Badji Mokhtar University Annaba
Electronics Department

Level 3: Telecommunication
Module: Telecommunication systems and networks

Digital Transmission and data coding, Lecture 3

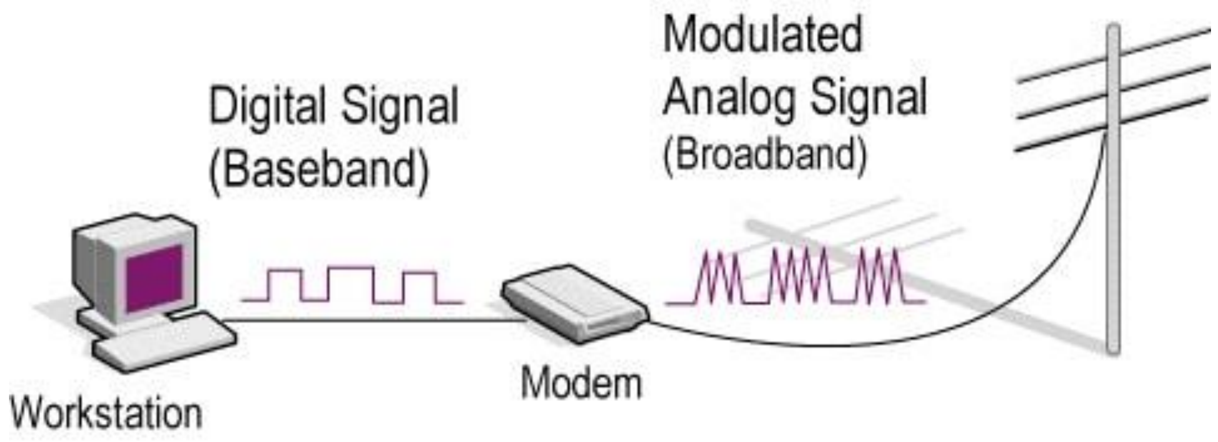
Contact:
seifallah.nasri@univ-annaba.org

Annaba, Algeria

Outline

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

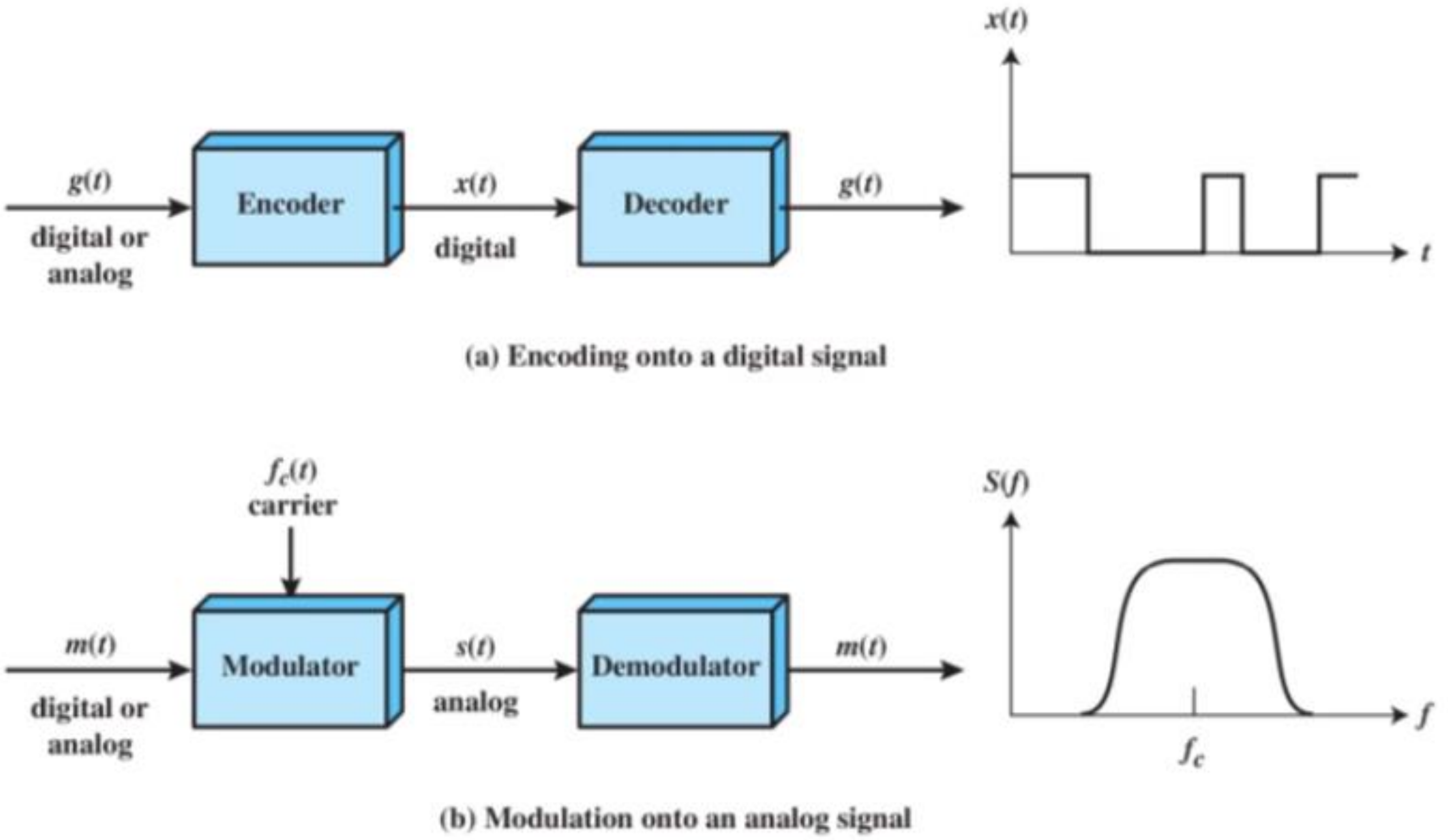
Transmission numérique : Dans ce cas les données transmises sont discrètes et se présentent sous forme de deux états (haut et bas) ou bien encore à plusieurs états. Cette technique consiste à modifier légèrement le signal, elle est essentiellement destinée à réduire la composante continue.
Cependant, 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**)

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.



- 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).

