HOMEWORK #12

9.1 $g_m = 1mAV^{-1}$

$r_o = \infty$

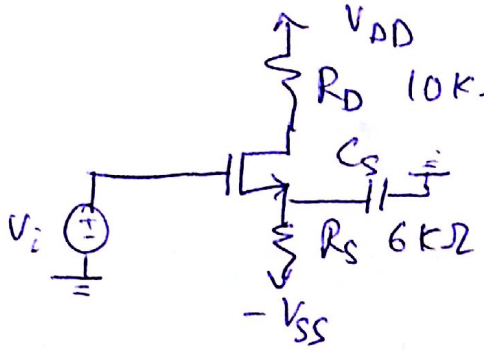
(Using $\pi^2 \simeq 10$)

$f_{p2} \simeq f_L = 20Hz = \frac{g_m}{2\pi C_S}$ ↳ dominant pole

$\Rightarrow C_S = \frac{g_m}{2\pi f_c} = \frac{1\times10^{-3}}{2\pi \times 20} \simeq \frac{\pi^2 \times 10^{-4.5}}{2\pi \times 20} \simeq \frac{\pi}{4} \times 10^{-5}$

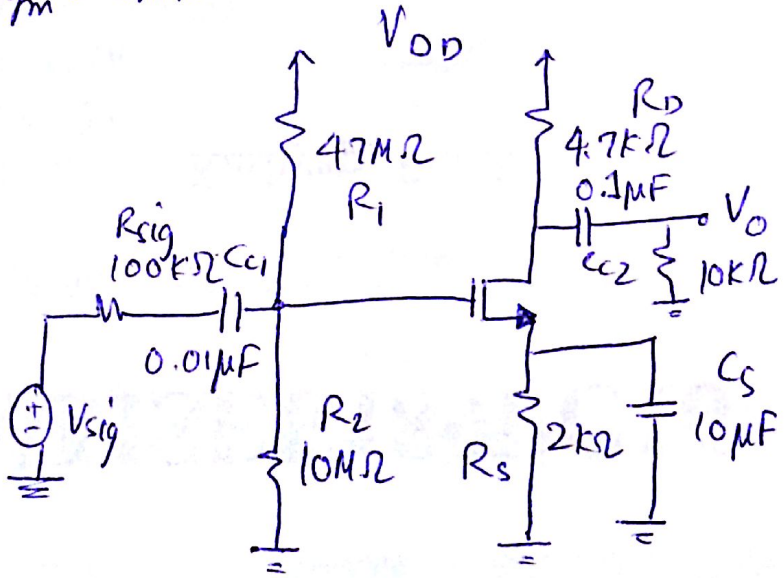
$= 0.77 \times 10^{-5}$

$= 7.7\,\mu F$



$A_{mid} = \frac{g_m R_D}{1 + g_m R_S} = \frac{1\times10}{1+1\times6} = \frac{10}{7} = 1.43\ V/V$

9.3 $g_m = 5mAV^{-1}$



$A_{mid} = -\frac{R_{in}}{R_{in}+R_{sig}} g_m (R_D \| r_o \| R_L) \simeq \frac{5m}{1u}(3k)$

$\simeq 15\ V/V$

$R_{in} = r_\pi \| R_1 \| R_2 \simeq 8M\Omega$ (high)

$= -\frac{8M}{8M+0.1M\Omega} \cdot 5m\,(4.7k \| 10k\Omega \| r_o)$

↳ $\simeq 1$ ↳ $\simeq 3k\Omega$

$f_{p2}\left(\underset{\text{(not true)}}{\simeq} f_L\right) = \frac{g_m}{2\pi C_S} = \frac{5m}{2\pi \times 10\mu} = \frac{5\times 10^{-3}}{2\pi\times 10^{-5}} = \frac{500}{2\pi} \simeq 75\,Hz$

$f_{p1} = \frac{1}{2\pi C_1 (R_a + R_{sig})} = \frac{1}{2\pi \times 10^{-8} \times (8M + 100k)}$

$\hookrightarrow R_{in} = R_1 \| R_2$

$= \frac{10^{8}}{2\pi \times 8M} = \frac{\pi^2 \times 10^8}{16\pi^2} \simeq 2\,Hz$

