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

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

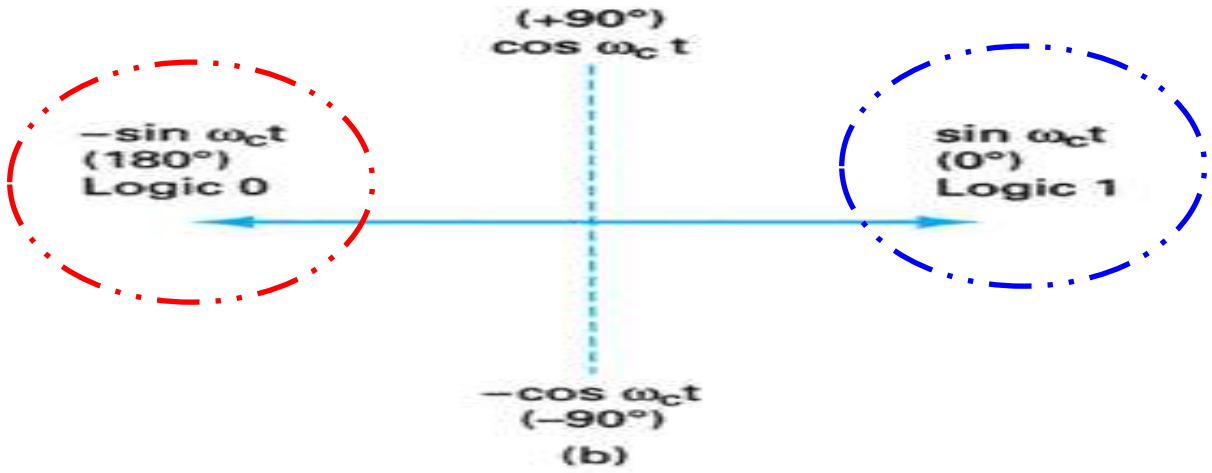
Phase Shift Keying (PSK)

- 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°

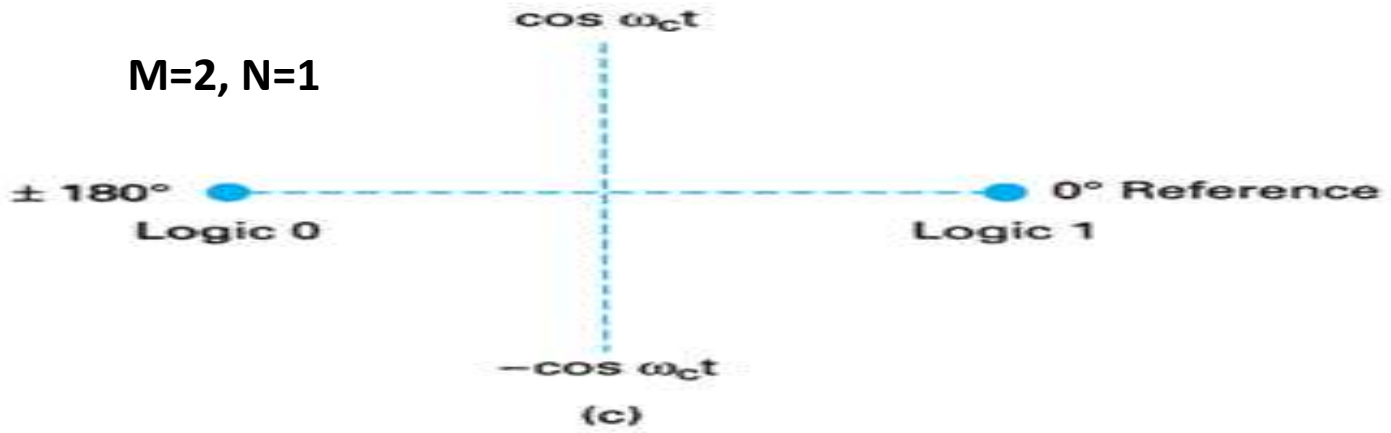
Cont'd...

