EEE-1222: Basic Electronics

Computer Science & Engineering (CSE)

Lecture PPT # 03

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Date: 2012 Year, 07 Month, 10 Day

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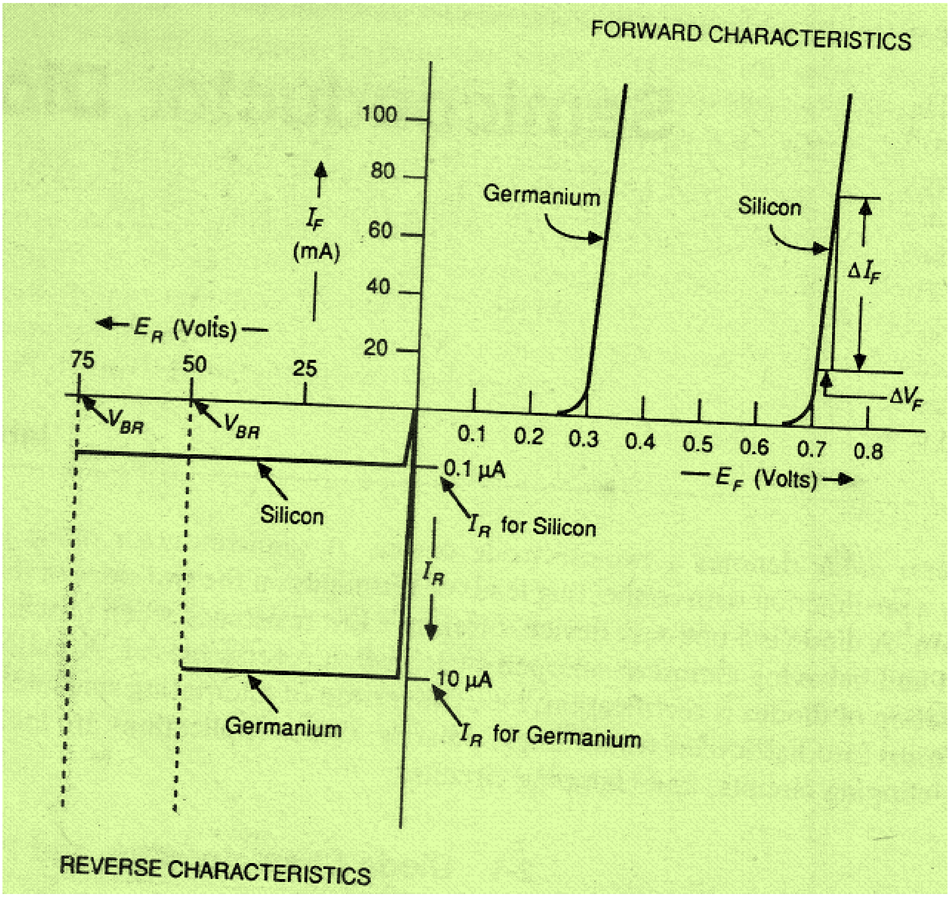
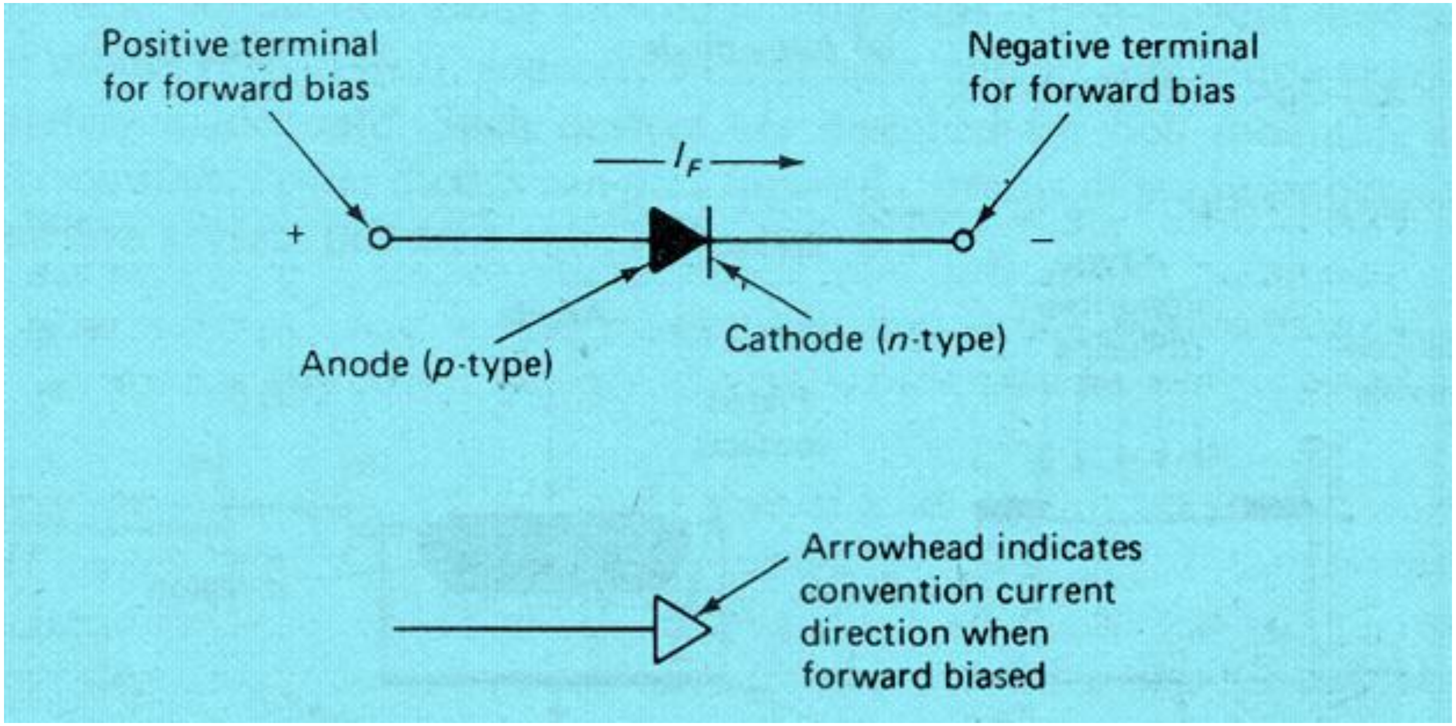
Diode Characteristics and Parameters

