Indian Institute of Technology Guwahati
Department of Electronics and Electrical Engineering
EE101 - Basic Electronics

Tutorial - 7 **Date: Jan 16, 2023**

1. Compute the current through the load R_L = 2 k Ω and the diode D by assuming Si diode with cut-in voltage of 0.7

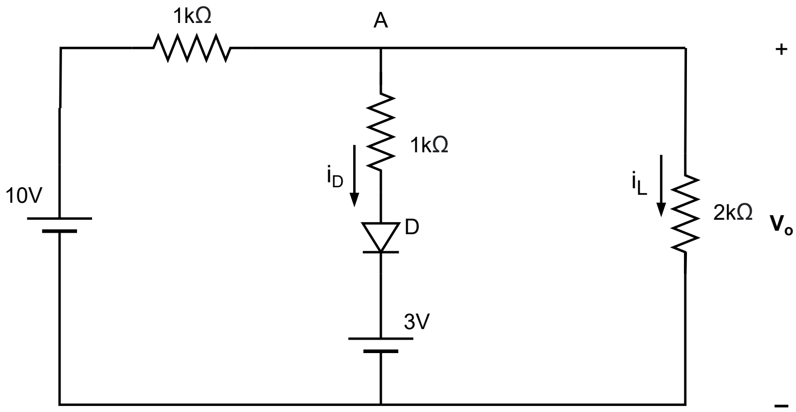

Figure 1

Solution:

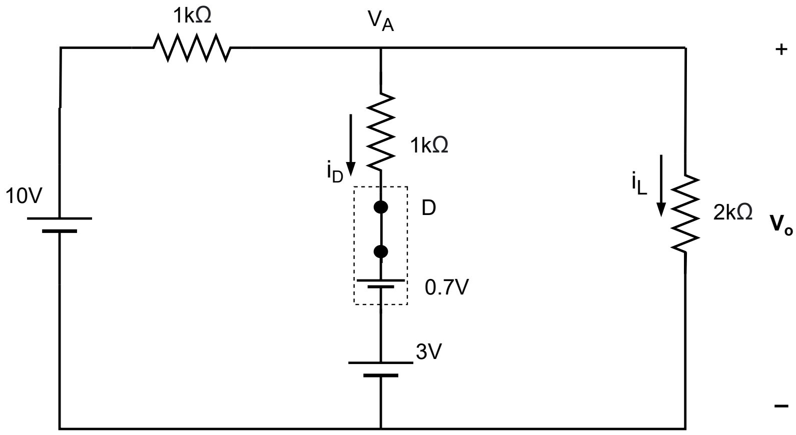

Figure 2

Applying KCL at node A

$$\begin{aligned}\frac{10 - V_A}{1} &= \frac{V_A - 3.7}{1} + \frac{V_A}{2} \\ 10 - V_A &= V_A - 3.7 + \frac{V_A}{2} \\ \frac{5V_A}{2} &= 13.7 \\ V_A &= 5.48V\end{aligned}$$

$$i_L = \frac{V_A}{R_L} = \frac{5.48V}{2k\Omega} = 2.74\, mA$$

$$i_D = \frac{5.48 - 3.7}{1k\Omega} = 1.78\, mA$$

2. Compute the minimum voltage required to turn the diode D "ON". Accordingly, find the transfer function (output V_o as a function of input v_i)

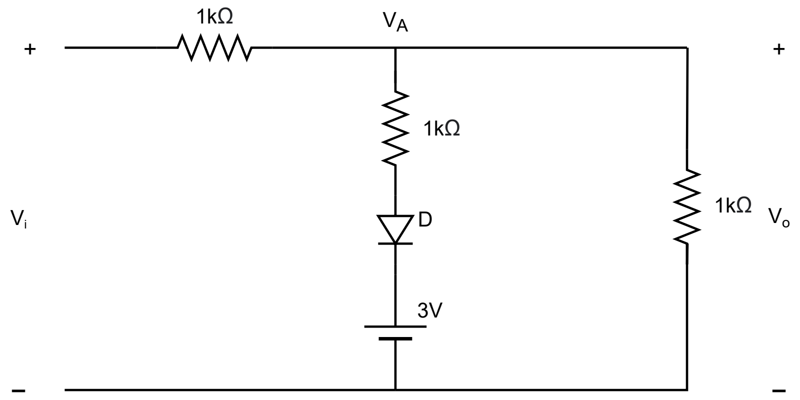

Figure 3

Solution:

$$V_i - V_A = V_A - 3.7 + V_A$$

$$V_i + 3.7 = 3V_A$$

$$V_A = \frac{1}{3}(V_i + 3.7)$$

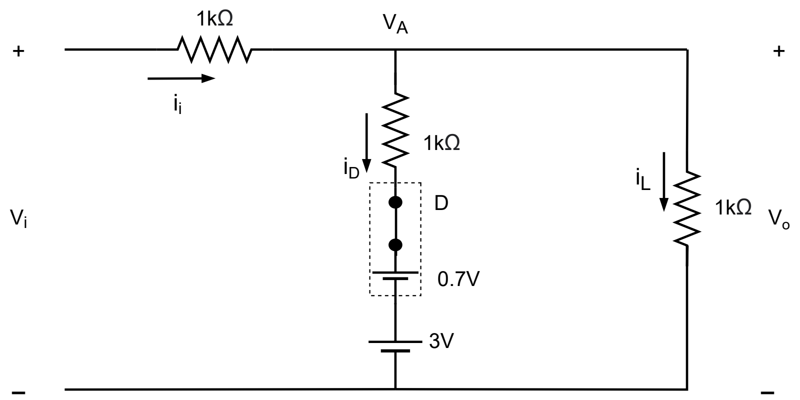

Figure 4

For the diode D to be On, we require

$$V_A \geq 3.7$$

$$\Rightarrow \frac{1}{3}(V_i + 3.7) \geq 3.7$$

$$V_i \geq 7.4V$$

The transfer function is given as

$$V_o = V_A$$

$$V_o = \frac{1}{3}(V_i + 3.7) \quad for \quad V_i \geq 7.4V$$

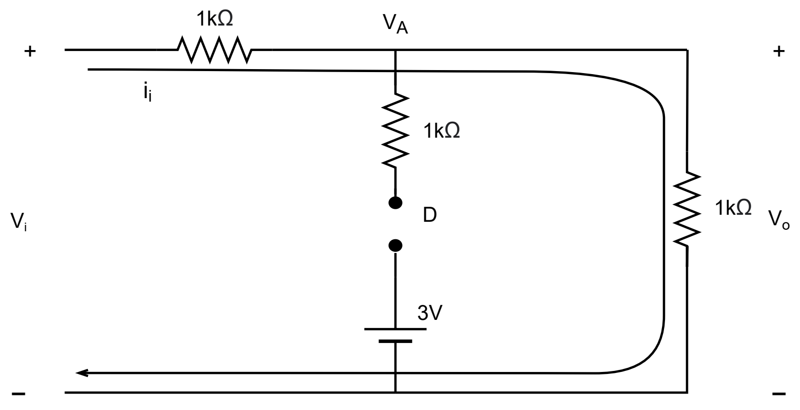

Figure 5

For $V_i \leq 7.4V$, diode D is reverse biased; the transfer function is given by

$$V_o = \frac{V_i}{2} \quad for \quad V_i \leq 7.4V$$

Hence,

$$V_o = \begin{cases} \frac{V_i}{2} & V_i \leq 7.4V \\ \frac{1}{3}(V_i + 3.7) & V_i \geq 7.4V \end{cases}$$

