Preface

The significance of the Control Systems and Simulation Lab is renowned in the various fields of engineering applications. For an Electrical Engineer, it is obligatory to have the practical ideas about the Control Systems and Simulation. By this perspective we have introduced a Laboratory manual cum Observation for Control Systems and Simulation Lab.

The manual uses the plan, cogent and simple language to explain the fundamental aspects of Control Systems and Simulation in practical. The manual prepared very carefully with our level best. It gives all the steps in executing an experiment.

**Guidelines to write your Observation Book**

1. Experiment Title, Aim, Apparatus, Procedure should be on right side.

2. Circuit diagrams, Model graphs, Observations table, Calculations table should be left side.

3. Theoretical and model calculations can be any side as per your convenience.

4. Result should always be in the ending.

5. You all are advised to leave sufficient no of pages between experiments for theoretical or model calculations purpose.

**DO’S and DON’TS in the LAB**

**DO’S:-**

1. .Proper dress has to be maintained while entering in the Lab. (Boys Tuck in and shoes, girls with apron).

2. All students should come to the Lab with necessary tools. (Cutting Pliers 6”, Insulation

Remover and phase tester)

3. Students should carry observation notes and record completed in all aspects.

4. Correct specifications of the equipment have to be mentioned in the circuit diagram.

5. Student should be aware of operating equipment.

6. Students should be at their concerned experiment table, unnecessary moment is restricted.

7. Student should follow the indent procedure to receive and deposit the equipment from the Lab

Store Room.

8. After completing the connections Students should verify the circuits by the Lab Instructor.

9. The reading must be shown to the Lecturer In-Charge for verification.

10. Students must ensure that all switches are in the OFF position, all the connections are removed.

11. All patch cords and stools should be placed at their original positions.

**DON’Ts:-**

1. Don’t come late to the Lab.

2. Don’t enter into the Lab with Golden rings, bracelets and bangles.

3. Don’t make or remove the connections with power ON.

4. Don’t switch ON the supply without verifying by the Staff Member.

5. Don’t switch OFF the machine with load.

6. Don’t leave the lab without the permission of the Lecturer In-Charge.

**JAWAHARLAL NEHRU TECHNOLOGICAL**

**UNIVERSITY HYDERABAD**

**III Year B.Tech. EEE I-Semester L T/P/D C**

**0 -/3/- 2**

**(55603)CONTROL SYSTEMS AND SIMULASTION LAB**

**LIST OF EXPERIMENTS**

1. Time response of Second order System.
2. Characteristics of Synchros.
3. Programmable logic controller – study and verification of truth tables of Logic Gates, Simple Boolean expressions and application of speed control of motor.
4. Effect of feedback on DC Servo motor.
5. Effect of P,PD,PI,PID controller on a second order system.
6. Temperature controller using PID.
7. Characteristics of Magnetic Amplifier.
8. Characteristics of AC servo motor.

**SIMULATION EXPERIMENTS.**

1. Linear system analysis (Time domain analysis, Error analysis) using MATLAB.
2. Stability analysis (Bode, Root Locus, Nyquist) of linear time invariant system using MATLAB.
3. State Space model for classical transfer function using MATLAB verification.

**EXPERIMENT - 1**

**TIME RESPONSE OS SECOND ORDER SYSTEM**

**AIM:** To study the time response of second order system with step input and

square input

**APPARATUS:**

|  |  |  |  |
| --- | --- | --- | --- |
| **S.No.** | **Nane of the Equipment** | **Rage** | **Qauntity** |
| 1 | Second order system study unit |  | 1 |
| 2 | CRO |  | 1 |
| 3 | CRO Probes |  | 2 |
| 4 | Multimeter |  | 1 |
| 5 | Cables |  | Required |

**Circuit diagram:**

R

2H

L

Square wave

Signal

0.32

C

10 KΏ

**THEORY:**

This unit consists of two parts:-

1. Signal source for second order system.
2. A second order system.

**a)Signal Source:**

The Signal source generates the necessary input excitation supply for the second order system under different damping factor and time constant. This part generates a square wave of 15 Hz approximately. A switch is provided to select square wave or step (DC) source. ON/OFF switch is provided for signal source.

Amplitude of the signal source can be varied from 0V to 15 V approximately for square wave and 0 V to 10 V approximately for DC source.

**b) Second order source:**

This part consists of a second order system built using Op-amp.

In order to study the behaviour of a second order system with varies damping factors, facility has been provide to select the damping factor -0.3,0.7,1 and2.

In order to study the behaviour of a second order system with different time Constants, facility has been provide to choose the constant at 3m sec or 5 sec.

The input & output terminals of the second order system are brought out on the front panel independently, So we can also use external signal source to study the frequency response if the system.

**SECOND ORDER SYSTEM USING R L C**

**PROCEDURE:**

1) Switch ON the mains supply to the unit, observe the signal source output by selecting square wave or step input and by varying amplitude potentiometer.

2) Make sure signal source is correct before connecting the input of the second order system.

3 ) Now Select square wave signal. Draw the input square wave signal.

4) Connect the output of square wave signal source to second order system using RLC.

5) Draw the second order system o/p for different values of damping factor 0 to 2 in steps of 0.1 by varying Potentiometer R provided.

6) Compare this with the theoretical wave forms.

7) Measure the R value using Digital DC voltmeter or multimeter between the I/P terminals with main switch in OFF position.

**SECOND ORDER SYSTEM STUDY UNIT**

**Connection diagram for SECOND ORDER SYSTEM using RLC**

OUTPUT

TO

CRO

**I**

**N**

**P**

**U**

**T**

SIGNAL SOURCE

AMPLITUDE

0.3

0.7

1

2

Damping factor

ON

POWER

SQ

STEP

OFF

5 Sec

3 m Sec

Time constant

Second order

system

OUTPUT

R

USING RLC

USING OP-AMP

OUTPUT

TO

CRO

Second order

system

USING OP-AMP

0.3

0.7

1

2

USING RLC

Damping factor

OUTPUT

**I**

**N**

**P**

**U**

**T**

SIGNAL SOURCE

AMPLITUDE

POWER

SQ

STEP

OFF

5 Sec

3 m Sec

Time constant

**SECOND ORDER SYSTEM STUDY UNIT**

**Connection diagram for SECOND ORDER SYSTEM using op amp for square input**

ON

TO MULTIMETER OR DSO

TO

Second order

system

USING OP-AMP

0.3

0.7

1

2

USING RLC

Damping factor

OUTPUT

**I**

**N**

**P**

**U**

**T**

SIGNAL SOURCE

AMPLITUDE

POWER

SQ

STEP

OFF

5 Sec

3 m Sec

Time constant

**SECOND ORDER SYSTEM STUDY UNIT**

**Connection diagram for SECOND ORDER SYSTEM using op amp for STEP input**

ON

**Front Panel Details:-**

**1. Power**  : Mains ON/OFF Switch to the unit with built in indicator.

**2. Amplitude** : Potentiometer to vary the amplitude of signal source.

**3. Sq./Step** : Switch to select square wave or step (DC) input.

**4. ON/OFF** : ON/OFF Switch for signal.

**5. OUTPUT** : Signal output points.

**6. Damping factor** : Switch to select damping factor 0.3/0.7/i&2.

**7 .INPUT** : Second order system input points to connect signal source.

**8. OUTPUT** : Second order system input points

**9. Time constant** : 3m sec/5 sec : Switch to select time constant.

**10. R (α)** : Potentiometer to vary damping factor of second order system using RLC

varying R.

