Chapter3: Semiconductor Devices and Circuits

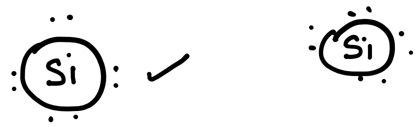
Topics

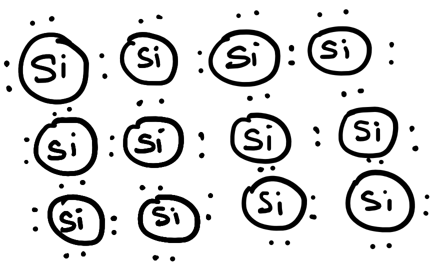
1. Working of P-N Junction Diode
2. Zener Diode
3. Diode Clipper Circuits
4. Diode Clamper Circuits
5. Half-wave and Full Wave diode rectifier
    a. DC Output current
    b. DC Output voltage
    c. RMS current and Voltage
    d. Rectifier Efficiency
    e. Ripple factor
    f. Peak Inverse Voltage

1. Working of P-N Junction Diode

Conductor.	Insulator	Semi conductor
		Ge Si.

Si





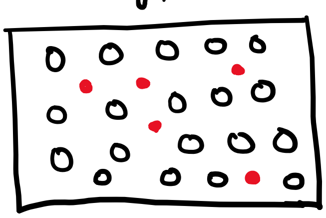
Si → Phosphorous
↓
$5e^-$
↓
$4 + 1$

N-type doping

P-type: Si is doped with Al → $3e^-$ in his valance shell

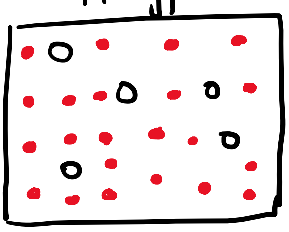
Si → 4 + Al (3; 1 hole formation)

P-type



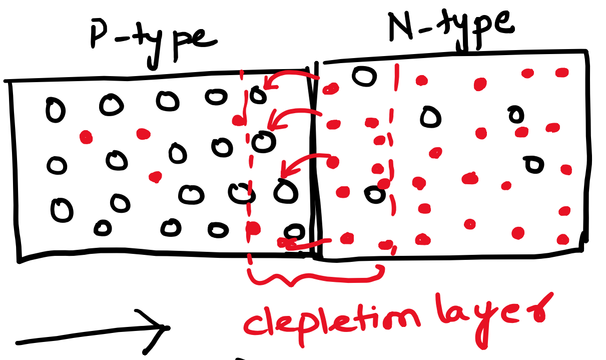
Excess holes

N-type



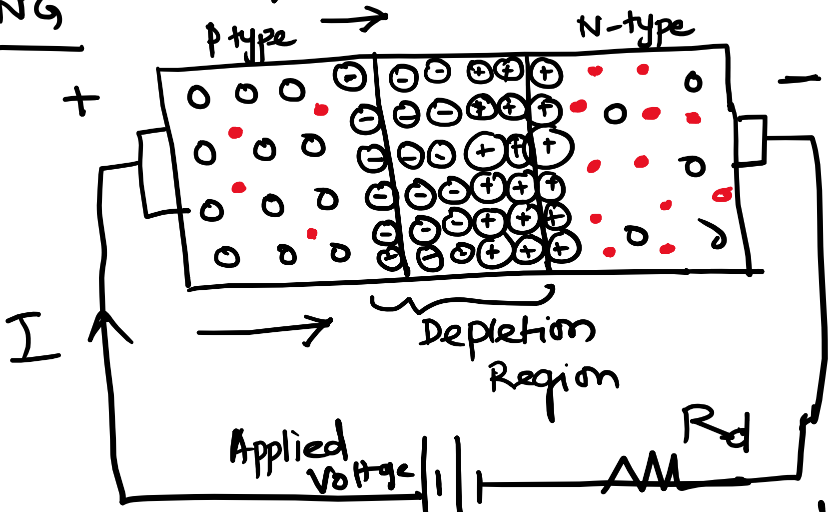
Excess electrons

• → e^-
o → Hole



FORWARD BIASING

Si →
Ge →

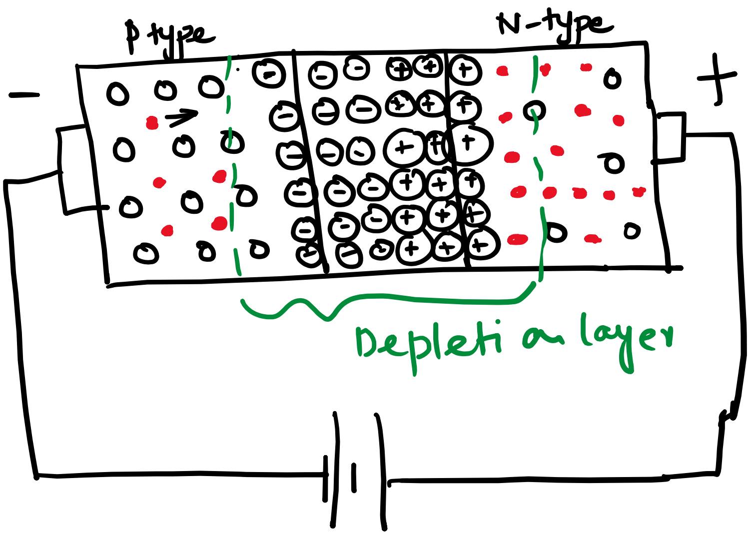


Applied voltage > Barrier potential

Amount of voltage required to forward bias :

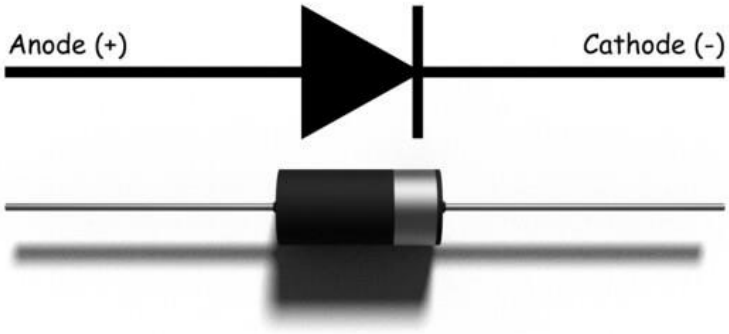
Si → 0.7V
Ge → 0.3V

REVERSE BIASING

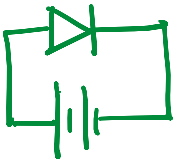


No current flow.

