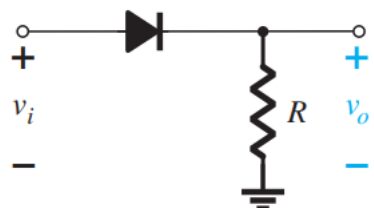
American International University- Bangladesh
Faculty of Engineering (FE)
Department of Electrical and Electronic Engineering (EEE)
EEE 2104: Electronic Devices Lab

Title of the Experiment: Study of Diode Clipping and Clamping Circuits.

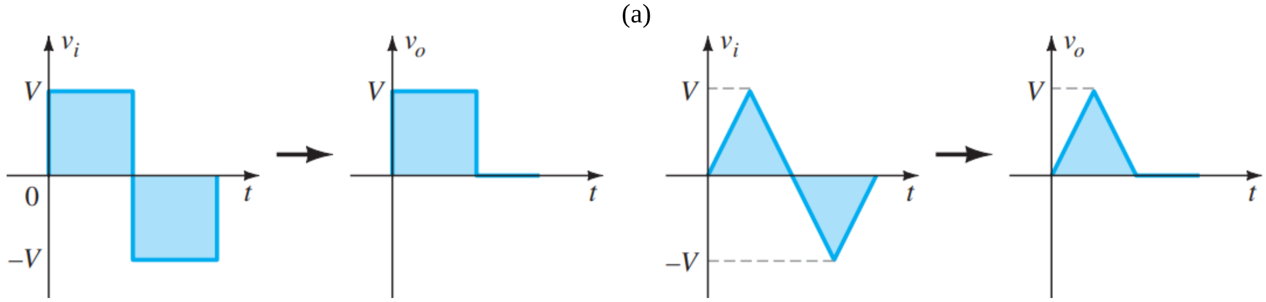
Objectives:
The objectives of this experiment are to
1. Study clipper circuits.
2. Study of clamper circuits.

Theory:
In electronics, a **clipper** is an electronic circuit designed to prevent the output of a circuit from exceeding a predetermined voltage level without distorting the remaining part of the applied waveform. On the other hand, a **clamper** is an electronic circuit that fixes either the positive or the negative peak excursions of a signal to a defined value by shifting its DC value.
Clippers are networks that employ diodes to "clip" away a portion of an input signal without distorting the remaining part of the applied waveform. Depending on the orientation of the diode, the positive or negative region of the applied signal is "clipped" off. There are two general categories of clippers:
1. Series clipper.
2. Parallel clipper.

Series Clipper:
The series configuration is defined as one where the diode is in series with the load as shown in Fig. 1 (a). This circuit is divided into two types, such as unbiased and biased series clipper circuits.
Figure 1 (a) shows the unbiased series clipper circuit, where no DC supply is connected in series with the diode. The response of the unbiased series configuration of Fig. 1 (a) to a variety of alternating waveforms is provided in Fig. 1 (b).



(a)



(b)

Figure 1: Unbiased series clipper: (a) Circuit diagram; (b) Input-output wave shapes (rectangular and triangular).

Figure 2 (a) shows the biased series clipper circuit, where a DC supply is connected in series with the diode. The response of the biased series configuration of Fig. 2 (a) to sinusoidal waveform is provided in Fig. 2 (b).

