ECEn 313 Final Exam

April 22

11:00am - 2:00pm

Winter 2009

Prof. Stephen M. Schultz – 422-1693

Name:____________________________

Instructions – Please Read

8” x 11” sheet of paper

Graphing calculator allowed

Feel free to bring lunch.

This exam consists of 10 problems. These problems will be graded as:

- full credit (10 points) if it is correct
- half credit (5 points) if you got the main concept but made some mistakes
- no credit (0 points) if you missed the problem

Appendix

Use the following parameters for all of the problems in this midterm exam.

A	Operational Amplifier Gain	300,000
GBW	Gain Bandwidth Product of Operational amplifier	5 MHz
V_d	Diode 'on' voltage	0.7 V
$\mu_n C_{ox} \frac{W}{L}$	Transconductance parameter (NMOS)	0.5 mA/V^2
$\mu_p C_{ox} \frac{W}{L}$	Transconductance parameter (PMOS)	0.3 mA/V^2
V_T	Thermal voltage (kT/q)	26 mV
V_{tn}	Threshold voltage (NMOS)	0.5 V
V_{tp}	Threshold voltage (PMOS)	-0.6 V
λ	Channel length modulation parameter (NMOS & PMOS)	0.02 V^{-1}
g_{mb}	Back gate effect	0.2 g_m
β	Current gain	100
V_{AN}	Early voltage for npn-BJT	50 V
V_{AP}	Early voltage for pnp-BJT	70 V
$V_{CE,\,sat}$	Collector-Emitter Saturation Voltage	0.2 V
$V_{BE,\,on}$	Base-Emitter Saturation Voltage	0.7 V

