Chapter 6

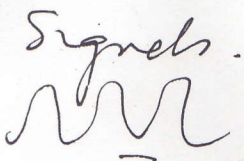
Information Sources & Signals

- Analog & Digital Signals.

  Analog signal is characterized by continuous mathematical functions 

  Digital has fixed set of values/levels. 

- Periodic & Aperiodic Signals.

  Periodic repeat  a pattern.

  time

- Sine Waves & Signal Characteristics.
  - Many natural phenomena occur in Sine waves
  - Electromagnetic radiation, sound travelling, water waves ex.
  - There are 4 important characteristics of Sine Wave Signals.
    - Frequency → the number of oscillations per second.
    - Amplitude → Difference between maximum and minimum signal heights.
    - Phase → How far from Start of Sine wave is shifted from a reference time (Offset added to ϵ)
    - Wavelength → Length of a cycle (Speed with which signal propagates).

Calculations

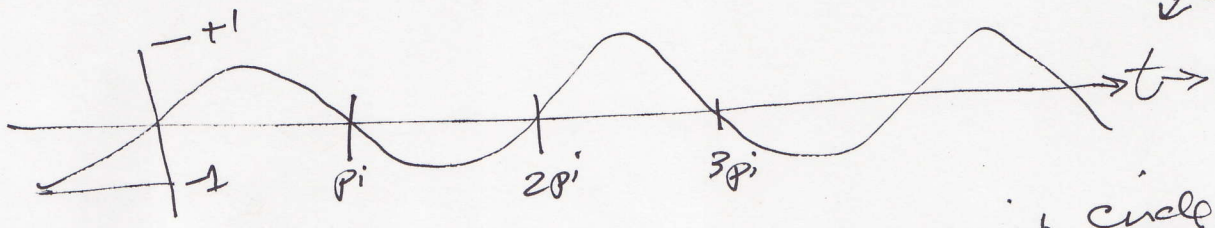
Amplitude ($\sin t$) : if ranges between −1 and +1 then amplitude is 1

t is the length of an arc on the unit circle.

Next page.

sin (t) (Vertical axis)

Horizontal axis
↓ time



t is the length of an arc on the unit circle
the curve oscillates between -1 and +1. The
curve repeats every 2pi. It repeats every 2π
because the circumference of a circle is 2π radians.

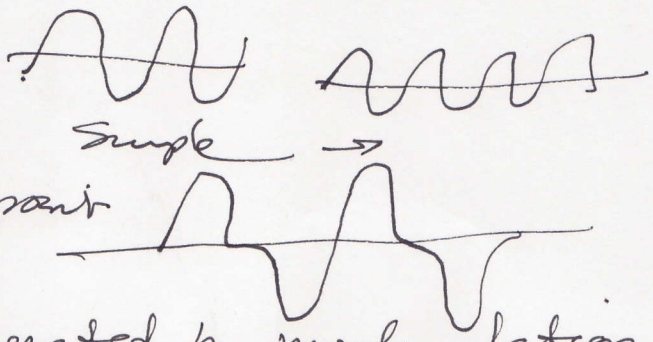
Amplitude
Sine(t) produces values between -1 and +1. It
has an amplitude of 1.

ϕ Phase. offset added to t that shifts the sin wave
to the right or left along the x-axis.

Frequency: the number of sine wave cycles
per second, Hertz. Inverse of the time
required for 1 cycle.

Composite Signals.

Most signals are classified as Composite because the signals can be decomposed into several simple Sine waves.



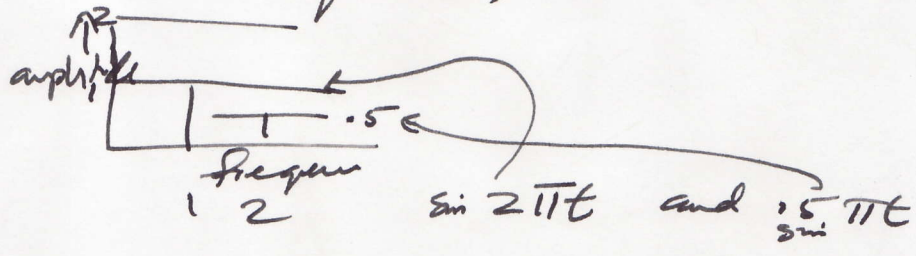
- Signals generated by modulation are usually composite

Fourier transforms is used to solve many problems in Science & Engineering.

