$P_{gain} = \frac{P_{out}}{P_{in}},\ dB = 10\log_{10}\left(\frac{P_2}{P_1}\right)$

Diodes

$I_d = I_s\left[e^{(V_d/nV_T)} - 1\right]$

$V_T = \frac{kT}{q}\begin{cases} k = 1.38\times10^{-23}\,J/K \\ T = K^o \\ q = 1.602\times10^{-19}J\end{cases}$

$r_d = \frac{V_T}{I_d}\begin{cases} V_T = .026\,V \\ @\ 300^o K\end{cases}$

Power Supply Filter

$\begin{cases} C \cong \frac{24}{FR(\%ripple)} \\ half-wave(3\% = 3) \\ F = line\ frequency\end{cases}$

$\begin{cases} C \cong \frac{8.6}{FR(\%ripple)} \\ fullwave \\ R = E_{load}/I_{load}\end{cases}$

BJT Basics

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

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

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

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

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

BJT Bias Analysis

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

$V_C = VCC - I_C R_C$

$V_B = VBB - I_B R_B$

$V_E = VEE + I_E R_E$

$V_C > V_B > V_E$

BJT AC Analysis

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

$r_{ct} = \infty$

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

$r_{et} = r_e + {R_B'}/{(\beta+1)}$

Edited by
D. Copeland

Common Emitter Analysis

$R_{in} = R_E||r_{bt}$

$R_O = R_C$

$A_V = \frac{-[\beta/(\beta+1)]R_C}{r_e + R_E'}$

Common Collector Analysis

$R_{in} = R_B||r_{bt}$

$R_o = R_E||r_{et}$

$A_{Vl} = \frac{R_E||R_L}{r_e + (R_E||R_L)}$

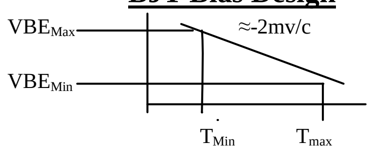
Common Base Analysis

$R_{in} = R_E||r_{et}$

$R_O = R_C$

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

BJT Bias Design



$K_T = \frac{I_{CMax}}{I_{CMin}}$

$VBB_{min} = \frac{K_T V_{BE\ Max} - V_{BE\ Min}}{K_T - 1}$

$V_{BE\ nom} = \frac{V_{BE\ Max} + V_{BE\ Min}}{2}$

$K_B = \frac{I_{C\ Max}}{I_{C\ Min}}$

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

$\beta_{Nom} = \sqrt{\beta_{Min}\cdot\beta_{Max}}$

$R_{B1} = R_B(VCC/VBB)$

$R_{B2} = R_{B1}/[(VCC/VBB) - 1]$

Common Emitter Design

(High Gain Case)

$V_{CQ}\widetilde{opt}\frac{2\left({R_C}/{R_L}\right)(VBB + V_{CB\ Min}) + K(VCC)}{2\left({R_C}/{R_L}\right)K}$

Where: $K \sim 0.2 \rightarrow 0.5$

(AC Gain)

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

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

Common Collector Design

$V_{EQ\ opt} = \frac{(VCC - V_{CE\ Sat})\left(1 + \frac{R_E}{R_L}\right)}{2 + (R_E/R_L)}$

JFET Basics

$I_D = I_{DSS}[1 - V_{GS}/V_P]^2$

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

$g_m = 2\sqrt{(I_D)(I_{DSS})}/V_P$

Bias Analysis $(R_S \neq 0)$

$V_K = VGG - VSS - V_P$

$V_R = V_P^2/I_{DSS}$

$X = |2V_K R_S/V_R|$

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

$V_D > (V_G - V_P), V_{DS} > (V_{GS} - V_P)$

$r_{dt} = \infty, r_{gt} = \infty, r_{st} = \frac{1}{g_m}$

Common Source Analysis

$R_{in} = R_G, \quad R_O = R_D$

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

Common Drain Analysis

$R_{in} = R_G, \quad R_O = R_S||\frac{1}{g_m}$

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

JFET Bias Design

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

$VGG = VSS + I_D R_S + V_{GS}$

$R_S = \frac{VGG - V_{GS} - VSS}{I_D}$

Frequency Response Analysis

(Low Cutoff)

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

$F_{C\ net} = \sqrt{F_{c1}^2 + F_{c2}^2 + F_{c3}^2 +}$

(High Frequency Cutoff)

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

$F_{C\ net} = \frac{1}{\sqrt{\frac{1}{F_{c1}^2} + \frac{1}{F_{c2}^2} + \frac{1}{F_{c3}^2} +}}$

(Cascade Factor)

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

$C_{Miller} = C_f[|A_V| + 1]$