/Sneha Kadam.

6) Communication systems.

* Introduction:

Communication is the process of exchanging information. It is used for conveying thoughts, ideas and feeling to one another.

A communication system is the means of conveying the information from one place to other place.

The best forms of electronic communication such as radio, television and internet have increased our ability to share information. Today they form the major part of our live.

In todays world every one is so it hard to imagine living without the knowledge & information that arrive from around the world by electronic communication.

* Block Diagram of communication system:-

A communication system is the means of conveying the information from one place to other place.

The block diagram of basic communication system is as shown below diagram,

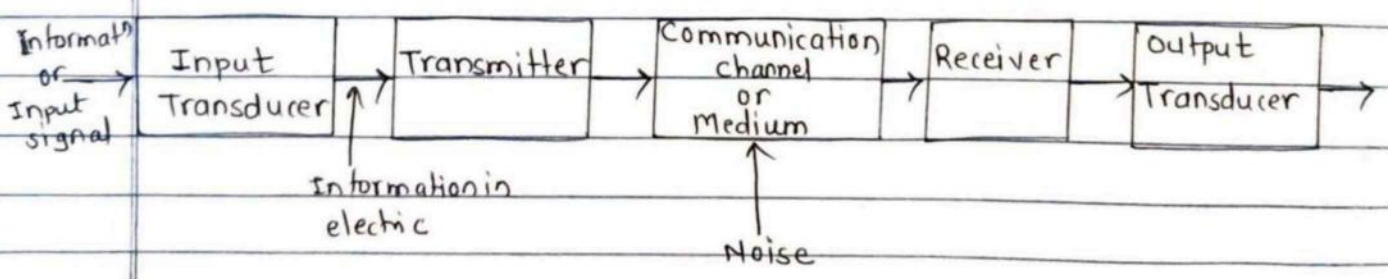


fig:- Block Diagram of Basic Communication system.

The elements of basic communication system are as follows:

Input transducer
Transmitter.
communication channel or medium.
Receiver
output transducer.

Input transducer:

The information or input signal that is to be transmitted can be in the form of a sound signal like speech or music or it can be in the form of pictures (TV signals) or it can be in the ~~forms of pictures~~ data information coming from a computer.

The information in the form of sound, pictures or data signals cannot be transmitted as it is.

first it has to be converted into a suitable electrical signal.

The input transducers commonly used in the communication systems are microphones, TV camera etc.

Transmitter:

The function of transmitter block is to convert the electrical equivalent of the information to a suitable form.

In addition to that it increases the power level of the signal. The power level should should be increased in order to increase range of transmitted signal.

The transmitter consist of the electronic circuits with such as amplifier, mixer, oscillator & power amplifier.

Communication chanel or mediam:

The communication chanel is the medium by which electric signal is transmitted from one to another. The communication medium can be a pair of conducting wire, coaxial cable, optical fiber cable or free space.

Noise: Noise is random, unwanted electrical signal which gets added to the transmitted signal when it is travelling towards the receiver. Due to noise, the quality of the transmitted information will get degrade. Noise is one of major problem in communication. Even though noise cannot be completely eliminated its effect can be reduced by using various techniques.

Receiver:

The process of reception is exactly opposite process of transmission. The received signal is amplified, demodulated and converted into a suitable form.

The receiver consist of electronic circuits like mixer, oscillator, detector, amplifier etc.

Output Transducer:

The output transducer converts electrical signal at the output of receiver back to the original form. i.e. sound or TV pictures etc.

The typical examples of the output transducer are loud speakers, picture tubes, computer monitor etc.

* Communication Media:-

A transmission / communication media is defined as medium over which information travels from sender to receiver. A communication channel is also called as medium.

classification of communication media.

The classification of media as follows,

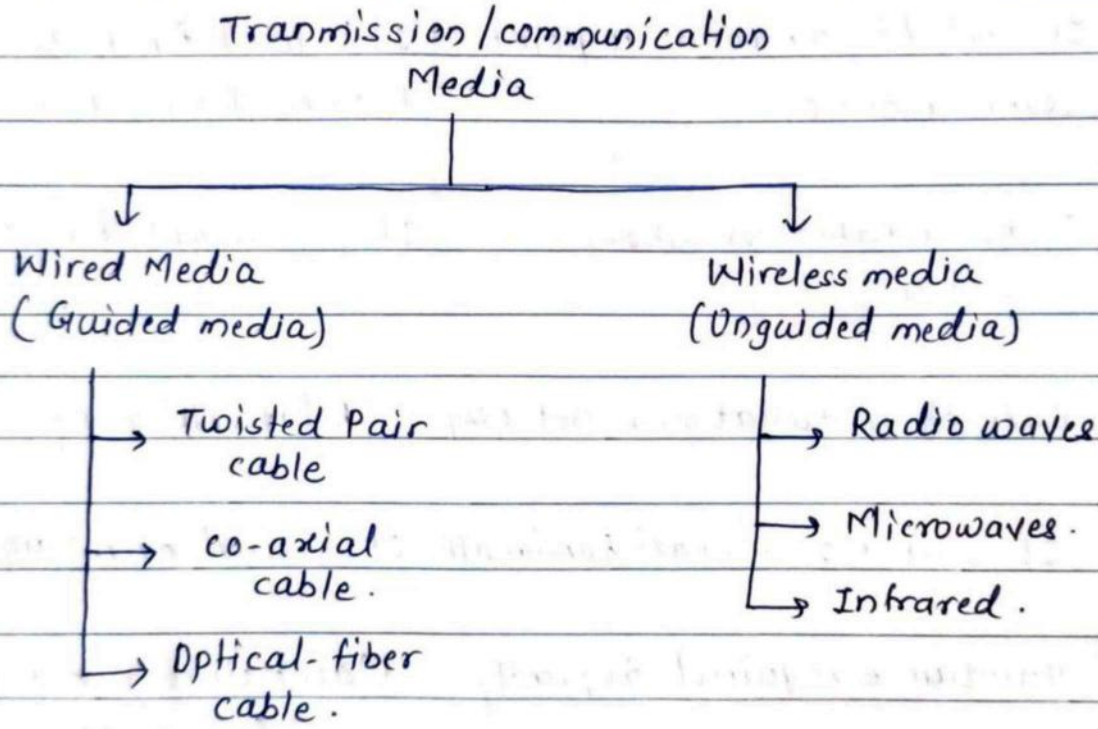


fig: classification of communication media.

The communication medium are mainly classed into two groups,

1. Wired medium.
2. Wireless medium.

* Comparison of wired & wireless media.

Sr. No.	Wired (Guided) Media	Wireless (unguided) Media.
1.	The signal is guided within medium.	The signal propogates as unguided electromagnetic waves.
2.	It suitable for point to point communication.	It is used for radio, TV broadcasting, satellite comm^n.
3.	It is suitable for short distance	It is suitable for long distance.
4.	Ease of installation is not easy	Relatively easy.
5.	It is used over small bandwidth	It is used over large bandwidth.
6.	Maintaince required frequently	Maintaince is not required frequently
7.	Examples are, Twisted pair cable, Co-axial cable, optical fiber cable.	Examples are, Radio waves, Microwaves, Infrared etc.

The types of wired media communication are,

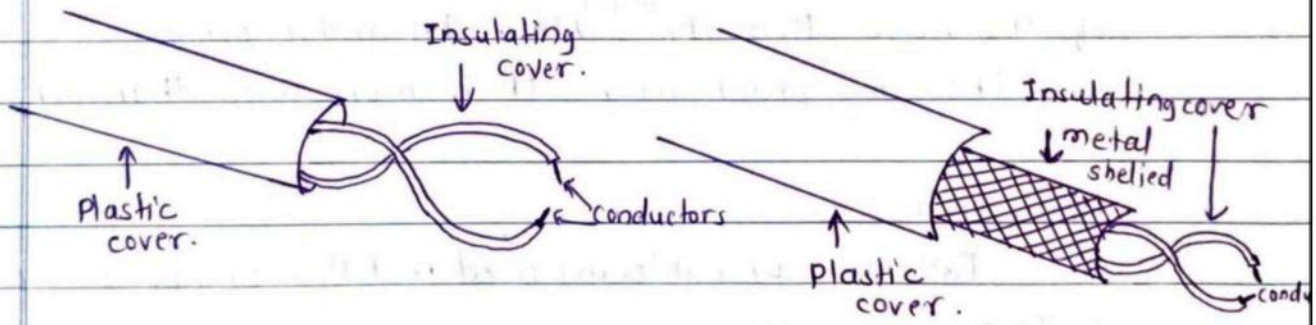
1. Twisted pair cable.
2. Co-axial Cable.
3. Optical fiber cable.

