CS25010
Basic Terminology and Concepts of Computer Communications - Part Two

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Computer Science

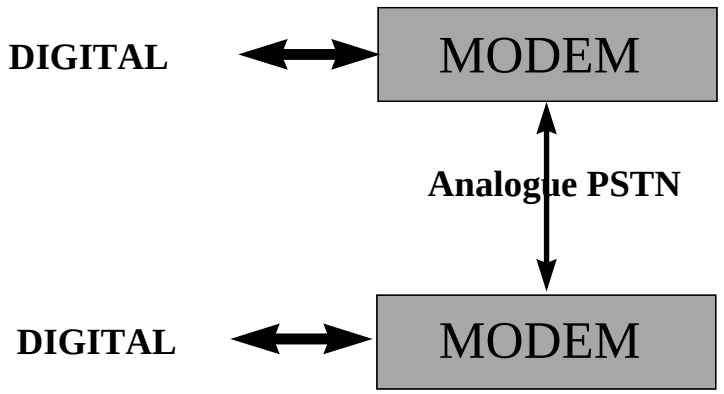
Publicly Available Networks

- **PSTN - Public Switched Telephone Network**
  - Originally full analogue dial-up network for voice
- **PSS (GNS) - Public Data Networks**
  - packet switched data network (circuit networks also exist)
- **Leased Lines**
  - hired 24 hours/day - analogue and digital
- **ISDN - Integrated Digital Services Network**
  - fully digitally dial-up network

PSTN - Public Switched Telephone Network

- Designed to carry the human voice
- frequencies for 20Hz to 20kHz present in voice but…..
- intelligibility o.k. if low frequencies and frequencies much above 3kHz lost
- PSTN typically has limits at about 300/400 Hz and above 3400/3500 Hz
- MODEMs must operate within these limits

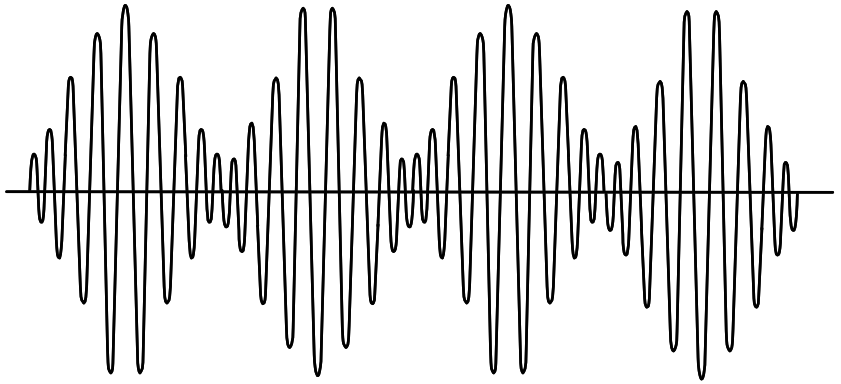
MODEMs



Modulation Methods

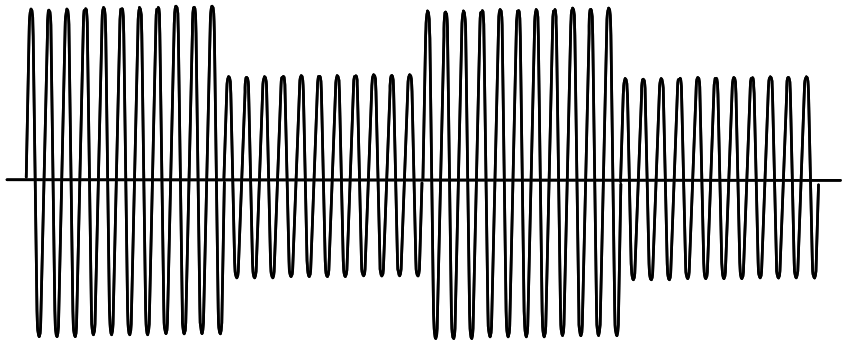
- Amplitude Modulation
- Frequency Modulation
- Phase Modulation

