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Ch.2 Signal, Transmission & Error Detection

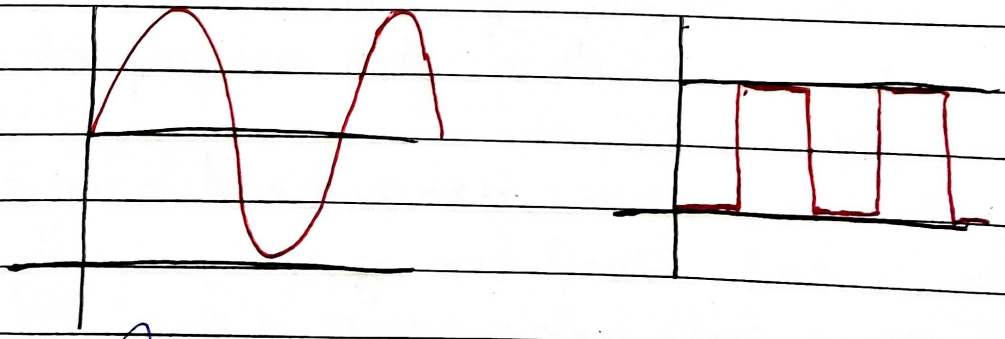
• Signal Type

• Analog Data.

Analog data is a continuous data, it represents a range of value. But it is susceptible to noise and quite challenging to transmission.
E.g., Human voice, clock's hand.

• Digital Data

Digital data is a dicrete data (i.e, not continuous) in 0s and 1s. It is less susceptible to noise and easier to transmit data as campared to analog signal.
E.g., Digital thermometer, PC.



Analog

Digital

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Analog Signal Vs. Digital Signal.

Parameter	Analog Signal	Digital Signal
Definition	A signal for conveying info. which is a continuous func^{r} of time is known as analog signal	A signal which is discrete func^{r} of time i.e., non-continuous signal is called as digital signal (0s & 1s)
Representation	An analog signal is typically represented using sinewave	A digital signal is typically represented using square wave
Bandwidth.	The bandwidth of an analog signal is low	The bandwidth of a digital signal is relatively high.
Suitability and noise susceptibility	The analog signals are more suitable for transmission for audio, video and other info. through comm. channel and analog signals get easily affected by noise	The digital signals are suitable for computing and digital operation such as data storage, and digital signals are less susceptible to noise and much more stable
Accuracy	The accuracy is low	The accuracy is high
Power	Analog signal uses more power	Digital signal uses less power

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	Analog signals uses analog circuits such as resistors, capicitors, etc	Digital signal uses digital circuits such as transistors, ICs, etc
Circuits		
Examples	Analog Examples: 1. Current 2. Voltage 3. Speed, etc	Digital examples: 1. Data processing. 2. Data Stocerage. 3. Data comm. etc
Application	Applications are: Landline phones thermometer electric fan, etc	Applications are Computer, Keyboard, digital watches. etc

- Digital Signals

- Bit rate:

  It is the rate at which bits of data are transmitted or processed per unit of time. It is measured in speed for e.g., Kbps, Mbps, Gbps, etc

- Bit length:

  Bit length refers to the no. of bits used to represent a single data element. It determine the no. of possible values that can be represented. For e.g., 8 bit of red, 8 bit of green and 8-bit of blue are combined for a 24 bit color.

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- Baud rate.

Baud rate is the rate at which the signal changes or symbols are transmitted per second, it measured in baud (Bd) or symbols per second

Bitrate = Baud Rate x Bits per Symbol.

- Transmission Impairment.
  ↳ Communication channels are not perfect. When a signal undergoes several impairment. (get damaged)

- Attenuation.
  ↳ It means loss energy. The strength of signal decreases with increasing distance which causes loss of energy. Amplifiers are use to amplify the attenuated signal. Calculated in desibles (dB); Attenuation = $10\log_{10}(P_2/P_1)$
- Distortion
  ↳ It means change in shape or form of the signal. The signal received at the end is different from the original signal sent.

Voice distortion: On calls, the voice sometimes get stranged, or unclear due to signal change during trans.

Video distortion: On TV broadcast, VCs, the video gets shaky or unclear or change in color due to distortion.

Data distortion: 0s and 1s flips, resulting incorrect information.

