Government Polytechnic Vaishali, Bihar

Under Department of Science, Technology and Technical Education, Bihar
Affiliated By State Board of Technical Education

LAB MANUAL

Control System and PLC

SUBJECT CODE – P2420404

Government Polytechnic Vaishali

Department of Electrical Engineering

Vision

To nurture industry-ready and ethically responsible diploma engineers in Electrical Engineering, equipped with modern technical skills, digital competence, and adaptability to support evolving industrial, infrastructural, and societal needs.

Mission

M1: To provide a student-centric and outcome-based learning ecosystem that integrates classroom instruction with modern laboratories, simulation software, digital learning platforms, and hands-on practices for effective knowledge acquisition.

M2: To impart application-oriented technical skills in electrical machines, power distribution systems, industrial wiring, control circuits, basic automation, and testing instruments, emphasizing safety standards, quality practices, and the use of contemporary tools and technologies.

M3: To strengthen industry readiness, employability, entrepreneurship, and preparedness for higher education through industry–institute interaction, internships, field exposure, expert lectures, skill development programs, guidance, innovation support, and awareness of emerging trends such as energy efficiency, renewable integration, and smart electrical systems.

M4: To foster professional ethics, teamwork, communication skills, problem-solving ability, environmental consciousness, and lifelong learning attitude, enabling diploma holders to contribute responsibly to industry, society, and national development.

Practical/Lab Session Outcomes (LSOs)

S.NO	Laboratory Experiment	Lab Session Outcomes
1	Speed -Torque characteristics of an DC servo motor.	Plot the speed torque characteristics of an DC Servo motor.
2	Speed Torque characteristics of an AC servo motor.	Plot the speed Torque characteristics of a AC servo motor.
3	AC Position Control system.	Perform test on AC servomotor to control the position.
4	DC Position Control system.	Perform test on DC servo motor to control the position without and with feedback (Both Degenerative and regenerative).
5	Synchro (Selsyn) transmitter and receiver pair.	Perform test on a given Synchro (Selsyn) transmitter and receiver pair.
6	Transient response of a first order system.	Plot the transient response of an RC circuit (First order system) when subjected to unit a step input.
7	Transient response of a second order system.	Plot the transient response of an RLC circuit (second order system) when subjected to unit a step input.

8	Determination of transient time response specification of an RLC series circuit (second order system).	Plot the transient time response of a series RLC circuit (second order system) and determine the rime response specifications.
9	Use open source software i.e. SCILAB to find the stability of the system.	Use open source software to analyze the given system characteristic equation to find the stability of the system.
10	Temperature control of a system using ONOFF controller.	Test the functionality of temperature control with ON-OFF controller.
11	Temperature control of a system using PI controller.	Use PI controller to control temperature of the given process.
12	Temperature control of a system using PD controller.	Use PD controller to control temperature of the given process.
13	Temperature control of a process using PID controller.	Use PID controller to control temperature of the given process.
14	Identification of Parts of a PLC and Input & Output devices of a PLC.	Identify different parts of a PLC and Input and Output devices.
15	Installation of a given PLC using proper procedure.	Install a given PLC using step by step procedure.

LIST OF EXPERIMENTS

1	Speed -Torque characteristics of an DC servo motor
2	Speed Torque characteristics of an AC servo motor
3	AC Position Control system
4	DC Position Control system
5	Synchro (Selsyn) transmitter and receiver pair
6	Transient response of a first order system
7	Transient response of a second order system
8	Determination of transient time response specification of an RLC series circuit (second order system)
9	Use open source software i.e. SCILAB to find the stability of the system
10	Temperature control of a system using ON OFF controller
11	Temperature control of a system using PI controller
12	Temperature control of a system using PD controller

13	Temperature control of a process using PID controller
14	Identification of Parts of a PLC and Input & Output devices of a PLC
15	Installation of a given PLC using proper Procedure

PRACTICAL OUTCOMES

CO	Statement
1	Apply the basics of control system to a given system.
2	Analyze time response of the first and second order control systems.
3	Determine the stability of a given control system using Routh-Hurwitz and Bode plot methods.
4	Use PID Controller to initiate control action in a given control system.
5	Use PLC to control the simple industrial processes.

PROGRAM EDUCATIONAL OBJECTIVES (PEO)

PEO No.	Program Educational Objectives Statements
PEO1	To prepare diploma holders with a strong foundation in electrical engineering fundamentals and state-of-the-art technologies, enabling continuous learning, skill upgradation, and adaptability to emerging industrial and technological trends.
PEO2	To develop professionally responsible diploma holders with effective communication skills, leadership qualities, ethical values, and the ability to work efficiently as individuals and as members of multidisciplinary teams.
PEO3	To enhance employability by providing industry-oriented training, hands-on experience, and exposure through industrial visits, internships, seminars, workshops, and interaction with industry professionals and academicians.
PEO4	To enable diploma holders to apply project-based learning, modern tools, and innovative approaches to develop solutions addressing technical, socio-economic, and environmental challenges in a sustainable and socially responsible manner.

PROGRAM SPECIFIC OUTCOMES

PSO1: Design, Install, operate, and troubleshoot electrical systems, machines and power circuits using modern tools while adhering to safety standards and environmental consideration.
PSO2: Work effectively in multidisciplinary teams to solve real-time electrical engineering problems and communicate technical information clearly and professionally.

PROGRAM OUTCOMES (POS)

P01: Basic and Discipline specific knowledge: Apply knowledge of basic mathematics, science and engineering fundamentals and engineering specialization to solve the engineering problems.

PO2: Problem analysis: Identify and analyse well-defined engineering problems using codified standard methods.

PO3: Design/ development of solutions: Design solutions for well-defined technical problems and assist with the design of systems components or processes to meet specified needs.

P04: Engineering Tools, Experimentation and Testing: Apply modern engineering tools and appropriate technique to conduct standard tests and measurements.

PO5: Engineering practices for society, sustainability and environment: Apply appropriate technology in context of society, sustainability, environment and ethical practices.

PO6: Project Management: Use engineering management principles individually, as a team member or a leader to manage projects and effectively communicate about well-defined engineering activities.

PO7: Life-long learning: Ability to analyze individual needs and engage in updating in the context of technological changes.

EXPERIMENT NO: 01

Speed–Torque Characteristics of a DC Servo Motor

Aim

To study and plot the speed–torque characteristics of a DC servo motor.

Theory

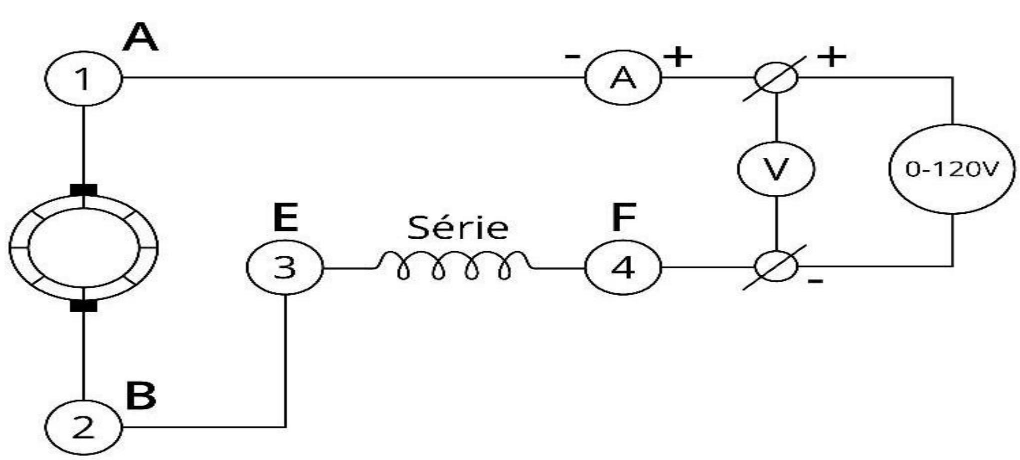
A DC servo motor is a specially designed motor used in automatic control systems for precise control of speed, position, and torque. It works on the principle of electromagnetic induction.

The speed–torque characteristic represents the relationship between speed and load torque. In a DC servo motor, speed decreases as torque increases. When load is applied, armature current increases, causing a voltage drop across armature resistance and Resulting in a decrease in speed.

At no-load condition, the motor runs at maximum speed. As the load increases, torque increases and speed decreases approximately linearly.

The basic equation is:

$N \propto (V - I_a R_a) / \varphi$



Practical Set-up / Circuit Diagram

The DC servo motor is connected to a DC power supply. An ammeter is connected in series to measure current and a voltmeter is connected across the supply. A tachometer is used to measure speed. Load is applied using a brake drum or rheostat arrangement.

Apparatus Required

DC servo motor, DC power supply, ammeter, voltmeter, tachometer, rheostat or brake arrangement, connecting wires

Precautions

1. Check all connections before switching ON the supply.
2. Do not exceed the rated voltage.
3. Apply load gradually.
4. Keep hands away from rotating parts.
5. Take readings carefully.
6. Switch OFF the supply after completion.

Procedure

1. Connect the circuit as per the set-up.
2. Switch ON the DC power supply.
3. Note the no-load speed of the motor.
4. Apply load gradually using the rheostat or brake.
5. Record the armature current for each load.
6. Measure and note the speed using a tachometer.
7. Repeat readings for different load values.
8. Switch OFF the supply after completion.

9. Plot the graph between speed and torque.

Observations and Calculations

S. No.	Voltage (V)	Current (A)	Torque (Nm)	Speed (RPM)
1				
2				
3				
4				

Torque is proportional to armature current:

$T \propto Ia$

Result

The speed–torque characteristics of the DC servo motor were studied. It is observed that speed decreases with increase in torque, showing an approximately linear relationship.

VIVA BOOK

1. Define a DC servo motor.
2. Explain the working principle of a DC servo motor.
3. Explain the speed–torque characteristics of a DC servo motor.
4. Differentiate between a DC motor and a DC servo motor.
5. Differentiate between speed control and torque control.

EXPERIMENT NO: 02

Speed–Torque Characteristics of an AC Servo Motor

Aim

To study and plot the speed–torque characteristics of an AC servo motor.

Theory

An AC servo motor is a two-phase induction motor specially designed for control systems where precise control of speed and position is required. It consists of two windings: a reference winding and a control winding placed at 90° to each other.

When AC supply is given to the reference winding and a control signal is applied to the control winding, a rotating magnetic field is produced. This Results in torque generation and rotation of the motor.

