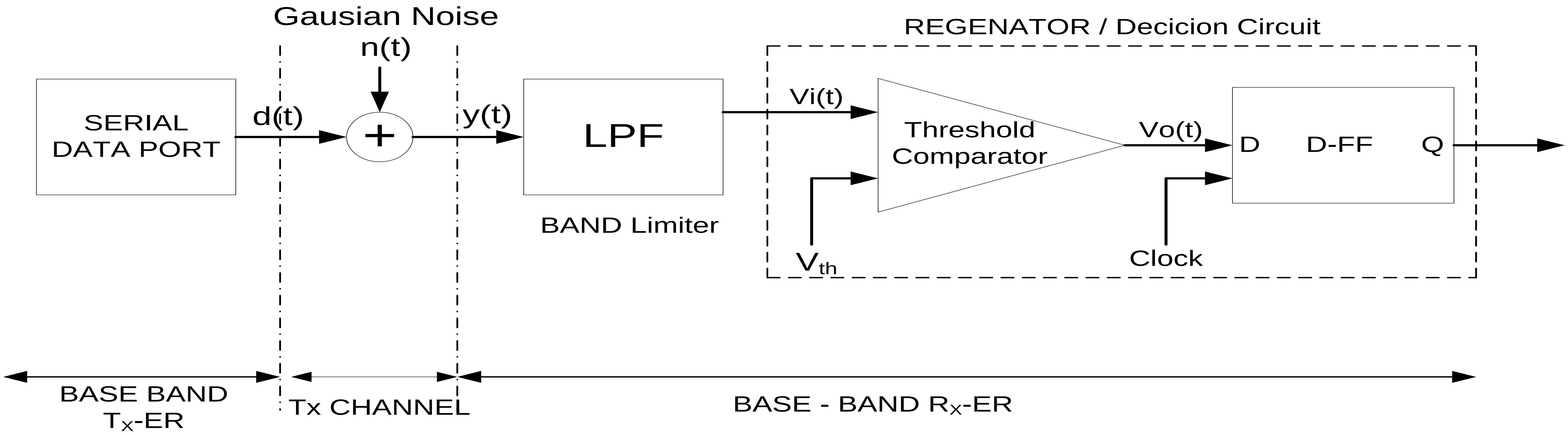
Sistem Komunikasi 1

Bab 11
Pengenalan Transmisi Digital

Baseband Digital Transmission Link



Sinyal Terima + AWGN

original message
d(t)

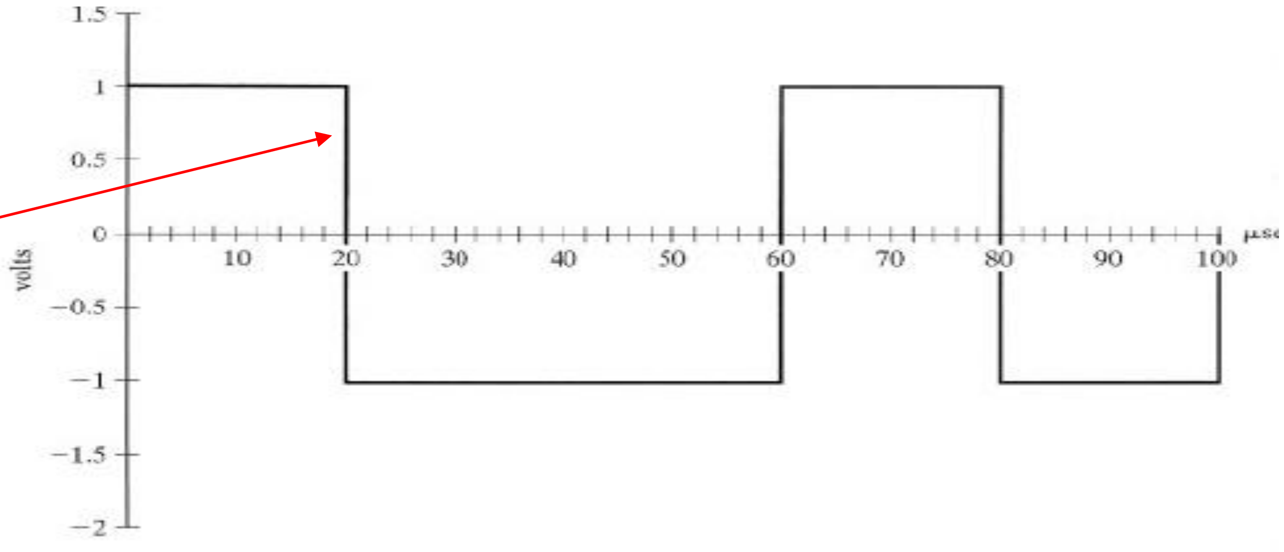
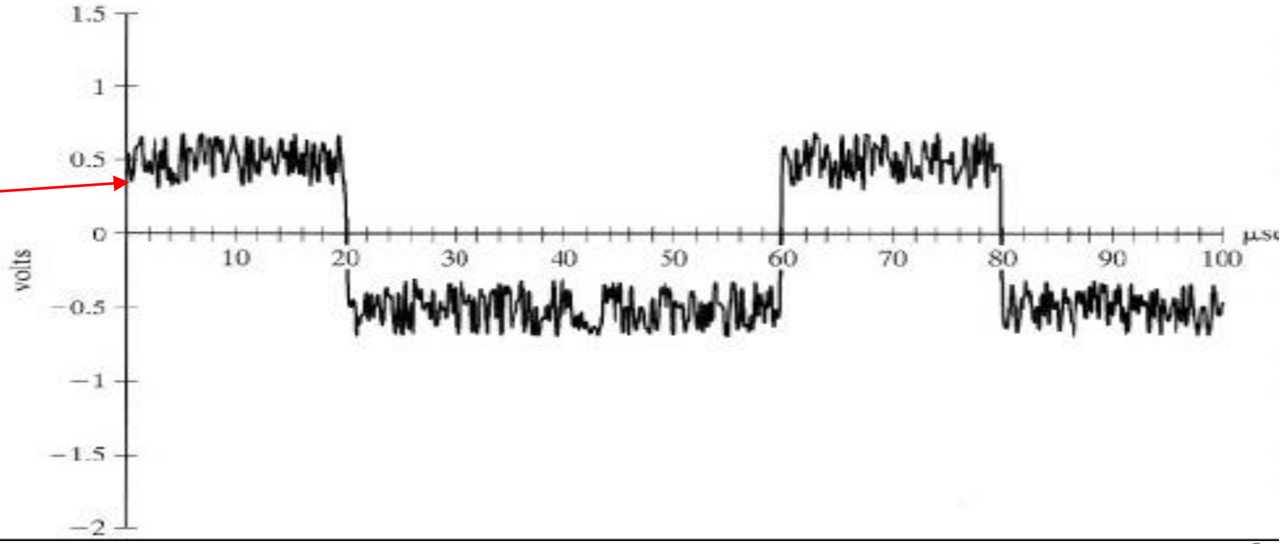


Figure 3-23a Transmitted signal for "10010" using rectangular pulses.

