BJT Amp Configuration Examples

CE amplifier

$\beta = 100$ $\quad I_{CQ} = 1mA$ $\quad R_L = 5k\Omega$

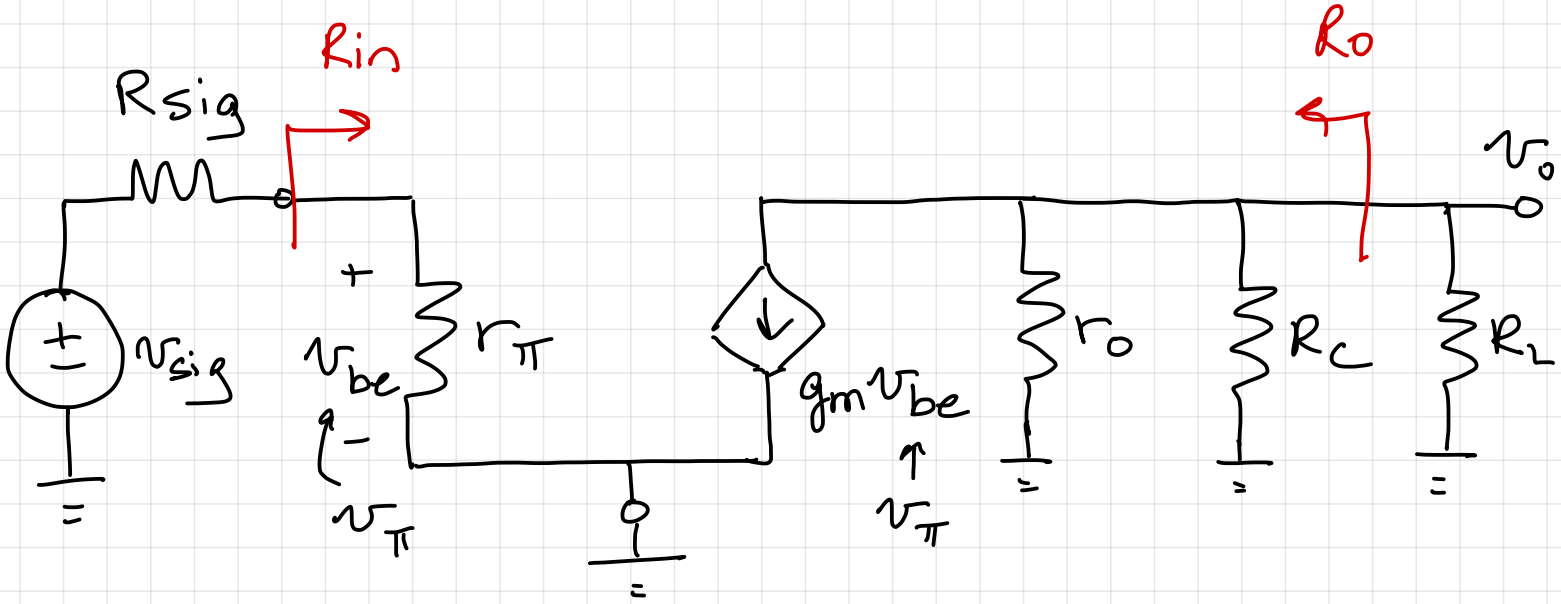
$V_A = 100$ $\quad R_C = 5k\Omega$ $\quad R_{sig} = 10k\Omega$

Finding g_m, r_π, r_o

$$g_m = \frac{I_{CQ}}{V_T} = \frac{1mA}{.025V} = 40\frac{mA}{V}$$

$$r_\pi = \frac{\beta}{g_m} = \frac{100}{40\times10^{-3}} = 2.5\times10^3 \quad 2.5k\Omega$$

$$r_o = \frac{V_A}{I_{CQ}} = \frac{100}{1} = 100k\Omega$$



$$R_{in} = r_\pi = 2.5\,k\Omega$$

$$R_o = r_o \| R_C = 100 \| 5 = 4.76\,k\Omega$$

$$G_v = \frac{v_o}{v_{sig}} = -g_m (r_o \| R_C \| R_L) \left(\frac{r_\pi}{r_\pi + R_{sig}} \right)$$

$$= -40\,(100 \| 5 \| 5) \left(\frac{2.5}{12.5} \right)$$

$$G_v = -19.52\ V/V$$

Let's do a redesign:

$I_{CQ} = 0.5mA$ => reduction to increase R_{in}

$$g_m = \frac{I_{CQ}}{V_T} = 20mA$$

$$r_\pi = 5\,k\Omega$$

$$r_o = \frac{V_A}{I_{CQ}} = 200\,k\Omega$$

$$G_v = -g_m (r_o \| R_C \| R_L) \left(\frac{r_\pi}{r_\pi + R_{sig}} \right)$$

$$= -20(200 \| R_C \| 5) \left(\frac{5}{15} \right)$$

$$= -20(R_C \| 4.88)(1/3)$$

$$= -6.67\,(R_C \| 4.88)$$

$$-6.67\left(\frac{R_C(4.88)}{R_C+4.88}\right) = -19.52$$

$$\boxed{R_C = 7.33\,k\Omega}$$

$$R_o = 200 \| 7.33 = 7.07\,k\Omega$$

$$R_{in} = 5k\Omega$$

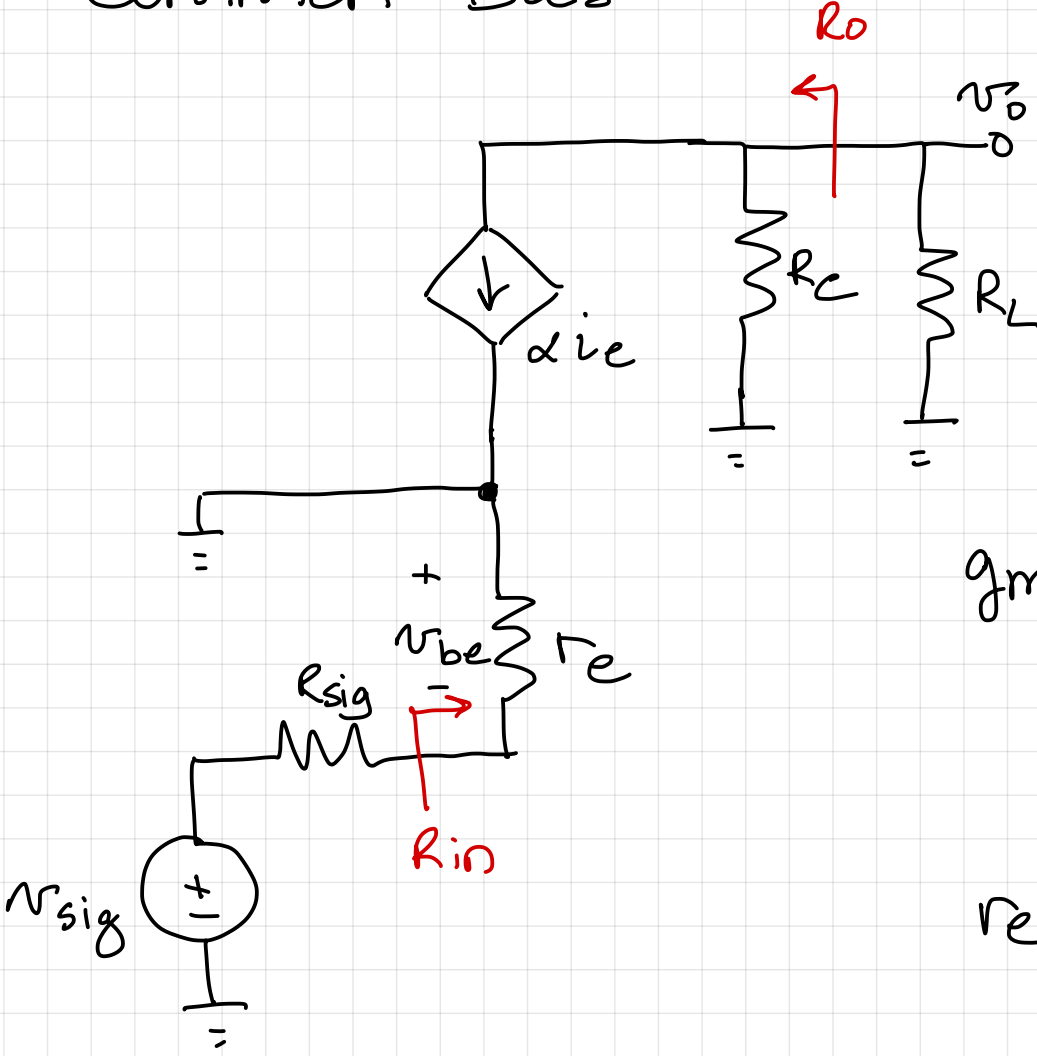
Common Base

$I_{CQ} = 1mA$

$R_C = 5k\Omega$

$R_L = 5k\Omega$

$R_{sig} = 5k\Omega$



$$g_m = \frac{I_{CQ}}{V_T}$$

$$= \frac{1}{.025} = 40\frac{mA}{V}$$

$$r_e = \frac{\alpha}{g_m} \approx \frac{1}{g_m}$$

$$= 25\Omega$$

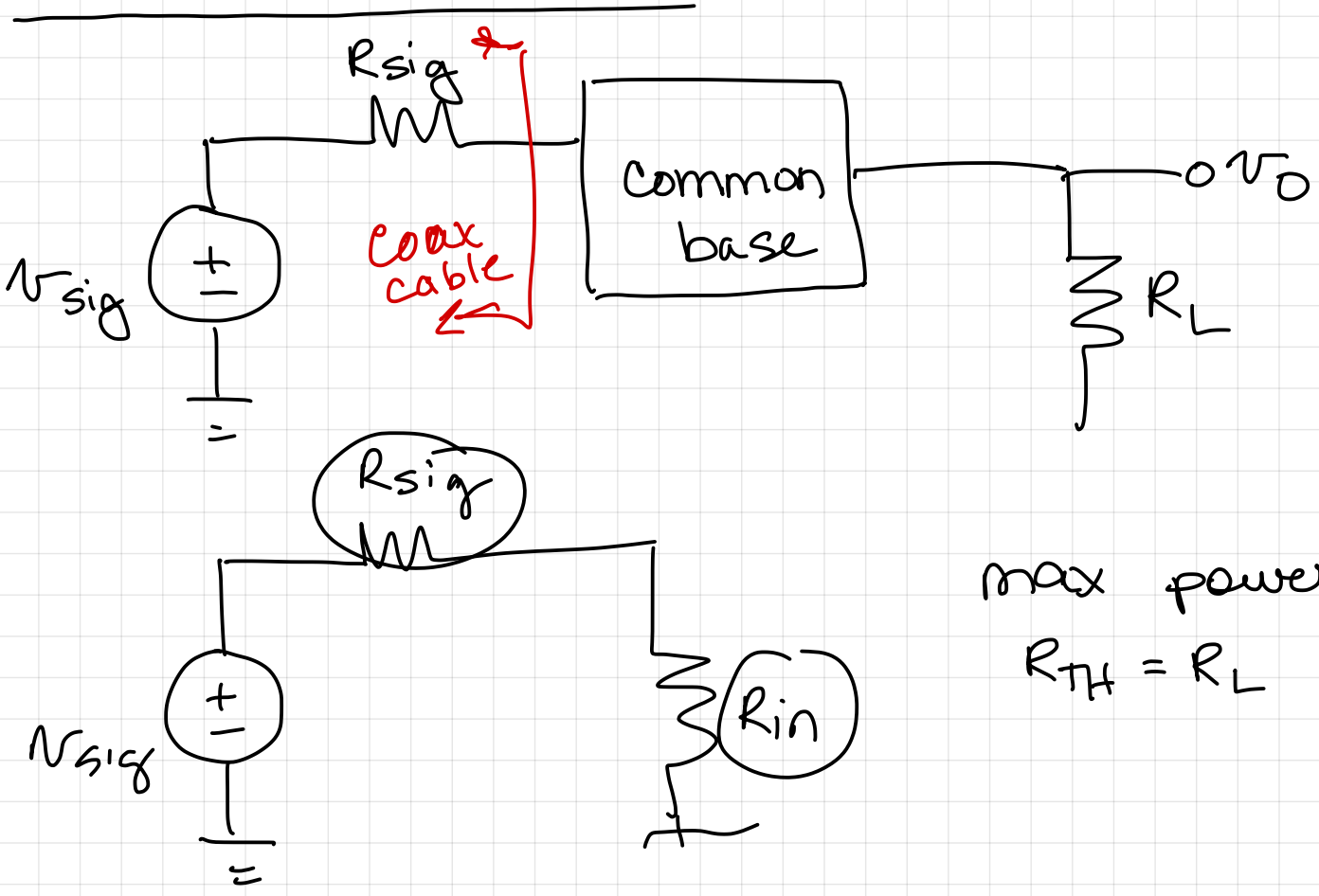
$$R_{in} = r_e = 25\Omega$$

$$R_o = R_c = 5k\Omega$$

$$\frac{v_o}{v_{sig}} = \left(\frac{r_e}{r_e + R_{sig}}\right)\left(g_m (R_c \| R_L)\right)$$

