UNIT V
ACTUATORS AND MECHATRONIC SYSTEM DESIGN

Types of Stepper and Servo motors
❖ Construction
❖ Working Principle
❖ Advantages and Disadvantages.
Design process
❖stages of design process
❖ Traditional and Mechatronics design concepts
Case studies of Mechatronics systems
Pick and place Robot
Engine Management system
Automatic car park barrier.

5.1 Actuators

- In a control system, the element which transforms the output of a controller into a controlling action/motion is called as **actuators.**
- Actuators produce physical changes such as linear and angular displacements.
- Examples of actuators are - solenoids, electric motors, hydraulic cylinders, pneumatic cylinders and motors.
- Actuators can handle the static or dynamic loads placed on it by control valve. The important aspects of actuators are proper selection and sizing.

Functions of actuator

An actuator has two major functions.

i) To respond an external signal directed to it causing inner valve to move accordingly hence to control flow rate of fluid by positioning the control valve.

ii) To provide support for valve accessories e.g. limit switches, solenoid valves.

5.2 Classification of Actuators

- Actuators are available in various forms to suit the particular requirement of process control.
- It can be classified into three main categories.

1. Pneumatic actuators
2. Hydraulic actuators
3. Electrical actuators

5.3 Stepper Motor

☞ [AU : May-2013, 2014, 2015, Dec.-2014, 2015, 16 Marks]

- A **stepper motor** is an electromechanical device which converts electrical pulses into discrete mechanical movements.
- These motors rotate a specific number of degrees as a respond to each input electric pulse.
- Typical types of stepper motors can rotate 2°, 2.5°, 5°, 7.5°, and 15° per input electrical pulse.
- Rotor position sensor or sensorless feedback based techniques can be used to adjust the output response in accordance with the reference command input.
- The speed of the motor shafts rotation is directly related to the frequency of the input pulses and the length of rotation is directly related to the number of input pulses applied.

- Stepper motors offers many attractive features such as :

i) Available resolutions ranging from several steps up to 400 steps (or higher) per revolution.

ii) Several horse power ratings.

iii) Ability to track signals as fast as 1200 pulses per second.

Stepper Motor Types

- There are three basic stepper motor types.

  1. Variable-reluctance 2. Permanent-magnet 3. Hybrid

5.3.1 Varibale- Reluctance (VR) Stepper Motor

- This type of stepper motor has been around for a long time.
- It is probably the easiest to understand from a structural point of view.
- Variable reluctance stepping motors have three to five windings and a common terminal connection, creating several phases on the stator.
- The rotor is toothed and made of metal, but is not permanently magnetized.

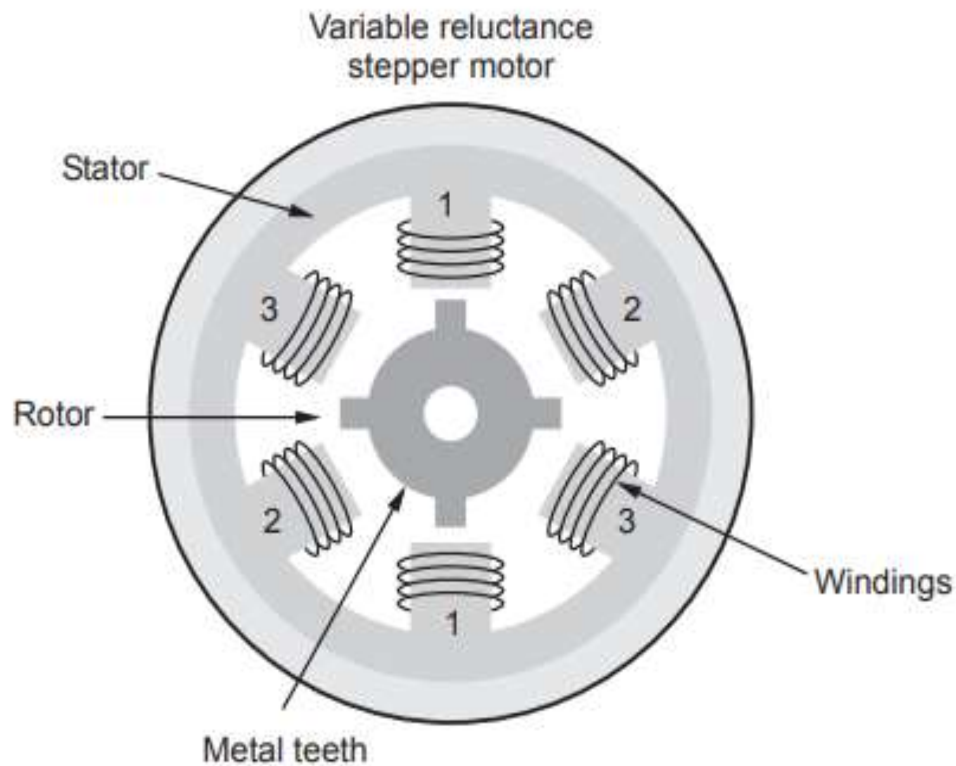


Fig. 5.3.1 Simple variable reluctance stepping motor

- A simplified variable reluctance stepping motor is shown in Fig. 5.3.1.
- In this figure, the rotor has four teeth and the stator has three independent windings (six phases), creating 30 degree steps.
- The rotation of a variable reluctance stepping motor is produced by energizing individual windings.
- When a winding is energized, current flows and magnetic poles are created, which attracts the metal teeth of the rotor.
- The rotor moves one step to align the offset teeth to the energized winding.
- At this position, the next adjacent windings can be energized to continue rotation to another step, or the current winding can remain energized to hold the motor at its current position.
- When the phases are turned on sequentially, the rotor rotates continuously.

The three steps shown in Fig. 5.3.2) move the rotor a quarter turn.

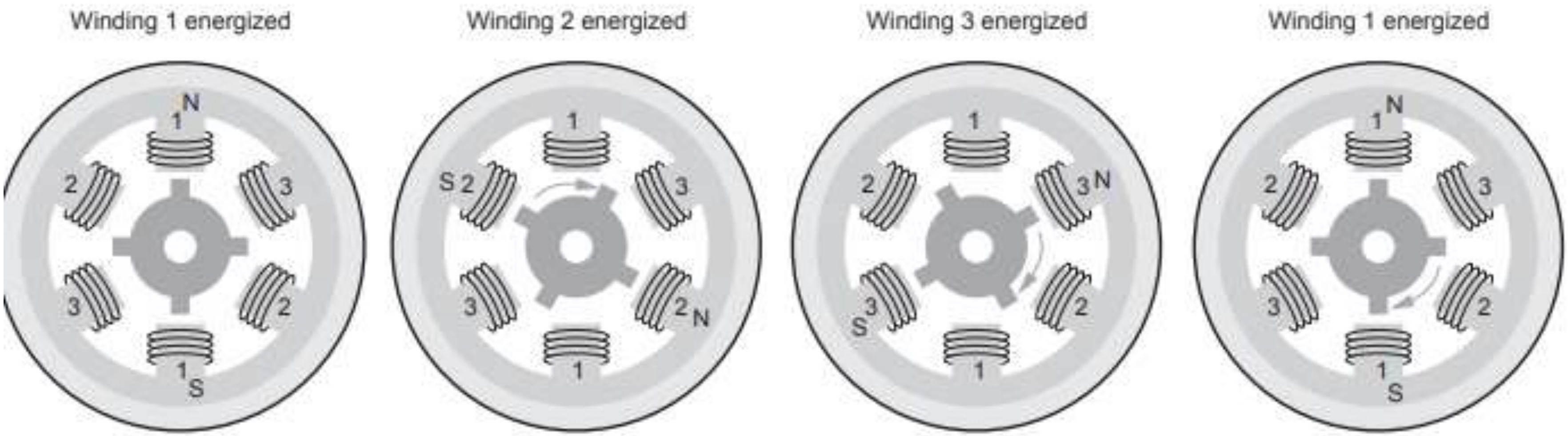


Fig. 5.3.2 Rotation control of variable reluctance stepping motor

- A full rotation requires 12 steps for a variable reluctance stepper motor.
- Typical variable reluctance motors have more teeth and use a tooth pole along with a toothed rotor to produce step angles near one degree.

