Electronic Devices and Circuits Lab
Experiment 6- Group 2

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Aim-

To design and understand the working of -

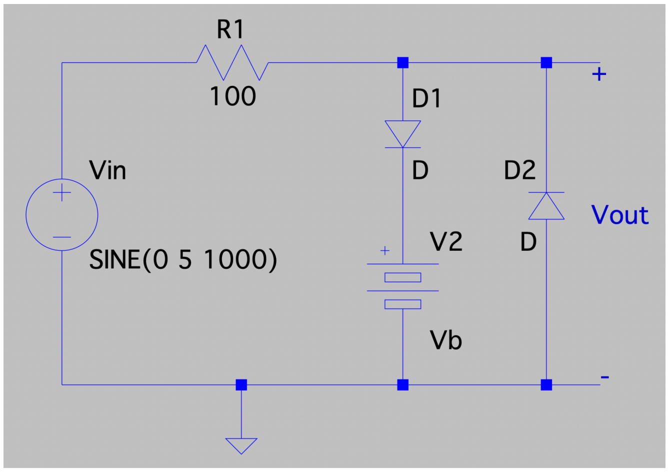
1) Clipper circuit with cutoff voltages as $V_1 = 1.5V$ and $V_2 = 2.2V$ with series resistance $R_S = 100\Omega$
2) Negative Clamper circuit with load resistance as $R_L = 10k\Omega$

Given the source voltage as $V_{in} = 5\sin(\omega t)$ and $f = 1kHz$.

Theory-

Clipper Circuits-

Clipper circuits are circuits which remove/clip off a portion of the input signal without causing any disturbance to the remaining part of the signal. They are used as protection devices which do not allow the voltage to exceed or reduce to a particular value, the upper limit is denoted as V_1 and lower limit is denoted as $-V_2$ (so that V_2 is positive). There are various types of clipper circuits which can be made using resistors, diodes, zener diodes and voltage sources. A classical example of a clipper circuit to obtain asymmetric clipping is shown below-



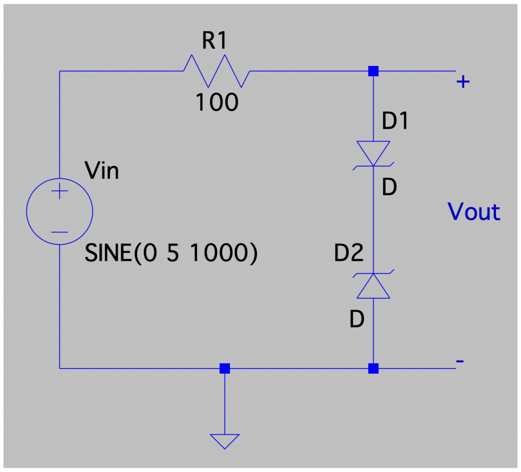
In this circuit when V_{in} is lesser than $V_b+0.7V$, the diode D1 is not forward biased enough to conduct current and so it acts as an open circuit with $V_{out}=V_{in}$.

When V_{in} exceeds $V_b+0.7V$ the diode D1 is in forward bias due to which it starts conducting and limits the output voltage to $V_b+0.7V$, so any voltage level above $V_b+0.7V$ is clipped off.

Similar thing happens when V_{in} is negative. When V_{in} is less than -0.7V the diode D2 is in forward bias due to which it starts conducting and limits the output voltage to -0.7V, so any voltage below -0.7V is clipped off. We can also add a battery in series with diode D2 to control the lower limit of cutoff voltage.

The use of a bias voltage means that the amount of the voltage waveform that is clipped off can be accurately controlled. But one of the main disadvantages of using voltage biased diode clipping circuits, is that they need an additional emf battery source.

So to overcome this we can use a zener diode. Zener diodes in forward bias act like any other diode in forward bias, i.e. it allows current to pass through it when the bias voltage is greater than 0.7V. But in reverse bias near the breakdown region the current increases sharply for a very small change in applied voltage, in other words it can keep the voltage constant across it even with a lot of current flowing through it. We can put this action to use for clipping the voltage by setting the breakdown voltage as the clipping voltage - forward bias voltage. Below is an example of a possible clipper circuit-