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- Noise
  Noise is any unwanted random signal that get mixed with the original signal resulting impairment. There are several type of noise

1. Thermal Noise : Caused by random movement of electrons in a conductor due to noise.

2. Impulse Noise: Sudden, short bursts of interferance due to lighting or switching spikes

3. Crosstalk : When a signal from one communication channel interferes with another nearby channel.

4. Intermodulated : Occurs when signal mixed with a non-linear system, producing unwanted frequency.

5. White noise. : Random noise that has same intensity at all frequency.

- Channel Capacity
  ↳ The max. rate (bps) at which data is transferred over a communication channel with arbitrarily low error possibility

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

- Nyquist theorem
  ↳ It describe the maximum symbol rate (data rate) in a noise free channel of finite bandwidth.

$$C = 2B\log_2 M$$

- Signal-to-Noise Ratio (SNR)
  ↳ The ratio of signal power to the noise power is called Signal to Noise ratio. (Signal quality).

$$SNR = \frac{P_{signal}}{P_{noise}}$$

★ SNR↑ signal quality ↑ ; SNR↓ signal quality ↓

- Noise Figure
  ↳ A measure of how much a device (like an amplifier) degrades SNR of a signal.

$$NF = \frac{SNR_{in}}{SNR_{out}}$$

For (dB)

$$NF = 10\log_{10}\left(\frac{SNR_{in}}{SNR_{out}}\right)$$

- Shannon's theorem
  ↳ The maximum data achievable over a comm. channel in the presense of noise.

$$C = B\log_2(1+SNR)$$

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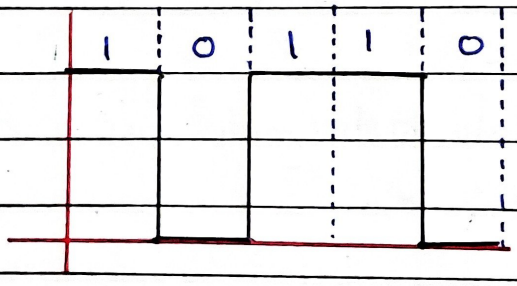
- Line Coding

- What are characteristics?
  ↳ 1. Making data suitable for transmission over a comm. channel by converting digital data into digital signal.
  2. Signal level: Line codes uses specific voltage level to represent 0s and 1s
  3. Timing: It insures start and end of each bit is detected by receiver.
  4. DC volt: Some line codes uses DC level (average volt) while some avoid it.
  5. Error detection: Certain line codes helps detect errors in transmission.
  6. Synchronization: Helps the receiver to stay in sync with sender.

- Unipolar: All the signal levels are either above or below the axis.

- NRZ (Non-Return-Zero): It is an unipolar coding scheme in which +ve voltage defines bit 1 and zero voltage define bit 0.

For e.g.,



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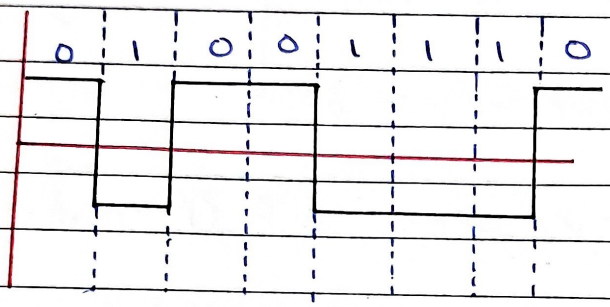
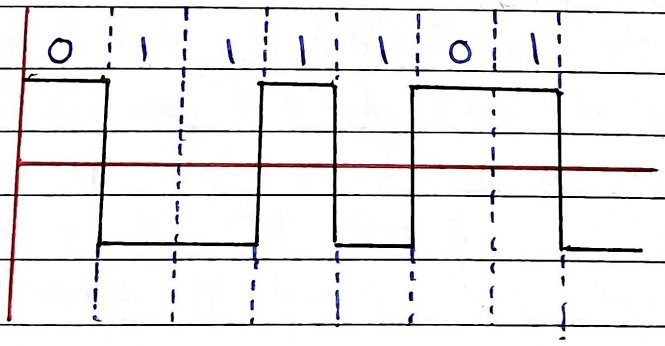
- Polar Scheme: In polar schemes, the voltage are on both side of the axis.

