

Multilevel Binary Pseudoternary

- ❑ Binary one represented by absence of line signal
- ❑ Binary zero represented by alternating positive and negative pulses
- ❑ No advantage or disadvantage over bipolar-AMI
- ❑ Each used in some applications

Multilevel Binary Issues

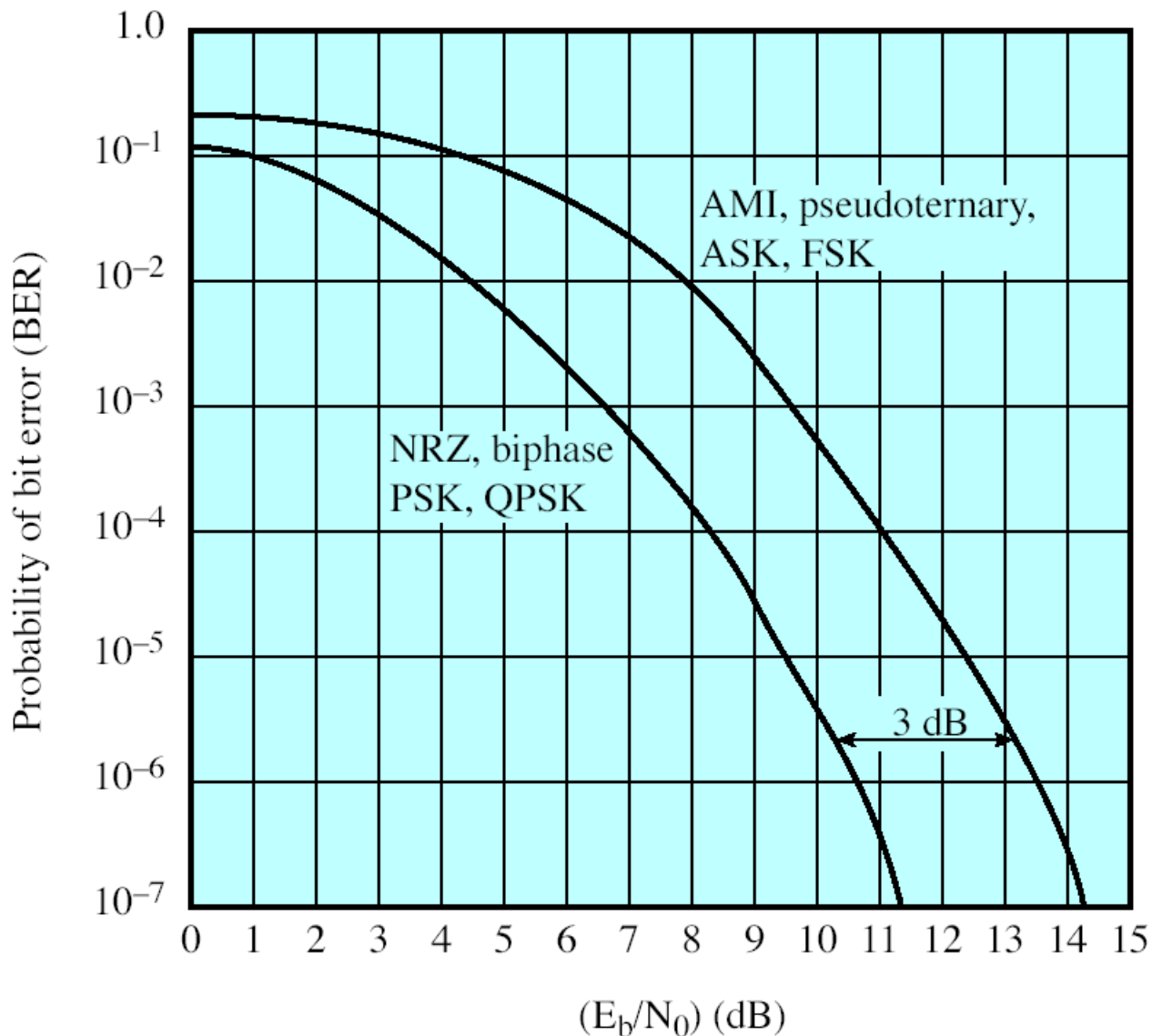
❑ Advantages:

- ❑ No loss of synchronization if a long string of 1's occurs, each introduce a transition, and the receiver can resynchronize on that transition
- ❑ No net dc component, as the 1 signal alternate in voltage from negative to positive
- ❑ Less bandwidth than NRZ
- ❑ Pulse alternating provides a simple mean for error detection

❑ Disadvantages

- ❑ receiver distinguishes between three levels: +A, -A, 0
- ❑ a 3 level system could represent $\log_2 3 = 1.58$ bits
- ❑ requires approx. 3dB more signal power for same probability of bit error

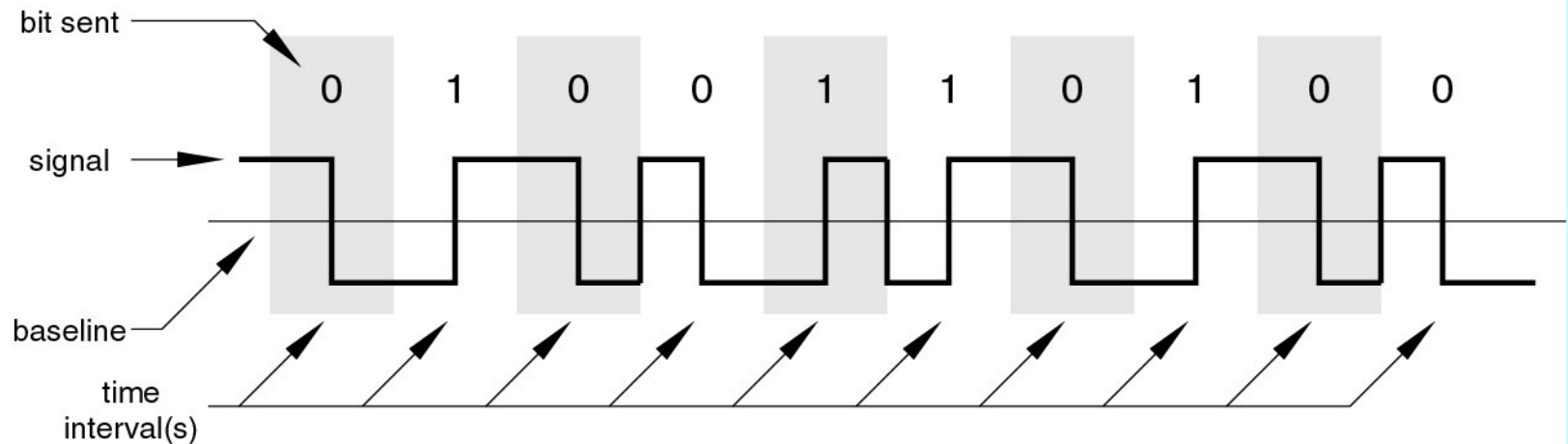
Theoretical Bit Error Rate (BER) For Various Encoding Schemes



Manchester Encoding

- ❑ has transition in middle of each bit period
- ❑ low to high represents binary one
- ❑ transition serves as clock and data
- ❑ high to low represents binary zero
- ❑ used by IEEE 802.3 (Ethernet) LAN standard