3. Assuming diodes to be ideal, determine the transfer function characteristics of the circuit

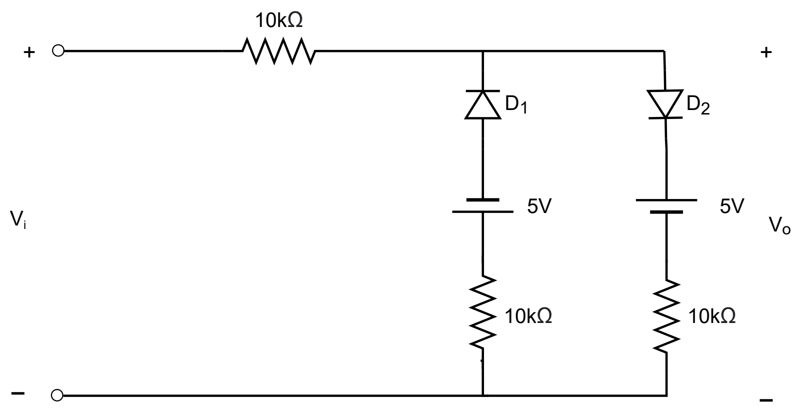

Figure 6

Solution

Case 1

$$V_i \leq -5V$$

$$D_1 \quad - \quad On \quad ; \quad D_2 \quad - \quad Off$$

$$V_o = V_i \frac{10}{10+10} - 5\frac{10}{10+10}$$

$$V_o = 0.5V_i - 2.5$$

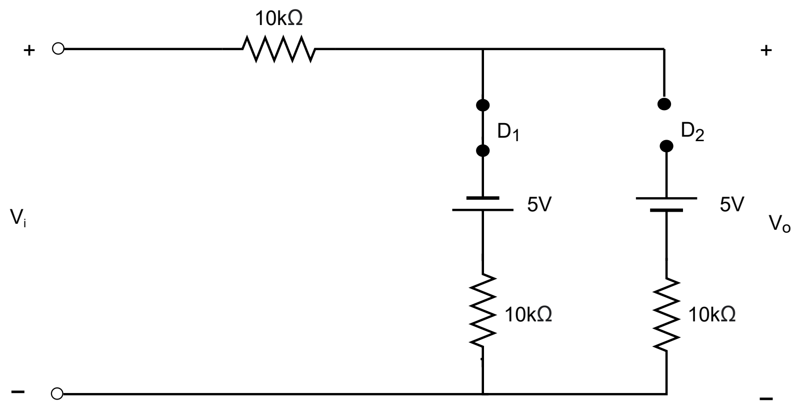

Figure 7

Case 2

$$V_i \geq 5V$$

$$D_1 \quad - \quad Off \quad ; \quad D_2 \quad - \quad On$$

$$V_o = V_i \frac{10}{10+10} + 5\frac{10}{10+10}$$

$$V_o = 0.5V_i + 2.5$$

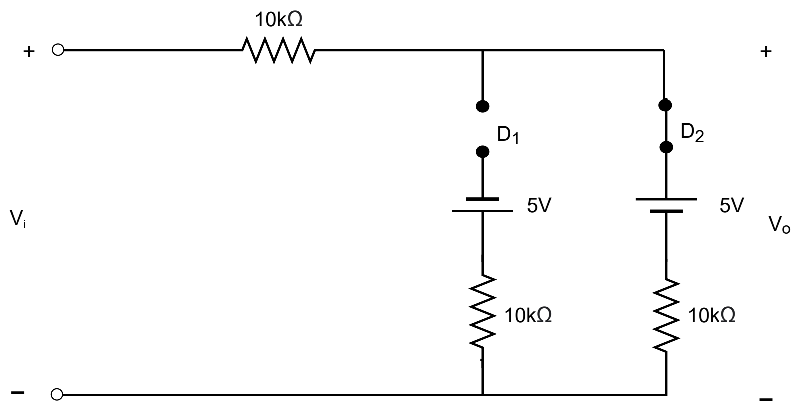

Figure 8

Case 3

$$-5 \leq V_i \leq 5V$$

