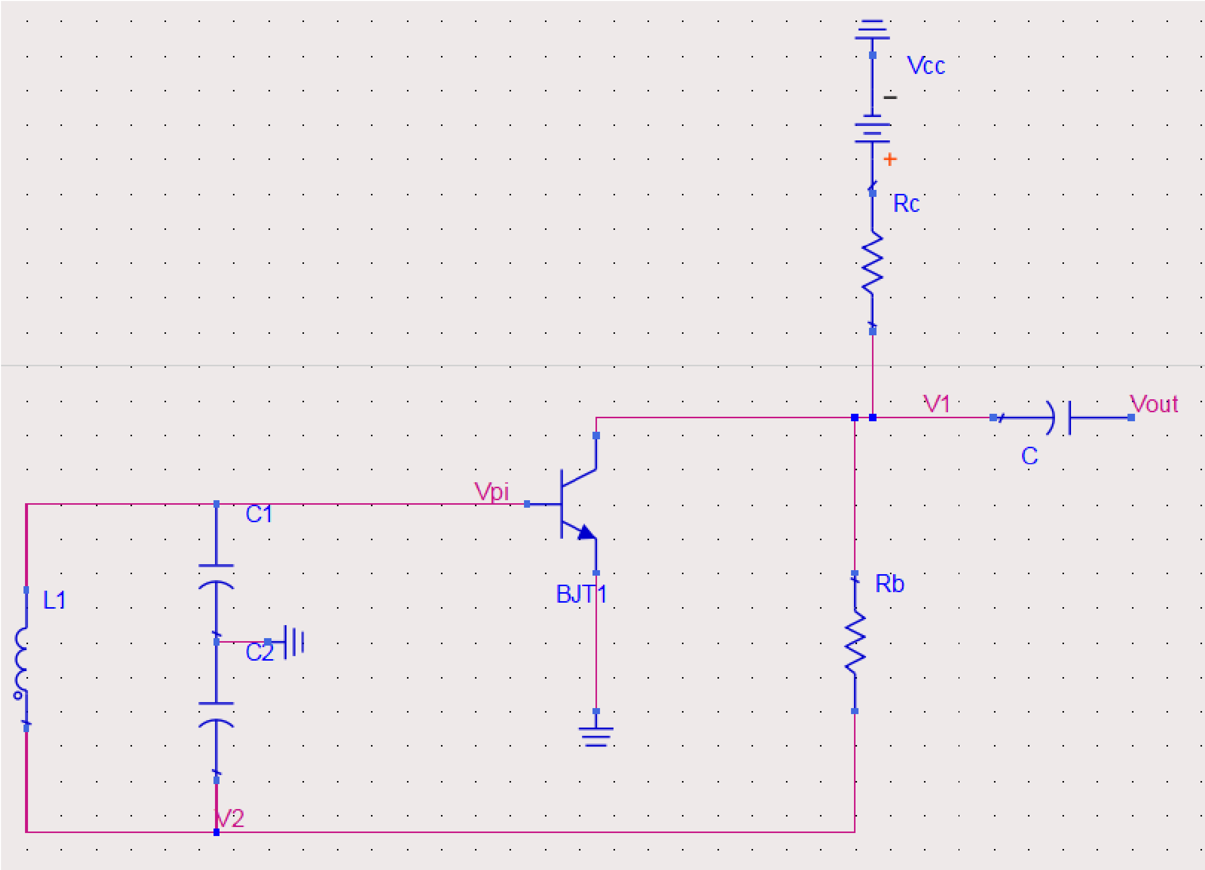


$$\frac{V_1 - V_{cc}}{R_C} + g_m . V_\pi + \frac{V_1 - V_2}{R_B} = 0$$

$$\frac{V_\pi}{r_\pi} + V_\pi . C_1 . s + \frac{V_\pi - V_2}{L.s} = 0$$

$$V_2 . C_2 . s + \frac{V_2 - V_1}{R_B} + \frac{V_2 - V_\pi}{L.s} = 0$$

$$\begin{bmatrix} \frac{1}{R_B} + \frac{1}{R_C} & -\frac{1}{R_B} & g_m \\ 0 & -\frac{1}{L.s} & \frac{1}{r_\pi} + C_1 . s + \frac{1}{L.s} \\ -\frac{1}{R_B} & C_2 . s + \frac{1}{R_B} + \frac{1}{L.s} & -\frac{1}{L.s} \end{bmatrix} . \begin{bmatrix} V_1 \\ V_2 \\ V_\pi \end{bmatrix} = \begin{bmatrix} \frac{V_{cc}}{R_C} \\ 0 \\ 0 \end{bmatrix}$$

