21. What is the open-circuit voltage gain, μf, in V/V for an NPN BJT operating in the forward-active region at 27°C with $I_C = 756\mu A$? Use $\beta = 127$, $V_A = 75V$, and $V_t = kT/q = 26mV$.

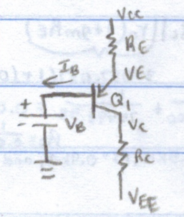
$$\mu f = g_m \cdot r_o \qquad g_m = \frac{I_C}{V_t} \qquad r_o = \frac{V_A}{I_C}$$

$$g_m = \frac{(756\times10^{-6})A}{(26\times10^{-3})V} = 0.02907 \qquad r_o = \frac{75V}{(756\times10^{-6})A} = 99206.35$$

$$\mu f = 0.02907 \cdot 99206.35 = \boxed{2883.93}$$

22. What is the device transconductance, g_m, in mA/V for an NMOS FET operating in saturation with $I_d = 200\mu A$? Use $W/L = 50$ and $k'_n = 100\mu A/V^2$. Neglect the effects of channel-length modulation and body effect.

23. For the BJT bias circuit shown, what is the emitter voltage, V_e, in volts? Use $V_{cc} = 8V$, $V_{ee} = -7V$, $V_b = -2.6V$, $R_C = 4.9k\Omega$, and $R_E = 5.9k\Omega$. Assume that the transistor is in the forward-active region, with $\beta = 48$ and $|V_{be(on)}| = 0.7V$.



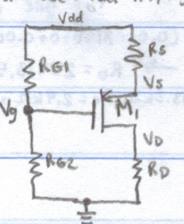
$$I_E R_E = V_{CC} - V_B - V_{EB} \qquad I_E = \frac{9.9}{R_E} = \frac{9.9V}{5900\Omega} = 0.001677797\,A$$

$$I_E R_E = 8 - (-2.6) - 0.7$$

$$V_E = V_{CC} - I_E R_E$$

$$V_E = 8 - 9.9 = \boxed{-1.9V}$$

24. For the MOSFET bias circuit shown, what is the source current, I_s, in milliamps? Assume the transistor is in the saturation region, and use: $V_{dd} = 11V$, $R_{g1} = 41.7k\Omega$, $R_{g2} = 59.8k\Omega$, $R_d = 1.0k\Omega$, $R_s = 8.2k\Omega$, $V_t = -0.7V$, and $|V_{on}| = 0.18$.



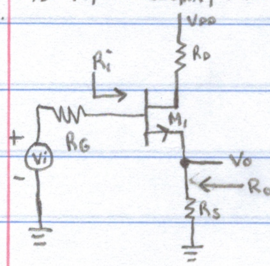
$$V_g = \left(\frac{R_{g2}}{R_{g1}+R_{g2}}\right)V_{dd} = \left(\frac{59800}{41700+59800}\right)11 = 6.481V$$

$$|V_{sg}| = |V_{on}| + |V_t| = 0.18 + 0.7 = 0.88V$$

$$V_s = V_{SG} + V_g = 0.88 + 6.481 = 7.361V$$

$$I_s = \frac{V_{DD} - V_s}{R_s} = \frac{11 - 7.361}{8200} = 0.000444A = \boxed{0.444mA}$$

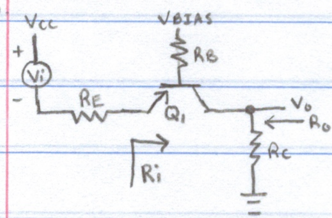
25. What is the low frequency voltage gain for the amplifier shown at 27°C with $R_d = 16.5k\Omega$, $R_s = 0.6k\Omega$ and $R_g = 3.9k\Omega$? Use $W/L = 17$, $I_d = 328\mu A$, $V_{TN} = 0.5V$, $k'_n = 100\mu A/V^2$.



$$g_m = \sqrt{2(k'_n)(W/L)(I_d)} = \sqrt{2(100\times10^{-6})(17)(328\times10^{-6})} = 0.001056\ A/V$$

$$A_V = \frac{R_s}{R_s + 1/g_m} = \frac{600}{600 + (1/0.001056)} = 0.38786 = \boxed{0.388}$$

26. What is the low frequency voltage gain for the amplifier shown at 27°C with $R_C = 24.3k\Omega$, $R_E = 0.1k\Omega$, and $R_B = 0.5k\Omega$? Use $I_C = 305\mu A$, $\beta = 32$, and $V_t = 26mV$.