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

(a)



(b)

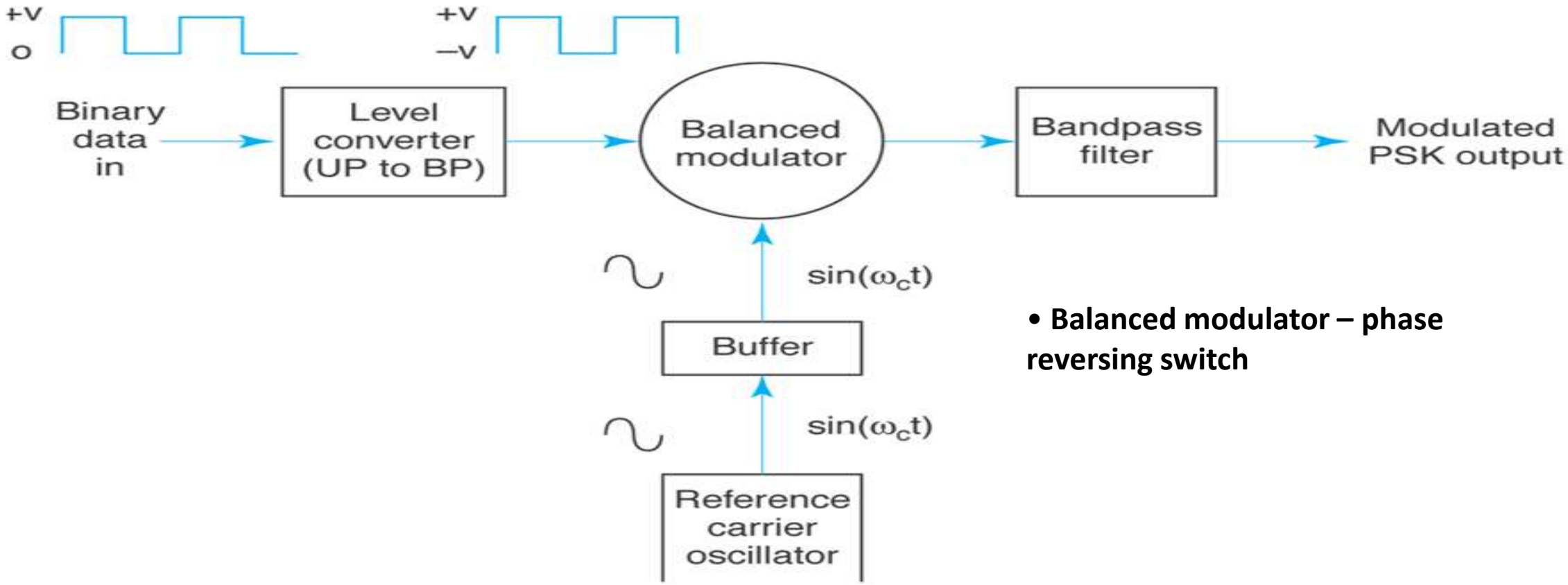


(c)

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

Cont'd...