5.3.2 Permanent Magnet Stepper Motor

- Permanent Magnet (PM) stepper motors are similar in construction to that of variable reluctance stepper motors except that the rotor is made of permanent magnet.
- A permanent magnet stepping motor consists of a stator with windings and a rotor with permanent magnet poles.
- Alternate rotor poles have rectilinear forms parallel to the motor axis.
- Stepping motors with magnetized rotors provide greater flux and torque than motors with variable reluctance.
- The motor, shown in Fig. 5.3.3, has three rotor pole pairs and two independent stator winding creating 30 degree steps.

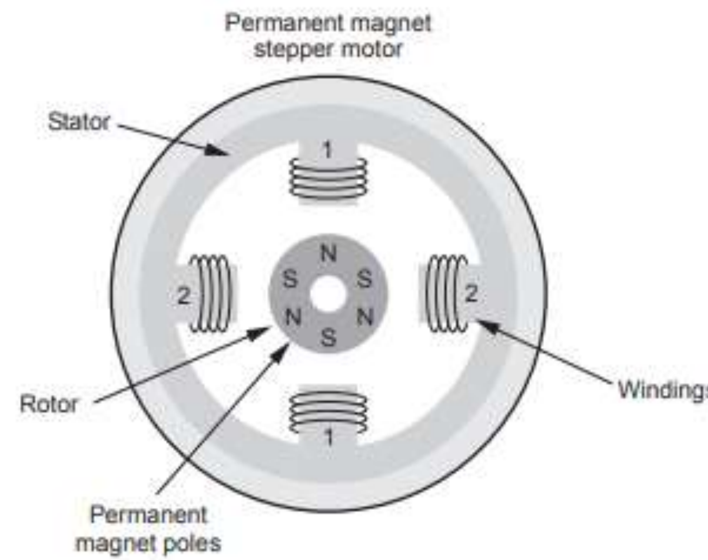


Fig. 5.3.3 Permanent magnet stepping motor

- Motors with permanent magnets are subjected to influence from the back-EMF of the rotor, which limits the maximum speed.
- Therefore, when high speeds are required, motors with variable reluctance are preferred over motors with permanent magnets.

5.3.3 Hybrid Stepper Motor

- The hybrid stepper motors have the combination of the best properties of variable reluctance and permanent magnet steppers, so they are more expensive than the PM stepper motor.
- This motors provide better performance with respect to step resolution, torque and speed.
- The rotor of a hybrid stepper is multi-toothed like the variable reluctance steppers and it contains an axially magnetized concentric magnet around its shaft.
- The teeth on the rotor provide an even better path which helps guide the magnetic flux to preferred locations in the air gap.
- The most commonly used types of stepper motors are the hybrid and permanent magnet.
- The designers prefer permanent magnets unless their project requires the hybrid steppers, since the cost of permanent magnet are less than of hybrids.

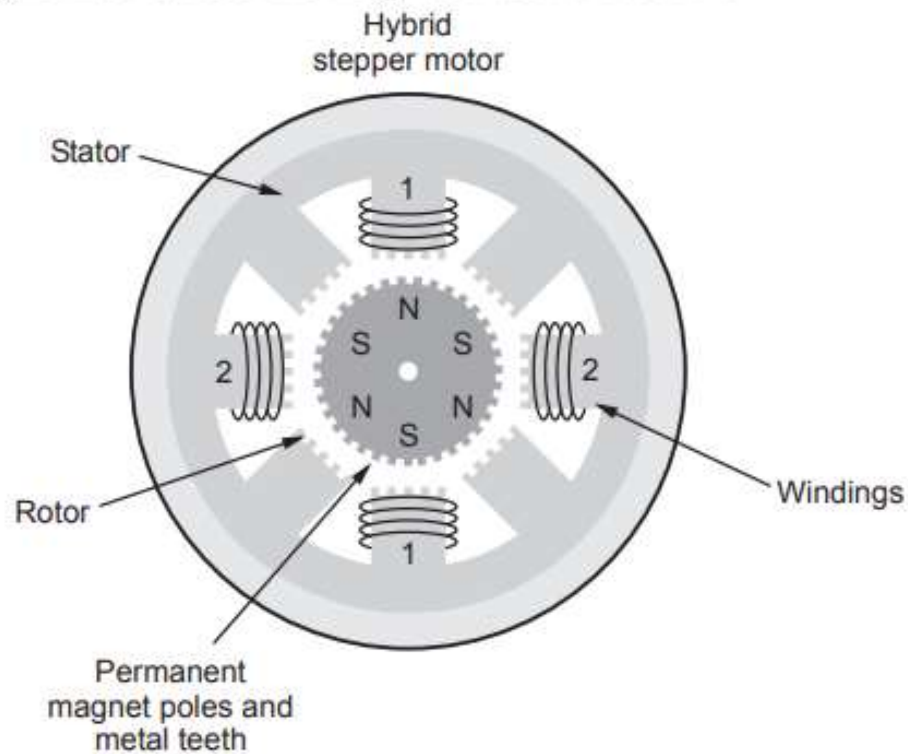


Fig. 5.3.4 Hybrid stepper motor

5.3.4 Advantages of Stepper Motor

1. The rotation angle of the motor is proportional to the input pulse.
2. The motor has full torque at standstill.
3. Precise positioning and repeatability of movement since good stepper motors have an accuracy of 3 – 5 % of a step and this error is non cumulative from one step to the next.
4. Excellent response to starting, stopping and reversing.
5. Very reliable since there are no contact brushes in the motor. Therefore the life of the motor is simply dependant on the life of the bearing.
6. The motors response to digital input pulses provides open-loop control, making the motor simpler and less costly to control.

5.3.5 Disadvantages of Stepper Motor

- They have low torque capacity (typically less than 2,000 oz-in) compared to DC motors.
- They have limited speed (limited by torque capacity and by pulse-missing problems due to faulty switching systems and drive circuits).

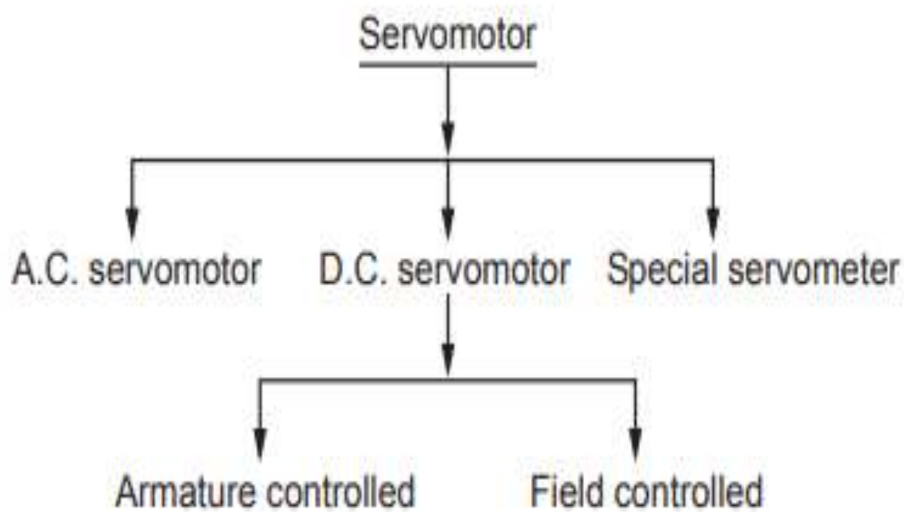
5.4 Servo Motor

- A servo motor is a simple electrical motor, controlled with the help of servo mechanism.
- **Servo motor** is a special type of motor which is automatically operated up to certain limit for a given command with help of error-sensing feedback to correct the performance.