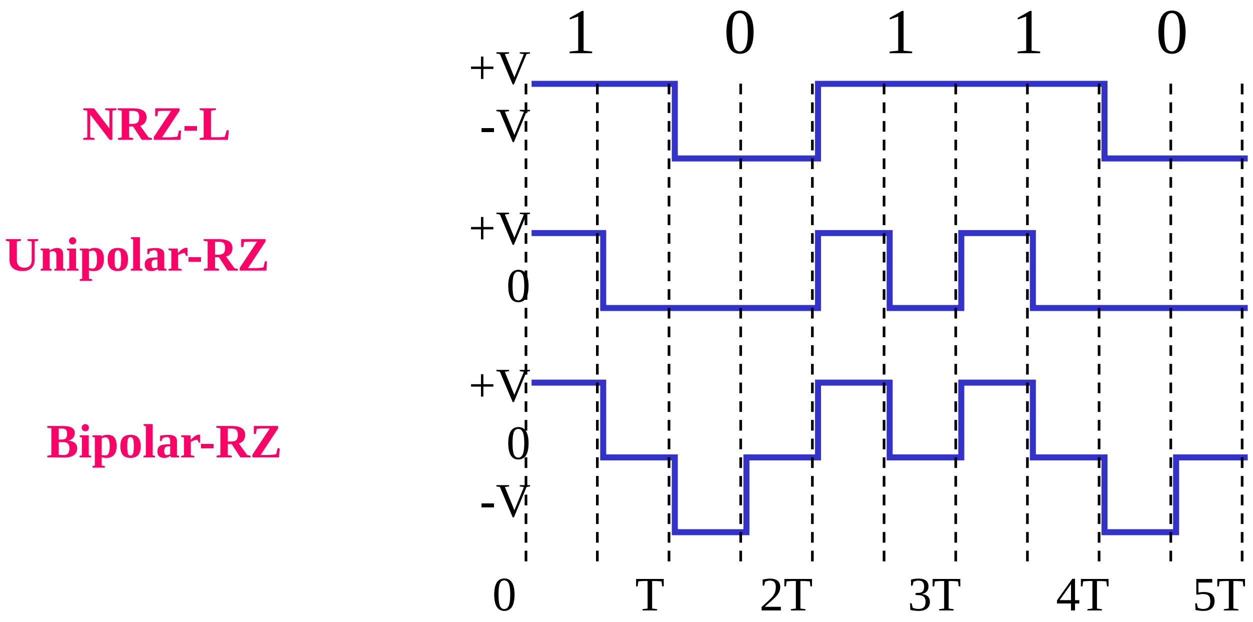
received wave
y(t)=d(t)+n(t)

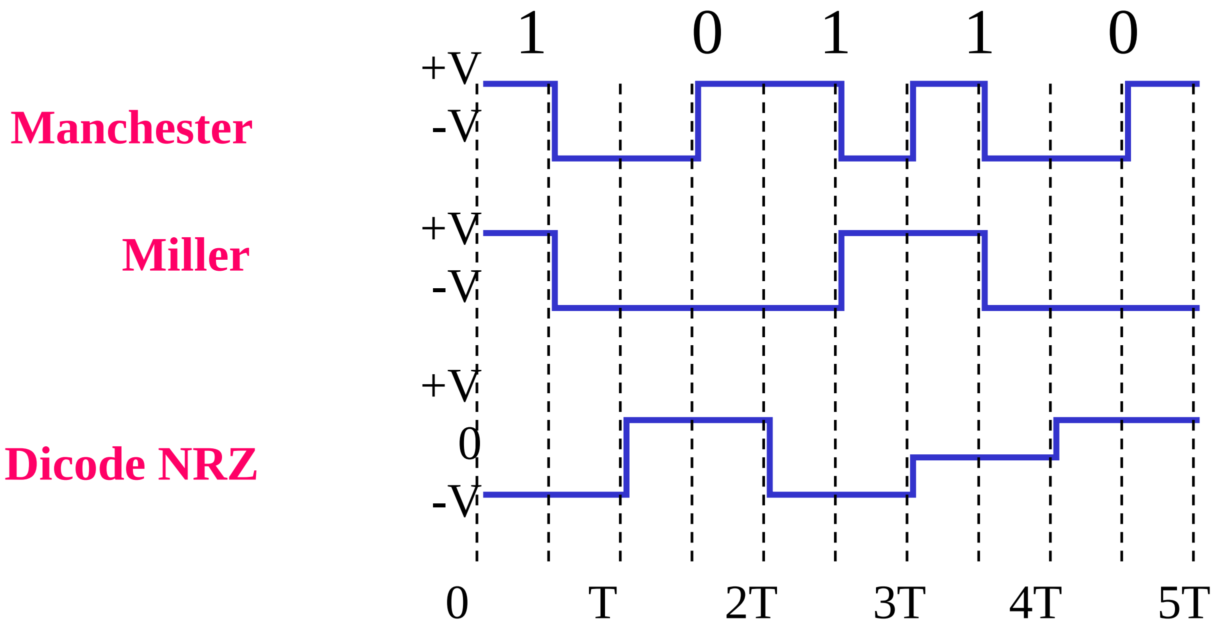


Bentuk gelombang/sinyal PCM

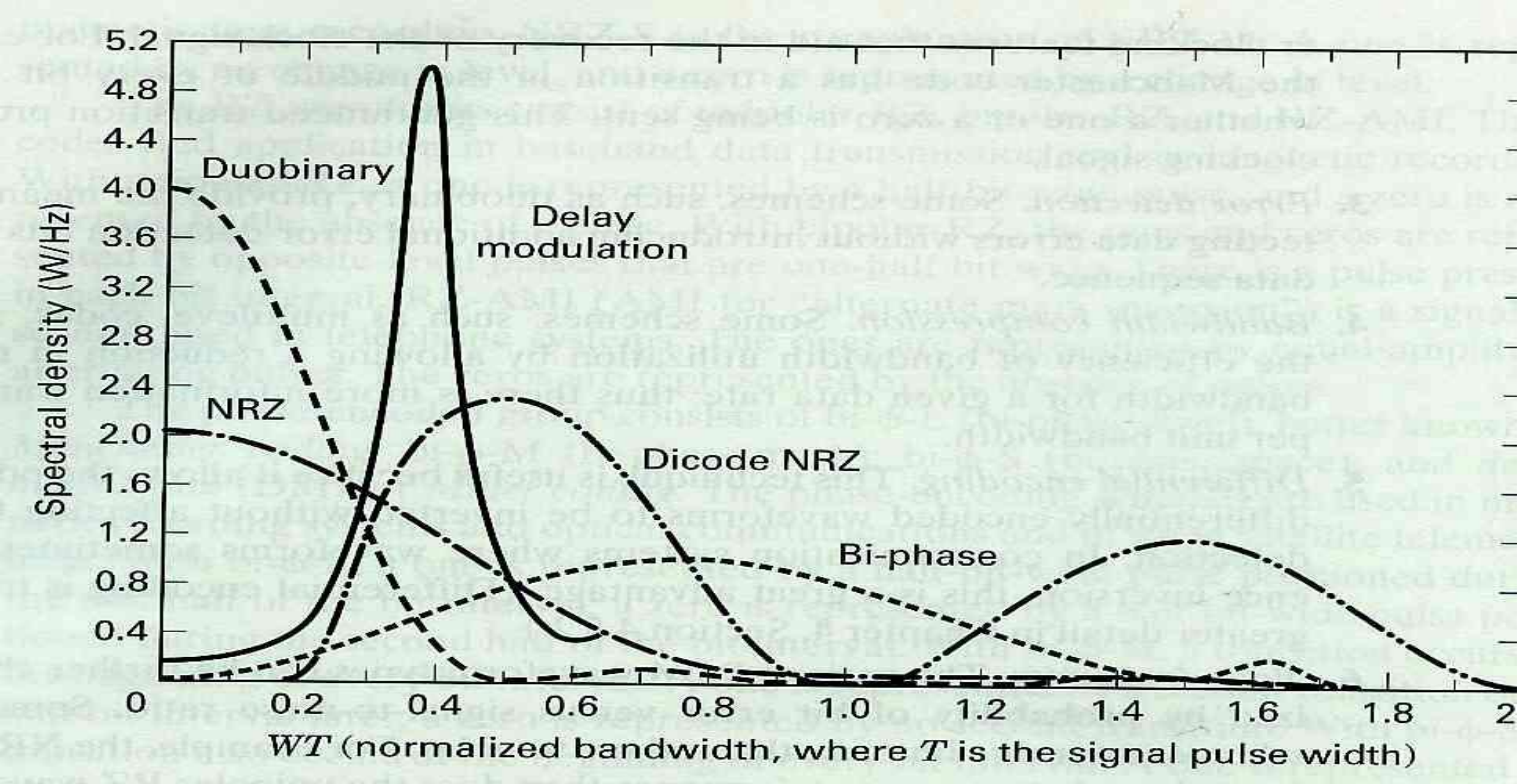
- NonReturn-to-Zero (NRZ)
- Return-to-Zero (RZ)

- Phase encoded
- Multilevel binary





Spectrum sinyal PCM



Introduction : Analog modulation and digital modulation

- **Both** analog and digital modulation systems **use analog carriers** to transport the information signal.
- In **analog modulation**, the **information is also analog**, whereas with **digital modulation, the information is digital** which could be computer generated data or digitally encoded analog signals.

