DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING
BANGLADESH UNIVERSITY OF ENGINEERING & TECHNOLOGY
COURSE NO.: EEE 208
EXPT. NO. 01

Name Of The Experiment: Study Of Diodes And Its Applications

Objective

The objective of this experiment is to study

- I-V Characteristic of Diode
- Diode Rectifier
- Diode Clipper Circuit
- Diode Clamper Circuit

Equipments Required

P-N junction diode(1N4003)	4 pieces
5V Zener diode	2 pieces
Resistors	1K, 10K
Capacitors	1μF, 1μF, 47μF
Bread board	one piece
Multimeter	one piece
chords and wire	lot
dc power suply	2 pieces
signal generator	one piece
oscilloscope	one unit

Theory

A p-n junction diode is a two-terminal device that acts as a one-way conductor. When a diode is forward biased as shown in Fig. 1(a), current I_D flows through the diode and current is given by

$$I_D = I_S\left[e^{\frac{V_a}{nV_T}} - 1\right] \tag{1}$$

where, n is the ideality factor and $1 \geq n \;\geq 2$. I_S is the reverse-saturation current and $V_T = kT/q$ is the thermal voltage. V_T is about 0.026V at room temperature.

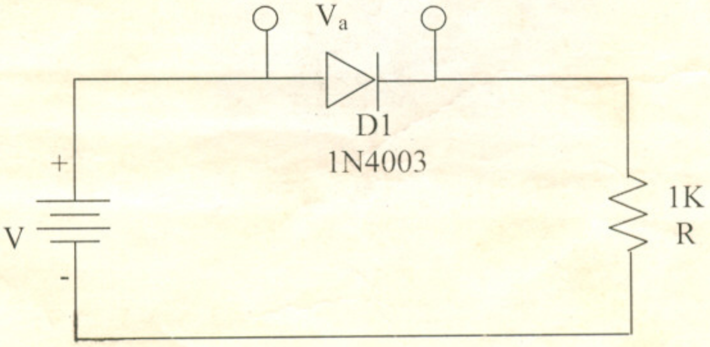


Fig.1 (a)

When it is reverse biased as shown in Fig. 1(b), $I_D = -I_S$ (for see eqn. (2)). As it is generally in pA (pico-amp) range, in many applications this current is neglected and diode is considered open.

$$I_D = I_S\left[e^{-V_R/V_T} - 1\right] = -I_S \quad \text{for } |V| >> V_T \tag{2}$$

The material for p-n junction diode is silicon semiconductor. Semiconductors are a group of materials having electrical conductivity intermediate between metals and insulators.

Metals: Al (aluminum), Cu (copper), Au (gold).
Insulators: Ceramic, Wood, rubber.
Semiconductor: Si (silicon), Ge (germanium), GaAs (gallium-arsenide)

P-type Silicon:

When an intrinsic silicon semiconductor is doped with Al impurities, it becomes p-type. At thermal equilibrium,

$$p_o = N_A \quad \text{and} \quad n_o = n_i^2/N_A$$

where, p_o is the hole concentration , n_o is the electron concentration , N_A is the doping density of impurities(acceptor atoms), n_i is the intrinsic concentration. $n_i = 1.5\text{x}10^{10}\text{cm}^{-3}$ for Si at room temperature .

N-type silicon:

When an intrinsic silicon semiconductor is doped with P(phosphorous) impurities it becomes n-type . At thermal equilibrium, $n_o=N_D$ and $P_o= n_i^2/N_D$. Here, N_D is the doping density of impurities (donor atoms).

In semiconductor both holes and electrons contribute to current.

