26.08.22

Unit: 1

Radar and Navigational Aids:

Radar - Radio detection and Ranging.

Uses: For detecting and getting distance of things.

Newton's III law,

Eg: Bat

Radar concepts:

Targets : airplanes, missiles, ship & automobiles.

In radar system, a signal is transmitted towards the target. The reflected signal is picked by the receiver. The reflected radio signal is called echo.

The radar unit then determine distance to the target.

Ability of radar to determine distance depends on exact speed of radio signal transmission. Must travel twice.

~~In~~ to obtain strong echo, wavelength of radar signal should be small compared to size of object being observed.

Doppler effect: car ——— high ——— low

Radar system - Fundamentals:

Tr / Rr > connected to directional antenna. (one antenna is used)

Two types: Pulsed Radar system ⇒ short duration of electromagnetic pulse for Tr & Rr

Continuous wave (CW) Radar system

unmodulated CW sinusoidal signal for Tr

(two antennas)

* Unit: 5 Qn Interprocess

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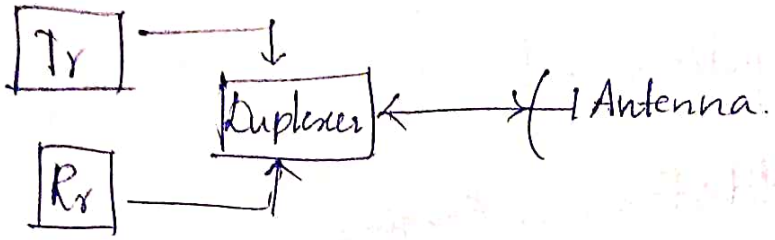
Principle:



Radar system: Tr, Rr, Duplexer, highly directional antenna.

Duplexer: 2 switches => TR - operates during Transmission
ATR - " " Reception.

Cycle: trigger signal is generated in ~~Tr~~ duplexer.
After getting this, it produce short duration rectangular pulse.

As soon as, a small fraction of pulse power is fed to duplexer, this ~~power~~ disconnects receiver from antenna and connects transmitter to it.

TR switch is ON,
ATR switch is OFF
O/P is fed into space.

The transmitted signals strike the target and echo signals are produced. Single antenna used for both Tr and Rr.

When echo reaches antenna, it disconnects Tr from Antenna.

↓

duplexer connects Receiver to Antenna.

ATR - ON
TR - off

The received pulses are amplified and demodulated by the receiver.

Applications: defence
Search Radar
Altimeters

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Radar Range equation: (Area of sphere = $4\pi r^2$)

to determine max. range.

Isotropic antenna → having same radiation in all directions.
(Also known as omnidirectional antenna.)

Directional antenna → Radiates in specific direction.

Transmitted pulse signal's power P_t,

Antenna isotropic,

Power density, $\rho = \frac{P_t}{4\pi r^2}$ → (1)

Directional antenna,

$P = \frac{A_p P_t}{4\pi r^2}$ → (2) A_p - max. Power gain.

Area ⇒ S ⇒ $P = \rho = \frac{A_p P_t S}{4\pi r^2}$ → (3)

Omnidirectional $\rho' = \frac{P}{4\pi r^2} = \frac{A_p P_t S}{(4\pi r^2)^2}$ → (4)

Receiving antenna's capture (A_0), $P' = \rho' A_0 = \frac{A_p P_t S A_0}{(4\pi r^2)^2}$ → (5)

Both Tr and Reception use same antenna,

$A_p = \frac{4\pi A_0}{\lambda^2}$ → (6) ⇒ $A_0 = \frac{A_p \lambda^2}{4\pi}$ → (*)

Sub (6) in (5),

$P' = \frac{4\pi A_0}{\lambda^2} \times \frac{P_t S A_0}{16\pi^2 r^4} = \frac{P_t S A_0^2}{4\pi r^4 \lambda^2}$ → (7)

$r_{max} = \left(\frac{P_t S A_0^2}{4\pi \lambda^2 P_{min}}\right)^{1/4}$ → (8) $r_{max} = \left[\frac{P_t A_p^2 \lambda^2 S}{(4\pi)^3 P_{min}}\right]^{1/4}$ → (9)

Sub (*) in (8).

Factors influencing max. Range:

$$r_{max} = \left[\frac{P_t A_p^2 \lambda^2 S}{(4\pi)^3 P_{min}}\right]^{1/4}$$

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i) max. range $\propto$ 1/4 of P_t

ii) Range ↑ Ap↑ capture Area.

iii) Area ↑ Range ↑

Pulsed Radar system:

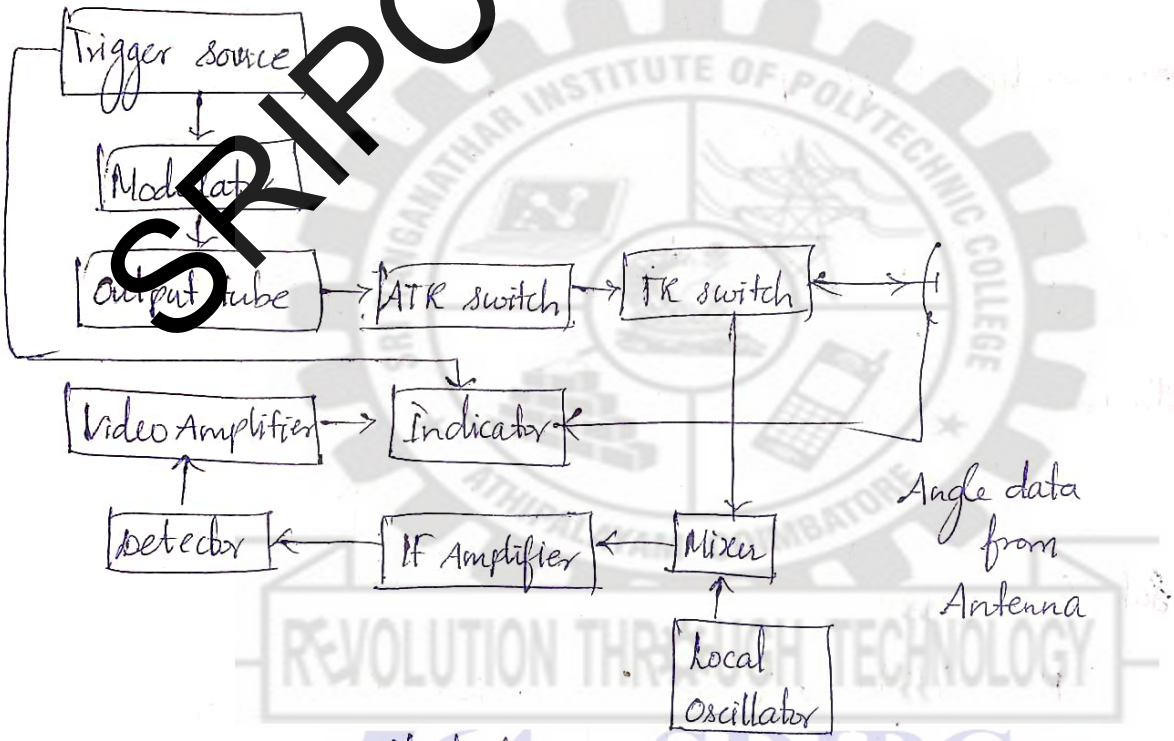
Information is sent in form of pulses.

Types:

Search Radar – For locating target

Tracking Radar – For finding range of target from radar To.

Basic pulsed radar system:



Block diagram

Trigger source:

Simple electronic circuit, Provide train of trigger pulses for actuating pulse modulator.

Pulse Modulator:

Provides rectangular voltage pulses.

Used as supply voltage for output tube

Like can on and off the output tube.

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Output tube: (communication channel)

For amplification. Carries signal from modulator to Duplexer.

Duplexer: TR, ATR switch.

Antenna: Tr, Rr

Mixer: 1st stage.

By mixing the received pulse with local oscillator signal, mixer reduces the pulse frequency by 30/60 MHz.

Lo:

Generates signal of high frequency than received pulses.

O/p is given to mixer.

IF Amp:

Amplifies the o/p of mixer.

Detector:

Detects signal pulses from the given o/p.

Video Amp:

Magnifies the received signal to required level.

Indicator:

Display device. PPI A-scope display.

Operation:

Tr may be Magnetron or Klystron → provides information in the form of pulses

Display methods: CRT Screen

Direct feeding to computer

Intensity Modulation.

- A-scope display
- PPI display ©

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Aircraft Landing System:

Ground Controlled Approach (GCA)

Instrument Landing System (ILS)

(a)

✓ Instrument Landing System (ILS):

Runaway localizer → to find correct direction.

Glide-path Equipment

Marker Beacon

⇓

GCA ⇒ (a)

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Telephony:

Telephone systems ⇒ Tele - far
Phone - sound.

Telephony ⇒ Conversion of sound signals into audio frequency analog electrical signal.

Then it is transmitted through wire and reconverted to original sound signal at receiver end.

Two modes: One way Communication system (Simplex)
Two way communication system (duplex)

Simplex: Only one way direction transmission

Transmitter on, Receiver off.

Duplex: two directions at same time.

Pair of wires used.

Telephone system Requirements: Transmit voice signals in both direction.

Each terminals send signal towards another terminal.

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Telephone circuits:

operate on duplex.

Telephone subscriber loop:

* pair of wires b/w subscriber location and telephone switching center.
* Telephone terminal set.
* A subscriber line interface circuit at switching location. Connects line.

Public Switched Telephone network: (PSTN) @

To provide two way voice communication b/w pair of subscribers.

Consists of telephone lines, fiber optic cables, microwave tr lines, comm. satellites and undersea Telephone cables. All are interconnected by switching centers.

PSTN is a dial-up Telephone network. Interconnection of switching centers and connection to subscribers.

Circuit switching ⇒ connection b/w two phones. Types: local
Regional
International

In earlier days, copper wires are used.

2000

1960, phone calls are made as digitized. Convert of manual switching to automatic switching.

10-digit Phone No. — — — — — — — — — —

↑ Exchange (switch)

↳ subscriber's number.

