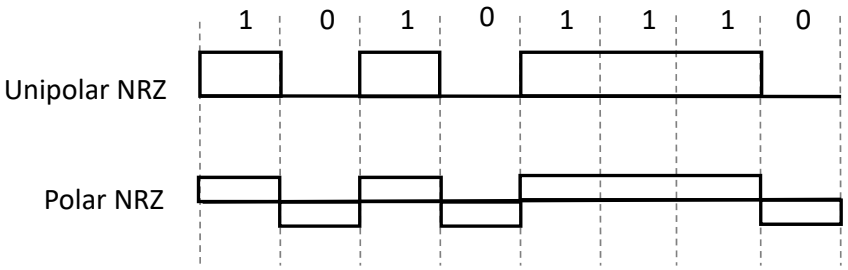
What is Line Coding?

- One method to convert a binary information sequence into signals that enter the communication channel
  - E.g., "1" maps to +A square pulse; "0" to –A square pulse

- Design considerations:
  - Timing recovery
  - Low complexity and implementation cost
  - Low power and energy efficient
  - Better immunity to noise and interference
  - Built-in error detecting capability

Unipolar & Polar Non-Return-to-Zero (NRZ) Coding



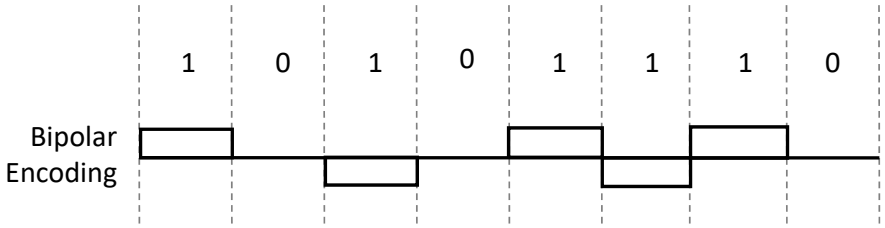
Unipolar NRZ

- "1" maps to +A pulse
- "0" maps to no pulse
- Average Power: High
  $0.5*A^2 + 0.5*0^2 = A^2/2$
- Long string of "1"s or "0"s
  - Poor timing
- Simple

Polar NRZ

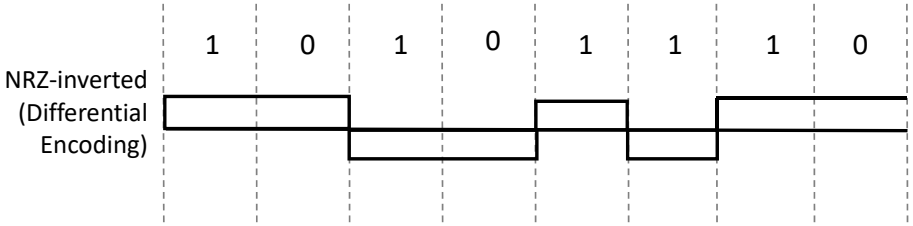
- "1" maps to +A/2 pulse
- "0" maps to –A/2 pulse
- Average Power: Lower
  $0.5*(A/2)^2 + 0.5*(-A/2)^2 = A^2/4$
- Long string of "1"s or "0"s
  - Poor timing
- Simple

Bipolar Coding



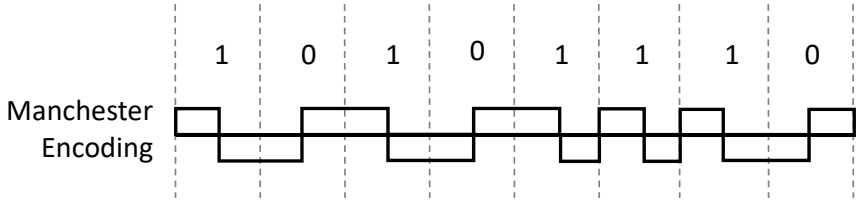
- Three signal formats: {–A/2, 0, +A/2}
- "1" maps to +A/2 or –A/2 in alternation
- "0" maps to no pulse
  - Every + pulse matched by – pulse
- String of "1"s produces a square wave
  - Spectrum centered at 1/(2T)
- Long string of "0"s causes receiver to lose synch
- Zero-substitution codes

NRZ-Inverted Coding



- Two signal formats: {–A/2, +A/2}
- "1" maps to transition in signal format at beginning of the bit interval
- "0" maps to no transition
- Differential line coding
- Errors occur in pairs
- Long string of "0"s causes receiver to lose synch

