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Daffodil International University

Department of Electronics and Telecommunication Engineering

Course Code: ETE 214

Experiment No: 01

Name of the experiment: I-V characteristics of diode

Objective:

The objective of this experiment is to study the forward characteristics of Diode.

Theoretical Background:

A diode is a bi-polar device that can be thought as an ordinary switch. Its action (ON/OFF) depends on the polarity at which it is connected in circuit. As shown in the figure 1-1(a) the diode has negative polarity marked by the ring on one side of the device (this side is called n-side of diode) and positive polarity on the other side (this side is called p side).

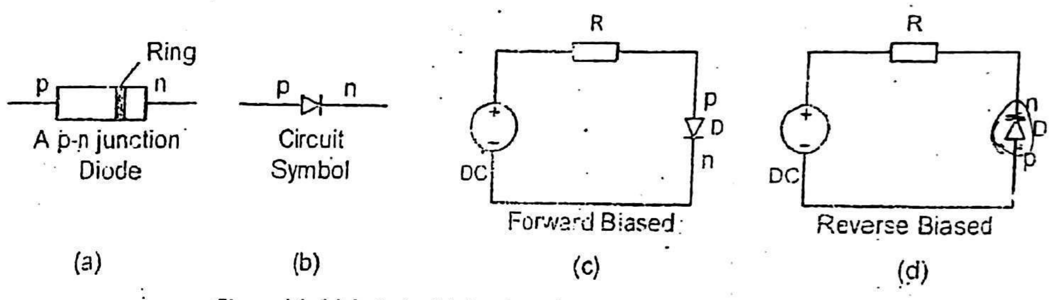
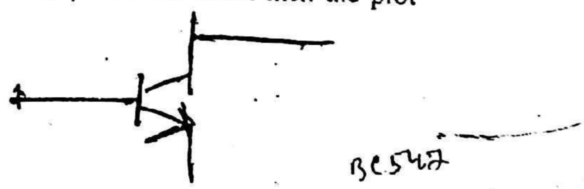
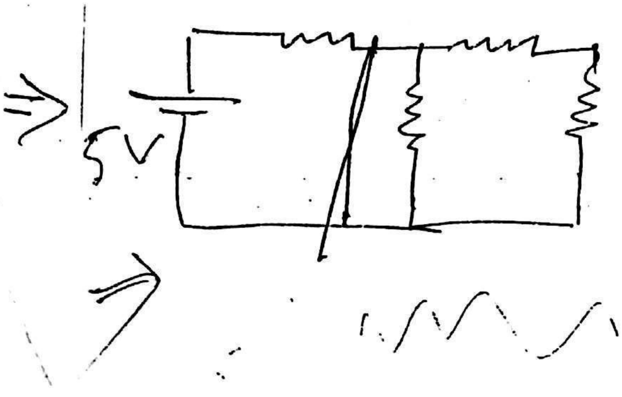


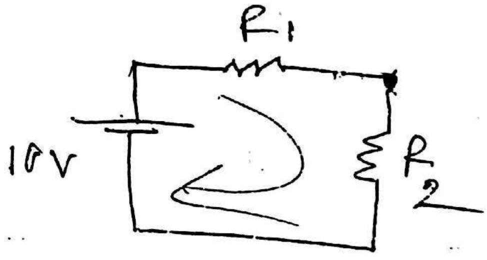
Figure 1-1: (a) A diode, (b) circuit symbol, (c) & (d) biasing condition

When the diode is connected across a voltage source with positive polarity of the source connected to p-side of the diode and negative polarity to n-side, the diode is said to be ***forward biased*** [figure 1-1(c)] and it acts like a closed (short circuit) switch and *ideally* it offers no resistance to the current path. If the polarity is reversed then the diode is said to be ***reverse biased*** [figure 1-1(d)] and it acts like open switch and *ideally* it dose not allow any current to pass through.