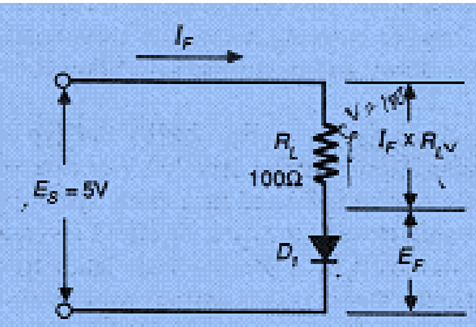


- Forward voltage drop
- Reverse saturation current
- Reverse breakdown voltage
- Dynamic resistance
- Maximum forward current

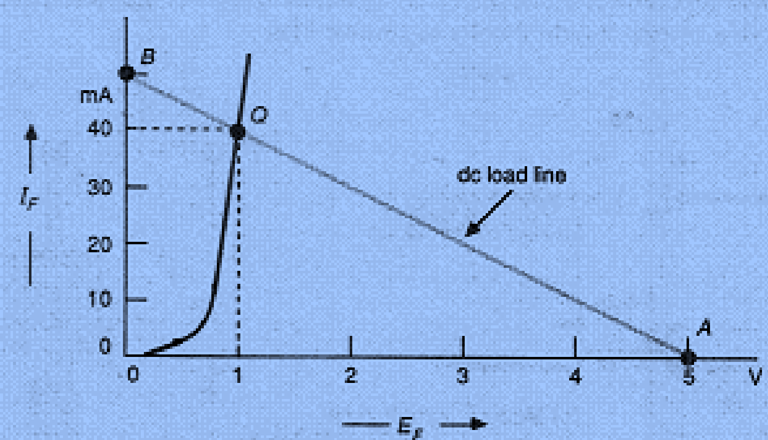
Diode Characteristics and Parameters



Graphical Analysis of Diode Circuits



(a) Diode-resistor series circuit



(b) Plotting the dc load line for a diode circuit.

$$E_S = I_F R_L + E_F$$

Graphical Analysis of Diode Circuits

From Eq. 2-1,

$$E_S = I_F R_L + E_F$$

When $I_F = 0$,

$$E_S = 0 + E_F$$

Therefore, the diode voltage is

$$E_F = E_S = 5\ \text{V}$$

Plot point A on the diode characteristics at $I_F = 0$ and $E_F = 5$ V.