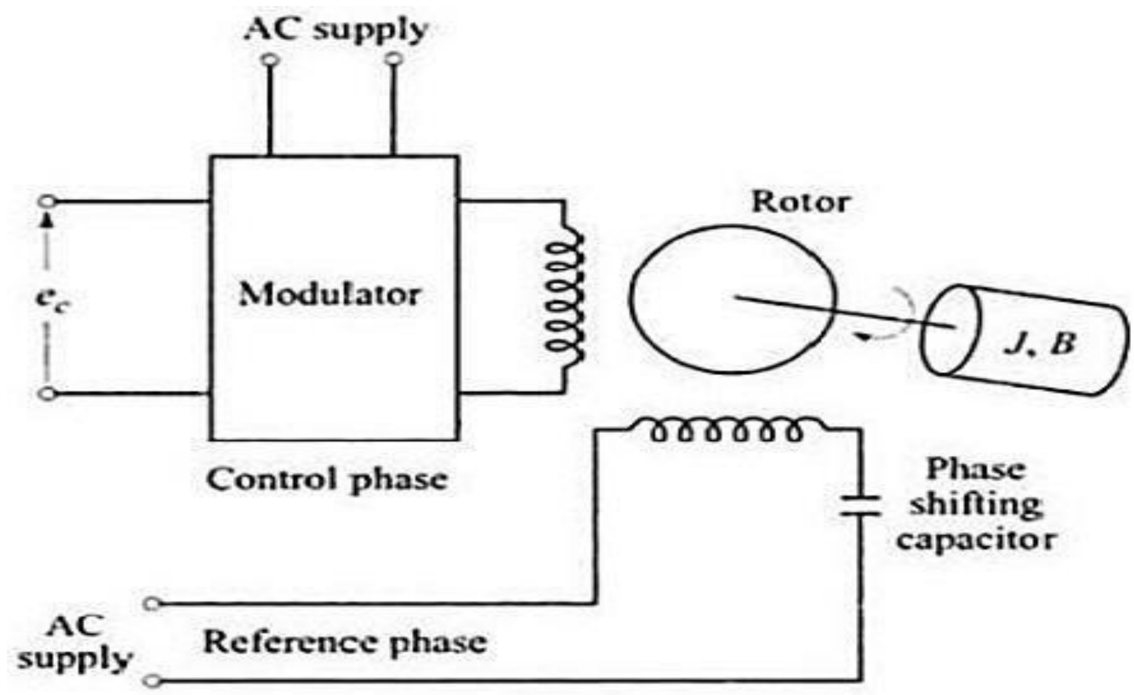
The speed–torque characteristic of an AC servo motor is generally linear over a wide range. The motor is designed to have high resistance in the rotor, which gives a negative slope characteristic, meaning speed decreases as torque increases.

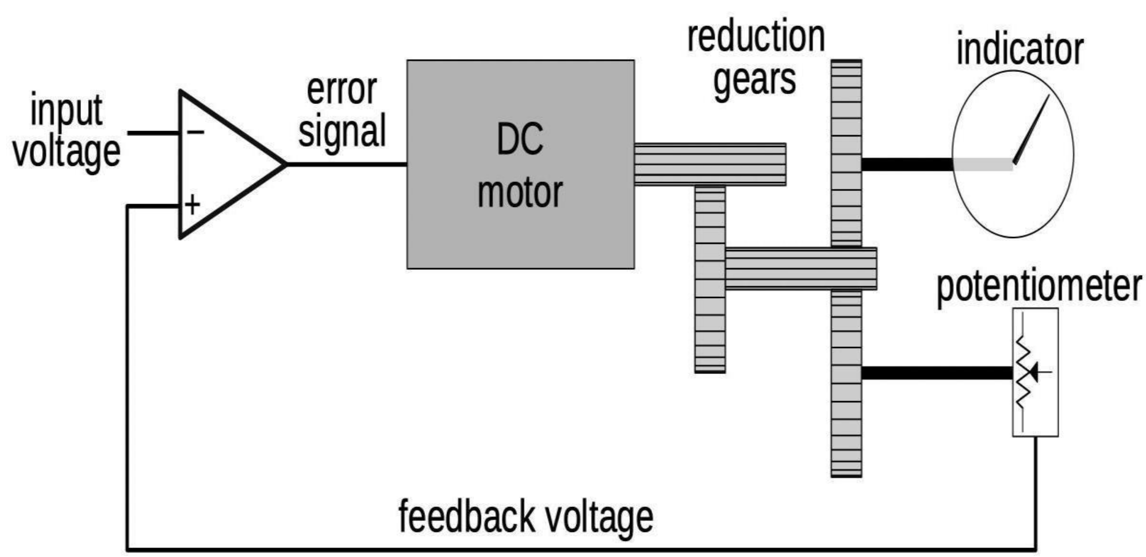
At no-load, the motor runs at high speed. As the load increases, torque increases and speed decreases. The direction of rotation depends on the phase difference of the control voltage.

Torque in an AC servo motor is approximately proportional to the control voltage: $T \propto V_c$

Where T is torque and Vc is control voltage.

Practical Set-up / Circuit Diagram





The AC servo motor is connected to an AC supply. The reference winding is connected to a constant AC source, while the control winding is supplied through a variable voltage source. Measuring instruments like ammeter, voltmeter, and tachometer are used. Load is applied using a brake or dynamometer arrangement to vary torque.

Apparatus Required

AC servo motor, AC power supply, variable AC source, ammeter, voltmeter, tachometer, brake drum or dynamometer, connecting wires

Precautions

1. Check all connections before switching ON the supply.
2. Do not exceed the rated voltage of the motor.
3. Apply load gradually.
4. Avoid touching moving parts.
5. Ensure proper insulation of wires.
6. Switch OFF supply after completing the experiment.

Procedure

1. Connect the circuit as per the given set-up.
2. Switch ON the AC supply.
3. Run the motor at no-load and note the speed.
4. Apply load gradually using the brake or dynamometer.
5. Record the current and control voltage for each load.
6. Measure the speed using a tachometer.
7. Repeat readings for different load conditions.
8. Switch OFF the supply after completing the readings.
9. Plot the graph between speed and torque.

Observations and Calculations

S. No.	Voltage (V)	Current (A)	Torque (Nm)	Speed (RPM)
1				

S. No.	Voltage (V)	Current (A)	Torque (Nm)	Speed (RPM)
2				
3				
4				

Torque relation:

$$T \propto V_c$$

Result

The speed–torque characteristics of the AC servo motor were studied. It is observed that speed decreases with increase in torque. The characteristic curve shows an approximately linear decreasing relationship.

VIVA BOOK

1. Define an AC servo motor.
2. Explain the working principle of an AC servo motor.
3. Explain the speed–torque characteristics of an AC servo motor.
4. Differentiate between AC servo motor and DC servo motor.
5. Differentiate between control winding and reference winding.

EXPERIMENT NO:03

AC Position Control System

Aim

To study the working of an AC position control system and observe its response for different input positions.

Theory

An AC position control system is a closed-loop control system used to control the angular position of a shaft. It mainly consists of an AC servo motor, a position sensor (such as a potentiometer), an error detector, and an amplifier.

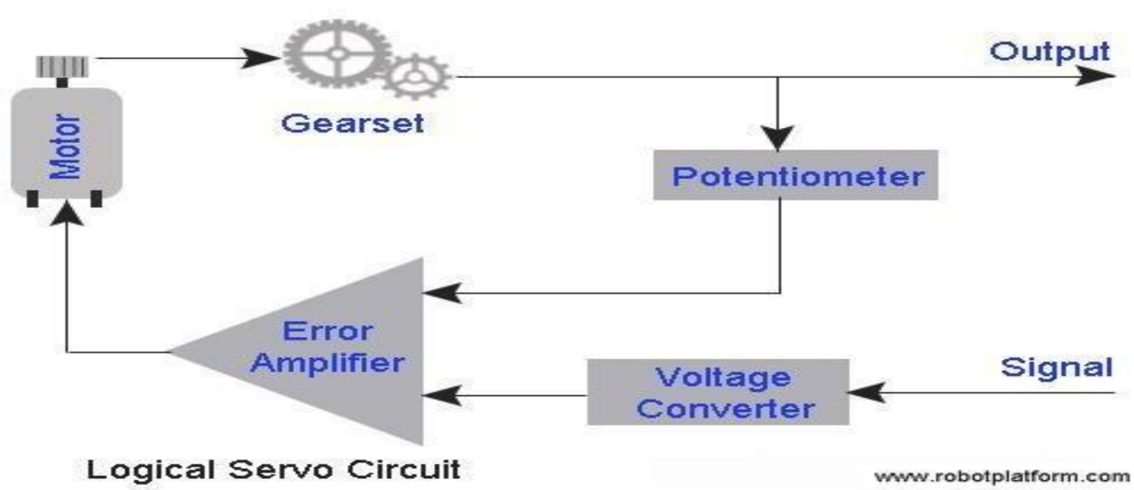
In this system, the desired position is given as input, and the actual position is continuously measured using a feedback device. The difference between the desired position and actual position is called error. This error signal is amplified and used to drive the AC servo motor.

The motor rotates in such a way that the error is reduced to zero. When the desired position is reached, the error becomes zero and the motor stops automatically.

The system works on the principle of negative feedback, which ensures accuracy and stability. The direction of rotation depends on the polarity of the error signal.

Error = Reference position − Actual position

Practical Set-up / Circuit Diagram



The setup consists of an AC servo motor connected to a control circuit. A potentiometer is used to set the desired position, and another potentiometer is used for feedback. The error detector compares both signals, and the amplifier drives the motor accordingly. Measuring instruments are used to observe system response.

Apparatus Required

AC servo motor, AC power supply, potentiometers, amplifier, error detector unit, voltmeter, connecting wires

Precautions

1. Check all connections before switching ON.
2. Do not exceed the rated voltage.
3. Ensure proper calibration of potentiometers.
4. Avoid loose connections.
5. Do not touch moving parts.
6. Switch OFF supply after the experiment.

Procedure

1. Connect the circuit as per the given set-up.
2. Switch ON the AC power supply.
3. Set a desired position using the input potentiometer.
4. Observe the motor movement towards the set position.
5. Note the final position and error, if any.
6. Change the input position and repeat the observations.
7. Record readings for different input positions.
8. Switch OFF the supply after completing the experiment.

Observations and Calculations

S. No.	Input Position	Output Position	Error	Response Time
1				
2				
3				
4				

Error calculation:

Error = Reference position − Actual position

Result

The AC position control system was studied successfully. It is observed that the motor moves to the desired position and reduces the error to nearly zero. The system provides accurate and stable position control.

VIVA BOOK

1. Define an AC position control system.
2. Explain the working principle of an AC position control system.
3. What is the role of feedback in a control system?
4. Differentiate between open-loop and closed-loop control systems.
5. Differentiate between AC servo motor and DC servo motor.

EXPERIMENT NO:04

DC Position Control System

Aim

To study the working of a DC position control system and observe its response for different input positions.

