LECTURE NOTE ON

MECHATRONICS

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Contents

Introduction to Mechatronics

* Mechatronics:-

→ Mechatronics may be defined as the synergistic combination of various engineering branchs in the design of product & manufacturing processes.

* Advantages & disadvantages of mechatronics.

Advantages:-

→ The product produce are cost effective & very good quality.
→ High degree of flexibility.
→ A mechatronics product can be better than just sum of its parts.
→ Greater extent of machine utilisation.
→ Due to the combination of control system & sensors in a complex system, capital expenses are reduced.
→ Greater productivity.

Disadvantages:-

→ High initial cost of the system.
→ It requires knowledge of different engineering fields for design & implementation.
→ Specific problems for various systems will have to be addressed separately & properly.
→ It is expensive to incorporate mechatronics approch to an existing system.

* Application of Mechatronics:-

→ Automotive mechanics.
→ Fax & photocopier machines.
→ Dishwashen.
→ Airconditioners & elevator controls.
→ Automotive washing machine.
→ Document Scanner.
→ VCRs & CD players.

* Scope of Mechatronics in industrial sector:-

→ Better design of product.
→ Better process planning.
→ Reliable & quality-oriented manufacturing.
→ Intelligent process control.

*Components of Mechatronics System :-

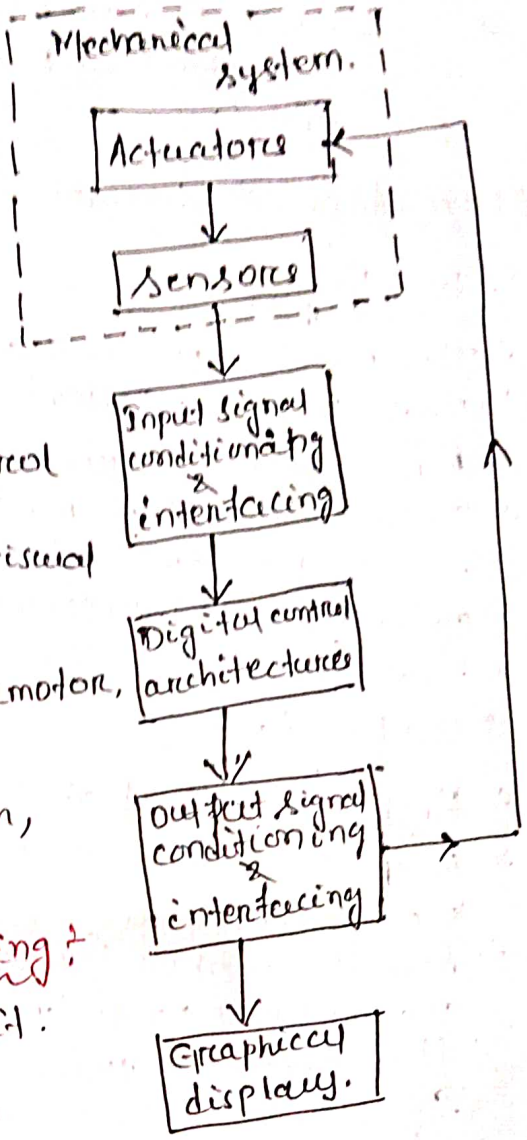
-> **Actuators :-** The actuators produce motion & cause some action.

-> **Sensors :-** The sensors detect the state of the system input & output.

-> **Digital Device :-** Digital Devices control the system.

-> **Conditioning & interfacing circuits :-** It provides connection between the control circuits & the input/output devices.

-> **Graphical displays :-** It provides visual feedback to users.



Examples :-

=> **Actuators :-** Solenoids, voice coils, demotor, stepper motor, servomotor.

=> **Sensors :-** Switches; potentiometer, photoelectrics, strain gauge.

=> **Input signal conditioning & interfacing :-** Filter, Amplifier, discreter circuit.

