Exam 1 Practice Problems

1) First check the bias point to verify operation in the forward active region.

\[ \frac{V_b}{10^3} + \frac{V_b - 15}{10^3} + \frac{V_b - 0.7}{101(100)} = 0 \]

\[ V_b \left( \frac{1}{10^3} + \frac{1}{10^3} + \frac{1}{101(100)} \right) = \frac{15}{10^3} + \frac{0.7}{101(100)} \]

\[ 119 \times 10^{-6} V_b = 2.19 \times 10^{-6} \]

\[ V_b = 1.84 \text{ V} \]

\[ I_c \approx I_e = \frac{1.14}{100} = 11.4 \text{ mA} \]

\[ V_{ce} = \left( 15 - 10^3(11.4 \times 10^{-3}) \right) - 1.14 = 2.46 \text{ V} \]

Hence, operation is in the forward active region.

Apply Table to find midbias quantities.

\[ g_m = \frac{I_c}{V_T} \]

\[ A_v = -g_m \left( \frac{R_c}{R_L} \right) = \frac{11.4}{26} = 0.438 \text{ S} \]

\[ = 0.438(10k11k) \]

\[ = 0.398 \]
Exam1 PP

1 cont) \( r_m = \frac{\beta}{g} = \frac{100}{0.438} = 228 \Omega \)

\[ R_i = R_{b11} (r_m + r_b) \quad [\text{Ignore } r_b] \]

\[ = 50 \times 11 (228) = 227 \Omega \]

\[ Av_{sm} = Av_i \frac{R_i}{R_i + R_s} = \frac{-398 (227)}{600 + 227} = -1.09 \]

\[ R_0 \approx R_c = 1k\Omega \]

\[ A_I = Av_i \frac{R_i}{R_L} = -9 \]

2) Apply Table to find midband quantities

\[ CE \omega / Re \]

\[ Av_i = -g_m \frac{(R_c || R_L)}{1 + g_m Re} = -8.9 \]

\[ R_i = R_{b11} \left[ r_m + r_b + (1 + \beta) R_e \right] = 8.56 k\Omega \]

\[ Av_{sm} = Av_i \frac{R_i}{R_i + R_s} = -8.32 \]

\[ R_0 \approx R_c = 1k\Omega \]

\[ A_I = Av_i \frac{R_i}{R_L} = -7.62 \]
Exam 1  PP

\[ A_{vi} = \frac{g_m (R_e l / R_i)}{C_B} = 3.98 \]
\[ R_i = R_{el} l / g_m = 2.2 \Omega \]
\[ A_{v_m} = \frac{A_{vi} R_i}{R_s + R_i} = 1.45 \]
\[ R_o \equiv R_c = 1 \Omega \]
\[ A_I = A_{vi} \frac{R_i}{R_L} = 0.0876 \]

CC

\[ A_{vi} = \frac{g_m}{G_L + C_e + g_m} = 0.977 \]
\[ R_i = R_{el} l \left[ r_i + r_o + \beta (R_e l l / R_i) \right] \]
\[ = 8.42 \Omega \]
\[ A_{v_m} = \frac{A_{vi} R_i}{R_s + R_i} = 0.912 \]
\[ R_o = R_{el} l \left[ \frac{r_i + r_o + (R_e l l / R_i)}{1 + \beta} \right] \approx 7.5 \Omega \]
\[ A_I = A_{vi} \frac{R_i}{R_L} = 0.822 \]
3) First check the bias point to verify operation in the forward active region.

\[
\frac{V_B - 15}{3k} + \frac{V_B - 0.7}{100(10^1)} = 0
\]

\[
V_B \left( \frac{1}{3k} + \frac{1}{100(10^1)} \right) = \frac{15}{3k} + \frac{0.7}{100(10^1)}
\]

\[
\Rightarrow V_B = \frac{5.07 \times 10^{-3}}{32.3 \times 10^{-6}} = 11.7 \text{ V}
\]

\[
V_E = 11 \text{ V} \Rightarrow I_E = \frac{11}{100} = 110 \text{ mA}
\]

\[
V_C = (15 - 10^3(110 \times 10^{-3})) - V_E < 0
\]

Clearly the BJT is not operating in the forward active region so the expressions in Table are not applicable. The BJT is in saturation.
4) List some basic advantages and disadvantages of CE, CB and CC.