Area code/national destination code.

International Phone call,

(00, 011) country codes.

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Electronic Switching system: (4)

ISDN (4)

Video phones (4)

Communication takes place through one:

* Coaxial cable
* Microwave space communication
* Satellite Communication

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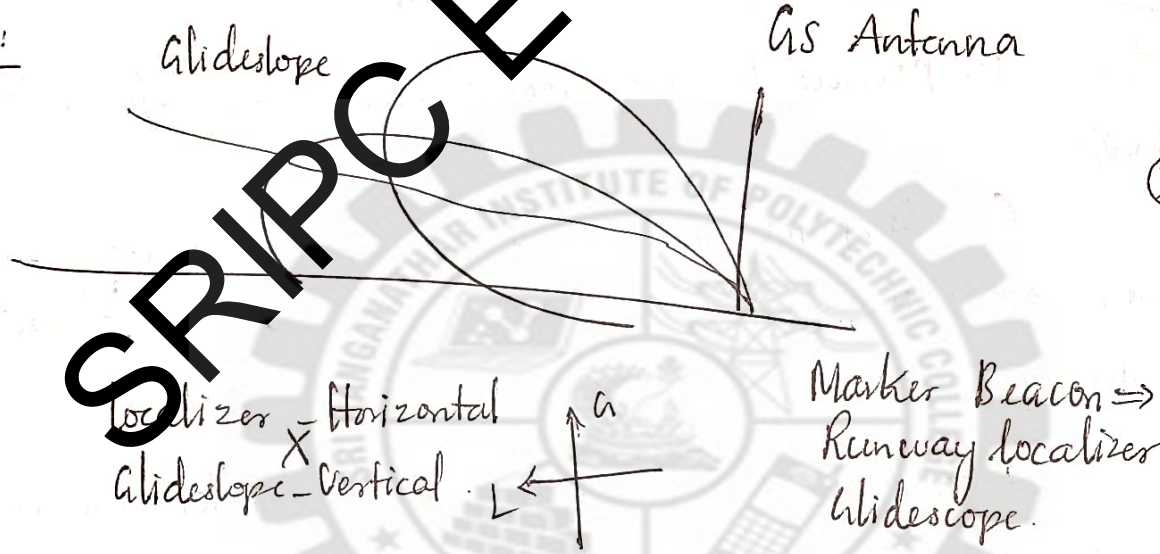
ILS:



GCA: 2 Radars.

1 radar - for short distance ⇒ ~~for glidepath~~

2nd radar - " (Actual)

Second radar = two displays.

1 ⇒ elevation as vertical displacement, range → this d. (for glidepath)

2 ⇒ azimuth on PPI Indicator.

⇓

(for direction approach

Adv

no Eqp required.

ord. radio receiver is enough.

D. Adv

human limits.

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Unit: 1 Notes.

Telephony:

Telephony involves the conversion of sound signals into an audio Frequency analog electrical signal. Then it can be transmitted over an electric transmission system and then reconverted to original sound signal at receiver end.

Types: *. One way communication system (Simplex system)

*. Two way communication system (Duplex system)

Public Switched Telephone Network (PSTN):

*. The basic purpose of the Public Telephone System is to provide two way voice communication between any pair of subscribers within the system.

*. The Public Switched Telephone Network (PSTN) is the network of the world's public circuit switched Telephone networks. It consists of Telephone lines, fiber optic cables, microwave transmission links, cellular networks, communication satellite and undersea Telephone cables.

*. All are interconnected by switching centers. This allows any telephone in the world communicate with any other.

*. PSTN is a public available dial-up telephone network. It is an interconnection of switching centers and connection to subscribers

*. The PSTN relies on circuit switching to connect one phone to another, the phone call is routed through numerous switching operating on a local, regional and international level. The connection between two phones is called circuit.

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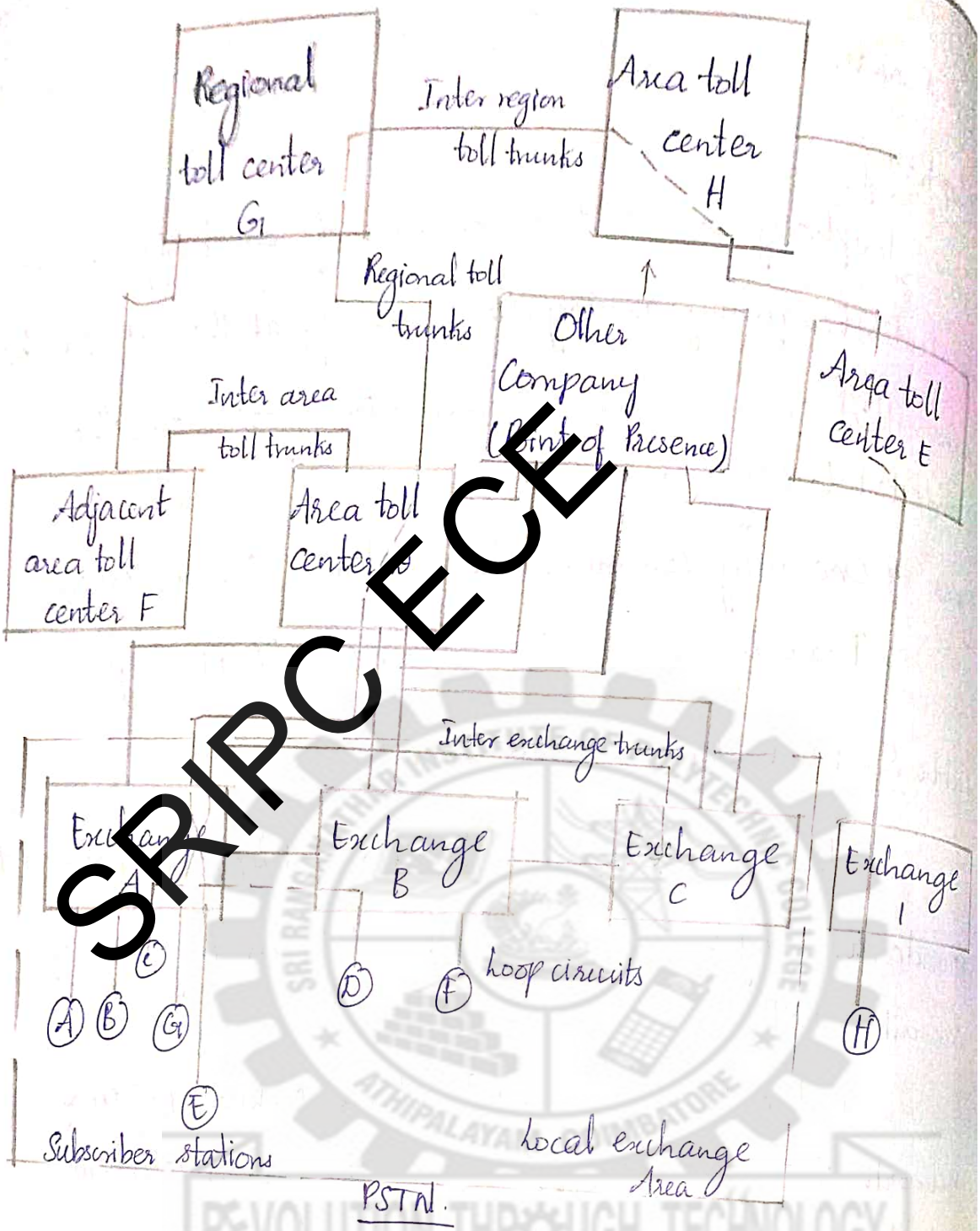

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Calls between each pair of exchanges within the systems are assigned first, second and third choice routes. The switching machine automatically attempts to select before indicating a 'trunk busy condition'.

Toll calls within a region may be made on first choice over direct trunks and on second choice through one or more immediate toll offices or third choice through regional toll office

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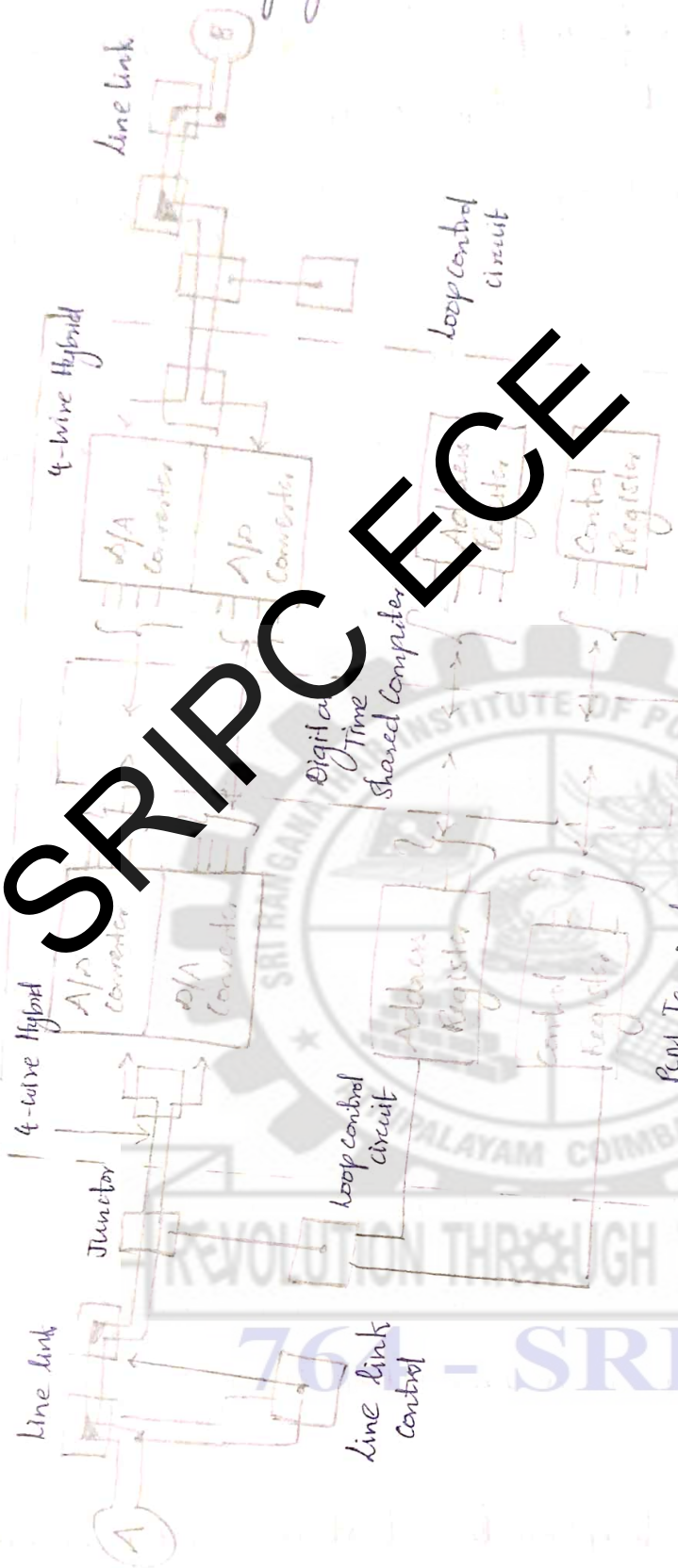
Electronic switching system



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In this system, each subscriber loop and interoffice trunk circuits terminate on an electronic point switch which performs the same function as the line link in a cross bar system.