-> **Digital control :-** Logic circuit, microcontroller, PLC,

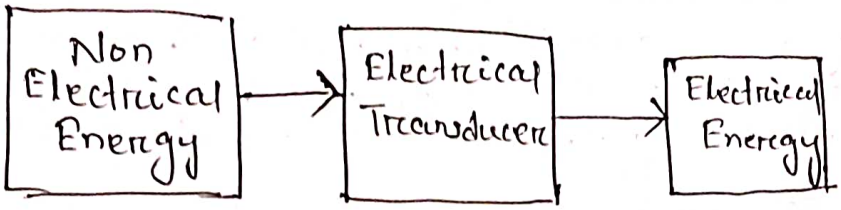
=> **Output signal conditioning & interfacing.** Amplifier, power transistors, power op-amps.

-> **Graphical displays :-** LED's, Digital displays, LCD, CRT.

Sensors & Transducers

* Transducers:-

- A transducers is a device that convert energy from one form to another.
- Usually a transducers converts a signal in one form of energy to a signal in another.
- The process of converting one form of energy to another is known as transduction.



* Classification of Transducers:-

- Primary & secondary type
- Analog & digital type
- Active & passive type
- Transducers & Inverse type.

* Primary & Secondary Transducers:-

- Suppose you need to measure pressure, in this case we use bourdon tube. So the bourdon tube acts as primary transducers.
- It senses the pressure & converts pressure into displacement of free end moves the core of the LVDT which produces output voltage proportional to pressure. Then we able to measure pressure.
- Here bourdon tube is primary transducers & LVDT is the secondary transducers.

* Analog & Digital Transducers:-

- Transducers converting the input physical phenomenon into an analogous output which is a continuous function of time.
- Ex- strain guage, thermocouple.
- The digital transducers convert input to electrical output in form of pulses.

* Active & Passive Transducers :-

⇒ Active transducers are those which ~~doesn't~~ don't need auxiliary power source to produce output.

⇒ Ex- Piezoelectric crystals, Tacho generators.

⇒ Passive Transducers are those which need to an auxiliary power source to produce output.

⇒ Ex- Linear potentiometer.

* Transducers & Inverse Transducers :-

⇒ Transducers, as mentioned earlier convert non electrical quantity to electrical quantity, where as inverse transducers converts electrical to non electrical quantity.

⇒ It converts electrical signals into mechanical vibrations.

* Electromechanical Transducers :-

⇒ Electromechanical transducers that convert or transduce electrical energy to mechanical energy.

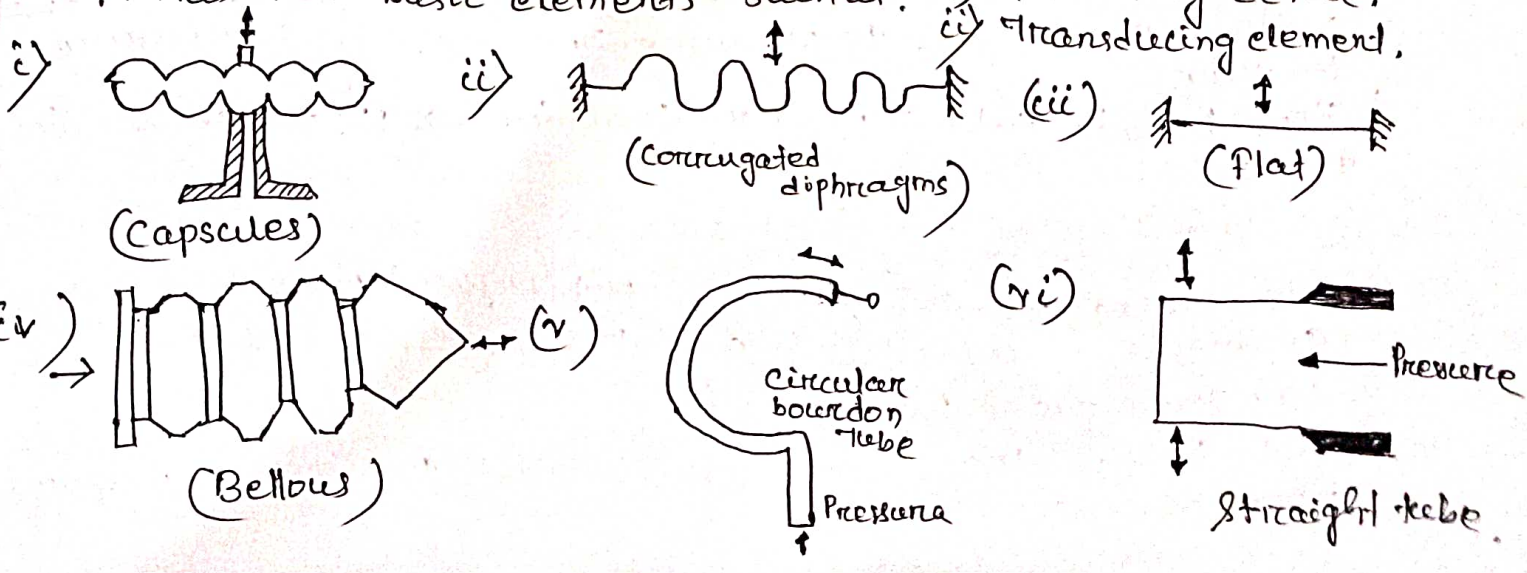
⇒ In an actuator mode electromechanical convert electrical to mechanical energy where as in a generator mode they perform the reverse function & convert mechanical to electrical energy.

