EE 351 Test _____

Seat code: _____(if applicable) **Name:_____**

Test rules: (you are only one cheating event away from academic misconduct)

- ✓ Do all work on test. Use the backside if necessary. **Extra paper not allowed**.
- ✓ Equations/data are supplied as follows. You may have no other notes.
- ✓ **All sheets of the test must remain stapled – do not remove any page.**
- ✓ You may have **1** approved calculator as described in test policies. However, for some tests it is possible that no calculator will be allowed.
- ✓ All other papers, books, purses, bags, etc. must be off the desk and on the floor out of site.
- ✓ You may have no cell phones, pagers, etc. in view. Any devices you have with you must be OFF unless approved by the instructor.
- ✓ Your desk must be free of anything not approved – thus you have only three items: the test, your calculator (if permitted for the test), and your pencils/erasers – none can have any notes.
- ✓ Caps or any kind of head gear or unusual attire are not allowed.
- ✓ Nothing can be in your lap or off the desktop, even if legitimate for the test.

General data and equations:

Standard R: 10 11 12 13 15 16 18 20 22 24 27 30 33 36 39 43 47 51 56 62 68 75 82 91

Standard C: 10 12 15 18 22 27 33 39 47 56 68 82

Unless otherwise indicated, use the following constants for all problems:

V_{BEnom} at 25 C = _____ volts dV_{BE}/dT = _____ mV/C

Temperatures: T_{min} = _____ C T_{nom} = _____ C T_{max} = _____ C

Beta: B_{min} = _____ **B_{nom}** = _____ B_{max} = _____

Design: K_T = _____ K_B = _____ V_{CEsat} = ____ V

JFET: I_{DSS} = _____ mA V_P = _____ V

$P_{gain} = \frac{Pout}{Pin}$ $dB = 10log_{10}\left(\frac{P_2}{P_1}\right)$

$T_C = (T_F + 40)\frac{5}{9} - 40$ $T_F = (T_C + 40)\frac{9}{5} - 40$ $T_K = T_C + 273$

$I_D = I_s\left[e^{\left(V_D/nV_T\right)} - 1\right]$ Use n = 1 for transistors, n = 2 for diodes

$V_T = kT/q$ k = 1.38E-23 J/K, T in kelvins, q = 1.602E-19 coulombs $r_d = \frac{nV_T}{I_D}$

$\%ripple \cong \frac{24}{FRC}$ half-wave $\%ripple \cong \frac{8.6}{FRC}$ full-wave

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

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

$V_C = V_{CC} - I_C R_C$ $V_B = V_{BB} - I_B R_B$ $V_E = V_{EE} + I_E R_E$

$r_e = \frac{V_T}{I_E}$ $r_{ct} = \infty$ $r_{bt} = (\beta + 1)(r_e + R'_E)$ $r_{et} = r_e + \frac{R'_B}{\beta+1}$

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CE: $A_V = \frac{-\left(\frac{\beta}{\beta+1}\right)R_C}{r_e+R'_E}$ CC: $A_{VL} = \frac{R_E||R_L}{r_e+R_E||R_L}$ CB: $A_V = \frac{\left(\frac{\beta}{\beta+1}\right)R_C}{r_e}$

$V_{BEmin} = V_{BE_{Tref}} + \frac{dV_{BE}}{dT}\left(T_{max} - T_{ref}\right)$ $V_{BEmax} = V_{BE_{Tref}} - \frac{dV_{BE}}{dT}\left(T_{ref} - T_{min}\right)$

$K_T = \frac{I_{Cmax}}{I_{Cmin}}$ $V_{BBmin} = \frac{K_T V_{BEmax} - V_{BEmin}}{K_T - 1}$ $V_{BEnom} = \frac{V_{BEmax}+V_{BEmin}}{2}$

$K_B = \frac{I_{Cmax}}{I_{Cmin}}$ $\left(\frac{R_B}{R_E}\right)_{max} = \frac{K_B\left(\frac{\beta_{max}+1}{\beta_{max}}\right) - \left(\frac{\beta_{min}+1}{\beta_{min}}\right)}{\left(\frac{1}{\beta_{min}}\right) - \left(\frac{K_B}{\beta_{max}}\right)}$ $\beta_{nom} = \sqrt{\beta_{min}\beta_{max}}$

Bias Design: $R_{B1} = R_B\left(\frac{V_{CC}}{V_{BB}}\right)$ $R_{B2} = \frac{R_{B1}}{\left(\frac{V_{CC}}{V_{BB}}\right) - 1}$

CE large signal design: $V_{CQopt} \cong \frac{2\left(\frac{R_C}{R_L}+1\right)(V_{BB}+V_{CBmin}) + KV_{CC}}{2\left(\frac{R_C}{R_L}+1\right)+K}$ where K ~ 0.2 to 0.5

$R'_E = \left(\frac{\beta}{\beta+1}\right)\left(\frac{R_C}{A_V}\right) - r_e$ $R_{E1} = \frac{R_E R'_E}{R_E - R'_E}$

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

$I_D = I_{DSS}\left(1 - \left(\frac{V_{GS}}{V_P}\right)\right)^2$ $V_{GS} = V_P\left(1 - \sqrt{\frac{I_D}{I_{DSS}}}\right)$ $g_m = \left|\frac{2\sqrt{I_D I_{DSS}}}{V_P}\right|$

$V_K = V_{GG} - V_{SS} - V_P$ $V_R = \frac{V_P^2}{I_{DSS}}$ $X = \left|\frac{2V_K R_S}{V_R}\right|$ $I_D = \left(\frac{V_R}{2R_S^2}\right)\left(X + 1 - \sqrt{2X+1}\right)$

n-channel: $V_D > (V_G - V_P)$ n-channel: $V_{DS} > (V_{GS} - V_P)$ $r_{dt} = \infty$ $r_{gt} = \infty$ $r_{st} = \frac{1}{g_m}$

CS: $A_V = \frac{-g_m R_D}{1+g_m R'_S}$ CD: $A_V = \frac{g_m R_S}{1+g_m R_S}$ CG: $A_V = g_m R_D$

Bias design: $V_{GG} = V_{SS} + I_D R_S + V_{GS}$ $R_S = \frac{V_{GG} - V_{GS} - V_{SS}}{I_D}$

$F_{CH} = \frac{1}{2\pi R_{shunt} C_{shunt}}$ $F_{CHnet} \cong \frac{1}{\sqrt{\frac{1}{F_{CH1}^2} + \frac{1}{F_{CH2}^2} + \cdots}}$ $C_{Miller} = C_f[|A_{VL}| + 1]$

$F_{CL} = \frac{1}{2\pi R_{series} C_{series}}$ $F_{CLnet} \cong \sqrt{F_{CL1}^2 + F_{CL2}^2 + \cdots}$

Cascade factors: 2: 0.664, 3: 0.510, 4: 0.435, 5: 0.386, 6: 0.350