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

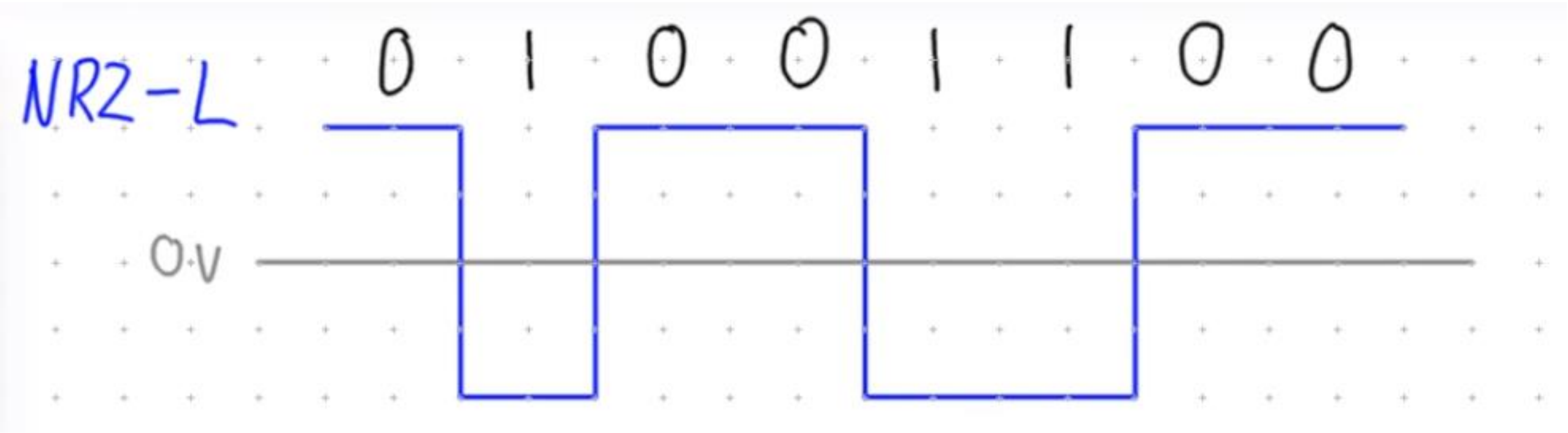
Pseudoternary
0 = positive or negative level, alternating for successive zeros
1 = no line signal

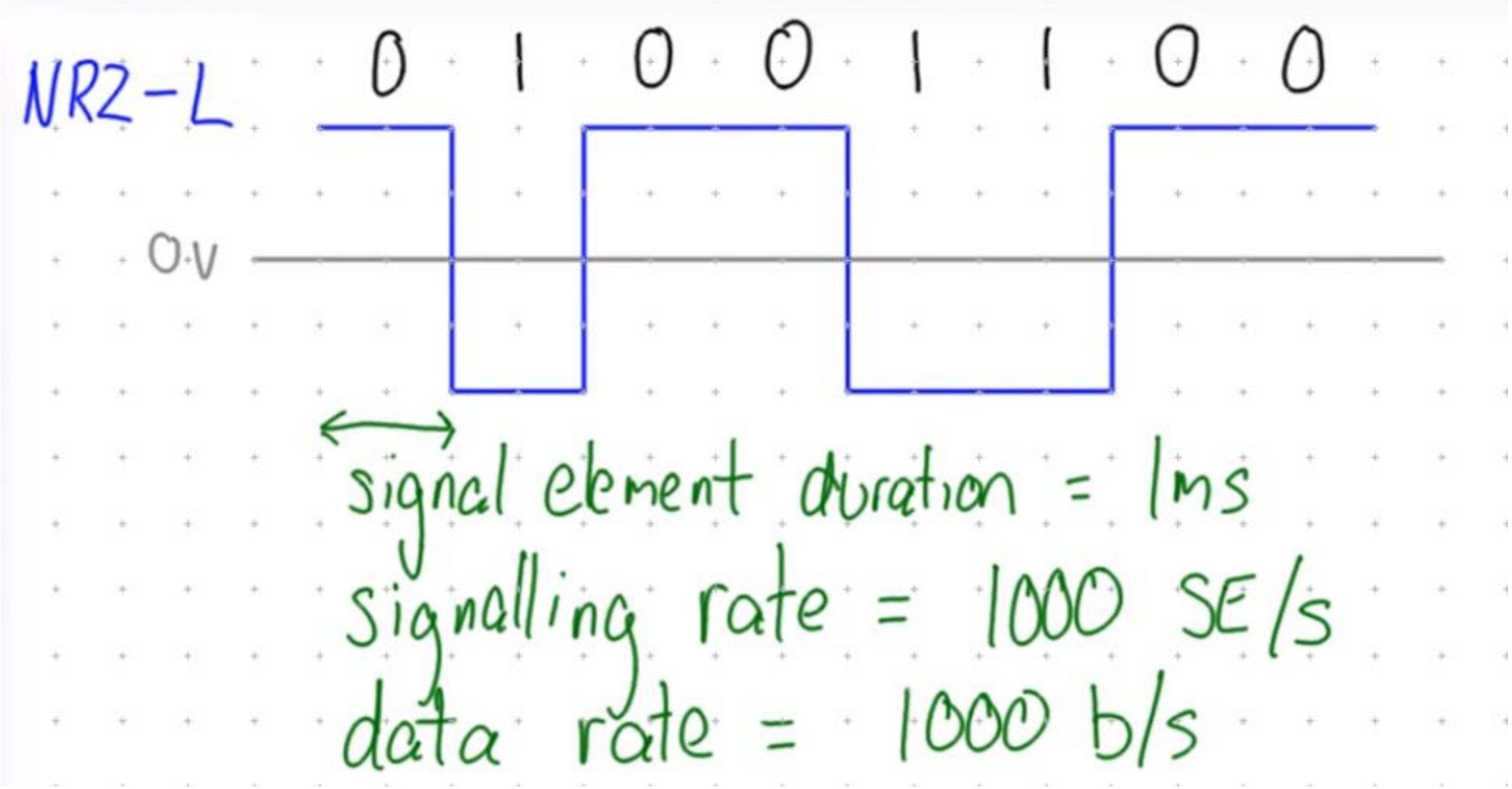
Manchester
0 = transition from high to low in middle of interval
1 = transition from low to high in middle of interval

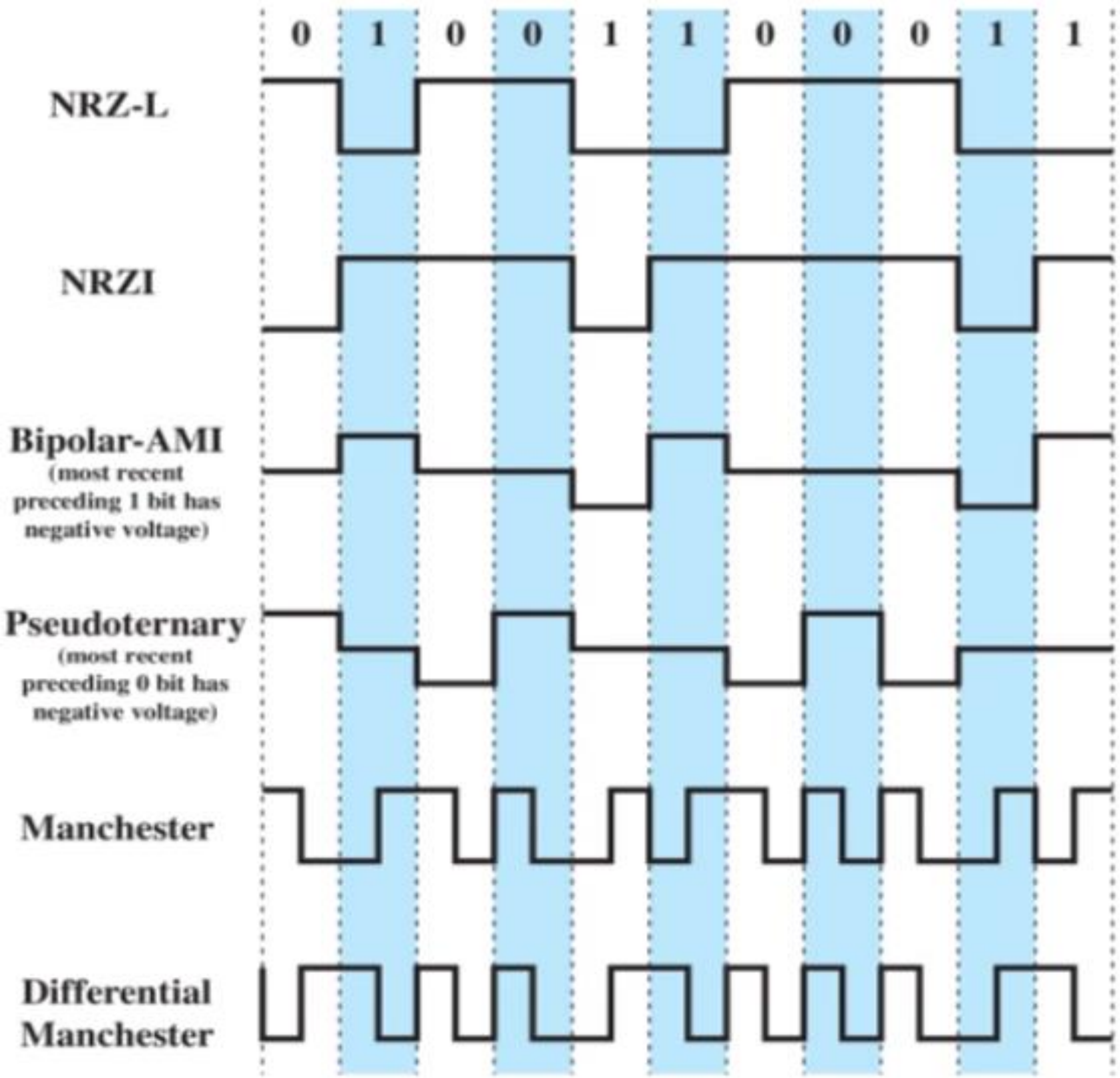
Differential Manchester
Always a transition in middle of interval
0 = transition at beginning of interval
1 = no transition at beginning of interval