**11. R** : Terminals to measure R (Resistance) of second order system using RLC

**PROCEDURE:-**

1. Switch ON the mains supply to the unit observe the signal source output by selecting square wave or step input and by varying amplitude potentiometer.

2 ) Make sure that the signal source is correct before connecting the input of the second order system.

1. Now select square wave signal and 3 m sec time constant. Draw the input square wav signal
2. Connect signal output to second order system input
3. Draw the second order system o/p for different values of damping factor 0.3, 0.7, 1 and 2. Compare this with the theoretical wave forms.
4. Select step input, adjust the amplitude potentiometer to get 5 Volts DC and select 5sec time constant .Switch off the signal.
5. Now Switch ON the signal, monitors the second order system o/p using a multimeter .Note down the o/p voltage for every second.
6. Draw the graph of time v/s voltage.
7. Repeat the same for different damping factor.
8. When testing a second order system with large time constant -5 sec, it is essential to supply a DC as a step voltage. This source provides a DC step input to the system by selecting sep signal and by switch ON the signal source from OFF to ON.
9. When testing a second order system with low time constant – 3 m sec ,the response of the system for a step input stabilizers to its final value within about 50-75m sec .In such case, the system response for a step can be studied by giving a repeated step, which is effectively, a square wave.
10. Input level to the system should be chosen so as to obtain the output response within the saturable voltage of op-amp +nor -15 V
11. The amplitude should be within 5 to 8 V. If a much lower input voltage is selected the other interference’s such as mains picks up can be become relatively higher & the response obtained may not be satisfactory.
12. The parameter of a second order system such as delay time, rise time, peak time, settling time and peak overshoot are important parameter to be understood.
13. For zeta less than I, the system is under damped and the system response shows overshoot for very low damping factor the step response is DC superimposed with an exponentially dying cosine waveform.
14. For zeta greater than 1, the system said to have over damped response. In practical system, the damping factor is set between 0.7 and 1.

Note: Use 3 pin grounded mains supply to the unit avoids line interference. Use proper CRO probe to see the output wave forms.

**TABULAR COLUMN:**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S.No.** | **R**  **in (Ώ)** | **L**  **in (Henry)** | **C**  **in (Farad)** | **Damping Factor** | **Delay**  **Time**  **(sec)** | **Rise Time**  **(sec)** | **Max.**  **power over shoot**  **(volts)** | **Peak**  **Time**  **(sec)** | **Setting**  **Time**  **(sec)** |  |
| 1 |  |  |  |  |  |  |  |  |  |  |
| 2 |  |  |  |  |  |  |  |  |  |  |
| 3 |  |  |  |  |  |  |  |  |  |  |
| 4 |  |  |  |  |  |  |  |  |  |  |
| 5 |  |  |  |  |  |  |  |  |  |  |
| 6 |  |  |  |  |  |  |  |  |  |  |
| 7 |  |  |  |  |  |  |  |  |  |  |
| 8 |  |  |  |  |  |  |  |  |  |  |

**Calculation:**

















**Model Graph:**

Vc (t)

tp

Mp

t

tr

td

O

**Result :**

**EXPERIMENT -2**

**CHARACTERSTICS OF SYNCHROS AND TRANSMITTER**

**Aim**: To study the characteristics of synchros as transmitter and synchro

Transmitter- Receiver pair.

**Apparatus:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Si.no** | **Name of the equipment** | **Range** | **Quantity** |
| **1** | Synchros pair unit |  | 1 |
| **4** | Patch cords. |  | 1 |

**Circuit Diagram:**

S2

S3

S2

N

S1

S3

S1

Stator

Rator

Ph

1-Φ

AC Supply

V

(0-75) V

MI

**THEORY:**

**Definition:** A synchros on electromagnetic transducer commonly used convert

an angular position of a shaft into an electric signal.

**Study of Synchro Transmitter and Receiver:-**

In this part or experiment we can see that because or the transformer action the angular position of rotor is transformed into a unique set of stator voltages.

**PROCEDURE:**

1. Make the connections as per CKT diagram.
2. Apply 50v AC supply to the transmitter.
3. Adjust the pointer on the rotor of the transmitters to zero position
4. Observe the position across to rotate of the receiver. If it is not zero the rotor, so as to obtain zero voltage and this value is referred to as electrical zero position of the receiver.
5. Holding firm by position of rotor shaft at transmitters slightly. Note down the voltage across the rotor of the receiver.
6. Now continue the readings up to 360 , in steps of 30 by increasing the angular positions of the transmitter in steps.
7. Take rotor shaft position of transmitters on X- axis and voltage on Y axis and draw a graph.
8. Draw graph by taking transmitter angular position on X- axis and receiver angular position on Y axis.

**Table: 1**

|  |  |  |
| --- | --- | --- |
| **S.No** | **Rotor angle of**  **θ Transmitter**  **(in Degrees)** | **Rotor angle of**  **θ receiver**  **(in Degrees)** |
| **1** |  |  |
| **2** |  |  |
| **3** |  |  |
| **4** |  |  |
| **5** |  |  |
| **6** |  |  |
| **7** |  |  |
| **8** |  |  |
| **9** |  |  |
| **10** |  |  |
| **12** |  |  |
| **13** |  |  |
| **14** |  |  |
| **15** |  |  |

**Model Graph:**

Y

X

**Circuit Diagram:**

(0-150) V

MI

S2

Rotor

Stator

N

Ph

50V, 1-Φ

AC Supply

V

V

S1 S2

V

S2 S3

(0-150) V

MI

S3

S1

(0-150) V

MI

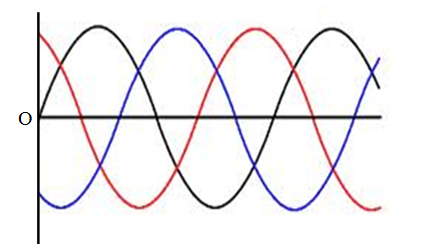
**PROCEDURE:**

1. Apply 50V AC to the rotor of synchro transmitter.
2. Measure the voltage between s1- s2, s2- s3, s3- s1 for various shaft positions from 0-3600.There voltage which have to be –ve sign has to be derived from the knowledge of voltage wave forms.
3. Plot the graph of rotor position in degrees Vs (S1-S2), (S2,-S3) and (S3-,S1) respectively.

