EE 567

Homework 11 Solution

Problem 1 (from Sklar, Digital Communications, 2nd ed.). Suppose an airplane terminal communicating with a satellite is equipped with a frequency hopping spread spectrum system transmitting with an EIRP of 20 dBW (dB Watts). The data rate is $R = 100$ bits/sec. The jammer is transmitting wideband Gaussian noise continually with $\text{EIRP}_J = 60$ dBW. Assume that $(E_b/J_0)_{reqd} = 10$ dB and that the path loss is identical for both the airplane terminal and the jammer.

a. Should the communicators be more concerned with jammer trying to jam the uplink or the downlink?

   Solution: The jamming of the uplink is of more concern since the jammer could degrade the communications of multiple terminals that are using the satellite. To achieve the same degradation on the downlink the jammer would have to jam each of the receiving terminals.

b. If it is desired to have an AJ margin of 20 dB, what should be the value of the hopping bandwidth W_{ss}?

   Solution: In this case we have

$$M_{\text{AJ}}\ (\text{dB}) = (\frac{J}{S})_{reqd}\ (\text{dB}) - (\frac{J}{S})_r\ (\text{dB})$$

   We will assume the path loss is the same for both the communicator and the jammer. We can then replace $(\frac{J}{S})_r$ with the ratio of transmitted jammer-to-signal power. Hence,

$$\begin{aligned} M_{\text{AJ}}\ (\text{dB}) &= (\frac{J}{S})_{reqd}\ (\text{dB}) - \text{EIRP}_J\ (\text{dBW}) + \text{EIRP}_T\ (\text{dBW}) \\ &= G_P\ (\text{dB}) - (\frac{E_b}{J_0})_{reqd}\ (\text{dB}) - \text{EIRP}_J\ (\text{dBW}) + \text{EIRP}_T\ (\text{dBW}) \end{aligned}$$

   Therefore,

$$G_P = 20\ (\text{dB}) + 10\ (\text{dB}) + 60\ (\text{dBW}) - 20\ (\text{dBW}) = 70\ (\text{dB})$$

   and

$$\begin{aligned} W_{SS} &= G_P\ (\text{dB}) + R\ (\text{dB} \cdot \text{Hz}) = 70\ (\text{dB}) + 20\ (\text{dB} \cdot \text{Hz}) \\ &= 90\ (\text{dB} \cdot \text{Hz}) = 1\ (\text{GHz}). \end{aligned}$$

Problem 2. Suppose we detect a signal as shown in class and now we wish to noncoherently integrate the detected samples. Using Albersheim's equation plot the probability of detection vs. SNR (dB) for a probability of false alarm of 10^{-6} and number of independent samples noncoherently integrated is $N = 32$. Repeat this for probability of false alarm of 10^{-4} and show both curves on the same graph. In each case your probability of detection should range from 0.1 to 0.9.

Solution:

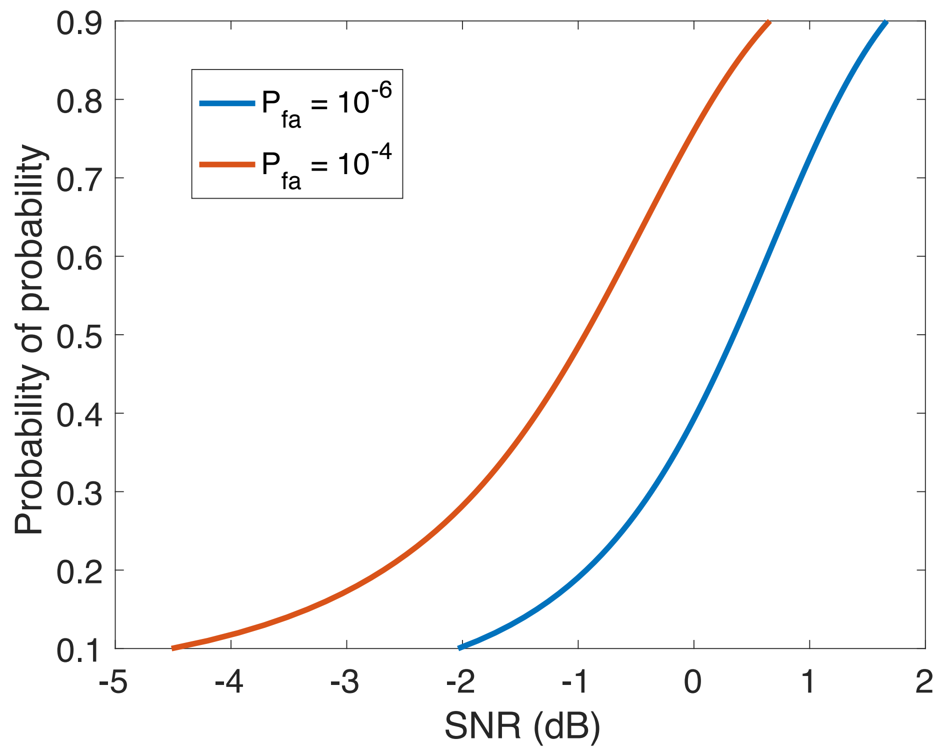

Figure 1: Probability of detection P_d vs. SNR (dB) for probability of false alarm P_{fa}

Appendix: MATLAB code

Problem 2:

```
clc; clear; close all;
N=32;
figure, hold on;
Pd=0.1:0.01:0.9;
B=log(Pd./(1-Pd));
Pfa=1e-6;
A=log(0.62/Pfa);
SNR=-5*log10(N)+(6.2+4.54./sqrt(N+0.44)).*log10(A+0.12*A*B+1.7*B);
plot(SNR,Pd,'linewidth',3);
Pfa=1e-4;
A=log(0.62/Pfa);
SNR=-5*log10(N)+(6.2+4.54./sqrt(N+0.44)).*log10(A+0.12*A*B+1.7*B);
plot(SNR,Pd,'linewidth',3);
box on;
xlabel('SNR (dB)','fontsize',16);
ylabel('Probability of probability','fontsize',16);
set(gca,'fontsize',18); ylim([0.1,0.9]);
legend('P_{fa} = 10^{-6}','P_{fa} = 10^{-4}');
```