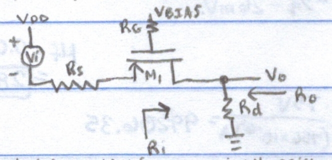


$$G_m = \frac{I_C}{V_t} = \frac{(305\times10^{-6})A}{(26\times10^{-3})V} = 0.01173 \qquad r_\pi = \frac{\beta}{g_m} = \frac{32}{0.01173} = 2727.86689\Omega$$

$$A_V = \frac{\beta \cdot R_C}{R_B + r_\pi + (\beta+1)R_E} = \frac{32 \cdot 24300}{500 + 2727.87 + (33)100} = \boxed{119.12}$$

What is the low frequency input resistance, R_i, in Ω for the amplifier shown at 27°C with $R_d = 15.6k\Omega$, $R_s = 0.4k\Omega$ and $R_g = 4.8k\Omega$? Use: $W/L = 53$, $I_d = 248\mu A$, $V_{TP} = -0.5V$, $k'n = 40\mu A/V^2$

27.



$I_d = \frac{1}{2}k'n(V_{GS}-V_t)^2$

$k'n = k'n \cdot W/L = (40\times10^{-6})(53) = 0.00212$

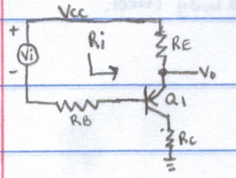
$\frac{I_d}{V_{gs}} = g_m = k'n(V_{gs}-V_t) = k'n\sqrt{\frac{2I_d}{k'n}}$

$g_m = \sqrt{2(k'n)(I_d)} = \sqrt{2(0.00212)(248\times10^{-6})} = 0.001025436$

$R_i = 1/g_m = 1/0.001025436 = \boxed{975.19\Omega}$

What is the low frequency input resistance, R_i, in $k\Omega$ for the amplifier shown at 27°C with $R_c = 47.0k\Omega$, $R_e = 0.6k\Omega$ and $R_b = 0.5k\Omega$? Use: $I_c = 282\mu A$, $\beta = 20$, $V_t = 26mV$.

28.



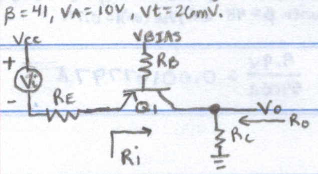
$g_m = \frac{I_c}{V_t} = \frac{(282\times10^{-6})}{(26\times10^{-3})} = 0.010846$

$r_\pi = \frac{\beta}{g_m} = \frac{20}{0.010846} = 1843.97$

$R_i = r_\pi + (\beta+1)R_E = 1843.97 + (21)(600) = 14443.97\Omega = \boxed{14.4k\Omega}$

What is the low frequency output resistance, R_o, in $k\Omega$ for the amplifier shown at 27°C with $R_c = 79.3k\Omega$, $R_e = 0.1k\Omega$, and $R_b = 0.6k\Omega$? Use: $I_c = 270\mu A$, $\beta = 41$, $V_A = 10V$, $V_t = 26mV$.

29.



$g_m = \frac{I_c}{V_t} = \frac{(270\times10^{-6})}{(26\times10^{-3})} = 0.0103846$

$R_o = R_c || r_o(1+g_m R_E)$

$r_o = \frac{V_A}{I_c} = \frac{10}{(270\times10^{-6})} = 37037.037$

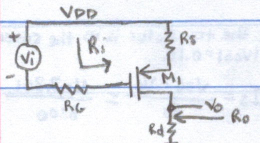
$37037.037(1+(0.0103846)100) = 75498.58$

$R_o = \frac{1}{79300} + \frac{1}{75498.58} = 0.000025856$

$R_o = \frac{1}{0.000025856} = 38676 = \boxed{38.7k}$

What is the low frequency output resistance, R_o, in $k\Omega$ for the amplifier shown at 27°C with $R_d = 98.5k\Omega$, $R_s = 0.9k\Omega$, and $R_g = 3.8k\Omega$. Use: $W/L = 16$, $I_d = 520\mu A$, $V_{TP} = -0.5V$, $k'p = 40\mu A/V^2$, $\lambda = 0.10$.

30.