A. Current-Voltage Characteristics

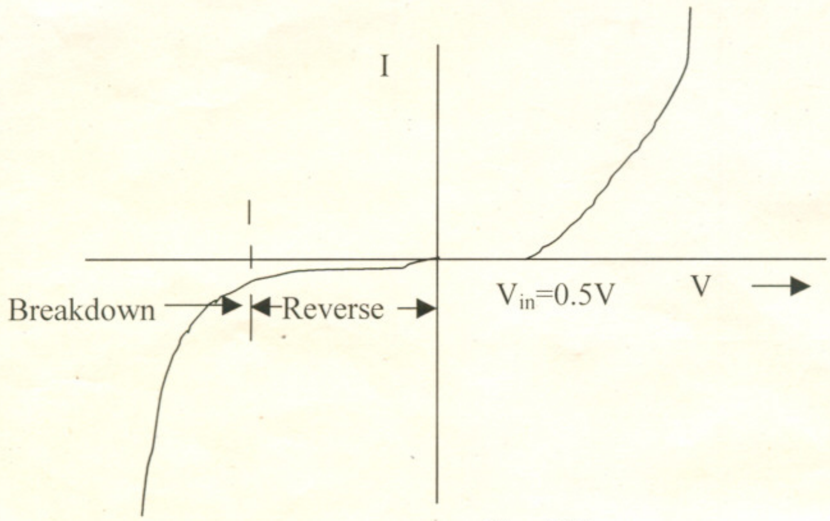


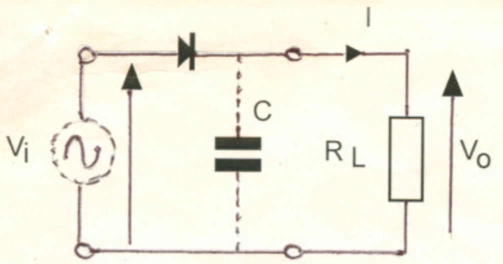
Fig. 1(b)

V_{in} is the cut-in voltage. Its value is usually 0.5V. At this voltage, diode is forward biased but even then I is very small and it is usually neglected. When diode is reverse biased and $V< V_K$, diode drives into breakdown and a large current will flow. The current can be limited by using resistor in diode circuit. If the slope (dI/dV) is very steep, the breakdown mechanism is called Zener breakdown. Zener diode can be used in regulator circuit.

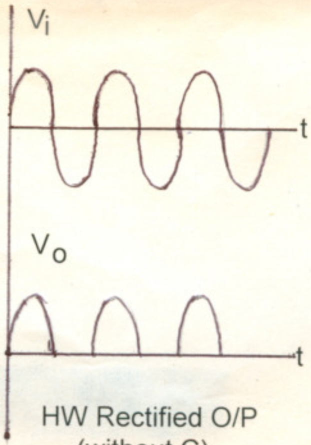
B. Diode Rectifiers

- Diodes can be used to RECTIFY O/P from ac supply to produce a dc supply
  - → on +ve half cycle of I/P wave
    - ⇒ diode is fwd. biased
    - ⇒ diode conducts
  - → on -ve half cycle of I/P wave
    - ⇒ diode is rev. biased
    - ⇒ diode does not conduct

HALF-WAVE RECTIFIER



HW Rectifier



HW Rectified O/P
(without C)

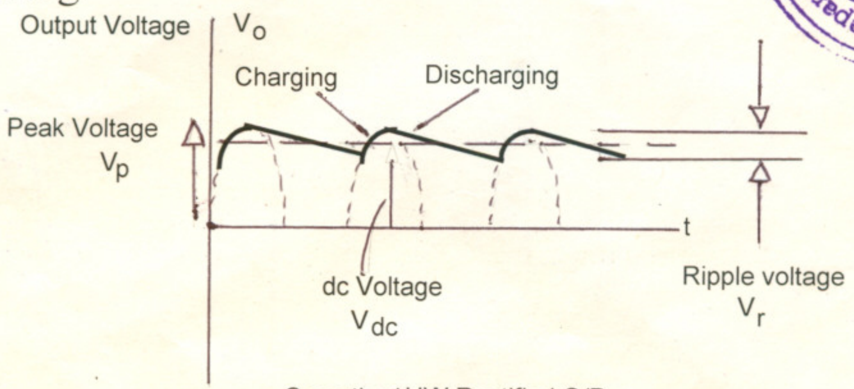
- Average voltage (as seen on dc voltmeter)

  $\mathbf{V_{ave} = V_p/\pi}$

- rms voltage (as seen on ac voltmeter)

  $\mathbf{V_{rms} = V_p/\sqrt{2}}$

Smoothing



Smoothed HW Rectified O/P

- If a capacitor is placed across output

  → capacitor charges on rising edge of +ve half-cycle

  → discharges on falling edge

  → O/P is smoothed
- Actual peak O/P will be reduced from peak I/P by value of forward. bias

