Question 1 (15 points) :

a) (7 points) Match R_L=50 Ω into R_{in}=5 Ω with Q=6 by using a T-match circuit and find the impedances of the components. Draw the circuit for low-pass response.

b) (8 points) Match R_L=50 – 20j Ω into R_{in}=5 Ω with Q=6 again by using a T-match circuit and find the impedances of the components. You can use a high-pass or low-pass circuit as required.

a-) $\frac{R_L = 50\,\Omega}{R_{in} = 5\,\Omega} = K = 10$

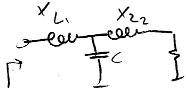
$$Q_R = \frac{[Q^2 K + 2K - K^2 - 1]^{1/2} - Q}{(K - 1}$$

$$= \frac{[36\times10 + 20 - 100 - 1]^{1/2} - 6}{9} = \frac{(360 + 20 - 100 - 1)^{1/2} - 6}{9}$$

$$= \frac{279^{1/2} - 6}{9} = 1.19 \Rightarrow |X_{L2}| = Q_R \times 50 = 1.19\times50 = 59.5\,\Omega$$

$Q_L = 6 - 1.19 = 4.81$

$Q_R = \frac{X_{L2}}{50\Omega} \Rightarrow$ $\boxed{X_{L2} = 1.19\times50 = 59.5\,\Omega}$

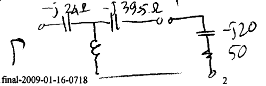


$Q_L = \frac{X_{L1}}{R_{in}} \Rightarrow$ $\boxed{X_{L1} = 4.81\times5 = 24.05\,\Omega}$

$R_p = (Q_R^2 + 1)50\Omega = 120.805$

$Q_T = 6 = \frac{R_P}{X_C} = \frac{120805}{X_C} \Rightarrow$ $\boxed{|X_C| = \frac{120.805}{6} = 20.13\,\Omega}$

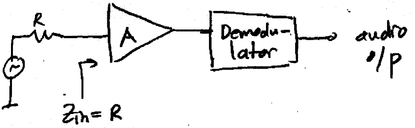
b-) Since the reactive portion negative, the configuration becomes



c-) $(F_{12}kT_0B)_{dB} = IP3 = IIP3 - 3(IIP3 - S_{in}) = 3S_{in} - 2IIP3$

$\frac{(F_{12}kT_0B)_{dB} + 2\,IIP3}{3} = S_{in} = \frac{-126.8 + 2\times 20}{3} = -28.9\,dBm$

Question 2 (25 points) :



The circuit shown above is constructed with an amplifier with G=9dB, F=4dB and IIP3=20dBm. The noise figure of the demodulator is 10dB.The amplifier presents matched load to the source. The noise bandwith of the modulator is 50 kHz and it requires at least 12 dB S/N at its input to function properly.

a) (10 points) What is the noise temperature ~~of the system,~~ — in dBm
b) (5 points) Find the signal level s(t) to let the demodulator function properly,
c) (10 points) If there are two equal-amplitude unwanted interfering signals at the input such that their third -order intermodulation product falls into the receiver bandwith, what is their signal level which decreases the S/N at the input of the demodulator by 3dB?

a-) $G = 8$ times, $F_1 = 2.51$ times $F_2 = 10$ times

$F_{1,2} = 2.5 + \frac{10-1}{8} = 2.5 + \frac{9}{8} = 3.625$

$T = (F-1)\,300\,K = (3.625 - 1)\times 300 = 787.5\,K$

b-)* $kTBF\left(\frac{S}{N}\right) = 1.38\times10^{-23}\times300\times50\times10^{3}\times16$

$= 3.312\times10^{-15}\,W = 3.312\times10^{-12}$ dB mWatts

$= -114.8$ dBm

c-) −114.8 dBm is 12 dB above ... level ⟹

noise level = $-114.8 + 12 = -126.8$ dBm

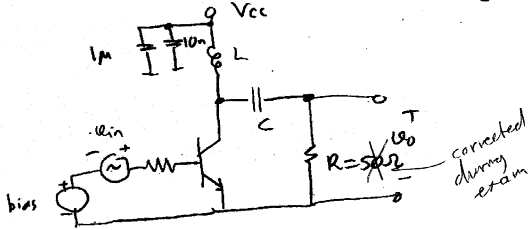
to increase noise + interference by 3dB ⟹
interference level = −126.8 dBm = level of 3rd order
int-products referred to the input.