However a practical diode does not comply with the ideal one. If the voltage across the diode is varied and current through diode corresponds to each voltage value are taken then the plot of current vs. voltage will be as follows:







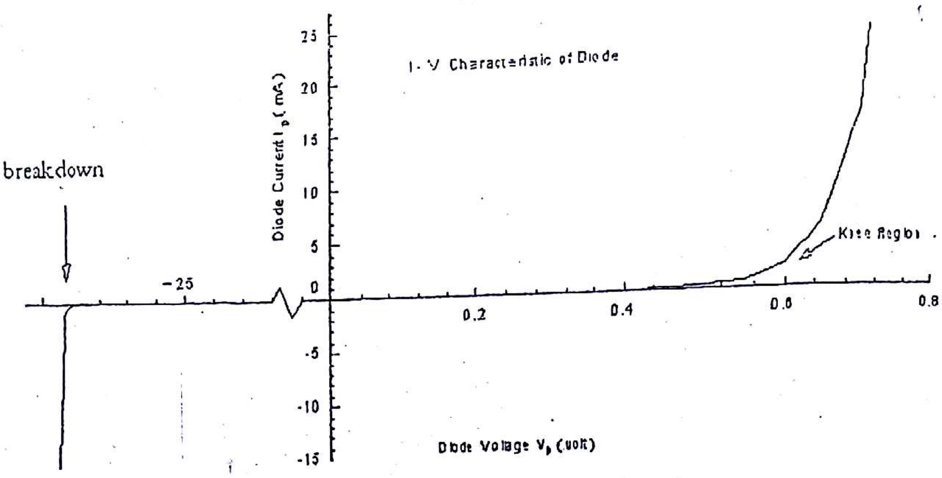


Figure 1-2: I-V Characteristics of Diode

This is known as the ***I-V characteristic of diode.*** From this characteristic we observe the followings:

The right side of the curve ($V_D > 0$) represents the 'forward biased' mode.

The left side of the curve ($V_D < 0$) represents the 'reverse biased' mode.

For the 'forward bias mode' we see that the diode current increases gradually at low V values then rises sharply after a particular value of V. This suggests that we can think a forward biased diode as a closed switch only beyond that particular voltage. This voltage, which is represented by the knee portion of the curve, is known as ***cut-in voltage*** of a diode. For *Si* (Silicon) diode it is near about 0.6 volt and for *Ge* (Germanium) diode it is near about 0.3 volt.

From the 'reverse bias portion' (left side of the curve) we see that the diode current is almost zero up to a modest range of voltage V. Beyond that the current increases almost infinitely implies that the diode will be burnt out at this voltage. This situation is known as ***reverse breakdown of diode*** and is always avoided.

For a given applied voltage diode will operate on a particular point on the characteristic curve called 'Q' point or quiescent point.

Applied DC voltage to a circuit containing a semiconductor diode will result in an operating point on the characteristic curve that will not change with time. The resistance of the diode at that operating point is called static resistance.

$$R_d = \frac{V_d}{I_d}$$

If AC voltage is applied, Q point will change with the applied voltage. A straight line drawn tangent to the curve through the Q point will define a particular change in voltage and current that can be used to determine the dynamic resistance.

$$r_d = \frac{V_d}{i_d}$$

Equipments and Components:

A. Equipment

- Variable dc power supply (0 ~ 30 volt) — 1 unit
- Multimeter — 1 unit

B. Components

- p-n junction diode (1N4003) — 1 piece
- Resistance (1kΩ, ¼ watt.) — 1 piece

Experimental Setup:

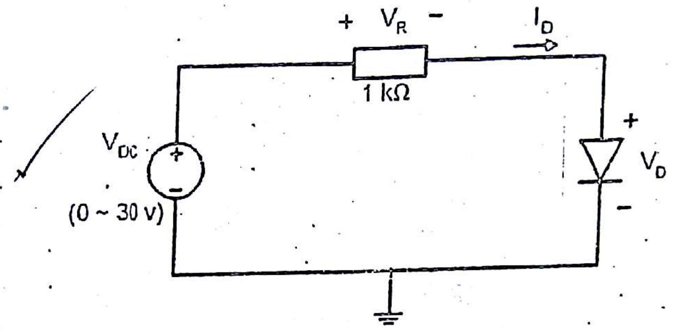


Figure 1-3: Experimental setup

Procedure:

Step 1: Measure the value of resistance accurately using multimeter.

Step 2: Construct the circuit as shown in Figure 1-3. Always turn on the power keeping the variable dc supply at 0 volt.

