Name: ______________________________ (please print)

Signature: ___________________________

ECE 3455
Quiz #6
May 4, 2009

Quiz duration: 30 minutes

1. You may have one 8 ½ x 11 in. "crib" sheet, written on both sides, during the quiz. You may have any calculator you choose, but no computers. No other notes or materials will be allowed.
2. Show all work necessary to complete the problem on these pages. A solution without the work shown will receive no credit.
3. Show units in intermediate and final results, and in figures.
4. If your work is sloppy or difficult to follow, points will be subtracted.

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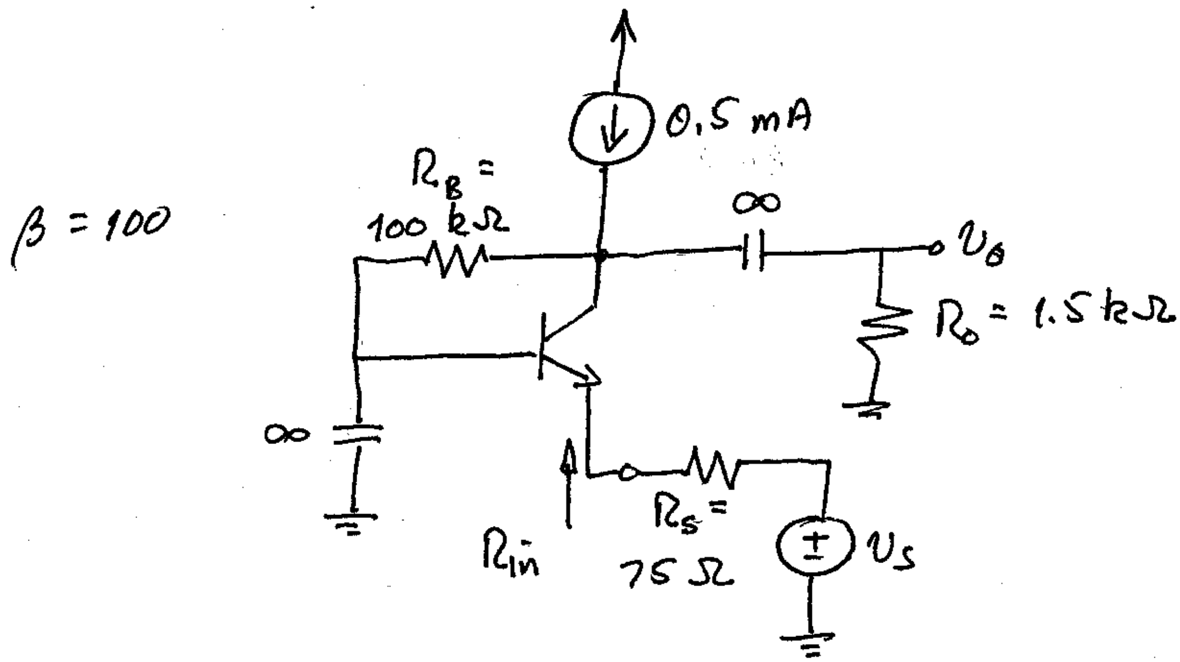
The BJT in the circuit below is biased in the linear (forward active) region. You may assume this without proving it.

i) Draw the ac model for this circuit.
ii) Find the input resistance seen by the source, R_{in}.
iii) Find the voltage gain v_o/v_S.



We do not need to prove active region, but we do need a value for either r_π or r_e (depending on which model we use). Clearly, $I_E = 0.5\,mA$ so

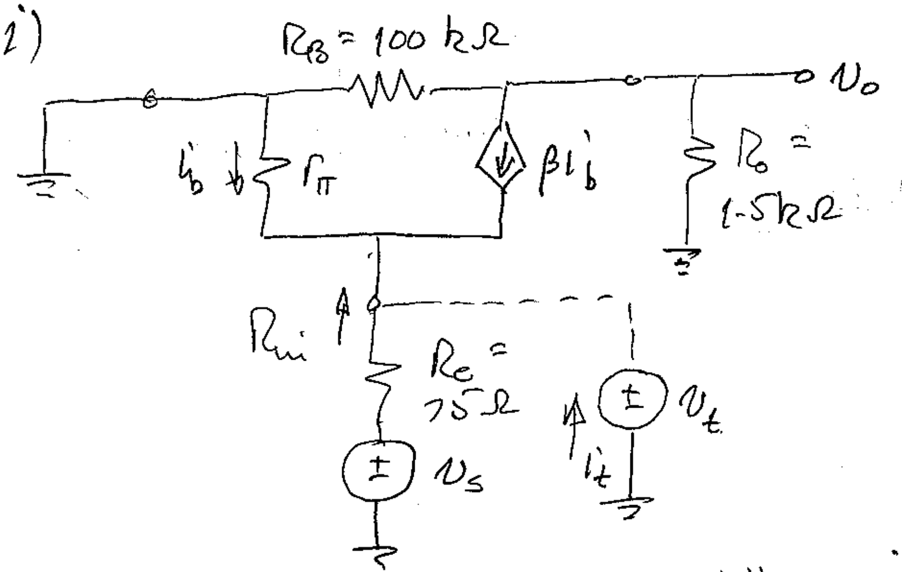
$$r_\pi = \frac{V_T}{I_B} = (\beta+1)\frac{V_T}{I_E} = 101\ \frac{25\,mV}{0.5\,mA} = 5050\ \Omega$$

