

Unit - 2

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Wave Shaping Circuits

06/12/24

* Wave Shaping Circuits :-

- To process of generating new wave form ^{from} older wave form by using a certain circuit.
- The circuit which is used for wave shaping is known as wave shaping circuit.
- The wave shaping is important in most of the signal process system and is performed by the circuit known as differentiators, integrators, clippers, clamper.

* NECESSITY of wave shaping circuit :-

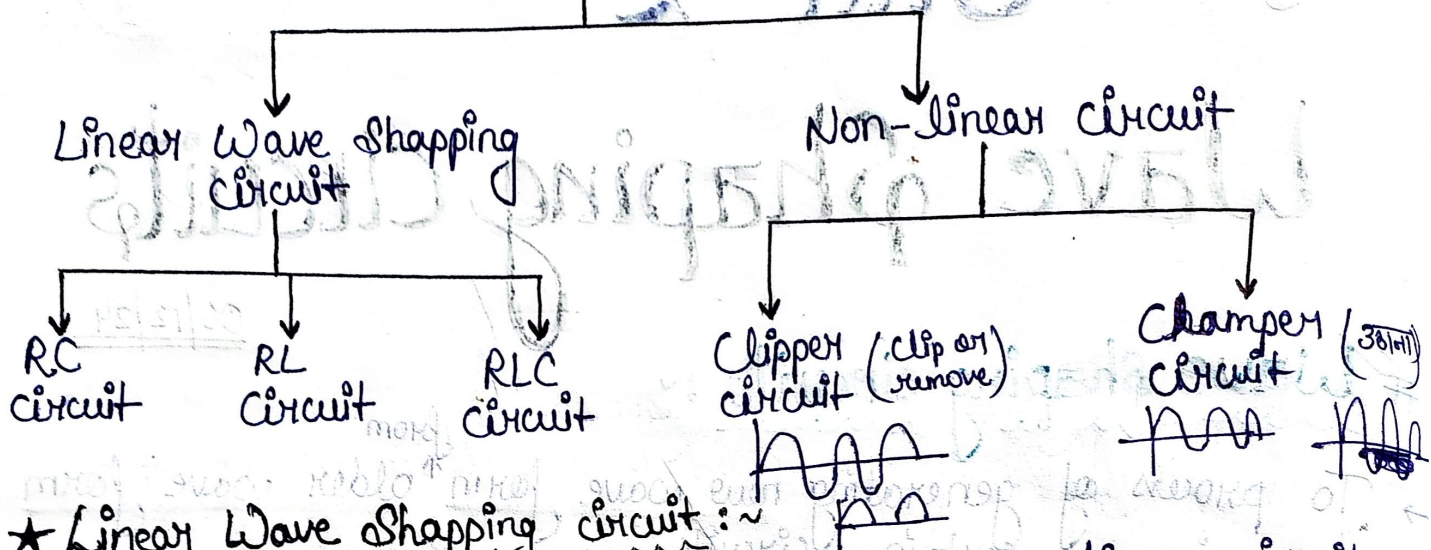
- To generate one wave form from other.
- To limit the voltage and current level.
- To hold the wave form to a particular DC level.
- To get the desired value of average and RMS voltage & current.

* CLASSIFICATION of wave shaping circuit :-

Depending upon the electronic components used in wave shaping circuit, it is classified as :-

Wave Shapping Circuit

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★ Linear Wave Shapping circuit :-

The circuit is constructed by using only linear circuit element such as resistors, capacitors, inductor is known as linear wave shapping circuit.

Such circuit are used to performs of differentiation and integration, summation, filtered etc.

1. RC Differentiator..

A circuit in which output voltage is directly proportional to the derivatives of the input is known as differentiation circuit.

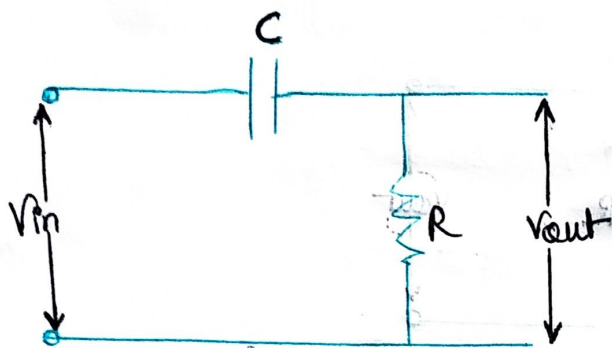
$$V_{out} \propto \frac{d}{dt} (\text{input})$$

Where.

$$V_{out} = R.C \frac{d(V_{in})}{dt}$$

Where, $R.C = \text{Time constant} = \tau$ (Tau)

A differentiator circuit may be realised by a simple series circuit.



It is important to note that merely an RC series circuit will not provide the voltage across R as a derivative of the input. It is also necessary to set the proper circuit value.

★ The conditions to be fulfilled are

- The time constant (RC) of the circuit should be much smaller than the time period of the input signal.

$$RC \ll T$$

$$T \ll T$$

- The value of X_C (Reactance)

∴ i.e. $X_C = \frac{1}{2\pi fC}$

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi \omega C}$$

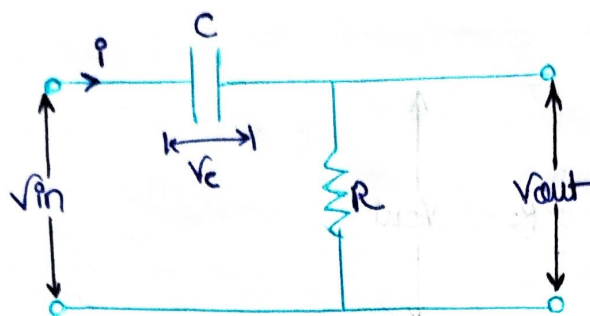
should not be smaller than 10 times of R .

i.e.

$$X_C \gg 10R$$

- When the given RC circuit fulfills the above condition then the voltage appearing across R will be derivative of the input.

RC Differentiator Circuit.... $V \cdot V \cdot I$ 09/12/24 22



If V_{in} is the input voltage, i is the resulting current then the instantaneous charge on the capacitor is given as $q = C V_c$, where V_c is the voltage across capacitor.

$$i = \frac{dq}{dt} = \frac{d(C V_c)}{dt}$$

$$i = \frac{C d V_c}{dt}$$

In the circuit X_c is very very greater than 10 times of R .

$X_c \gg 10$ times of R

$$\text{So, } V_{in} = V_c$$

$$i = \frac{C d V_{in}}{dt}$$

$$V_{out} = i R$$

$$V_{out} = \frac{C d V_{in}}{dt} \times R$$

$$V_{out} = RC \frac{d V_{in}}{dt}$$

$RC = \text{Time constant}$

$$I = RC$$

$$V_{out} = RC$$

$$V_{out} = I \frac{d V_{in}}{dt}$$

$$V_o \propto \frac{d V_{in}}{dt}$$

Advantage...

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- ① Simple Construction
- ② Low Cost
- ③ Easy to Design
- ④ Small size
- ⑤ Linearity

$$\left\{ \text{Gain} = \frac{\text{Output voltage}}{\text{Input voltage}} \right.$$

Disadvantages...

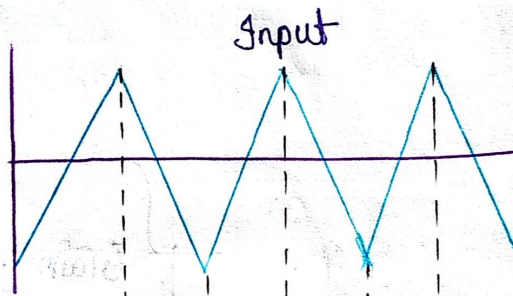
- ① Operation is highly dependent on frequency of input signal.
- ② Gain is less than 1.
- ③ For proper operation one time constant has to be small.
- ④ Distortion is introduced in the output.

Applications...

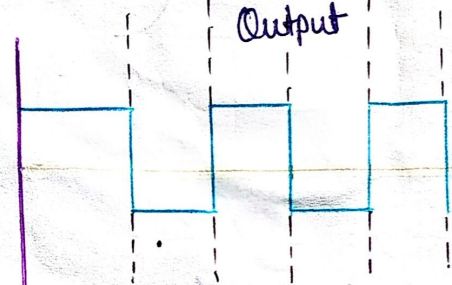
- ① To generate a square wave form from triangular signal.
- ② To generate the impulse signal from the square signal.
- ③ Used as passive high pass filter.
- ④ Used in active filter.
- ⑤ In analog converter.
- ⑥ In the clock circuit of digital circuitry.

$$\frac{1}{sR} = \text{Integrator}$$

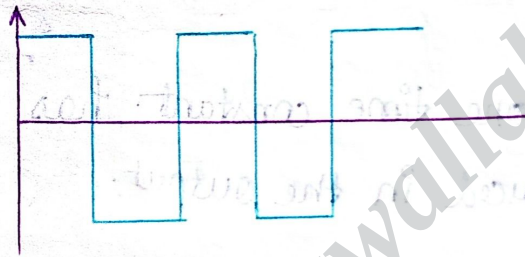
Triangular
Signal



Square
Signal



Square
Signal



Impulse
Signal



1) RC Integrator

A circuit that gives an output voltage is directly proportional to the integral of its input is known as integrating circuit.

$$\text{Output} \propto \int \text{input}$$

$$V_{\text{out}} = \frac{1}{R_c} \int V_{\text{in}} dt$$

$$\frac{1}{RC} = \text{Time Constant}$$

- An integrator circuit may be realised by a simple RC series circuit is taken across the capacitor C.
 - The output voltage across Capacitor C will be integral of the input voltage.
 - It is important note that an RC series circuit will not provide voltage across capacitor C as integral of the input.
- ★ The conditions to be full filled for making an RC series circuit as an integral are given below:-
- ① The time constant RC of the circuit should be very large as compare to the time period of the input signal.