<table>
<thead>
<tr>
<th>CE</th>
<th>CB</th>
<th>CC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adv.</td>
<td>High voltage and current gains (with Re bypassed)</td>
<td>High voltage gain</td>
</tr>
<tr>
<td>Disadv.</td>
<td>Somewhat low Rin</td>
<td>Very low Rin</td>
</tr>
</tbody>
</table>

CS, CG and CD stages have roughly the same advantages and disadvantages as the corresponding BJT stages. FET stages tend to have higher input impedance but also lower voltage gain (due to lower gm).
5) First check the bias point to verify that the JFET is operating in the constant current region. Assume constant current region so

\[ I_D = I_{DSS} (1 - \frac{V_{GS}}{V_P})^2 \]

\[ I_D = 10 \times 10^{-3} \left( 1 - \frac{6 - 1320 I_D}{2} \right)^2 \]

\[ = 10 \times 10^{-3} (1 + 3 - 660 I_D)^2 \]

\[ = 10 \times 10^{-3} (16 - 5.28 \times 10^3 I_D + 4356 \times 10^3 I_D^2) \]

\[ \Rightarrow 4.356 \times 10^3 I_D^2 - 53.8 I_D + 16 = 0 \]

Roots are

\[ I_D = \frac{7.36}{mA}, 4.99 \text{ mA} \]

Won't work since

\[ V_{GS} = V_{GC} - R_0 I_D = -3.72 < V_P \]

\[ \Rightarrow \text{For } I_D = 4.99 \text{ mA} \]

Bias info:

\[ V_{GS} = 6 - (12 - 500 (4.99 \times 10^{-3})) = -3.505 < V_T \]

This ensures constant current region.

\[ \Rightarrow V_{DS} = 12 - (1320 + 500) I_D = 2.92 V \]
Exam 1 PP

5cont) Next, apply equations from Table.

\[ g_m = -\frac{2I_{ps3}}{V_p}(1 - \frac{V_{ssq}}{V_p}) \]

\[ = 7.07 mS \]

\[ A_{vi} = -g_m(R_{lll}R_{lll}r_d) \]

\[ = -7.07 \times 10^{-3}(10k\Omega 500) = -3.37 \]

\[ R_i = 50k\Omega \]

\[ A_{vm} = A_{vi} \frac{R_i}{R_s + R_i} = -3.33 \]

\[ A_I = A_{vi} \frac{R_i}{R_L} = 16.9 \]

\[ R_0 \equiv R_D = 500\Omega \]

6) Apply Table

CS w/R_0

\[ A_{vi} \equiv -\frac{R_{lll}R_i}{R_0} = -0.361 \]
Exam I PP

(c cont) \[ R_i = 50k\Omega \quad A_{u_{sm}} = A_u i \frac{R_i}{R_s + R_i} = -3.57 \]
\[ A_i = A_u i \frac{R_i}{R_i} = -0.072 \]
\[ R_o \approx R_d = 500\Omega \]

**CG**
\[ A_v i = g_m (R_o || R_u || \frac{1}{j\omega_m}) = 3.37 \]
\[ R_i = R_o || \frac{1}{g_m} = 128\Omega \]
\[ A_{u_{sm}} = A_u i \frac{R_i}{R_s + R_i} = 0.592 \]
\[ A_i = A_u i \frac{R_i}{R_L} = 0.043 \]
\[ R_o \approx R_d = 500\Omega \]

**CD**
\[ A_v i = g_m (R_d || R_o || R_u || \frac{1}{j\omega_m}) = 0.892 \]
\[ R_i = 50k\Omega \quad A_{u_{sm}} = A_u i \frac{R_i}{R_i + R_s} = 0.881 \]
\[ A_i = A_u i \frac{R_i}{R_L} = 4.46 \]
\[ R_o = (R_o || R_d || \frac{1}{j\omega_m}) = 128\Omega \]
Exam II PP