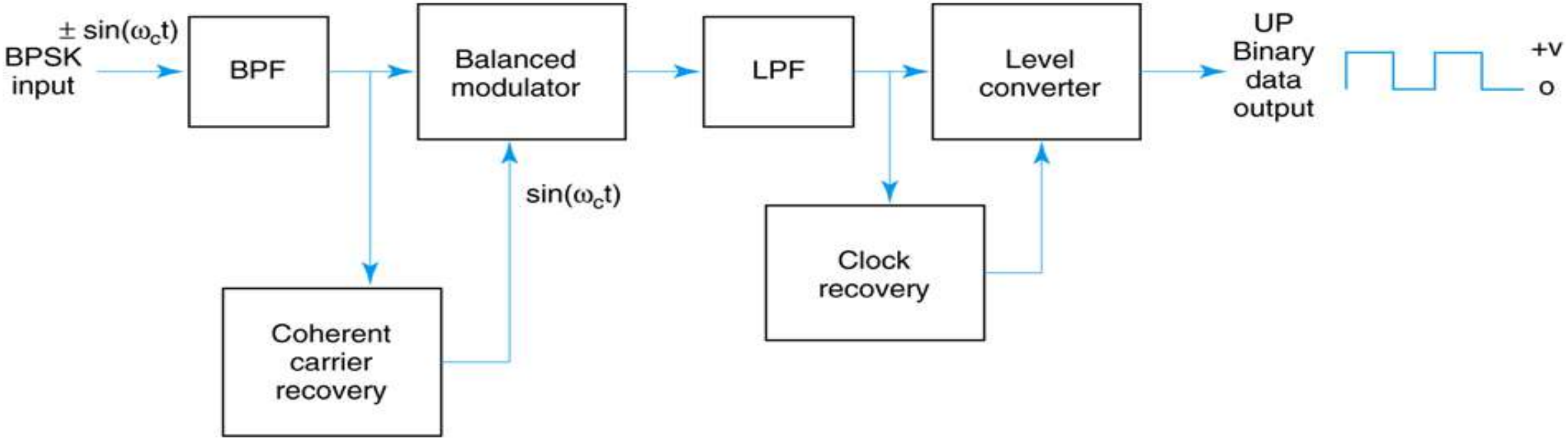
BPSK Transmitter



- **Balanced modulator – phase reversing switch**

Cont'd...

