

Digital CW Modulation techniques.

Amplitude

shift keying

ASK

Frequency

Shift keying

FSK

Phase

shift keying

PSK

Typical Sources of Communication Data

Link Budget Analysis: Digital Modulation, Part 1

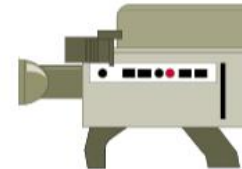
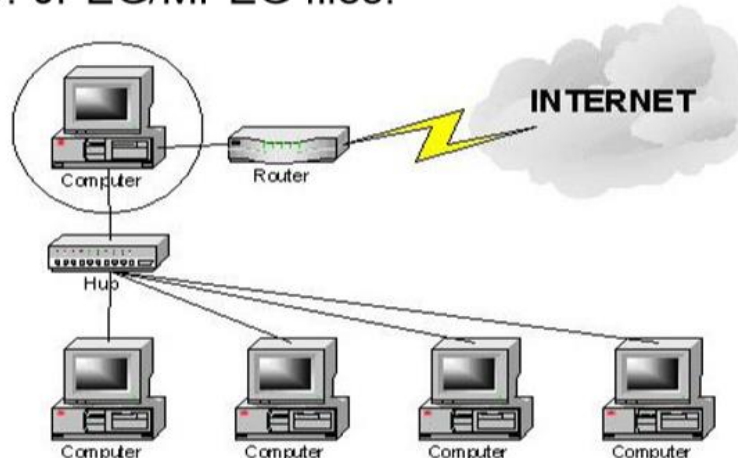
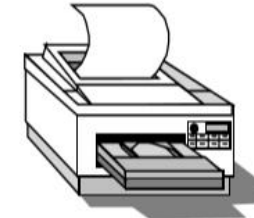
1. Analog Data Sources: Produces continuous-time output using a device that converts the real analog signal to electrical voltage.

- A. Speech/Voice/Telephone.
- B. Music/Sound.
- C. Moving and static images.
- D. And also: temperature, speed, time...



2. Digital Data Sources: Produces discrete-time output using a device that processes logical digital signals (binary, ASCII).

- A. Computer files/Keyboards/Monitors/Printers.
- B. E-mail sent over the internet.
- C. Digital storage devices (Compact Discs, DVDs, etc...)
- D. JPEG/MPEG files.

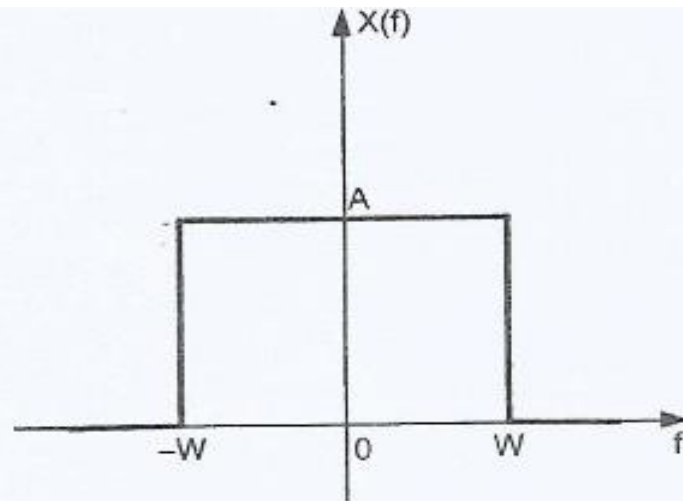


DIGITAL CONTINUOUS WAVE (CW) MODULATION TECHNIQUES

- ❑ When a digital signal is to be transmitted over a long distance, it needs CW modulation.
- ❑ The transmission media can be radio, cable or other type of chan.
- ❑ A sinusoidal carrier signal of some high frequency , F_0 is used for modulation.
- ❑ The digital message signal modulates some carrier parameters like frequency, phase or amplitude. The result modulated signal has the carrier with some deviation in frequency. This deviation is called Bandwidth of the channel.
- ❑ Thus the channel has to transmit some range of frequencies or band.

