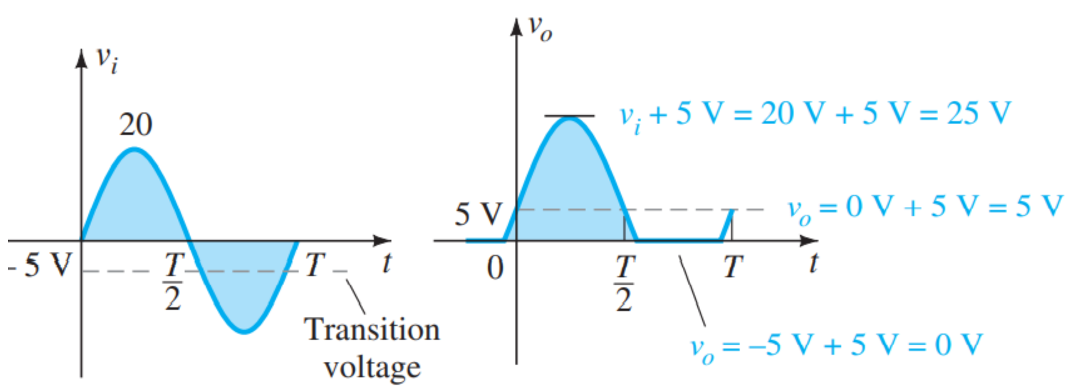


Figure 2.4.11

2.4.4. Series negative clipper (unbiased)

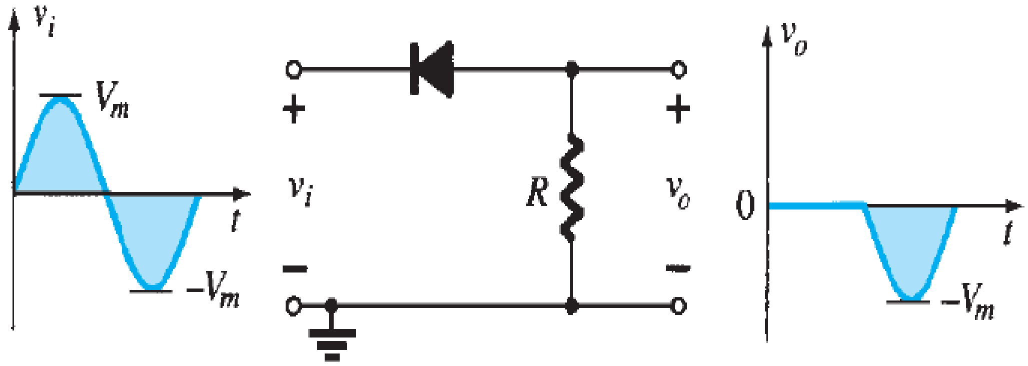


Figure 2.4.12

2.4.5. **Series negative clipper with dc supply (RB diode**)

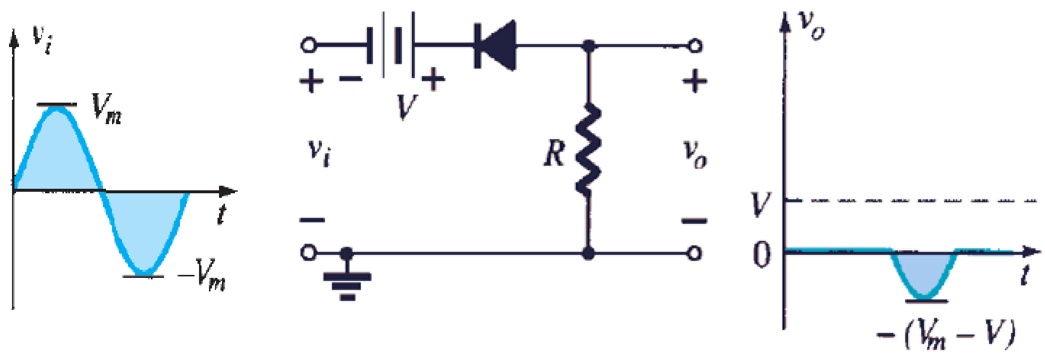


Figure 2.4.13

2.4.6. Series negative clipper with dc supply (FB diode)

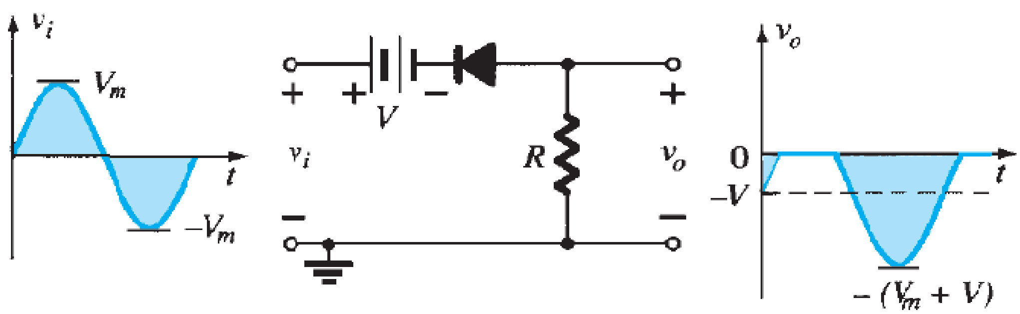


Figure 2.4.14

2.5. Parallel Clipper

A clipper Circuit in which diode is in parallel with Load.

