W2 (2)

# Computer Networks

## Signal Encoding Techniques (Digital to Digital)

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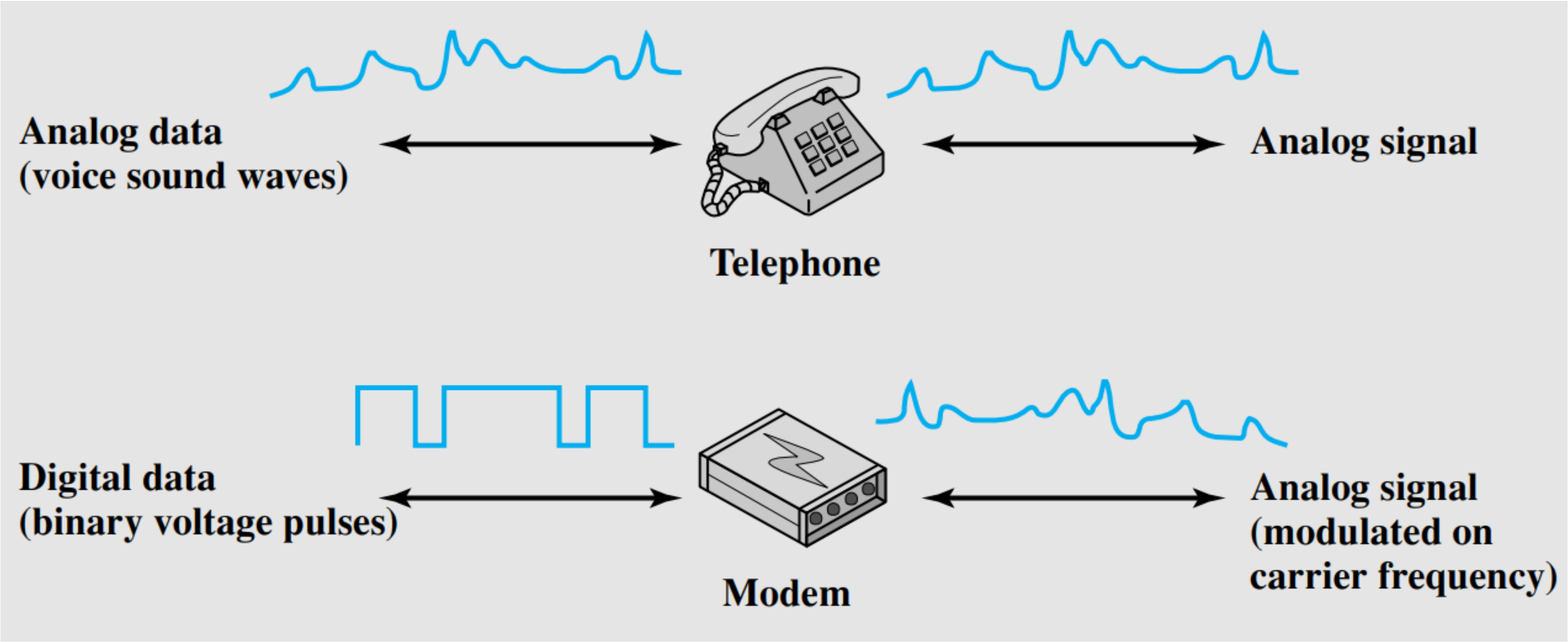
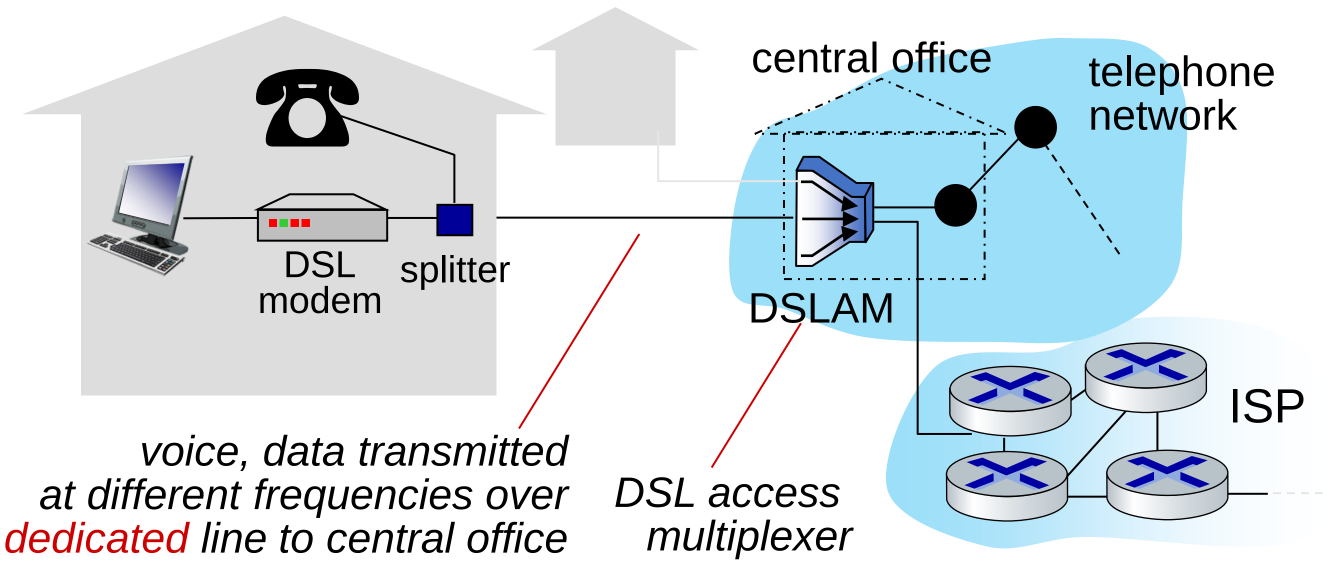
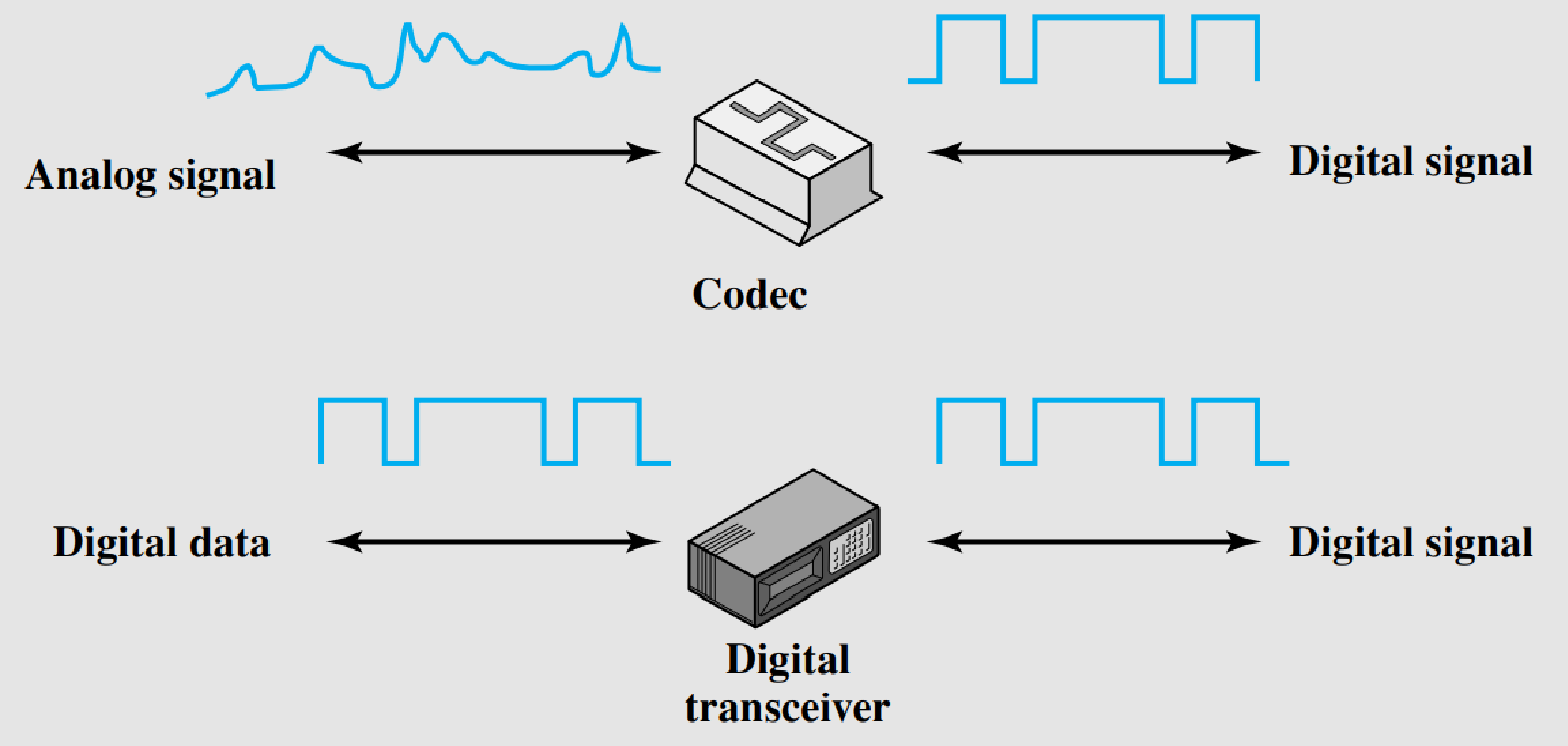
# Analog Signal



