Data Encoding – Chapter 5 (part 1)

COSC 3213

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Signal Encoding Techniques

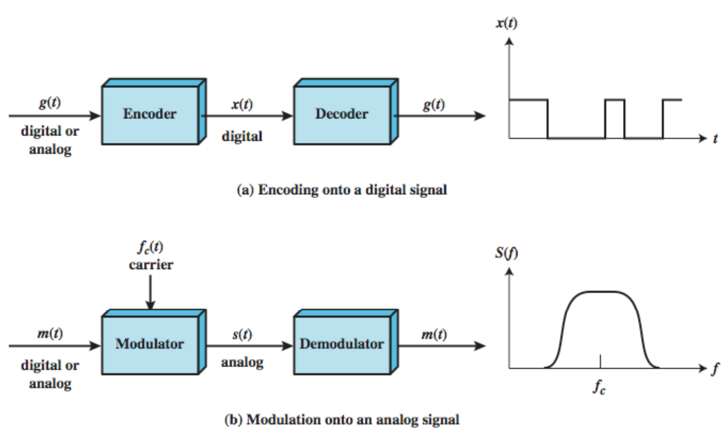


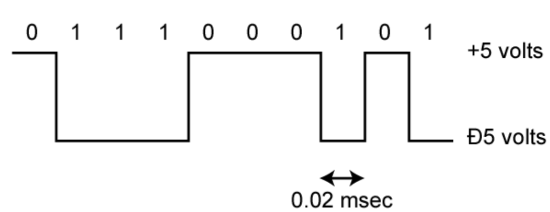
Figure 5.1 Encoding and Modulation Techniques

Encoding Techniques

- Digital data, digital signals (5.1)
- Analog data, digital signals (5.3)
- Digital data, analog signals (5.2)
- Analog data, analog signals (5.4)

Digital Data, Digital Signals (5.1)

- Digital signal
  - —discrete, discontinuous voltage pulses
  - —each pulse is a signal element
  - —binary data encoded into signal elements



Some Terms (1)

- Unipolar
  - —All signal elements have same sign
- Polar
  - —One logic state represented by positive voltage the other by negative voltage
- Data rate
  - —Rate of data transmission in bits per second
- Duration or length of a bit
  - —Time taken for transmitter to emit the bit

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Some Terms (2)

- Modulation rate
  - —Rate at which the signal level changes
  - —Measured in baud = signal elements per second
- Mark and Space
  - —Binary 1 and Binary 0 respectively

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Interpreting Signals

- Need to know
  - —Timing of bits - when they start and end
  - —Signal levels
- Factors affecting successful interpreting of signals
  - —Signal to noise ratio
  - —Data rate
  - —Bandwidth
  - —Encoding scheme

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Comparison of Encoding Schemes (1)

- Signal Spectrum
  - —Lack of high frequencies reduces required bandwidth
  - —Lack of dc component allows ac coupling via transformer, providing isolation
  - —Concentrate power in the middle of the bandwidth
- Clocking
  - —Synchronizing transmitter and receiver
  - —External clock
  - —Sync mechanism based on signal

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Comparison of Encoding Schemes (2)

- Error detection
  - —Can be built in to signal encoding
- Signal interference and noise immunity
  - —Some codes are better than others
- Cost and complexity
  - —Higher signal rate (& thus data rate) lead to higher costs
  - —Some codes require signal rate greater than data rate

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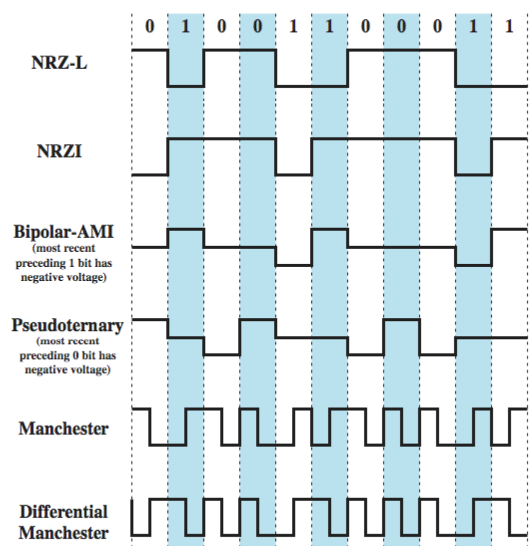
Encoding Schemes



- **B8ZS**
- **HDB3**

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Encoding Schemes (2)

- Nonreturn to Zero-Level (NRZ-L)
- Nonreturn to Zero Inverted (NRZI)
- Bipolar -AMI
- Pseudoternary
- Manchester
- Differential Manchester
- B8ZS
- HDB3

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Nonreturn to Zero-Level (NRZ-L)

- Two different voltages for 0 and 1 bits
- Voltage constant during bit interval
  - —no transition I.e. no return to zero voltage
- e.g. Absence of voltage for zero, constant positive voltage for one
- More often, negative voltage for one value and positive for the other

