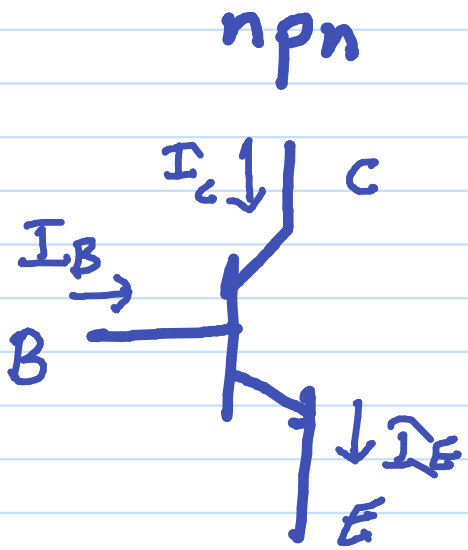
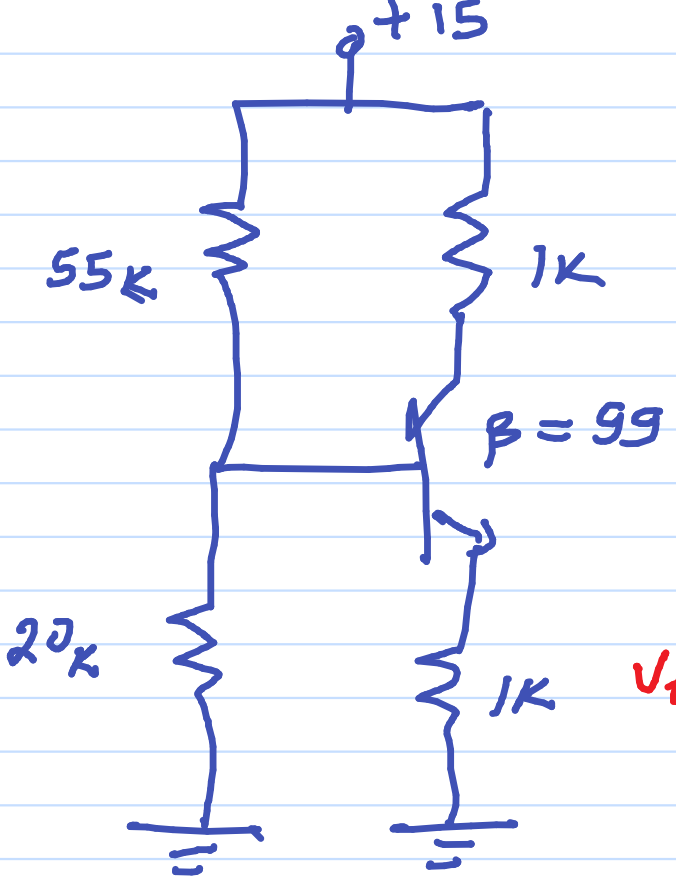
BJT Transistors