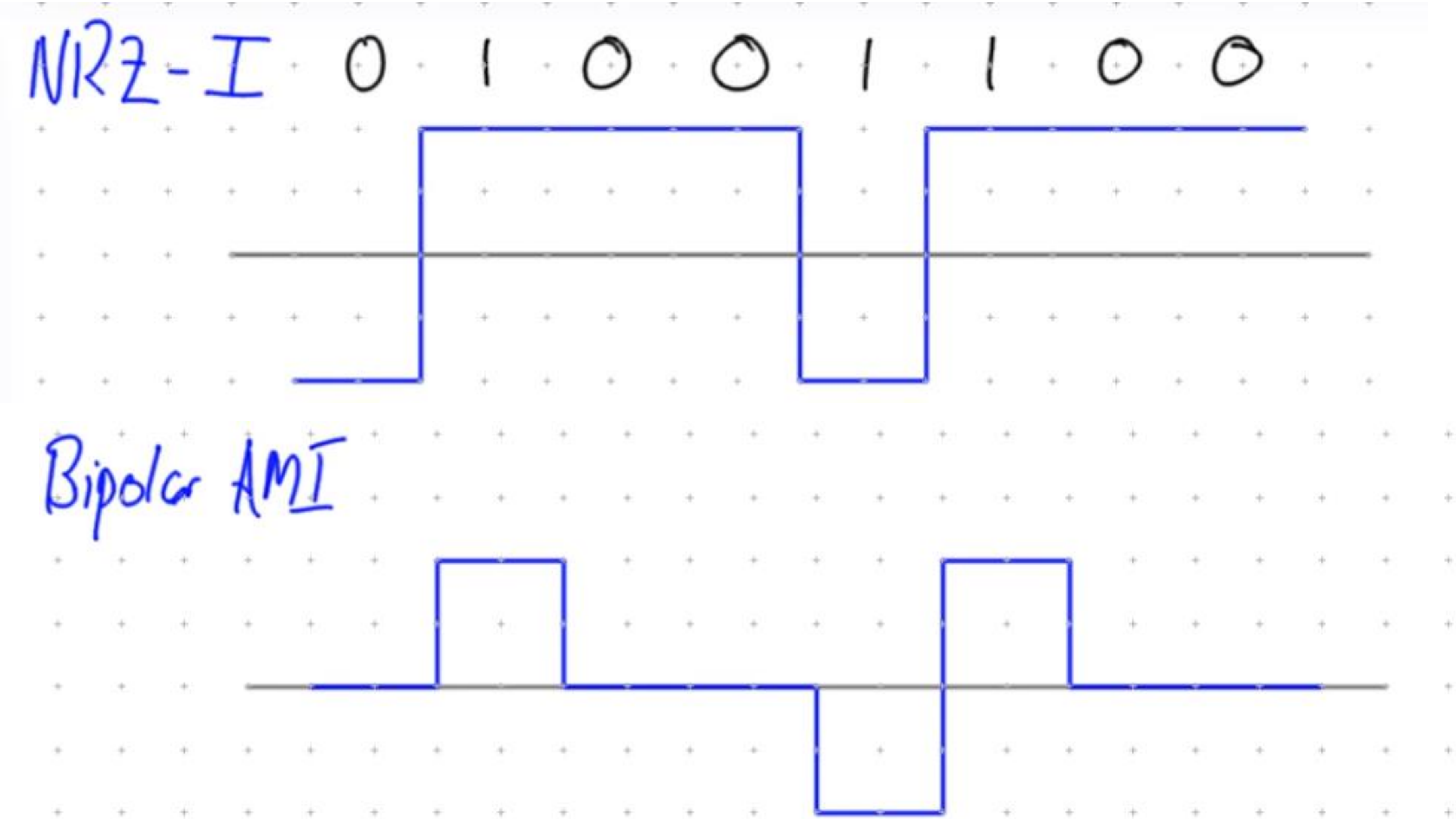
B8ZS
Same as bipolar AMI, except that any string of eight zeros is replaced by a string with two code violations