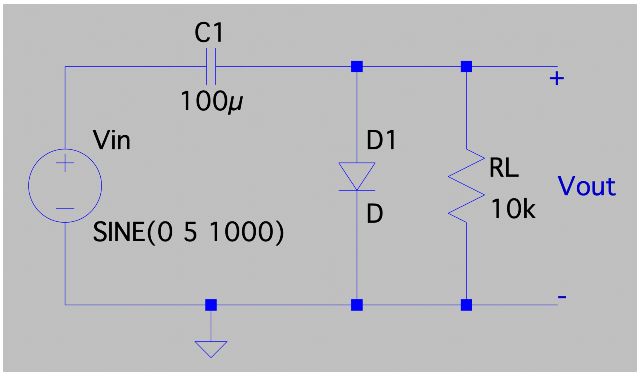
In this circuit when V_{in} (is positive) is lesser than $V_{BR,\ D2} + 0.7V$, $V_{out}=V_{in}$ since there is no conduction path as there is not enough voltage to reach the breakdown region of D2 even though D1 might be forward biased.

But when V_{in} is greater than $V_{BR,\ D2} + 0.7V$ the diode D2 has reached its breakdown region which enables it to conduct current and clip off the voltage to $V_{BR,\ D2} + 0.7V$.

When V_{in} (is negative) is greater than $-(V_{BR,\ D1} + 0.7V)$, $V_{out}=V_{in}$ and when V_{in} is lesser than $-(V_{BR,\ D1} + 0.7V)$, V_{out} is clipped to $-(V_{BR,\ D1} + 0.7V)$ for the same reasons as stated above.

Negative Clamper Circuits-

Clamper circuit is a circuit which shifts the input signal to a desired DC level without changing the shape of the input waveform. They are also called DC restorers. A negative clamper adds a negative DC voltage to the input voltage. This circuit can be made using capacitor, resistor and a diode. To reduce the transient effects of the capacitor we choose the values of R_L and C such that $R_LC >>$ Time Period of the input voltage. The circuit used for this experiment is given below-



In this circuit we assume that there is no charge on the capacitor and as the input voltage $V_{in}= 5\sin(\omega t)$ the circuit provides a clamp of almost 5V.

In the positive half of the first cycle-
Until $V_{in} < 0.7V$ the diode will not be in forward bias so it acts as an open circuit which allows the resistance to come into play. As the time constant was very high the capacitor does not gain any charge so $V_{out} = V_{in}$.

As soon as V_{in} exceeds 0.7V the diode will be in forward bias so it acts as a short circuit with voltage across it fixed at 0.7V (seen as a straight line). So the resistor is shorted and also during this time the capacitor also gets charged until V_{in} hits its maximum value, i.e. 5V.

So till $t = 0.25$ms the diode is forward biased and the capacitor is charged to 4.3V (5V - 0.7V) and voltage across the diode is 0.7V.

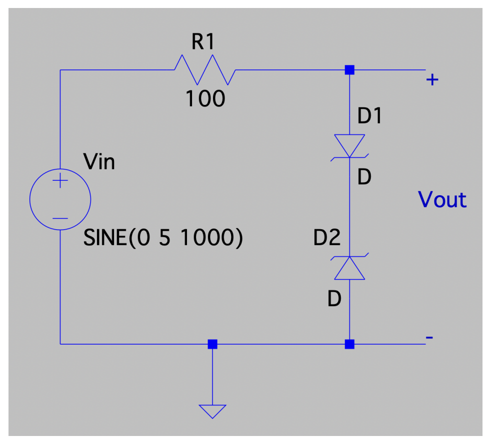
Now when V_{in} decreases from 5V, the voltage across the diode dips below 0.7V which causes it to behave as an open circuit as it is not in forward bias anymore.

Since the diode acts as an open circuit, it allows the resistor to come into play. As the resistance value is very high the capacitor loses an insignificant amount of charge which results in a constant voltage across the capacitor. So V_{out} will be equal to the voltage across the resistor which is $V_{out} = V_{in} - 4.3V = 5\sin(\omega t) - 4.3V$ (From KVL). This expression continues to be true even when the input voltage is in the negative half of the first cycle as the diode will never be in reverse bias.

In further cycles, the diode becomes forward biased when $V_{in} = 5V$ (which is momentary) and the capacitor retains its voltage at 4.3V, i.e. the output waveform is always shifted by 4.3V and not 5V due to the diode.

Procedure and Calculations-

Clipper Circuits-



Given that $V_1 = 1.5V$ and $V_2 = 2.2V$

From the above discussed theory we have $V_1 = V_{BR,\,D2} + 0.7V$ and $V_2 = V_{BR,\,D1} + 0.7V$

Substituting the above values we get -

$V_{BR,\,D2} = 0.8V$ and $V_{BR,\,D1} = 1.5V$

Here the forward bias voltage of both zener diodes is 0.7V.