2.5.1. Parallel positive clipper (Unbiased)

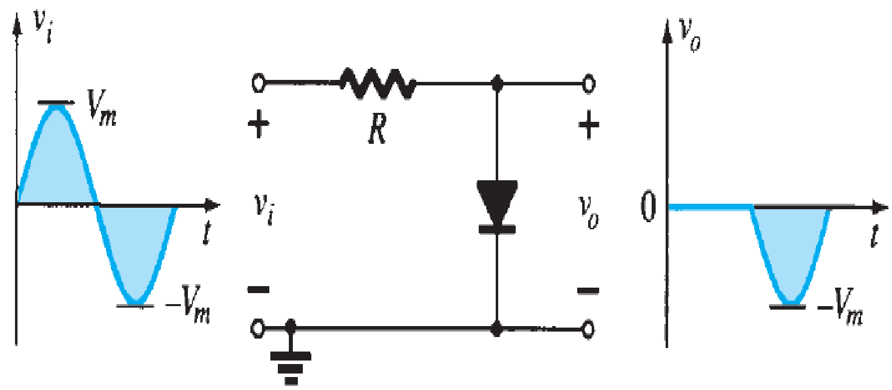


Figure 2.5.1

2.5.2. Parallel Positive Clipper with dc supply (RB diode)

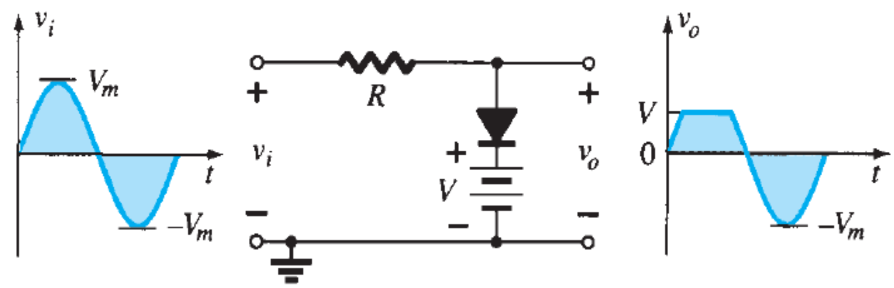


Figure 2.5.2

2.5.3. Parallel positive Clipper with dc supply (FB diode)

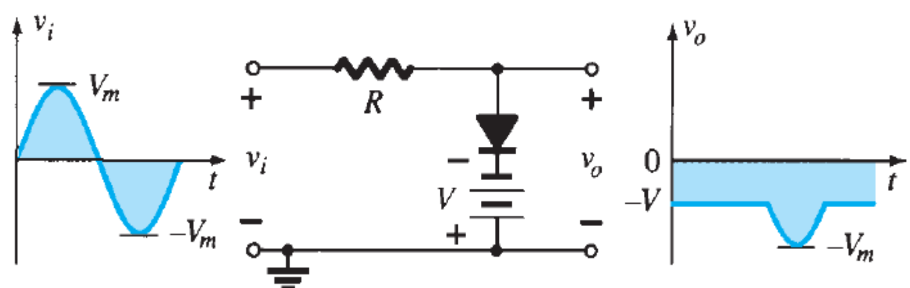


Figure 2.5.3

2.5.4. Parallel Negative clipper (Unbiased)

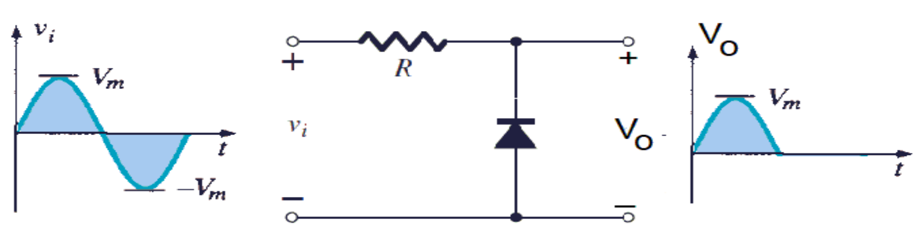


Figure 2.5.4

2.5.5. Parallel Negative clipper with dc supply (RB diode)

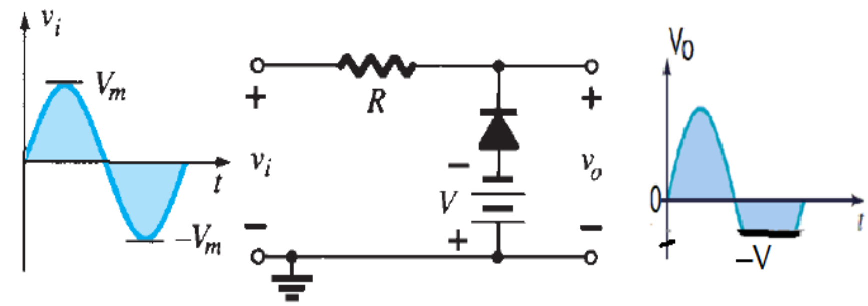


Figure 2.5.5

2.5.6. **Parallel Negative clipper with dc supply (FB diode)**

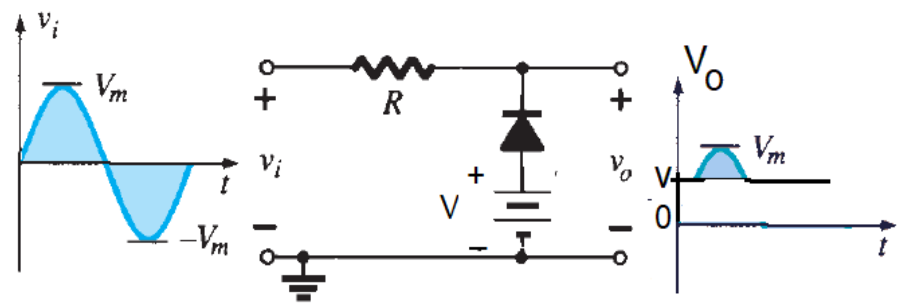


Figure 2.5.6

3. Clamper

3.1. Introduction to Clamper

A circuit which shifts the input signal UP/DOWN without changing its Peak-to-Peak voltage is called **Clamper,** and the process is known as **Clamping.** It is also known as **Peak detector.** Obviously to shift the signal up/down there must be a passive component along with a diode which stores a dc voltage. Capacitor is a passive component which stores dc voltage after charging.

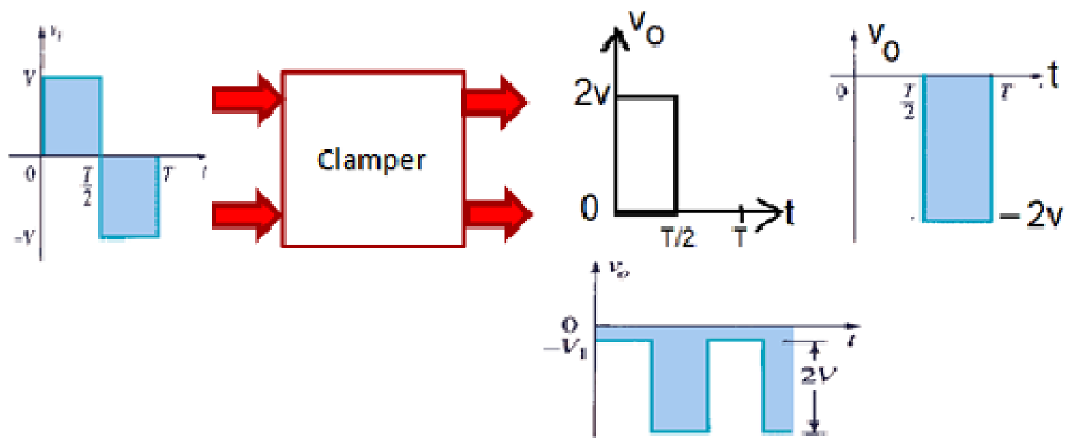


Figure 3.1

In this circuit the value of load resistance high such that the capacitor neighter gets charged nor gets discharged through the through it, this means the capacitor will gets charged only when the diode is in forward bias. Once the capacitor gets full charge (detects peak value of the circuit), it holds the charge (voltage) and diode become in reverse bias permanently. The input signal will be shift up/down by a voltage equal to the voltage across the capacitor. i.e. $V_O = V_{in} \pm V_C$

3.2. Need to study Clamper

In some applications we need to change the dc level (average value) of signal, for this we use Clamper circuit. It is also use in removing the distortions and identification of polarity of the circuits. For improving the reverse recovery time, clampers are also used.

3.3. Types of Clampers

On the basis of output signal there are two types of clampers.