$$= \left(\frac{25}{25 + 5000}\right)\left(40 (5 \| 5)\right)$$

$$\frac{v_o}{v_{sig}} = 0.5 \ V/V$$



max power

$R_{TH} = R_L$

Design

$R_{in} = 50\Omega$ $\qquad$ $r_e = 50\Omega$

$R_{in} = r_e$ $\qquad$ $r_e \cong \frac{1}{g_m} = 50$

$g_m = \frac{20mA}{V}$

Design

$G_V = 40\ V/V$

$40 = g_m (R_C \| R_L) \left(\frac{r_e}{50+50} \right)$ $\quad \cdot 1/2$

$r_e \quad R_L$

$\frac{40}{20} = (R_C \| R_L)\left(\frac{1}{2}\right)$

$g_m = \frac{I_{CQ}}{V_T}$

$\frac{80}{20} = R_C \| R_L$

$I_{CQ} = g_m V_T$

$= 20(.025)$

$I_{CQ} = 0.5mA$

$\boxed{R_C \| R_L = 4}$

Common Collector

CC amp

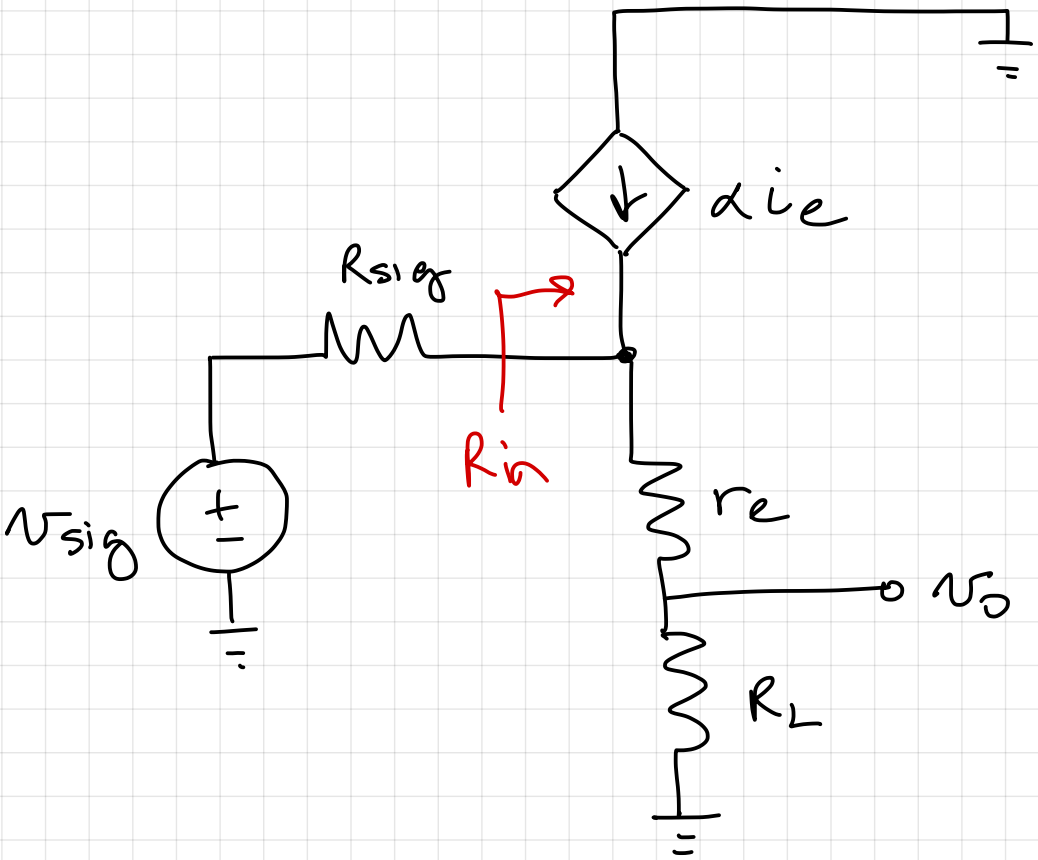
$\beta = 100$ $\quad I_{CQ} = 5mA$

$R_{sig} = 10k\Omega$ $\quad R_L = 1k\Omega$

$$g_m = \frac{I_{CQ}}{V_T}$$

$$= \frac{5}{.025}$$

$$= 200 \frac{mA}{V}$$



$$r_e \cong \frac{1}{g_m}$$

$$= 5\Omega$$

$$R_{in} = (1+\beta)(r_e + R_L)$$

$$= (1 + 100)(5 + 1000)$$

$$= (101)(1005)$$

$$R_{in} = 101.5 k\Omega$$

$$R_o = r_e = 5\Omega$$

$$G_V = \frac{(\beta+1)(R_L)}{(1+\beta)(r_e+R_L)+R_{sig}}$$

$$= \frac{(101)(1000)}{(101)(1005)+10000}$$

$$\boxed{G_V = 0.91 \text{ V/V}}$$