  $V_p(out) = V_p(in) - 0.7\ V$

Ripple voltage

- A finite load current I causes capacitor voltage to drop by V_r during ac cycle

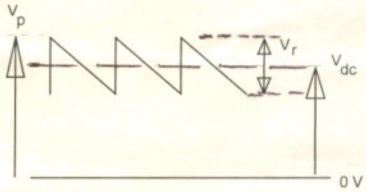
  → ripple in O/P is approx. sawtooth in shape → neglect charging time

  → assume discharge takes one complete period (T)
- Charge flowing from capacitor in time T

  $Q = IT$

- Fall in capacitor voltage = pk-pk ripple

  $V_r = Q/C = IT/C$



→ But T = 1/f (f is ac frequency)

$\mathbf{V_r(HW) = I/Cf}$ **HW Ripple Voltage**

- As the ripple voltage increases the average (dc) O/P voltage decreases

  $V_{dc} = V_p - 1/2(V_r)$

$\mathbf{V_{dc} = V_p - 0.5Cf}$ **HW dc Voltage**

- Ripple factor defines magnitude of smoothing effect

  $\mathbf{r = (V_r/V_{dc})\ 100\%}$ **Ripple factor**

Peak Inverse Voltage

PIV is the peak reverse voltage that appears across the diode when it is reverse-biased.

$PIV = V_m$

Full Wave Rectifier

- Better rectification is obtained if circuit conducts on both I/P half-cycles
- On first half-cycle

→ At same time terminal B is -ve, D3 conducts to lower end of load

- On next half cycle

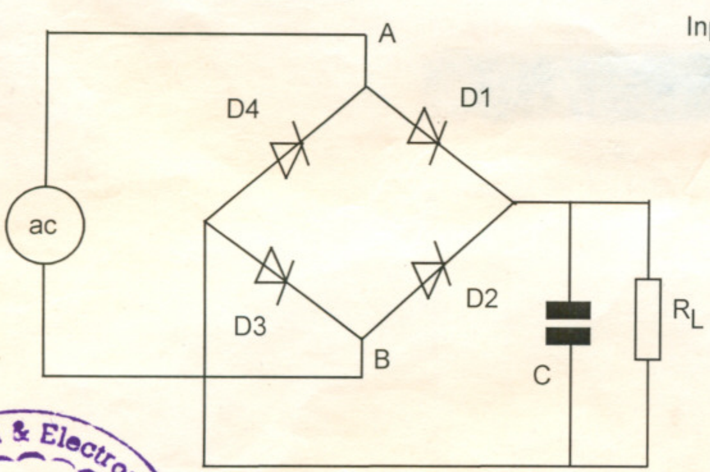
→ Terminal A is -ve and B is +ve, D2 conducts to top end of load, D4 conducts to lower end

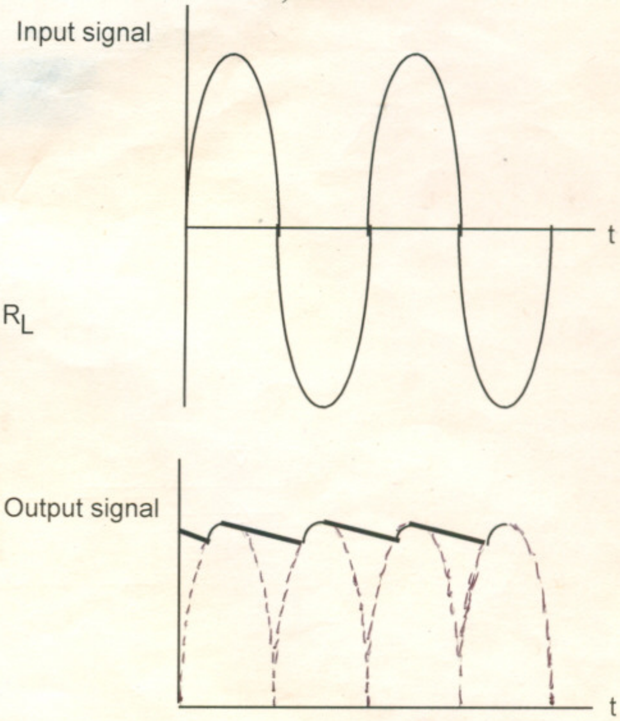
$V_{ave} = 2V_p/\pi$ (without smoothing capacitor)