1. Twisted Pair cable :-

The two commonly used types of twisted pair cables are as follows,

1. Unsheilded twisted pair (UTP)
2. Sheilded Twisted Pair (STP).

The construction of UTP & STP cables are as shown in below figure (a) & (b) respectively.



fig(a):- Construction of Unsheilded Twisted Pair cables

fig(b): Construction of sheilded Twisted Pair cables.

A twisted pair consist of two insulated conductors twisted together in the shape of spiral as shown in above fig (a) & (b). It can be either sheilded or unsheilded.

UTP:- Unsheilded Twisted Pair.

The unsheilded twisted pair (UTP) cables are very cheap and easy to install. But they are badly affected by the electromagnetic noise interference.

The insulated wires are no sheilded, but they are twisted around each other.

Noise and electromagnetic interference is high.

Installation is easy.

It has low to moderate bandwidth.

STP:- sheilded Twisted Pair.

It has a metal sheild to cover each pair of twisted insulating conductors.

This is known as metal sheild which is normally connected to ground so as to reduce the interference of the noise. But this makes cable bulky and expensive.

Therefore practically UTP is more used than STP.

Applications:

Twisted Pair cables are used in following application,

1. Telephone system.
2. Local Area Network.
3. Ethernet f ring network.
4. Internet Services Digital Network (ISDN).

2. Co-axial Cables:

The construction of co-axial cable is as shown in below figure.

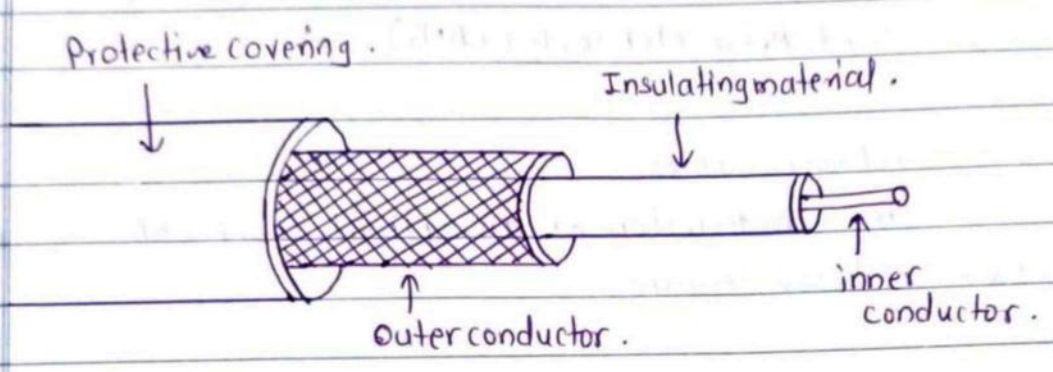


fig: Construction of co-axial cable.

It consist of two concentric conductors namely as inner conductor and outer conductor separated by a dielectric material.

The external conductor is in the form of metalic sheild and used for sheilding purpose. The co-axial cable may contain one or more pair.

Due to sheild provided, this cable has excellent noise immunity.

It has large bandwidth and low losses.

This cable is suitable for point to point or point to multiband applications.

These cables are costlier than twisted pair cables but they are cheaper than optical fiber cables.

Co-axial cables are easy to install.

Applications of co-axial cables:

1. Analog Telephone Network.
2. Digital Telephone Network.
3. Cable TVs.
4. Local Area Networks (LANs).

3. Optical fiber Cables:

The construction of an optical fiber cable is as shown in below figure,

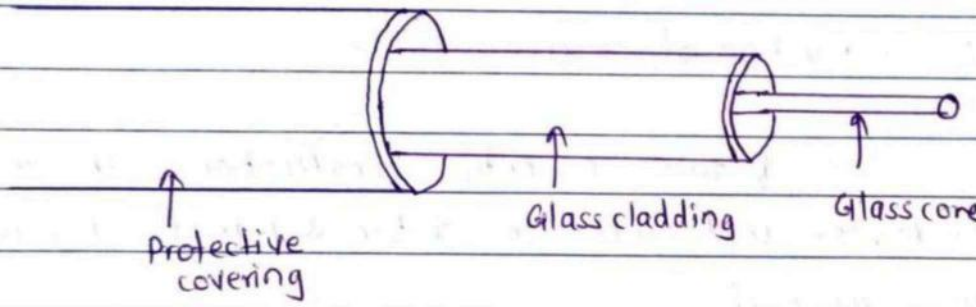


fig:- Construction of optical fiber cable.

It consist of inner glass core surrounded by a glass cladding which has a lower refractive index and a protective covering as shown in above figure.

Digital signals are transmitted in the form of modulated light signal.

The core and cladding are usually made of high quality silica glass, although they can be made of plastic as well.

A light source is placed at the end of the fiber and light passes through it and exists at other end of the cable. The fiber optic cable can carry information such as voice, video computer data etc.

Voice and video signals are converted into binary or digital pulses before being transmitted by a light beam. At receiving end, the light beam is converted into binary or digital pulses and then into original voice or video signals.

Principle of Light Propagation in fiber:

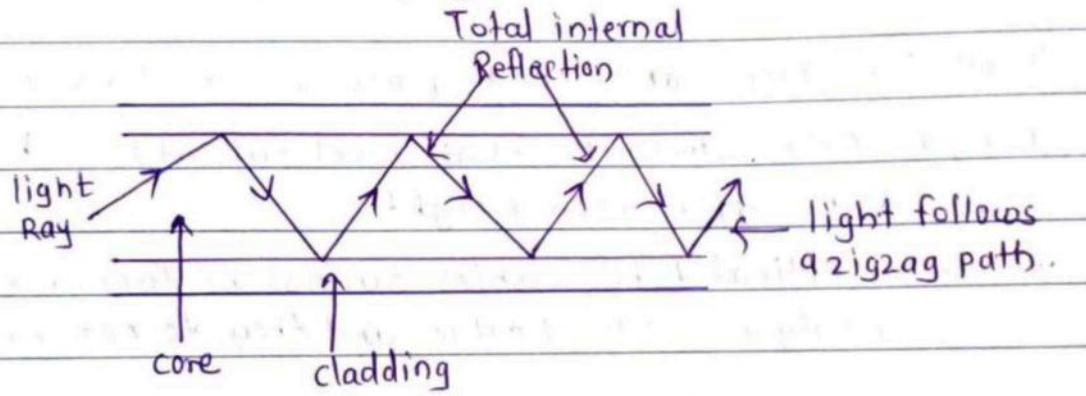


fig:- Light follows a zigzag path within optical fiber.

The light in optical fiber cable travels through the core by constantly bouncing from cladding, a principal called total internal reflection.

The above figure shows how light follows the path inside optical fiber cable.

Because of cladding does not absorb any light from core, the light wave can travel great distance. However, some of light signal degrades within fiber, mostly due to impurities in glass.

Advantages of optical fiber cables:

1. Wider Bandwidth:
   Higher information carrying capability.
2. Lower loss: Less signal attenuation over long distance.
3. Light weight: Useful where low weight is critical.
4. Small size: More cables can be placed in smaller place.
5. Strength: More strengther than electrical cables & hence can support more weight.
6. Security: optical fiber cables can not be tapped as easily as electrical cables and they do not radiates singals
7. Crosstalk: There is no crosstalk inside the optical fiber cable.
8. Speed: It can transmit data with very high speed.
9. Greater safety: They do not carry electricity, therefore, there is no shock hazard. They are also insulators so they are not susceptible to lightning strikes as electrical cables.

Applications:

1. Telephone system.
2. LANs.

* comparison between wired transmission / communication medium.

	Twisted Pair cable.	Co-axial cable	optical fiber cable
1.	Uses electrical signal for transmission.	Uses electrical signal for transmission.	Uses light signal for transmission.
2.	Affected due to electromagnetic field.	Affected due to electromagnetic field.	Does not get affected by electromagnetic field
3.	Low cost	medium cost	High cost.
4.	Low Bandwidth	medium Bandwidth	High Bandwidth
5.	Supports low data rate.	Supports medium data rate.	Supports High data rates.
6.	Power loss due to conduction	Power loss due to conduction	Power loss due to absorption, scattering & bending.
7.	Possibility of short circuit betn 2 conductor	Possibility of short ckt betn two conductors.	No possibility of short circuit.
8.	Easy to installation	Easy to installation	Difficult for installation
9.	High attenuation	Medium attenuatn	Low Attenuation.

* Wireless transmission Media :-

As name indicates, in wireless transmission, there is no wire or any guided media as a communication chanel.