Amplitude Modulation



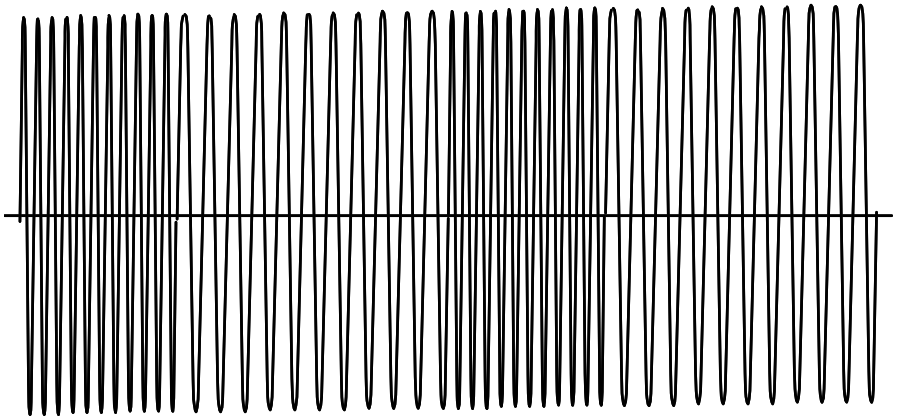
Analogue Carrier modulated by Analogue Data

Amplitude Shift Keying



Analogue Carrier modulated by Digital Data
Carrier frequency fixed, two amplitudes

Frequency Shift Keying

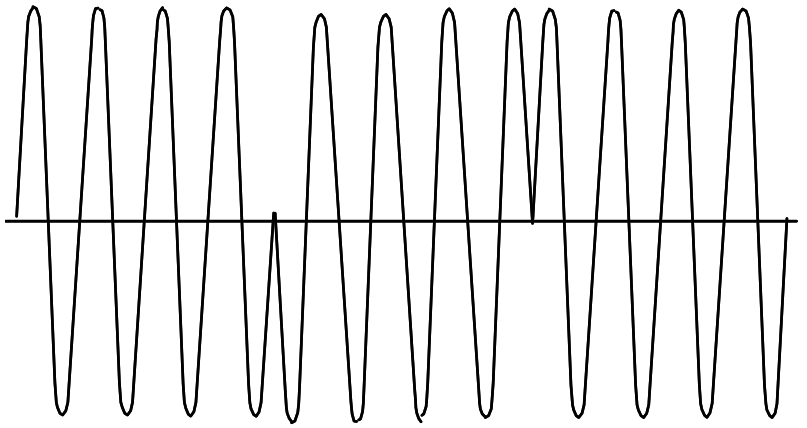


Analogue Carrier modulated by Digital Data
two carrier frequencies used

CCITT V21 Modem Standard

		Frequency	Centre
Originate	MARK	980	1080
End	SPACE	1180	
Answer	MARK	1650	1750
End	SPACE	1850	

Phase Shift Keying



Carrier frequency fixed, but 180 degree phase changes occur

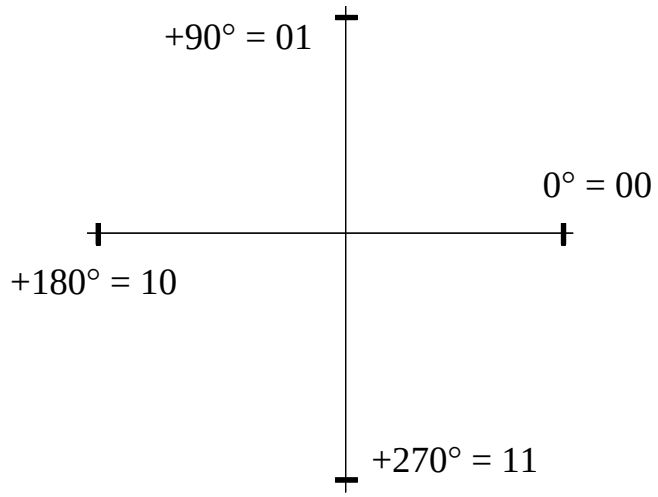
Multiple Level Signalling

- One signal event does not have to represent a single binary digit
- Therefore one signal event might provide > 1 bit of data
- (**bit** means binary digit)

