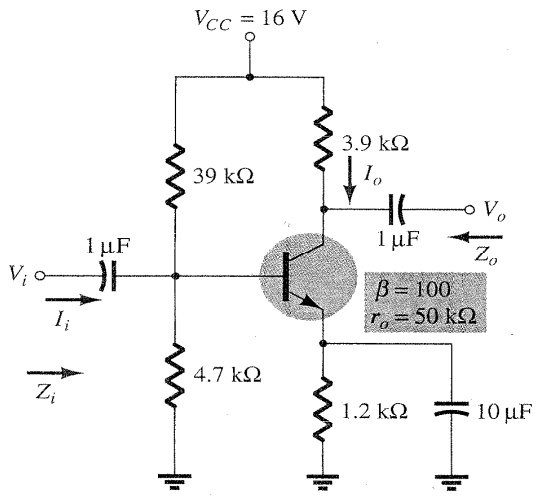
Chapter 5 #15, 19, 25, 29

Note Title 10/28/2012

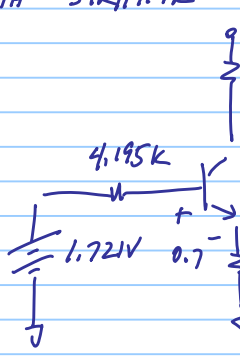
15)



a) Determine r_e. Requires DC analysis.

$V_{TH} = \frac{16(4.7k)}{4.7k + 39k} = 1.721V$ Thevenin analysis quickest.

$R_{TH} = 39k \| 4.7k = 4.195k$



KVL:

$0 = 1.721 - I_B(4.195k) - 0.7 - 1.2k I_E$

$\beta = 100$

$1.021 = I_B(4.195k) + (\beta+1) I_B(1.2k)$

$1.021 = I_B(4.195k + (101)(1.2k))$

$1.021 = I_B(4.195k + 121.2k)$

$I_B = 1.021 / (4.195k + 121.2k)$

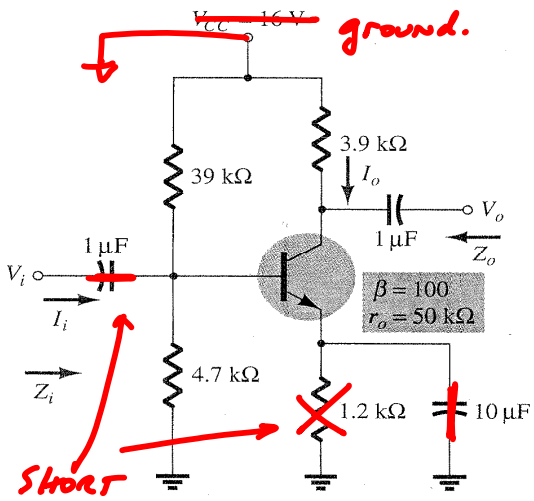
$I_B = 8.142\,\mu A$

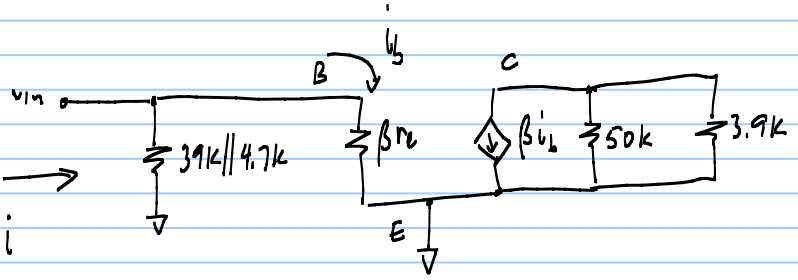
$I_E = (\beta+1) I_B = (101)(8.142\mu A)$