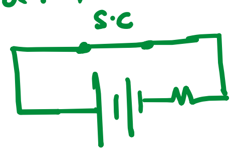
→ I



Anode cathode

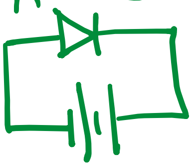


Forward bias

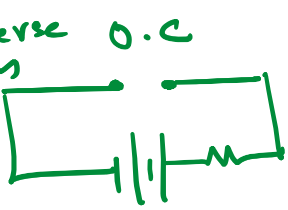


Si → 0.7 V

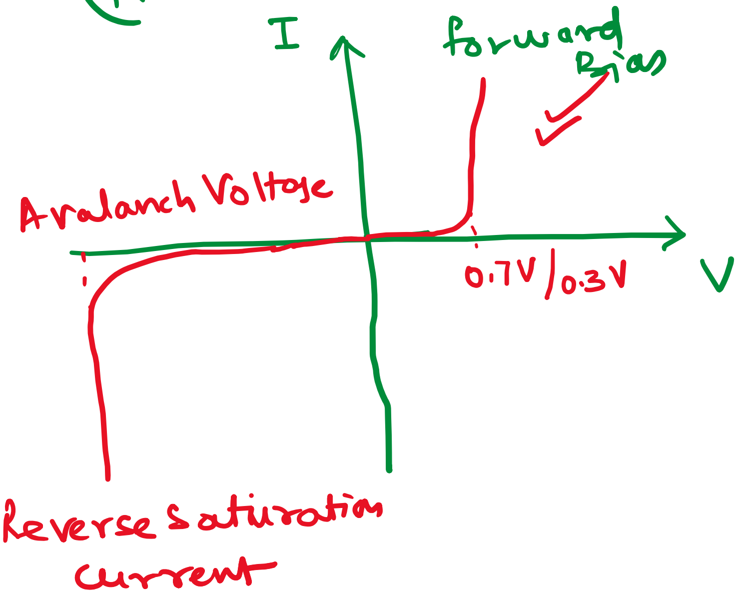
Ge → 0.3V



Reverse Bias

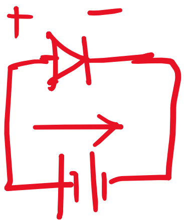


- Zener diode
- Light Emitting diode (LED)
- Schottky diode
- PIN diode

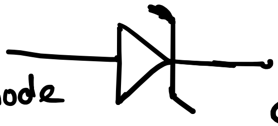


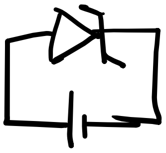
→ I = 0

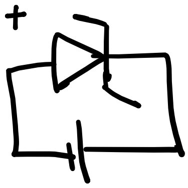
→ I_f

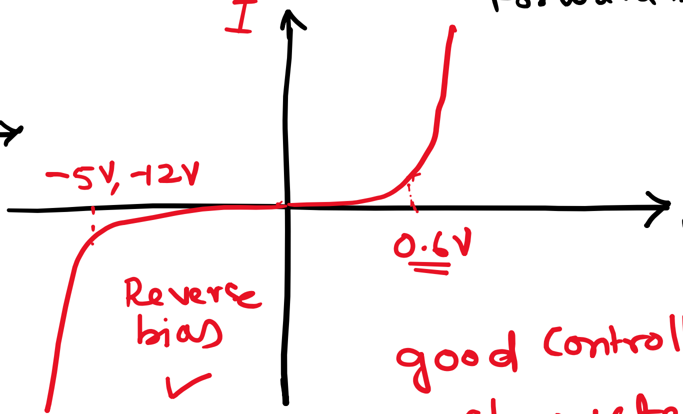


2. Zener Diode

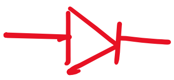
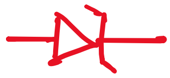
Anode  cathode.

Forward  → diode → $V_z = 0.6V$ Forward Bias

Reverse  →

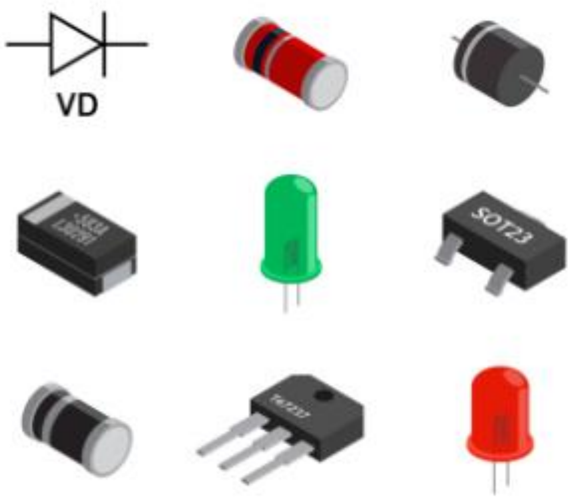


good controllable characteristics

Diode	Zener diode
Anode  cathode	
$\rightarrow I_f$	$\rightarrow I_f$, $\leftarrow I_R$.
Unidirectional	Bi-directional mode

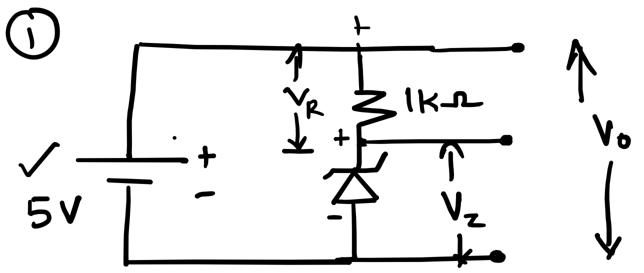
P-N. Diode & Zener diode.

