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DATA COMMUNICATION

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ADDITIONAL BOOK

UNIT-I

SIGNATURE OF HALL INVIGILATOR

①

Communication:-

Communication is the ability to send and receive message reliably and which is realiability (or) Predictable forms of the system.

History of communication:-

1837 - telegraph
1876 - telephone
1910 - US govt - Regulations
1915 - Transcontinental Phone Services
1951 - Direct dialed long distance services
1960 - Data communication over telephone
1970 - online are the real time System (On-line transactions)
1980 - Personal computer
1984 - Cell Phone
1990 - LAN (Local area N/w)
1993 - Internet.

Communication classification:-

- Based on signal < Analog / Digital
- Based on modulation usage < Base band (Ex. Mick) / Broad band
- Based on medium < guided (Ex. wire, optical communication) / unguided (Ex. Air, Mobile comm.)
- Based on frequency - VLF, LF, MF, VHF, UHF, SHF

William Stallings:-

Data and computer communications - 7th Edition

① **A communication Model:-**

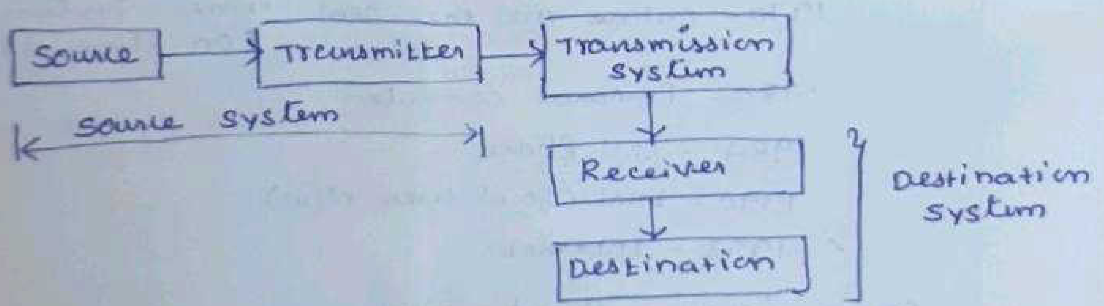
- Source:-
  - generates data to be transmitted
- Transmitter:-
  - converts data into transmittable signal.

- Transmission System:-
  - carries Data
- Receiver:-
  - converts received signal into data
- Destination:-
  - Takes incoming data

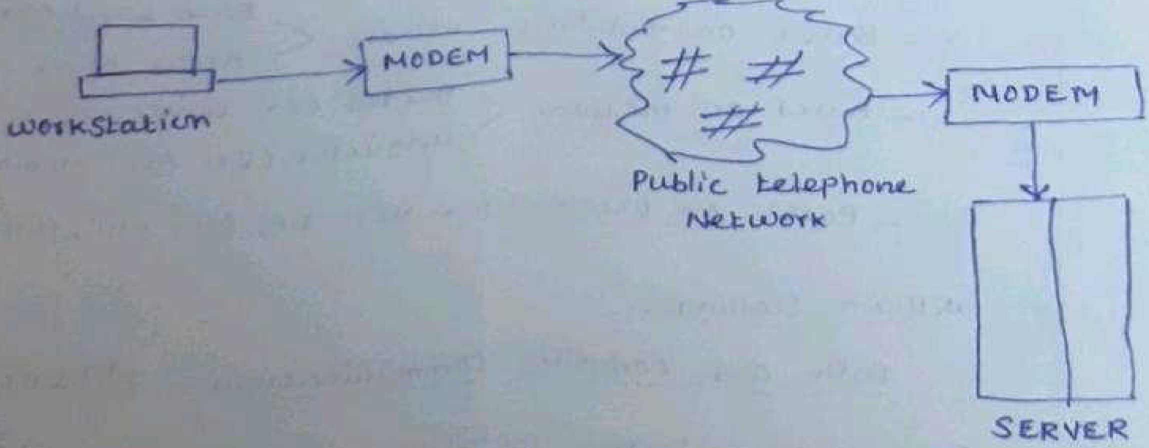
② Communications tasks:-

Transmission system utilization - Addressing
Interfacing - Routing
Signal generation - Recovery
Synchronization - Message formatting
Exchange Management - Security
Error detection and correction - Network Mangement
Flow control

③ Simplified Communications Model - Diagram

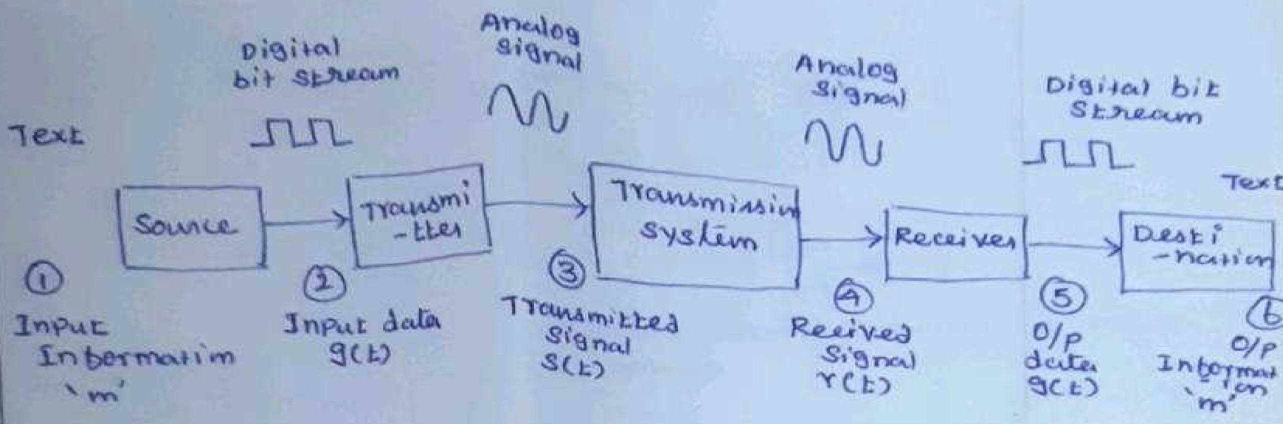


(a) General block diagram



(b) Example

④ Simplified Data Communication:-



Data communication Link:-

Link :- It is the physical communication pathway that transports data from one device to another.

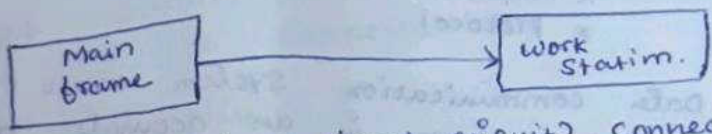
* The link configuration may either a
  * Point - to - Point link
  * Multi point link.

* Point - to - Point link :-

Connects just one sender and receiver together

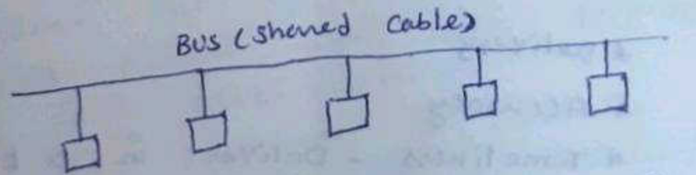
Example :- Remote control of T.V

Point to Point link



* Multipoint :-

(also called a shared circuit) connects a number of senders and receivers together.



Advantages:-

- It is cheaper and simpler to wire

DisAdvantages:-

- It is one computer can use the circuit at a time.

→ Data Communication :-

- Transmission of sequence of binary code is called data communication.

- codes are created stored and processed by computer and their peripherals.

- The five basic components of data communication
  * Message
  * The sender
  * The receiver
  * Medium
  * Protocol

- Data communication system must transmit data to the correct destination in an accurate and timely manner.

- The effectiveness of data communication depends on
  * Delivery
  * Accuracy
  * Timeliness - Deliver in a timely manner.

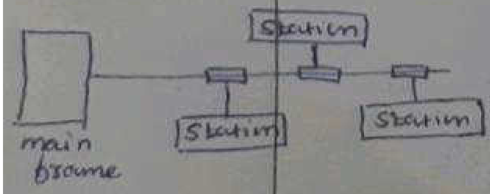
- Data transmission requires :-
  * Encoding bits as energy
  * Transmitting energy through medium
  * Decoding energy back into bits
  * Transmitter and receiver must agree on encoding scheme.

→ Networking :-

a) Point-to-Point

- Point to point communication not usually practical
  - Devices are too far apart
  - Large set of devices would need impractical number of connections.

(b) MultiPoint



- Solution is a communications network (MULTIPOINT)
  - wide Area Network (WAN)
  - Local area Network (LAN)
  - Metropolitan area Network (MAN)

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WAN

- Large geographical area
- Crossing public rights of way
- Rely in past on common carrier circuits
- Alternative technologies
  - Circuit switching
  - Packet switching
  - Frame relay
  - Asynchronous transfer Mode (ATM)

Circuit switching

- Dedicated communication path established for the duration of the conversation.

(Ex) - telephone N/w

Packet switching :-

- Data sent out of sequence.
- Packets passed from node to node between source and destination.
- used for terminal to computer · computer to computer communication.
- Data rate upto :- 64kbps

Frame relay :-

- Packet switching systems have large overheads to compensate for errors.
- Modern systems are more reliable
- Data rate upto 2Mbps

ATM :- (Cell Relay)

- Evolution of frame relay
- fixed packet length
- constant data rate
- Anything from 10Mbps to Gbps

LOCAL AREA NETWORKS (LAN)

- Smaller scope
  - Building or small campus
- usually owned by same organization as attached devices.
- Data Rates much higher
- usually broadcast systems

Metropolitan Area Networks (MAN)

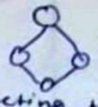
- MAN
- Middle ground b/w LAN and WAN
- Private or Public N/w
- High speed
- Large area

Categories of topology

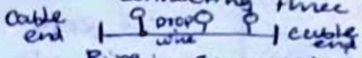
Topology: Mesh, Star, Bus, Ring

Mesh - fully connected N/w

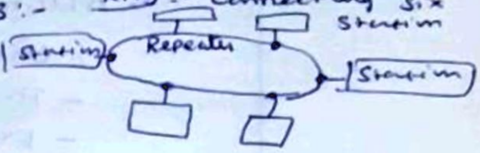
Star :-



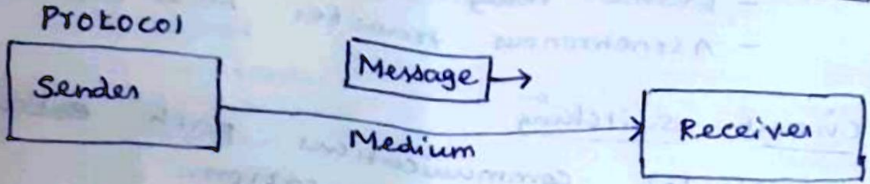
Bus :-



Ring :- Connecting six station



DATA COMMUNICATION SYSTEM COMPONENTS :-

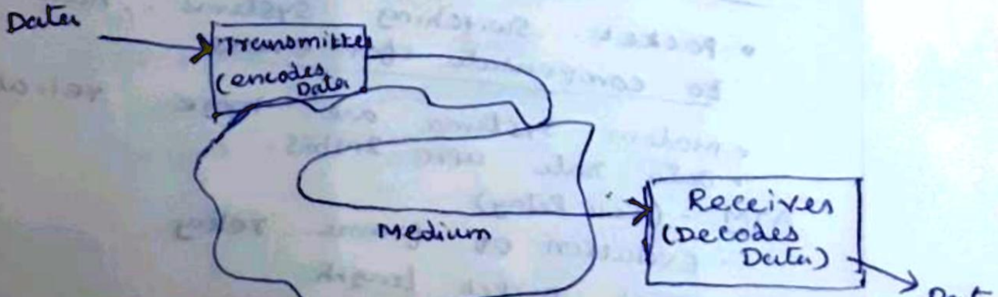


Message :- It is the information / data to be communicated (It may be text, numbers, pictures, sound or video)

Sender :- Sends the message. It may be a computer, workstation, telephone (or) a video camera.