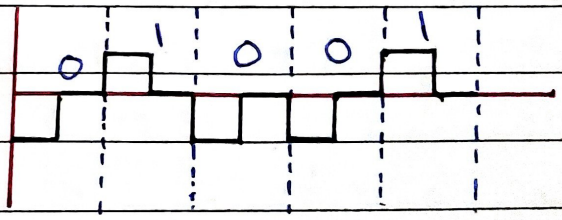
- NRZ-L: The level of the voltage determines the value of the bit, typically 1 maps to Logic level high and 0 maps to logic level low. (Negative voltage)



- NRZ-I: Two level signal has transition at a boundary if the nxt bit is ~~not~~ logical 1, and does not transit if the nxt bit is logical 0.



- RZ: This uses 3 values the -ve and zero voltage. In this scheme, signal returns to '0' in the middle of each bit.



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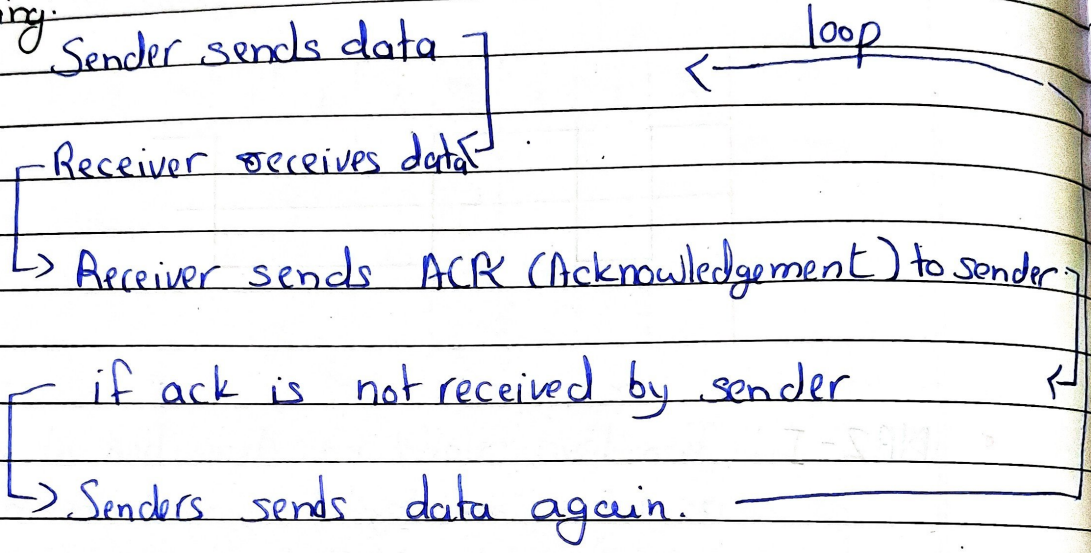
- ARQ (Automatic Repeat Request)
  ↳ ARQ is an error control method used in comm. systems to ensure reliable data transmission. It automatically asks sender to resend data if it is lost or corrupted.

Working:



1. Stop n' wait ARQ
   In this, the frame/packet is sent at a time, after sending frame, sender waits for ACK, meanwhile it keeps the copy ready of next frame. When receiver receives the frame correctly, it sends ACK to sender. If ACK is not received, sender resends the frame/packet.

2. Go back.
   In this method, sender can send multiple frames at once with each frame has its unique number. While receiving, receiver checks every frame, if frame matches with expected no. it accepts and sent an ACK. If frame does not match, receiver discards it and re-sends an ACK for the last correct frame. and sender re-sends the frames from last ACK.

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3. Selective Repeat ARQ
↳ This is similar to Go back, but the difference is if only one frame get corrupted or lost, only that frame is re-send. In this receiver keeps the track of earliest missing frames and sends that sequence no. in ACK.

- Hamming Code
Hamming code is a techniique or it is an error-correcting code used to ensure data accuracy during transmi-ssion or storage. Hamming code detects and corrects the error that can occur when the data is moved from sender to receiver or stored. It adds extra bits to the original data, allowing the system to detect and correct single bit errors.

- FEC (Forword Error Correction) telecomm.
↳ It is a digital signal processing techique used in ECs to control errors in dta transmission over noisy or unreliable channel without needing sender to retransmit data.

  - The FEC encoder adds extra bits called Redundant bits or parity bit, to the OG data block while transmitting data
  - The FEC decoder at the receving end checks redundant bits and mathematical relationship established by sender.
  - This not only detects but also corrects the limited no. of bit error. Eliminating ARQ.