When $E_F = 0$,

$$E_S = I_F R_L + 0$$

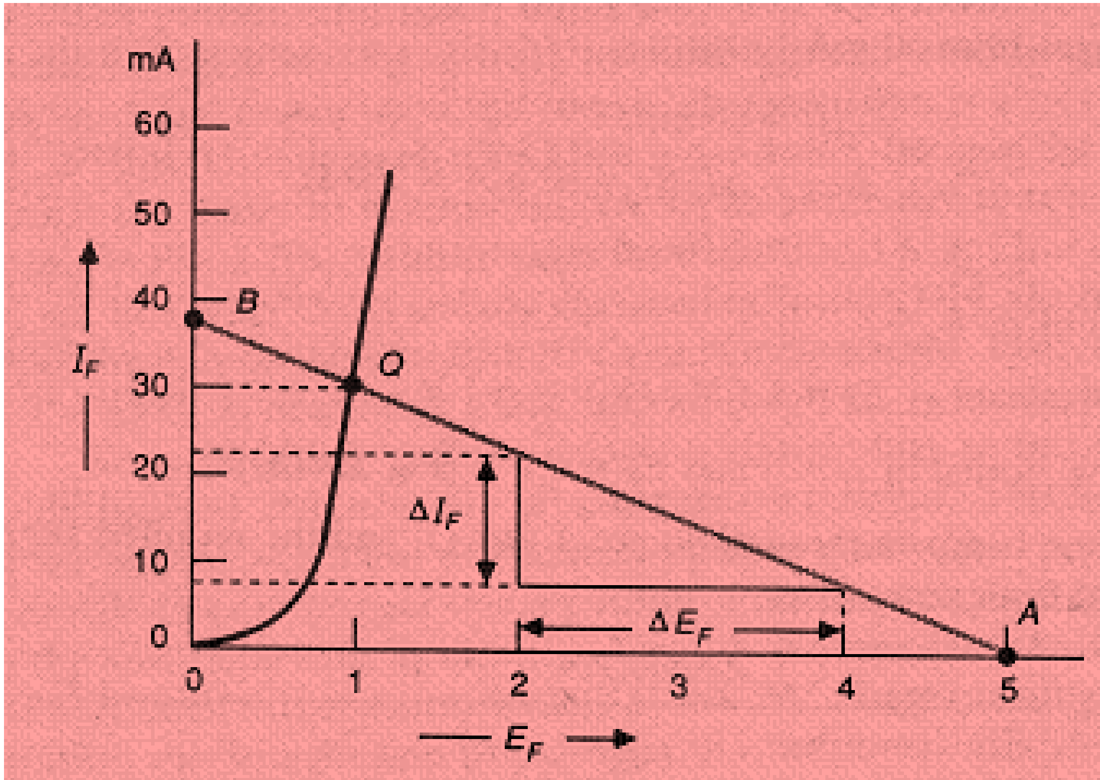
or,

$$I_F = \frac{E_S}{R_L}$$

$$= \frac{5\ \text{V}}{100\ \Omega} = 50\ \text{mA}$$

Plot point B on the diode characteristics at $I_F = 50$ mA and $E_F = 0$. Now draw the dc load line through points A and B.

Graphical Analysis of Diode Circuits



(a) Determining the value of R_L for a given supply voltage and forward current.

Graphical Analysis of Diode Circuits

Example 2-2 For the circuit shown in Fig. 2-5(a), determine a new value of load resistance which will give a forward current of 30 mA.

Solution

From Eq. 2-1,

$$E_F = E_S - I_F R_L$$

When $I_F = 0$, $E_F = E_S = 5\text{ V}$

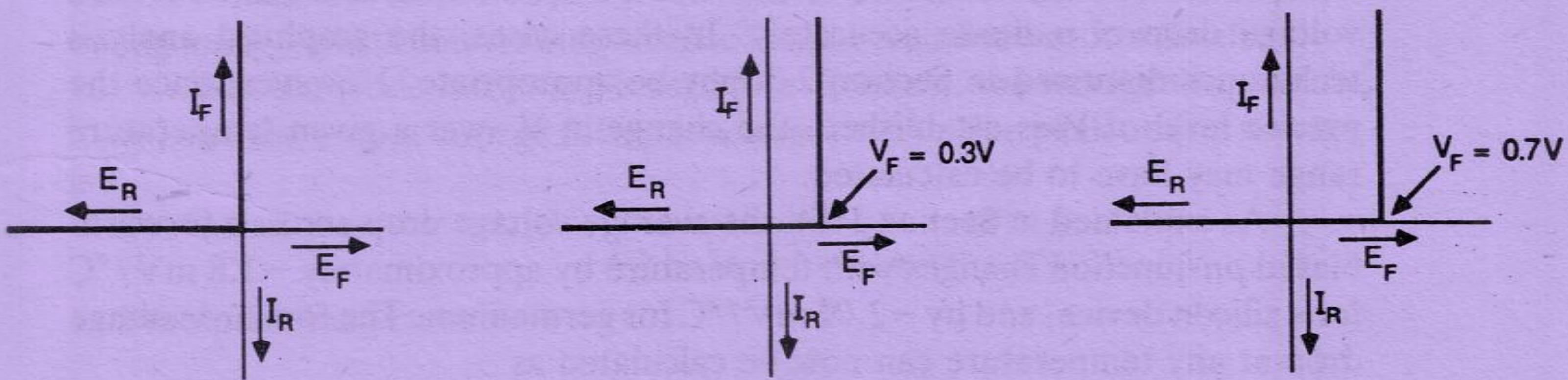
Plot point A on the characteristics [Fig. 2-6(a)] at $I_F = 0$ and $E_F = 5$ V.

Point Q is plotted on the device characteristic at $I_F = 30$ mA.

The new dc load line is now drawn through points A and Q, and R_L is determined as the reciprocal of the slope of the load line.

$$R_L = \frac{\Delta E_F}{\Delta I_F} = \frac{2\text{ V}}{15\text{ mA}} = 133\ \Omega$$