Diode Types:

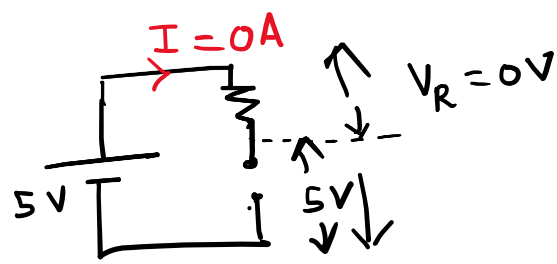


Examples with Zener Diode

①

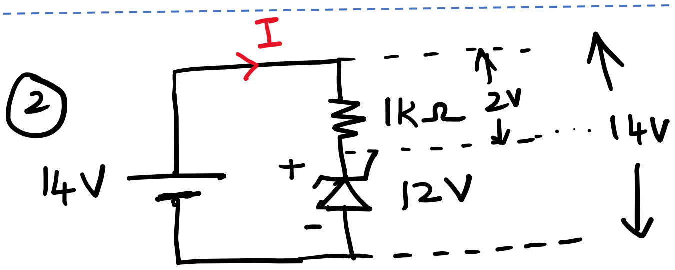


⇒



Given:- Rated Reverse breakdown voltage of Zener diode = 12V

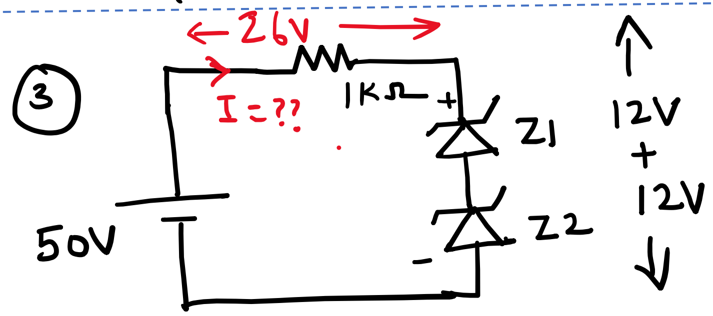
②



$$I = \frac{V}{R} = \frac{2}{1k\Omega} = 2mA$$

Given: { 0.6V → Forward bias cond of Zener diode
12V → Reverse breakdown Voltage a/c Z_D.

③

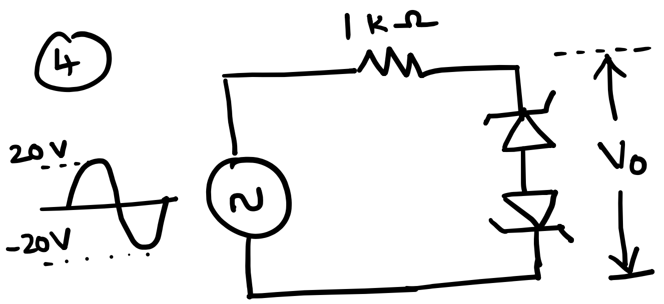


= 24V

$$I = \frac{26}{1k\Omega} = 26mA.$$

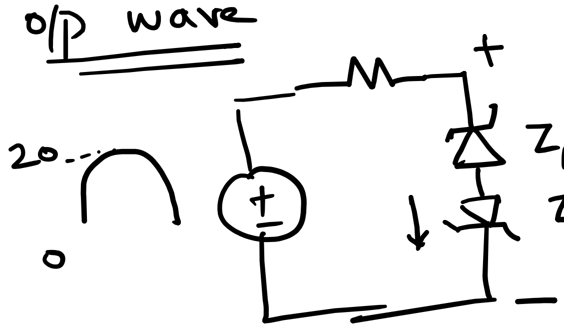
Given: 12V → Reverse breakdown voltage across Z_1 & Z_2

④

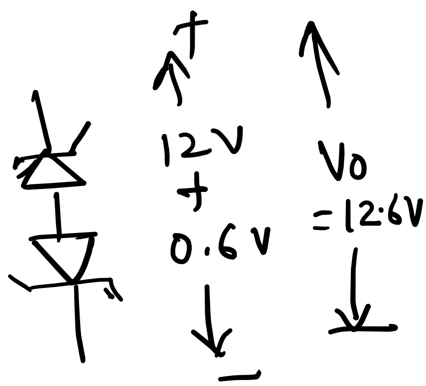


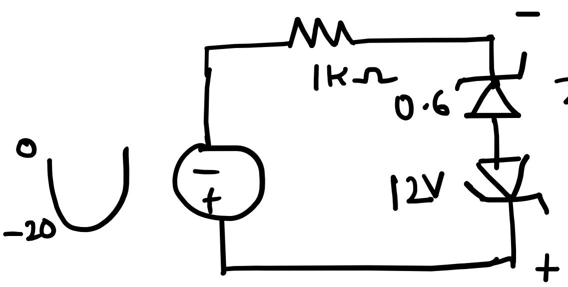
Given:- Forward bias breakdown voltage = 0.6V
Reverse " " " = 12V