Manchester Coding & *m*B*n*B Coding



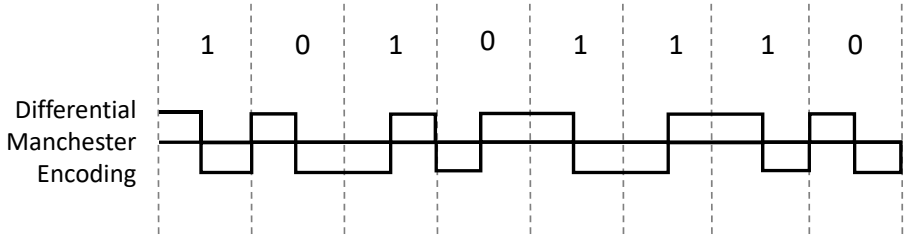
Manchester

- "1" maps to A/2 first T/2, -A/2 last T/2
- "0" maps to –A/2 first T/2, A/2 last T/2
- Every interval has transition in middle
  - Easy timing recovery
  - Double the minimum bandwidth
- Simple to implement
- Used in 10 Mbps Ethernet & other LAN systems

*m*B*n*B

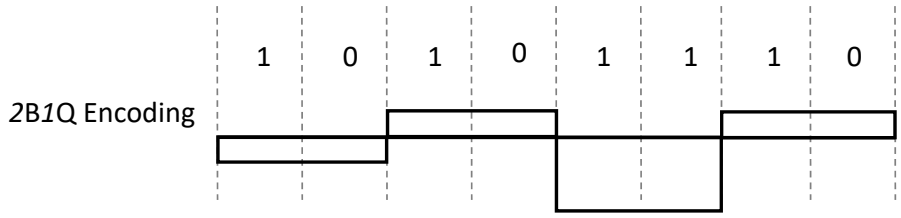
- Maps block of *m* information bits into *n* pulses
- Manchester code is *1*B*2*B code
- *4*B*5*B code is used in 100 Mbps Ethernet
- *8*B*10*B code is used in Gigabit Ethernet
- *64*B*66*B code is used in 10 Gbps Ethernet

Differential Manchester Coding



- Systematic error in polarity (i.e., + become – and vice versa) is possible
  - Manchester Coding can not handle this type of error
- Differential Manchester Coding provides robustness to this type of error
  - "1" maps to transition in signal format at beginning of the bit interval
  - "0" maps to no transition
  - Another type of differential line coding
  - Errors occur in pairs

2B1Q Coding* & *mBnL* Coding



2B1Q

	Previous level: positive	Previous level: negative
Next bits	Next level	Next level
"00"	+A/2	-A/2
"01"	+3A/2	-3A/2
"10"	-A/2	+A/2
"11"	-3A/2	+3A/2

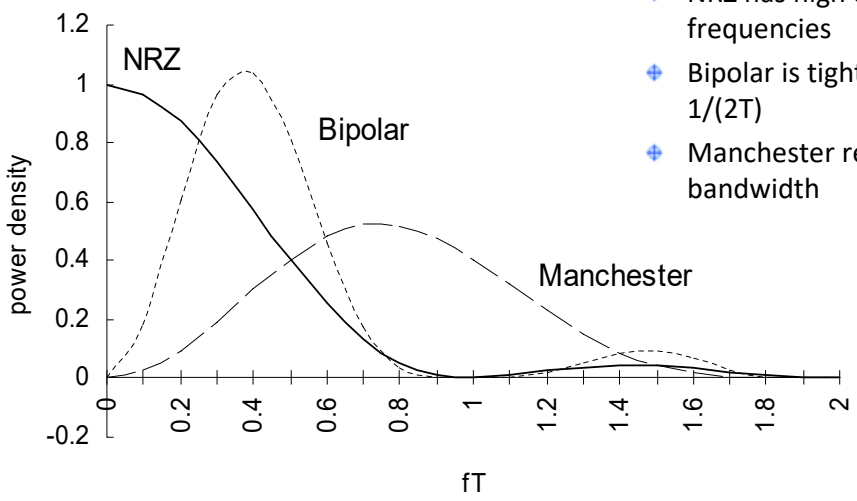
mBnL

- Maps block of *m* information bits into *n* pulses
- There is a total of L different levels of pulses

** This version of 2B1Q coding is based on "Data Communications and Networking" by Behrouz A. Forouzan.*

Spectra of Line Codes

- Assume "1"s & "0"s are independent and equal-probable



- NRZ has high content at low frequencies
- Bipolar is tightly packed around 1/(2T)
- Manchester requires high bandwidth