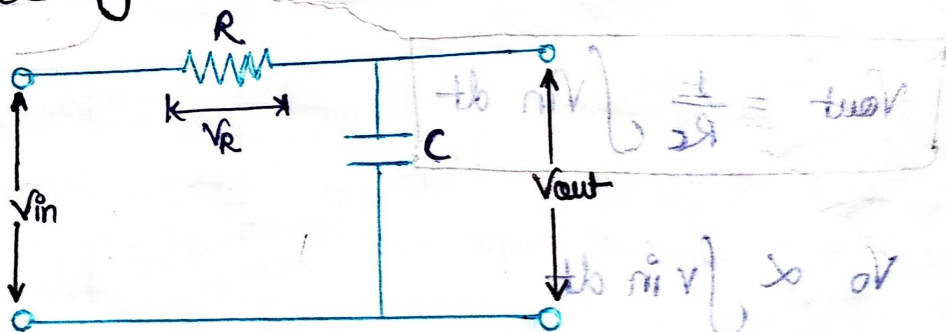
$$\text{i.e } RC \gg T$$

- ② The value of R should not be smaller than 10 times the capacitor reactants.

$$R \geq 10X_C \geq \frac{10}{2\pi fC}$$

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi fC}$$

RC Integrator Circuit.....



- When the given RC circuit full fills the above condition then the voltage appearing across capacitor C will be integral of the input.

$$V_{out} = \frac{1}{R_c} \int V_{in} dt$$

$$V_{in} = V_R$$

$$V_{in} = V_R \text{ because } R \geq 10X_c \geq \frac{10}{2\pi f_c}$$

the value of current

$$i = \frac{V_R}{R} = \frac{V_{in}}{R}$$

- The charge on capacitor at any instant voltage.

$$q = \int i dt$$

$$q = \int \frac{V_{in}}{R} dt$$

$$q = \frac{1}{R} \int V_{in} dt$$

- The Output voltage V_{out} across Capacitor

$$V_{out} = V_C = \frac{q}{C}$$

$$V_o = \frac{1}{R} \int V_{in} dt$$

$$V_{out} = \frac{1}{R_c} \int V_{in} dt$$

$$V_o \propto \int V_{in} dt$$

$$\begin{cases} q = C V_C \\ V_C = \frac{q}{C} \end{cases}$$

Advantages....

- Simple construction
- Low cost
- Easy to design
- Small size.
- Linearity

Disadvantages....

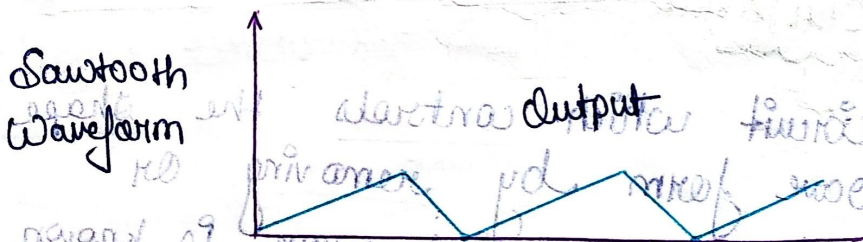
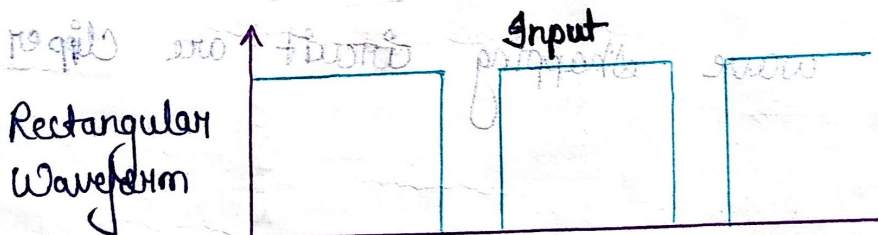
- Operation is highly dependent on frequency of input signal.
- Gain is less than 1, i.e., signal gets attenuated.
- For proper operation, The time constant has to be large.

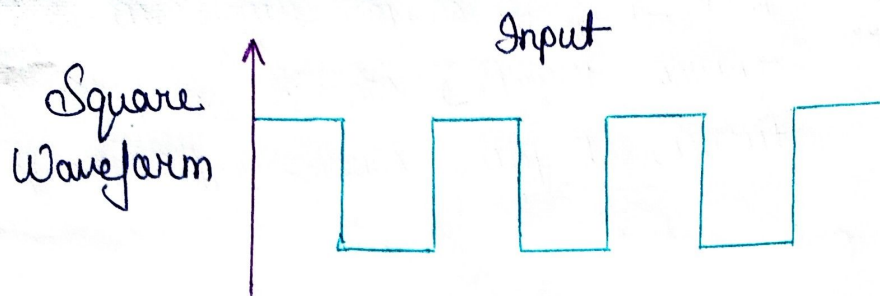
$$RC > T$$

Application....

- To generate sine signal from cosine signal.
- To generate sawtooth signal from rectangular signal.
- To generate triangular signal from square wave input.
- As a passive low pass filter.

Input and Output Waveform





* Non Linear Wave Shapping Circuit.....

- These non-linear wave shapping circuit are those which is constructed by non-linear element such as diode, transistor along with linear circuit element.
- Such circuit are used to perform ~~perform~~ function of clamping and clipping.
- The non-linear wave shapping circuit use the switching property of diode and transistor to realise the various functions.
- The non-linear wave shapping circuit are clippers and clamper.

* 2. Clippers Circuits.....

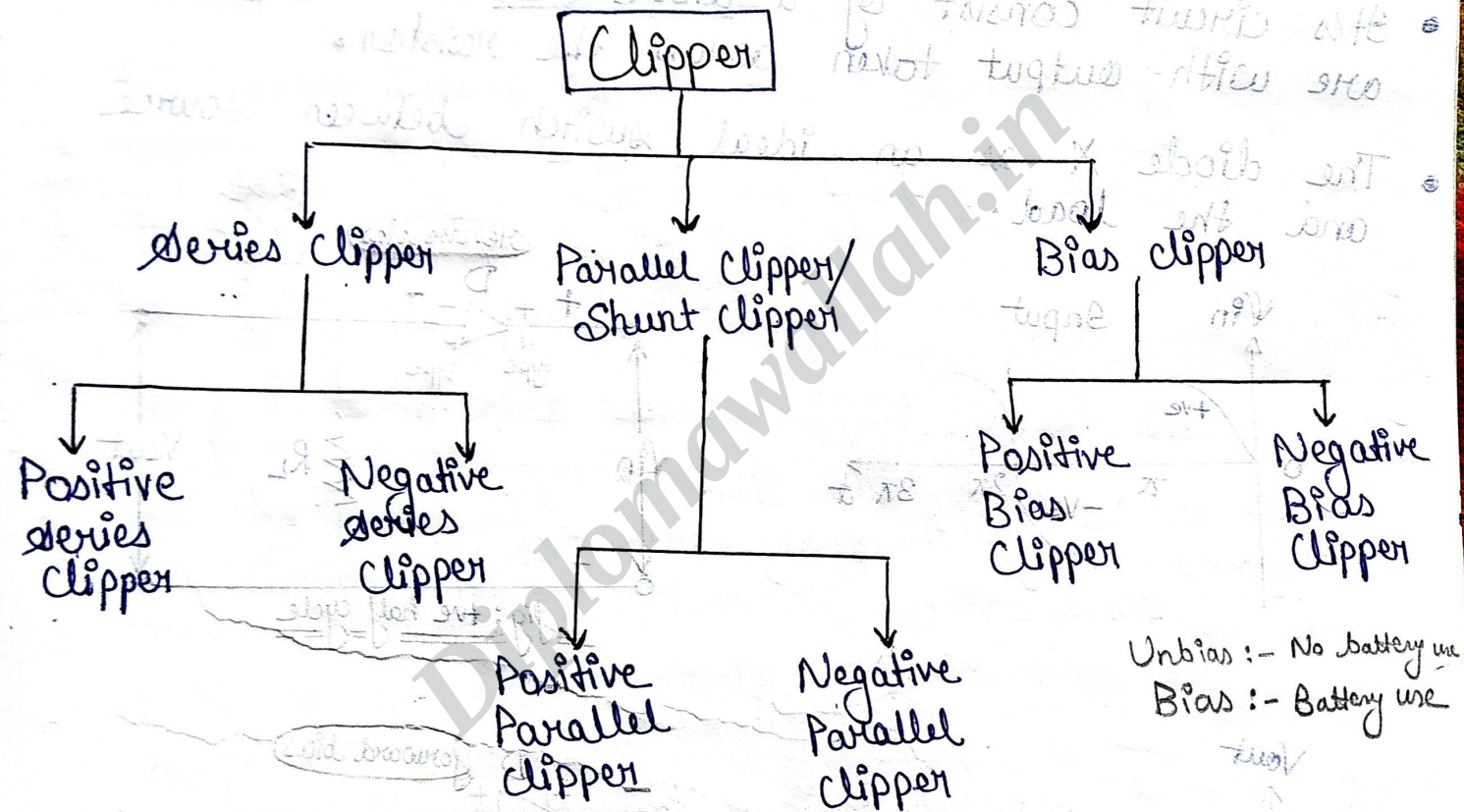
→ A wave shapping circuit which controls the shape of the output wave form by removing or clipping a portion of the applied wave is known as

Clipper circuit.

