EEE 411/511 Final Exam
13 Jan, 2005
Solutrons

Questron 1:

The VCO input voltage must be

$$1V + 3 \times \frac{143-120}{160-120} = 1 + 3 \times \frac{23}{40} = 2.725V$$

if the PLL is locked.

P.D. output ise $\frac{2.725V}{2} = 1.3625V$

The phase difference $\varphi_{in} - \varphi_{out}$ required to have 1.3625V at the P.D. output can be found from the graph.

$$-\pi + \frac{(1.3625 + 7)}{12} \times 2\pi = \pi \times [1.39375 - 1] = 0.39375\pi \text{ radian}$$

$= 1.237$ rad or
$= 70.875°$ $\Rightarrow$

$$v_o(t) = 3 \cos(2\pi \times 143000t - 70.875°)$$

Final

2

Question 2 :

a-) $\frac{f_{in}}{R} = 0.2\text{ MHz} \Rightarrow R = \frac{f_{in}}{0.2\text{ MHz}} = \frac{10\text{ MHz}}{0.2\text{ MHz}} = 50$

$\boxed{R = 50}$

b-) $\frac{800}{0.2} = \frac{f_{out}}{f_{ref}} = 4000 = M_1$

$M_1 = A \times 32 + S = 125 \times 32 + 0$

or

$= 124 \times 32 + 32$

$= \underbrace{(124-32)}_{A} 32 + \underbrace{32}_{S} \times (32+1)$

$= 92 \times 32 + 32$

$\left.\begin{array}{l} A = 92 \\ S = 32 \end{array}\right\}$ is another solution

b-) $f_o = 840\text{ MHz}$ $M_2 = \frac{840}{0.2} = 4200$

$\frac{M_1}{32} = \frac{4200}{32} = 131.25$

$4200 = 131 \times 32 + S \Rightarrow S = 8$

$4200 = \underbrace{(131 - S)}\times 32 + S \times (32+1)$

$A \times 32 + S \times 33$

$= \underbrace{123}_{A} \times 32 + \underbrace{8}_{S} \times 33$

Question 3

Final

(3)

a-) $g_m > \frac{1}{R_T(n_1 - n_1^2)}$ $n_1 = 0.2$ $n_2 = \frac{1}{10}$

$R_T = 5000\Omega \parallel \frac{50\Omega}{n_2^2} = 5000\Omega \parallel 5000$

$= 5000 \parallel 5000 = 2500\Omega$

$g_m > \frac{1}{2500 \times (\frac{1}{5} - \frac{1}{25})} = 2.5 \times 10^{-3}$

$9 \times 10^{-3} > 2.5 \times 10^{-3}$ => oscillation condition is satisfied

b-) $V_t = 2 I_{BIAS} R (1 - n)$

$= 2 \times 10^{-3} \times \quad \times (1 - 0.2)$

$= 2 \times \cancel{10^{-3}} \cdot 2.5 \times \cancel{10^{3}} \times 0.8$

$= 4V$ peak

$V_{out} = \frac{4\,V_{peak}}{10} = 0.4\ V_{pek} = 400\ mV_{peak}$

c-) The DC voltage of the drain is

$15V - 1mA \times 5000\Omega = 10V$

The AC voltage is $4V_{peak}$

d-) To calculate the Q of the tank circuit first we must calculate the equivalent load at the specific drive level of the transistor.

$$R_{eq} = 5000 \,//\, 50 \times \frac{1}{n_2^2} \,//\, \frac{1}{G_m} \cdot \frac{1}{n_1^2}$$

$$= 5000 \,//\, 50 \times \frac{1}{0.01} \,//\, \frac{1}{G_m \times 0.04}$$

$$G_m = \frac{2 I_{BIAS}}{V_1}$$ where V_1 is the source-to-gate voltage

$$V_1 = n V_t = 4V \times 0.2 = 0.8V$$

$$G_m = \frac{2 \times 10^{-3}}{0.8} = 0.0025 \text{ mhos} \Rightarrow$$

$$R_{eq} = 2500\Omega \,//\, \frac{400\Omega}{0.04} = 2500\Omega \,//\, 10000\Omega$$

$$= 2000\Omega$$

$$Q = \frac{R_{eq}}{X_L} = \frac{R_{eq}}{X_C} \Rightarrow X_L = X_C = \frac{R_{eq}}{Q} = \frac{2000\Omega}{20} = 100\Omega$$

$$w = 6.28 \times 10^8 \text{ rad/sec}$$

$$L = \frac{X_L}{w} = 1.59 \times 10^{-7} H = 159 nH$$

$$C = \frac{1}{X_C w} = 1.59 \times 10^{-11} F = 15.9 pF$$

Questron 4

Let us first find the input & output impedances of the shunt-serres amplifrer. the input load is

