Appendix

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

$\mu_n C_{ox} \frac{W}{L}$	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

MOSFET Information

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

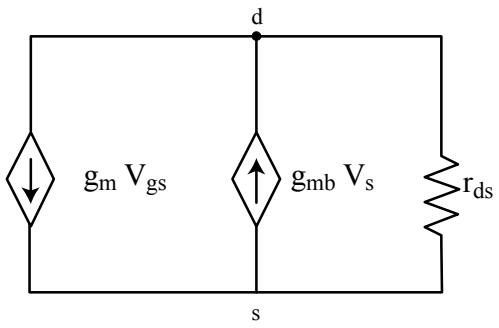
$$I_{DQ} = \mu C_{ox} \frac{W}{2L}\left[V_{GS} - V_T\right]^2 \left[1 + \lambda \left(V_{DS} - \left(V_{GS} - V_T\right)\right)\right]$$

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

$$r_{ds} = \frac{1}{\lambda I_{DP}}$$

$g_{mb}=0.2g_m$

Small signal model:



BJT Information

$$I_C = \beta I_B$$

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

$$I_E = (\beta + 1) I_B$$

$$I_C = \alpha I_E$$

$$\alpha = \frac{\beta}{\beta + 1}$$

$$r_e = \frac{V_T}{I_E}$$

$$r_\pi = \frac{\beta V_T}{I_C} = (\beta + 1) r_e = \frac{V_T}{I_B}$$

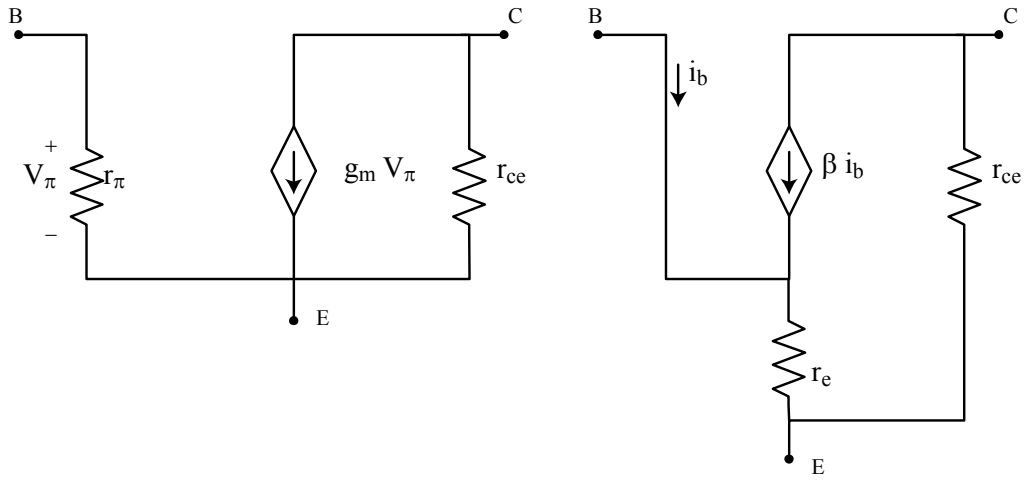
$$g_m = \frac{I_C}{V_T} = \frac{\beta}{r_\pi} = \frac{\alpha}{r_e}$$

$$r_{ce} = \frac{V_A}{I_{C,sat}} = \frac{V_A + V_{CE}}{I_{CQ}}$$

$$C = \frac{K_1}{\sqrt{0.8 - V}}$$

$$f_T = \frac{1}{2\pi\ r_e\ C_\pi}$$

Small signal models:



Feedback Stability

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