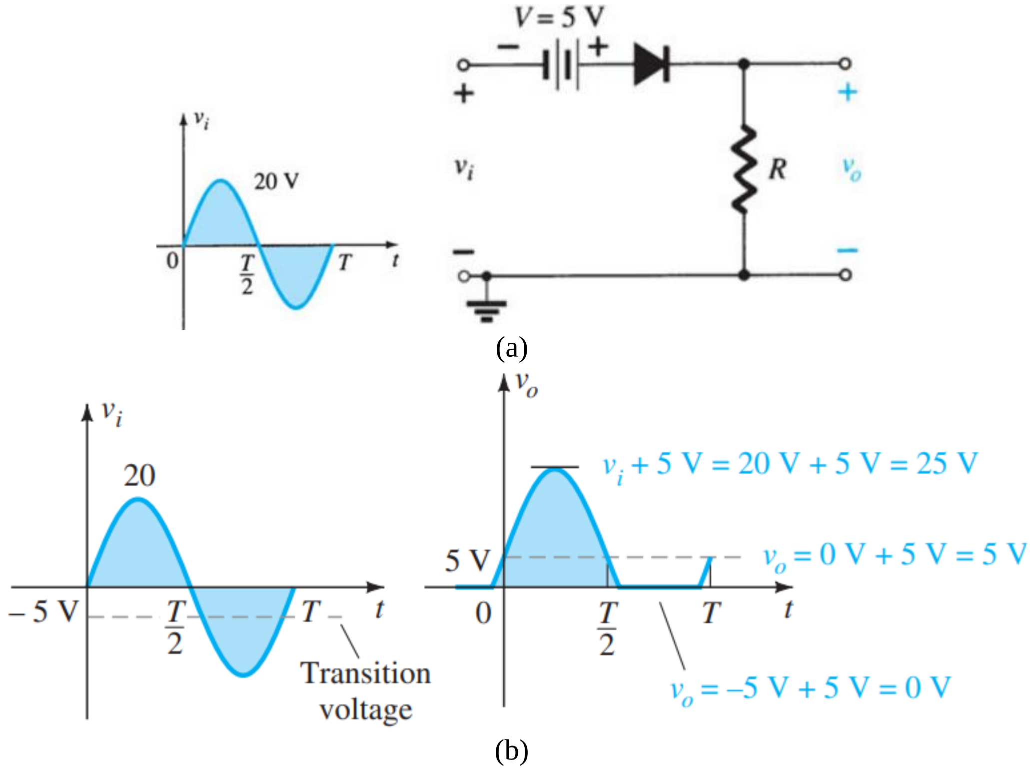


Figure 2: Biased series clipper: (a) Circuit diagram; (b) Input-output wave shapes (sinusoidal).

Parallel Clipper:
The network of Fig. 3 (a) is the simplest of parallel diode configurations with the output for the same inputs as in Fig. 1 (b). The parallel clipper has the diode in a branch parallel to the load. The analysis of parallel configurations is very similar to that applied to series configurations. This circuit is divided into two types, such as unbiased and biased parallel clipper circuits. Figure 1 (a) shows the unbiased parallel clipper circuit, where no DC supply is connected in series or parallel with the diode. The response of the unbiased parallel configuration of Fig. 3 (a) to a variety of alternating waveforms is provided in Fig. 3 (b).