The switch points are provided by using transistors or thyristors.

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To make a call, loop A energies the link control circuit, which searches for a free computer terminal circuit and closes the link points to connect it to it.

A junctor circuit separates the control signals and supplies the loop currents.

The loop control circuit receives the dialled or pulsed number.

The proper command number is entered into the control register to tell the computer to complete the connection.

Once the terminal circuit has been engaged, the computer periodically samples the address and control registers.

When the command is picked up, it acts to find a second free terminal in the group which can access the destination loop.

The control and address numbers are entered into second unit registers. The loop control circuit picks up the free link circuit to connect the called loop.

Integrated Service Digital Network (ISDN):

It is a new communication standard for providing an end to end connectivity over a digital link. It is a circuit switched digital network.

Conventional telephone lines that are used to carry ISDN data are called ISDN lines.

It provides efficient and cost effective solution to connect office LANs with high bandwidth digital services.

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Features of ISDN:

* Connecting remote users to a LAN.
* It provides a data rate of 3 Mbps on a local link and 64kbps / 128Kbps over a wide area link.
* High speed internet access.
* Video Conferencing.
* Local, national and international Telephones.
* High Flexibility.

Architecture:

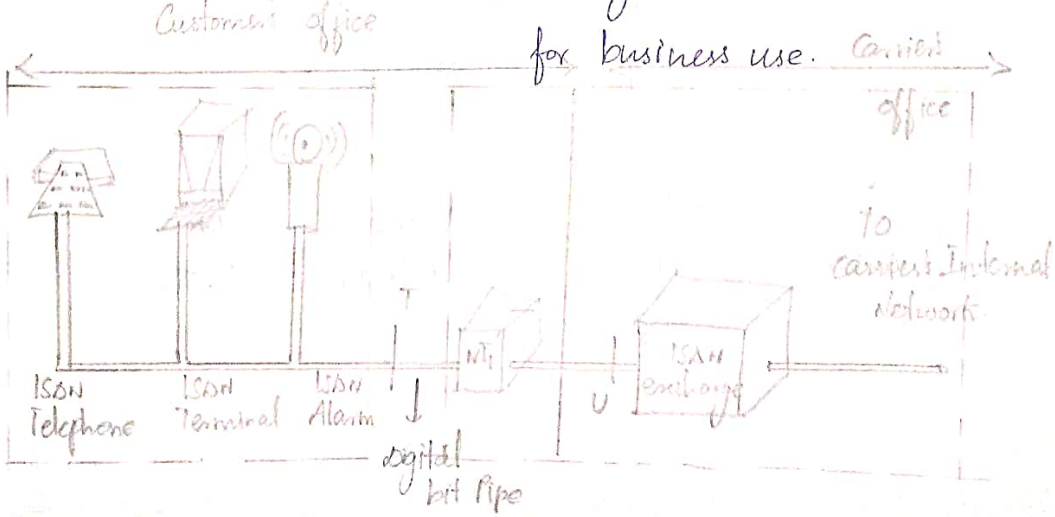
It consists of customer's equipment and the interface between the customer and telephone company.

Basic idea is digital pipe. It is a conceptual pipe between the customer and carrier through which bits flow. The bits can flow in both direction.

The digital bit pipe can support multiple independent channels by time division multiplexing.

Principal standards of bit Pipe: i) A low bandwidth standard for home use.

ii) A higher bandwidth standard for business use.



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Twisted pair is used for the connection. The NT1 Box has connector on it, into which a passive bus cable can be inserted.

Upto 8 ISDN telephones, terminals, alarms and other devices can be connected to cable.

NT2 called Private Branch exchange is connected to NT1 providing interface for Telephones and terminals.

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Video Phones:

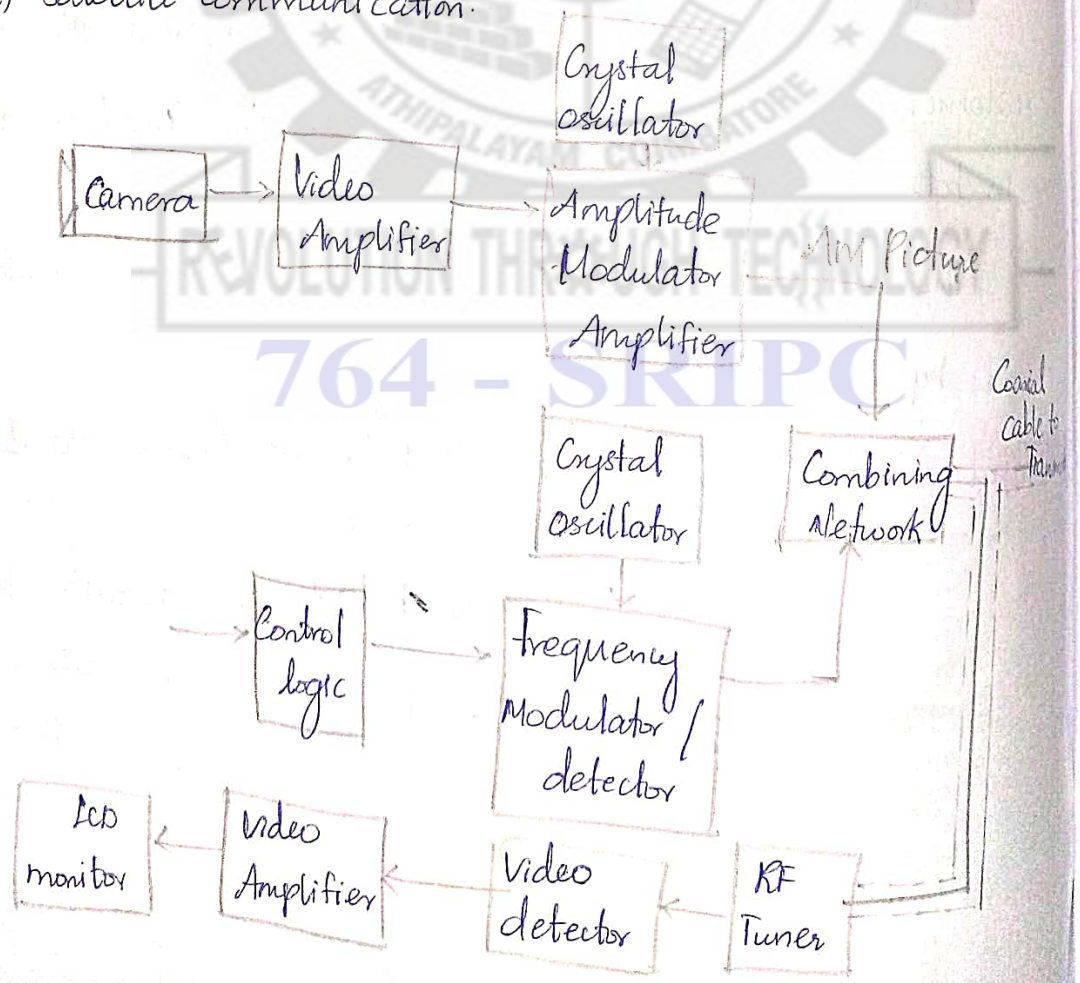
Video phone are operated in the principle of television transmission and reception.

Communication takes place through one of the means.

i) Coaxial cable links.

ii) Microwave space communication.

iii) Satellite Communication.



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The video signal from camera is amplified and applied to modulator amplifier, where the video signal is amplitude modulated. The modulated tone is then transmitted.

When the user dials the number of outgoing calls, the dial pulses produce tones and the call is processed through switching telephone networks.

Transmitter is switched on and acknowledgement is sent. The video-voice combining network at both ends is switched on and amplitude modulated picture is combined with frequency modulated voice and transmitted.

Thus audio-cum video path is established.

Uses:

In Industries.
Research centres.
Big Organisations.

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UNIT: II

DIGITAL COMMUNICATION.

Digital Comm.

Digital _ discrete

Analog - Continuous signal.

Uses:

computer - computer communication

data storing.

Programming

data collection.

DC => Two types. On line System -> data given/taken directly from/to Computer.

Off line system.

data is transmitted to or from card, paper tape, disc.

On-line system => Real time

non-real time.

Simplex - only one direction.

Semi-duplex - both direction (not at same time)

Full duplex - both direction at same time

Basic Elements: digital waveform => function of time, have only discrete set of values.

Digital waveform => 0's and 1's.

Analog waveform - func of time, have continuous range of values.

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UNIT - II

DIGITAL COMMUNICATION

Digital Communication.

It utilizes digital signals appearing in discrete steps. In this system, output of the data source is transmitted from one point to another.