**Table: 2**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S.NO** | **Position of Rotor shaft (in Degrees)** | **V(S1-S2)**  **In Volts** | **V(S2-S3)**  **In Volts** | **V(S3-S1)**  **In Volts** |
| 1 |  |  |  |  |
| 2 |  |  |  |  |
| 3 |  |  |  |  |
| 4 |  |  |  |  |
| 5 |  |  |  |  |
| 6 |  |  |  |  |
| 7 |  |  |  |  |
| 8 |  |  |  |  |
| 9 |  |  |  |  |
| 10 |  |  |  |  |
| 11 |  |  |  |  |
| 12 |  |  |  |  |
| 13 |  |  |  |  |

**Model Graph:**



**RESULT**:

**EXPERIMENT - 3**

**PROGRAMMABLE LOGIC CONTROLLER**

**STATIC APPLICATIONS PANELS:**

The static applications panels (SAP) are simulation modules of various applications that usually come across in industrial environment such as motor control, level controlling process, controlling industrial automation, etc.

For each SAP dedicated panels are designed terminals to connect input and output are brought outside the panels. Input like switch or sensor will be defined using push buttons or toggle switches and outputs like motor ,relay coil, contractor will be defined through LED’S attractive stickers are designed with different colours to differentiate input and output with designations.

**CONNECTION BETWEEN SAP AND PLC:**

Each SAP module requires digital input and digital output. In the main panel of PLC the digital inputs are brought out to the panels and clearly designed for example.

Digital inputs as ,- 0,- 1, - 2, - - - - - - - - - -

Digital outputs as - 0,- 1,- 2,- - - - - - - - - - -

On all the SAP modules the required input and output are brought out to the terminals and designed accordingly. Match the inputs to inputs and outputs to outputs.

**PLC TRAINER**

+24V

-24V

GND

+15V

-15V

GND

**DC POWER SUPPLY**

24V

250mA

AC SUPPLY Ssupply

- 0

- 1

- 2

- 3

- 4

- 5

- 6

- 7

**DIGITAL INPUTS**

- 0

- 1

- 2

- 3

- 4

- 5

**DIGITAL OUTPUTS**

**MASTER PLC**

|  |  |  |
| --- | --- | --- |
| **SYMBOL** | **NOTATION** | **ADDRESES** |
|  | Normally open | X,Y,M,S,T,C |
|  | Normally close | X,Y,M,S,T,C |
|  | Functional block | TMR,BIN,AOD, |
|  | Output coil | YMS |
|  | Rising edge pulse | X,Y,M,S,T,C |
|  | Falling edge pulse | X,Y,M,S,T,C |

POWER

RS 232

ON

**PROGRAMMABLE LOGIC CONTROLLER**

**AIM**: To study and verify the truth tables of logic gates, simple Boolean expressions and application of speed control to motor.

**APPARATUS:**

|  |  |  |  |
| --- | --- | --- | --- |
| **s.no** | **Name of the equipment** | **Range** | **Type** |
| 1 | system |  | 1 |
| 2 | WPL software |  | 1 |
| 3 | plc trainer kit   1. Logic gates simulation 2. Boolean algebra demorgan’s theorem 3. applications of speed control of motor |  | 1 |
| 4 | Connecting wires |  | required |

**LOGIC GATES simulation:**

**CIRCUIT DIAGRAM:**

INPUT-1

NORMAL

NOT

INPUT-2

+24V

GND

INV

AND

OR

EX-OR

**i). LOGIC GATES simulation:**

**PROCEDURE:**

1. make the connections as per circuit diagram.
2. click the**’ start ’** button
3. Select **‘All programmes ’** and the delta industrial automation.
4. Open ’ **WPL software ‘** and click **‘’ write to PLC ’’** and then select **‘ ALL ’** and **‘ok ’**
5. Click the **‘stop’** to cancel previous programmes.
6. Click on **‘ FILE ’** and **‘’** **open ‘’** select ‘ **logic gate** ‘ and **run** the programmes.
7. Now, by varying the inputs in the circuit diagram observe the output.
8. Verify the change in output for various combinations of inputs.

**TRUTH TABLE:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **INPUT-1** | **INPUT-2** | **AND gate** | **OR gate** | **EX-OR gate** |
| **0** | **0** | **0** | **0** | **0** |
| **0** | **1** | **0** | **1** | **1** |
| **1** | **0** | **0** | **1** | **1** |
| **1** | **1** | **1** | **1** | **0** |

**ii) .BOOLEAN ALGEBRA (DEMORGAN’S THEOREM):**

**CIRCUIT DIAGRAM:**

=

=

+24V

-0

-1

-2

-3

GND

-1

-0

-2

-3

-4

-5

B

A

C

A

B

C

1st LAW

2nd LAW

**ii) .BOOLEAN ALGEBRA (DEMORGAN’S THEOREM):**

**PROCEDURE:**

1. make the connections as per circuit diagram.
2. click the**’ start ’** button
3. Select **‘All programmes ’** and the delta industrial automation.
4. Open ’ **WPL software ‘** and click **‘’ write to PLC ’’** and then select **‘ ALL ’** and **‘ok ’**
5. Click the **‘stop’** to cancel previous programmes.
6. Click on **‘ FILE ’** and **‘’** **open ‘’** select **‘ Boolean expressions ‘** and **run** the programmes.
7. Now, by varying the inputs in the circuit diagram observe the output.
8. Verify the change in output for various combinations of inputs.

**OBSERVATION TABLE :**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **A** | **B** | **C** |  |  |  |  |
| **0** | **0** | **0** | **0** | **0** | **1** | **1** |
| **0** | **0** | **1** | **0** | **0** | **1** | **1** |
| **0** | **1** | **0** | **1** | **1** | **1** | **1** |
| **0** | **1** | **1** | **0** | **0** | **1** | **1** |
| **1** | **0** | **0** | **0** | **0** | **1** | **1** |
| **1** | **0** | **1** | **0** | **0** | **0** | **0** |
| **1** | **1** | **0** | **0** | **0** | **1** | **1** |
| **1** | **1** | **1** | **0** | **0** | **1** | **1** |

**iii).APPLICATIONS OF SPEED CONTROL OF MOTOR:**

**CIRCUIT DIAGRAM:**

**PLC TRAINER**

**DC MOTOR CONTROL USING RELAYS**

FWD

REV

FWD

REV

MOTOR

MOTOR

ON

MOTOR

OFF

MOTOR

CONTROL

TIMER

CONTROL

MOTOR CONTROL

+24V DC

GND

**iii).APPLICATIONS OF SPEED CONTROL OF MOTOR:**

**PROCEDURE:**

1. make the connections as per circuit diagram.
2. click the**’ start ’** button
3. Select **‘All programmes ’** and the delta industrial automation.
4. Open ’ **WPL software ‘** and click **‘’ write to PLC ’’** and then select **‘ ALL ’** and **‘ok ’**
5. Click the **‘stop’** to cancel previous programmes.
6. Click on **‘ FILE ’** and **‘’** **open ‘’** select **‘ applications of speed control of motor ‘** and **run** the programmes.
7. Start the motor and observe the change in direction of relation of motor by varying input.