BPSK Receiver



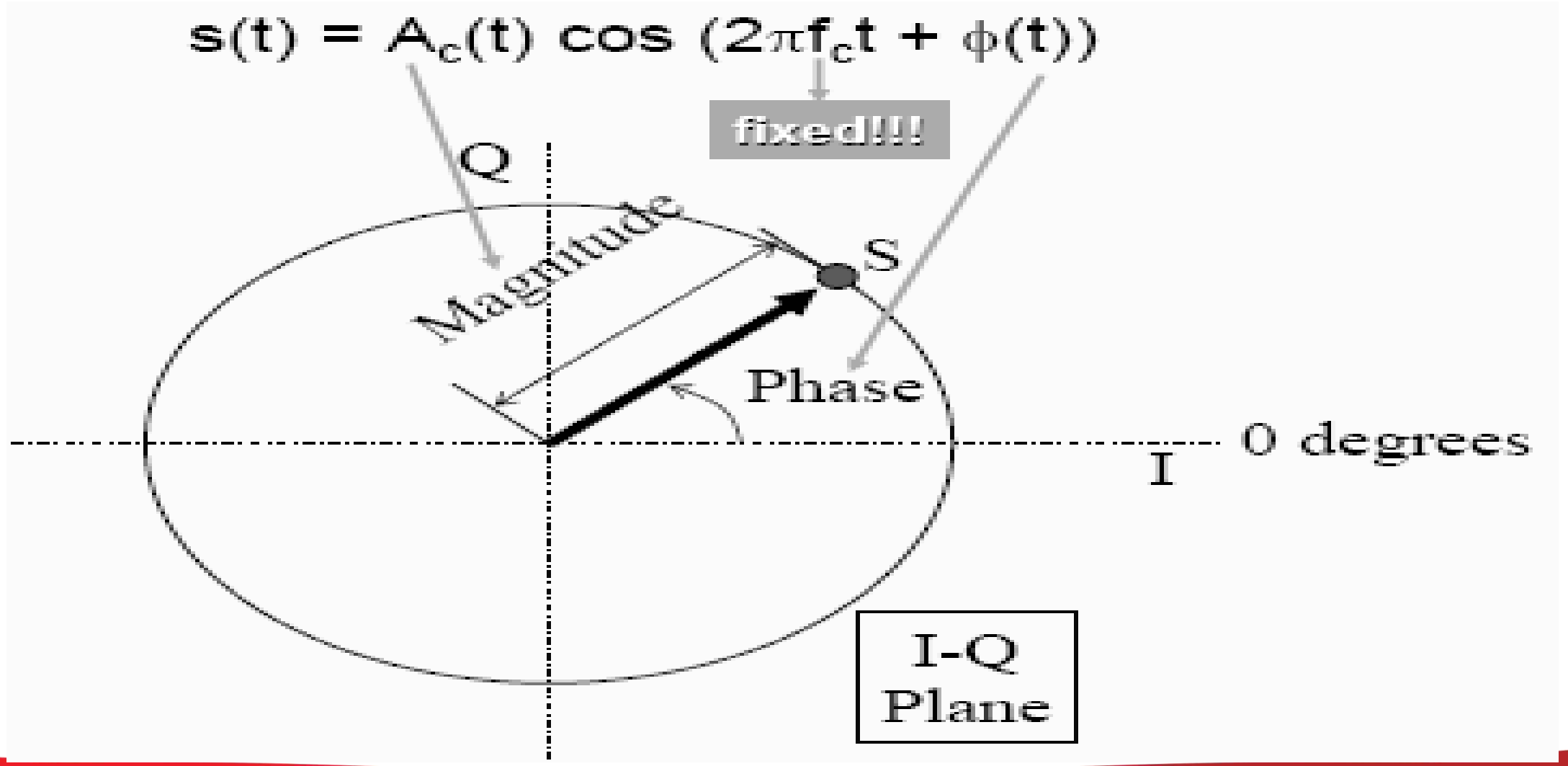
CONSTELLATION DIAGRAM

