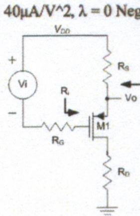
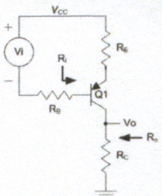
30. What is the low frequency output resistance, Ro, in Ω for the amplifier shown at 27° C with Rd = 35.2kΩ, Rs = 0.6kΩ and Rg = 9.5kΩ. Use: W/L = 67, Id = 156μA, VTP = -0.5V, k'p = 40μA/V^2, λ = 0 Neglect body effect.



$g_m = \sqrt{2 \cdot k'p \cdot (W/L) \cdot I_d} = \sqrt{2 \cdot (40\times10^{-6})(67)(156\times10^{-6})} = 0.0009144$

$R_o = R_S \parallel 1/g_m \doteq \frac{1}{600} + 0.0009144 = \frac{1}{0.002581085} = \boxed{387.4\Omega}$

29. What is the low frequency output resistance, Ro, in kΩ for the amplifier shown at 27° C with Rc = 62.3kΩ, Re = 0.9kΩ and Rb = 0.9kΩ ? Use: Ic = 28μA, β = 22, VA = 10V, and Vt = kT/q = 26mV. Use the "short-cut approach" discussed in class.



$g_m = \frac{I_C}{V_t} = \frac{(28\times10^{-6})}{(26\times10^{-3})} = 0.001077$

$r_\pi = \frac{\beta}{g_m} = 20428.57$

$r_o = \frac{V_A}{I_C} = \frac{10}{(28\times10^{-6})} = 357142.86$

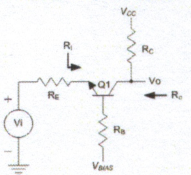
$R_{o1} = r_o\left[1 + \frac{\beta R_E}{R_b + R_E + r_\pi}\right] + \frac{R_E}{1 + \left(\frac{R_E}{r_\pi + R_b}\right)}$

$= 357142.86\left[1 + \frac{22 \cdot 900}{900 + 900 + 20428.57}\right] + \frac{900}{1 + \left(\frac{900}{20428.57 + 900}\right)} = 675266.28 + 863.56 = 676129.84$

$R_o = R_C \parallel R_{o1} = \frac{1}{62300} + \frac{1}{676129.84} = \frac{1}{0.00001753} = 57043.86\Omega = \boxed{57.04K\Omega}$

57.2kΩ (moodle)

26. What is the low frequency voltage gain for the amplifier shown at 27° C with Rc = 40.6kΩ, Re = 0.1kΩ and Rb = 0.5kΩ ? Use: Ic = 48μA, β = 197, and Vt = kT/q = 26mV. Neglect the effect of base-width modulation.



$g_m = \frac{I_C}{V_t} = \frac{(48\times10^{-6})}{(26\times10^{-3})} = 0.001846$

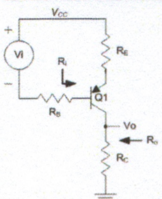
$V_{BE} = -V_i \cdot \frac{1}{1 + g_m\left(\frac{R_B}{(\beta+1)} + R_E\right)}$

$V_o = -g_m V_{BE} R_C \rightarrow \frac{V_o}{V_i} = g_m R_C\left(\frac{1}{1 + g_m\left(\frac{R_B}{\beta+1} + R_E\right)}\right) \Rightarrow \frac{V_o}{V_i} = \frac{g_m R_C}{1 + \frac{g_m R_B}{\beta+1} + g_m R_E} =$

$\frac{0.001846 \cdot 40600}{1 + \left(\frac{0.001846 \cdot 500}{197 + 1}\right) + (0.001846 \cdot 100)} =$

63.02 (calculated)
62.97 (moodle answer)

25. What is the low frequency voltage gain for the amplifier shown at 27° C with Rc = 36.6kΩ, Re = 0.1kΩ and Rb = 1.0kΩ ? Use: Ic = 971μA, β = 44, and Vt = kT/q = 26mV. Neglect the effect of base-width modulation.



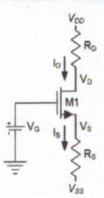
$g_m = \frac{I_C}{V_t} = \frac{(971\times10^{-6})}{(26\times10^{-3})} = 0.037346$

$r_\pi = \frac{\beta}{g_m} = \frac{44}{0.037346} = 1178.167$

$A_V = \frac{-\beta R_C}{R_B + r_\pi + (\beta+1)R_E} = \frac{(-44)(36600)}{1000 + 1178.167 + (45 \cdot 100)} = \boxed{-241.14}$

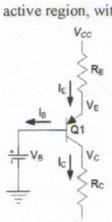
24. For the MOSFET bias circuit shown, what value of Rd in kilohms is needed to allow the maximum possible peak-to-peak signal swing on the drain without clipping? Use: Vdd = 8V, Vss = -7V, Vg = -0.6V, Rs = 4.8kΩ, Vt = 0.5V, and Von = 0.15. (Remember that Von = Vov = Vgs-Vt) Neglect the effect of channel-length modulation and body effect. (Hint: Be sure to keep the MOSFET in saturation!)

$V_{GS} = V_{ON} + V_t = 0.15 + 0.5 = 0.65$



$-V_G + V_{GS} + I_S R_S + V_{SS} = 0 \longrightarrow -(-0.6) + 0.65 + I_S(4800) + 7V = 0 \longrightarrow I_S = \frac{-8.25}{4800} = -0.00172$ $\quad I_S = I_D$

23. For the BJT bias circuit shown, what is the base current, Ib, in microamps? Use Vcc = 7V, Vee = -8V, Vb = 2.9V, Rc = 1.8kΩ, and Re = 6.8kΩ. Assume that the transistor is in the forward-active region, with β = 46 and |Vbe(on)| = 0.7V. Neglect the effects of base-width modulation.



$V_E = V_{be} + V_b = 0.7 + 2.9 = 3.4$

$I_E = \frac{V_{CC} - V_E}{R_E} = \frac{7 - 3.4}{6800} = 0.0005$

$I_B = \frac{I_E}{(1+\beta)} = \frac{0.0005}{(1+46)} = 0.000010638\,A = \boxed{10.6\mu A}$