**RESULT:**

**EXPERIMENT - 4**

**EFFECT OF FEEDBACK ON D.C. SERVOMOTOR**

**AIM:-**

To study the performance characteristic of a DC motor angular position Control system.

**APPARATUS:-**

1. DC position control system kit - 1no

**Circuit Diagram:**

NULL INDICATOR

+12

- 12

O/P POT ()

I/P POT ()

0

20

40

60

80

100

0

20

40

60

80

100

Tacho In

Degen.

Regen.

Tacho OUT

Amp.gain control ()

Feedback

control ()

**Figure No.1**

**Front panel layout for D.C position control**

POWER SUPPLY

LOAD

SERVO

AMPLIFIER

TR

CONNECTER STRIP

D.C SERVO MOTOR

POWER

AMPLIFIER

NULL

INDICATOR

**FIGURE NO.1A**

**TOP VIEW OF D.C POSITION CONTROL SYSTEM**

D.C TACHO

**FIGURE NO.1B**

**SIDE VIEW OF D.C POSITION CONTROL SYSTEM**

GND

LEFT SIDE VIEW

SW

FUSE

P.L

RIGHT SIDE VIEW

**THEORY:**

**OPERATING INSTRUCTIONS:**

1). Before switching on the mains, see that the switches SW3,SW4(On the LHS panel) are in down ward position i.e. ON position

2). Keep the input potentiometer in 10 degree position.

3). Adjust the potentiometer (amplifier gain adj) in mid position.

4).now switch ON the main unit LED ‘ R ‘ and LED ‘’ G ‘’ should glow.

**PROCEDURE:**

**Operation without stabilizing feedback ( in off position i.e. Tacho out.)**

1). Now slowly advance the input potentiometer in clockwise direction. The output potentiometer along with load will be seen to be following the change in the input potentiometer.

2). When the input is disturbed , the null indicator will be showing some indication but when it may be noted that when input pot is moved in anticlockwise direction, the output pot also moves in the reverse direction.

**STEP CHANGE IN INPUT:**

Keep the pot at around 180 degree position. Pot also will be in the same position.

Now change the input pot in a step fashion by about 60 to 80 degree (in fact approximating step input) , the output will be observed to change in oscillatory mode before it settles to a final position. The tendency for oscillations is found to be dependent on the amplifier again setting. For high gain there are too many oscillations where as low gain oscillations are reduced but with static error.

**OPERATION WITH STABILIZING FEEDBACK:**

1). Now put the SW1 switch in lower position .i.e, Tacho in position .SW2 must be in down ward position i.e, degenerative mode. Keep P4 in fully anti clock wise direction out again indicates oscillations.

2). Now take the pot P1 to position, effect the step input change in one of the direction. Output again indicates oscillations.

3). Now advance tacho gain pot (P4) in clockwise direction the output now is observed to follow the input in a smooth fashion without oscillation. If the tacho gain pot (P4) is too much advanced, the out put now follows input in a sluggish fashion indicating over damped system. Now take the pot P1 to 180 degree position.

4).Now the switch SW2 in upward position i.e, regenerative mode. Now if the pot P1 is disturbed, the output pot P2 is found to oscillate continuously around desired position As the amount of feedback is adjusted the frequency and amplitude of output is observed to vary.

5). Warning:-Do not operate the DC position control in the regenerative mode for long time. This can damage the potentiometers.

6). Bring the switch in down ward position.

**OBSERVATION – Table-1**

Plot the output angle versus input for both system I.e. with out and with stabilizing feed back by looking to the nature of rotation of the output potentiometer and disc mounted on it.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SI.No** | **Input angular position in degrees** | **Out put angular position in degrees** | **Without stabilizing Feed back up ward** | **Remarks** |
| 1 |  |  |  |  |
| 2 |  |  |  |  |
| 3 |  |  |  |  |
| 4 |  |  |  |  |
| 5 |  |  |  |  |
| 6 |  |  |  |  |
| 7 |  |  |  |  |
| 8 |  |  |  |  |
| 9 |  |  |  |  |
| 10 |  |  |  |  |

**2.Note**: that these are typical readings and there can be piece to piece variation because the servomotor pots are having linearity of 1%. It is better to operate in the region of j15 degrees to 330 degrees to avoid zero crossing and possible damage of potentiometers.

**OBSERVATION – Table-2**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SI.No** | **Input angular position in degrees** | **Out put angular position in degrees** | **With stabilizing Feed back down ward** | **Remarks in regenerative mode** |
| **1** |  |  |  |  |
| **2** |  |  |  |  |
| **3** |  |  |  |  |
| **4** |  |  |  |  |
| **5** |  |  |  |  |
| **6** |  |  |  |  |
| **7** |  |  |  |  |
| **8** |  |  |  |  |
| **9** |  |  |  |  |

Do not operate this mode for long time.

**OBSERVATION – Table-3**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SI.No** | **Input angular position in degrees** | **Out put angular position in degrees** | **With stabilizing Feed back down ward** | **Remarks in Degenerative mode** |
| 1 |  |  |  |  |
| 2 |  |  |  |  |
| 3 |  |  |  |  |
| 4 |  |  |  |  |
| 5 |  |  |  |  |
| 6 |  |  |  |  |
| 7 |  |  |  |  |
| 8 |  |  |  |  |
| 9 |  |  |  |  |

**PRECAUTIONS:-**

1). Please do not cross zero degree position by moving pot i.e. donot operate between 330 degrees and 10 degrees.

2). Do not try to rotate output potentiometer by hand. This may damage the potentiometer.

3). Student s should note the following : Try to understand the function of output potentiometer.

4). The null indicator indicates a small deviation from zero indication at various positions of angle

and . This is so because of backlash in the gear, friction and the fact that some definite torque is required to be produced by the motor. So that the system can be set in to rotation. More over this torque goes on changing from position to position. Hence this error.

5). Observe the effect of change in amplifier gain. Higher the gain smaller is the error.

6). When system is not using keep in off position. (Upward position) to avoid heating and possible damage of the power stage.