- If the motor as controlled device, associated with servo mechanism is DC motor, then it is commonly known **DC Servo Motor**.
- If the controlled motor is operated by AC, it is called **AC Servo Motor**.

5.4.1 Types of Servo Motors

- The servomotor are basically classified depending upon the nature of the electricity supply to be used for it's operation.
- The types of servomotor are shown in the chart.



i. DC Servo Motors

☞ [AU: Dec.-2013, May-2014, 8 Marks]

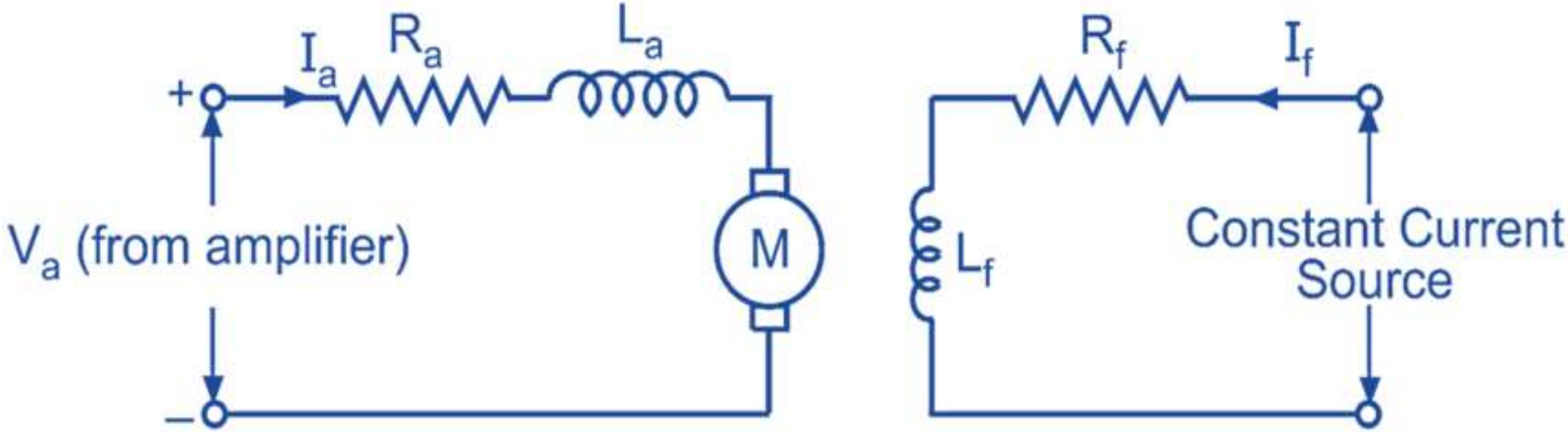
Servomotor features :

1. Linear relationship between the speed and electric control signal.
2. Steady state stability.
3. Wide range of speed control.
4. Linearity of mechanical characteristics throughout the entire speed range.
5. Low mechanical and electrical inertia.
6. Fast response.

Construction :

- A DC servo motor consists of a small DC motor, feedback potentiometer, gearbox, motor drive electronic circuit and electronic feedback control loop.
- It is more or less similar to the normal DC motor.
- The stator of the motor consists of a cylindrical frame and the magnet is attached to the inside of the frame.
- The rotor consists of brush and shaft.
- A commutator and a rotor metal supporting frame are attached to the outside of the shaft and the armature winding is coiled in the rotor metal supporting frame.

- A brush is built with an armature coil that supplies the current to the commutator.
- At the back of the shaft, a detector is built into the rotor in order to detect the rotation speed.
- With this construction, it is simple to design a controller using simple circuitry because the torque is proportional to the amount of current flow through the armature.



I_a
R_a
L_a
+
−
V_a (from amplifier)
M
L_f
R_f
I_f
Constant Current
Source

Working Principle of DC Servo Motor

- A DC reference voltage is set to the value corresponding to the desired output.
- This voltage can be applied by using another potentiometer, control pulse width to voltage converter, or through timers depending on the control circuitry.
- The dial on the potentiometer produces a corresponding voltage which is then applied as one of the inputs to error amplifier.
- In some circuits, a control pulse is used to produce DC reference voltage corresponding to desired position or speed of the motor and it is applied to a pulse width to voltage converter.
- In digital control, microprocessor or microcontroller are used for generating the PWM pluses in terms of duty cycles to produce more accurate control signals.

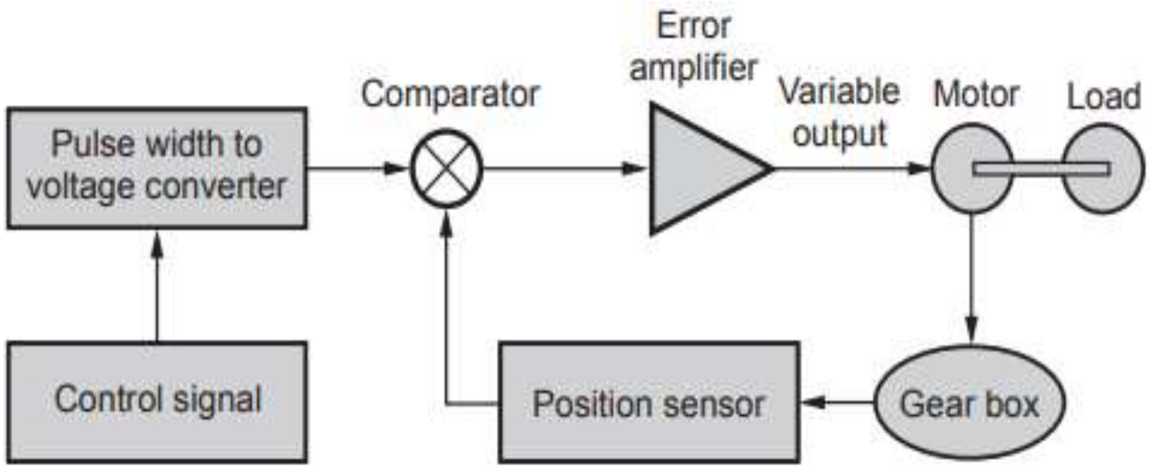


Fig. 5.4.1 Block diagram of Servo motor

- The feedback signal corresponding to the present position of the load is obtained by using a position sensor.
- This sensor is normally a potentiometer that produces the voltage corresponding to the absolute angle of the motor shaft through gear mechanism.
- Then the feedback voltage value is applied at the input of error amplifier (comparator).
- The error amplifier is a negative feedback amplifier and it reduces the difference between its inputs.
- It compares the voltage related to current position of the motor (obtained by potentiometer) with desired voltage related to desired position of the motor

(obtained by pulse width to voltage converter), and produces the error either a positive or negative voltage.

- This error voltage is applied to the armature of the motor.
- If the error is more, the more output is applied to the motor armature.
- As long as error exists, the amplifier amplifies the error voltage and correspondingly powers the armature.
- The motor rotates till the error becomes zero.
- If the error is negative, the armature voltage reverses and hence the armature rotates in the opposite direction

- **DC Servo motor Advantages**

1. High output power relative to motor size and weight.
2. Encoder determines accuracy and resolution.
3. High efficiency. It can approach 90% at light loads.
4. High torque to inertia ratio. It can rapidly accelerate loads.
5. Has "reserve" power. 2-3 times continuous power for short periods.
6. Has "reserve" torque. 5-10 times rated torque for short periods.
7. Motor stays cool. Current draw proportional to load.
8. Usable high speed torque. Maintains rated torque to 90 % of NL RPM
9. Audibly quiet at high speeds.
10. Resonance and vibration free operation.