7) First check the bias point to verify that the JFET is operating in the constant current region. Assume constant current region:

\[ I_D = I_{DSS} \left(1 - \frac{V_{GS}}{V_P}\right)^2 \]

\[ = 10 \times 10^{-3} \left(1 - \frac{6 - 520I_D}{-2}\right)^2 \]

\[ = 10 \times 10^{-3} \left(4 - 260I_D\right)^2 \]

\[ \Rightarrow 676I_D^2 - 21.8I_D + .16 = 0 \]

\[ I_D = 11.3 \text{ mA}, 20.95 \text{ mA} \]

Looking at 20.95 mA, notice that:

\[ V_{GS} = 6 - R_0I_D = -4.89 < V_{GS} \]

Looking at 11.3 mA, we have:

\[ V_{GS} = .129 \text{ V} > V_P \]

However, \[ V_{GD} = 6 - (12 - 500(11.3 \times 10^{-3})) \]

\[ = -.35 \text{ V} > V_P \]

Since the JFET is operating in the triode region, Table cannot be applied.
In problem 1 we verified the proper Q point for the BJT stage and in problem 5 we verified the proper Q point for the JFET stage. Let's draw the small signal model:

\[ R_{in} \approx 227 \Omega \quad R_0 \approx 500 \Omega \]

2nd stage is CG:

\[ A_{v12} = +g_m(\frac{R_0}{11R_L}) = 7.07 \times 10^{-3} \left( \frac{500}{11 \times 10k} \right) = 3.37 \]

\[ A_{v11} = -g_m(\frac{R_{01}}{R_{in}}) \quad \text{where} \quad R_{in} = 128 \Omega \quad (\text{Prob}) \]

\[ = -0.438 \left( \frac{1k}{128} \right) = -49.7 \]

\[ A_{v_{sm}} = A_{v11} A_{v12} \frac{R_{in}}{R_{in} + R_s} \]

\[ = -46 \]
Exam I PP

(continued)

\[ A_{I_1} = A_{v_{i1}} \frac{R_{in}}{R_{in}} = -88.1 \]

\[ A_{I_2} = A_{v_{i2}} \frac{R_{in}}{R_L} = .043 \]

So, \[ A_{It} = A_{I_1}, A_{I_2} = -3.8 \]
Exam I practice problem solutions

9) First consider the Q pt. Assuming forward active region we have:

\[ 15 - 300kI_B - 0.7 - 100I_B(10) = 0 \]

\[ I_B = \frac{14.3}{300k + 100(10)} = 4.61 \text{ mA} \]

\[ I_C = 4.61 \text{ mA} \]

\[ \Rightarrow V_{CE} = 15 - 1k(4.61 \text{ mV}) - 100 \left( \frac{100}{1000} \right)(4.61 \text{ mV}) \]

\[ = 9.92 \text{ V} \] so clearly operation is in forward active region.

\[ g_m = \frac{I_C}{V_T} = \frac{4.61 \text{ mA}}{26 \text{ mV}} = 0.177 \text{ S} \]

\[ r_m = \frac{100}{.177} = 565.72 \]

Assume corner frequencies are widely separated so we can treat effects of \( C_1, C_2, C_3 \) separately.
Exam I practice problem solutions

Effect of $C_1$: $\frac{1}{\frac{1}{1 \mu F}}$

\[ \omega_{C_1} = \frac{1}{(10)(600 + 300(11.565))} = 8.59 \text{ rps} \]

Effect of $C_2$: $\frac{1}{\frac{1}{10 \mu F}}$

\[ \omega_{C_2} = \frac{1}{(10)(11k)} = 9.09 \text{ rps} \]
Exam I: Practice problem solutions

Effect of $C_E$: Use result from formula sheet

\[ R_s^\prime + \frac{U_{TR}}{565} \]

\[ V_s^\prime \quad \frac{5997}{565} \]

\[ \frac{1008}{\pi} \quad V_H \]

\[ \frac{17347}{10} \quad K \]

\[ 10 \quad K \]

\[ 5 \quad K \]

\[ + \quad U_0 \]

\[ \omega_{CE_1} = \frac{1}{R_E C_E} = 10 \text{ KHz} \]

\[ \omega_{CE_2} = \frac{R_s^\prime + r_T + (1 + \beta) R_E}{C_E R_E (R_s^\prime + r_T)} = 96.8 \text{ KHz} \]