O/P wave



Z_1 = Reverse biased
Z_2 = Forward biased

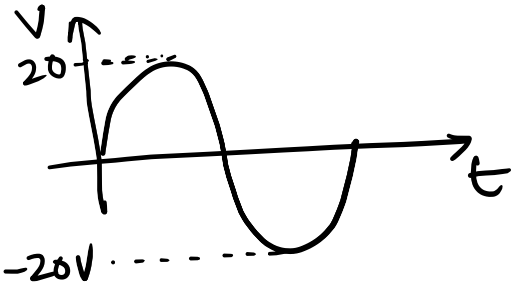


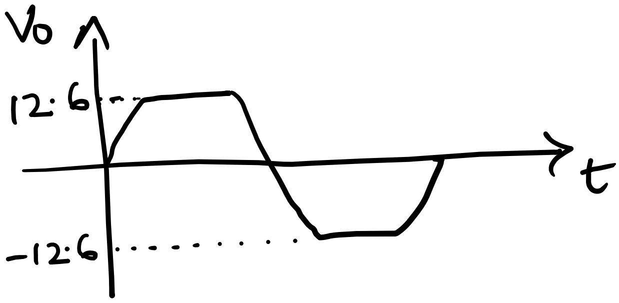


$Z_1 \rightarrow$ Forward biased

$Z_2 \rightarrow$ Reverse biased

$V_o = -12.6V$





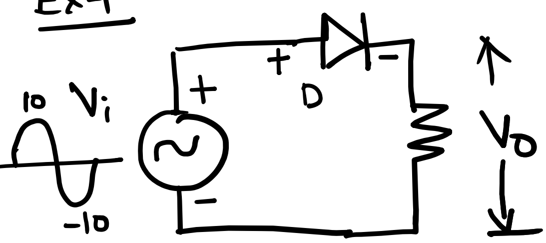
3. Diode Clipper Circuits:

Series / Shunt

Purpose is to clip the unwanted portion of the voltage.

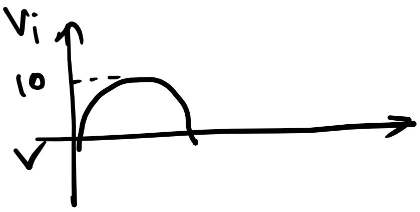
Components required :- Diode, resistor

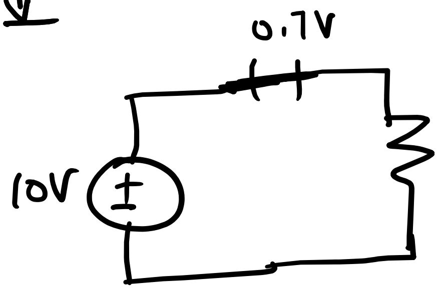
Ex-1



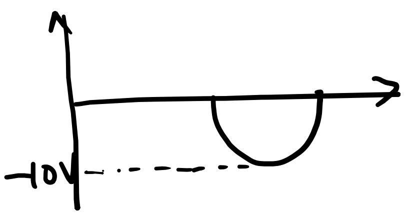
Given:- Diode forward bias $V_{drop} = 0.7V$ (Si)

