Telemetry System

Semester 3rd

Chapter-1

Telemetry Principles

Prof Z D Mehta
Instrumentation and control Department
Government Polytechnic Ahmedabad

Telemetry Principles

What is Telemetry?

The term telemetry is derived from the two Greek terms: *"tele"* and *"metron"*, which mean *"remote"* or *"far off"* and *"measure"*, respectively. Accordingly, telemetry is the measurement of remote (or far-off) variables or quantities. A physical variable or quantity under measurement is called *measurand*.

Where is Telemetry Required?

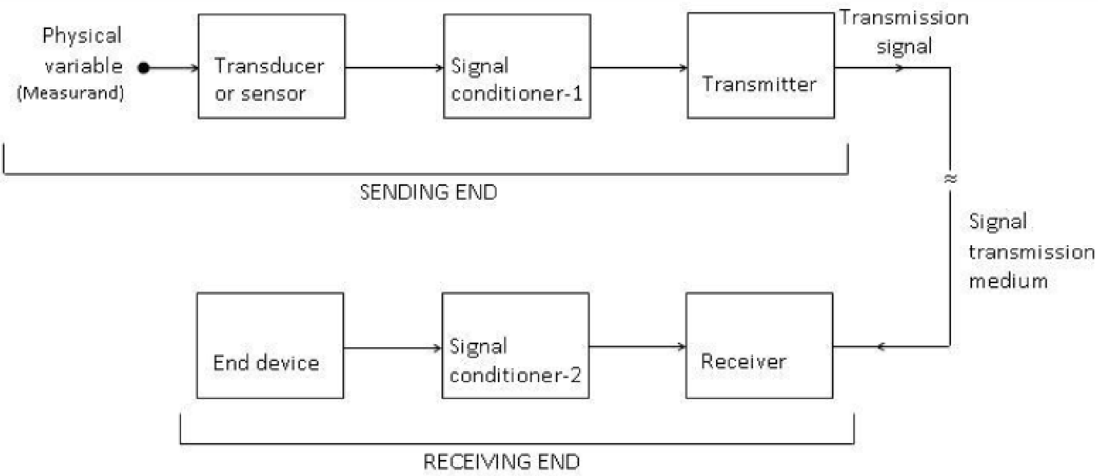
Use of telemetry techniques becomes essential in two situations, or in other words for two cases, given below, where the conventional measurement or local measurement techniques cannot work:

(a) *Distant location of the measurand:* Telemetry uses electrical communication for transmitting electrical signal representing the value of the measurand from the location of the measurand to the location of the user.

(b) Inaccessibility of the measurand: In such a situation, the electrical output of the transducer (or sensor) sensing the measurand, or that of the associated signal conditioner, cannot be accessed by conventional method of connecting wires. Therefore, the electrical output is converted to a radio wave, which is then transmitted to the user's location. This type of telemetry is called *Radio Telemetry*. If this radio telemetry is meant for covering only a short distance as the user is not physically far off from the measurand, then it is called *Short Range Radio Telemetry*.

Block diagram of Telemetry system

Block schematic of a basic telemetry system is given below. Location of the physical variable or measurand (from where the information, that is, the value of the measurand is sent) is called the *Sending End* of the telemetry system while the location of the user or the end device (where the information is received and used) becomes the *Receiving End* of the telemetry system. 2



Purpose and function(s) of each of building-block or element of the telemetry system shown in the figure are briefly described below:

(a) Transducer or Sensor: Converts the physical variable to be telemetered (that is, the measurand) into an electrical quantity. This quantity in most cases is either an electrical parameter (variable resistance, inductance or capacitance) or an electrical signal (voltage or current).

(b) Signal Conditioner-1: Converts the *electrical output* (which may or may not be a signal, as explained above) of the transducer (or sensor) into an *electrical signal* compatible with the next element, i.e. the transmitter. The incompatibility could be either in the form (such as parameter versus signal, voltage versus current, analog versus digital, etc) or in the magnitude of the signal (that is, it is too weak to be used by the next element).