- **DC Servo motor Disadvantages**

1. Requires "tuning" to stabilize feedback loop.
2. Motor "runs away" when something breaks. Safety circuits are required.
3. Complex. Requires encoder.
4. Brush wear out limits life to 2,000 hrs. Service is then required.
5. Peak torque is limited to a 1% duty cycle.
6. Motor can be damaged by sustained overload.
7. Bewildering choice of motors, encoders, and servodrives.
8. Power supply current 10 times average to use peak torque.
9. Motor develops peak power at higher speeds. Gearing often required.
10. Poor motor cooling. Ventilated motors are easily contaminated.

ii. AC Servo Motor

☞ [AU : May-2013, 2014, Dec.-2013, 8 Marks]

- Most of the servomotors used in the low power servomechanism are a.c. servomotors.
- The a.c. servomotor is basically two phase induction motor.
- The output power of a.c. servomotor varies from fraction of watts to few hundred of watts. The operating frequency is 50 Hz to 400 Hz.

Features of A.C. Servomotor

The various features of a.c. servomotor are,

1. Light in weight for quick response.
2. Robust in construction.
3. It is reliable and its operation is stable in nature.
4. Smooth and noise free operation.
5. Large torque to weight ratio.
6. Large resistance to reactance ratio.

Construction

- The A.C servomotor is basically consists of a stator and a rotor.
- The stator carries two windings, uniformly distributed and displaced by 90° in space, from each other.
- On winding is called as main winding or fixed winding or reference winding. The reference winding is excited by a constant voltage a.c. supply.
- The other winding is called as control winding.
- It is excited by variable control voltage, which is obtained from a servoamplifier.
- The winding are 90° away from each other and control voltage is 90° out of phase with respect to the voltage applied to the reference winding.
- This is necessary to obtain rotating magnetic field.
- The schematic stator is shown in the Fig. 5.4.2.

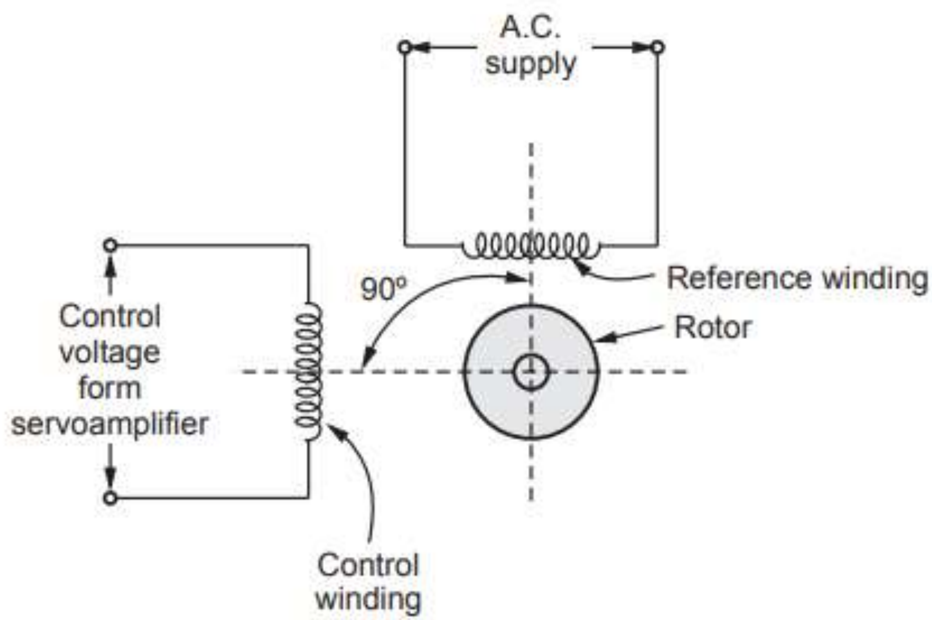


Fig. 5.4.2 Stator of A.C. servomotor

Working Principle of AC Servo Motor

- The schematic diagram of servo system for AC two-phase induction motor is shown in the figure below.
- In this, the reference input at which the motor shaft has to maintain at a certain position is given to the rotor of synchro generator as mechanical input theta.
- This rotor is connected to the electrical input at rated voltage at a fixed frequency.

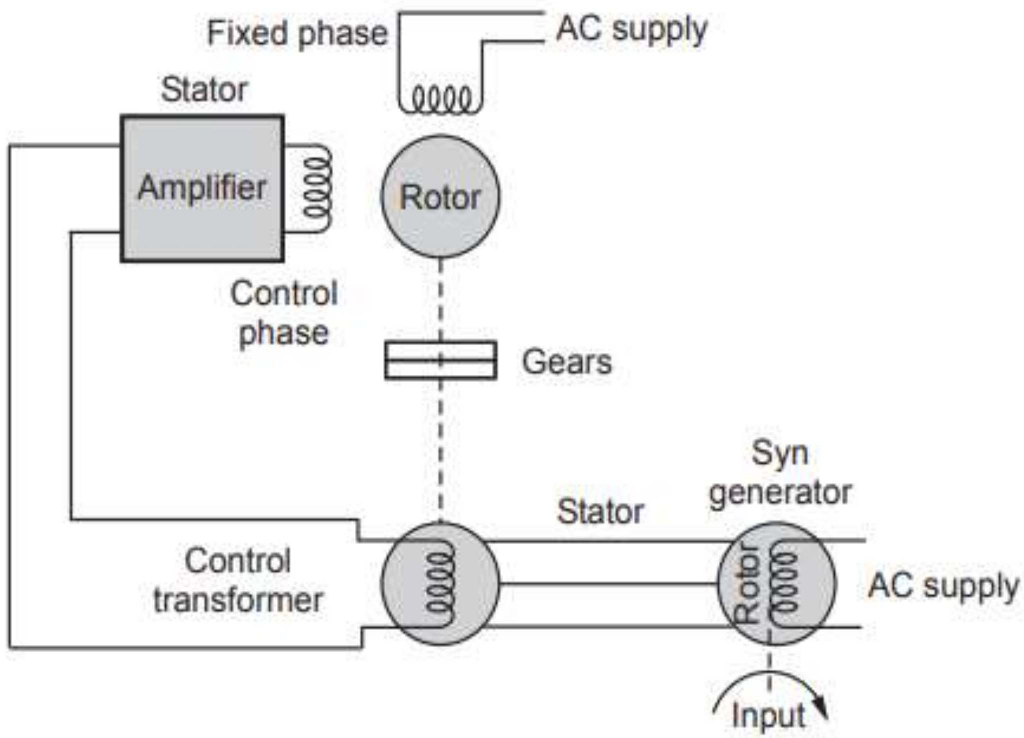


Fig. 5.4.3 Schematic diagram of AC servo system

- The three stator terminals of a synchro generator are connected correspondingly to the terminals of control transformer.
- The angular position of the two-phase motor is transmitted to the rotor of control transformer through gear train arrangement and it represents the control condition alpha.
- Initially, there exist a difference between the synchro generator shaft position and control transformer shaft position.
- This error is reflected as the voltage across the control transformer.

- This error voltage is applied to the servo amplifier and then to the control phase of the motor.
- With the control voltage, the rotor of the motor rotates in required direction till the error becomes zero.
- This is how the desired shaft position is ensured in AC servo motors.
- Alternatively, modern AC servo drives are embedded controllers like PLCs, microprocessors and microcontrollers to achieve variable frequency and variable voltage in order to drive the motor.
- Mostly, pulse width modulation and Proportional-Integral-Derivative (PID) techniques are used to control the desired frequency and voltage.
- The block diagram of AC servo motor system using programmable logic controllers, position and servo controllers is given below.

