EECS 562

Homework 11

1. A received signal is r(t) is composed of the transmitted signal x(t) plus noise n(t), i.e., r(t)=x(t)+n(t). The received signal is r(t) is input to a filter H(f) to produce the output signal y(t).

a. Find the output S/N in dB given H(f) is an IBPF centered at 1 GHz with a bandwidth B of 360 kHz and the following parameters

$S_n(f) = \frac{N_0}{2}$ $N_0 = 8\text{x}10^{-13}$

$x(t) = A\cos(2\pi f_c t)$ with f_c=1GHz A = $8\text{x}10^{-3}$

b. As N_0 decreased the output S/N decreases, circle TRUE or FALSE.

2. A Wi-Fi receiver has a bandwidth of 20 MHz with a receiver sensitivity of -65 dBm and a noise figure of 4 dB. What is the minimum predetection S/N in dB. The receiver sensitivity is defined as the minimum received signal power (pre-detection) that will provide a demodulated signal with acceptable performance, e.g., BER. Assume $T_i = T_a = T_o$ and G_P=1

3. What is the noise available power in Watts/Hz of

a. An ideal resister at 290^0K

b. An amplifier with an equivalent noise temperature of 10 000^0K.

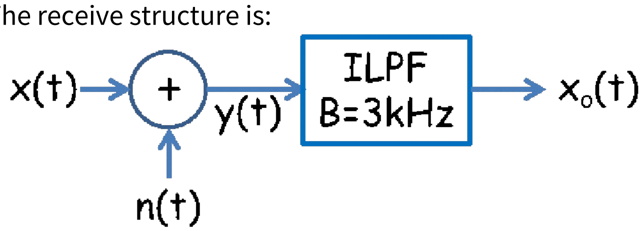
4. A WiFi access points transmit 11dBm. A receiver sensitivity of -65 dBm is required for acceptable performance. Use a path loss model of:

$L_P = 31 + 33\log(r)$ dB

where r in meters is distance between the transmitter (Access Point) and WiFi receiver. Find maximum value of r.

5. A received signal, y(t), is the sum of the desired information signal x(t) and noise, n(t). y(t) = x(t) + n(t). Here x(t) = $4\cos(2\pi 1000t) + 2\cos(2\pi 5000t)$ and $S_N(f) = 5\text{x}10^{-5}$ W/Hz.

The receive structure is:



a. What is the power in x(t)?

b. Find the output signal-to-noise ratio in dB.

c. How would you redesign the receiver structure to improve the output signal-to-noise ratio?

6. The downlink - base station transmitting to a receiving hand set (UE) has the following parameters:

eNodeB transmit power	16 dBW
Transmit antenna gain	10 dB
Carrier frequency	2000 MHZ
Distance between UE and ENodeB	2.5 km
Receive antenna gain	0 dB
Receiver antenna temperature	290 K
UE noise figure	2 dB
Bandwidth	20 MHz
Path loss exponent	3

a. What is the UE noise temperature?

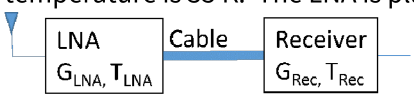
b. What is the path loss in dB?

c. What is the UE (output) S/N_{pre}?

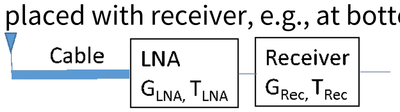
d. The transmitter needs to communicate to a UE 5 km from the transmitter with the same output S/N found above. What system parameter would your change to compensate for the increase path loss? Specify if you would INCREASE or DECREASE the selected system parameter and by how much.

7. Calculate the overall equivalent system noise temperature and noise figure for the following cases

a. For the system shown below the receiver noise figure is 10 dB, the cable loss is 5 dB, the Low Noise Amplifier (LNA) gain is 50 dB and its noise temperature is 100K. The antenna noise temperature is 35 K. The LNA is placed with the antenna.



b. Repeat the calculation of when the system of is arranged as shown below. The LNA is placed with receiver, e.g., at bottom of tower.



c. Which configuration (a) or (b) exhibits better performance? If the antenna is at the top of a 50 ft tower would you place the LNA at the antenna and run a cable to the receiver at the bottom of the tower, or run a cable from the antenna to a combined LNA/receiver at the bottom of the tower?

8. Go to the RF-Lamda site https://www.rflambda.com/product/amplifiers/lownoiseamplifier and find the gain and noise figure and frequency range of the LNA RLNA01G02GA?

9. Go to ReceptionMaps.com to explore the intensity maps of radiated power from TV broadcasters. Click TV Reception Maps in the upper left. Enter the address for Eaton Hall 1520 West 15th St. Lawrence Kansas 66045, on next screen click on WDFA-TV. For the antenna height of 1, 5, and 10 ft what is the receiver power in dBm? Explain the trend.

10. Starlink is a constellation of satellites providing internet access. As of November 2023 there were about 6500 satellites in orbit; the goal is to deploy about 12,000 satellites. Starlink “like” systems parameters are:

Satellite transmit power P_T	3 dB_W
Transmit antenna size	0.5 m
Transmit carrier frequency	12.5 GHz
Receive antenna size	0.2 m
Receiver noise temperature	323^o
Antenna template	290^o
Total system losses (Margin)	4.5 dB
System data rate	180 Mb/s
Modulation	64 QAM

Distance	550 km

a. Find the system bandwidth.
b. find the Noise Figure
c. Find the $(S/N)_{\text{pre}}$.
d. Assume Starlink satellites are launched on a Falcon 9 rocket, one launch costs $60 million and 60 Starlink satellites can be launched on one Falcon 9 rocket. The cost/satellite is $1 million. The cost of a satellite is proportional to its weight and power consumption. What is the cost is per Watt of transmit power - P_T?
e. Given that the signal-to-noise power ratio found in part c. has to maintained what system parameter would you change and by how much to reduce the cost per satellite to $500,000.

11. The communications system for the Perseverance Mars Rover Communications System parameters are approximately the following:

Transmit carrier frequency	7.5GHz
Rover transmit power	?
Transmit antenna size	0.3 m
Distance to Mars	360 million km
Receive antenna size	70 m
Receiver antenna temperature	50 K
Receiver System Noise Figure	1.29dB
Bandwidth	500 Hz
Required $(S/N)_{\text{pre}}$	3dB

a. What propagation exponent should be used in calculating the propagation loss?
b. Find the required power (in dB_W) needed by rover radio transmitter on the surface of Mars to meet the required $(S/N)_{\text{pre}}$?
c. The distance between Earth and Mars is not constant due to their elliptical orbits around the Sun. The the maximum distance between Earth and Mars ~401 million km from Earth. The rover needs to communicate to Earth with the same output S/N found above. What system parameter would your change to compensate for the increase path loss between Mars and the Earth? Specify a new value for the parameter.