Hence, the gain $A_v$ becomes

0.707 $A_{v_{\text{max}}}$ at about

\[ F_{CE_2} = 15.4 \text{ KHz} \]

\[ Z_{in} = Z_{in, \text{midband}} = R_{\text{11}} r_m = 564 \Omega \]

\[ Z_{in} \approx Z_{in} \quad \text{at} \quad 100 \text{ KHz} \]
Exam I practice problem solutions

10) A pt found in problem 9

Test to see if Miller transformation is a reasonable approximation.

\[
[C_u + C_0] \ll (R_{L1}||R_s) C_u g_m \quad \text{(Formula)}
\]

\[
1\mu \ll 51\mu \Rightarrow \text{good approximation}
\]

\[
A_{ui} = -g_m(R_{L1}||R_s) \approx -161
\]

So the Miller transformed circuit becomes:

\[
\text{[Diagram of the transformed circuit]}
\]
Exam I practice problem solutions

Two corner frequencies are present. For the input RC network

\[ \omega_1 = \frac{1}{(300,1156/11600)(16\pi)} = 20.5 \text{Mrps} \]

For the output RC network

\[ \omega_2 = \frac{1}{(9.09)(1p)} = 1.1 \text{Gbps} \]

So, clearly the high frequency point at which \( A_{\text{v}} \) becomes 0.707 \( A_{\text{v.m}} \) is \( f_1 = 3.26 \text{ MHz} \).

\[ Z_{\text{in}} \approx Z_{\text{in, midband}} = \frac{R_{\text{ll}}}{} = 544 \Omega \]
11) We found the Q pt. for this circuit in problem 9. Once again we assume the corner frequencies are widely separated.

\[ \text{Effect of } \frac{C_1}{600 \Omega, 1 \mu F} \]

But this simply becomes

\[ \text{Zinc} = \frac{1}{g_m} \]

So, \( \omega_c = \frac{1}{(605.3 \times C_1)} = 1.65 \text{ k} \text{Hz} \)
Exam J practice problem solutions

Effect of $C_2$

\[
\omega_2 = \frac{1}{(10\mu F)(11k)} = 9.09 \text{ rps}
\]

Effect of $C_B$

\[
V_{in} = -V_{\pi} \left( r_\pi + Z_B \right) g_\pi
\]

\[
V_o = g_m \left( R_{c1} R_o \right) V_{\pi}
\]

\[
\Rightarrow \frac{V_o}{V_{in}} = \frac{g_m \left( R_{c1} R_o \right)}{r_\pi + Z_B}
\]
ExampI practice problem
solutions

\[ i_{in} = \frac{V_{in}}{R_{E}} - (g_{m} + g_{m'}) v_{m} \]

\[ = V_{in} \left[ G_{E} + (g_{m} + g_{m'})(\frac{r_{T}}{R_{S} + Z_{B}}) \right] \]

So

\[ Z_{in} = \frac{V_{in}}{i_{in}} = \frac{1}{G_{E} + (g_{m} + g_{m'})(\frac{r_{T}}{R_{S} + Z_{B}})} \]

Finally,

\[ \frac{V_{o}}{V_{s}} = \frac{V_{o}}{V_{in}} \frac{Z_{in}}{R_{S} + Z_{in}} \]

So

\[ \frac{V_{o}}{V_{s}} = \frac{g_{m} (R_{c} || R_{L}) r_{T}}{r_{T} + Z_{B}} \frac{1}{G_{E} + (g_{m} + g_{m'})(\frac{r_{T}}{R_{S} + Z_{B}})} \]

\[ = \frac{g_{m} (R_{c} || R_{L}) r_{T}}{r_{T} + Z_{B}} \frac{1}{G_{E} + (g_{m} + g_{m'})(\frac{r_{T}}{R_{S} + Z_{B}})} \]

\[ = \frac{1}{G_{E} + (g_{m} + g_{m'})(\frac{r_{T}}{R_{S} + Z_{B}})} \]

\[ + 1 \]

\[ = \frac{G_{E} + (g_{m} + g_{m'})(\frac{r_{T}}{R_{S} + Z_{B}})}{G_{E} + (g_{m} + g_{m'})(\frac{r_{T}}{R_{S} + Z_{B}}) + 1} \]
Exam practice problem solutions