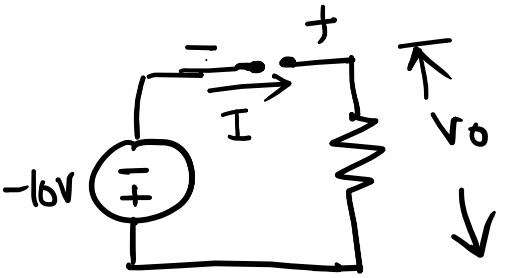
In +ve ½ cycle : 'D' is forward biased



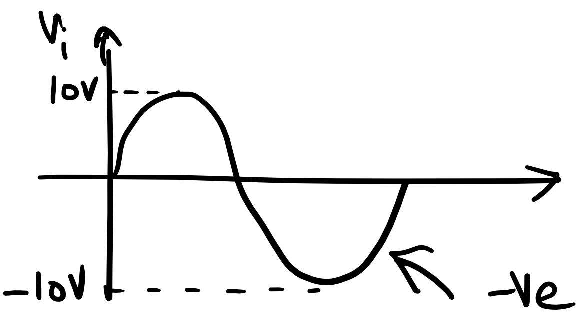


$V_o = 9.3V$

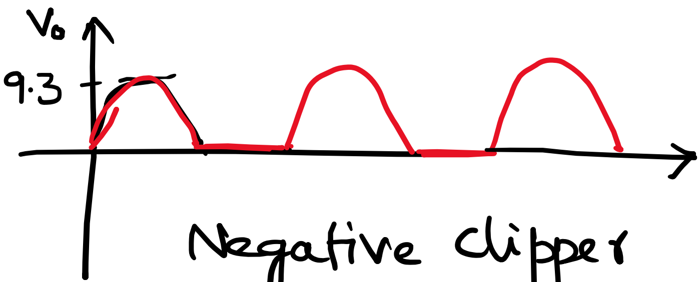




$V_o = 0$

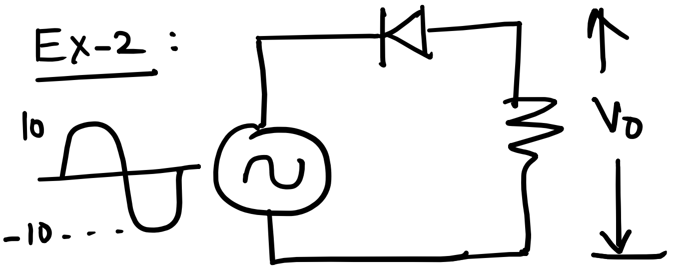


-ve So



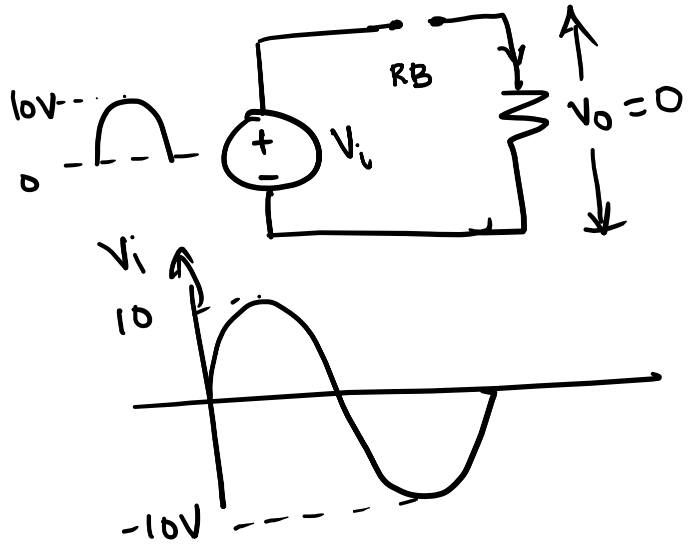
Negative clipper circuit

Ex-2 :

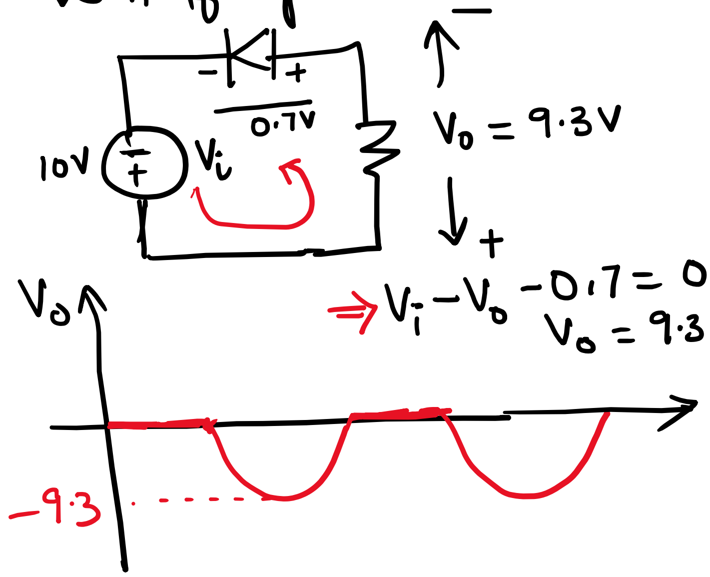


Positive clipper circuit

+ve half cycle



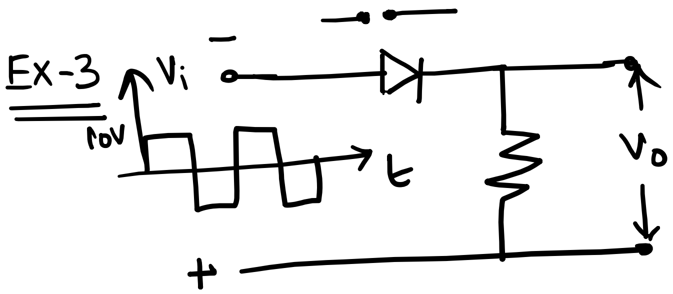
-ve half cycle



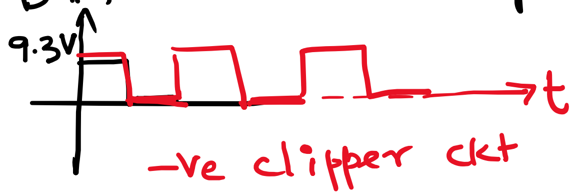
$\Rightarrow V_i - V_0 - 0.7 = 0$

$V_0 = 9.3V$

Ex-3

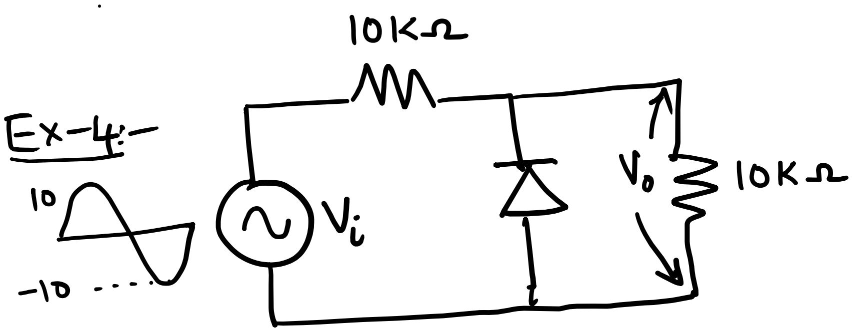


D : forward bias Voltage = 0.7V.