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Nonreturn to Zero Inverted

- Nonreturn to zero inverted on ones
- Constant voltage pulse for duration of bit
- Data encoded as presence or absence of signal transition at beginning of bit time
- Transition (low to high or high to low) denotes a binary 1
- No transition denotes binary 0
- An example of differential encoding

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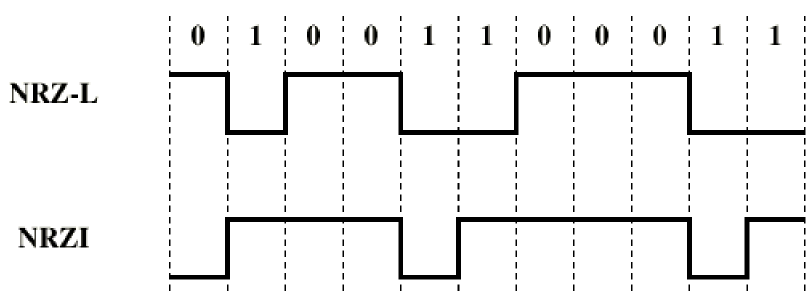
NRZ



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Differential Encoding

- NRZI is an example of differential encoding
- Data represented by changes rather than levels
- More reliable detection of transition rather than level
- In complex transmission layouts it is easy to lose sense of polarity

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NRZ pros and cons

- Pros
  - —Easy to engineer
  - —Make good use of bandwidth
- Cons
  - —dc component
  - —Lack of synchronization capability
- Used for magnetic recording
- Not often used for signal transmission

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Multilevel Binary

- Use more than two levels
- Bipolar-AMI
  - zero represented by no line signal
  - one represented by positive or negative pulse
  - one pulses alternate in polarity
  - No loss of sync if a long string of ones (zeros still a problem)
  - No net dc component
  - Lower bandwidth
  - Easy error detection

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Multilevel Binary Pseudoternary

- One represented by absence of line signal
- Zero represented by alternating positive and negative
- No advantage or disadvantage over bipolar-AMI

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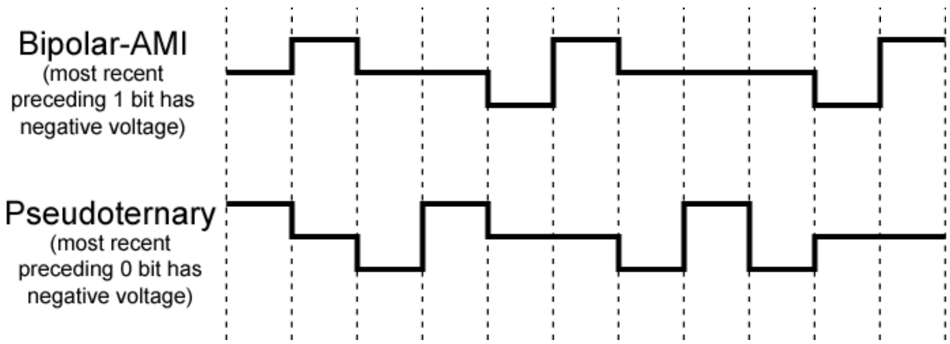
Bipolar-AMI and Pseudoternary



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Multilevel Binary Issues

- Synchronization needed for long runs of 0's or 1's
  - can insert additional bits (used in low-rate ISDN)
  - scramble data (later)
- Overcoming NRZ problems, but ...
- Not as efficient as NRZ
  - Each signal element only represents one bit
  - In a 3 level system could represent $\log_2 3 = 1.58$ bits
  - Receiver must distinguish between three levels (+A, -A, 0)
  - Requires approx. 3dB more signal power for same probability of bit error

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Biphase

- Manchester
  - — Transition in middle of each bit period
  - — Transition serves as clock and data
  - — Low to high represents one
  - — High to low represents zero
  - — Used by IEEE 802.3
- Differential Manchester
  - — Midbit transition is clocking only
  - — Transition at start of a bit period represents zero
  - — No transition at start of a bit period represents one
  - — Note: this is a differential encoding scheme
  - — Used by IEEE 802.5

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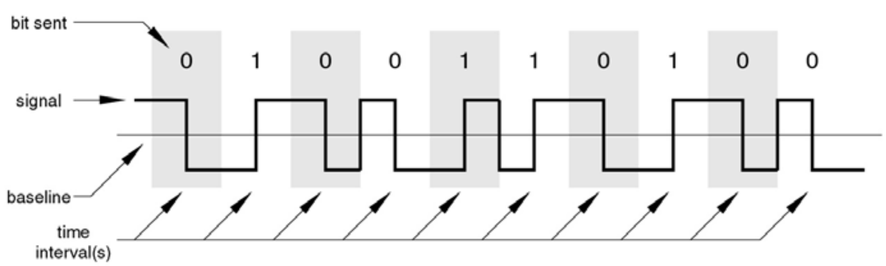
Manchester Encoding