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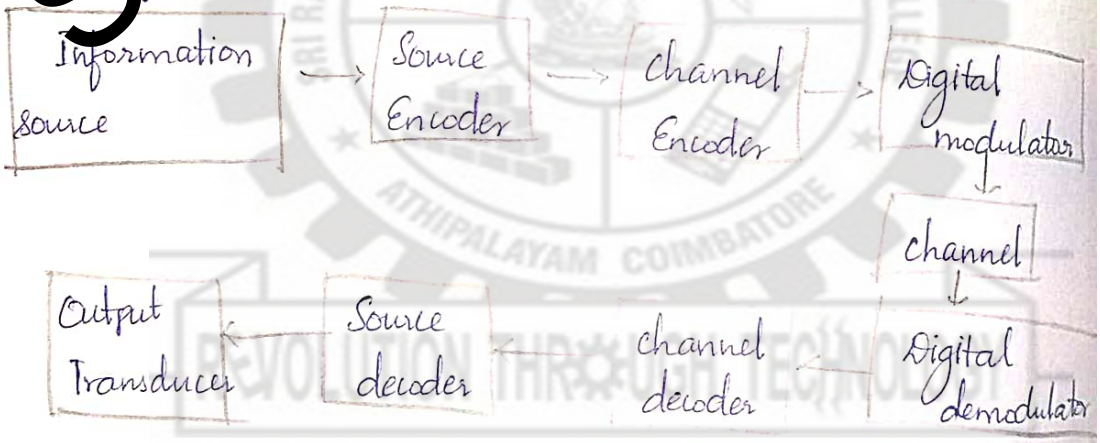
Uses:

*. Computer to computer communication.
*. Programming
*. Data collection.
*. Alarm system.
*. Transfer Travel and accomodation booking services.

Block diagram:



A digital communication system transfers information from a digital source to a sink.

Advantages of digital communication:

*. Relatively inexpensive digital circuits can be used.
*. Privacy is preserved by data encryption.
*. Data from voice, video and data sources can be merged and transmitted over a common channel.

* Errors can often be corrected by use of coding.
* Greater dynamic range is possible.

Disadvantages:

→ More bandwidth is required.
→ Synchronization is required.

Block diagram of digital system

Basic elements:

Information source:

It generates the message signal to be transmitted. The analog signal can be transmitted to digital by sampling and quantization.

Source Encoder:

The symbols are converted to digital form by source encoder. It assigns codewords to symbols.

Channel Encoder:

It converts the message or information signal in the form of binary sequence.

channel encoding is done to avoid errors. The channel encoder adds some redundant binary bits to input sequence.

Digital modulator:

It maps the input binary sequence to analog signal waveform.

Channel:

It is a physical medium used for transmitting signals from transmitter to receiver.

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Digital demodulator:

It converts the input modulated signal to sequen of binary bits.

Channel Decoder:

It reconstructs error free signal and reduce effe noise.

Source decoder:

It performs reverse operation of source encoder. It converts binary output into symbol sequence.

Characteristics of Digital Transmission Circuits:

Bandwidth Requirement:

Data in most systems use pulse type of energy. The data stream is similar to square wave signal with rapid transition from one voltage level to another.

The data circuits must provide a bandwidth for the data transmission.

If the data is transmitted with greater speed, it requires larger bandwidth to transmit it.

Speed:

The transmission speed is described in 'Baud rate'. Baud is unit of signalling speed.

When all pulse have equal duration, the speed in bauds expresses no. of pulses transfer per second.

One cycle must contain a maximum of 2 bauds. (The maximum signalling speed is equal to twice of bandwidth.)⇒

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Nyquist rate:

The effect of noise on data channel can be reduced by increasing signal to Noise Ratio.

Relation between SNR, Nyquist rate and channel bandwidth:

$$\frac{S}{N} = 2^{NR/\delta f} - 1$$

where $\frac{S}{N}$ - signal to Noise Ratio.

NR - Nyquist rate

δf - channel bandwidth.

Equalizers:

The process of adjusting the volume of different frequenc bands within an audio signal is called equilization. The equipment used to do this is called equilizer.

ASCII code:

ASCII stands for American Standard Code for Information Interchange. It is a seven bit code.

First 3 bits represent whether a number, letter or character is coded.

Last 4 bits represent actual code of number, letter or character.

It contains 128 combination of characters.

Advantages: Error detection can be achieved by increasing the total no. of bits to 8.

It can be easily used in computer.

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EBCDIC code:

EBCDIC code stands for Extended Binary Coded Decimal Interchange.

It is an 8-bit fixed length code. All 8 bits are used representing the information.

It is also based on Binary coded decimal format.

Advantages: i) Readily used in computers.

ii) Total no. of combination is higher.

Disadvantage:

There is no provision of parity bit. Error correction is not possible.

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Error detection and correction codes:

During transmission, errors may be produced by noise and transmission system impairment.

Error correction at receiver is more complicated, so it is necessary for data users to determine of data and decide what level of error correction and detection is suitable.

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Parity check codes:

It is used for detecting error that arise in storing and moving words by adding bits to each character code group.

A parity bit (0 or 1) is added at the end of character. Types: Even Parity

Odd Parity.

Even Parity → Adding an extra bit to group of bits to make whole number of 1's as even.

Eg: 0111 → It has three one's.

01111 → 1 is added, to make it even number of 1's.

Odd parity → Adding extra bit to make it odd number of 1's.

Eg: 011

0111.

Parity bits can be added to row of code bits called horizontal parity.

Parity bits can be added to column → Vertical parity.

By using the two parity schemes concurrently, it is possible to determine which bit is an error.

Forward error-correcting codes:

If the error correction is made by the receiver station without retransmission, it is called forward error correcting codes.

It is done by including sufficient redundancy in the transmitted data.

Hamming codes:

This code adds several parity check bits to data bits.

It adds three parity bits to the data bits.

Eg:

P_1	P_2	1	P_3	1	0	1
1	2	3	4	5	6	7
		D		D	D	D

P - Parity bits

D - data bits.

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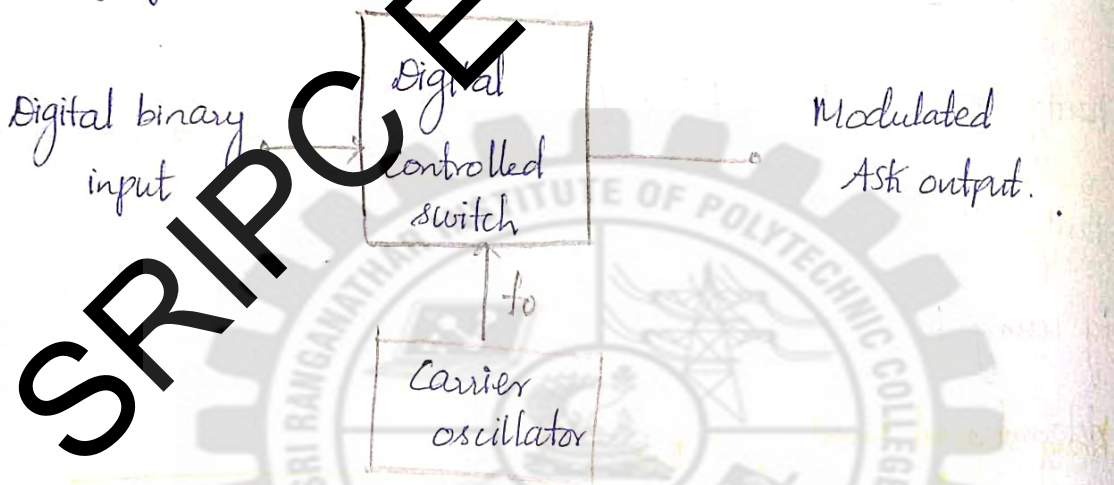
Ask Modulator

In amplitude shift keying (ASK) modulation, the digital signal is switched in between amplitude levels of digital signal.

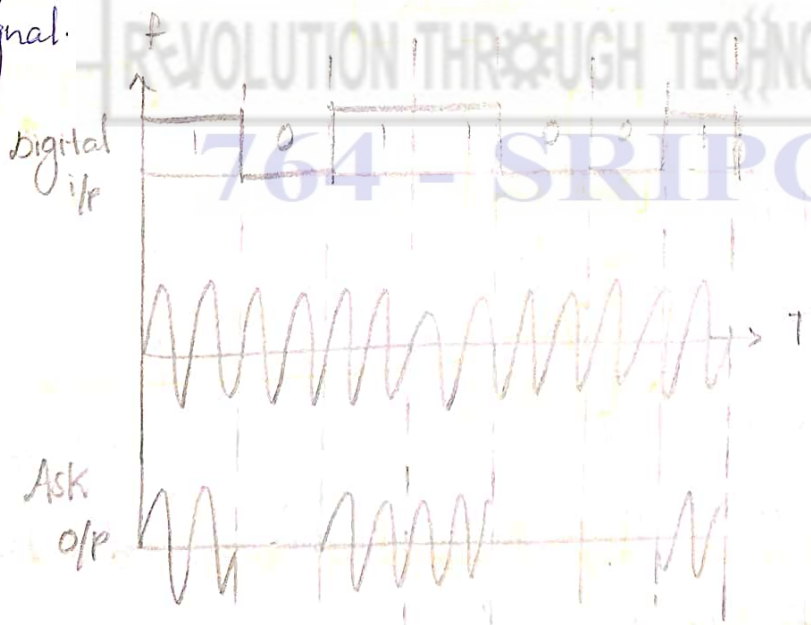
The carrier signal is ON and OFF, in accordance with input signal.

The carrier signal is transmitted during high level input (1) and blocked during low level input (0). It is also called ON-OFF Keying.



Carrier oscillator produces sine wave signal with carrier Frequency. The switch operates in accordance with digital binary input signal.