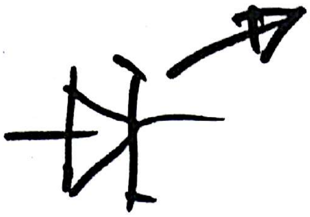
Step 3: Vary input voltage V_{DC} (slightly) so that the voltage across the diode appears 0.1 volt. At this stage measure V_R and V_D. Note down the readings in the table. Determine the diode current I_D (in this case the same current flows through 'R') using the following:

$$I_D = \frac{V_R}{R}$$

Step 4: Repeat step 3 for every values of V_D (as given in the table 1-1). Each time you have to adjust the supply voltage.

Step 5: Now reverse the polarity of the dc power supply and repeat steps 2 and 3 to complete table 1-2.

V_D (volts)	V_{DC} (volts)	V_R (volts)	I_D (mA)
–1.0			
–2.0			
–3.0			
–4.0			
–5.0			
–6.0			
–7.0			
–8.0			
–9.0			
10.0			



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Daffodil International University

Department of Electronics and Telecommunication Engineering

Course Code: ETE 214

Experiment No: 02

Name of the experiment: Study of Zener diode characteristics

Theoretical Background:

The diodes we have studied before do not operate in the reverse breakdown region because this may damage them. A *zener diode* is different; it is a silicon diode, which is manufactured to be operated in the breakdown region. It is used to build voltage regulator circuits that hold the load voltage almost constant despite large change in *line voltage* and *load resistance*. Figure 1 shows the symbol of the zener diode.

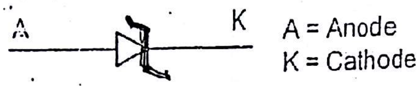
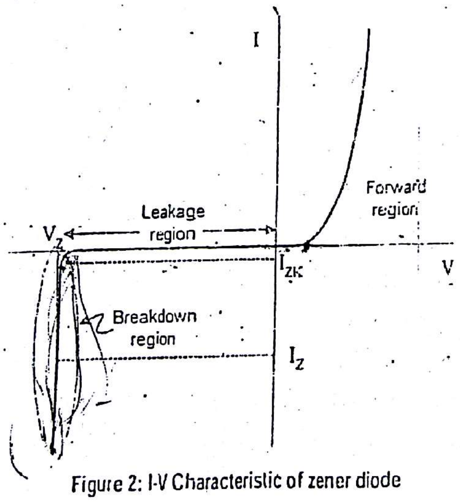


Figure 1: Circuit symbol of zener diode

I-V characteristic curve:



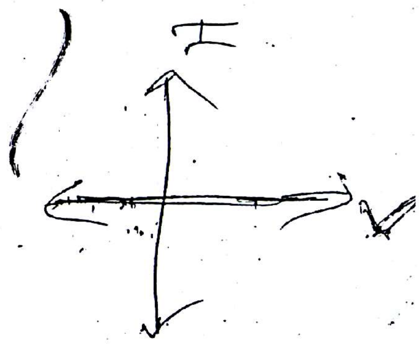


Figure 2: I-V Characteristic of zener diode

1 KΩ

1K

The zener diode can have a breakdown voltage ranging from about 2 volts to 200 volts. These diodes can operate in any of the three regions: forward, leakage and breakdown. Figure 2 shows the I-V graph of *Zener diode*. Though a zener diode can be operated in any of the three regions, it is intended to be used in breakdown region.

- In the forward region it works as an ordinary diode.
- In the leakage region (between zero and breakdown) it has only a small reverse current.
- In the breakdown it has a sharp knee, followed by an almost vertical increase in current. The voltage is almost constant, approximately equal to V_Z over most of the breakdown region.

Zener resistance:

When a zener is operating in the breakdown region, an increase in current produces a slight increase in voltage. That is it has a bulk resistance in the p and n region.

Characteristics:

- It maintains a constant output voltage even though the current through it changes.
- For normal operation, it is connected in reverse bias condition.
- To get the breakdown operation, the source voltage must be greater than the zener breakdown voltage.

Approximation:

First approximation: As the voltage remains constant across the zener though the current through it changes, it is considered as a voltage source according to the first approximation.

Second approximation: A zener resistance is in series with an ideal battery approximated.