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.**

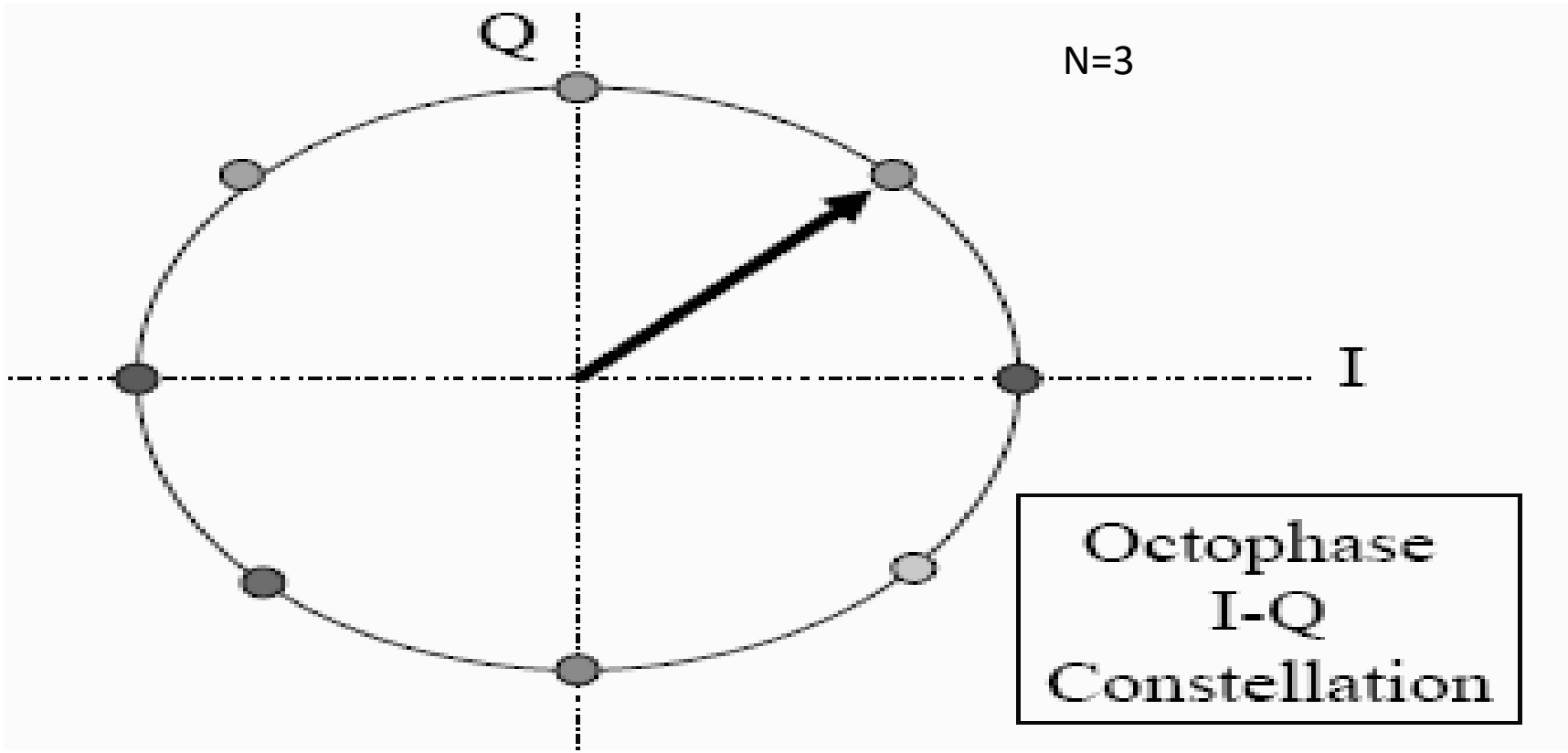
Cont'd...