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

Manchester Encoding



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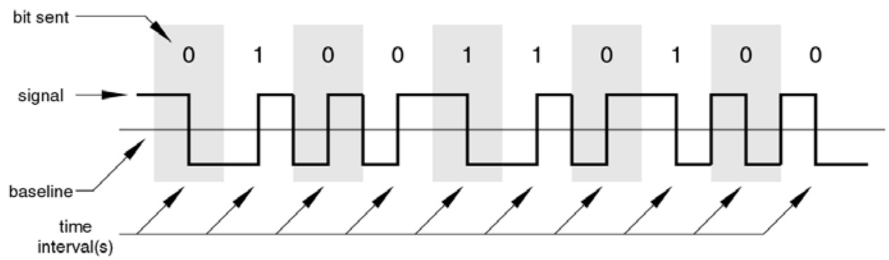
Differential Manchester Encoding

- midbit transition is clocking only
- transition at start of bit period representing 0
- no transition at start of bit period representing 1
  - this is a differential encoding scheme
- used by IEEE 802.5

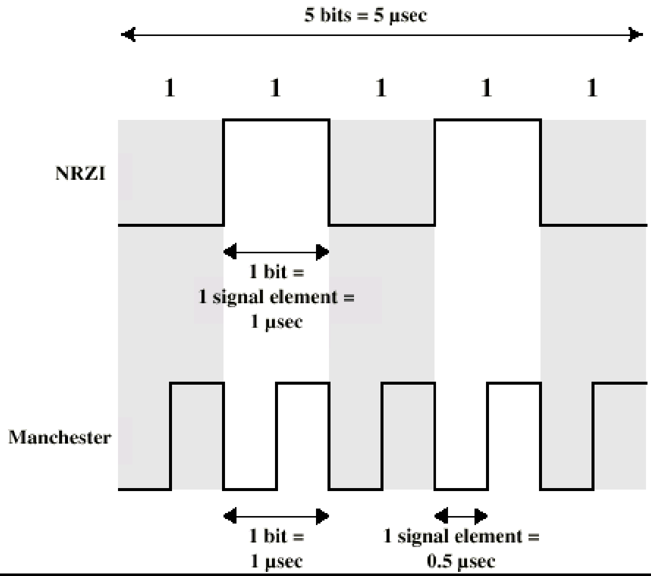
Differential Manchester Encoding



Biphase Pros and Cons

- Con
  - At least one transition per bit time and possibly two
  - Maximum modulation rate is twice NRZ
  - Requires more bandwidth
- Pros
  - Synchronization on mid bit transition (self clocking)
  - No dc component
  - Error detection
    - Absence of expected transition

Modulation Rate



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Scrambling

- use scrambling to replace sequences that would produce constant voltage
- these filling sequences must
  - produce enough transitions to sync
  - 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

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B8ZS

- Bipolar With 8 Zeros Substitution
- Based on bipolar-AMI
- If octet of all zeros and last voltage pulse preceding was positive encode as 000+-0-+
- If octet of all zeros and last voltage pulse preceding was negative encode as 000-+0+-
- Causes two violations of AMI code
- Unlikely to occur as a result of noise
- Receiver detects and interprets as octet of all zeros

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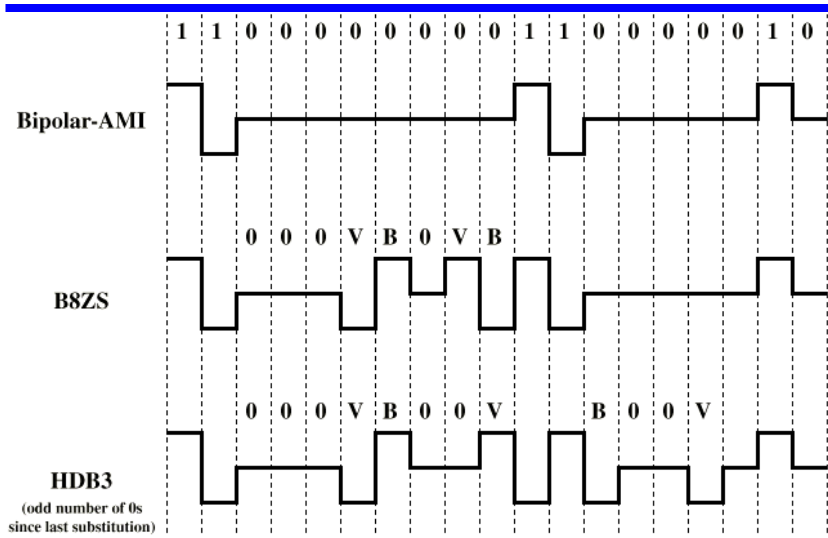
B8ZS and HDB3



B = Valid bipolar signal
V = Bipolar violation

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HDB3

- High Density Bipolar 3 Zeros
- Based on bipolar-AMI
- String of four zeros replaced with one or two pulses

Table 5.4 HDB3 Substitution Rules

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

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Reading

- Section 5.1, Stallings' book
- Exercise: problem 5.6, Stallings' book

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