Wireless communication take place through air or vaccum.

The two antennas are used transmitting antenna & receiving antenna.

The signal from sender to receiver travel in the form of electromagnetic radiation through air.

The three wireless media are mostly used,

1. Radio waves.
2. Microwaves.
3. Infrared.

1. Radio waves. (10KH2 to 1 GH2)

The range of electromagnetic spectrum between 10KH2 to 1GH2 is called radio frequency. (RF)

Radio waves include the following types,

1. Short wave used in AM radio.
2. Very High frequency (VHF) used in FM radio & TV.
3. Ultra High frequency (UHF) used in TV.

Radio waves can broadcast ominidirectionally or directionally.

They can travel long distance.

Radio waves are easy to generate.

They can penetrate buildings easily so they are widely used for communications both indoor & outdoor applications.

Applications of radio waves are,

1. Wireless LAN.
2. Radio Broadcasting.
3. Guided Missiles.
4. Television transmission.
5. RADAR.
6. Airplane Navigation.

2. Microwaves.

The electromagnetic waves having frequencies in the range of 1 to 300 GHz are known as microwaves.

These frequencies are higher than radio frequencies and produce better throughput & performance.

The microwaves are unidirectional and travel in straight lines. Therefore, microwaves can be narrowly focused concentrating all the energy into a small beam using a parabolic antenna like satellite TV dish.

Microwaves requires line of sight transmission. Line of sight means that the transmitter & receiver must be in view of each other.

Microwaves permits data transmission rate about 16 Giga bits per second.

Applications.

1. Wireless LAN.
2. Satellite communication.
3. Point to point communication bet^n stations.
4. Mobile telephone Network uses microwaves.

3. Infrared waves :-

Infrared is wireless transmission medium that sends signals using light waves.

Unguided infrared waves (light) are widely used for short range communication. The remote control used in TV, VCR all uses infrared communications.

They are relatively directional, cheap and easy to build, but have a major drawback, that they do not pass through solid objects.

Since infrared do not pass through solid objects they are blocked by solid walls and infrared system in one room of building do not interfere with similar system in adjacent room.

It provides low bandwidth.

Applications :-

1. In remote control of home appliances : e.g. TV, VCR, VCD & DVD player.
2. Indoor wireless LANs.
3. Keyboard, mouse, printers, scanners and for controlling fan, air conditions.

* Electromagnetic Spectrum:

In wireless communication, electromagnetic waves are used as media of transfer of information.

The information signal is converted into electromagnetic signal before transmission.

The electromagnetic (EM) waves consist of both electric and magnetic fields and they can travel a long distance through space.

The range of all possible frequencies of EM waves is called as electromagnetic spectrum.

The following fig. shows the electromagnetic spectrum.

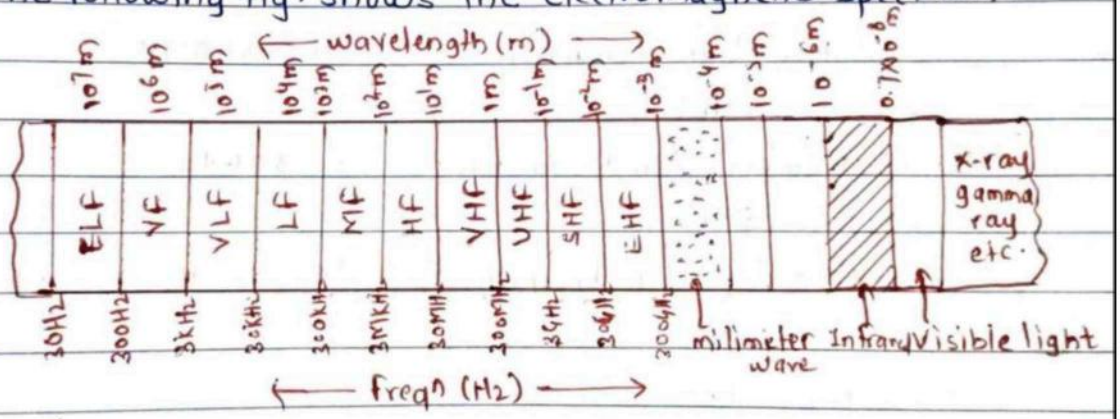


Fig: Complete Electromagnetic spectrum.

In midrange includes most commonly used radio frequencies for two way communications, televisions & other application.

In EM spectrum, we have used frequency as well as wavelength in order to define various segments.

wavelength is given by,

$$\lambda = \frac{c}{f} = \frac{\text{speed of light}}{\text{frequency}}.$$

$c = 3 \times 10^8$ m/s

We can obtain value of wavelength(λ) if freqⁿ is known.

segments of electromagnetic spectrum as shown below table,

Sr.No.	Name	frequency.	Wavelength
1.	Extremely low freq^{n} (ELF)	30-300 Hz	10^{7} to 10^{6} m
2.	Voice frequency (VF)	300-3000 Hz	10^{6} to 10^{5} m
3.	Very Low frequency (VLF)	3-30 KHz	10^{5} to 10^{4} m
4.	Low frequencies (LF)	30-300 KHz	10^{4} to 10^{3} m
5.	Medium frequencies (MF)	300-3000 KHz	10^{3} to 10^{2} m
6.	High frequencies (HF).	3.-30 MHz	10^{2} to 10 m
7.	Very High frequencies (VHF).	30-300 MHz	10 to 1 m
8.	Ultra High frequencies (UHF)	300-3000 MHz	1 to 10^{-1} m
9.	~~Extremely~~ Super High frequencies (SHF)	3-30 GHz	10^{-1} to 10^{-2} m
10.	Extremely High frequencies (EHF)	30-300 GHz.	10^{-2} to 10^{-3} m
11.	Intrared.	—	0.7 to 10 um
12.	Visible light	—	0.4 to 0.8 um

* Allotment of frequency Bands for Different Applications:

Various frequency bands such as LF, MF, RF, VHF, UHF etc. in EM are allotted in different communication applications.

Sr No.	Frequency Band	Frequency	Applications.
1.	Extremely low frequency (ELF)	30-300Hz.	Power transmission
2.	Voice freq^n (VF)	300-3000Hz	Audio Applications.
3.	Very Low frequency (VLF)	3-30KHz	Submarine communication, Navy, military communication.
4.	Low frequency (LF)	30-300KHz	Aeronautical & marine navigation
5.	Medium frequency. (MF)	300-3000KHz	AM radio broadcasting, marine & aeronautical communication.
6.	High freq^n (HF)	3-30MHz	short wave transmission.
7.	Very High frequency (VHF)	30-300MHz	TV Broadcasting, FM Broadcasting.
8.	Ultra High frequency (UHF)	300-3000MHz	TV channels, military applications.
9.	Super High frequency (SHF)	3-30GHz	Satellite communication and RADAR.
10.	Extremely High frequency (EHF).	30-300GHz	Satellite communication & specialized radars.

* Mobile Communication System:- (cellular concept):-

Mobile communication refers to the conversation established between two users at two different places with their hand held equipment.

Initially the focus of mobile communication was towards voice but later it also dealt with data. That include electronic mail, internet access, short message service, electronic address book, games, calculator. further research is in process to attract people towards commercial product.

In cellular systems, a single high power transmitter (large cell) is replaced by many low power transmitter (small cell) as shown in below fig.

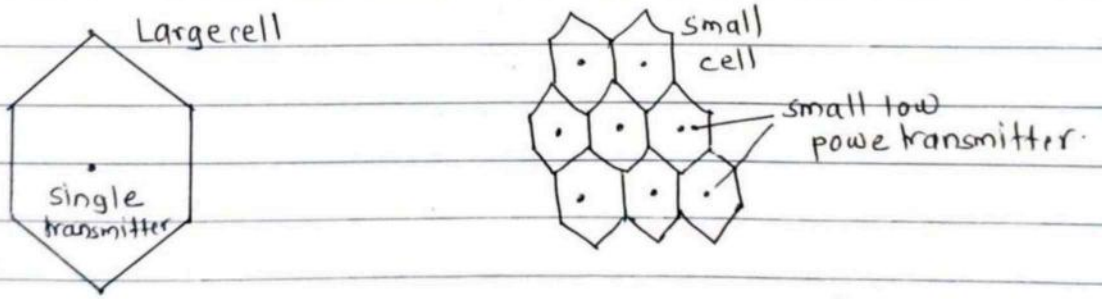


Fig:- The cellular concept.

A cellular mobile communications system uses a large number of low power wireless transmitter to create cell.

