

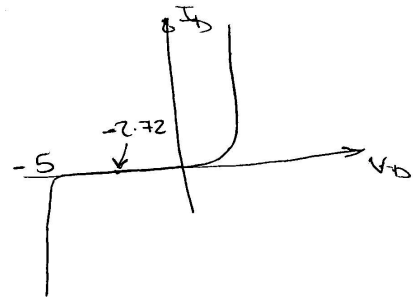
* Determine the diode operating point for $V_{in} = 30V$, $V_{in} = 70V$, $V_{in} = -5V$, $V_{in} = -30V$

* For $V_{in} = 30V$, if we assume Zener is in cut-off

$$V_L = \frac{30 \times 0.1}{1.1} = 2.7272V < V_Z$$

$$I_L = \frac{2.7272}{0.1} = 27.27 \text{ mA}$$

Q-point is $(0A, -2.7272V)$



* For $V_{in} = 70V$, if we assume Zener is cut-off

$$V_L = \frac{70 \times 0.1}{1.1} = 6.3636V > V_Z \quad (\text{A contradiction})$$

So Zener must be in breakdown region

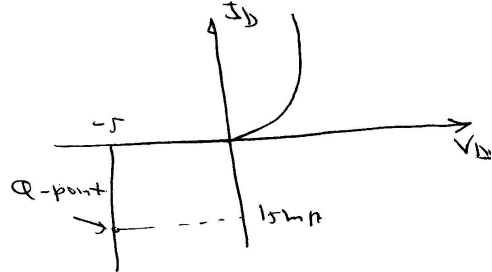
$$V_L = V_Z = 5V$$

$$I_L = \frac{5}{0.1k} = 50 \text{ mA}$$

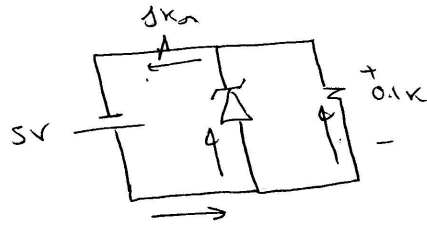
$$I_r = \frac{70 - 5}{1k} = 65 \text{ mA}$$

$$I_Z = I_r - I_L = 15 \text{ mA}$$

Q-point is $(15 \text{ mA}, -5V)$



* If $V_{in} = -5V$, we have the following circuit

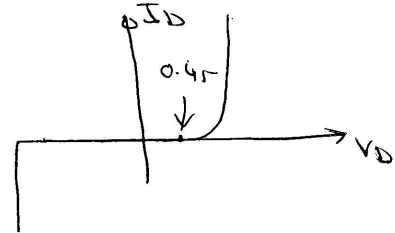


Assuming that diode is reverse biased

$$V_L = -5 \times \frac{0.1}{1.1} = -0.4545 \Rightarrow V_D = 0.4545 < V_{D, on}$$

$$\therefore I_L = \frac{-0.4545}{0.1k} = -4.5 \text{ mA}$$

$$I_D = I_L = -4.5 \text{ mA}$$



* If $V_{in} = -30V$, the diode is assumed reverse biased

we get

$$V_L = -30 \times \frac{0.1}{1.1} = -2.7272 \Rightarrow V_D = 2.7272 > V_{D, on}$$

It follows that diode must be on

$$V_D = 0.7$$

$$I_L = \frac{-0.7}{0.1k}$$

$$= -7 \text{ mA}$$

$$I_D = \frac{-30 - (-0.7)}{1k} = \frac{-29.3}{1k} = -29.3 \text{ mA}$$

$$\therefore I_D = 29.3 - 7 = 22.3 \text{ mA}$$

Q-point $(0.7, 22.3 \text{ mA})$

