ELEG 309 Formula Sheet

Final Exam

May 21, 2000

$$\text{Voltage gain}\,(A_v) = \frac{v_O}{v_I}, \quad \text{in dB} \quad 20\log|A_v| \tag{1}$$

$$\text{Current gain}\,(A_i) = \frac{i_O}{i_I}, \quad \text{in dB} \quad 20\log|A_i| \tag{2}$$

$$\text{Power gain}\,(A_p) = \frac{P_L}{P_I}, \quad \text{in dB} \quad 10\log|A_p| \tag{3}$$

$$A_v = \left.\frac{dv_O}{dv_I}\right|_{\text{at Q}} \tag{4}$$

$$A_{vo} = \left.\frac{v_o}{v_i}\right|_{i_o=0}\ (V/V), \quad A_{is} = \left.\frac{i_o}{i_i}\right|_{v_o=0}\ (A/A) \tag{5}$$

$$G_m = \left.\frac{i_o}{v_i}\right|_{v_o=0}\ (A/V), \quad R_m = \left.\frac{v_o}{i_i}\right|_{i_o=0}\ (V/A) \tag{6}$$

$$T(\omega) = \frac{V_o(\omega)}{V_i(\omega)}, \quad T(s) = \frac{V_o(s)}{V_i(s)} \tag{7}$$

$$\frac{K}{1+(s/\omega_0)}, \quad \frac{Ks}{s+\omega_0}, \quad s = j\omega \tag{8}$$

$$y(t) = Y_\infty - (Y_\infty - Y_{0+})e^{-t/\tau} \tag{9}$$

$$\frac{v_O}{v_I} = -\frac{R_2}{R_1}, \quad \frac{v_O}{v_I} = \frac{-R_2/R_1}{1+(1+R_2/R_1)/A} \tag{10}$$

$$\frac{V_o(s)}{V_i(s)} = -\frac{Z_2(s)}{Z_1(s)} \tag{11}$$

$$v_O(t) = -\frac{1}{CR}\int_0^t v_I(t')\,dt' - V_C \tag{12}$$

$$\frac{V_o(s)}{V_i(s)} = -\frac{1}{sCR} \tag{13}$$

$$v_O(t) = -CR\,\frac{dv_I(t)}{dt} \tag{14}$$

$$\frac{V_o(s)}{V_i(s)} = -sCR \tag{15}$$

$$\frac{v_O}{v_I} = 1 + \frac{R_2}{R_1}, \quad \frac{v_O}{v_I} = \frac{1+(R_2/R_1)}{1+[1+(R_2/R_1)]/A} \tag{16}$$

$$A(s) = \frac{A_0}{1+s/\omega_b}, \quad \omega_t = A_0\,\omega_b, \quad A(s) \simeq \frac{\omega_t}{s} \tag{17}$$

$$I_B = \frac{I_{B1}+I_{B2}}{2}, \quad I_{OS} = |I_{B1}-I_{B2}| \tag{18}$$

$$i = I_S(e^{v/nV_T}-1) \simeq I_S e^{v/nV_T}, \quad V_T = \frac{kT}{q} \tag{19}$$

$$V_2 - V_1 = 2.3\,nV_T \log\frac{I_2}{I_1} \tag{20}$$

$$n_i^2 = BT^3 e^{-E_G/kT} \tag{21}$$

$$J_p = -qD_p\,\frac{dp}{dx}, \quad J_n = qD_n\,\frac{dn}{dx} \tag{22}$$

$$v_{drift} = \mu_p E, \quad \frac{D_n}{\mu_n} = \frac{D_p}{\mu_p} = V_T \tag{23}$$

$$n_{n0} \simeq N_D, \quad p_{p0} \simeq N_A, \quad n_{n0}p_{n0} = n_i^2 = n_{p0}p_{p0} \tag{24}$$

$$V_0 = V_T \ln\left(\frac{N_A N_D}{n_i^2}\right) \tag{25}$$

$$r_d = \frac{nV_T}{I_D} \tag{26}$$

$$i_C = I_S e^{v_{BE}/V_T} \tag{27}$$

$$i_C = \beta\,i_B = \alpha\,i_E, \quad i_E = (\beta+1)i_B \tag{28}$$

$$i_E = i_B + i_C \tag{29}$$

$$\alpha = \frac{\beta}{\beta+1}, \quad \beta = \frac{\alpha}{1-\alpha} \tag{30}$$