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- ❑ Such type of transmission digital signal after modulation is called **bandpass transmission.**
- ❑ The word bandpass is used because the range of frequencies does not start from '0' Hz to W Hz. if it is like this. It called lowpass signal.
- ❑ As shows in fig. below, the spectrum of low-pass signal is centered around '0'Hz, the highest frequency is 'W' Hz, then the BW= W Hz.



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- The spectrum of bandpass signal shown below, shows that the signal is centered around $\mp f_0$ Hz, then its bandwidth is $2W$ HZ.

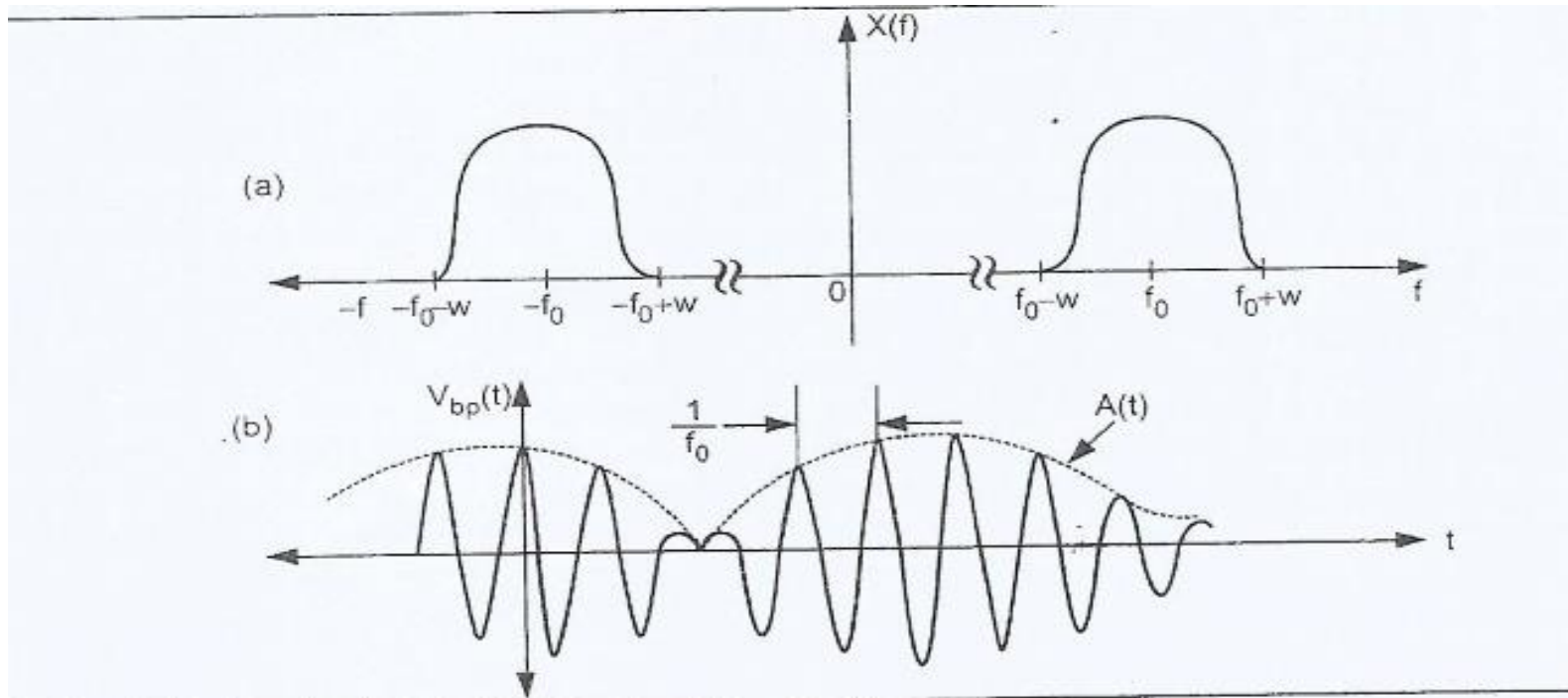


Fig. 8.2 (a) Spectrum of a bandpass signal
(b) Its waveform in time domain

We can write,
$$X(f) = \begin{cases} 0 & \text{for } |f| < f_0 - W \\ \text{None zero} & \text{and } |f| > f_0 + W \\ & \text{elsewhere} \end{cases}$$

Digital CW modulation types

- When it is required to transmit digital signals on bandpass channel, the **Amplitude, Frequency or Phase** of the sinusoidal carrier is varied in accordance with the incoming digital signal.
- Since the digital signal is in **discrete steps**, the modulation of the carrier is also done in **discrete steps**.
- Hence this type of modulation(**Digital Modulation**) is also called **switching or signaling**.