- Negative Clamper: Shift the signal downward
- Positive Clamper: Shift the signal Upward

3.4. Negative Clampers

3.4.1. Unbiased

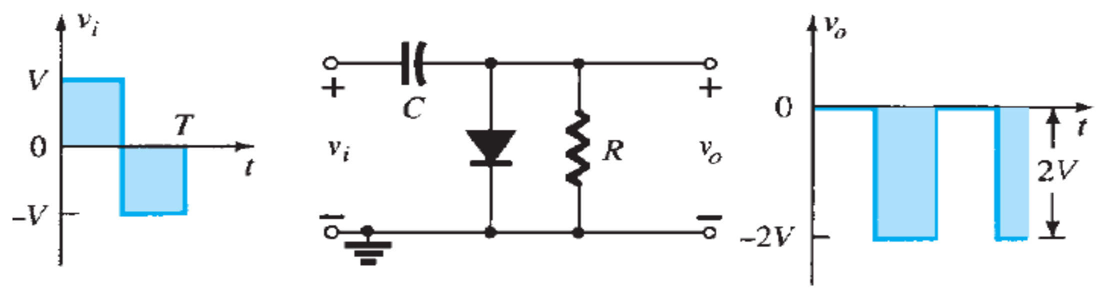


Figure 3.4.1

Necessary Condition of Clamper circuit: $R_L C \geq 100T$, where T is the time period of input signal.

Steps to draw output waveform:

i. First charge capacitor when diode is in forward bias.

ii. Calculate voltage across the capacitor.

iii. Once the capacitor gets full charged, diode become in reverse bias whether the input is positive half cycle or negative half cycle.

iv. Calculate output voltage by applying KVL, we get:

$V_O = V_{in} \pm V_C$

$V_O = V_{in} + V_C$ For positive clamper

$V_O = V_{in} - V_C$ For negative clamper

Working: For positive half cycle, diode is in forward bias, capacitor gets charged rapidly till voltage $V_C = V$,

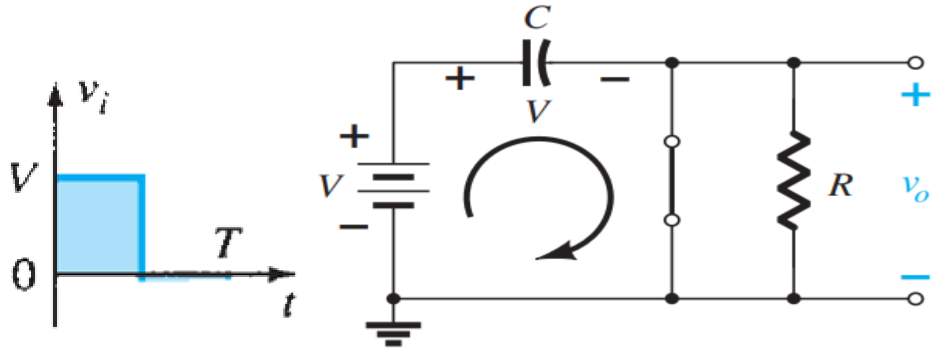


Figure 3.4.2

Apply KVL, we get, $V_C = V$ (ideal diode) and $V_C = V - 0.7v$ (practical diode)

For negative half cycle, diode is in reverse bias (open circuited).

Note: One the capacitor gets full charged, diode become in permanently reverse biased whether the input is positive half cycle or negative half cycle.

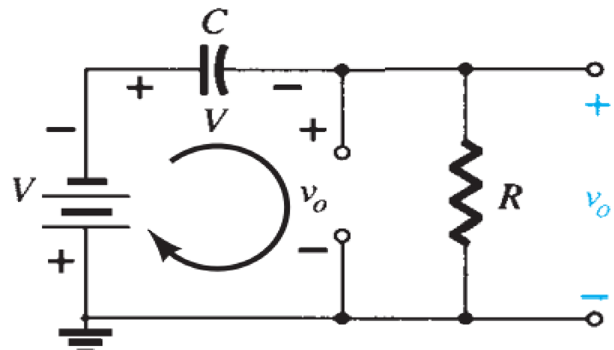


Figure 3.4.3

Apply KVL, we get, $V_O = V_{in} + V_C = V_{in} + V$,

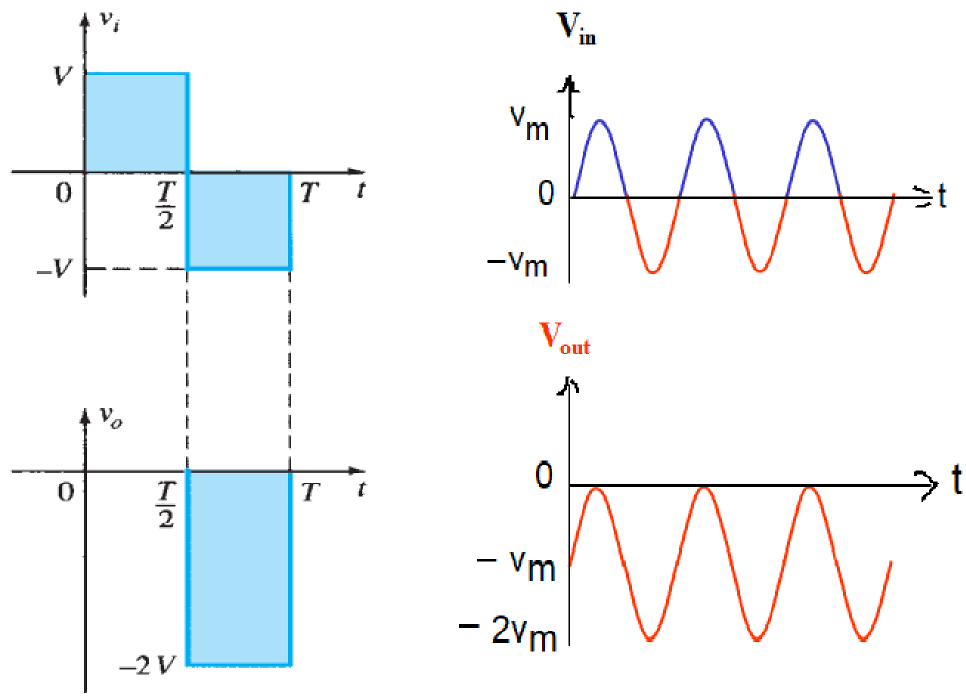
For positive half cycle, $V_{in} = V$

$$V_O = V_{in} + V$$

For negative half cycle, $V_{in} = -V$

$$V_O = V_{in} - V$$

Waveforms:



For Square wave

For sinusoidal wave

Figure 3.4.4

3.4.2. Negative Clamper with dc supply (RB diode)

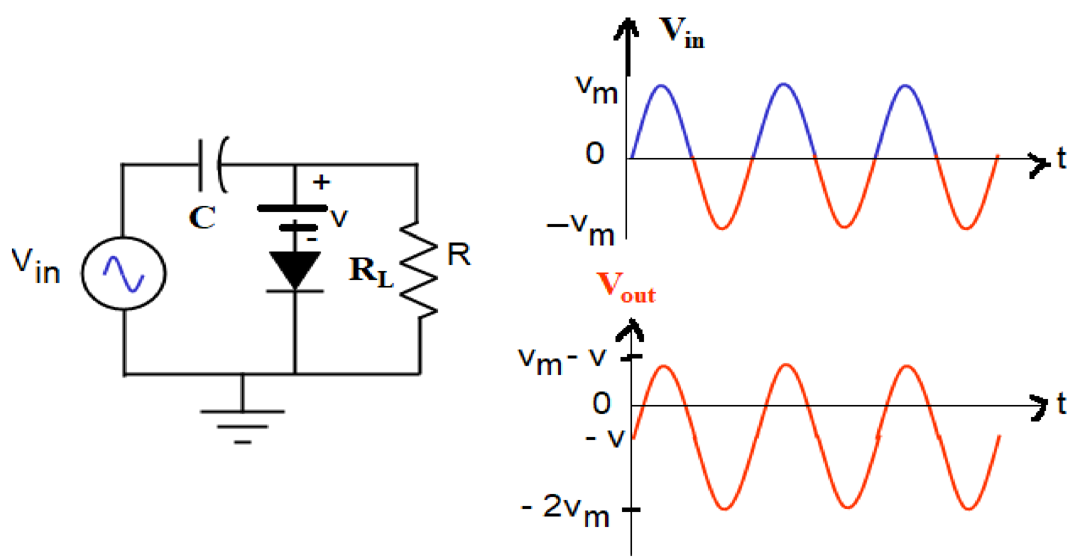
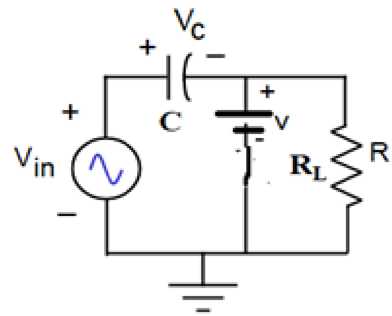


Figure 3.4.5

Working:

Case 1: when $V_{in} > V$, diode is in Forward bias, capacitor charges till voltage V_c



Apply KVL, we get

$V_{in} - V_c - V = 0$

OR $V_c = V_m - V$

Figure 3.4.6

Case 2: After capacitor gets full charged, diode become in reverse bias for positive as well as negative half cycles.

Apply KVL, we get

$V_{in} - V_c - V_o = 0$

OR $V_o = V_{in} - V_c$

where, $V_c = V_m - V$

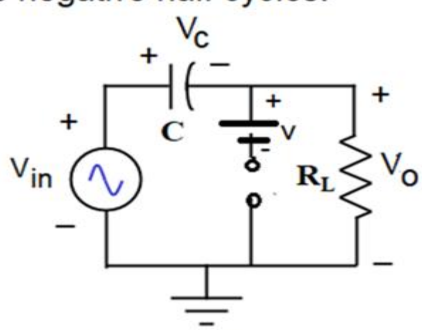


Figure 3.4.7

Input-Output waveforms:

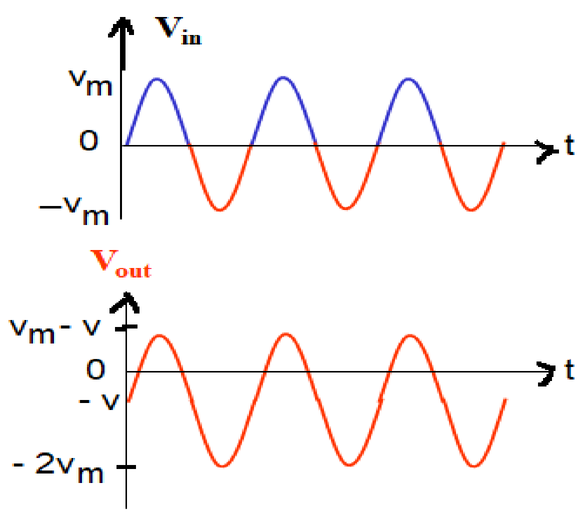


Figure 3.4.8

3.4.3. Negative clamper with dc supply (FB diode)

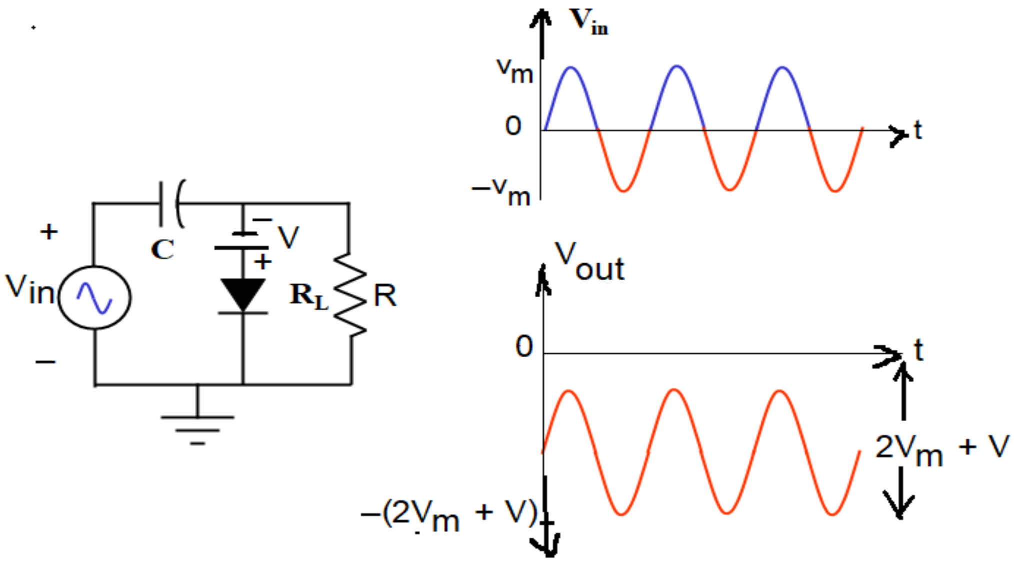


Figure 3.4.9

Working:

Case 1: When $V > -V$, Diode is in forward bias, Capacitor charges till voltage V_c

Apply KVL, we get

$V_{in} - V_c + V = 0$

OR $\boxed{V_c = V_m + V}$

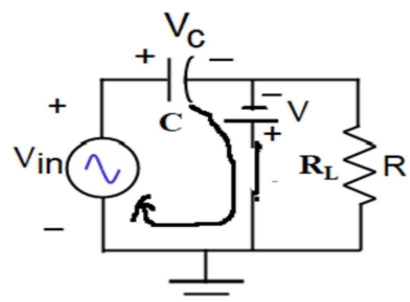


Figure 3.4.10

Case 2: After capacitor gets full charged, diode becomes in reverse bias (open circuited)

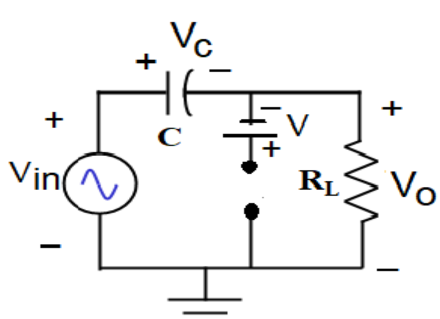


Figure 3.4.11

Apply KVL, we get

$V_{in} - V_c - V_o = 0$

OR $\boxed{V_o = V_{in} - V_c}$

where, $V_c = V_m + V$

Input-output waveforms:

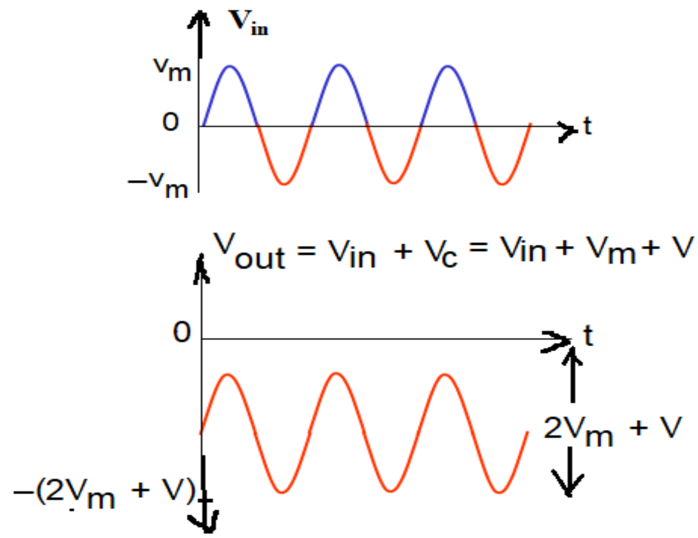


Figure 3.4.12

3.5. Positive Clamper

3.5.1. Unbiased

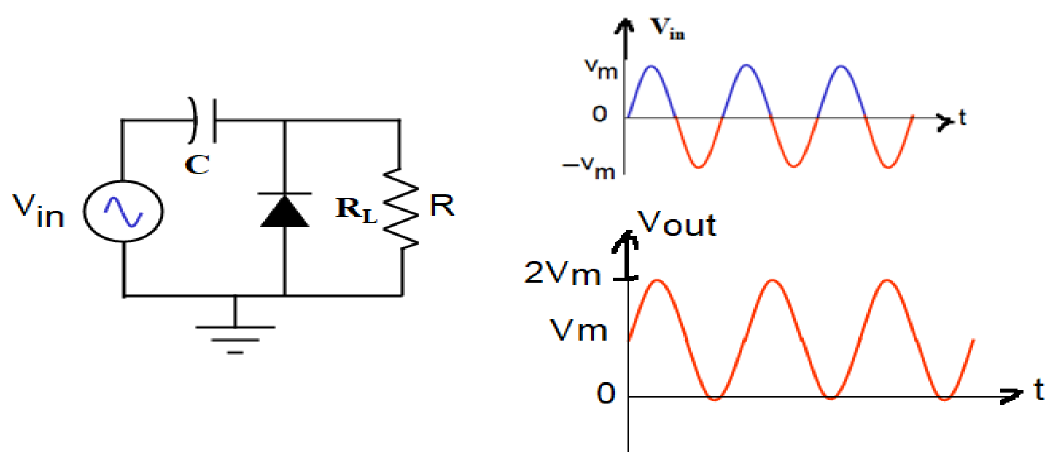


Figure 3.5.1

3.5.2. Positive Clamper with dc supply (RB diode)

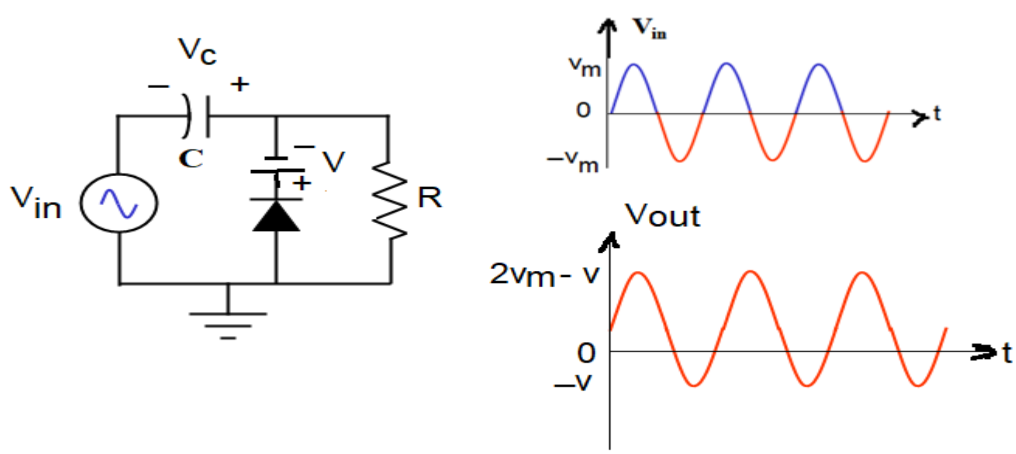


Figure 3.5.2

3.5.3. Positive Clamper with dc supply (FB diode)

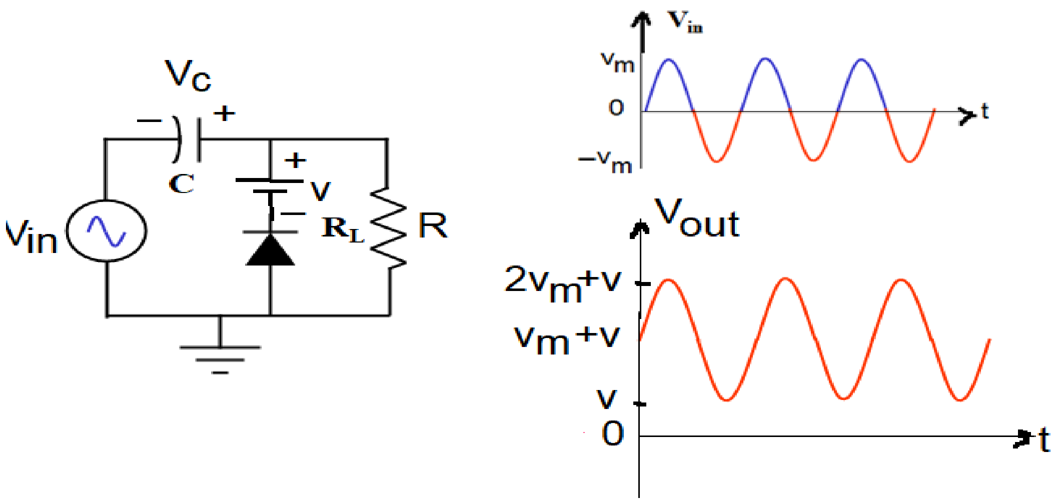


Figure 3.5.3

4. Voltage Multiplier

4.1. Introduction to Voltage Multiplier

A Circuit which multiplies the peak value of input signal by Two times, three times, Four times and so on is called **Voltage Multiplier.** In this circuit there are capacitors and diodes are connected such that the output taken across the capacitor(s) is n times of the peak value of input signal, where n =2,3,4----. The combination of a diode and a capacitor is called Peak detector. If there are n peak detector then output will be nV_m.

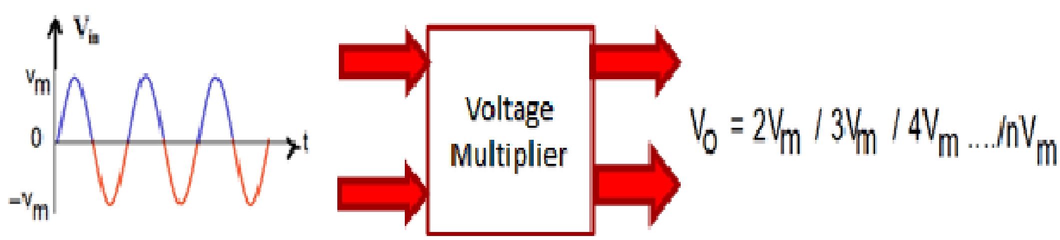


Figure 4.1

4.2. Need to study Voltage Multiplier

In some applications in physics or in Engineering there is need of high voltage with moderate or low current. For this voltage multiplier is suitable to use because using this we can convert a few volts to thousands of volts without using transformer for the purpose of high energy experiments.