Each cell is served by at least one fixed location transceiver, known as basestation or cell site.

The cells are hexagonal in structure. A group of cells are called as cluster.

cluster size: Only certain cluster sizes are possible, principally due to geometry of a hexagoan & allows cluster sizes of 3, 4, 7 & 12 etc.

Frequency Reuse:

In a cellular network, each cell uses a diff. set of frequencies from neighboring cell, to avoid interference & provide guaranteed bandwidth within cell. The coverage area of cells are called as footprint. This footprint is limited by boundaries so that same group of channels can be used in different cells that are far enough away from each other so that their frequencies do not interfere.

* Basic structure of Mobile Phone System :→

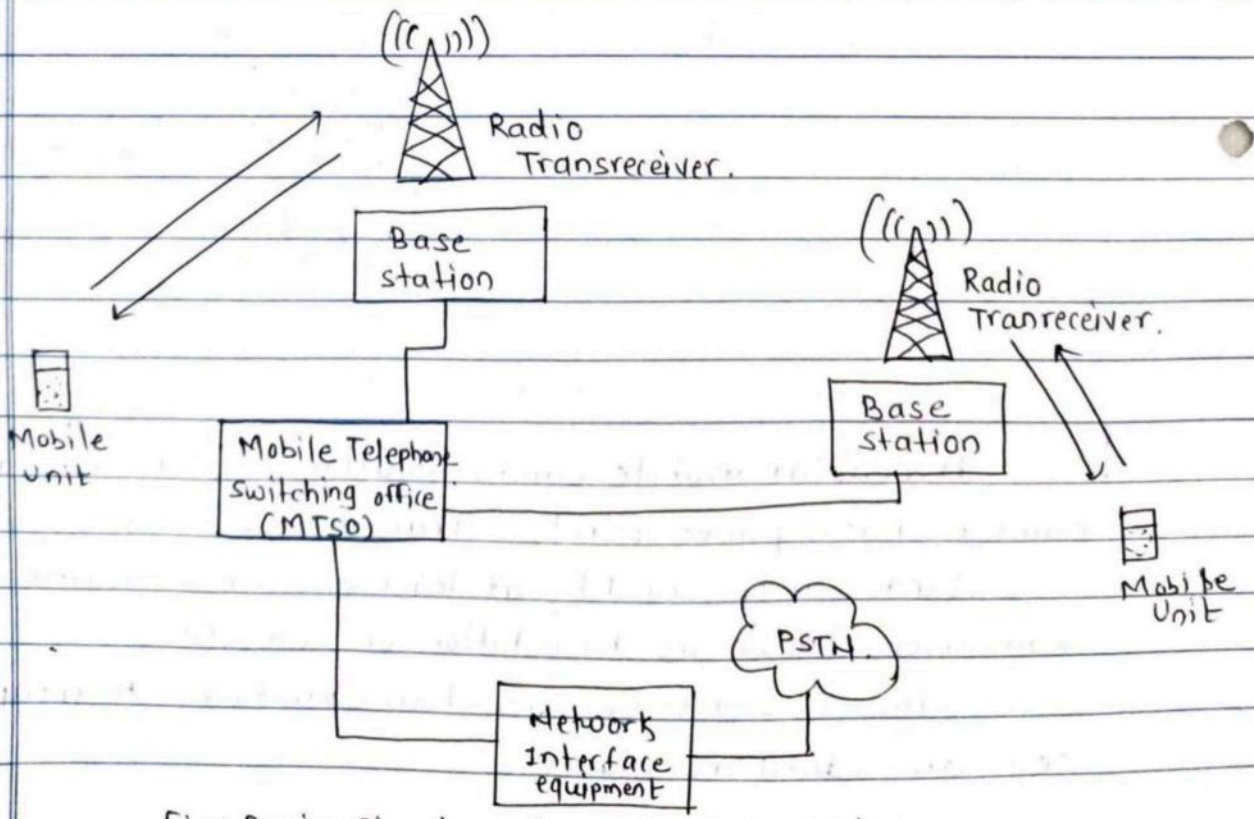


fig: Basic Structure of Mobile Phone system.

The figure shows the basic structure of mobile/cellular phone system. The cellular communicationsystem consist of following major components that work together to provide mobile service to subscriber:

1. A network of radio base station forming base station subsystem.
2. Mobile Telephone switching office (MTSO): The circuit switched network for handling voice calls & text etc.
3. The Public ~~Network~~ switched Telephone Network (PSTN): To connect subscribers to the wider telephony N/W.

Radio Base station:

The term base station is used to refer to the physical location of radio equipment that provides coverage within a cell. A list of hardware located at a base station includes power sources, interface equipment, radio frequency transmitter & receivers and antenna system.

It acts as bi-directional interface between mobile phone & cellular radio system.

The link from a phone to the RBS is called as forward link/uplink while other way is termed reverselink/downlink.

The Mobile Telephone switching office (MTSO) is central office for mobile switching. It consists of Mobile switching center (MSC), field monitoring and relay stations for switching calls from base stations to wireline central offices (PSTN).

Any phone connects to cellular network via an RBS (Radio Base station) at a corner of the corresponding cell which in turn concepts to the Mobile Switching Center (MSC). The MSC provides a connection to the Public switched Telephone Network (PSTN).

In analog cellular networks, the MSC controls the system operations such as calls, track billing information and locates cellular subscribers.

* GSM system :→ (Global System for Mobile).

GSM group system is a second generation (2G) cellular system developed in Europe.

It uses digital modulation and network level architecture & services.

GSM provides subscribers with high quality digital wireless phone service & clarity as well as enhanced call security & privacy.

Block diagram of GSM system :-

GSM system consist of many subsystems such as,

1. Mobile station (MS).
2. Base station subsystem (BSS).
3. Network & switching subsystem. (NSS)
4. Operating subsystem (OS).

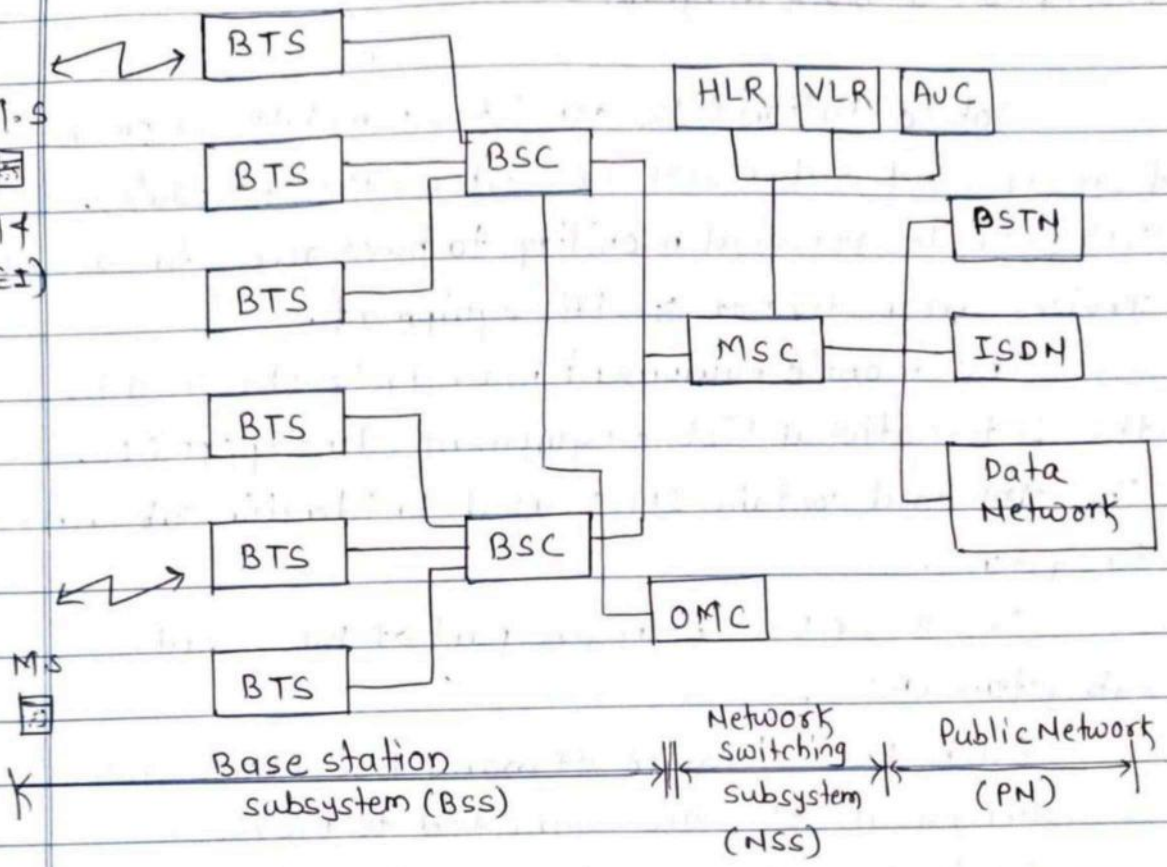


Fig:- GSM System Architecture.