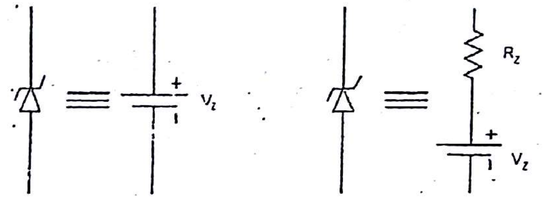


Figure 3: (a) First approximation; (b) Second approximation

Equipments and Components:

A. Equipment

Digital Multi-Meter	1 unit
Trainer Board	1 unit
Power supply	1 unit

B. Components

Zener diode (5 volt)	1 piece
Resistance (220 Ω, 470 Ω, 1 KΩ)	1 piece each
Potentiometer (10 KΩ)	1 piece

Experimental Setup:

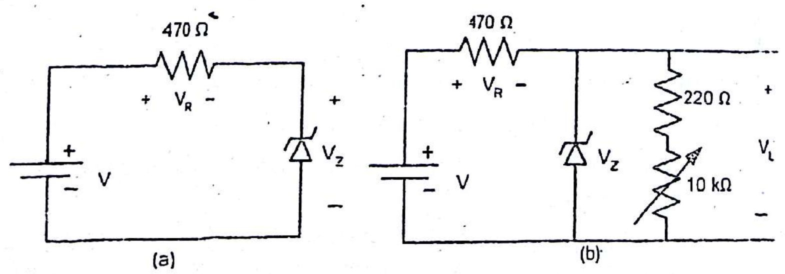


Figure 4: (a) Setup 1; (b) Setup 2

Procedure:

Step 1: Connect the circuit as shown in the figure 4(a).

Step 2: By varying the supply voltage V take necessary data and complete table 4-1.

Step 3: Connect the circuit as shown in the figure 4-4(b). (Load =220 Ω + 10 KΩ POT)

Step 4: Applying 10 volts as V and keeping the POT at maximum resistance position power up the circuit.

Step 5: Gradually decrease the POT resistance and complete the table 4-2.

Step 6: Replace Load with a 1 KΩ resistance, vary the supply voltage and take reading for table 4-3.

Data:

Resistance: R_{470} =......................

Table 1

Supply Voltage V (volts)	Voltage across Resistance V_R (volt)	Zener Voltage V_Z (volt)	Zener Current $I_Z = V_R/R_1$ (mA)
1.0			
2.0			
3.0			
4.0			
4.5			
5.0			
6.0			
7.0			
8.0			
10.0			
11.0			
12.0			

Table 2

R_{220} =..........................

=........................

V_R(mV)	V_L	I_L

Table 3

R_{1K}

V (volts)	V_L
5.0	
6.0	
7.0	
8.0	
9.0	
10.0	
11.0	
12.0	

Report:

1. Plot the V-I characteristics of the zener diode. Determine the zener breakdown voltage from the plot.
2. Plot V_L vs. I_L for the data of table 2. Find the voltage regulation.
3. Plot V_L vs. V for the table 3. Find the voltage regulation.
4. Discussion

Daffodil International University
Department of Electronics and Telecommunication Engineering
Course Code: ETE 214
Experiment No: 03
Name of the experiment: Study of Diode Rectifiers

Theoretical Background:

A rectifier converts an AC voltage into a DC voltage. From the diode characteristic curve it is known that a diode works like a switch. In the forward bias condition it becomes ON and OFF in the reverse bias condition. If an AC voltage is applied across a diode only one half-cycle will be conducted due to the ON action, other half cycle will be clipped off. In the output the load will get DC.

Diode rectifier can be of two types. They are-

a) Half-wave rectifier,
b) Full-wave rectifier.

Half-wave rectifier:

Half-wave rectifier circuit can be built by using a single diode as was discussed earlier. The circuit diagram and the wave shapes of the input and output voltage are shown below:

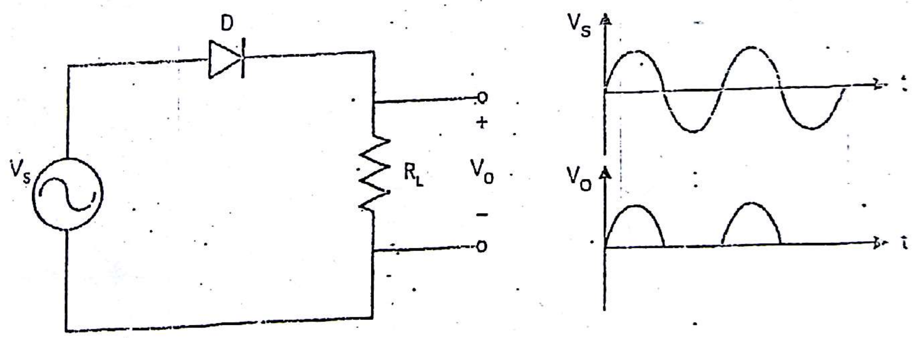


Figure 1: Half wave rectifier

- In this circuit the load receives approximately half of the input power,
- Average dc voltage is very low,
- Due to the presence of ripple output voltage is not smooth one.