$$\det\left(\begin{bmatrix} \frac{1}{R_B} + \frac{1}{R_C} & -\frac{1}{R_B} & g_m \\ 0 & -\frac{1}{L.s} & \frac{1}{r_\pi} + C_1 . s + \frac{1}{L.s} \\ -\frac{1}{R_B} & C_2 . s + \frac{1}{R_B} + \frac{1}{L.s} & -\frac{1}{L.s} \end{bmatrix}\right) = 0$$

$$\left(\frac{1}{R_B}+\frac{1}{R_C}\right).\left[\left(\frac{1}{L.s}\right)^2-\left(\frac{1}{r_\pi}+C_1.s+\frac{1}{L.s}\right).\left(C_2.s+\frac{1}{R_B}+\frac{1}{L.s}\right)\right]$$
$$+\left(-\frac{1}{R_B}\right).[\left(-\frac{1}{R_B}\right)\left(\frac{1}{r_\pi}+C_1.s+\frac{1}{L.s}\right)+\left(\frac{1}{L.s}\right).g_m=0$$

$$\left[\frac{C_2}{R_C.r_\pi}+\frac{C_1}{R_C.R_B}+\frac{C_2}{R_B.r_\pi}\right].s+\left[\frac{1}{R_C.r_\pi.L}+\frac{1}{R_C.R_B.L}+\frac{1}{R_B.r_\pi.L}+\frac{g_m}{L.R_B}\right].\frac{1}{s}$$
$$+\left[\frac{C_1.C_2}{R_C}+\frac{C_1.C_2}{R_B}\right].s^2+\left[\frac{C_1+C_2}{R_C.L}+\frac{1}{R_C.R_B.r_\pi}+\frac{C_1+C_2}{R_B.L}\right]=0$$

$$\left[\frac{C_2}{R_C.r_\pi}+\frac{C_1}{R_C.R_B}+\frac{C_2}{R_B.r_\pi}\right](j.w)+\left[\frac{1}{R_C.r_\pi.L}+\frac{1}{R_C.R_B.L}+\frac{1}{R_B.r_\pi.L}+\frac{g_m}{L.R_B}\right].\left(\frac{1}{j.w}\right)=0$$

$$-w^2.\left[\frac{C_2}{R_C.r_\pi}+\frac{C_1}{R_C.R_B}+\frac{C_2}{R_B.r_\pi}\right]+\left[\frac{1}{R_C.r_\pi.L}+\frac{1}{R_C.R_B.L}+\frac{1}{R_B.r_\pi.L}+\frac{g_m}{L.R_B}\right]=0$$

$$w^2=\frac{(\beta+1).R_C+R_B+r_\pi}{L.(C_1.R_B+C_2.(R_C+r_\pi)}$$

$$w^2\cong\frac{(\beta+1).R_C}{L.(C_1.R_B+C_2.(R_C)}=\frac{(\beta+1).\frac{R_C}{R_B}}{L.\left(C_1+C_2.\left(\frac{R_C}{R_B}\right)\right)}\cong\frac{(\beta+1)}{L.C_2}$$

$$C_2.\frac{R_C}{R_B}\gg C_1\quad\rightarrow\quad R_C>R_B$$

$$-w^2.\left[\frac{C_1.C_2}{R_C}+\frac{C_1.C_2}{R_B}\right]+\left[\frac{C_1+C_2}{R_C.L}+\frac{1}{R_C.R_B.r_\pi}+\frac{C_1+C_2}{R_B.L}\right]=0$$