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- If the amplitude of the carrier is switched depending on the incoming digital signal, then it is called Amplitude Shift Keying (**ASK**). This is similar to analog Amplitude Modulation(AM)
- If the frequency of the carrier is switched depending on the incoming digital signal, then it is called Frequency Shift Keying (**FSK**). This is similar to analog Frequency Modulation(FM)
- If the Phase of the carrier is switched depending on the incoming digital signal, then it is called Phase Shift Keying (**PSK**). This is similar to Analog Phase Modulation(PM).
- In Digital modulations instead of transmitting one bit a time, two or more bits are transmitted simultaneously. This called **M-ARY** transmission.

Modulation: Types and Techniques

Link Budget Analysis: Digital Modulation, Part 1

1. Analog Modulation: When the information-bearing message signal is continuous-time analog, then the modulation is called analog modulation.

Common analog modulation techniques:

- A. AM: Amplitude modulation : Message is carried in $A(t)$. $S(t) = A(t) \cos(\omega_c t + \varphi_0)$.
- B. FM: Frequency modulation: Message is carried in $\omega(t)$. $S(t) = A_0 \cos(\omega(t) + \varphi_0)$.
- C. PM: Phase modulation : Message is carried in $\varphi(t)$. $S(t) = A_0 \cos(\omega_c t + \varphi(t))$.

2. Digital Modulation: When the information-bearing message signal is discrete-time digital, then the modulation is called digital modulation.

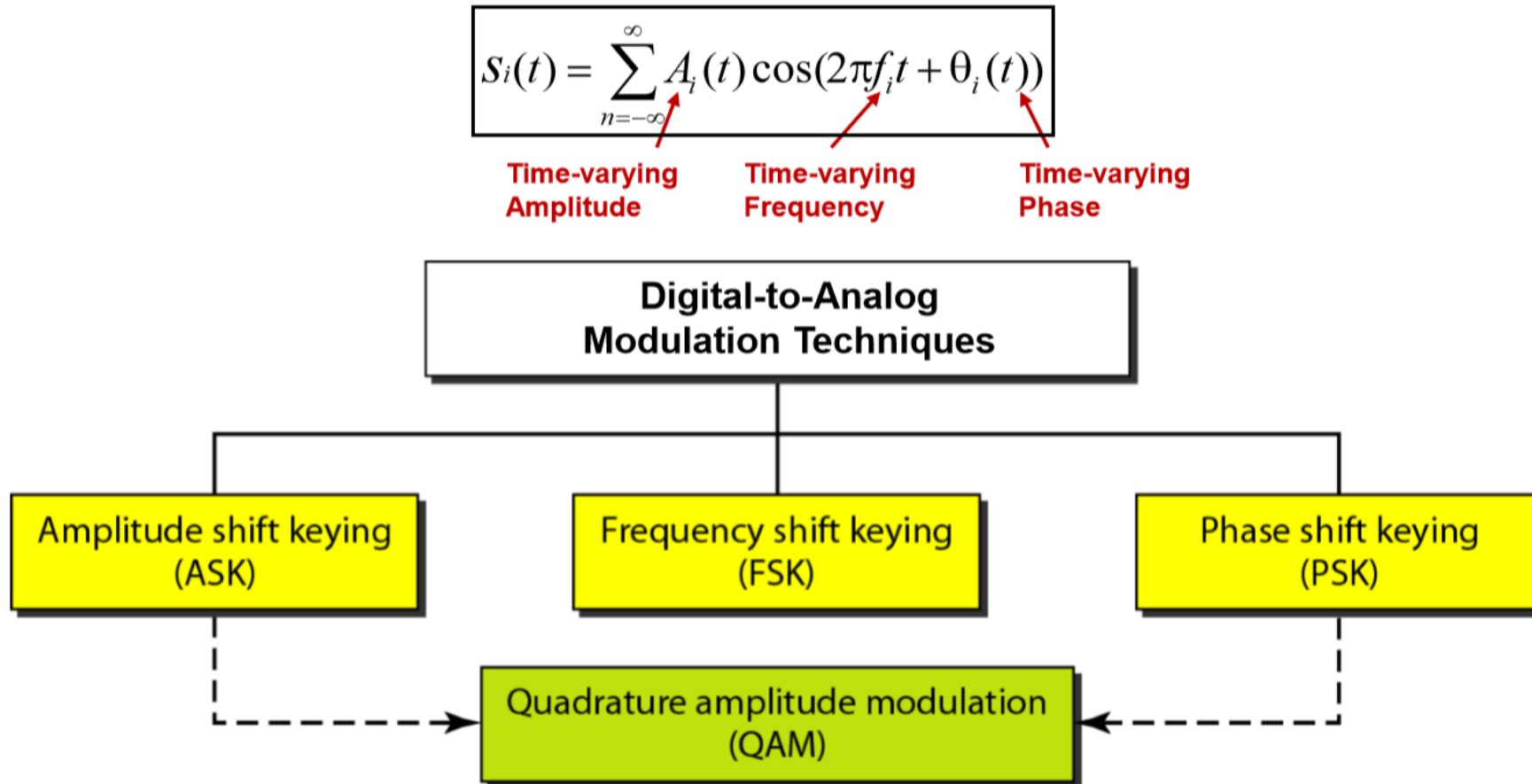
Common digital modulation techniques:

- A. ASK: Amplitude Shift Keying : Message signal changes the carrier's **amplitude**.
- B. FSK: Frequency Shift Keying: Message signal changes the carrier's **frequency**.
- C. PSK: Phase Shift Keying : Message signal changes the carrier's **phase**.
- D. QAM: Quadrature Amplitude Modulation. A combination of ASK and PSK.

3. For Binary (2-level) Digital Modulation ($M = 2$):

- A. BASK: Binary Amplitude Shift Keying.
- B. BFSK: Binary Frequency Shift Keying.
- C. BPSK: Binary Phase Shift Keying.

Types of Digital-to-Analog Modulations



- Bit rate is the number of bits transmitted per second: $R_b = kR_s$.
- Baud rate is the number of signal elements transmitted per second: $R_s = R_b/k$.
- In the analog transmission of digital data, if a signal unit is composed of k bits, then the bit rate is k times higher than baud rate. Baud rate determines the channel bandwidth required to transmit the modulated signal.

Digital Bandpass Modulation Techniques

Link Budget Analysis: Digital Modulation, Part 1

In digital communications, the modulating baseband message signal: $m(t)$ is a binary or M-ary digital data stream. The carrier is usually a sinusoidal signal.

1. **Baseband digital message signal:** $m(t)$

2. **Analog sinusoidal carrier signal:**

A. Carrier signal: $A_c \cos(2\pi f_c t + \phi_c)$

3. **ASK: Amplitude Shift Keying.**

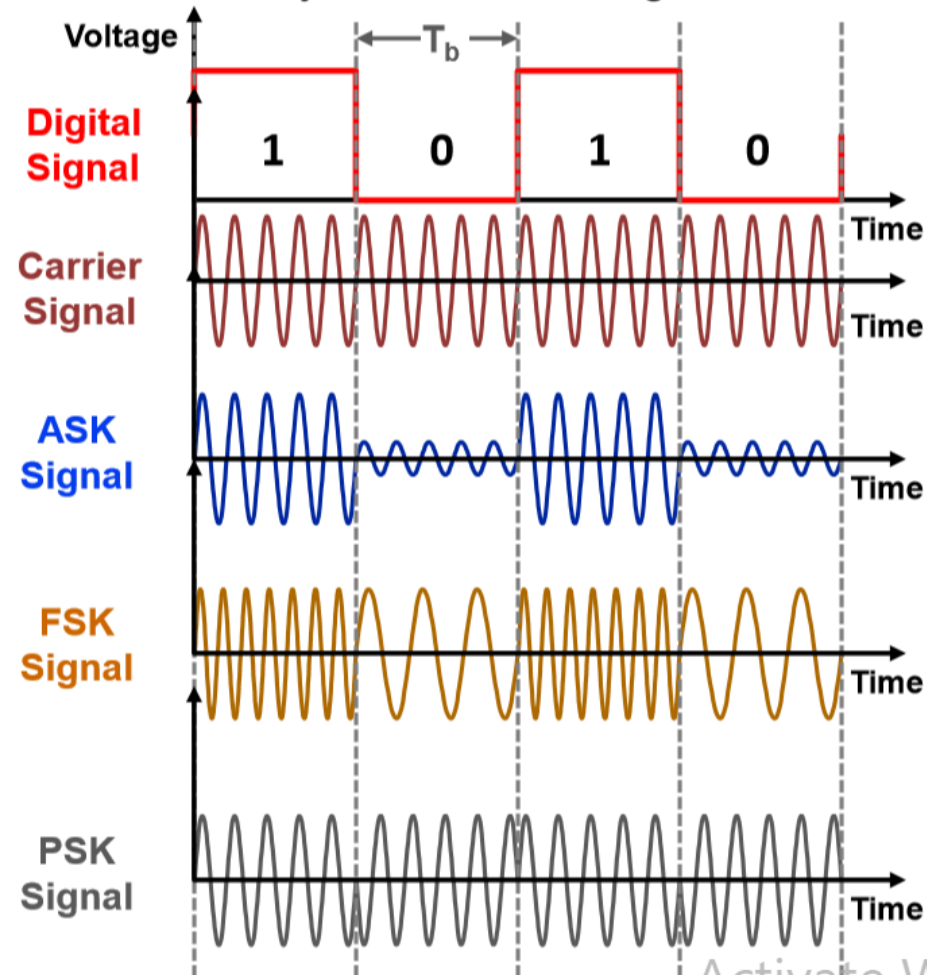
A. Message signal changes the carrier's **amplitude**: $A_i(t)$.

4. **FSK: Frequency Shift Keying.**

A. Message signal changes the carrier's **frequency**: $f_i(t)$.

5. **PSK: Phase Shift Keying.**

A. Message signal changes the carrier's **phase**: $\phi_i(t)$.



Coherent detection and non coherent detection

- Digital modulation techniques can be:
 - **Coherent (synchronous) Detection**- in this type the local carrier generated at the receiver is phase locked with the carrier at the transmitter. The detection(Demodulation) is done by correlating received noisy signal and locally generated carrier.