Full-wave rectifier:

In the full-wave rectifier both the half cycle is present in the output. Following two circuits are used as full-wave rectifier:

a) Full-wave rectifier using center-tapped transformer and
b) Full-wave bridge rectifier.

Using a center-tapped transformer: Two diodes will be connected to the ends of the transformer and the load will be between the diode and the center tap. The circuit diagram and the wave shapes are shown in figure 2:

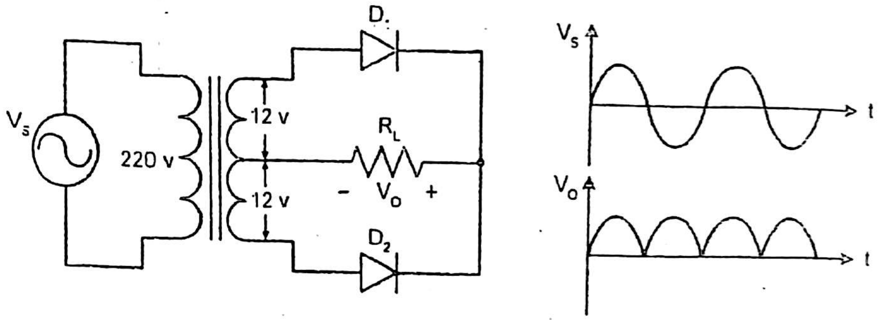


Figure 2: Full wave rectifier using center tapped transformer

This circuit has some advantages over the first one:

- Wastage of power is less,
- Average DC output increase significantly,
- Wave shape becomes smoother.

Disadvantages are:

- Require more space and becomes bulky because of the transformer.

Bridge rectifier: a bridge rectifier overcomes all disadvantages described above.

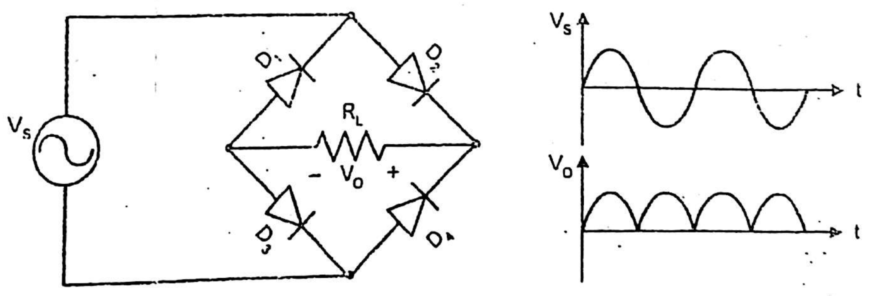
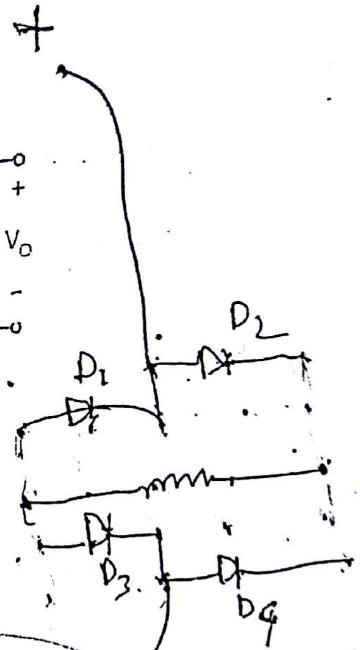


Figure 3: Bridge rectifier

... smooth dc voltage. It produces some ripple in

B. Component

- Resistance (10k) — 1 piece
- Capacitor (100μF, 47μF) — 1 piece each
- Diode (1N4003) — 4 pieces



Experimental Setup:

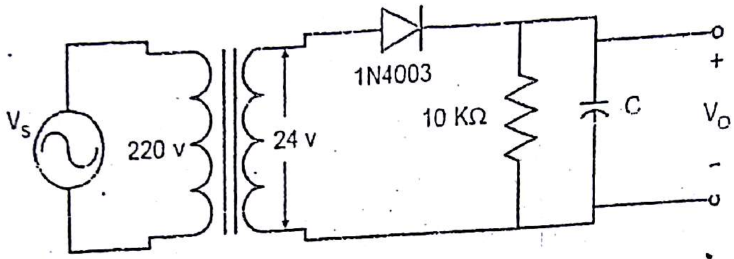


Figure 4: Practical half wave rectifier

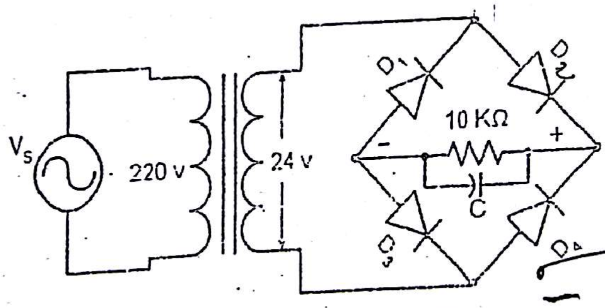
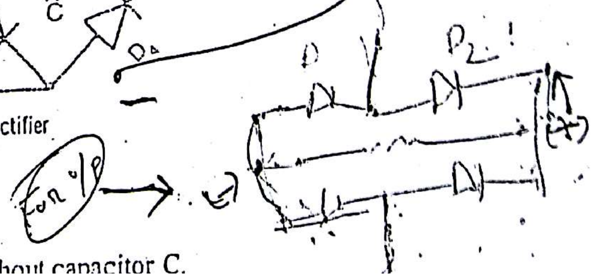


Figure 5: Full wave bridge rectifier



Procedure:

... figure 4 but without capacitor C.

Data:

Table 1: Data for half wave rectifier of fig 4

	V_o (Oscilloscope) volts	V_o (Multimeter) volts
No capacitance		
47 μF capacitance		

Table 3: Data for full wave rectifier of fig 5

	V_o (Oscilloscope) volts	V_o (Multimeter) volts
No capacitance		
47 μF capacitance		
100 μF Capacitance		

Report:

4. Draw all the observed wave shapes at least for two cycles:

(a) Input wave shape

(b) Half wave unfiltered

(c) Half wave filtered with 47μF

(d) Full wave unfiltered (Bridge rectifier)

(e) Full wave filtered with 47μF (Bridge rectifier)

(f) Full wave filtered with 100μF (Bridge rectifier)

5. What are the effects and significance of using filter capacitor?

6. Discussion

Theoretical Background:

Clipper:

- Clippers remove signal voltage above and bellow a specified level. In the last experiment, half wave rectifier can also be called as a clipper circuit. Because it clipped off the negative half cycle of the input signal.
- A diode connected in series with the load can clipped off any half cycle of the input depending on the orientation of the diode (figure 1).

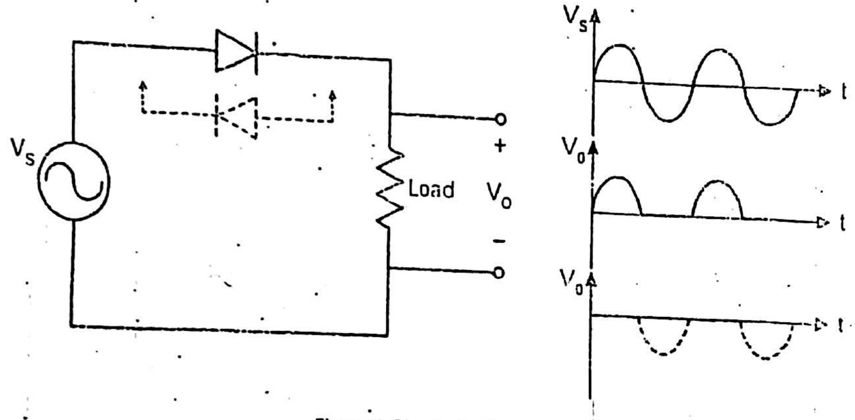


Figure 1: Simple diode clipper

- It is also possible to clip off a certain part of the input signal bellow a specified signal level by using a voltage source in reverse bias condition with the diode. If a battery of V volts is added to it, then for V_S above (V+0.7) volts the diode becomes forward bias and turns ON. The load receives power above this voltage level.