$R_s = 600\,\Omega \;//\; 3600\,\Omega \;//\; 3600\,\Omega$

$600\,\Omega \;//\; 1800\,\Omega = 450\,\Omega$

$R_L = R_s$ at a shunt serres amplifrer

$\Rightarrow \quad R_3 // 600 = 450\,\Omega \Rightarrow$

$$\boxed{R_3 = 1800\,\Omega}$$

$$R_s = R_L = \frac{R_F}{1 - A_v} = 450 \Rightarrow$$

$$R_F = (1-(-3)) \times 450 = 450 \times 4 = 1800\,\Omega$$

$$\boxed{R_F = 1800\,\Omega}$$

$$R_1 = R_E - \frac{1}{g_m} \quad \text{and } R_E = \frac{R_{in}}{1 - A_v} = \frac{450}{4} = 112.5\,\Omega$$

$$R_1 = 112.5 - \frac{1}{g_m} = 112.5 - 66.\overline{66} = 45.83\,\Omega$$

$$\boxed{R_1 = 45.83\,\Omega}$$

$$\boxed{R_2 = 8000 - R_1 = 7954\,\Omega \approx 8000\,\Omega}$$

Final

6

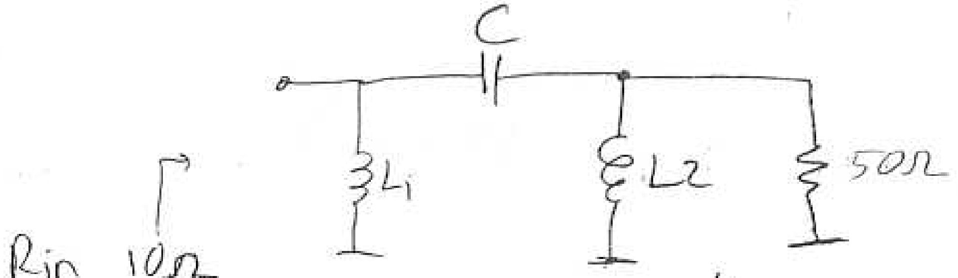
Question 5

a-) The impedance that the transistor must see at the fundamental component of the current is given by

$$R = \frac{10V}{1A} = 10\Omega$$

if the amplifier should operate with maximum efficiency at the maximum output.

The π-match circuit composed of the inductor and the capacitor, also acts as the tuned circuit to provide only the fundamental current & voltage.



$$K = \frac{R_{in}}{R_L} = \frac{10}{50} = 0.2$$

$$Q_R = \frac{\left[Q^2K + 2K - K^2 - 1\right]^{1/2} - Q}{K-1} = 7$$

$Q_L = 10 - 7 = 3$

$R_I\,(Q_R^2 + 1) = R_L = 50 \qquad R_I = \frac{R_L}{Q_2^2+1} = \frac{50}{1.9+1} = 1\Omega$

$Q = \frac{X_C}{R_I} \Rightarrow X_C = Q \times R_I = 20 \times 1 = 10\Omega$

$w = 2\pi f = 2\pi \times 2\times10^8 = 1.2566\times$ rad/sec $\Rightarrow$

Final

7

$$C = \frac{1}{X_C \omega} = 7.9577 \times 10^{-11} F = 79.58 pF$$

$$Q_R = \frac{R_L}{X_{L_R}} \Rightarrow X_{L_2} = \frac{R_L}{Q_R} = \frac{50}{7} = 7.1429$$

$$L_2 = \frac{X_{L_2}}{\omega} = \frac{7.1429}{1.2566 \times 10^9} = 5.684 \times 10^{-9} H = 5.684 nH$$

$$Q_L = \frac{R_{in}}{X_{L_1}} = \frac{10}{X_{L_1}} \Rightarrow X_{L_1} = \frac{10}{Q_L} = \frac{10}{3} = 3.33 \Omega$$

$$L_1 = \frac{X_{L_1}}{\omega} = \frac{3.33 \Omega}{1.2516 \times 10^9} = 2.6526 \times 10^{-9} H = 2.653 nH$$

b-) Max o/p power $= \frac{V_p I_p}{2} = \frac{10V \times 1A}{2} = 5$ Watts