Where, MS → Mobile station.

BTS → Base Transreceiver controller.

BSC → Base station controller

MSC → Mobile service switching center.

HLR → Home location Register.

VLR → Visitor location Register.

AUC → Authentication center.

OMC → Operation support Subsystem.

PSTC → Public switching & Telephone controller.

SIM → Subscriber Identity Module.

IMEI → International Mobile Equipment Identity.

Description of block diagram:-

Mobile station (MS) consists of mobile equipment (terminal) & smart card called SIM (subscriber Identity Module). SIM provides personal mobility to have access to subscribed services irrespective of specific equipment.

The mobile equipment is uniquely identified by the International Mobile Equipment Identity (IMEI). The SIM card contains IMSI used to identify subscriber to system.

The BTS & BSC both are part of Base station subsystem (BSS).

Each Bss is made of many BSCs (Base station controllers) & all BSCs are connected to MSC.

Each BSC has hundreds of BTSs (Bus Transreceiver stations) connected to it. These BTs are controlled by corresponding BSCs.

The BTSs are connected to BSCs either physically via microwave links.

The interface betⁿ BTs to BSC is called as Abis interface.

The BSCs are physically connected to MSC via dedicated lines or microwaves.

The NSS contains 3 different database called Home location Register (HLR), Visitor Location Register (VLR) & Authentication Center (AUC).

The HLR is a database containing the subscriber information & location information of each user, who is staying in the same city as MSC.

Each subscriber is assigned a unique International Mobile Subscriber Identity (IMSI) & this number will identify each user.

VLR database is used to temporarily store the IMSI and customer information for roaming subscriber.

AUC is ~~eor~~ strongly protected database which takes care of authentication and handles the encryption keys for all the subscribers in HLR & VLR.

The OSS supports one or more operation maintance centers. The OMC is used for monitoring & maintaining the performance of each MS, BS, BSC & MSC used in a GSM system.

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TCOER
BXE notes.

5) Sensors

Introduction:-

Instrumentation has become the heart of the industrial applications because instrumentation facilitates system automation.

The following diagram shows the blocks diagram of a instrumentation system. It indicates the necessary elements and their functions in a general measuring system.

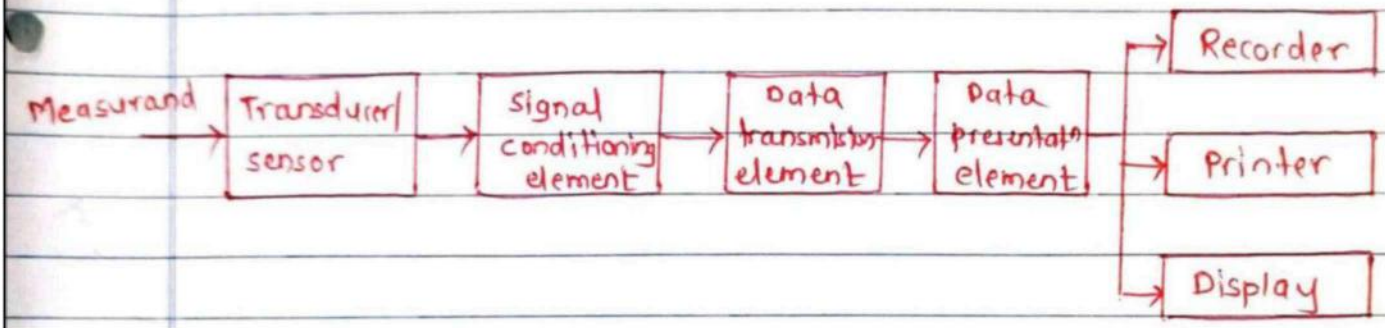


fig: Block Diagram of an instrumentation system.

Measurand: Most of the times input to the instrumentation system is the physical quantity such as temperature, pressure, displacement, force etc. such non-electrical input quantity is called measured.

Transducer / Sensor:

A transducer / sensor converts the non-electrical input measurand into a proportional electrical signal such as voltage or current.

Signal conditioning Elements:

It processes the output of the transducer & makes it suitable for control, recording & display.

Data Transmission Element:

The signal conditioning element processes the output of the transducer and makes it suitable for control, recording & display.

The examples of data transmission elements are,

1. Electrical cables/wires 2. fiber optics cables.
3. Radio links.

Data Presentation Element:

The transmitted data may be used for monitoring, controlling or analyzing purpose. So to get information in proper form, according to the purpose for which it is intended for, the data presentation elements ~~are~~ does the following fun^n;

1. Amplification 2. Demodulation.
3. A/D or D/A conversion. etc.

Recorder, pointer & display unit:-

These are used to monitor the variations in certain process.

1. Active Sensor :-

The sensors which do not need any external source of power for their operation are ~~etc~~ called as active sensor.

Active sensors are self generating device which operate under energy conversion principle.

examples are,

Thermocouple, photocell, piezoelectric, transducer.

2. Passive sensors :-

The sensors that need external power supply for their operation are called as passive sensor.

They are not self generating type sensor.

These sensors produce the output signal in the form of variation in resistance, capacitance or some other electrical parameter which is proportional to the input quantity to be measured.

examples are,

1. LDR, thermistor, strain guage, capacitor transducer.

Difference between Active sensor and passive sensor:-

	Active Sensor	Passive Sensor.
1.	These sensors does not require ~~powe~~ external power supply for operation	These sensors requires external power supply for operation.
2.	They are self generating type sensor.	They are not self generating type sensors.
3.	They produce electrical parameter such as voltage or current proportional to the physical parameter under measurement.	They produce the output signal in the form of variation in resistance, capacitance or some other electrical parameter which is proportional to i/p quantity to be measured.
4.	They are costly.	They are cheap.
5.	examples are, Thermocouple, photocell, piezoelectric, ~~etc~~.	examples are, Thermistor, RTD, LDR, LVDT, photo-transistor.

* characteristics of sensors (selecting a sensor):-

Sensors are selecting depending upon following parameter / characteristics,

1. Nature of measurement:

The selection of sensor will naturally depend upon the nature of quantity to be measured.

2. Sensing Range:

Sensors should be selected according to their sensing range.

3. Respond speed.

As the requirements of application sensor must be selected according to respond speed / time.

4. Linearity:

The relation between the output and input of a transducer should be linear. Linearity is very imp. characteristics while selecting sensor.

5. Accuracy:

The actual output produced by sensor to the ideal value of quantity being measured. for any sensor accuracy should be high.

6. High stability and reliability:

There should be a minimum amount of error in measurement and it should be unaffected by temperature, vibrations and other envioronmental vibrations.

7. Cost and availability:

General factors involved in selection are cost and availability.

8. Ruggedness:

It is the ability of a sensor to withstand overloads. A good sensor must have a high value of ruggedness.

9. low maintaince:

A sensor should selected according to its simplicity, reliability and maintenance cost.

10. Time span:

The time span indicates the time period for which a sensor works ~~reo~~ reliably. According to application sensor should be selected so that it will works properly for the desired time span.

* Motion Sensor - LVDT.

LVDT - Linear Variable Differential Transducer is a variable inductance displacement transducer in which the inductance is varied according to displacement.