A Mathematician named Fourier discovered that it is possible to decompose a composite signal into its constituent parts, a set of Sine functions each with a frequency, amplitude and phase.

Time and Frequency Domain Representations.

A frequency domain graph shows a set of simple Sine waves that continues constitutes a composite function. The y axis gives amplitude and x axis gives frequency



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Bandwidth

Every transmission medium has a defining bandwidth associated with it.

Bandwidth is the basic measure of information carrying capacity of a transmission link.
It is the range of useable frequencies.
Frequencies are expressed in hertz.

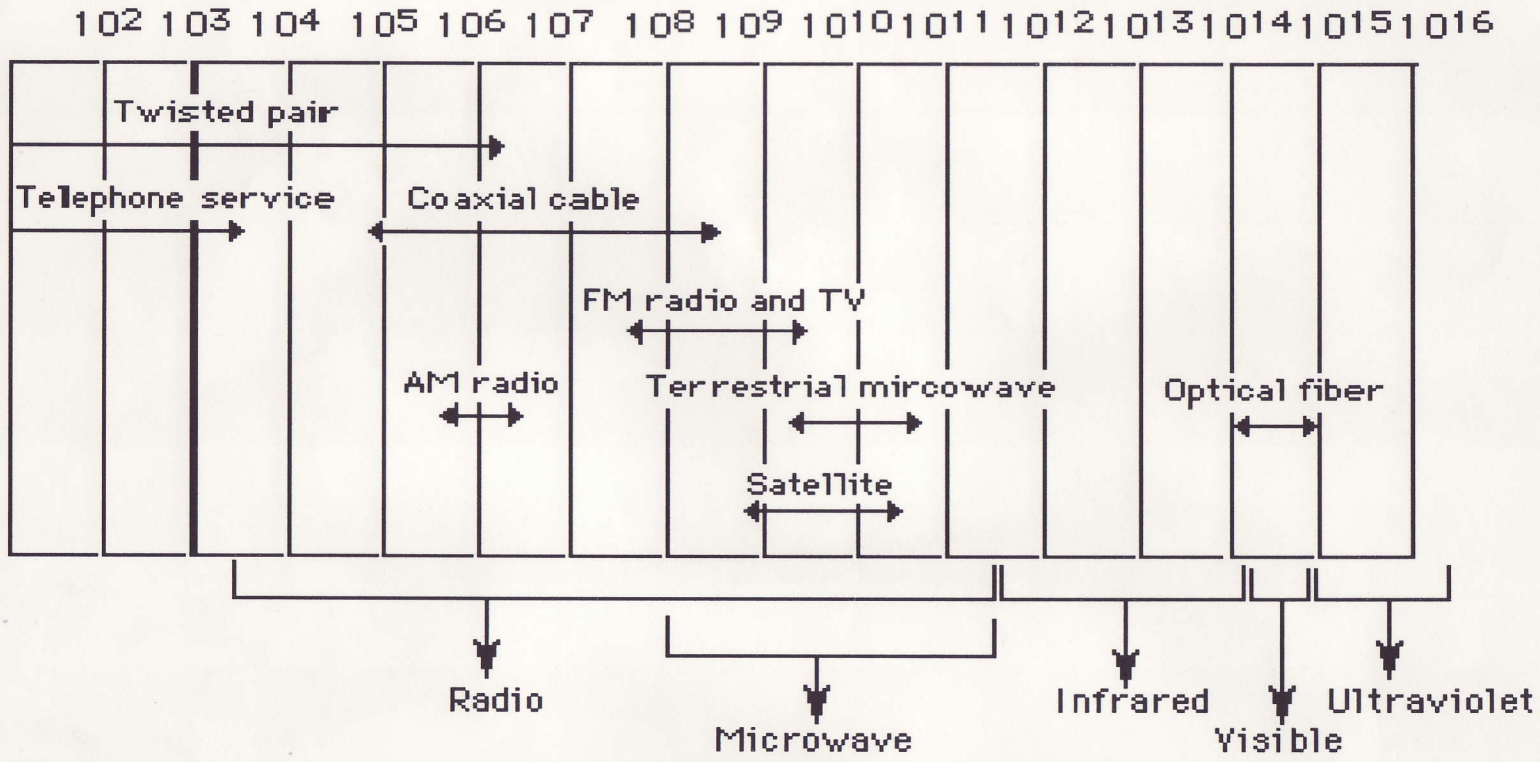
Fiber optics operates in the near IR region at 10^{14} cycles per second. frequencies in this region are 30 to 400 tera-hertz