$$w^2=\frac{1}{C_T.L}+\frac{1}{C_1.C_2.r_\pi.(R_C+R_B)}$$

$$\frac{1}{C_1.C_2.r_\pi.(R_C+R_B)}\ll\frac{1}{C_T.L}$$

$$\frac{1}{r_\pi.(R_C+R_B)}\ll\frac{(C_1+C_2)}{L}\sim\frac{10^{-12}}{10^{-6}}=10^{-6}$$

$$r_\pi.(R_C+R_B)\gg10^6$$

$$r_\pi.(R_C+R_B)\sim10^8$$

$$r_\pi\sim10^3$$

$$(R_C+R_B)\sim10^5$$

$$C_T = \frac{C_1 . C_2}{C_1 + C_2}$$

$$w \cong \frac{1}{\sqrt{C_T . L}}$$

$$L = 1\mu H$$

$$f = 187\ MHz$$

$$w = 2\pi . f\ , L\ \rightarrow C_T = 0.72436\ pF$$

$$n = 0.04$$

$$C_2 = 18.109\ pF$$

$$C_1 = 0.7545\ pF$$

$$w^{\,2} = \frac{(\beta + 1) . R_C + R_B + r_\pi}{L . (C_2 \, . R_B + C_1 \, . (R_C + r_\pi)} = \frac{1}{C_T . L} = 2\pi . f = 1.380520785 \times 10^{18}$$

Assume : $I_c = 100\ \mu A$

$$r_\pi = \frac{\beta . V_T}{I_C} = 26\ K\Omega$$

$$I_c = I_s . \left(e^{\frac{V_{BE}}{n . V_T}} - 1 \right) \rightarrow V_{BE} = 0.718\ V$$

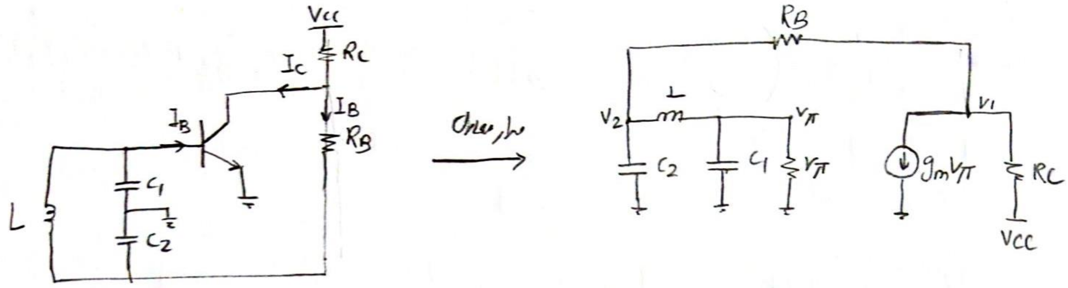
DC analysis:

V_{cc} = 12v

Vc = 0.728 v

$$V_{cc} = 12\ V\ , V_C = 0.728V \rightarrow R_B = 10\ K\Omega \rightarrow R_C = 111\ K\Omega$$

$$\frac{(\beta + 1) . R_C + R_B + r_\pi}{L . (C_2 \, . R_B + C_1 \, . (R_C + r_\pi)} = 5.299 \times 10^{18} \cong 1.38 \times 10^{18}$$



$$\text{KCL @}V_1: \quad \frac{V_1 - V_{cc}}{R_C} + g_m V_\pi + \frac{V_1 - V_2}{R_B} = 0$$

$$\text{KCL @}V_\pi: \quad \frac{V_\pi}{r_\pi} + V_\pi C_1 S + \frac{V_\pi - V_2}{LS} = 0$$

$$\text{KCL @}V_2: \quad V_2 C_2 S + \frac{V_2 - V_1}{R_B} + \frac{V_2 - V_\pi}{LS} = 0$$

$$\left(\frac{1}{R_C} + \frac{1}{R_B}\right) V_1 + \left(-\frac{1}{R_B}\right) V_2 + g_m V_\pi = \frac{V_{cc}}{R_C}$$