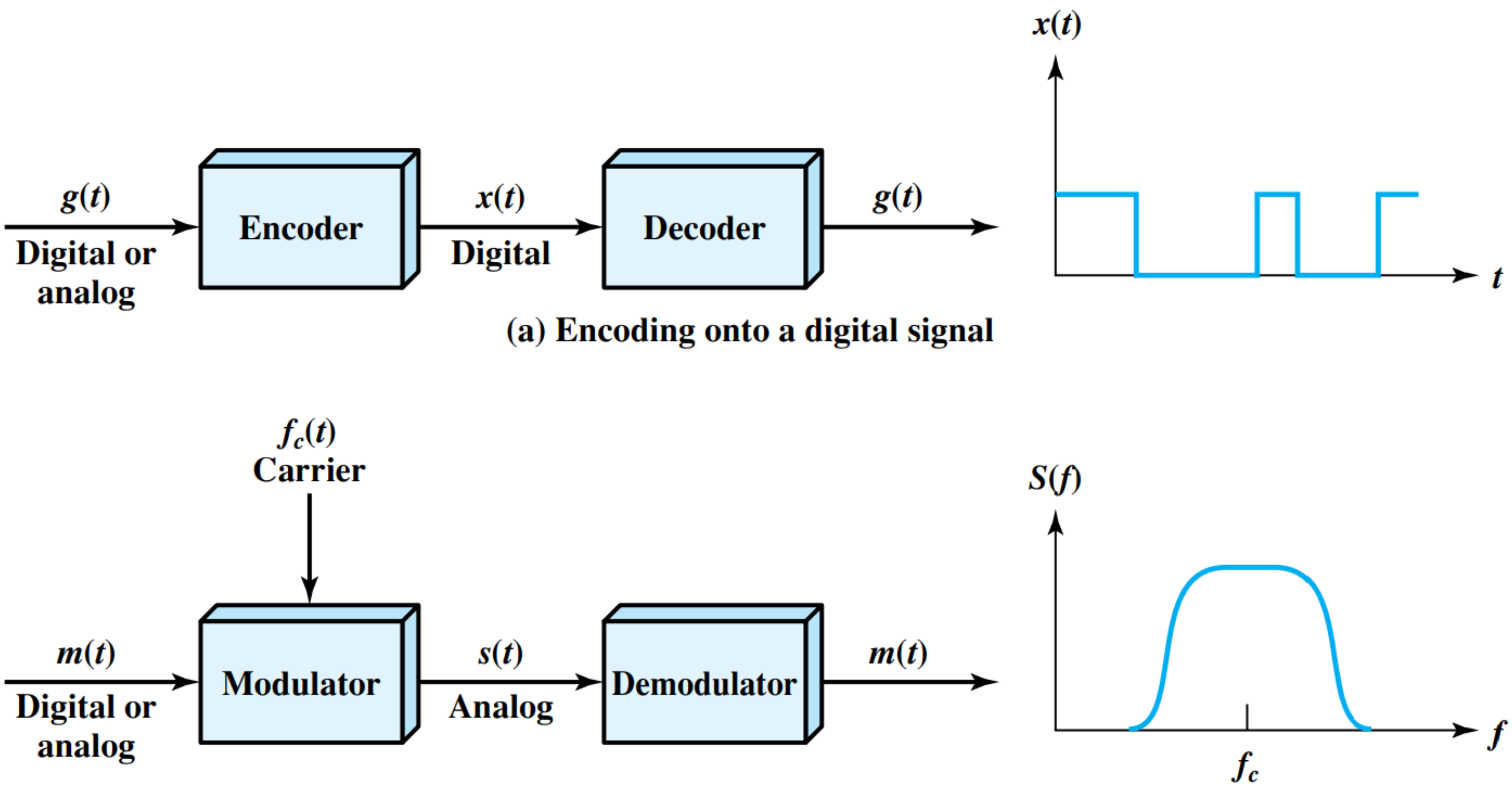
# Analog Signal



# Digital Signal



# Signal Encoding Techniques




(a) Encoding onto a digital signal

(b) Modulation onto an analog signal

# Digital Data → Digital Signals

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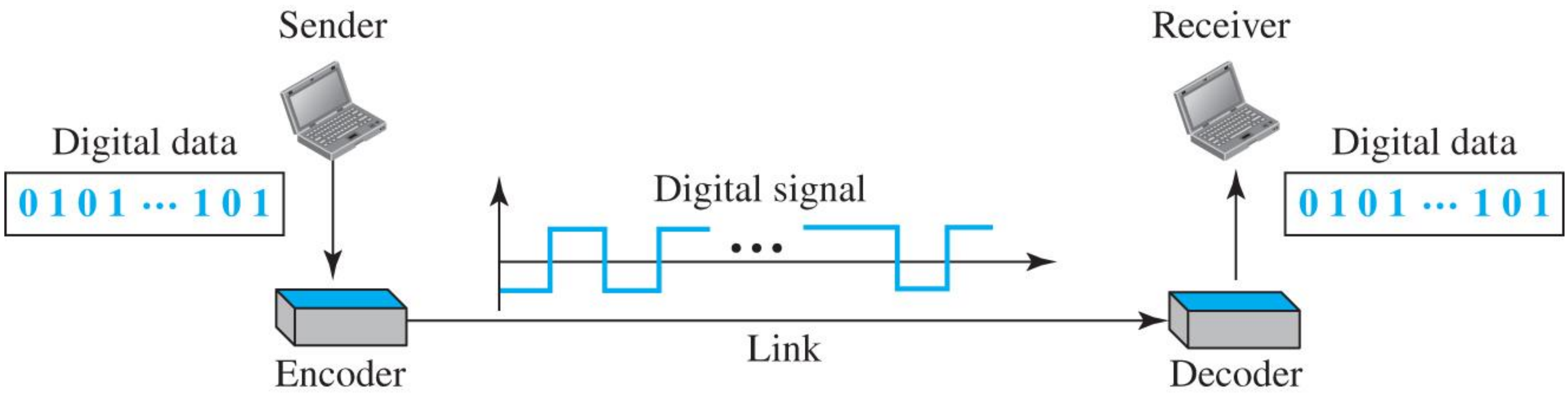


# Evaluation Criterias of Encoding Techniques

- Signal spectrum, DC component and bandwidth
  - No DC component is desirable
  - Encoding with less bandwidth is preferable
- Clocking
  - Transmitted signal can be used by the receiver for synchronizing
- Error detection
  - Encoding scheme can have some inbuilt error detection mechanism

# NRZ-L

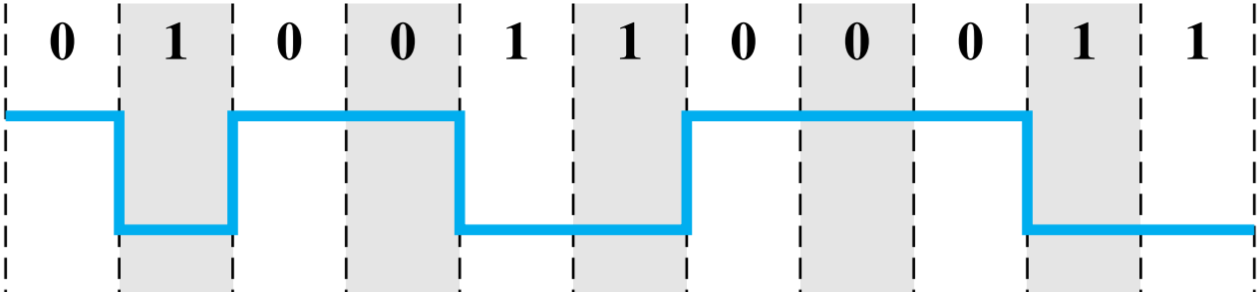
$\mathrm{PSD}(f) = A^2 T_b \mathrm{sinc}^2(\pi f T_b)$

0 = High level

1 = Low level

PSD(f): This represents the Power Spectral Density as a function of frequency f.
A: This is the amplitude of the signal.
T_b : This represents the time duration of each bit in the signal.