(c) Transmitter: Its purpose is to transmit the information signal (a signal containing information, i.e. a signal which is a function of the value of the measurand) coming from the signal conditioner-1 using a suitable carrier signal to the receiving end. It may perform one or more of the following functions:

(i) *Modulation:* Modulation of a carrier signal by the information signal.

(ii) *Amplification:* As and if required for the purpose of transmission.

(iii) *Signal Conversion:* As and if required for the purpose of transmission. For example, voltage to current conversion, or analog to digital conversion, or electrical signal to radio wave conversion, or electrical signal to optical beam conversion, depending on the nature of the carrier signal and the signal transmission medium.

(iv) *Multiplexing:* If more than one physical variables need to be telemetered simultaneously from the same location, then either frequency-division multiplexing (FDM) or time-division multiplexing (TDM) is used.

(d) Signal Transmission Medium: It is the medium or link that connects the sending or transmitting end to the receiving end, over which the transmitter can transmit its output signal to the receiver.

(e) Receiver: Its purpose is to receive the signal(s) coming from the transmitter (located at the sending end of the telemetry system) via the signal transmission medium and recover the information from the same. It may perform one or more of the following functions:

(i) Amplification: Amplification of the received signal as and if required for the purpose of further processing.

(ii) Demodulation: Demodulation of the received signal to recover information signal. The demodulation process has to be complementary of the modulation performed by the transmitter.

(iii) Reverse Signal Conversion: This conversion is generally the reverse of the conversion performed by the transmitter. Thus the receiver is required to perform current to voltage conversion, or digital to analog conversion, or radio wave to electrical signal conversion, or optical beam to electrical signal conversion, depending on the nature of the carrier signal and the signal transmission medium.

(iv) De-multiplexing: It refers to the process of segregating or separating various information signals so that they can be delivered to their respective end devices. The process in the receiver has to be essentially the reverse of the multiplexing carried out by the transmitter.

(f) Signal Conditioner-2: Processes the receiver output as necessary to make it suitable to drive the given end device.

(g) End Device: The element is so called because it appears at the end of the system. Depending on the purpose of the telemetry in the given situation, the end device may be performing one of the following functions:

(i) *Analog Indication:* Analog indication of the value of the measurand through the deflection of a pointer on a scale. The device used is very often a permanent magnet moving coil (PMMC) meter.

(ii) *Digital Display:* Digital display of the value of the measurand on LEDs, LCD, monitor screen etc.

4

(iii) *Digital Storage:* Storage of the digital value of the measurand in electronic or optical storage device for a later use.

(iv) *Data Processing:* The digital values of the mesurand may be given to a data processor, such as a microprocessor, digital signal processor or computer, for analysis etc.

(v) *Closed-Loop Control:* The analog or digital output of the signal conditioner-2, representing the value of the measurand, may be fed to an *automatic controller* as the *feedback signal*.

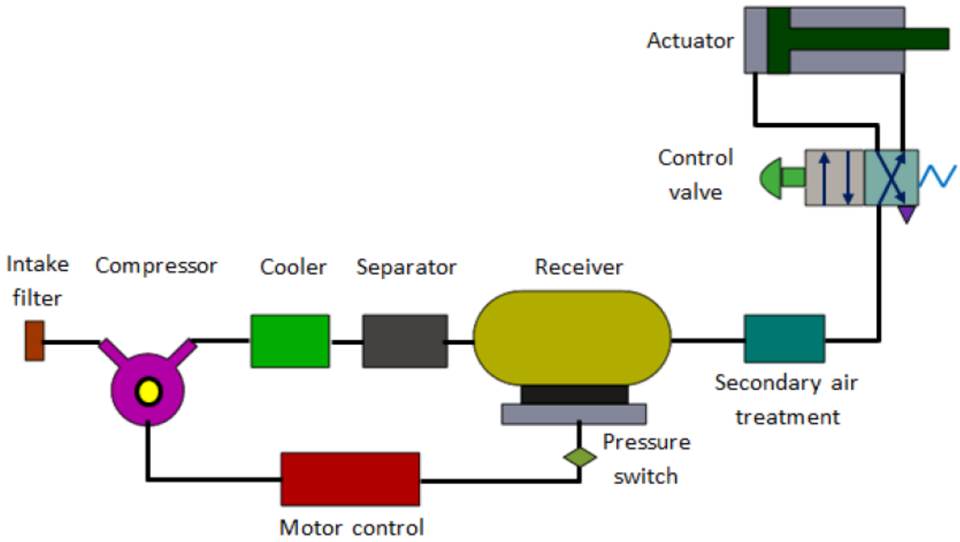
Types of Telemetry System

The Telemetry system can be classified as follow:

- **According to Energy Medium**
    - Pneumatic Telemetry,
    - Hydraulic Telemetry
- **According to Electrical**
    - Current Telemetry, Voltage Telemetry
    - Pulse Telemetry
- **According to Signal Type**
    - Analog Telemetry,
    - Digital Telemetry

Pneumatic Telemetry

Pneumatic technology deals with the study of behavior and applications of compressed air in our daily life in general and manufacturing automation in particular. Pneumatic systems use air as the medium which is abundantly available and can be exhausted into the atmosphere after completion of the assigned task



Important components of a pneumatic system are as below:

a) Air filters: These are used to filter out the contaminants from the air.

b) Compressor: Compressed air is generated by using air compressors. Air compressors are either diesel or electrically operated. Based on the requirement of compressed air, suitable capacity compressors may be used.

c) Air cooler: During compression operation, air temperature increases. Therefore coolers are used to reduce the temperature of the compressed air.

d) Dryer: The water vapor or moisture in the air is separated from the air by using a dryer.

e) Control Valves: Control valves are used to regulate, control and monitor for control of direction flow, pressure etc.

f) Air Actuator: Air cylinders and motors are used to obtain the required movements of mechanical elements of pneumatic system.

g) Electric Motor: Transforms electrical energy into mechanical energy. It is used to drive the compressor.

h) Receiver tank*:* The compressed air coming from the compressor is stored in the air receiver.

Advantages of Pneumatic Telemetry

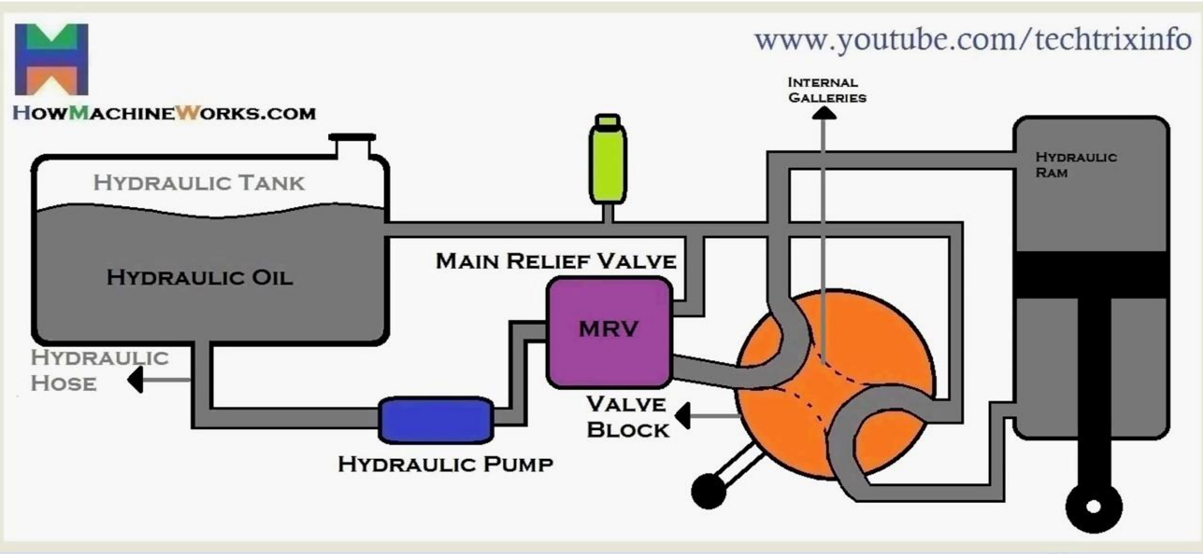
- High effectiveness
- High durability and reliability
- Simple design
- High adaptability to harsh environment
- Safety