Copper wire operated at frequency of 300 to 3,300 hertz.

Microwave radio signals range from 2 to 25 gigahertz. So it can be split up into different channels.

Frequency (cycles/second)	Range	Use
→ 10^2		Telegraph/teletype
→ 10^3	300 Hz to 3 kHz Voice Frequency	Telephone
10^4	3 kHz to 30 kHz	
10^5	30 to 300 kHz	Navigational Radio
→ 10^6	300 kHz to 3 MHz	Radio Broadcast
10^7	3 to 30 MHz	Amateur Radio
10^8	30 to 300 MHz	Mobile radio
10^9	300 MHz 3 GHz	TV
10^{10}	3 to 30 GHz	Space/Satellite Com.

Electromagnetic Spectrum



Bandwidth of Analog Signal.

Difference between the highest & lowest frequencies of constituent parts as yielded by fourier analysis.

Taking the example given in figure 6.7 (P.99) the bandwidth is $5 - 1 = 4$ KHz.

Digital & Signals & Signal Levels. P.100

Some systems use voltage to represent digital values. Only two levels of voltage ~~needed~~ to indicate 0 or 1. Multiple levels of voltage may be used to indicate multiple bits. See fig. 6.8 for example.

example:
- −5 volt = 00
- −2 volt = 01
- +2 volt = 10
- +5 volt = 11

Electronic systems must be sensitive enough to distinguish between voltage levels, if multiple levels are used.

Band & Bits per Second.

How much data can be sent in a given time?

1. Rate at which data can be sent depends upon
2. Number of signal levels.
- Amount of time given to each signal level.

Band rate: How many times the signal changes per second. So Band only takes into account the second item, not the first. Therefore band rate is not the same as bits per second.

If .001 seconds is given to a signal, then the band rate is 1000. If the number of signal levels are 2, like +5 V to −5 V then the ~~bit~~ rate also is 1000. If it has 4 signal levels then the bits per second is 2000.

Converting Digital to Analog. Why do that?
In order to transmit digital data over analog lines. Serial communications using modems.

Basis of analog signaling is a continuous constant frequency known as the carrier signal.

Conversion of digital signal to analog is approximate, ~~involving~~ building a composite signal from only few sine waves (as few as three). See figure 6.9 on page 103.

This type of digital conversion to analog and vice-a-versa are handled by ~~A/D converters~~ A/D convertors.

Telephone ~~co~~ network was designed to transmit analog signals in the voice frequency range of about 300 to 3400 Hz.

See next page

Digital data, analog signals

—This scheme is useful when using telephone lines.