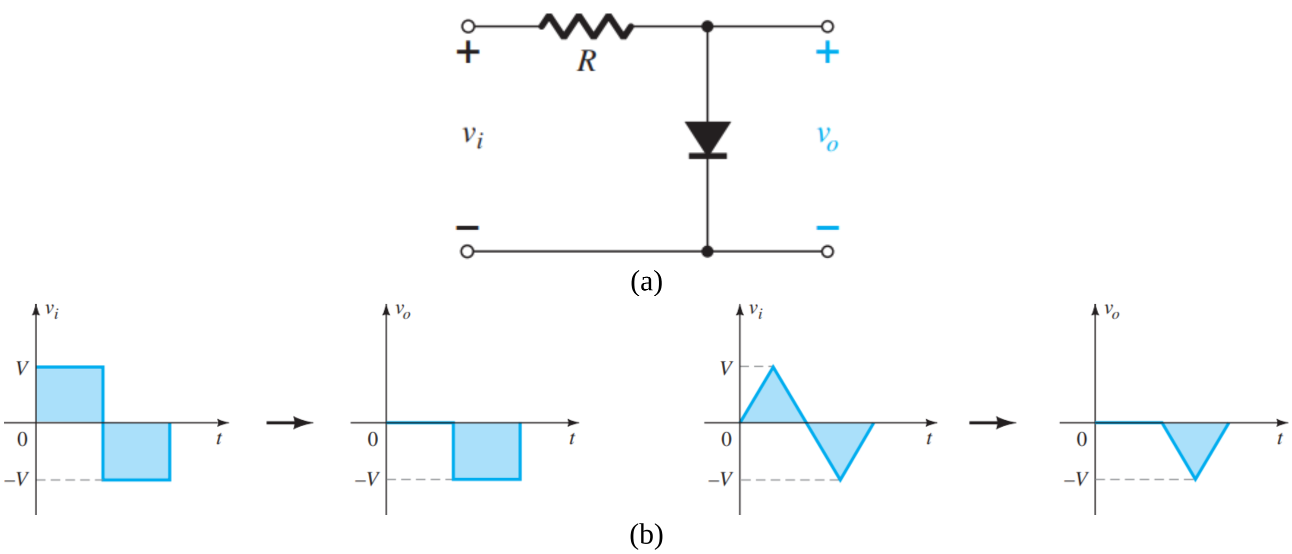
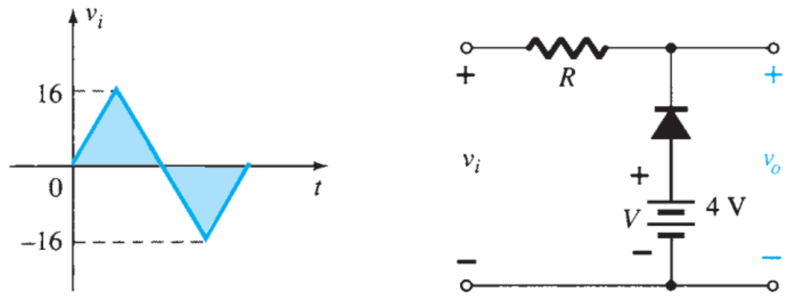
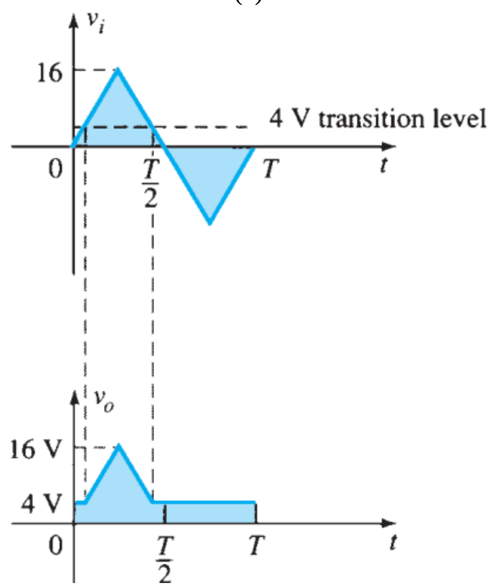


Figure 3: Unbiased parallel clipper: (a) Circuit diagram; (b) Input-output wave shapes (rectangular and triangular).

Figure 4 (a) shows the biased parallel clipper circuit, where a DC supply is connected in series with the diode. The response of the biased parallel configuration of Fig. 4 (a) to sinusoidal waveform is provided in Fig. 4 (b).



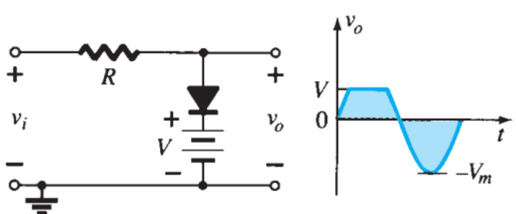
(a)



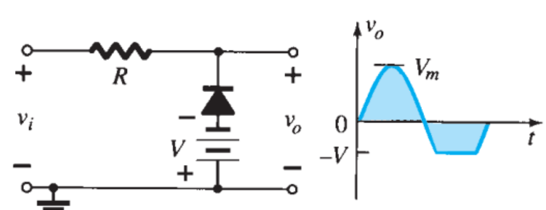
(b)

Figure 4: Biased parallel clipper: (a) Circuit diagram; (b) Input-output wave shapes (triangular).