Receiver :- Receives the message.

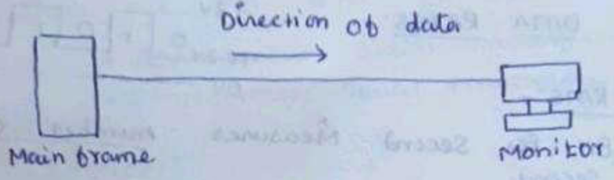
Medium :- Transmission medium is the physical path that carries the signal. (It may be a twisted pair. Co-axial cable, fiber optic cable)



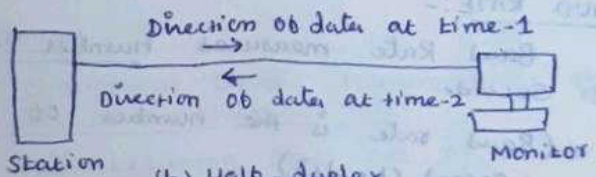
Protocol :- It is a set of rules that govern the data communication.

TRANSMISSION MODE :-

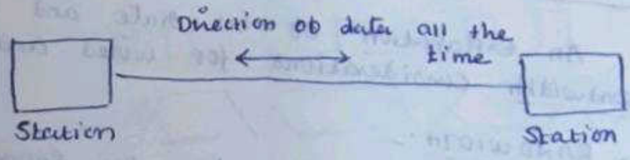
1) Simplex
2) half - duplex
3) Full - duplex



(a) Simplex



(b) Half - duplex



(c) Full - duplex

Simplex

* It is one way communication. Data only flows in one direction.
* Simplex device is not a transceiver.
* Example :- FM radio Station and your car radio.

Duplex :-

* The devices do act as transceivers.
* Duplex communication data flows in both directions.
* Data flows bi-directionally.

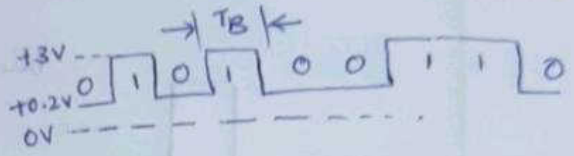
Full duplexing:-

* The devices transmit and receive data at the same time.
* Data to flow in both directions simultaneously.
* Example:- Telephone system.

Half duplex:-

* The devices allow both transmission and receiving, but not at the same time.
* But not simultaneous transmit and receive.
* Example:- walkie - talkie system.

DIGITAL DATA RATES:-



→ BIT RATE:-

* Bit per second measures number of bits transmitted per second.

('N'- is the number of bits per second(bPS))

* Data rate (R) = 1/TB

→ BAUD RATE:-

Baud Rate measures number of signal changes per second.

(Baud rate is the number of signal elements per second (bauds))

Difference b/w Bit Rate and Baud Rate:-

An explanation of bit rate and baud rate and related Bandwidth considerations for wired and wireless data comm/.

→ BANDWIDTH:-

* Measured in cycles per second (or) Hertz
* Theoretical upper limit is called Bandwidth.
* Nyquist sampling theorem expresses relationship b/w B.W and maximum data transmission speed.
* Noise limits, maximum data transmission rate.

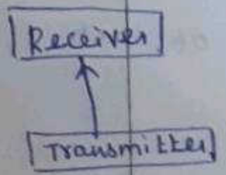
SERIAL DATA FORMAT:-

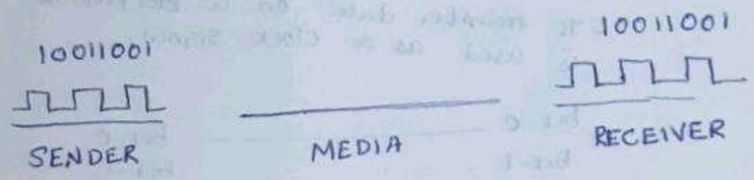
* Information being transfered b/w data processing equipment and peripherals is in the form of digital data.

* Information transmitted is either a
  1) Serial Mode
  2) Prallel Mode

i) Serial Mode (Example 8 bit)

- Each bit is sent over a single wire, one after the other.
- usually no signal lines are used to convey clock (timing information)
- There are two types of serial mode
  - Asynchronous serial transmission.
  - Synchronous serial transmission.



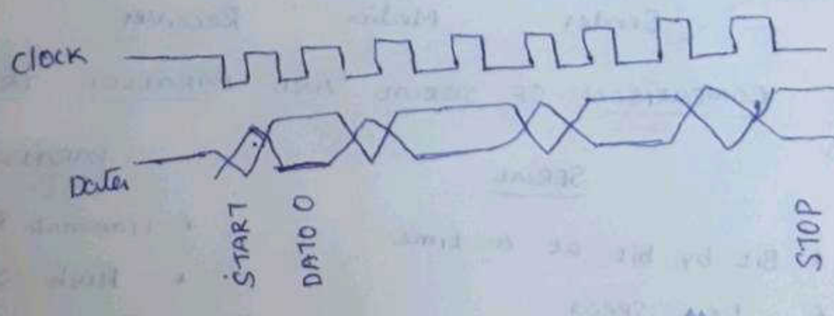


Synchronous :-

* Synchronous Serial transmission, the data is sent in block at a constant rate.

The beginning and end of a block are identified with specific bytes or bit patterns.

* Requires clock signal to synchronize transmitter and receiver.
* continuous transmission to keep clock sync.
* Data transfer rate is determined by clock rate

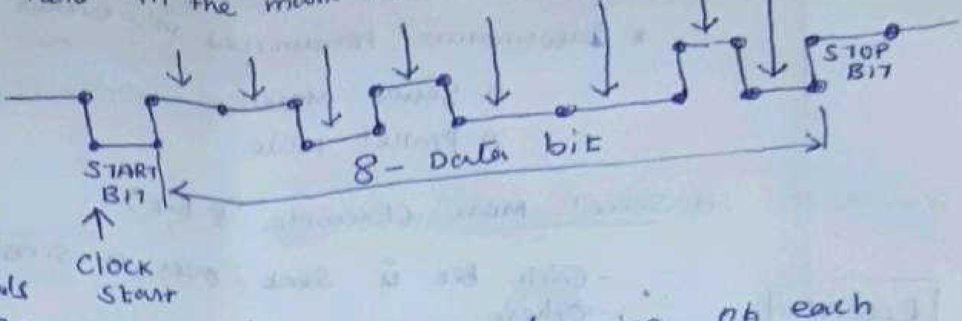


Note:-

Data = high, clock = high – Idle state
Data = high, clock = Low – communication Inhibited
Data = Low, clock = high – Host request-to-send.

Asynchronous:-

- In asynchronous serial communication, the electrical interface is held in the mark position b/w characters



- Start and stop bits represent framing of each character.

* Transmitter and receiver operate independently
- Transmitter sends data at any time
- RX. is ready to accept data at all time.
- No need for clock signals But during transmission format and transfer rate of data must match.

PARALLEL DATA FORMAT:-

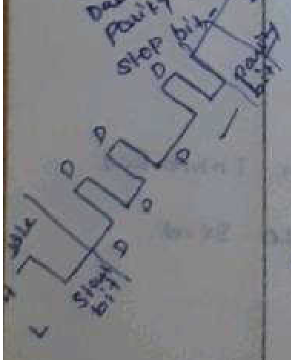
- Each bit uses a separate wire.
- To transfer data on a parallel link, a separate line is used as a clock signal.

bit-0 ———— bit-0
bit-1 ———— bit-1
bit-2 ———— bit-2
bit-3 ———— bit-3
bit-4 ———— bit-4
bit-5 ———— bit-5
bit-6 ———— bit-6
bit-7 ———— bit-7

Sender Media Receiver.

Data format
- Start bit - indicates the beginning of word.
- Data bit - data used in transmitting
- Parity bit - checks integrity of data
- Stop bit - indicates the end of word.

* Idle - 1
Start bit - 0
Data bit - 0 (or) 1
Parity - 0 (or) 1
Stop bit - 1



COMPARISON OF SERIAL AND PARALLEL TRANSMISSION:-

SERIAL

* Bit by bit at a time
* Less speed
* Long distance
(Ex) Mouse modem
* Serial requires less transfer lines
* Transfers one bit at a time
* Slow comparatively but less expensive.

PARALLEL

* Transmit 8bit at a time.
* High speed
* Short distance
. Printer
* Parallel requires more transfer lines
* Bits have to be synchronized
* Fast, but expensive.

Scanned by Scanner Go

DATA ENCODING:-

• We must transform data into signals to send them from one place to another.

Why Encoding
- Three factors determine successfulness of receiving signal.
  - S/N ↓
  - Data rate ↑
  - Bandwidth ↑
- More factor can be used to improve
- encoding scheme.