Introduction to Digital Modulation

Offer **several outstanding advantages over traditional analog** system.

- Ease of processing
- Ease of multiplexing
- Noise immunity

Applications:

Low speed voice band data comm. modems
High speed data transmission systems
Digital microwave & satellite comm. systems
Mobile *communication systems*

Important Criteria

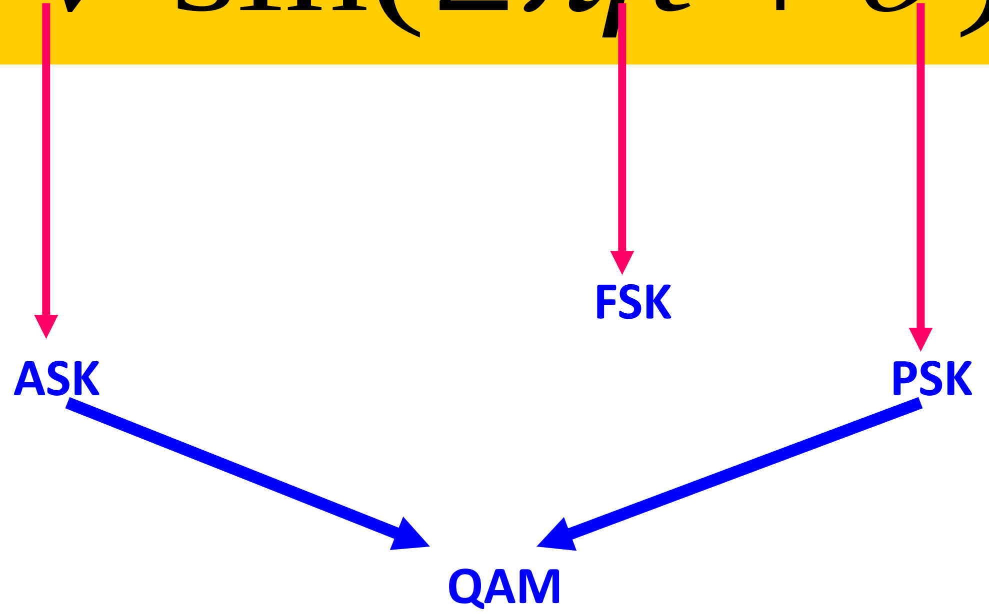
1. **High spectral efficiency**
2. **High power efficiency**
3. **Robust to multipath**
4. **Low cost and ease of implementation**
5. **Low carrier-to-co channel interference ratio**
6. **Low out-of-band radiation**

Cont'd…

7. Constant or near constant envelop
8. Bandwidth Efficiency
   - Ability to accommodate data within a limited bandwidth
   - Tradeoff between data rate and pulse width
9. Power Efficiency
   - To preserve the fidelity of the digital message at low power levels.
   - Can increase noise immunity by increasing signal power

Forms of Digital Modulation

$$v(t) = V \sin(2\pi f t + \theta)$$



Forms of Digital Modulation

$$v(t) = V \sin(2\pi f t + \theta)$$

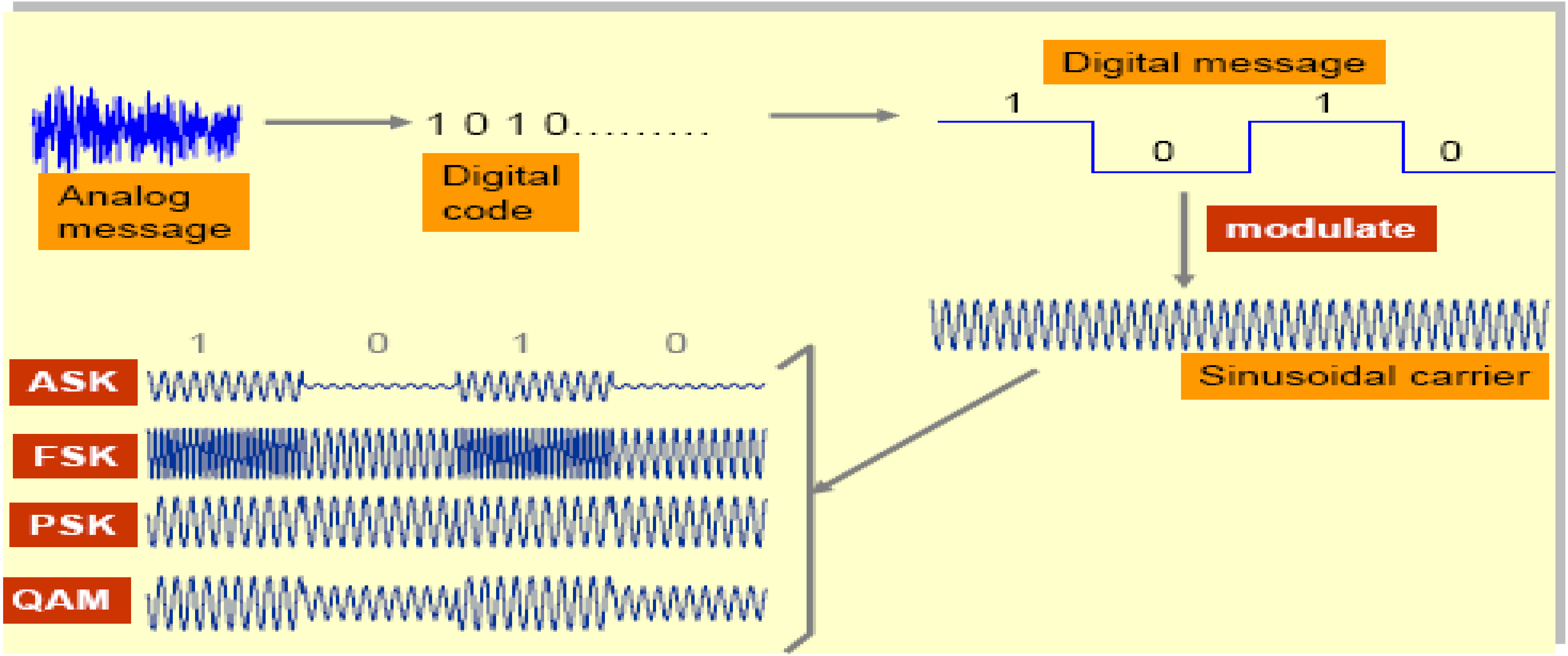
- If the *amplitude, V* of the carrier is varied proportional to the information signal, a digital modulated signal is called **Amplitude Shift Keying (ASK)**
- If the *frequency, f* of the carrier is varied proportional to the information signal, a digital modulated signal is called **Frequency Shift Keying (FSK)**

Cont'd…

- If the phase, θ of the carrier is varied proportional to the information signal, a digital modulated signal is called Phase Shift Keying (PSK)

- If both the amplitude and the phase, θ of the carrier are varied proportional to the information signal, a digital modulated signal is called Quadrature Amplitude Modulation (QAM)

Cont'd...