\[ \frac{U_o}{U_s} = \frac{g_m (R_C || R_L) \frac{g_m}{R_T}}{G_s + \frac{G_s}{G_s + (g_m + g_m^\pi) (\frac{R_T}{R_T + 2B})}} \]

\[ = \frac{g_m (R_C || R_L) \frac{g_m}{R_T} G_s}{G_s + G_E (\frac{R_T}{R_T + 2B}) + (g_m + g_m^\pi) (\frac{R_T}{R_T + 2B}) (R_s + 1)} \]

\[ = \frac{g_m (R_C || R_L) G_s}{G_s + G_E + g_m + g_m^\pi} \left[ \frac{j \omega C_B + G_E}{j \omega C_B + G_B + \frac{g_m^\pi (G_s + G_E)}{G_s + G_E + g_m + g_m^\pi}} \right] \]

So, \( \omega_B = \frac{1}{R_BC_B} = 3.33 \text{ rps} \)

\[ \omega_{C_B_2} = \left( \frac{g_m^\pi (G_s + G_E)}{G_s + G_E + g_m + g_m^\pi} \right) \frac{1}{C_B} \]

\[ = 112 \text{ rps} \]

Hence, the 0.707 Arms frequency is \( f_c = 13.7 \text{ Hz} \).

\[ Z_{in}(100kHz) \equiv Z_{in, midband} = 5.3 \Omega \]
Exam I practice problem solutions

12) We found the Q pt. for this circuit in problem 9.

Assuming the corner frequencies are widely separated we can examine them separately:

\[ \omega_c = \frac{1}{(5.7 \text{pF})(5)} = 35.1 \text{ G} \cdot \text{rps} \]

\[ \omega_c = \frac{1}{(9.09 \text{F})(1 \text{p})} = 1.1 \text{ G} \cdot \text{rps} \]

so the 0.707Au\text{sm} frequency is

\[ f_{c2} \approx 17.5 \text{MHz} \]

\[ Z_{in}(100 \text{kHz}) = Z_{in_{\text{midbandQ}}} = 5.3 \Omega \]
13) First, examine the Q pt. and make sure operation is in the constant current region.

\[ V_{GS} = -1 - 360 I_D \]

Assuming the constant current region:

\[ I_D = 2.5 m (1 - 360 I_D + 2)^2 \]

\[ I_D = 2.5 m (1 - 360 I_D)^2 = 2.5 m - 1.8 I_D + 324 I_D^2 \]

or

\[ I_D^2 - 324 - 2.8 I_D + 2.5 m = 0 \]

\[ \Rightarrow I_D = \frac{2.8 \pm \sqrt{(2.8)^2 - 4(1)(2.5)(-324)}}{2(1)} \]

\[ I_D = 7.82 \text{ mA} \text{ or } 1.01 \text{ mA} \]

\[ V_{GS} < V_P \quad V_{GS} = -1.363 \text{ V} \]

\[ V_{DS} = 12 - 1k(1.01mA) - 360(1.01mA) \]

\[ = 10.63 \text{ V} \]

\[ V_{GD} = V_{GS} - V_{DS} = -12 \text{ V} \text{ so operation is in the constant current region.} \]
Exam I practice problem solutions

\[ g_m = 2k(V_{GS} - V_p) = 5m(-1.363 + 2) = 3.19 \text{ mS} \]

Once again, assume the corner frequencies are widely separated.

**Effect of C1**

\[ \omega_{c1} = \frac{1}{(100 \, \text{ k}) (1 \, \mu)} = 9.94 \text{ rps} \]

**Effect of C2**

\[ \omega_{c2} = \frac{1}{(1 \, \text{ k}) (1 \, \mu)} = 90.9 \text{ rps} \]
Exam I practice problem solutions