Figure 5 (a) shows the **biased parallel positive clipper circuit**, where a DC supply is connected in series with the diode to clip off the positive half-cycle of the wave with its response curve. Figure 5 (b) shows the **biased parallel negative clipper circuit**, where a DC supply is connected in series with the diode in reverse direction to clip off the negative half-cycle of the wave with its response curve. Figure 5 (c) shows the **biased parallel dual clipper circuit**, where a DC supply is connected in series with the diode to clip off both the positive and negative half-cycles of the wave with its response curve. Here, sinusoidal input voltage is used.



(a)



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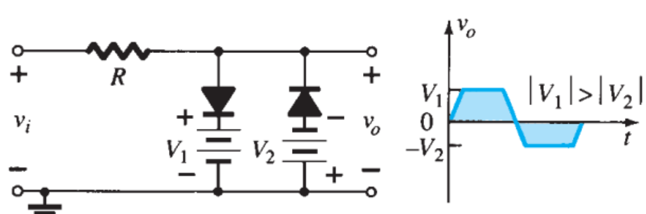


(c)

Figure 5: Biased parallel clipper circuit diagram and waveshapes: (a) Positive clipper; (b) Negative clipper; (c) Both sides clipper.

Clamper:

A clamper is a network constructed of a diode, a resistor, and a capacitor that shifts a waveform to a different DC level without changing the appearance of the applied signal. Additional shifts can also be obtained by introducing a DC supply to the basic structure. The chosen resistor and capacitor of the network must be chosen such that the time constant determined by the time constant, $\tau = RC$ is sufficiently large to ensure that the voltage across the capacitor does not discharge significantly during the interval the diode is nonconducting. Throughout the lab experiment, we assume that the capacitor fully charges or discharges within five time constants (5τ). The clamper circuits can be used to restore DC levels in communication circuits that have passed different filters.

Clamping networks have a capacitor connected directly from input to output with a resistive element in parallel with the output signal. The diode is also in parallel with the output signal but may or may not have a series DC supply as an added element. There are two types of clamper circuits:

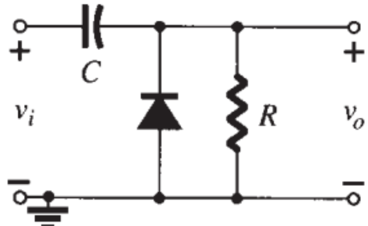
1. Positive clamper circuit
2. Negative clamper circuit

Besides, each type again may be divided into further two types, such as-

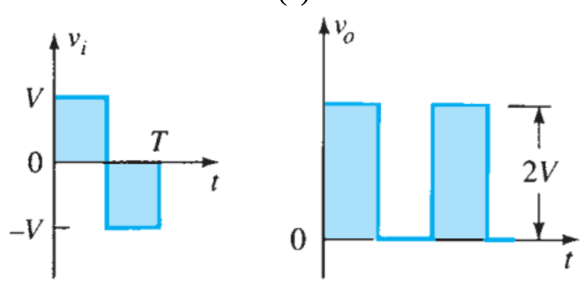
1. Unbiased positive clamper circuit
2. Unbiased negative clamper circuit
3. Biased positive clamper circuit
4. Biased negative clamper circuit

Positive Clamper:

An unbiased positive clamper circuit adds positive DC voltage level (the output waveform is identical to that of the input, but the lowest peak clamped to zero) as shown in Fig. 6 (a) and (b). The biased positive clamper takes the DC level to a more positive direction depending on the applied DC voltage connected in series with the diode as shown in Fig. 7 (a) and (b).

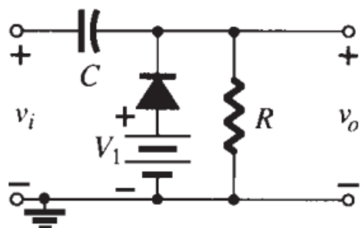


(a)

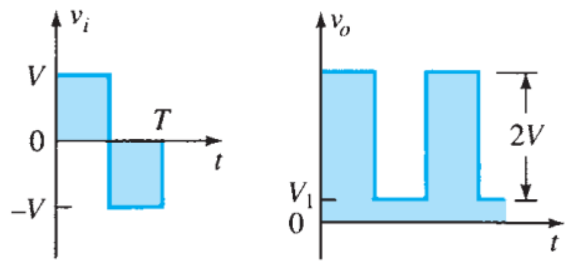


(b)

Figure 6: Unbiased positive clipper: (a) Circuit diagram; (b) Input-output wave shapes (square).