 - **Non Coherent (Envelop Detection)**- in this type , the detection does not need receiver carrier to be phase locked with transmitter carrier. The advantages of such as a system is that the system become **simple**, but the drawback is that **error probability increases**.
- The different digital modulation techniques are used for specific application areas.
- The choice is made such that the **transmitted power and channel bandwidth are best exploited**.

Digital modulation – important requirements

Any digital modulation technique should satisfy following important requirements:

- 1) maximum data rate
- 2) Minimum probability of symbol error
- 3) Minimum transmitted power
- 4) Minimum channel bandwidth
- 5) Maximum resistance to interfering signal
- 6) Minimum circuit complexity

Advantages of digital carrier(CW) system over baseband digital transmission (directly without modulation)

- I. The digital modulated signal (Passband) become a high frequency signal, so it can be transmitted over long distances with the help of standard communication media such as Radio channels, Cables, Fiber optic cables.**
- II. The result modulated signals are analog in nature. Hence all the types of analog channels can be used for transmission.**
- III. Because if modulation of analog carrier, multiplexing techniques can also be employed for bandwidth conservation.**
- IV. Baseband digital transmission mainly suffers from intersymbol interference and crosstalk. These problems are absent in Digital CW modulation**
- V. There are large number of digital modulation methods(techniques). These can be selected as per input signal and application.**
- VI. Baseband signal transmission needs fiber optic cable or co-axial cable to carry the signals. while CW modulated signals can be transmitted on Radio.**