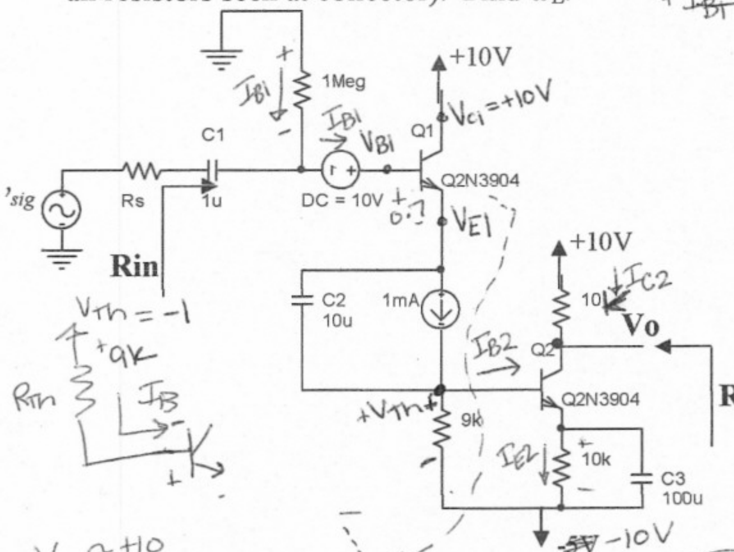
The material we have covered so far this semester is summarized (but NOT limited to) below:

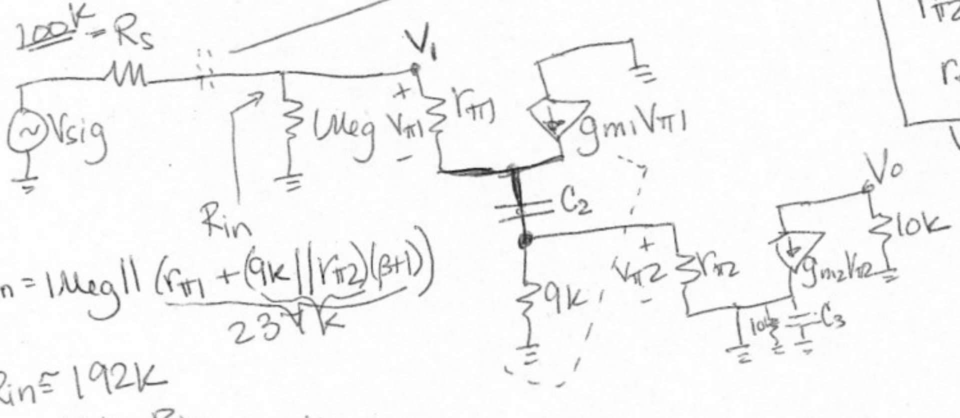
1. Understand the basic operation of a BJT:
- Cutoff, saturation, active. Analyze a circuit for all current equations and voltages (current relationships)
  - Make sure to be able to take a Thevenin Equivalence and use Resistance Reflection Rules.
2. Understand the bias point concept for linear amplification.
3. Be able to separate the DC and AC analysis for a circuit containing a BJT.
4. Be able to analyze a circuit (with or without cap in it) containing a BJT for DC operation.
5. Be able to draw a small-signal model of a BJT circuit.
6. Analyze a small-signal circuit to find overall gain, midband gain, input resistance, and output resistan
7. Determine ω_L or f_L.

Use $|V_{BE}|=0.7$, $\beta=100$, ignore r_o.
The 0.25A current source is not ideal and may have a voltage drop across it.
(a) Solve the circuit for the **DC** values. (assume capacitors act as open). Find all currents and voltages
(b) Solve the circuit for midband gain, V_o/v_{sig}, Rin(ignore Rs), and Rout(include all resistors seen at collector). Find ω_L.