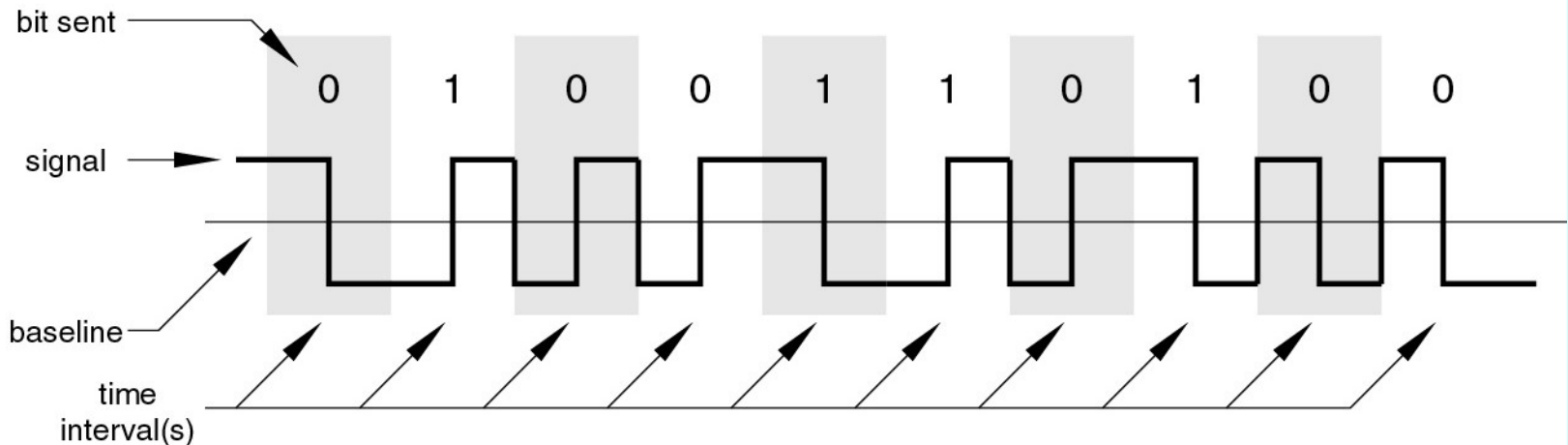
Manchester Encoding



Differential Manchester Encoding

- ❑ midbit transition is clocking only
- ❑ transition at start of bit period representing binary 0
- ❑ no transition at start of bit period representing binary 1
- ❑ used by IEEE 802.5 token ring LAN

Differential Manchester Encoding



Advantages and disadvantages of Manchester Encoding

❑ Disadvantages

- at least one transition per bit time and possibly two
- maximum modulation rate is twice NRZ

$$D = \frac{R}{L}$$

D: Modulation rate, [baud]

R: Data Rate, [bps]

L: number of bits per signal elements

- requires more bandwidth

❑ Advantages

- synchronization on mid bit transition (self clocking codes)
- has no dc component
- has error detection capability (the absence of an expected transition can be used to detect errors)

Modulation Rate versus Data Rate

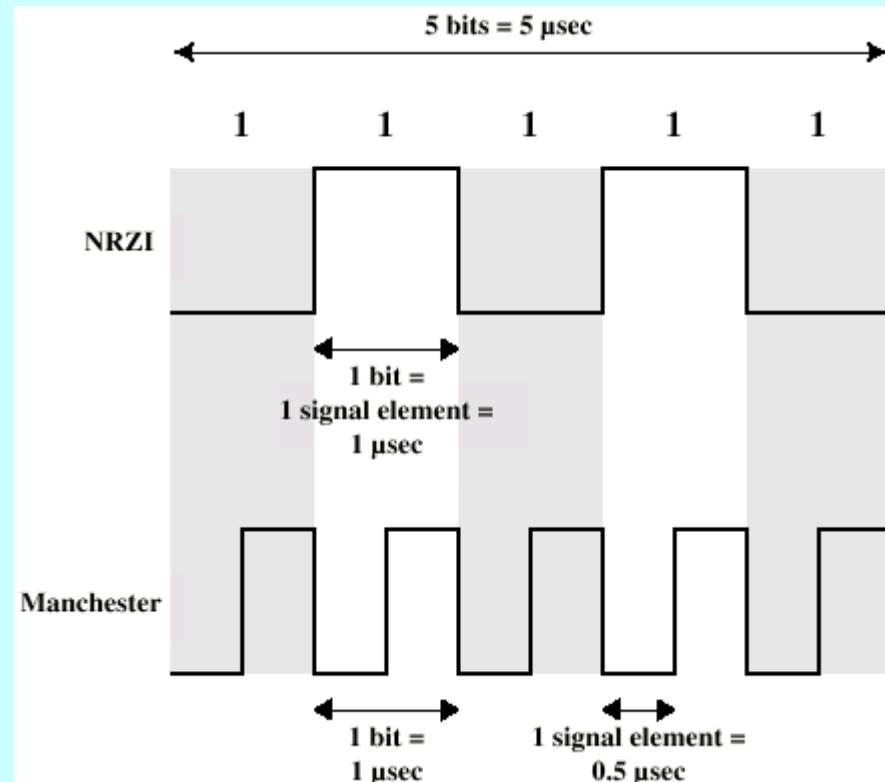
❑ Data rate (expressed in bps)

➤ Data rate or bit rate $R=1/T_b=1/1\mu\text{s}=1\text{Mbps}$

❑ Modulation Rate (expressed in baud) is the rate at which signal elements are generated