Theory

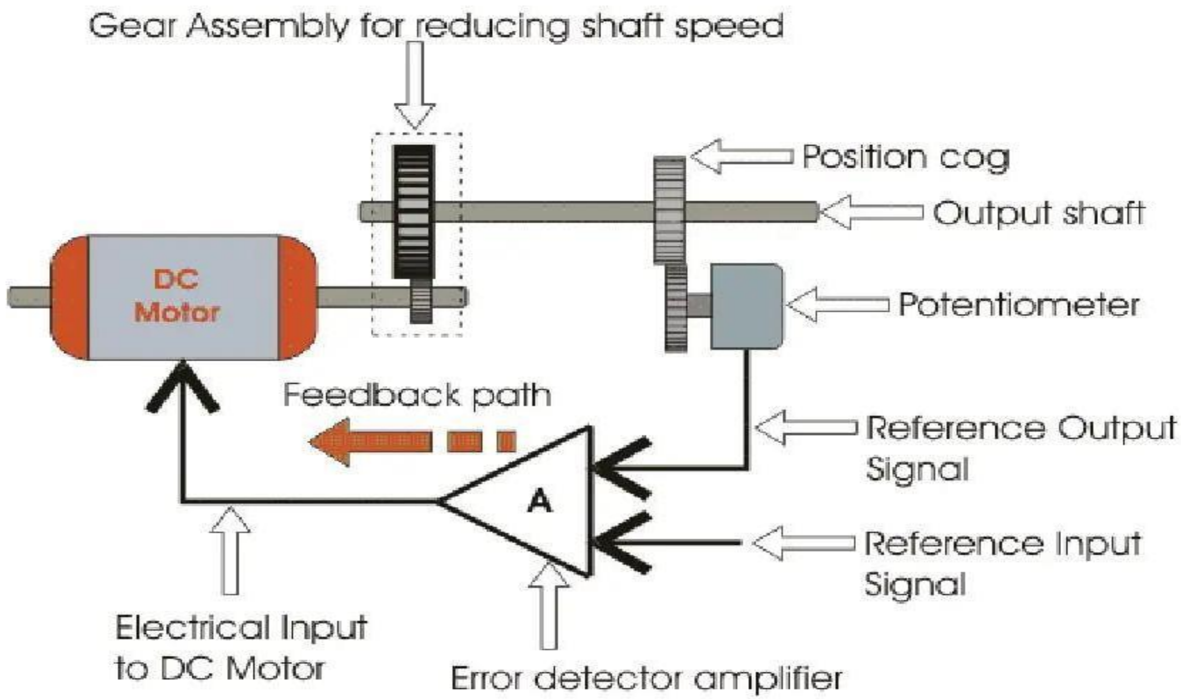
A DC position control system is a closed-loop control system used to control the angular position of a shaft using a DC servo motor. It consists of a DC servo motor, a feedback device (usually a potentiometer), an error detector, and an amplifier.

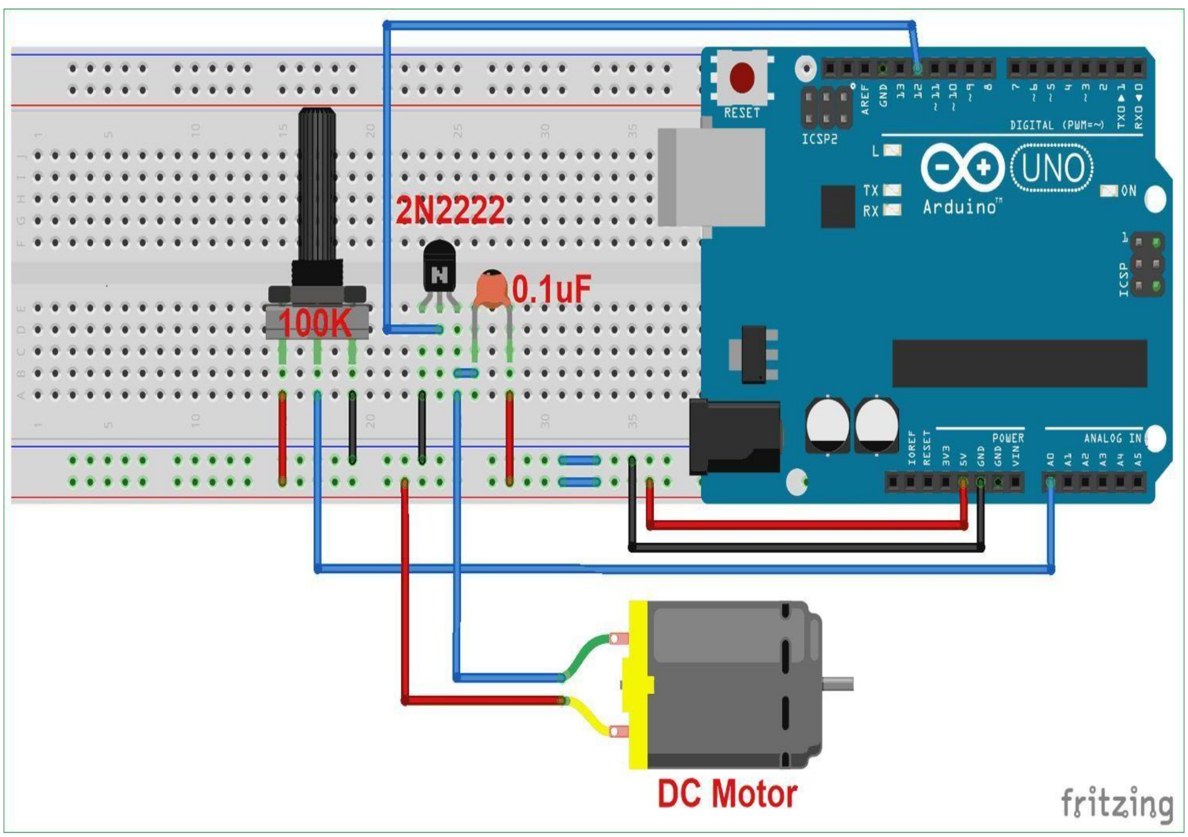
In this system, a desired position is given as input. The actual position of the motor shaft is continuously measured using a feedback potentiometer. The difference between the desired position and actual position is called error. This error signal is amplified and used to drive the DC servo motor.

The motor rotates in a direction that reduces the error. When the actual position becomes equal to the desired position, the error becomes zero and the motor stops. This system works on the principle of negative feedback, providing high accuracy and stability.

Error = Reference position − Actual position

Practical Set-up / Circuit Diagram


Gear Assembly for reducing shaft speed
Position cog
Output shaft
DC Motor
Potentiometer
Feedback path
Reference Output Signal
A
Reference Input Signal
Electrical Input to DC Motor
Error detector amplifier


2N2222
0.1uF
100K
DC Motor
fritzing

The setup consists of a DC servo motor connected to a control circuit. A potentiometer is used to set the desired position, and another potentiometer is used as a feedback device. The error detector compares the input and feedback signals. The amplifier strengthens the error signal and drives the motor to reach the desired position.

Apparatus Required

DC servo motor, DC power supply, potentiometers, amplifier, error detector unit, voltmeter, connecting wires

Precautions

1. Check all connections before switching ON the supply.
2. Do not exceed the rated voltage.
3. Ensure proper calibration of potentiometers.
4. Avoid loose connections.
5. Keep hands away from moving parts.
6. Switch OFF the supply after completing the experiment.

Procedure

1. Connect the circuit as per the given set-up.
2. Switch ON the DC power supply.
3. Set a desired position using the input potentiometer.
4. Observe the rotation of the motor shaft.
5. Note the final position reached by the motor.
6. Calculate the error between input and output positions.
7. Repeat the experiment for different input positions.
8. Record all observations carefully.

9. Switch OFF the supply after completion.

Observations and Calculations

S. No.	Input Position	Output Position	Error	Response Time
1				
2				
3				
4				

Error calculation:

Error = Reference position − Actual position

Result

The DC position control system was studied successfully. It is observed that the motor reaches the desired position and minimizes the error. The system provides accurate and stable position control.

VIVA BOOK

1. Define a DC position control system.
2. Explain the working principle of a DC position control system.
3. What is meant by error in a control system?
4. Differentiate between open-loop and closed-loop control systems.
5. Differentiate between AC servo motor and DC servo motor.

EXPERIMENT NO:5

Synchro (Selsyn) Transmitter and Receiver Pair

Aim

To study the operation of a synchro transmitter and receiver pair and observe the position correspondence between them.

Theory

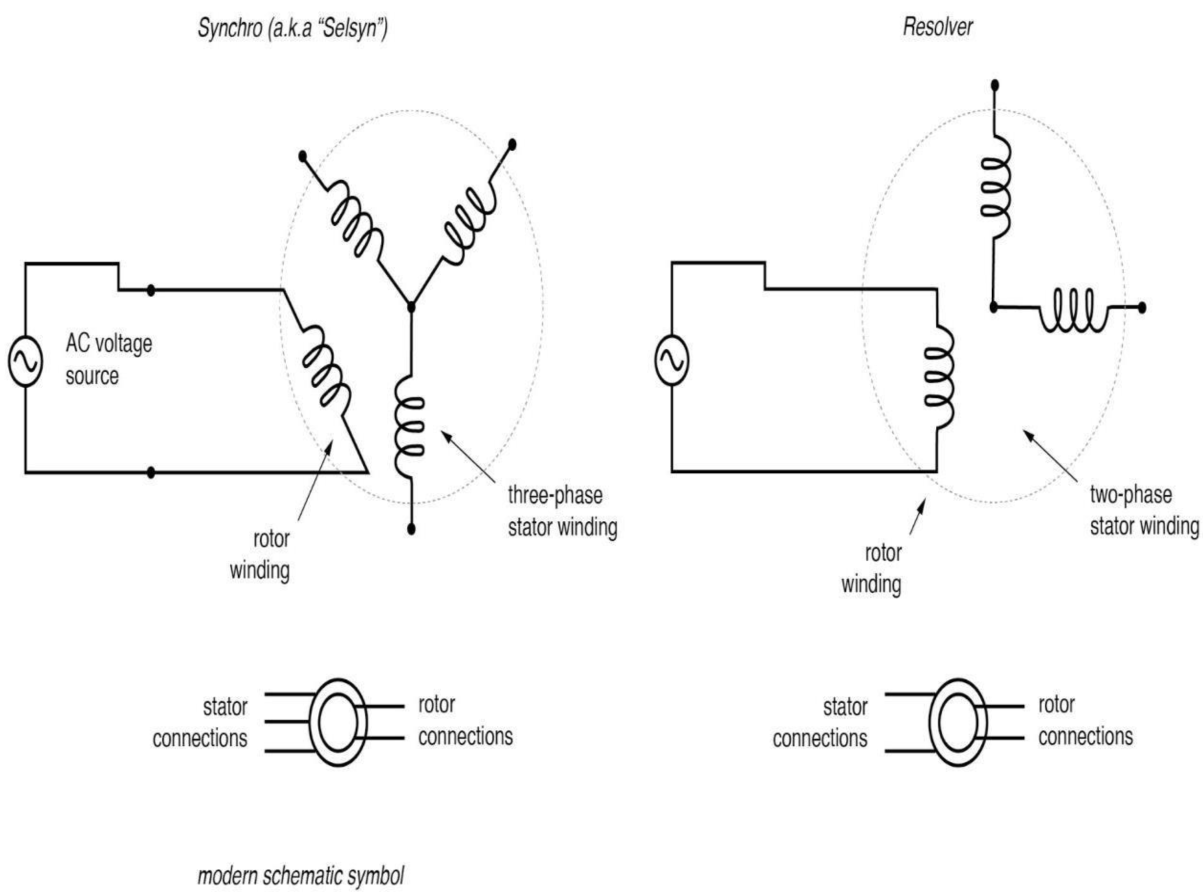
A synchro, also known as a selsyn, is an electromechanical device used to transmit angular position from one location to another. It consists of two main parts: a transmitter and a receiver.