$I_E = 1mA$ $I_C = \alpha I_E = .99m$
$I_B = \frac{1m}{101} \approx 10\mu$
$+I_{B1}(1Meg) - 10 + V_{B1} = 0$
$V_{B1} = +10 - I_B(1Meg) = 0V$
$V_{E1} = V_{B1} - V_{BE} = -0.7V$
$V_{C1} = +10$
$V_{C1} > V_{B1} > V_{E1}$ ACTIVE
$V_{th} = 1m(9k) - 10 = 9 - 10 = -1V$
R_{th}: 9k
$I_B = \frac{I_E}{\beta+1}$
$-1 - I_B(9k) - 0.7 - I_E(10k) + 10 = 0$
$\frac{(+10-1-0.7)}{\frac{9k}{101}+10k} = I_E$
$I_E = 0.8m$, $I_B = 8\mu$, $I_C = .79m$
$V_{C2} \approx +10$
$V_B = -1 - 8\mu(9k) = -1.1$
$V_E = -1.8V$ ACTIVE

$V_o = -g_{m2} V_{\pi 2}(10k)$
$r_{\pi 2} = \frac{V_T}{I_B} = \frac{25m}{8\mu}$
$r_{\pi 2} = 3125$, $g_{m2} = \beta / r_\pi = 32m$
$r_{\pi 1} = \frac{25m}{10\mu} = 2500$, $g_{m1} = 40m$



$V_{\pi 2} = V_1 \frac{(r_{\pi 2}||9k)(\beta+1)}{(r_{\pi 2}||9k)(\beta+1) + r_{\pi 1}} = 0.99V_1$
$(r_{\pi 2}||9k) \approx 2320$
$R_{in} = 1Meg || (r_{\pi 1} + (9k||r_{\pi 2})(\beta+1))$, $\approx 237k$
$R_{in} \approx 192K$
$V_1 = \frac{V_{sig} \cdot R_{in}}{R_{in} + 100k} \approx .66 V_{sig}$
$V_o = -g_{m2}(.99)(.66)V_{sig}(10k)$
$\frac{V_o}{V_{sig}} = 209 V/V$

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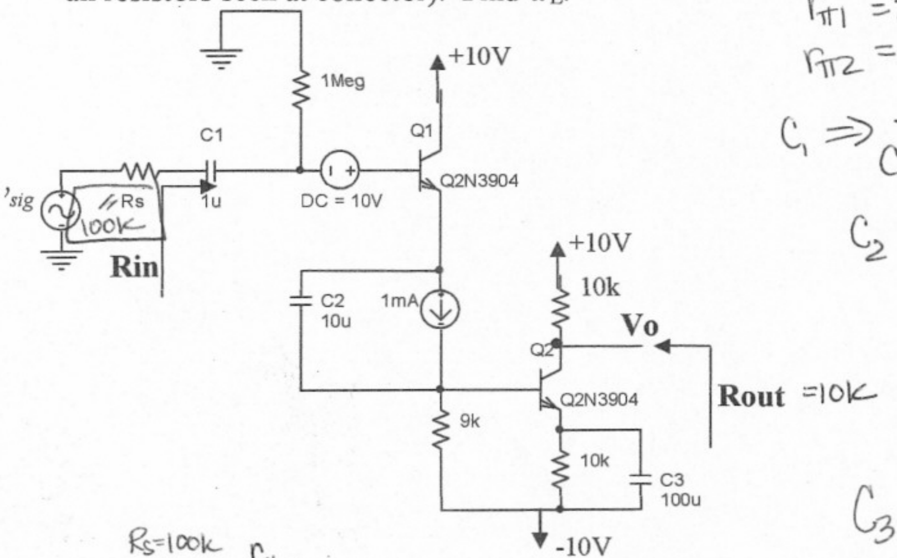