Analog message
1 0 1 0..........
Digital code
Digital message
1
0
1
0
modulate
Sinusoidal carrier
1
0
1
0
ASK
FSK
PSK
QAM

Example 1

For the digital message 1101 1100 1010, sketch the waveform for the following:

a. ASK

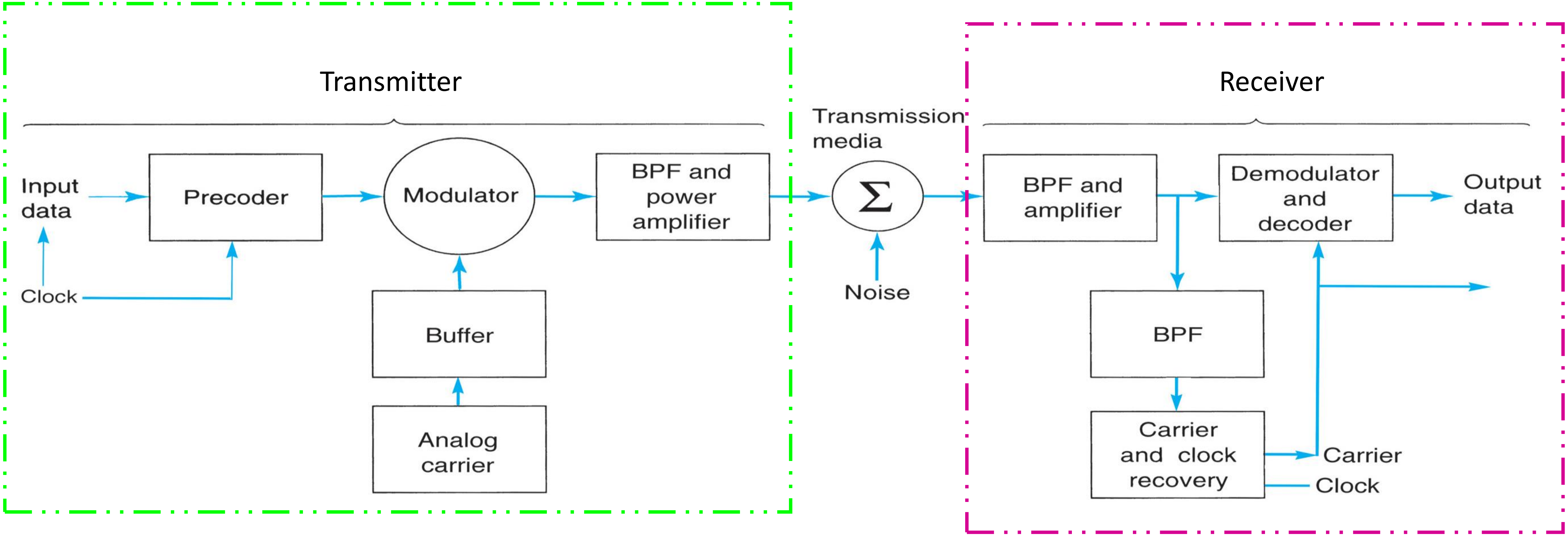
b. FSK

c. PSK

d. QAM

Block Diagram

Simplified block diagram of a digital modulation system



Cont'd…

- Precoder performs level conversion & encodes incoming data into group of bits that modulate an analog carrier.
- Modulated carrier filtered, amplified & transmitted through transmission medium to Rx.
- In Rx, the incoming signals filtered, amplified & applied to the demodulator and decoder circuits which extracts the original source information from modulated carrier.

M-ary Encoding

- It is often advantageous to encode at a level higher than binary where there are more then two conditions possible.
- The number of bits necessary to produce a given number of conditions is expressed mathematically as

$$N = \log_2 M \quad \text{OR} \quad M = 2^N$$

Where N = number of bits necessary

M = number of conditions, level or combinations possible with N bits.

Cont'd…

- Each symbol represents n bits, and has M signal states, where $M = 2^N$.
- Example;

  A digital signal with four possible conditions (voltage levels, frequencies, etc) is an M-ary system with number of possible conditions, M=4.

Example 2

Find the number of voltage levels which can represent an analog signal with

a. 3 Bits
b. 8 bits
c. 12 bits

Ans: M=8,256,4096

Digital Modulation Techniques

- Amplitude Shift Keying (ASK)
- Frequency Shift Keying (FSK)
- Phase Shift Keying (PSK)
- Quadrature Amplitude Modulation (QAM)

Amplitude Shift Keying (ASK)

The simplest digital modulation technique

A binary information signal is directly modulates the amplitude of an analog carrier.

Similar to standard AM except there are only two output amplitudes possible.

Amplitude Shift Keying (ASK)

Changes in amplitude of the carrier signal

- A **binary information signal** directly modulates the amplitude of an analog carrier.
- Sometimes called *Digital Amplitude Modulation (DAM)*

$$v_{ask}(t) = [1 + v_m(t)]\frac{A}{2}\cos(\omega_c t)$$

Where $v_{ask}(t)$ = amplitude shift keying wave

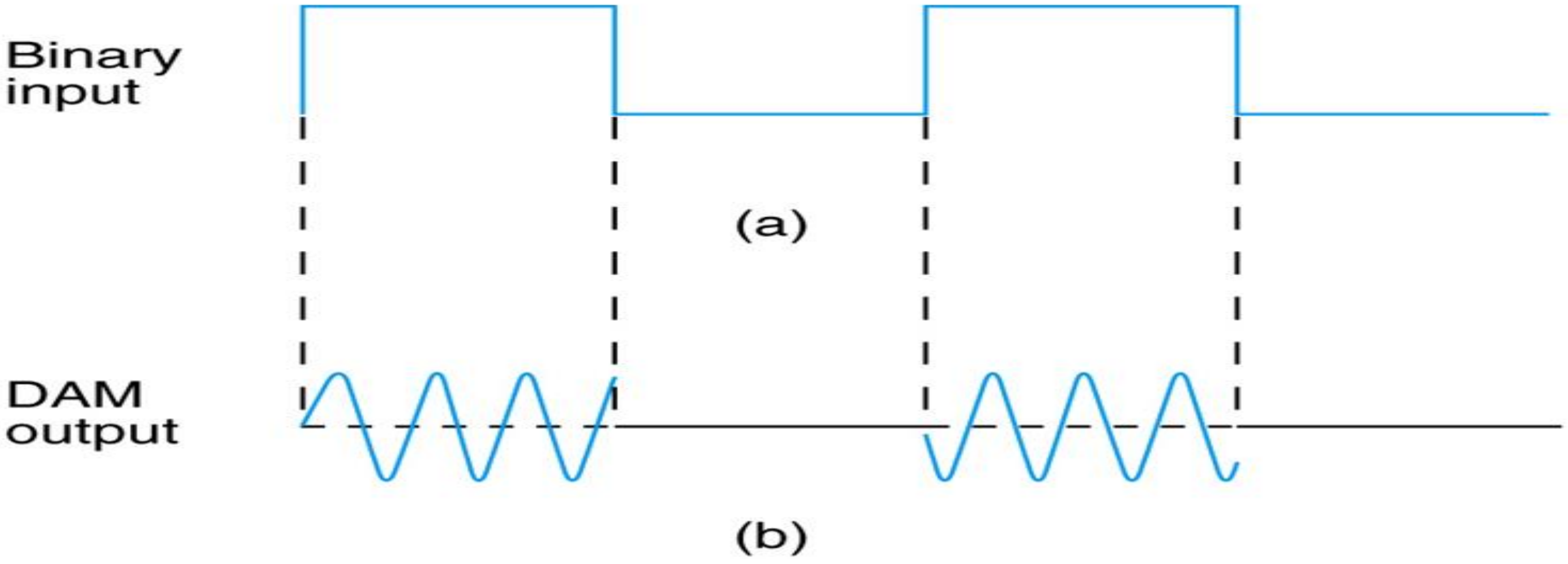
$v_m(t)$ = digital information signal (volt)

A/2 = unmodulated carrier amplitude (volt)

ω_c = analog carrier radian frequency (rad/s)

The modulating signal is the normalized binary waveform

Cont'd...



Digital Amplitude Modulation

$$v_{ask}(t) = \begin{cases} A\cos(\omega_c t) \ \ for \quad \text{logic'1'}, v_m(t) = +1V \\ 0 \qquad for \quad \text{logic'0'}, v_m(t) = -1V \end{cases}$$

Frequency Shift Keying (FSK)

Also the relatively **simple digital modulation technique**

Similar to standard FM except the modulating signal is the **binary signal that varies between 2 discrete voltage levels** rather than a continuously changing analog waveform.