The linear variable differential transformer consist of a single primary winding P_1 and two secondary windings S_1 & S_2 wound on a hallow cylindrical former as shown in following fig. The secondaries have an equal number of turns but they are connected in series opposition so that the e.m.f.s induced in the coils oppose each other & the output voltage is given by,

$$E_{out} = E_{s_1} - E_{s_2}.$$

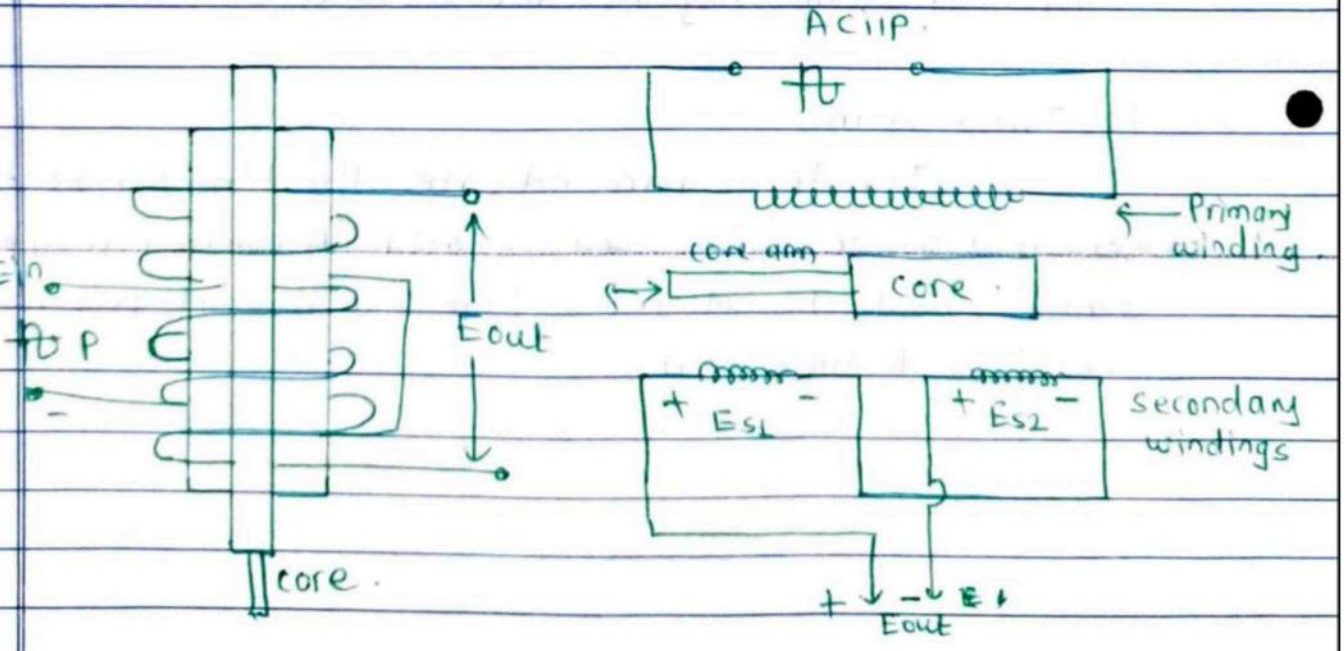


fig:- Linear variable differential transformer.

The primary winding is connected to an a.c. source, whose frequency may range from 50Hz to 20kHz.

A movable soft iron core slides inside the hollow former. The position of the movable core determines the flux linkage between the a.c. excited primary winding and each of two secondary windings.

The core made up of nickel-iron alloy is slotted longitudinally to reduce eddy current losses.

The displacement to be measured is applied to an arm attached to core.

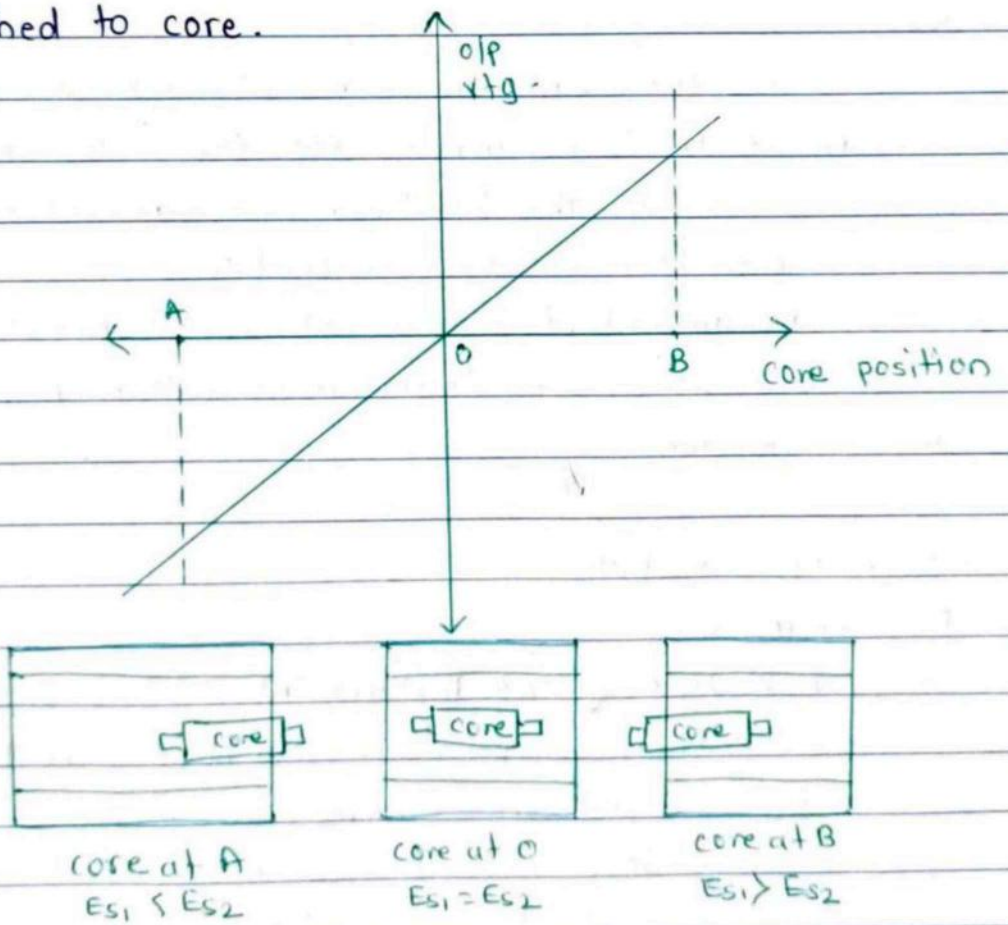


fig: Output voltage of LVDT at different core position.

operation:

When a.c. source is applied to primary and with the core in the centre or reference position, the induced e.m.fs in secondaries are equal ($E_{s1} = E_{s2}$) and since they oppose to each other, the o/p voltage will be zero volt.

When the core is forced to move the right (Position A), more flux links the right-hand coil than the left hand coil. i.e. $E_{s1} < E_{s2}$. Therefore, E_{out} is negative.

Similary, when an externally applied force moves the core to the left hand position (Position B), more magnetic flux links the left-hand coil than right hand coil. i.e. $E_{s1} > E_{s2}$. Therefore, E_{out} is positive.

The amount of output voltage of an LVDT is a linear function of core displacement within a limited range of motion.

Advantages of LVDT:-

A) Mechanical.

1. Wide range of displacement : ± 0.005 to ±25inch.
2. Frictionless operation : No physical contact exists between the core and coil structure.
3. Ruggedness : Good mechanical life.
4. Insensitive to temperature changes.
5. Highly repetable response.

B) Electrical.

1. Linearity : Better
2. High sensitivity.
3. Resolution : Infinite.
4. Electrical isolation is better.

Applications of LVDT.

1. The LVDT can be used in all applications where displacement ranging from fractions of a few mm to a few cm leave to be measured.

2. Acting as a secondary transducer, LVDT can be used as a device to measure force, weight and pressure etc.

* Temperature sensors :-

Thermocouple :-

Thermoelectric transducer is a temperature transducer which converts thermal energy into an electrical energy. The most commonly used thermoelectric transducer is thermocouple.

It is an active temperature sensor which does not require external power supply.

If the two wires of different metals are joined together forming closed circuit and if two junctions formed are at different temperatures, an electric current flows around a closed circuit. This is called as seebeck effect.

If two metals used are copper and iron, then the current flows from copper to iron at hot junction and from iron to copper at cold junction as shown in below figure,

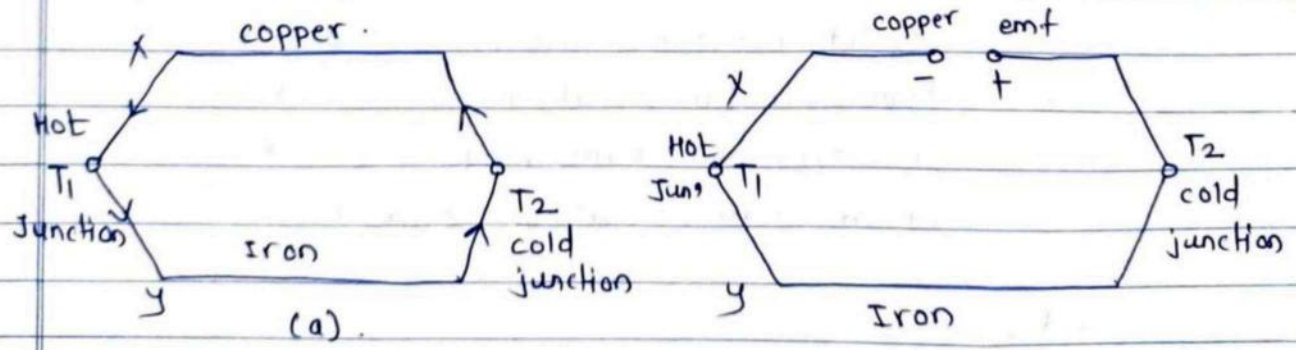


fig:- Seebeck Effect.