The synchro transmitter converts mechanical angular position into an electrical signal. The synchro receiver converts this electrical signal back into the same angular position. Both units have a rotor and three stator windings placed 120° apart.

When AC supply is given to the rotor of the transmitter, voltages are induced in the stator windings depending on the rotor position. These voltages are transmitted to the stator windings of the receiver. Due to this, a magnetic field is produced in the receiver, causing its rotor to rotate and align with the transmitter rotor position.

Thus, the receiver follows the transmitter position, maintaining angular synchronization.

Practical Set-up / Circuit Diagram



The setup consists of a synchro transmitter and a synchro receiver. The rotor of the transmitter is connected to an AC supply. The stator windings of the transmitter are connected to the stator windings of the receiver. When the transmitter shaft is rotated, the receiver shaft follows the same angular position.

Apparatus Required

Synchro transmitter, synchro receiver, AC power supply, voltmeter, connecting wires

Precautions

1. Check all connections before switching ON the supply.
2. Do not exceed the rated voltage.
3. Ensure proper alignment of shafts.

4. Avoid loose connections.
5. Do not rotate shafts forcefully.
6. Switch OFF supply after the experiment.

Procedure

1. Connect the circuit as per the given set-up.
2. Switch ON the AC supply.
3. Set the transmitter shaft to a known position.
4. Observe the position of the receiver shaft.
5. Rotate the transmitter shaft to different angles.
6. Note the corresponding position of the receiver shaft.
7. Compare both positions and record observations.
8. Repeat for multiple angular positions.
9. Switch OFF the supply after completion.

Observations and Calculations

S. No.	**Transmitter Angle (°)**	**Receiver Angle (°)**	**Error (°)**
1			
2			
3			
4			

Error calculation:

Error = Transmitter angle − Receiver angle

Result

The synchro transmitter and receiver pair was studied successfully. It is observed that the receiver shaft follows the transmitter shaft position with very small error, showing accurate angular position transmission.

VIVA BOOK

1. Define a synchro (selsyn).
2. Explain the working principle of a synchro system.
3. What is the function of a synchro transmitter and receiver?
4. Differentiate between synchro and potentiometer.
5. Differentiate between open-loop and closed-loop systems.

EXPERIMENT NO:6

Transient Response of a First Order System

Aim

To study the transient response of a first order system and determine its time constant.

Theory

A first order system is a system whose behavior can be described by a first order differential equation. It is commonly represented by the transfer function:

$G(s)= K/1+\tau sK$

where K is system gain and τ (tau) is the time constant.

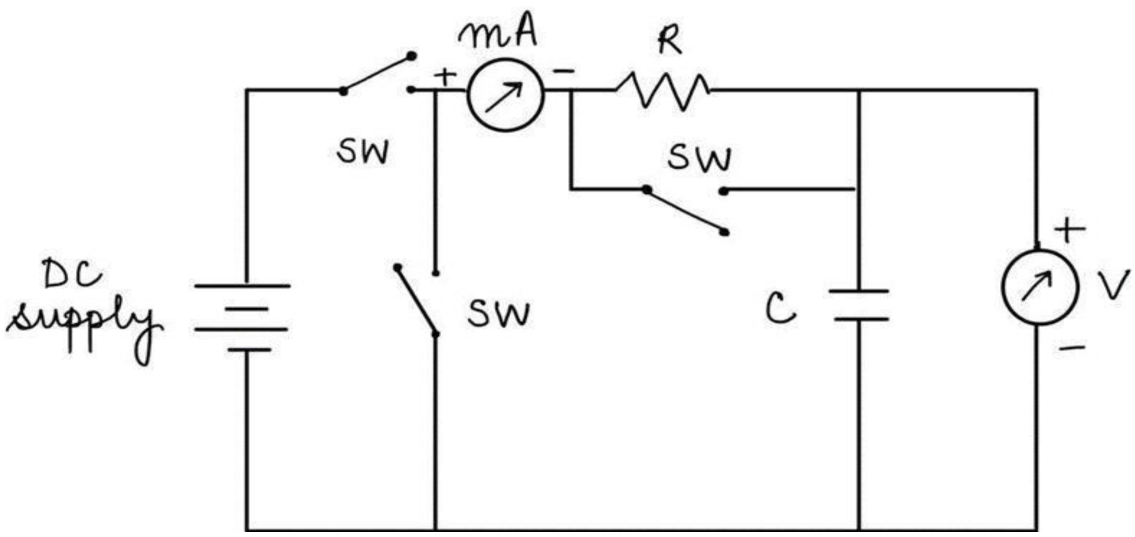
When a step input is applied to a first order system, the output does not reach its final value instantly but rises gradually. This response is called the transient response.

The time constant τ is the time required for the output to reach 63.2% of its final value. The response of a first order system for a step input is given by:

$y(t)=K(1-e^{-t/\tau})$

The response is smooth and does not have oscillations. The speed of response depends on the value of τ. Smaller τ means faster response, while larger τ means slower response.

Practical Set-up / Circuit Diagram



The setup consists of an RC circuit representing a first order system. A step input is applied using a function generator. The output is taken across the capacitor and observed using an oscilloscope. The waveform is used to study the transient response.

Apparatus Required

Resistor, capacitor, function generator, oscilloscope, DC power supply, connecting wires

Precautions

1. Check all connections before switching ON.
2. Use proper values of resistor and capacitor.
3. Do not exceed voltage ratings.
4. Ensure proper grounding of oscilloscope.
5. Take readings carefully.
6. Switch OFF supply after experiment.

Procedure

1. Connect the RC circuit as per the given setup.
2. Apply a step input using the function generator.
3. Observe the output waveform on the oscilloscope.
4. Measure the final steady-state value of the output.
5. Determine the time at which output reaches 63.2% of final value.
6. Calculate the time constant τ.
7. Repeat the experiment for different values of R or C if required.
8. Record all observations.
9. Switch OFF the supply after completion.

Observations and Calculations

S. No.	Final Value	63.2% Value	Time (t)	Time Constant (τ)
1				
2				
3				
4				

Formula used: $\tau = RC$

Step Response Equation

$y(t)=K(1-e^{-t/\tau})$

Result

The transient response of the first order system was studied successfully. The time constant was determined from the graph and it is observed that the system response follows an exponential rise.

VIVA BOOK

1. Define a first order system.
2. What is transient response?
3. Explain the significance of time constant.
4. Differentiate between transient and steady-state response.
5. Differentiate between first order and second order systems.

EXPERIMENT NO:7

Transient Response of a Second Order System

Aim

To study the transient response of a second order system and determine its characteristics.

Theory

A second order system is a system whose behavior is described by a second order differential equation. It is commonly represented by the transfer function:

$$G(s) = \frac{Ks^4}{\left(s^2 + 2\zeta\omega_n s + \omega_n^2\right)^2}$$

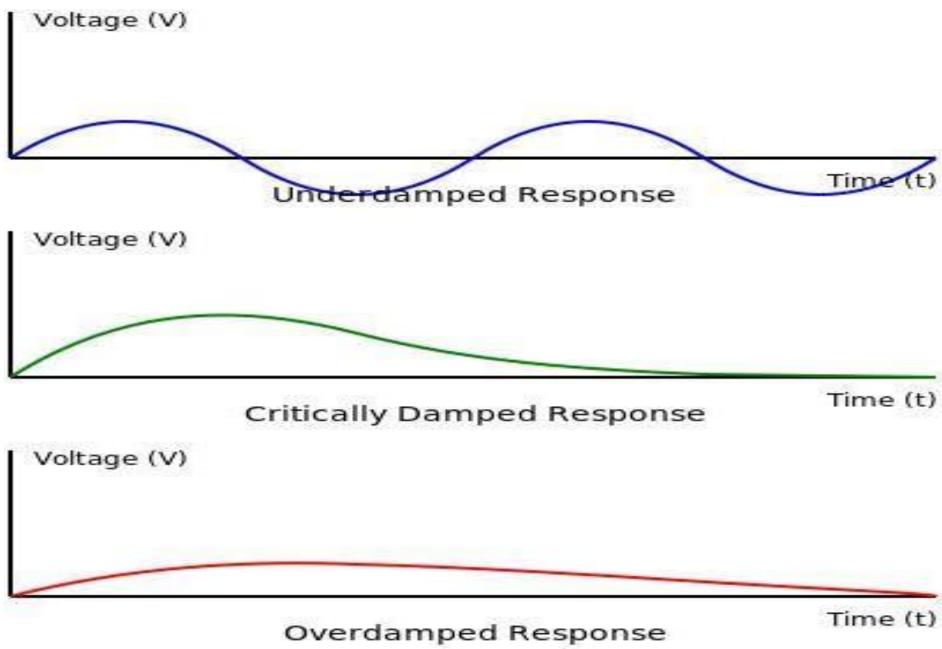
where K is system gain, $\omega_n$is natural frequency, and ζ is damping ratio.

When a step input is applied, the system response depends on the value of damping ratio:

- If (ζ< 1), the system is underdamped and shows oscillations
- If (ζ = 1), the system is critically damped and reaches final value quickly without oscillation
- If (ζ > 1), the system is overdamped and responds slowly without oscillation

Important parameters of transient response include rise time, peak time, maximum overshoot, and settling time. The system response may oscillate before reaching steady state depending on damping.

Practical Set-up / Circuit Diagram



The setup consists of an RLC circuit representing a second order system. A step input is applied using a function generator. The output is observed across one of the elements using an oscilloscope. The waveform shows oscillations and is used to study transient characteristics.

Apparatus Required

Resistor, inductor, capacitor, function generator, oscilloscope, power supply, connecting wires

Precautions

1. Check all connections before switching ON.
2. Use proper values of R, L, and C.
3. Do not exceed voltage ratings.
4. Ensure proper grounding of oscilloscope.