- For FW rectification, ripple frequency is twice ac I/P frequency

$V_r(FW) = 0.5\ Cf$ **Ripple voltage**

$V_{dc} = V_p - 0.25\ Cf$ **dc Voltage** (as seen on dc voltmeter)

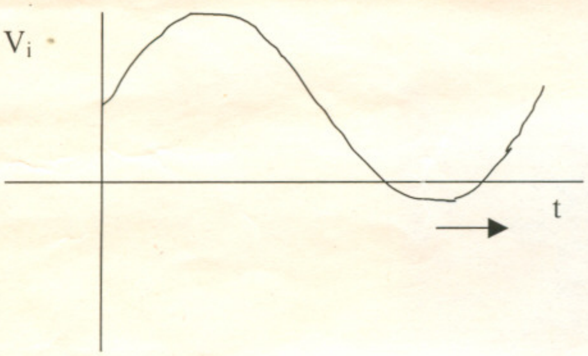




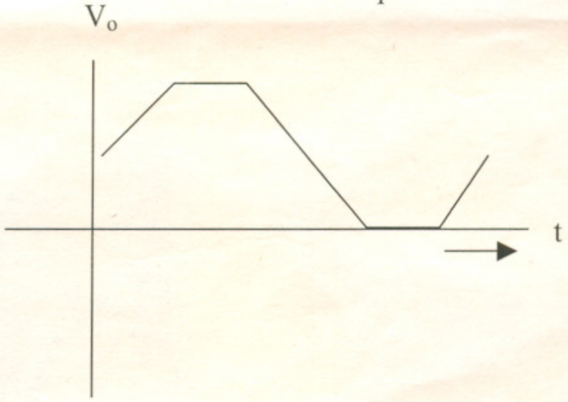
C. Clipper circuits:

Limiter or clippers are used to cut-off or eliminate a portion of an ac signal. A limiter can be realized by using diode and resistor as shown in Fig 1.

Input to a limiter



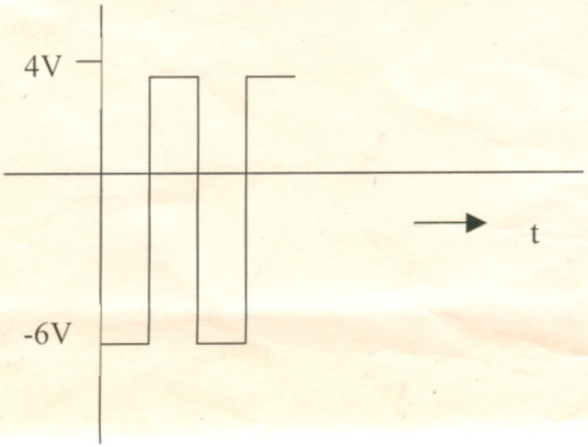
Output



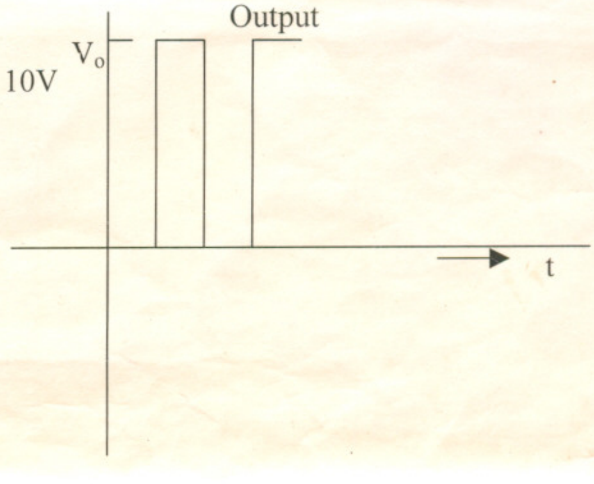
D. Clamper circuits:

The clamper circuit is one that will clamp a signal to a different dc level.