- Problems:
  - Lack of clock recovery during long string of 0 or 1s 🙁
  - Has d.c. component 🙁

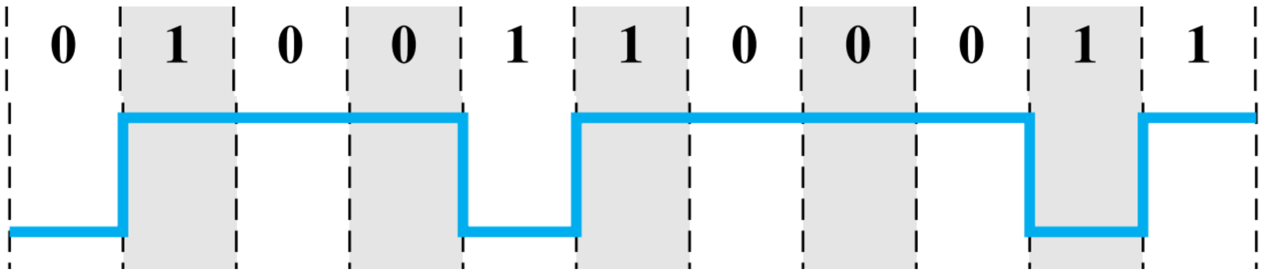


# NRZ-I

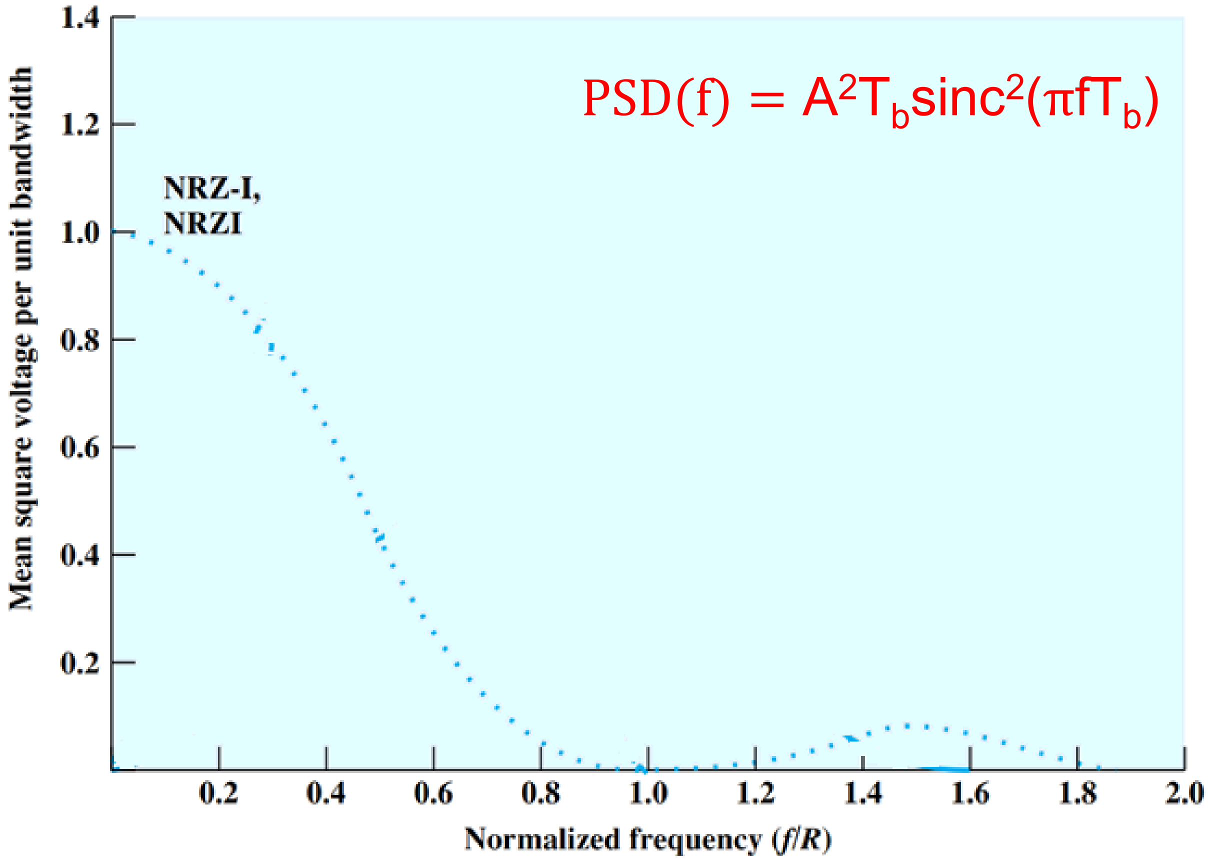
$\mathrm{PSD}(f) = A^2 T_b \mathrm{sinc}^2(\pi f T_b)$

1 = change of signal level (on-off or off-on)
0 = no change of signal level

- Fixes clocking problem for long string of 1 bits 🥹
- Problems:
  - Lack of clock recovery during long string of 0 bits 🙁
  - Has d.c. component 🙁



# Performance of Encoding Schemes

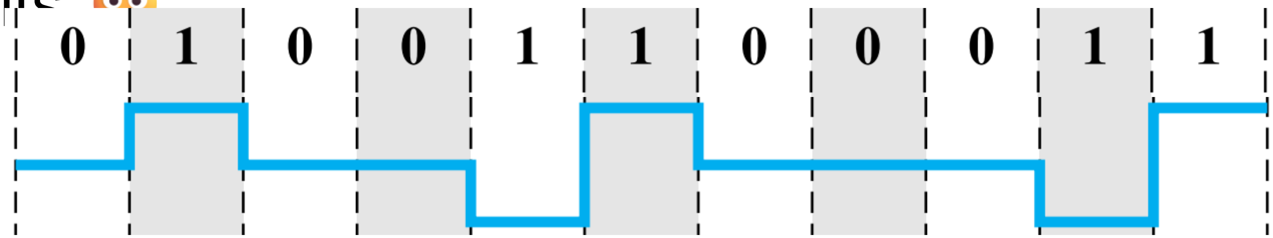


# Bipolar-AMI

Uses 3 signal levels: +V, 0, -V $PSD(f) = A^2 T_b \mathrm{sinc}^2(\pi f T_b)\sin^2(\pi f T_b)$