$r_{\pi 1} = 2500$, $g_{m1} = 40m$

$r_{\pi 2} = 3125$, $g_{m2} = 32m$

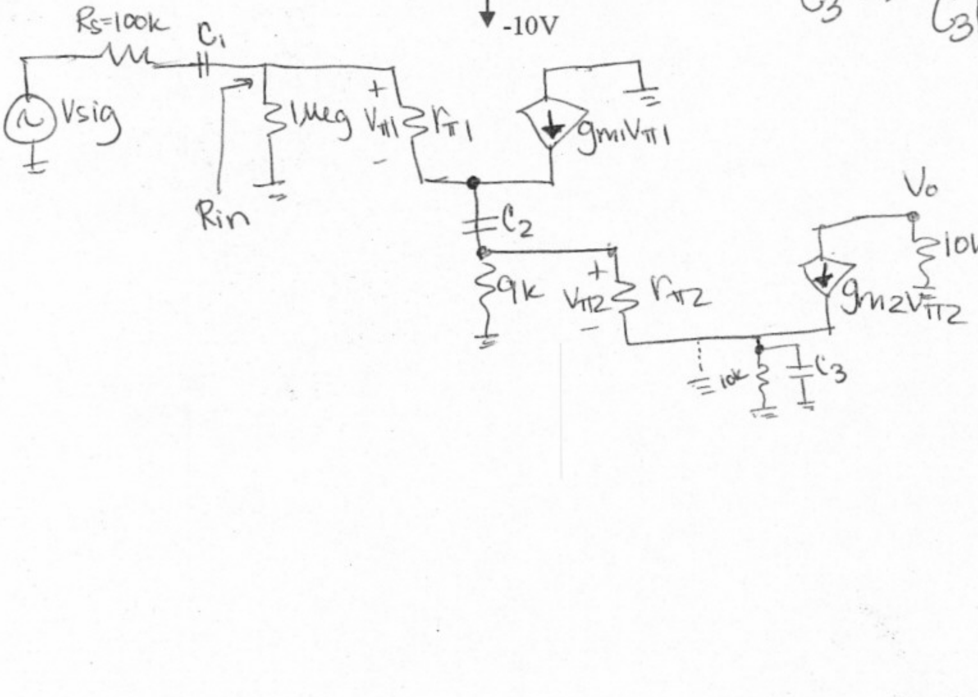
$C_1 \Rightarrow \dfrac{1}{C_1(R_s+R_{in})} = \dfrac{1}{1\mu(100k+192k)} = 3.4\,\frac{rad}{sec}$

$C_2 \Rightarrow \dfrac{1}{C_2\left[\left(\frac{r_{\pi 1} + 1M\|100k}{\beta+1}\right) + (9k\|r_{\pi 2})\right]}$

$= \dfrac{1}{10\mu(925+2320)} \approx 31\,\frac{rad}{sec} \approx 5Hz$

$C_3 \Rightarrow \dfrac{1}{C_3\left[10k \,\Big\|\, \dfrac{\left[r_{\pi 2} + 9k\|\left(\frac{r_{\pi 1} + 1M\|100k}{\beta+1}\right)\right]}{\beta+1}\right]}$ (900)

$\dfrac{1}{C_3[10k\|39]} = 257\,\frac{rad}{sec} \approx 41Hz$



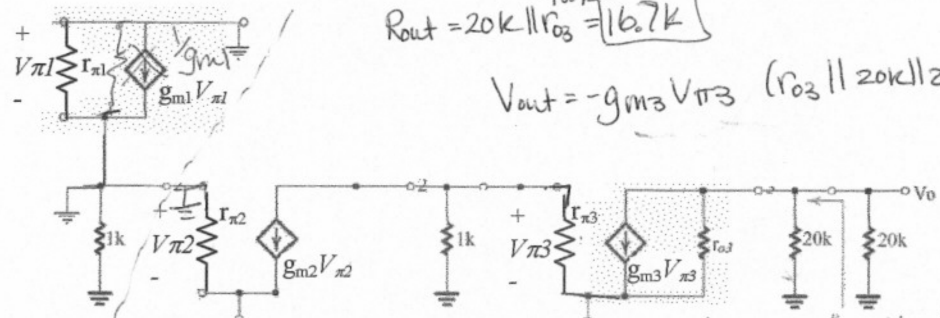
2. Use $|V_{BE}|=0.7$, $\beta=100$. Use $g_{m1}=1mA/V$, $g_{m2}=2mA/V$, $g_{m3}=4mA/V$, $r_{o3}=100k$. Find Vo/Vsig, Rout(ignore 20k on the right), Rin(ignore 50 from signal source).

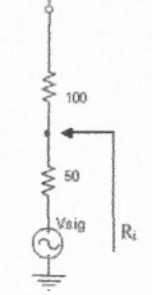
$r_{\pi 2} = \frac{\beta}{g_{m2}} = 50k$

$R_{in} = 100 + \frac{r_{\pi 2}}{\beta+1} = 100 + \frac{50k}{101} = \boxed{595}$

$r_{\pi 3} = \frac{100}{4m} = 25k$

$R_{out} = 20k \| r_{o3} = \boxed{16.7k}$ (100k)