Advantages of electromechanical Transducers :-

⇒ Less power consumption.
⇒ Friction & mass inertia effects minimum.
⇒ More compact instrumentation
⇒ Possibility of non-contact measurements.
⇒ Good frequency & transient response.

* Transducers Actuating Mechanisms :-

It has two basic elements such as :- i) Activating device.
ii) Transducing element.



* Displacement Sensor :-

=> A displacement sensor is an electromechanical device used to convert mechanical motion into a variable ~~vibrations~~ electrical current, voltage or electric signals & the reverse.

=> The actuating mechanism used primarily for automatic control system or as mechanical motion sensors in measurement technology.

* Position Sensor :-

=> A position sensor typically consists of two fundamental parts.

=> One parts remains fixed in position while the other part moves with the mechanism whose displacement is being measured.

=> The exact Nature & therefore the size of the fixed & moving portions depend on the sensing technology being used.

* Velocity Sensor :-

=> A velocity sensor is a sensor that responds to velocity rather than absolute position.

=> Example :- dynamic microphones and velocity receivers.

=> Movement causes the coil to move relative to the magend which in turn generates a voltage that is proportional to the velocity of that movement.

* Motion Sensor :-

=> A motion sensor is an electronic device that is design to detect measure movement.

=> Motion sensor are used primarily in home and business security system.

=> Motion sensors are typically three major components

- => Sensor unit
- => An embedded computer.
- => Hardware.

* Force Sensor :-

=> A force sensor is defind as a transducer that converts an input mechanical load, weight, tension, compression or pressure into an electrical output signal.

=> Force sensors are also commonly known as force transducers.

* Pressure Sensor :-

=> A pressure sensor is a device for pressure measurement of gases or liquids.

=> Pressure is an expression of the force required to stop a fluid from expanding, & is usually stated in terms of force per unit area.

* Temperture Sensor :-

=> A temperture sensor is a device used to measure temperture.

=> This can be air temperture, liquid temperture or the temperture of solid matter.

=> Some temperture sensors require direct contact with physical object that is being monitored, while other indirectly measure the temperture of an object.

* Light Sensor :-

=> The light sensor is a passive device that converts the light energy into an electrical signal output.

=> The light sensors are more commonly known as photoelectric Devices or photo sensors because they convert light energy into electronic signals.

=> A light sensor generates an output signals indicating the intensity of light by measuring the radiant energy.