Input to a clamper

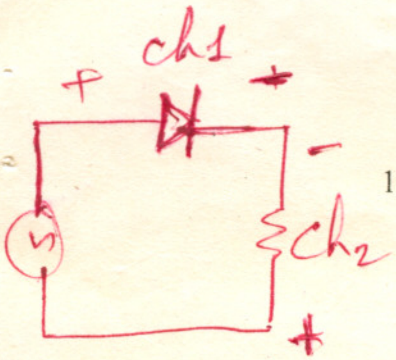


Output



Circuits & Procedures

A. Circuit for I-V Characteristics of Diode



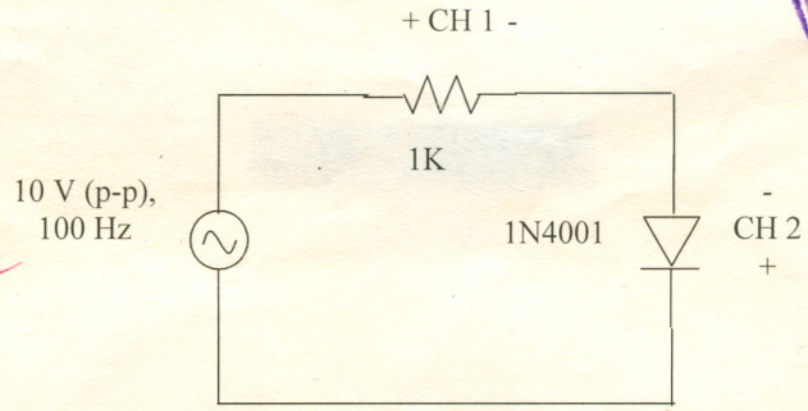


Fig. 1.1 Circuit diagram for obtaining diode characteristic from oscilloscope

Procedures

1. Construct the circuit as shown in the Fig. 1.1 on breadboard. Set the oscilloscope in **X-Y mode** and locate the zero point on oscilloscope display. Observe and draw the output.
2. Repeat step1 by increasing supply frequency to 5 kHz.
3. Reconnect CH1 to AC source [+ve top, –ve bottom] and interchange the +ve/-ve of CH2 across the diode. Draw the scope output at **dual mode**.

Reports

1. Explain the result obtained in step 2.
2. In step 3, "CH2 will show half wave rectified output, either taken across the diode or across the resistor" explain.

B. Circuit for Diode Rectifier

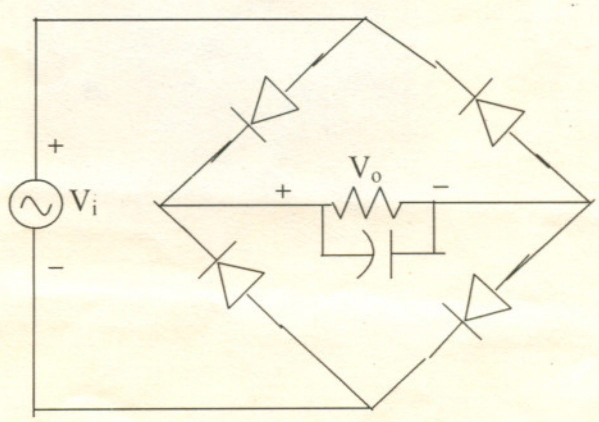


Fig. 1.2 Circuit diagram for bridge rectifier

Procedures

1. Construct the circuit of Fig. 1.2 without the capacitor. Observe and sketch V_i, V_o. **DO NOT TRY** to observe V_i, V_o simultaneously. Measure ac and dc components of V_o with multimeter.

2. Connect 1μF capacitor as shown in Fig.1.2 and repeat step 1.

3. Replace 1 μF capacitor by 47μF for Fig.1 and repeat step 1.

Reports

1. Calculate the average and effective values of the load voltage (V_0) in circuits of Fig. 1.2 without capacitor. Compare these values with those obtained with the multimeter.