Conversion Methods
- Digital to Digital
- Analog to digital
- Digital to Analog
- Analog to Analog

Digital to Digital:-
Data stored in computer are 0's and 1's to be carried from one place to another (inside or outside the PC) converted to digital signal.
Example:- Transmitting data from PC to printer. ⟷ [Digital transmitter] ⟷

Analog to digital:-
(Converting voice in a telephone line) Analog to digital conversion to decrease the effect of noise. It is called digitizing. ⟷ [CODEC] ⟷

Voice into Analog signal → Mobile Telephone lines

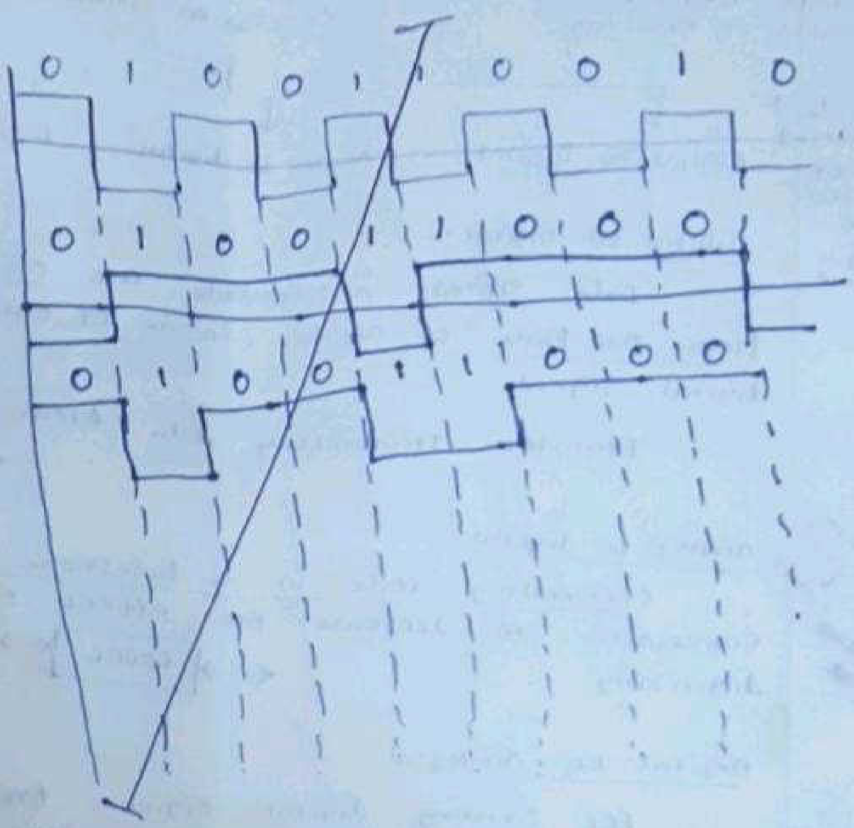
Digital to Analog:-
For sending digital signal from one place to another place using the public telephone line. This is called Modulating a digital signal. ⟷ [MODEM] ⟷

Analog - Analog:-
* Analog signal is sent over long distances using analog medium. It is called as Modulating of analog signal.
Example:- Music from radio system. ⟷ [Telephone] ⟷

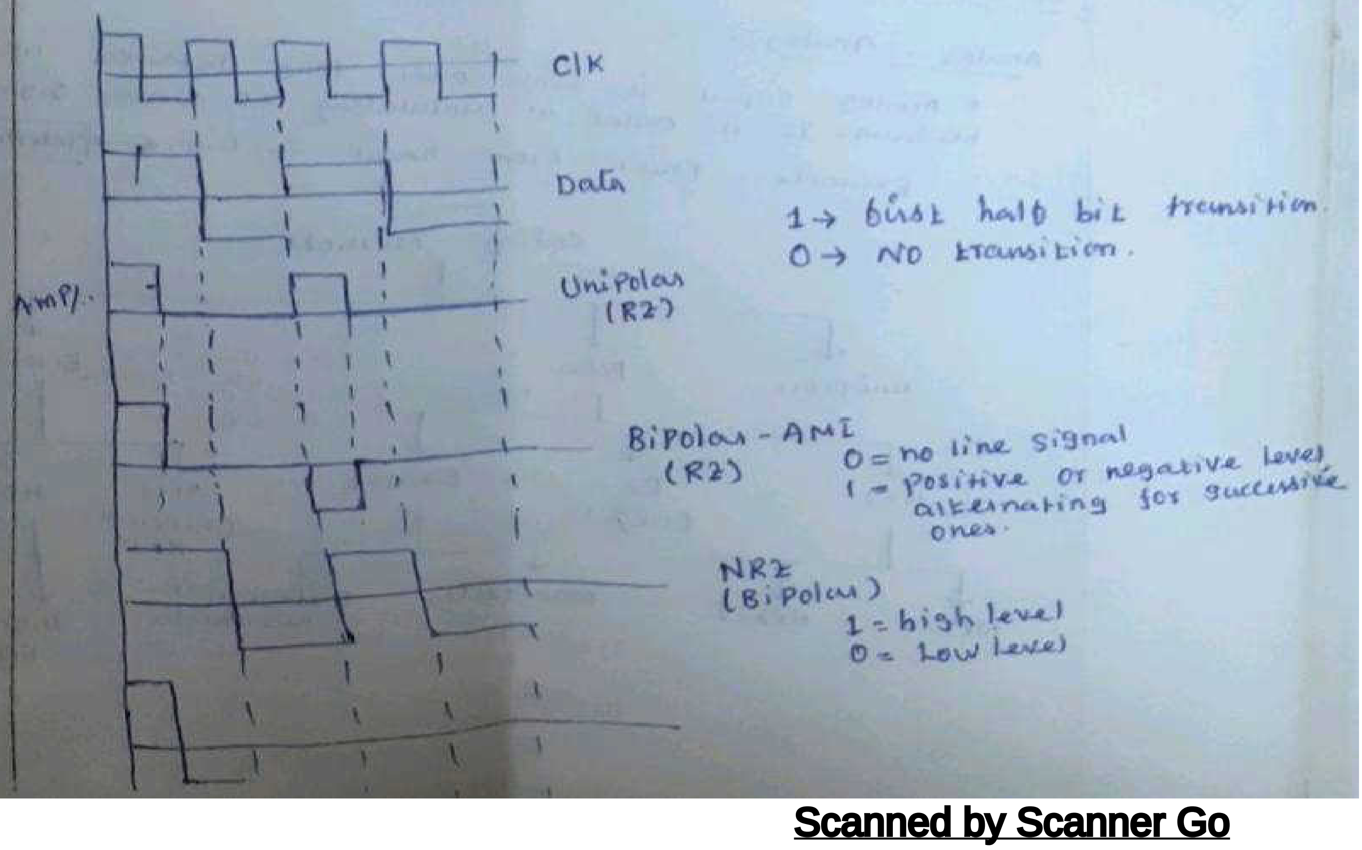
Coding Methods
- Unipolar
- Polar
  - NRZ
    - NRZ-L
    - NRZ-I
  - RZ (URZ)
  - Biphase
    - Manchester
      - 1 → low-to-high transition
      - 0 → high to low transition
    - Differential Manchester
      - 1 - absence of transition at the beginning of the bit interval
      - 0 - presence of transition at the beginning of the bit interval.
- Bipolar
  - 1 → alternating +½, -½ voltage
  - 0 → 0 voltage.
  - AMI (Bipolar RZ)
  - HDB3 → High Density Bipolar-3
  - B8ZS
  - Scrambling Tec
    - a) No reduction in data rate
    - 1) Produce constant voltage
    - 2) No dc component
    - 3) No long sequences of zero level line signal

UNIPOLAR:-

* All signal level are on one side of the time axis - either above (or) below



UNIPOLAR



[uses two different voltage levels (one positive and one negative) as the signal elements for the two binary digits]

NRZ :- (NON Return to zero)

| 1 – negative voltage |
| 0 – Positive voltage |

* Signal is always either positive or negative.

NRZ - L

* Level of the signal depends on the type of bit it represents.
* +ve voltage usually means the bit '1'
* -ve voltage means the bit '0'
* This representation may be used in vice versa

0 → negative voltage
1 → positive voltage

NRZ - L is used for short distances b/w terminal and modem or terminal and computer.

NRZ - I

* Inversion of the voltage level represents a 1-bit. It is the transition b/w a +ve and (-)ve voltage.

'1' → either a low-to high or a high to low transition

'0' → no signal transition at the beginning of the bit time.

RZ (Return to zero)

* Any time data contain a '1' or '0'

Bi-Polar Encoding :-

'1' — alternating +½, -½ voltage

'0' — 0 voltage

—— x ——

⇒ STANDARDS AND PROTOCOLS :-

STANDARDS

- Provide a fixed way for hardware and software system (different companies) to communicate.

TYPES :-

* Formal Standards developed by an industry or government standards making body
* De-facto Standards Emerge in the market place and widely used

Organizations for communication Standards :-

* Standards are developed by cooperation among
  - Standards creation committees
  - forums
  - Government regulatory agencies.

* Standards creation committees :-

1) International standards organization (ISO)
2) International Telecommunications union (ITU)
3) American national standards Institute (ANSI)
4) Institute of Electrical and Electronics Engineers (IEEE)
5) Electronic Industries Association (EIA)
6) Internet Engineering task Force (IETF)

* Standards Processes :-
  - Specification
    Identifying the problems to be addressed.
  - Identification
    Identifying solution to the problems and choose the 'optimum' solution.
  - Acceptance
    uniform solution accepted recognized by industry.

Major Standards Bodies:-

• ISO (International or Standard organization)

* Technical recommendations for Data communication Interfaces

* Composed of each country's national Standards Orgs.

* Based in geneva, Switzerland (www.iso.ch)

* Dedicated to worldwide agreement on International Industrialized nations.

* Objective
  - compatibility
  - Improved quality
  - Increased quality
  - Increased productivity
  - Decreased prices.

• ITU (International Telecommunications union)

* Technical recommendations about telephone, telegraph and data communications interfaces

* Composed of representatives from each country in UN

* Based in geneva, switzerland (www.itu.int)

* Two popular standards developed by ITU

  1) 'V' Series - transmission over phone lines

  2) 'X' Series - transmission over public digital N/w, email and directory services and ISDN.

• ANSI (American national Standards Institute)

* Coordinating organization for US

* www.ansi.org

* ANSI members include
  1) Professional Societies
  2) Industry associations
  3) governmental and regulatory bodies
  4) consumer groups

* ANSI Members discussing the Internetwork planning and engineering, ISDN services, signalling and architecture and optical hierarchy.

- **IEEE** (Institute of Electrical and Electronics Engineers)
  - Professional society also develops mostly LAN standards (802.3, 802.4 and 802.5 standards)
  - standards.ieee.org
  - Professional society involved:-
    1) computing
    2) communication
    3) electrical Engineering
    4) Electronics.
  - Aim to advance theory, creativity and product quality in the field of electrical, Electronics Engineering.