Output:



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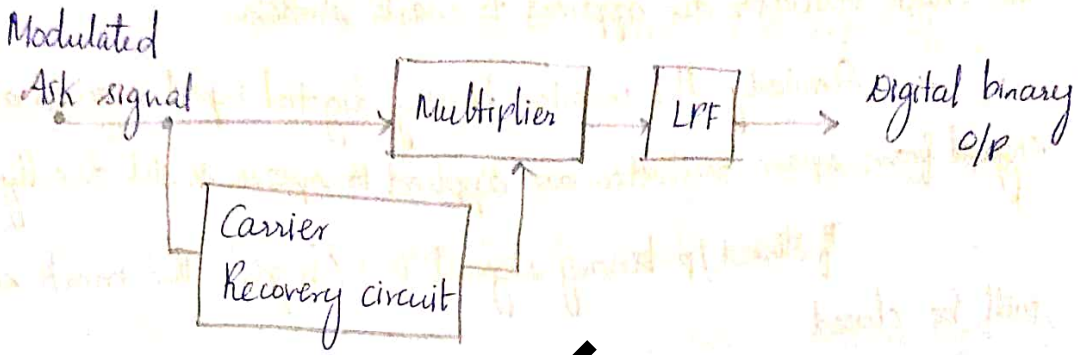
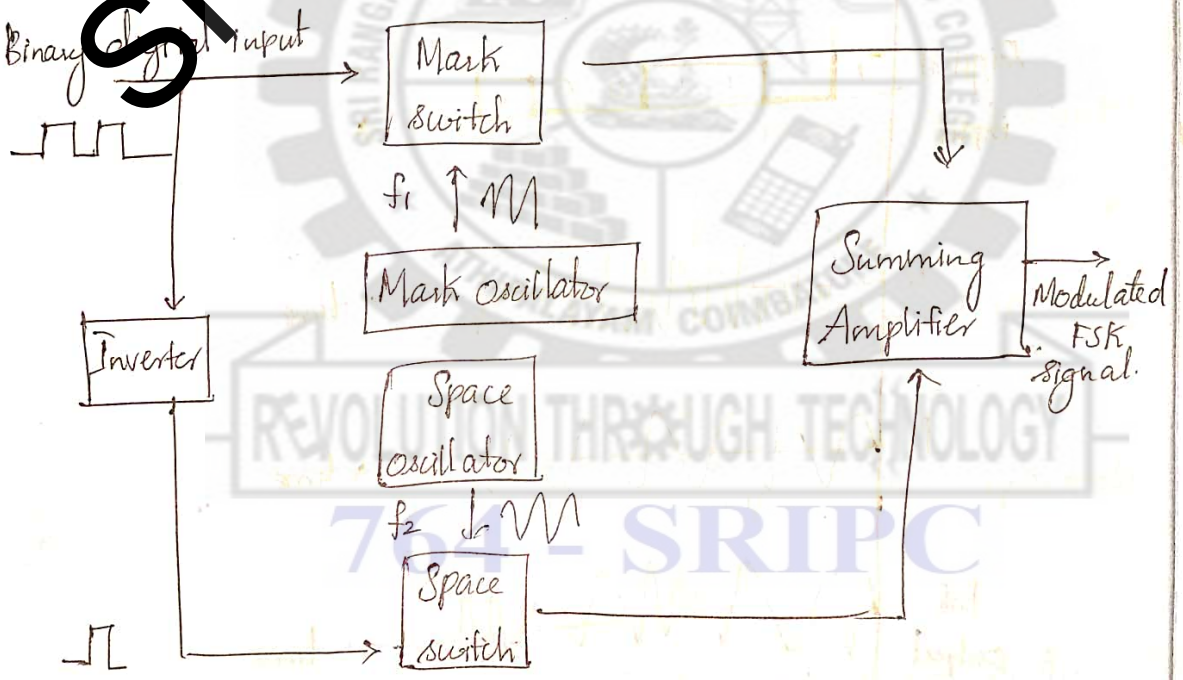
Ask demodulator:



Carrier Recovery circuit is used to generate a local carrier signal. The carrier frequency produced in circuit is used to lock vco in PLL. The local generated carrier signal and received modulated signal, both are applied to multiplier directly.

The unwanted signal at o/p is removed by low pass filter.

Fsk Modulator:



The Stream of digital signal is given to the mark switch and the inverter.

The mark oscillator produces a sine wave signal with the carrier frequency of f1. Similarly, the oscillator produces the another sine wave signal with carrier frequency of f2

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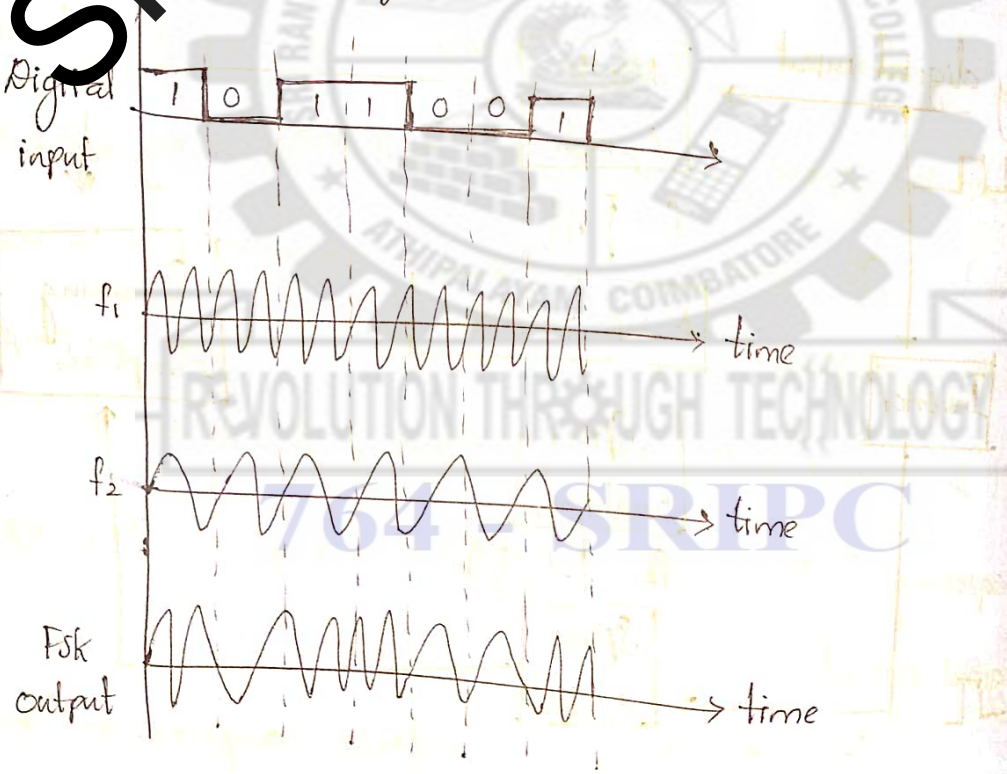
The binary digital input signal and the signal from the mark oscillator are applied to mark switch.

Similarly, the inverter binary digital input signal and signal from space oscillator are applied to space switch directly.

If the i/p binary signal is 1 (high), the mark switch will be closed.

Now, the signal from mark oscillator with frequency f_1 is passed to summing amplifier through mark switch.

The mark signal which is high voltage signal is inverted by inverter and becomes low voltage signal. So space switch is open. As a result, the signal from space oscillator does not reach summing amplifier.



If the digital input signal is 1 (High), the o/p of summing amplifier will be the signal with frequency of f_1. Conversely, if the digital input signal is 0 (low), then o/p will be signal with frequency f_2.

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Fsk Demodulator:

The modulated fsk signal is applied to input of demodulator.

The mark signal with frequency f_1 is passed through mark band pass filter and detected by mark detector.

The signal is given as input to non-inverting input of difference amplifier.

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Similarly, the space signal with frequency f_2 is passed by space band pass filter and detected by space detector.

This demodulated signal is given as i/p to inverting input of difference amplifier. The output of difference amplifier will be signal with positive voltage, if the signal with frequency f_1 reach input of difference amplifier. This represents digital signal '1'.

Conversely, the o/p of difference amplifier will be the signal with negative voltage, if the signal with frequency f_2 reach the i/p of difference amplifier.

This represents digital signal '0'.