Sometimes called as ***Binary Frequency Shift Keying (BFSK)***

Frequency Shift Keying (FSK)

Changes in the freq of the carrier signal

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

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

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

V_c = peak analog carrier amplitude (volt)

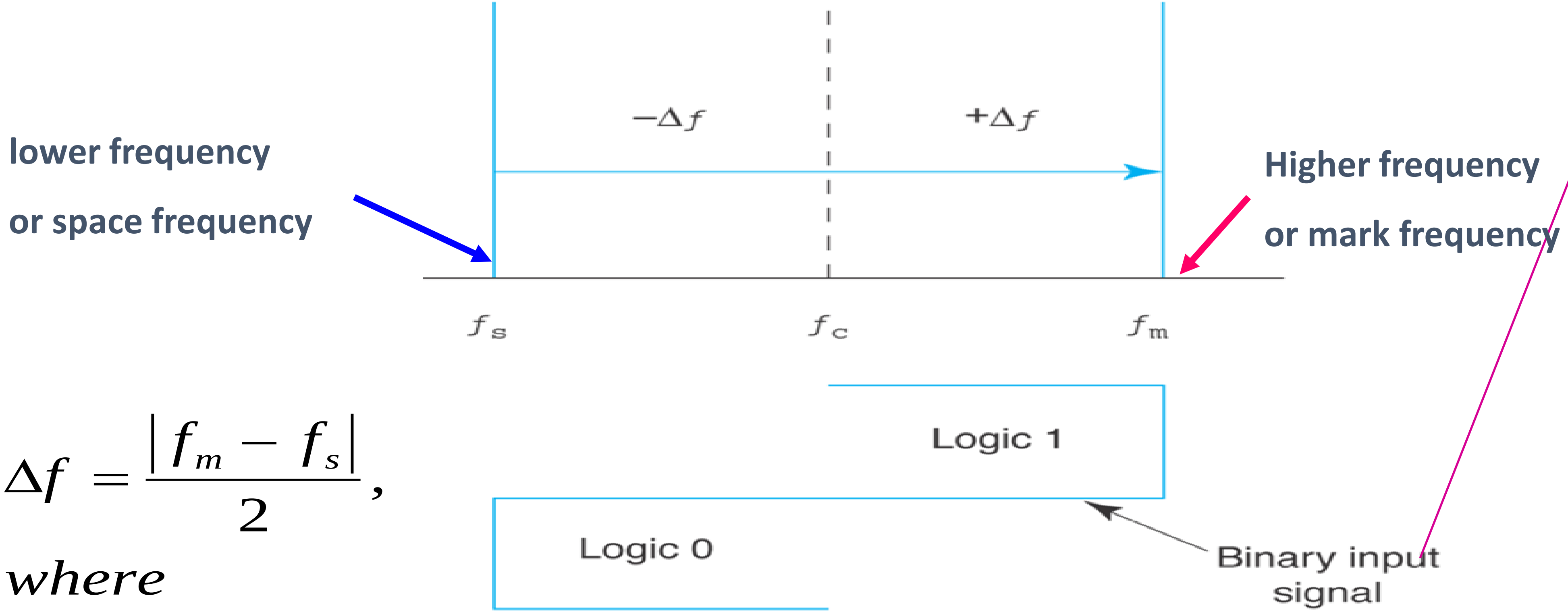
f_c = analog carrier center frequency (Hz)

Δf = peak shift in analog carrier frequency (Hz)

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

The modulating signal is a normalized binary waveform

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



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

where

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

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

Exercise

Prove the following equations to represent binary 1 and 0 respectively.

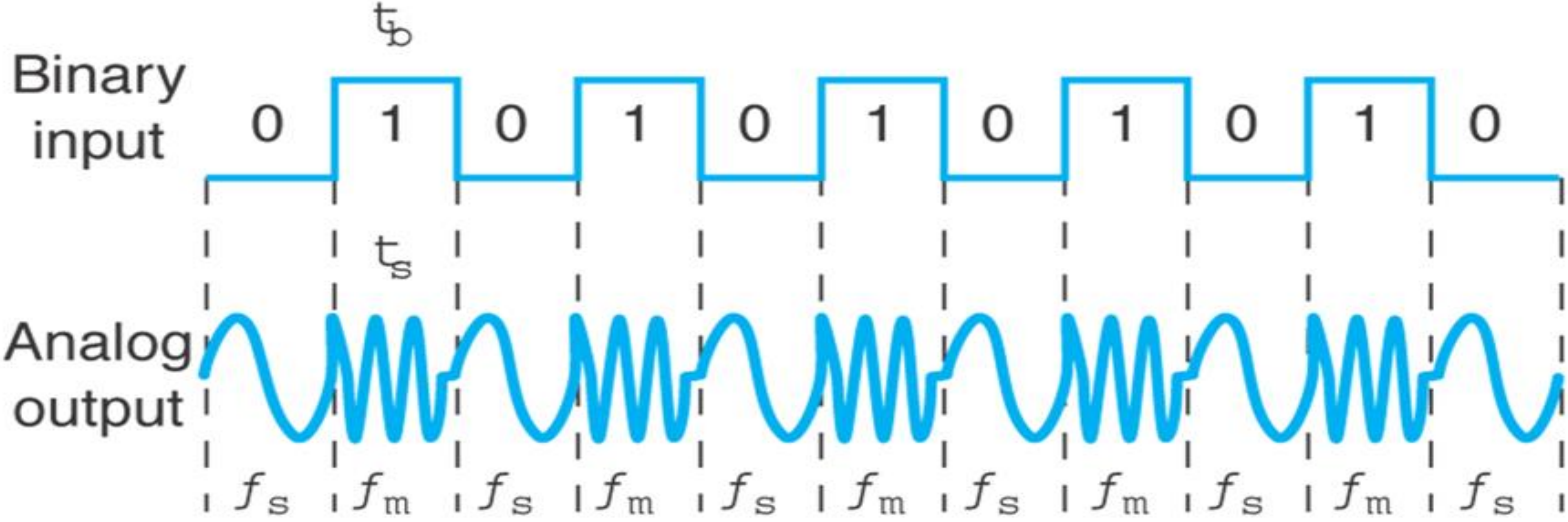
a) $$v_{ask}(t) = [1 + v_m(t)]\frac{A}{2}\cos(\omega_c t)$$

5 marks

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

5 marks

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



f_m , mark frequency; f_s space frequency

Cont'd...

Binary Input	Frequency Output
0	Space (f_s)
1	Mark (f_m)

- **Baud for FSK determined by setting N=1**

$$baud = \frac{f_b}{1} = f_b$$

Example 3

For an FSK signal, given a mark frequency = 49kHz, a space frequency = 51kHz and input bit rate =2kbps.

Determine

(a) The peak frequency deviation

(b) Minimum bandwidth

(c) Baud for a binary FSK signal

Ans: 1kHZ,6kHz,2000

Solution

The peak frequency deviation

$$\Delta f = \frac{|49kHz - 51kHz|}{2} = 1kHz.$$

Minimum bandwidth

$$B = 2(1000 + 2000) = 6kHz$$

Baud for a binary FSK signal, for FSK,N=1

$$Baud = \frac{2000}{1} = 2000$$

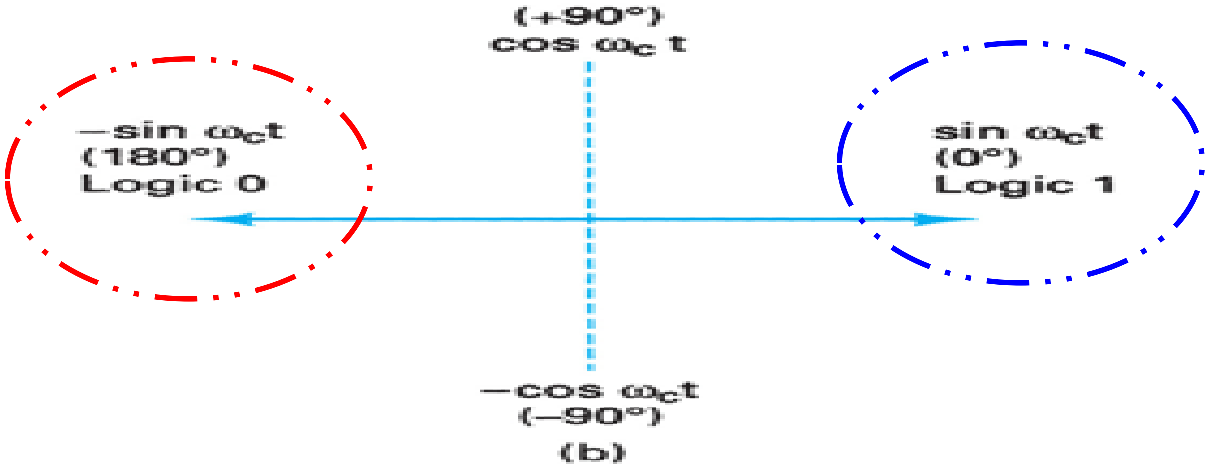
Phase Shift Keying (PSK)