- **EIA** (Electronic Industries Association)
  - An association of electronics manufacturers in the US
  - provide activities include public awareness education development

- **IETF** (Internet Engineering task force)
  - Develope internet standards
  - No official membership (any one welcomes)
  - www.ietf.org.
  - Reviews internet software and hardware.
  - concerned with speeding the growth and evolution of Internet communications.

Some Data communication standards:-

Layer	Common standards
5. Application Layer	HTTP, HTML (web) MPEG, H.323 (audio/video) IMAP, POP (e-mail)
4. Transport layer	TCP (Internet) SPX (Novell LANS)
3. Network layer	IP (Internet) IPX (Novell LANS)
2. Data link layer	Ethernet (LAN) Frame Relay (WAN PPP (dial-up via Modem for MAN)
1. Physical layer	RS-232 cable (LAN) category '5' twisted pair (LAN) V.92 (56kbps) modem.

Protocols

Definition

- Protocol is a set of rules that govern all aspect of data communication b/w computers on a N/w

- These rules include guidelines that regulate the following characteristics of a N/w

Elements of Protocol:-

1) Syntax

The structure or format of the data.

Example

A simple protocol,

Sender address	Receiver address	Data
8-bit	8-bit	

← 64 bits →

(ii) Semantics

Refers to the meaning of each section of bits.

(iii) Timing

Refers to two characteristics

(a) when data to be sent

(b) How fast it can be sent

Chary. of Protocol:-

a) Direct / Indirect

communication b/w two entities maybe direct or Indirect.

(i) point-to-point link

(ii) Multipoint link

(b) Structure

to be handled as a unit

(c) Symmetric / asymmetric

Refer previous notes

(d) Standard / non standard

Refer previous notes

Common Protocol used

Protocol	Rep.	Remarks
Point-to-Point	PPP	used to manage N/w Comm. over a Modem
Transmission control protocol	TCP/IP	Backbone Protocol. The most widely used Protocol
Internet Package Exchange	IPx	Standard Protocol
NetBIOS extended user Interface	NetBEUI	Running only window-based clients.
File transfer protocol	FTP	Used to send and received file.
Simple mail transfer protocol	SMTP	used to send Email over a N/w
Hyper text transfer protocol	HTTP	used Internet
Apple Talk	Apple Talk	Peer-to-peer N/w Protocol
OSI model	OSI Layers	Information busy. travels through '7' layers.

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Data Communication and Networking

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DATA COMMUNICATION :-

* Transmission of sequence of binary code is called data communication.

* Codes are created stored and processed by computer and their peripherals

* The link used for data communication are digital

* Five basic components of a data communication system are 1) the Message
 2) Sender
 3) Receiver
 4) Medium
 5) Protocol

* Data communication system must transmit data to the correct destination in an accurate and timely manner

* The effectiveness of data communication depends on the following aspects

- Delivery - System must be deliver data to the correct destination.

- Accuracy - System must deliver accurate data. Data have be altered in transmission and left uncorrected are unusable.

- Timeliness :- Deliver in a timely manner

* Data transmission requires :-
 - Encoding bits as energy
 - Transmitting energy through medium
 - Decoding energy back into bits

Note :- Energy can be electric current, radio, infrared, light.

DATA COMMUNICATION SYSTEM COMPONENTS :-

1) Message :-

* It is the information/data to be communicated.
* It may be
  - Text
  - Numbers
  - Pictures
  - Sound
  - Video
  - any combination

2) Sender :-

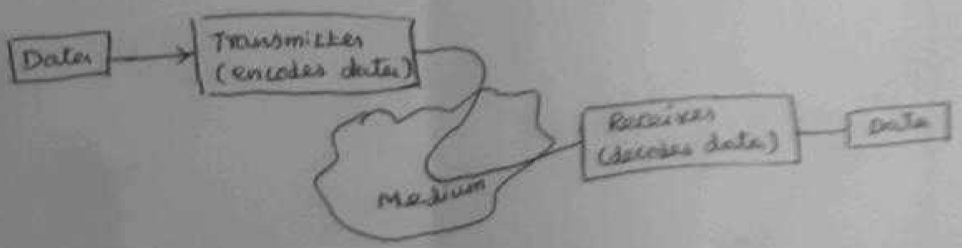
* Sends the message.
* It may be
  - Computer
  - Workstation
  - Telephone
  - Video camera
  - Any other standard communicating device.

3) Receiver :-

* Receives the message

3) Medium :-

* Transmission medium is the physical path that carries the signal.
* It may be
  - Twisted pair
  - Co-axial cable
  - Fiber optic cable
  - laser and radio wave
* Transmitter encodes data as energy and transmits energy through medium.
  - Requires special hardware for data encoding
  - Requires hardware connection to transmission medium.



* Media can be copper, glass, air...
* copper wire → Expensive, limited transmission speed
* Glass fiber:-
  - Higher speed
  - More resistant to electro-magnetic interference

Protocol

It is a set of rules that govern the data communication.

Data communication Link:-

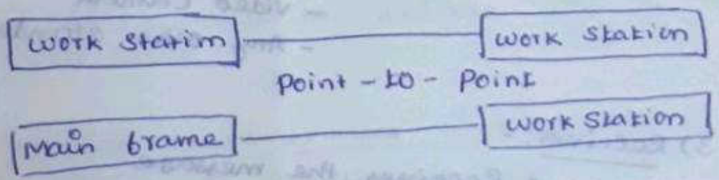
Link :- * It is the physical communication pathway that transports data from one device to another.

* The line configuration or the link may either a
  1) Point - to - Point
  2) Multi - Point

1) Point - to - Point :-

Point - to - Point connects just one sender and receiver together

Ex:- Remote control of TV



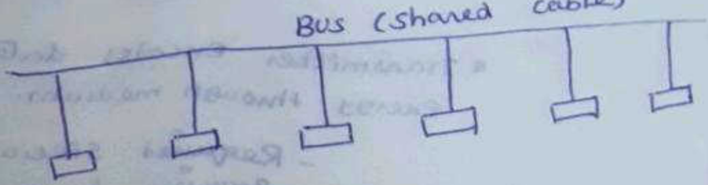
2) MultiPoint:- (also called shared circuit)

connects a number of senders and receivers together

the advantages:- of MultiPoint is that it is cheaper and simpler to wire.

Disadvantages:-

only one computer can use the circuit at a time.



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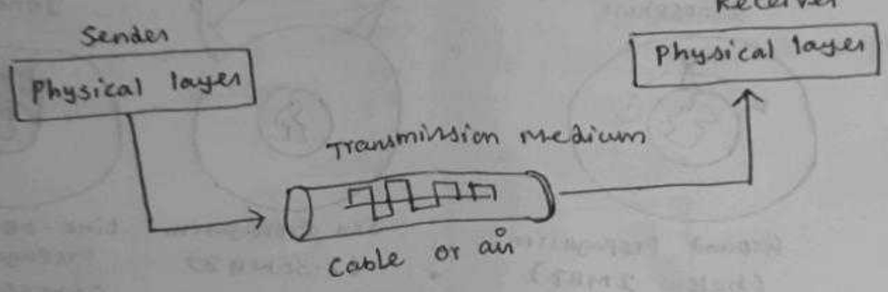
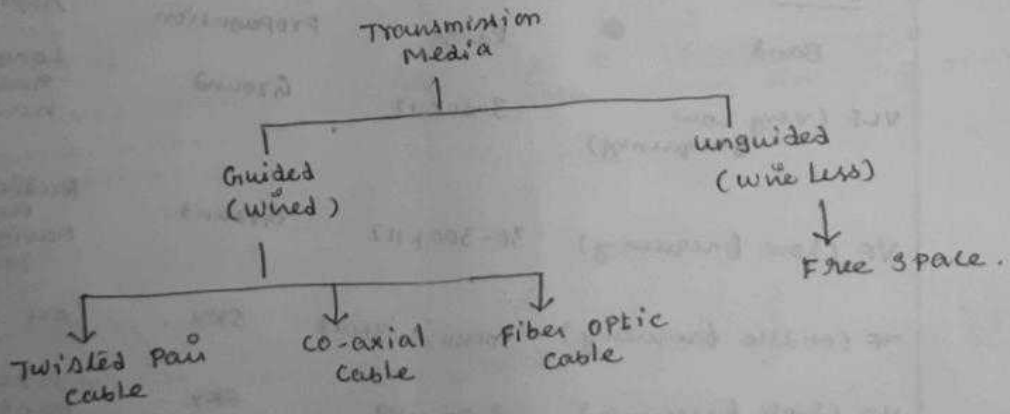
Transmission Media :-

Transmission medium and Physical layer :-



Classes of transmission Media :-



Guided Media :-

Guided media, which are those that provide a conduit from one device to another, include twisted pair cable, coaxial cable, and fiber-optic cable.

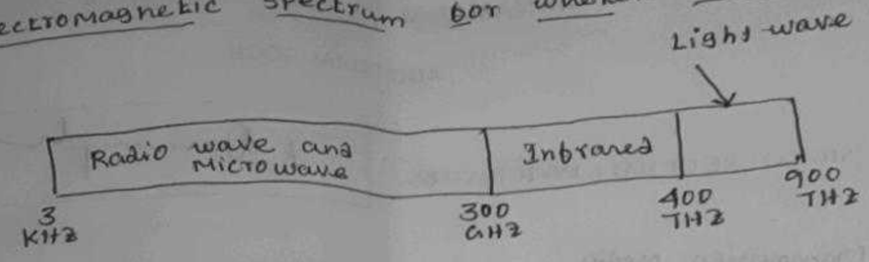
unguided Media :- wireless :-

unguided Media transport electromagnetic waves without using a physical conductor. This type of communication is often referred to as wireless communication.

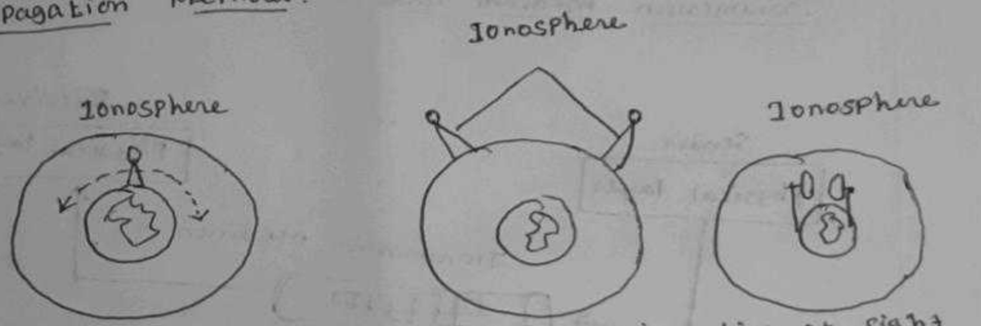
Topics discussed in this section:-

1) Radio waves.
2) Micro waves
3) Infrared.