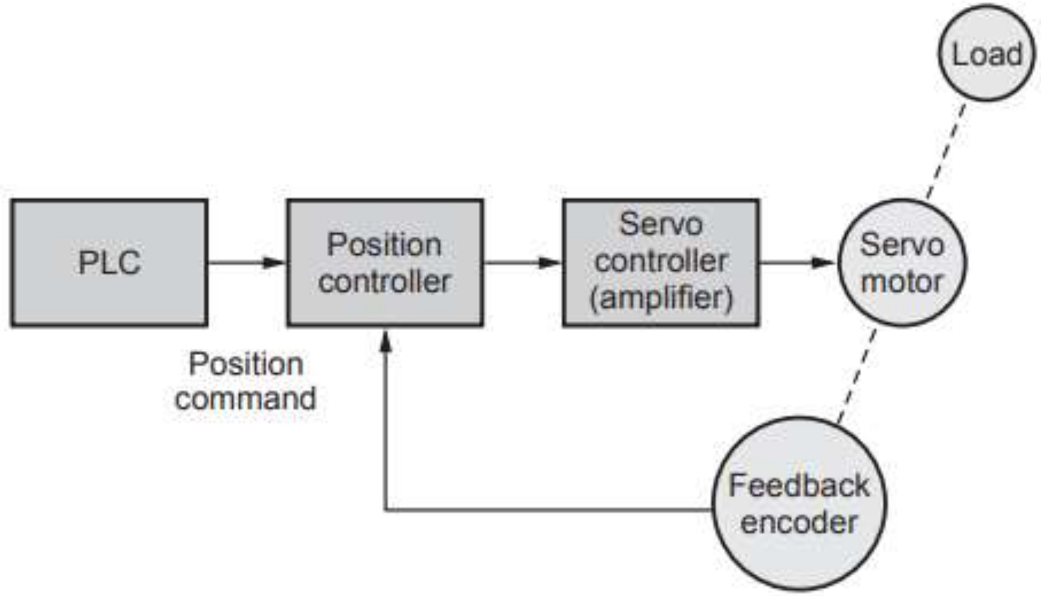


Fig. 5.4.4 Block diagram of AC servo motor

Advantages of AC servomotors are :

1. Low cost.
2. Higher efficiency and less maintenance (because no commutator and brushes).

Disadvantages of AC servomotors are :

1. Non-linear Characteristics.
2. More difficult to control in positioning applications.

5.4.3 Difference between the DC and AC Servo Motors

DC Servo Motor	AC Servo Motor
It delivers high power output	Delivers low output of about 0.5 W to 100 W
It has more stability problems	It has less stable problems
It requires frequent maintenance due to the presence of commutator	It requires less maintenance due to the absence of commutator
It provides high efficiency	The efficiency of AC servo motor is less and is about 5 to 20 %
The life of DC servo motor depends on the life on brush life	The life of AC servo motor depends on bearing life
It includes permanent magnet in its construction	The synchronous type AC servo motor uses permanent magnet while induction type doesn't require it.
These motors are used for high power applications	These motors are used for low power applications

5.4.4 Comparison of Stepper and Servomotor

Sr. No.	Stepper motor	Servo motor
1.	Stepper motor controller can only issue a move command. There is no check that the motor has reached the desired position.	Servomotor has position encoder attached to the drive motor. The position encoder gives actual position of motor shaft. If any positioning error exists, the servo controller may take corrective active to ensure that the motor moves to the proper position.
2.	Stepper motor can not move large loads.	Servomotor can move large loads up to 50 hp.
3.	Stepper motor requires DC pulses.	Servomotor works on either AC or DC.
4.	Design is simple.	Design is complicated.
5.	Stepper Motors have a large number of poles, magnetic pairs generated by a permanent magnet or an electric current.	Servo motors have very few poles; each pole offers a natural stepping point for the motor shaft.
6.	Speed is slow.	Speed is faster.
7.	Stepper motors are generally operated under open-loop control.	Servo motors are generally operated under closed-loop control.
8.	Less costly.	High costly.

5.5 Stages in Designing Mechatronics Systems

☞ [AU : May-2013, 2014, 2 Marks]

The design process consists of the following stages :

Stage I : Need for design

- The design process begins with a need. Needs usually arise from dissatisfaction with existing situation.
- Needs may come from inputs of operating or service personal or from customer through sales or marketing representatives.
- They may be to reduce cost, increase reliability or performance or just change because of public has become bored with the product.

Stage 2 : Analysis of problem

- Probably the most critical step in design process is the analysis of the problem i.e., to find out the true nature of the problem.

- The true problem is riot always what it seems to be at the first glance.
- Its importance is often over looked because this stage requires such small part of the total time to relate the final design.
- It is advantageous to define the problem as broadly possible.
- If the problem is not accurately defined, it will lead to waste of time on designs and will not fulfil the need.

Stage 3 : Preparation of specification

- The design must meet the required performance specifications.
- Therefore, specification of the requirements can be prepared.
- This will state the problem definition of special technical terms, any constraints placed on the solution, and the criteria that will be used to evaluate the design. Problem statement includes all the functions required of the design, together with any desirable features.

Stage 4 : Generation of possible solution

- This stage is often called as conceptualisation stage.
- The conceptualisation step is to determine the elements, mechanisms, materials, process of configuration that in some combination or other result in a design that satisfies the need.
- This is the key step for employing inventiveness and creativity.
- A vital aspect of this step is synthesis

Stage 5 Synthesis

- Synthesis is the process of taking elements of the concept and arranging them in the proper order, sized and dimensioned in the proper way.
- Outline solutions are prepared for various possible models which are worked out in sufficient details to indicate the means of obtaining each of the required functions.
- This stage involves a thorough analysis of the design.
- The evaluation stage involves detailed calculation, often computer calculation of the performance of the design by using an analytical model.
- The various solutions obtained in stage 4 are analysed and the most suitable one is selected.

Stage 6 : Production of detailed design

- The detail of selected design has to be worked out.
- It might have required the extensive simulated service testing of an experimental model or a full size prototype in order to determine the optimum details of design.

5.6 Traditional and Mechatronics Designs

- Engineering design is a complex process which involves interaction between many skills and discipline.
- In traditional design, the components are designed through mechanical, hydraulic or pneumatic components and principles.
- But in mechatronics approach, mechanical, electronics, computer technology and control engineering principles are included to design a system.
- For example design of weighing scale might be considered only in terms of the compression of springs and a mechanism used to convert the motion of spring into rotation of shaft and hence movements of a pointer across a scale.
- In this design measurement of weight is depended on the position of weight on the scale.
- If we want to overcome foresaid problem, other possibilities can be considered.
- In mechatronics design, the spring might be replaced by load cells with strain gauges and output from them used with a microprocessor to provide a digital readout of the weight on an LED display.

- This scale might be mechanically simpler, involving fewer components and moving parts. But the software is somewhat complex.
- Similarly the traditional design of the temperature control for a central AC system involves a bimetallic thermostat in a closed loop control system.
- The basic principle behind this system is that the bending of the bimetallic strip changes as the temperature change and is used to operate an ON/OFF switch for the temperature control of the AC system.
- The same system can be modified by mechatronics approach.

  - This system uses a microprocessor controlled thermo couple as the sensor.
  - Such a system has may advantages over traditional system.
  - The bimetallic thermostat is less sensitive compared to the thermodiode.
  - Therefore the temperature is not accurately controlled.
  - Also it is not suitable for having different temperature at different time of the day because it is very difficult to achieve.
  - But the microprocessor controlled thermodiode system can overcome fore said difficulties and is giving precision and programmed control.
  - This system is much more flexible.
  - This improvement in flexibility is a common characteristic of the mechatronics system when compared with traditional system.

5.6.1 Comparison between Traditional and Mechatronics Design

☞ [AU : May 2013, Dec. 2013, 2014, May 2014, 2 Marks]

Sr. no.	Traditional design	Mechatronics design
1.	It is baseed on traditional system such as mechanical, hydraulic and pneumatic	It based on mechanical, electronics, computer technology and control engineering
2.	Less flexible	More flexible
3.	Less accurate	More accurate
4.	More complicate mechanism in design.	Less complicate mechanism design
5.	It involves more components and moving parts.	It involves fewer compounds and moving parts.

