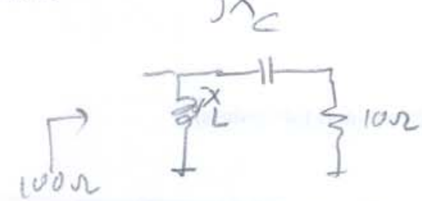
EE411/511 Final exam
Solutions

06/01/2009

(1)

a-)



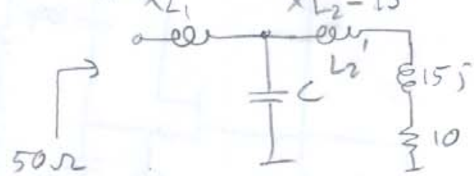
$$Q^2+1 = \frac{100}{10} = 10 \Rightarrow Q = 3$$

$$X_C = 3 \times 10 = 30\,\Omega$$

$$X_L = \frac{100}{Q} = \frac{100}{3} = 33.3\,\Omega$$

b-)

i-) T-Match



$$\frac{R_L}{R_{in}} = K = \frac{10}{50} = 0.2 \qquad Q = 5$$

$$Q_R = \frac{[Q^2K + 2K - K^2 - 1]^{1/2} - Q}{K-1} = \frac{[25\times0.2 + 0.2\times2 - 0.04 - 1]^{1/2} - 5}{0.2-1}$$

$$= 3.6399 \approx 3.64$$

$$Q_L = 1.36$$

$$X_{L_2} = Q_R \times 10\,\Omega = 36.4 \Rightarrow X_{L_2} - 15 = 21.4\,\Omega \quad Z_{L_2}' = 21.4j$$

$$X_{L_1} = 50 \times Q_L = 50 \times 1.36\,\Omega = 68\,\Omega$$

$$R_I = 10\,\Omega \times (Q_R^2+1) = 10 \times 14.25 = 142.5\,\Omega$$

$$X_C = \frac{142.5}{Q} = 28.5\,\Omega$$

ii-) π-match: Convert the load into parallel:

$$Q = \frac{15}{10} = 1.5 \quad R_p = (Q^2+1)10\,\Omega = 32.5\,\Omega \quad X_{Lp} = X_{Ls}\frac{Q^2+1}{Q^2} = 15 \times \frac{3.25}{2.25} = 21.\overline{6}$$

$$K = \frac{R_{in}}{R_L} = \frac{50}{32.5} = \quad \Rightarrow Q_R = 2.19, \; Q_L = 2.81$$

$$\Rightarrow \frac{R_{Lp}}{X_{L_2}} = Q_R \Rightarrow X_{L_2} = \frac{R_{Lp}}{Q_R} = \frac{32.5}{2.19} = 14.85\,\Omega$$

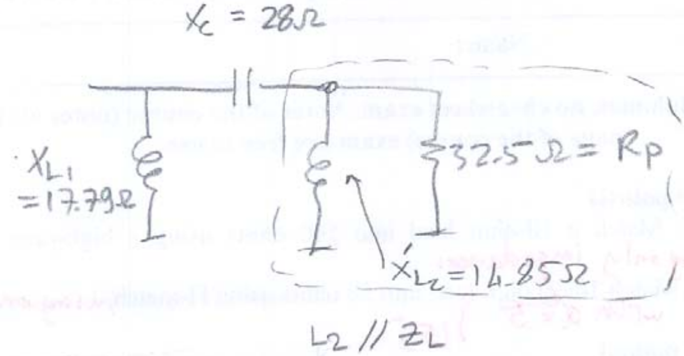
$$\frac{R_{in}}{X_{L_1}} = Q_L \Rightarrow X_{L_1} = \frac{R_{in}}{Q_L} = \frac{50}{2.81} = 17.79\,\Omega$$

$$R_I = \frac{R_{Lp}}{Q_R^2+1} = \frac{32.5}{2.19^2+1} = 5.61\,\Omega \Rightarrow X_C = Q\,R_I = 5 \times 5.61 = 28\,\Omega$$

06/01/2007

(2)