$$i_c = g_m v_\pi, \quad V_T \simeq 25\,\text{mV} \tag{31}$$

$$g_m = \left.\frac{\partial i_C}{\partial v_{BE}}\right|_{i_C=I_C} \tag{32}$$

$$r_\pi = \frac{v_{be}}{i_b} = \frac{\beta}{g_m}, \quad r_e = \frac{v_{be}}{i_e} = \frac{\alpha}{g_m}, \quad r_\pi = (\beta+1)r_e \tag{33}$$

$$g_m = \frac{I_C}{V_T}, \quad r_e = \frac{V_T}{I_E}, \quad r_\pi = \frac{V_T}{I_B}, \quad r_o = \frac{V_A}{I_C} \tag{34}$$

$$\frac{v_o}{v_b} = -\frac{\alpha R_C}{r_e + R_e} \tag{35}$$

$$C_{ox} = \frac{\epsilon_{ox}}{t_{ox}} \tag{36}$$

$$\epsilon_{ox} = 3.97\epsilon_o = 3.5 \times 10^{-13}\text{F/cm} \tag{37}$$

$$\mu_n = 580\text{cm}^2/\text{Vs} \tag{38}$$

$$k'_n = \mu_n C_{ox} \tag{39}$$

$$i_D = k'_n \frac{W}{L}\left[(v_{GS} - V_t)v_{DS} - \frac{1}{2}v_{DS}^2\right] \tag{40}$$

$$i_D = \frac{1}{2}k'_n \frac{W}{L}(v_{GS} - V_t)^2(1 + \lambda v_{DS}) \tag{41}$$

$$\frac{V_{A1}}{V_{A2}} = \frac{L_1}{L_2} \tag{42}$$

$$r_o = \frac{V_A}{I_D} \tag{43}$$

$$V_t = V_{t0} + \gamma\left[\sqrt{2\phi_f + V_{SB}} - \sqrt{2\phi_f}\right] \tag{44}$$

$$\gamma = \frac{\sqrt{2qN_A\epsilon_s}}{C_{ox}} \tag{45}$$

$$g_m = \left.\frac{\partial i_D}{\partial v_{GS}}\right|_{v_{GS}=V_{GS}} \tag{46}$$

$$g_m = \sqrt{2k'_n \frac{W}{L} I_D} \tag{47}$$

$$\chi = \frac{\partial V_t}{\partial V_{SB}} \tag{48}$$

$$A_v = \frac{v_o}{v_i} \tag{49}$$

$$A_v = -\frac{\sqrt{2k'_n\left(\frac{W}{L}\right)_1}}{\frac{1}{|V_{A1}|} + \frac{1}{|V_{A2}|}} \frac{1}{\sqrt{I_{REF}}} \tag{50}$$

$$A_v = \left(g_{m1} + g_{mb1} + \frac{1}{r_{o1}}\right)(r_{o1}||r_{o2}) \tag{51}$$

$$i_i = (g_{m1} + g_{mb1})v_i + \frac{v_i - v_o}{r_{o1}} \tag{52}$$

$$A_v = \frac{g_{m1}}{g_{m1} + g_{mb1} + \frac{1}{r_{o1}} + \frac{1}{r_{o2}} + \frac{1}{R_L}} \tag{53}$$

$$R_o = (1/g_{m1})||(1/g_{mb1})||r_{o1}||r_{o2} \tag{54}$$

$$A_v = -\sqrt{\frac{(W/L)_1}{(W/L)_2}} \tag{55}$$

$$t_{PHL} = \frac{2C}{k'_n(W/L)_n(V_{DD} - V_t)} \times \times \left[\frac{V_t}{V_{DD} - V_t} + \frac{1}{2}\ln\left(\frac{3V_{DD} - 4V_t}{V_{DD}}\right)\right] \tag{56}$$

$$t_{PHL} = \frac{1.6C}{k'_n(W/L)_n V_{DD}} \tag{57}$$

$$g_{mb} = \chi g_m \tag{58}$$

$$g_m = k'(W/L)(V_{GS} - V_t) \tag{59}$$

$$g_m = \frac{2I_D}{V_{GS} - V_t} \tag{60}$$

$$\lambda = 1/V_A \tag{61}$$

$$f_{3dB} = \frac{f_t}{1 + R_2/R_1} \tag{62}$$

$$\text{SR} = \frac{dv_O}{dt} \tag{63}$$

$$\omega_M v_{omax} = \text{SR} \tag{64}$$