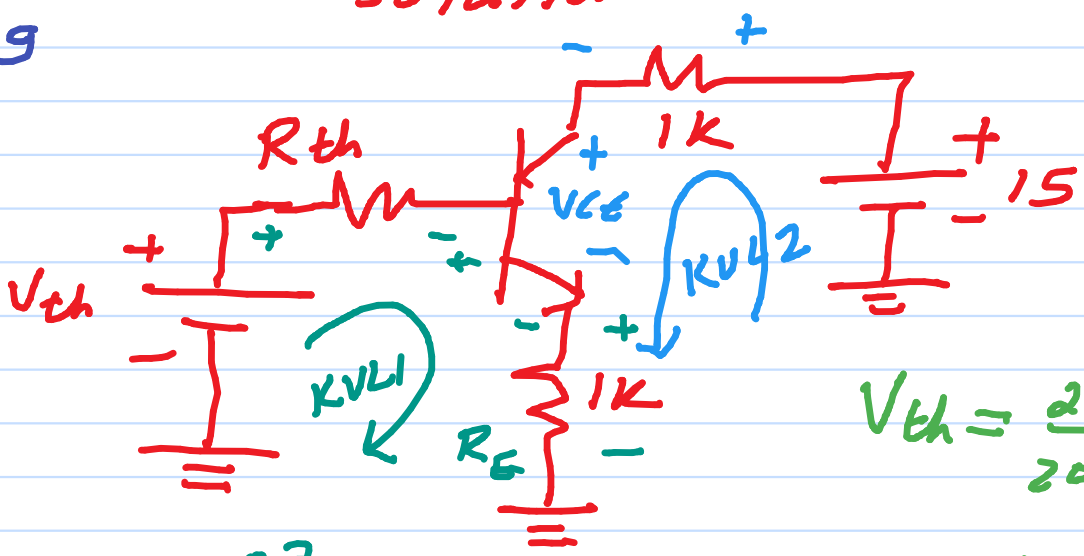
Junction BE	Junction BC	Mode of operation
off	off	Cut-off → $I_C = I_B = I_E = 0$
ON	ON	Saturation → $V_{CE} = V_{CE(sat)} \approx 0.2V$
ON	OFF	Active/Linear $V_{CE} > V_{CE(sat)}$ $I_C = \beta I_B$ $I_E = I_B + I_C$

DC Bias



Calculate $I_B, I_C, I_E, V_{CE}, V_{BC}$

⇓ solution



$$V_{th} = \frac{20K}{20K+55K} \cdot 15 = 4\ V$$

$$R_{th} = 20K \,//\, 55K = 14.66K$$

KVL1: $V_{th} = I_B R_{th} + V_{BE} + I_E \cdot R_E$ ($V_{BE} \approx 0.7$)

$$\therefore I_B = \frac{V_{th} - 0.7}{R_{th} + R_E(\beta+1)} = \frac{4 - 0.7}{14.66K + 1K(99+1)} = \frac{3.3}{114.66K} = 28.78\ \mu A$$

$$I_C = \beta I_B = 2.85\ mA \ ; \ I_E = (\beta+1) I_C = 2.878\ mA$$

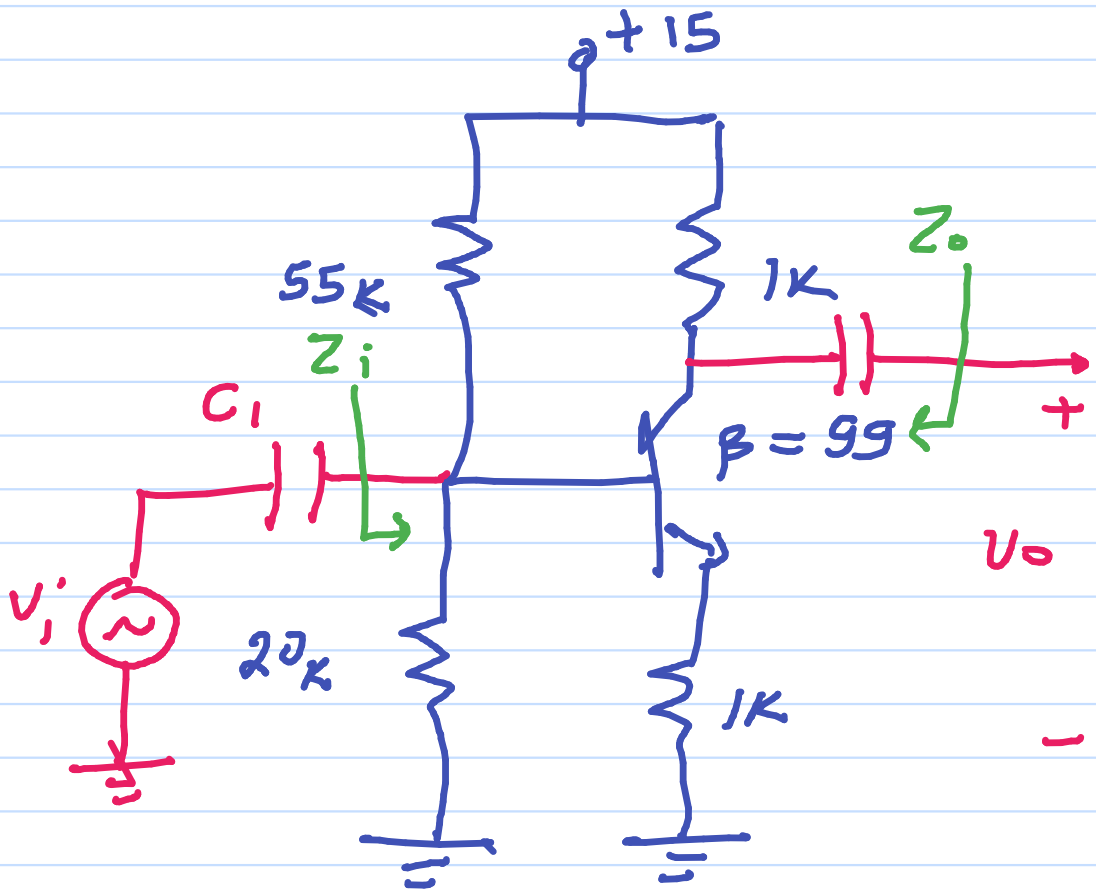
KVL2: $V_{CE} = 15 - I_C \cdot 1K + I_E \cdot 1K = 15 - 2.85 - 2.878 =$