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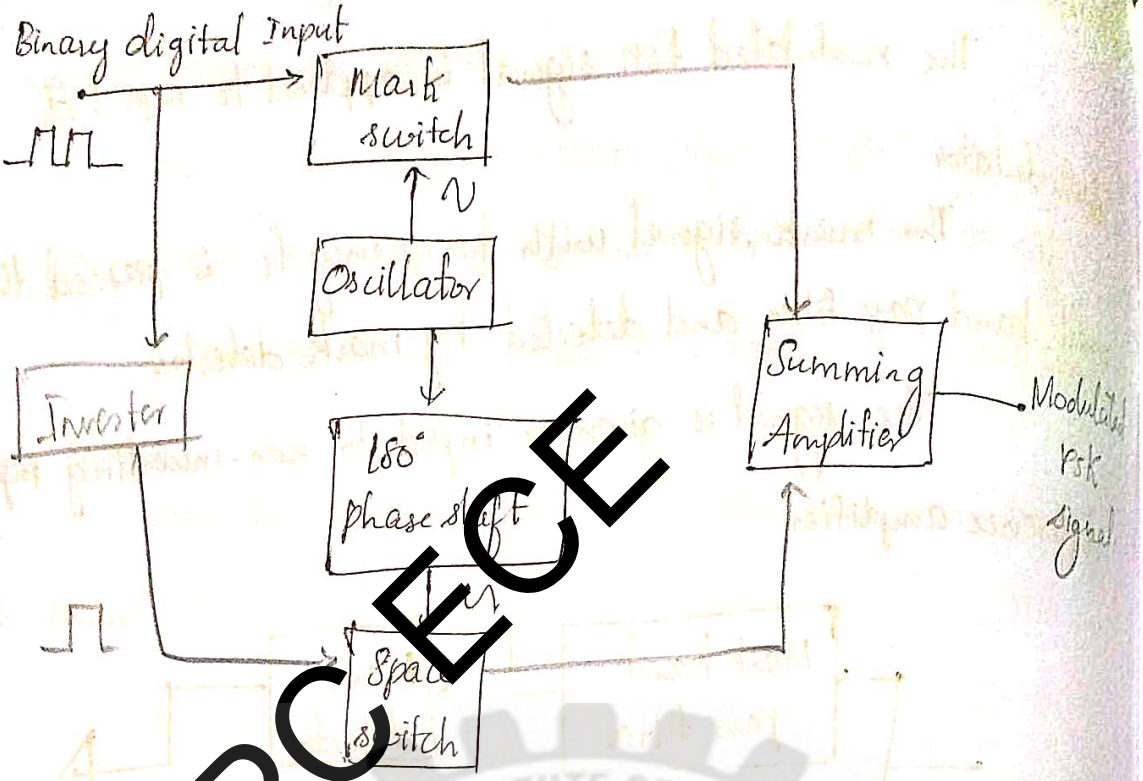
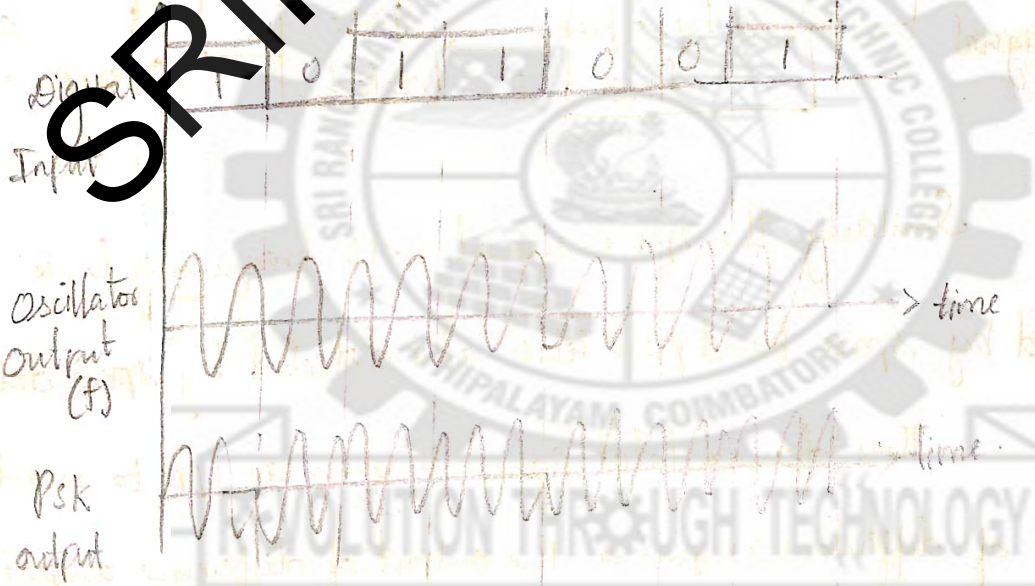
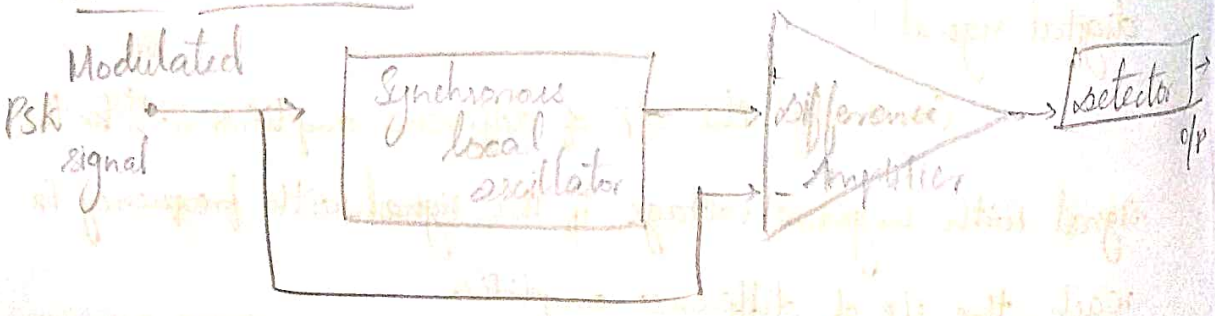
Psk Modulator:





Phase shift keying

Psk demodulator:



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Unit-III

Optical Communication

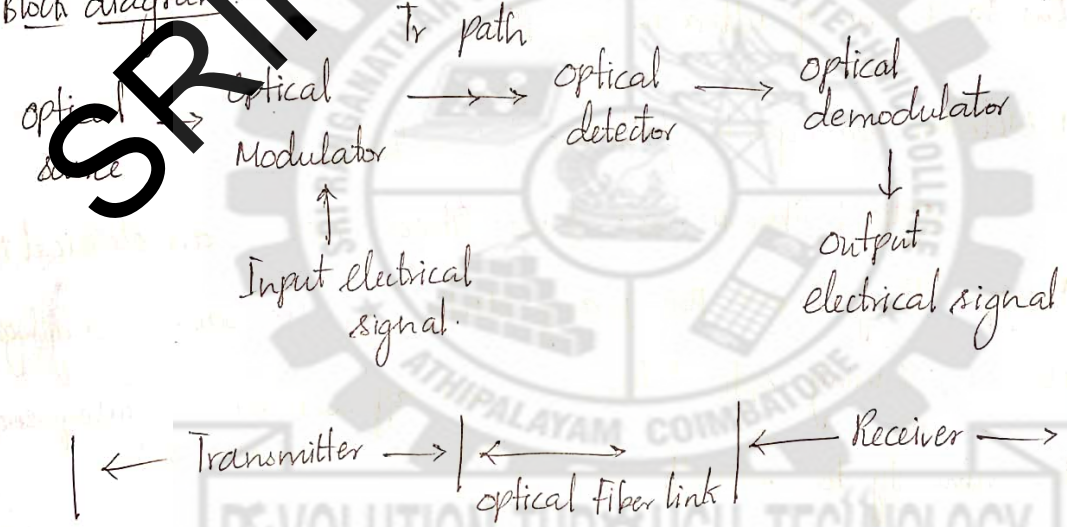
Optical fibers are increasingly replacing wire transmission lines in communication system. Such fiber lines offer several important advantages over wirelines.

Light is effectively the same as radio frequency radiation, but its frequency is High.

Information carrying capacity is High.

Material: Silica glass or silicon dioxide.

Block diagram:



The input electrical signal modulates the intensity of light from the optical source.

The optical carrier can be modulated internally or externally.

The transmission channel is optical fiber link.

At receiver, the electrical signal is separated from optical carrier by demodulator. Thus, original electrical signal is obtained.

In the receiver stage, (the photo detector like avalanche photodiode (APD) or positive intrinsic negative (PIN) diode converting optical pulses into electrical pulses.)

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A decoder converts the electrical pulse into electrical signal original.

Advantages.

i) Wider Bandwidth: $I^{nformation} \propto$ carrier frequency.

optical carrier frequency => 10^{13} to 10^{15} Hz.

Radio Frequency => 10^{6} Hz

microwave frequency => 10^{10} Hz

optical fiber yields great transmission bandwidth.

ii) Low Transmission loss:

fibers have transmission loss of 0.002 dB/km are used.

Due to usage of ultra low loss fibers.

iii) Dielectric waveguide / Electrical Isolation:

optical fiber is made from silica which is an electrical isolator Therefore, they do not pickup any electromagnetic wave or any high current lightning. optical fibers are not affected by any interference.

iv) Immunity to crosstalk:

There is no crosstalk because of absence of optical interference.

v) Signal security:

The transmitted signal through fibers does not radiate. The signal cannot be tapped from fiber in easy manner.

vi) Small size and weight:

Have small radii, flexible and lightweight than copper cables.

vii) Ruggedness and flexibility:

fiber cables can be bent or twisted without damage.

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viii) System Readability and easy maintenance:

optical fibers are made from silica glass which does not undergo any chemical reaction or corrosion. Not easily affected by parameters

ix) Low cost:

Raw material is easily available. Overall system cost including maintenance is very low.

Disadvantages:

i) Low power - Popular light emitting sources are restricted to very low power devices.

ii) Distance -> because of low power sources, the distance between repeater amplifiers must be relatively short.

iii) Modulation -> limited types of modulation techniques are used.

iv) Nuclear radiation: The glass will darken when exposed to neutron bombardment. The harder the glass, the more quickly it will discolour.

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Principles of light transmission in a fiber using Ray theory:

When light ray enters on one end of glass fiber under light conditions, most of light will propagate or move down the length of fiber. A small part of light will be lost due to internal absorption, but a portion of light will be contained and guided to far end. Such a fiber is called light pipe or light guide.

Light stays because it is not totally reflected. Light entering follows a zig-zag path through series down the length of fiber.

Total internal Reflection: Two conditions:

i) $n_1 > n_2$
Core cladding.

ii) $\phi_i > \phi_c$

$$\sin \phi_c = \frac{n_2}{n_1}$$

ϕ_i - Angle b/w ray and normal

θ_c ϕ_c - the minimum angle at which external light rays may enter air/glass interface and still propagate down the fiber.

Refraction occurs when $\theta_i < \theta_c$. Refracted ray pass through wall into cladding by refraction and become lost.

A ray of light enters core n_0 from n_1 lauch region with an angle of incidence θ_0 and leaves interface at an angle of refraction θ_1, which is smaller than θ_0.

Snell's law: θ_0 - incident angle

θ_1 - refraction angle.

$$n_0 \sin\theta_0 = n_1 \sin\theta_1.$$

$$\sin\theta_0 = \left(\frac{n_1}{n_0}\right) \sin\theta_1.$$

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Effects of light rays in optical fibes:

Transmission of light ray in an optical fiber...via series of total internal reflections.

The ray have $\theta_i > \theta_c$ and is reflected at same angle to normal. The light ray is known as meridional ray as it passes through axis of fiber core.

It is a simplest ray. If any impefections occurs would result in loss of light ray.

optical fiber.

- It is a dielectric waveguide that operates at optical frequencies
- This fiber waveguide is cylindrical in form.
- It confines electromagnetic energy in the form of light and guides in direction parallel to its axis.

