\[ a\rightarrow \]

\[ Q^2 + 1 = \frac{100}{10} = 10 \implies Q = 3 \]

\[ X_e = 3 \times 10 = 30 \text{ \Omega} \]

\[ X_L = \frac{100}{Q} = \frac{100}{3} = 33.3 \text{ \Omega} \]

\[ X_{L2} - \frac{15}{50} \]

\[ R_L = K = \frac{10}{50} = 0.2 \quad Q = 5 \]

\[ Q_e = \frac{[Q^2 K + 2K - (K - 1)^{1/2}] - Q}{K - 1} = \frac{[25 \times 0.2 + 0.2 \times 0.04]}{0.2 - 1} = 3.6399 = 3.64 \]

\[ Q_c = 1.36 \]

\[ X_{L2} = Q_c X_L = 3.6 \times 33.3 = 120 \text{ \Omega} \implies X_{L2} = \frac{25}{15} = \frac{2.5}{15} = 2.5 \text{ \Omega} \]

\[ X_{L1} = 50 \times X_L = 50 \times 33.3 = 655 \Omega \]

\[ R_s = 10 \times (Q_e^2 + 1) = 10 \times 14.25 = 142.5 \text{ \Omega} \]

\[ X_c = \frac{142.5}{2} = 28.5 \text{ \Omega} \]

\[ b\rightarrow \]

\[ R_s = R_L = 100 \Omega \]

\[ = \]

\[ (Q - 1) \quad T\text{-Match: Convert the load into parallel:} \]

\[ Q = \frac{15}{10} = 1.5 \]

\[ R_p = (Q^2 + 1) \frac{X_L}{R_L} = \frac{32.5 \times 33.3}{100} = 21.6 \text{ \Omega} \]

\[ K = \frac{R_s}{R_L} = \frac{50}{100} = 0.5 \quad Q_c = 2.19 \quad Q_c = 2.19 \]

\[ \Rightarrow \]

\[ R_{ep} = \frac{R_s}{Q_c} = \frac{32.5}{2.19} = 14.85 \text{ \Omega} \]

\[ R_s = R_{ep} = \frac{50}{Q_c} = \frac{50}{2.19} = 22.8 \Omega \]

\[ R_s = R_{ep} = \frac{32.5}{2.19^{2} + 1} = 17.79 \text{ \Omega} \]

\[ X_{c} = 5 \times 56 = 28 \text{ \Omega} \]
\( X_c = 28 \Omega \)

\[
\begin{align*}
X_{L_1} &= \frac{17.79 \Omega}{2} \\
X_{L_2} &= \frac{14.85 \Omega}{2} \\
X_{L_p} &= 21.6 \Omega \\
X_{L_2} \parallel X_{L_p} &= X_{L_2} = 14.85 \Omega \Rightarrow \\
X_{L_2} &= \frac{14.85 \times 21.6}{21.6 - 14.85} = 47.52 \Omega \Rightarrow \\
\text{The matching circuit becomes} \\
Z_c &= -j28.52 \\
Z_L &= \frac{15}{3} + j10 \Omega
\end{align*}
\]
Q. 2

a) $E_{KTB} = 9 \times 6 \times 10^{-13}$ Watts = $-120.2$ dBm = $-92.2$ dBm

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

b) $\text{IP}_{3} = -\frac{2\text{IP}_{3} + 3\times \text{SIN}}{7}$

The interfering signal is $\text{IP}_{3}, \frac{7}{p}$

$\text{IP}_{3} = -2 \times 25 + 3 \times 3 = -59$ dBm

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

= $-51$ dBm

Q. 3

a) $I_{max} = 14 \Rightarrow I_{peak} = \frac{14}{2} = 0.5 \text{A}$

$V_{p} = 8 - V_{sat} = 7 \text{V}$

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

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

$q_{L} = \sqrt{\frac{a^{2}K + 2K - I^{2} - 1^{2}}{1 - 1}} = 6.61$

$q_{L} = 3.39$

$r_{L} = \frac{R_{L}}{q_{L}^{2} + 1} = \frac{50}{6.61^{2} + 1} = 1.188 \Omega$

$x_{L} = 0 \times r_{L} = 10 \times 1.188 = 11.88 \Omega \quad C = 142 \mu F$

$x_{L} = \frac{50}{q_{L}} = 7.50 \Omega \quad L_{2} = 12.18 \text{H}$

$x_{L} = \frac{14}{q_{L}} = 4.13 \Omega \quad L_{1} = 6.5 \text{H}$

b) $\eta = \frac{7 \times 0.5 A}{2} = \frac{7}{16} = 0.4375$
Solutions

Q 4

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

\[ R'_L = 50 \times 4^2 = 800 \Omega \Rightarrow R = \frac{800}{800} = 400 \Omega \]

\[ n = \frac{1}{4} \]

\[ 9m > \frac{1}{0.400 \times 0.25 \times 0.75} = 0.013 \] $\$

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

\[ V_p = 0.795 \text{ V} \text{ since here } n = 0.25 \]

\[ V_{tank} = \frac{0.795}{0.25} = 3.177 V_p \]

\[ V_{tank} = 3.177 = 2 \, I_{bias} \times R(1-n) \]

\[ 3.177 = 2 \times I_{bias} \times 400 \times 0.75 \]

\[ I_{bias} = \frac{3.177}{2 \times 400 \times 0.75} = 0.005294 = 5.3 \text{ mA} \]

Q 5

\[ \frac{8 \text{ GHz}}{6} = 1.333 \text{ GHz} > 500 \text{ MHz} \]

\[ \frac{8 \text{ GHz}}{16} = 500 \text{ MHz} = 500 \text{ MHz} \]

barely divides \( \Rightarrow \) choose 16/17

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

\[ 3250 = NP + A \quad P = 16 \]

\[ \frac{3250}{16} = 203.125 \Rightarrow N = 203 \]

\[ A = 3250 - NP = 3250 - 203 \times 16 = 2 \]
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 T-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=1.38×10^23 J/K.

Question 3)  (22 points)

![Circuit Diagram]

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 \( L_1 \), \( L_2 \) 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.

T. Royhan
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 $f_{off} = 2$ 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.