5.7 Case Studies of Mechatronics System

- Mechatronics systems are widely used now days in many industries.
- Some of the examples are explained here

5.7.1 Case Study 1 : Pick and Place Robot

☞ **[AU : Dec.-2013, May-2015, Dec.-2016, 16 Marks]**

- Pick and place robot is the one which is used to pick up an object and place it in the desired location.

- It can be a cylindrical robot providing movement in horizontal, vertical and rotational axes, a spherical robot providing two rotational and one linear movement, an articulate robot or a SCARA robot (fixed robots with 3 vertical axes rotary arms).
- Pick and place robot actually consists of :

1. **A Rover :** It is the main body of the robot consisting of several rigid bodies like a cylinder or a sphere, joints and links. It is also known as a manipulator.
2. **End Effector :** It is the body connected to the last joint of the rover which is used for the purpose of gripping or handling objects. It can be an analogy to the arm of a human being.
3. **Actuators :** They are the drivers of the robot. It actually actuates the robot. It can be any motor like servo motor, stepper motor or pneumatic or hydraulic cylinders.
4. **Sensors :** They are used to sense the internal as well as the external state to make sure the robot functions smoothly as a whole. Sensors involve touch sensors, IR sensor etc.
5. **Controller :** It is used to control the actuators based on the sensor feedback and thus control the motion of each and every joint and eventually the movement of the end effector.

Working of a Basic Pick N Place Robot :

- The basic function of a pick and place robot is done by its joints.
- Joints are analogous to human joints and are used to join the two consecutive rigid bodies in the robot.
- They can be rotary joint or linear joint.
- To add a joint to any link of a robot, we need to know about the degrees of freedom and degrees of movement for that body part.
- Degrees of freedom implement the linear and rotational movement of the body and Degrees of movement imply the number of axis the body can move.

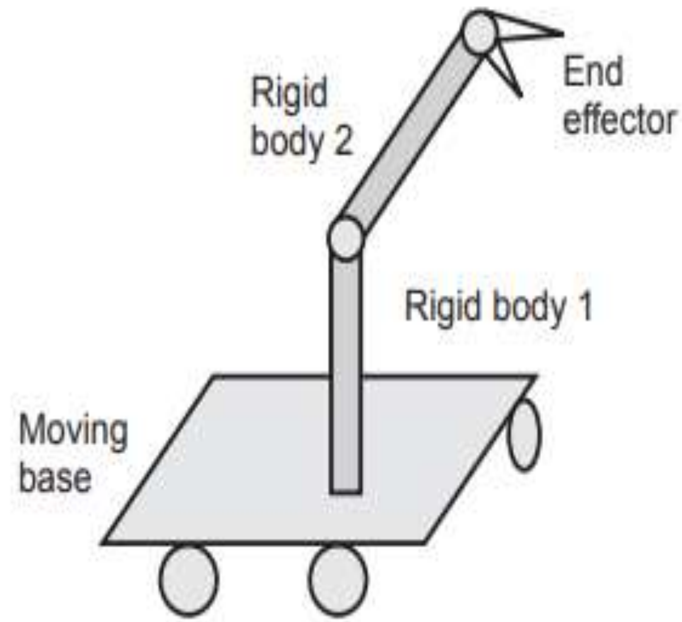


Fig. 5.7.1 Pick N Place Robot

Advantages

1. They are faster and can get the work done in seconds compared to their human counterparts.
2. They are flexible and have the appropriate design.
3. They are accurate.
4. They increase the safety of the working environment and actually never get tired.

Practical Applications of Pick and Place Robot :

1. **Defence Applications :** It can be used for surveillance and also to pick up harmful objects like bombs and diffuse them safely.
2. **Industrial Applications :** These robots are used in manufacturing, to pick up the required parts and place it in correct position to complete the machinery fixture. It can be also used to place objects on the conveyer belt as well as pick up defective products from the conveyer belt.
3. **Medical Applications :** These robots can be used in various surgical operations like in joint replacement operations, orthopaedic
and internal surgery operations. It performs the operations with more precision and accuracy.

5.7.2 Case Study 2 : Engine Management System[EMS]

☞ [AU : Dec.-2013, 2014, 2016, May-2015, 16 Marks]

- Engine management system is, now-a-days, used in many of the modern cars such as Benz, Mitsubishi, and Toyota etc.
- This system uses many electronic control system involving micro controllers.
- The generalised block diagram of this system is shown in Fig. 5.7.2.
- The objective of the system being to ensure that the engine is operated at its optimum settings.
- The system consists of many sensors for observing vehicle speed, engine temperature, oil and fuel pressure, airflow etc.
- These sensors are supplying input signals to the micro controller after suitable signal conditioning and providing output signals via drivers to actuate corresponding actuators.
- A single cylinder engine consists of some of these elements in relation to an engine is shown in Fig. 5.7.2.
- The engine sensor is an inductive type.
- It consists of a coil and sensor wheel.