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- A half wave rectifier is an example of clipper.
- Clipping circuit is also known as voltage limiters, amplitude selectors and slicers.
- Clipping circuits consist of non-linear and linear devices.
↓ diode, transistor ↓ RLC

* Types of Clipper Circuit....



* I. Series Clipper Circuit....

→ In this clipper circuit the diode is connected in series with the load. So, this is known as series clipper circuit.

Clipper circuit AC ke unwanted waveform ko remove or slide ko clip karata hai.



There are two types of ~~ser~~ Clipper Circuit..... 30

- (i) Positive Series Clipper Circuit
- (ii) Negative Series Clipper Circuit

(i) Positive Series Clipper Circuit...

- The clipper which removes the positive half cycle of the input voltage is called the positive clipper.
- It's circuit consist of a diode (D) and a resistor are with output taken across the resistor.
- The diode $\times$ as an ideal switch between source and the load. (Internal

Input

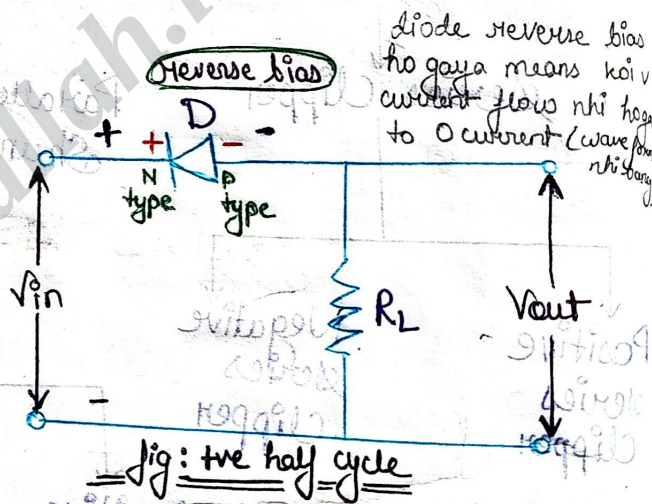
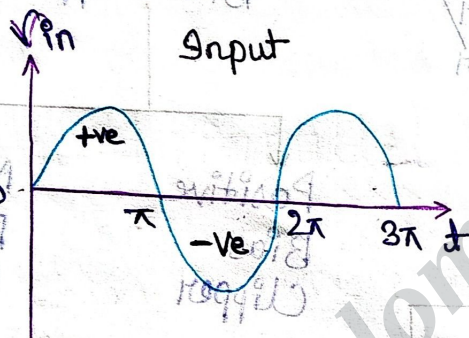
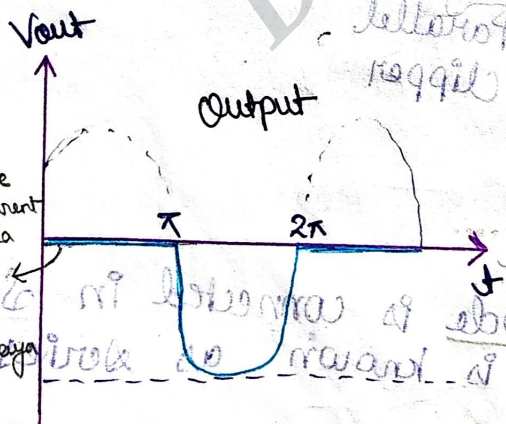


Fig: +ve half cycle

Output



Means ^{series} +ve clipper me +ve cycle clip ho sakta he.

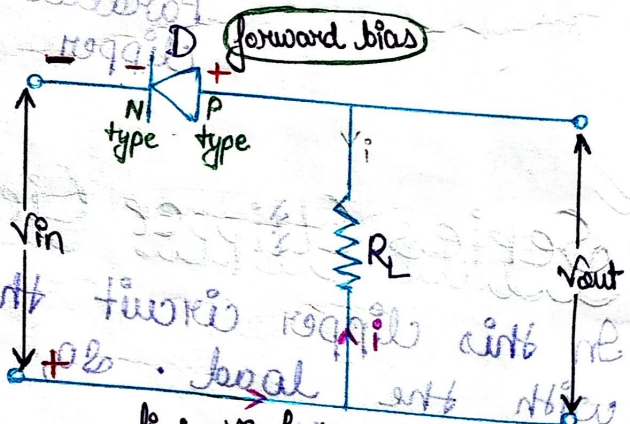


Fig: -ve half cycle

diode forward bias me he means current flow hoga. means jab -ve cycle denge to current flow hoga yahi load me aayega means aub output me hume waveform milega.

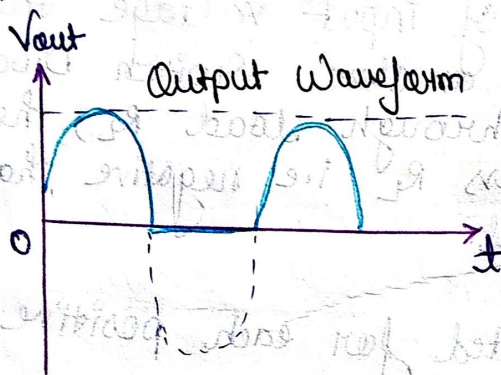
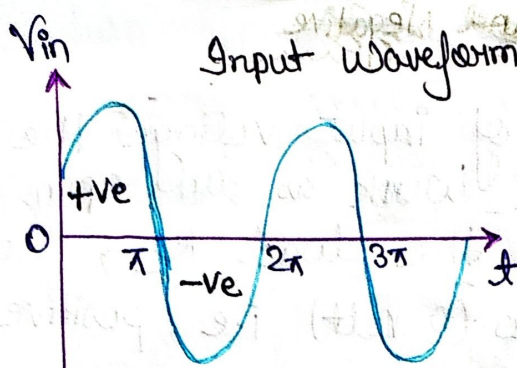
Operation of positive clipper

- During positive half cycle of input voltage the diode D is reverse biased and work as an open switch. No current flow through the load R_L , hence output voltage V_o is zero (0 volt) i.e, positive half cycle is clipper off.
- During negative half cycle of input voltage the diode D is forward bias and as close. Switch Diode D allow to flow current through load R_L , hence a output V_o is obtained across R_L i.e negative half cycle is appears across the load.
- The above process is repeated for each positive and negative half cycle of input signals.

ii) Negative Series Clipper Circuit:-

- The negative clipper is that which removes the negative half cycles of the input voltage is called the negative clipper.
- This circuit is commonly used in electronic devices to protect them from excessive negative voltages.
- It's circuit consist of a diode, a resistor, and a voltage source.
- The diode is connected in series with the input signal, and the resistor is connected in parallel with the diode.

Means series
-ve clipper
me -ve half
cycle clip/remove
ho maha he....



Forward bias

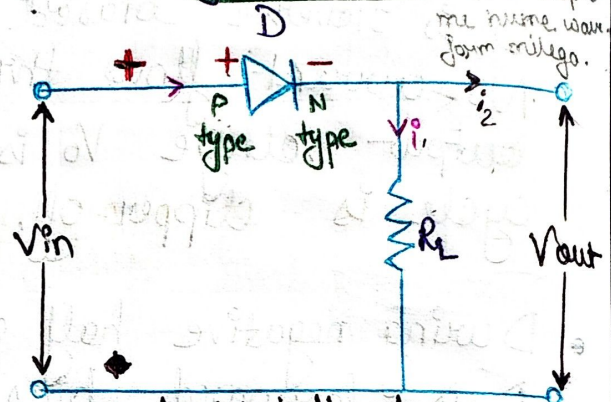


fig: +ve half cycle

Reverse bias

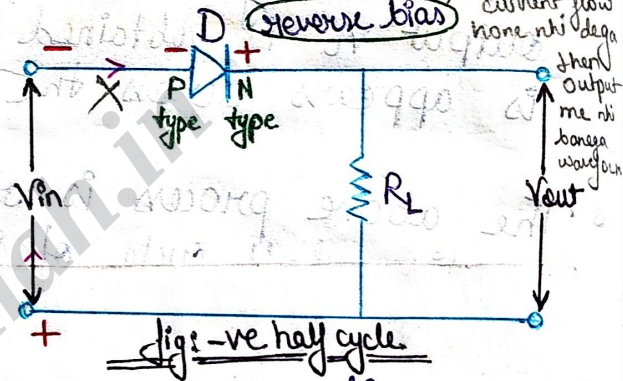


fig: -ve half cycle

Operation :-

- During positive half cycle of input voltage the diode D is forward-biased and work as an close switch. Diode D allow to flow current through load R_L . Hence a output voltage V_o is obtained across R_L i.e. positive half cycle is appears across the load.
- During negative half cycle of input voltage the diode D is reverse-biased and work as an open switch. No current flow through the load R_L , Hence output voltage V_o is zero (0 volt) i.e. negative half cycle is clipper off.