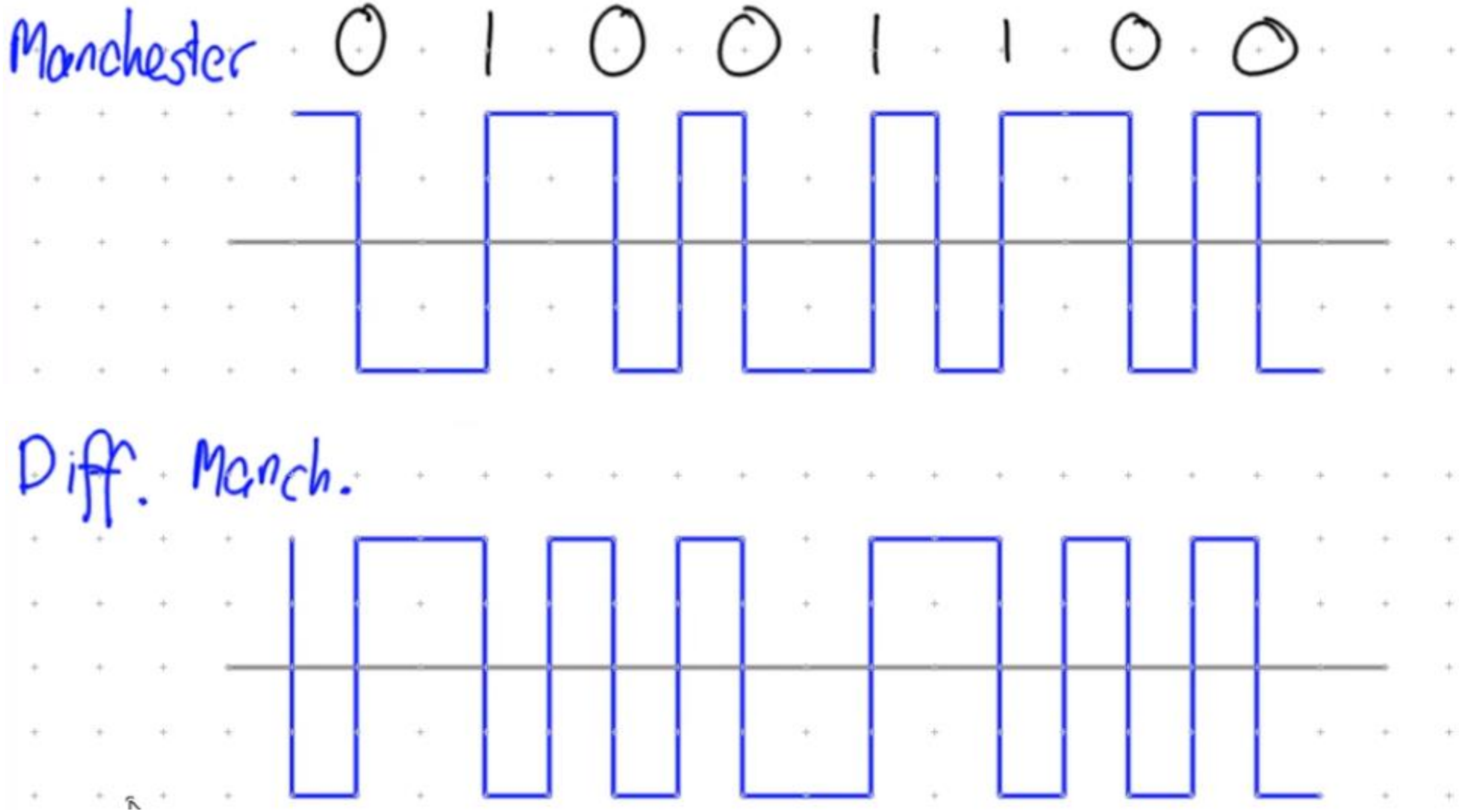
HDB3
Same as bipolar AMI, except that any string of four zeros is replaced by a string with one code violation


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


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

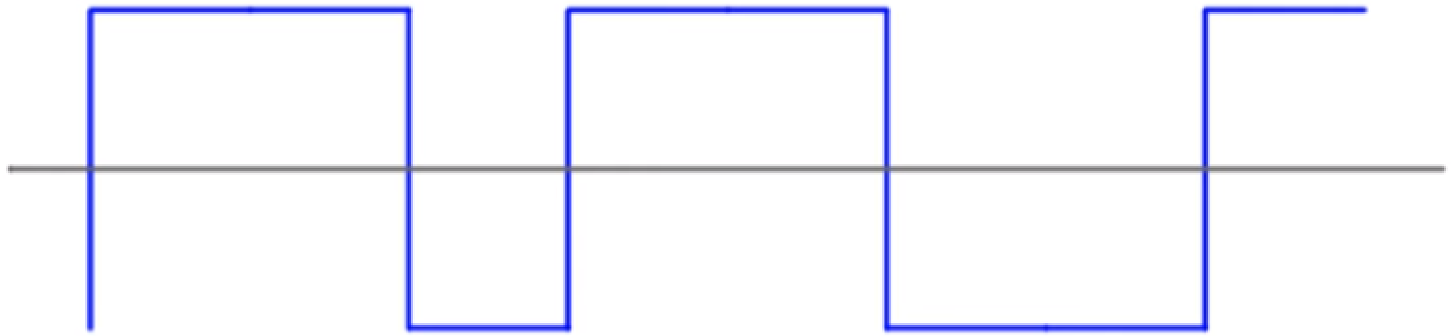

NRZ-I
0 1 0 0 1 1 0 0
Bipolar AMI

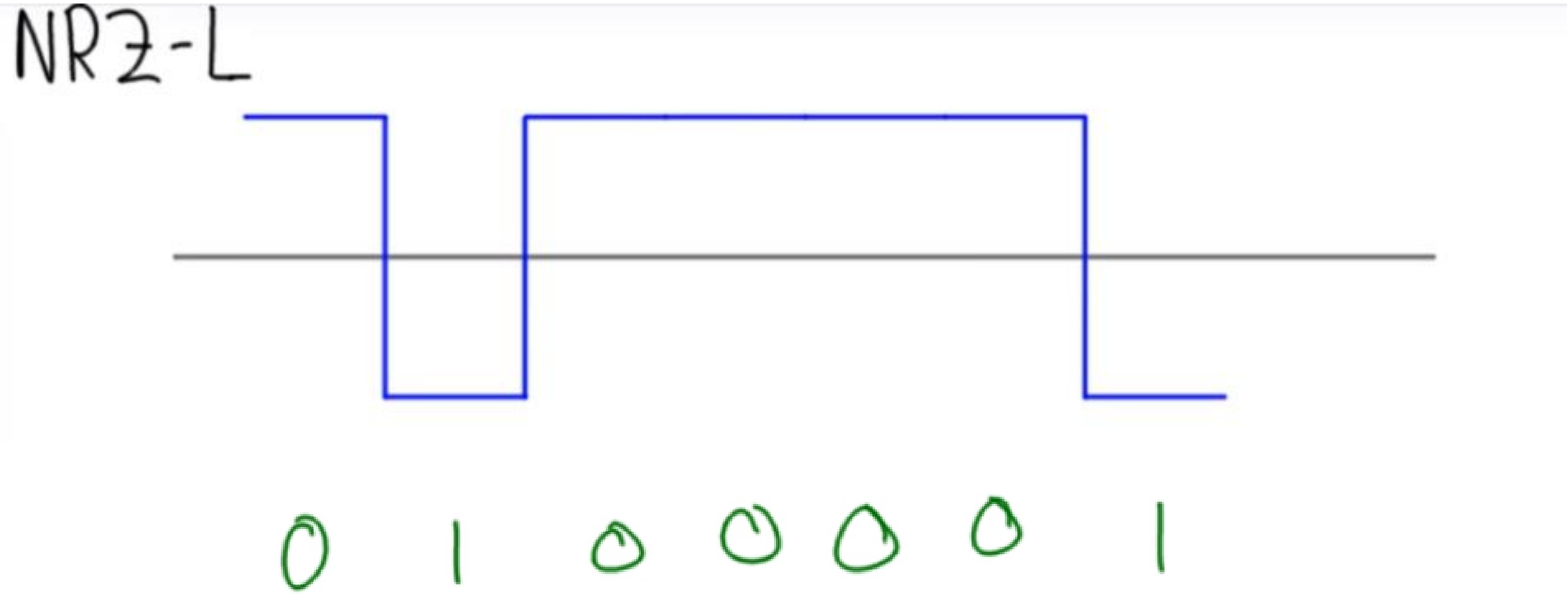

Manchester
0 1 0 0 1 1 0 0
Diff. Manch.

