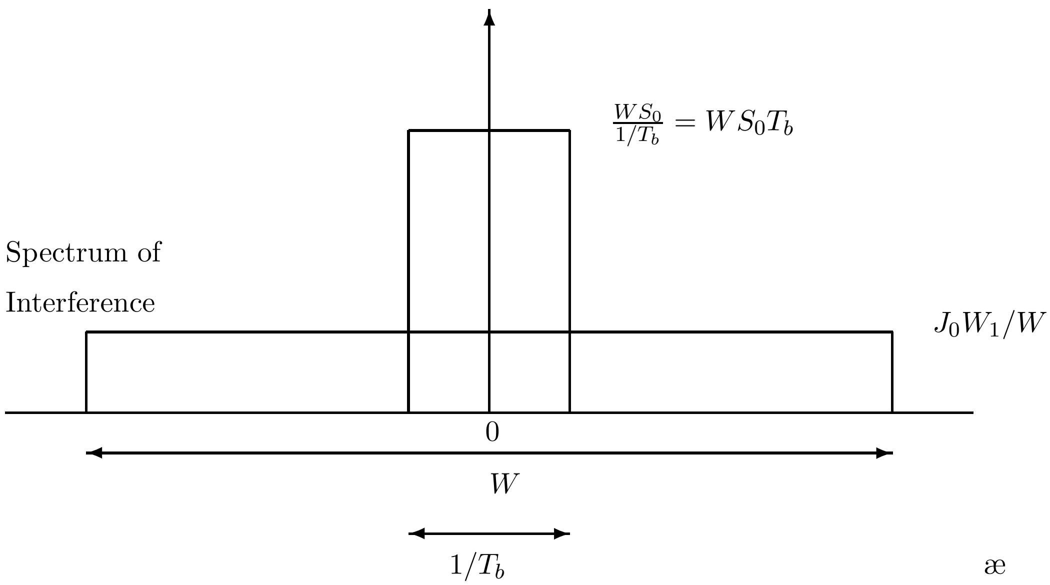
Problem 13.2 :

The PN spread spectrum signal has a bandwidth W and the interference has a bandwidth W_1, where $W >> W_1$. Upon multiplication of the received signal $r(t)$ with the PN reference at the receiver, we have the following (approximate) spectral characteristics



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After multiplication with the PN reference, the interference power in the bandwidth $1/T_b$ occupied by the signal is

$$\left(\frac{J_0W_1}{W}\right)\left(\frac{1}{T_b}\right) = \frac{J_0W_1}{WT_b}$$

Prior to multiplication, the noise power is J_0W. Therefore, in the bandwidth of the information-bearing signal, there is a reduction in the interference power by a factor $WT_b = \frac{T_b}{T_c} = L_c$, which is just the processing gain of the PN spread spectrum signal.

Problem 13.8 :

(a) We are given a system where $(J_{av}/P_{av})_{dB} = 20\ dB, R = 1000\ bps$ and $(\mathcal{E}_b/J_0)_{dB} = 10\ dB$. Hence, using the relation in (13-2-38) we obtain

$$\begin{aligned}
\left(\frac{W}{R}\right)_{dB} &= \left(\frac{J_{av}}{P_{av}}\right)_{dB} + \left(\frac{\mathcal{E}_b}{J_0}\right)_{dB} = 30\ dB \\
\frac{W}{R} &= 1000 \\
W &= 1000R = 10^6 Hz
\end{aligned}$$

(b) The duty cycle of a pulse jammer for worst-case jamming is

$$\alpha^* = \frac{0.71}{\mathcal{E}_b/J_0} = \frac{0.7}{10} = 0.07$$

The corresponding probability of error for this worst-case jamming is

$$P_2 = \frac{0.083}{\mathcal{E}_b/J_0} = \frac{0.083}{10} = 8.3 \times 10^{-3}$$

Problem 13.11 :

If the jammer is a pulse jammer with a duty cycle $\alpha = 0.01$, the probability of error for binary PSK is given as

$$P_2 = \alpha Q\left(\sqrt{\frac{2W/R}{J_{av}/P_{av}}}\right)$$

For $P_2 = 10^{-5}$, and $\alpha = 0.01$, we have

$$Q\left(\sqrt{\frac{2W/R}{J_{av}/P_{av}}}\right) = 10^{-3}$$

Then,

$$\frac{W/R_b}{J_{av}/P_{av}} = \frac{500}{J_{av}/P_{av}} = 5$$

and

$$\frac{J_{av}}{P_{av}} = 100 \;\; (20\; dB)$$

Problem 13.12 :

$$c\left(t\right) = \sum_{n=-\infty}^{\infty} c_n p\left(t - nT_c\right)$$

The power spectral density of $c(t)$ is given by (8.1.25) as

$$\Phi_c(f) = \frac{1}{T_c}\Phi_c(f)\left|P(f)\right|^2$$

where

$$\left|P(f)\right|^2 = (AT_c)^2 \sin c^2 (fT_c)\,, \quad T_c = 1\mu\,\mathrm{sec}$$

and $\Phi_c(f)$ is the power spectral density of the sequence $\{c_n\}$. Since the autocorrelation of the sequence $\{c_n\}$ is periodic with period N and is given as

$$\phi_c(m) = \begin{cases} N, & m = 0, \pm N, \pm 2N, \ldots \\ \\ -1, & \text{otherwise} \end{cases}$$

then, $\phi_c(m)$ can be represented in a discrete Fourier series as

$$\phi_c(m) = \frac{1}{N}\sum_{k=0}^{N-1} r_C(k)\, e^{j2\pi mk/N}, m = 0, 1, \ldots, N-1$$

where $\{r_c(k)\}$ are the Fourier series coefficients, which are given as

$$r_c(k) = \sum_{m=0}^{N-1} \phi_c(m)\, e^{-j2\pi km/N}, k = 0, 1, \ldots, N-1$$

and $r_c(k+nN) = r_c(k)$ for $n = 0, \pm 1, \pm 2, \ldots$. The latter can be evaluated to yield

$$\begin{aligned} r_c(k) &= N + 1 - \textstyle\sum_{m=0}^{N-1} e^{-j2\pi km/N} \\ &= \begin{cases} 1, & k = 0, \pm N, \pm 2N, \ldots \\ N+1, & \text{otherwise} \end{cases} \end{aligned}$$

The power spectral density of the sequence $\{c_n\}$ may be expressed in terms of $\{r_c(k)\}$. These coefficients represent the power in the spectral components at the frequencies $f = k/N$. Therefore, we have

$$\Phi_c(f) = \frac{1}{N}\sum_{k=-\infty}^{\infty} r_c(k)\,\delta\left(f - \frac{k}{NT_c}\right)$$

Finally, we have

$$\Phi_c(f) = \frac{1}{NT_c}\sum_{k=-\infty}^{\infty} r_c(k)\left|P\left(\frac{k}{NT_c}\right)\right|^2 \delta\left(f - \frac{k}{NT_c}\right)$$