0 = no signal (0 voltage)
1 = alternating +V and -V

- No d.c. component (alternating +V and -V)
- Can detect some bit errors (consecutive +V or -V)
- Problems:
  - Loss of synchronization during long string of 0 bits
  - Inefficient usage: 3 signal levels is used to represent 2 bits

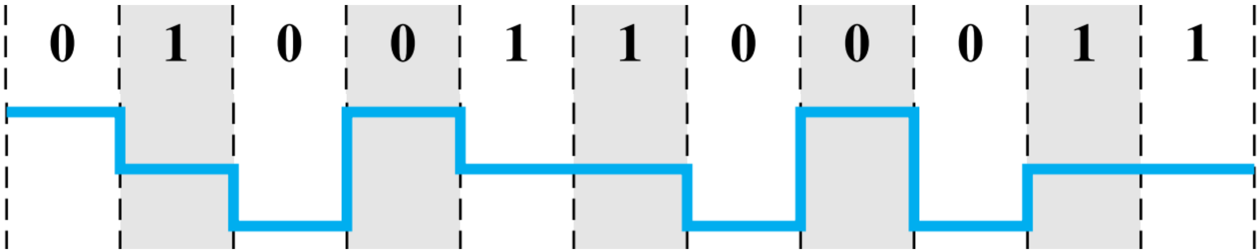


# Pseudoternary

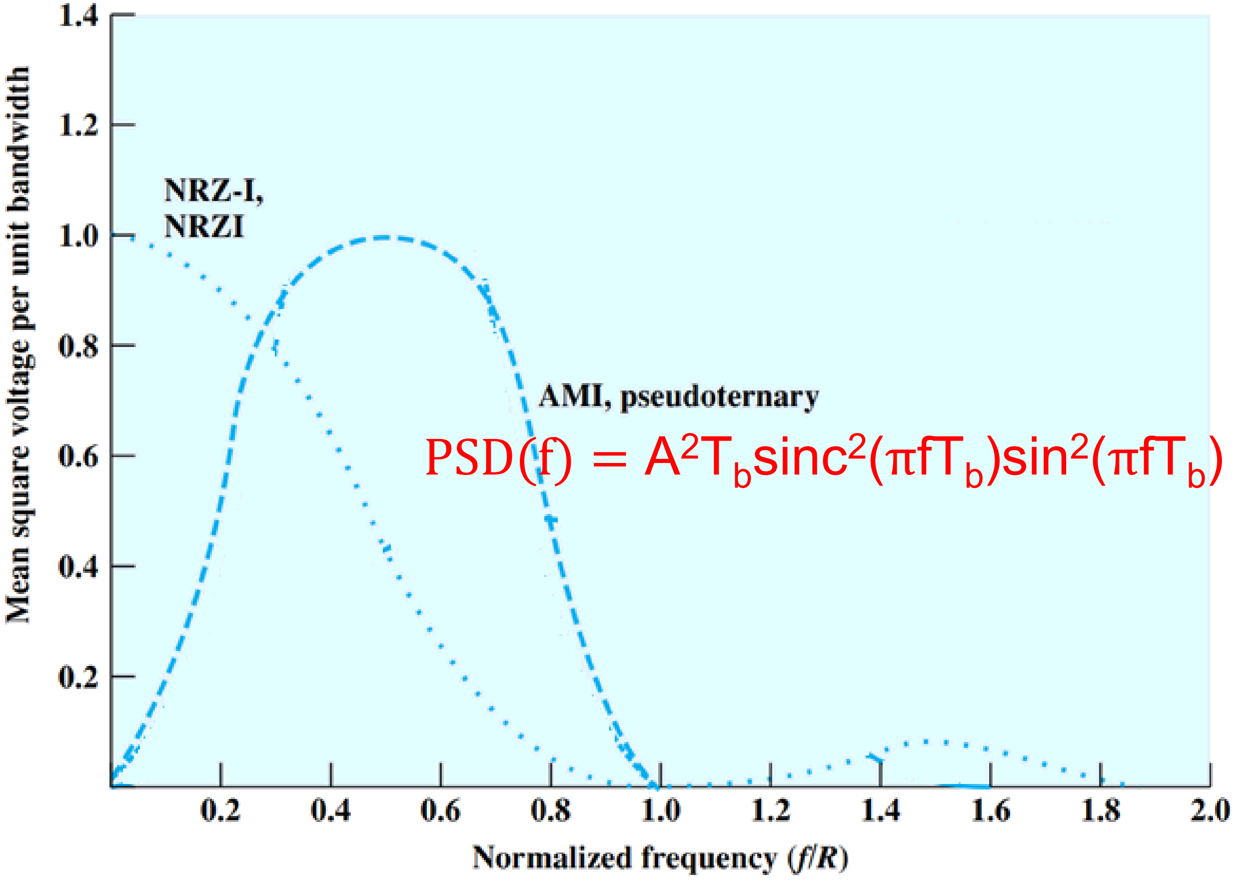
$\mathrm{PSD}(f) = A^2 T_b \mathrm{sinc}^2(\pi f T_b) \sin^2(\pi f T_b)$

Same as Bipolar-AMI except reverses signaling:

1 = no signal (0 voltage)
0 = alternating +V and -V



# Performance of Encoding Schemes




$$\mathrm{PSD}(f) = A^2 T_b \operatorname{sinc}^2(\pi f T_b)\sin^2(\pi f T_b)$$

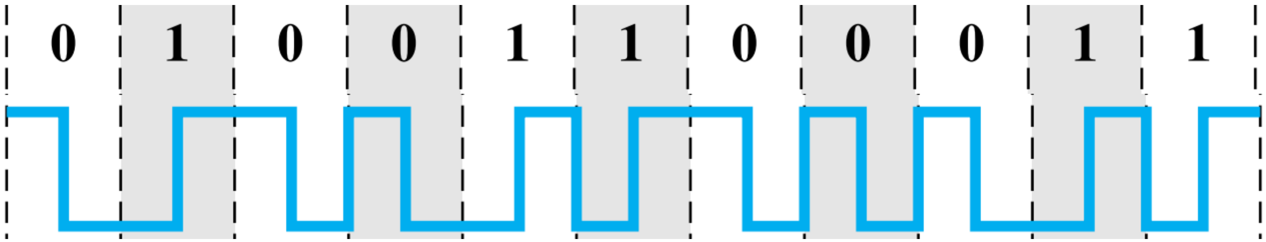
# Manchester Encoding

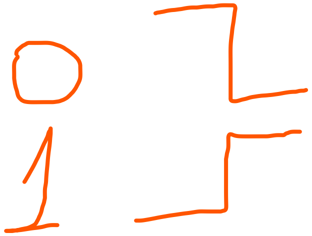
Always transition in middle of bit period:
  0 = high-to-low transition
  1 = low-to-high transition

$$\mathrm{PSD}(f) = A^2 T_b \mathrm{sinc}^2\left(\frac{\pi f T_b}{2}\right) \sin^2\left(\frac{\pi f T_b}{2}\right)$$

Transition at beginning of bit period when necessary

- Good clock recovery, error detection capability, no d.c. component 🥹
- Bandwidth requirement is higher 🙁



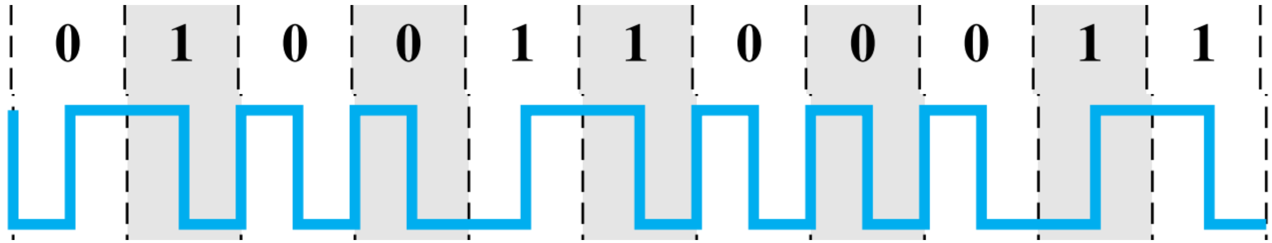



# Differential Manchester Encoding

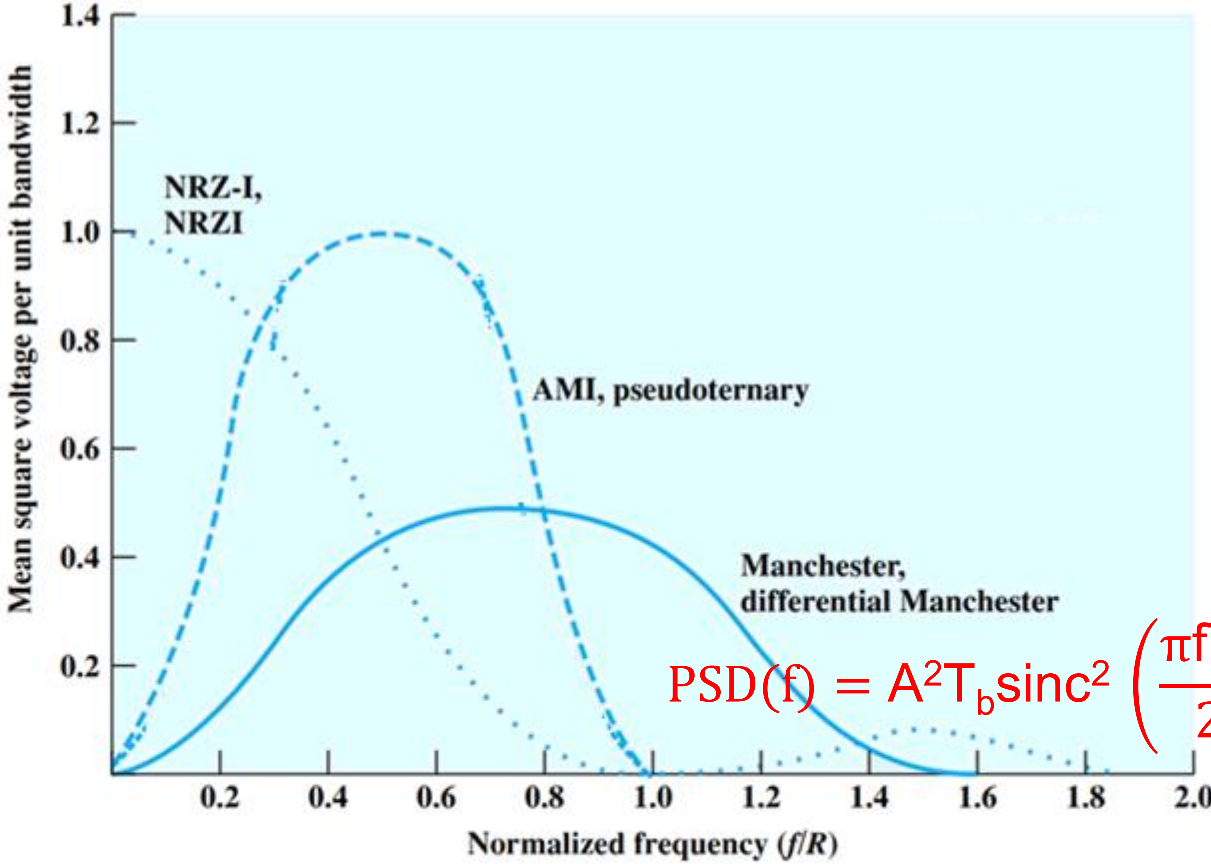
$$\mathrm{PSD(f)} = A^2T_b\mathrm{sinc}^2\left(\frac{\pi f T_b}{2}\right)\sin^2\left(\frac{\pi f T_b}{2}\right)$$