- Another form of angle-modulated, constant amplitude digital modulation.
- **Binary digital signal** input & **limited number of output phases possible.**
- **M-ary digital modulation scheme** with the **number of output phases defined by M.**
- The simplest PSK is Binary Phase-Shift Keying (BPSK)
  - N= 1, M=2
  - Two phases possible for carrier with one phase for logic 1 and another phase for logic 0
  - The output carrier shifts between two angles separated by 180°

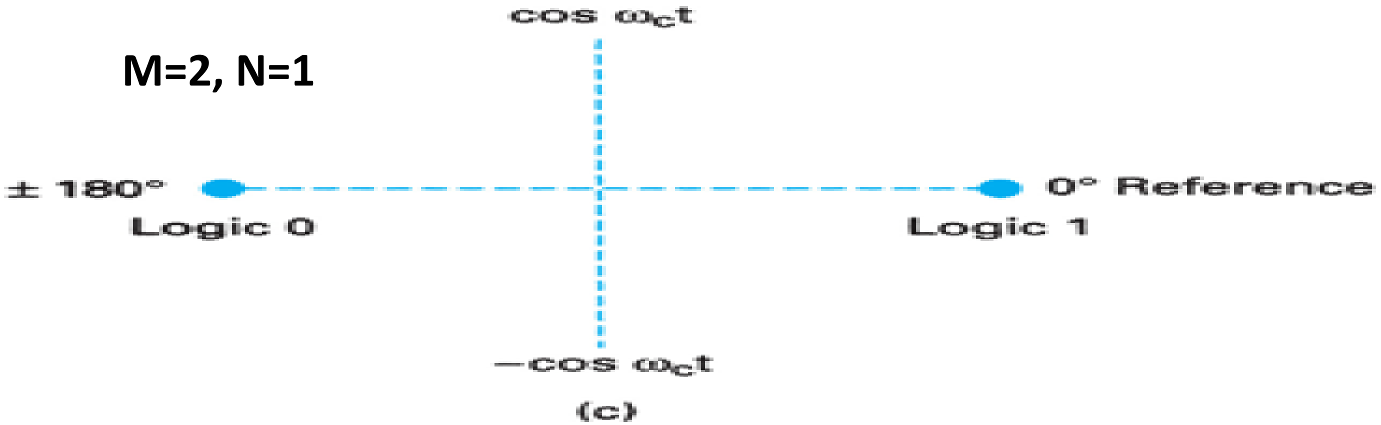
Cont'd...

Binary input	Output phase
Logic 0 Logic 1	180° 0°

(a)



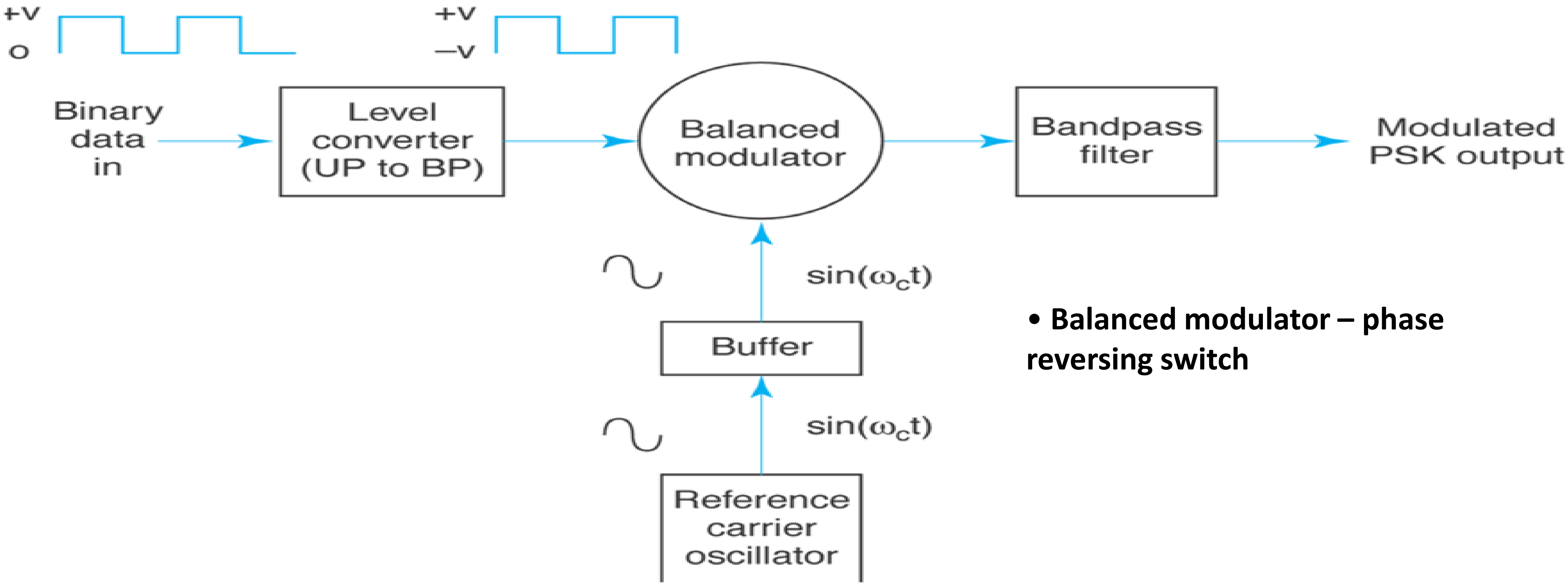
M=2, N=1



a) Truth Table   b) Phasor Diagram   c) Constellation Diagram

Cont'd...

BPSK Transmitter



- **Balanced modulator – phase reversing switch**

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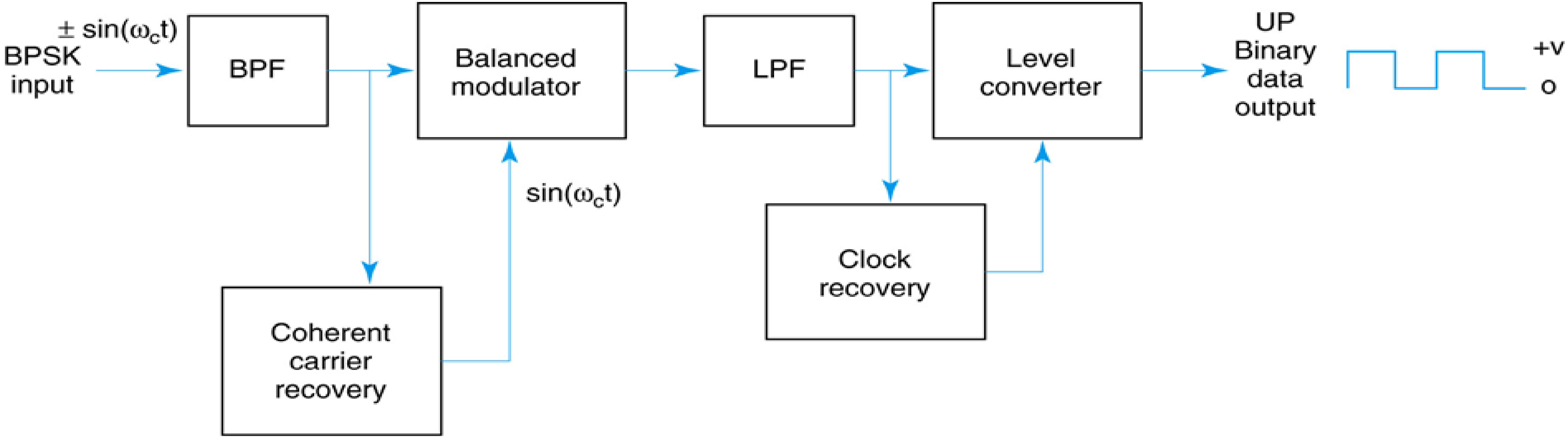
BPSK Receiver



