Fundamentals of Electrical Engineering

Digital Communication

- Bit transmission schemes
- Transmission bandwidth



Digital Communication Model

Analog message





(Almost) *all* channels for digital communication are analog



Signal Set Design

Assign a signal to each bit value, forming a signal set

<u>Binary Phase</u> Shift Keying (BPSK)



T - bit interval (time taken to transmit a bit) Datarate R = 1/T bits/s



Digital Transmission (BPSK)











Transmission Bandwidth

- Bandwidth depends on the bit sequence
- What's the worst case bit sequence?



• Spectrum given by Fourier series

$$c_k = \begin{cases} \frac{2}{j\pi k} & k \text{ odd} \\ 0 & k \text{ even} \end{cases} \qquad f_k = \frac{k}{2T}$$



Transmission Bandwidth

Use 90% bandwidth

$$\min_{K} \frac{|c_0|^2 + 2\sum_{k=1}^{K} |c_k|^2}{|c_0|^2 + 2\sum_{k=1}^{\infty} |c_k|^2} \ge 0.90$$

For BPSK, K = 3

Baseband BPSK, bandwidth =
$$\frac{3}{2T} = \frac{3}{2}R$$

Modulated BPSK, bandwidth = $\frac{3}{T} = 3R$



Transmission Bandwidth (FSK)



Transmission Bandwidth

- BPSK: bandwidth (modulated) = 3R
- FSK: if $k_1 = k_0 + 1$, bandwidth = 2R



Digital Communication

• Assign a signal set

$$\begin{array}{ccc} ``0" &\longleftrightarrow s_0(t) \\ ``1" &\longleftrightarrow s_1(t) \end{array} & 0 \le t < T \end{array}$$

• Datarate determined by source *and* channel



- Signal set choice affects...
 - * bandwidth
 - * reception performance