$$0 \quad V_1 + \left(-\frac{1}{LS}\right) V_2 + \left(\frac{1}{r_\pi} + C_1 S + \frac{1}{LS}\right) V_\pi = 0$$

$$\left(-\frac{1}{R_B}\right) V_1 + \left(C_2 S + \frac{1}{R_B} + \frac{1}{LS}\right) V_2 + \left(-\frac{1}{LS}\right) V_\pi = 0$$

$$\underbrace{\begin{bmatrix} \frac{1}{R_B} + \frac{1}{R_C} & -\frac{1}{R_B} & g_m \\ 0 & -\frac{1}{LS} & \frac{1}{r_\pi} + C_1 S + \frac{1}{LS} \\ -\frac{1}{R_B} & C_2 S + \frac{1}{R_B} + \frac{1}{LS} & -\frac{1}{LS} \end{bmatrix}}_{Y} \underbrace{\begin{bmatrix} V_1 \\ V_2 \\ V_\pi \end{bmatrix}}_{V} = \underbrace{\begin{bmatrix} \frac{V_{cc}}{R_C} \\ 0 \\ 0 \end{bmatrix}}_{I_S}$$

$$\det(Y) = 0$$

$$\left(\frac{1}{R_B} + \frac{1}{R_C}\right)\left[\left(\frac{1}{LS}\right)^2 - \left(\frac{1}{r_\pi} + \frac{1}{LS} + C_1 S\right)\left(C_2 S + \frac{1}{R_B} + \frac{1}{LS}\right)\right] + \left(-\frac{1}{R_B}\right)\left[\left(\frac{-1}{R_B}\right)\left(\frac{1}{r_\pi} + \frac{1}{LS} + C_1 S\right) + \frac{g_m}{LS}\right] = 0$$

$$\left(\frac{1}{R_B}+\frac{1}{R_C}\right)\underbrace{\left[\frac{1}{(LS)^2}-\left(\frac{C_2S}{r_\pi}+\frac{1}{r_\pi R_B}+\frac{1}{r_\pi LS}+\frac{C_2}{L}+\frac{1}{R_BLS}+\frac{1}{(LS)^2}+C_1C_2S^2+\frac{C_1S}{R_B}+\frac{C_1}{L}\right]\right.}_{\to K}$$

$$-\frac{1}{R_B}\left[-\frac{1}{R_Br_\pi}-\frac{1}{R_BLS}-\frac{C_1S}{R_B}+\frac{g_m}{LS}\right]=0$$

$$\left(\frac{1}{R_B}\right)(K)+\frac{1}{R_C}(K)+\frac{1}{R_B}\left[\frac{1}{R_Br_\pi}+\frac{1}{R_BLS}+\frac{C_1S}{R_B}-\frac{g_m}{LS}\right]=0$$

$$\left(\frac{1}{R_B}\right)\left[-\frac{C_2S}{r_\pi}-\frac{1}{r_\pi R_B}-\frac{1}{r_\pi LS}-\frac{C_1+C_2}{L}-\frac{1}{R_BLS}-C_1C_2S^2-\frac{C_1S}{R_B}+\frac{1}{R_Br_\pi}+\frac{1}{R_BLS}+\frac{C_1S}{R_B}-\frac{g_m}{LS}\right]$$

$$+\frac{1}{R_C}(K)=0$$

$$-\frac{1}{R_B}\left[\frac{C_2S}{r_\pi}+\frac{1}{r_\pi LS}+\frac{C_1+C_2}{L}+C_1C_2S^2+\frac{g_m}{LS}\right]-\frac{1}{R_C}(-K)=0$$

$$\frac{C_2}{r_\pi R_B}S+\frac{1}{r_\pi R_BLS}+\frac{C_1+C_2}{R_BL}+\frac{C_1C_2}{R_B}S^2+\frac{g_m}{LR_BS}+\frac{C_2S}{r_\pi R_C}+\frac{1}{r_\pi R_BR_C}+\frac{1}{r_\pi R_CLS}+\frac{C_1+C_2}{LR_C}$$