Ideal Diode and Practical Diode



(a) Characteristics of an ideal diode

(b) Approximate characteristics of germanium diode

(C) Approximate characteristics of a silicon diode

Rectification

Half-Wave Rectification

$$E_P = V_P - V_F \qquad (2\text{-}3)$$

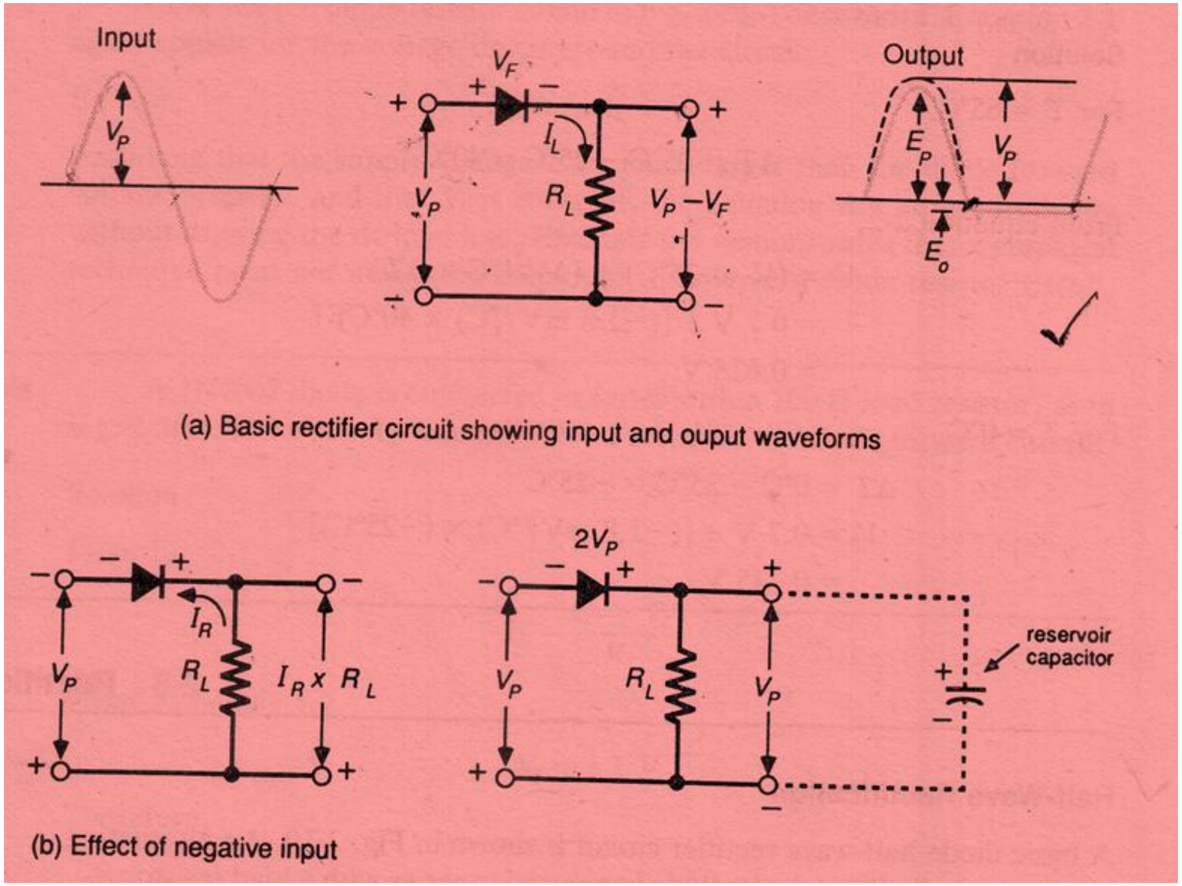
$$I_P = \frac{V_P - V_F}{R_L} \qquad (2\text{-}4)$$