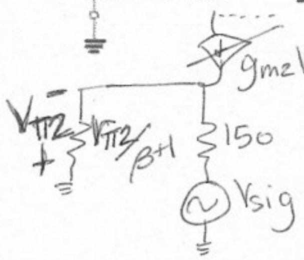




$V_{out} = -g_{m3}V_{\pi 3}(r_{o3} \| 20k \| 20k) = -4m(9091)V_{\pi 3}$

$V_{\pi 3} = -g_{m2}V_{\pi 2}(1k \| r_{\pi 3})$

$V_{\pi 3} = -2m(962)V_{\pi 2}$

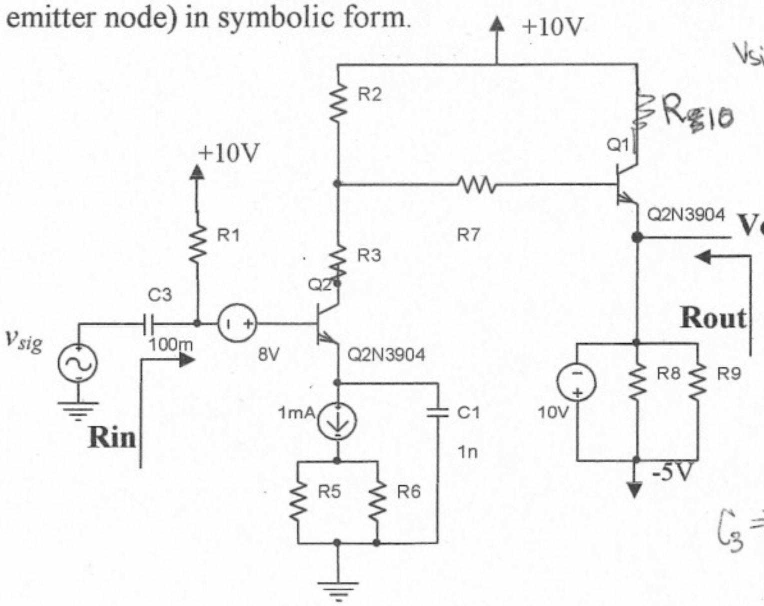


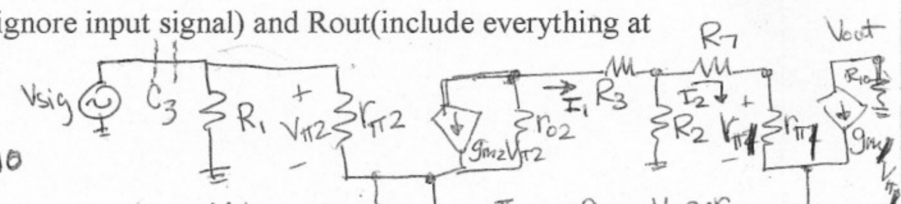
$V_{\pi 2} = \frac{-V_{sig}\left(\frac{r_{\pi 2}}{\beta+1}\right)}{\frac{r_{\pi 2}}{(\beta+1)} + 150} = \frac{-V_{sig}(495)}{495+150} = -0.77V_{sig}$

$\frac{V_{out}}{V_{sig}} = -4m(9091)(-2m)(962)(-0.77) = \boxed{-54 V/V}$

$V_{\pi 2} = \frac{-V_{sig}(r_{\pi 2})}{r_{\pi 2} + 150(\beta+1)} = -0.77V_{sig}$

3. Draw the small-signal equivalent circuit. Find Rin(ignore input signal) and Rout(include everything at emitter node) in symbolic form.





✓ $V_{\pi 2} = V_{sig}$

$I_1 = \frac{-g_{m2}V_{\pi 2} \cdot r_{o2}}{r_{o2} + (R_3 + R_2 \| (R_7 + r_{\pi 1}))}$

$\frac{V_{out}}{V_{sig}} \Rightarrow V_{out} = -g_{m1}V_{\pi 1} \cdot R_{10}$

$I_2 = \frac{I_1 \cdot R_2}{R_2 + R_7 + r_{\pi 1}}$

$V_{\pi 1} = I_2(r_{\pi 2})$

$\frac{V_{out}}{V_{sig}} = \frac{-g_{m1} R_{10} \cdot r_{\pi 2} \cdot R_2 - g_{m2} V_{\pi 2} r_{o2}}{(R_2 + R_7 + r_{\pi 1})(r_{o2} + [R_3 + R_2 \| (R_7 + r_{\pi 1})])}$

$C_3 \Rightarrow \frac{1}{C_3(R_1 \| r_{\pi 2})} = \frac{1}{100m\left(\frac{R_1 \cdot r_{\pi 2}}{R_1 + r_{\pi 2}}\right)}$

$C_1 \Rightarrow \frac{1}{C_1\left(\frac{r_{\pi 2} \| R_1}{\beta+1}\right)}$