5. Take readings carefully.
6. Switch OFF supply after experiment.

Procedure

1. Connect the RLC circuit as per the given setup.
2. Apply a step input using the function generator.
3. Observe the output waveform on the oscilloscope.
4. Measure rise time, peak time, and settling time from the graph.
5. Note the maximum overshoot.
6. Determine the damping nature of the system.
7. Repeat for different values of components if required.
8. Record all observations.
9. Switch OFF the supply after completion.

Observations and Calculations

S. No.	Rise Time	Peak Time	Overshoot (%)	Settling Time
1				
2				
3				
4				

Standard Second Order System

$$G(s) = \frac{Ks^4}{\left(s^2 + 2\zeta\omega_n s + \omega_n^2\right)^2}$$

Result

The transient response of the second order system was studied successfully. It is observed that the system response depends on damping ratio and may exhibit oscillations before reaching steady state.

VIVA BOOK

1. Define a second order system.
2. What is damping ratio?
3. Explain transient response of a second order system.
4. Differentiate between underdamped and overdamped systems.
5. Differentiate between first order and second order systems.

EXPERIMENT NO:8

Determination of Transient Time Response Specification of an RLC Series Circuit (Second Order System)

Aim

To determine the transient response specifications of an RLC series circuit and study its second order behavior.

Theory

An RLC series circuit is a second order system consisting of a resistor (R), inductor (L), and capacitor (C). When a step input is applied, the circuit exhibits transient response before reaching steady state.

The behavior of the circuit depends on the damping ratio (ζ), which is given by:

$\zeta = 2\ R$

The natural frequency is:

$$\omega = \frac{1}{\sqrt{LC}}$$

Based on damping ratio:

- $\zeta < 1 \rightarrow$ Underdamped (oscillatory response)
- $\zeta = 1 \rightarrow$ Critically damped (fast response, no oscillation)
- $\zeta > 1 \rightarrow$ Overdamped (slow response, no oscillation)

Important transient response specifications are:

- Rise time: time to reach final value initially
- Peak time: time to reach maximum peak
- Maximum overshoot: amount by which response exceeds final value
- Settling time: time to reach and stay within a small range of final value

The setup consists of a series RLC circuit connected to a function generator to provide step input. The output voltage is observed across the capacitor using an oscilloscope. The waveform obtained is used to determine transient response specifications.

Apparatus Required

Resistor, inductor, capacitor, function generator, oscilloscope, power supply, connecting wires

Precautions

1. Check all connections before switching ON.
2. Use proper values of R, L, and C.
3. Do not exceed voltage ratings.
4. Ensure proper grounding of oscilloscope.
5. Take readings carefully.
6. Switch OFF supply after completion.

Procedure

1. Connect the RLC series circuit as per the setup.
2. Apply a step input using the function generator.
3. Observe the output waveform on the oscilloscope.
4. Measure rise time from the waveform.
5. Measure peak time and maximum overshoot.
6. Determine settling time from the graph.
7. Calculate damping ratio and natural frequency if required.
8. Record all readings carefully.
9. Switch OFF the supply after completion.

Observations and Calculations

S. No.	Rise Time	Peak Time	Overshoot (%)	Settling Time
1				
2				
3				
4				

Damping Ratio Formula

$$\zeta = \frac{c}{2\sqrt{mk}}$$

Natural Frequency

$$\omega = \frac{1}{\sqrt{LC}}$$

Result

The transient response specifications of the RLC series circuit were determined successfully. It is observed that the system exhibits second order behavior and the response depends on the damping ratio.

VIVA BOOK

1. Define a second order system.
2. What is damping ratio?
3. Explain transient response of an RLC circuit.
4. Differentiate between underdamped and overdamped response.
5. Differentiate between rise time and settling time.

EXPERIMENT NO:9

Use of open source software (SCILAB) to find the stability of a system

Aim

To determine the stability of a control system using SCILAB software.

Theory

Stability of a system refers to its ability to return to equilibrium after a disturbance. A system is said to be stable if its output remains bounded for a bounded input.

In control systems, stability can be analyzed using the characteristic equation obtained from the transfer function. If all the roots (poles) of the characteristic equation have negative real parts, the system is stable. If any pole has a positive real part, the system is unstable.

SCILAB is an open source software used for numerical computation and simulation. It provides tools to analyze system stability using methods like pole-zero plot, root locus, and step response.

For a transfer function:

G(s)=D(s)/N(s)

The stability depends on the denominator polynomial D(s).

The setup consists of a computer system with SCILAB software installed. A transfer function is defined in SCILAB, and commands are used to obtain pole-zero plots, root locus, and step response to analyze system stability.

Apparatus Required

Computer system, SCILAB software

Precautions

1. Enter the transfer function correctly.
2. Check syntax of SCILAB commands.

3. Use proper scaling in graphs.
4. Verify Results with different methods.
5. Save outputs for reference.
6. Do not close software without saving work.

Procedure

1. Open SCILAB software.
2. Define the transfer function using numerator and denominator.
3. Use commands to find poles of the system.
4. Plot pole-zero diagram.
5. Plot root locus of the system.
6. Generate step response of the system.
7. Observe whether the system is stable or unstable.
8. Record all outputs and graphs.
9. Conclude the stability of the system.

Observations and Calculations

S. No.	Transfer Function	Poles	Stability	Remarks
1				
2				
3				
4				

Stability Condition

System is stable if all poles have negative real parts

Result

The stability of the given system was determined using SCILAB. It is observed that the system is stable when all poles lie in the left half of the s-plane.

VIVA BOOK

1. Define stability of a system.
2. What is meant by poles of a system?
3. Explain how stability is determined using SCILAB.
4. Differentiate between stable and unstable systems.
5. Differentiate between pole-zero plot and root locus.

EXPERIMENT NO:10

Temperature Control of a System using ON–OFF Controller

Aim

To study the temperature control of a system using an ON–OFF controller and observe its behavior.

Theory

An ON–OFF controller is the simplest type of control system used to maintain a desired temperature. In this method, the controller has only two states: ON and OFF.

When the temperature of the system falls below the set value, the controller switches ON the heater. When the temperature exceeds the set value, the controller switches OFF the heater. This causes the temperature to oscillate around the desired set point.

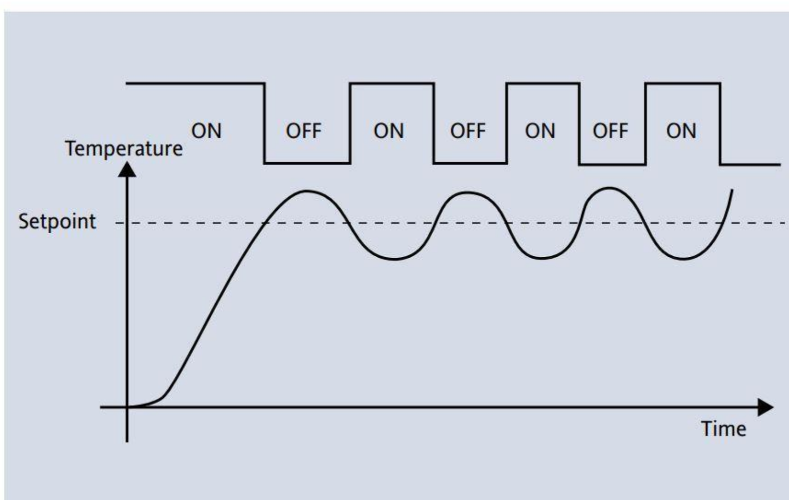
The difference between the upper and lower switching points is called hysteresis. It prevents frequent switching of the controller.

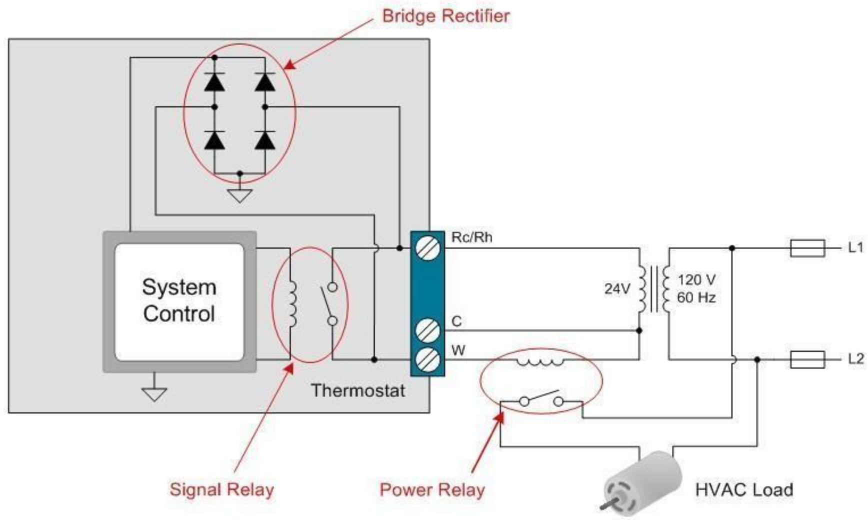
The ON–OFF control law can be written as:

- Output = ON, when error > 0
- Output = OFF, when error < 0

Where error = Set temperature − Actual temperature

Practical Set-up / Circuit Diagram





The setup consists of a heating element, temperature sensor, and ON–OFF controller. The sensor measures the temperature and sends feedback to the controller. The controller switches the heater ON or OFF depending on the set temperature.

Apparatus Required

Heating element, temperature sensor, ON–OFF controller, power supply, thermometer or display unit, connecting wires

Precautions

1. Check all connections before switching ON.
2. Do not exceed temperature limits.
3. Handle heating element carefully.
4. Avoid contact with hot surfaces.
5. Ensure proper insulation of wires.
6. Switch OFF supply after experiment.

Procedure

1. Connect the system as per the given setup.
2. Switch ON the power supply.
3. Set the desired temperature on the controller.

4. Observe the heating process as temperature rises.
5. Note the temperature at which the heater switches OFF.
6. Allow the temperature to fall and note when heater switches ON again.
7. Record the upper and lower temperature limits.
8. Repeat for different set temperatures if required.
9. Switch OFF the system after completion.

Observations and Calculations

S. No.	Set Temperature	ON Temperature	OFF Temperature	Hysteresis
1				
2				
3				
4				

Hysteresis = OFF temperature − ON temperature

Result

The temperature control using ON–OFF controller was studied successfully. It is observed that the system maintains temperature within a range and oscillates around the set value due to hysteresis.

VIVA BOOK

1. Define an ON–OFF controller.
2. Explain the working of an ON–OFF temperature control system.
3. What is hysteresis in control systems?
4. Differentiate between ON–OFF controller and proportional controller.
5. Differentiate between open-loop and closed-loop control systems.