(a)

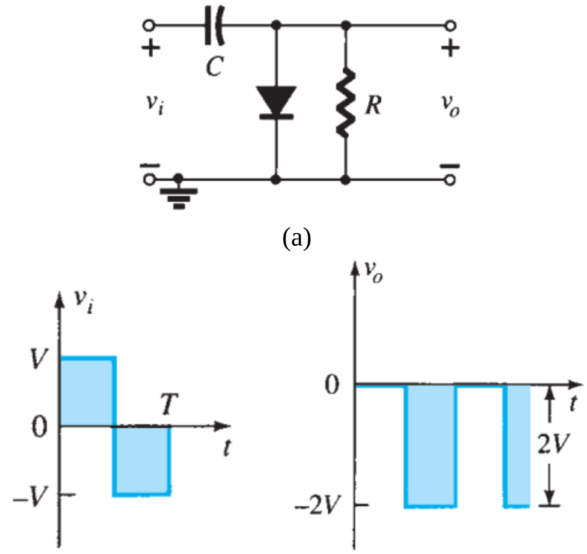


(b)

Figure 7: Biased positive clipper: (a) Circuit diagram; (b) Input-output wave shapes (square).

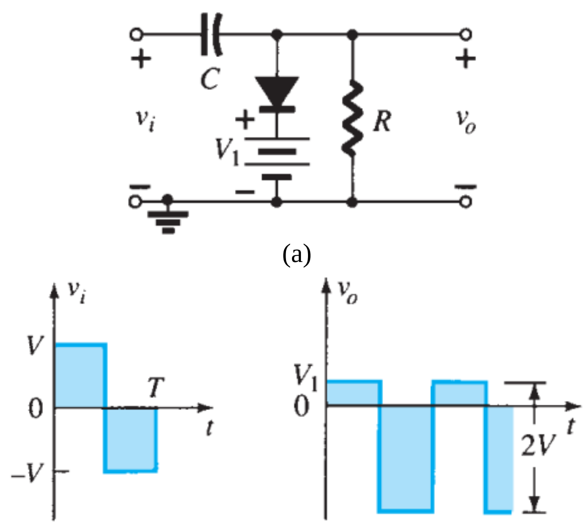
Negative Clamper:

An unbiased negative clamper circuit adds negative DC voltage level (the output waveform is identical to that of the input, but the lowest peak clamped to zero) as shown in Fig. 8 (a) and (b). The biased negative clamper takes the DC level to a more negative direction depending on the applied DC voltage connected in series with the diode as shown in Fig. 9 (a) and (b).



(b)

Figure 8: Unbiased negative clipper: (a) Circuit diagram; (b) Input-output wave shapes (square).



(b)

Figure 9: Biased negative clipper: (a) Circuit diagram; (b) Input-output wave shapes (square).

Pre-Lab Homework:
Students will be provided with the upcoming lab manuals, and they will be asked to prepare the theoretical (operations/working principle) information on the topic from the textbook.
Besides, they must implement the circuit (as given in Figures 1-8) using a MultiSIM simulator. Observe the input-output wave shapes and take the snapshots using the snipping tool. Measure the values of different key parameters and fill up the tables (Tables 1 and 2) based on the simulation results.

Apparatus:

SL#	Apparatus	Quantity
1	Diode	1
2	Resistance (1 kΩ, 10 kΩ)	1 each
3	Capacitors (10 and 22 μF)	1 each
4	Pencil Battery with battery case	2+1
5	Project Board	1
6	Function Generator	1
7	Oscilloscope	1
8	Multimeter	1
9	Connecting Leads	10

Precaution!
The following is a list of some of the special safety precautions that should be taken into consideration when working with diodes:

1. **Never remove or insert a diode into a circuit with voltage applied.**
2. **Ensure a replacement diode into a circuit is in the correct direction.**
3. **Make sure the correct connection of the transformer.**
4. **When testing a diode, ensure that the test voltage does not exceed the diode's-**
   a. **Maximum allowable voltage.**
   b. **Ensure a replacement diode into a circuit is in the correct direction.**