Electromagnetic spectrum for wireless communication



Propagation Methods:-



Ground Propagation (below 2MHz)

Sky Propagation (2-30MHz)

Line-of-sight Propagation (above 30MHz)

Bands:-

Band	Range	Propagation	Application
VLF (very Low frequency)	3-30KHz	Ground	Long-range radio navigation
VF (Low frequency)	30-300KHz	Ground	Radio beacons and navigational locators
MF (Middle frequency)	300KHz-3MHz	Sky	AM radio
HF (high frequency)	3-30 MHz	Sky	Citizens band (CB), aircraft comm/.
VHF (Very high freq)	30-300MHz	Sky and line-of-sight	VHF TV, FM radio
UHF (ultrahigh freq)	300MHz-3GHz	Line-of sight	UHF TV Cellular Phone, Paging, satellite
SHF (superhigh freq)	3-30GHz	LOS	satellite comm/.
EHF (extremely high freq)	30-300GHz	LOS	Radar, satellite.

Scanned by Scanner Go

* Radio waves:- are used for Multicast communications. such as radio and television, and paging systems. They can penetrate through walls. Highly regulated. use omni directional antenna.

Omni directional Antenna.

Microwaves:-

Microwaves are used for unicast communication such as cellular telephones, satellite networks, and wireless LAN's. Higher frequency ranges cannot penetrate walls. use directional antennas - Point to Point line of sight comm.

a) Dish Antenna (b) Horn antenna

Infrared

Infrared signals can be used for short - range communication in a closed area using line - of sight propagation.

Note:-

Transmission Media
↓
(i) Transmission Medium and Physical layer.
(ii) classes of transmission Media

- Transmission Media
  - Guided (wired)
    - Twisted Pair cable
      - (1) Explaination
      - (2) Diagram
      - (3) UTP and STP Cables
      - (4) categories of unshielded twisted Pair cables.
      - (5) UTP connector
      - (6) UTP Performance
    - Co-axial cable
      - 1) Explaination
      - 2) Diagram
      - 3) categories of co-axial cables
      - 4) BNC connector
      - 5) Co-axial cable Performance.
    - Fiber-optic cable
      - (1) Fiber optic Bending of light ray
      - (2) optical fiber.
      - (3) propagation Modes → Mode
        - Multimode
          - Step index
          - Graded Index
        - single Mode
      - (4) Fiber types
      - (5) Fiber construction.
      - (6) Fiber optic cable connectors
      - (7) optical fiber Performance.
  - Unguided (wireless)
    - (i) Free space
      - Radio waves
      - Micro waves
      - Infrared.
    - (ii) Electromagnetic spectrum
    - (iii) Propagation Methods
      - (i) Ground propagation.
      - (ii) Sky propagation.
      - (iii) Space wave.
    - (iv) Bands
    - (v) wireless channel.

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Wireless transmission:-

* Communication frequencies :-
  - Frequency in the VHF - SHF range are used
  - Regulation bodies.

* Antenna :-
  - Theoretically :- equal radiation in all directions
  - Reality :- directive effects, sectorized antennas

* Signal Propagation:-
  - Classification :- Analog / Digital, periodic / Aperiodic
  - Parameters :- Amplitude, Frequency and phase shift.

* Modulation techniques :-
  - Amplitude, Frequency, phase.

* Multiplexing Mechanisms:-
  - Space (SDM), Frequency (FDM), Time (TDM), code (CDM)

Cellular concept:- / Cellular Telephone

* Limited number of frequency ⇒ limited channels
* Single high Power Antenna ⇒ limited number of -
* Smaller cells + frequency reuse possible ⇒ More number of users.
* Base station (BS) :- Implement Space division multiplex
  - Each BS covers a certain transmission area (cell)
  - Each BS is allocated a portion of the total number of channels available.
  - Cluster :- group of nearby BS that together use all available channels.
* Mobile Stations communicate only via the base station
  - FDMA, TDMA, CDMA may be used within a cell
* As demand increases (more channels are needed)
  - Number of base stations is increased.
  - Transmitter power is decreased correspondingly to avoid interference.

* Cell Size:- (100m) in cities to 35km

* Cell Shape:-
  + Hexagonal is usefull for theoretical

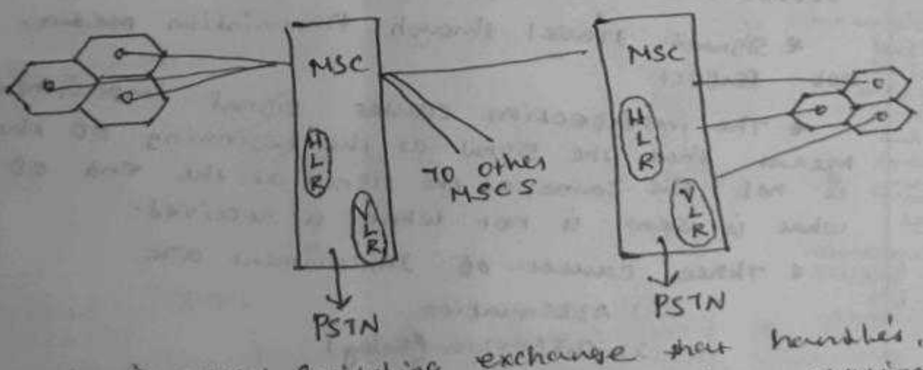
* BS Placement :-
  - Center
    - Omni - directional Antenna
  - Edge - excited cell
    - Sectored directional Antenna

* Advantages!-
  - higher capacity
  - higher number of users
  - ↓ transmission power.

* Problems!-
  * fixed network
  * hand over
  * Interference with other cell (co-channel, Adjacent channel)

* Important Issues!-
  - cell sizing
  - Frequency reuse planning
  - channel allocation strategies.

* Cellular system Architecture!-
  * Each cell is served by a base station (BS)
  * Each BS is connected to a (MSC) through fixed links
  * Each MSC is connected to other MSC and PSTN.



* Each MSC is a local switching exchange that handles.
  - switching of mobile user from one base station to another.
  - Locating the current cell of a mobile user.

    HLR → Permanent.
    VLR → visitor location register.

* Call Setup!-
  1) outgoing call setup:-
  2) Network activity
  3) Incoming call setup
  4) Network activity.

* Hand-off :-
  - BS initiated
  - Mobile assisted
  - Intersystem

* Cellular Implementations :-

* First-Generation :- Analog cellular system (450-900 MHz)
  - Frequency shift keying for signaling.
  - FDMA for spectrum sharing
  - NMT (Europe), AMPS (US)

* Second Generation :- Digital cellular system (900, 1800 MHz)
  - TDMA / CDMA for spectrum sharing.
  - Circuit switching
  - GSM (Europe), IS-136 (US), PDC (Japan)

* 2.5G :- Packet switching extensions :-
  - Digital :- GSM to GPRS
  - Analog :- AMPS to CDPD

* 3G :-
  - High speed, data and Internet services.
  - IMT-2000.

(10)

TRANSMISSION IMPAIRMENT :-

* Signals travel through transmission media, which are not perfect.
* The imperfection causes signal impairment. This means that the signal at the beginning of the medium is not the same as the signal at the end of the medium. What is sent is not what is received.
* Three causes of impairment are
  1) Attenuation.
  2) Distortion (Delay)
  3) Noise.

* With any communication system, the signal that is received may differ from the signal that is transmitted, due to various transmission impairment.
* Consequences
For, Analog → degradation of signal quality
For, Digital :- bit error.

Attenuation :-

* Means loss of energy → weaker signal
* When a signal travels through a medium it loses energy overcoming the resistance of the medium.
* Amplifiers are used to compensate for this loss of energy by amplifying the signal.

Measurement of Attenuation :-

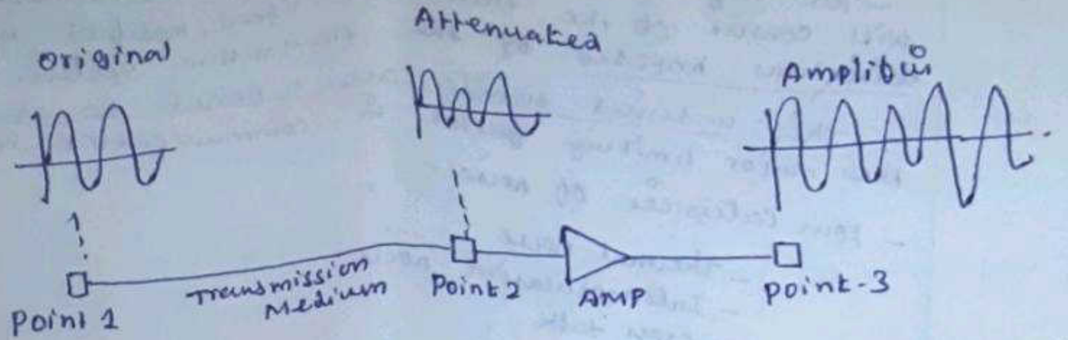
The loss or gain of energy the unit "Decibel" is used.

$$dB = 10 \log_{10} P_2/P_1$$

P_1 - input signal

P_2 - output signal

Attenuation:-



Let as consider:-

* signal travels through a transmission medium and its power is reduced to one half.

* That means $P_2 = \frac{1}{2} P_1$

* In this case the attenuation (loss of power) can be calculated as,

$$10 \log_{10} \frac{P_2}{P_1} = 10 \log_{10} \frac{0.5 P_1}{P_1} = 10 \log_{10} 0.5 = 10(-0.3) = -3dB$$

* A loss of 3dB (-3dB) is equivalent to losing one-half the power.

⇒ A signal travels through an amplifier, and its power is increased 10 times. This means that $P_2 = 10P_1$. In this case, the amplification (gain of power) can be calculated as

$$\Rightarrow 10 \log_{10} \frac{P_2}{P_1} = 10 \log \frac{10 P_1}{P_1}$$

$$\Rightarrow 10 \log_{10} 10 = 10(1) = 10dB$$

Distortion:- (Delay)

* Delay distortion occurs because the velocity of propagation of a signal through a guided medium varies with frequency.

* Signal will arrive at the receiver at different times, resulting in phase shifts between the different frequencies.

* Delay Distortion:-
  - one bit position will spill over into other bit positions
  - Intersymbol Interference.

Noise:-

- For any data transmission event, the received signal will consist of the transmitted signal, modified by the various distortions imposed by the transmission system.

- The undesired signals are refered to as noise, which is the major limiting factor in communication system performance.