Actuators - Mechanical, Electrical

* Mechanical Actuators *

- Machine, Kinematic Link, Kinematic Pair :

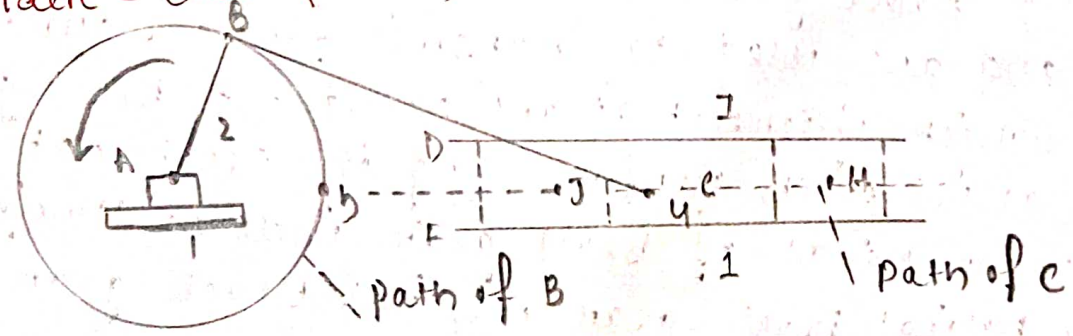
⇒ Machine - A machine is a device of mechanical structure that uses power to apply forces and control movement to perform an intended action.

⇒ Kinematic Link - It is defined as the part of machine which has a relative motion with respect to some other part of same machine is called kinematic link.

⇒ Kinematic Pair - The two links or element of a machine, when in contact with each other are said to form a pair. If the relative motion between them is completly or successfully constrained the pair is known as Kinematic pair.

⇒ Mechanism, Slider crank Mechanism -
The way in which the parts of a machine are interconnected and guided to produce a required output motion from a given input motion is known as the mechanism of the machine.

⇒ Slider - crank Mechanism -



Slider - crank mechanism, arrangement of mechanical parts designed to convert straight line motion to rotary motion, as in a reciprocating piston engine, or to convert rotary motion, as in a reciprocating piston pump.

* Gear Drive, Spur gear, Bevel gear, Helical gear, worm gear :-

⇒ Gear Drive - Same sized and shaped teeth cut at equal distances along a flat surfaces on a straight rod is called a gear drive. A gear rack is a cylindrical being with the radius of the pitch cylinder being infinite. By meshing with a cylindrical gear pinion, it converts rotational motion into linear motion.

⇒ Spur gear - Gears having cylindrical pitch surfaces are called cylindrical gears. Spur gears belong to the parallel shaft gear group and are called with cylindrical gears with a tooth line which is straight and parallel to shaft. Spur gears are the most widely used gears that can achieve high accuracy with relatively easy production processes.

⇒ Bevel gear - Bevel gear have a cone shaped appearance and are used to transmit force between two shafts which intersect at one point. A bevel gear has a cone at its pitch surface and its teeth cut along the cone. Kinds of bevel gear include straight bevel gear, helical bevel gear, spiral bevel gear.

⇒ Helical gear – Helical gear are used with parallel shaft similar to spur gear and are cylindrical gears with winding tooth lines. They have better teeth meshing than spur gears and have superior quitness and can transmit higher loads, making them suitable for high speed applications.

⇒ Worm Gear – A screw shape cut on a shaft is the worm, the matting gear is the worm wheel, and together on non-intersecting shafts is called a worm gear. Worms and worm wheels are not limited to cylindrical gears shapes.

* Belt & Belt drive :-

⇒ Belt – A belt is a loop of flexible material used to link two or more rotating shafts mechanically, most often parallel. Belts may be used as a source of motion to transmit power, efficiently or to track relative movement. Belts are looped over pulleys and may be have a twist between the pulleys and the shafts needed not be parallel.

⇒ Belt Drive – Belt drive is a machinery, pair of pulleys attained to usually parallel shafts and connected by an encircling flexible belt that can serve to transmit and modify rotary motion from one shaft to the other. Most belts are consists of flat leather with V-shaped cross section running on grooved pulleys.