$$Both \quad D_1 \quad and \quad D_2 \quad - \quad Off$$

$$V_o = V_i$$

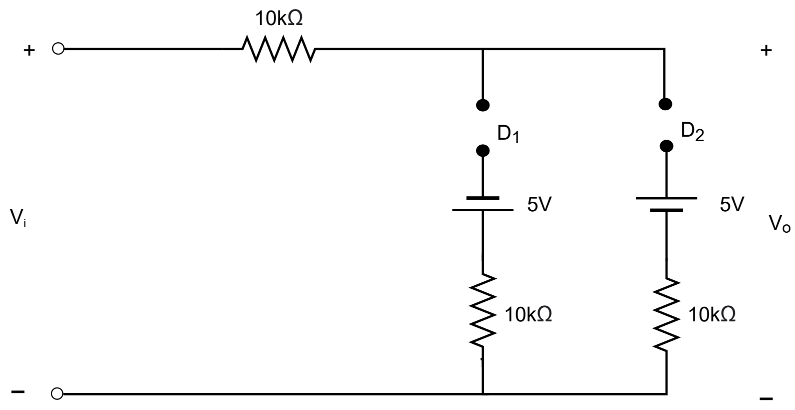

Figure 9

This is represented graphically as

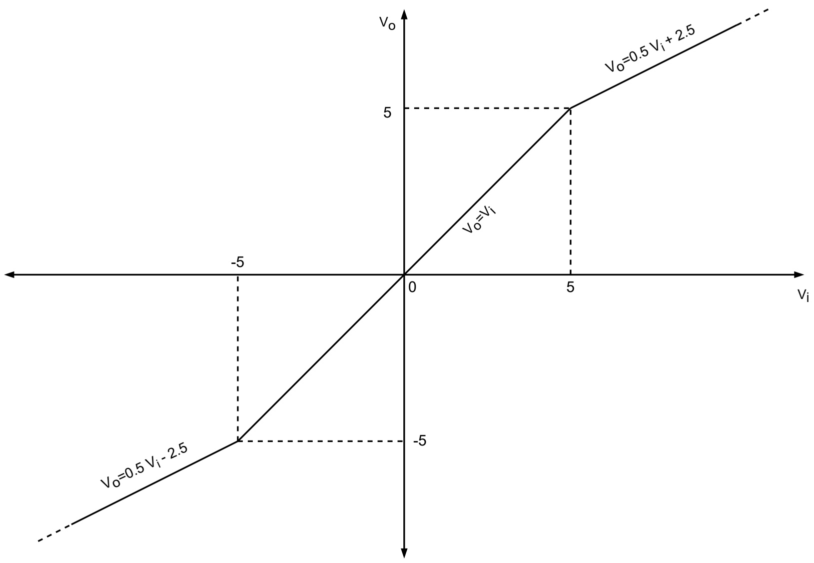

Figure 10

4. Calculate the line currents in the three-wire $Y - Y$ system of Figure 11.

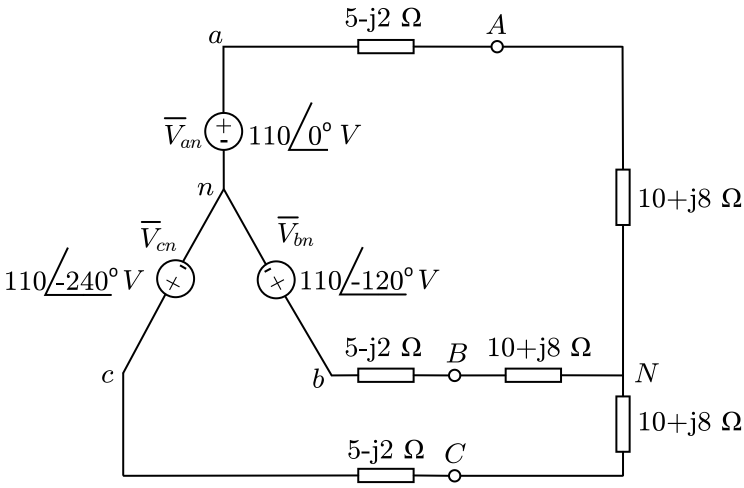

Figure 11 Three-wire $Y - Y$ system.

Solution

Note: $\overline{bar}$ indicates phasor quantity.

The three-phase circuit in Figure 11 is balanced. We may replace it with its single-phase equivalent circuit.

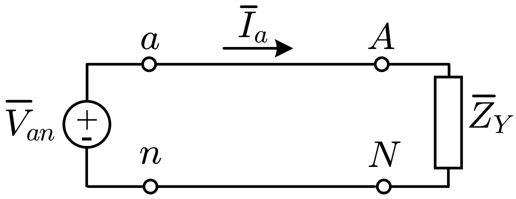

Figure 12 Single-phase equivalent circuit.