$g_m = \sqrt{2k'p(W/L)I_D} = \sqrt{2(40\times10^{-6})(16)(520\times10^{-6})} = 0.0008158$

$g_{mb} = 0$, $g_{de} = \lambda \cdot I_d = 0.10 \cdot (520\times10^{-6}) = 0.000052$

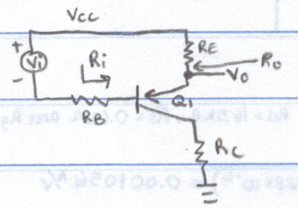
$r_o = \frac{1}{g_{de}} = \frac{1}{0.000052} = 19230.77$

$R_o = R_d || r_o(1+(g_m+g_{mb}+g_{de})R_s) = 98500 || 19230.77(1+(0.0008158+0+0.000052)900)$

$R_o = 98500 || 34250.385 \longrightarrow R_o = 25413.58 = \boxed{25k\Omega}$

Estimate the maximum low frequency voltage gain for the amplifier shown at 27°C with $R_c = 43.3k\Omega$, $R_e = 2.9k\Omega$ and $R_b = 0.4k\Omega$.

31.



$\frac{R_c}{R_c+R_b} = \frac{43300}{43300+400} = 0.991 = \boxed{1}$

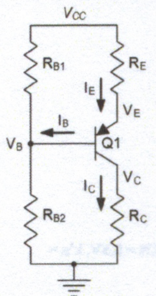
21. What is the open-circuit voltage gain, µf, in V/V for an PNP BJT operating in the forward-active region at 27° C with Ic = 859µA? Use: β = 18, VA = 65V and Vt = kT/q = 26mV.

$g_m = \frac{I_c}{V_t} = \frac{(859\times10^{-6})}{(26\times10^{-3})} = 0.033$ $\quad r_o = \frac{V_A}{I_c} = \frac{65}{(859\times10^{-6})} = 75669.383$ $\quad \mu_f = g_m \cdot r_o = 0.033 \cdot 75669.383 = \boxed{2500}$

22. What is the output resistance, rds, in kΩ for an NMOS FET operating in saturation with Id = 835µA? Use: λ = 0.40

$r_{ds} = \frac{1}{I_d \cdot \lambda} = \frac{1}{(835\times10^{-6})\cdot 0.40} = 2994.0119 = \boxed{2.99k\Omega}$

23. For the BJT bias circuit shown, what is the collector current, Ic, in milliamps? Use Vcc = 12V, Rb1 = 27.5kΩ, Rb2 = 20.2kΩ, Rc = 1.1kΩ, and Re = 4.5kΩ. Assume that the transistor is in the forward-active region, with β = 35 and |Vbe(on)| = 0.7V. Neglect the effects of base-width modulation.



$V_B = \frac{R_{b2}\cdot V_{cc}}{R_{b1}+R_{b2}} = \frac{20200\cdot 12}{27500+20200} = 5.082V$

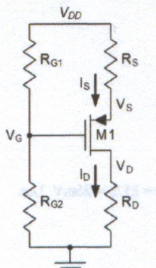
$V_E = V_B + 0.7 = 5.782V$

$I_E = \frac{V_{cc}-V_E}{R_E} = \frac{12-5.782}{4500} = 0.00138A$

$I_B = \frac{I_E}{1+\beta} = \frac{0.00138}{1+35} = 0.000038$

$I_C = I_B \cdot \beta = 0.000038 \cdot 35 = 0.00133 = \boxed{1.33mA}$

24. For the MOSFET bias circuit shown, what is the source voltage, Vs, in Volts? Assume that the transistor is in the saturation region, and use: Vdd = 11V, Rgl = 49.4kΩ, Rg2 = 56.2kΩ, Rd = 4.1kΩ, Rs = 9.7kΩ, Vt = -0.5V, and |Von| = 0.44. (Remember that |Von| = |Vov| = |Vgs|-|Vt|) Neglect the effect of channel-length modulation and body effect.

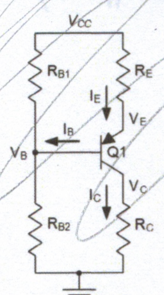


$V_g = \left(\frac{R_{g2}}{R_{g1}+R_{g2}}\right) V_{dd} = \left(\frac{56200}{49400+56200}\right) 11 = 5.85$

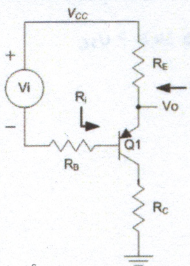
$V_{sg} = 0.44 + |-0.5| = 0.94$

$V_s = 0.94 + 5.85 = \boxed{6.79V}$

25. For the BJT bias circuit shown, what is the collector current, Ic, in milliamps? Use Vcc = 12V, Rb1 = 27.5kΩ, Rb2 = 20.2kΩ, Rc = 1.1kΩ, and Re = 4.5kΩ. Assume that the transistor is in the forward-active region, with β = 35 and |Vbe(on)| = 0.7V. Neglect the effects of base-width modulation.