* Bearing - The term "bearing" is derived from the verb to bear a bearing being a machine element that allows one part to bear another. The simplest bearing are bearing surfaces cut or formed into a part with varying degrees of control over the form size, roughness and location of the surface. other bearing are separate devices installed into a machine part.

* Electrical Actuator :

• Switches and relay :

A switch is an electromechanical device used to make or break the circuits.

(1) Switches can be controlled mechanically.
(2) It controls the flow of current by opening or closing of circuits.
(3) It is used to open or close the contacts.
(4) A switch makes a direct contact or connection.

• Relay :

(1) Relay is an electromechanical devices used to make or break the circuits.
(2) Relay can be controlled electronically.
(3) It controls high power circuits with low power signals by opening / closing the contacts.
(4) It operates fast.

* Solenoid - A solenoid is a device comprised of a coil of wire, the housing and a movable plunger. When an electrical current is introduced, a magnetic field forms around the coil which draws the plunger.

(1) The coil is made of many turns of tightly wound copper wire.
(2) The housing, usually made of iron or steel, surrounds the coil concentrating the magnetic field generated by the coil.

when an electrical current is introduced, a magnetic field forms around the coil which draws the plunger in. The solenoid converts electrical energy to mechanical energy.

* DC Motors - A DC motor is defined as a class of electrical motors that converts electrical energy into mechanical energy. A DC motor is any of a class of rotary electrical motor that converts DC electrical energy to mechanical energy. The most common types rely on the forces produced by magnetic field.

* AC motors - An AC motor is an electric machine that converts alternating current into mechanical energy. AC motor's application range from industrial bulk power conversion from electrical to mechanical to household small power conversion. The AC motor may be single phase or three phase. Nikol Tesla invented the first AC induction motor in 1887. The two main types of AC motors are induction & synchronous motors.

* Specification and control of stepper motor -

(1) Size 42.3 mm^2 X 48mm, not including the shaft.
(2) Weight 350g (13oz)
(3) Shaft diameter : 5mm "D"
(4) Voltage rating : 4V
(5) Output shaft supported by two ball bearings.

* Control of Stepper motor -

Stepper motor controls voltage drives are used to apply a constant positive or negative voltage drives to each winding to drive motion. However, it is winding current not voltage that applies torque to the stepper motor shaft. It since wastes power in the

resistor and generators heat. It is therefore considered a low performing option.

How can we control the speed of stepper motor?

Speed of a stepper motor can be controlled by changing its switching speed on by changing the length of the time delay loop.

- characteristics -

① rotation in both direction
② a holding torque at zero speed
③ capability for digital control
④ precision angular incremental changes.
⑤ repetition of accurate motion.

* Servo Motors DC and AC ?

Difference between AC servo motor and DC servo motor-

characteristics	AC servo motor	DC servo Motor
① Efficiency	Low about (5-20%)	High
② Speed & torque	High speed working	Adaptable to a limited torque.
③ Stability	less stability issues	More problems of stability
④ Noise	No radio frequency	Brushes cause frequency noise
⑤ Weight & size	Lighter weight and small in size	Heavy weight
⑥ Output power	Deliver low power normally between 0.5 W and 100 W	Provide high power
⑦ Operation	Have stable and smooth operation	Noisy operation

Programmable Logic Controllers

* Introduction :-

A programmable logic controllers (PLC) is a specialized computers used to control machine and process. PLC stands for programmable logic controllers. They basically used to control automated system in industries. They are one of the most advanced and simplest forms of control system which are now replacing hared-wired logic relays at a large scale.

* Advantages of PLC :-

- They are users friendly and easy to operate.
- They elimate the need of hard-wired relay logic.
- They are fast.
- It is suitable for automation in industries.
- Its input and output modulus can be extended depending upon the requirements.