In this case the output voltage is

$$E_O = -I_R \times R_L \qquad (2\text{-}5)$$

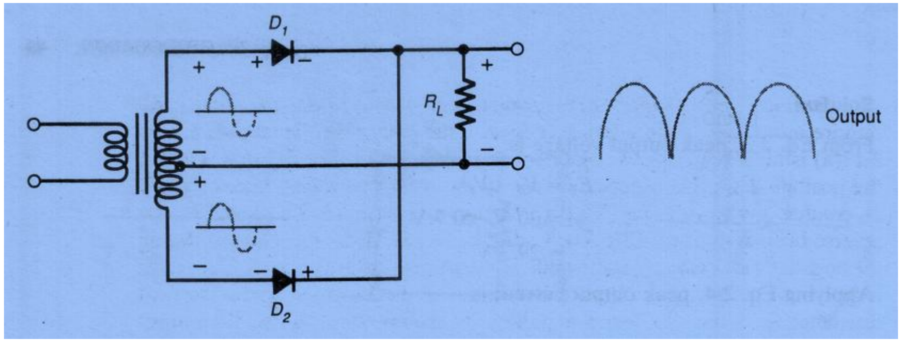
Rectification

Half-Wave Rectification



Rectification

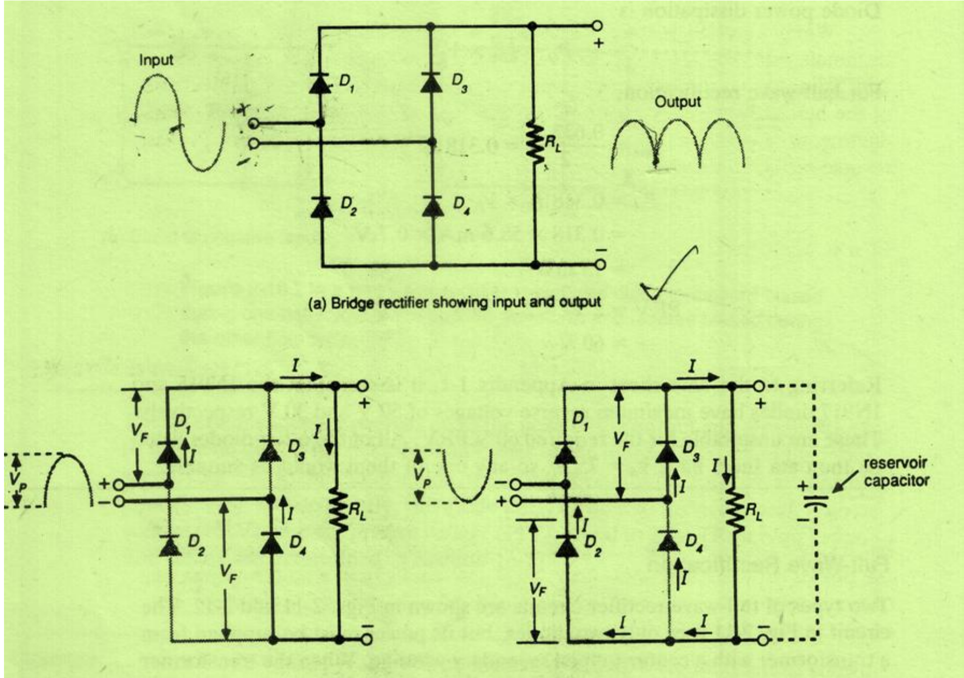
Full-Wave Rectification



$$E_P = V_P - 2V_F$$

$$V_P = (V_F \text{ for } D_3) + (V_R \text{ for } D_1)$$

$$V_R = V_P - V_F \approx V_P$$



(a) Bridge rectifier showing input and output

(b) During positive half cycle

(c) During negative half cycle

Rectification

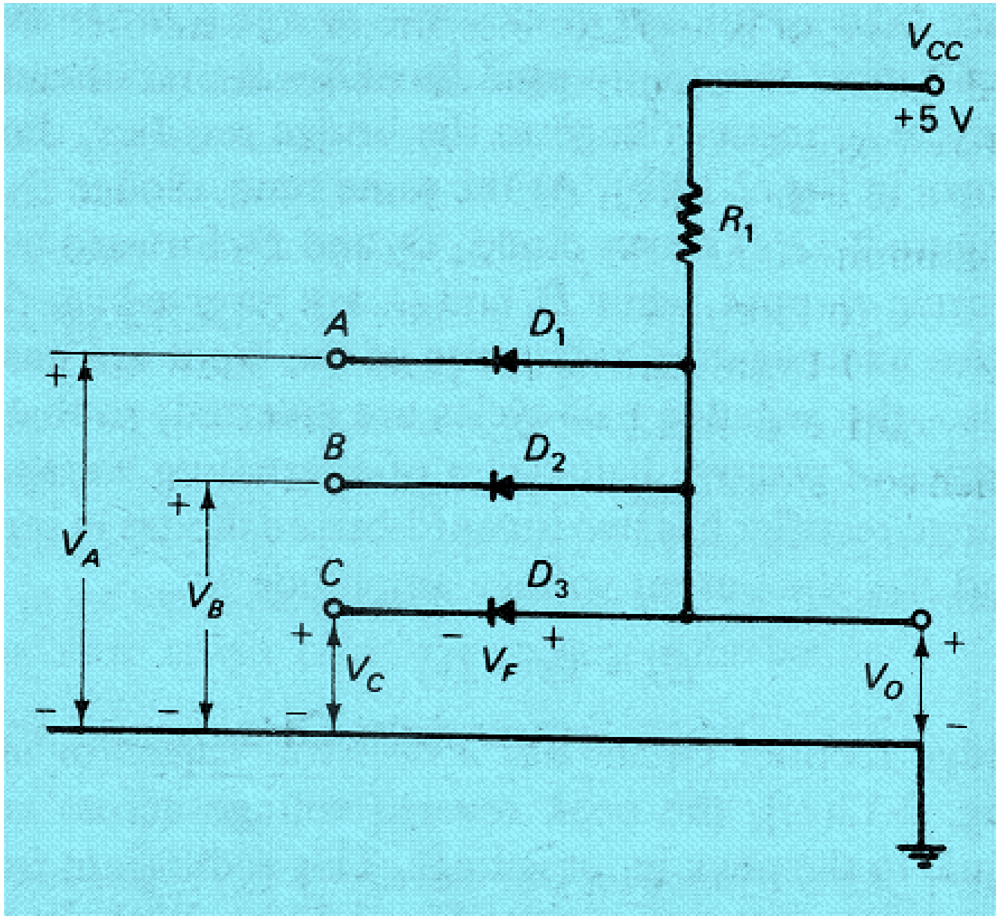
A diode with $V_F = 0.7$ V is connected as a half-wave rectifier, as shown in Fig. 2-10. The load resistance is $R_L = 500\ \Omega$, and the input voltage has a peak amplitude of 30 V. Calculate the peak positive output voltage, the peak load current, and the diode power dissipation. Also, determine the PRV for the diode, and select a suitable device

$$
\begin{aligned}
E_P &= V_P - V_F \\
&= 30\text{ V} - 0.7\text{ V} \\
&= 29.3\text{ V}
\end{aligned}
$$

