Information Technology

Spring Semester

Mobile and Sensor Networks

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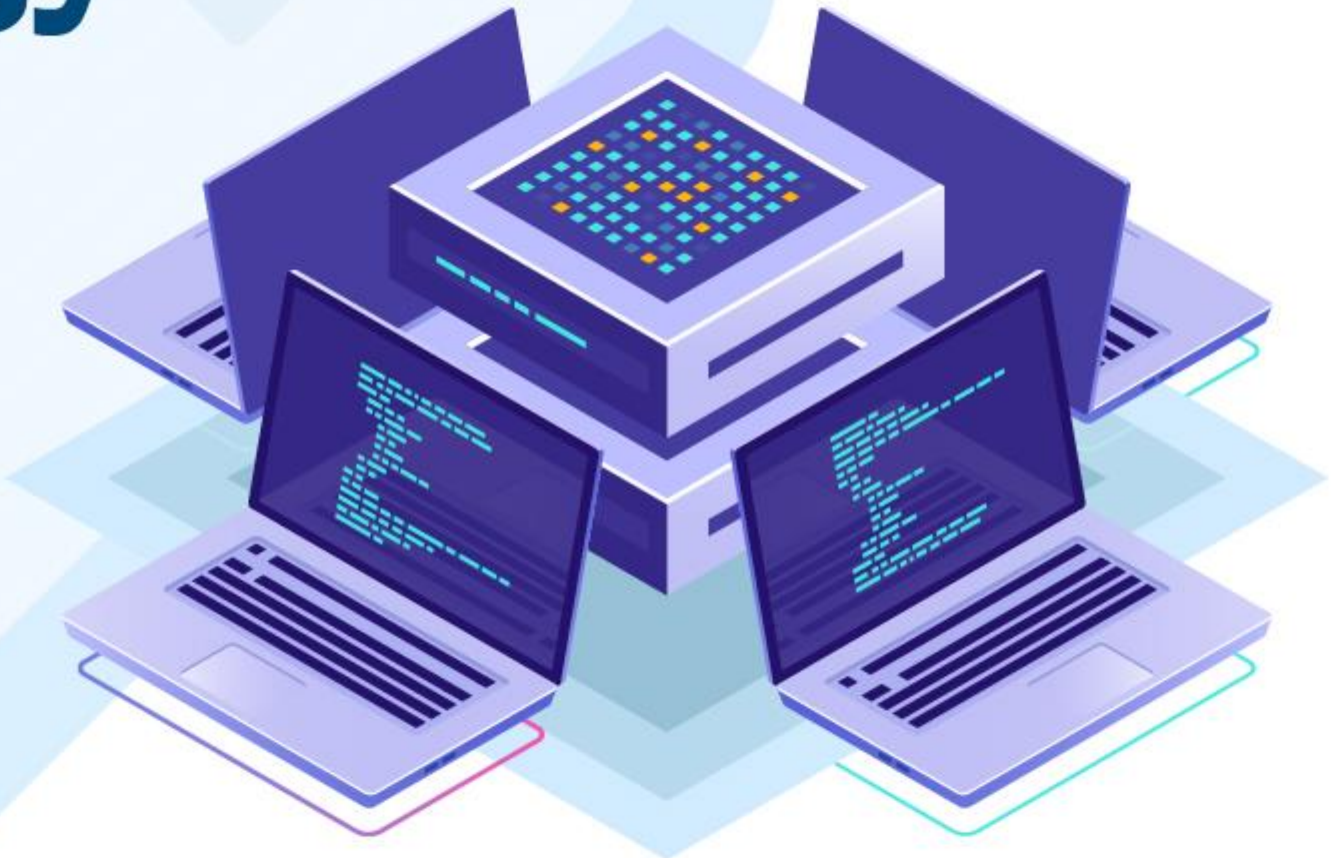
Lec_6



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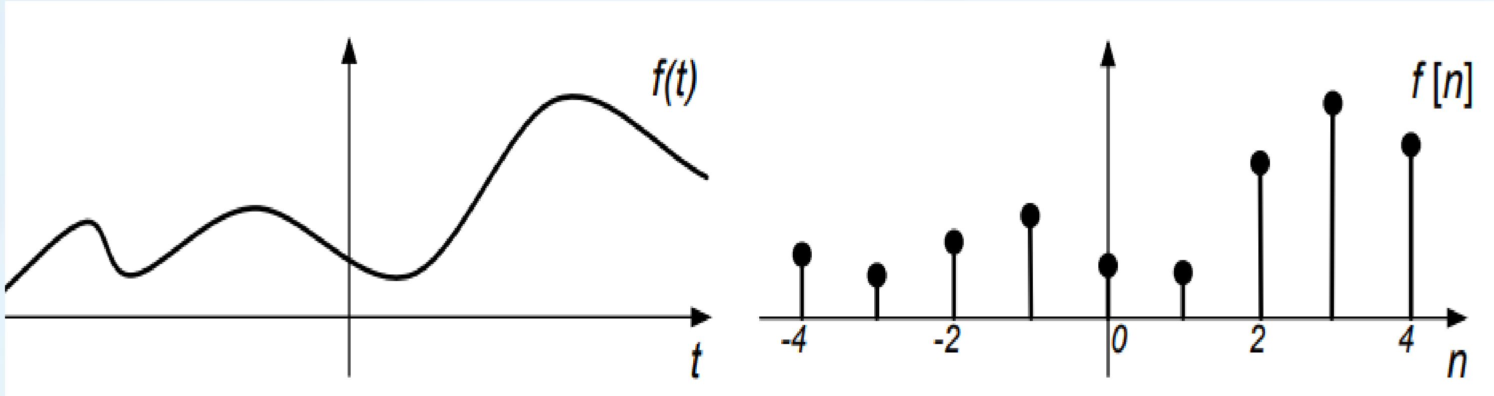
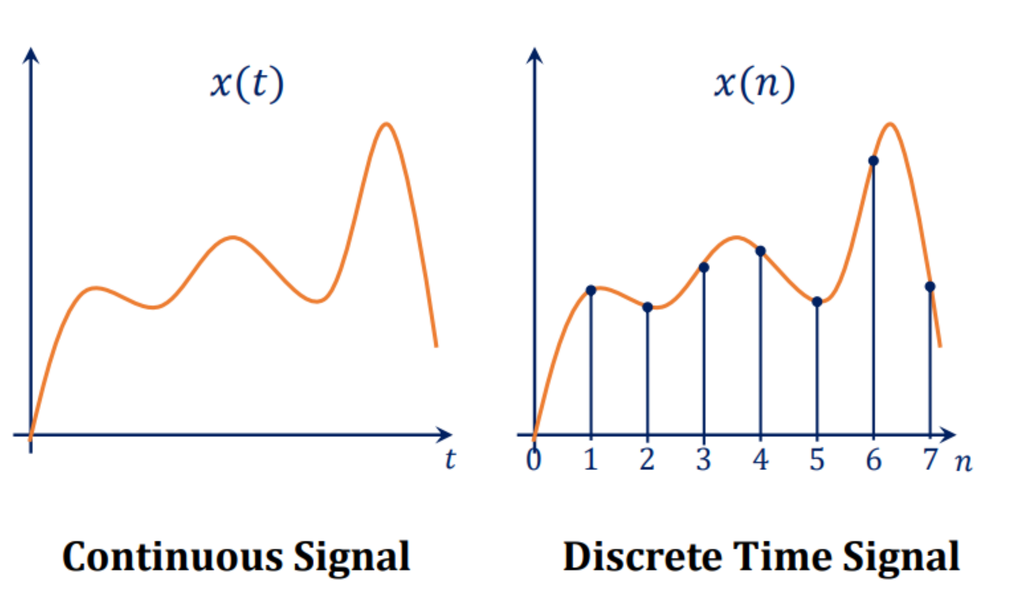
Continuous and Discrete Time Signals

- **Continuous Time Signal**: A signal that is specified for every value of time t .eg audio and video recordings
- **Discrete Time Signal:** A signal that is specified only at discrete points $of\ t = nT$.

