

**EE 354**  
**Modern Communication Systems**

**FSK**

**Spring 2014**

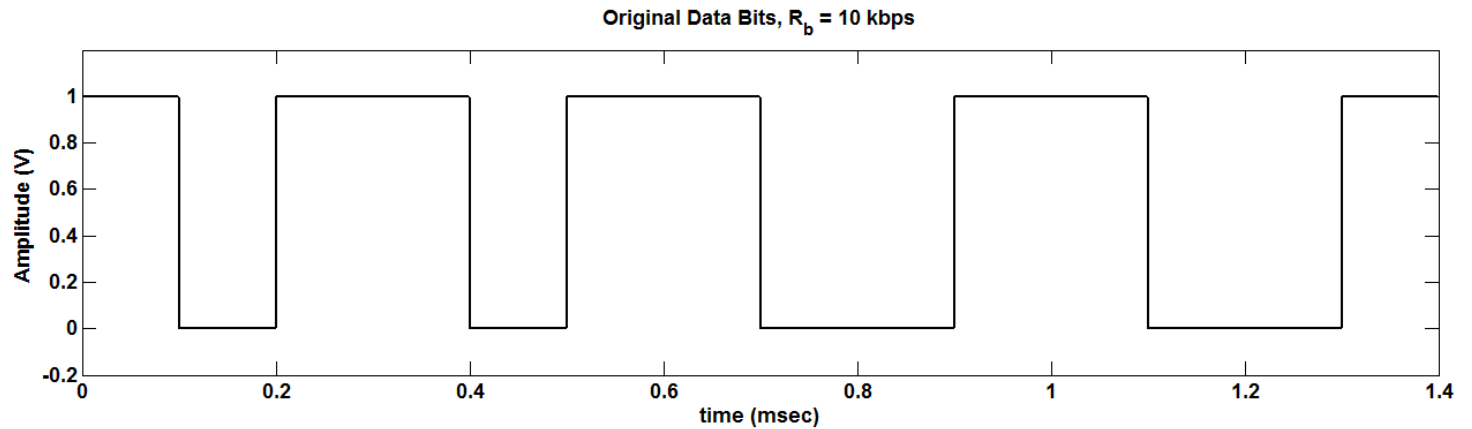
**Instructor: C. R. Anderson**



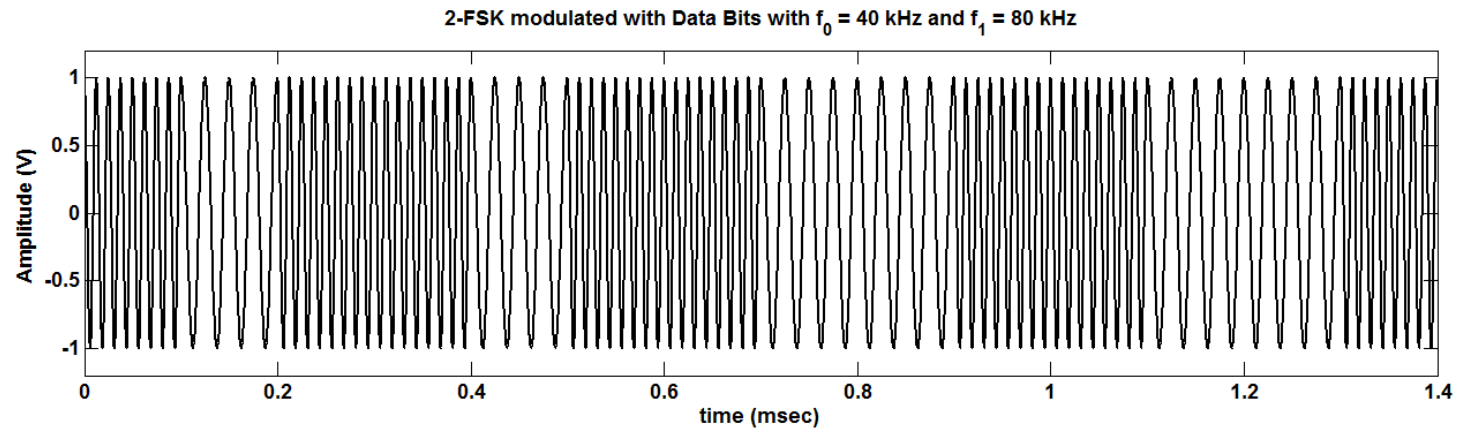
# Frequency Shift Keying

1 0 1 1 0 1 1 0 0 1 1 0 0 1

Unipolar  
NRZ Data



FSK  
Waveform



# FSK Power Spectral Density

**Recall:** Frequency Shift Property of the Fourier Transform:

$$\mathfrak{F}[s(t)\cos(2\pi f_c t)] = \frac{1}{2}S(f - f_c) + \frac{1}{2}S(f + f_c)$$