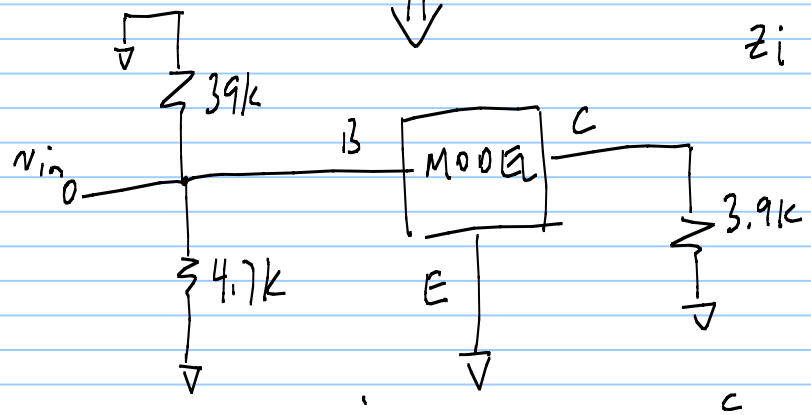
$I_E = 0.822mA$

Finally $r_e = \frac{0.026}{I_E} = \boxed{31.6\,\Omega = r_e}$

b) Use r_e. Now draw ac model. Red shows shorts for ac model.

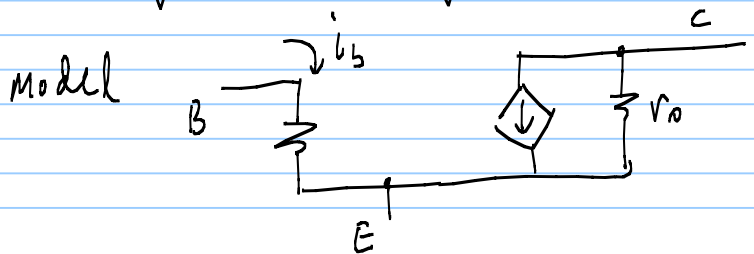


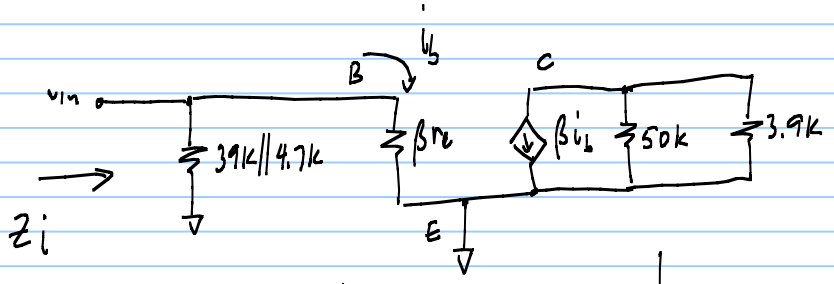




plugged in transistor model.

39k in parallel to 4.7k.





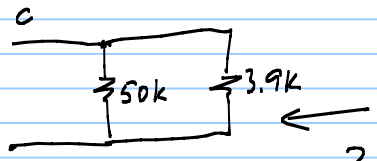
$$z_i = 39k \,||\, 4.7k \,||\, \beta r_e = \frac{1}{\frac{1}{39k} + \frac{1}{4.7k} + \frac{1}{(100)(31.6)}} = 1.802k$$

* Using approx. method instead of thevenin.

$V_B = 1.721V$, $V_E = 1.021$ & $I_E = 1.021/1.2k = 0.851mA$ $\therefore r_e = \frac{0.026}{I_E} = 30.56\Omega$

$$z_i = \frac{1}{\frac{1}{39k} + \frac{1}{4.7k} + \frac{1}{(100)(30.56)}} = 1.77k, \text{ slightly different}$$

Output resistance



$$z_o = 3.9k \,||\, 50k = \frac{1}{\frac{1}{3.9k} + \frac{1}{50k}}$$

$$z_o = 3.62k\Omega$$

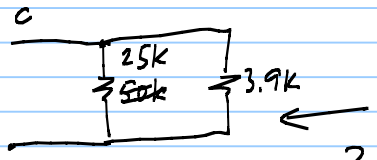
* if r_o ignored, $z_o = 3.9k$

Gain:

$$A_v = \frac{-R_c || r_o}{r_e} = \frac{-3.9k \,||\, 50k}{31.6} = -114.5$$

Repeat for $r_o = 25k$. Does not change r_e or Z_{in}. Z_{out} & A_V changed.