The above process is repeated for each positive and negative half cycle of input signals.

* II. Parallel / Shunt Clipper Circuit :-

12 | 12 | 24 | 33

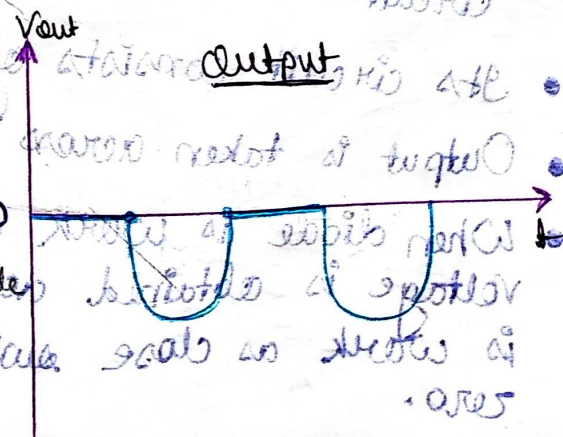
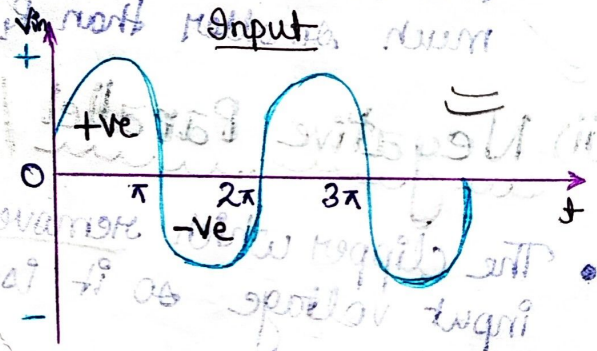
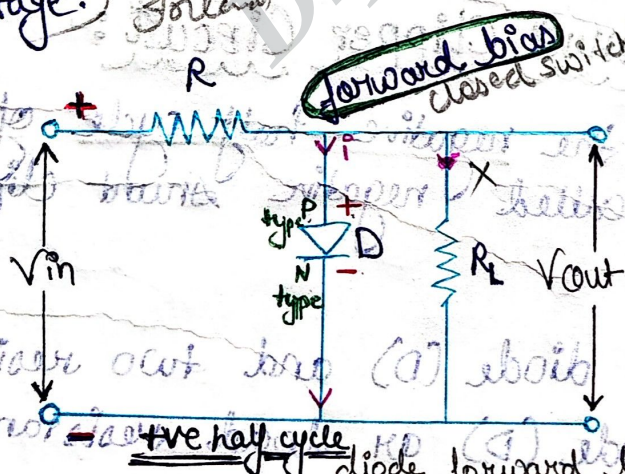
- In this clipper circuit the diode is connected in parallel with the load, so this is known as parallel or shunt clipper circuit.

There are two types of shunt clipper:-

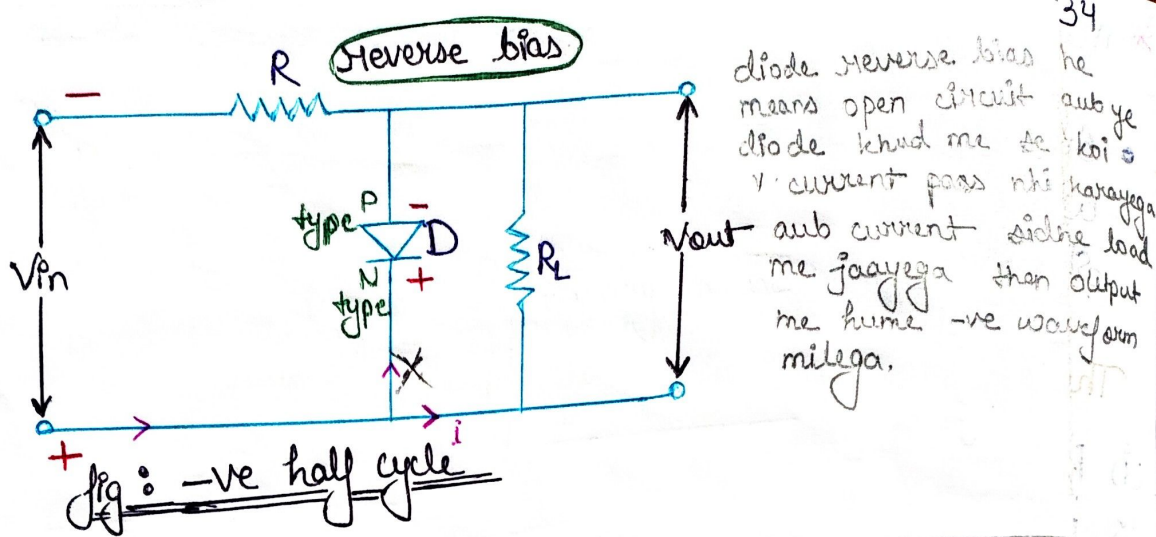
- Positive shunt clipper circuit
- Negative shunt clipper circuit

(i) Positive shunt clipper circuit :-

- The clipper which removes the positive half cycle of the input voltage so it is called positive shunt clipper circuit.
- Its circuit consist of a diode (D) and two resistors.
- Output is taken across diode or load resistance (R_L).
- When diode is work as open switch than output voltage is obtained across load R_L , but when diode is work as close switch than output voltage is zero.
- One of the diode is connected in series with input voltage.



diode ke resistance $D = \infty$ he means current flow noga. $V_{out} = 0$ because current ideal diode ke through pass ho gaya. Output (load) me kuch aaya nhi means $V_o = 0$ potential.



Operation:-

- During positive half cycle of input voltage the diode D is forward biased and acts as a closed switch so the voltage drop across the diode or across the load resistance R_L is zero. Thus output voltage during the positive half cycle is zero.
- During negative half cycle of input voltage the diode D is reverse biased and acts as an open switch. Therefore the entire input voltage appears across the diode or across the load resistance R_L . The value of R should be much smaller than R_L .

(ii) Negative Parallel / Shunt Clipper Circuit:-

- The clipper which removes the negative half cycle of the input voltage so it is called negative shunt clipper circuit.
- Its circuit consists of a diode (D) and two resistors.
- Output is taken across diode (D) or load resistance (R_L).
- When diode is work as open switch then output voltage is obtained across load R_L , but when diode is work as close switch then output voltage is zero.

- One of the diode is connected in series with input voltage. Internal

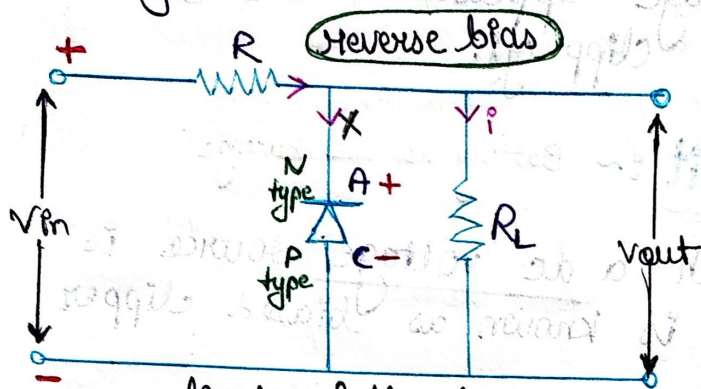


Fig: +ve half cycle

diode reverse bias me he means circuit open he to current to jayega nhi use wo load me jayega means +ve half cycle ke lye waveform banega.