- Easy selection of speed and pressure
- Environmental friendly

Disadvantages of Pneumatic Telemetry

- Relatively low accuracy
- Low loading
- Processing required before use
- Uneven moving speed
- Noise

Hydraulic Telemetry System:



- A hydraulic system circulates the same fluid repeatedly from a fixed reservoir that is part of the prime mover.
- The fluid is an almost non-compressible liquid, so the actuators it drives can be controlled to very accurate positions, speeds, or forces.
- Most hydraulic systems use mineral oil for the operating media but other fluids such as water, ethylene glycol, or synthetic types are not uncommon. Hydraulic systems usually have a dedicated power unit for each machine.
- The main components of a typical hydraulic systems are as below:

  a)Hydraulic tank: stores liquid /fluid

  b)Hydraulic pump: A hydraulic pump is a mechanical source of power that converts mechanical power into hydraulic energy (hydrostatic energy i.e. flow, pressure). It generates flow with enough power to overcome pressure induced by the load at the pump outlet.

  c)Main relief valve: A hydraulic valve properly directs the flow of a liquid medium, usually oil, through your hydraulic system. The direction of the oil flow is determined by the position of a spool

d)Filter: Remove dust particals before liquids enters into tank

Advantages of Hydraulic system:

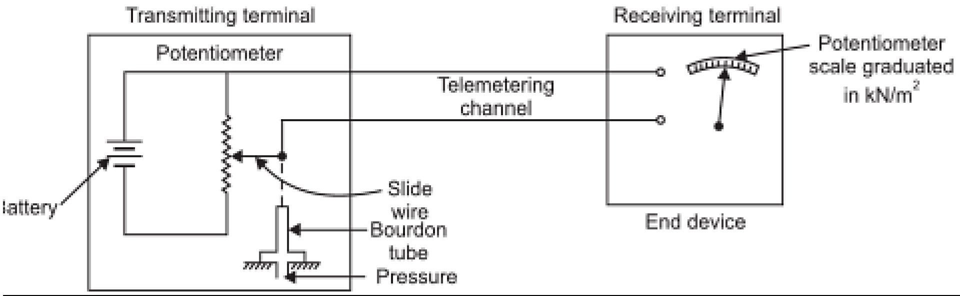
- It gives more power than pneumatic systems.
- Its reliable to operate.

Disadvantages of Hydraulic system:

- Slower motion than pneumatic.
- Complex construction.
- Leakage of oil problem
- More maintenance than pneumatics

Voltage Telemetry System:

- In these systems the *measurand is converted to A.C. or D.C. voltage.*
- For such systems, the *self-balancing potentiometers are the usual receivers.*



Construction :

— It consists of a slide-wire potentiometer connected in series with a battery at the transmitting terminal. The sliding contact is connected to the bourdon tube used for pressure measurement.

— At the receiving terminal a null balance D.C. potentiometer or a recorder is used.

— In between the transmitting terminal and the receiving terminal, a pair of wires form a telemeter channel.

Working/Operation :

— With the change of pressure in the system, the bourdon tube actuates the slider of the potentiometer. Consequently, the voltage changes at the transmitting end.

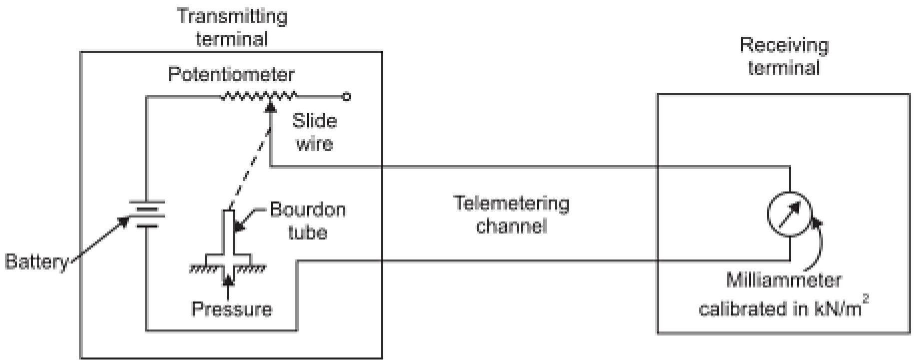
— This voltage is carried by the telemetering channel to the receiving terminal, where it is measured with the help of null balanced D.C. potentiometer indicator calibrated in terms of pressure scale (kN/m^2) or recorded if required. Some systems make use of the deflection type indicators to measure voltage; these indicators are calibrated for the line resistance. Basically, a null balance D.C. potentiometer reduces the current carried by the telemetering channel with negligible resistance.