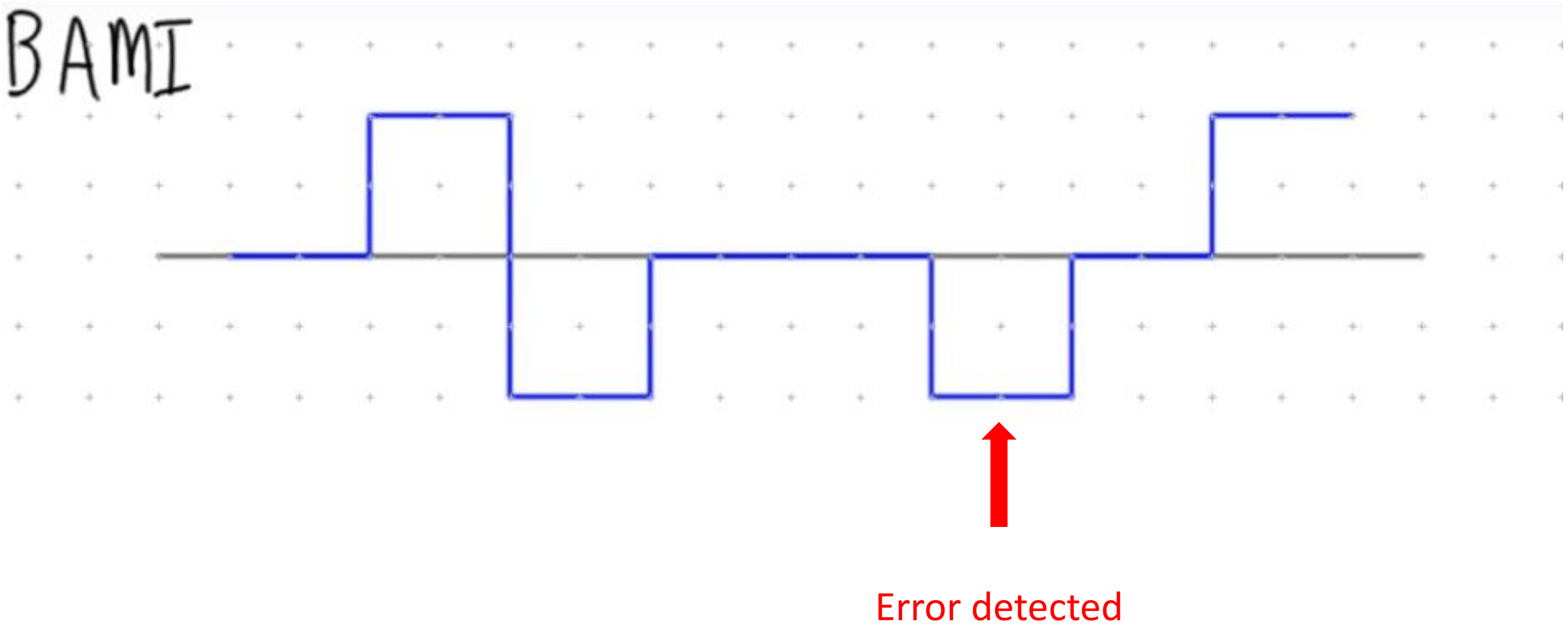
Examples of technologies that use encoding schemes