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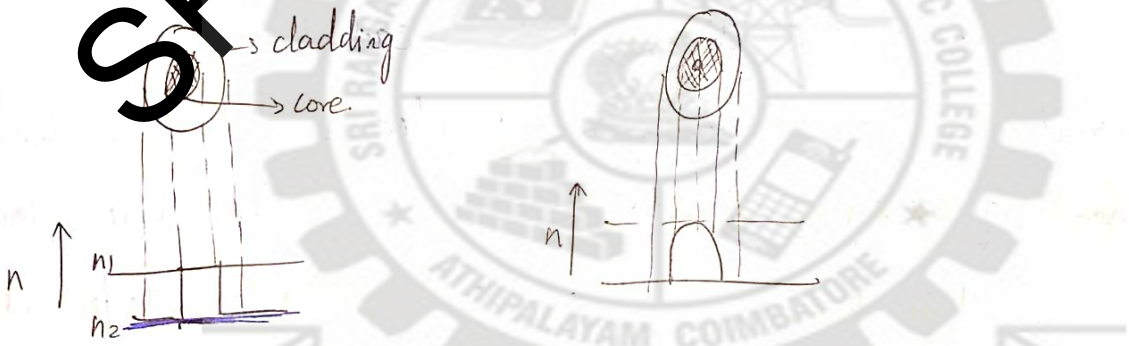
The propagation of light is described in modes. Each guided ~~pattern~~ mode is a pattern of electric and magnetic field that is repeated along the fiber at equal intervals.

The cylindrical shaped central part -> core. Core is surrounded by solid dielectric cladding. Cladding is not necessary for light propagation.

cladding reduces scattering loss and adds mechanical strength to fiber. ($n_1 > n_2$)

In low and medium loss fibers, core material is glass and is surrounded either by glass or plastic cladding.

Step Index and Graded Index fiber:



Two basic ways of defining index of refraction variation across the cable.

Step Index fibers, n_1 and n_2 are sharply defined in step.

ie: Core has one constant index of refraction N_1
cladding has one constant N_2.

Graded Index fiber, n_1 and n_2 are not smooth.

Index of refraction is High at centre and declining to outer edge of the core linearly. N_2 is constant.

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* LED

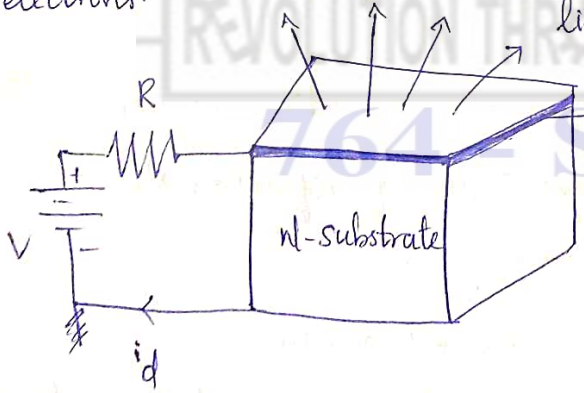
LED stands for Light Emitting Diode. A light emitting diode works by the process of spontaneous emission when it is forward biased and conducting current.

One side of diode junction is P-type material containing mostly holes. The other side of junction is N-type material containing mostly free electrons.

At zero bias, a depletion separates the P and N regions of diode. When forward bias is applied, the barrier potential across depletion region is reduced. Hence electrons and holes are free to cross the barrier to conduct current.

Recombination occurs. When each hole-electron pair recombines, a single photon of light is released, which carries the amount of energy required to liberate an electron from valence band.

The intensity of light emitted is proportional to forward current conducted by the junction, which controls number of holes and electrons.



The LED is formed by diffusing this transparent layer of P material into surface of N- substrate. Light is emitted within the junction.

LEDs used for fiber optics are Gallium Arsenide (GaAs) with various dopants. Dopants used are Phosphorus (P), Indium (In)

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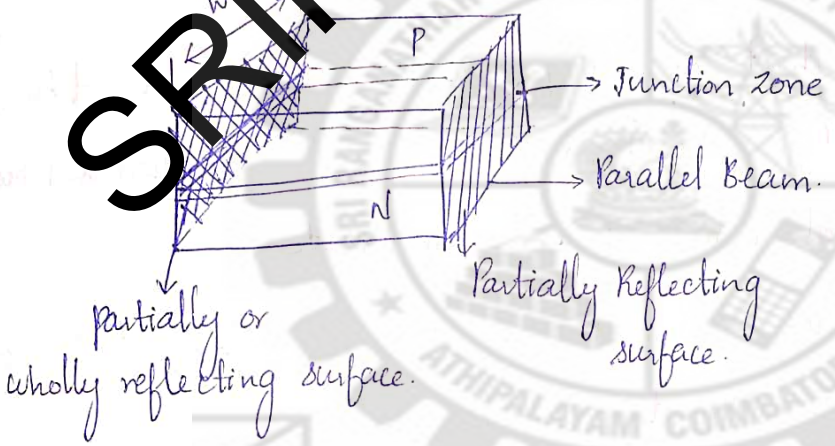
and Aluminium (Al). Diodes cover the bandgaps in the range of as to 2.0eV.

Semiconductor LASER:

LASER is an acronym for "Light Amplification by Stimulated Emission of Radiation". Laser is a light source whose radiation has high intensity, high monochromaticity and high directionality.

Laser action has been obtained by gases such as neon or carbondioxide. Semiconductor laser uses the solid semiconductor as the lasing material.



In this, when a hole-electron pair is created by absorption of energy. It is raised from ground or valence energy state to a higher conduction energy state represented by the energy gap.

An electron raised to higher energy state will remain in that state for a short period. Then it will recombine with hole and revert to lower valence state, giving off photon of energy.

The laser action can be enhanced by placing a reflecting surface at each end of junction region to form Fabray ~~Feroy~~ Perot Resonant cavity.

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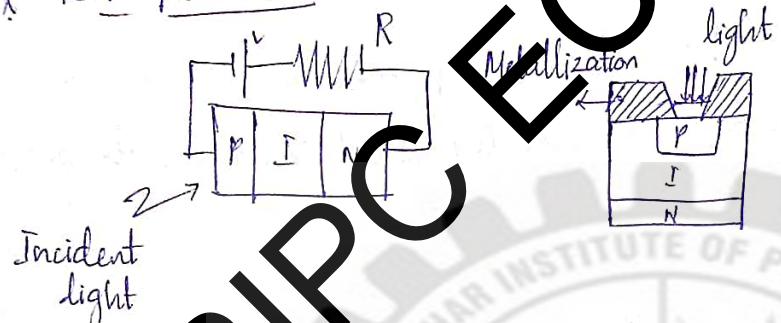
One reflecting surface is made partial so that part of incident light will pass out of junction instead of reflecting back.

The two surfaces are made parallel, so that light will bounce back and forth several times.

This also tend to the light into a parallel beam emerging from one end of chip making it easier to couple to a fiber.

PIN photodiode:



The sensitivity of PN photodiode can be improved by including a lightly doped 'N' layer between the junction and more heavily doped n+ contact region to form 'PIN' diode.

The intrinsic layer is made thick enough so that most photons pass through without ionizing.

The PIN diode is under reverse bias voltage. So the intrinsic region is fully depleted of carriers.

When an incident photon has energy greater than or equal to the bandgap energy of photodiode, the electron-hole pair is created due to absorption of photon.

They are separated by high electric field present in the depletion region and collected across reverse biased junction. This give rise to photo current flow in the external circuit.

The PIN photodiode acts as linear device such that photo current is directly proportional to incident optical power.

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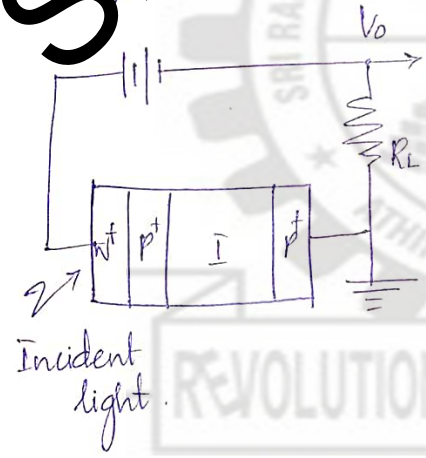
* Avalanche Photo diode

It consists of four regions $P^+ - I - P - N^+$ in order to develop a very high electric field in intrinsic region. It is used to produce new electron-hole pairs by ionization.

This impact ionization leads to avalanche breakdown in reverse biased diode. So these diodes have high sensitivity and responsivity over PIN diodes.

Light enters the diode through P^+ region and is absorbed in the intrinsic region, which also act as collector region for photo generated carriers.

Further, the pairs are separated by electric field. The photo generated electrons drift through intrinsic region to PN^+ junction, where high electric field exists.



In avalanche region, the charge carrier multiplication takes place by impact ionization. (Highly accelerated electrons in region collide with bound electrons of valence band and release more electrons) or avalanche effect.

These diodes have highest sensitivity.

Disadvantage: ~~First~~*, carriers in intrinsic region have long transit time which slows response as in PIN diode.

* The avalanche factor adds noise.

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Applications of optical fibers:

- Military
- Civil
- Networking.
- Industry.
- Telecommunications.
- Business.

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8. Block diagram of optical Communication systems:

* The input electrical signal modulates the intensity of light from the optical source.

* The optical carrier can be modulated internally or externally using an electro-optic modulator.

* Electro optic modulators are widely used as external modulators, which modulates the light by changing its refractive index through given input electrical signal.

* The transmission channel is optical fiber link.

* At the receiver end, the electrical signal is separated fr the optical carrier by demodulator.

* Thus original electrical signal is obtained.