**RESULT:**

**EXPERIMENT- 5**

**EFFECT OF P,PD,PI,PID CONTROLLER ON A SECOND ORDER SYSTEM**

**AIM:-** To study the performance characteristics of an analog PID controller using simulated systems.

**APPARATUS:**

|  |  |  |  |
| --- | --- | --- | --- |
| **S.NO** | **NAME OF THE EQUIPMENT** | **RANGE** | **QUANTITY** |
| 1 | P.I.D controller on a Second order system kit |  | 1 |
| 2 | C.R.O |  | 1 |
| 3 | C.R.O probes |  | 2 |
| 4 | Connecting wires |  | required |

**CIRCUIT DIAGRAM:**

**PID CONTROLLER**

K

PROCESS OR PLANT

COMMAND

RESPONSE

CONTROLLER

**BLOCK DIAGRAM OF THE SYSTEM**

ON

Time constant

First order system

Second order system

Integrator

P

I

D

FREQUENCY

AMPLITUDE

LEVEL

SQUARE

TRIAGLE

INV.AMP

SUPPLY

0.3

0.7

1

2

ON

OFF

ON

OFF

CONTROLLER

D. C

DISPLAY

**PID CONTROLLER**

**PID CONTROLLER FRONT PANEL**

OFF

**CONTROLLER UNIT**: This is a very well designed unit to study the PID Controllers. This unit consists of signal sources, a digital voltmeter, a PID controller, Different process with built-in stabilized DC supply.

**SIGNAL SOURCES**: This part consists of variable low frequency square wave and triangle wave generator with variable amplitude.

The square wave is used as command input to the system. The square wave is treated as repeated step input. The triangular wave is used for external -deflection in the CRO.

**POWERSUPPLY AND DIGITAL VOLTMETER:** This unit is built-in regulated power supply of +12V and -12V. A variable DC 0-12V is available on the panel and be used as a dc input or set voltage.

A 3 digit digital voltmeter of 19.99 volt is provided on the panel to measure different state voltages like set voltage, feedback voltage and output voltage.

**ERROR DETECTOR:** The error detector is a unity gain adder which adds the set voltage with the feedback voltage.

**INVERTING AMPLIFIER**: It is unity gain inverting amplifier. This amplifier he inserted in the loop, if required to ensure Ve or Ve feedback. We can check the effect of Ve feedback.

**CONTROLLER**: The controller is an analog positional - Integrate Derivative (PID) in which the PID parameters are adjustable. The values can Potentiometers with dial.

**Proportional Gain – -** 0 to 20

**Integral gain - -** 0 – 1000

**Derivative gain - -** 0-0.01

**PROCESS**: In practical the process or plant is the part of the system which produces the desired response under the influence of command signal.

In this unit the process is an analogue simulation of Different blocks.

**FRONT PANEL DETIALS:-**

1. **MAINS**  : Mains ON/OFF Switch with built in indicator
2. **SQUARE**  : Variable Square wave output-0-2 V
3. **LEVEL**  : Potentiometer to vary the amplitude of square wave and Triangle wave
4. **FREQUENCY**  : Potentiometer to vary the frequency of square wave and Triangle wave
5. **TRIANGLE**  : Triangle wave o/p for triggering purpose in x-y mode
6. **AMPLITUDE** : Potentiometer to vary the DC voltage from 0-12 V
7. **D.C.**  :Variable to o/p- 0-12 V
8. **GND**  : Ground Terminal.
9. **DPM** : digit DC Voltmeter to measure DC Voltage at different points.
10. : +Ve input of error detector – Set voltage
11. : -Ve input of error detector – feedback voltage
12. : Error Voltage
13. **P** :10 turn potentiometer to vary the proportional gain from0 to 20 with

indicating dial

1. **I**  : 10 turn potentiometer to vary the integral gain from 10 to 1000
2. **D**  : 10 turn potentiometer to vary the derivative gain from 0 to 0.01
3. **CONTROLLER**  : PID Controller with variable PID Parameters.
4. **ON/OFF** : ON/OFF Switch for P.I.D individually.
5. **+**  : Adder
6. **INV .AMP** : Units gain inverting amplifier to find the effect of positive feedback
7. PROCESS

\*FIRST ORDER SYSTEM : First order system with time constant of -3 msec.

\* SECOND ORDER SYSTEM: Second order system with time constant of -5 msec.

α : Damping factor can vary from 0 to 2 by varying R.

\*Time Constant : 1 m sec-suitable for-square wave input

\*Integrator : 2 m sec time with phase shift.

**Theory:**

PID Controller are Very often used in industrial process control to ensure that a parameter such as speed temperature flow etc is maintained to be a constant desired value. P.I.D stands for proportional Integral Derivative control, as the controller uses all these in the feedback. One can also have P control, PI or PD controllers depending on the requirement. All these are feedback controllers with variable values for P, I, and D.

To enable training of students in all these aspects, a PID controller with built in set point generation, controller and simulated process are provided for studying the performance of the controller in closed loop.

**PROPORTIONAL CONTROLLER:**

A proportional control feeds back a value proportional to the measured value, to establish a constant value for the measured value of the parameter, against incidental disturbances in a system.

The first stage of the controller error amplifier is a differential amplifier that establishes the difference between the set value and the measured value. This error is then amplifier and feedback to control the parameter. This amplification is proportional to P-Gain, a low gain means loose control and high gain means tight control. Proportional controller always has a finite steady state error.

Error = - Set voltage

**INTEGRAL CONTROLLER:**

T he rate of change of the output from the integral controller is proportional to the error.

Ti is integral time constant. When there is a large error the controller output changes rapidly to correct the error. As the error gets smaller, the controller output changes more slowly as long as there is an error. The controller output will continue to change. Once the error is zero, the output change also goes to zero. This means the controller holds the output which eliminates the error. The Transfer function of integral controller is

The integral controller has very poor dynamic response.

**DERIVATIVE CONTROLLER:**

The output of the derivative controller is proportional to the Rate of change of error.

= =

The derivative controller responds to change in error to overcome the process inertia. It produces an output only for changes in error and hence it is mostly used in combination with other type of controllers. Generally it is combined with PI controller to improve the dynamics of the process.

**PROPORTIONAL +INTEGRAL (PI) CONTROLLER**:-

This is one of the most popular forms of control, since in this case, the finite error is always zero. However one has to ensure that proper P-and I gain are choosen. Appropriate for the delay s encountered in the control.

With non optimised P and I the response may show an overshoot, or in certain cases. The system may itself become unstable- oscillatory.

Proportional + Integral controller is an effort to combine the advantages of both good transient response from proportional and error dimination from integral controller. The transfer function of PI – controller is (+)

**PROPORTIONAL + DERIVATIVE CONTROLLER:**

In many P Controllers, the system delays might make the final response poor for a step change in the set value. In these cases, one can resort to controlled derivative feedback to improve the step response and dynamic performance of the loop.