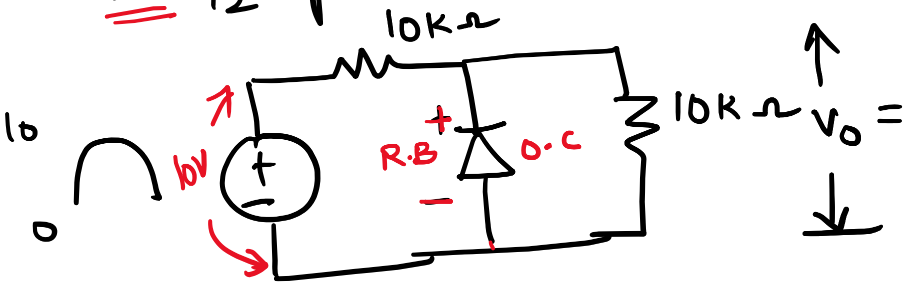
-ve clipper ckt

Ex-4:-



Given: forward bias Diode drop = 0.7V

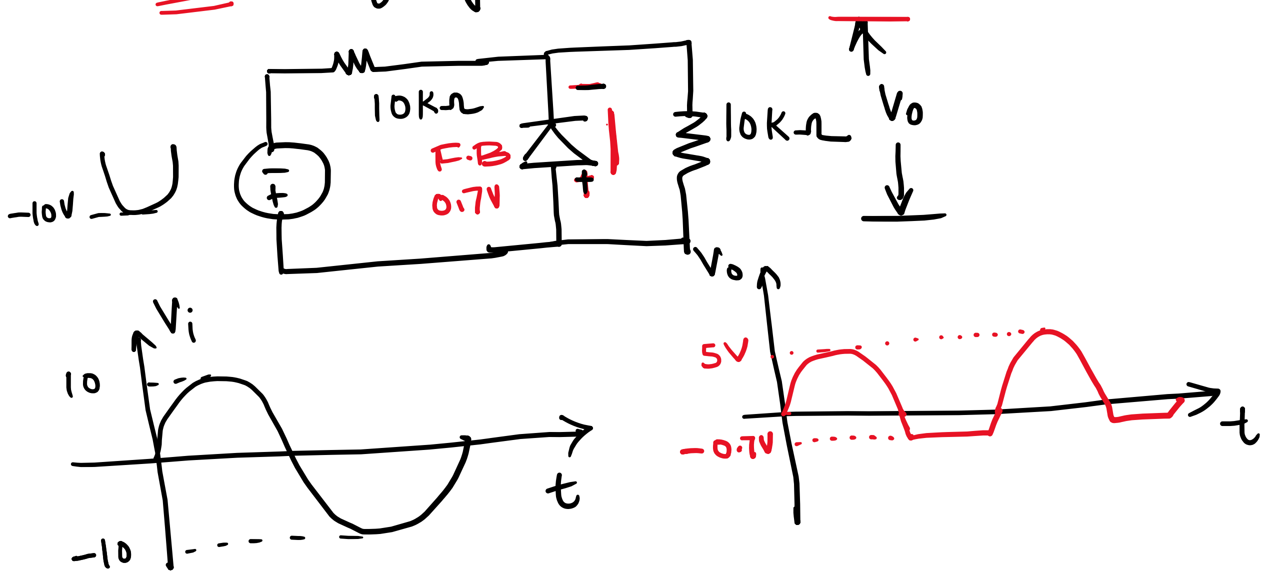
+ve 1/2 cycle



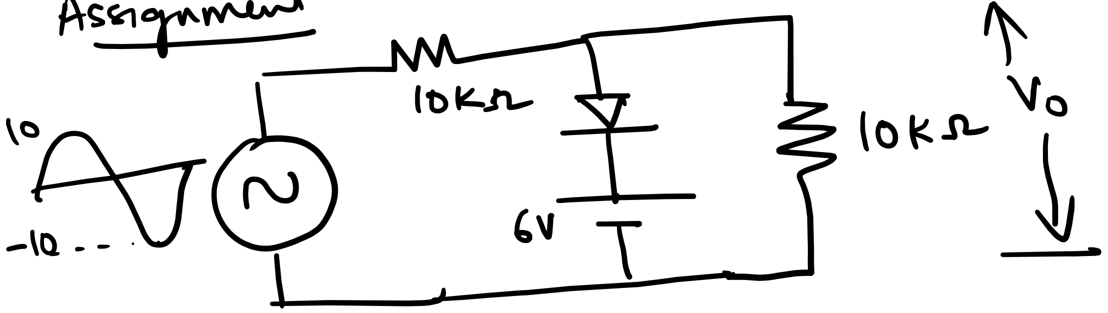
$V_0 = 10V * \left[\frac{10\,k\Omega}{20\,k\Omega}\right]$