26. What is the low frequency voltage gain for the amplifier shown at 27° C with Rc = 32.7kΩ, Re = 0.5kΩ and Rb = 0.8kΩ ? Use: Ic = 631µA, β = 50, and Vt = kT/q = 26mV. Neglect the effect of base-width modulation.



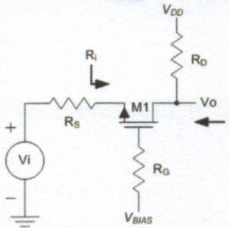
$g_m = \frac{I_c}{V_t} = \frac{(631\times10^{-6})}{(26\times10^{-3})} = 0.0243$

$r_\pi = \frac{\beta}{g_m} = \frac{50}{0.0243} = 2060.22$

$A_v = \frac{(\beta+1)R_E}{R_B + r_\pi + (\beta+1)R_E} = \frac{(51)500}{800+2060.22+(51)500} = \boxed{0.899}$

27. What is the low frequency input resistance, Ri, in Ω for the amplifier shown at 27° C with Rd = 48.4kΩ, Rs = 10.0kΩ and Rg = 7.6kΩ ? Use: W/L = 95, Id = 509µA, VTN = 0.5V, k'n = 100µA/V^2. Neglect the effect of channel-length modulation and body effect.

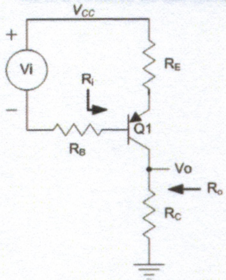
27. What is the low frequency input resistance, Ri, in Ω for the amplifier shown at 27° C with Rd = 48.4kΩ, Rs = 10.0kΩ and Rg = 7.6kΩ ? Use: W/L = 95, Id = 509μA, VTN = 0.5V, k'n = 100μA/V^2. Neglect the effect of channel-length modulation and body effect.



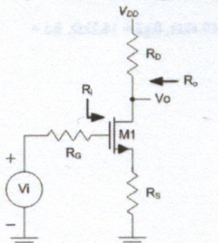
$$g_m = \sqrt{2k'n(W/L)(I_d)} = \sqrt{2(100\times10^{-6})(95)(509\times10^{-6})} = 0.00311$$

$$R_i = \frac{1}{g_m} = \frac{1}{0.00311} = \boxed{321.56\Omega}$$

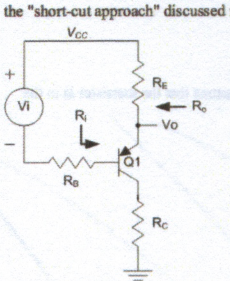
28. What is the low frequency input resistance, Ri, in kΩ for the amplifier shown at 27° C with Rc = 44.3kΩ, Re = 4.3kΩ and Rb = 0.3kΩ ? Use: Ic = 449μA, β = 12, and Vt = kT/q = 26mV. Neglect the effect of base-width modulation.



29. What is the low frequency output resistance, Ro, in kΩ for the amplifier shown at 27° C with Rd = 37.2kΩ, Rs = 0.8kΩ and Rg = 2.9kΩ. Use: W/L = 16, Id = 482μA, VTN = 0.5V, k'n = 100μA/V^2, λ = 0.05 Neglect body effect.



30. What is the low frequency output resistance, Ro, in Ω for the amplifier shown at 27° C with Rc = 34.7kΩ, Re = 0.5kΩ and Rb = 0.8kΩ? Use: Ic = 410μA, β = 10, and Vt = kT/q = 26mV. Use the "short-cut approach" discussed in class, and neglect the effect of base-width modulation.