- 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

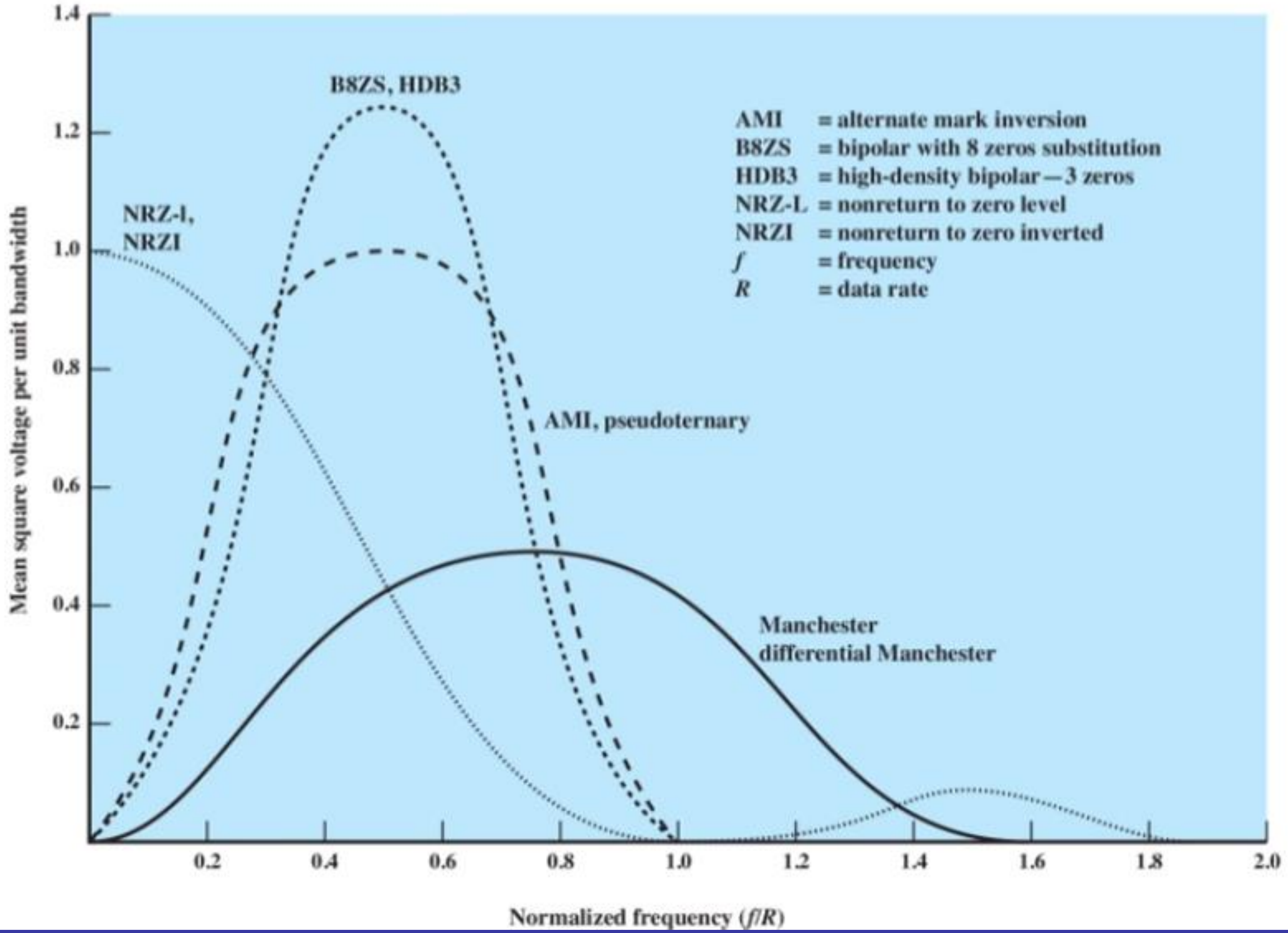
Signal spectrum

- 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

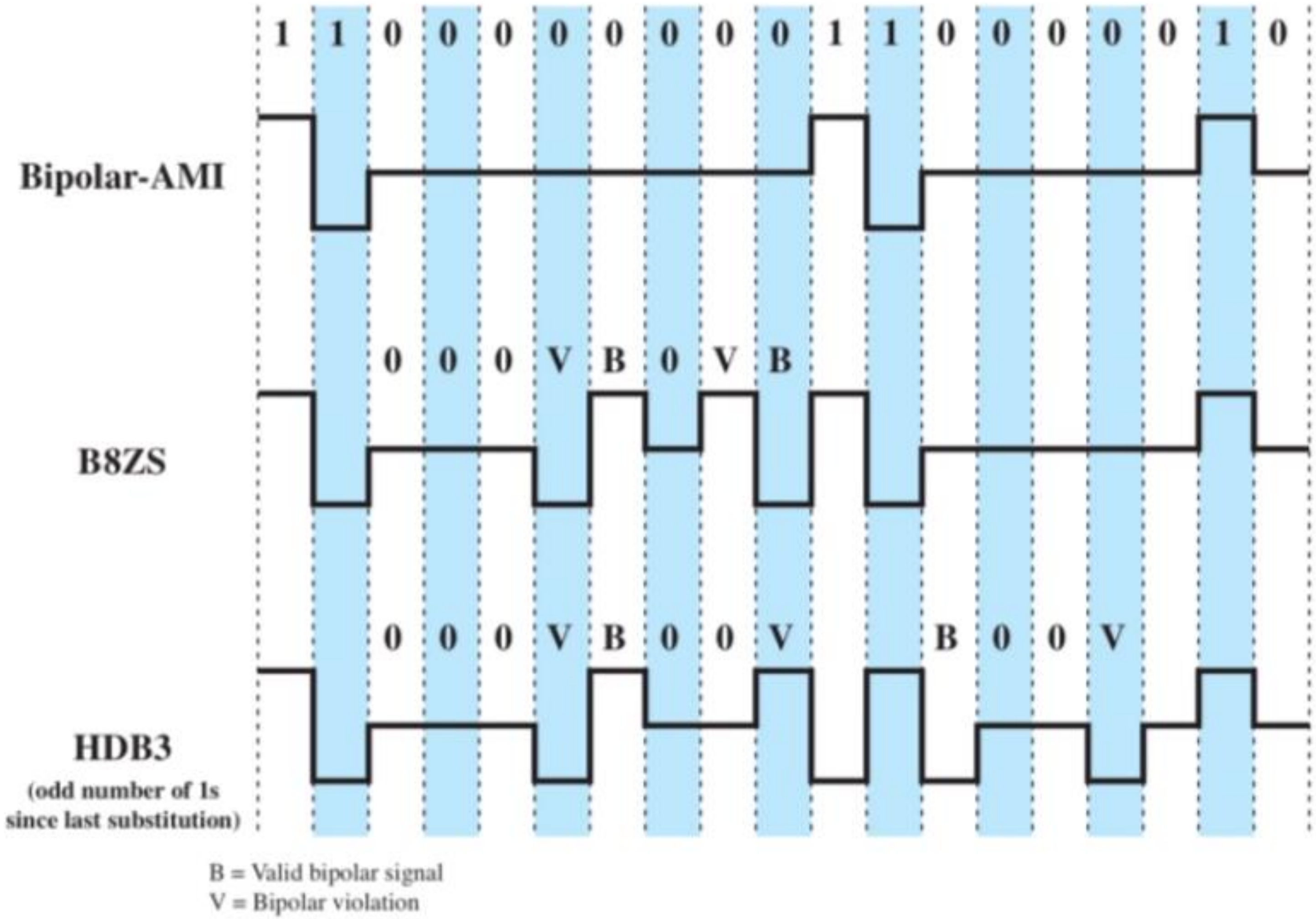
Signal Interference

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

Cost and complexity

- Desire smaller signaling rate to achieve a given data rate

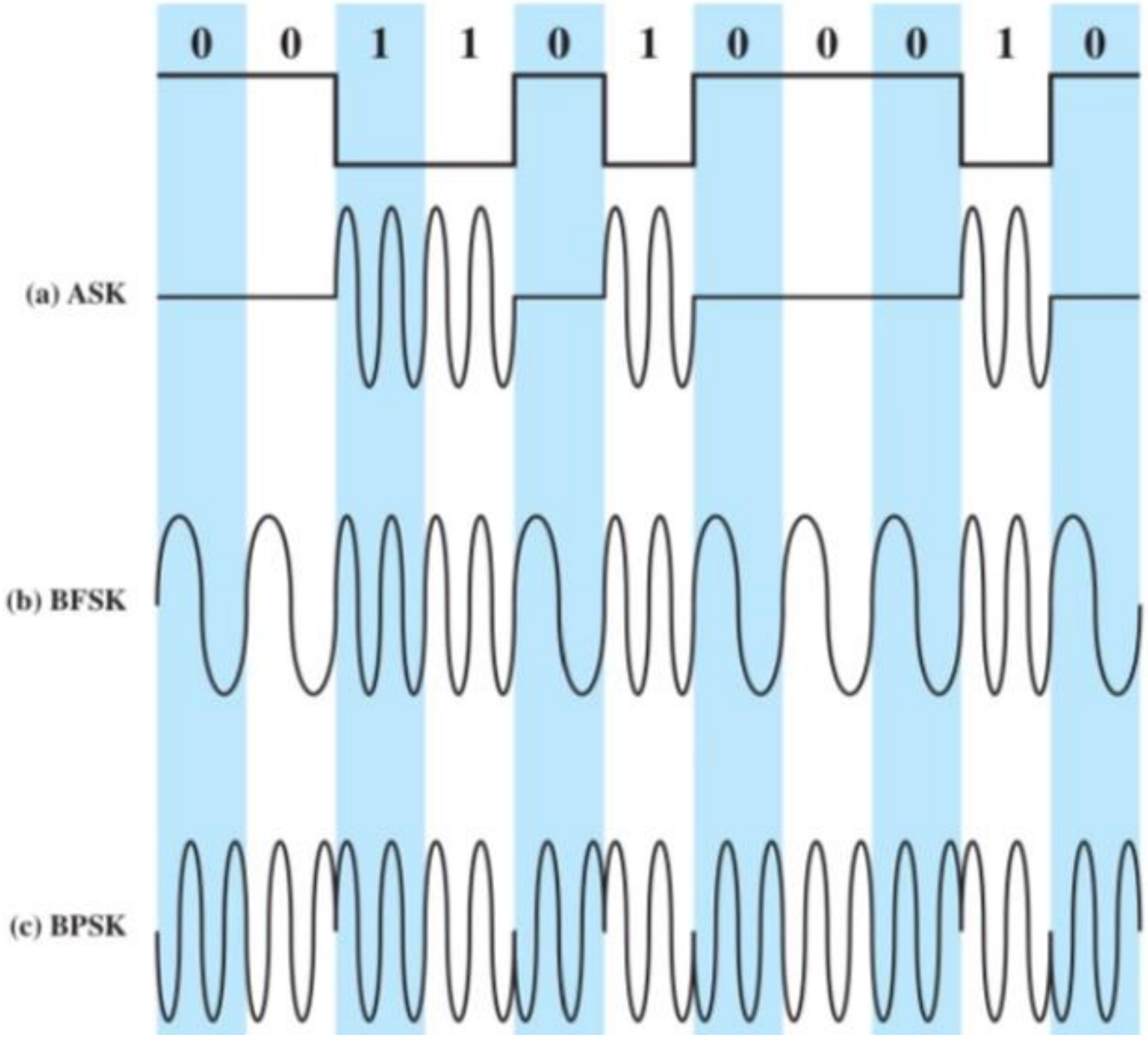