EXPERIMENT NO:11

Temperature Control of a System using PI Controller

Aim

To study temperature control of a system using a PI controller and observe its response.

Theory

A PI (Proportional–Integral) controller is used to improve the performance of control systems by reducing steady-state error and improving accuracy. It combines proportional action and integral action.

The proportional part produces an output proportional to the error, while the integral part accumulates the error over time and eliminates steady-state error.

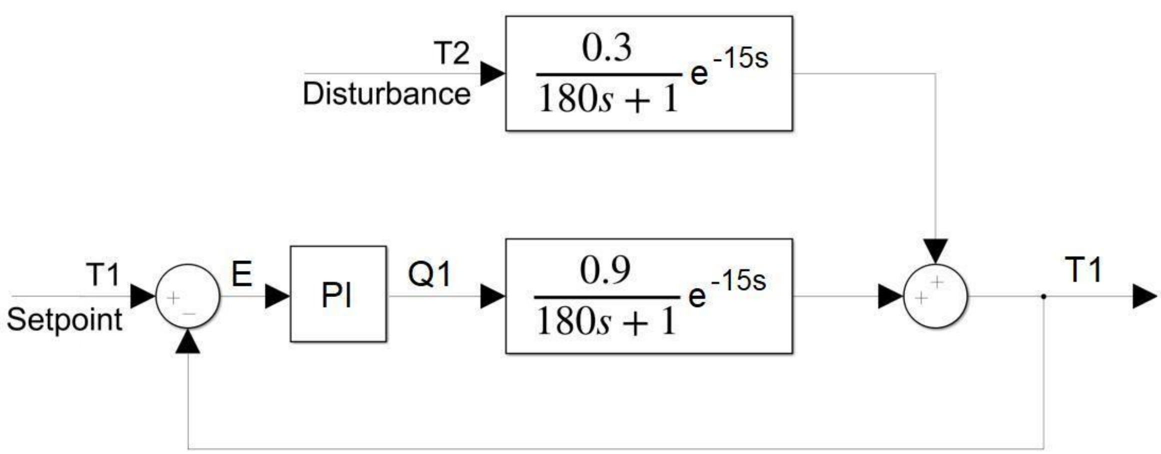
The control law of a PI controller is:

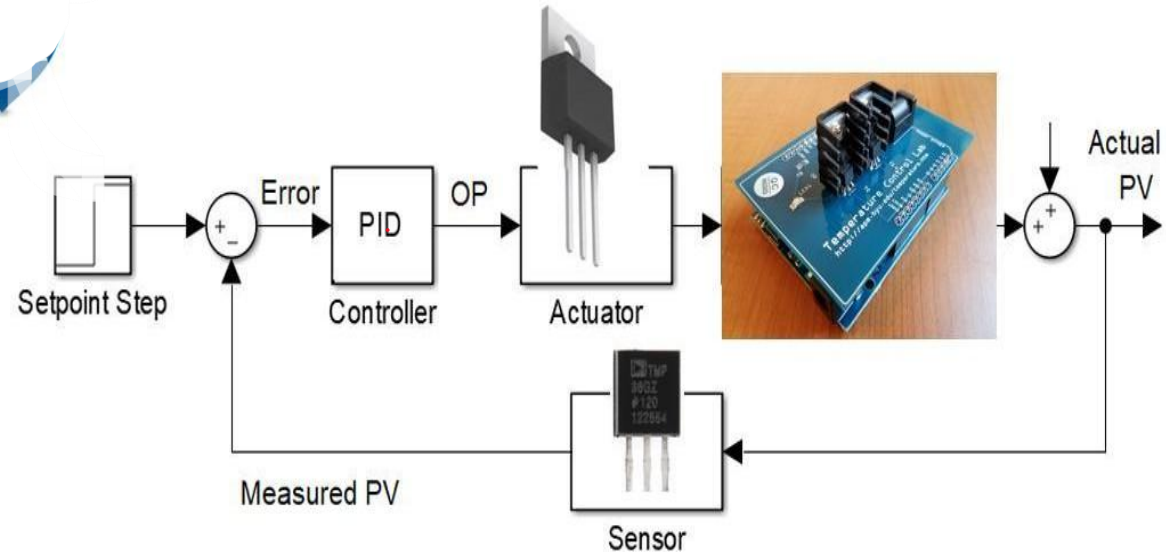
$u(t)=K_p.e(t)+K_i\int e(t)dt$

Where ($u(t)$) is controller output, ($e(t)$) is error, (K_p) is proportional gain, and (K_i) is integral gain.

In temperature control, the controller continuously adjusts the heater power based on the error between set temperature and actual temperature. This Results in smoother control and minimal oscillations compared to ON–OFF control.

Practical Set-up / Circuit Diagram





The setup consists of a heating element, temperature sensor, PI controller, and power supply. The sensor measures temperature and sends feedback to the controller. The controller processes the error and adjusts the heater input accordingly to maintain the desired temperature.

Apparatus Required

Heating element, temperature sensor, PI controller, power supply, temperature display unit, connecting wires

Precautions

1. Check all connections before switching ON.
2. Do not exceed temperature limits.
3. Handle heating element carefully.
4. Avoid touching hot surfaces.
5. Ensure proper insulation.
6. Switch OFF supply after completion.

Procedure

1. Connect the system as per the given setup.
2. Switch ON the power supply.
3. Set the desired temperature on the controller.
4. Adjust proportional and integral gains if required.
5. Observe the temperature response of the system.
6. Record rise time and steady-state value.
7. Note any overshoot or oscillations.
8. Repeat for different settings if required.
9. Switch OFF the system after completion.

Observations and Calculations

S. No.	Set Temperature	Actual Temperature	Error	Response Time
1				
2				
3				
4				

Error = Set temperature − Actual temperature

PI Control Law

$u(t)=K_p.e(t)+K_i\int e(t)dt$

Result

The temperature control using PI controller was studied successfully. It is observed that the system reduces steady-state error and provides smooth and accurate temperature control.

VIVA BOOK

1. Define a PI controller.
2. Explain the working of a PI controller in temperature control.
3. What is steady-state error?
4. Differentiate between ON–OFF controller and PI controller.
5. Differentiate between proportional control and integral control.

EXPERIMENT NO:12

Temperature Control of a System using PD Controller

Aim

To study temperature control of a system using a PD controller and observe its response.

Theory

A PD (Proportional–Derivative) controller is used to improve the dynamic response of a control system. It combines proportional action with derivative action.

The proportional part produces an output proportional to the error, while the derivative part predicts the future trend of the error by considering its rate of change. This helps in reducing overshoot and improving system stability.

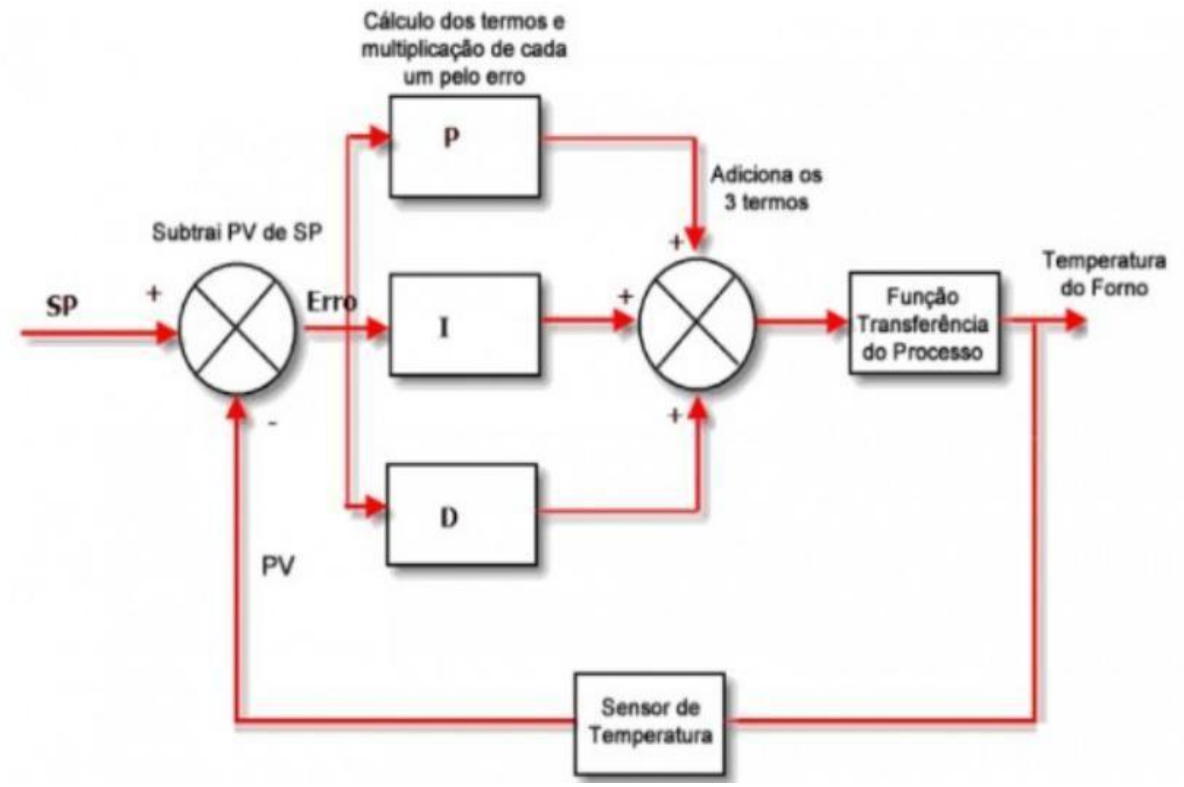
The control law of a PD controller is:

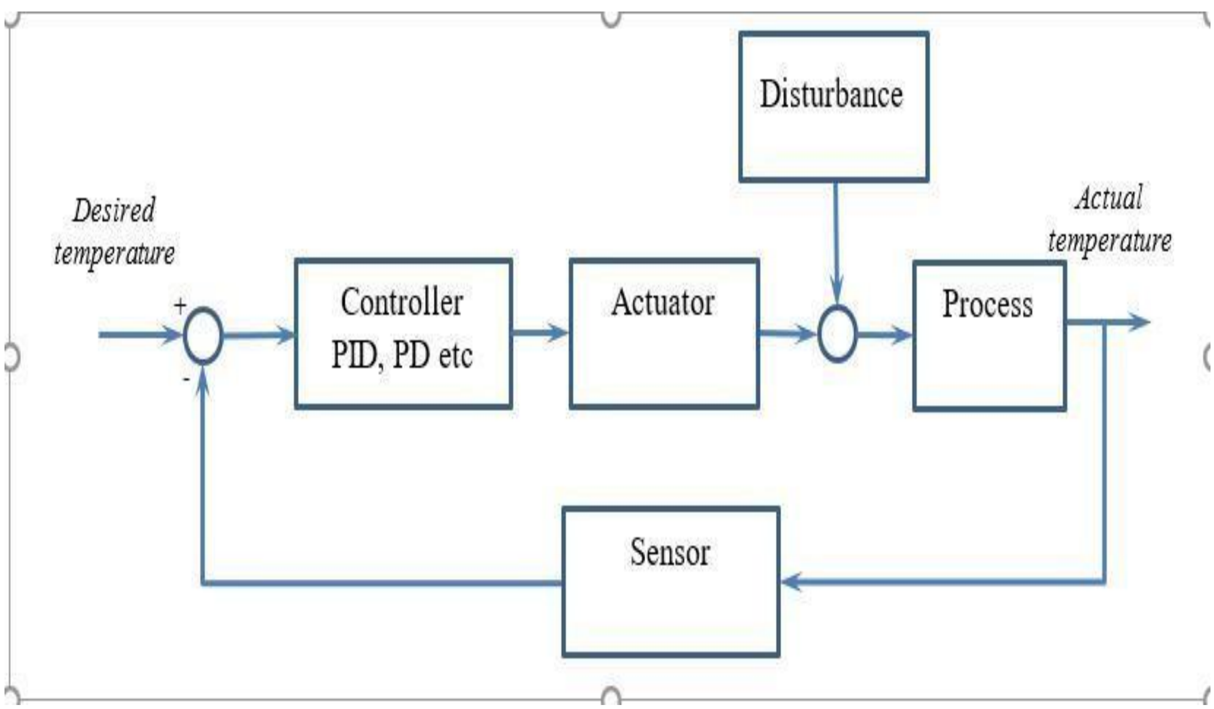
$u(t)=K_p e(t)+K_d.de(t)/dt$

Where u(t) is controller output, e(t) is error, (K_p) is proportional gain, and (K_d) is derivative gain.

In temperature control, the PD controller adjusts the heater input based on both the present error and its rate of change. This Results in faster response and reduced overshoot, but it cannot eliminate steady-state error completely.

Practical Set-up / Circuit Diagram





The setup consists of a heating element, temperature sensor, PD controller, and power supply. The sensor measures temperature and sends feedback to the controller. The controller processes the error and its rate of change to control the heater input.

Apparatus Required

Heating element, temperature sensor, PD controller, power supply, temperature display unit, connecting wires

Precautions

1. Check all connections before switching ON.
2. Do not exceed temperature limits.
3. Handle heating element carefully.
4. Avoid touching hot surfaces.
5. Ensure proper insulation of wires.
6. Switch OFF supply after completion.

Procedure

1. Connect the system as per the given setup.
2. Switch ON the power supply.
3. Set the desired temperature.
4. Adjust proportional and derivative gains.
5. Observe the temperature response of the system.
6. Record rise time and overshoot.
7. Note steady-state condition.
8. Repeat for different settings if required.
9. Switch OFF the system after completion.

Observations and Calculations

S. No.	Set Temperature	Actual Temperature	Error	Response Time
1				
2				
3				
4				

Error = Set temperature − Actual temperature

PD Control Law

$u(t)=K_p e(t)+K_d.de(t)/dt$

Result

The temperature control using PD controller was studied successfully. It is observed that the system provides faster response and reduced overshoot, but steady-state error is not completely eliminated.

VIVA BOOK

1. Define a PD controller.
2. Explain the working of a PD controller in temperature control.
3. What is derivative control action?
4. Differentiate between PI controller and PD controller.
5. Differentiate between proportional control and derivative control.

EXPERIMENT NO:13

Temperature Control of a Process using PID Controller

Aim

To study temperature control of a process using a PID controller and observe its performance.

Theory

A PID (Proportional–Integral–Derivative) controller is widely used in control systems to achieve accurate and stable control. It combines proportional, integral, and derivative actions to improve system response.

The proportional part reacts to present error, the integral part eliminates steady-state error by accumulating past error, and the derivative part predicts future error to reduce overshoot.

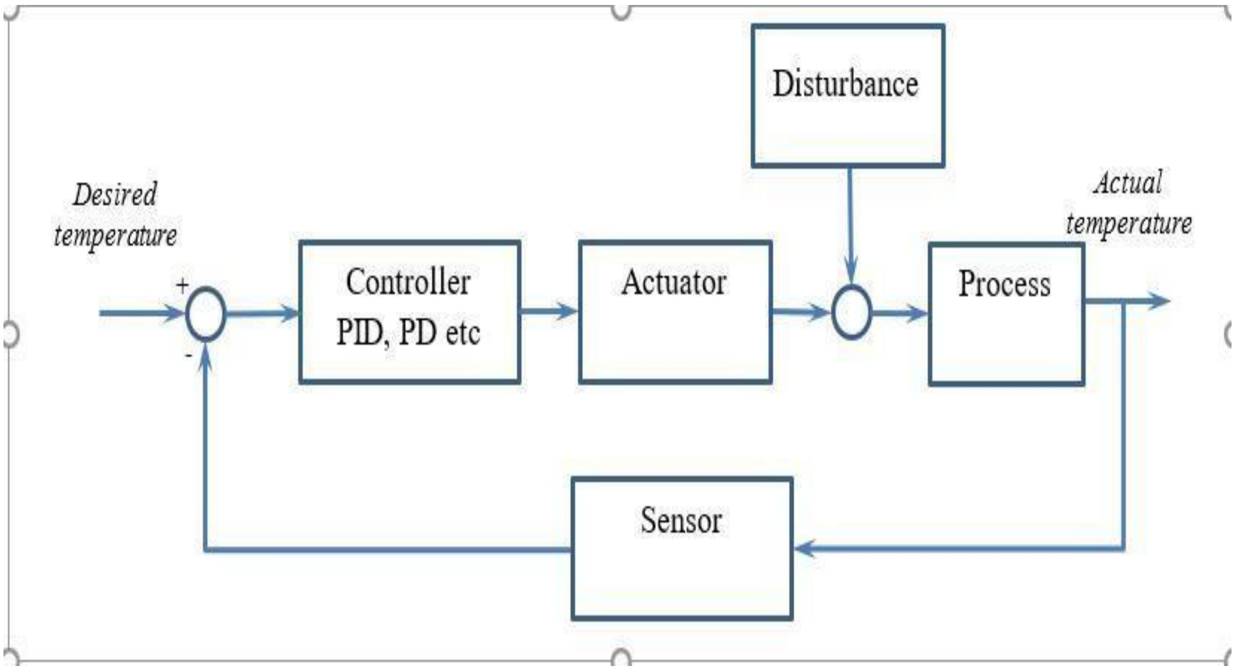
The control law of a PID controller is:

$$u(t) = K_p . e(t) + K_i \int e(t)dt + K_d . de(t)/dt$$

Where u(t) is controller output, e(t) is error, (K_p), (K_i), and (K_d) are proportional, integral, and derivative gains respectively.

In temperature control, the PID controller continuously adjusts the heater input based on error, ensuring fast response, minimal overshoot, and zero steady-state error. It provides better performance compared to ON–OFF, PI, and PD controllers.

Practical Set-up / Circuit Diagram



The setup consists of a heating element, temperature sensor, PID controller, and power supply. The sensor measures temperature and provides feedback to the controller. The PID controller processes the error and adjusts the heater input to maintain the desired temperature accurately.

Apparatus Required

Heating element, temperature sensor, PID controller, power supply, temperature display unit, connecting wires

Precautions

1. Check all connections before switching ON.
2. Do not exceed temperature limits.
3. Handle heating element carefully.
4. Avoid touching hot surfaces.
5. Ensure proper insulation of wires.

6. Switch OFF supply after completion.

Procedure

1. Connect the system as per the given setup.
2. Switch ON the power supply.
3. Set the desired temperature.
4. Adjust PID controller parameters (Kp, Ki, Kd).
5. Observe the temperature response of the system.
6. Record rise time, overshoot, and steady-state value.
7. Note the settling time of the system.
8. Repeat for different parameter settings if required.
9. Switch OFF the system after completion.

Observations and Calculations

S. No.	Set Temperature	Actual Temperature	Error	Response Time
1				
2				
3				
4				

Error = Set temperature − Actual temperature

PID Control Law

$$u(t) = K_p.e(t) + K_i \int e(t)dt + K_d .de(t)/dt$$

Result

The temperature control using a PID controller was studied successfully. It is observed that the system provides fast response, reduced overshoot, and eliminates steady-state error, Resulting in accurate temperature control.

VIVA BOOK

1. Define a PID controller.
2. Explain the working of a PID controller in temperature control.
3. What is the role of integral action in a PID controller?
4. Differentiate between PI and PID controllers.
5. Differentiate between PD and PID controllers.

EXPERIMENT NO:14

Identification of Parts of a PLC and Input & Output Devices of a PLC

Aim

To study and identify the different parts of a PLC and understand various input and output devices used with it.

Theory

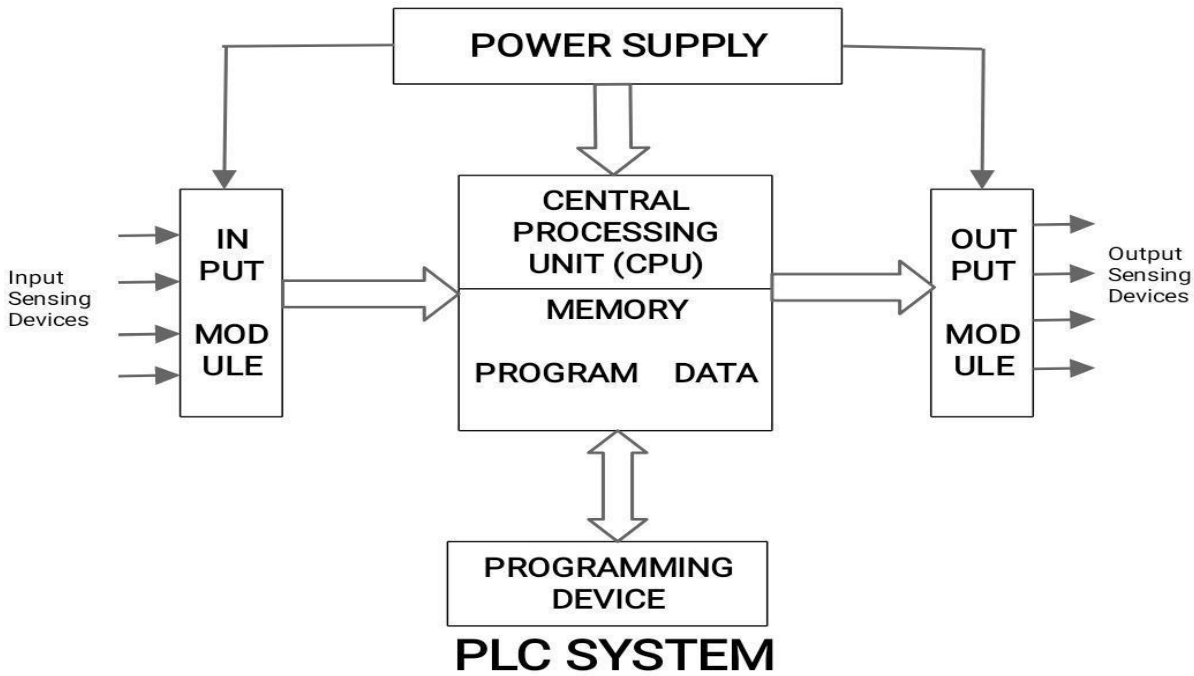
A Programmable Logic Controller (PLC) is a digital electronic device used for automation and control of industrial processes. It replaces conventional relay-based control systems and provides flexibility, reliability, and ease of programming.