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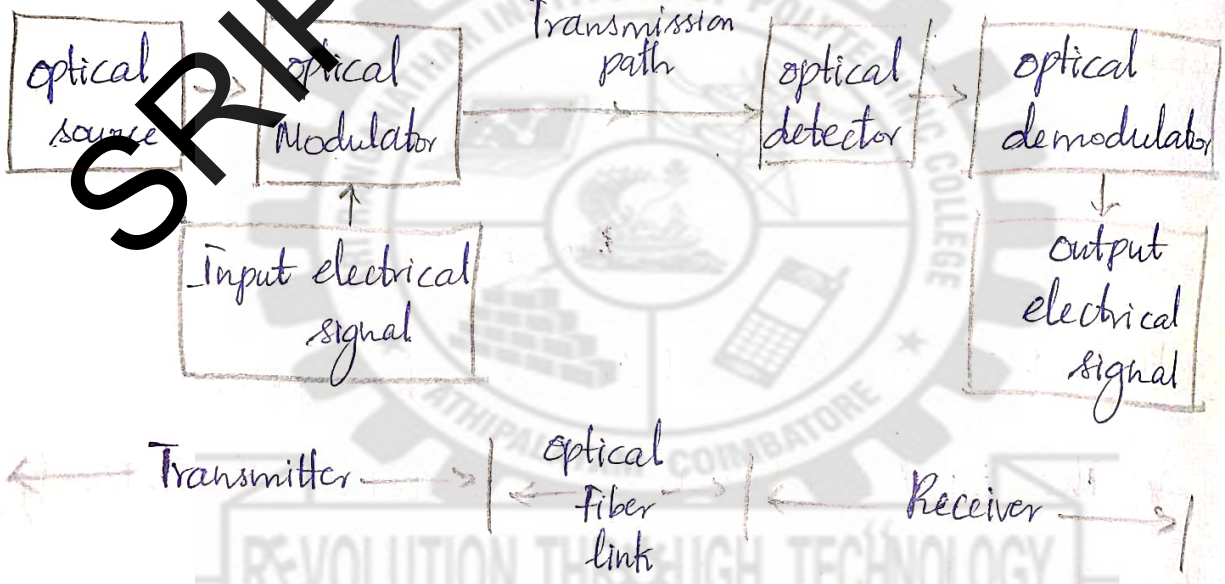
* In digital optical communication system, the input electrical signal is in the form of coded digital pulses.

* These electrical pulses modulates the light from LED or laser and convert them into optical pulses.

* In the receiver stage, the photo detector like Avalanche photodiode (APD) or PIN diode converts the optical pulses into electrical pulses.

* A decoder converts the electrical pulses into original electrical signal.

(X)



Advantages:
* Wider Bandwidth.
* Low Transmission loss.
* Small size and weight
* Low cost.

Disadvantage:
* Low Power
* Limited Application.

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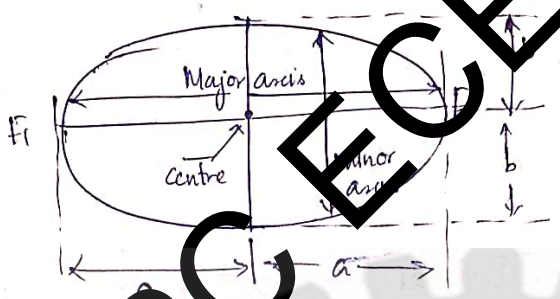
Unit IV.

1. Kepler's I, II and III laws:

Kepler's first law states that the satellite will follow an elliptical path in its orbit around primary body.

An ellipse has two focal points shown as F1 and F2.



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Foci F1 & F2, the semimajor axis a and semiminor axis b of an ellipse. The centre of mass of the two body system, termed as barycenter is always centered on one of the foci.

This is a special case, because of the enormous difference between masses of earth and satellite. The center of mass always coincide with center of earth, which is one of foci.

This is an important point because the geometric properties of ellipse are normally made with reference to one of the foci, which can be selected to be the one centered in the earth.

Eccentricity of ellipse $\Rightarrow e = \frac{\sqrt{a^2 - b^2}}{a}$

The semimajor axis 'a' and eccentricity 'e' are two significant parameters.

Kepler's II law

This states that for equal time intervals, the satellite sweeps out equal areas in orbital plane, focussed at baycenter.

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Assuming that the satellite travels distance S_1 and S_2 meters in one second, the areas A_1 and A_2 will be equal. The average velocities are S_1 and S_2 m/s.

Because of equal area law, Distance S_1 is greater than distance S_2 and hence velocity S_1 is greater than velocity S_2.

Velocity will be greatest at the point of closest approach to earth (Perigee) and will be least at the farthest point from earth (Apogee).

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Kepler's III law:

This states that the square of the periodic time of orbit is proportional to cube of the mean distance between two bodies.

The mean distance is equal to semimajor axis α.

For artificial satellites,

Kepler's law $\Rightarrow \boxed{\alpha^3 = \mu / n^2}$

n - mean motion of satellite in radians per second.

μ - Earth's geocentric gravitational constant.

with α in meters, the value of μ is 3.986005×10^{14} m^3/sec^2.

With 'n' in radians per second, the orbital period in seconds is given by, $P = \frac{2\pi}{n}$.

The important of Kepler's III law is that it shows there is a fixed relationship between period and size.

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One very important orbit is geostationary orbit which is determined by rotational period of earth.

Launching orbits:

The satellites are launched in geostationary orbit. If satellite is placed in geostationary orbit, the tracking antennas are not needed for finding position of satellites.

To achieve geostationary orbit, the satellite must be accelerated to a velocity of 10.1 km/s and raised to a distance of nearly 42000 km from centre of the earth.

This is achieved by using launch vehicles.

Types: i) Expendable launch vehicle.

ii) Space Transportation system (STS) or space shuttle or Reusable.

One common method based on Hohmann transfer principle is used for placing many satellites into geostationary orbit.

*. Using this system, the satellite is first placed into low earth orbit with altitude of around 150 miles.

*. Once in the correct position in this orbit, the launch vehicles are fired to put the satellite into an elliptical orbit called as transfer orbit.

The perigee of transfer orbit is at LEO and apogee is at Geostationary orbit.

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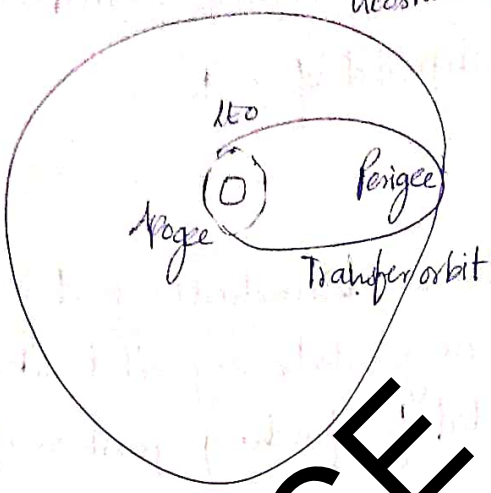
Geostationary orbit.



At the transfer orbit, a rocket engine called "Apogee kick motor" (AKM) places satellite into circular geosynchronous orbit with zero inclination.

When satellite reaches the final altitude, the rocket or booster is again fired to retain it in geostationary orbit with the correct velocity.

Types:
* Low Earth orbit (LEO)
* Transfer Orbit
* Geostationary orbit (GEO)

1. LEO (Low Earth Orbit)

It is an orbit around the earth with altitude of above 160 km (period = 88 mins).

The orbital velocity needed to maintain a stable LEO is about 7.8 km/s but reduces with increased orbital altitude.

A LEO is simplest and cheapest for satellite placement Satellites in LEO will not be visible from any given point on Earth at all times.

2. Transfer Orbit:

This is an elliptical orbit used to transfer a satellite from a low altitude orbit to geostationary orbit.

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The apogee is about 36,000 km. When satellite reaches this point, its apogee kick motor is fired to inject satellite into geostationary orbit.

3. Geostationary Orbit (GEO)

This circles the earth above equator from west to east at height of about 36,000 km.

It takes 23 hrs, 56 mins and 4 seconds.

Satellites in GEO orbit appear to be stationary over a fixed position.

Speed is about 3 km/sec.

As satellites in this orbit continuously cover large portion, it makes this ideal for telecommunications for monitoring weather patterns and environmental conditions.

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Satellite orbit system:

* A satellite orbiting the earth stays in position because the centrifugal force on the satellite balances the gravitational force on earth.

* Satellite should be at height greater than 36,000 km.

The choice of orbit is very important. It determines

⇒ The transmission path loss and delay time.

⇒ Earth coverage area.

⇒ Point farthest from Earth (Apogee)

⇒ point at closest to earth (Perigee)

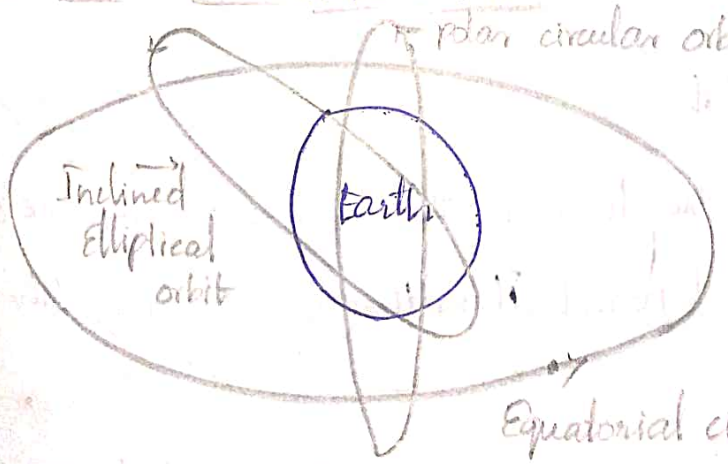
⇒ Angle from the earth's equatorial plane to the orbital plane measured counter clockwise at ascending node (Inclination).

Types: i) Inclined Elliptical orbit.

ii) Polar circular orbit

iii) Geostationary orbit.

Communication satellite orbit.



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i) Inclined Elliptical orbit:

* It is not widely used. The main advantage is that it provides coverage of the polar region.

* The highest point of orbit is arranged to occur over the region of more coverage. This puts satellite at its greatest height and therefore gives earth greatest coverage.

* It does not permit continuous contact with satellite from the fixed spot.

* The inclination angle is about 63.4° and cover polar regions for about 8 - 12 hours daily.

ii) Circular polar orbit:

* It is not used for communication satellites.

* They make one trip one around the earth every 100 minute approximately.

* This orbit is closer to earth and passes or very close to the poles. The inclination is close to 90°.

* The average height of these orbits is 800-1000 km above earth.

iii) Geo stationary orbit:

* The periodic time is the time taken for one complete orbit earth's rotational period. It is the synchronous orbits which is mostly used.

* The rotational period of earth about its own axis is 23 hours 56 minutes.

* The satellite appears stationary to an observer on earth - hence the name geostationary.

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