Output Resistance



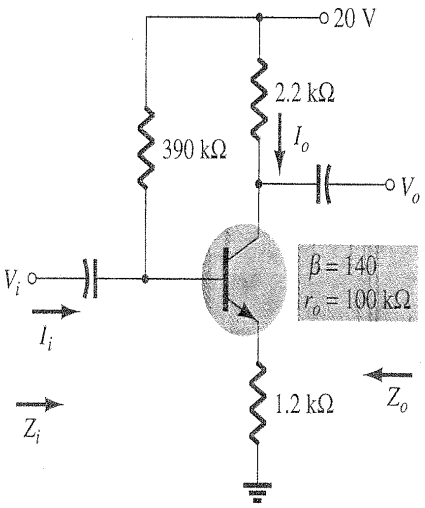
$$Z_o = 3.9k \parallel 25k = \frac{1}{\frac{1}{3.9k} + \frac{1}{25k}}$$

$$Z_o = 3.37k$$

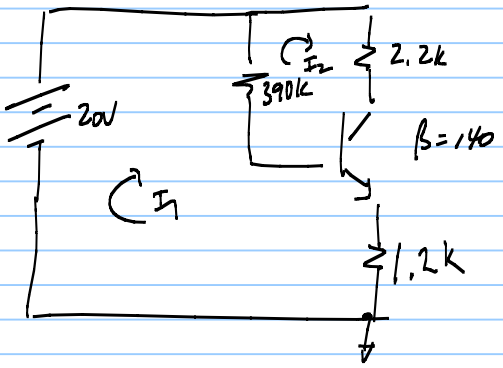
Gain:

$$A_V = \frac{-R_c \parallel r_o}{r_e} = \frac{-3.9k \parallel 25k}{31.6} = -106.8$$

19)



a) Determine r_e. Required DC analysis.



MESH #1

$20 - 390k I_1 + 390k I_2 - 0.7 - I_1(1.2k) = 0$

$19.3 = 391.2k I_1 - 390k I_2$

MESH #2

$I_c = \beta I_B$

$I_2 = \beta(I_1 - I_2)$

$I_2 = \beta I_1 - \beta I_2 \quad I_2 + \beta I_2 = \beta I_1$

$\beta I_1 - (\beta+1) I_2 = 0$

$140 I_1 - 141 I_2 = 0$

#1 $19.3 = 391.2k I_1 - 390k I_2$

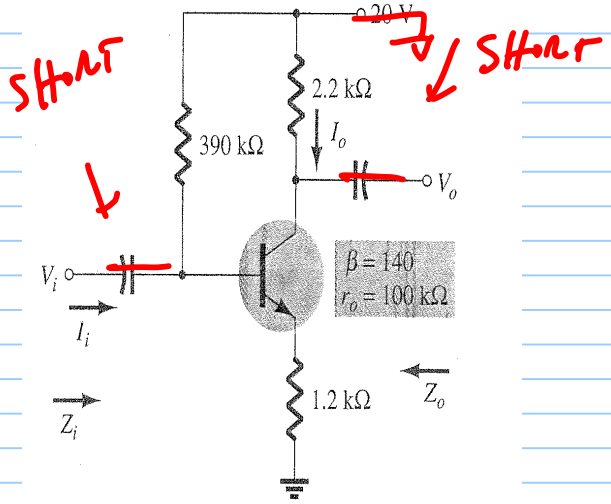
\+ $0 = -387.23k I_1 + 390k I_2$

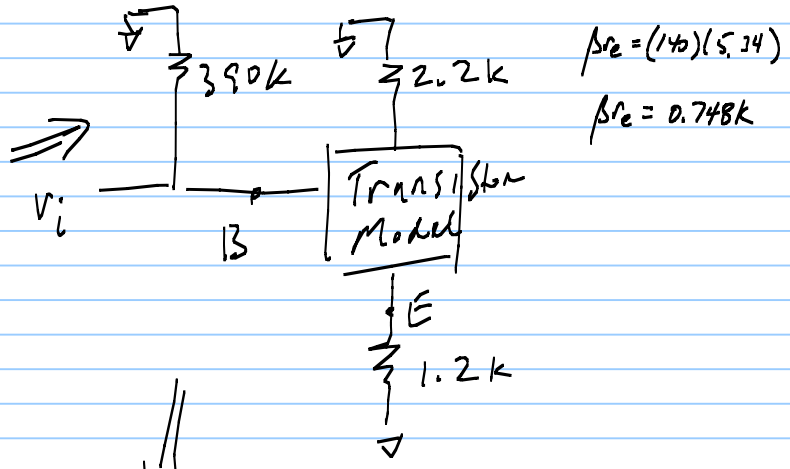
X $\frac{-390k}{141}$ to make I_2 go away.

$19.3 = 3.966k I_1$

$I_1 = 4.866 mA = I_E \Rightarrow r_e = \frac{0.026}{I_E} = 5.34\Omega$

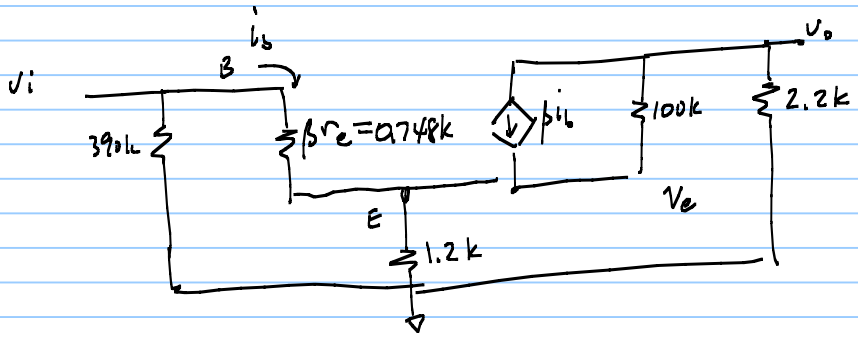
b) next, Z_i & Z_o required ac model



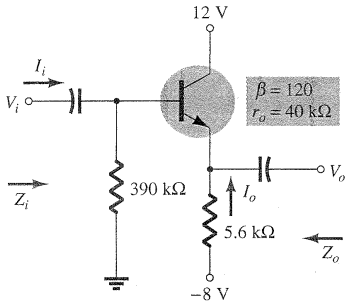


$\beta r_e = (140)(5.34)$

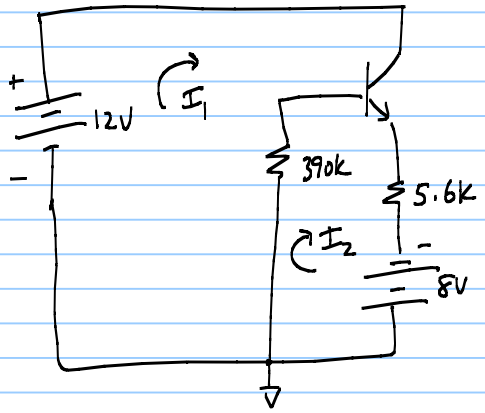
$\beta r_e = 0.748k$



25)



As with all others, find r_e first. Requires DC analysis.