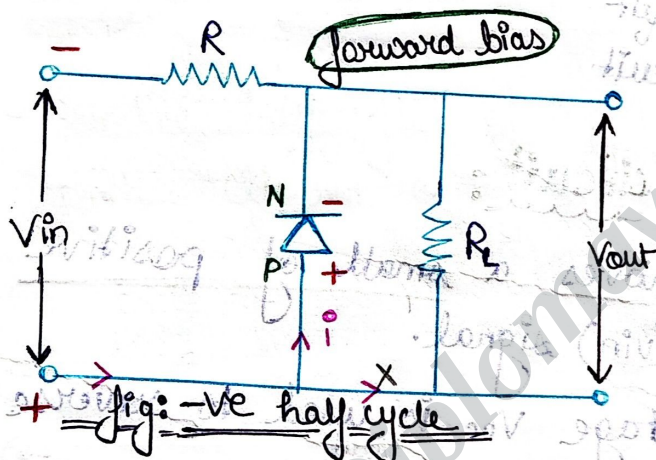
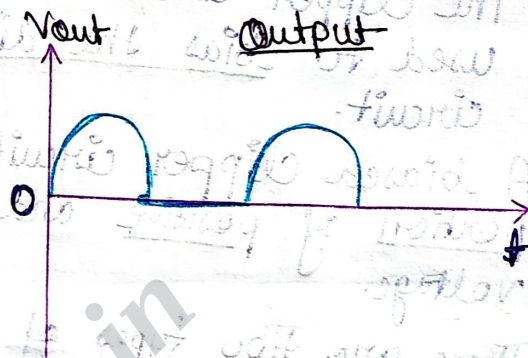
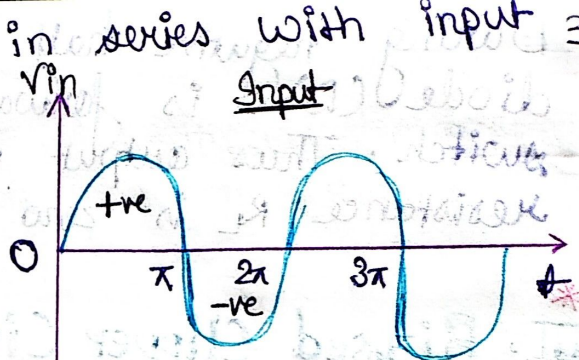


Fig: -ve half cycle

diode forward bias he means (close circuit) +ve terminal se current aayega aur iske pass do haste he diode wale hashte me current jayega load resistance wale hashte me current nhi jayega. kyunki uska resistance high he. but diode ideal diode he uska resistance low he that's why current use jayega.

Operation :-

- During positive half cycle of input voltage the diode (D) is reverse biased and acts as a open switch. So the voltage drop across the diode or across the load resistance R_L is obtained. Thus output voltage during the positive half cycle is appear across load R_L .

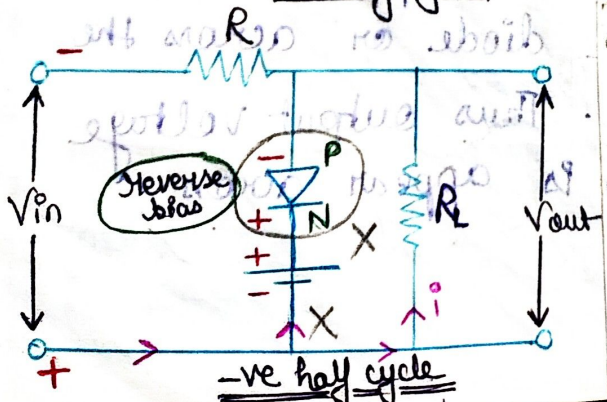
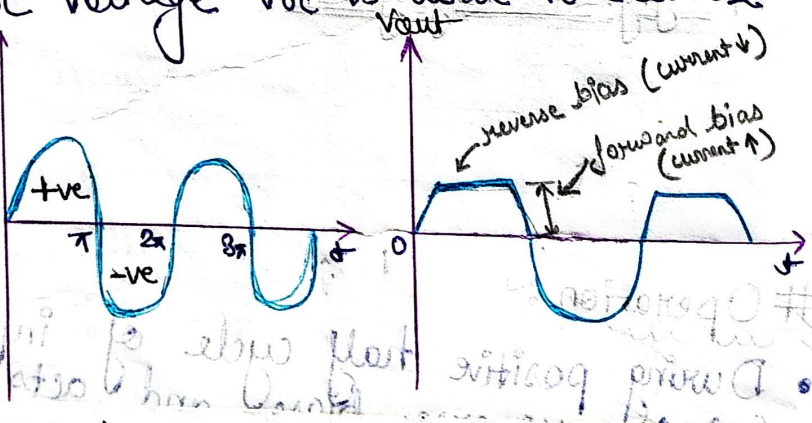
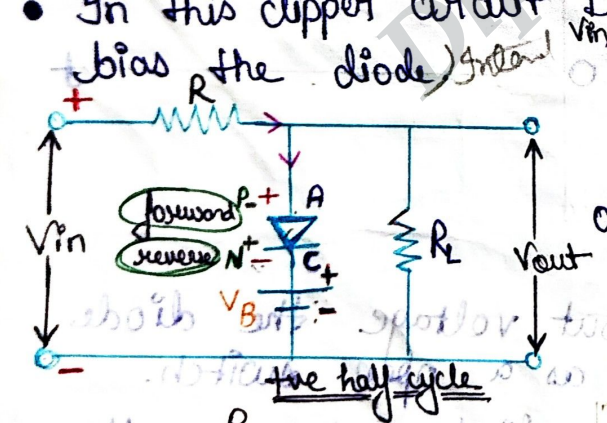
- During negative half cycle of input voltage the diode (D) is forward bias and acts as a close switch. Thus output voltage appears across load resistance R_L is zero or clip off.

III. Biased Clipper Circuit :- Battery ka use karenge

- The clipper circuit in which a dc voltage source is used to bias the diode is known as biased clipper circuit.
- A biased clipper circuit is used to remove a small portion of positive and negative half cycle of the signal voltage.
- There are two types of biased clipper circuit:-
 - Positive biased clipper circuit.
 - Negative biased clipper circuit.

(i) Positive biased clipper circuit :- Battery use

- The clipper circuit which removes a small of positive half cycle of input voltage (V_{in}) signal.
- In this clipper circuit DC voltage V_{oc} is used to reverse bias the diode.



diode forward bias tha to thora current flow hua uske bad ruk gaya kyunki battery usko + or - de rahi he means reverse bias isliye current ruk gaya.

diode reverse bias he means open circuit to current to usme jayega nhi kyunki circuit tuta hua he to current load resistance me jayge to hume output me waveform full milega.

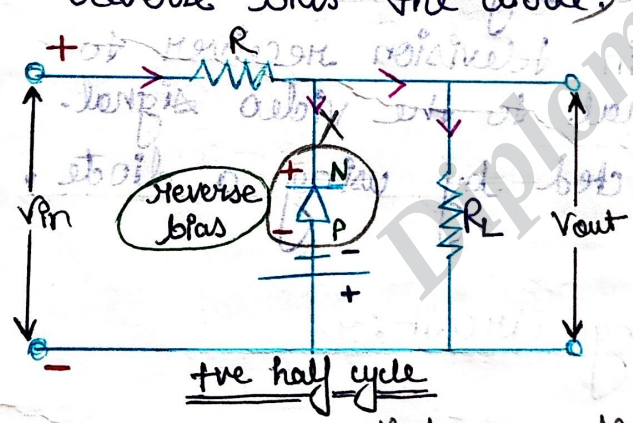
#Operation-

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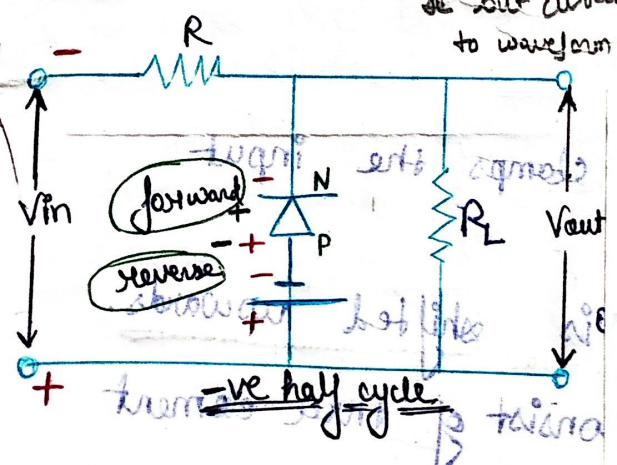
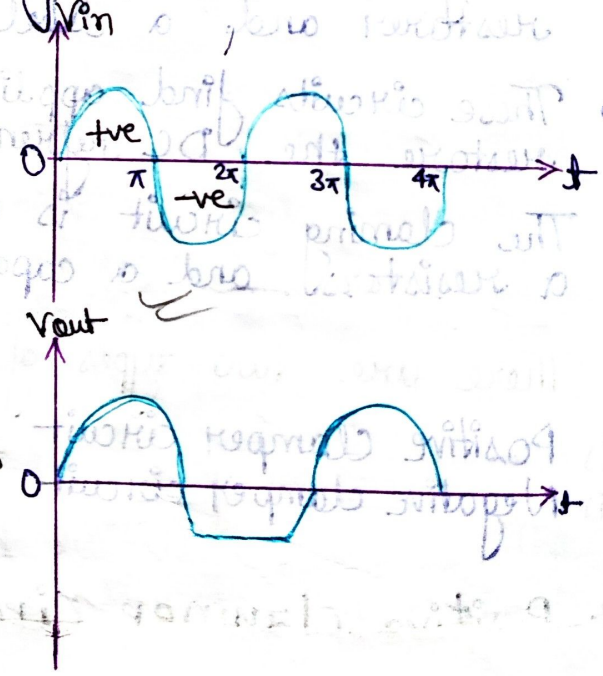
- When the voltage input voltage V_{in} is positive but does not exceed DC voltage V_{DC} , diode D remains reverse biased. In this case most of the input voltage appears across the output.
- When the input voltage V_{in} is negative, the diode D is reverse biased and behaves as a open switch. In this case entire negative half cycle appears across the load. The value of resistance R_L so that in negative half cycle is output voltage is equal to input voltage i.e $V_o = V_{in}$.