**P – I – D CONTROL:**

In P –I Controllers, derivative feedback may be employed to bring in stability of the system or to improve the dynamic performance. All these are feedback controllers, with variable values for P, I and D.

**EXPERIMENT**

**OPEN LOOP - CONTROLLER**

**CIRCUIT DIAGRAM**

ON

OFF

D. C.

Time constant

First order system

Second order system

Integrator

FREQUENCY

AMPLITUDE

LEVEL

SQUARE

TRIAGLE

ON

OFF

ON

OFF

CONTROLLER

INV.AMP

MAINS

P

I

D

DISPLAY

**PID CONTROLLER –OPEN LOOP**

**PROPORTIONAL CONTROLLER – (Open Loop)**

1. Make the connections as given in the figure.
2. Connect DC voltage of 0.5 volts to PID input.
3. Connect feedback input to ground. Vary the proportional gain pot. (10 turn pot with dial indicator ) Total proportional gain is 20. S0, 10 corresponds to gain 20 and 1 corresponds to gain - 2.
4. Switch ON P Controller and keep I and D controller at OFF position.
5. Vary the proportional gain pot and note down the output voltage and entered in an tabular column. Here, it works as simple amplifier.

**OPEN LOOP CONTROLLER - OBSERVATION TABLE:**

|  |  |  |  |
| --- | --- | --- | --- |
| **SL .No** |  | **Gain** |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

**INEGRAL CONTROLLER:- (Open Loop)**

1. Make the connections as given in the circuit diagram.
2. Connect a small voltage of 0.2 Volts to the input.
3. Connect feedback input to Ground. Switch OFF P and D controller – switch ON I controller.
4. Set I gain to some value and observe the output with the digital voltmeter; we can observe that the output builds up as a ramp till it.

Reaches saturation voltage. We can also check this by connecting square wave of small amplitude and we can observe a triangular wave at the output.

**DERIVATIVE CONTROLLER (Open Loop):-**

1. Make the connections as given in the circuit diagram.
2. Connect DC voltage to input, connect feedback input to ground switch OFF P&I controller and switch ON D Controller.
3. We can observe that the output voltage is zero at all conditions. This can be observed by varying the input Dc supply. We can also observe the derivative controller by giving triangular wave at the output.

**EXPERIMENT**

**CLOSED LOOP- CONTROLLER**

**PROORTIONAL CONTROLLER -(CLOSED LOOP):-**

1. Make the connections as given in the circuit diagram.
2. Keep I and D controllers at OFF position.
3. Connect DC supply to . Connect First order plant in the loop.
4. Note down,, for different P – gain and entered in the tabular column. We can observe that the Error voltage =

Check with the Theoretical value and the practical result.

1. Next Connect Integrator on the loop. Integrator has 180 degree phase shift.
2. When we connected directly to the feedback input, it works as positive feedback, now the feedback added with the set voltage and the error voltage will reach is maximum.
3. This is the effect o f positive feedback on the closed loop system . To make it – ve feedback connect integrator output to the Feedback input through inverting amplifier as shown in the figure.
4. Since the plant itself is an integrator, the error will be automatically zero, without I controller also.
5. Next connect Second order system in the loop and also connect Square wave input and keep the Damping factor of Second order system constant (0.3) by adjusting R value provided on the front panel and observe the wave form at by varying P-Gain.
6. You can observe that as the P-Gain increases error decreases but oscillations increase.
7. If P gain is less error is more but oscillations are less.

**CIRCUIT DIAGRAM :-**

SQUARE

TRIAGLE

D. C.

SUPPLY

FREQUENCY

AMPLITUDE

LEVEL

CONTROLLER

INV.AMP

Time constant

First order system

Second order system

Integrator

ON

OFF

OFF

ON

OFF

DISPLAY

P

I

D

ON

**PID CONTROLLER - CLOSED LOOP**

**OBSERVATION TABLE -1**

**PROORTIONAL CONTROLLER -(CLOSED LOOP):-**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **SL .No** | **P-Gain-G** | **Set Voltage-** | **Feedback Voltage -** | **Error Voltage- error** | **Calculated Error=** |
| 1 |  |  |  |  |  |
| 2 |  |  |  |  |  |
| 3 |  |  |  |  |  |
| 4 |  |  |  |  |  |
| 5 |  |  |  |  |  |
| 6 |  |  |  |  |  |
| 7 |  |  |  |  |  |
| 8 |  |  |  |  |  |
| 9 |  |  |  |  |  |
| 10 |  |  |  |  |  |

**INTEGRAL CONTROLLER(CLOSED LOOP):-**

1. Make the connections as given in the circuit diagram.
2. Keep P and D controller at Off position.
3. Connect Second order system in the loop and also connect Square wave input and keep the Damping factor of Second order system constant (0.3) by adjusting R value provided on the front panel and observe the wave form at by varying I-Gain.
4. We can observe that the system shows zero offset error but very poor dynamic performance.

**PROPORTIONAL +INTEGRAL (PI) CONTROLLER -(CLOSED LOOP):-**

1. Make the connections as given in the circuit diagram. Keep P and D controller at off position.
2. Connect DC supply to.
3. Repeat the same procedure for first order system. Second order system for different Values of P and I gain.
4. Enter the results in the tabular column.
5. Connect the square wave input and keep the damping factor constant (0.3) by adjusting R value provided on the front panel.
6. And observe the both input and wave forms on CRO by varying both P gain and I gain. You can observe that study state error is zero with PI controller. You can observe that the I gain is more again oscillations are more.

**OBSERVATION TABLE -2**

**PROPORTIONAL +INTEGRAL (PI) CONTROLLER -(CLOSED LOOP):-**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **SL .No** | **P-Gain-G** | **I-Gain** | **Set Voltage-**  **(volts)** | **Feedback Voltage -**  **(volts)** | **Error Voltage- error** |
| 1 |  |  |  |  |  |
| 2 |  |  |  |  |  |
| 3 |  |  |  |  |  |
| 4 |  |  |  |  |  |
| 5 |  |  |  |  |  |
| 6 |  |  |  |  |  |
| 7 |  |  |  |  |  |
| 8 |  |  |  |  |  |
| 9 |  |  |  |  |  |
| 10 |  |  |  |  |  |

**PROPORTIONAL +INTEGRAL+ DERIVATIVE (PID) CONTROLLER-(CLOSED LOOP):-**

1. Make the connections as given in the circuit diagram. C
2. Connect DC supply to.
3. Repeat the same procedure for first order plant. Second order plant
4. Enter the results in the tabular column.
5. Connect the square wave input and connect second order system and damping factor constant (0.3) by adjusting R. observe the wave form at I/P and .
6. You can observe that by increasing the D gain over shoots is minimizing thus the transient response of the system is improved and offset is also avoided.