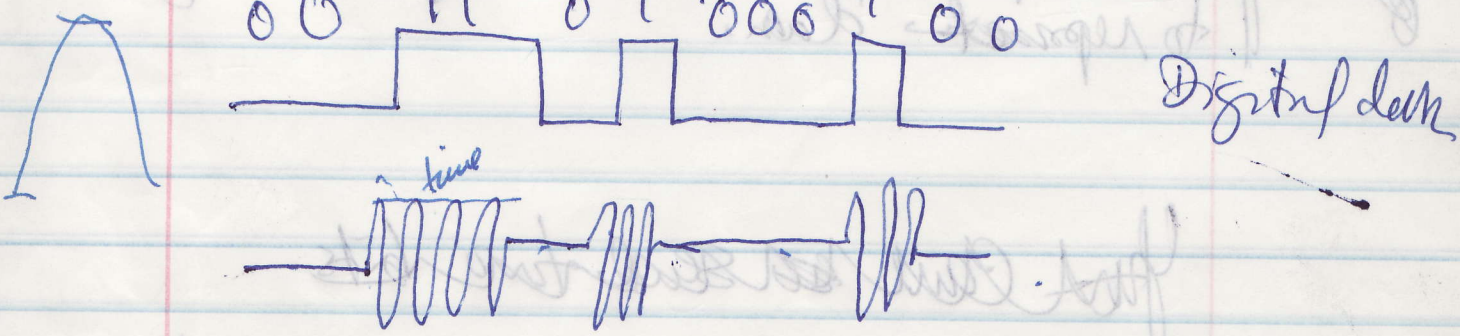
Telephone network was designed to transmit analog signals in the voice frequency range of about 300 to 3400 Hz.

A Modem is required to change from data to analog.

We can use 3 encoding techniques.

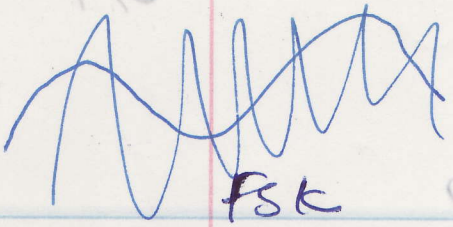
ASK Amplitude Shift Keying
FSK Frequency Shift Keying
PSK Phase Shift Keying.

In ASK two binary values are represented by two different amplitudes of the carrier frequency.

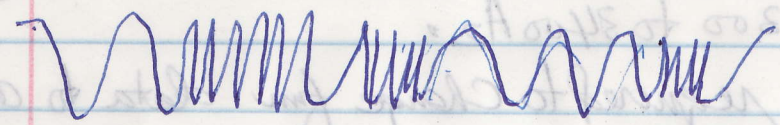


One is represented by the presence of the carrier at a constant amplitude.

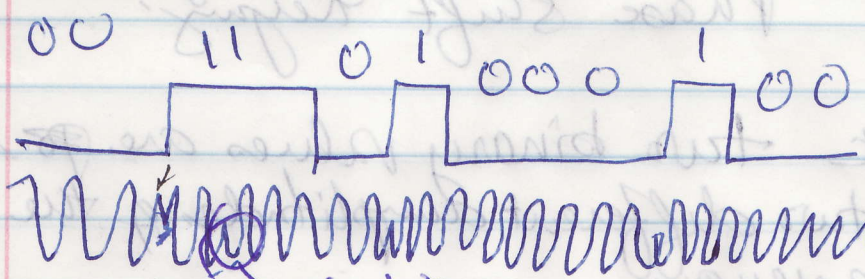
Zero is represented by the absence.



FSK



PSK



These phase of the carrier signal is shifted to represent data.

You can use two bits.

You can use 90° shift or 45° shift to increase data transmission

A 9600 bps modem uses 12 phase angles.