2. Calculate the ripple factors for each of the three cases and compare with the ideal values.

3. Which capacitor acts as a better filter? Explain your answer.

4. What are the advantages and disadvantages of the full wave center tapped and bridge rectifier circuit?

C. Circuits for Clipping

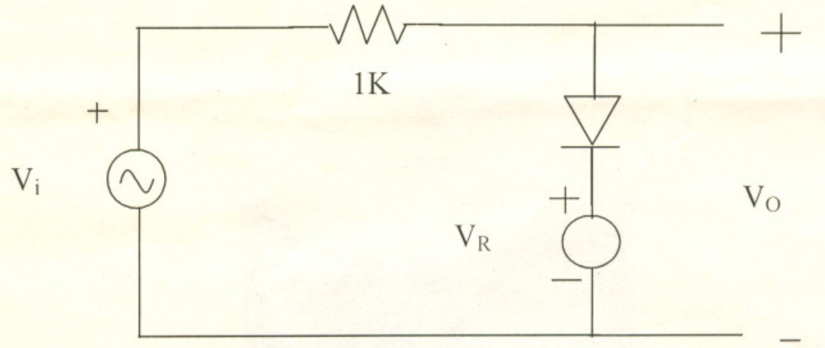


Fig. 1.3

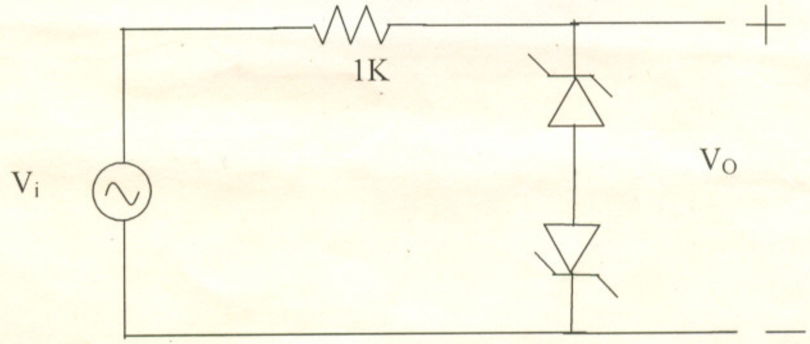


Fig. 1.4

Procedures

1. Construct the circuit shown in Fig.1.3. Observe V_i and V_o simultaneously on the oscilloscope and sketch the waveforms.

2. Reverse the polarity of the diode in Fig.1.3 and repeat step 1.

3. Construct the circuit shown in Fig. 1.4 and repeat the procedure in step 1 and 2.

Reports

1. Design a circuit in which the input voltage V_i =5 sin ωt and the output should be limited between + 2.5 V and – 3.5 V. Assumes that the diodes are ideal.

2. Sketch the output voltage of the circuit of Fig. 1.4 if V_i =5 sin(2000πt).

3. How will V_o change if the polarities of the two Zener diodes in the circuit of Fig. 1.4 are reversed?

D. Circuit for Clamping

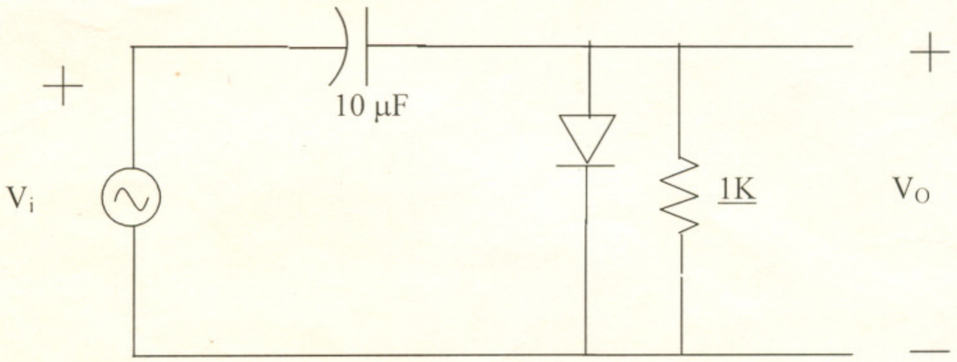


Fig. 1.5

Procedures

1. With 10Vpp **square wav** construct the circuit shown in Fig.1.5. Observe V_i and V_o simultaneously on the oscilloscope and sketch the waveforms.
2. Reverse the polarity of the diode in Fig.1.5 and repeat step 1.

Reports

1. Sketch the output voltage of the circuit of Fig. 1.5 if V_i =5 sin(2000πt).

Modified by: Yeasir Arafat