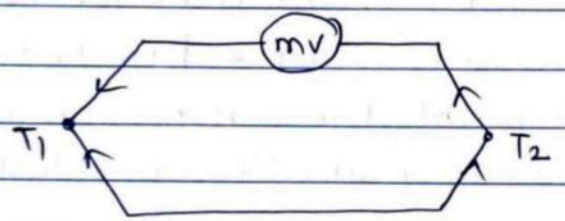
construction and operation of thermocouple:

When two dissimilar metal 'x' & 'y' are joined together to form two junctions J_1 & J_2.

If these junctions are kept at temp. T_1 & T_2 then a thermal emf is produced which is proportional to temp. difference $T_1 - T_2$.

$$e = K(T_1 - T_2).$$

A milivoltmeter is used tomeasure thermally generated emf as shown in below,



material used for thermocouple:

Different metals used for manufacturing thermocouple & their temp. ranges are as follows,

Copper - constantan alloy: 0 - 2000°f

Iron - constantan alloy: 0 - 1200°F

Platinum - Rhodium alloy - 0 - 3000°F

chromel - Alumel alloy - 0 - 900°F.

Advantages:-

1. Wide temperature range (-200°c to 1100°c)
2. External dc source is not required.
3. Good sensitivity.

Applications of thermocouples:

Thermocouples are used for the applications for which a wide temperature range operation is required.

Thermocouples are also used in those applications where temperatures at remote places are to be measured.

Resistance type temperature sensors (RTD):

Defn: RTD is defined as temp. sensor whose resistance changes in proportion with its temp.

Principle:

The principle of operation of resistance type temp. sensors (RTD) is based on fact the resistance of substances like metals & semiconductors changes with change in temp.

RTD stands for Resistance Temperature Detector.

The resistance of metal increase with increase in temp. Therefore metals have a positive temp. co-efficient of resitivity

However, some semiconductor materials have a negative temp. coeffient resistivity.

The relation between resistance of temp. sensor & temp. is given by,

$$R_t = R_0(1 + at + bt^2).$$

where, a & b are constant, t is change in temp.

The resistance type temperature sensors are of two types:

1. Platinum Resistance Thermometer (PRT).
2. Thermistor.

Platinum resistance element is most popular option for any application because of its high accuracy and reproducibility.

Whereas semiconductor materials are used for thermistor.

Platinum Resistance Thermometer (RPRT).

Construction.

Following fig. shows simplest type of open wire construction of platinum resistance thermometer (PRT).

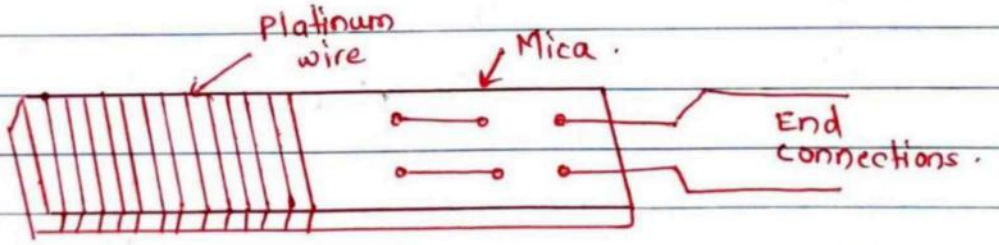


fig: Construction of an open wire PRT (RTD).

The platinum wire is wound in the form of spirals on an insulating material such as mica or ceramic.

This wire is in direct contact with the gas or liquid whose temperature is to be measured. This gas or liquid however should not be corrosive or conductive.

Principle:

The resistance of the platinum wire changes with change in temperature of the gas or liquid.

The maximum temperature measurable in continuous operation is 1000°K i.e. 727°C.

This type of sensors have a positive temperature coefficient of resistivity as they are made from metals.

The variations in resistance of PRT are converted into proportional voltage variations by connecting it in wheatstone's bridge as shown in below figure,

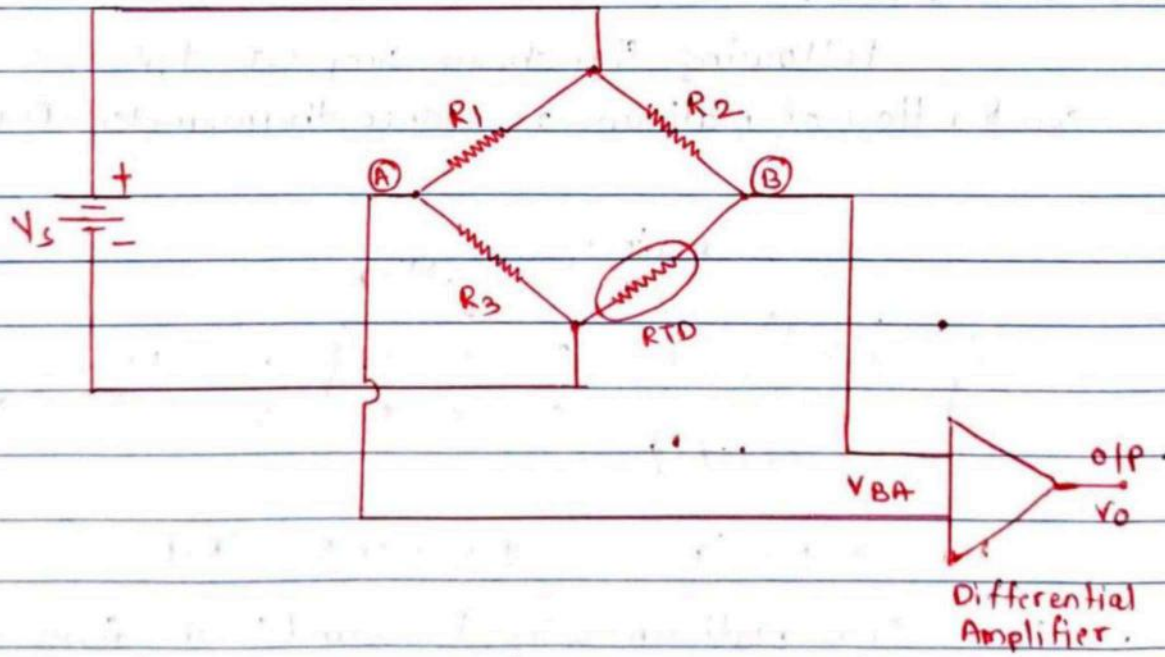


fig: Bridge circuit for measurement using RTD.

The voltage at point A is given by following exp.

$$V_A = \frac{R_3}{(R_1+R_3)} \times V_s.$$

Advantages of RTD:

1. They can be used for measurement of small as well as large temperature differences.
2. High accuracy.
3. Good dynamic response
4. Wide temperature range (-200°C to 650°C).
5. No need of temp. compensation.

* Biosensors :-

A biosensor is a device that measures biological or chemical reactions by generating signals proportional to concentration of an analyte in the reaction. It includes a combination of biological detecting elements like sensor system and a transducer.

A typical biosensor is as shown below figure. It consist of following components,

1. Analyst 2. Bioreceptor. 3. Transducer.

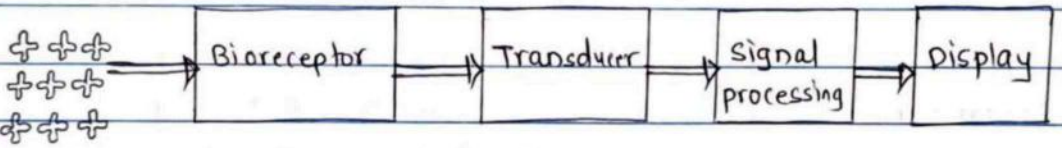


fig:- Biosensor.

Analyte! A substance of interest that needs detection. for instance, glucose is an 'analyte' in a biosensor designed to detect glucose.

Bioreceptor: A molecule that specifically recognizes analyte is known as bioreceptor.

Enzymes, cells, aptamers, deoxyribonucleic acid (DNA) & antibodies are some examples of bioreceptors. The process of signal generation upon interaction of the bioreceptor with the analyte is termed bio-recognition.