0 = transition at beginning of bit period (low-to-high or high-to-low, depending on previous output level)
1 = no transition at beginning of bit period

- Similar properties as Manchester encoding
- Bandwidth requirement is higher 🙁



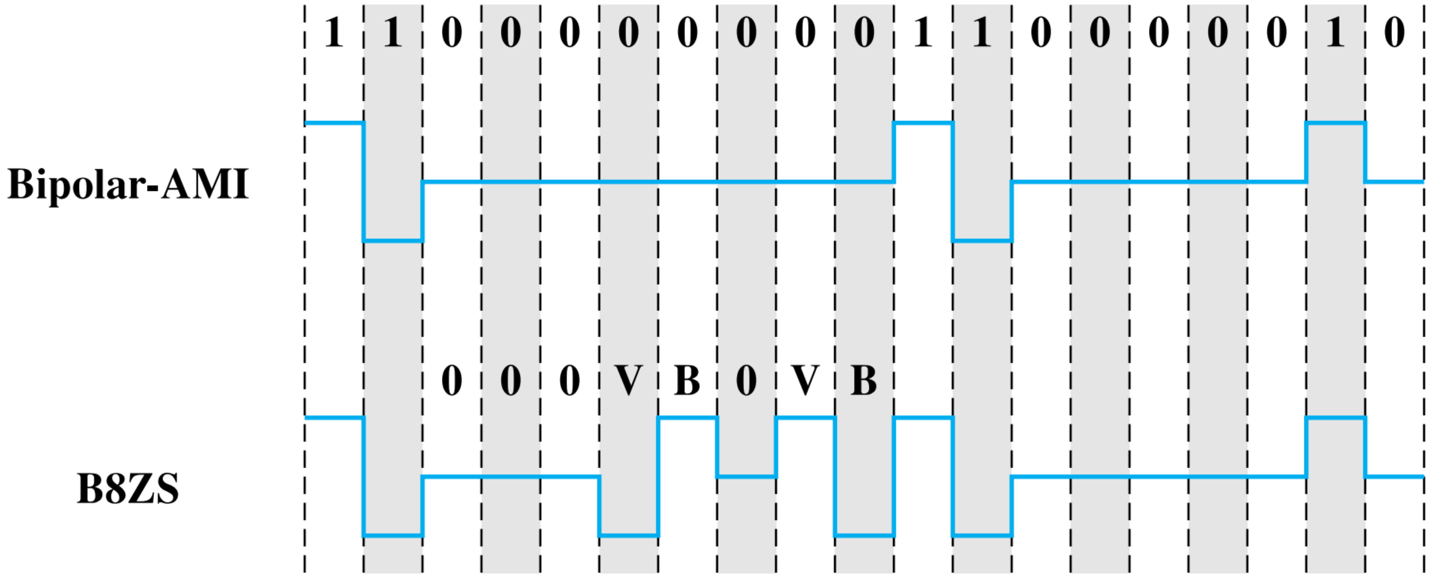
# Performance of Encoding Schemes




$$\mathrm{PSD}(f) = A^2 T_b \operatorname{sinc}^2\left(\frac{\pi f T_b}{2}\right)\sin^2\left(\frac{\pi f T_b}{2}\right)$$

# B8ZS

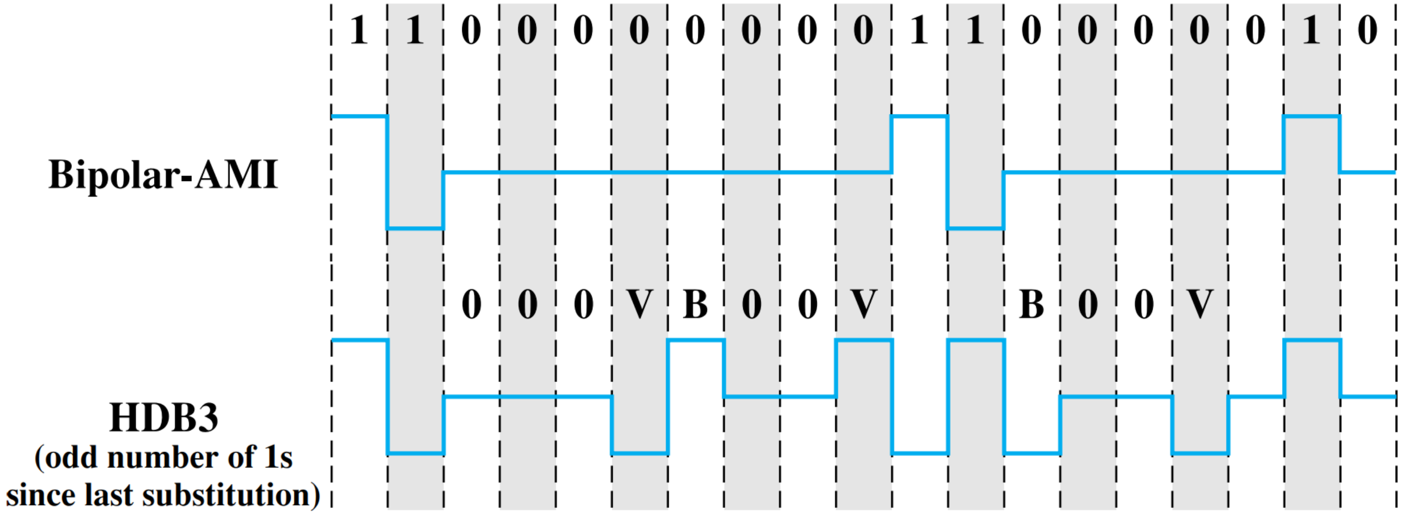
- ❑Based on Bipolar-AMI
- ❑8 consecutive 0s are encoded as:
  - If the last voltage pulse preceding this octet was + → encode as 000+-0-+
  - If the last voltage pulse preceding this octet was - → encode as 000-+0+-