- Four categories of noise:-
  - Thermal noise
  - Intermodulation noise
  - Cross talk
  - Impulse noise

① Thermal noise:-

* Due to thermal agitation of electrons
* It is present in all electronic devices and transmission medium, and is a function of temperature.

② Intermodulation noise

- when signals at different frequencies share the same transmission medium, the result may be Intermodulation noise

- Intermodulation like - sum of two frequency, multiple of two frequency.

③ Cross talk

- It is an unwanted coupling b/w signal paths. It can occure by electrical coupling b/w nearby twisted pairs.

- Cross talk is of the same order of magnitude as, or less than thermal noise.

④ Impulse noise:-

- irregular pulses or noise spikes of short duration and of relatively high amplitude.

- It is the primary source of error in digital data communication.

EIA - 232 Interface / V.24

(3) * There are two types of devices
(i) DTE - Data terminal equipment
(ii) DCE - Data circuit terminating equipment.

* EIA - 232 defines a set of signals for connecting DTE equipment to DCE equipment.

* Mechanical Specification:-
- It specifies the connector, assignment of Interchange circuit to pins, size and dimensions etc.
- 25 pin connector known as D-connector is used
- The length of the cable may not exceed 15 meters.

* Electrical specification:-
- It defines the voltage levels and type of signal to be transmitted in either direction b/w DTE & DCE
- NRZ-L encoding method

* Functional Specification:-
- EIA - 232 uses two type of connectors.
(i) DB-25 } Diagram Refer page No:- 43
(ii) DB-9 }

(3) RS-232 Voltage:-

* Binary data uses two voltage level (values)
Binary '0' = +3V to +25V
" '1' = -3V to -25V
* The transmitting device can send any value within the range of mark or space.
* The voltage b/w -3V to +3V is invalid for RS - 232
* -3V (or) above +3V, effects of noise are reduced.

(3) RS - 232 signals

* signals are divided into four functional groups.
They are data group
control group
timing group
secondary group.

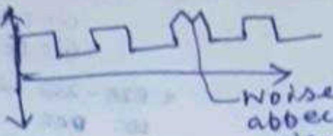
Tabulation Refer to page No:- 45

(3) RS - 423 Standard:-

* This standard is similar to RS - 232 standard with some few changes.
* RS - 423 standard used for unbalanced circuit. It allows multiple receiver, longer distance and faster data rate.
* RS - 423
- single ended
- uses common signal ground for all lines.
- It allows multiple receivers but only one transmitter is possible.
- The distance upto 4000 ft are possible with RS - 423 Interface.
- It allows data rate of 100 k bits / sec

- upto ten receivers can be connected to a single transmitter.
- It uses the voltage levels of +3.6V to 6V for binary '0'
  -3.6V to -6V for binary '1'

Fig Refers to page No:- 51

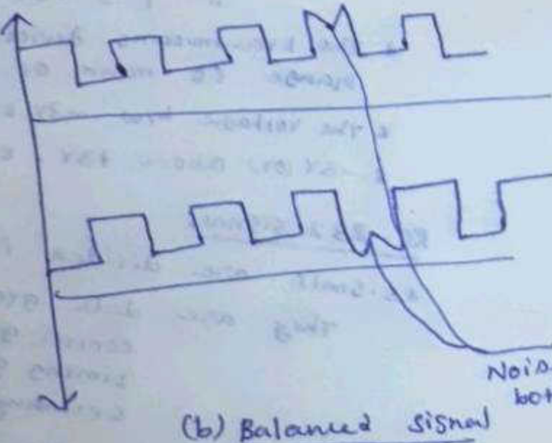


Unbalanced.

③ **RS-422 Standard:-**

* RS-422 specifies that a generator is to be able to produce a voltage b/w 2 and 6V for each logic level
* It uses +2V to +6V for binary '0'
  -2V to -6V for binary '1'
* It supports distance upto 4000 ft for data transfer.

* **RS-422a Standards**
  - 10 receivers and single transmitter.
  - There is no common ground
  - Noise is reduced and the quality of the signal is improved.
  - higher Data rate upto 10M bit's /sec are possible with RS-422 Interface.
  - It is also called balanced circuit.



(b) Balanced signal

(A) Network

Advantages:-

- Allow groups of users to exchange information and share data.
- Allow easy and efficient communication among individuals, including e-mail.
- Allow users to share peripherals such as printers, scanners, fax machines, and other devices.

LAN (Local Area Network)

It works within limited geographical area.
(i.e.) within one building or complex.

WAN (wide area N/w)

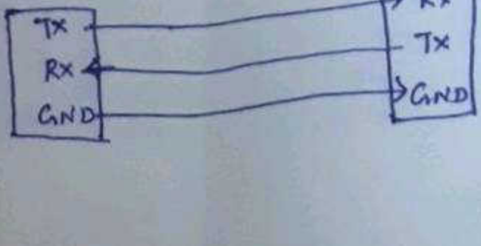
Span distances measured in miles.
(i.e.) two or more separate LANS linked together.

NIC (Network Interface card)

- Also known as a Network adapter.
- Integrated circuit board that plugs into the internal circuitry.
- Allow members of a local-area N/w to communicate with each other.
- NIC is the Physical Interface from the computer or peripheral to the medium.
- Most computers use parallel data line internally to send data b/w the CPU
- Most N/w media transmit data in a single line, called serial transmission.
- NIC
  Translate
  Parallel into serial for outgoing message
  Serial into parallel for incoming message.

□ Serial communication ports use the RS 232 standard:-

- DB9 or DB25 type connector.
- +/- 12volts
- serial means one bit at a time.
- uses
  - Networking computers
  - Modem
  - Mouse & printers.



Parallel Data Transmission:-

- 5 volt Logic
- Transmission of 1 Byte at a time or 8 bits
- Bi-directional capabilities.

MODEM:-

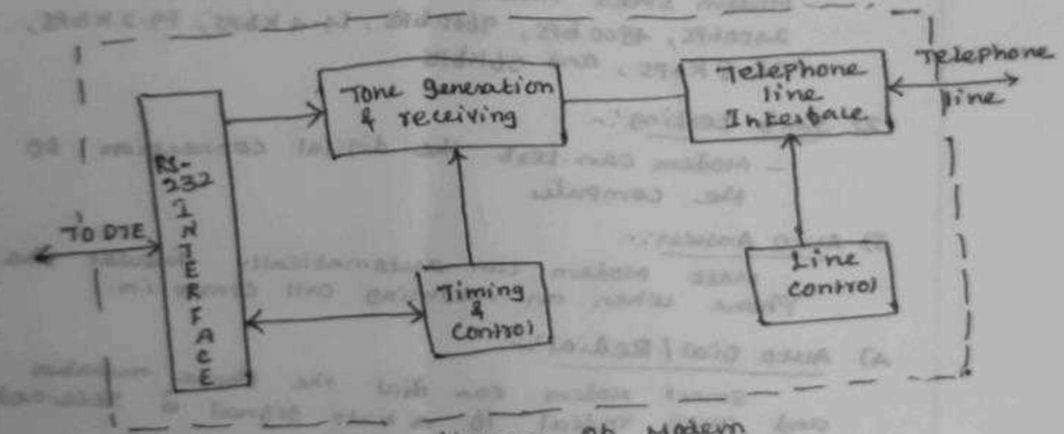
– Phone lines are designed for analog, voice signals. For data communication using phone line requires a special communication devices.

– Special communication device Modem is used with telephone line for data transfer.

– MODEM means Modulator - Demodulator.

– Modem uses the data signal modulator & Demodulator process takes place b/w telephone system.

– Any system, whether simplex, half duplex or full duplex at the transmitting end and the receiving end, requires a Modem.



Block diagram of Modem

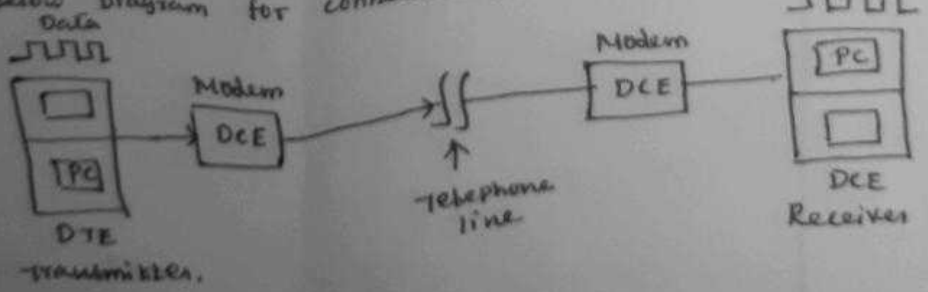
Function:-

1) At the transmitting end:-

* To takes data form the RS-232 Interface and converts this data into appropriate tones.

2) At the Receiving Modem:-

* Receive tones from the phone line. Demodulate these tones into 1s and 0s (ones and zeros)
* Below Diagram for connectivity of Modem.



* The concept is to use tones of various frequency, Phase or amplitude to represent the binary data.
* Since voice is made up of many tones combined. Different Modems use frequency modulation (FM), Phase Modulation (PM) and Amplitude Modulation (AM)
* Digital Modulation uses three types of Modulation where
  1) ASK
  2) PSK
  3) FSK

Operation of Modem:-

* consider a Modem which uses FSK
  It uses 1000HZ to send binary '0'
  It uses 2000 HZ to send binary '1'
* The signal transmitted very long distance attenuation occure.
* The receiving circuitry, first amplify the signal and reduced noise factor.
* The rate at which Modulation level is changed is called baud rate.

Features of Modem:-

1) Speed:-
   - Speed is Measured in bit per second.
   - Modem speed rate, 300 bPS, 600 bPS, 1200 bPS, 2400bPS, 4800 bPS, 9600 bPS, 14.4 KbPS, 19.2 KbPS, 28.8 KbPS, and 56KbPS.

2) Self testing:-
   - Modem can test the digital connection to the computer

3) Auto Answer:-
   Most Modem can automatically answer the Phone when an incoming call comes in.

4) Auto Dial / Redial:-
   Smart modem can dial the Phone number and auto redial if a busy signal is received.