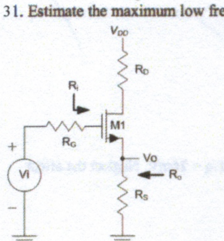
$$g_m = \frac{I_c}{V_t} = \frac{(410\times10^{-6})}{(26\times10^{-3})} = 0.015769$$

$$r_\pi = \frac{\beta}{g_m} = \frac{10}{0.015769} = 634.15$$

$$R_o = R_E \| \left(\frac{r_\pi + R_B}{\beta+1}\right)\left(1 + \frac{R_C}{r_o}\right) \rightarrow R_o = R_E \| \left(\frac{r_\pi + R_B}{\beta+1}\right) \quad \text{since } r_o = \infty \Rightarrow 500 \| \left(\frac{634.15 + 800}{11}\right)$$

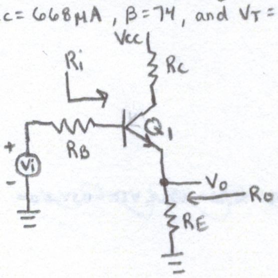
$$\frac{1}{R_o} = \frac{1}{500} + \frac{1}{130.3769} = \boxed{103.4\Omega}$$

31. Estimate the maximum low frequency voltage gain for the amplifier shown at 27° C with Rd = 42.4kΩ, Rs = 0.2kΩ and Rg = 2.0kΩ.



$\boxed{1}$

25. What is the low frequency voltage gain for the amplifier shown at 27°C with $R_C = 39.2k\Omega$, $R_E = 4.5k\Omega$ and $R_b = 0.3k\Omega$? Use $I_C = 668\mu A$, $\beta = 74$, and $V_T = 26mV$.



$$g_m = \frac{I_c}{V_t} = \frac{(668\times10^{-6})}{(26\times10^{-3})} = 0.02569$$

$$r_\pi = \frac{\beta}{g_m} = \frac{74}{0.02569} = 2880.24$$

$$A_v = \frac{(\beta+1)(R_E)}{R_B + r_\pi + (\beta+1)R_E} = \frac{(74+1)(4500)}{300 + 2880.24 + (74+1)4500} = \boxed{0.99}$$

21. What is the base-to-emitter resistance, $r\pi$, in kΩ for an NPN BJT operating in the forward-active region at 27° C with Ic = 708µA? Use: β = 50 and Vt = kT/q = 26mV.

$$g_m = \frac{I_c}{V_t} = \frac{(708\times10^{-6})}{(26\times10^{-3})} = 0.02723$$

$$r_\pi = \frac{\beta}{g_m} = \frac{50}{0.02723} = 1836.16\Omega = \boxed{1.84k\Omega}$$

22. What is the open-circuit voltage gain, µf, in V/V for an PMOS FET operating in saturation with Id = 923µA and Von = |Vgs-Vt| = 734mV ? Use: λ = 0.49

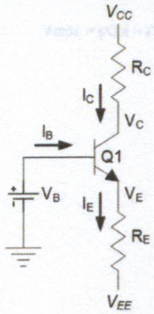
$$g_m = \frac{2I_d}{V_{ON}} = \frac{2(923\times10^{-6})}{(734\times10^{-3})} = 0.002515$$

$$\text{gain} = r_o \cdot g_m = 2211.0686 \cdot 0.002515 = \boxed{5.56}$$

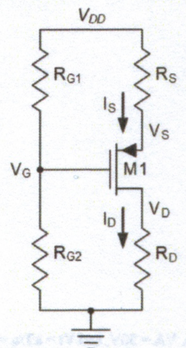
$$r_o = \frac{1}{\lambda \cdot I_d} = \frac{1}{0.49 \cdot (923\times10^{-6})} = 2211.0686$$

23. For the BJT bias circuit shown, what is the collector voltage, Vc, in volts? Use Vcc = 5V, Vee = -8V, Vb = 1.4V, Rc = 4.5kΩ, and Re = 4.9kΩ. Assume that the transistor is in the forward-active region, with β = 91 and |Vbe(on)| = 0.7V. Neglect the effects of base-width modulation.

$$V_B = V_{be} + I_E R_E + V_{ee} \rightarrow 1.4 = 0.7 + I_E(4900) - 8 \rightarrow \frac{8.7}{4900} = I_E = 0.001776$$



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 = 14V, Rg1 = 51.6kΩ, Rg2 = 50.7kΩ, Rs = 6.1kΩ, Vt = -0.4V, and |Von| = 0.12. (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!)