* Selection and uses of PLC :-

- Transportation system likes conveyor Belt System.
- Packing and Labeling system in food and Beverage.
- Automatic Bottle or Liquid Filling System.
- Glass industries for glass production of pages, Books or Newspapers.
- Glass industries for production of recording data.
- Cement industry for manufacturing or mixing the right quality and quantities of raw materials and accuracy of data regarding.
- Automatic Drainage watere pump monitoring and controlling system.
- Time and count-base control system for an industrial machine.
- Transportation system like escalator and Elevator.

* Architecture basic internal structure -

Interior architecture is the design of a building or shelter inside out, or design of a new interiore for a type of home that can be fixed. The art of and science of designing and erecting buildings and their interiores along with other related physical features by a licensed architect. The internal paths along which digital signals flow are called buses.

* What is the basic structure of PLC?

The main component of a PLC consist of a central processing Unit (CPU), power supply, programming device and input and output (I/O) modules. The CPU is the brain of the PLC and carries out programmed operations.

* What exactly does an interior architect do?

Simply put an interior architect designs buildings interior and space planning while an interior designer focuses on the actual furnishing and decoration of an interiore. The CPU controls and process the operations within the PLC. It is supplied with a clock that has a frequency of typically between 1 and 8 MHz. This frequency determine the operating speed of the PLC and provides the timing of all elements in the system. It might be tracks on a printed circuit board or wires in a ribbon cable.

* Input/output Processing and Programming -

How will you process the input and output of PLC?

In a PLC system there will usually be dedicated modules for inputs and dedicated modules for outputs. An input modules detect the status of input signals such as push buttons, switched, temperature sensore etc... An output module controls devices such as relays, motor starters, lights etc..

PLC is continuously running through its program and updating it as a result of the input signal, each such loop is called a cycle.

* What is a ladder in PLC ?

Ladder logic is used to develop software for Programmable logic controllers (PLCs) used in industrial control application. The name is based on the observation that programs in this language resemble ladders, with two vertical rails and a series of horizontal rungs between them.

The PLC executes the program loaded into it one rung at a time. As the PLC begins to process the rung, it reads the instruction on the left and determine if the logic evalute to True when a hypothetical current is able to pass through the instruction.

* Master and Jump controllers →

How to use JUMP instruction in PLC ladder logic ?

Jump instruction in ladder logic is used to skip some process or rungs according to the requirements. It is paired with Lebel which is used to limit the skipping the process.

What is jump control in PLC ?

Jump instruction in Laddler logic is used to skip some process or rungs according to the requirements. It is paired with Lebel which is used to limit the skipping the process.

What does a master control relay do ?

In an electrical circuit master control reelays are used to shut down a selection of an electrical system. In Laddler logic, MCR is used to turn ON one selection of a programming line. There is a selection of ladder logic implemented between the MCR instruction.

How do you use jump instructions ?

A Jump instruction like "jump" just switched the CPU to executing a different piece of code. It's the assembly equivalent of "goto", but unlike goto, jumps are not considered shameful in assembly.

Two methoreds of processing:

1- Continuous Updating

2- Mass Updating

Continuous Updating:

The CPU Scanning the input channels as they occure in the program instructions. Each input is Examined indivisually. The output is latched so that they reetain their status until the next update mass input/ output copying: It works in the following process:

(1) Scan all the inputs and copy into RAM.

(2) Fetch and decode and execute all program instruction in sequence, copying output instruction to RAM.

(3) Once the program is executed, the CPU perform diagnostics and communication tasks.

(4) Update all outputs Repeat the sequence. Input/ output processing input/output.

* Input/output Unit *

(1) The input/output Unit provides interface between the system and the outside world.

(2) The input/output interface provides isolation and signal conditioning functions so that sensors and actuators can often be directly connected to them without the need for other circuitry.

(3) Out device: motors, starting coils, Solenoid valve etc. Input device: Temperature sensor, flow sensor,

(4) encoders etc....

Mnemonics :→

The appropriate product category. A ladder diagram written in alphanumeric characters for easier understanding than the machine language program to be executed by CPU Unit. The mnemonics code can be converted to a ladder diagram in PLC.