Encoding rules for B8ZS and HDB3

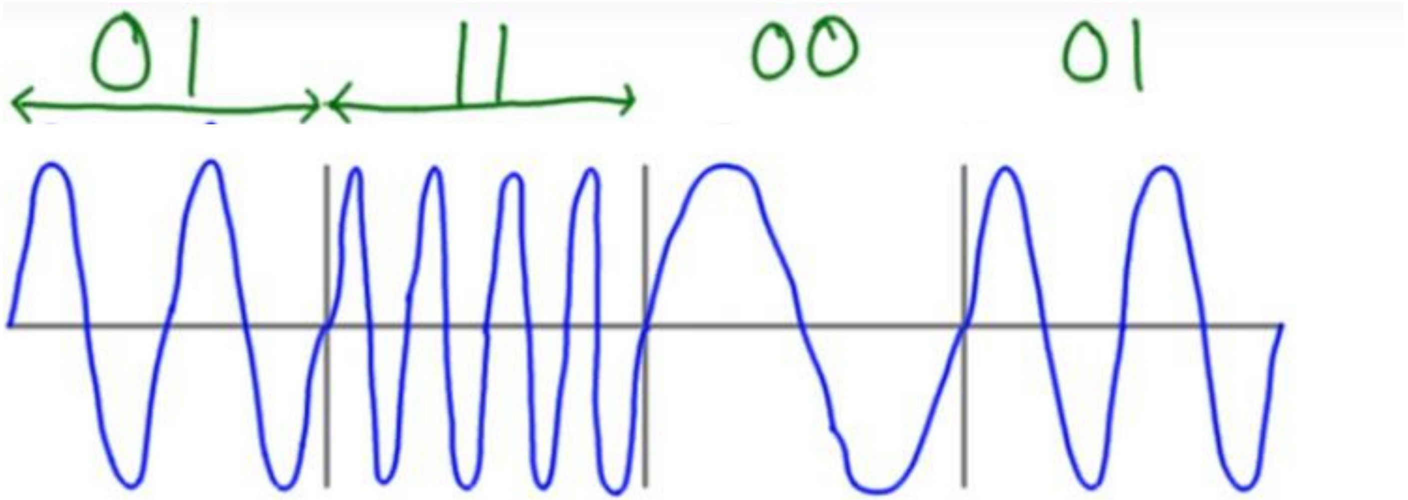


Digital Data, Analog Signals

- 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

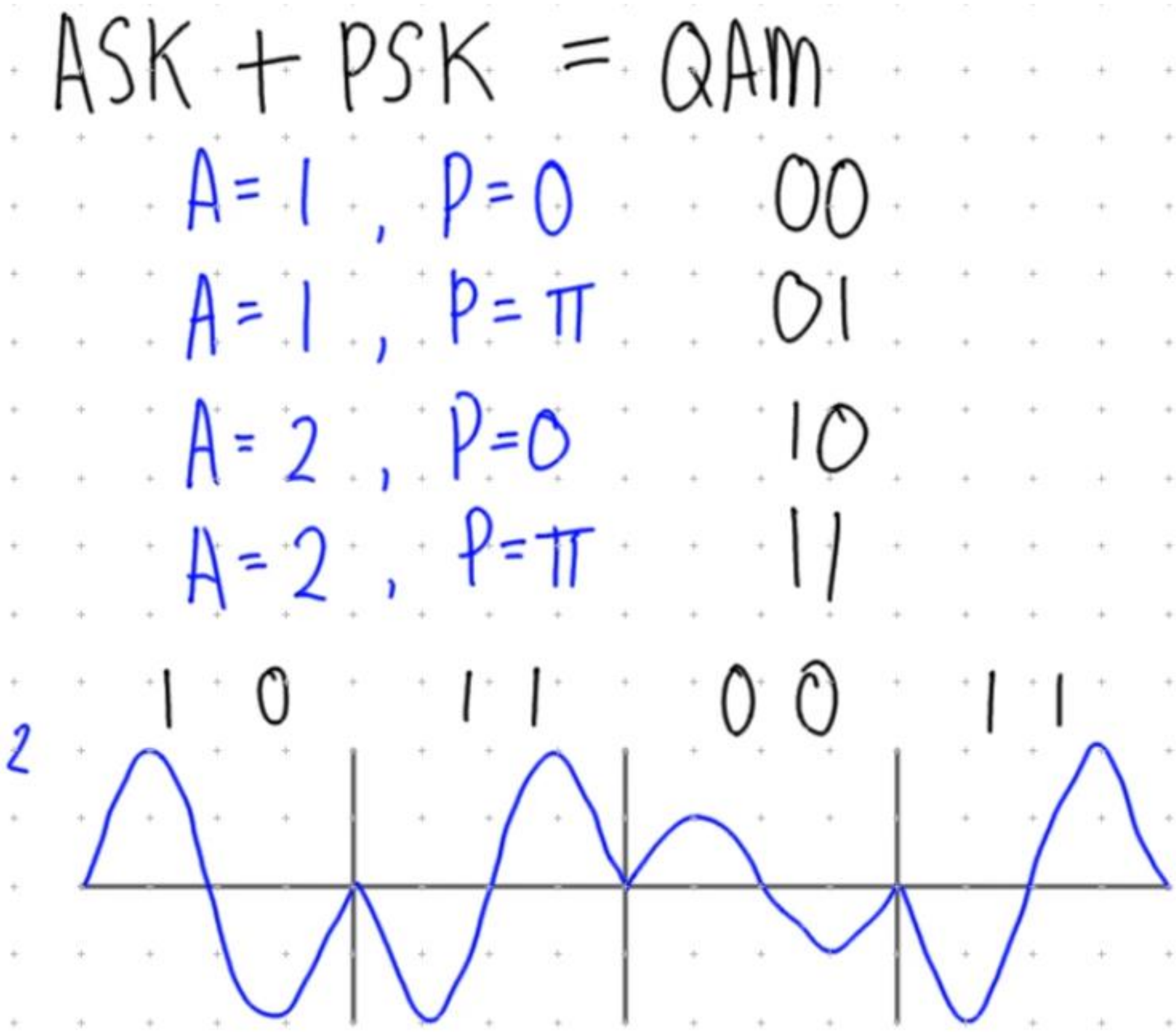
- 3 basic modulation techniques:
  1. Amplitude Shift Keying (ASK)
  2. Phase Shift Keying (PSK)
  3. Frequency Shift Keying (FSK)
- Resulting a signal which occupies a bandwidth centred on carrier frequency.