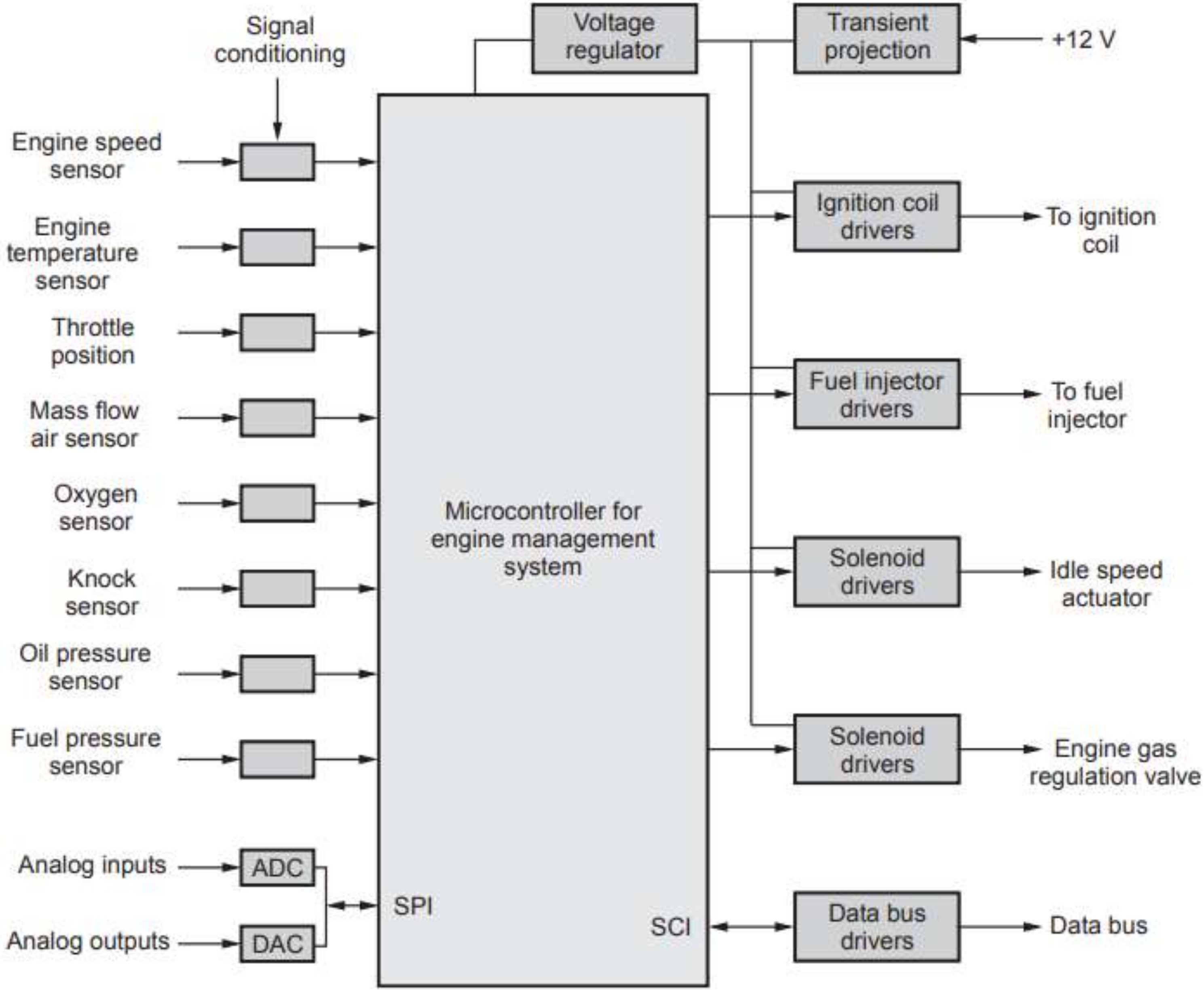


Fig. 5.7.2 Block diagram of Engine Management system

- The inductance of the coil changes as the teeth of the sensor wheel pass it and so results in an oscillating voltage.
- The engine temperature sensor is generally thermocouple which is made of bimetallic strip or a thermistor.
- The resistance of the thermistor changes with change in engine temperature this results in voltage variation.
- Hot wire anemometer is used as a sensor for measuring mass airflow rate.
- The basic principle is that the heated wire will be cooled as air passes over it.
- The amount of cooling is depending on the mass rate of flow.
- The oil and pressure sensors are diaphragm type sensors.

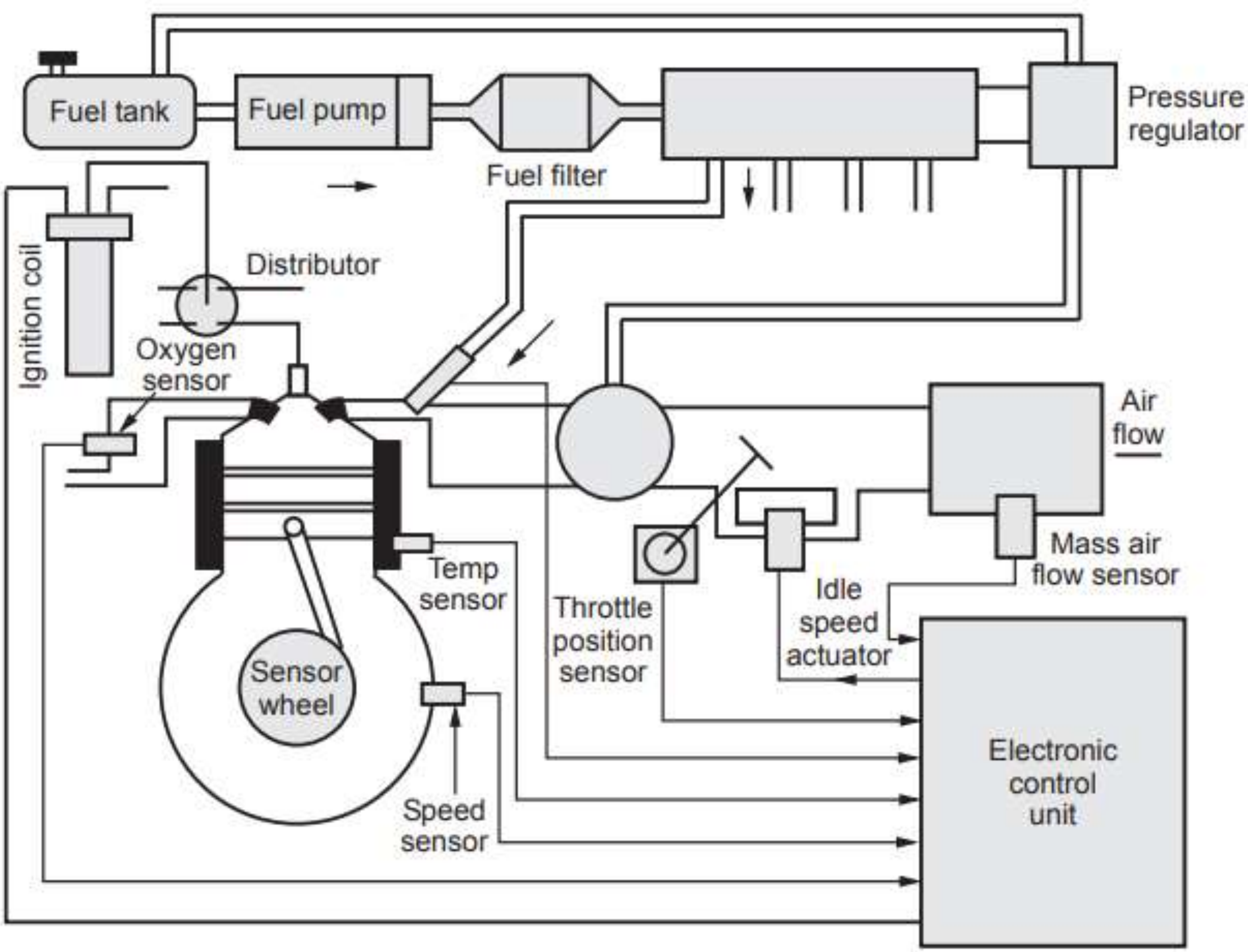


Fig. 5.7.3 Engine Management system with sensors and actuators

- According to the pressure variation, the diaphragm may contract or expand and activates strain gauges which produce voltage variation in the circuit.
- The oxygen sensor is usually a close end tube which is made of Zirconium oxide with porous platinum electrode on the inner and outer Surfaces
- The sensor becomes permeable to oxygen ions at about 300°C.
- This results in generation of voltage between the electrodes.
- The various drivers such as fuel injector drivers, ignition coil drivers.
- Solenoid drivers and used to actuate actuation according to the signal by various sensors.
- Analog signals given by sensors are converted into digital signal by using analog to digital converters (ADC) and sent it to micro controllers.
- The various output digital signals are converted into analog signals by DAC(i.e., Digital to Analog Converter) and shown in various recorders or meters

5.7.3 Case Study 3 : Automatic Car Park System

☞ [AU : May-2013, 2014, 2015, 16 Marks]

- Consider an automatic car park system with barriers operated by coin inserts.
- The system uses a PLC for its operation.
- There are two barriers used namely in barrier and out barrier.
- In barrier is used to open when the correct money is inserted while out barrier open when the car is detected in front of it.
- Fig. 5.7.4 Shows a schematic arrangement of an automatic car park barrier.