$$V_G = \frac{V_{DD} \cdot R_{G2}}{R_{G1} + R_{G2}} = \frac{14 \cdot 50700}{51600 + 50700} = 6.938$$

$$|V_t| + V_{ON} = 0.4 + 0.12 = 0.52 = V_{GS}$$

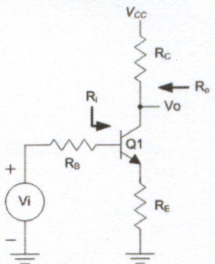
$$V_S = V_{GS} + V_G = 6.938 + 0.52 = 7.458$$

$$I_d = \frac{V_{DD} - V_S}{R_S} = \frac{14 - 7.458}{6100} = 0.00107$$

$$V_{DMAX} = \frac{V_S + |V_t|}{2} = \frac{6.938 + 0.4}{2} = 3.669$$

$$R_d = \frac{V_{DMAX}}{I_d} = \frac{3.669}{0.00107} = 3428.97\Omega = \boxed{3.43k\Omega}$$

25. What is the low frequency voltage gain for the amplifier shown at 27° C with Rc = 19.3kΩ, Re = 0.1kΩ and Rb = 0.9kΩ ? Use: Ic = 26µA, β = 187, and Vt = kT/q = 26mV. Neglect the effect of base-width modulation.

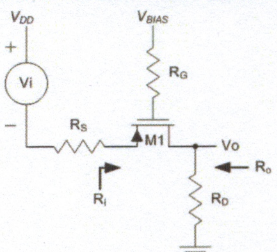


$$g_m = \frac{I_c}{V_t} = \frac{(26\times10^{-6})}{(26\times10^{-3})} = 0.001$$

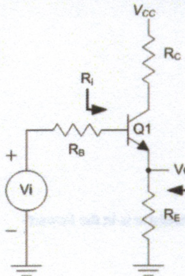
$$r_\pi = \frac{\beta}{g_m} = \frac{187}{0.001} = 187000$$

$$A_v = \frac{-\beta R_c}{R_B + r_\pi + (\beta+1)R_E} = \frac{(-187)(19300)}{900 + 187000 + (187+1)(100)} = \boxed{-17.46}$$

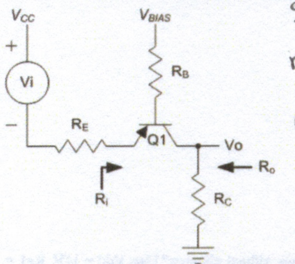
26. What is the low frequency voltage gain for the amplifier shown at 27° C with Rd = 34.6kΩ, Rs = 1.1kΩ and Rg = 1.5kΩ ? Use: W/L = 17, Id = 697µA, VTP = -0.5V, k'p = 40µA/V^2. Neglect the effect of channel-length modulation and body effect.



27. What is the low frequency input resistance, Ri, in kΩ for the amplifier shown at 27° C with Rc = 33.7kΩ, Re = 0.4kΩ and Rb = 0.3kΩ ? Use: Ic = 129μA, β = 189, and Vt = kT/q = 26mV. Neglect the effect of base-width modulation.



28. What is the low frequency input resistance, Ri, in Ω for the amplifier shown at 27° C with Rc = 40.3kΩ, Re = 0.1kΩ and Rb = 0.2kΩ ? Use: Ic = 281μA, β = 37, and Vt = kT/q = 26mV. Neglect the effect of base-width modulation.

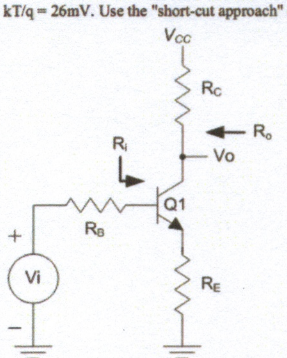


$$g_m = \frac{I_c}{V_t} = \frac{(281\times10^{-6})}{(26\times10^{-3})} = 0.0108$$

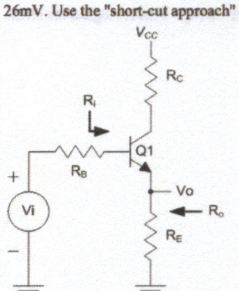
$$r_\pi = \frac{\beta}{g_m} = \frac{37}{0.0108} = 3423.4875$$

$$R_i = \frac{r_\pi + R_B}{\beta+1} = \frac{3423.4875 + 200}{37+1} = 95.355 = \boxed{95.4\Omega}$$

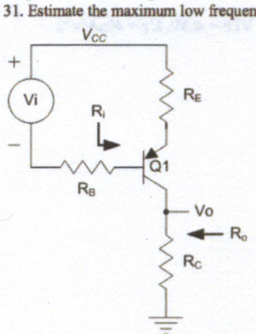
29. What is the low frequency output resistance, Ro, in kΩ for the amplifier shown at 27° C with Rc = 76.4kΩ, Re = 0.5kΩ and Rb = 0.6kΩ ? Use: Ic = 876μA, β = 193, VA = 50V, and Vt = kT/q = 26mV. Use the "short-cut approach" discussed in class.



