EE 567

Homework 11 Solutions

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 the 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

$$M_{AJ}\ (\text{dB}) = \left(\frac{J}{S}\right)_{reqd}(\text{dB}) - \left(\frac{J}{S}\right)_{r}(\text{dB}).$$

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

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

Therefore,

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

and

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

Problem 2 (from Sklar, Digital Communications, 2nd ed.). Assume that a repeat-back jammer is located $d = 30$ km away from the communicator. Assume further that the jammer can monitor any uplink transmission from the communicator to a nearby satellite. How fast must the communicator hop his frequency to evade the repeat-back jammer? Assume that the jammer can change its jamming frequnecy in zero time and that the only differential delay between the communicator's uplink signal and the jamming uplink signal is the propogation delay from the communicator to the jammer.

Solution: To evade the repeat-back jammer the communicator must ensure the transmission time at a particular frequency and the jammer's attempt to disrupt that transmission using that frequency do not overlap in time. Thus, the duration of each hop (how long the communicator dwells at a particular frequency) must satisfy

$$T_{hop} \leq \frac{d}{c} = \frac{3 \times 10^4 \text{ m}}{3 \times 10^8 \text{ m/sec}} = 10^{-4} \text{ sec}$$

where c is the speed of light. Thus, $R_{hop} \geq 10,000$ hops/sec.