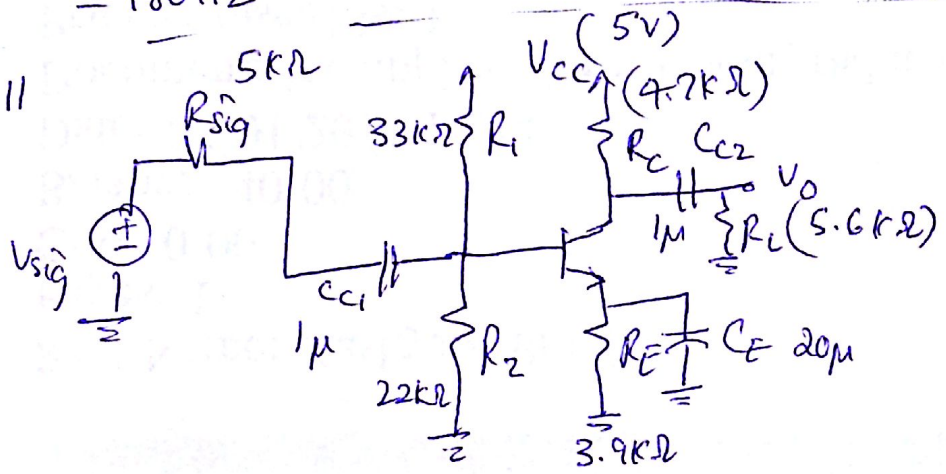
$f_{p3} = \frac{1}{2\pi C_2 (R_D + R_L)} = \frac{1}{2\times\pi\times 10^{-7}\times(4.7k+10k)} = \frac{10^{7}\times 4}{2\pi\times 15k}$

$= \frac{10\times\pi^2\times 10^2}{2\pi\times 15} \simeq 100\,Hz$

$f_L \simeq \Sigma f_{pi}$

$\simeq 180\,Hz$

9.11



$I_E \simeq 0.3\,mA$

$\beta = 120$

$r_\pi = \frac{\beta}{g_m} \rightsquigarrow \frac{0.3}{25} = 12m\Omega$

$= \frac{\beta}{\alpha I_E} V_T$

$= \frac{\beta+1}{I_E} V_T$

$= \frac{121\times 25m}{0.3m}$

$\simeq 40k\Omega$

$r_o = \frac{V_A}{I_E} \rightsquigarrow \infty$

$R_{in} = (R_1 \| R_2) \| R_\pi = R_B \| r_\pi$

$= 33k \| 22k \| 40k = 10k\Omega$

$A_M = \frac{R_{in}}{R_{in}+R_{sig}} g_m (R_C \| R_E \| r_o)^{\infty}$

$= \frac{10k}{(10+5)k} 12m\,(4.7k \| 5.6k) = \frac{2}{3}\times 12m \times 2.5k = \boxed{-20\,V/V}$

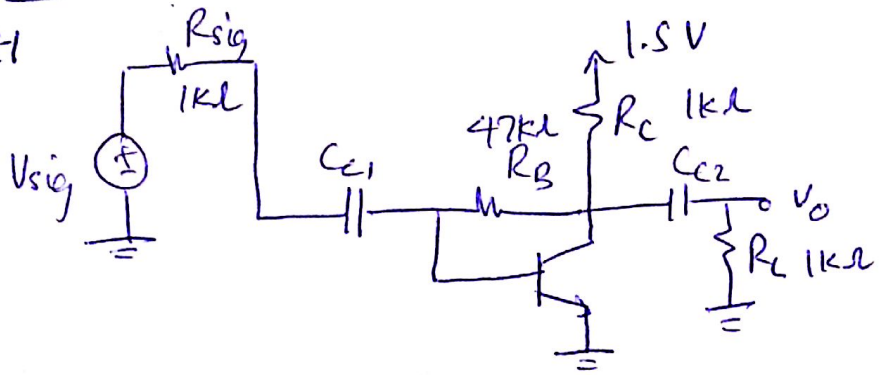
$f_{p1} = \frac{1}{2\pi C_{C1}(R_{in}+R_{sig})}$ ($R_B \| r_\pi$) $= \frac{10^6}{2\pi(10k+5k)} = \frac{10^6}{3\times 2\pi\times 1k} = \frac{\pi\times 10}{3\pi} \simeq 10\,Hz$

$f_{p2} = \frac{\beta}{2\pi C_E [r_\pi + R_B \| R_{sig}]} = \frac{\pi\times 10^3\times 10^6}{2\pi\times 80\,[40k + 33k\|22k\|15k]} = \frac{3\pi\times 10^{2}}{4+k} \simeq 22\,Hz$

9.11 Contd $f_{p3} = \frac{1}{2\pi C_{C2}(R_c + R_L)} = \frac{10^6}{2\pi \times (4.7K + 5.6K)} = \frac{10^6 / 82}{2\pi \times 10K} = \frac{\pi^2 10^5}{2\pi} \simeq 15\,Hz$

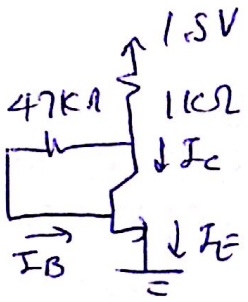
$f_L \simeq \Sigma f_{pi} = 47\,Hz$ //

9.41



$\beta = 100$
$C_\mu = 0.8pF$
$f_T = 600MHz$
Assume $V_{BE(On)} = 0.7V$

(a)