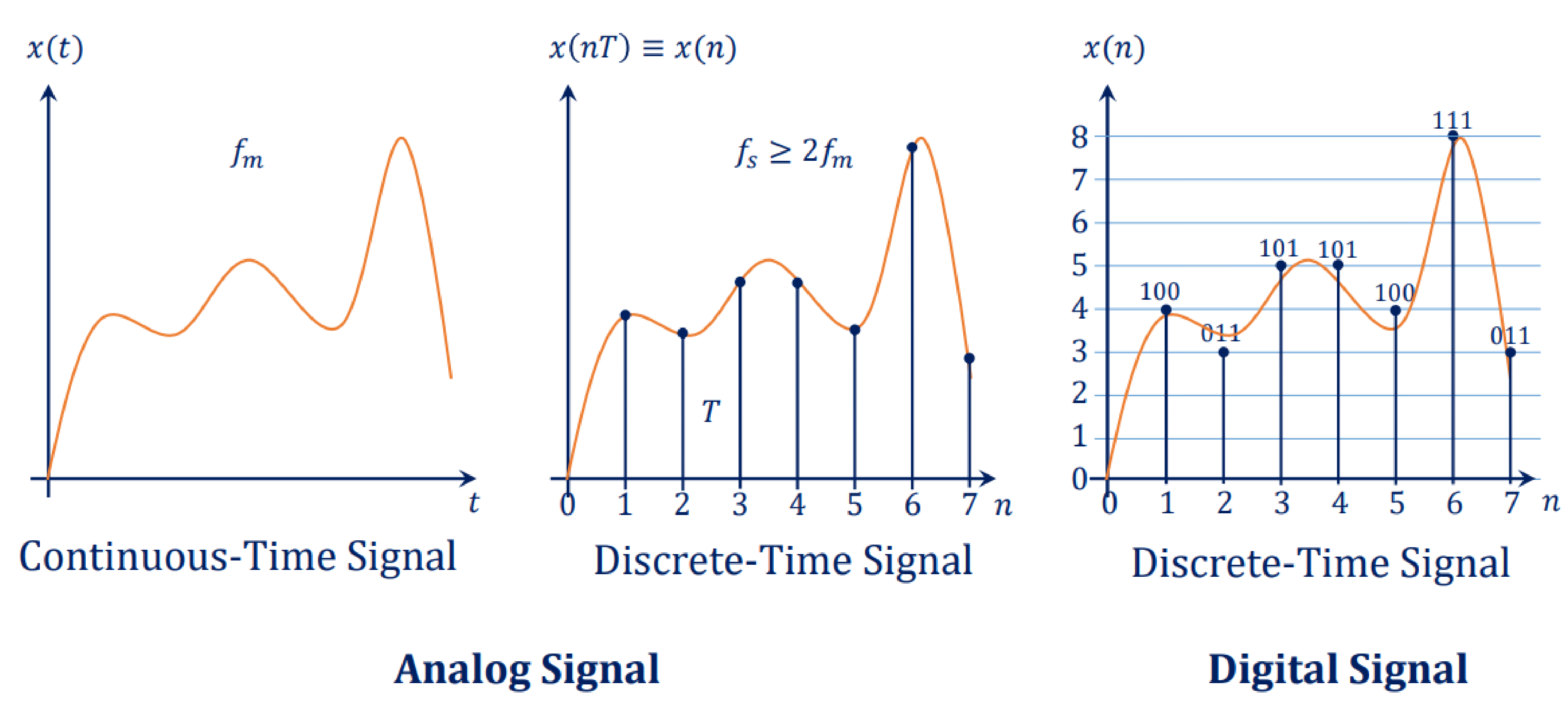




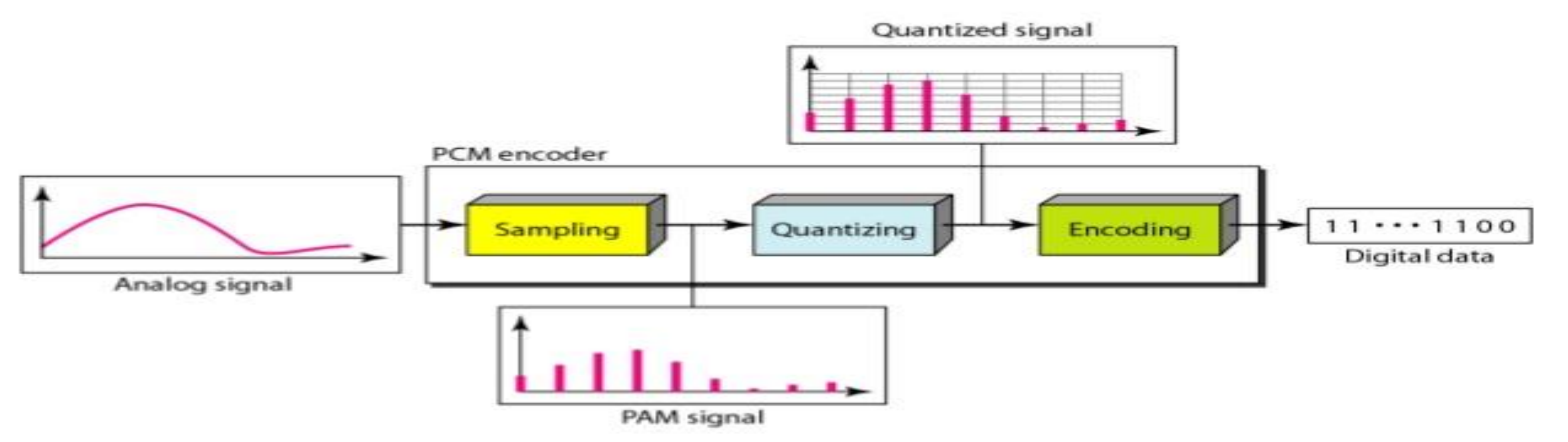
Classification of Signals

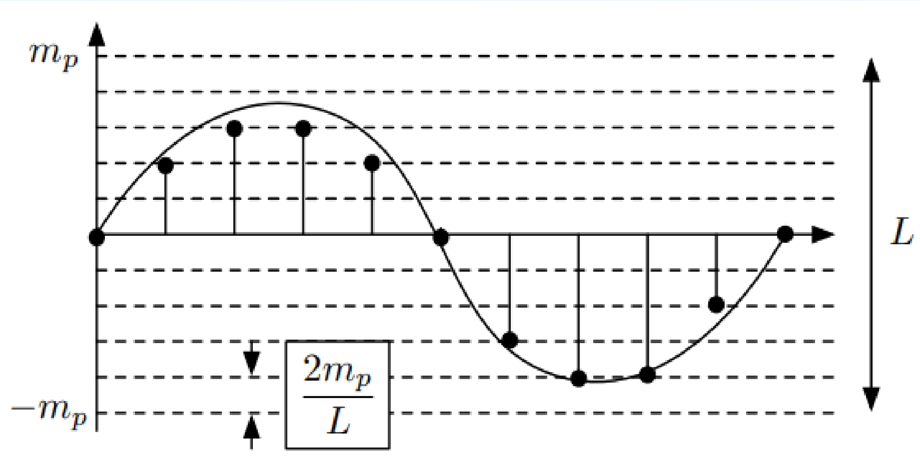
Analogue and Digital

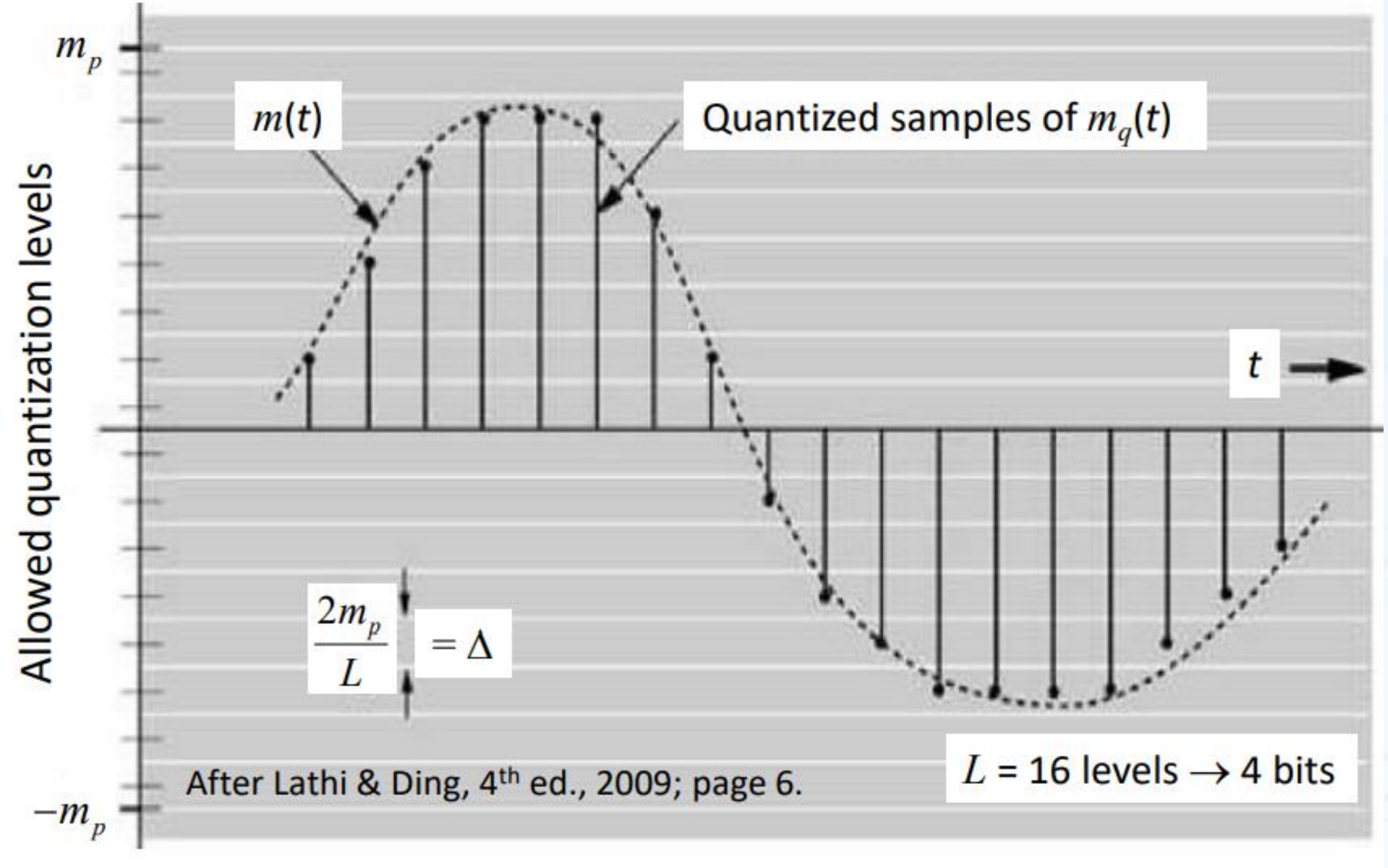
- **Analogue Signal**: A signal whose amplitude can have values in continuous range (values can take on infinite (uncountable) values
- **Digital Signal:** A signal whose amplitude can take only finite number of values.



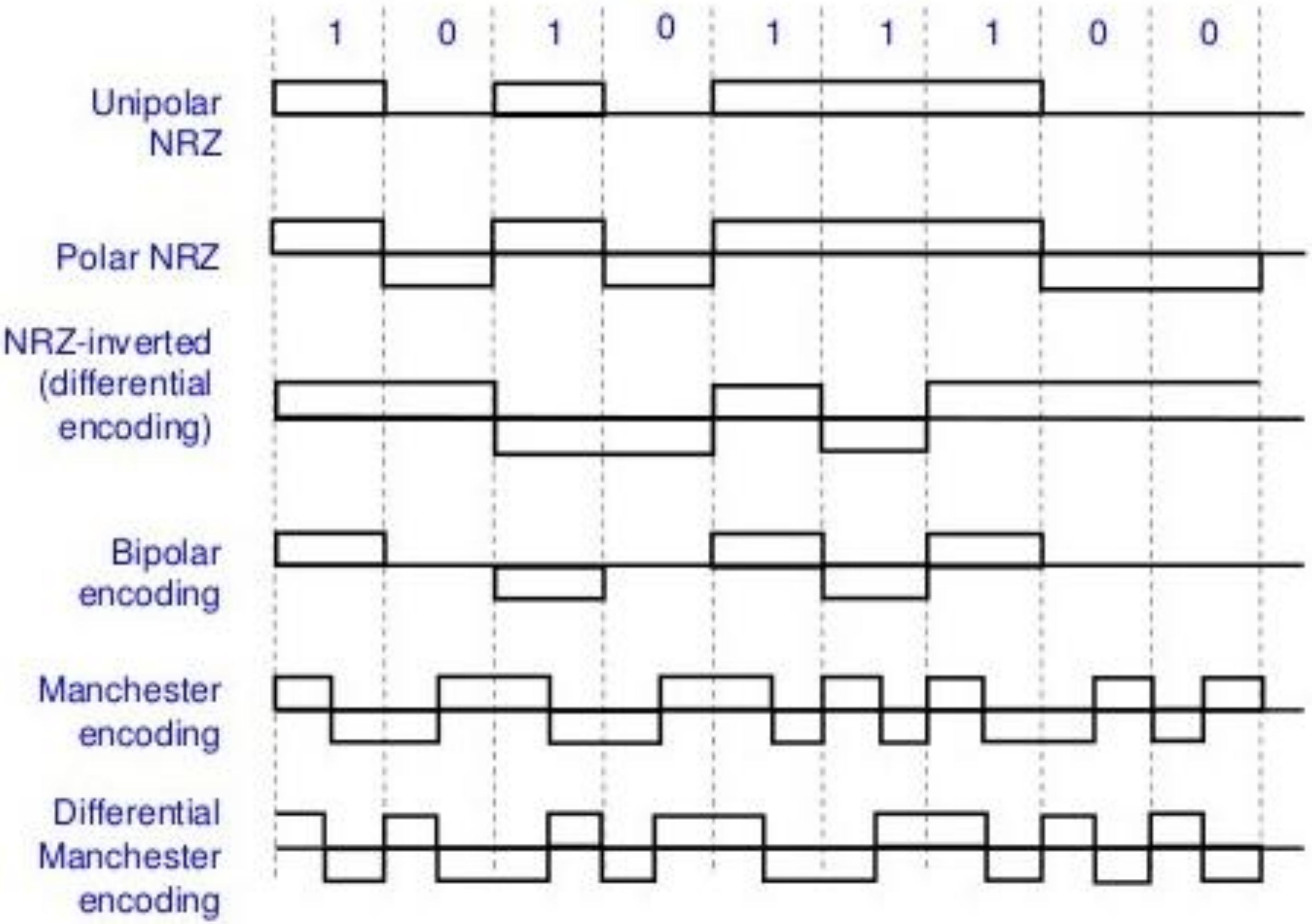
Analog to Digital Converter




m_p
L
$\frac{2m_p}{L}$
$-m_p$

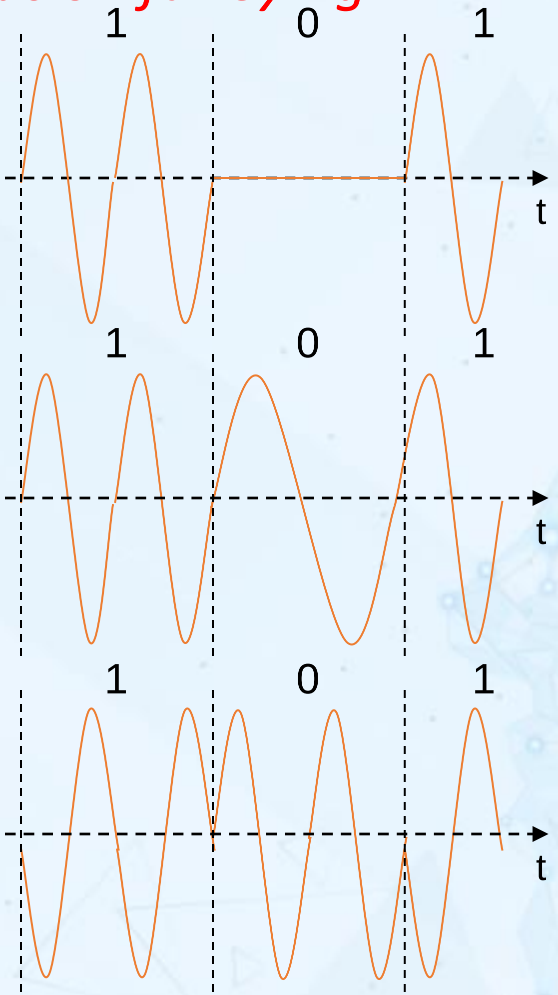

m_p
$m(t)$
Quantized samples of $m_q(t)$
Allowed quantization levels
t
$\frac{2m_p}{L} = \Delta$
After Lathi & Ding, 4th ed., 2009; page 6.
L = 16 levels → 4 bits
$-m_p$

Line coding examples



Digital modulation

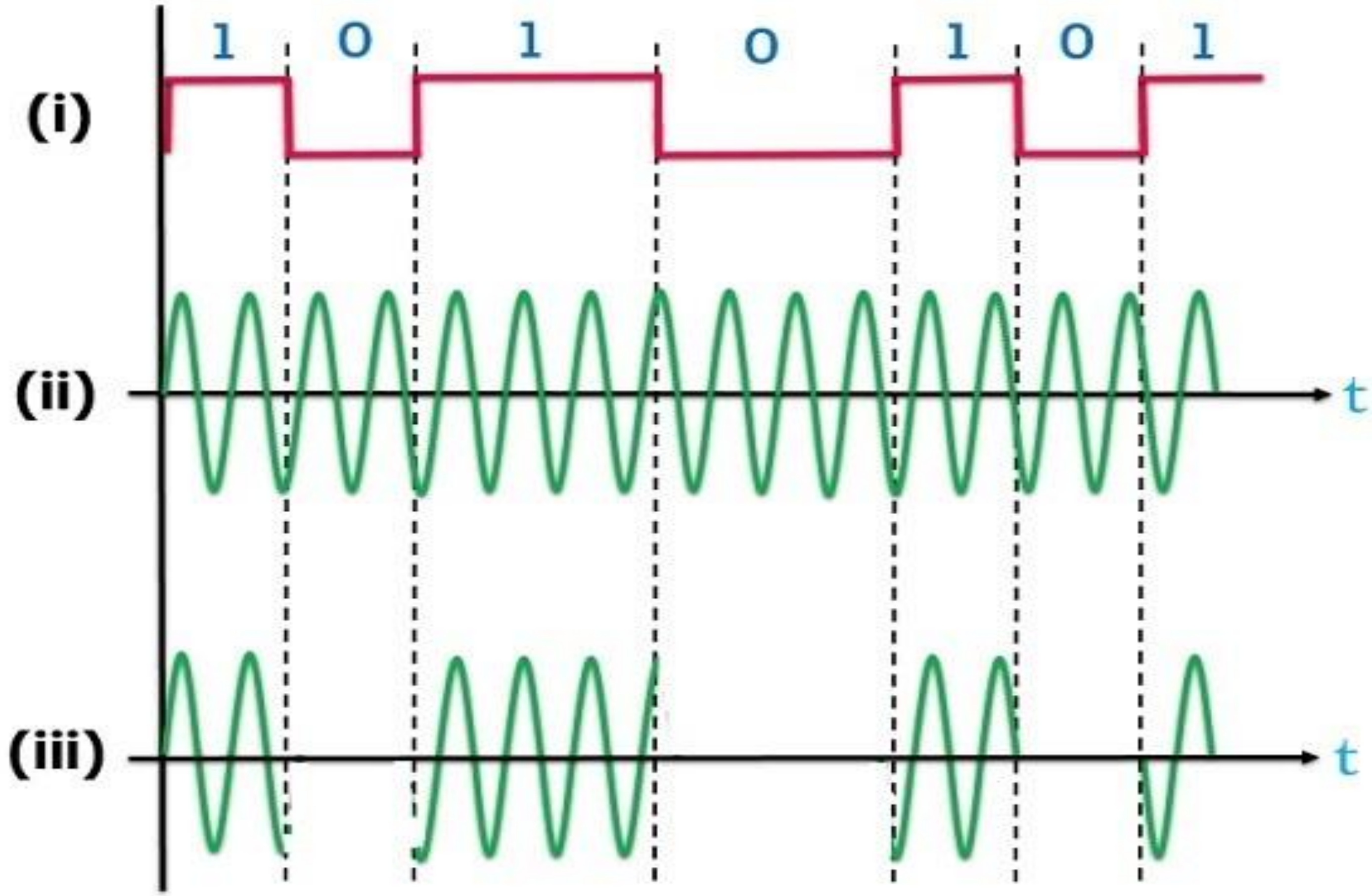
- Modulation of *digital signals known as Shift Keying*
- *Amplitude Shift Keying (ASK):*
  - very simple
  - low bandwidth requirements
  - very susceptible to interference
- *Frequency Shift Keying (FSK):*
  - needs larger bandwidth
- *Phase Shift Keying (PSK):*
  - more complex
  - robust against interference



Amplitude Shift Keying (ASK)

- Amplitude shift keying (ASK) is the simplest form of ***digital modulation techniques***.
- It is the digital version of amplitude modulation (AM).
- ASK uses a *finite number of amplitudes*, each assigned a unique pattern of binary digits.
- Usually, *each amplitude encodes an equal number of bits*.
- Frequency and phase of the carrier are kept constant .

Amplitude Shift Keying (ASK)



(i) = Digital bit sequence
(ii) = Carrier wave
(iii) = ASK modulated wave

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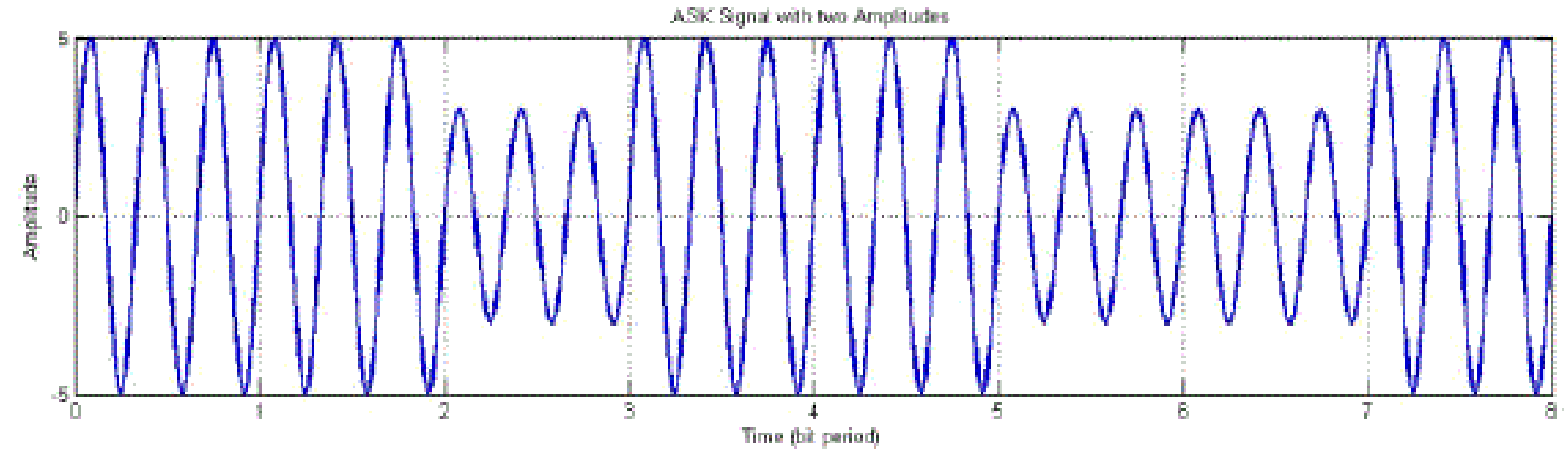
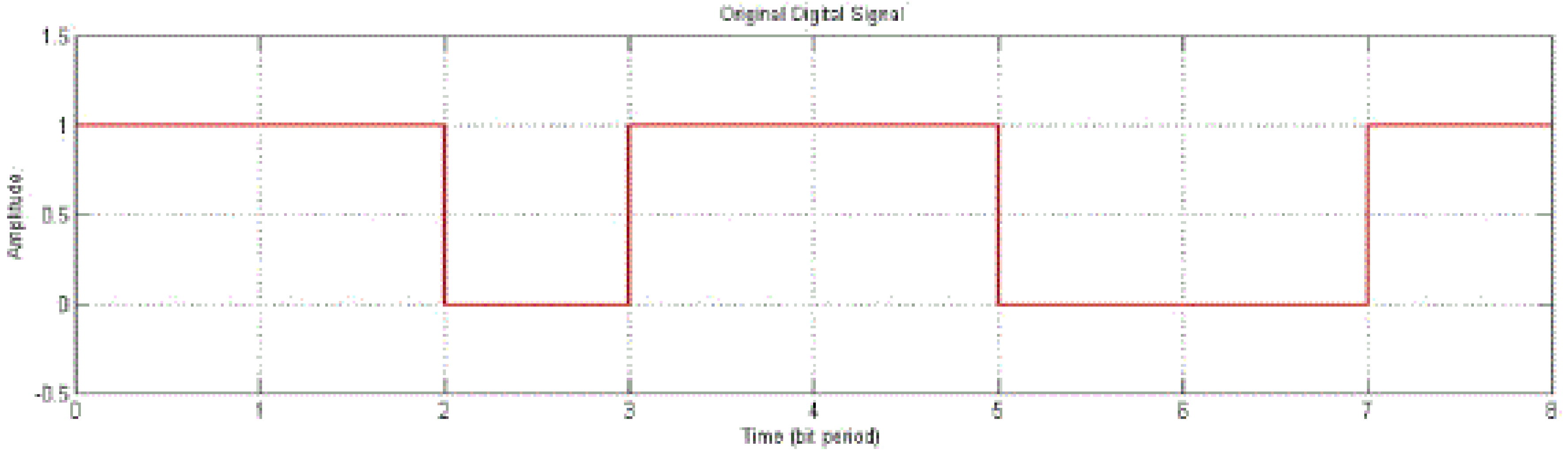

ASK Signal with two Amplitudes
Amplitude
5
0
-5
0
1
2
3
4
5
6
7
8
Time (bit period)


Original Digital Signal
Amplitude
1.5
1
0.5
0
-0.5
0
1
2
3
4
5
6
7
8
Time (bit period)

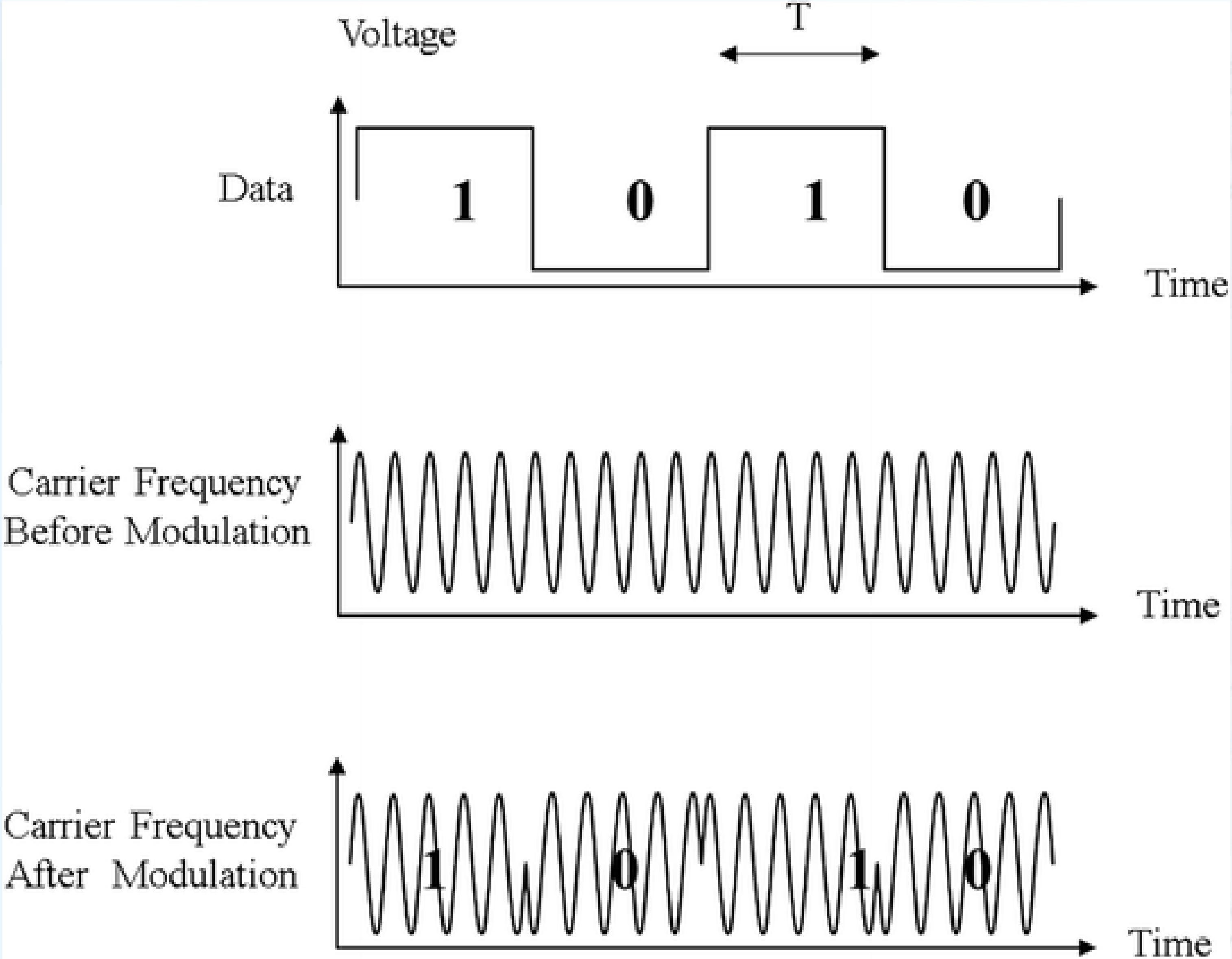
Phase Shift Keying (PSK)

- In digital transmission, *the phase of the carrier is discretely varied* with respect to a reference phase and according to the data being transmitted.
- Phase shift keying (PSK) is a method of transmitting and receiving digital signals in which the phase of a transmitted signal is varied to convey information.

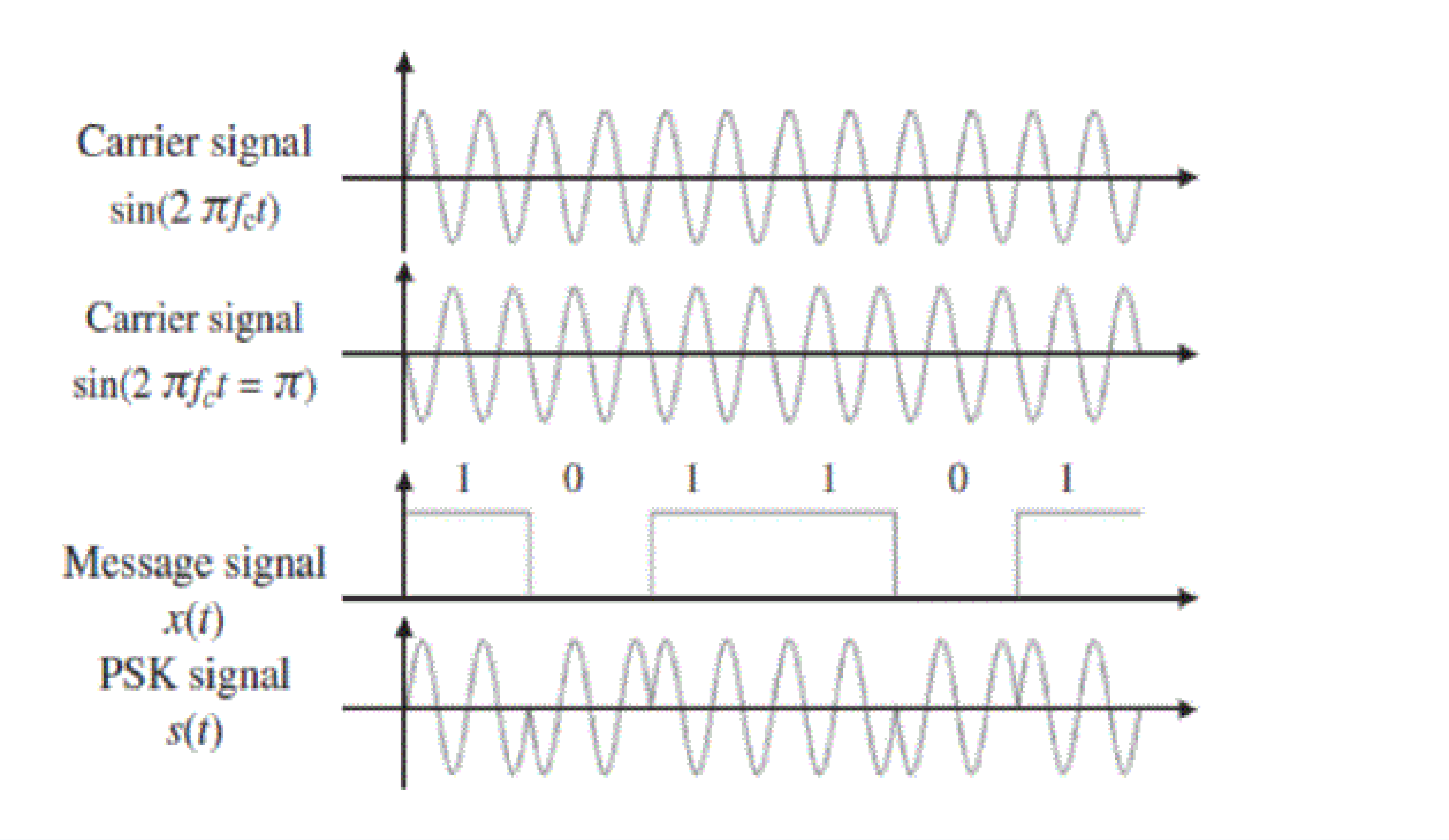
Phase Shift Keying (PSK)

- For example, when encoding, the phase shift could be 0◦ for encoding a “0” and 180◦ for encoding a “1,” thus *making the representations for “0” and “1” apart by a total of 180◦.*
- This kind of PSK is also called binary phase shift keying (*BPSK*) since 1 bit is transmitted in a single modulation symbol.
- Figure 1 shows the waveforms of BPSK.

Phase Shift Keying (PSK)



Phase Shift Keying (PSK)



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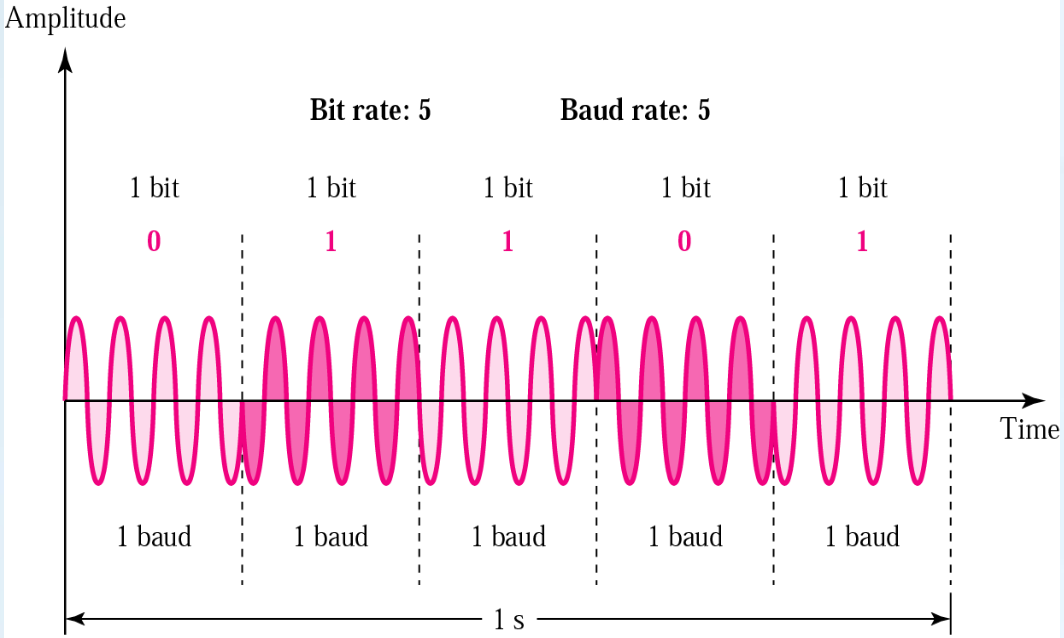
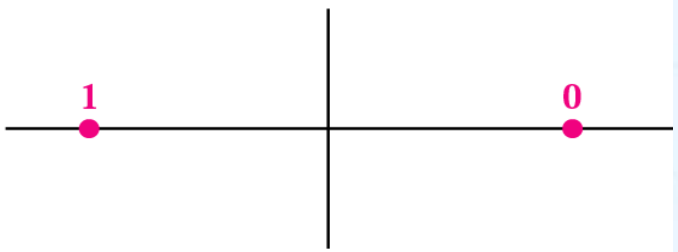
Phase Shift Keying



- Phase of the carrier is varied to represent digital data (binary 0 or 1)
- Amplitude and frequency remains constant.
- If phase 0 deg to represent 0, 180 deg to represent 1. (2-PSK)
- PSK is not susceptible to noise degradation that affects ASK or bandwidth limitations of FSK

Bit	Phase
0	0
1	180

Bits

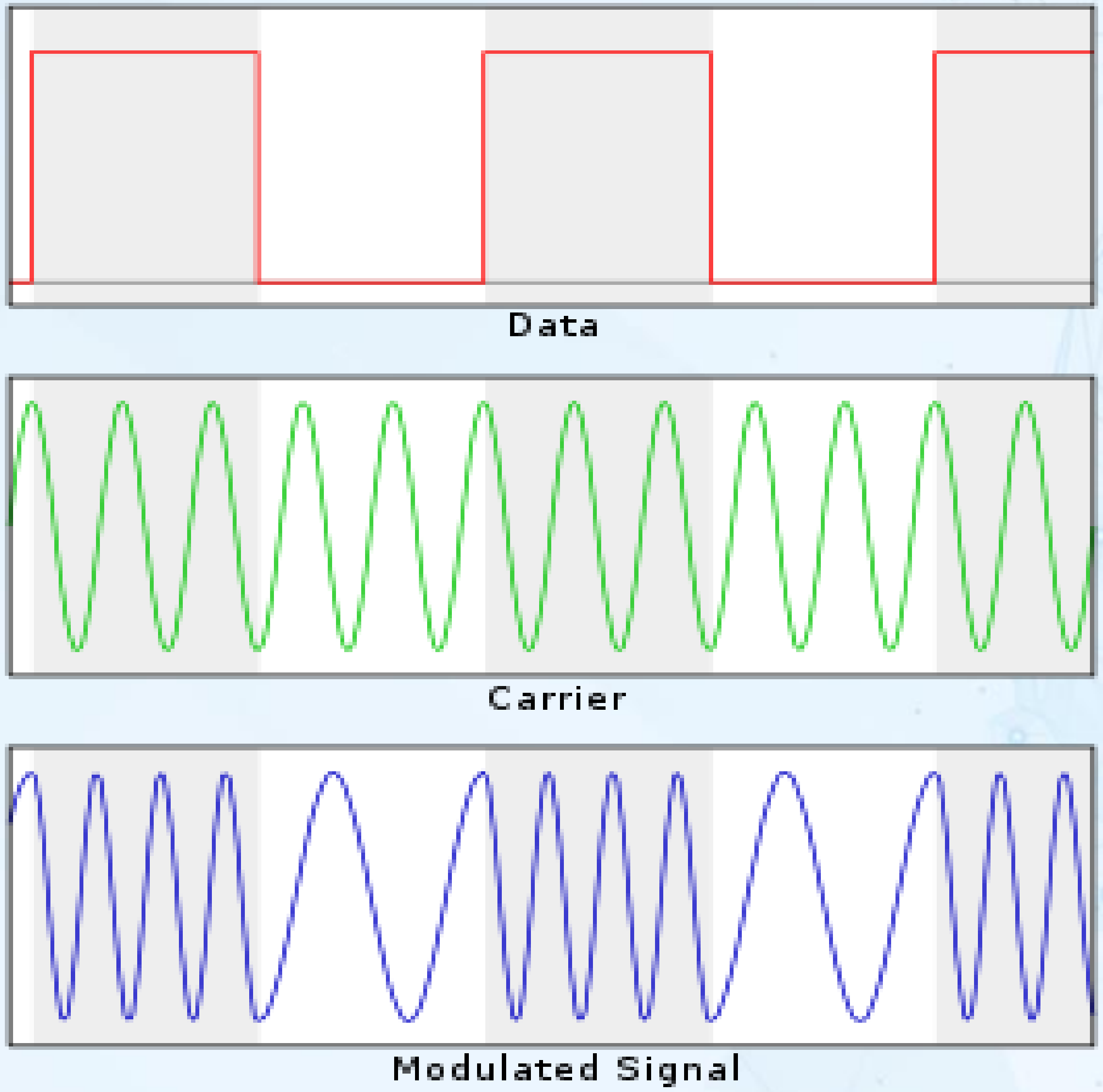


Constellation diagram

Frequency Shift Keying (FSK)

- FSK is a frequency modulation scheme in which digital information is transmitted through discrete frequency changes of a carrier wave.
- The simplest FSK is *binary FSK* (BFSK).
- BFSK uses a pair of discrete frequencies to transmit binary (0s and 1s) information.
- With this scheme, the "1" is called the mark frequency and the "0" is called the space frequency .

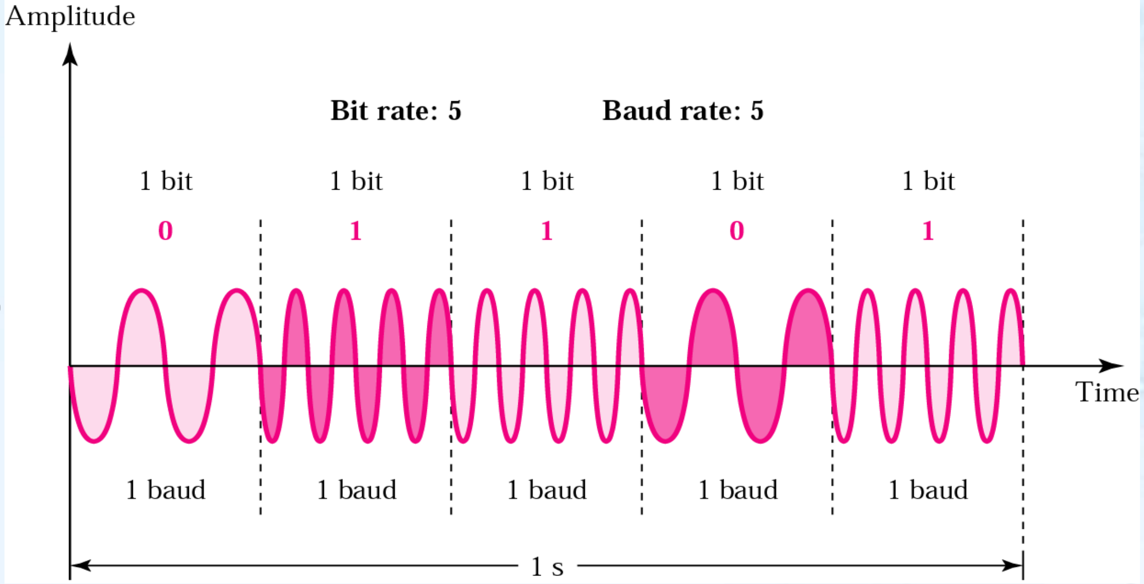
Frequency Shift Keying (FSK)



Frequency Shift Keying (FSK)

- *Frequency of the carrier is varied to represent digital data (binary 0/1*)
- Peak amplitude and phase remain constant.
- Avoid noise interference by looking at frequencies (change of a signal) and ignoring amplitudes.
- f_1 and f_2 equally offset by equal opposite amounts to the carrier freq.

$$s(t) = \begin{cases} A\cos(2\Pi f_1 t) & binary1 \\ A\cos(2\Pi f_2 t) & binary0 \end{cases}$$



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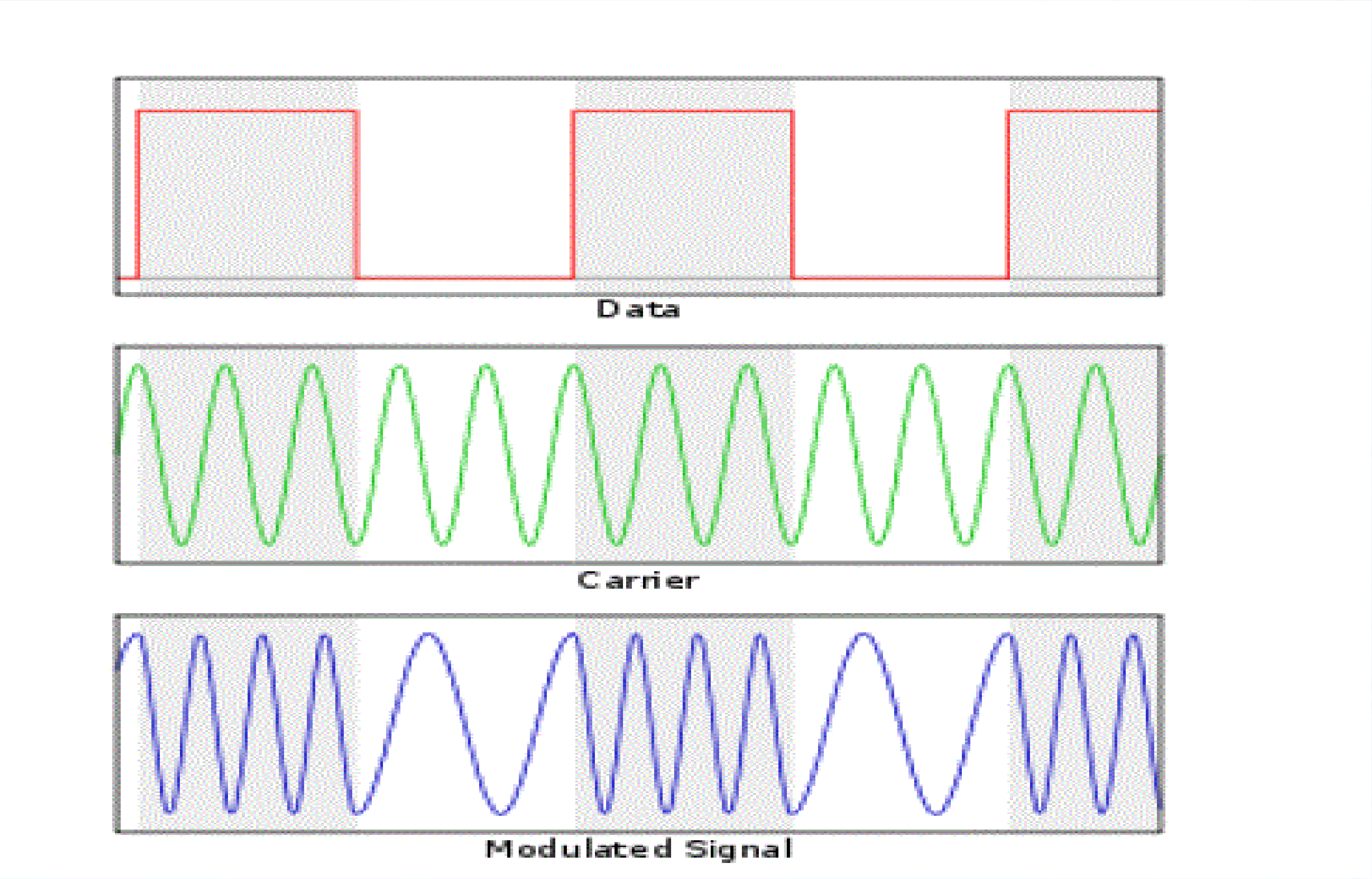
Frequency Shift Keying (FSK)

- Most early telephone-line modems used audio frequency-shift keying to send and receive data, up to rates of about 1200 bits per second.

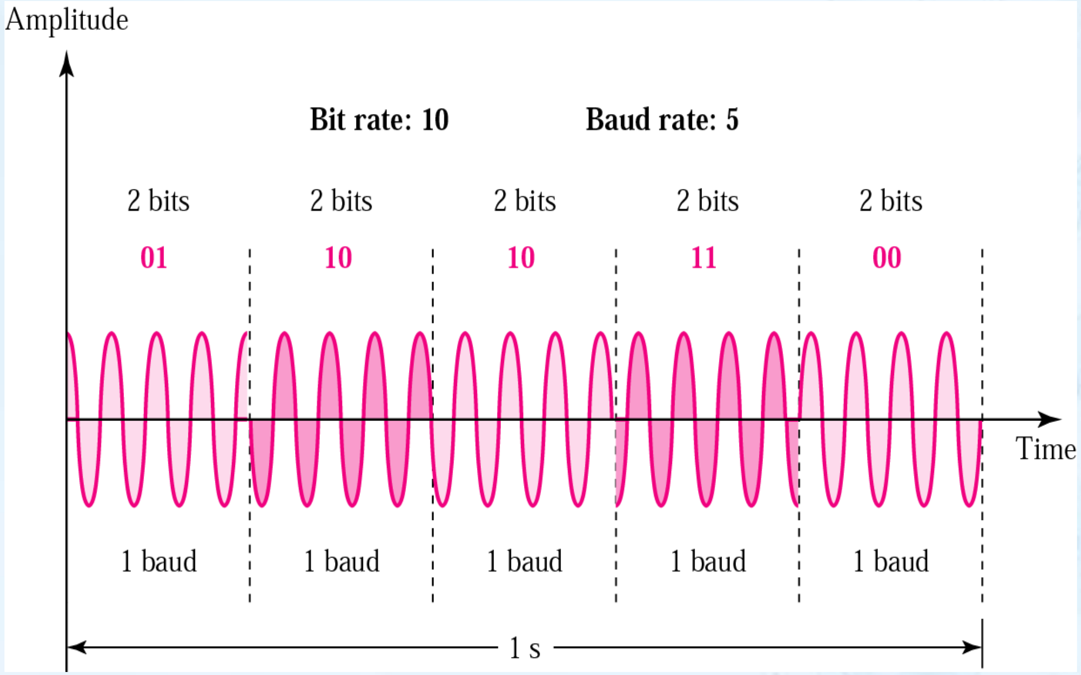


Quadrature Amplitude Modulation (QAM)

- Quadrature amplitude modulation (QAM) is simply a combination of AM and PSK, *in which two carriers out of phase by 90◦ are amplitude modulated.*
- The figure shows an example for 4-QAM signal in which each transmitted symbol represents 2bits.
- Another example for 8-QAM signal in which each transmitted symbol represents 2bits.

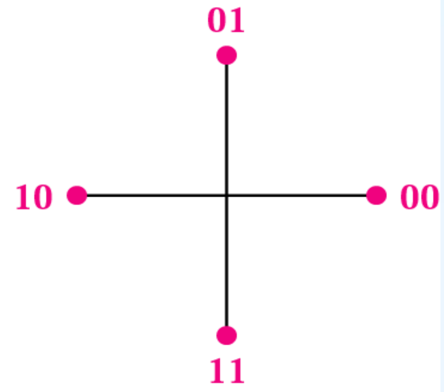
4-PSK (QPSK) method

With $4 = 2^2$ different phases, each phase can represent 2 bits.



Dibit	Phase
00	0
01	90
10	180
11	270

Dibit
(2 bits)



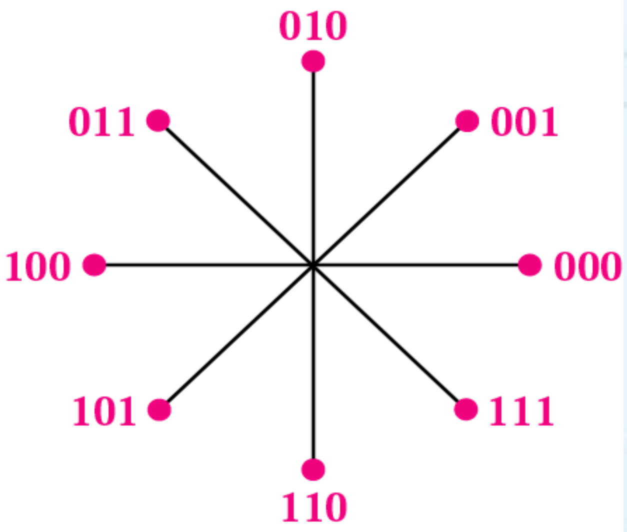
Constellation diagram

8-PSK

- We can extend, by varying the the signal by shifts of 45 deg (instead of 90 deg in 4-PSK)
- With $8 = 2^3$ different phases, each phase can represents 3 bits (tribit).

Tribit	Phase
000	0
001	45
010	90
011	135
100	180
101	225
110	270
111	315

Tribits
(3 bits)



Constellation diagram

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THANK YOU FOR WATCHING

QUESTIONS?