**OBSERVATION TABLE -3**

**PROPORTIONAL +INTEGRAL+ DERIVATIVE (PID) CONTROLLER-(CLOSED LOOP):-**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **SL .No** | **P-Gain-G** | **I-Gain** | **D-Gain** | **Set Voltage-**  **(volts)** | **Feedback Voltage -**  **(volts)** | **Error Voltage- error** |
| 1 |  |  |  |  |  |  |
| 2 |  |  |  |  |  |  |
| 3 |  |  |  |  |  |  |
| 4 |  |  |  |  |  |  |
| 5 |  |  |  |  |  |  |
| 6 |  |  |  |  |  |  |
| 7 |  |  |  |  |  |  |
| 8 |  |  |  |  |  |  |
| 9 |  |  |  |  |  |  |
| 10 |  |  |  |  |  |  |

**TESTING WITH CRO:-** P-I-D Controller can also be tested with square wave input. And observe the response on a regular CRO. For testing the PID controller for square wave do not connect First order system and integrator in the closed loop., as there blocks time constant is more compare to the time period of the square wave input. Connect one channel of CRO to the Square wave input with respect to ground and other channel at . We can also connect the CRO in X-Y mode and verify the results. Connect X-input to triangle waveform and Y –input to feedback input – , Draw the results for P, PI ,PID Controllers and for different P-I-D gains.

**Model graph:**

2 times steady state value X

2 times peak response Y

S.S.ERROR =

PEAK PERCENT OVER SHOOT =

Time constant

First order system

Second order system

Integrator

P

I

D

FREQUENCY

AMPLITUDE

LEVEL

SQUARE

TRIAGLE

INV.AMP

SUPPLY

0.3

0.7

1

2

ON

OFF

ON

OFF

CONTROLLER

D. C

DISPLAY

**PID CONTROLLER FOR SQUARE WAVE INPUT**

**PID CONTROLLER**

Time constant

First order system

Second order system

Integrator

P

I

D

FREQUENCY

AMPLITUDE

LEVEL

SQUARE

TRIAGLE

INV.AMP

SUPPLY

0.3

0.7

1

2

ON

OFF

ON

OFF

CONTROLLER

D. C

DISPLAY

**PID CONTROLLER FOR INTEGRATOR LOOP**

**PID CONTROLLER**

**MODEL GRAPH:**

Y

Y

X

X

**(a).Typical P & I oscilloscope trace**

**(b).Typical P + I+D oscilloscope trace**

**FIG.OSCILLOSCOPE TRACES FOR TRANIENT RESPONSE OF PID MODULE**

**RESULT:**

**EXPERIMENT - 6**

**TEMPERATURE CONTROL USING PID**

**AIM:**

**APPARATUS:**

|  |  |  |  |
| --- | --- | --- | --- |
| **SL.No.** | **Name of the Equipment** | **Range** | **Quantity** |
| 1 | Temperature controller -PID kit |  | 1 |
| 2 | stop watch |  | 1 |
| 3 | connecting wires |  | required |

**CIRCUIT DIAGRAM:**

TIME PROPOR TIONAL CIRCUIT

230

% OF POWER INDICATOR

CONTROL SIGNAL

+15V

-15V

DEVIATION METER

P.S.U

LAMP HEATER

EXTERNAL DISTURBANCE COOLING FAN WITH REGULATOR

SOLID STATE RELAY

A.C MAINS

SET

AMPLIFIER

MODEL

BRIDGE EXCITATION 2.35 VOLTS

RTD SENSOR

P

I

D

MODEL PROCESS UNDER CONTROLL

SET

+

-

RTD

**SIMPLIFIED BLOCK DIAGRAM FOR P.I.D . CONTROLLER**

**FIGURE NO - 1**

**FRON PANEL DETAILS:-**

1. **1, 2, 3 :-** Terminals (Red & Black ) on the left the front panel are used to patch various modes of control action.

2. **SET :-** Ten turn pot is used to set the process temperature in a precise fashion (1 ohm = 2.5 degree ) It is normally set at position of 20 Ohm. This represents a process temp. of 50 degree centigrade plus or minus 5 degree centigrade. We have to use multiplying factor of 5 to get the exact process temperature. ADJUST pot can be used for this purpose.

3. **RTD SENSOR:-** This 5 pin Amphenol socket establishes the connection with model process by making inter connection for RTD sensor. Deviation meter and of power meter by means of 5 wire cable.

4. **PROPORTIONAL COLUMN:-**Proportional band is controlled by means a potentiometer and a toggle switch. Total control is from 1% to 100%.

Preset on proportional P.C.B. is meant for adjusting the output power to 50% when the deviation is zero. Potentiometer marked “ADJ.DEVIATION “on the front panel is used to adjust deviation meter to plus or minus 5 degree centigrade when the set pot is disturbed by 2 ohms on either side. This is calibration adjustment and this may be checked right at the experiment.

5. **INTEGRAL COLUMN:-** The rotary switch and bottom potentiometer provide coarse and fine adjustment for integral times in seconds. The push button (RESET) must be pushed before integral action.

5. **DERIVATIVE COLUMN:-** The rotary switch and bottom potentiometer provide coarse and fine adjustment for integral times in seconds. The push button (RESET) must be pushed before derivative action.

**HEATER SOCKET:-** The 8 pin female socket provides connection to the model process for the heater and cooling fan.

6. **PROPORTIONAL CONTROL**:-Proportional action is a made of controller action in which is a continuous linear relation between values of deviation and manipulated variable. Thus the action of the controlled variable is repeated and amplified in the action of the final control element.

**CONTROLLER TRANSFER EQUATION:-**

Consider fig.6 the feedback signal is V/K1 where V is the output and K1 is the proportion of signal feedback.

This is summed with the deviation signal and the sum is amplified by gain A o produce the output V. i.e.

(0+V/K1)A=V

i.e

V=

Now A>K1,K1/A tends to zero i.e.-K1\*0

This is the required relation for proportional control (Single term). K1 is called proportional sensitivity or proportional gain or proportional action factor. It is usually expressed in terms in term of inverse function (proportional band).This is because of the has limit of 0 to 100 % of maximum available heater power valve opening etc. so that it is convenient to refer the system parameters ti this scale.

Consequently if the output swing is obtained for an output swing when K1=1, the proportional band is 100%. If the output swing is obtained for 0/10, then K1= 10 and proportional band is 10%. In this process zero deviation is made to correspond to 50% of power output.

Suppose the process is giving zero deviation for normal load on it with proportional control. Now the load is increased, the output power must also be increased to bring the error back to zero i.e deviation from normal condition.

