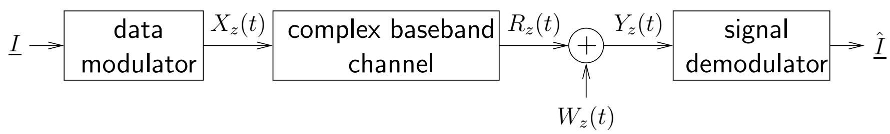
Digital Communication Basics:



The main idea [Ch. 6]:

- Say $\underline{I}$ represents K_b binary bits. Can assign $\underline{I} = i$ for $i \in \{0, 1, 2, \ldots, 2^{K_b} - 1\}$.
- To communicate $\underline{I} = i$, we transmit (complex baseband) waveform $x_i(t)$.
- The receiver infers $\hat{\underline{I}}$ from the output of the noisy channel.

We consider these constraints:

- Bandwidth (when spectrum is shared)
- Power (for interference and battery life)
- Data rate (must support application)
- Error rate (e.g., bit errors or word errors)
- Complexity

We don't consider these:

- Delay (e.g., in speech communication)
- Peak-to-average power ratio (nb. amplifier linearity)
- Size, Weight (e.g., antenna spacing)
- Probability of intercept (e.g., in military apps)

We use these metrics to characterize system performance:

- Reliability (Fitz calls this "performance")
  - Proportion of bits or words received in error at a particular level of E_b/N_o (i.e., bit energy per noise spectral density).
- Spectral efficiency η_B
  - Information rate (in bits/sec) transmitted per Hz of bandwidth.
  - For total info rate W_b (bits/sec) and bandwidth B_T, we have $\eta_B = \frac{W_b}{B_T}$.
- Complexity

Limits on data communication

- Shannon showed that reliable (i.e., error free) communication is possible at spectral efficiency η_B:

$$\eta_B \;<\; \log_2(1 + \text{SNR}) \quad \text{bits/sec/Hz}$$

- We can write SNR as

$$\text{SNR} = \frac{P_S}{P_N} = \frac{E_b W_b}{N_o B_T} = \frac{E_b}{N_o}\eta_B$$

- Thus we can determine the upper limit to achievable spectral efficiency (as a function of $\frac{E_b}{N_o}$) via

$$\eta_B \;=\; \log_2\!\left(1 + \tfrac{E_b}{N_o}\eta_B\right)$$

Acheivable spectral efficiency is below line: