Badji Mokhtar University Annaba

Electronics Department

Level 3: Telecommunication

Module: Telecommunication systems and networks

Digital Transmission and data coding, Lecture 4

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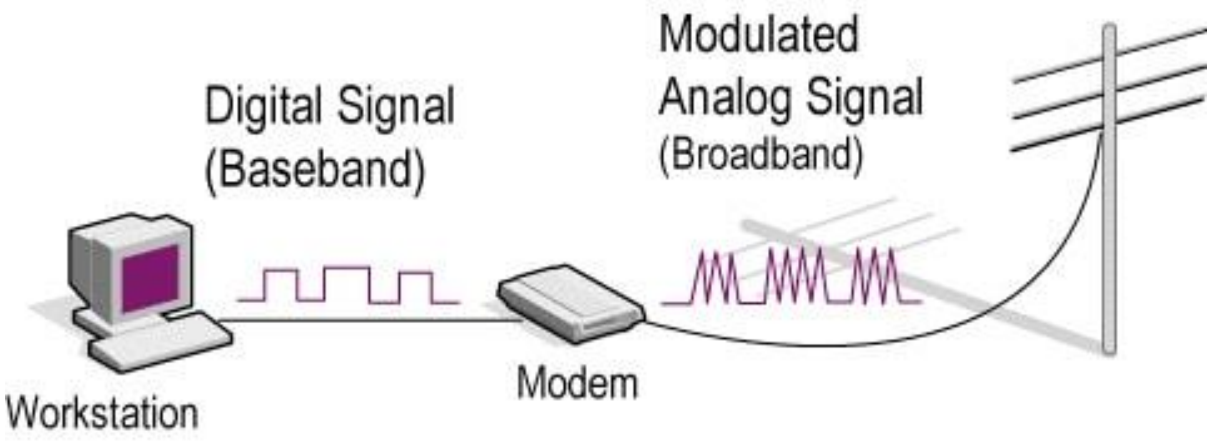
Outline

- Introduction
- Digital data, digital signals
- Digital data, analog signals
- Analog data, analog signals

Transmission numérique : Dans ce cas les données transmises sont discrètes et se présentent sous forme de deux états (haut et bas) ou bien encore à plusieurs états. Cette technique consiste à modifier légèrement le signal, elle est essentiellement destinée à réduire la composante continue.
Cependant, les composantes hautes fréquences étant fortement atténuées, la transmission sera limitée en distance : c'est **la transmission en bande de base**. (**Baseband**)



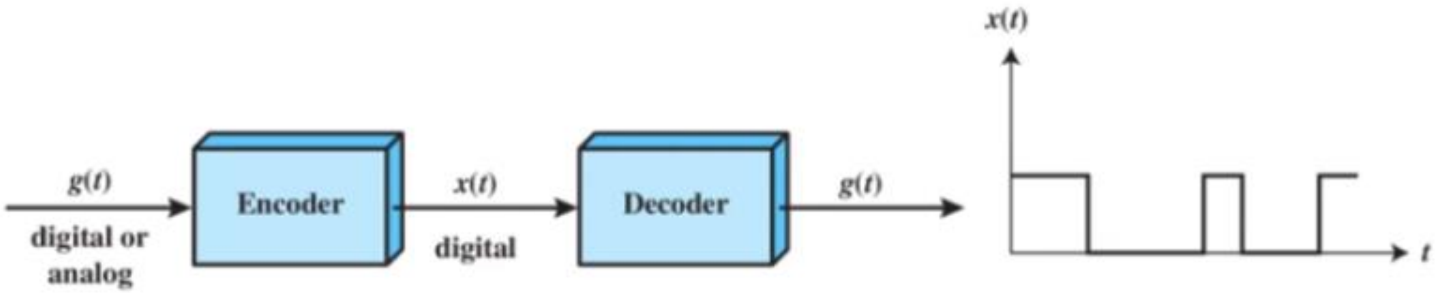
Transmission analogique : les données transmises sont sous forme analogique. Autrement dit, elles évoluent d'une manière continue par rapport au temps. Cette technique translate le spectre du signal à émettre dans une bande de fréquences mieux admise par le système de transmission, c'est la **transmission large bande**. (**Broadband**)

Signal Encoding Techniques

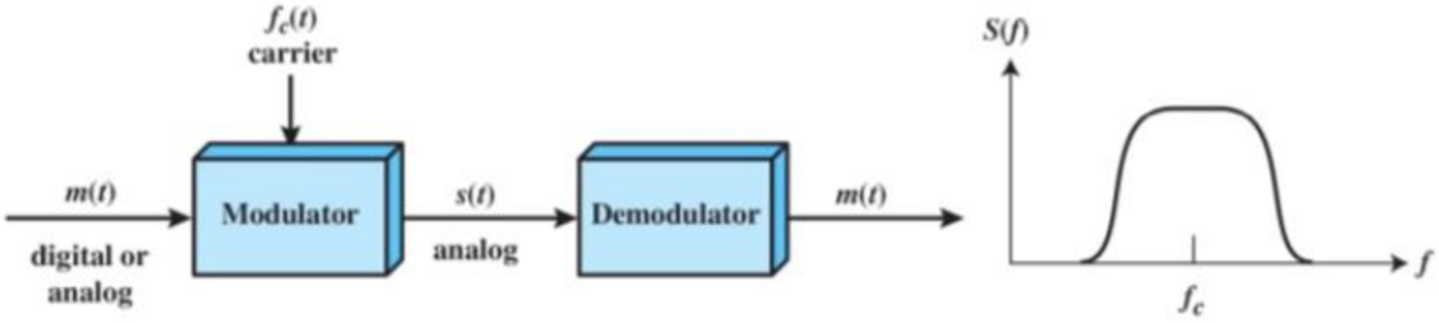
- Signals transmitted chosen to optimize use of transmission medium
  - E.g. conserve bandwidth, minimize errors
- Digital signaling: digital or analog data encoded into digital signal
- Analog signaling: digital or analog data transmitted by analog carrier signal using modulation
  - Baseband signal is the input data signal
  - Carrier signal has frequency $f_{carrier}$
  - Modulated signal is output

Encoding and Modulation Techniques

- Digital Signaling: Digital or analog data, g(t), encoded into digital signal, x(t).
- Analog signaling: digital or analog data transmtted by analog carrier signal (signal porteur) using modulation.



(a) Encoding onto a digital signal



(b) Modulation onto an analog signal

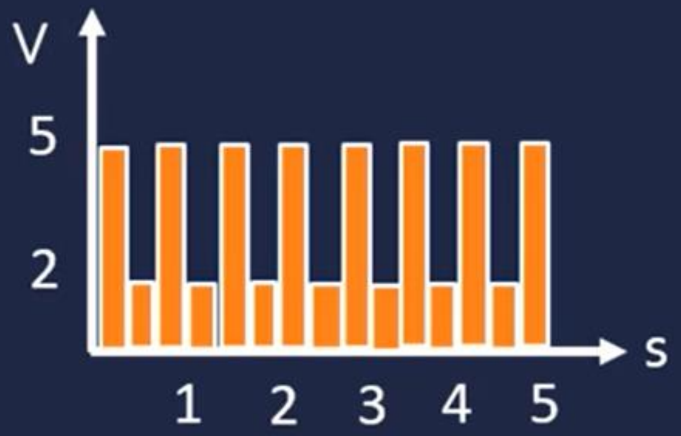
- Digital signal: sequence of discrete voltage pulses
- Each pulse is a signal element
- Binary data transmitted by encoding each bit (data element) into signal elements
  - E.g. binary 1 represented by lower voltage level, binary 0 for higher level.

- Data rate (*débit binaire*) = data elements or bits per second; signaling or modulation rate (*rapidité de modulation*) = signal elements per second (baud).

Baud Rate

- ...is the rate at which signals can change (pulses / second)
- The unit is the baud (Bd), and it is a measurement of **speed**

- This has a baud rate of 1 Bd, as the signal only changes once a second (taken to be the end)



- This has a baud rate of 3 Bd
- 3 pulses in 1 second

Digital data, digital signals

Bit Rate

- ...is the rate at which data is sent (bits / second)
- The unit is bits per second (bps), and it is *also* a measurement of **speed**

- This has a baud rate of 1 Bd, *and* a bit rate of 1 bps – only 2 voltage levels so only 1 bit per signal
- Baud rate still 1 Bd, but the bit rate is 2 bps – now each signal represents 2 bits

Nonreturn to Zero-Level (NRZ-L)
0 = high level
1 = low level

Nonreturn to Zero Inverted (NRZI)
0 = no transition at beginning of interval (one bit time)
1 = transition at beginning of interval

Bipolar-AMI
0 = no line signal
1 = positive or negative level, alternating for successive ones

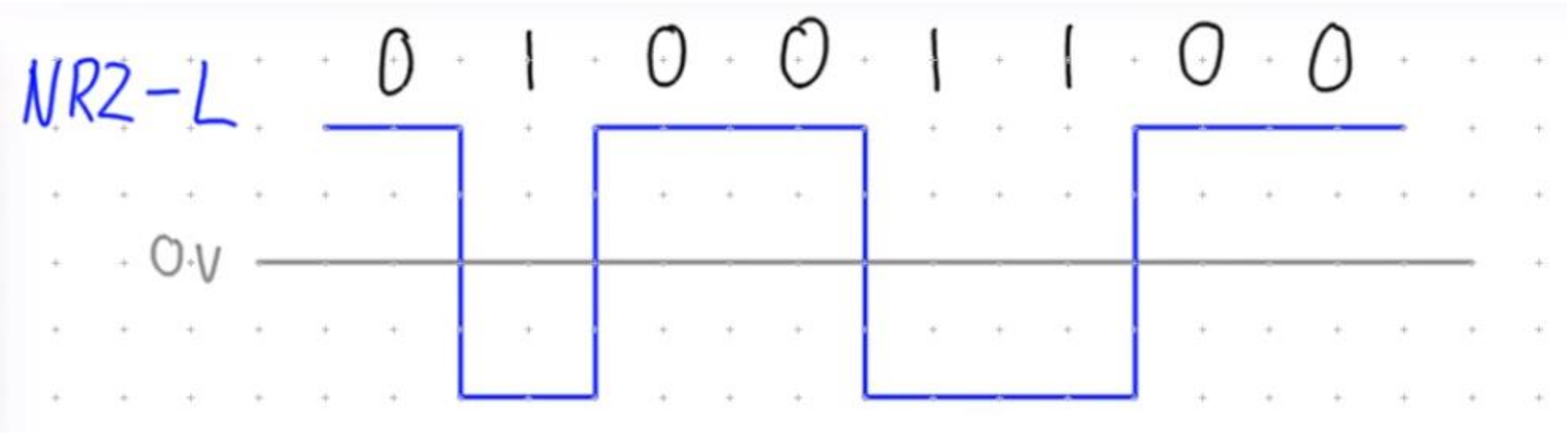
Pseudoternary
0 = positive or negative level, alternating for successive zeros
1 = no line signal

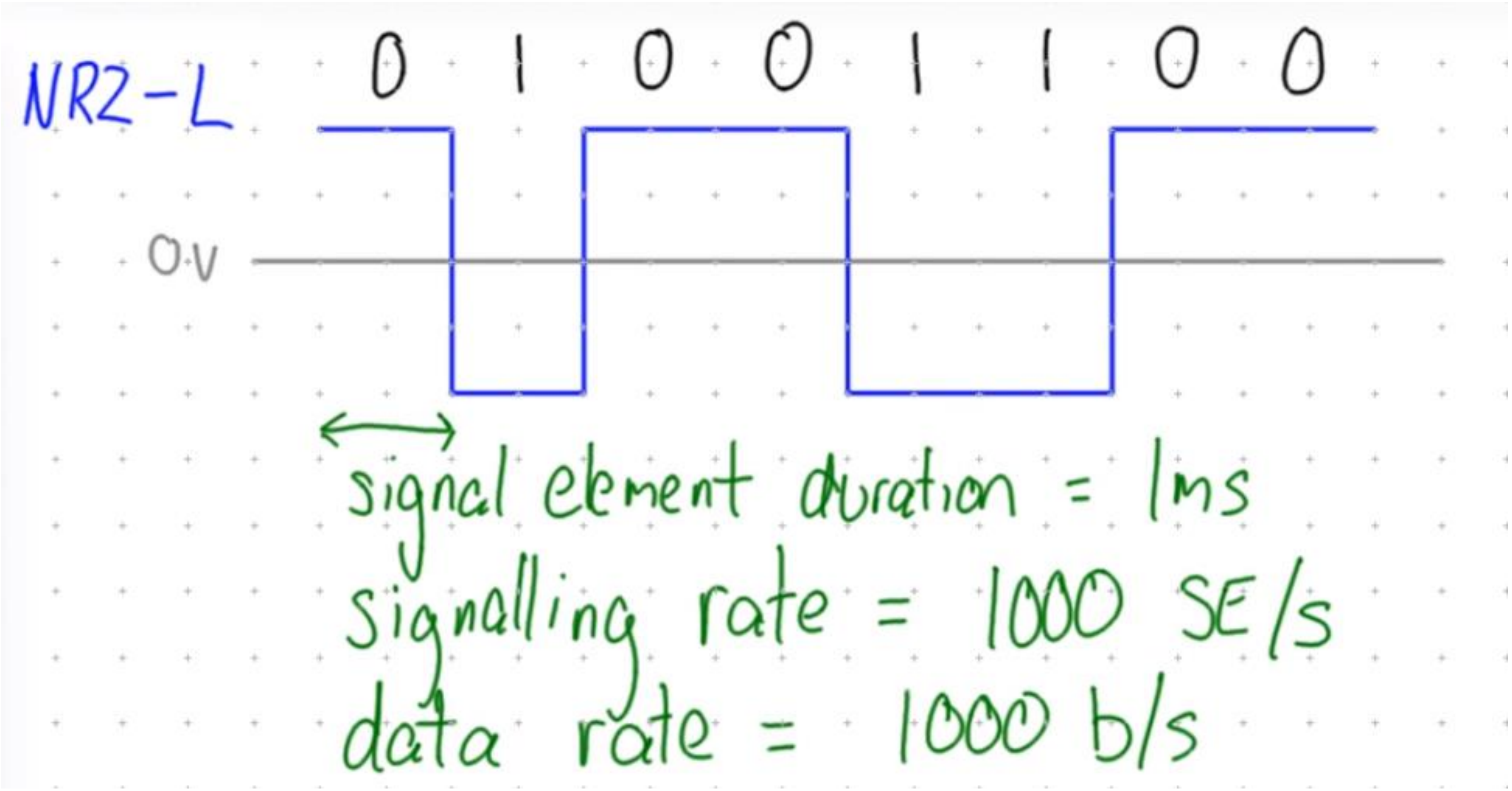
Manchester
0 = transition from high to low in middle of interval
1 = transition from low to high in middle of interval

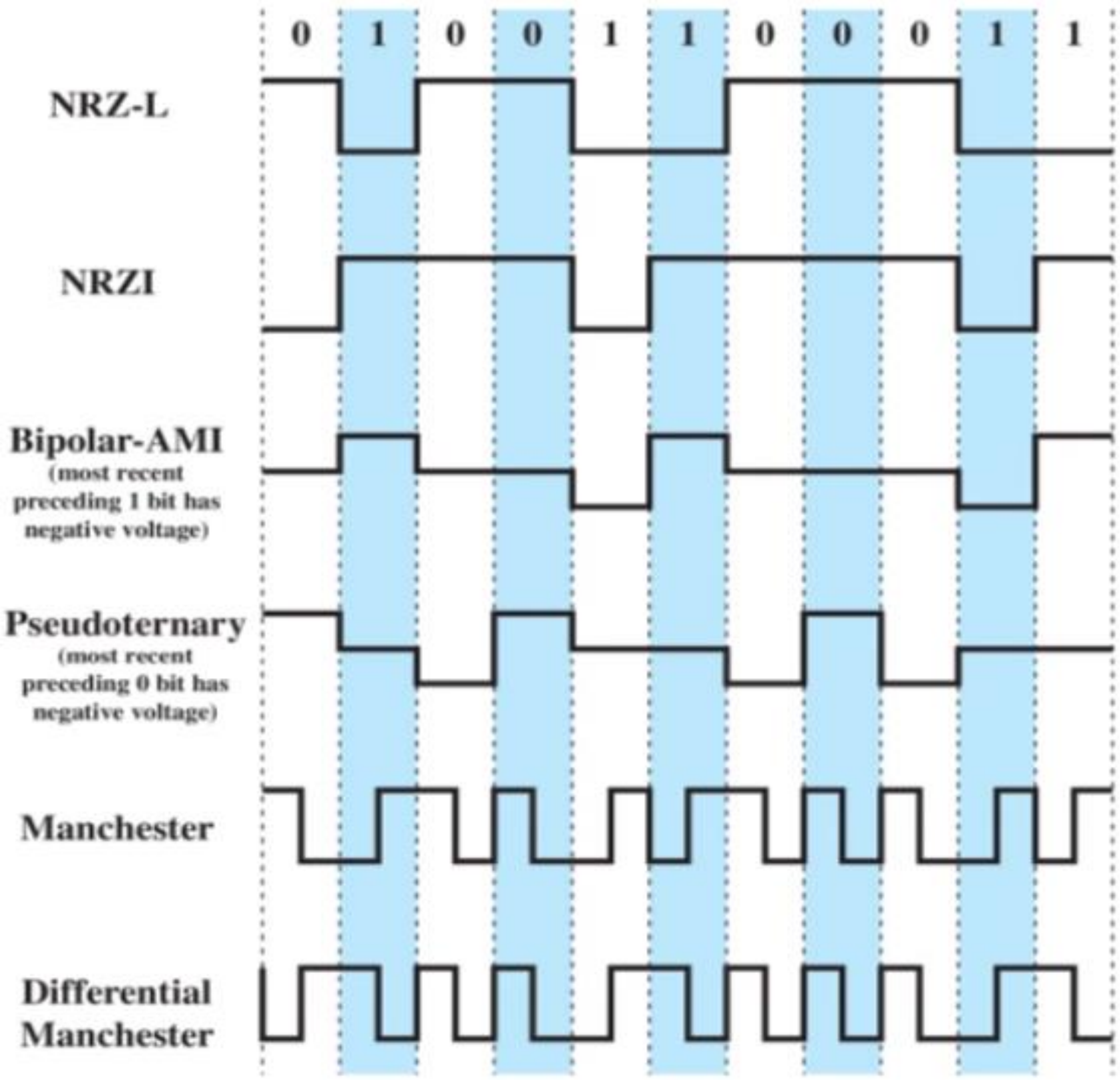
Differential Manchester
Always a transition in middle of interval
0 = transition at beginning of interval
1 = no transition at beginning of interval

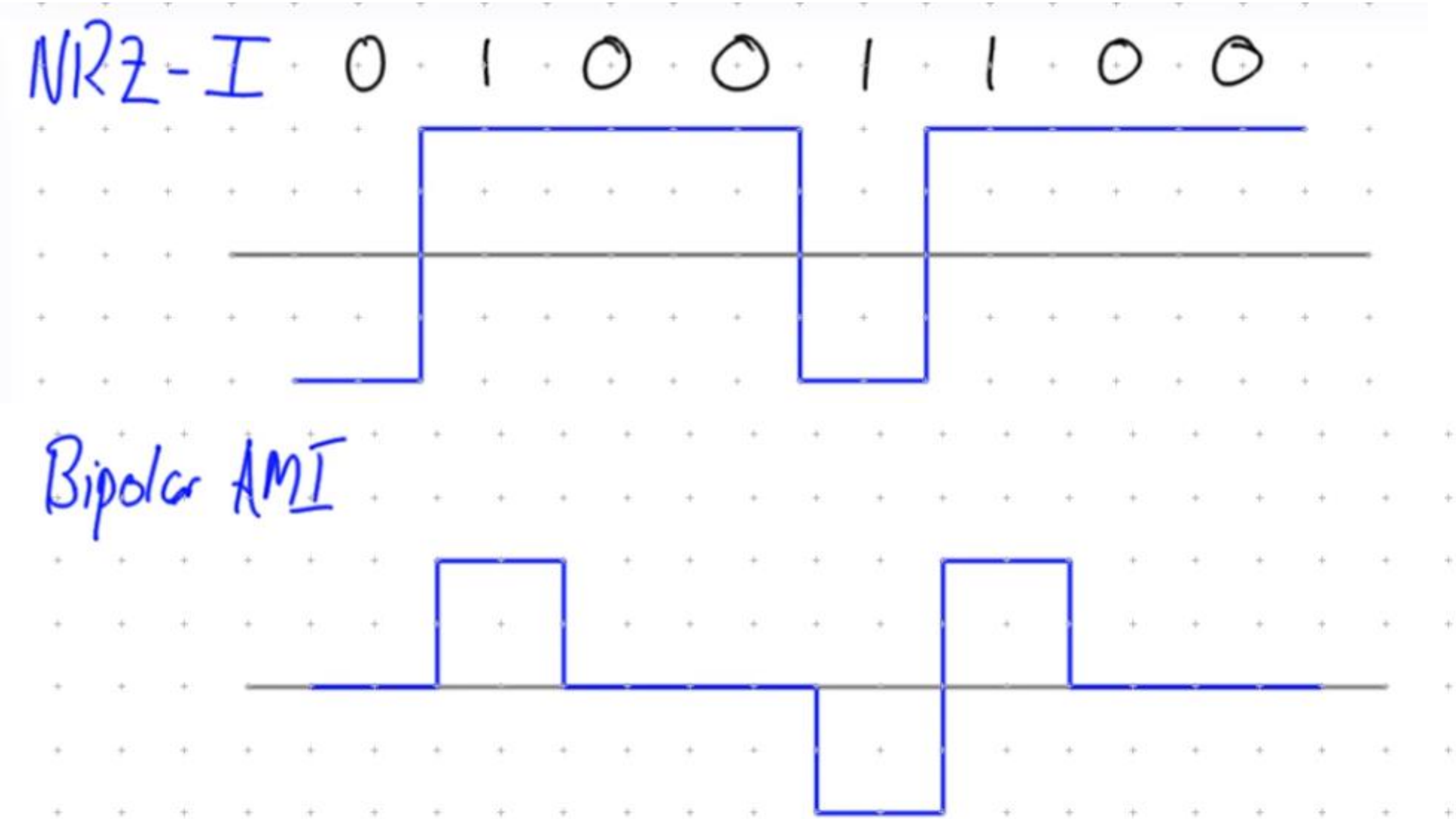
B8ZS
Same as bipolar AMI, except that any string of eight zeros is replaced by a string with two code violations

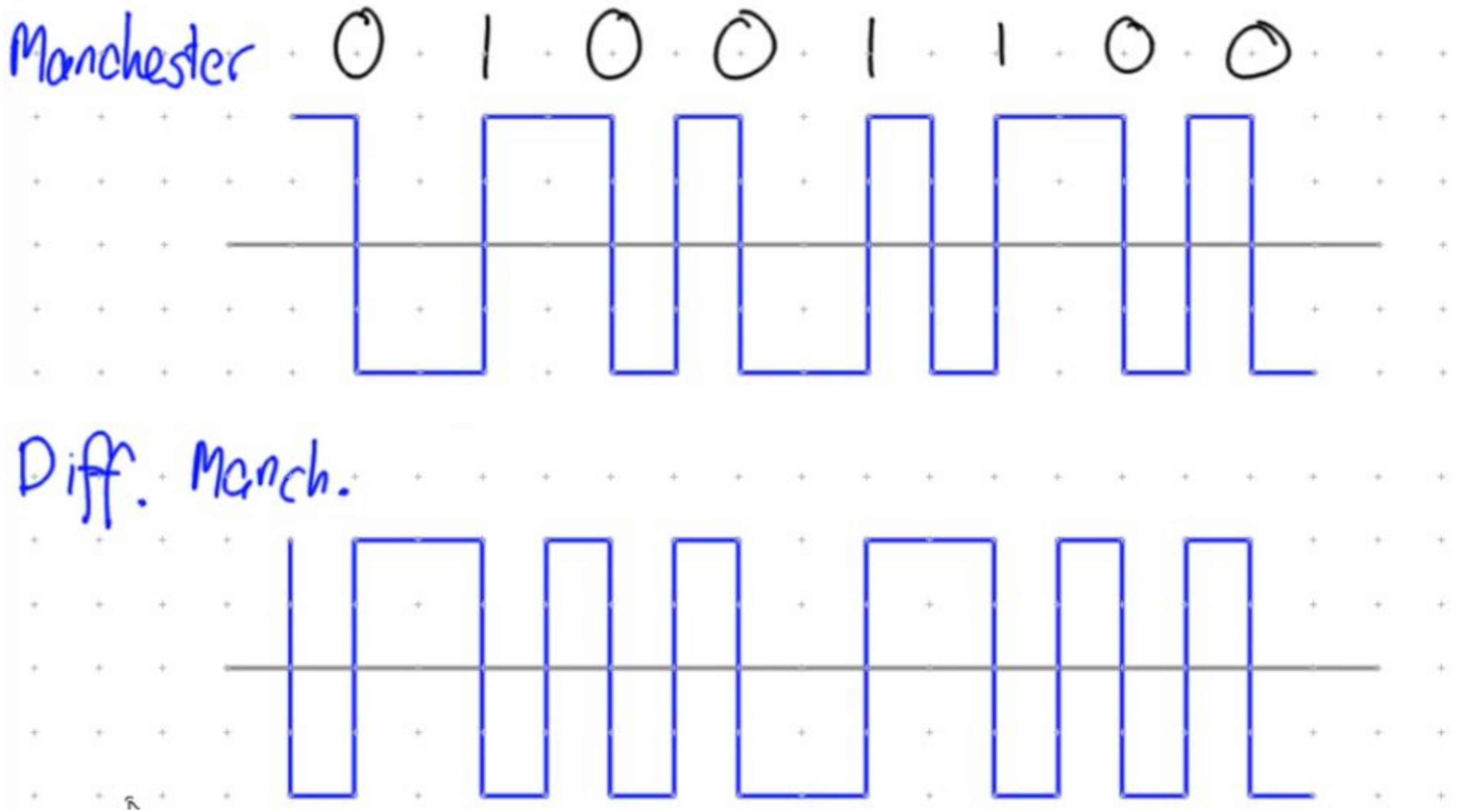
HDB3
Same as bipolar AMI, except that any string of four zeros is replaced by a string with one code violation


NRZ-L
0 1 0 0 1 1 0 0
0 V


NRZ-L
0 1 0 0 1 1 0 0
0 V
signal element duration = 1ms
signalling rate = 1000 SE/s
data rate = 1000 b/s


0 1 0 0 1 1 0 0 0 1 1
NRZ-L
NRZI
Bipolar-AMI
(most recent preceding 1 bit has negative voltage)
Pseudoternary
(most recent preceding 0 bit has negative voltage)
Manchester
Differential Manchester

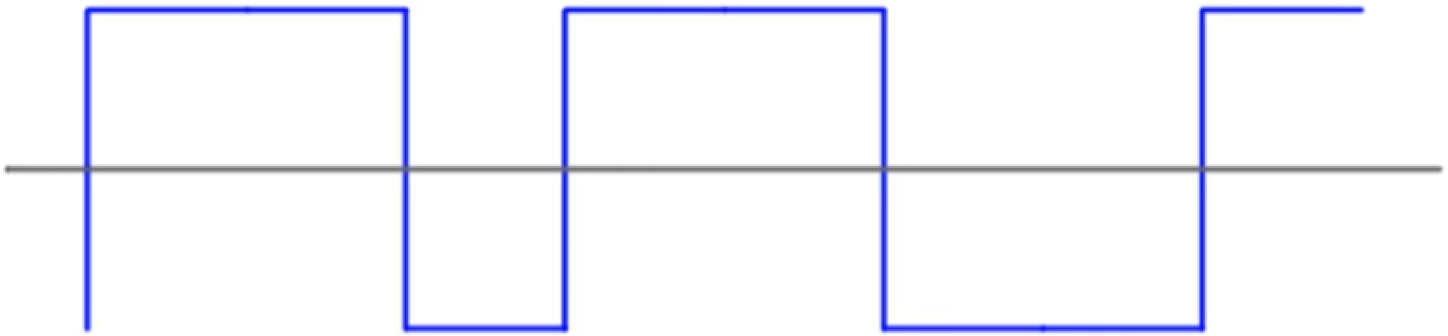

NRZ-I
0 1 0 0 1 1 0 0
Bipolar AMI

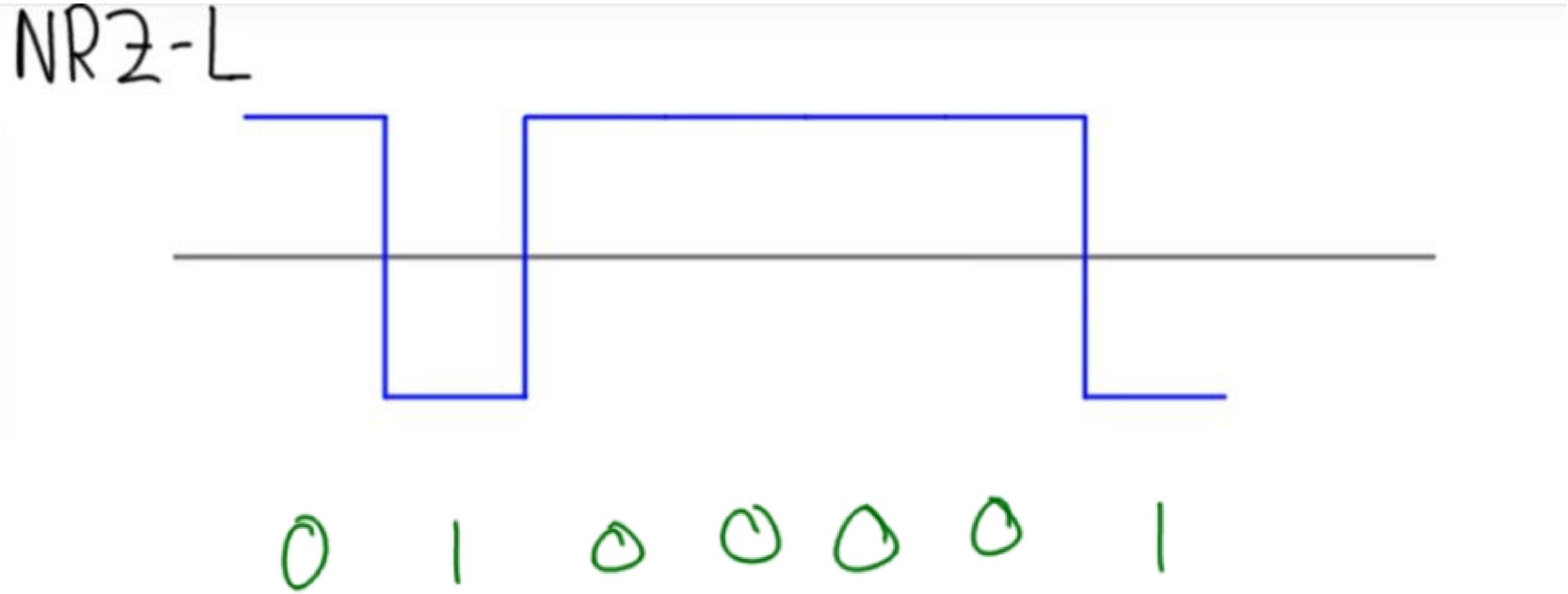

Manchester
0 1 0 0 1 1 0 0
Diff. Manch.

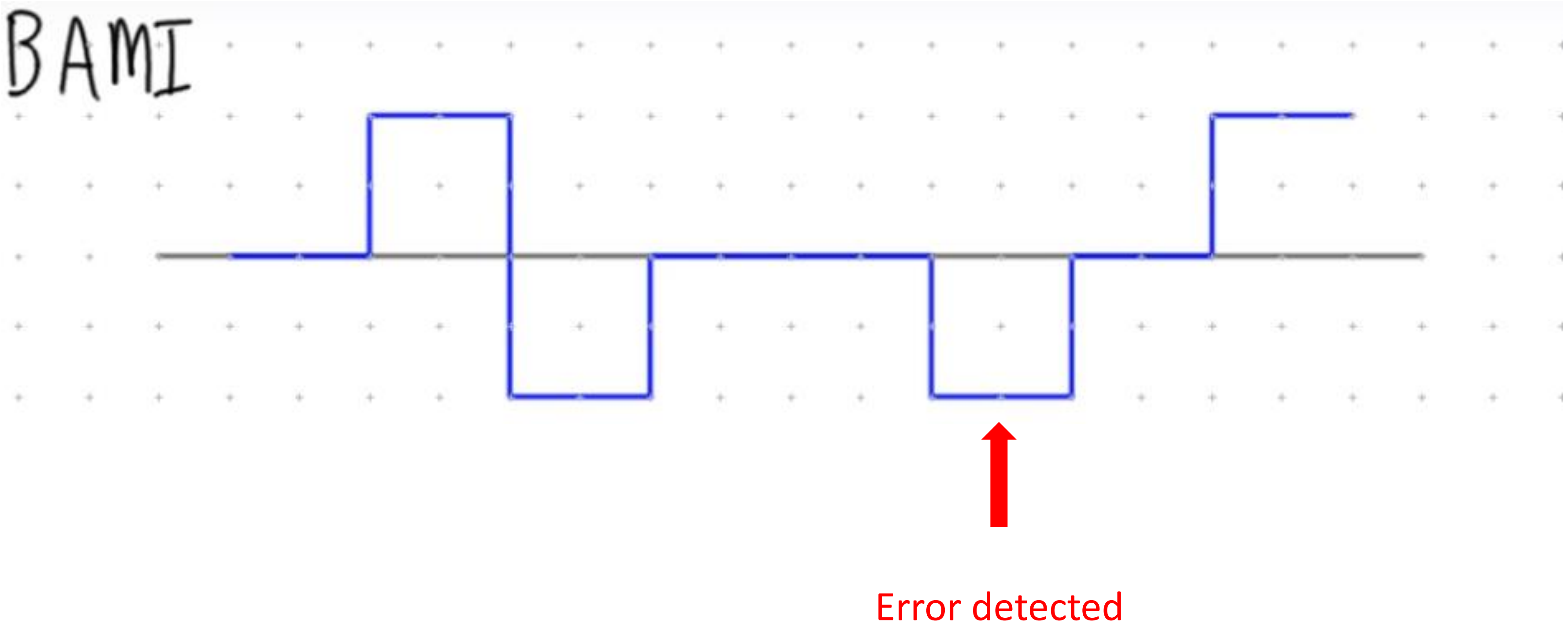
Examples of technologies that use encoding schemes

- NRZ/NRZI: RS-232, HDLC, USB,…..
- Manchester: Ethernet, Token Ring,…..
- Multilevel Binary: US T-carrier and European E-carrier telecommunication systems.
- Binary data transmitted by encoding each bit (data element) into signal elements.

✓ Find the bits sequence of the following digital signal :




NRZ-L
0
1
0
0
0
0
1


BAMI
Error detected

Comparing different encoding schemes

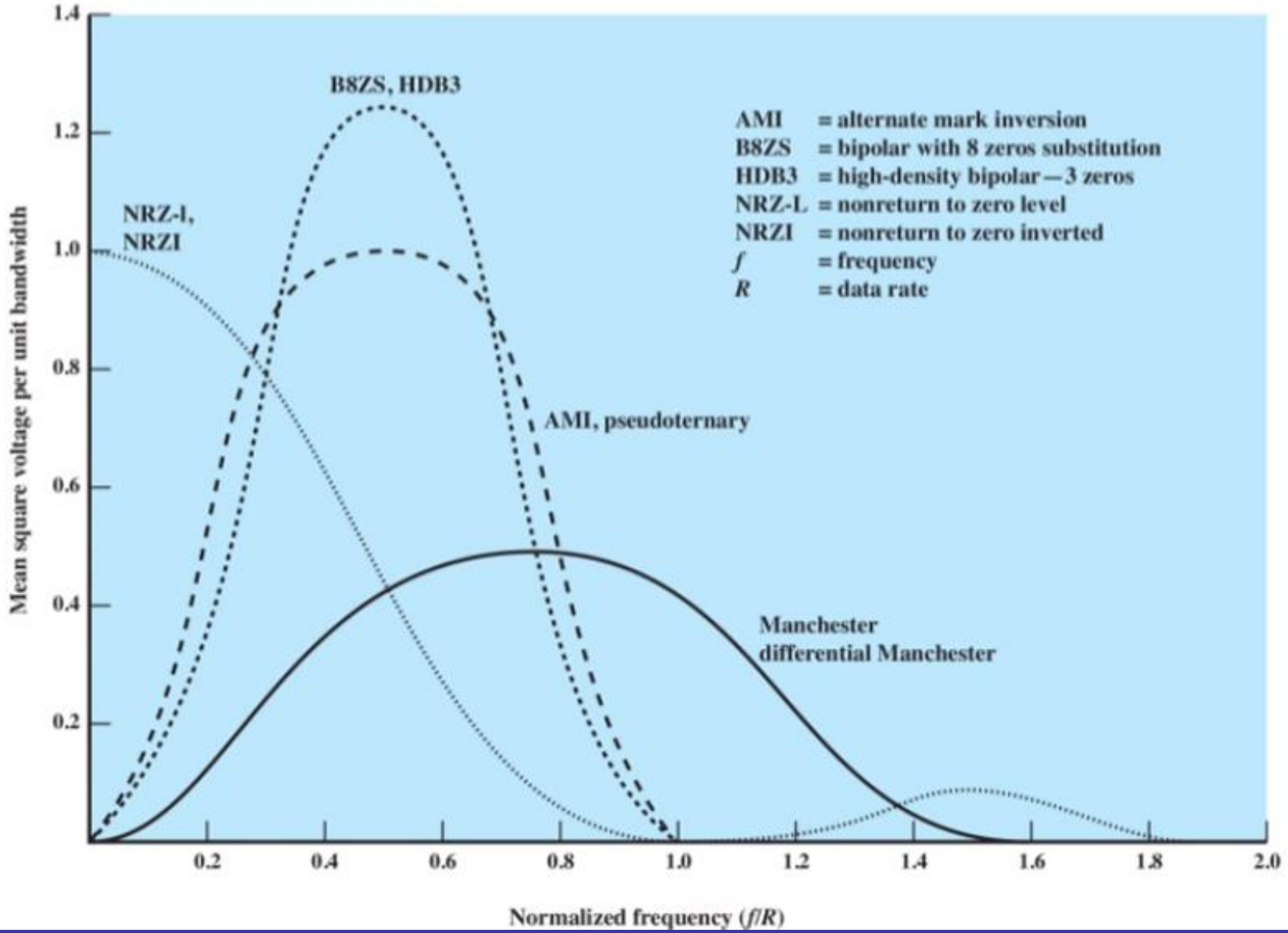
Signal spectrum

- High frequency components are not desired to preserve a narrow bandwidth
- DC component (Composante continue) is not desired so ac coupling can be used (reduces bit error rate)
- Concentrate transmitted power in middle of bandwidth

Clocking and Synchronisation

- Transmitted signal can be used by receiver to synchronise bit timing

Spectral density of various signal encoding schemes



Comparing different encoding schemes

Error Detection

- Receiver can detect some bit errors from the received signal

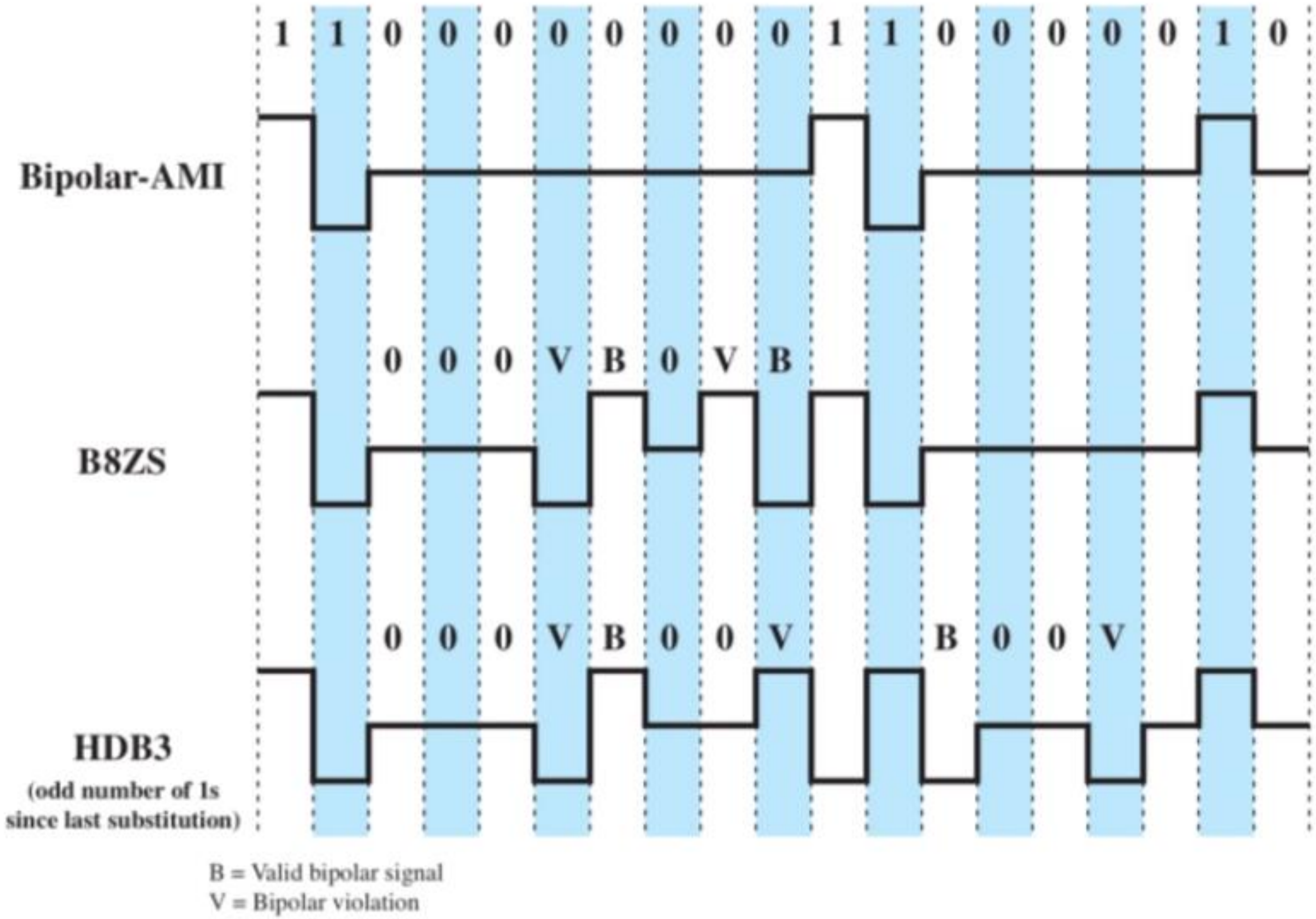
Signal Interference

- Provide good performance (few bit errors) in presence of noise

Cost and complexity

- Desire smaller signaling rate to achieve a given data rate

Encoding rules for B8ZS and HDB3



Encoding rules for B8ZS and HDB3

Improving Synchronization

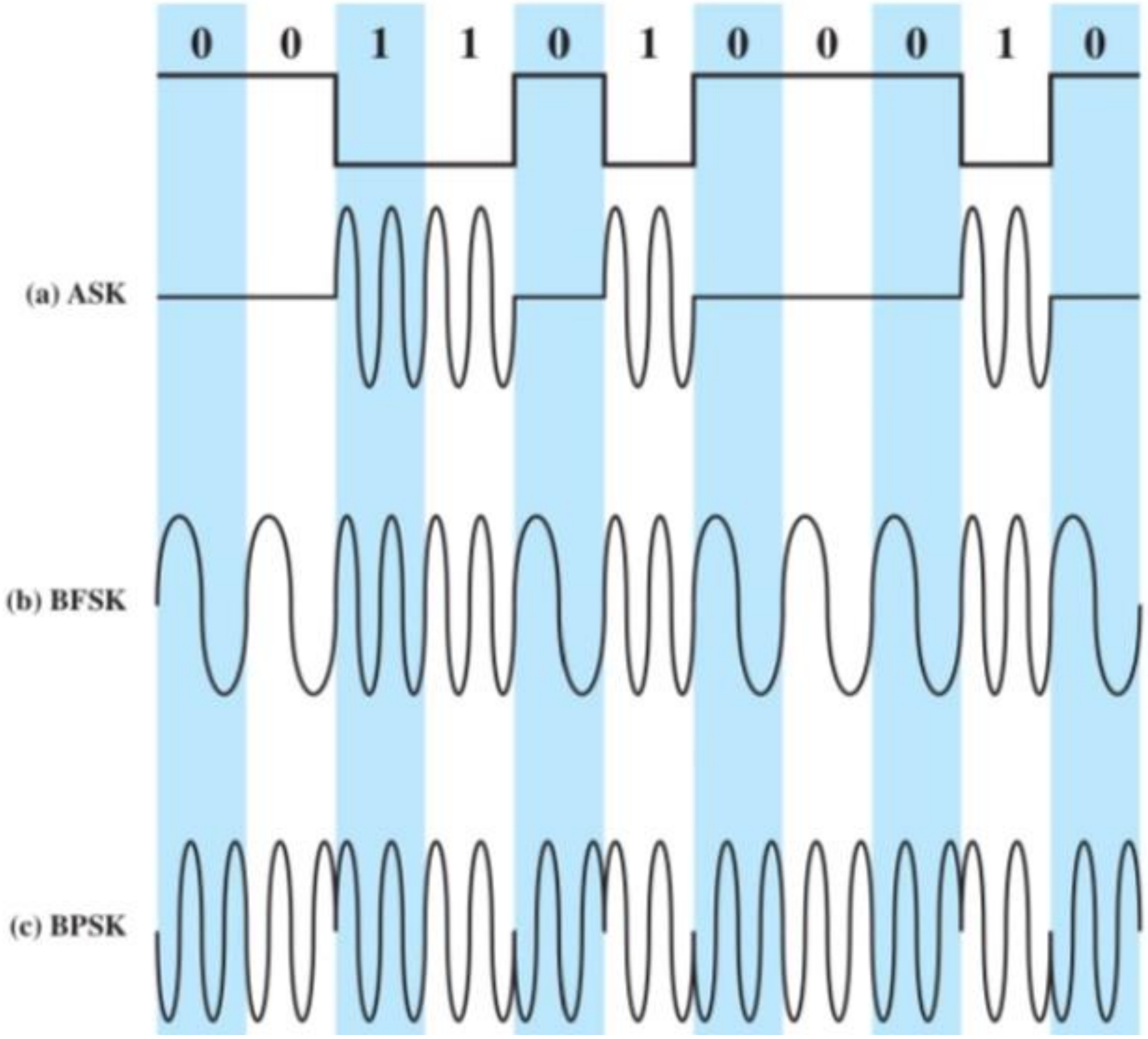
- In Bipolar AMI a long sequence of 0's makes it difficult for the receiver to synchronize
- Solution: if long sequence of same bit, replace with special sequence of bits
- B8ZS (Bipolar with 8-zeros substitution)
  - If 8 0's and last pulse was positive, replace 8 0's with $000+-0-+$
  - If 8 0's and last pulse was negative, replace 8 0's with $000-+0+-$
- HDB3 (High density bipolar 3-zeros)

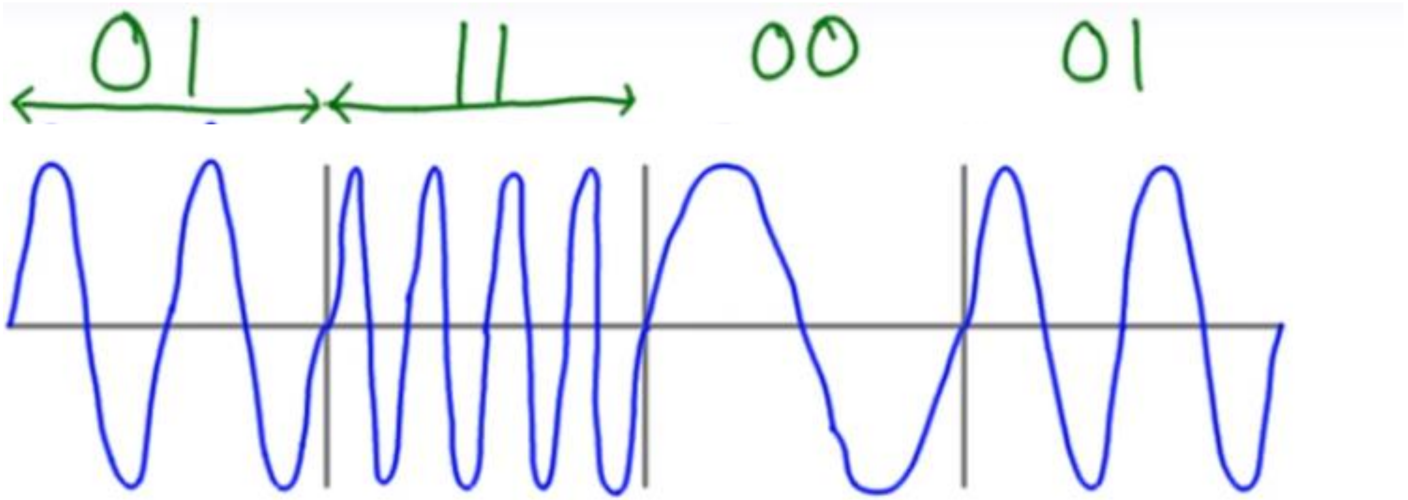
	Number of Bipolar Pulses (ones) since Last Substitution	
Polarity of Preceding Pulse	**Odd**	**Even**
–	000–	+00+
+	000+	–00–

Digital Data, Analog Signals

- Transmit digital data over media that only support analog signals, e.g. telephone network, microwave systems.
  - Telephone network designed to transmit signals in voice-frequency (300 to 34000 Hz)
  - Modems (modulator-demodulator) convert digital data to signals in this frequency range

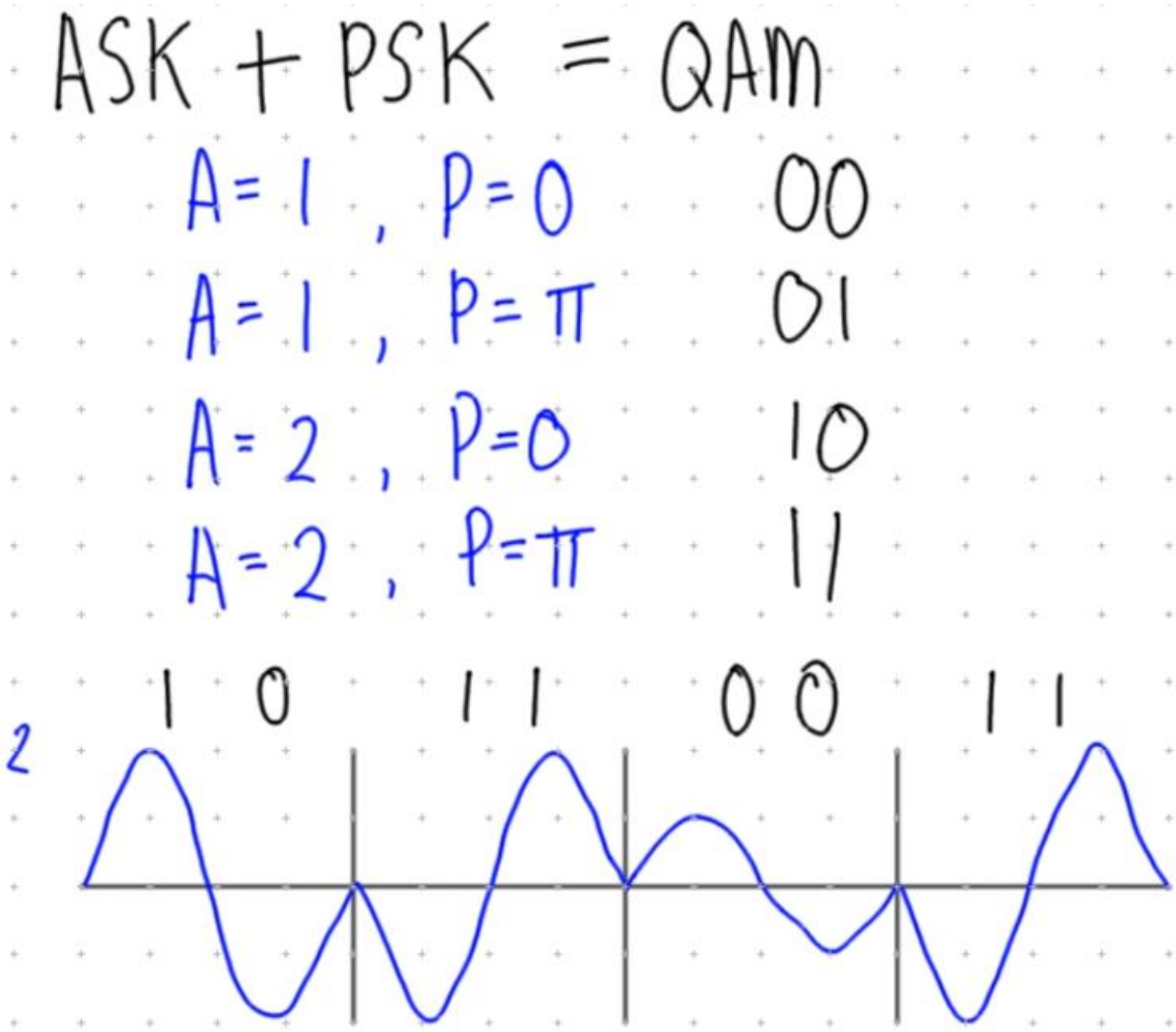
- 3 basic modulation techniques:
  1. Amplitude Shift Keying (ASK)
  2. Phase Shift Keying (PSK)
  3. Frequency Shift Keying (FSK)
- Resulting a signal which occupies a bandwidth centred on carrier frequency.


0
0
1
1
0
1
0
0
0
1
0
(a) ASK
(b) BFSK
(c) BPSK



FSK scheme:

f	00
2f	01
3f	10
4f	11


ASK + PSK = QAM
A=1 , P=0 00
A=1 , P=π 01
A=2 , P=0 10
A=2 , P=π 11
1 0
1 1
0 0
1 1
2

Comparing the Shift Keying Schemes

Amplitude Shift Keying

- Inefficient modulation technique
- Used on voice lines < 1200 bps and optical fibre

Frequency Shift Keying

- Used on voice lines, coaxial cable, HF radio systems
- Extended with M frequencies: improve efficiency, higher error rate

Phase Shift Keying

- Used in wireless transmission systems
- Extended M phases, e.g. QPSK (M=4)
- Combined with ASK: Quadrature Amplitude Modulation (QAM); used in ADSL and wireless systems

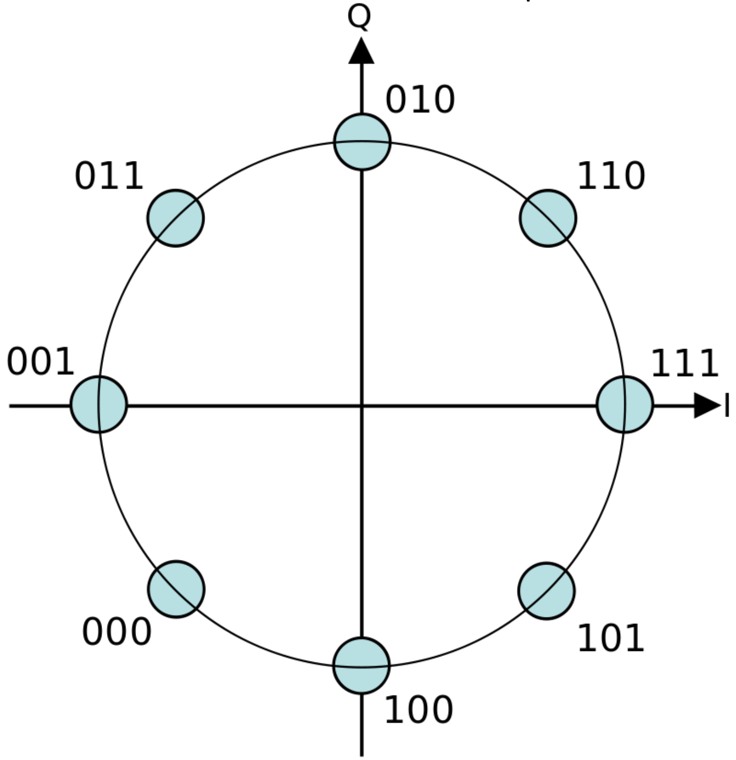
Example of technologies using Shift Keying

- ASK: optical fibre, RFID
- FSK: HF / shortwave radia, UHF/VHF radio comms, RFID
- PSK and QAM: mobile phones, Wi-Fi, calbe modems, xDSL, DVB,…..

A constellation diagram is a representation of a signal modulated by a digital modulation scheme such as quadrature amplitude modulation or phase-shift keying.

It displays the signal as a two-dimensional xy-plane scatter diagram in the complex plane at symbol sampling instants.

The angle of a point, measured counterclockwise from the horizontal axis, represents the phase shift of the carrier wave from a reference phase. The distance of a point from the origin represents a measure of the amplitude or power of the signal.



An 8-PSK. Information transmitted according to the scheme described in the above diagram is encoded as one of 8 "symbols", each representing 3 bits of data. Each symbol is encoded as a different phase shift of the carrier sine wave: 0°, 45°, 90°, 135°, 180°, 225°, 270°, 315

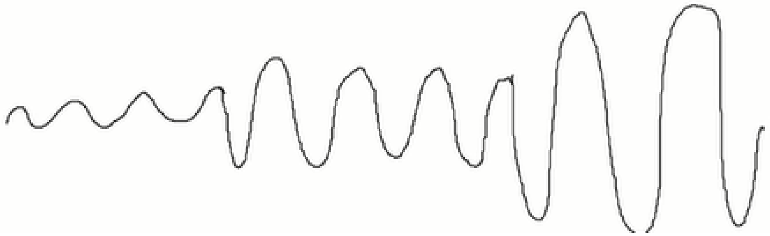
ASK: $y(t) = A_k \cos(\omega_c t + \phi_c)$

ex: $A_k = \{0, 1\}$

0 1 1 0 1 1

ex: $A_k = \{\overset{00}{0}, \overset{01}{1}, \overset{10}{2}, \overset{11}{3}\}$

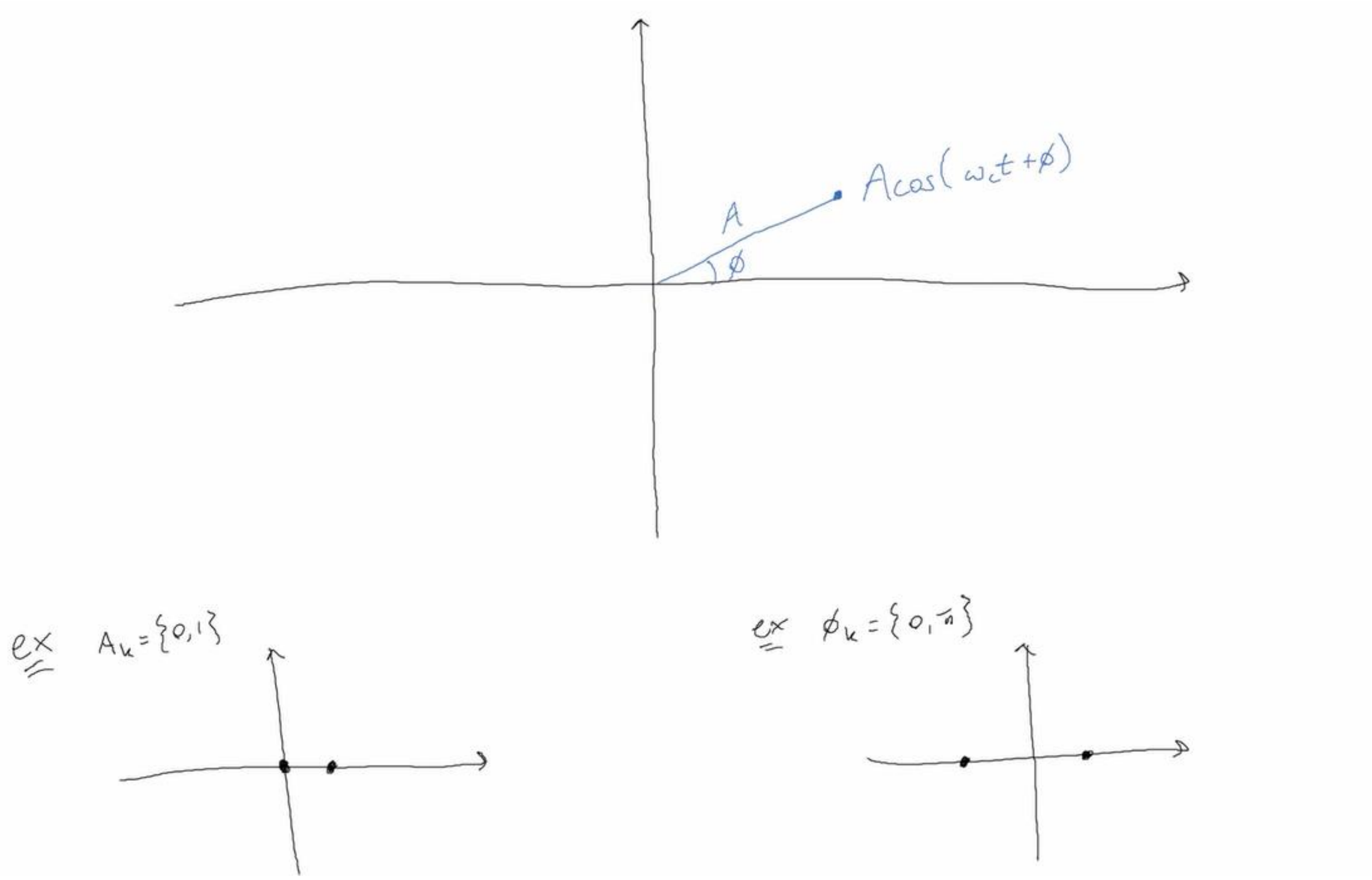
0 1 1 0 1 1



PSK: $y(t) = A_c \cos(\omega_c t + \phi_k)$

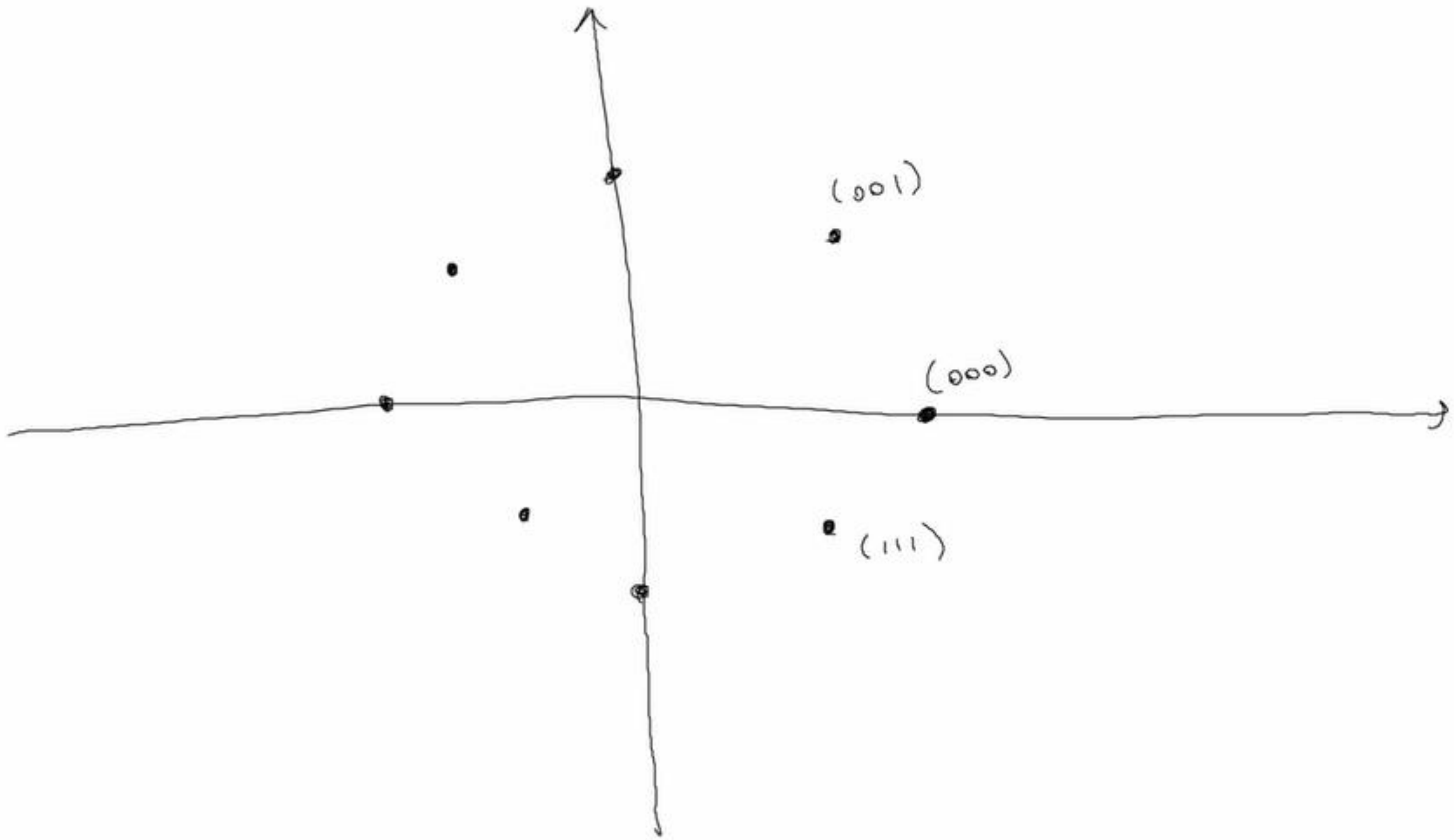
ex: $\phi_k = \{\overset{0}{0}, \overset{1}{\pi}\}$