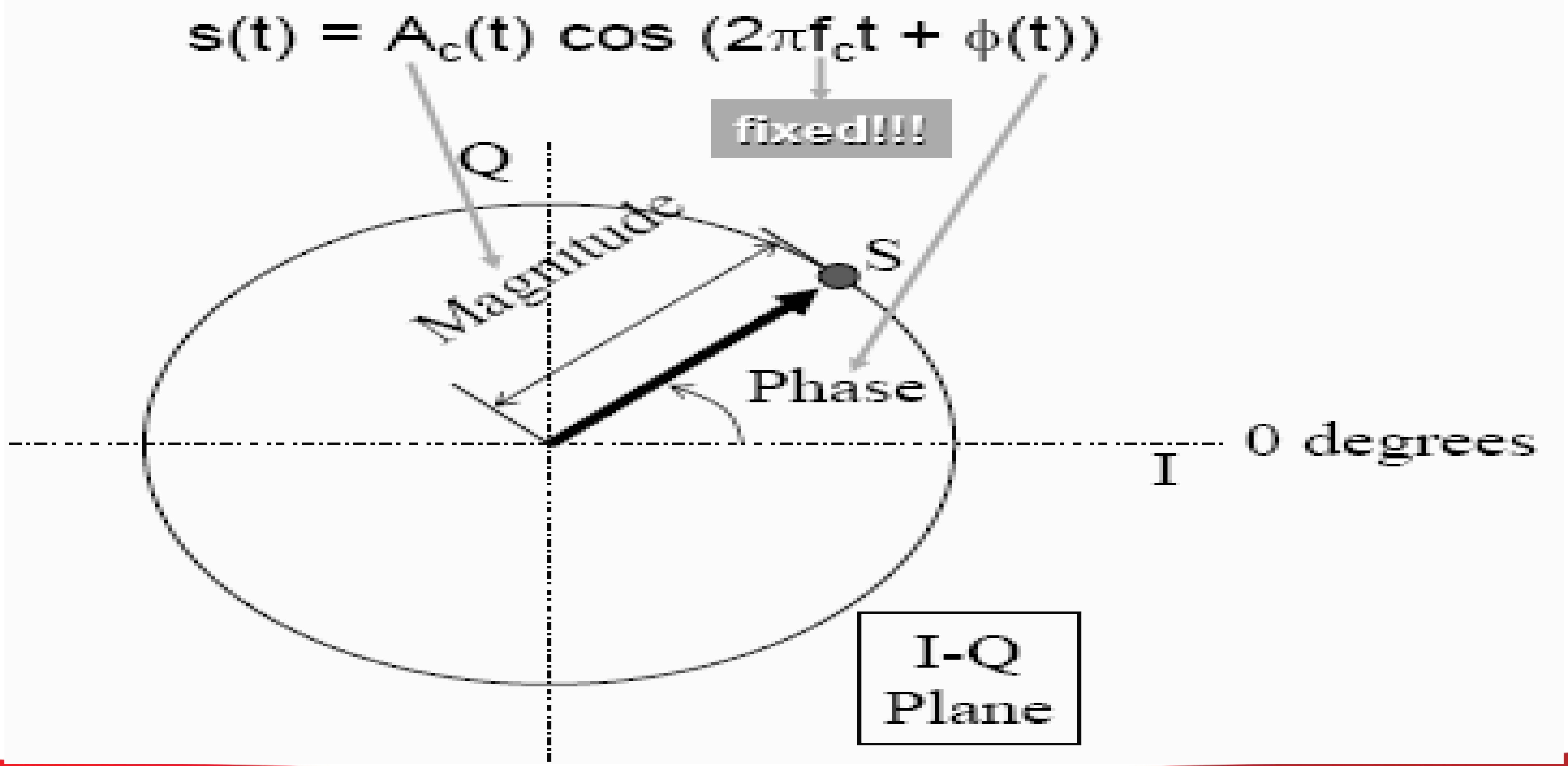
CONSTELLATION DIAGRAM

Definition : A graphical representation of the complex envelope of each possible symbol state.

- The **x-axis represents the in-phase** component and the **y-axis the quadrature component** of the complex envelope

- The **distance between signals** on a constellation diagram **relates to how different the modulation waveforms are and how easily a receiver can differentiate between them.**

Cont'd...

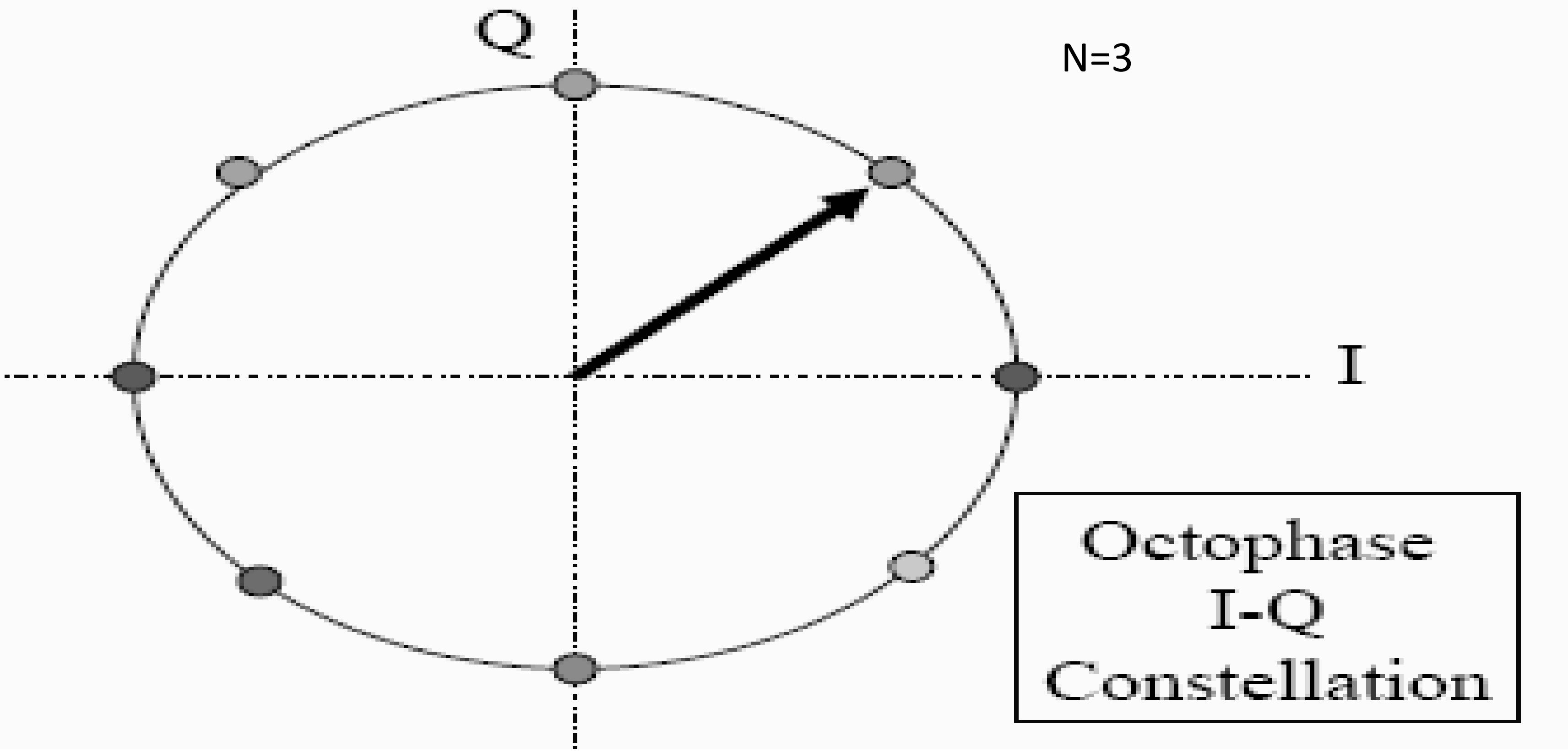


s(t) = Ac(t) cos (2πfct + φ(t))
fixed!!!
Q
Magnitude
S
Phase
0 degrees
I
I-Q Plane

Cont'd...