$$
I_P = \frac{V_P - V_F}{R_L} = \frac{29.3\text{ V}}{500\ \Omega}
$$

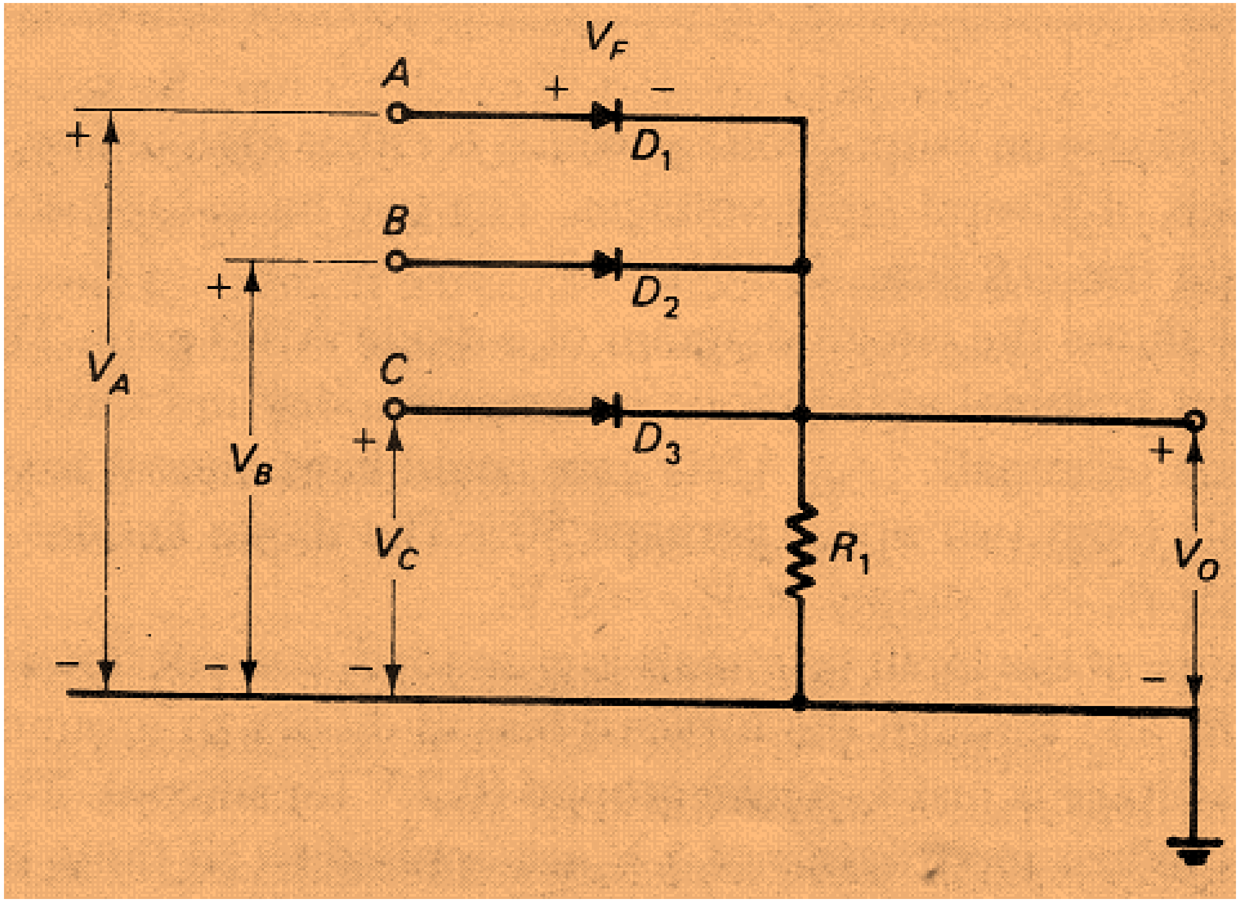
Diode Logic Circuits

AND Logic

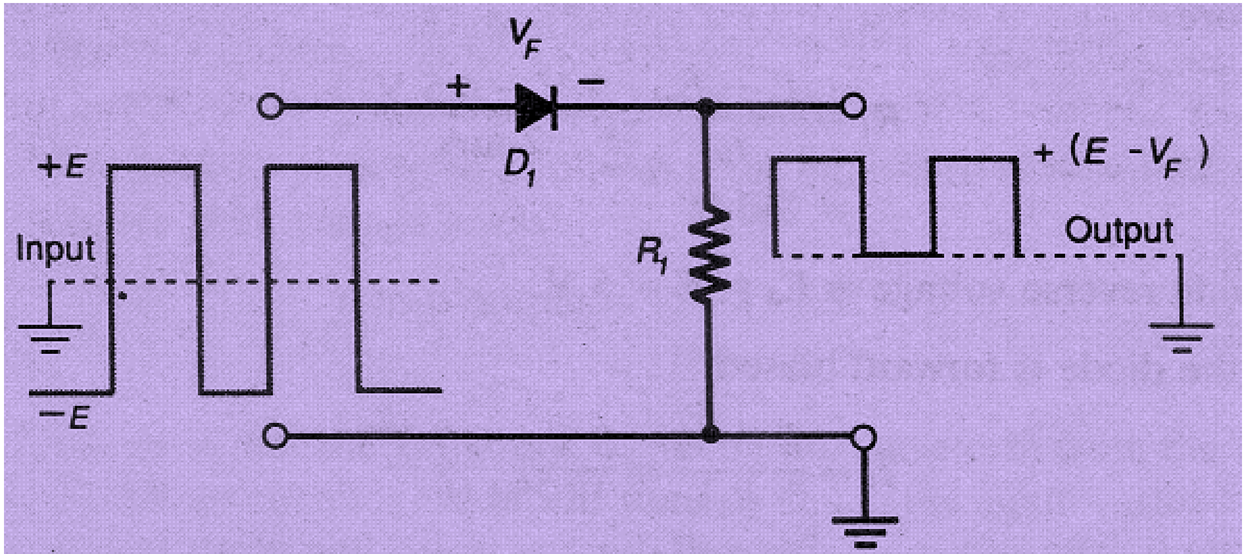


Diode Logic Circuits

OR Logic

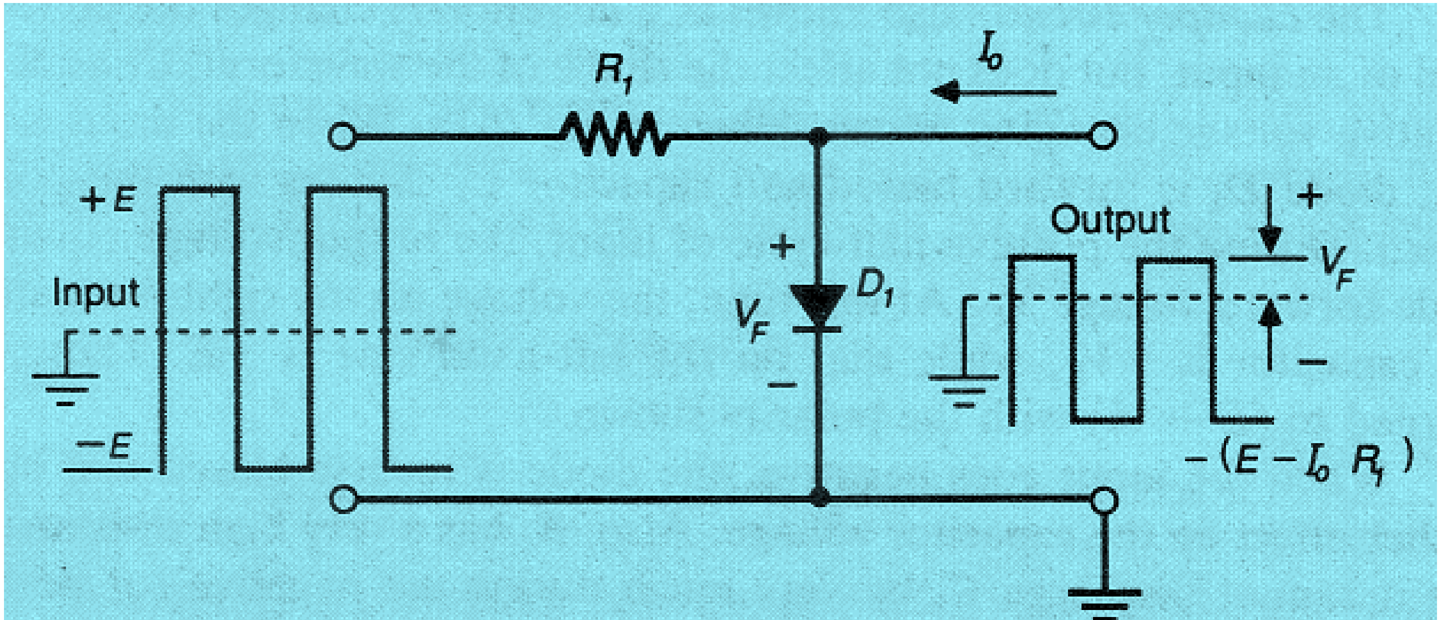


Diode Clipping and Clamping Circuits



(a) Negative series clipper

Diode Clipping and Clamping Circuits



(b) Positive shunt clipper

Diode Clipping and Clamping Circuits