**Effect of **$C_0$**

\[
\begin{align*}
\frac{V_o}{V_{gs}} &= -g_m (R_c / (R_c + R_g)) \\
V_G &= \frac{R_c V_{so}}{R_s + R_c} \\
V_S &= Z_0 - g_m V_{gs} \\
V_{gs} &= \frac{R_c V_{so} - Z_0 g_m V_{gs}}{R_s + R_c} \\
\text{So} \quad \frac{V_{gs}}{V_{so}} &= \frac{R_c}{R_s + R_c} \left(1 + g_m Z_0 \right)
\end{align*}
\]
Exam I practice problem solutions

\[ \frac{V_o}{V_{so}} = -g_m \frac{(R_c + R_e)}{R_s + R_e} \frac{1}{1 + g_m \left( \frac{j \omega C_o + G_o}{R_s + R_e} \right)} \]

\[ = -g_m \frac{(R_c + R_e)}{R_s + R_e} \frac{1}{j \omega C_o + G_o} \]

\[ \omega C_{o_1} = \left( \frac{1}{R_s X_C_o} \right) = 2.78 \text{ k } \text{rps} \]

\[ \omega C_{o_2} = \frac{G_o + g_m}{C_o} = 5.96 \text{ k } \text{rps} \]

so, \( A_{v3} \) becomes 0.707 of \( A_{v3m} \)

at \( f_{c_{o_2}} = 949 \text{ Hz} \)

\[ Z_{in} (100 \text{ kHz}) = \frac{Z_{in_{dB}}}{100 \text{ k}^2} = 100 \text{ k}^2 \]
14) We already determined the Q pt in problem 13. \( g_m = 3.18 \text{mS} \)

\[ \frac{600 \Omega}{2 \mu F} \quad \frac{1 \mu F}{1 \text{K} \Omega} \quad \frac{3 \mu F}{1 \text{M} \Omega} \quad \frac{\frac{3.18}{\mu F}}{X_{U_3}} \quad \frac{90 \text{K} \Omega}{} \]

Determine if the Miller transformation leads to a reasonable approximation.

Criterion is

\[
(C_{gd} + C_c) \ll \frac{(R_s || R_g) C_{gd} g_m}{(\text{sheet})} \]

\[ 2 \mu \ll \frac{(600)(2 \mu)(3.18 \text{mS})}{3} \]

\[ \Rightarrow 2 \mu \ll 1.9 (2 \mu) \]

Not necessarily a good approximation in this case but it should still provide some idea of the frequency performance.
Exam I practice problem solutions

\[ A_{\text{in}} = -g_m \left( R_e/11R_L \right) = 2.89 \]

Look at the 2 corner frequencies introduced:

\[ \omega_{c1} = \frac{1}{(2\pi)(10.8\text{p})} = 155 \text{ M} \text{rps} \]

\[ \omega_{c2} = \frac{1}{(2\pi)(90.9\text{p})} = 550 \text{ M} \text{rps} \]

So, our best guess of the 0.707\(A_{\text{in}} \)m frequency is:

\[ f_{\text{m}} = 24.7 \text{ MHz} \]

\[ Z_{\text{in}}(100\text{kHz}) = Z_{\text{midband}} = 100\text{k}\Omega \]
The Miller transformation applies to amplifier circuits where a capacitor connects input and output points in the circuit.

\[ \text{C} \]

\[ \begin{array}{c}
+ \\
\text{Vin} \\
- \\
1 \text{C} \\
\end{array} \quad \begin{array}{c}
+ \\
\text{Vo} \\
- \\
\frac{1}{\text{C}} \\
\end{array} \]

A nodal equation at the input has the term \((\text{Vin} - \text{Vo})(j\omega C)\).

But \(A_{vi} = \frac{\text{Vo}}{\text{Vin}}\). If the high frequency corner frequencies of \(A_{vi}\) are much higher than the lowest high corner frequency of \(A_{vs}\) then \(C\) can be replaced by \((1 - A_{vi})C\) to find the lowest high corner frequency of \(A_{vs}\) since

\[ (\text{Vin} - \text{Vo})(j\omega C) \leq \text{Vin}(1 - A_{vi})(j\omega C) \]

in that case.
Exam II practice problem solutions

We already found the Q pt. for this circuit. $g_m = 3.18 \text{mS}$.

Once again, assume the corner frequencies are widely separated.