4.3. Types of Voltage Multiplier

There are two types of Voltage Multiplier.

1. Voltage doubler
   i. Half wave Duubler
   ii. Full wave Doubler
2. Tripler or Quadrupler

4.4. Voltage Duobler

4.4.1. Half wave doubler

The output is taken across only one capacitor.

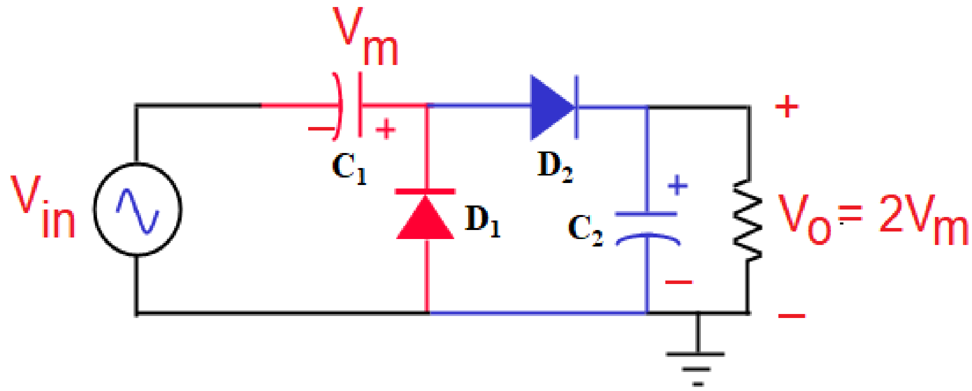


Figure 4.2

Working: Case 1: For negative half cycle, D_1 is in forward bias and D_2 is in Reverse bias, C_1 gets charged till voltage V_m.

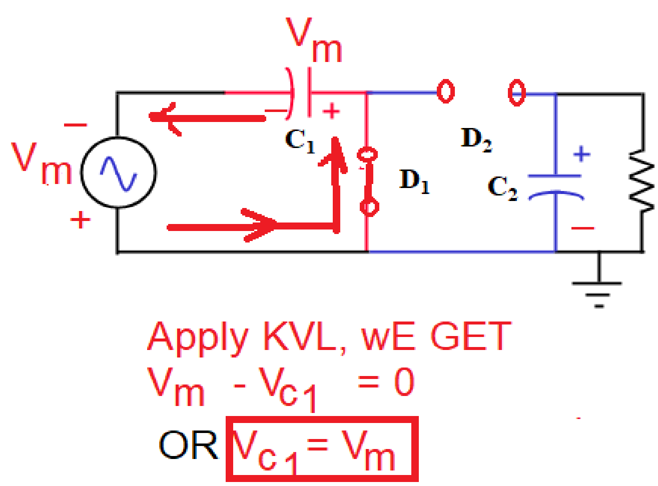


Figure 4.3

Case 2: For positive half cycle, D_1 is in reverse bias due to input polarity and C_1 voltage. D_2 is in forward bias due to input polarity as well as C_1 voltage.

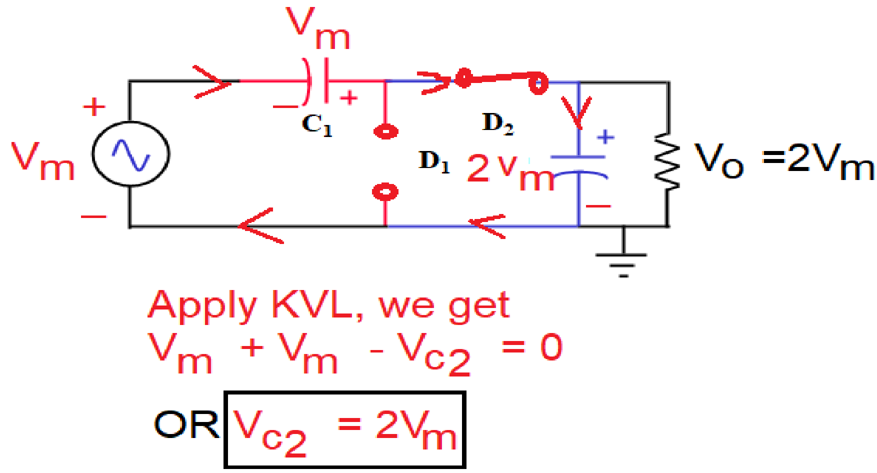


Figure 4.4

If we are taking output across C_2, we get $V_O = 2V_m$. **Since the output voltage is across the one capacitor which has charged during the half cycle only, that is why it is called Half wave doubler.**

4.4.2. Full wave Voltage Doubler

The output is taken across Two Capacitors.

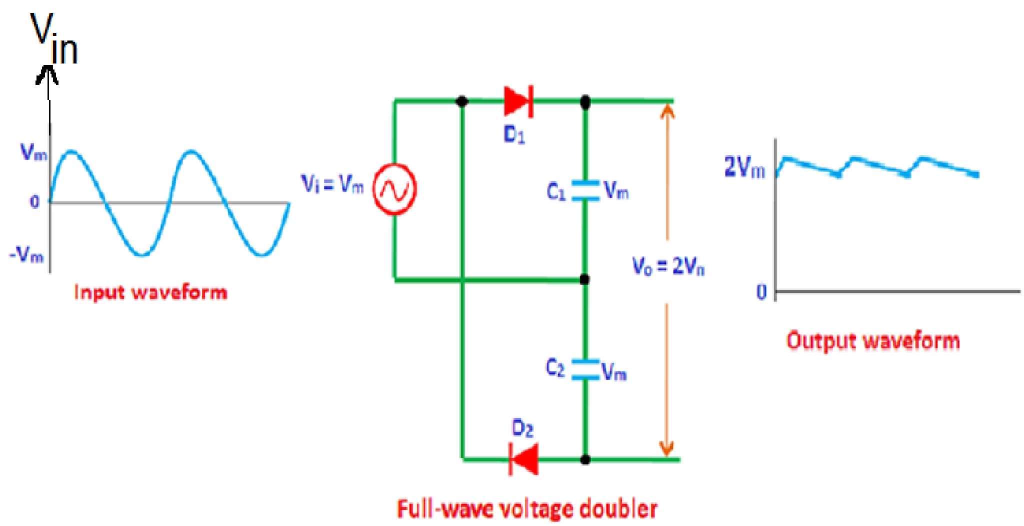


Figure 4.5

Working:

During positive half cycle:

During the positive half cycle of the input AC signal, diode D_1 is forward biased, So the diode D_1 allows electric current through it. This current will flow to the capacitor C_1 and charges it to the peak value of input voltage I.e., V_m. As shown in figure.