# HDB3

- Based on Bipolar-AMI

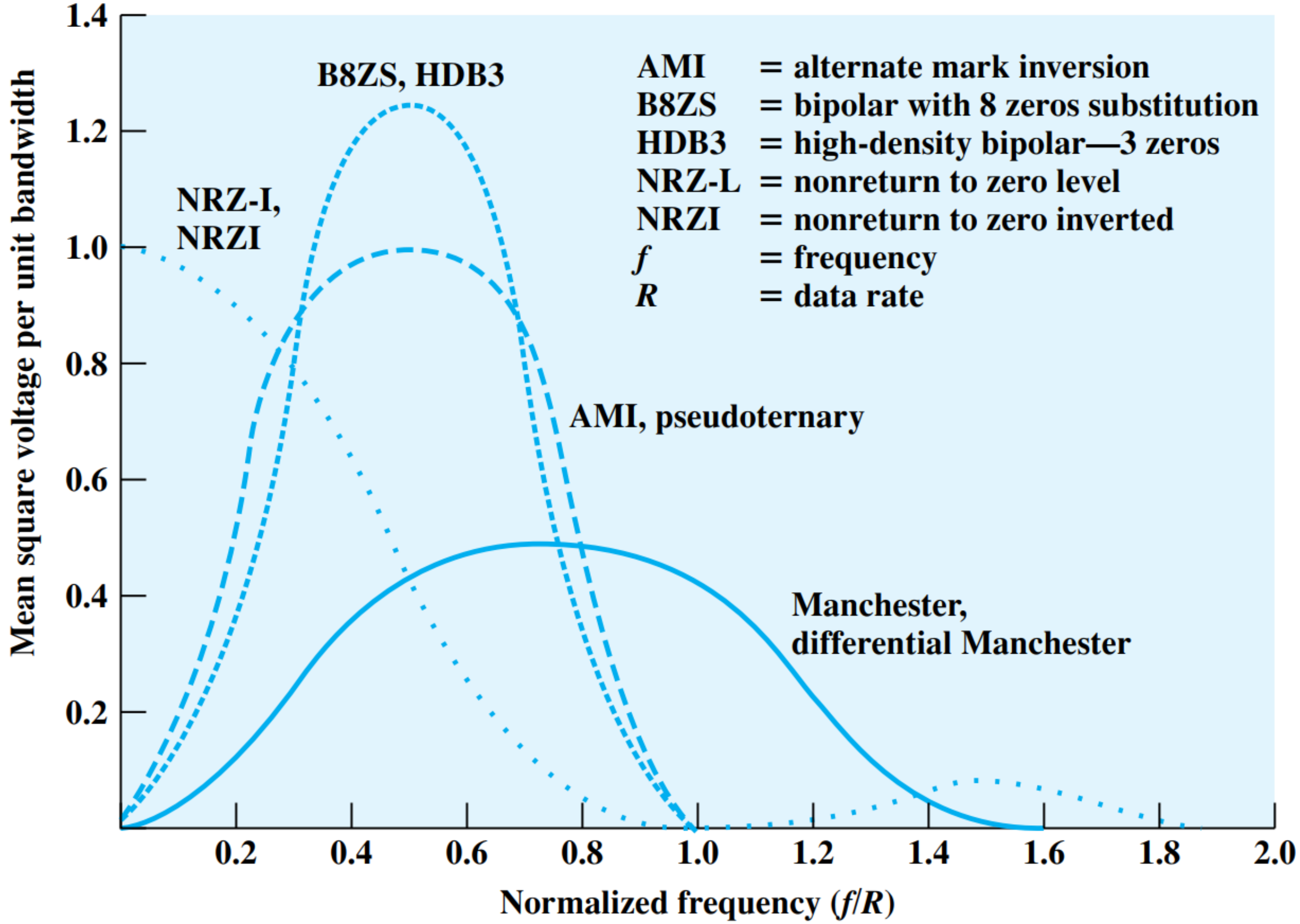
| Polarity of Preceding Pulse | Number of Bipolar Pulses (ones) since Last Substitution: Odd | Even |
|---|---|---|
| − | 0 0 0 − | + 0 0 + |
| + | 0 0 0 + | − 0 0 − |



# Advantages B8ZS and HDB3

- No d.c. component 🙂
- Fixes clocking problem for long string of both 0 and1s 🙂
- Error detection capability 🙂

# Comparison of Encoding Schemes



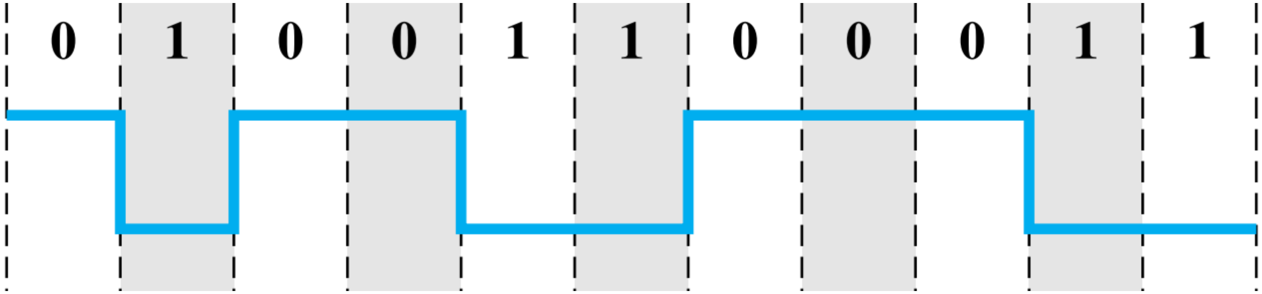
# Unipolar vs Polar Encoding

## ❑Polar

- One logic state represented by positive voltage and the other by negative voltage

## ❑Unipolar

- All signal elements have the same sign



# Summary

- Signal encoding techniques (Digital data → Digital signals):
  - Different encoding techniques discussed
    - NRZ-L and NRZ-I
    - Bipolar-AMI and Pseudoternary
    - Manchester and Differential Manchester
    - B8ZS and HDB3
  - Comparison of the encoding schemes