Such systems use primary sensing elements (detectors) such as *microphones, tachometers, bourdon tubes or differential transformers as all produce voltage signal.*

Disadvantage : These systems are affected by line resistance, leakage, interfering sources nearly, noise and require higher-quality circuits than current systems, especially for low voltages.

- The voltage telemetering system is *limited for transmission upto 300 metres distances.*
- A voltage telemetering system is *very much suited for adding several input voltages in series* provided the measurement is *linear*. However, this system needs a relatively *more expensive receiving terminal*. This system is normally *not suitable* to the use of many receivers at the same time.

Current Telemetry System:



Construction :

— It consists of a slide-wire potentiometer in series with a battery.

— The slider is connected to the bourdon tube which measures pressure.

— At the receiving terminal, a multimeter is connected in series, which is calibrated in terms of pressure scale (kN/m^2).

Working/Operation :

— When the pressure in the system changes, the bourdon tube moves the sliding contact thereby changing the current at the transmitting terminal.

— This current passes to the receiving terminal through the pairs of wires (telemetering channel) and at the receiving terminal it is measured by the milliammeter.

These days, the following *improved versions* of this system are used :

1. Motion balance system; 2. Force balance system

1. Motion balance current telemetering system :

In this system slide-wire potentiometer is replaced by a position detector like inductor transducer or capacitor transducer.

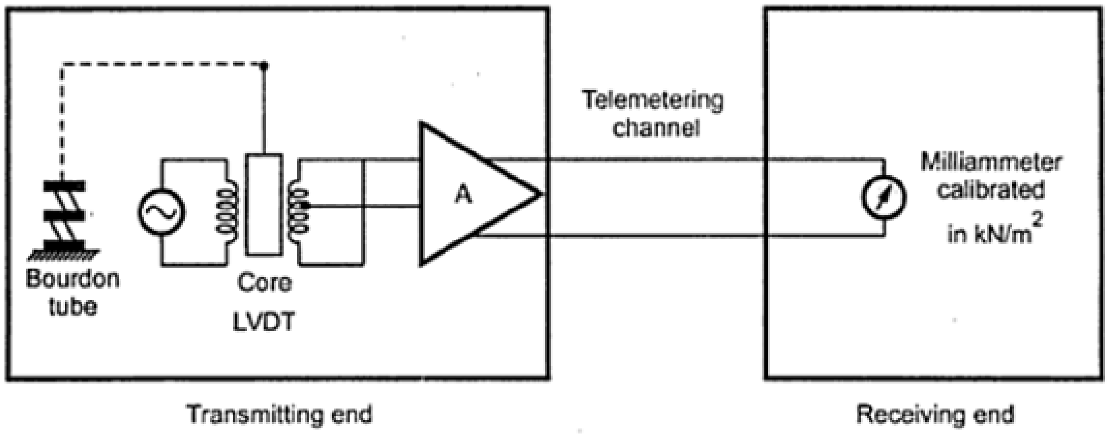


Fig.19.7

Fig. 19.7. shows a motion balance current telemetering system where a linear variable differential transducer (LVDT) has been used as inductive transducer :

— The pressure acting on the bourdon tube causes a displacement which moves the core of the LVDT, thereby producing a voltage output which is *amplified* by an amplifier and then *rectified*.

— This voltage *produces D.C. current in the telemetering channel* and is measured by a D.C. milliammeter directly calibrated in terms of pressure being measured.

2. Force balance current telemetering system :

In this system *part of the current output is fed back to oppose the motion of the input variable being measured.*

Fig. 19.8. shows the force balance current telemetering system :

— The bourdon tube, after sensing change in pressure, rotates the feedback force coil.