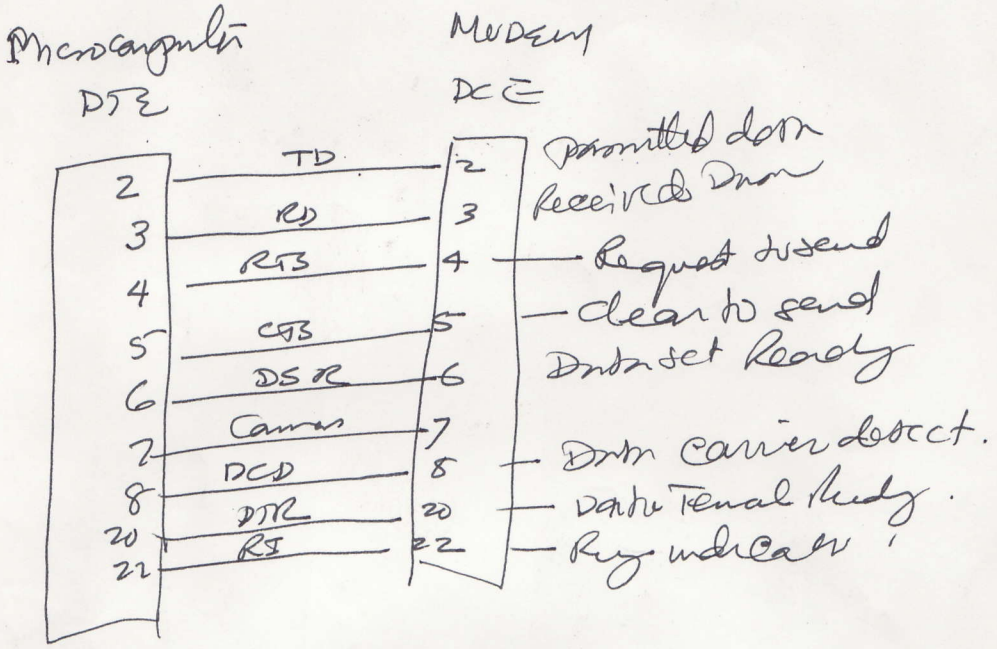
Modulo-2 arithmetic Simplifies hardware design enormously because modulo 2 arithmetic has no carries or borrows.

Exclusive or.

$$\begin{array}{r} 01010101 \\ +\ 01010101 \\ \hline 00000000 \end{array}$$

Modulo addition

6-10



This ↓

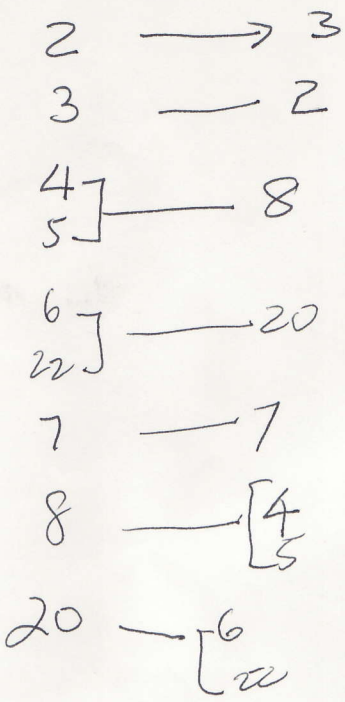
Answering an incoming Call.

1. Rig is signaled on Pin 22.
2. Microcomputer tells modem to answer call by asserting pin #20 (~~Test~~ Data Terminal Ready)
3. Modem asserts Data Set Ready (pin 6).
4. Carrier detect checks #8. DCD.
5. ~~Modem data~~ data exchange begins

Talk about full duplex & Half Duplex mode

The Null Modem

To connect two DTEs together.



INTERFACING. Physical Interface Standards

DTE. Tata terminal equipment. (computer - or terminal)

DCE data circuit - terminating equipment (Modem)

DCE is RESPONSIBLE FOR TRANSMITTING AND RECIEVING BITS, ONE AT A TIME, OVER A TRANSMISSION MEDIUM. DCE MUST INTERACT WITH DTE. THE SET OF WIRES used for this interaction is referred to as interchange circuits.

EIA-232-D Electronic Industries Association

RS-232 Standard was first issued in 1962.

RS-232-C Published in 1969.

EIA-232-D Published in 1987.

RS232 calls for a 25 pin Connecter. — DB 25.

A voltage more negative than -3 volts is interpreted as binary 1.

A voltage more positive than +3 volts is interpreted as binary 0.

Use with <20 Kbps and distance < 15 meters.