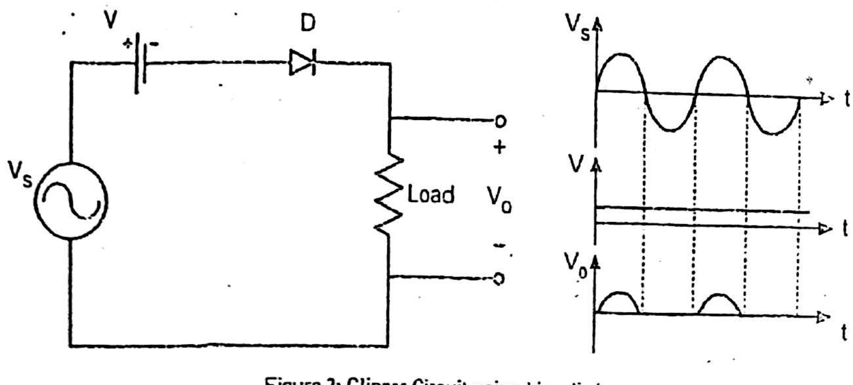


Figure 2: Clipper Circuit using bias diode

- A diode connected in parallel with the load can clip off the input signal above 0.7 v to any one half cycle depending on the connection of the diode. Using two diodes in parallel and in opposite direction both the half cycle can be limited to a 0.7 v.

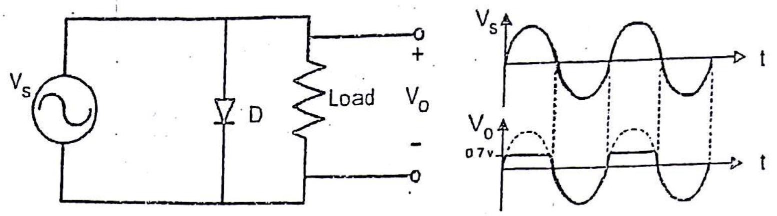


Figure 3: Parallel Clipper Circuit and its output

- Using a biased diode it is possible to limit the output voltage to a specified level depending on the attached battery voltage. Either the half cycles or both of them can be clipped off above a specified level.

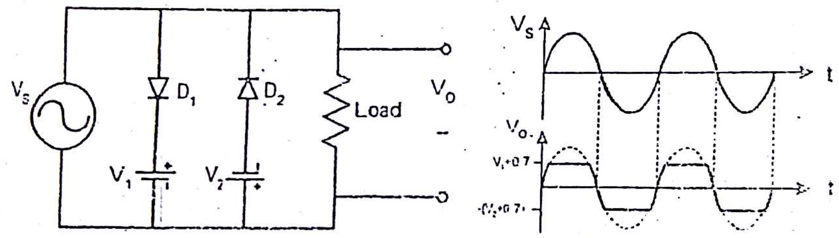


Figure 4: Biased Parallel Clipper and its output

In practical case for both the series and parallel clippers voltage source is not added. Required voltage levels are maintained by adding more semiconductor diode.

Clamper:

A dc clamper circuit adds a dc voltage to the input signal. For instance, if the incoming signal varies from –10v to +10v, a positive dc clamper will produce an output that ideally swings from 0v to 20v and a negative clamper would produce an output between 0v to –20v.

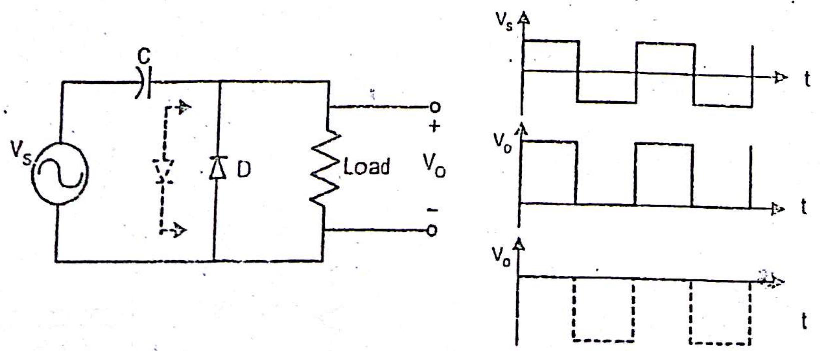


Figure 5: Clamper circuit and output

Equipments and Components:

A. Equipment

- DC Power supply, — 1 unit
- Trainer board — 1 unit
- Oscilloscope — 1 unit

B. Component

- Diode (1N4003) — 1 piece
- Resistance: (100 kΩ) — 1 piece
- Capacitance: (0.1 μF) — 1 piece

Experimental Setup:

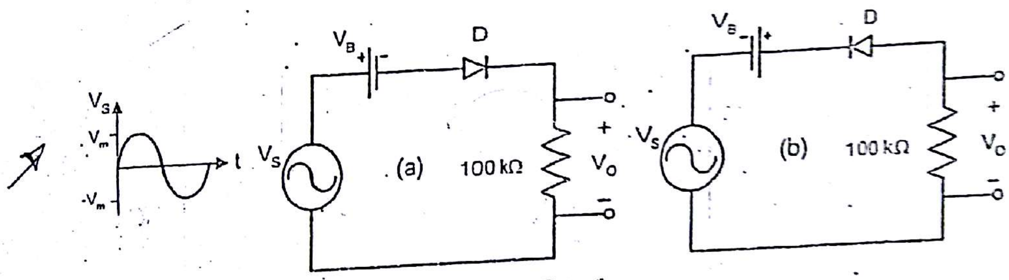


Figure 6: Setup 1

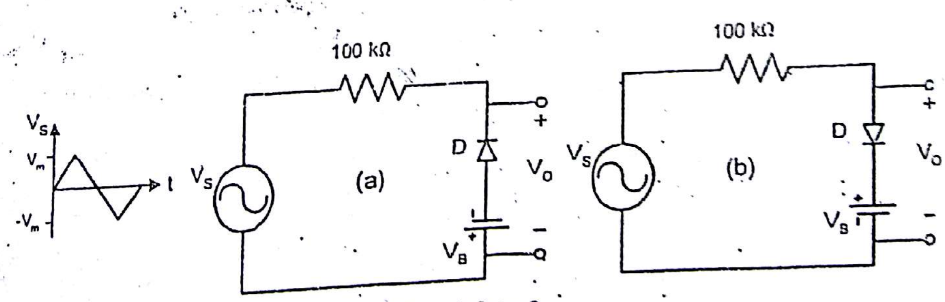


Figure 7: Setup 2

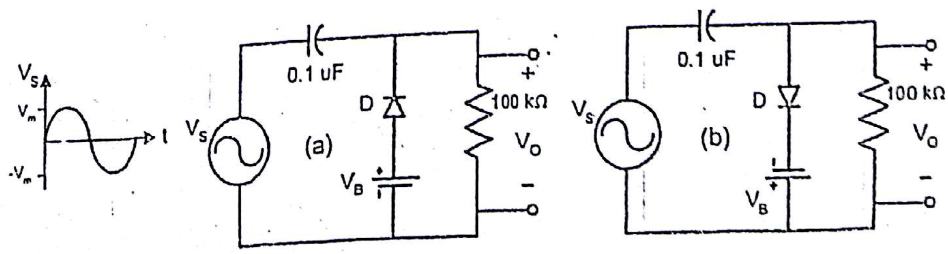


Figure 8: Setup 3

Procedure:

Step 1: Connect the circuit as shown in the figure 6. Use a sinusoidal voltage source with 5 volts peak (V_m).

Step 2: Observe the wave shapes for various values of V_B and draw V_B =1 V, 2.5 V and 4 V for each circuit. Where V_m is the maximum value of the input signal.

Step 3: Do the same as in steps 1-2 for circuits in figure 7 & 8 using V_S wave shape as drawn beside each figure having V_m = 5 volts.

Report:

1. Draw the input and output wave shapes of the different circuits.
2. We need to clip signal in both half cycles like in figure 9.

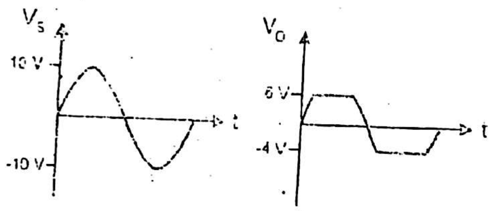


Figure 9

Design a clipper circuit that can do the above task. Mention clearly the battery voltage level. (Assume practical diode with V_D=0.7 V.)

3. Discussion

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