(ii) Negative Biased Clipper Circuit:

- The clipper circuit which remove a small portion of negative half cycle of input voltage (V_{in}) signal.
- In this clipper circuit DC voltage V_{DC} is used to reverse bias the diode.



diode reverse bias he means current flow nhi hoga diode se but current R_L me jaayega to waveform banega.



diode forward bias hua current flow karega fir battery se usme - or + aa jaayega means battery use reverse bias bana rahi aur current flow nhi hoga.

Operation:

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- When the input voltage V_{in} is positive, the Diode D is reverse bias and behave as an open switch. In this case entire positive half cycle appears across the load.
- When the input voltage V_{in} is negative but does not exceed DC voltage, V_{D-C} diode D remains reverse biased. In this case most of the input voltage appears across the output.

* 2) Clamper Circuit....

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clamper circuit DC level ke waveform ko shift karta he.

- Clamping circuit shifts or clamps a signal to a different DC level.
- In other words clamping circuit introduce a DC level to an AC level/signal.
- Therefore the clamping circuit is also known as DC restorer and a level/signal shifter.
- These circuits find application in television receiver to restore the DC reference signal to the video signal.
- The clamping circuit is constructed by using a diode, a resistor and a capacitor.

There are two types of clamping circuit:-

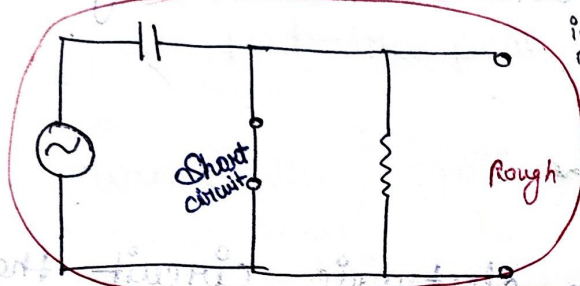
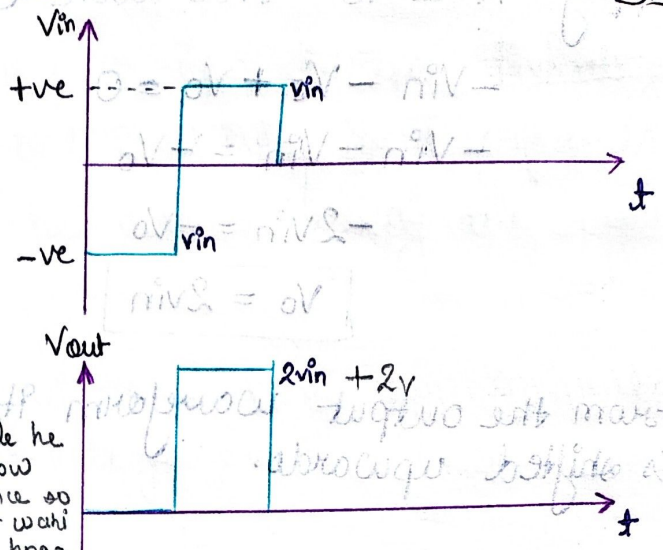
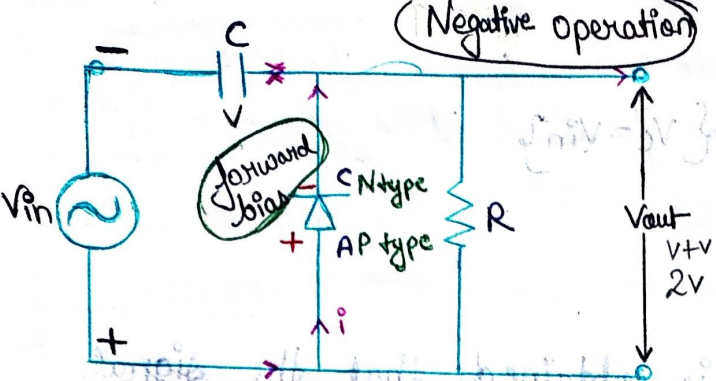
- (i) Positive clamper circuit
- (ii) Negative clamper circuit

(i) Positive Clamper Circuit :-

- Positive clamper is a circuit which clamps the input signal waveform positively.
- In other words, the AC input is shifted upwards.
- The clamping network will always consist of three element is a capacitor, diode and resistor.

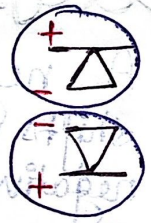
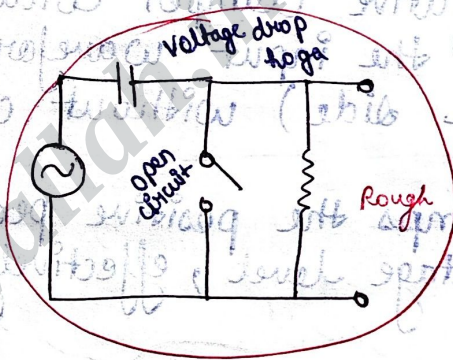
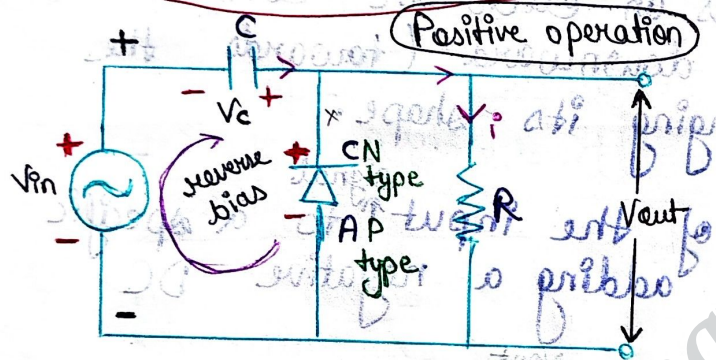
• Output is taken across the resistor R .

Negative operation



ideal diode means low resistance so current wahi se pass hoga

Positive operation



Operation :

- During the -ve half cycle of the input signal the diode is forward bias and behaves as short circuit. Since, the charging time constant is quit small, the capacitor is charged to V_{in} volts very quickly during this period V_{out} is equal to zero.
- During the +ve half cycle input switching to V_{in} volts the diode is reverse bias and acts as an open circuit. Now the capacitor works as a battery and it discharge through resistor R . But since the discharge time constant (R_C) is very large, the capacitor fully discharge capacitor V volts during the off time of the diode.

Apply KVL to the above circuit, we have....

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$$-V_{in} - V_C + V_o = 0$$

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

$$\{V_C = V_{in}\}$$

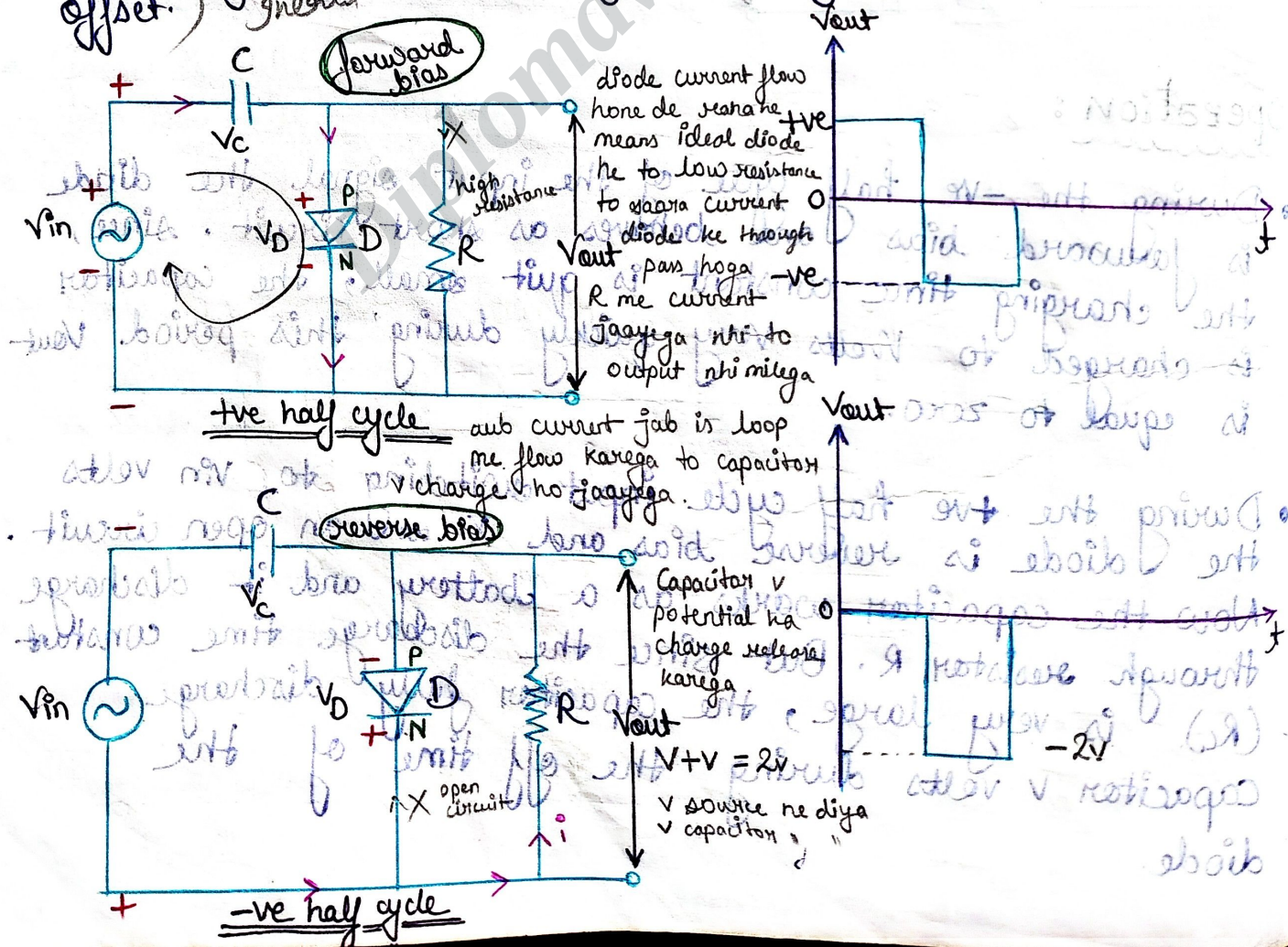
$$-2V_{in} = -V_o$$

$$V_o = 2V_{in}$$

- From the output waveform it is obtained that the signal is shifted upwards.