➤ Maximum modulation rate for Manchester is

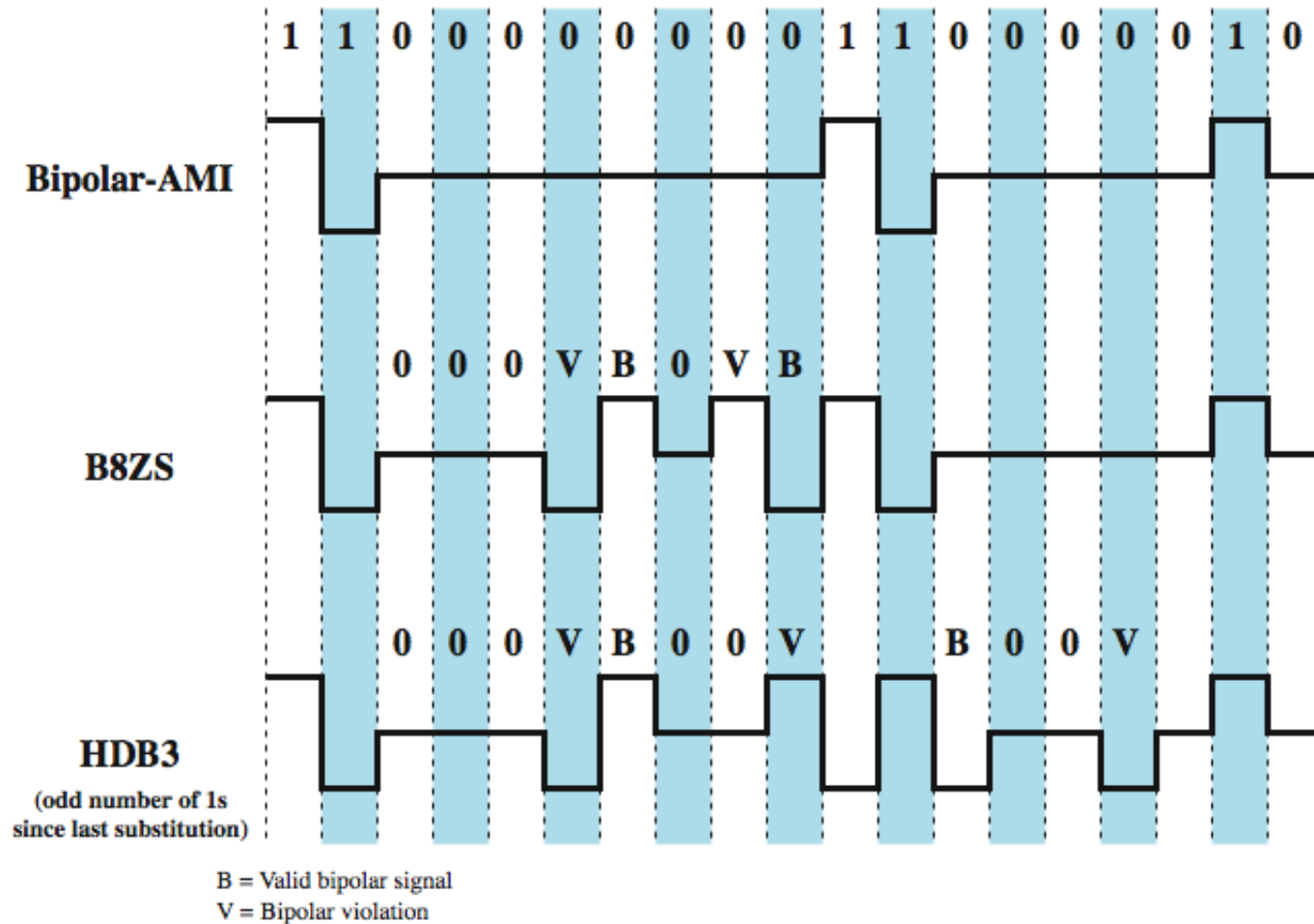
$$D=1/(0.5T_b)=2/1\mu\text{s}=2\text{Mbaud}$$



Scrambling

- ❑ Use scrambling to replace sequences that would produce constant voltage
- ❑ These filling sequences must
 - produce enough transitions to maintain synchronization
 - be recognized by receiver & replaced with original
 - be same length as original
- ❑ Design goals
 - have no dc component
 - have no long sequences of zero level line signal
 - have no reduction in data rate
 - give error detection capability

B8ZS and HDB3



Bipolar with 8-Zero Substitution (B8ZS)