— As the coil rotates, the flux linkages between the primary and secondary windings change. This change in flux linkages varies the amplitude of the amplifier. The output is connected to the feedback force coil which produces a force opposing the bourdon tube input.

This system of current telemetering *increases the accuracy as small variations are required which result in better linearity.*

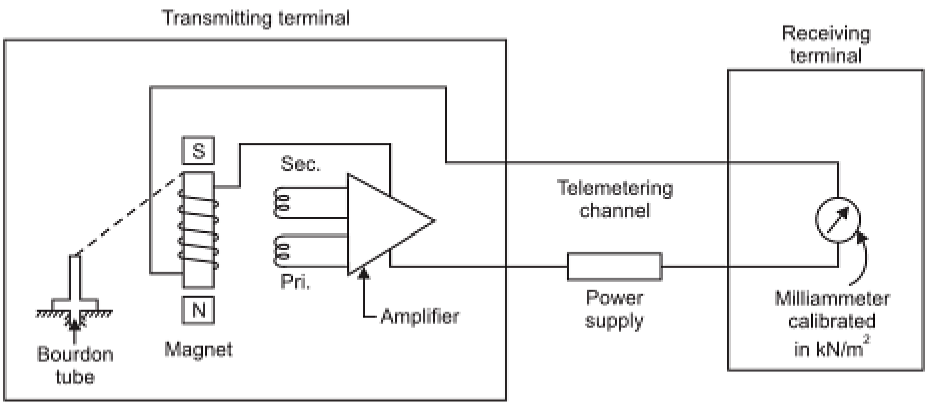


Fig. 19.8. Force balance current telemetering system.

Advantages of current telemetering system :

(*i*) The current systems can develop higher voltages than most voltage systems and, consequently, it can be made more immune to the effect of thermal and inductance voltages in the interconnecting leads as well as line resistance.

(*ii*) Simple D.C. milliammeters can be used with special calibration for line resistance.

(*iii*) Several receivers can be operated simultaneously.

(*iv*) The received signals can be added or subtracted directly.

(*v*) Changes in line resistance are compensated by basic feedback method.

(*vi*) The response of the system to an input change is almost instantaneous.

(*vii*) The energy level is adequately high to minimise the effects of extraneous voltages.

- This system is *also not suitable for long distance* since the current output is varied by means of an adjustable resistance in the line.

Pulse Telemetry System

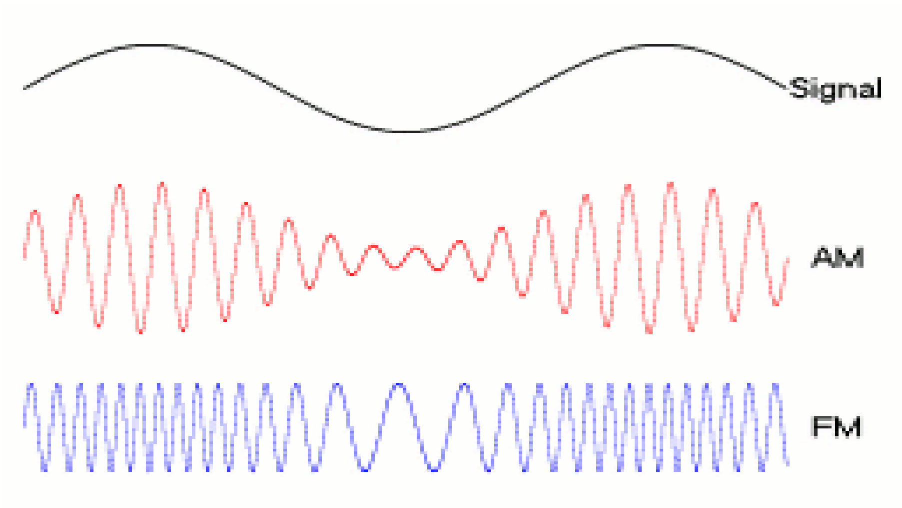
These telemetry systems use a pulse carrier, which is modulated using one of the pulse modulation techniques.