(ii) Negative Clamper Circuit :-

- A negative clamper circuit is an electronic circuit that shifts the input waveform downward (towards the negative side) without changing its shape.
- It clamps the positive peak of the input ^{signal} to a specific DC voltage level, effectively adding a negative DC offset.



Operation :

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- During the positive half of the input AC signal, the diode becomes forward-biased and conducts. The capacitor charges to the peak value of the input voltage.

The voltage across the capacitor is now approximately equal to the peak input voltage (V_m).

- During the negative half cycle of input signal, ~~the~~ ~~becomes zero~~ the diode is reverse-biased and stops conducting.

The capacitor maintains its charge and acts as a voltage source, effectively shifting the waveform downward.

The total output waveform is shifted negatively by an amount equal to the capacitor's charge voltage.

17/12/24

* # Voltage Multiplier...

- Voltage multiplier is a modified capacitor filter circuit that delivers a DC voltage twice or more than of the peak value (Amplitude) of the input AC voltage.

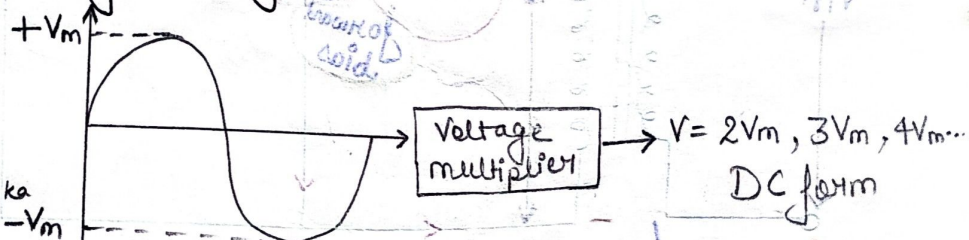
Such power supplies are used for high voltage and low current device such as cathode ray tubes.

There are two types of voltage multiplier :-

(i) Voltage doubler

(ii) Voltage tripler

- Voltage multiplier AC input waveform ka maximum potential ko badha dega multiply kar dega like $2V_m$, $3V_m$
- AC signal ko DC form me convert karoga.



Voltage Multiplier

$V_m \rightarrow 2V_m$

Voltage multiplier ne double kar diya

$V_m \rightarrow 3V_m$

Voltage doubler

Voltage tripler

Half Wave voltage doubler

Full Wave voltage doubler

Half Wave Voltage tripler

Full wave voltage tripler

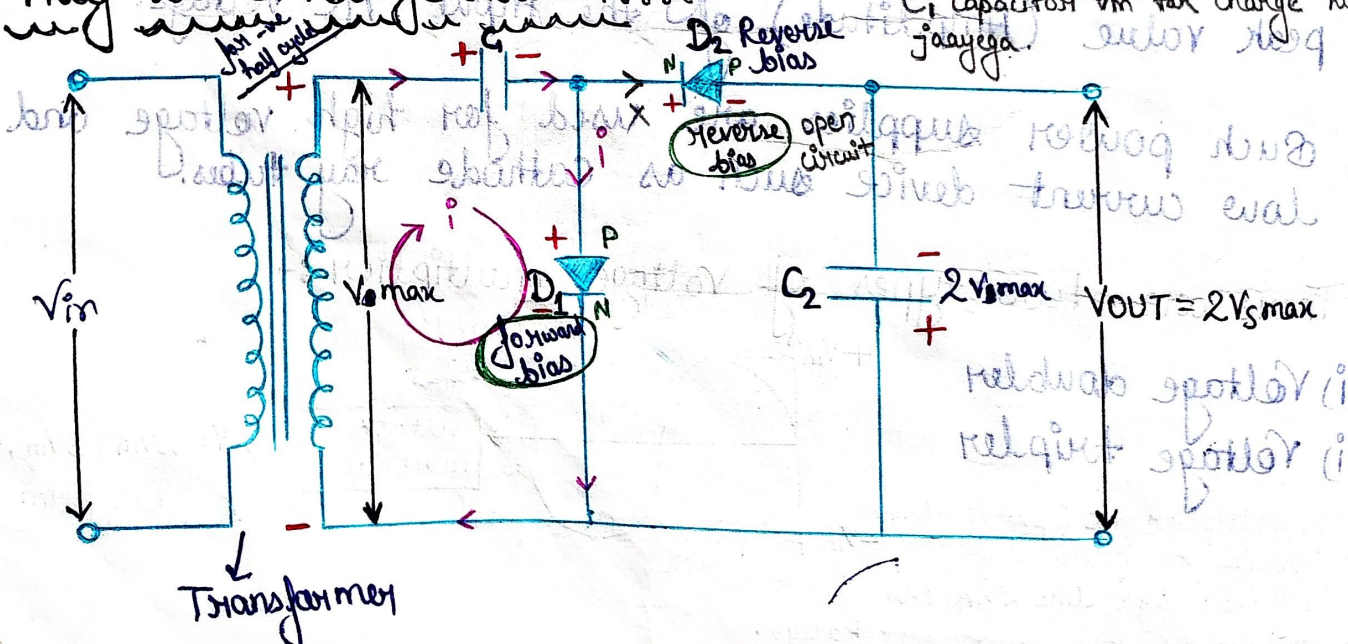
(i) Voltage Doubler...

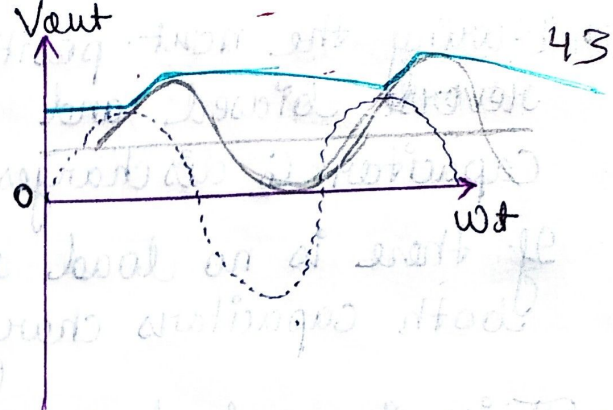
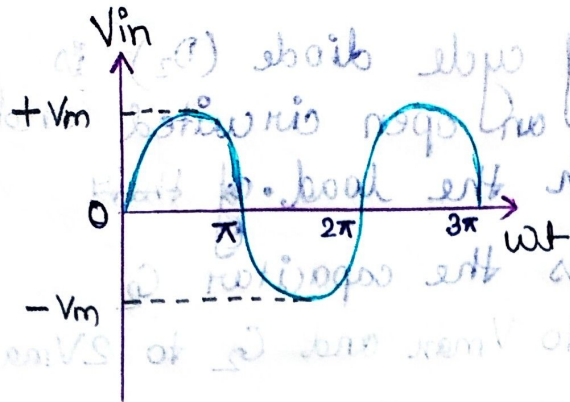
- It is the type of diode rectifier circuit which can produce an output voltage two times greater than that of applied input voltage.
- There are used to maintain relatively low transformer peak voltage by stepping up the peak output voltage two times the peak of rectified voltage.

There are two types of voltage doubler...

- (i) Half wave voltage doubler
- (ii) Full wave voltage doubler

* Half wave voltage doubler...





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Operation:

- The circuit of half wave voltage doubler is shown in Fig.. During the positive half cycle of the AC input voltage Diode (D_1) is in forward bias (Diode (D_2) does not conduct because it is reverse ^{conducts} biased) and charges C_1 peak value of V_{max} with the polarity.
- During the negative half cycle of the input voltage of Diode D_2 gets forward bias and conducts charging Capacitor C_2 .