A positive shunt clipper circuit has an input voltage of $E = \pm 5$ V. The negative output voltage is to be -4.5 V when I_o is 2 mA. Determine the value of R_1, and specify the diode forward current and reverse voltage.

When the diode is reverse biased,

$$E_o = E - I_o R_1$$

Therefore,

$$R_1 = \frac{E - E_o}{I_o} = \frac{5\text{ V} - 4.5\text{ V}}{2\text{ mA}}$$

$$= 250\ \Omega$$

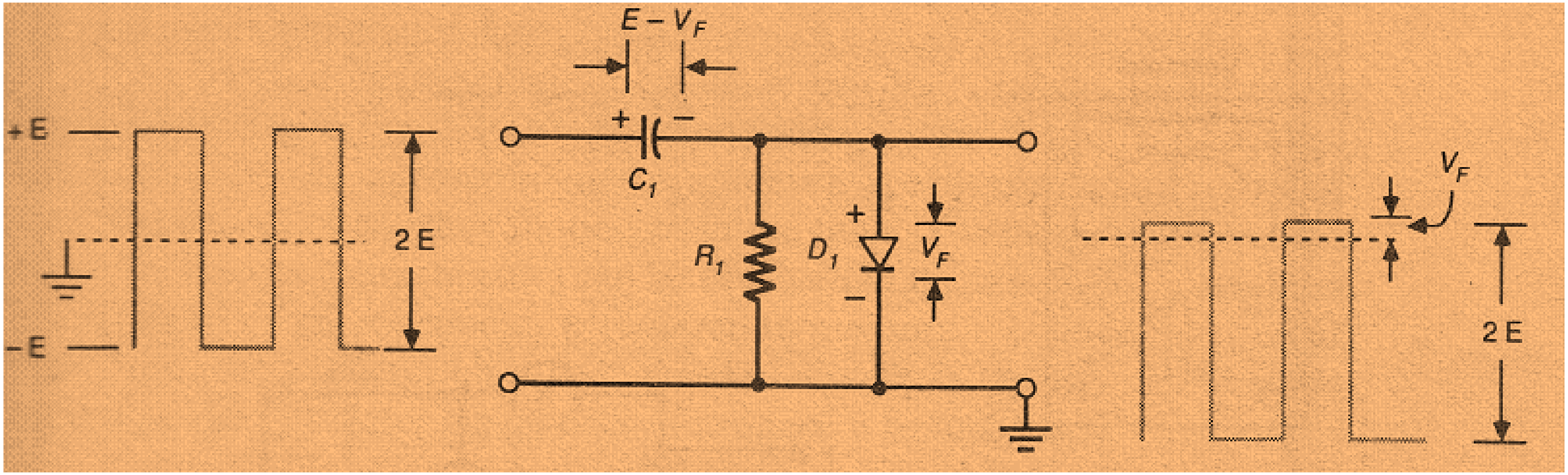
The diode reverse voltage is $E_R \simeq E = 5$ V.