$$+\frac{1}{R_CR_BLS}+\frac{C_1C_2S^2}{R_BR_C}+\frac{C_1S}{R_BR_C}=0$$

$$\left[\frac{C_2}{R_Cr_\pi}+\frac{C_1}{R_BR_C}+\frac{C_2}{R_Br_\pi}\right]S+\left[\frac{1}{r_\pi R_CL}+\frac{1}{R_BR_CL}+\frac{1}{R_Br_\pi L}+\frac{g_m}{LR_B}\right]\frac{1}{S}$$

$$\left[\frac{C_1C_2}{R_C}+\frac{C_1C_2}{R_B}\right]S^2+\left[\frac{C_1+C_2}{R_CL}+\frac{1}{r_\pi R_BR_C}+\frac{C_1+C_2}{LR_B}\right]=0$$

$$F=AS+\frac{B}{S}+CS^2+D=0\quad\to\quad S=jw$$

$$F=Ajw+\frac{B}{jw}+(-w^2)C+D=0$$

$$F=j\left(Aw-\frac{B}{w}\right)+\left(D-w^2C\right)=0$$

$$F=0 \longrightarrow A\omega - \frac{B}{\omega} = 0 \rightarrow B = A\omega^2 \qquad \omega^2 = \frac{B}{A} \quad (\mathrm{I})$$

$$\hookrightarrow D - \omega^2 C = 0 \qquad D = C\omega^2 \qquad \omega^2 = \frac{D}{C} \quad (\mathrm{II})$$

$$(\mathrm{I}) : \omega^2 = \frac{\frac{1}{r_\pi R_C L} + \frac{1}{R_B R_C L} + \frac{1}{R_B r_\pi L} + \frac{g_m}{L R_B}}{\frac{C_2}{R_C r_\pi} + \frac{C_1}{R_B R_C} + \frac{C_2}{R_B r_\pi}} = \xrightarrow{\times\, r_\pi R_C R_B L}$$

$$* \quad \omega^2 = \frac{R_B + r_\pi + R_C + R_C \overbrace{g_m r_\pi}^{B}}{C_1 R_B L + C_2 r_\pi L + C_2 R_C L} = \frac{R_B + r_\pi + (B+1) R_C}{L\left(C_2(R_C + r_\pi) + C_1 R_B\right)}$$

$$(\mathrm{II}) : \omega^2 = \frac{\frac{C_1 + C_2}{R_C L} + \frac{1}{r_\pi R_B R_C} + \frac{C_1 + C_2}{L R_B}}{\frac{C_1 C_2}{R_C} + \frac{C_1 C_2}{R_B}} \quad \underline{\times\, R_C R_B L}$$

$$\omega^2 = \frac{(C_1 + C_2) R_B + (C_1 + C_2) R_C + \frac{L}{r_\pi}}{L\,(C_1 C_2 R_B + C_1 C_2 R_C)} = \frac{(C_1 + C_2)(R_B + R_C) + \frac{L}{r_\pi}}{L C_1 C_2 (R_B + R_C)}$$

$$\omega^2 = \frac{(C_1 + C_2)(R_B + R_C)}{L C_1 C_2 (R_B + R_C)} + \frac{1}{r_\pi C_1 C_2 (R_B + R_C)}$$

$$\omega^2 = \frac{1}{L \frac{C_1 C_2}{C_1 + C_2}} + \frac{1}{r_\pi C_1 C_2 (R_B + R_C)} = \frac{1}{L C_T} + \Delta$$

$$\text{if } \Delta \ll \frac{1}{L C_T} \rightarrow \omega^2 \simeq \frac{1}{L C_T} \rightarrow f = \frac{1}{2\pi \sqrt{L C_T}} \qquad C_T = \frac{C_1 C_2}{C_1 + C_2}$$