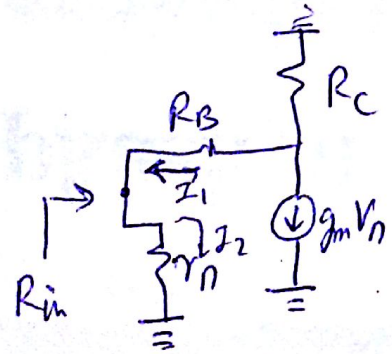
$1.5V = I_E(1K\Omega) + 47K\Omega(I_B)$
$-0.7V$
$0.8V = I_B\,101 + 47 I_B$
$\Rightarrow I_B = \frac{0.8\,mA}{148} = 5.4\mu A$
$I_E = 0.55\,mA$ // $\simeq I_C$

(b) $g_m = \frac{I_C}{V_T} = \frac{0.55m}{25m} = 21.8mV$

$r_\pi = \frac{\beta}{g_m} = \frac{100}{21.8} = 4.6K\Omega$

(c) $A_{mid} = \frac{R_{in}}{R_{in}+R_{sig}} g_m (R_c \| R_L) = \frac{4.6K}{5.6K} \times 21.8mV \times \frac{1}{2} K\Omega$
↳ r_π (neglecting R_B) $= 8.95\,V/V$

(d)



$R_{in} = \frac{V_\pi}{-I_1 + I_2}$ (I_2 was neglected)

$\Rightarrow i_e R_c + i_b R_B + (i_b + i_b) r_\pi = 0$

$\Rightarrow V_\pi = i_e R_c + i_b R_B + i_b r_\pi$

$R_{in} = \frac{V_\pi}{i_b} = (\beta+1) R_c + R_B + r_\pi$
$\simeq 150K\Omega$

(e) A_{mid} as $R_{in} \uparrow \Rightarrow A_{mid} \to g_m(R_c \| R_L) \simeq 11\ V/V$

(r_n neglected, $\beta = 95$)

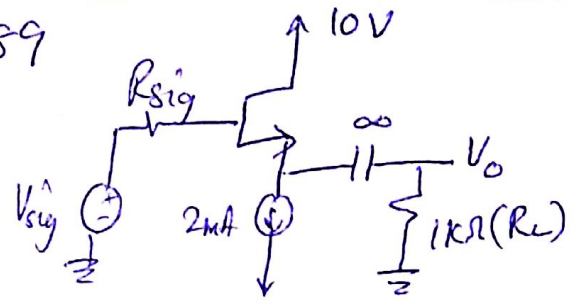
(f) $C_{in} = C_\mu(1+g_m R_L') + C_\pi = 5pF + 0.8pF(1+21.8m\frac{1K}{2}) \simeq 15pF$ (where $R_L' = R_c \| R_L$)

$f_T = \frac{g_m}{2\pi(C_\pi + C_\mu)} \Rightarrow C_\pi = \frac{g_m}{2\pi f_T} - C_\mu = \frac{21.8m}{2\pi \times 600M} - 0.8pF = 5.78 - 0.8pF \simeq 5pF$

(g) $f_H = 1/2\pi C_{in} R_{sig}'$ ($R_{sig}' = r_\pi \| R_B \| R_{sig} = 1K\Omega$) $\Rightarrow f_H = \frac{10^9}{2\pi \times 15p \times 1K} = \frac{1000 \times 10^6}{2\pi \times 15} = 10MHz$

($C_{gs} = 60 f_H$ ... makes sense)

9.89



$\beta = 100$ $f_T = 400MHz$ $C_\mu = 2pF$

$g_m = \frac{I_C}{V_T} = \frac{2m}{25m} = 80mV$ $r_\pi = \frac{\beta}{g_m} = 1.25K\Omega$

$A = \frac{R_{in}}{R_{in}+R_{sig}} g_m R_L$ ($r_\pi \to$)

$C_{in} = C_\pi + C_\mu(1+g_m R_L)$

$C_\pi = \frac{g_m}{2\pi f_T} - C_\mu = \frac{80mV}{2\pi\ 400M} - 2p = (31.8-2)pF \simeq 30pF$

$\Rightarrow C_{in} = 30p + 2p(1+80) = 192pF$

(a) $R_{sig} = 1K\Omega$

$A = \frac{1.25K}{1.25K+1K} \cdot 80mV/V = 44.44\ V/V$

$f_H = \frac{1}{2\pi R_{sig}' C_{in}} = \frac{1}{2\pi \times 0.5K \times 192p} = 1.65MHz$

$R_{sig}' = r_\pi \| R_{sig} = 1.25K \| 1K$

(b) $R_{sig} = 10K\Omega$

$A = \frac{1.25}{1.25+10} \times 80 = 8.8\ V/V$

$f_H = \frac{1}{2\pi R_{sig}' C_{in}} = \frac{1}{2\pi \times 1K \times 192p} = 0.8MHz$

($R_{sig}' = 10K \| 1.25K$)

(c) $R_{sig} = 100K\Omega$

$A = \frac{1.25}{101.25} \times 80 = 0.98\ V/V$

$f_H = \frac{1}{2\pi \times R_{sig}' C_{in}} \simeq 0.8MHz$

($R_{sig}' = 100K \| 1.25$)