EE351 TEST NOTES 12/5/10 KUHN

$P_{gain} = \frac{P_{out}}{P_{in}}$

$dB = 10\log_{10}\left(\frac{P_2}{P_1}\right)$

$I_d = I_s\left[e^{\frac{V_D}{nV_T}} - 1\right]$

$V_T = \frac{KT}{q}$ | $K = 1.38E{-}23$ J/K, $T = K$, $q = 1.602E{-}19$

$r_d = \frac{V_T}{I_d}$ | $V_T = 0.026$ @ 300K

Power Supply Filter

$C \approx \frac{24}{FR(\%ripple)}$ half-wave (3% = 3)

$C \approx \frac{8.6}{FR(\%ripple)}$ full wave, F = line freq, R = Eload/Iload

BJT

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

$I_B = \frac{I_C}{\beta} = \frac{I_E}{\beta+1}$

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

BJT Bias Anal.

$I_E = \frac{V_{BB} - V_{BE} - V_{EE}}{R_E + \frac{R_B}{\beta+1}}$

$V_C = V_{CC} - I_C R_C$

$V_B = V_{BB} - I_B R_B$

$V_E = V_{EE} + I_E R_E$

$V_C > V_B > V_E$

BJT AC Anal.

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

$r_{ct} = \infty$

$r_{bt} = (\beta+1)(r_e + R_E')$

$r_{et} = r_e + \frac{R_B'}{\beta+1}$

CE: $R_{in} = R_B \| r_{bt}$

$R_o = R_C$

$A_v = \frac{-\left(\frac{\beta}{\beta+1}\right) R_C}{r_e + R_E'}$

CC: $R_{in} = R_B \| r_{bt}$

$R_o = R_E \| r_{et}$

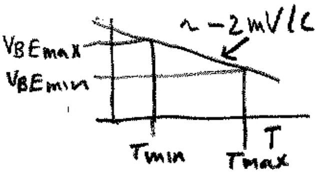
$A_{v_\ell} = \frac{R_E \| R_L}{r_e + R_E \| R_L}$

CB: $R_{in} = R_E \| r_{et}$

$R_o = R_C$

$A_v = \left(\frac{\beta}{\beta+1}\right)\frac{R_C}{r_e}$

BJT Bias Design



$K_T = \frac{I_{Cmax}}{I_{Cmin}}$

$V_{BBmin} = \frac{K_T V_{BEmax} - V_{BEmin}}{K_T - 1}$

$V_{BEnom} = \frac{V_{BEmax} + V_{BEmin}}{2}$

$K_B = \frac{I_{Cmax}}{I_{Cmin}}$

$\left(\frac{R_B}{R_E}\right)_{max} = \frac{K_B\left[\frac{\beta_{max}+1}{\beta_{max}}\right] - \left[\frac{\beta_{min}+1}{\beta_{min}}\right]}{\frac{1}{\beta_{min}} - \frac{K_B}{\beta_{max}}}$

$\beta_{nom} = \sqrt{\beta_{min}\beta_{max}}$

CE (high gain case)

$V_{CQ_{opt}} \approx \frac{2\left(\frac{R_C}{R_L}\right)(V_{BB} + V_{CBmin}) + K V_{CC}}{2\left(\frac{R_C}{R_L}\right) K}$

$K \sim 0.2 \rightarrow 0.5$

CC

$V_{EQopt} = \frac{(V_{CC} - V_{CEsat})\left(1 + \frac{R_E}{R_L}\right)}{2 + \frac{R_E}{R_L}}$

$V_{BB} = (V_{EQ} + V_{BE}) + \frac{V_{EQ}\left(\frac{R_B}{R_E}\right)}{\beta+1}$

$I_E = \frac{V_{BB} - V_{BE} - V_{EE}}{R_E\left(1 + \frac{R_B/R_E}{\beta+1}\right)}$

CE BJT AC gain

$R_E' = \left(\frac{\beta}{\beta+1}\right)\left(\frac{R_C}{-A_v}\right) - r_e$

$R_{E1} = \frac{R_E R_E'}{R_E - R_E'}$

JFET

$I_D = I_{DSS}\left[1 - \frac{V_{GS}}{V_P}\right]^2$

$V_{GS} = V_P\left[1 - \sqrt{\frac{I_D}{I_{DSS}}}\right]$

$g_m = 2\sqrt{\left|\frac{I_D I_{DSS}}{V_P}\right|}$

Bias Anal. $R_S \neq 0$

$V_K = V_{GG} - V_{SS} - V_P$

$V_R = \frac{V_P^2}{I_{DSS}}$

$X = \left|\frac{2 V_K R_S}{V_R}\right|$

$I_D = \left(\frac{V_R}{2R_S^2}\right)\left[X + 1 - \sqrt{2X+1}\right]$

$V_D > (V_G - V_P)$

$V_{DS} > (V_{GS} - V_P)$

$r_{dt} = \infty$

$r_{gt} = \infty$

$r_{st} = \frac{1}{g_m}$

CS:

$R_{in} = R_G$

$R_o = R_D$

$A_v = \frac{-g_m R_D}{1 + g_m R_S'}$

CD:

$R_{in} = R_G$

$R_o = R_S \| \frac{1}{g_m}$

$A_v = \frac{g_m R_S}{1 + g_m R_S}$

JFET BIAS DBS

$V_{GS} = V_P\left[1 - \sqrt{\frac{I_D}{I_{DSS}}}\right]$

$V_{GG} = V_{SS} + I_D R_S + V_{GS}$

$R_S = \frac{V_{GG} - V_{GS} - V_{SS}}{I_D}$

Freq Response Low Cutoff

$F_c = \frac{1}{2\pi R_{series} C_{series}}$

$F_{c\,net} = \sqrt{F_{c_1}^2 + F_{c_2}^2 + F_{c_3}^2 + \ldots}$

High Freq Cutoff

$F_c = \frac{1}{2\pi R_{shunt} C_{shunt}}$

$F_{c\,net} = \frac{1}{\sqrt{\frac{1}{F_{c_1}^2} + \frac{1}{F_{c_2}^2} + \frac{1}{F_{c_3}^2} + \ldots}}$

$C_{miller} = C_f\left[|A_v| + 1\right]$

Cascade Factors

1	1
2	0.644
3	0.510
4	0.435
5	0.386
6	0.350