Alternatively, $$r_e = \frac{V_T}{I_E} = \frac{r_\pi}{\beta+1} = 50\ \Omega$$

Using a hybrid pi model we get...

Room for Extra Work

i)



If we remove v_s, R_e and substitute a test source, we have

$$i_t = -(\beta+1) i_b$$

$$i_b = -v_t / r_\pi$$

$$\therefore R_{in} = \frac{v_t}{i_t} = \frac{r_\pi}{\beta+1}$$

ii)

$$\boxed{R_{in} = 50\,\Omega}$$

iii)

$$\frac{v_o}{R_B} + \frac{v_o}{R_o} + \beta i_b = 0 \quad (1)$$

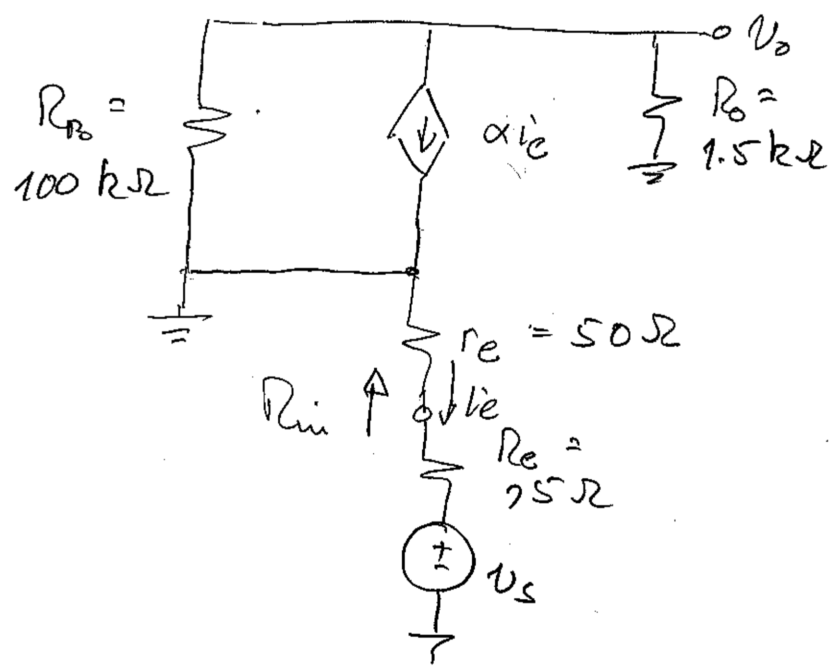
$$i_b r_\pi + (\beta+1) i_b R_e + v_s = 0 \quad (2) \quad \Rightarrow \quad i_b = \frac{-v_s}{r_\pi + (\beta+1) R_e}$$

$$\therefore v_o \left(\frac{1}{R_B} + \frac{1}{R_o} \right) = v_s \frac{\beta}{r_\pi + (\beta+1) R_e}$$

Substituting R's gives $\boxed{\frac{v_o}{v_s} = 11.7\ V/V}$

we could also have used a T-model...

Room for Extra Work



ii) $R_{in} = r_e = 50\Omega$

iii) $\frac{v_o}{R_o} + \frac{v_o}{R_B} + \alpha i_e = 0$ ① $i_e = -\frac{v_s}{r_e + R_e}$ ②

Note: $\alpha = \frac{\beta}{\beta+1}$ and $i_e = (\beta+1) i_b$

$\Rightarrow \frac{v_o}{R_o} + \frac{v_o}{R_B} + \beta i_b = 0$

which is the same equation we got before.

$v_o\left(\frac{1}{R_o} + \frac{1}{R_B}\right) = \frac{v_s \cdot \alpha}{r_e + R_e} \Rightarrow \frac{v_o}{v_s} = 11.7\ V/V$