Modulation
(An Overview)

Kameswari Chebrolu

Recap

- Nodes generate data (bits: 1's and 0's)

- Links carry signals in the form of electromagnetic waves

- Learnt some theory: Signals and bandwidth, Shannon Theorem, goals of modulation

- Ready for: Converting data into signals
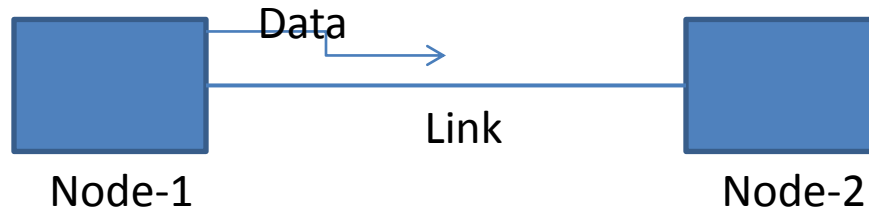
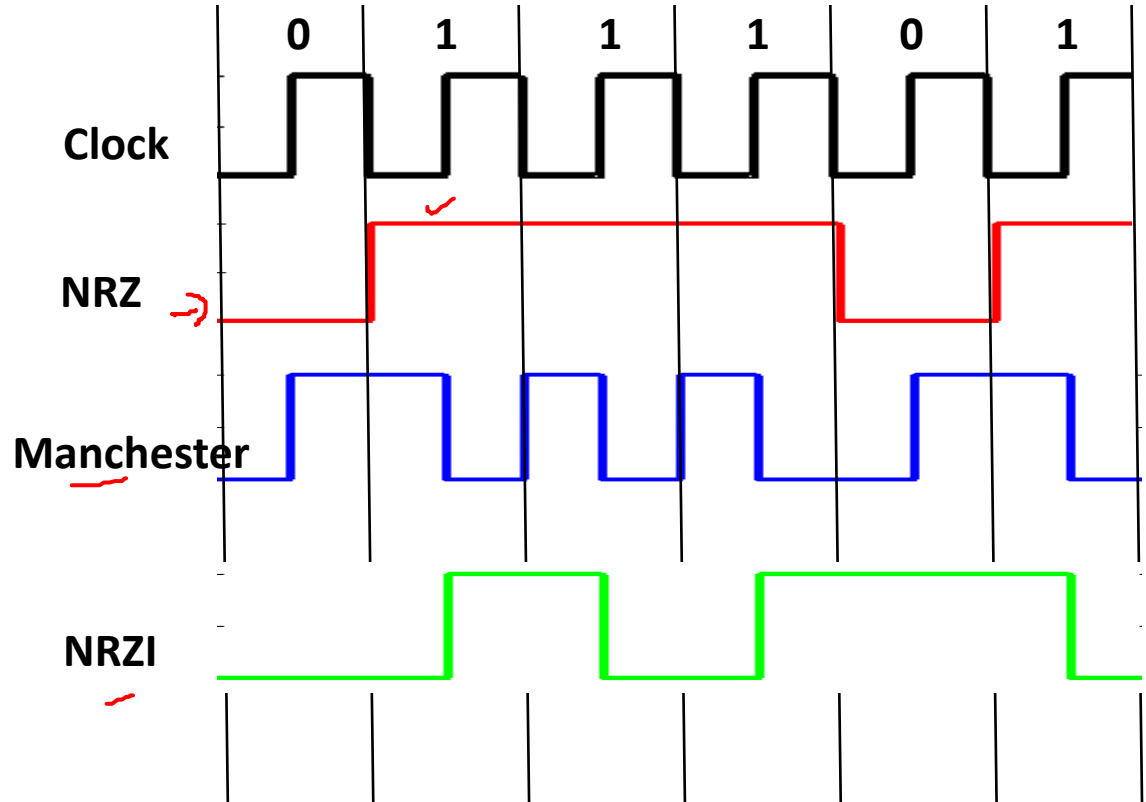# Two approaches to Modulation

- Line Encoding (also called Digital Baseband Modulation)
  - Used in Ethernet, FDDI (fiber optics)

- Passband Modulation
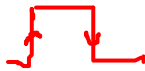 - Used in Wireless, ADSL → Asymmetric Digital Subscriber Line

Line Encoding

NRZ

- Convert bits to "high" and "low" signals (voltage or power levels)
- Uses: Ethernet and FDDI
- Advantages: Quite simple

Limitations of Line Codes

data rate
lower BW

- Bandwidth of line-coded signals is rather large (due to abrupt changes in signal) →
Bandwidth of link (physical media) needs to be large
  - Alternatively if the link bandwidth is fixed, these signals undergo more distortion
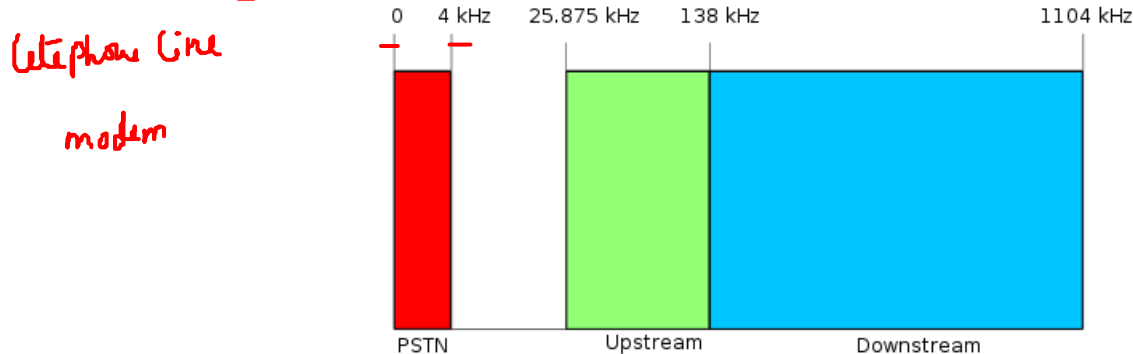
aurplh freq → ∞

