Wave Shaping Circuits :- Wave Shaping is a part of signal processing where the signal waveform has to be properly shaped before amplification.

* In this process the output may vary in shape from input because of influence of the circuit elements on the signal.

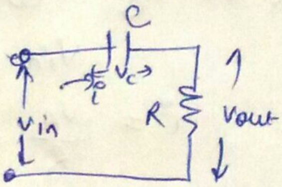
* Wave-shaping may be of two types →

(i) Linear wave shaping - In this, signal shape is altered by transmitting it through a linear network [network consisting of linear element such as R, L and C]
Thus R-C, R-L and R-L-C circuits are categorised as linear wave shaping circuits.

(ii) Non-linear wave shaping - In this, the shape of a signal is moderated by transmitting it through a non-linear n/w. [N/w consisting diode, transistor, vacum tube]
The application of this kind of circuits in amplitude limiting, clipping & clamping of signals.

R-C Differentiator :- A circuit that gives an output voltage proportional to the derivative of its input.

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



The output across R will be the derivative of input Vin voltage.

To make R-C series circuit as a differentiator, there are conditions :-

(i) The time constant RC << T [time period of the i/p signal]

(ii) The value of $X_C \left(\frac{1}{2\pi f C}\right)$ should not smaller the 10R

$$X_C \geq 10R$$

* Vin - i/p voltage   i = instantaneous current.

Charge through capacitor $q = C V_c$ [V_c → intantaneous voltage across capacitor C]

$$i = \frac{dq}{dt} = \frac{d}{dt}[C V_c]$$

$$i = C \cdot \frac{dV_c}{dt}$$

$$i = C\frac{dV_{in}}{dt} \quad \text{— (1)}$$

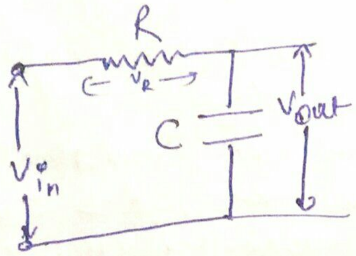
∴ as $X_C \geq 10R$
$V_c = V_{in}$

output voltage $V_{out} = iR$ ⇒ $V_{out} = RC\frac{dV_{in}}{dt}$

$V_{out} \propto \frac{dV_{in}}{dt}$

Application - R-C differentiator [High Pass filter] is employed to generate pips for triggering electronic circuits such as multivibrators, flip-flops etc.

RC - Integrator - A circuit that gives an output voltage directly proportional to the integration of its i/p is known as integrating circuit.



$$\text{output} = \int \text{Input}$$

The conditions to be fulfilled for making an RC series circuit as an integrator are given below :-

(i) $RC \gg T$ [the time constant RC should be very large as compared to the time period of i/p signal]

(ii) R should not smaller than 10 times the capacitive reactance.

$$R \geq 10X_C \Rightarrow R \geq \frac{10}{2\pi f C}$$

* as $R \gg X_C$ so output voltage = i/p voltage [Large voltage drop across R]

$$V_{in} = V_R$$

$$i = \frac{V_R}{R} = \frac{V_{in}}{R} \quad \text{—(I)}$$

Charge across capacitor $q = \int i\,dt = \frac{1}{R}\int V_{in}\,dt$ —(II) (from eq (I))

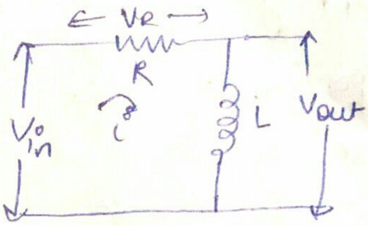
output $$V_{out} = \frac{q}{C} = \frac{1}{CR}\int V_{in}\,dt$$ (from eq (II))

$$V_{out} \propto \int V_{in}\,dt$$

Application - RC Integrator (low pass filter) used in generation of triangular and ramp waveforms. It also used in discrimation b/w pulses of different lengths

R-L differentiator :- The output across the inductor is proportional to the derivative of i/p voltage

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



To make R-L differential, there are conditions -

(i) The time constant $\left(\tau = \frac{L}{R}\right) << T$

(ii) The value of $X_L \leq 10R$ $(X_L = 2\pi f)$

* as the value of R is very large so voltage drop across it $V_R = 0$

$V_{in} = V_R$

the instantaneous current $i = \frac{V_R}{R} = \frac{V_{in}}{R}$ —— (i)

voltage across inductor $V_{out} = L \frac{di}{dt}$

$V_{out} = L \frac{d}{dt}\left(\frac{V_{in}}{R}\right)$ from eq (1)

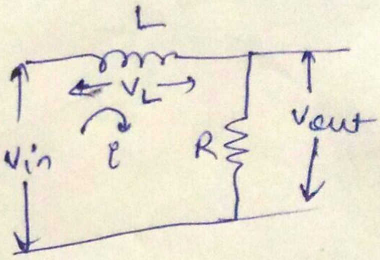
$V_{out} = \left(\frac{L}{R}\right) \frac{dV_{in}}{dt}$