Q-1 continued

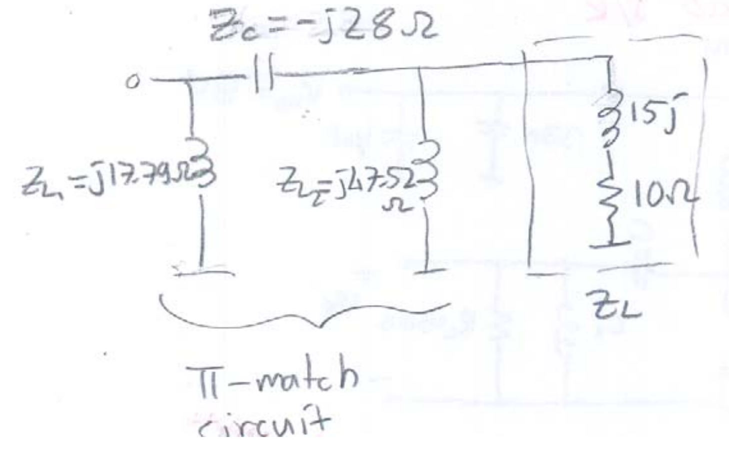


$X_{Lp} = 21.6\,\Omega$

$X_{L_2} \,//\, X_{Lp} = X'_{L_2} = 14.85\,\Omega \Rightarrow$

$$X_{L_2} = \frac{14.85 \times 21.6}{21.6 - 14.85} = 47.52 \Rightarrow$$

The matching circuit become



06/01/2007

(3)

Q-2

a-) $FKT_0B = 9.6\times10^{-13}$ watts $= -120.2\,dBW = -90.2\,dBm$

S/N required $= 8\,dB \Rightarrow S_{req} = -90.2 + 8 = -82.2\,dBm$

$= 6\times10^{-12}\,W$

$= 6\times10^{-9}\,mW$

b-) $IP3_{i/p} = -2\times IP3 + 3\times S_{in}$

The interfering signal is $IP3_{i/p}$

$IP3_{i/p} = -2\times25 + (-3\times3) = -59\,dBm$

$\Rightarrow$ The required signal level is $-59\,dBm + 8\,dB$

$= -51\,dBm$

Q-3)

a-) $I_{max} = 1A \Rightarrow I_{peak} = \frac{1A}{2} = 0.5A$

$V_P = 8 - V_{sat} = 7V$

$R_{opt} = \frac{7V}{0.5A} = 14\,\Omega$

$R_L = 50\,\Omega$ $\quad R_{in} = 14\,\Omega$ $\quad K = \frac{R_{in}}{R_L} = \frac{14}{50} = 0.28$

$$Q_R = \frac{[Q^2K + 2K - K^2 - 1]^{1/2} - Q}{K-1} = 6.61$$

$Q_L = 3.39$

$R_I = \frac{R_L}{Q_R^2+1} = \frac{50}{6.61^2+1} = 1.1188\,\Omega$

$X_C = Q\times R_I = 10\times1.1188 = 11.188\,\Omega$ $\quad C = 142\,pF$

$X_{L_2} = \frac{50}{Q_R} = 7.564\,\Omega$ $\quad L_2 = 12.18\,nH$

$X_{L_1} = \frac{14}{Q_L} = 4.13\,\Omega$ $\quad L_1 = 6.57\,nH$

b-) $\eta = \frac{7V\times0.5A/2}{8V\times0.5A} = \frac{7}{16} = 0.4375$

Solutrons

Q 4

a-) $g_m > \frac{1}{R(n-1)n}$

$R_L' = 50 \times 4^2 = 800\Omega \Rightarrow R = 800 // 800 = 400\Omega$

$n = \frac{1}{4}$

$g_m > \frac{1}{400 \times 0.25 \times 0.75} = 0.01\bar{3}$ S

b-) $8dBm = 6.3mW = \frac{V_p^2}{2 \times 50} \Rightarrow V_p^2 = 6.3 \times 10^{-3} \times 10^{-2} = 0.63$

$V_p = 0.795V$ since here $n = 0.25$

$V_{tank} = \frac{0.795}{0.25} = 3.177 V_p$

$V_{tank} = 3.177 = 2 I_{BIAS} R(1-n)$

$3.177 = 2 \times I_{BIAS} 400 \times 0.75$

$I_{BIAS} = \frac{3.177}{2 \times 400 \times 0.75} = 0.00529A = 5.3mA$

Q-5-) $\frac{8GHz}{6} = 1.33GHz > 500MHz$

$\frac{8GHz}{16} = 500MHz = 500MHz$

barely divides $\Rightarrow$ choose 16/17

$f_{ref} = 2MHz \Rightarrow M = NP + A = \frac{6500}{2} = 3250$

$3250 = NP + A \quad P = 16$

$\frac{3250}{16} = 203.125 \Rightarrow N = 203$

$A = 3250 - NP = 3250 - 203 \times 16 = 2$

EEE411/511 Final Exam, 06 January 2007, 09.00, 150 Minutes

Student no:	Name:

This is a no cellphones, no cheatsheet closed-book exam. Notes of the course (notes at the web page of the course) exam are free to use.

Question 1) (20 points)

a) (10 points) Match a 10-ohm load into 100 ohms using a high-pass L-match circuit using only impedances,

b) (10 points) Match 10+15j ohm load into 50 ohms using Π-match with Q=5 using only impedances.

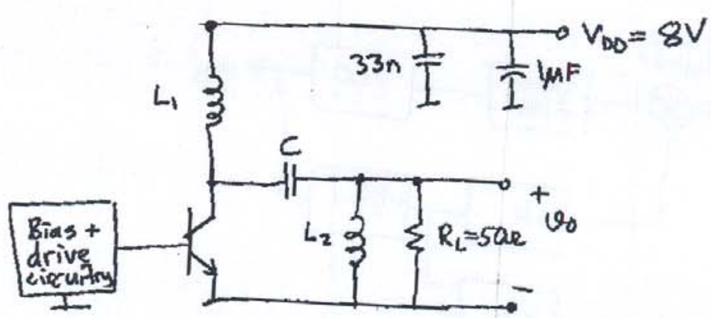
Question 2) (22 points)

An amplifier with the following parameters is given. The parameters are; BW=30 MHz, Noise Figure = 9 dB, IIP3 = 25 dB (Input referred third order intercept point), please answer the following questions:

a) (10 points) What should be the input signal level in order that the S/N at the output of the amplifier is 8 dB,

b) (12 points) A signal along with two unwanted high level signals is applied to the input of the amplifier. The unwanted signals are Δf and 2Δf Hertz away from the signal and their amplitudes are -3dBm's. What should be level of the input signal in order to have the signal-to-interference level equal to 8 dB again (Please note that the intermodulation product of the unwanted signals act as interference on the signal). Note that Boltzmann's constant $K=1.38\times10^{-23}$.

Question 3) (22 points)

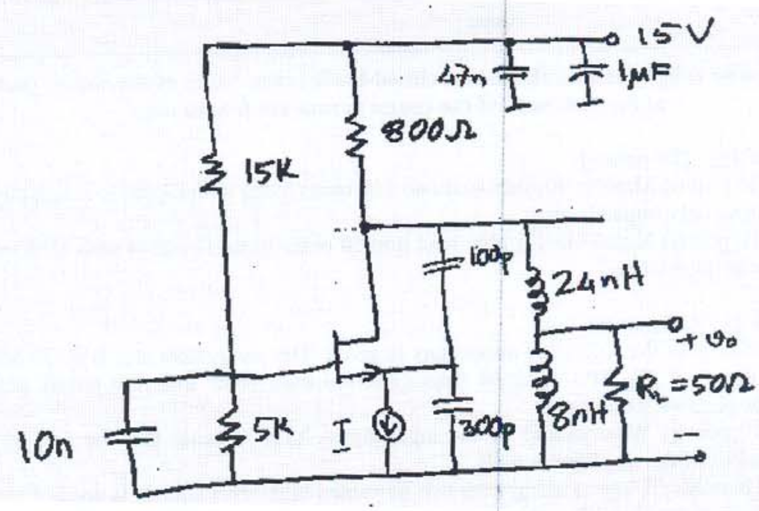


The circuit given above is operated as a class A amplifier at 100 MHz. In this circuit, V_{CESAT} = 1 Volts and I_{max} = 1 amps. Please carry out the following:

a) (12 points) Match the load resistor R_L to obtain maximum power transfer to it by calculating the values of L1, L2 and C. The Q of the match must be 10,

b) (10 points) Find the efficiency of the amplifier when delivering maximum power output to the load.

Question 4) (20 points)

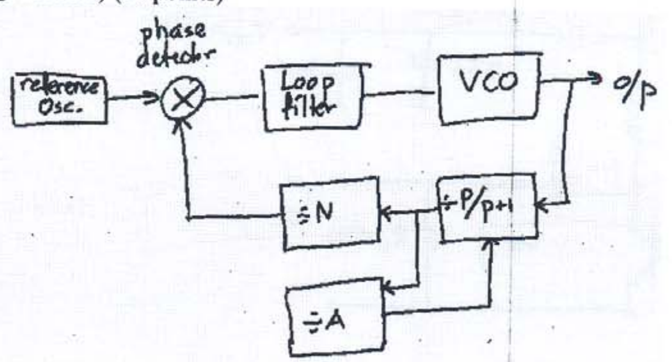


For the oscillator circuit given above (assume that DC bias is designed correctly):

a) (10 points) Find the minimum value of g_m to start oscillation,

b) (10 points) Set the source bias current I to make the power output to the load (R_L) 8 dBm.

Question 5) (16 points)



At the frequency synthesizer shown above f_{ref} = 2 MHz. The N and A dividers are guaranteed to operate up to 500 MHz. The output frequency band of the synthesizer is 6-8 GHz. There are two prescalers available for design. They are divide by 6/7 and 16/17 prescalers. Choose the right prescaler and find a pair of N and A values to operate the frequency synthesizer at 6.5 GHz.