- ❑ To overcome the drawback of the AMI code that a long string of zeros may result in loss of synchronization, the encoding is amended with the following rules:
 - If 8 zeros occurs and the last voltage pulse was positive, then the 8 zeros are encoded as 000+−0−+
 - If zeros occurs and the last voltage pulse was negative, then the 8 zeros are encoded as 000−+0+−

High Density Bipolar-3 zeros (HDB3)

- ❑ The scheme replaces strings with 4 zeros by sequences containing one or two pulses
- ❑ In each case, the fourth zero is replaced with a code violation (V)
- ❑ successive violations are of alternate polarity

Table 5.4 HDB3 Substitution Rules

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

Digital Data, Analog Signal

❑ Main use is public telephone system

- has freq range of 300Hz to 3400Hz
- use modem (modulator-demodulator)

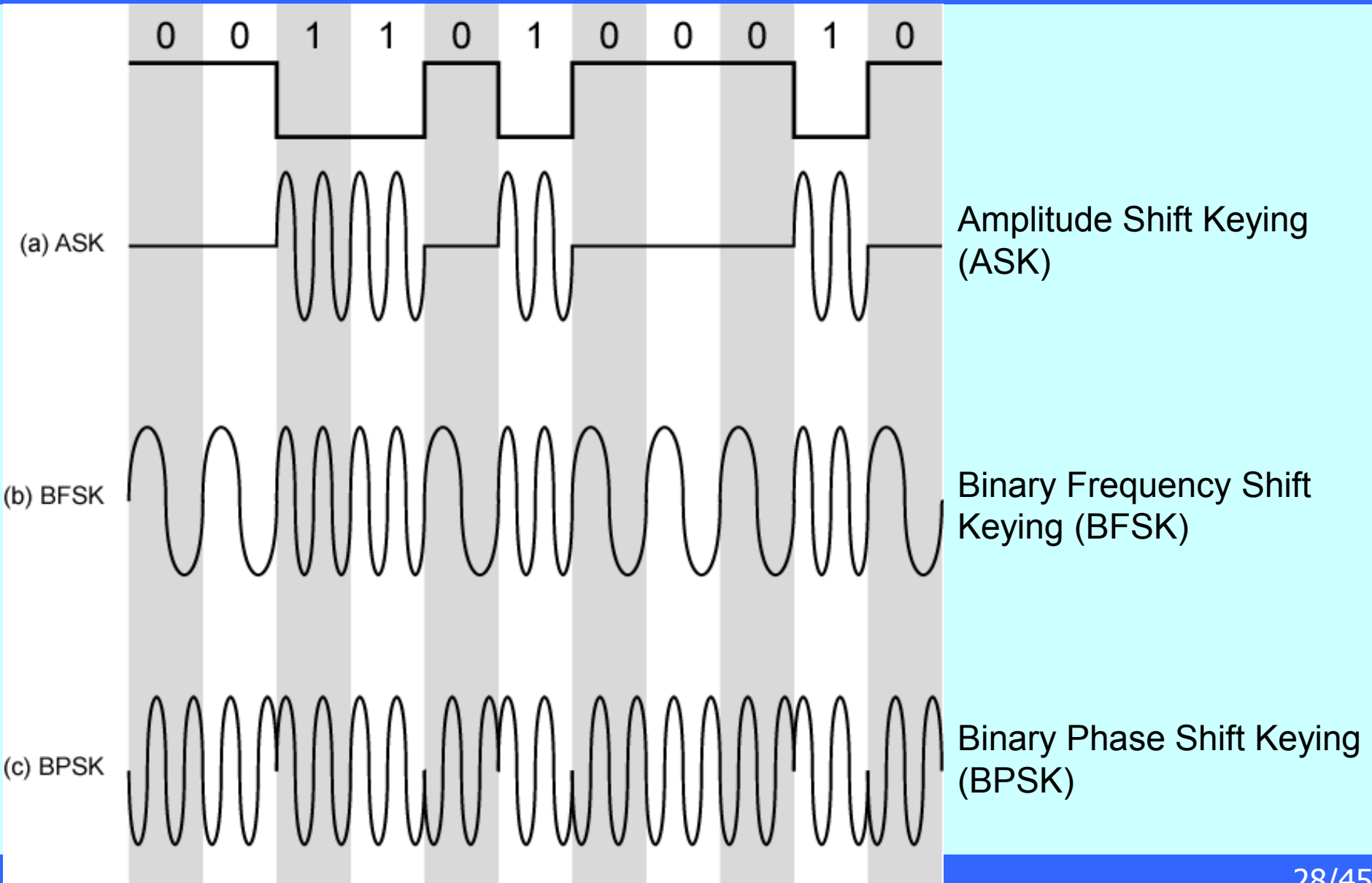
❑ The digital data modulates the amplitude A , frequency f_c , or phase θ of a carrier signal