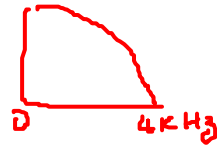- Presence of DC component hinders transmission
  - E.g. AC coupling via transformers not feasible

Limitations of Line Codes

- Baseband Modulation infeasible when signal has to be sent in designated spectrum band
  - E.g. WiFi (Wireless) allocated band is 2.4-2.4835Ghz.
  - ADSL: Data band can't overlap with voice band

Telephone Line

modem

| 0 | 4 kHz | 25.875 kHz | 138 kHz | | 1104 kHz |

PSTN   Upstream   Downstream

NRZ — 2000kps

0   4KHz

100   106 KHz

Passband Modulation

- Embed information in the amplitude, frequency or phase of a carrier signal [sinusoid: $cos(2\pi f_c t)$]

  A, phase, freq.

  – Carrier frequency: f_c

  f_c

  – Spectrum centered around carrier frequency

- Used in Wireless and ADSL

Passband Modulation

A, F, P

- ASK: Amplitude Shift Keying

- BFSK: Binary Frequency Shift Keying

  $f_c - \delta$
  $f_c + \delta$

- BPSK: Binary Phase Shift Keying

  $\cos 2\pi f_c t$

  $\cos(2\pi f_c t + 40)$
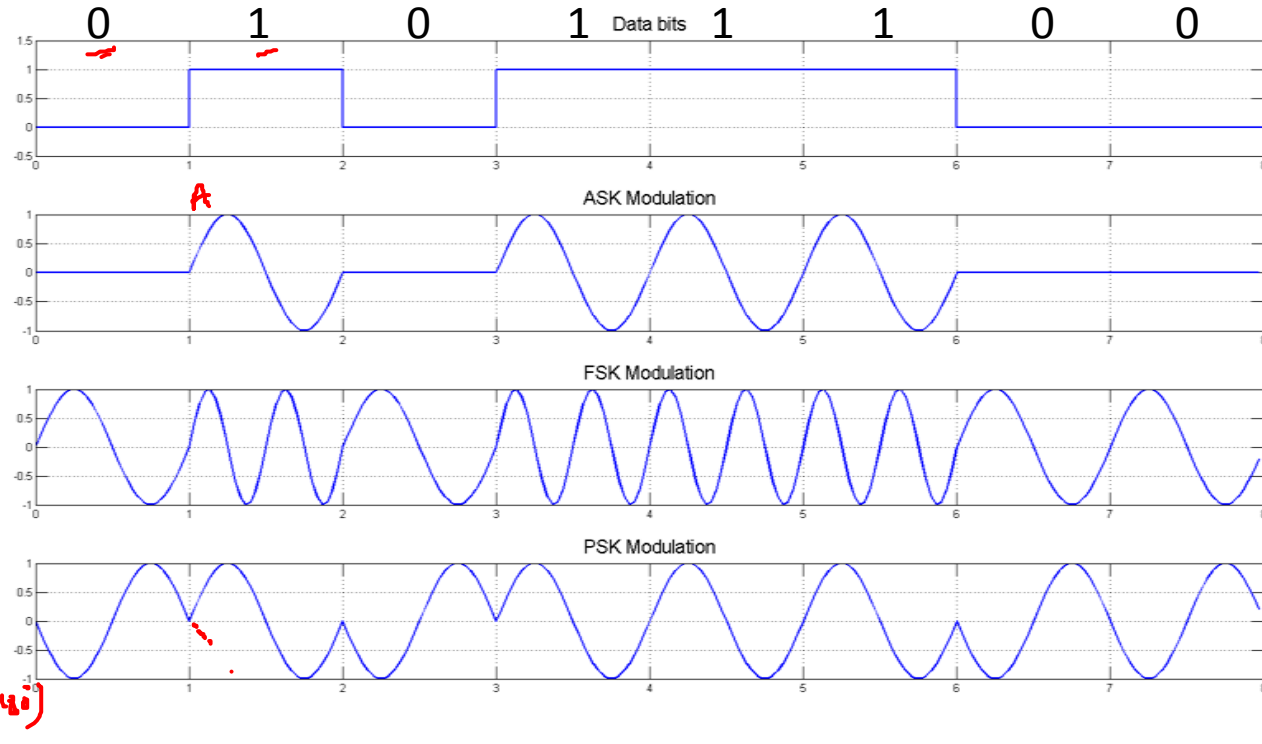
Summary

- Two approaches towards converting bits to signals:
  - Line Coding: Not very efficient
    - Will cover a few popular line coding techniques (E.g. codes used in Ethernet)
  - Passband Modulation: Helps shift signal to desired frequency band
    - Very sophisticated techniques exist that achieve high bandwidth efficiency (not the focus of this course)