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

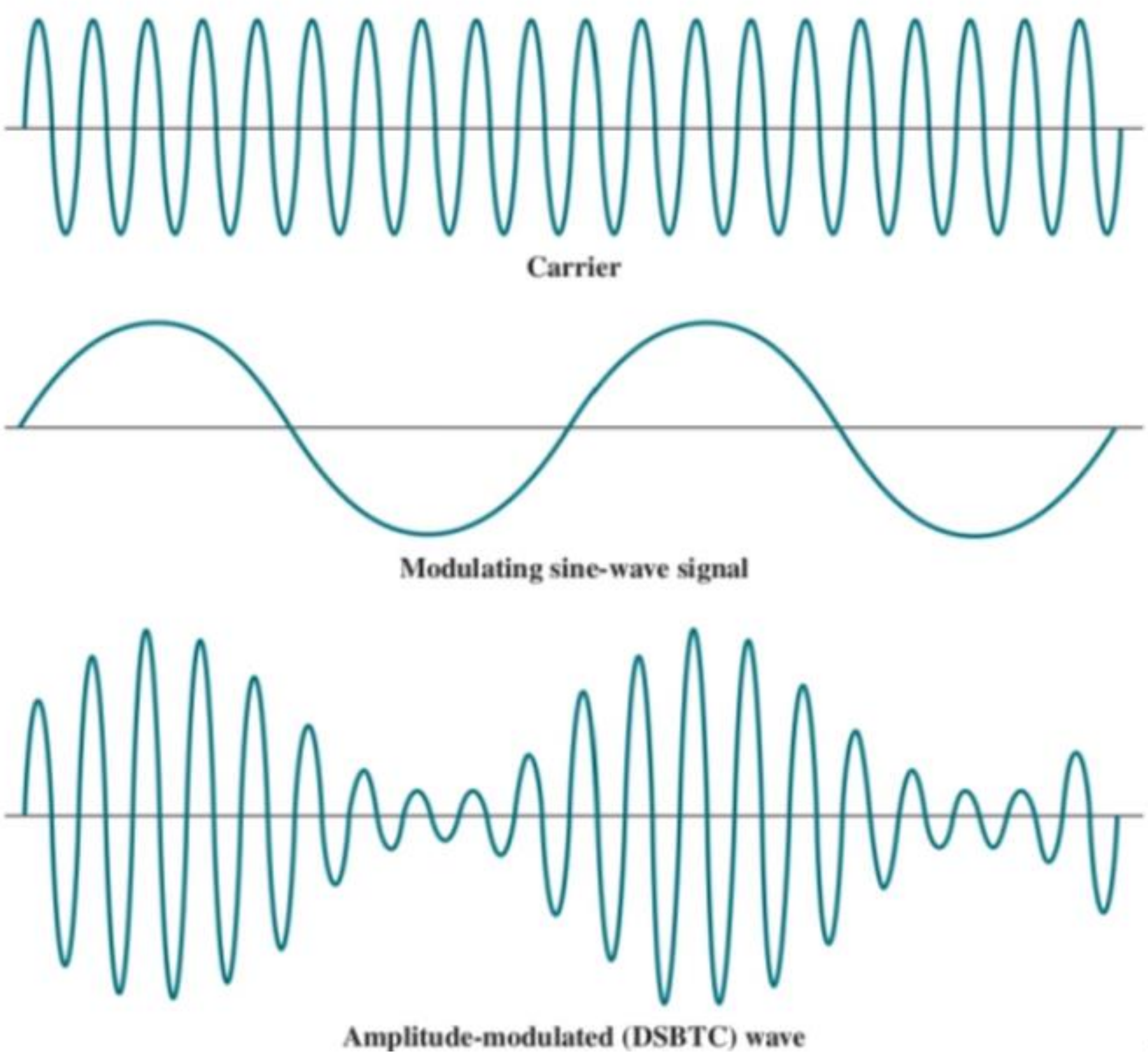
Phase Shift Keying

- 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

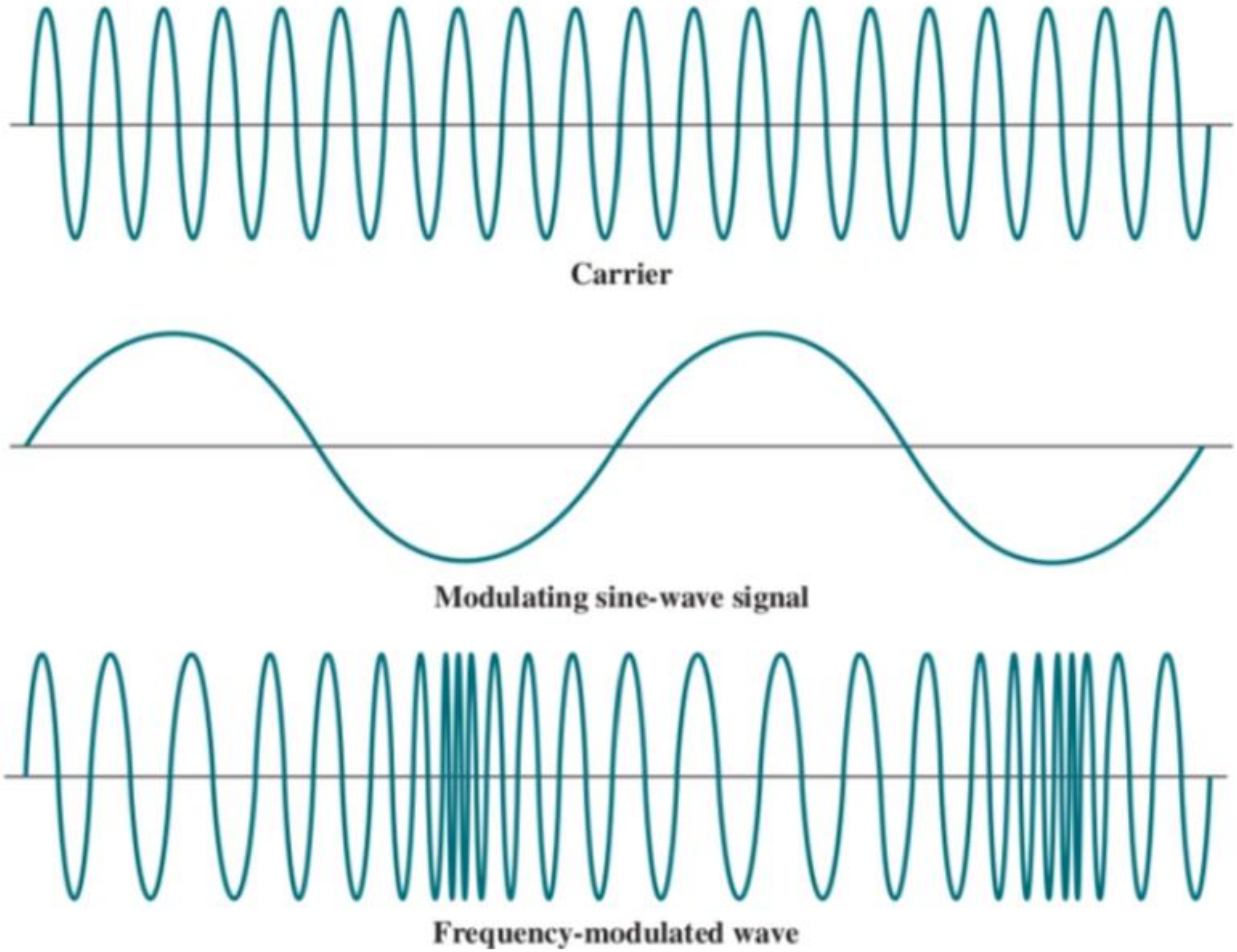
Example of technologies using Shift Keying

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

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