Transducer:

In a biosensor role of transducer is to convert bio-recognition event into a measurable signal.

Biosensors are employed in applications such as disease monitoring, drug discovery and detection of pollutants, disease-causing, micro-organism and markers that are indicators of a disease in bodily fluids.

Working Principle.

- Biosensors are operated based on the principle of signal transduction. These components include a bio-recognition element, a biotransducer & electronic system composed of a display processor and amplifier.

- The bio-recognition element, essentially a bioreceptor is allowed to interact with a specific analyte. The transducer measure this interaction & outputs a signal. The intensity of signal output is proportional to the concentration of the analyte. The signal is then amplified & processed by the electronic system.

Types of biosensor:

Biosensors can be of following types.

1. Electrochemical biosensors.
2. Amperometric biosensors.
3. Potentiometric biosensors.
4. Physical biosensors.
5. Optical biosensors.
6. Wearable biosensors.

Application of biosensor:-

Some of the major application of biosensors are listed below,

1. Medicine and health:-

Biosensors are used for quantitiative estimation of several biologically important substances in body fluids. e.g. glucose, urea, cholesteral. etc.

2. Industry:

Biosensors can be used for monitoring of fermentation products and estimation of various ions.

3. Pollution control:

Biosensors are very helpful to monitor enviornmental pollution.

4. Military:

Biosensors have been developed to detect the toxic gases and other chemical agents used during war.

5. food industry.

6. Insulin treatment.

7. Metabolites Measurement.

* Mechanical Sensor (strain Gauge) :-

Stress is a measurement of how much internal pressure a material is under when a force acts on it.

strain is what happens as a result of stress. If a material is stressed by a force, it changes shape & gets a little bit longer or shorter.

Principle of working of strain gauges.

When force is applied to any metallic wire its length increases due to strain. The more is the applied force, more is the strain and more is the increase in length of wire. If L_1 is the initial length of the wire and L_2 is the final length after application of force, the strain is given as,

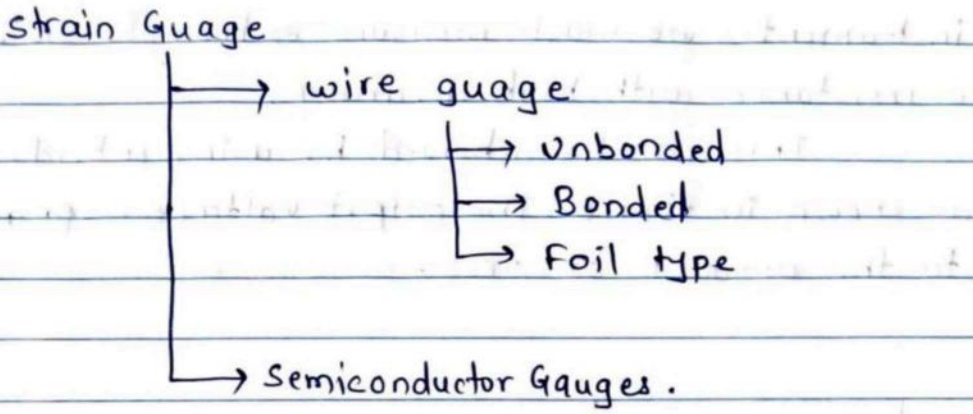
$$\varepsilon = (L_1 - L_2) / L_1.$$

The resistance of a uniform wire is directly proportional to its length and inversely proportional to its cross-sectional area.

$$R = \frac{\rho l}{A}.$$

Here R is the resistance of the wire in ohms, l is length of wire & A is cross sectional area.

Types of strain guage.



* Semiconductor strain ~~Guta~~ Gauge.

Principle:

If a metal conductor is streched or compressed, its resistance changes due to change in its length and it's diameter.

Similarly there is a change in the value of resistivit of a semiconductor when it is strained. This property is called as the piezo resistivity.

The semiconductor strain gauges operate on the piezo resistive property of doped silicon and germanium.

Construction.

Semiconductor strain guages are fabricated from single crystral of silicon and germanium.

figure shows below construction of a semiconductor strain guage.

The resistance of semiconductor guage changes mainly due to changes in resistivity of semiconductor material itself.

Working.

In order to use strain guages as a practical instrument, we must measure extremely small changes in resistance with high accuracy.

This can be acheived by using a bridge circuit as shown in figure. The output voltage is proportional to the amount of stress.

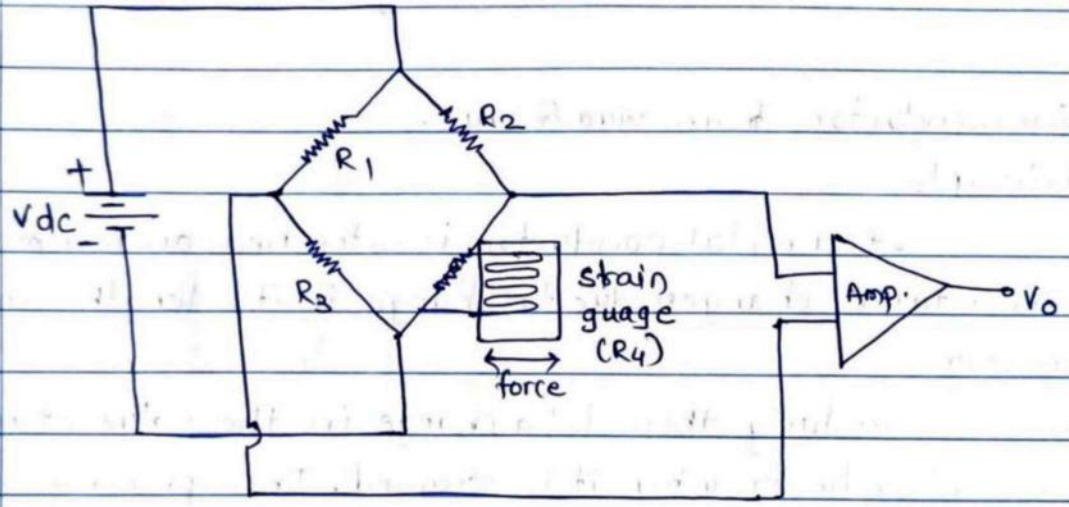


fig: Connecting a strain guage in a bridge.

This increase its sensitivity twice or four times respectively as compared to a single guage.

Advantages:-

1. change in resistance is much higher than that of conventional metal alloy types.
2. High guage factor.
3. chemical inetness.
4. Small size.

Disadvantages.

1. Poor linearity.
2. More expensive.
3. Sensitive to changes in temperature.

Applications of strain guage.

Strain guages are used for applications such as pressure measurement, weight measurement etc.

* IoT Based Data Acquisition & Automation system:

A Data acquisition system is a collection of hardware & software that measures & records physical or electrical signals to create data. Automation system that controls industrial processes such as supervisory control & data acquisition system. (SCADA)

Following block diagram of IoT based data acquisition & automation system show that data flows from sensors to the user interface

Different component of block diagram & their functions are as follows:

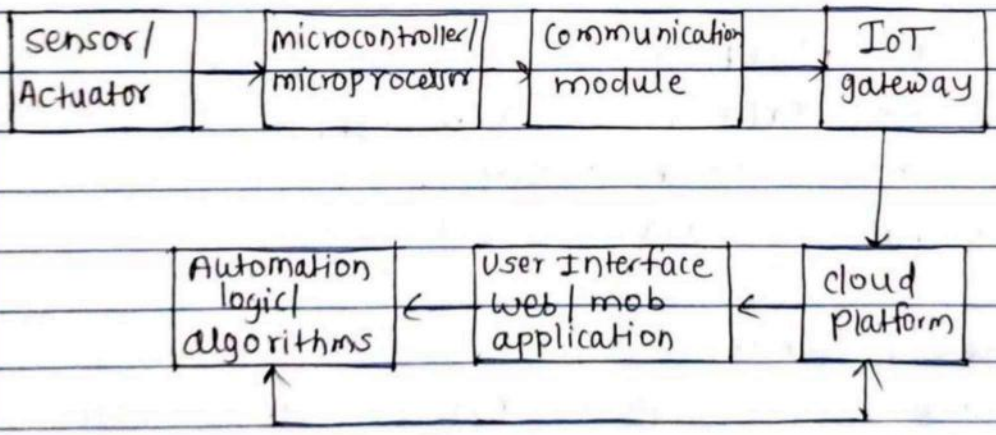


fig- Block diagram of IoT based data Acquisition & automation system

1. Sensors:

collect data from the environment.
e.g. temp sensor, humidity sensor, motion sensor.