We obtain $\overline{I}_a$ from the single-phase analysis as

$$\overline{I}_a = \frac{\overline{V}_{an}}{\overline{Z}_Y}$$

where, $\overline{Z}_Y = (5 - j2) + (10 + j8) = 15 + j6 = 16.155\underline{/21.8^\circ}$. Hence,

$$\overline{I}_a = \frac{110\underline{/0^\circ}}{16.155\underline{/21.8^\circ}} = 6.81\underline{/-21.8^\circ}\ A$$

Since the source voltages in Figure 11 are in positive sequence, the line currents are also in positive sequence.

$$\overline{I}_b = \overline{I}_a\underline{/-120^\circ} = 6.81\underline{/-141.8^\circ}\ A$$
$$\overline{I}_c = \overline{I}_a\underline{/-240^\circ} = 6.81\underline{/-261.8^\circ} = 6.81\underline{/98.2^\circ}\ A$$

5. A balanced abc-sequence Y-connected source with $|\overline{V_{an}}| = 100\,V$ is connected to a Δ-connected balanced load $(8 + j4\,)\;\Omega$ per phase as shown in Figure 13. Calculate the phase and line currents.

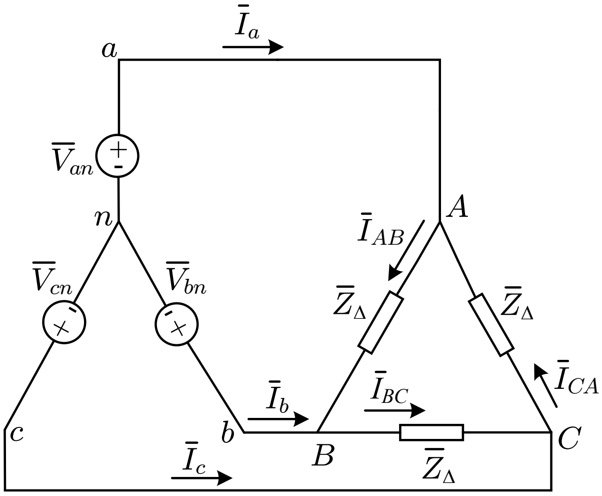

Figure 13 Three-wire $Y - \Delta$ system.

Solution

METHOD 1:

The load impedance is

$$\overline{Z}_\Delta = 8 + j4 = 8.944\underline{/26.57^\circ}\;\Omega$$

If the phase voltage $\overline{V}_{an} = 100\underline{/10^\circ}$, then the line voltage is

$$\overline{V}_{ab} = \sqrt{3}\overline{V}_{an}\underline{/30^\circ} = 100\sqrt{3}\underline{/10^\circ + 30^\circ} = \overline{V}_{AB}$$

or,

$$\overline{V}_{AB} = 173.2\underline{/40^\circ}$$

The phase currents are

$$\overline{I}_{AB} = \frac{\overline{V}_{AB}}{\overline{Z}_\Delta} = \frac{173.2\underline{/40^\circ}}{8.944\underline{/26.57^\circ}} = 19.36\underline{/13.43^\circ}\;A$$

$$\overline{I}_{BC} = \overline{I}_{AB}\underline{/-120^\circ} = 19.36\underline{/-106.57^\circ}\;A$$

$$\overline{I}_{CA} = \overline{I}_{AB}\underline{/+120^\circ} = 19.36\underline{/133.43^\circ}\;A$$

The line currents are

$$\overline{I}_a = \sqrt{3}\overline{I}_{AB}\underline{/-30^\circ} = \sqrt{3}(19.36)\underline{/13.43^\circ - 30^\circ} = 33.53\underline{/-16.57^\circ}\;A$$

$$\overline{I}_b = \overline{I}_a\underline{/-120^\circ} = 33.53\underline{/-136.57^\circ}\;A$$

$$\overline{I}_c = \overline{I}_a\underline{/+120^\circ} = 33.53\underline{/103.43^\circ}\;A$$

METHOD 2:

Alternatively, using single-phase analysis,

$$\overline{I}_a = \frac{\overline{V}_{an}}{\frac{\overline{Z}_\Delta}{3}} = \frac{100\underline{/10^\circ}}{2.981\underline{/26.57^\circ}} = 33.54\underline{/-16.57^\circ}\;A$$

Other line currents are obtained using the abc phase sequence as above.

That's it.