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

Cont'd...

M=8

N=3

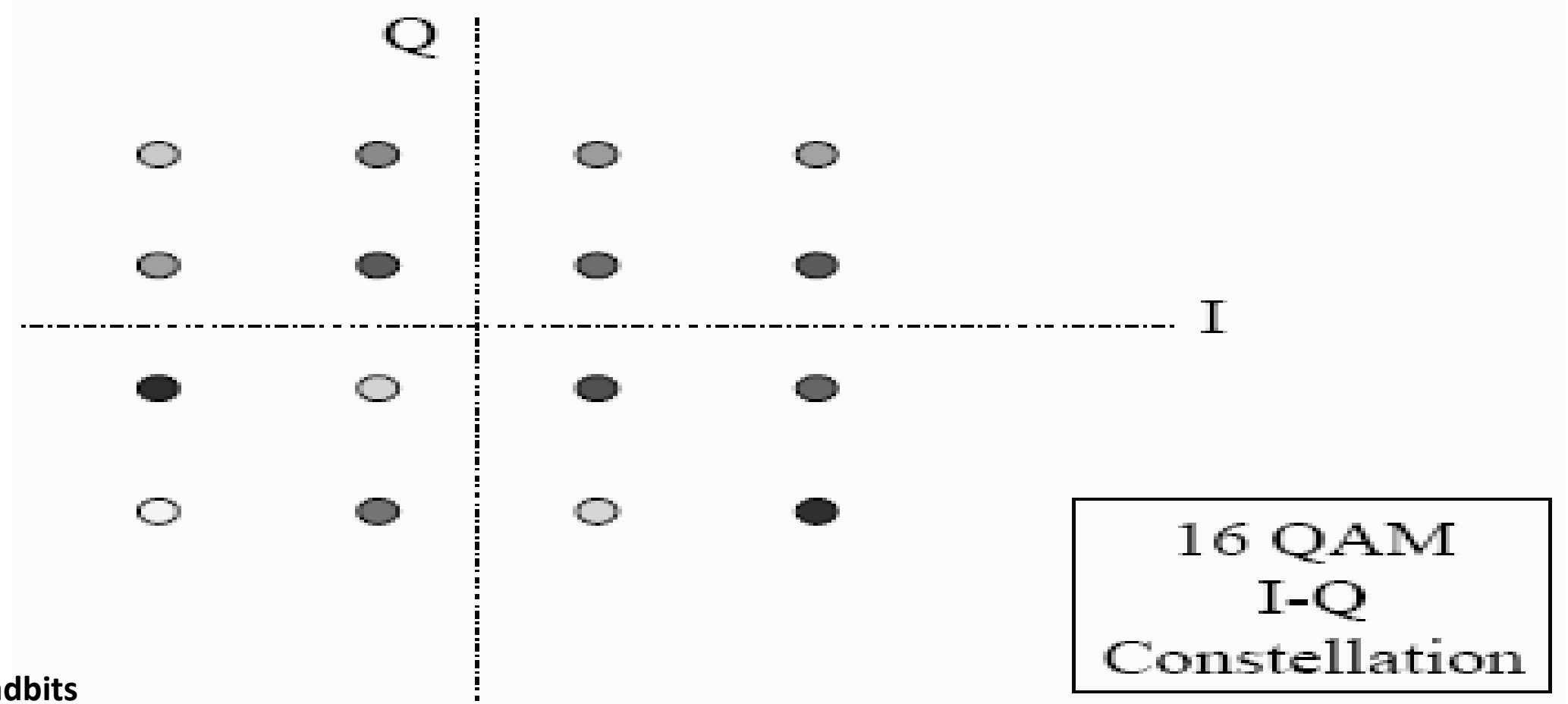


tribits

Quadrature Amplitude Modulation (QAM)

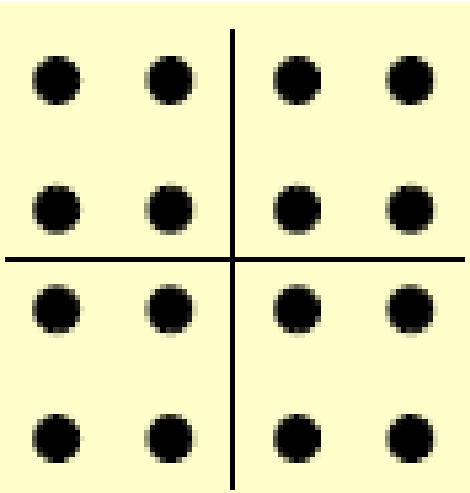
- Combine amplitude and phase-shift keying.
- Similar with PSK except that it is not a constant amplitude signal. Both amplitude and phase change.
- Method of voice band data transmission.
- QAM = 4-PSK

Cont'd...

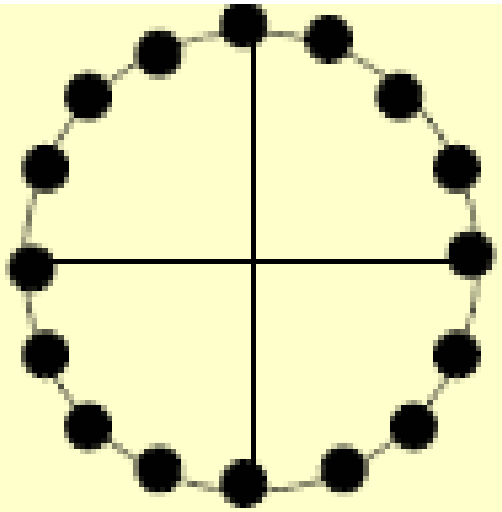


quadbits

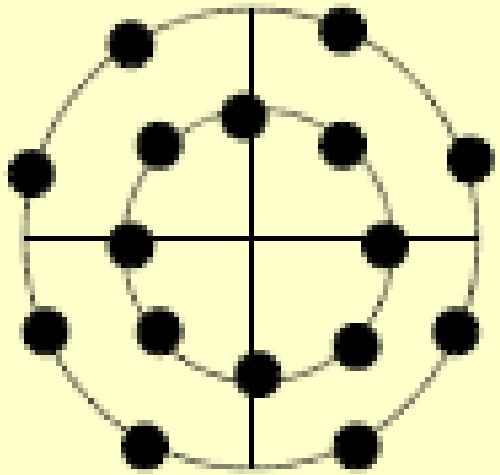
Cont'd...



16 QAM



16 PSK



16 APSK

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