Experimental Procedures:

1. Measure the actual value of the 1 kΩ resistor.
2. Connect the circuit as shown in Figure 1 (a).
3. Turn on the AC power supply (function generator) with the voltage control nob at 0 V.
4. Rotate the amplitude control nob from 0 V to 10 V (maximum voltage) gradually.
5. Select the sinusoidal waveform and set the frequency to 100 Hz.
6. Connect the oscilloscope to observe the wave shapes of the input and output voltages in the dual channel mode of the oscilloscope across the load.
7. Measure the peak AC voltage of the input and output waves from the oscilloscope screen. Record the images of the wave forms.
8. Vary the input signals' amplitude and frequency and observe the effects of variation.
9. Change the wave shapes from sinusoidal to triangular and rectangular. Observe the input and output voltages on the oscilloscope screen. Measure the peak AC voltage of the input and output waves. Record the images of the wave forms.
10. Record the measured data in Table 1.
11. Turn off the power supply.
12. Connect the circuits as shown in Figures 2 (a) to 9 (a). Then repeat steps 3-11, but record data in Tables like Table 1.

Table 1 Data Table for the Circuit of Figure 1 (a) – 5 (a)

Wave Shape	Peak Input Voltage, V_i (V) (From Oscilloscope)	Peak Output Voltage, V_o (V) (From Oscilloscope)
Sinusoidal		
Triangular		
Rectangular		

Table 2 Data Table for the Circuit of Figure 6 (a) – 9 (a)

Wave Shape	Peak Input Voltage, V_i (V) (From Oscilloscope)	Peak Output Voltage, V_o (V) (From Oscilloscope)
Rectangular		

Questions:

1. Show the difference between your simulated and measured values. Comment on the results and interpret the experimental and simulation data.
2. Take the images from the oscilloscope screen and present them in the lab report. Explain the outputs.
3. What are the effects of varying the input signal's amplitudes, frequency, and types of DC bias voltage?
4. What is the difference between diode-based clipper and clamper circuits?
5. Discuss the overall aspects of the experiment. Did your results match the expected ones? If not, explain.

References:

[1] Robert L. Boylestad, Louis Nashelsky, Electronic Devices and Circuit Theory, 9th Edition, 2007-2008

[2] Adel S. Sedra, Kenneth C. Smith, Microelectronic Circuits, Saunders College Publishing, 3rd ed., ISBN: 0-03-051648-X, 1991.

[3] American International University–Bangladesh (AIUB) Electronic Devices Lab Manual.

[4] David J. Comer, Donald T. Comer, Fundamentals of Electronic Circuit Design, John Wiley & Sons Canada, Ltd., ISBN: 0471410160, 2002.

[5] Resistor values: *https://www.eleccircuit.com/how-to-basic-use-resistor/*, accessed on 20 September 2023.

List the references that you have used to answer the "Discussion" section.

Appendix A:

Steps for analyzing the clipper circuit:

Step 1: Take careful note of where the output voltage is defined.

Step 2: Try to develop an overall sense of the response by simply noting the "pressure" established by each supply and the effect it will have on the conventional current direction through the diode.

Step 3: Determine the applied voltage (transition voltage) that will result in a change of state for the diode from the "off" to the "on" state.

Step 4: It is often helpful to draw the output waveform directly below the applied voltage using the same scales for the horizontal axis and the vertical axis.

Steps for analyzing the clamper circuit:

Step 1: Start the analysis by examining the response of the portion of the input signal that will forward bias the diode.

Step 2: During the period that the diode is in the "on" state, assume that the capacitor will charge up instantaneously to a voltage level determined by the surrounding network.

Step 3: Assume that during the period when the diode is in the "off" state the capacitor holds on to its established voltage level.

Step 4: Throughout the analysis, maintain a continual awareness of the location and defined polarity for v_o to ensure that the proper levels are obtained.

Step 5: Check that the total swing of the output matches that of the input.