$= 5V$

-ve half cycle



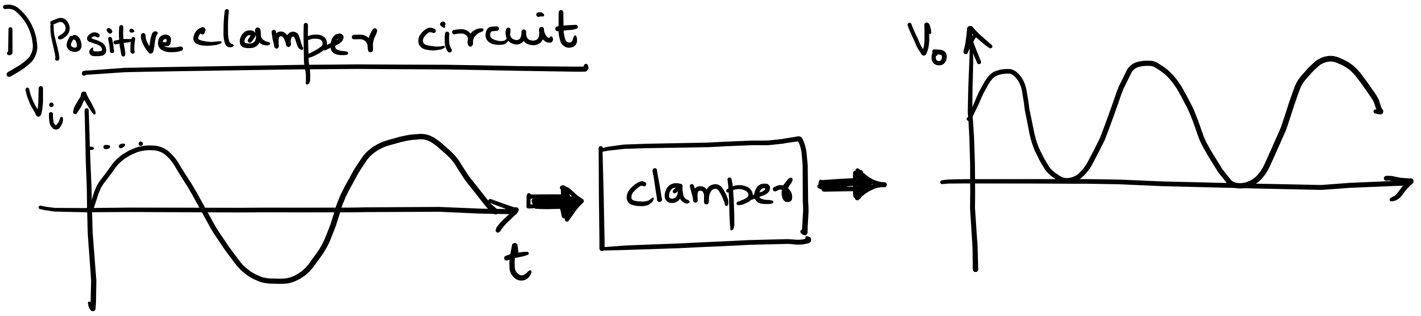
Assignment



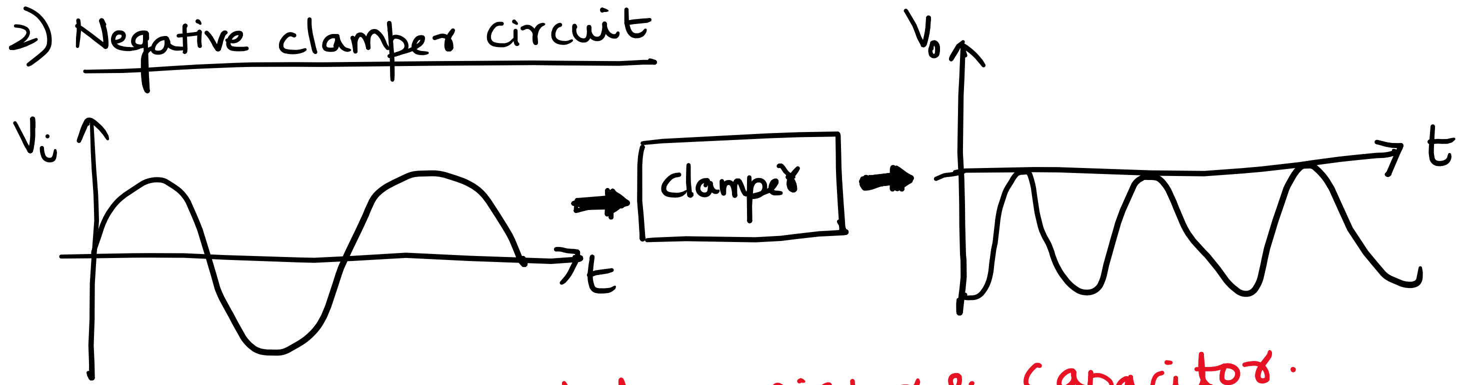
Given :-
Diode forward bias drop = 0.7V

4. Diode Clamper Circuits: These circuits are designed to change the DC level of the signal, without changing the shape of the signal.

1) Positive clamper circuit

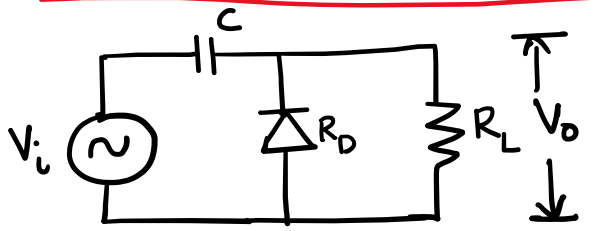


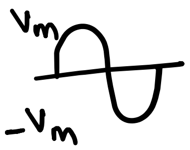
2) Negative clamper circuit



Designed using :- Diode, resistor & capacitor.

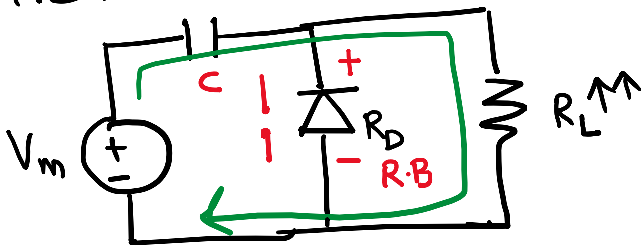
Positive clamper Circuit:





Assumption:- Discharging circuit's time constant ($\tau_d = R_L C$) is much higher than charging circuits time constant ($\tau_c = R_D C$)

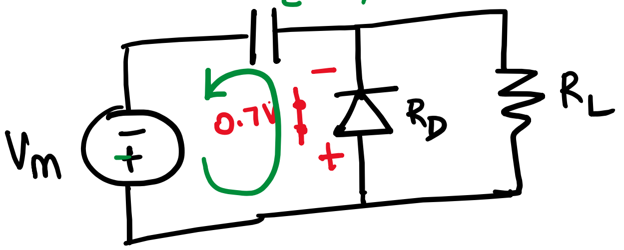
+ve ½ cycle:



$$\tau_d = 5 R_L C$$

-ve half cycle

c → quicked changed



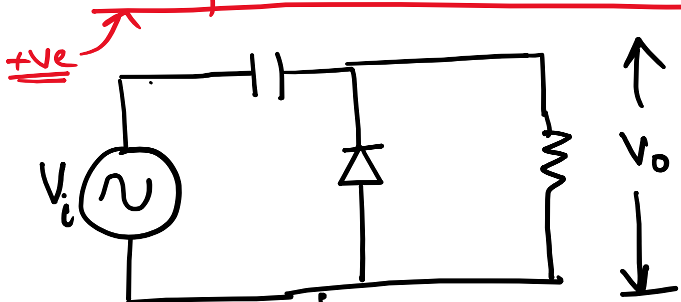
$$\tau_c = 5 R_D C$$

$$\tau_d >>> \tau_c$$

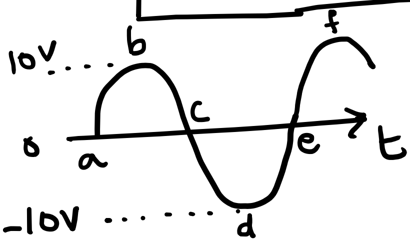
$$5 R_L C >>> 5 R_D C$$

$$\boxed{R_L >>> R_D} \Rightarrow R_L = 100 R_D$$

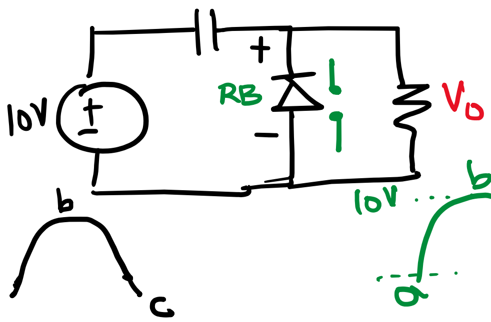
Clamper Circuit With Numerical Values

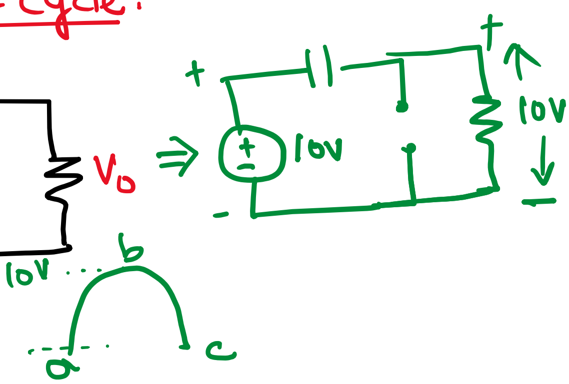


Given:- Diode drop = 0.3V in Forward Bias

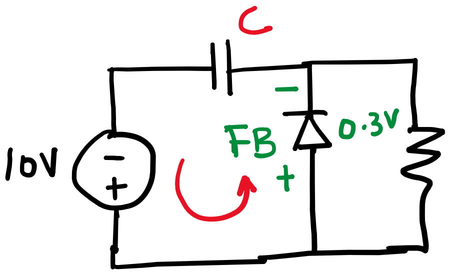


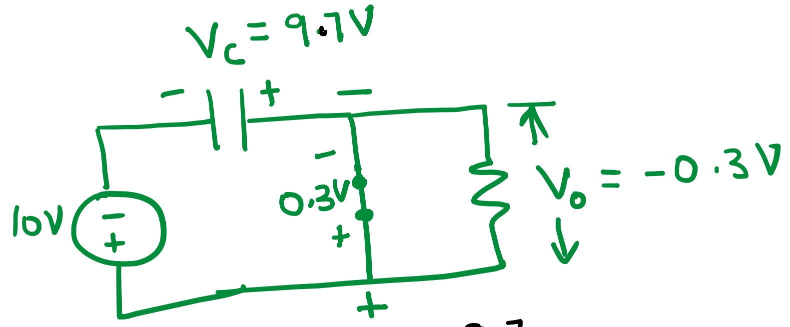
+ve half cycle:-

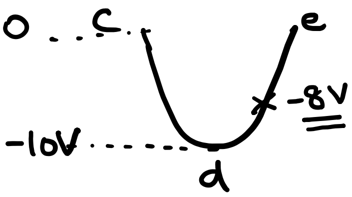


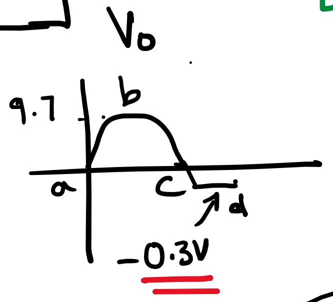


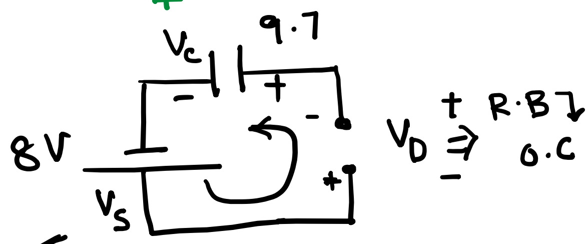
-ve half cycle









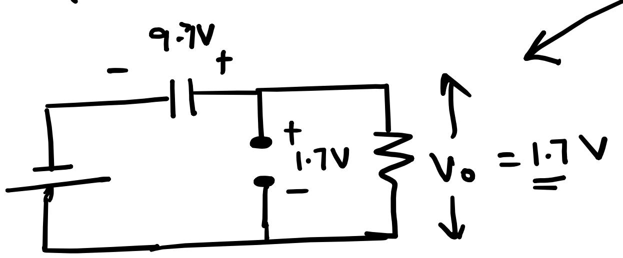


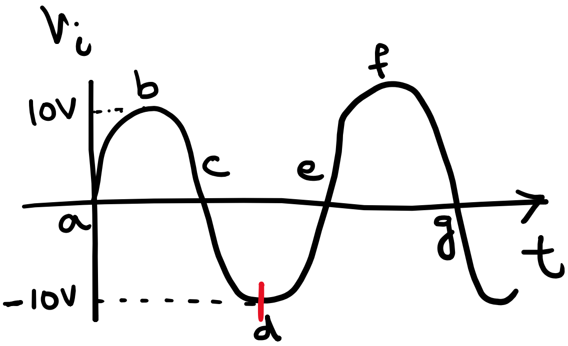
$$V_S - V_D - V_C = 0$$

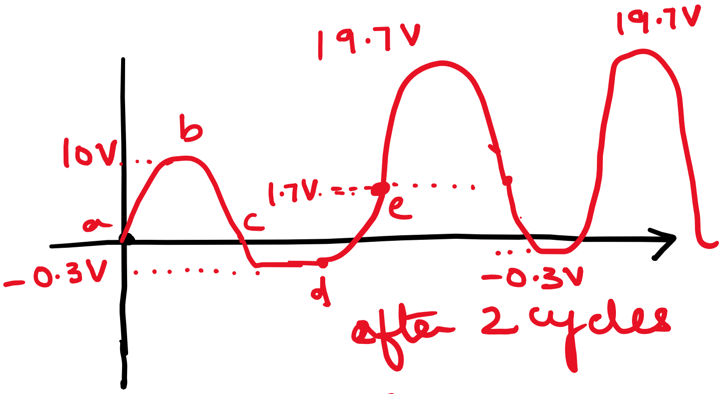
$$8 - V_D - 9.7 = 0$$

$$V_D = -1.7V$$

Final







after 2 cycles or so.....

-ve clamper circuit