#1 $I_c = \beta I_B$

$I_1 = \beta(I_2 - I_1) = \beta I_2 - \beta I_1$

$(1+\beta) I_1 - \beta I_2 = 0$

$121\, I_1 - 120\, I_2 = 0$ → ×$\frac{395.6k}{121}$

#2

$8 - 0.7 = I_1(390k + 5.6k) - I_2(390k)$

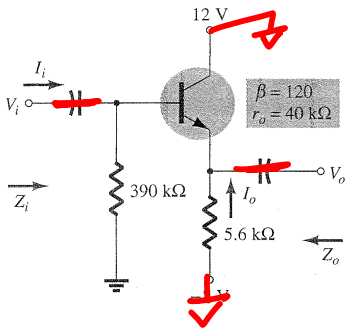
$7.3 = 395.6k\, I_1 - 390k\, I_2$

$7.3 = 395.6k\, I_1 - 390k\, I_2$

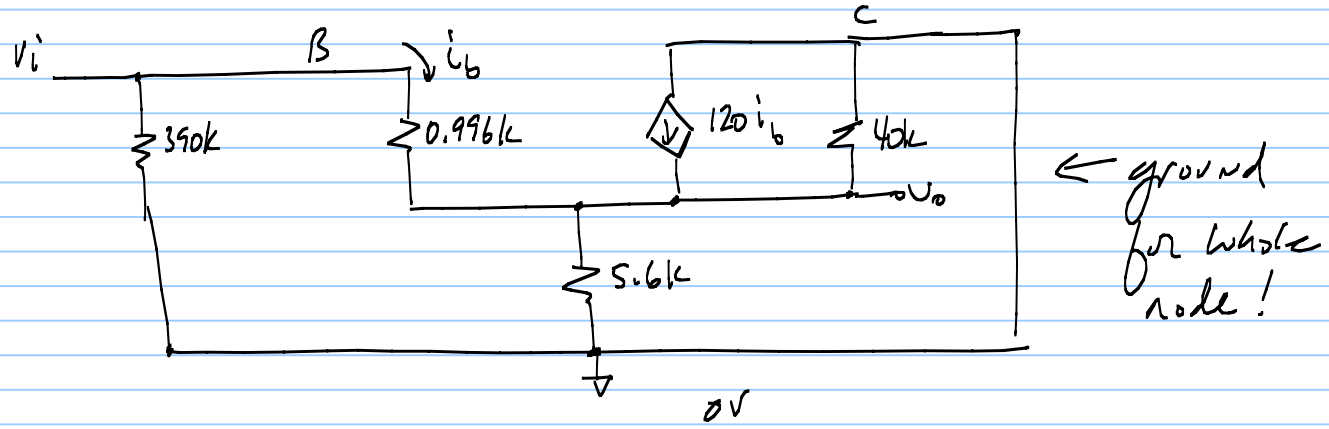
$0 = -395.6k\, I_1 + 392.33k\, I_2$

$7.3 = 2.331k\, I_2 \Rightarrow I_2 = 3.132\,mA \Rightarrow r_e = \frac{0.026}{I_E}$

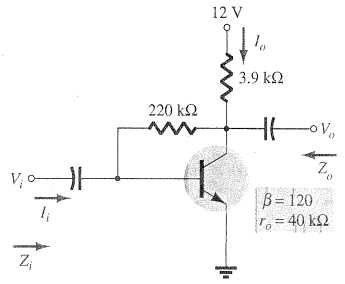
w/ $I_2 = I_E$, $\boxed{r_e = 8.301\,\Omega}$

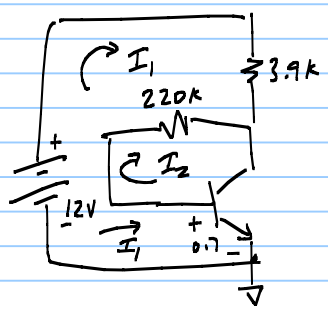


$\beta r_e = (120)(8.301\Omega) = 0.996 k\Omega$



29)





#1 $12 - I_1(3.9k) - 220k\,I_1 + 220k\,I_2 - 0.7 = 0$

$11.3 = 223.9k\,I_1 - 220k\,I_2$

#2 $I_c = \beta I_B$ $\quad I_2 = \beta(I_1 - I_2) = \beta I_1 - \beta I_2 = 120I_1 - 120I_2$

$0 = 120I_1 - 121I_2$

$\times \frac{220k}{121}$ to remove I_2, leaving $I_1 = I_E$.

$11.3 = 223.9k\,I_1 - 220k\,I_2$

$0 = -218.182k\,I_1 + 220k\,I_2$

$11.3 = 5.718k\,I_1$

$I_1 = 1.976\,mA = I_E$

$r_e = 26\,mV / 1.976\,mA = \boxed{13.156\,\Omega = r_e}$ $\quad \beta r_e = (120)(13.15) = 1.578k$

AC model: short 12V, short caps.