Sri SAI RAM ENGINEERING COLLEGE

INSTITUTE OF TECHNOLOGY

West Tambaram, Chennai - 44

YEAR	SEM
II	III

EC 8394

UNIT No. 3 DIGITAL MODULATION

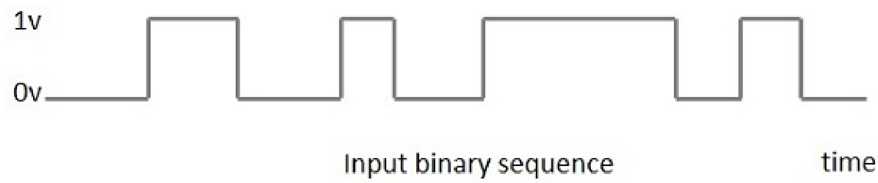
3.1.2 FREQUENCY SHIFT KEYING (FSK)

Version: 1.XX

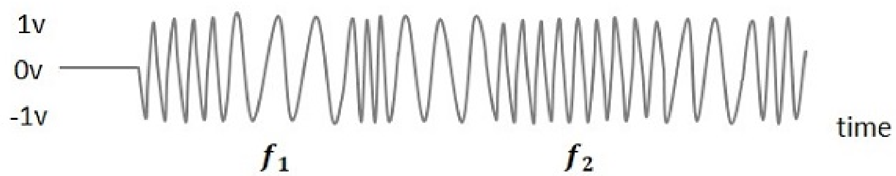
FREQUENCY SHIFT KEYING (ASK)

FSK is the digital modulation technique in which the frequency of the carrier signal varies according to the digital signal changes. FSK is a scheme of frequency modulation.

The output of a FSK modulated wave is high in frequency for a binary High input and is low in frequency for a binary Low input. The binary 1s and 0s are called Mark and Space frequencies.



Input binary sequence



FSK Modulated output wave

MATHEMATICAL EXPRESSION FOR FSK:

The phase shift in carrier frequency (Δf) is proportional to the amplitude of the binary input signal (vm(t)) and the direction of the shift is determined by the polarity

$$v_{fsk}(t) = V_c \cos\{2\pi[f_c + v_m(t)\Delta f]t\} \quad -(1)$$

Where $v_{fsk}(t)$ = binary FSK waveform

V_c = peak analog carrier amplitude (volt)

f_c = analog carrier center frequency (Hz)

Δf = peak shift in analog carrier frequency (Hz)

$v_m(t)$ = binary input signal (volt)

The modulating signal is a normalized binary waveform

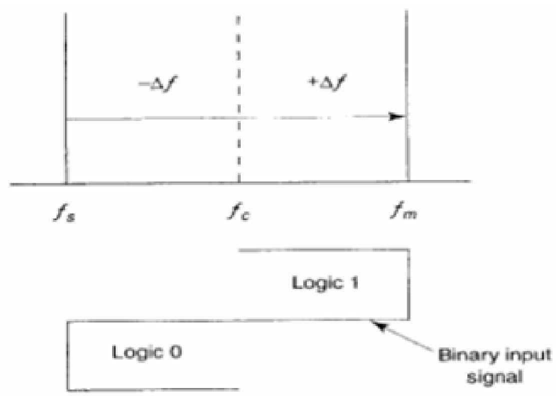
Where,

+1 V=logic 1

-1 V=logic 0

$$v_{fsk}(t)=\begin{cases} V_c\cos\{2\pi[f_c+\Delta f]t\}\, for & \text{logic'1'}, v_m(t)=+1 \\ V_c\cos\{2\pi[f_c-\Delta f]t\}\, for & \text{logic'0'}, v_m(t)=-1 \end{cases}$$

With binary FSK, the carrier center frequency (fc) is shifted (deviated) up and down in frequency domain by binary input signal as shown



FSK in the frequency domain

$$\Delta f = \frac{|f_m - f_s|}{2},$$

where

$$\Delta f = \text{frequency deviation (Hz)}$$

$$|f_m - f_s| = \text{absolute difference between mark \& space frequency (Hz)}$$

FSK Bandwidth:

$$B = |(f_s - f_b) - (f_m - f_b)| = |f_s - f_m| + 2f_b = 2(\Delta f + f_b)$$

FSK Modulator:

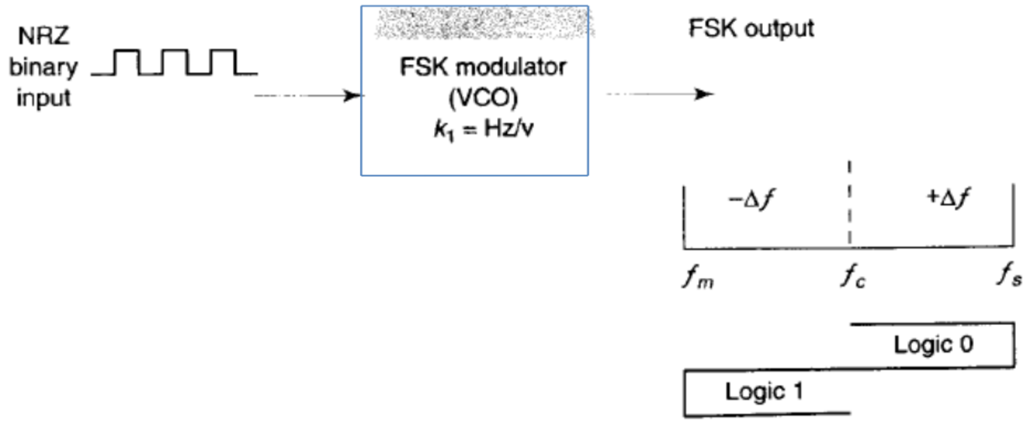


Figure 1 FSK MODULATOR

- Figure 1 shows a simplified binary FSK modulator, which is very similar to a conventional FM modulator and is very often a voltage-controlled oscillator (VCO).
- The center frequency (f_c) is chosen such that it falls halfway between the mark and space frequencies.
- A logic 1 input shifts the VCO output to the mark frequency, and a logic 0 input shifts the VCO output to the space frequency
- Consequently, as the binary input signal changes back and forth between logic 1 and logic 0 conditions, the VCO output shifts or deviates back and forth between the mark and space frequencies.
- A VCO-FSK modulator can be operated in the sweep mode where the peak frequency deviation is simply the product of the binary input voltage and the deviation sensitivity of the VCO.
- With the sweep mode of modulation, the frequency deviation is expressed mathematically as

$$\Delta f = v_m(t)k_l$$

$v_m(t)$ = peak binary modulating-signal voltage (volts)
k_l = deviation sensitivity (hertz per volt).

FSK Demodulators:

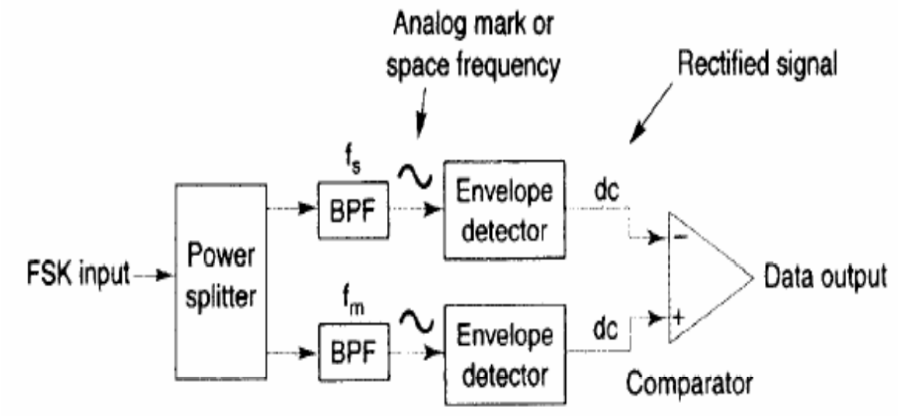


Figure 2 FSK DEMODULATOR-NONCOHERENT

- The FSK input signal is simultaneously applied to the inputs of both bandpass filters (BPFs) through a power splitter.
- The respective filter passes only the mark or only the space frequency on to its respective envelope detector.
- The envelope detectors, in turn, indicate the total power in each passband, and the comparator responds to the largest of the two powers.

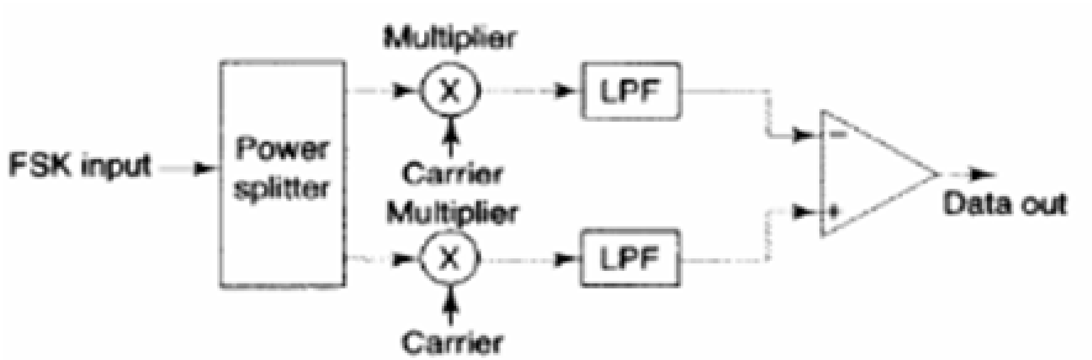


Figure 3 FSK DEMODULATOR-COHERENT

- The incoming FSK signal is multiplied by a recovered carrier signal that has the exact same frequency and phase as the transmitter reference.
- However the two transmitted frequencies (the mark and space frequencies) are not generally continuous; it is not practical to reproduce a local reference that is

coherent with both of them. Consequently, coherent FSK detection is seldom used.

- The most common circuit used for demodulating binary FSK signals is the Phase locked loop (PLL).

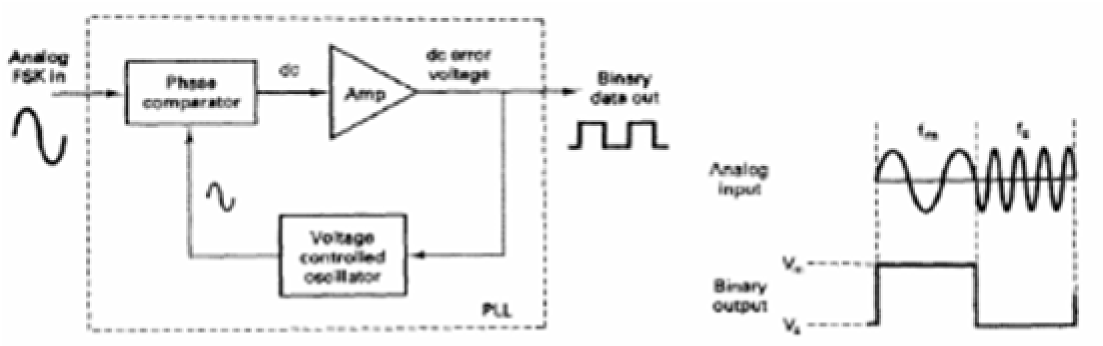


Figure 3 FSK DEMODULATOR-COHERENT-PLL

- As the input to the PLL shifts between the mark and space frequencies, the dc error voltage at the output of the phase comparator follows the frequency shift.
- Because there are only two input frequencies (mark and space), there are also only two output error voltages.
- One represents a logic 1 and the other a logic 0.

Advantages of FSK

1. Zero amplitude variations
2. Supports a high data rate.
3. Low probability of error.
4. High SNR (signal to noise ratio).
5. More noise immunity than the ASK
6. Error-free reception can be possible with FSK
7. Preferable in high-frequency communications Simple technique

Disadvantages of FSK

1. It requires more bandwidth than the ASK and PSK(phase shift keying)

2. Due to the requirement of large bandwidth, this FSK has limitations to use only in low-speed modems which the bit rate is 1200bits/sec.
3. The bit error rate is less in AWGN channel than phase shift keying.