ERM 5500 – RF & Microwave Design

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Tutorial Sheet

1. For the receiver in Fig. 1, calculate:
   (a) The noise figure of the system.
   (b) The overall gain of the system.
   (c) The minimum detectable signal at the input of the system.

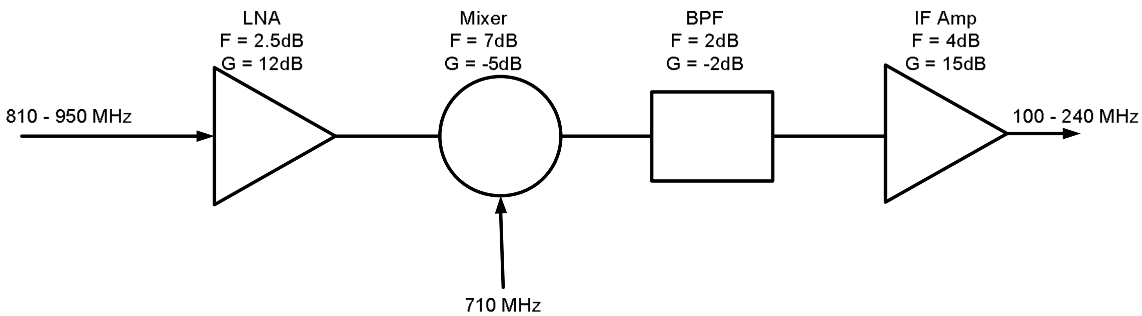

Figure 1

5. For the receiver in Fig. 2, calculate:
   (a) The noise figure of the system.
   (b) The overall gain of the system.
   (c) The minimum detectable signal at the input of the system.

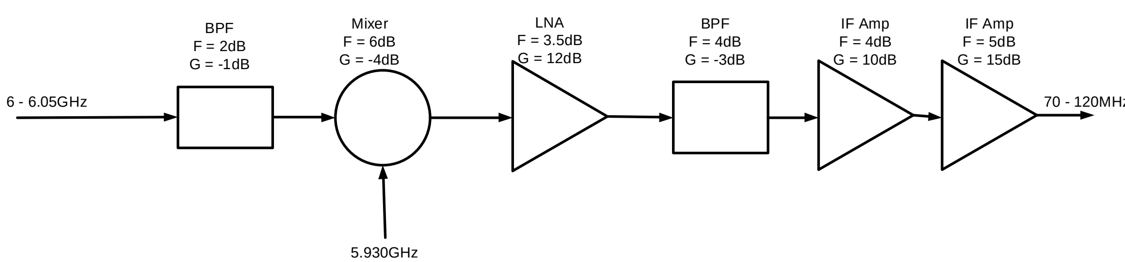

Figure 2

6. If the output power at the 1-dB compression point of an amplifier, having a gain of 12 dB over a bandwidth of 1.2 MHz and a noise figure of 2.5 dB, is 10 mW, calculate the dynamic range of the system.

7. The intercept point in the transfer characteristic of a nonlinear system is found to be 25 dBm. If a -5 dBm signal is applied to this system, find the intermodulation ratio.

8. A receiver operating at 900 MHz with its bandwidth at 1 MHz and noise figure at 16 dB. If its input impedance is 50 Ω and IP3 is 20 dBm, then find its dynamic range.

9. Discuss the following performance parameters:

   (a) Minimum Detectible signal, (b) Gain compression, (c) Intermodulation Distortion Ratio, (d) Second-order harmonics, (e) Third-order intercept point, (f) Dynamic range

10. A nonlinear amplifier has transfer function $v_{out} = 5v_{in} - 0.05v_{in}^2 - 0.1v_{in}^3$, a noise figure of 3 dB and a bandwidth of 100 MHz. If an input signal $v_{in} = 0.1\cos(1.01*10^6 t) + 0.08\cos(1.012*10^6 t)$ is applied to this circuit, calculate:

    a. The noise of the system.

    b. The gain compression.

    c. The intermodulation distortion ratio.

    d. The third-order intercept point.

    e. The dynamic range.

11. A 250 Ω load is to be matched with a 50 Ω line. Design (a) a resistive network, and (b) a reactive network to match the load. Discuss the performance of the two designs.

12. Use the analytical approach to design a two-component matching network that matches a load $Z_L = (80 + j20)\Omega$ to the source impedance $Z_S = (10 + j25)\Omega$, at a frequency of 1.2 GHz.

13. Design a two-component matching network for a load consisting of a 40 Ω resistor in series with a 2.5 nH inductor connected to a 50 Ω source. Determine the possible topologies that can be used and determine the component values at 500 MHz.

14. Design a T-type matching network that transforms $Z_L = (100 - j25)\Omega$ to the source impedance $Z_S = (20 - j40)\Omega$ at a nodal quality factor of Q = 4. Calculate the values at 900 MHz.

15. Design a Pi-type matching network that transforms $Z_L = (100 - j25)\Omega$ to the source impedance $Z_S = (20 - j40)\Omega$ at a nodal quality factor of Q = 4. Calculate the values at 900 MHz.

16. Analyze the heterodyne receiver architecture and compare it with the Image-reject receiver.

17. Design an active bias network for a BJT transistor operating at I_c = 12 mA, V_{ce} = 2.5 V and V_{cc} = 5V. Assume that both transistors have β = 150 and V_{be} = 0.7 V.

18. Determine the stability regions of a transistor whose measured S-parameters are: S11 = $0.6\angle 45°$, S12 = $0.2\angle -20°$, S21 = $6\angle 75°$, and S22 = $0.5\angle -45°$.

19. Given that a transistor is found to be unstable in the desired frequency range, indicate how this can be situation can be rectified to stabilize the circuit.