Digital Data to Digital Signals

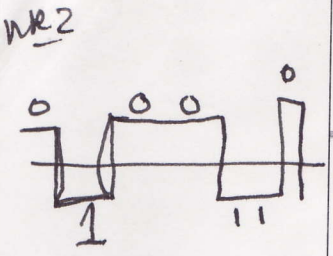
- NRZ
- Multilevel Binary
  - Bipolar-AMI
  - Pseudoternary
- Biphase
  - Manchester and differential Manchester

Digital signal is a sequence of discrete discontinuous voltage pulses. Each pulse is a signal element.

1. Unipolar → only positive voltage used.
2. Polar → Both positive & negative

Data Signaling Rate - bps.

Duration or length of a bit is the amount of time it takes for the transmitter to emit the bit.



Modulation →

$\frac{1}{R}$ (or) $\frac{1}{\text{bps}}$.

Modulation Rate (baud rate) → the rate at which signal level is changed.

This depends upon the encoding technique used.

→ It is possible to transmit more than 1 bit per modulation.

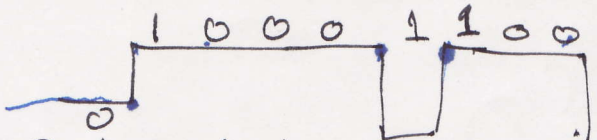
∴ baud rate and bps are not the same

NR2 – Non return to zero.

- Easiest way to encode. Use 2 diff voltage levels.
- During a bit transmission the voltage does not return to zero.

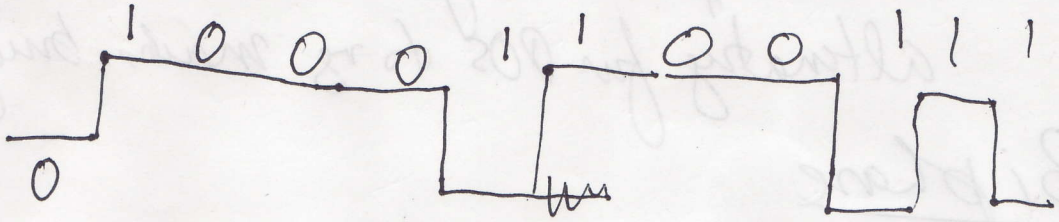
NRZi → A variation to NR2. Non-return to zero-inverted ones.

No transition → zero.
Transition → one.



In twisted pair - if sending and receiving wires are improperly connected NRZi is not affected.

A variation of NR2 is known as NR2I.
Non return to zero — invert on ones.
No transition indicates zero.
A transition indicates one.

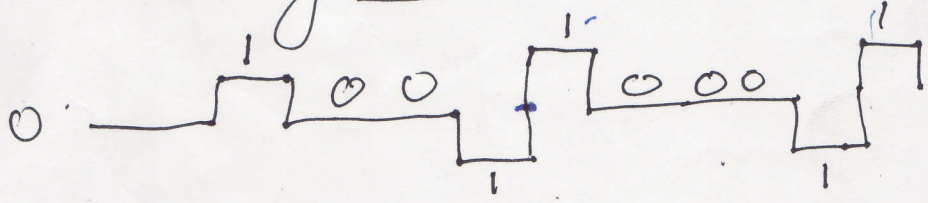


NR2I is an example of differential encoding
In decoding adjacent elements are compared for polarity changes. In twisted pair wiring if sending and receiving wires are improperly wired, this scheme is not affected.

Multi Level Binary

This technique uses more than two signal levels.

Bi polar - AMI - (alternate mark inversion)
a binary 0 is represented by no line signal.
binary 1 is represented by a positive or negative voltage.
The binary ones must alternate in polarity



Advantages. — no loss of synchronization in case of continuous one's transmitted. Receiver can synchronize with each transition

B3 Multilevel Binary - Pseudoternary.