30. What is the low frequency output resistance, Ro, in Ω for the amplifier shown at 27° C with Rc = 33.7kΩ, Re = 0.2kΩ and Rb = 0.1kΩ ? Use: Ic = 227μA, β = 84, VA = 50V, and Vt = kT/q = 26mV. Use the "short-cut approach" discussed in class, and neglect the effect of base-width modulation.



31. Estimate the maximum low frequency voltage gain for the amplifier shown if the bias voltage across Rc is 1849mV and the bias voltage across Re is 202mV.



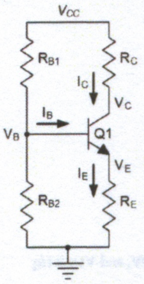
$$\frac{-R_c}{R_e} = \frac{(-1849\times10^{-3})}{(202\times10^{-3})} = \boxed{-9.15}$$

21. What is the transconductance, gm, in mA/V for an PNP BJT operating in the forward-active region at 27° C with Ic = 632μA? Use Vt = kT/q = 26mV

$$gm = \frac{I_c}{V_t} = \frac{(632\times10^{-6})}{(26\times10^{-3})} = 0.02431\ A/V \rightarrow \boxed{24.31\ \frac{mA}{V}}$$

22. What is the device transconductance, gm, in mA/V for a PMOS FET operating in saturation with Id = 423μA and Von = |Vgs-Vt| = 115mV ? Neglect the effects of channel-length modulation and body effect.

23. For the BJT bias circuit shown, what is the emitter current, Ie, in milliamps? Use Vcc = 11V, Rb1 = 37.5kΩ, Rb2 = 27.2kΩ, Rc = 4.2kΩ, and Re = 2.4kΩ. Assume that the transistor is in the forward-active region, with β = 73 and |Vbe(on)| = 0.7V. Neglect the effects of base-width modulation.



$$V_{TH} = \frac{V_{CC}\cdot R_{b2}}{R_{b1}+R_{b2}} = \frac{11\cdot 27200}{37500+27200} = 4.6244$$

$$R_{TH} = (R_{B1}\,||\,R_{B2}) = \frac{(37500)(27200)}{(37500)+(27200)} = 15765.0696$$

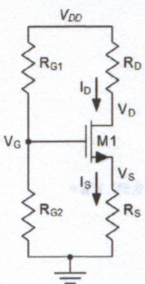
$$4.6244 = (I_B)(15765.0696) + 0.7 + R_E I_E \rightarrow 4.6244 = (I_B)(15765.0696) + 0.7 + 2400(I_E)$$

$$I_B = \frac{I_E}{1+\beta} = \frac{I_E}{74}$$

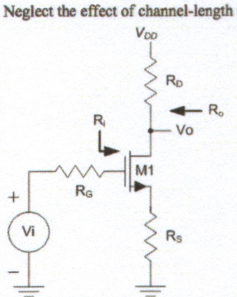
$$4.6244 - 0.7 = I_E\left(\frac{15765.0696}{74}\right) + 2400(I_E) \rightarrow 3.9244 = I_E(2613.041) \rightarrow \frac{3.9244}{2613.041} = I_E$$

$$I_E = 0.00150185A = \boxed{1.50mA}$$

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 = 13V, Rg1 = 43.9kΩ, Rg2 = 43.5kΩ, Rs = 9.6kΩ, Vt = 0.6V, and Von = 0.43. (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!)



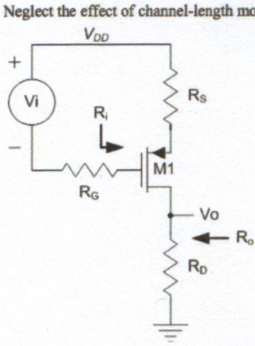
25.~~26~~. What is the low frequency voltage gain for the amplifier shown at 27° C with Rd = 22.8kΩ, Rs = 8.6kΩ and Rg = 8.1kΩ ? Use: W/L = 64, Id = 920μA, VTN = 0.5V, k'n = 100μA/V^2. Neglect the effect of channel-length modulation and body effect.