Voltage on a capacitor: $v_c(t) = v_i + (v_t - v_i)\left(1 - e^{-t/RC}\right)$

Standard Inverting Op Amp Configuration

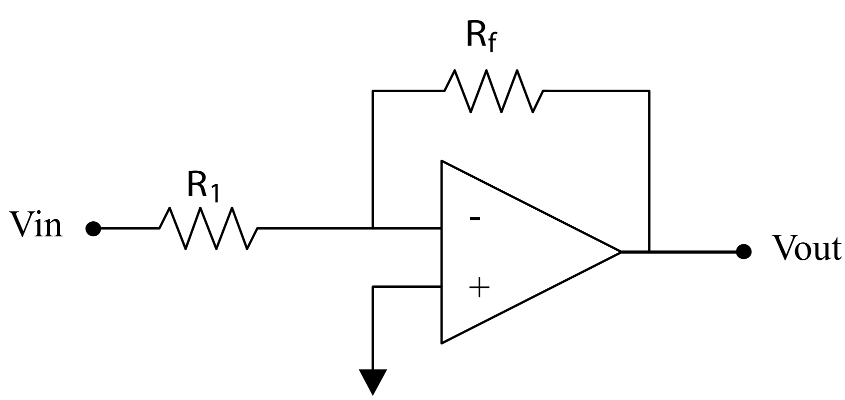


Figure 1

Feedback Factor: $F = \dfrac{R_1}{R_1 + R_f}$

Midband Gain: $A_{MB} = -\dfrac{R_f}{R_1}$

Upper frequency Corner: $f_{H1} = f_{Ho}\left(1 + A_{MBo}F\right)$

Standard Non-Inverting Op Amp Configuration

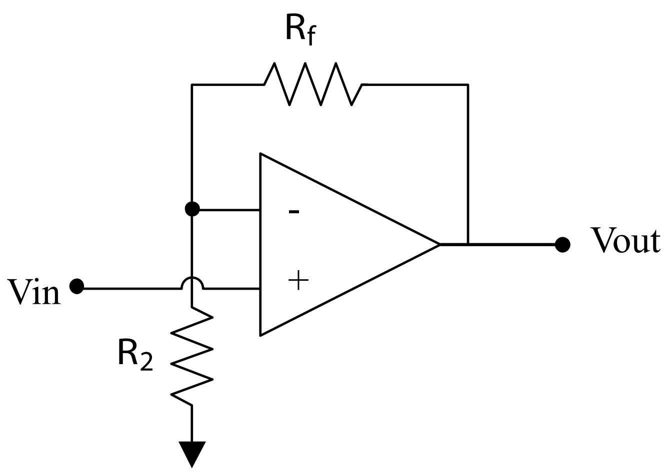


Figure 2

Feedback Factor: $F = \dfrac{R_2}{R_2 + R_f}$

Midband Gain: $A_{MB} = \dfrac{R_2 + R_f}{R_2}$

Upper frequency Corner: $f_{H1} = f_{Ho}\left(1 + A_{MBo}F\right)$

Diode current equation: $I_D = 10^{-14}\left[e^{0.026V} - 1\right]$

Diode resistance: $r_D = \dfrac{0.026}{I_D}$

MOSFET Information

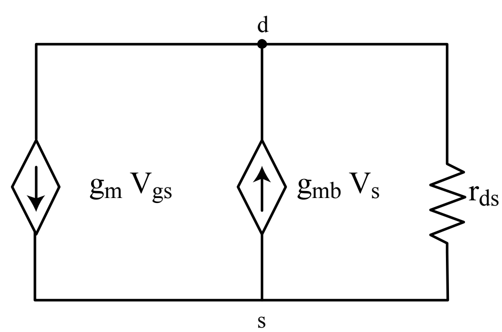
$$I_{DQ} = \mu C_{ox} \frac{W}{L}\left[\left(V_{GS} - V_T\right) V_{DS} - \frac{1}{2} V_{DS}^2\right]$$

$$I_{DQ} = \mu C_{ox} \frac{W}{2L}\left[V_{GS} - V_T\right]^2 \left[1 + \lambda\left(V_{DS} - \left(V_{GS} - V_T\right)\right)\right]$$

$$g_m = \sqrt{2\mu C_{ox} \frac{W}{L} I_{DQ}}$$

$$r_{ds} = \frac{1}{\lambda I_{DP}} \qquad g_{mb} = 0.2 g_m$$

Small signal model:



BJT Information

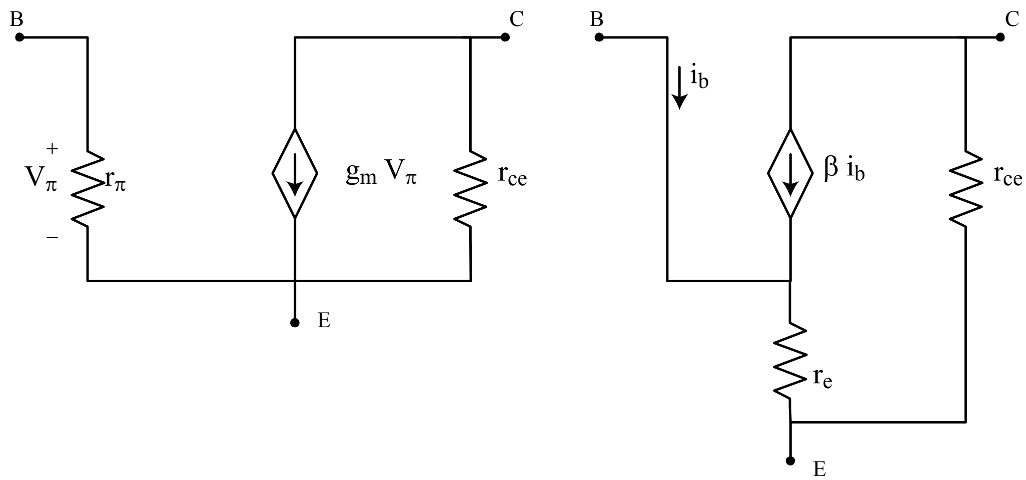
$$I_C = \beta I_B \qquad I_C = \beta I_B \left(1 + \frac{V_{CE}}{V_A}\right) \qquad I_E = \left(\beta + 1\right) I_B$$

$$I_C = \alpha I_E \qquad \alpha = \frac{\beta}{\beta + 1} \qquad r_e = \frac{V_T}{I_E}$$

$$r_\pi = \frac{\beta V_T}{I_C} = \left(\beta + 1\right) r_e = \frac{V_T}{I_B} \qquad g_m = \frac{I_C}{V_T} = \frac{\beta}{r_\pi} = \frac{\alpha}{r_e}$$

$$r_{ce} = \frac{V_A}{I_{C,sat}} = \frac{V_A + V_{CE}}{I_{CQ}} \qquad C = \frac{K_1}{\sqrt{0.8 - V}} \qquad f_T = \frac{1}{2\pi\, r_e\, C_\pi}$$

Small signal models:



Feedback Stability

$$AF = \frac{-A_{MB}\, F}{-\left(2 + \frac{P_1 + P_2}{P_3} + \frac{P_1 + P_3}{P_2} + \frac{P_2 + P_3}{P_1}\right)}$$