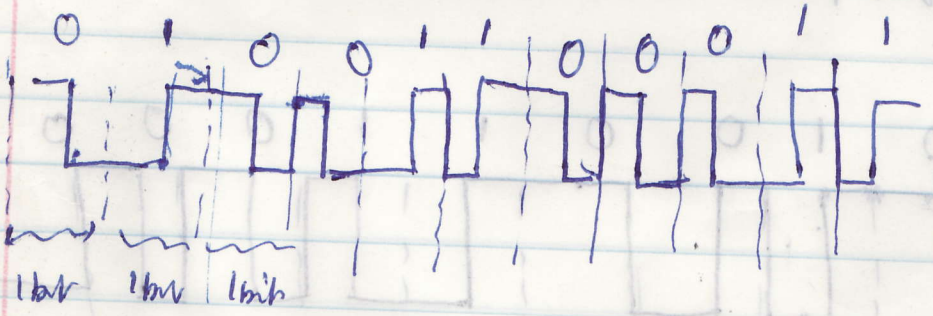
Absence of line signal marks binary 1.
alternate pulses to represent marks. binary zero.

B4 Biphase

Manchester code. There is a transition at the middle of each bit period.

Biphase Manchester Code
- There is transition at the middle of each bit period.
- This transition serves as a clocking mechanism
- Low to high represents a 1
- High to low represents a 0.

This technique is used in local area networks with Ethernet.
This is used in high speed transmission up to 10 Mbps



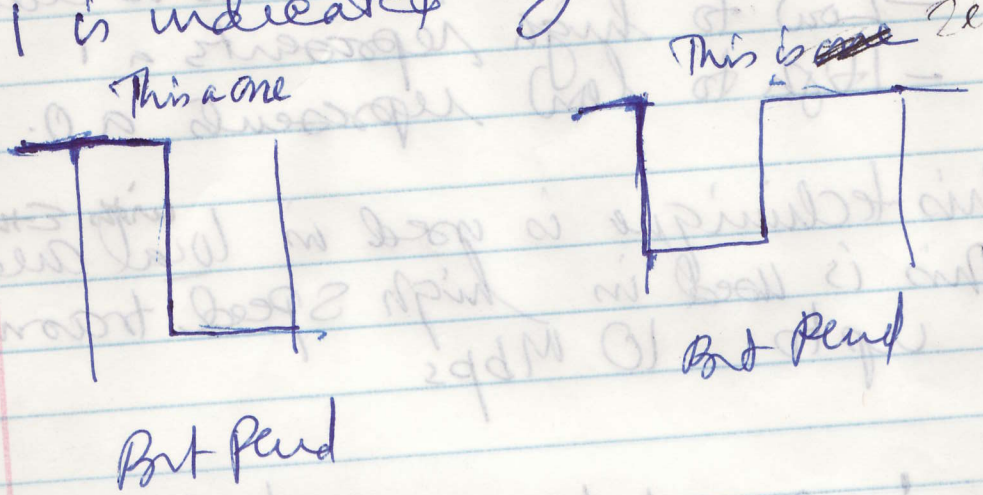
When you need two zeros or ones you have to shift

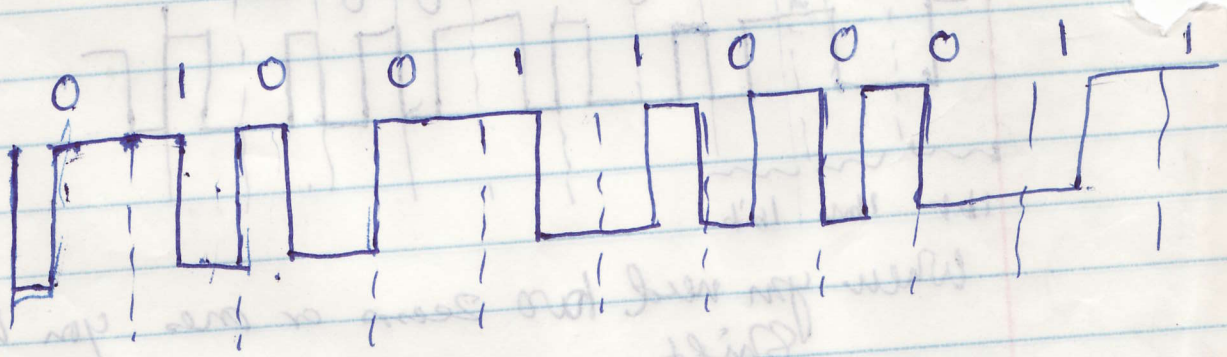
Differential manchester. (Or phase Encoding)