When the diode is forward biased,

$$I_F \simeq \frac{E - V_F}{R_1} = \frac{5\text{ V} - 0.7\text{ V}}{250\ \Omega}$$

$$= 17.2\text{ mA}$$

Diode Clipping and Clamping Circuits

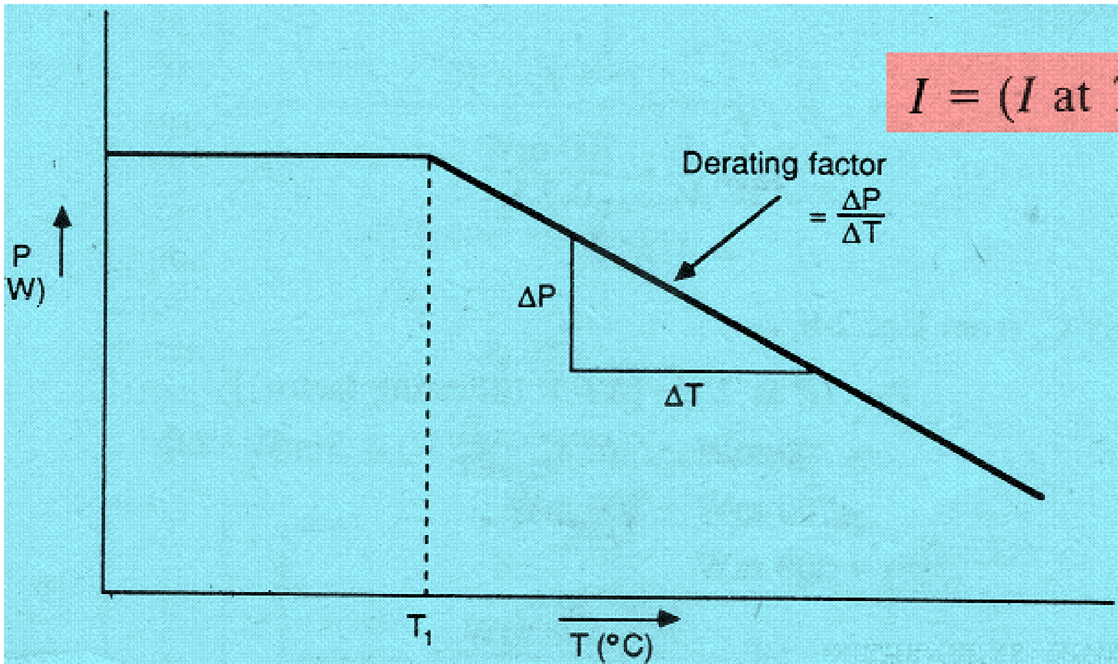


$$\text{Output} = -E - (E - V_F) = -(2E - V_F)$$

$$\text{p-to-p output} = V_F - [-(2E - V_F)] = 2E$$

Power Dissipation in Diodes

$$I = (I \text{ at } T_1) - [\Delta T \times (\text{derating factor})]$$



Power versus temperature graph

$$P = (P \text{ at } T_1) - [\Delta T \times (\text{derating factor})]$$

Or, Current vs. Temperature Graph!

Power Dissipation in Diodes

The maximum power that may be dissipated in a diode is listed on the data sheet as 700 mW at 25°C. The derating factor specified is 5 mW/°C. If the diode forward voltage drop is 0.7 V, calculate the maximum forward current that may be passed at 25°C and at 65°C.

At 25°C,

$$P = I_F \times V_F$$

or

$$I_F = \frac{P}{V_F} = \frac{700 \text{ mW}}{0.7 \text{ V}}$$

$$= 1 \text{ A}$$

At 65°C, from Eq. 2-8,

$$\begin{aligned} P &= (P \text{ at } T_1) - [\Delta T \times (\text{derating factor})] \\ &= 700 \text{ mW} - [(65°\text{C} - 25°\text{C}) \times 5 \text{ mW/°C}] \\ &= 700 \text{ mW} - 200 \text{ mW} \\ &= 500 \text{ mW} \end{aligned}$$

$$I_F = \frac{P}{V_F} = \frac{500 \text{ mW}}{0.7 \text{ V}}$$

Q & A