$$gm = \sqrt{2k'_n(W/L)I_d} = \sqrt{2\cdot(100\times10^{-6})(64)(920\times10^{-6})} = 0.00343$$

$$A_v = \frac{-gmR_d}{1+gmR_s} = \frac{(-0.00343)(22800)}{1+(0.00343\cdot 8600)} = \boxed{-2.56}$$

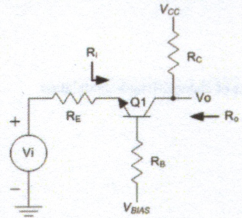
26. What is the low frequency voltage gain for the amplifier shown at 27° C with Rd = 15.5kΩ, Rs = 0.5kΩ and Rg = 5.4kΩ ? Use: W/L = 59, Id = 936μA, VTP = -0.5V, k'p = 40μA/V^2. Neglect the effect of channel-length modulation and body effect.



$$gm = \sqrt{2k'_p(W/L)I_d} = \sqrt{2(40\times10^{-6})(59)(936\times10^{-6})} = 0.0021$$

$$A_v = \frac{-gm\,R_d}{1+gm\,R_s} = \frac{(-0.0021)(15500)}{1+(0.0021\cdot 500)} = \boxed{-15.88}$$

27. What is the low frequency input resistance, Ri, in Ω for the amplifier shown at 27° C with Rc = 38.7kΩ, Re = 0.2kΩ and Rb = 0.7kΩ ? Use: Ic = 874μA, β = 124, and Vt = kT/q = 26mV. Neglect the effect of base-width modulation.

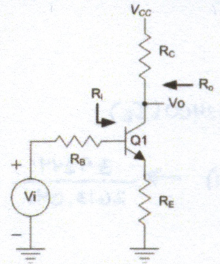


28. What is the low frequency input resistance, Ri, in kΩ for the amplifier shown at 27° C with Rc = 31.4kΩ, Re = 0.7kΩ and Rb = 0.7kΩ ? Use: Ic = 652μA, β = 164, and Vt = kT/q = 26mV. Neglect the effect of base-width modulation.

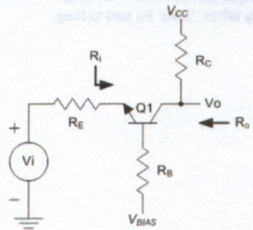
$$gm = \frac{I_c}{V_t} = \frac{(652\times10^{-6})}{(26\times10^{-3})} = 0.0251$$

$$r_\pi = \frac{\beta}{gm} = \frac{164}{0.0251} = 6539.877$$

$$R_i = r_\pi + (1+\beta)R_E \longrightarrow 6539.877 + (1+164)(700) = 122039.877\Omega = \boxed{122.04k\Omega}$$



29. What is the low frequency output resistance, Ro, in kΩ for the amplifier shown at 27° C with Rc = 96.5kΩ, Re = 0.4kΩ and Rb = 0.2kΩ ? Use: Ic = 870μA, β = 51, VA = 50V, and Vt = kT/q = 26mV. Use the "short-cut approach" discussed in class.

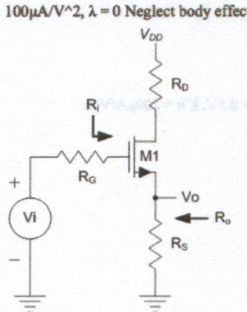


30. What is the low frequency output resistance, Ro, in Ω for the amplifier shown at 27° C with Rd = 21.6kΩ, Rs = 1.0kΩ and Rg = 7.5kΩ. Use: W/L = 95, Id = 990μA, VTN = 0.5V, k'n = 100μA/V^2, λ = 0 Neglect body effect.

$$gm = \sqrt{2k'n(W/L)(I_d)} = \sqrt{2\cdot(100\times10^{-6})(95)(990\times10^{-6})} = 0.00434$$

$$R_o = R_s \| \left(\frac{1}{gm}\right) = \frac{1}{R_o} = \frac{1}{R_s} + gm \Rightarrow \frac{1}{1000} + 0.00434 \Rightarrow 0.00533705$$

$$R_o = \frac{1}{0.00533705} = \boxed{187.37\Omega}$$



31. Estimate the maximum low frequency voltage gain for the amplifier shown at 27° C with Rd = 35.1kΩ, Rs = 0.2kΩ and Rg = 1.4kΩ.

$$\frac{1400\cdot200}{1400+200} = \boxed{175}$$