$$\approx 9.272\ V$$

$$V_{BC} = V_{BG} - V_{CE} \simeq 0.7 - 9.27 \simeq -8.57$$

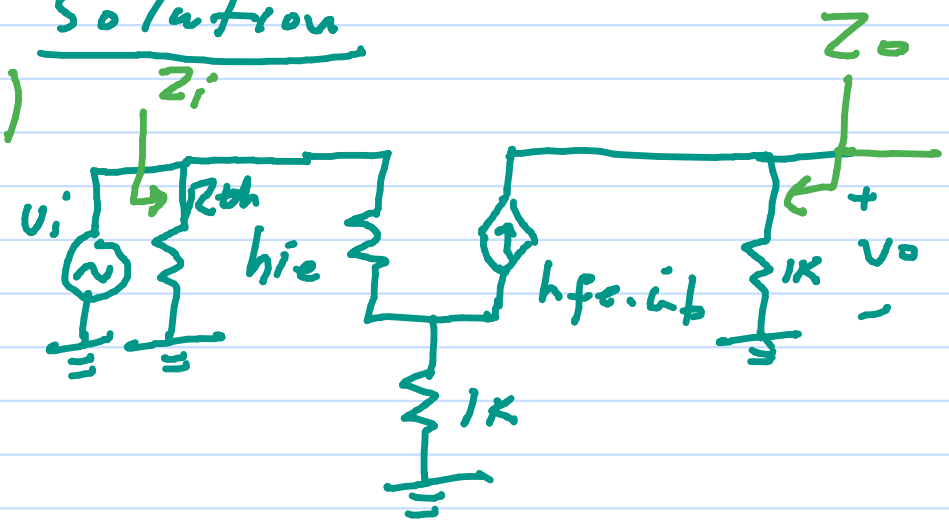
AC small-signal analysis

Calculate A_v, Z_i, Z_o



Solution

1) Z_i



$$V_o = -h_{fe}.i_b\,(1K)$$

$$i_b = \frac{V_i}{h_{ie} + 1K\,(h_{fe}+1)}$$

$$A_v = -\frac{h_{fe}.1K}{h_{ie} + 1K\,(h_{fe}+1)}$$

2) $Z_i = R_{th} \,//\, (h_{ie} + 1K\,(h_{fe}+1))$

3) $Z_o = 1K$

4) $h_{ie} = \frac{V_T}{I_{BQ}} = \frac{25.69\,mV}{28.78\,\mu A} \Rightarrow 892\,\Omega$