Small: Δ

$$\Delta = \frac{1}{C_1 C_2\, r_\pi (R_C + R_B)} \ll \frac{1}{L \frac{C_1 C_2}{C_1 + C_2}}$$

$$\frac{1}{r_\pi (R_C + R_B)} \ll \frac{C_1 + C_2}{L} \sim \frac{10^{-12}}{10^{-6}} = 10^{-6}$$

$$r_\pi (R_B + R_C) \gg 10^6 \rightarrow r_\pi (R_B + R_C) \sim 10^8$$

$$r_\pi \sim 10^3 \quad , R_B + R_C \sim 10^5$$

$$*: \quad w^2 = \frac{R_B + r_\pi + (B+1)R_C}{L(C_2(R_C + r_\pi) + C_1 R_B)} \simeq \frac{(B+1) R_C}{L(C_2 R_C + C_1 R_B)}$$

$$\frac{(\beta+1)R_C}{L(C_2 R_C + C_1 R_B)} \sim \frac{10^2 R_C}{10^{-6} \times 10^{-12}(C_2 R_C + C_1 R_B)} = \frac{10^{20} R_C}{C_1 R_B + C_2 R_C} \sim 10^{18}$$

$$f = 187\,M$$

$$\frac{10^{20} R_C / R_B}{C_1 + C_2 \frac{R_C}{R_B}} \simeq \frac{10^{20}}{C_2} \rightarrow 10^2 \qquad \frac{R_C}{R_B} C_2 \gg C_1 \qquad R_C \gg R_B$$

design

$$f = 187 \times 10^6$$

$$L = 1\mu H \rightarrow C_T = \frac{1}{(2\pi f)^2 L} = 7.243643 \times 10^{-13}$$

feedback

$$n = 0.04 = \frac{C_1}{C_1 + C_2} = 0.04 \qquad \frac{C_1 C_2}{C_1 + C_2} = 7.243643 \times 10^{-3}$$

$$\rightarrow C_2 = 18.109\,PF \qquad C_1 = \frac{4}{96} C_2 = 0.7545\,PF$$

$$r_\pi = \frac{B V_T}{I_C} \quad , r_\pi \sim 10^3$$

$$r_\pi = \frac{10^2 \times 26 \times 10^{-3}}{I_C} \sim 10^3 \qquad I_C \sim \frac{10^{-1} \times 26}{10^3} = 10^{-4} \times 26 \rightarrow I_C = 100\mu A$$

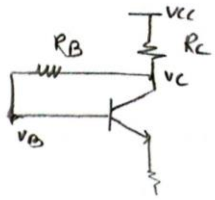
$$I_C = 100\mu A \rightarrow r_\pi = 26\,K\Omega$$

$$I_C = I_S (e^{\frac{V_{BE}}{V_T}} - 1) \qquad V_{BE} = V_T \ln\left(\frac{I_C}{I_S} + 1\right) \simeq 0.718V$$

assume: $V_C = 0.728$, $V_{CC} = 12V$ $\qquad R_C = \frac{V_{CC} - V_C}{I_E} = \frac{(12 - 0.728)}{(1.01)100\mu A} = 111.603\,k\Omega$

$$R_C \simeq 111\,k\Omega$$

$V_B = V_{BE} = 0.718$

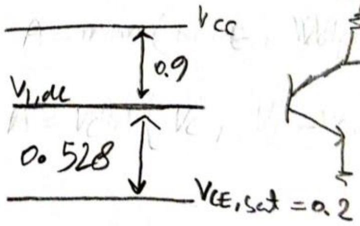


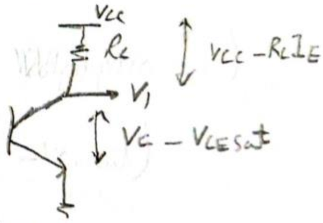
$$R_B = \frac{V_C - V_B}{I_B} = \frac{0.728 - 0.718}{1\mu A} = 10K\Omega$$

$$\left[\begin{array}{l} V_{CC} = 12V \\ R_C = 111\ K\Omega \\ R_B = 10K\ \Omega \end{array}\right.$$

$$\left[\begin{array}{l} C_1 = 0.7595PF \\ C_2 = 18.109PF \\ L = 1\mu H \end{array}\right.$$

$V_1 = V_C + A\cos wt$





$A = 0.528$

$V_1 = 0.728 + 0.528\cos wt$

$V_{out} = 0.528\cos wt = 528^{m}\cos wt$