4-12 DATA COMMUNICATIONS MODEMS

The most common type of data communications equipment (DEC) is the *data communications modem.* Alternate names include *datasets, dataphones,* or simply *modems.* The word *modem* is a contraction derived from the words *modulator* and *demodulator.*

In the 1960s, the business world recognized a rapidly increasing need to exchange digital information between computers, computer terminals, and other computer-controlled equipment separated by substantial distances. The only transmission facilities available at the time were analog voice-band telephone circuits. Telephone circuits were designed for transporting analog voice signals within a bandwidth of approximately 300 Hz to 3000 Hz. In addition, telephone circuits often included amplifiers and other analog devices that could not propagate digital signals. Therefore, voice-band data modems were designed to communicate with each other using analog signals that occupied the same bandwidth used for standard voice telephone communications. Data communications modems designed to operate over the limited bandwidth of the public telephone network are called *voice-band modems.*

Because digital information cannot be transported directly over analog transmission media (at least not in digital form), the primary purpose of a *data communications modem* is to interface computers, computer networks, and other digital terminal equipment to analog communications facilities. Modems are also used when computers are too far apart to be directly interconnected using standard computer cables. In the transmitter (modulator) section of a modem, digital signals are encoded onto an analog carrier. The digital signals modulate the carrier, producing digitally modulated analog signals that are capable of being transported through the analog communications media. Therefore, the output of a modem is an analog signal that is carrying digital information. In the receiver section of a modem, digitally modulated analog signals are demodulated. Demodulation is the reverse process of modulation. Therefore, modem receivers (demodulators) simply extract digital information from digitally modulated analog carriers.

The most common (and simplest) modems available are ones intended to be used to interface DTEs through a serial interface to standard voice-band telephone lines and provide reliable data transmission rates from 300 bps to 56 kbps. These types of modems are sometimes called *telephone-loop modems* or *POTS modems*, as they are connected to the telephone company through the same local loops that are used for voice telephone circuits. More sophisticated modems (sometimes called *broadband modems*) are also available that are capable of transporting data at much higher bit rates over wideband communications channels, such as those available with optical fiber, coaxial cable, microwave radio, and satellite communications systems. Broadband modems can operate using a different set of standards and protocols than telephone loop modems.

A modem is, in essence, a transparent repeater that converts electrical signals received in digital form to electrical signals in analog form and vice versa. A modem is transparent, as it does not interpret or change the information contained in the data. It is a repeater, as it is not a destination for data—it simply repeats or retransmits data. A modem is physically located between digital terminal equipment (DTE) and the analog communications channel. Modems work in pairs with one located at each end of a data communications circuit. The two modems do not need to be manufactured by the same company; however, they must use compatible modulation schemes, data encoding formats, and transmission rates.

Figure 4-27 shows how a typical modem is used to facilitate the transmission of digital data between DTEs over a POTS telephone circuit. At the transmit end, a modem receives discrete digital pulses (which are usually in binary form) from a DTE through a serial digital interface (such as the RS-232). The DCE converts the digital pulses to analog signals. In essence, a modem transmitter is a *digital-to-analog converter* (DAC). The analog signals are then outputted onto an analog communications channel where they are transported through the system to a distant receiver. The equalizers and bandpass filters shape and band-limit the signal. At the destination end of a data communications system, a modem receives analog signals from the communications channel and converts them to digital pulses. In essence, a modem receiver is an *analog-to-digital converter* (ADC). The demodulated digital pulses are then outputted onto a serial digital interface and transported to the DTE.

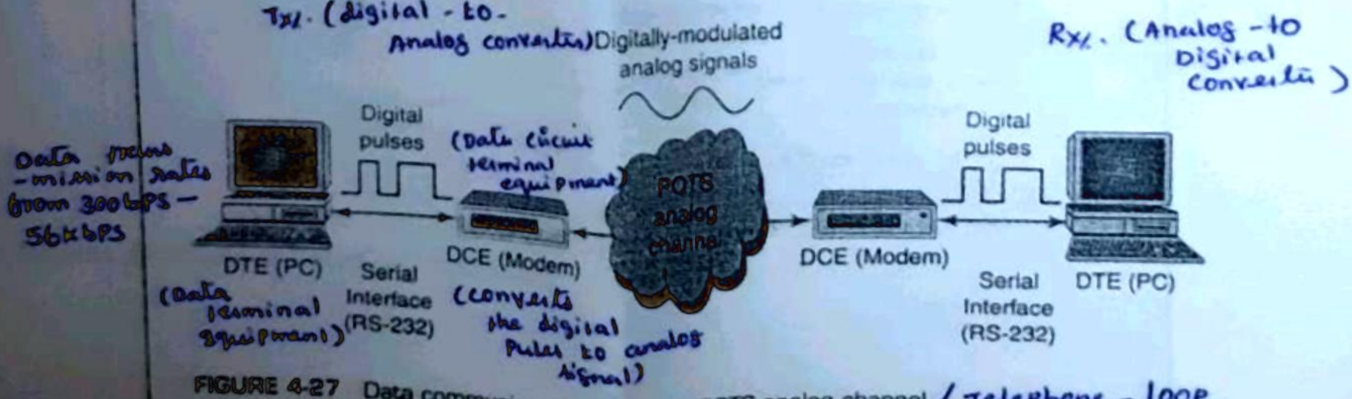


FIGURE 4-27 Data communications modems - POTS analog channel

4-12-1 Bits per Second versus Baud

The parameters *bits per second* (bps) and *baud* are often misunderstood and, consequently, misused. Baud, like bit rate, is a rate of change; however, baud refers to the rate of change of the signal on the transmission medium after encoding and modulation have occurred. Bit rate refers to the rate of change of a digital information signal, which is usually binary. Baud is the reciprocal of the time of one output *signaling element*, and a signaling element may represent several information bits. A signaling element is sometimes called a *symbol* and could be encoded as a change in the amplitude, frequency, or phase. For example, binary signals are generally encoded and transmitted one bit at a time in the form of discrete voltage levels representing logic 1s (highs) and logic 0s (lows). A baud is also transmitted one at a time; however, a baud may represent more than one information bit. Thus, the baud of a data communications system may be considerably less than the bit rate.

4-12-2 Bell System–Compatible Modems

At one time, Bell System modems were virtually the only modems in existence. This is because AT&T operating companies once owned 90% of the telephone companies in the United States, and the AT&T operating tariff allowed only equipment manufactured by Western Electric Company (WECO) and furnished by Bell System operating companies to be connected to AT&T telephone lines. However, in 1968, AT&T lost a landmark Supreme Court decision, the *Carterfone decision*, which allowed equipment manufactured by non-Bell companies to interconnect to the vast AT&T communications network, provided that the equipment met Bell System specifications. The Carterfone decision began the *interconnect industry*, which has led to competitive data communications offerings by a large number of independent companies.

The operating parameters for Bell System modems are the models from which the international standards specified by the ITU-T evolved. Bell System modem specifications apply only to modems that existed in 1968; therefore, their specifications pertain only to modems operating at data transmission rate of 9600 bps or less. Table 4-11 summarizes the parameters for Bell System–equivalent modems.

4-12-3 Modem Block Diagram

Figure 4-28 shows a simplified block diagram for a data communications modem. For simplicity, only the primary functional blocks of the transmitter and receiver are shown.

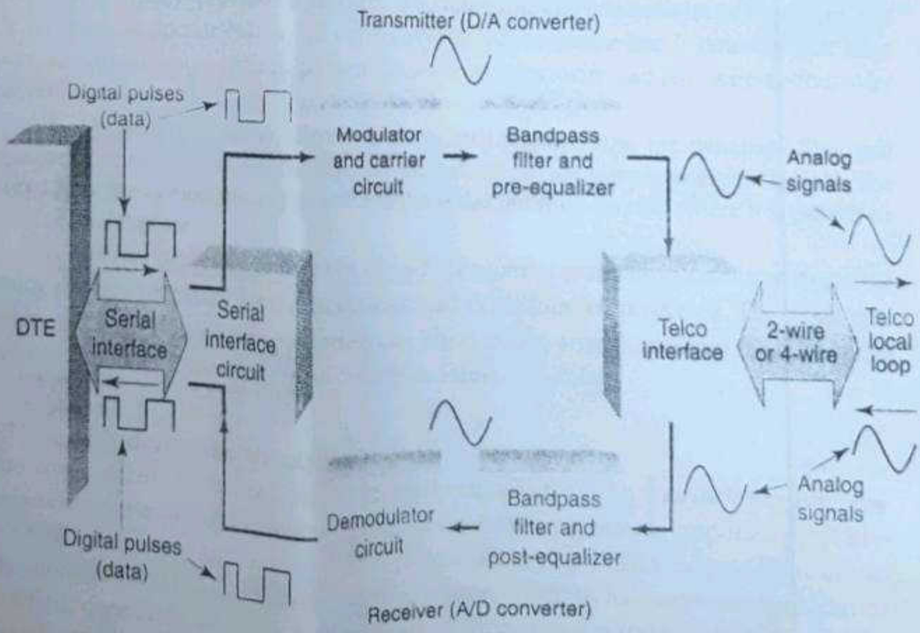


FIGURE 4-28 Simplified block diagram for an asynchronous FSK modem

The basic principle behind a modem transmitter is to convert information received from the DTE in the form of binary digits (bits) to digitally modulated analog signals. The reverse process is accomplished in the modem receiver.

The primary blocks of a modem are described here:

1. *Serial interface circuit.* Interfaces the modem transmitter and receiver to the serial interface. The transmit section accepts digital information from the serial interface, converts it to the appropriate voltage levels, and then directs the information to the modulator. The receive section receives digital information from the demodulator circuit, converts it to the appropriate voltage levels, and then directs the information to the serial interface. In addition, the serial interface circuit manages the flow of control, timing, and data information transferred between the DTE and the modem, which includes handshaking signals and clocking information.

2. *Modulator circuit.* Receives digital information from the serial interface circuit. The digital information modulates an analog carrier, producing a digitally modulated analog signal. In essence, the modulator converts digital changes in the information to analog changes in the carrier. The output from the modulator is directed to the transmit bandpass filter and equalizer circuit.

3. *Bandpass filter and equalizer circuit.* There are bandpass filter and equalizer circuits in both the transmitter and receiver sections of the modem. The transmit bandpass filter limits the bandwidth of the digitally modulated analog signals to a bandwidth appropriate for transmission over a standard telephone circuit. The receive bandpass filter limits the bandwidth of the signals allowed to reach the demodulator circuit, thus reducing noise and improving system performance. Equalizer circuits compensate for bandwidth and gain imperfections typically experienced on voiceband telephone lines.

4. *Telco interface circuit.* The primary functions of the telco interface circuit are to match the impedance of the modem to the impedance of the telephone line and regulate the amplitude of the transmit signal. The interface also provides electrical isolation and protection and serves as the demarcation (separation) point between subscriber equipment and telephone company–provided equipment. The telco line can be two-wire or four-wire, and the modem can operate half or full duplex. When the telephone line is two wire, the telco interface circuit would have to perform four-wire-to-two-wire and two-wire-to-four-wire conversions.