For the negative half cycle, the lower end of the transformer secondary is positive while upper end is negative. Now starting from the bottom of the transformer secondary and moving clock wise. and applying KVL to the loop.

$$-V_m - V_{C1} + V_{C2} = 0$$

$$V_{C2} = V_{C1} + V_m$$

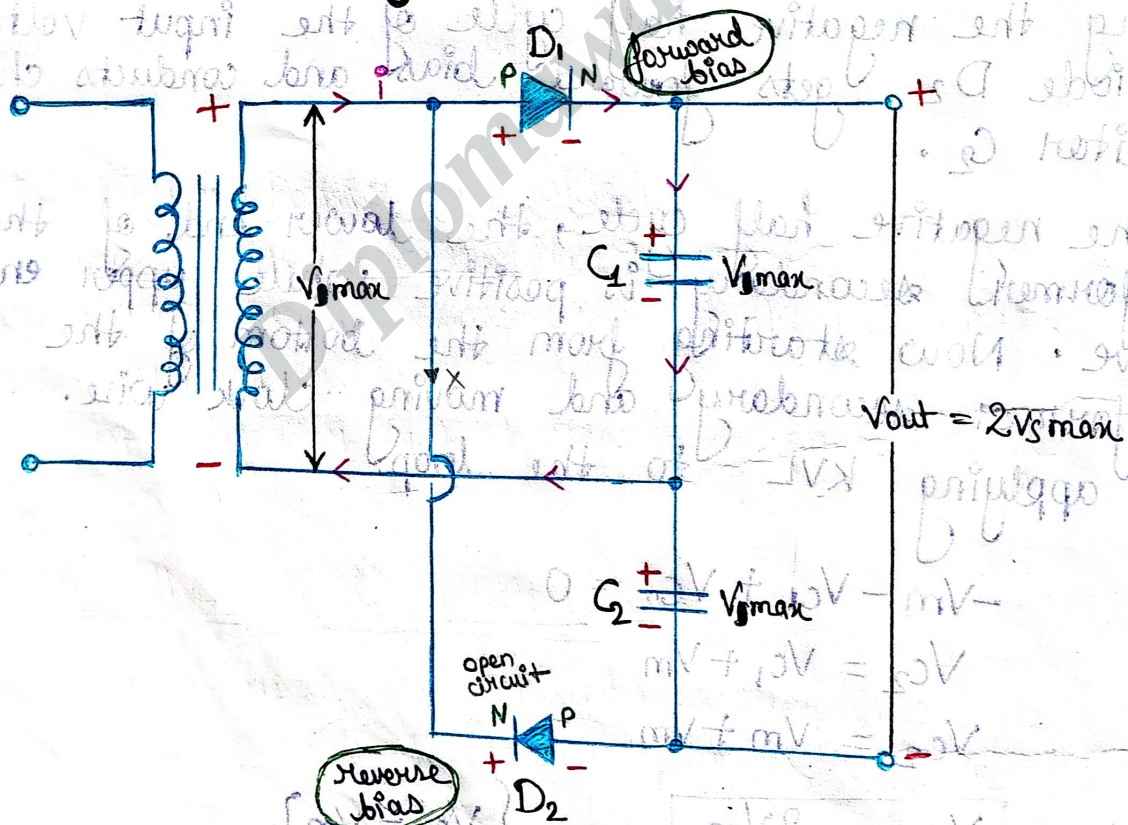
$$V_{C2} = V_m + V_m$$

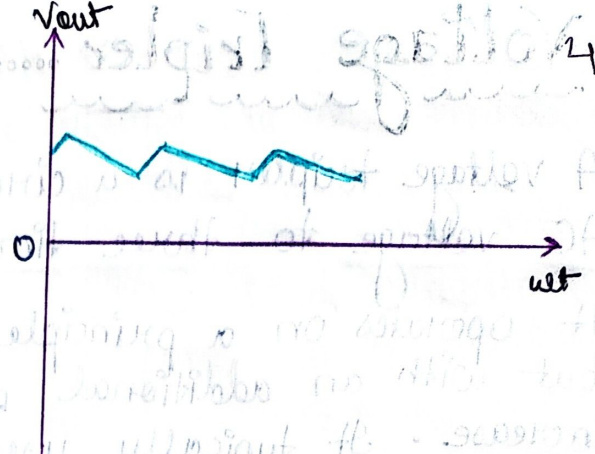
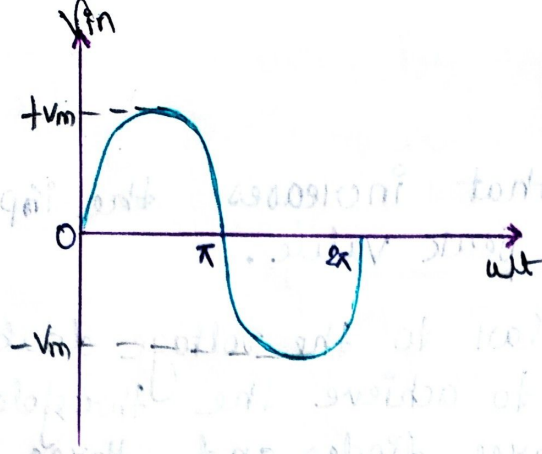
$$\boxed{V_{C2} = 2V_m}$$

$$\left\{ V_{C1} = V_m \right\}$$

- During the next positive half cycle diode (D_2) is reverse biased and acts as an open circuit and capacitor C_2 discharges through the load. If there is no load across the capacitor C_2 both capacitors charged C_1 to V_{max} and C_2 to $2V_{max}$.
- There is a load connected to the output terminals of the voltage doubler the capacitor C_2 discharges a little bit and the voltage across capacitor C_2 drops slightly.
- The capacitor C_2 gets recharged again in the next half cycle. The ripple frequency will be signal frequency (50 Hz).

★ Full Wave Voltage doubler....





Operation:

★ Positive Half-cycle (First Half of AC wave):

- When the AC input is at a positive peak (e.g. $+V_{in}$), diode D_1 becomes forward biased and conducts. Current flows through D_1 charging capacitor C_1 to the peak voltage of the AC input.

Diode D_2 is reverse biased during this half-cycle, so it does not conduct. The output voltage across C_2 is 0 during this half-cycle.)

★ Negative Half-cycle (Second Half of AC wave):

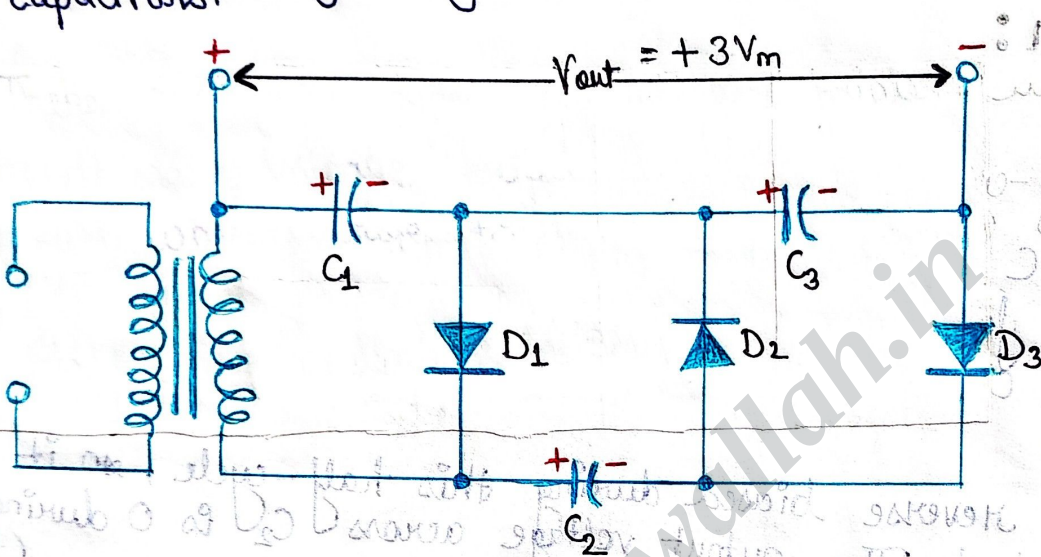
- When the AC input is at a negative peak (e.g. $-V_{in}$), diode D_2 becomes forward biased and conducts. Capacitor C_1 now provides a voltage (V_{in}) across the circuit, and C_2 charges to approximately $2 \cdot V_{in}$ (because the AC input is now negative and the voltage across C_1 adds to this negative peak).

During this half-cycle, diode D_1 is reverse biased, and no current flow through it.

Charging the third capacitor (C_3):

(ii) Voltage Tripler

- A voltage tripler is a circuit that increases the input AC voltage to three times its peak value.
- It operates on a principle similar to the voltage doubler, but with an additional stage to achieve the threefold increase. It typically uses three diodes and three capacitors.



Operation.. (Positive half cycle)

- ★ Charging the first capacitor (C_1) :
- ★ During the positive half cycle of the AC input, the first diode (D_1) conducts.
- The first capacitor (C_1) charges to the peak voltage (V_{peak}) of the AC signal.
- ★ Charging the second capacitor (C_2) :
- The second diode (D_2) conducts during this cycle.
- C_2 charges to twice the input peak voltage ($2 \times V_{peak}$) using the charge stored in C_1 .

Negative half cycle

- ★ Charging the third capacitor (C_3) :

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- During the negative half-cycle, D_3 conducts.
 - C_3 charges to $3 \times V_{peak}$ using the voltage across C_2 and the AC signal.

At the output, the voltage across the third capacitor (C_3) is approximately three times the peak input voltage ($3 \times V_{peak}$).

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