During negative half cycle:

During the negative half cycle of the input AC signal, the diode D_2 is forward biased, So the diode D_2 allows electric current through it. This current will flow to the capacitor

C_2 and charges it to the peak value of the input voltage I.e., V_m. As shown in figure 4.6

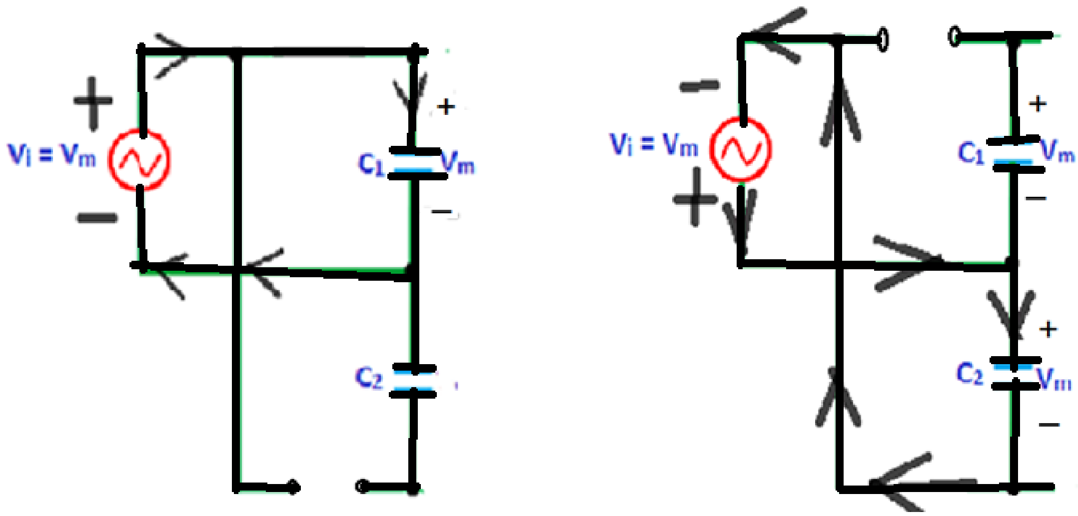


Figure 4.6

Now if we take output voltage across C1 & C2, we get

$V_O = V_m + V_m = 2V_m$

Since we are taking output voltage across the both capacitors C1 & C2 simultaneously, which have charged during the positive and negative half cycles (Full wave) respectively. So, it is called full wave voltage Doubler.

4.5. Tripler / Quadrupler

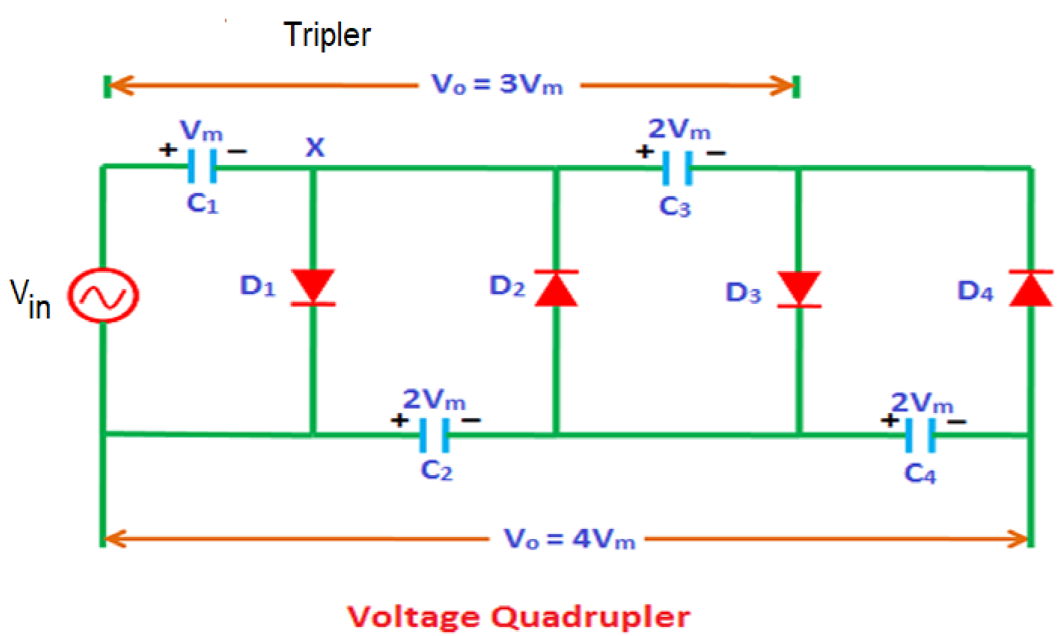


Figure 4.7

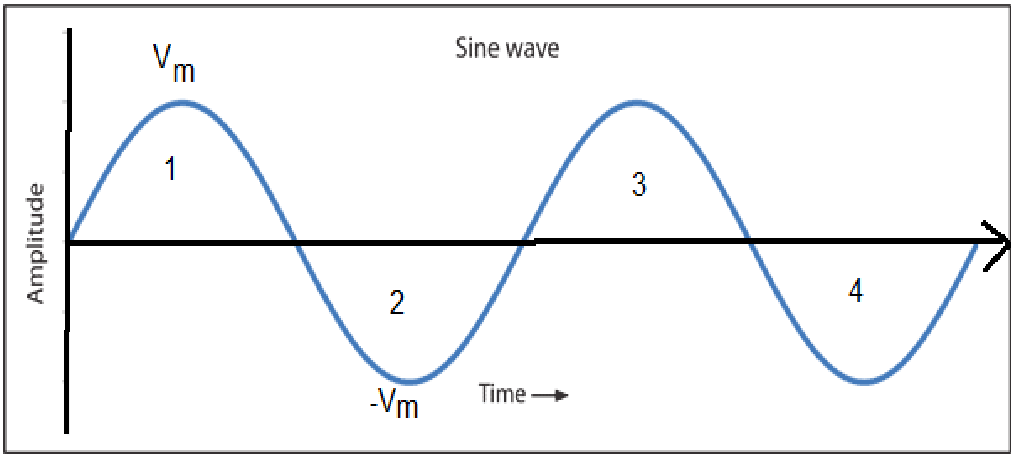


Figure 4.8: Input signal

Working: During first positive half cycle (half cycle 1):

During the first positive half cycle of the input AC signal, the diode D_1 is forward biased whereas diodes D_2, D_3 and D4 are reverse biased. Hence, the diode D_1 allows electric current through it. This current will flow to the capacitor C_1 and charges it to the peak value of the input voltage I.e., V_m.

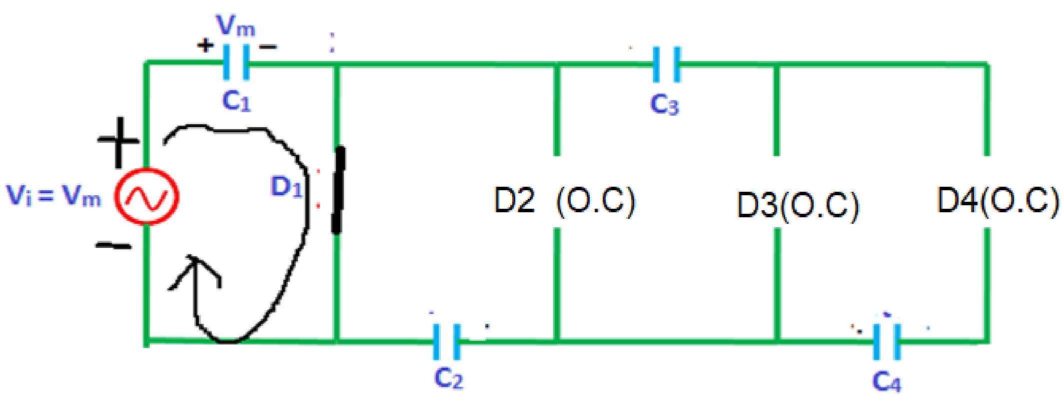


Figure 4.9

During first negative half cycle (half cycle 2):

During the first negative half cycle, diode D_2 is forward biased and diodes D_1, D_3 and D_4 are reverse biased. Hence, the diode D_2 allows electric current through it. This current will flow to the capacitor C_2 and charges it. The capacitor C_2 is charged to twice the peak voltage of the input signal ($2V_m$). This is because of the charge (V_m) stored in the capacitor C_1 is discharged during the negative half cycle.