5. *Demodulator circuit.* Receives modulated signals from the bandpass filter and equalizer circuit and converts the digitally modulated analog signals to digital signals. The output from the demodulator is directed to the serial interface circuit, where it is passed on to the serial interface.

6. *Carrier and clock generation circuit.* The carrier generation circuit produces the analog carriers necessary for the modulation and demodulation processes. The clock generation circuit generates the appropriate clock and timing signals required for performing transmit and receive functions in an orderly and timely fashion.

4-12-4 Modem Classifications

Data communications modems can be generally classified as either *asynchronous* or *synchronous* and use one of the following digital modulation schemes: amplitude-shift keying (ASK), frequency-shift keying (FSK), phase-shift keying (PSK), or quadrature amplitude modulation (QAM). However, there are several additional ways modems can be classified, depending on which features or capabilities you are trying to distinguish. For example, modems can be categorized as internal or external; low speed, medium speed, high speed, or very high speed; wide band or voice band; and personal or commercial. Regardless of how modems are classified, they all share a common goal, namely, to convert digital pulses to analog signals in the transmitter and analog signals to digital pulses in the receiver.

Some of the common features of data communications modems are listed here:

1. Automatic dialing, answering, and redialing
2. Error control (detection and correction)
3. Caller ID recognition
4. Self-test capabilities, including analog and digital loopback tests
5. Fax capabilities (transmit and receive)
6. Data compression and expansion
7. Telephone directory (telephone number storage)
8. Adaptive transmit and receive data transmission rates (300 bps to 56 kbps)
9. Automatic equalization
10. Synchronous or asynchronous operation

4-12-5 Asynchronous Voice-Band Modems

Asynchronous modems can be generally classified as low-speed voice-band modems, as they are typically used to transport asynchronous data (i.e., data framed with start and stop bits). Synchronous data are sometimes used with an asynchronous modem; however, it is not particularly practical or economical. Synchronous data transported by asynchronous modems is called *isochronous transmission*. Asynchronous modems use relatively simple modulation schemes, such as ASK or FSK, and are restricted to relatively low-speed applications (generally less than 2400 bps), such as telemetry and caller ID.

There are several standard asynchronous modems designed for low-speed data applications using the switched public telephone network. To operate full duplex with a two-wire dial-up circuit, it is necessary to divide the usable bandwidth of a voice-band circuit in half, creating two equal-capacity data channels. A popular modem that does this is the Bell System 103–compatible modem.

4-12-5-1 Bell system 103–compatible modem. The 103 modem is capable of full-duplex operation over a two-wire telephone line at bit rates up to 300 bps. With the 103 modem, there are two data channels, each with their own mark and space frequencies. One data channel is called the *low-band channel* and occupies a bandwidth from 300 Hz to 1650 Hz (i.e., the lower half of the usable voice band). A second data channel, called the *high-band channel*, occupies a bandwidth from 1650 Hz to 3000 Hz (i.e., the upper half of the usable voice band). The mark and space frequencies for the low-band channel are 1270 Hz and 1070 Hz, respectively. The mark and space frequencies for the high-band channel are 2225 Hz and 2025 Hz, respectively. Separating the usable bandwidth into two narrower bands is called *frequency-division multiplexing* (FDM). FDM allows full-duplex (FDX) transmission over a two-wire circuit, as signals can propagate in both directions at the same time without interfering with each other because the frequencies for the two directions of propagation are different. FDM allows full-duplex operation over a two-wire telephone circuit. Because FDM reduces the effective bandwidth in each direction, it also reduces the maximum data transmission rates. A 103 modem operates at 300 baud and is capable of simultaneous transmission and reception of 300 bps.

4-12-5-2 Bell system 202T/S modem. The 202T and 202S modem are identical except the 202T modem specifies four-wire, full-duplex operation, and the 202S modem specifies two-wire, half-duplex operation. Therefore, the 202T is utilized on four-wire private-line data circuits, and the 202S modem is designed for the two-wire switched public telephone network. Probably the most common application of the 202 modem today is caller ID, which is a simplex system with the transmitter in the telephone office and the receiver at the subscriber's location. The 202 modem is an asynchronous 1200-baud transceiver utilizing FSK with a transmission bit rate of 1200 bps over a standard voice-grade telephone line.

4-12-6 Synchronous Voice-Band Modems

Synchronous modems use PSK or quadrature amplitude modulation (QAM) to transport synchronous data (i.e., data preceded by unique SYN characters) at transmission rates between 2400 bps and 56,000 bps over standard voice-grade telephone lines. The modulated carrier is transmitted to the distant modem, where a coherent carrier is recovered and used to demodulate the data. The transmit clock is recovered from the data and used to clock the received data into the DTE. Because of the addition of clock and carrier recovery circuits, synchronous modems are more complicated and, thus, more expensive than asynchronous modems.

PSK is commonly used in medium speed synchronous voice-band modems, typically operating between 2400 bps and 4800 bps. More specifically, QPSK is generally used with 2400-bps modems and 8-PSK with 4800-bps modems. QPSK has a bandwidth efficiency of 2 bps/Hz; therefore, the baud rate and minimum bandwidth for a 2400-bps synchronous modem are 1200 baud and 1200 Hz, respectively. The standard 2400-bps synchronous modem is the Bell System 201C or equivalent. The 201C modem uses a 1600-Hz carrier frequency and has an output spectrum that extends from approximately 1000 Hz to 2200 Hz. Because 8-PSK has a bandwidth efficiency of 3 bps/Hz, the baud rate and minimum bandwidth for 4800-bps synchronous modems are 1600 baud and 1600 Hz, respectively. The standard 4800-bps synchronous modem is the Bell System 208A. The 208A modem also uses a 1600-Hz carrier frequency but has an output spectrum that extends from approximately 800 Hz to 2400 Hz. Both the 201C and the 208A are full-duplex modems designed to be used with four-wire private-line circuits. The 201C and 208A modems can operate over two-wire dial-up circuits but only in the simplex mode. There are also half-duplex two-wire versions of both modems: the 201B and 208B.

High-speed synchronous voice-band modems operate at 9600 bps and use 16-QAM modulation. 16-QAM has a bandwidth efficiency of 4 bps/Hz; therefore, the baud and minimum bandwidth for 9600-bps synchronous modems is 2400 baud and 2400 Hz, respectively. The standard 9600-bps modem is the Bell System 209A or equivalent. The 209A uses a 1650-Hz carrier frequency and has an output spectrum that extends from approximately 450 Hz to 2850 Hz. The Bell System 209A is a four-wire synchronous voice-band modem designed to be used on full-duplex private-line circuits. The 209B is the two-wire version designed for half-duplex operation on dial-up circuits.

Table 4-13 summarizes the Bell System voice-band modem specifications. The modems listed in the table are all relatively low speed by modern standards. Today, the Bell System–compatible modems are used primarily on relatively simple telemetry circuits, such as remote alarm systems and on metropolitan and wide-area private-line data networks, such as those used by department stores to keep track of sales and inventory. The more advanced, higher-speed data modems are described in a later section of this chapter.

4-12-7 Modem Synchronization

During the request-to-send/clear-to-send (RTS/CTS) delay, a transmit modem outputs a special, internally generated bit pattern called a *training sequence*. This bit pattern is used to synchronize (train) the receive modem at the distant end of the communications channel. Depending on the type of modulation, transmission bit rate, and modem complexity, the training sequence accomplishes one or more of the following functions:

1. Initializes the communications channel, which includes disabling echo and establishing the gain of automatic gain control (AGC) devices
2. Verifies continuity (activates RLSD in the receive modem)
3. Initialize descrambler circuits in receive modem
4. Initialize automatic equalizers in receive modem
5. Synchronize the receive modem's carrier to the transmit modem's carrier
6. Synchronize the receive modem's clock to the transmit modem's clock

(4) Digital Data Transmission:- (Base band)

* Pulses representing binary digits can modulated a carrier frequency for efficient transmission through a limited Bw link.
* These are useful in many applications involving the use of high Bw cables such as in ISDN connections over twisted pair
* PCM voice (or) data at 1.544 MbPS and higher rate in special cable.
* The key issues here are:-
  1. synchronization.
  2. Line coding.

Advantages of Digital Transmission:-

- Produces fewer errors
- permits higher transmission rates
- More efficient.
- more secure.
- Integrating voice, video and data on the same circuit is also far simplex with digital transmission.

Synchronous Vs Asynchronous Communication:-

Synchronous	Asynchronous
* Common clock pulse is used for both Tx and Rx	separate clock pulse is used for Tx and Rx
* Initially synchronous pulse is transmitted then data is transmitted in block	Each character have special start and stop bit
* continuous data transmission	Discreate type data transmission
* speed	speed
* Transmission rates 2400, 4800, 9600 bits/sec	Transmission rates 75, 110, 300 and 1200 bits/sec
* Suitable for file transmission	used for transmitting character keyboard to up
* costly	Less cost

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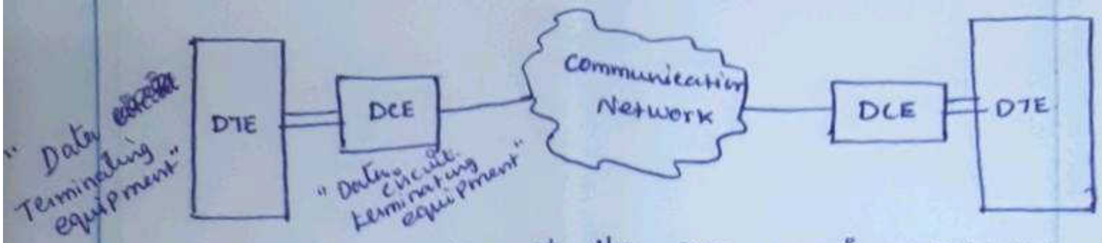
ADDITIONAL BOOK

2

SIGNATURE OF HALL INVICILATOR

(2) DTE - DCE INTERFACE :-

* DCE Means data circuit terminating equipment, ie (Modem)
* DTE means data terminal equipment (ie) computer



* The computing system of the DTE contains software needed to establish and control the communication link b/w the primary and secondary station. (protocol)
* An application program used by the DTE called a protocol.
* DCE includes any functional unit that transmit or receive data in the form of Analog / Digital signal through a N/W
* DCE is responsible for transmitting and receiving bits,
* This interface define mechanical, electrical, functional and procedural chey..

1) Mechanical chy. → actual physical connection of the DTE to the DCE

2) Electrical chy. → Voltage level and timing of voltage change.

3) Functional chy. → Functions are data, control, timing, electrical ground. etc...

4) Procedural chy. → Sequence of events for transmitting data, based on the functional chy.