

Problem 10.17. For a rectangular pulse shape, by how much does null-to-null transmission bandwidth increase, if the transmission rate is increased by a factor of three?

Solution

Without loss of generality, consider the baseband BPSK signal:

$$s(t) = \sum_k b_k h(t - kT),$$

where T is the symbol duration, $b_k = +1$ or -1 for transmitted 1 or 0, respectively. The pulse $h(t)$ is rectangular,

$$h(t) = \text{rect}\left(\frac{t - T/2}{T}\right).$$

The Fourier transform $H(f)$ of $h(t)$ is

$$\begin{aligned} H(f) &= T \text{sinc}(fT) \cdot e^{-j2\pi fT/2} \\ &= T \frac{\sin(\pi fT)}{\pi fT} e^{-j\pi fT} \end{aligned}$$

Inspecting a plot of the sinc function, we see the null-to-null transmission bandwidth of $H(f)$ is $B = 2/T$. When the transmission rate is increased by a factor three, we have the new symbol duration $T' = T/3$. The null-to-null bandwidth $B' = 2/T' = 3B$, increased by a factor of 3.