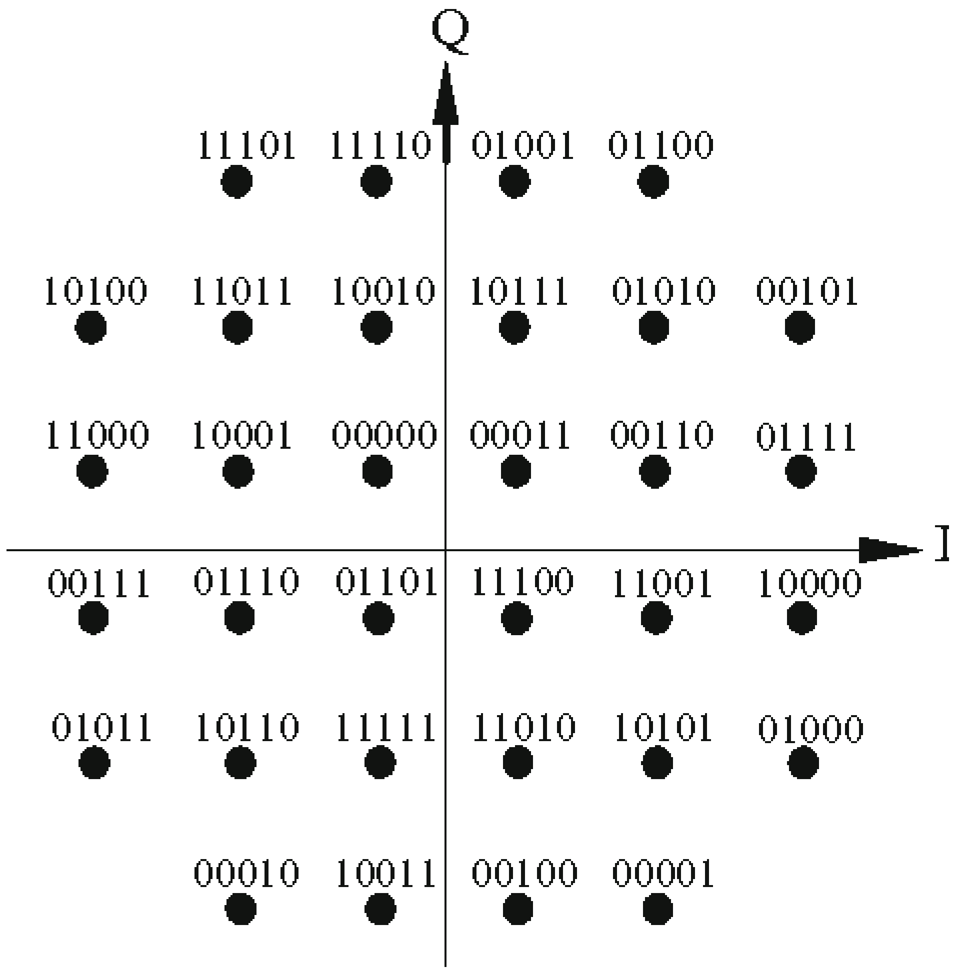
0 1 1 0 1 1


A
ϕ
Acos(ω_c t + ϕ)
ex
A_k = {0,1}
ex
ϕ_k = {0, π}

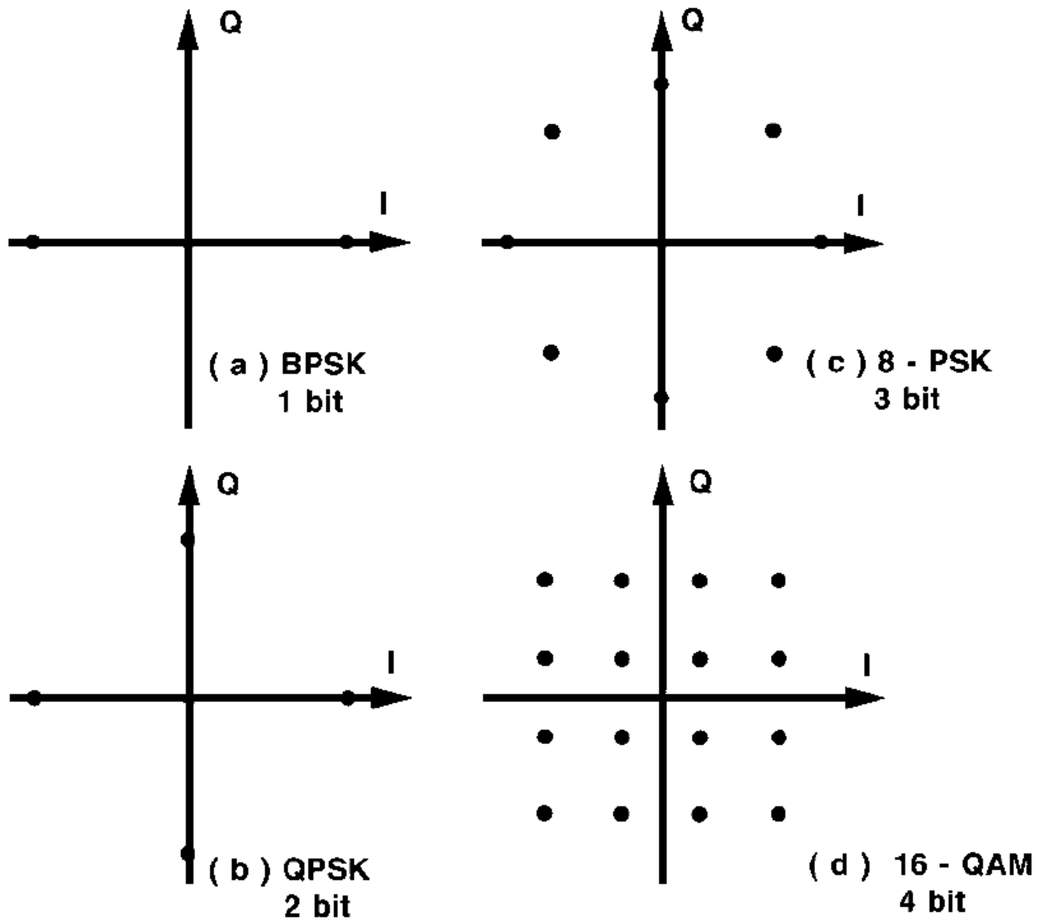
ex

8-PSK

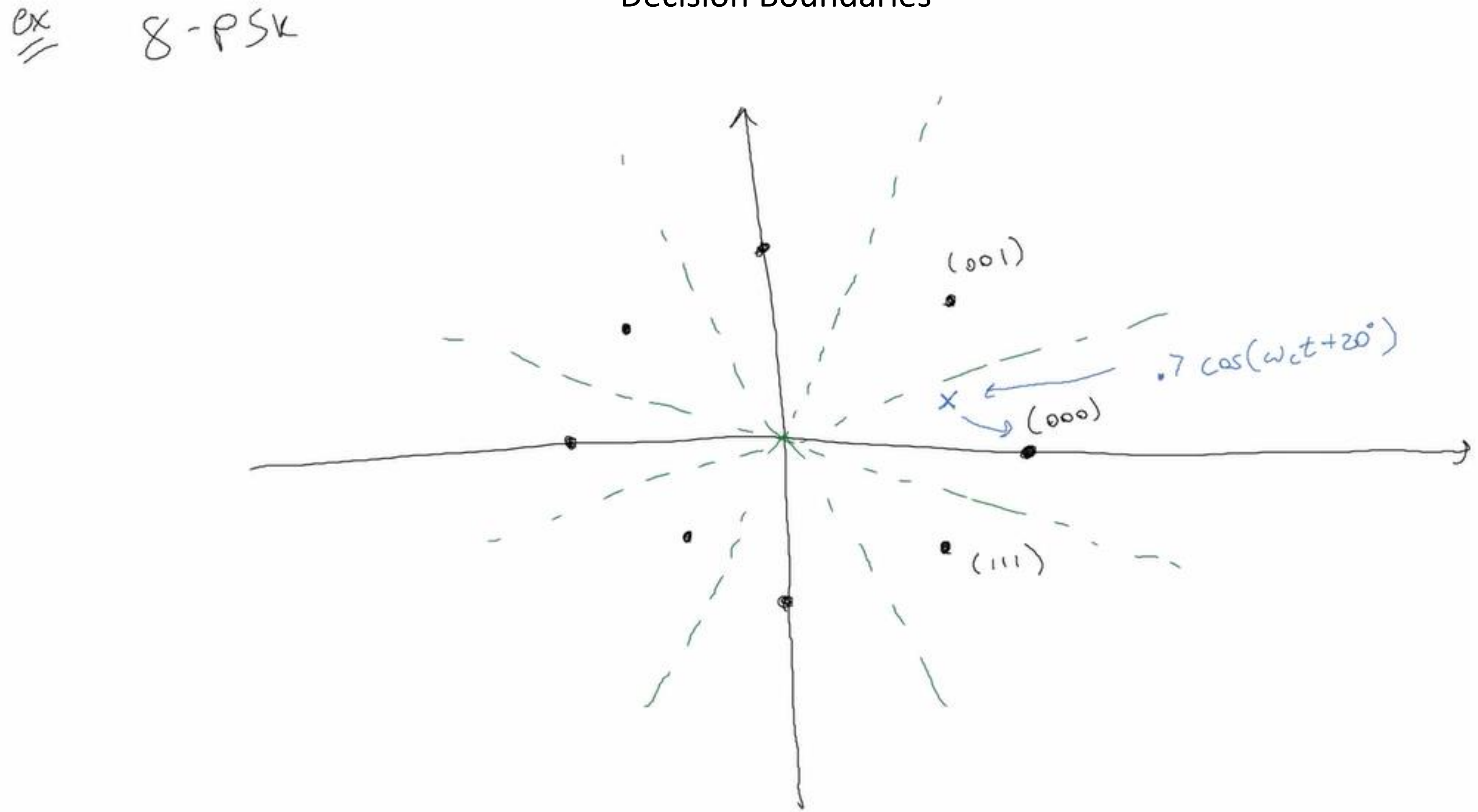



Q
11101 11110 01001 01100
10100 11011 10010 10111 01010 00101
11000 10001 00000 00011 00110 01111
I
00111 01110 01101 11100 11001 10000
01011 10110 11111 11010 10101 01000
00010 10011 00100 00001

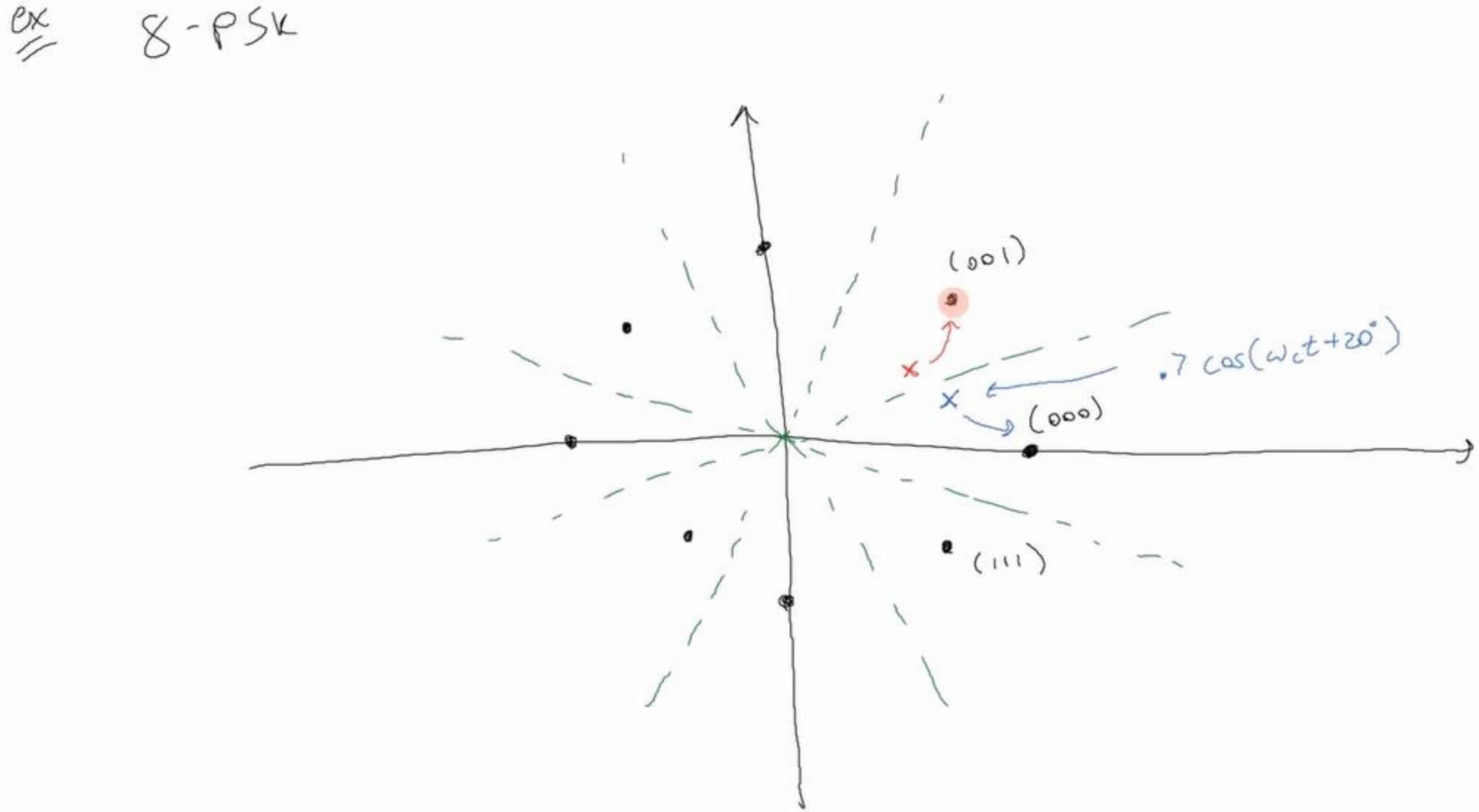
32 - QAM (5 bits)