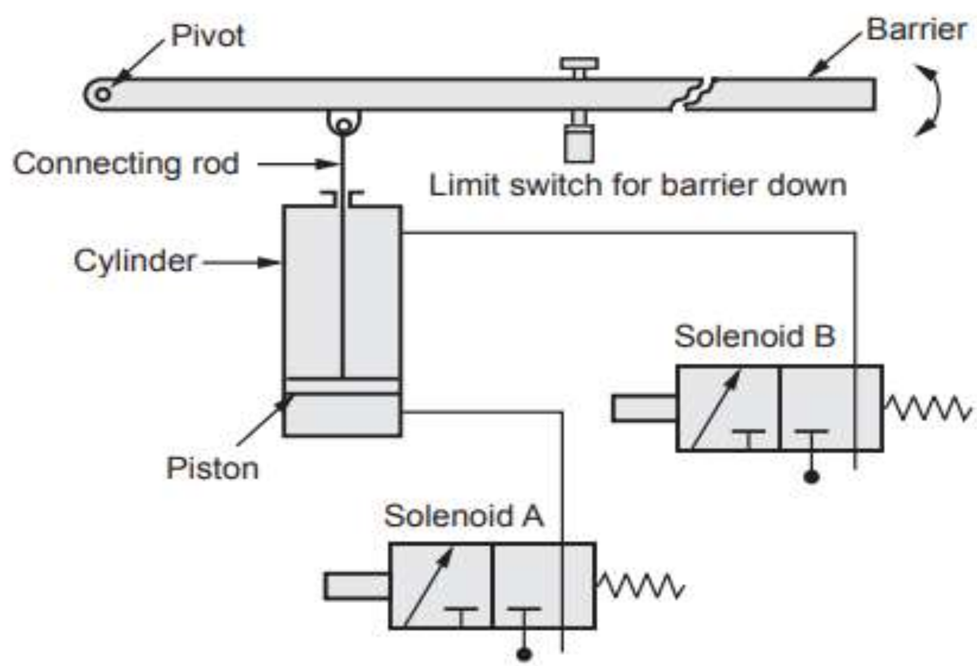


Fig. 5.7.4 Automatic car park barrier system

- It consists of a barrier which is pivoted at one end, two Solenoid valves A and Band a piston cylinder arrangement.
- A connecting rod connects piston and barrier as shown in Fig. 5.7.4.
- Solenoid valves are used to control the movement of the piston.
- Solenoid A is used to move the piston upward in turn barrier whereas solenoid B is used to move the piston downward.
- Limit switches are used to detect the foremost position of the barrier.
- When current flows through solenoid A, the, piston in the cylinder moves upward and causes the barrier to rotate about its pivot and raises to let a car through.
- When the barrier hits the limit switch, it will turns on the timer I give a required time delay.

- After that time delay, the solenoid B activated which brings the barrier downward by operating piston in the cylinder.
- This principle is used for both the barriers.

- Fig. 5.7.5 shows a PLC arrangement to operate the barrier.

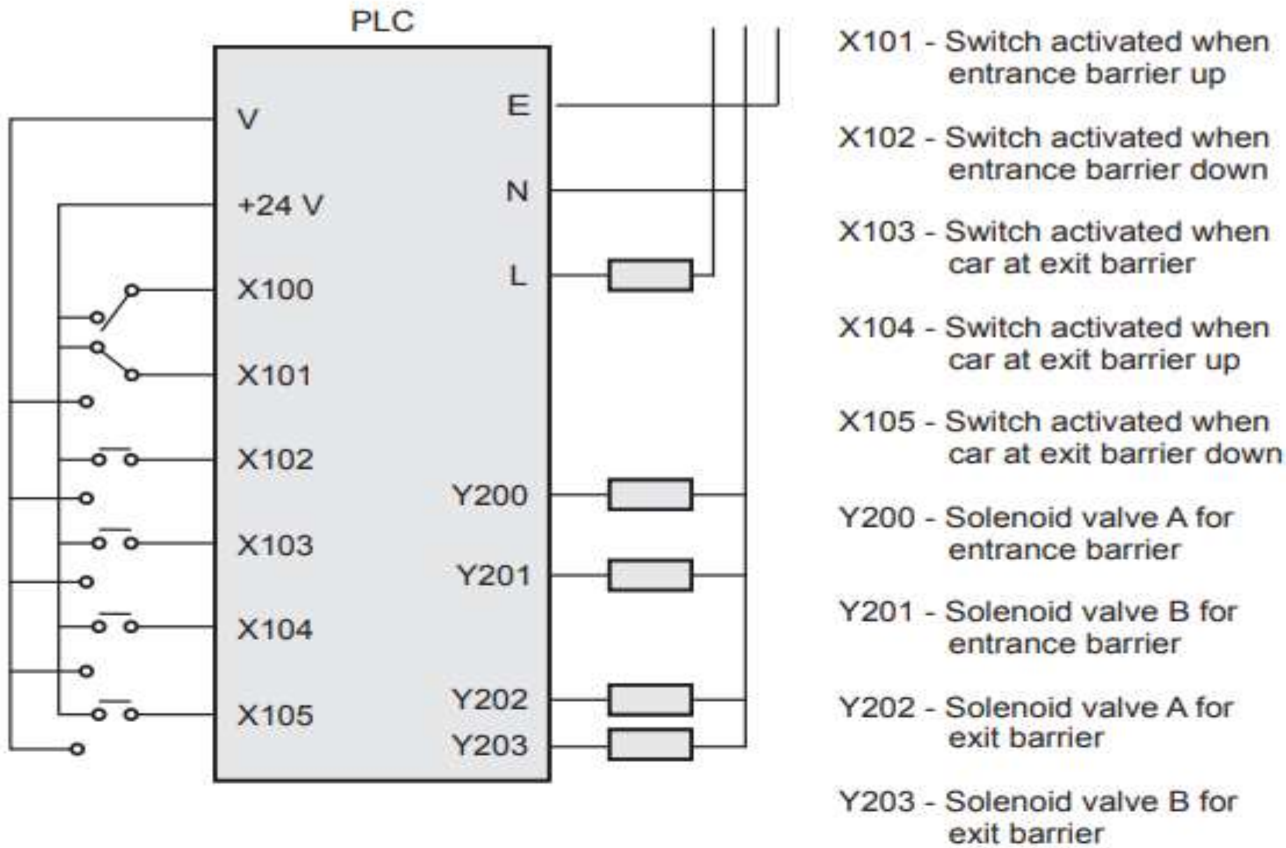
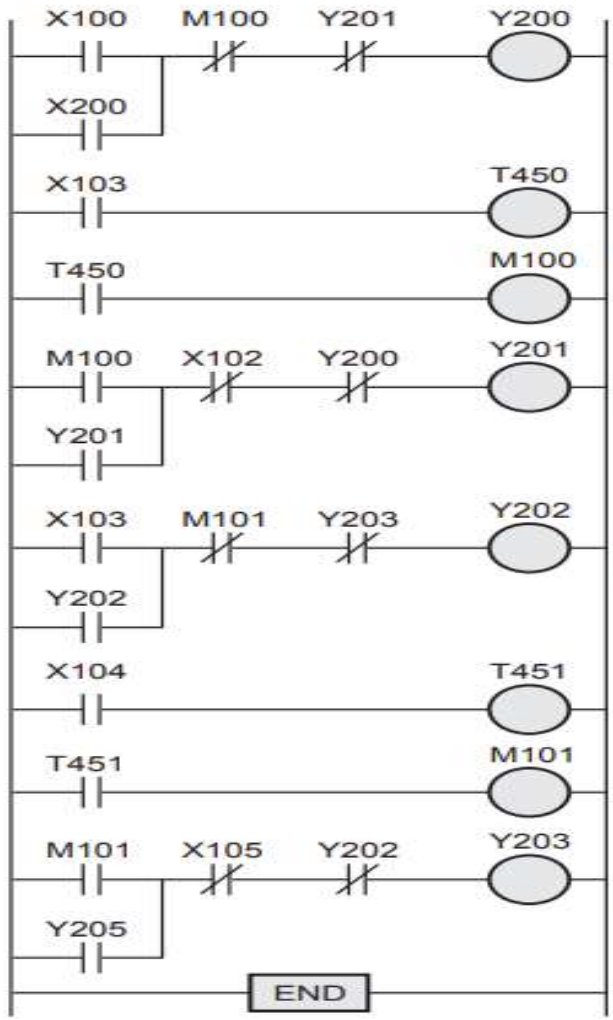


Fig. 5.7.5 PLC arrangement for operating barrier

- Fig. 5.7.6 Shows the ladder program for that PLC system. (See Fig. 5.7.6 on next page.)



Coin operated input
X100 is required to lift the entrance barrier
Y200 energies solenoid A

When the barrier is in upward position input
X101 starts timer

After 205 the internal relay M100 energised

This results in Y201 energising solenoid B
of entrance barrier and barriers comes down

Car operated input X103 is required to lift the
exit barrier. Y202 then energises solenoid A
of exit barrier

Input X104 starts timer when barrier up

After 205 the internal relay M101 energised

This results in Y203 energising solenoid B
of exit barrier and barrier comes down

Fig. 5.7.6 Ladder program for PLC system