At the middle of each period there is a transition. This transition has nothing to do with 0 or 1. It is just for synchronization
0 is indicated by ~~a change in~~ a presence of ~~from~~ transition at the beginning ~~of a bit~~

0 is indicated by the presence of transition at the beginning of a bit period.

1 is indicated by the absence.





For Fast ethernet, Multilevel transition (MLT-3) is used. A change in voltage indicates 1, no change mean zero.
There are 5 voltage levels used.

~~Digital~~

Analog to Digital. Very Popular now.
- Pulse code Modulation (PCM)
- Delta Modulation

PCM - level of an analog signal is measured repeatedly at fixed time intervals and coverted digital form.
- Each measurement is known as a sample.
- The sample is ~~(measure voltage)~~ Quantized by converting it to a small integer value which is then encoded into specific format.
- The Quantized value is obtained by making sets of slots ranging from minimum to maximum levels. See fig 6.15 p. 107.

Delta modulation ~~Same~~ Variation of PCM.
~~Also takes Samples~~

How much Sampling is good?
Use Nyquist theorem.

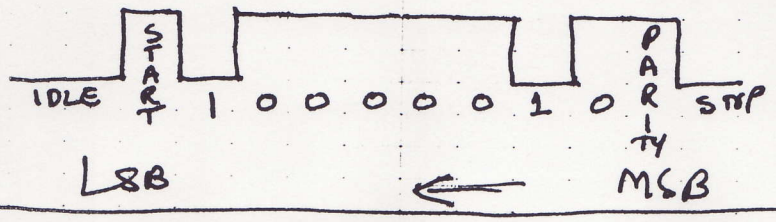
Encoding and Data Compression

Sending char A

01000001

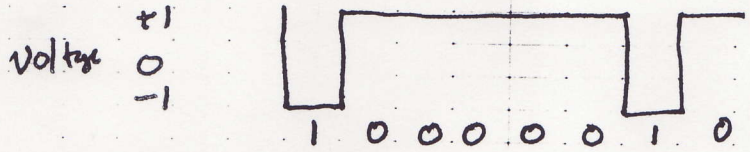
MSB LSB

Asynchronous Transmission

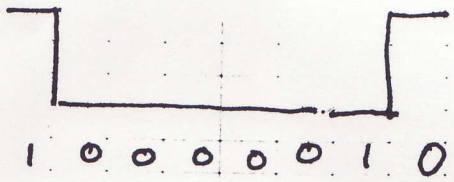


8 Bit Data
Even parity

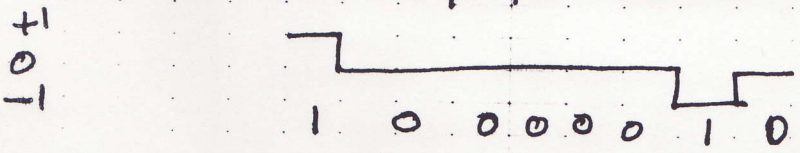
NRZ 1 = Negative Voltage 0 = Positive Voltage



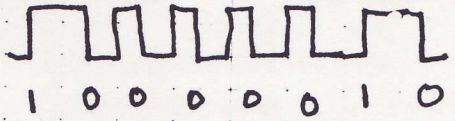
NRZ-I 1 = Transition 0 = No transition



Bipolar AMI 1 = Neg or pos - alternate 0 = No line signal



Biphase Manchester 1 = Low to high 0 = High to low. Transition middle



Differential Manchester 1 = Absence of Transition at the beginning
0 = Presence of Transition at the beginning