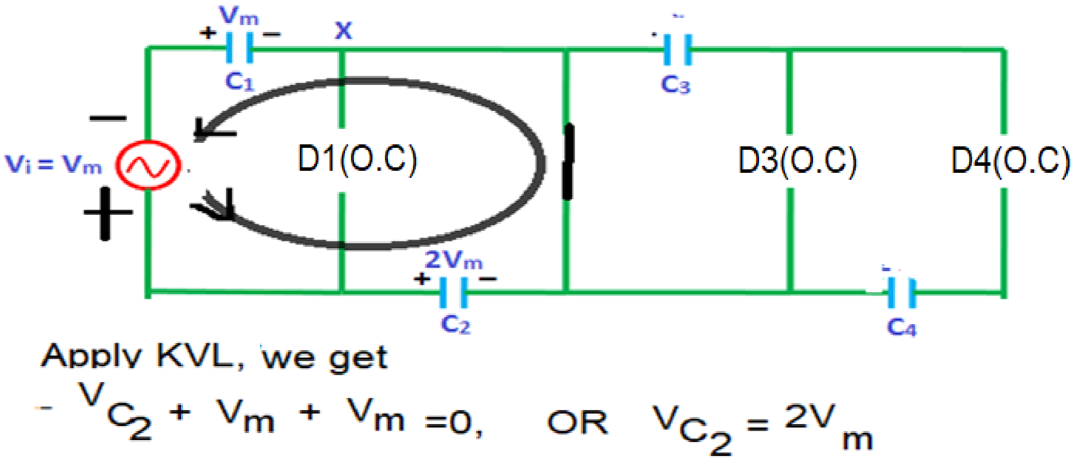


Figure 4.10

During second positive half cycle (half cycle 3):

During the second positive half cycle, the diode D_3 is forward biased and diodes D_1, D_2 and D_4 are reverse biased. Diode D_1 is reverse biased due to the negative voltage of C1 and, diode D_2 and D_4 are reverse biased because of their orientation. As a result, the voltage ($2V_m$) across capacitor C_2 is discharged. This charge will flow to the capacitor C_3 and charges it to the same voltage $2V_m$.

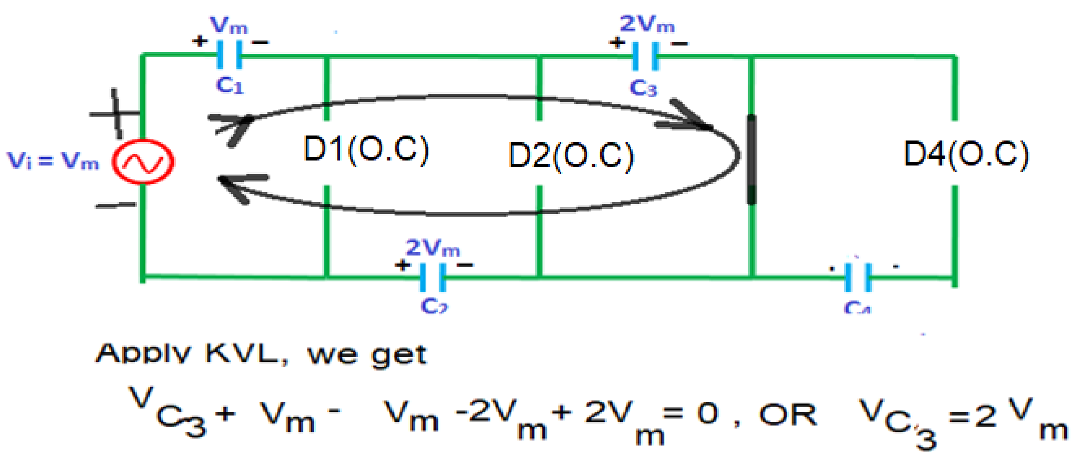


Figure 4.11

During second negative half cycle (half cycle 4):

During the second negative half cycle, diode D_4 is forward biased whereas diodes D_1,D_2 and D3 are reverse biased. As a result, the charge ($2V_m$) stored in the capacitor C_3 is discharged. This charge will flow to the capacitor C_4 and charges it to the same voltage ($2V_m$).

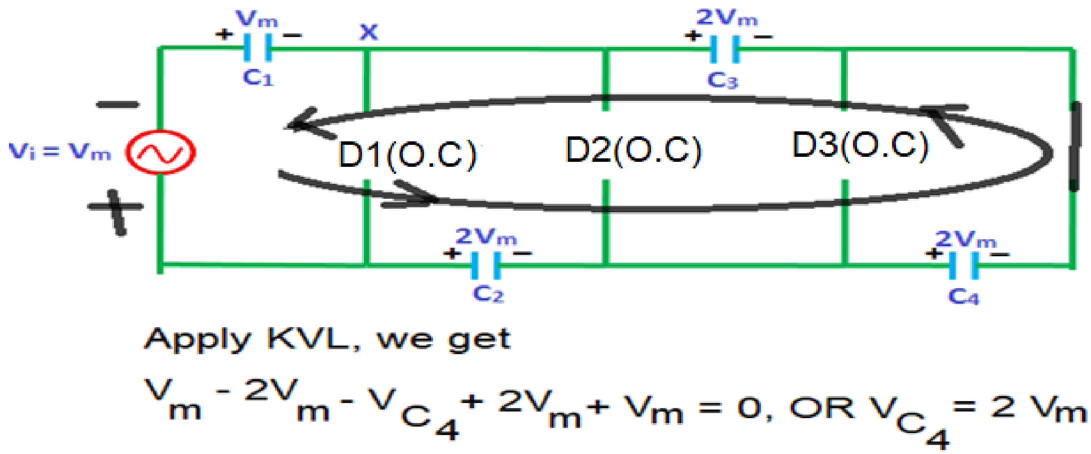


Figure 4.12

Conclusion:

The capacitors C_1 and C_3 are in series and the output voltage is taken across the two series connected capacitors C_1 and C_3. The voltage across capacitor C_1 is V_m and capacitor C_3 is $2V_m$. So, the total output voltage is equal to the sum of capacitor C_1 voltage and capacitor C_3 voltage I.e., $C_1 + C_3 = V_m + 2V_m = 3V_m$. Hence it is Tripler.

The capacitors C_2 and C_4 are in series and the output voltage is taken across the two series connected capacitors C_2 and C_4. The voltage across capacitor C_2 is $2V_m$ and capacitor C_4 is $2V_m$. So, the total output voltage is equal to the sum of capacitor C_2 voltage and capacitor C_4 voltage I.e., $C_2 + C_4 = 2V_m + 2V_m = 4V_m$. Hence it is Quadrupler