M=8

N=3

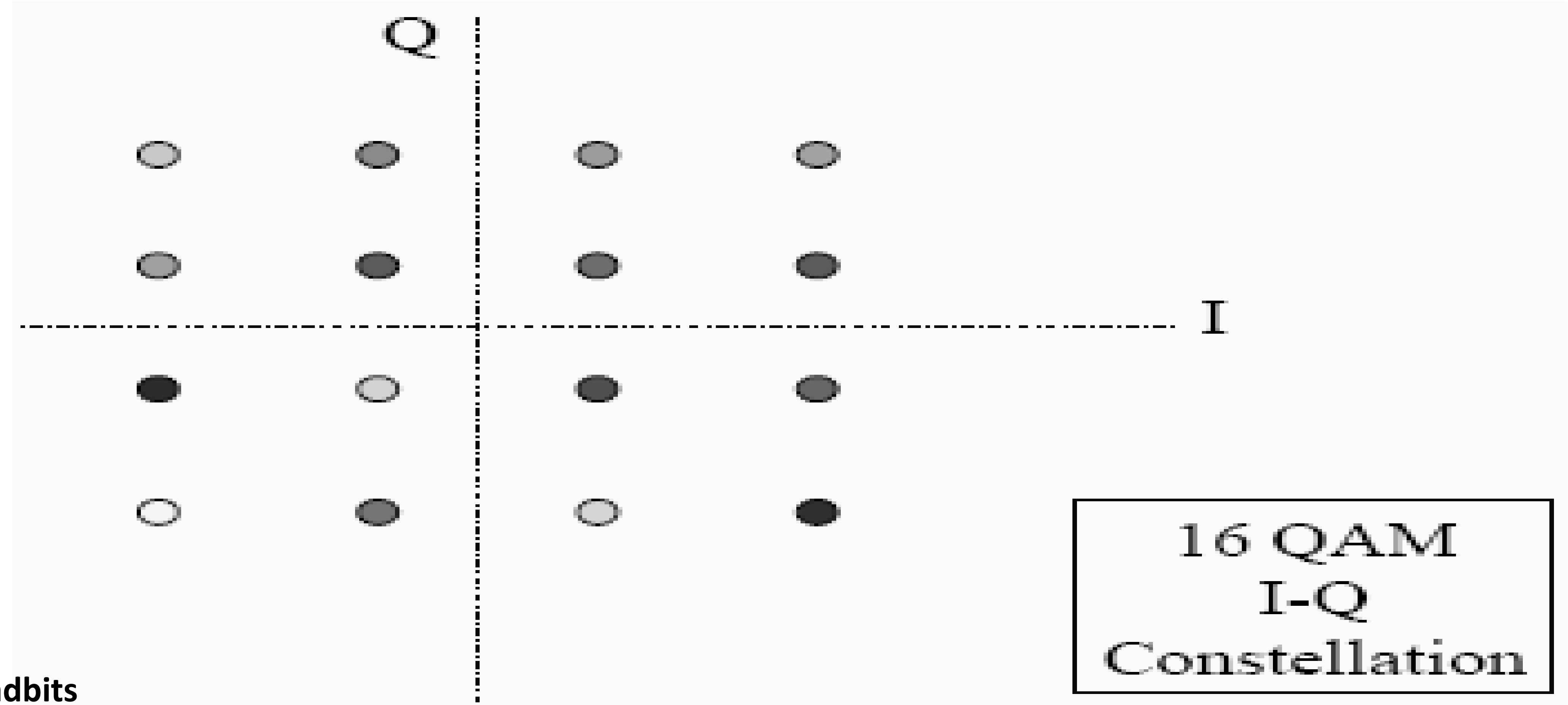


tribits

Quadrature Amplitude Modulation (QAM)

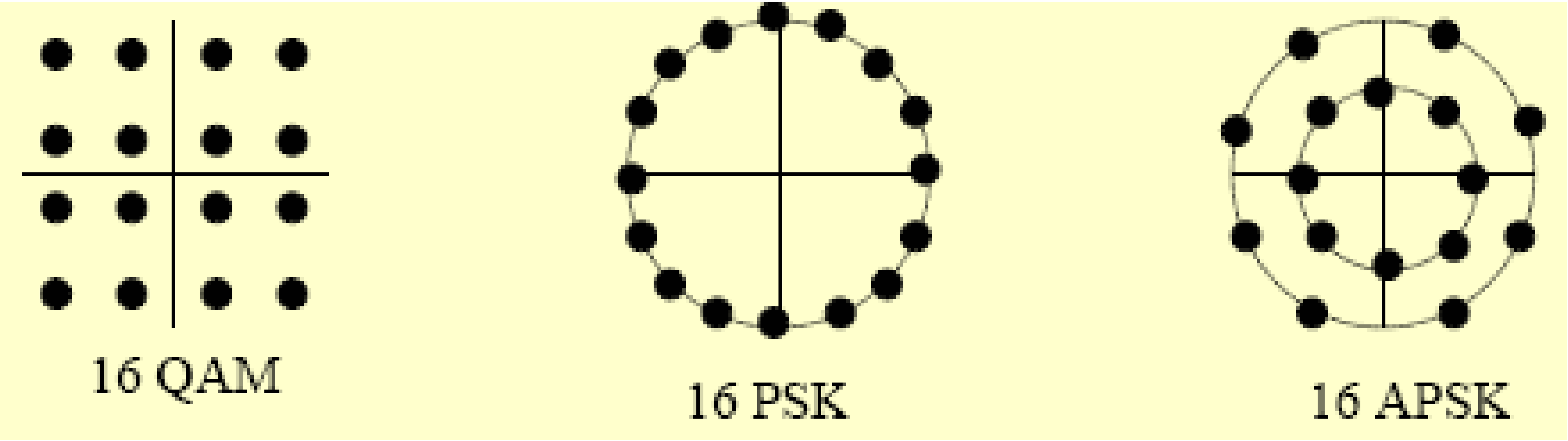
- Combine amplitude and phase-shift keying.
- Similar with PSK except that it is not a constant amplitude signal. Both amplitude and phase change.
- Method of voice band data transmission.
- QAM = 4-PSK

Cont'd...



quadbits

Cont'd...



Both amplitude and phase vary

Constant amplitude, phase varies

Cont’d...

- **Amplitude and phase shift keying can be combined to transmit several bits per symbol.**
  - **Often referred to as linear as they require linear amplification.**
  - **More bandwidth-efficient, but more susceptible to noise.**

- **For M = 4, 16QAM has the largest distance between points, but requires very linear amplification. 16PSK has less stringent linearity requirements, but has less spacing between constellation points, and is therefore more affected by noise.**

- **High level M-ary schemes (such as 64-QAM) are very bandwidth-efficient but more susceptible to noise and require linear amplification**

Bandwidth Efficiency

- Used to compare the performance of one digital modulation technique to another.

$$B\eta = \frac{\text{Transmission bit rate (bps)}}{\text{Minimum bandwidth (Hz)}}$$

CONCLUSION

- To decide which modulation method should be used , we need to make considerations of

  a) Bandwidth
  b) Speed of Modulation
  c) Complexity of Hardware

End of Module 11