Q
I
(a) BPSK
1 bit
(c) 8 - PSK
3 bit
(b) QPSK
2 bit
(d) 16 - QAM
4 bit

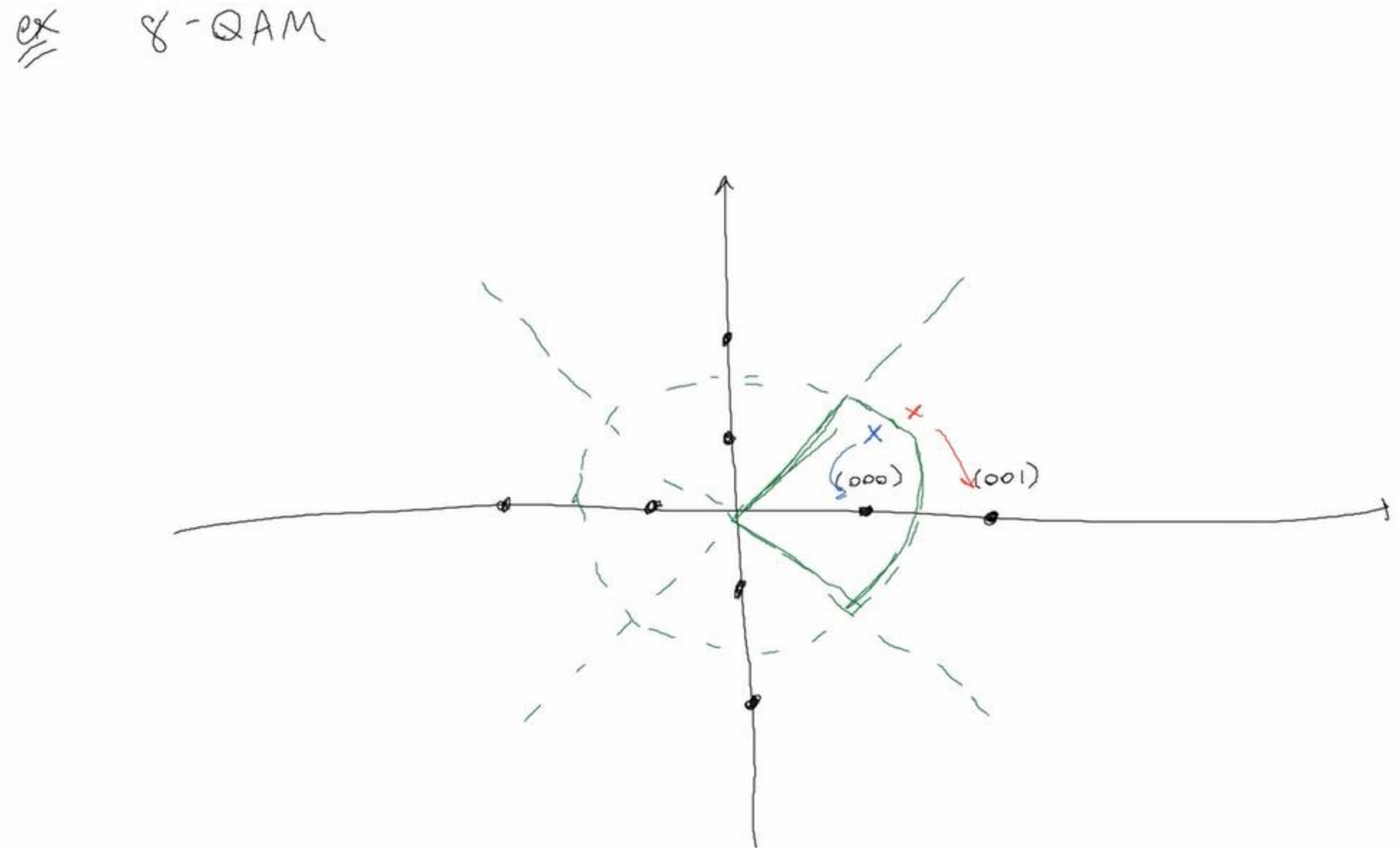
Decision Boundaries



Decision Boundaries



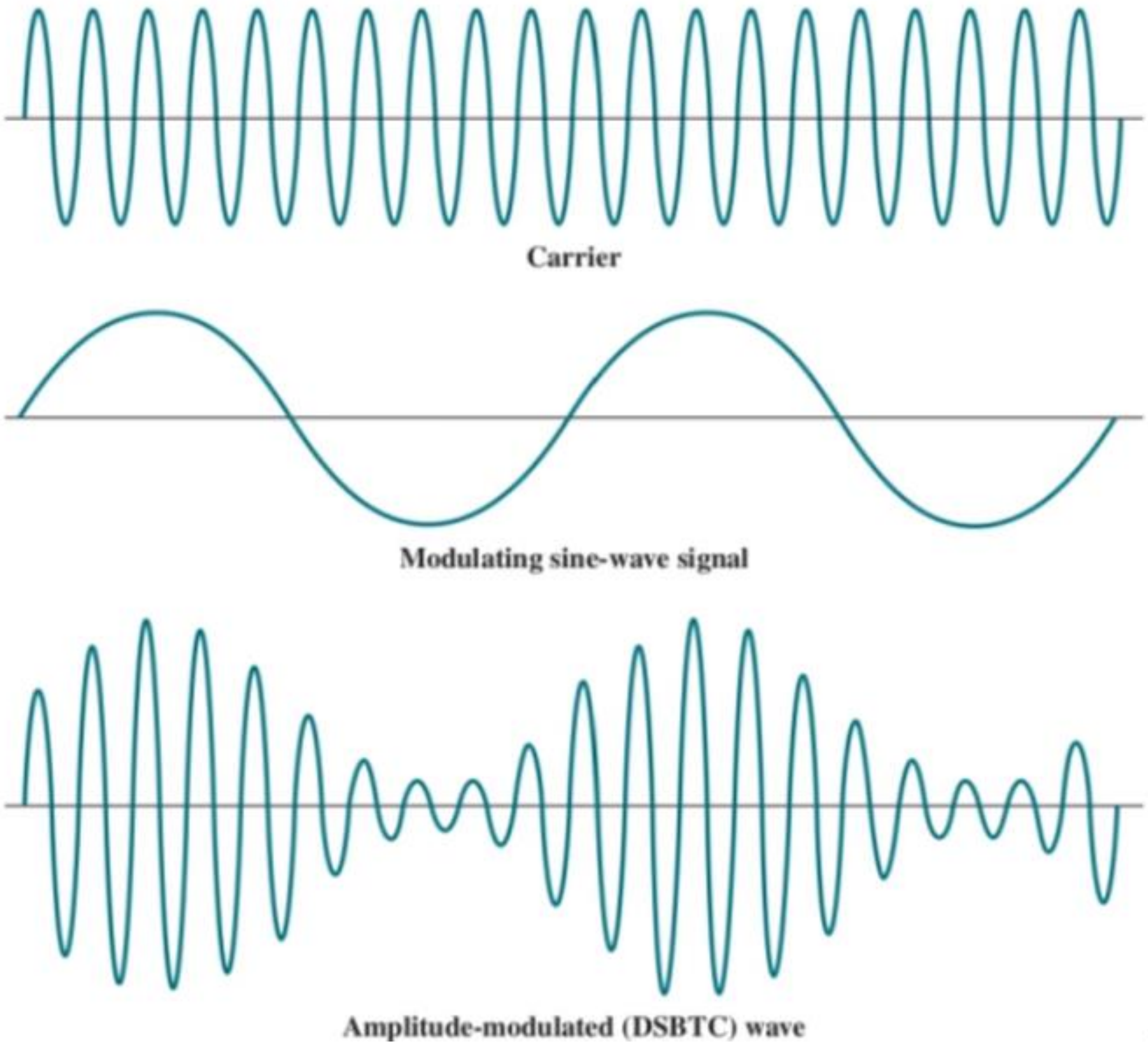
Decision Boundaries



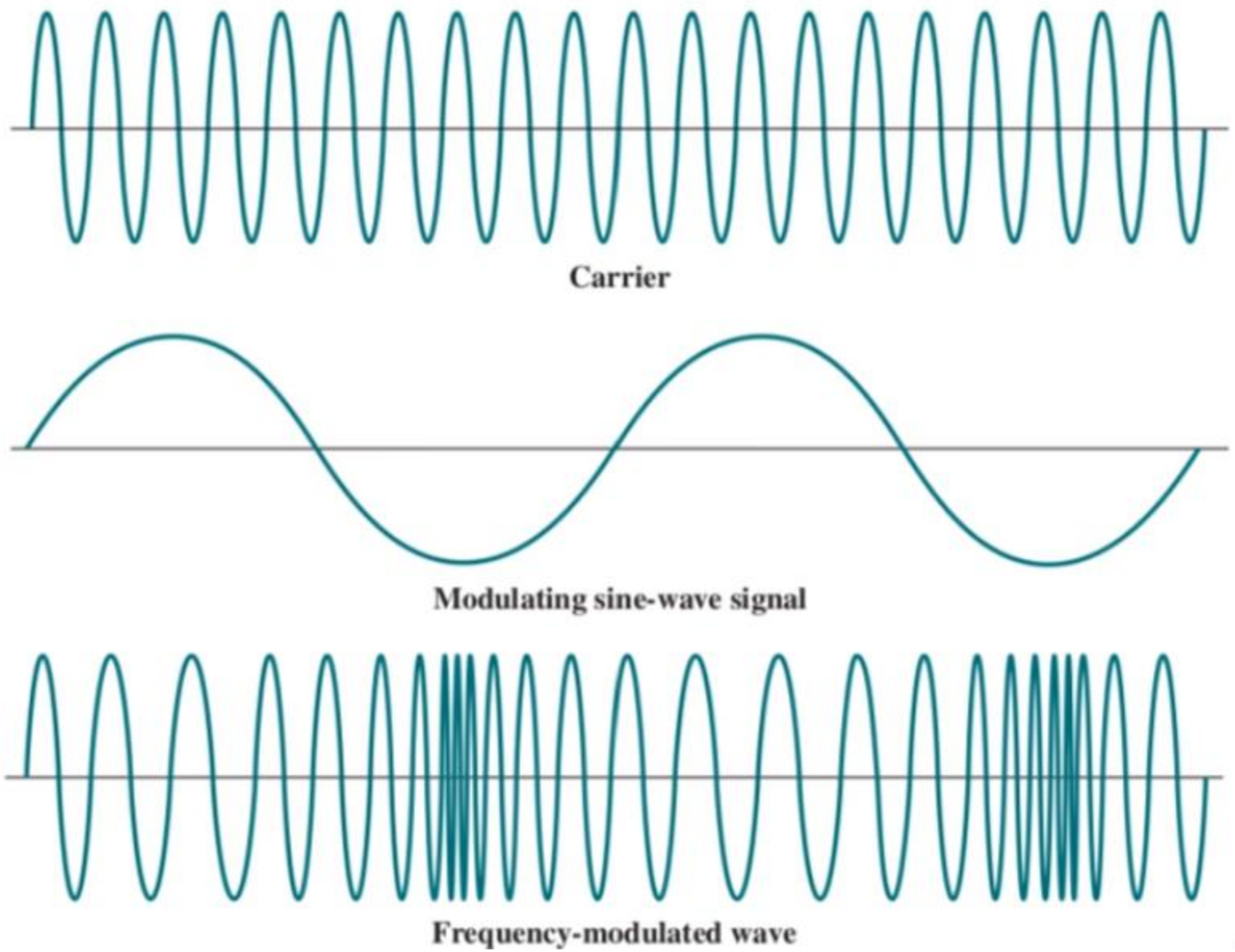
Modulating Signals

- Combine input signal, $m(t)$, and carrier at frequency f_c to produce signal $s(t)$ whose bandwidth is centered on f_c
- Why? If analog transmission systems . . .
  - Digital data must be convereted to analog form (e.g. PSK, FSK)
  - Analog signals may need to be transmitted at higher frequency than analog data
  - Changing frequency of analog data allows for frequency division multiplexing (sending different ananlog data in one analog signal)
- Principal techniques: amplitude modulation (AM), frequency modulation (FM), phase modulation (PM)

Amplitude Modulation of a Sine-Wave Carrier by a Sine-Wave Signal



Frequency Modulation of a Sine-Wave Carrier by a Sine-Wave Signal



Thank you for your attention