**Which means that the PSD will be:**

$$S_\phi(f) = \left| \frac{1}{2}S(f - f_c) \right|^2 + \left| \frac{1}{2}S(f + f_c) \right|^2$$

$M_\phi$  is the baseband PSD of the NRZ bitstream.

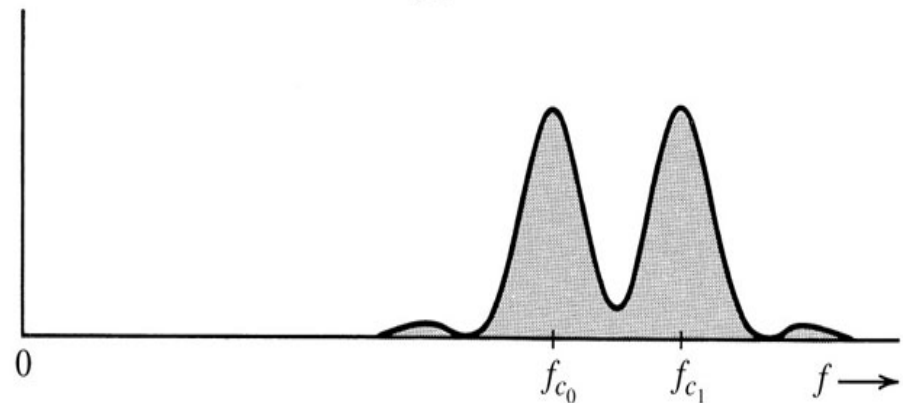
$$S_\phi(f) = \frac{1}{4}M_\phi(f - f_c) + \frac{1}{4}M_\phi(f + f_c)$$

Note:  $M_\phi(f) \propto \text{sinc}^2(f)$

**Note:** For FSK we have two different carrier frequencies  $f_{c_0}$  &  $f_{c_1}$ !

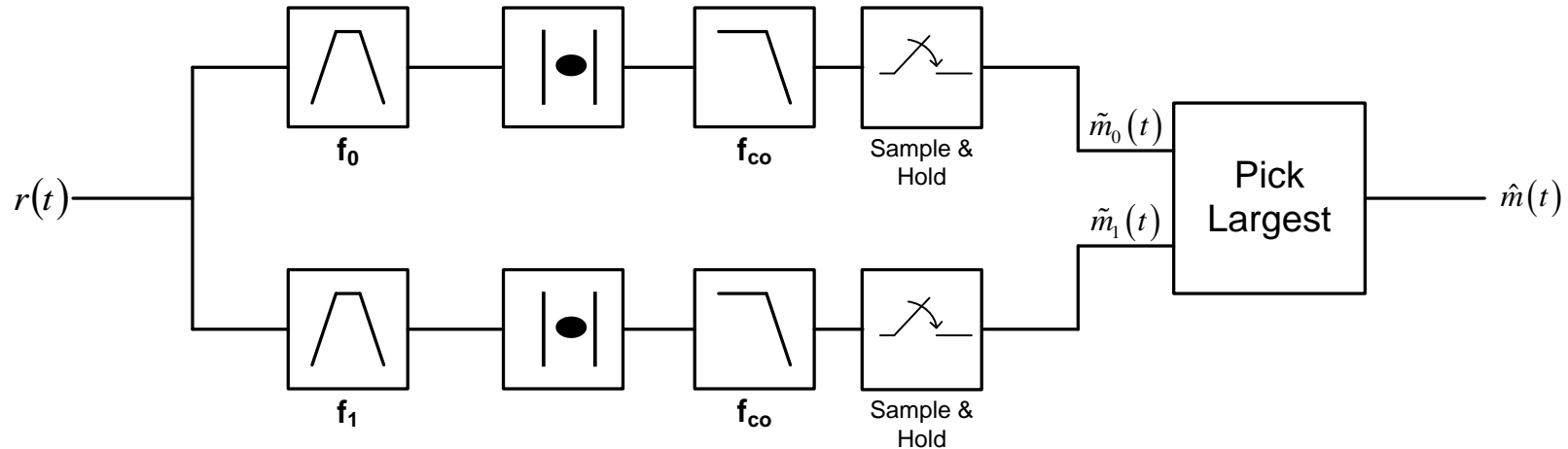
## The Result:

For FSK: Effectively creating **two ASK** signals at two different carrier frequencies.

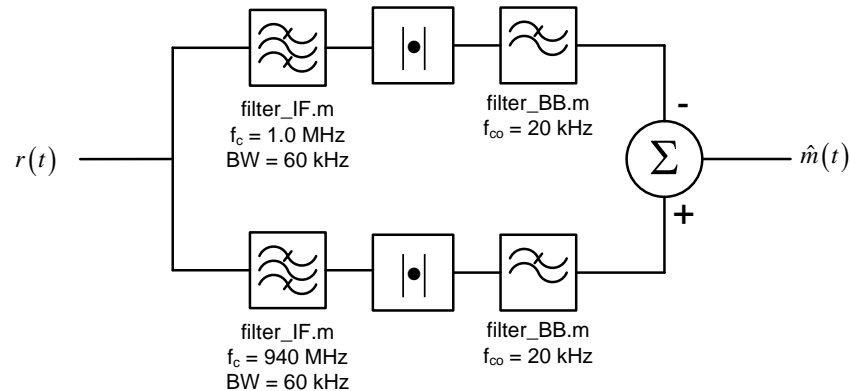


# Incoherent Demodulation of FSK

## Block Diagram of incoherent FSK Demodulator:



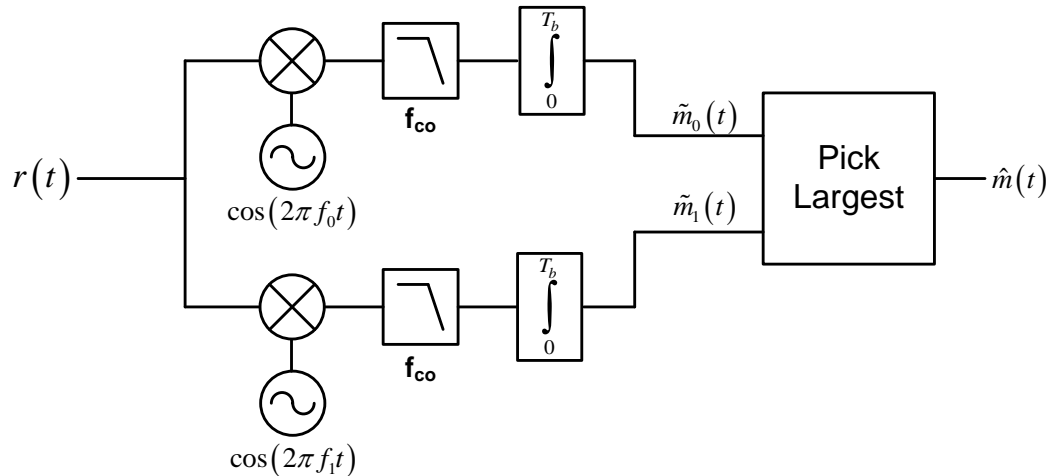
## Incoherent FSK Demod in Software (example from lab):



**Note:** We have the same analysis as ASK: the noise will be transformed to have a Rayleigh and Rician PDF.

# Coherent Demodulation of FSK

## Block Diagram of coherent FSK Demodulator:



## Coherent FSK Demod in Software (example from lab):

**Note:** The coherent receiver is a Matched Filter (MAP) Receiver. The performance will be equal to the **orthogonal** MAP Receiver performance.

# Example

**Given:** A 2.5 Mbps coherent BFSK system suffers AWGN with  $\frac{N_0}{2} = 10^{-20}$  watts/Hz.

With no noise, the amplitude of the received signal is across an input impedance of  $50\Omega$ .

**Find:** What is the probability of bit error for an Incoherent and Coherent Receiver?