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

Application - To generate a time delay

R-L integrator :- The output across the resistor is directly proportional to the integral of input voltage

$$V_{out} \propto \int V_{in}$$



Condition :-

(i) Time constant $\tau >> T$

(ii) $X_L \gtrsim 10R$

Current through inductor $i = \frac{1}{L} \int V_L \, dt$ —— (i)

outputor across R $V_{out} = iR$

$V_{out} = \frac{R}{L} \int V_L \, dt$ from eq (1) $V_L = V_{in}$

$$V_{out} \propto \int V_{in}$$

Non-linear wave shaping circuits :-

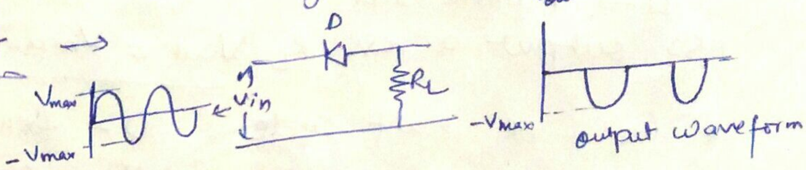
① Clipping circuits :- A wave shaping circuit which controls the shape of the output waveform by removing or clipping a portion of the applied wave is known as clipping ckt. These circuits used in radars, digital computers and other electronic system.

Clippers may be - (i) Positive clippers (ii) Negative clipper (iii) Biased clippers (iv) Combination clippers

Ⓐ Positive clippers - The clipper which removes the positive half cycle of the i/p voltage.

(i) Positive series clipper circuit →

↳ In this diode is in series with R_L.

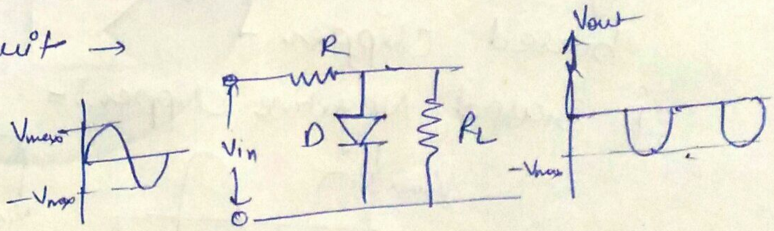


* when V_{in} has +ve half cycle the diode (D) is in reverse bias so $V_{out} = 0$

* when V_{in} has -ve half cycle the diode (D) is in forward bias so $V_{out} = -V_{max}$

(ii) Positive shunt clipper circuit →

↳ In this diode is in ∥el with R_L.



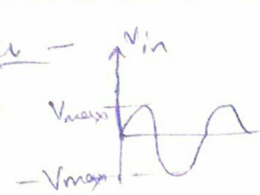
* when V_{in} has +ve half cycle the diode D is in forward bias so all voltage drop across diode, the output of R_L is zero $V_{out} = 0$

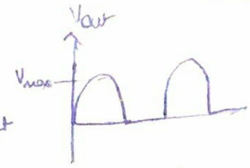
* when V_{in} has -ve half cycle the diode D is in reverse bias so all voltage drop across R_L.

$V_{out} = -V_{max}$

Ⓑ Negative clippers :- The clipper which removes the negative half cycle of the i/p voltage.

(I) Negative series clipper -

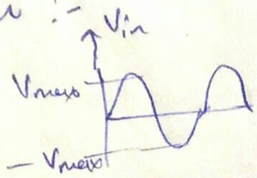


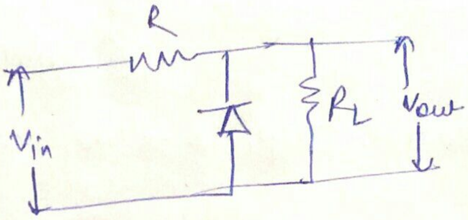


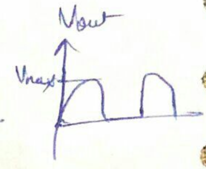
* for +ve half cycle diode D is in forward bias so $V_{out} = V_{max}$

* for -ve half cycle diode D is in reverse bais so R_L output $V_{out} = 0$

(II) Negative shunt clipper :-





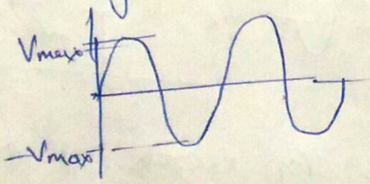


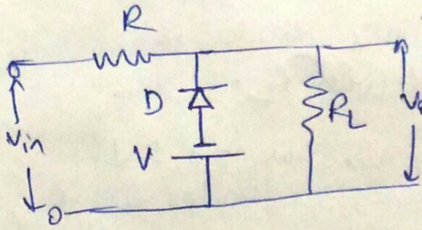
* for +ve half cycle D → Reverse bias so output across R_L $V_{out} = V_{max}$

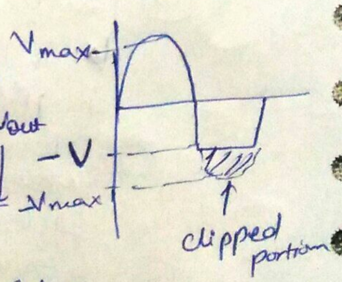
* for -ve half cycle D - forward bias so all voltage drop across diode & the output voltage across $R_L = 0$

(C) Biased clipper :- Sometimes it is desired to remove a small portion of positive or negative half cycle of the signal voltage. so at this condition we use biased clipper -

(i) Biased Negative clipper :-





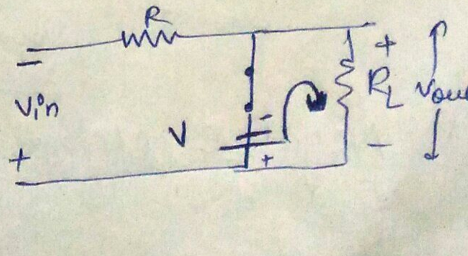


* for +ve half cycle - The diode is in reverse bias so voltage drop across R_L $V_{out} = V_{max}$

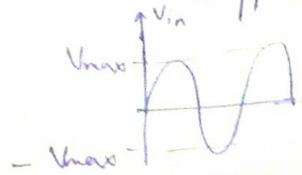
* for -ve half cycle → The diode is in forward bias

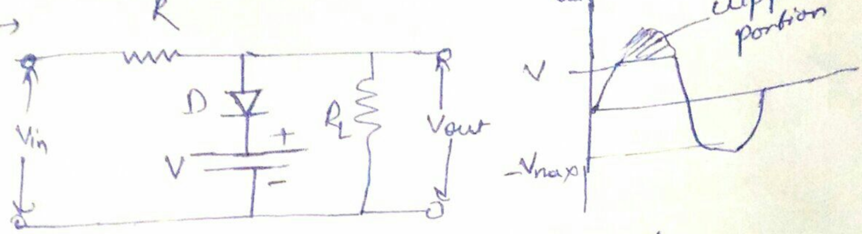
$-V - V_{out} = 0$

$V_{out} = -V$



(11) Biased Positive Clipper →

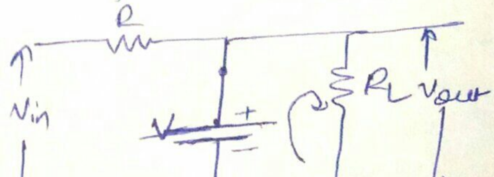




* for +ve half cycle → diode D is in forward biased

$V - V_{out} = 0$

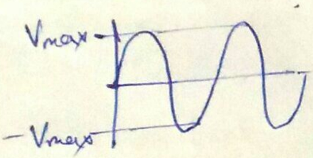
$$V_{out} = V$$

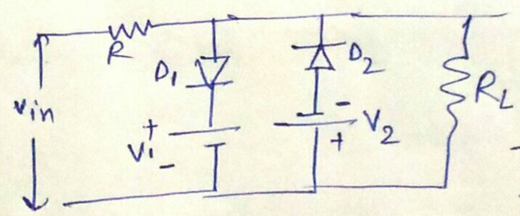


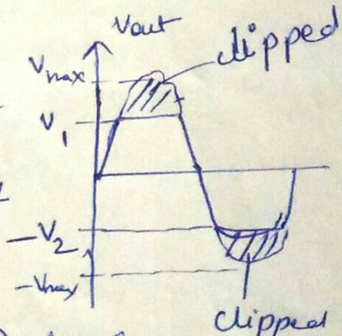
* for -ve half cycle → D is in reverse bias, all voltage drop across R_L

$$V_{out} = V_{max}$$

(D) Combination clipper → when a portion of both +ve & -ve of each half cycle of i/p is to be clipped combination clipper is employed.



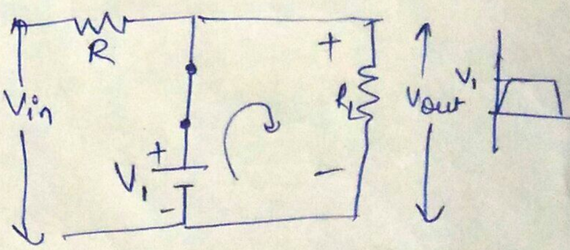




* when +ve half cycle of Vin → The diode D_1 is in forward bias while D_2 is in reverse bias so →

$V_1 - V_{out} = 0$

$$V_{out} = V_1$$



* when -ve half cycle of vin occurs - The diode D_1 is off (R.B.) & D_2 is ON (forward bias)

$-V_2 - V_{out} = 0$

$$V_{out} = -V_2$$