A PLC mainly consists of the following parts:

- CPU (Central Processing Unit): It is the brain of the PLC which processes inputs and executes control programs.
- Power Supply: Provides required DC power to the PLC components.
- Input Module: Receives signals from input devices like switches and sensors.
- Output Module: Sends signals to output devices like motors, relays, and lamps.
- Memory: Stores the program and data.
- Programming Device: Used to write and load the control program into the PLC.

Input devices provide signals to the PLC such as push buttons, limit switches, and sensors. Output devices receive signals from the PLC such as motors, solenoids, relays, and indicator lamps.

Practical Set-up / Circuit Diagram



The setup consists of a PLC training kit with input devices like switches and sensors connected to input modules, and output devices like lamps or relays connected to output modules. The PLC processes input signals and controls output devices accordingly.

Apparatus Required

PLC trainer kit, push buttons, switches, sensors, relays, indicator lamps, power supply, connecting wires

Precautions

1. Check all connections before switching ON.
2. Do not exceed rated voltage.
3. Ensure proper wiring of input and output devices.
4. Avoid short circuits.
5. Handle components carefully.

6. Switch OFF supply after completion.

Procedure

1. Identify different parts of the PLC on the trainer kit.
2. Observe the CPU, power supply, input and output modules.
3. Connect input devices like push buttons to input terminals.
4. Connect output devices like lamps or relays to output terminals.
5. Switch ON the power supply.
6. Press input switches and observe corresponding outputs.
7. Verify operation of each input and output device.
8. Record observations.
9. Switch OFF the supply after completion.

Observations and Calculations

S. No.	Input Device	Output Device	Observation
1			
2			
3			
4			

Result

The different parts of the PLC and input/output devices were identified successfully. It is observed that the PLC processes input signals and controls output devices effectively.

VIVA BOOK

1. Define a PLC.
2. Explain the function of CPU in a PLC.
3. What are input and output devices in a PLC?
4. Differentiate between input module and output module.
5. Differentiate between PLC and relay-based control system.

EXPERIMENT NO:15

Installation of a Given PLC using Proper Procedure

Aim

To study and perform the correct installation Procedure of a Programmable Logic Controller (PLC).

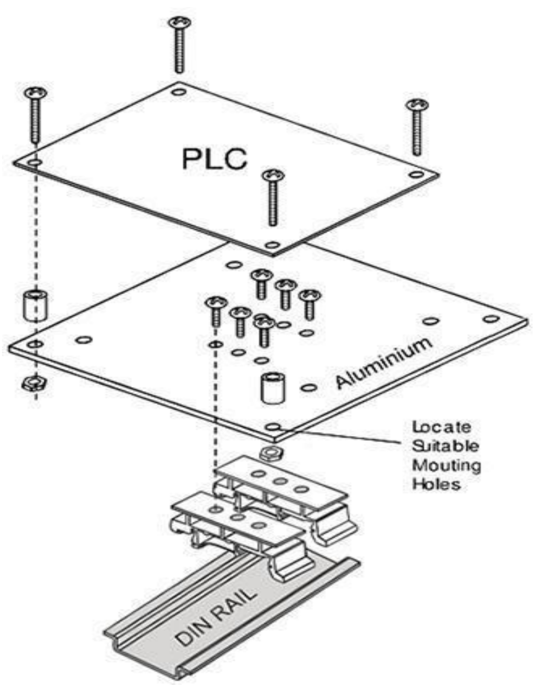
Theory

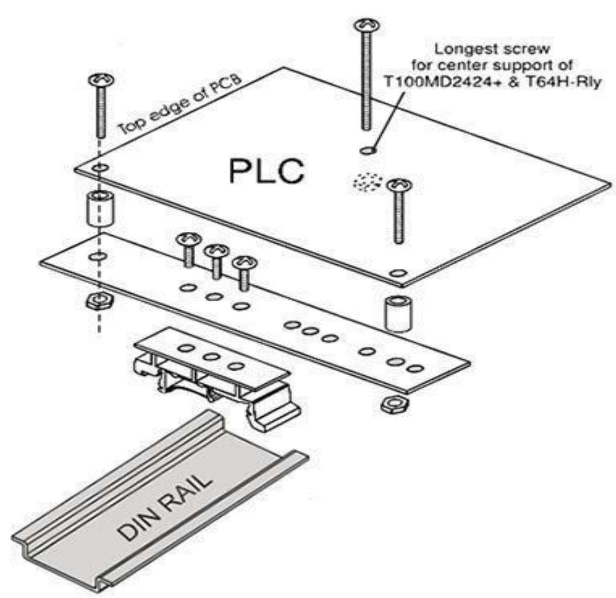
A Programmable Logic Controller (PLC) is an industrial digital controller used for automation and control of machines and processes. Proper installation of a PLC is essential for safe and reliable operation.

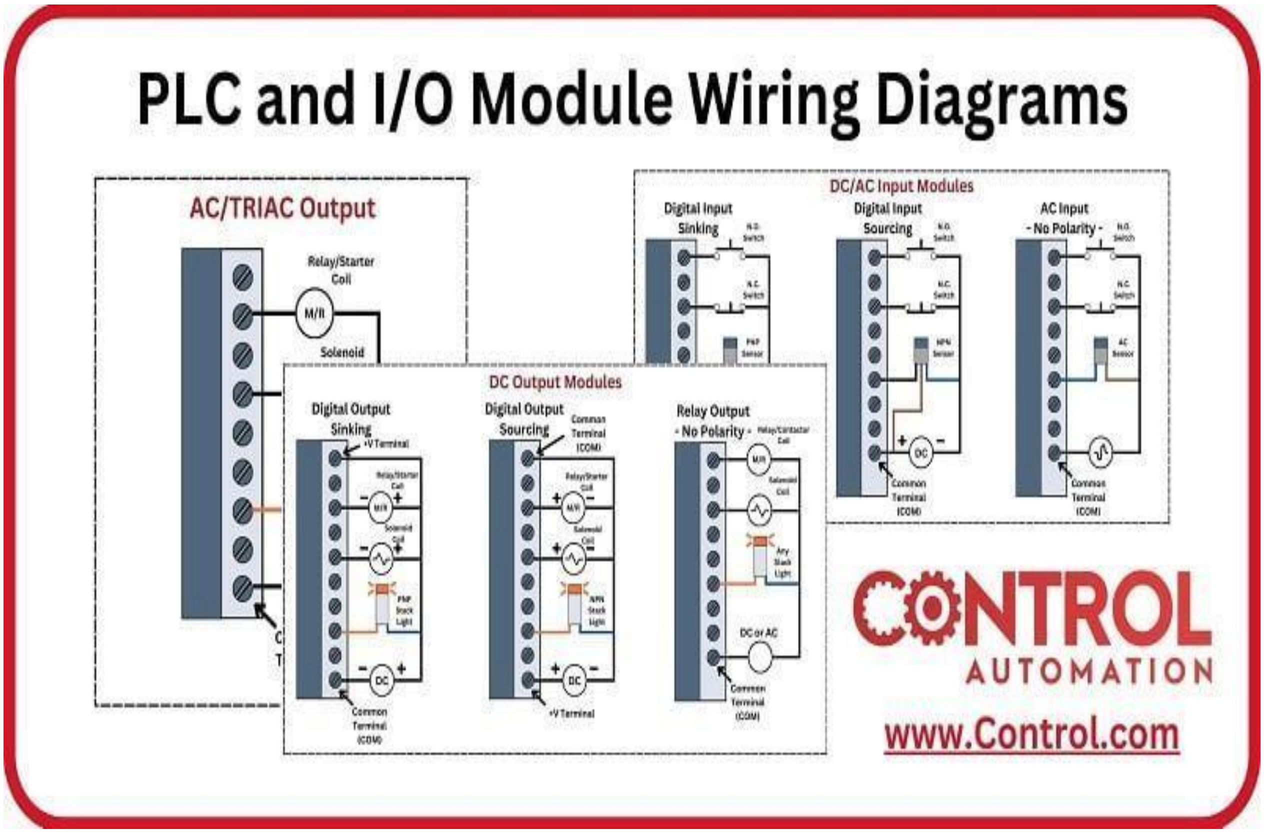
Installation involves mounting the PLC, providing proper power supply, grounding, and connecting input and output devices. The environment should be free from dust, moisture, and excessive temperature.

Correct wiring ensures that input signals are properly received and output devices operate correctly. Proper earthing is necessary to avoid electrical hazards and ensure stable operation.

Practical Set-up / Circuit Diagram







The setup consists of a PLC mounted on a panel or DIN rail. The power supply is connected to the PLC. Input devices are wired to input terminals and output devices are connected to output terminals. Proper grounding and cable management are ensured.

Apparatus Required

PLC unit, power supply, mounting panel or DIN rail, input devices, output devices, connecting wires, screwdriver, tools

Precautions

1. Ensure power supply is OFF before installation.
2. Check voltage ratings before connection.
3. Use proper earthing for safety.
4. Avoid loose or improper wiring.

5. Keep the environment clean and dry.
6. Handle PLC components carefully.

Procedure

1. Select a suitable location for PLC installation.
2. Mount the PLC securely on a panel or DIN rail.
3. Connect the power supply to the PLC.
4. Provide proper grounding to the system.
5. Connect input devices to input terminals.
6. Connect output devices to output terminals.
7. Check all wiring connections carefully.
8. Switch ON the power supply.
9. Verify proper functioning of the PLC system.

Observations and Calculations

S. No.	Step Performed	Observation	Remarks
1			
2			
3			
4			

Result

The PLC was installed successfully using the proper Procedure. It is observed that correct installation ensures safe operation and proper functioning of the control system.

VIVA BOOK

1. Define a PLC.
2. What are the basic steps in PLC installation?
3. Why is proper grounding important in PLC systems?
4. Differentiate between installation and wiring.
5. Differentiate between PLC and microcontroller.