$20 - \frac{(20-(-126.8))}{3}$ = int. signal level = −28.93 dBm ≅ −29 dBm

b-)* $kT_0B = 2\times10^{-16}$ Watts = 3dB − 160dBW = −157dB dBW = −127dBm

$F_{12}kT_0B = 3.65\times2\times10^{-16} = 7.3\times10^{-16}\,W = -151.2\,dBW = -121.2\,dBm$

Question 3 (20 points) :



A power amplifier as shown above is operated at 100 MHz. It is driven to function in class-B mode. The transistor T_1 can handle 2A and 20V as maximum current and voltage respectively without being damaged.

a) (10 points) Find the values of V_{cc}, C and L in orded to get the maximum power output from this amplifier,

b) (5 points) Find the maximum output power,

c) (5 points) Find the average current drawn from the power supply at the maximum output level.

a-) $R_{op} = \frac{V_{max}}{I_{max}} = \frac{20V}{2V} = 10\Omega \Rightarrow$ Match 5Ω into 10Ω

$2 = \frac{10\Omega}{5\Omega} = 1 + Q^2 = 1 + 1^2 \Rightarrow Q = 1$

$|X_C| = Q \times R_L = 5\Omega \Rightarrow C = \frac{1}{wX_C} = 3.18\times10^{-10}F = 318pF$

$Q = \frac{R}{|X_L|} = \frac{10}{|X_L|} \Rightarrow |X_L| = \frac{10}{1} = 10\Omega$

$L = \frac{X_L}{w} = 1.59\times10^{-8} = 15.9nH$

$V_{cc} = \frac{V_{max}}{2} = 10V$

b-) $P_{out} = \frac{V_P I_P}{2} = \frac{10V \times 1A}{2} = 5W$

V_P, fundamental $I_P = \frac{I_{RF}}{2}$

or at the o/p $\frac{\frac{10V}{\sqrt{2}} \sqrt{2}\,1A}{2} = 5W$

c-) $I_{av} = \frac{1}{T}\int_0^T I(t)dt = \frac{1}{T}\int_0^{T/2} I_{RF} \sin\frac{2\pi}{T}t\,dt = \frac{I_{RF}}{\pi} = \frac{2A}{\pi} = 0.636A$

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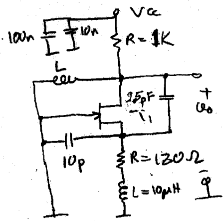
Question 4 (20 points) :



L = 10µH is too large
sınavda söylendi.

An oscillator as shown above is constructed. Please answer the following:

a) (7 points) Find the minimum transconductance of the transistor to start the oscillation,
b) (6 points) Find the value of L to have the oscillation at 70 MHz,
c) (7 points) Find the source current of the transistor T1 in order to have 2Vp-p output voltage

a-) $g_m > \dfrac{1}{R\,n\,(1-n)} = \dfrac{1}{1000 \times 0.2 \times 0.8} = 0.00625$ mhoes

b-) $C_{eq} = \dfrac{10 \times 2.5}{12.5} = 2p \qquad L = \dfrac{1}{w^2 C} = \dfrac{1}{(2\pi\, 70 \times 10^6)^2 \times 2 \times 10^{-12}}$
$= 2.58 \times 10^{-6} = 2.58\,\mu H$

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

$I_{BIAS} = \dfrac{1}{2 \times 1000 \times 0.8} = 6.25 \times 10^{-4} A = 0.625\, mA$

$4.398K \approx 4.4K\hat{j} = X_{L_s}$

$10\mu H \rightarrow X_L = 10 \times 10^{-6} \times w =$

$R_s = 120\Omega \quad \rightarrow Q = \frac{4400}{120} = 36.65$

$R_p = (Q^2+1) R_s = 1344 \times 120 = 161323\,\Omega$

$X_p = \frac{4.4 \times 1344}{1343} \cong 4.4 K\hat{j}$

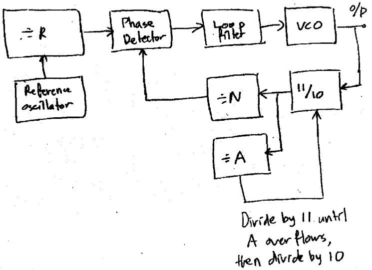
$L_p \cong 10\mu H$

$\Rightarrow R_p$ is negligable even before it is divided by n^2

R_p over the tank $= \frac{161323\,\Omega}{0.2^2} = 4M\Omega$

$\frac{L_p}{n^2} = \frac{10\mu H}{0.2^2} = 10\mu H \times 25 = 250\mu H$

Question 5 (20 points) :



The block diagram of a PLL circuit is given above. The reference oscillator frequency is 10 MHz. The operating frequency range of the PLL is 500-600 MHz. The channel spacing is 100kHz. Maximum possible phase detector frequency is used in the system.

a. (5 points) Find the value of R,
b. (10 points) Find the minimum value of the register A and the ~~maximum~~ minimum value of the register N in order to be able to generate all the frequencies in the range given above.
c. (5 points) Find a set of values of N and A for generating an output frequency of 555.5 MHz within the constraints of step (b).

a-) $R = 100 = \frac{10\,MHz}{0.1\,MHz}$

b-) $M = NP + A$ where $P = 10$ and $A < N$

$A_{min} = 9$ is needed to cover the intermediate frequences when N is increased by one.

M for $100\,MHz$ is 6000

$6000 = N \times 10 + 0 \Rightarrow N = \frac{6000}{10} = 600$

c-) $5555 = NP + A \Rightarrow A = 5,\ N = 555$