$$A \cos(2\pi f_c t + \theta)$$

❑ Modulation techniques

- Amplitude Shift Keying (ASK)
- Frequency Shift Keying (FSK)
- Phase Shift Keying (PSK)

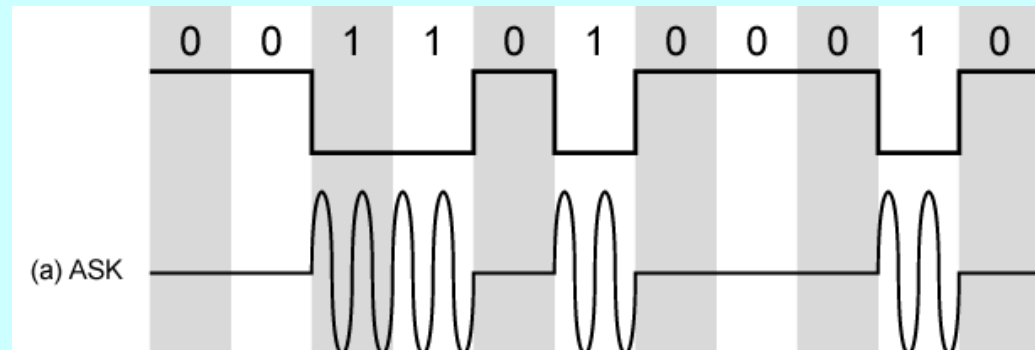
Modulation Techniques



Amplitude Shift Keying (ASK)

- ❑ In ASK, the two binary values are represented by two different amplitudes of the carrier frequency
- ❑ The resulting modulated signal for one bit time is

$$s(t) = \begin{cases} A \cos(2\pi f_c t), & \text{binary 1} \\ 0, & \text{binary 0} \end{cases}$$

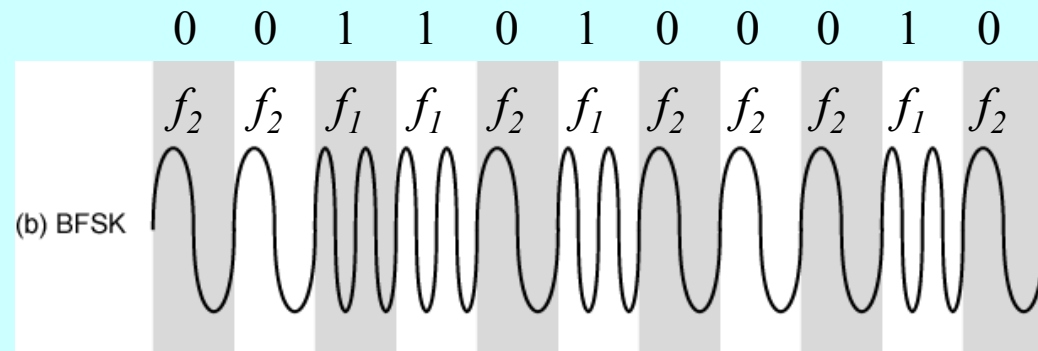


- ❑ Susceptible to noise
- ❑ Inefficient modulation technique
- ❑ used for
 - up to 1200bps on voice grade lines
 - very high speeds over optical fiber

Binary Frequency Shift Keying (BFSK)

- ❑ The most common form of FSK is Binary FSK (BFSK)
- ❑ Two binary values represented by two different frequencies (f_1 and f_2)

$$s(t) = \begin{cases} A \cos(2\pi f_1 t), & \text{binary 1} \\ A \cos(2\pi f_2 t), & \text{binary 0} \end{cases}$$



- ❑ less susceptible to noise than ASK
- ❑ used for
 - up to 1200bps on voice grade lines
 - high frequency radio (3 to 30MHz)
 - even higher frequency on LANs using coaxial cable