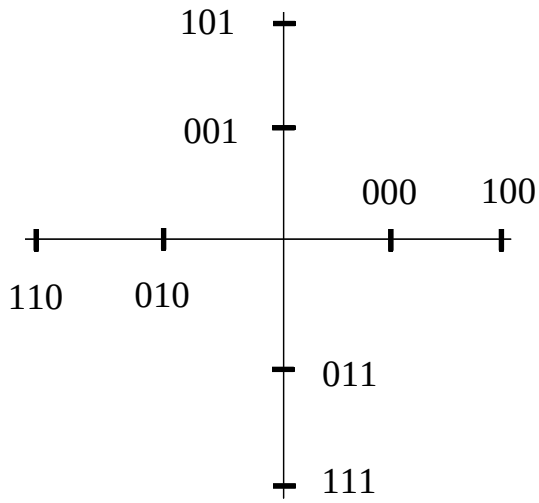
BELL 201C Modem Standard (USA)

Data		**Phase Shift**
00		**45 degrees**
01		**135 degrees**
10		**225 degrees**
11		**315 degrees**

Another Example



Hybrid - Amplitude Modulated Phase Shift Keying



Baud Rate v Data Rate

- Baud Rate
  - The number of signalling events per second.
  - The number of times per second that a data transmission channel changes state
- Data Rate
  - The number of data bits transmitted per second
- IF &only IF
  - each signalling event gives 1 BIT of information then Baud Rate == Data Rate

Remember Earlier Examples...

- Phase Modulation with 4 different phase changes then each signalling event gives 2 bits of data and so…
- Data Rate == 2 * Baud Rate
- Phase / Amplitude hybrid had 4 different phase changes and 2 amplitudes and so…
- Data Rate == 3 * Baud Rate

Maximum Data Rates

- Information Theory lectures come later but…
- Two limits, calculated by Nyquist and Shannon/Hartley provide some real hard limits and what can be achieved via communications channels including the PSTN

Nyquist

- Ignoring noise, the maximum date rate = C on a channel with a bandwidth B and with M levels per signalling element then …

$$C = 2 * B \log_2 M$$

Phase Modulation (0,90,180,270)

$$C = 2 * B \log_2 M$$

$$B = 3000$$

$$M = 4$$

$$C = 2 * 3000 \log_2(4)$$

$$= 6000 * 2$$

$$= 12000 bps$$

Shannon and Hartley

- B = Bandwidth
- S = signal power N = noise power
- SNR = signal-to-noise ratio in decibels (dB)

$$SNR = 10 \log_{10}\left(\frac{S}{N}\right)$$

THEN

$$C = B \log_2\left(1 + \frac{S}{N}\right) bps$$

Typical values for PSTN

$$B = 3000$$

$$SNR = 20dB$$

$$SNR = 20 = 10\log_{10}(\tfrac{S}{N})$$

$$\therefore \tfrac{S}{N} = 10^{(\frac{20}{10})} = 10^2 = 100$$

$$\therefore C = 3000\log_2(1+100) = 19963bps$$

Multiple Channels over Media

- Multiplexing versus Concentrating
- Multiplexer
  - Combines multiple channels in a transparent way
- Concentrator
  - Combines but processes data too, code compression takes place.

Frequency v Time v Statistical Time Multiplexing

- Frequency
  - Bandwidth of media split into different frequency bands used for different channels
- Time
  - Whole bandwidth allocated to one channel for a small time slot then to another channel- fixed width time slots
- Statistical Time
  - Like `time' but with variable time slots, allows for busy and quiet channels.