**Effect of $C_1$**

\[
\begin{array}{c}
\text{600 \Omega} \quad 1 \mu F \quad 3.18 \text{mS} \times \text{Vgs} \\
\text{V_s} \quad \text{360 \Omega} \quad \frac{909 \Omega}{2} \quad V_o \\
\end{array}
\]

From Table $Z_{io} \approx R_0 - \frac{1}{g_m} = 168 \Omega$

So, $\omega_c = \frac{1}{(600 + 168)(1 \mu F)} = 1.3 \text{ kbps}$

**Effect of $C_2$**

\[
\begin{array}{c}
\text{600 \Omega} \quad 3.18 \text{mS} \times \text{Vgs} \quad 1 \mu F \\
\text{V_s} \quad \text{360 \Omega} \quad \frac{1 \text{k\Omega}}{2} \quad \frac{10 \text{k\Omega}}{2} \\
\end{array}
\]

$\omega_c = \frac{1}{(10 \text{k\Omega})(1 \mu F)} = 90.9 \text{ rps}$
Exam I practice problem solutions

Effect of \( C_2 \):

\[
\begin{align*}
&\text{3.18 mV} \times 3,600 \Omega = 11,368 \text{V} \\
&\text{5.23 mV} \times 9 \Omega = 0.0471 \text{V} \\
&\text{5.90 mV} + \text{5.23 mV} = 11.13 \text{mV} \\
&\frac{10 \Omega}{1 \mu F} \approx 10 \Omega
\end{align*}
\]

Since both ac and dc currents in the gate are assumed to be negligible then any corner frequency associated with the 100 k\( \Omega \) 1 \( \mu F \) approaches dc (0 Hz).

Hence, the 0.707 Avsm frequency is

\[
f_0 = 207 \text{Hz}
\]

\[
Z_{in}(100 \text{kHz}) \approx Z_{in \text{ mid band}} = 168 \Omega
\]

\[
Z_{in}(100 \text{kHz}) \approx Z_{in \text{ mid band}} = 168 \Omega
\]
Exam II practice problem solutions

17) Same Q pt. as problem 13

\[ V_s \quad 600 \Omega \quad \frac{1}{3pF} \quad \frac{1}{909} \quad \frac{1}{2pF} \quad \frac{1}{\frac{360}{\pi}} \quad \text{at } \frac{3.18mV_0}{V_0} \]

The two corner frequencies associated with this circuit (assuming they are widely spaced) is:

\[ \omega_c_1 = \frac{1}{600(168)(3p)} = 2.53 \text{Grps} \]

\[ \omega_c_2 = \frac{1}{909(2p)} = 550 \text{Mrips} \]

Hence, the 0.707 A_{\text{rms}} frequency is \[ f_c_2 = 87.5 \text{MHz} \]

\[ Z_{1n}(100\text{kHz}) \approx Z_{\text{mddband}} = 168\Omega \]
1b) \[ CMRR = 1 + \beta_m \cdot 2 \cdot R_{EE} \]

\[ \beta_m = \frac{0.005}{0.03} = 0.1925 \]

So, \[ CMRR = 1 + 2(0.1925)(500) \]

\[ = 193 \text{ or } 46 \text{ dB} \]

b) \[ CMRR = 1 + 192(2)(10^2) \]

\[ = 3841 \text{ or } 72 \text{ dB} \]

c) Use of the active current source leads to a tremendous increase in CMRR.
19) \[ I_{\text{source}} = \frac{30 - 0.7}{60} = 0.488 \text{ mA} \]

This is the collector current through Q2. Assuming Q1 has the same parameters as Q2, \[ V_{CE_{Q2}} \approx \frac{1}{2} \left( 15 - 100 \left( 4.8 \times 10^{-3} \right) \right) \]

\[ = 7.48 \text{ V} \]

\[ r_{o_{Q2}} = r_{o_{Q1}} = \frac{V_A}{I_{\text{source}}} = 205 \text{ k}\Omega \]

\[ g_{m1} = \frac{I_{\text{source}}}{V_T} = 0.188 \text{ S} \]

\[ r_{\pi} = \frac{100}{g_{m1}} = 5.32 \text{ k}\Omega \]

So, the small signal (midband) model is:

\[ \frac{V_o}{V_{\pi \pi}} = -g_{m1} (205 \text{k} \Omega) (205 \text{k} \Omega) (1 \Omega) = -1748 \]

\[ \frac{V_{\pi \pi}}{V_s} = \frac{R_i}{R_s + R_i} = \frac{4.8 \text{k} \Omega}{5.41 \text{k} \Omega} = 0.889 \]

\[ \Rightarrow A_{V_s} = \frac{V_o}{V_s} = -15.54 \]