There are four telemetry systems in this category:

1. Pulse amplitude modulation (PAM) telemetry system
2. Pulse width modulation (PWM) telemetry system
3. Pulse phase modulation (PPM) telemetry system
4. Pulse code modulation (PCM) telemetry system

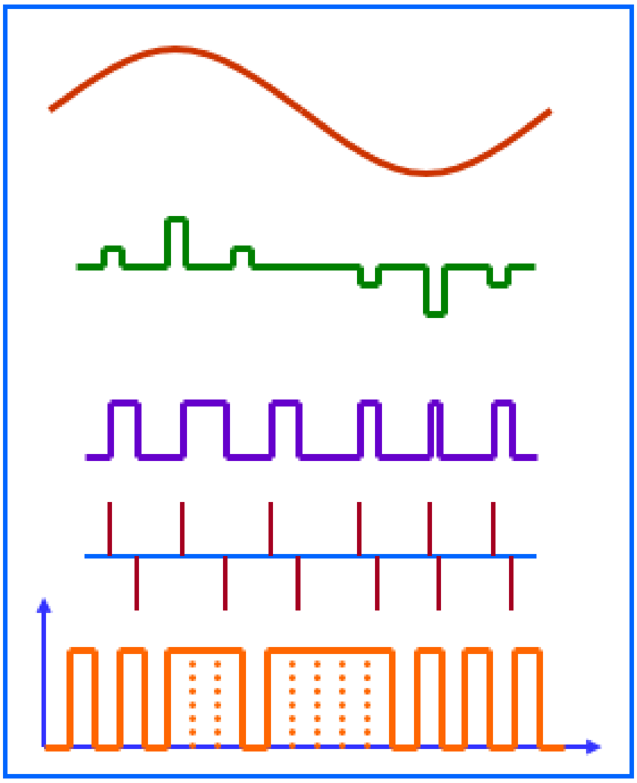
Analog Telemetry

If the information in the form of current, voltage, Possion, frequency than the system is called analog system



Digital Telemetry

If the information is transmited in the form of pulses than the system is called Digital telemetry system



COMPARISION OF HYDRAULIC, PNEUNATIC AND ELECRIC TELEMETRY:

Criteria	**Electrical system**	**Hydraulic system**	**Pneumatic system**
Energy Production	Hydro, nuclear	Pump, Electrically Driven	Compressor, Electrically Driven
Availability Of Medium	Generally Available Everywhere	Obtaining And Disposing Of Oil Is Costly	Air is freely available
Energy Storage	In Batteries and cells to a small extent; Expensive and maintenance difficult	Limited storage capability in accumulator, Gas is needed as an auxiliary medium	Large amount can stored in receiver tank without amount of extent.
Energy Transmission	Large distance, even beyond 1000km	Up to 100 m	Up to 1000 m

Cost of Energy	Smallest	High	Highest
Controllability	Limited means of control, High cost	Speed control is very good especially in slow speed range	Speed control is easy, but uniform speed is not possible
Linear force	Lower forces , Poor efficiency, problem of overloading , high energy consumption during no-load and large physical size	Large forces due to high pressure, good controllability, and possibility of large stoke	Force limited up to (50000 N)due to low pressure and cylinder, high speed operation(up to 1.5 m/s) , high acceleration, stroke up to 10 m possible
Rotary force	Using electric motors, highest efficiency, limited speed	Using hydraulic motors, good efficiency, easily controllable when moving slow, high performance due to high pressure	Using air motors, very high speed, up to 50000 rpm, simple, reversible
Adjustment of force	Very complicated	Simple due to pressure regulating valve	Simple due to pressure regulating valve
Consumption at standstill	Standstill with load and no specific precaution leads to destruction	Maximum energy consumption at full force	No energy consumption at standstill
Overloading	Not loadable at standstill	Loadable until standstill	Loadable until standstill
Temperature influence	Insensitive to variations in temperature	sensitive to variations in temperature	Relatively insensitive to variations in temperature
Leakage	Lethal accident risk at high voltage	Lose of energy and environment fouling	Loss of energy
Handling	Specialized knowledge required	More intricate	Good result obtainable
Noise	Loud actuating noise of contactors and relays	Pump noise at high pressure	Unpleasant exhaust noise can be reduced by installing silencers.