Negative Clamper Circuits-

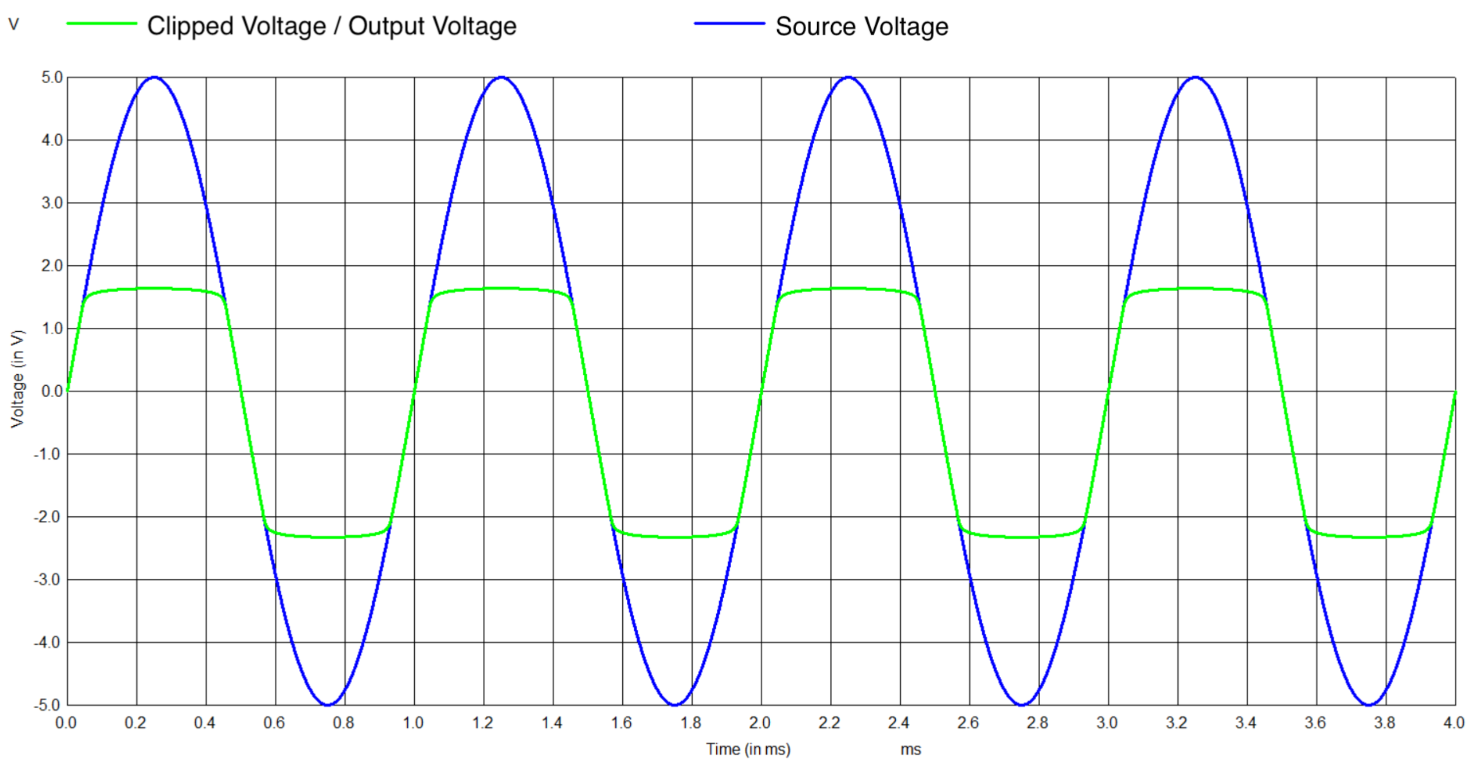
The circuit's time constant, $\tau = R_L C$ must be at least 10 times the time period of the input voltage for a good clamping circuit. Hence $R_L = 10k\Omega$ and $C = 100\mu F$.

Conclusions-

1) We can design clipper circuits with any clipping voltages just by changing the zener diodes.
2) Clipper circuits can be used to eliminate amplitude noise or voltage spikes and can also be used as safety devices so that voltage does not exceed some limit.
3) The time constant of a clamper circuit must be high enough to eliminate the transient effects.
4) Clamper circuits can be used as DC restorers.

Plots-

For Clipper Circuit-



For Negative Clamper Circuit-