This finite error which occurs when the process loads are varied is called as offset. The only way to reduce the offset and hold the process parameter at the set point is to increase the proportional gain. But too high gain may introduce instability.

**THEORY:-**

The problem of a process a control originates with the necessity for minimizing the effect of change in the load variables. The process and the automatic controller acting together compromise the control system and the characteristics of the process as well as of the controller affect the performance of the complete system. The PID controller is designed to bring ti the notice of the student various aspects of the problem of process control.

**DESCRIPTION OF THE SYSTEM:-**

The system consists of a versatile controller and electrically heated model process and a conditioning unit.

The model is an aluminium process block surrounded by a symmetrically located lamp bank which serves to heat the process block. Platinum resistance thermometer is used in order to sense the temperature of the process block. The model is a speeded version of an industrial process with the time constants shorted to make the experiment of appropriate duration for engineering college laboratories and university labs.

The control problem investigated that of maintaining the process temperature under variation of heat losses by changing the flow of cooling air passed through the model.

The conditioning unit uses a stabilized power supply feeding a bridge circuit for which PT-100 element forms one of the four arms. The required process temperature is adjusted with the 3 help of a precision ten turn helical potentiometer with dial.

The error signal is suitably modified to drive a temp. Deviation meter.

Following are the various modes of control which can be patched on the system.

1. Proportional controller (P)

2. Proportional + Integral (P+I)

3. Proportional+ Derivative (P+D)

4. Proportional+ Integral+ Derivative (P+I+D)

All the normal parameters such as proportional band, integral and derivative time etc. are adjusted over a wide range. The percentage of power indicates output as the percentage of full power supplied to the heater.

The control power to the process heater (lamp bank ) is obtained by using a soiled state relay. The control section is electrically isolated from the conditioning unit with help of an operational isolator (I.E.D. and photo transistor link) the flow of cooling air is generated with the help of a fan which is controlled from a solid state regulator using a triac circuit.

**EXPERIMENT - (I)**

**PROPORTIONAL ACTION**

**AIM:** To study phenomenon of offset for proportional controller when he load on the process is varied.

**IRCUIT DIAGRAM:**

A

V

ISOLATOR

**PROPORTIONAL (P) SCHEMATIC DIAGRAM**

**CONNECTIONS AND TYPICAL SETTINGS**

PROPORTIONAL BAND

PROPORTIONAL BAND

ADJUST

PROPORTIONAL

OR

SET

RTD sensor

3

2

1

Heater socket

**Note :** for proportional band or gain adjustments, both the alternatives are shown and are valid.

If SET pot is adjusted at 20 ohms with null on deviation meter , then ADJUST pot is used to get +/- 5 degrees

Deviation with set pot disturbed by 2 ohms on either side.

**FIGURE -2**

**PROCEDURE:-**

1. Established the connection between the conditioning unit and the model process with the help of cables provided.
2. Refer figure 6. And connect Red 3 and Black 1 with the help of patch card.
3. Set the “SET” potentiometer at the position of 18 Ohms corresponds to 45 degree centigrade of temperature.
4. Set the proportional band control to 10% i.e.K1 = 10
5. Now turn ON the power supply and also turn On the fan. Place the fan regulator at low position.
6. Wait until the deviation indicator stabilizes at some point Record the deviation readings and percentage of power reading at interval of 15 seconds.
7. Now suddenly increase the fan speed to full level by moving fan control to high position.
8. Now note down the deviation meter reading when the pointer stabilizes. Record the deviation meter readings. The difference between the two readings i.e.step8 and step6 is the offset (steady state error).
9. Now you may increase the gain to 100 i.e. proportional band to 1% and Repeat the step 5 to 8 .In this expt. You will observe that the offset error is reduced.
10. Draw the graph of Time v/s deviation and Time v/s power.
11. You may perform experiment with various gain settings.

**INTEGRAL ACTION:-**

Integral action is a made of control action in which the value of the manipulated variable is changed at a rate proportion to the deviation. Thus if the deviation is doubled over a previous value the final control element is moved twice as fast.

The integral action adjustment is the integral time. For a step change of deviation the integral time is time required to add increment the response equal to the original step change of response. Integral action is used alone very seldom.

The integral action is generally used in association with proportional action. As a result of integral action the offset error is almost reduced to zero. But the transient response is adversely effected. In other words the integral action has a destabilizing effect on the process under the conditions of load variations.

**PROPORTIONAL AND ITEGRAL ACTION:**

With reference to fig. 7 the signal fed back where “S “is the Laplace operator

\*

\*) A=V

herefore V = K1 0/ (K1/A- SCR/1+SCR)

Writing K2=K1/CR where K2 is Know as integral action factor and transforming we have if A>K1

V=K1\*0=K1/SCR=K1\*0-K2 0dt

The purpose integral action is to eliminate the steady state error.

When 0 =

In steady state 0 tends to 0ss as s tends to0.

Consequently 0ss=0. The Practical integrator suffers from the capacitor leakage resistance and small amount of error might be obtained .The effect of integral action is to produce a phase lag of (K2/K1)

The phase lag depends inversely upon integral time T.

**P.I.D CONTROLLER (TYPICAL READING)**

**PROPORTIONAL ACTION 180 Ώ =45 Degree C SET**

**Low Disturbance ( Fan Low speed)**

**Tabular Column:**

|  |  |  |  |
| --- | --- | --- | --- |
| **SI. No.** | **Time in Seconds** | **Deviation Degree C** | **% of Power** |
| 1 |  |  |  |
| 2 |  |  |  |
| 3 |  |  |  |
| 4 |  |  |  |
| 5 |  |  |  |
| 6 |  |  |  |
| 7 |  |  |  |
| 8 |  |  |  |
| 9 |  |  |  |
| 10 |  |  |  |
| 11 |  |  |  |
| 12 |  |  |  |

**REMANIS STABLE AT TIME INTERVAL**

**High Disturbance (Fan high speed)**

|  |  |  |  |
| --- | --- | --- | --- |
| **SI. No.** | **Time in Seconds** | **Deviation Degree C** | **% of Power** |
| 1 |  |  |  |
| 2 |  |  |  |
| 3 |  |  |  |
| 4 |  |  |  |
| 5 |  |  |  |
| 6 |  |  |  |
| 7 |  |  |  |
| 8 |  |  |  |
| 9 |  |  |  |
| 10 |  |  |  |
| 11 |  |  |  |
| 12 |  |  |  |

**REMANIS STABLE AT TIME INTERVAL**

**PROPORTIONAL ACTION:-**

**MODEL GRAPH:**

TIME

SET TEMPERATURE =C

TIME

DEVIATION

% OF POWER

DEVIATION IN CCC00000000000000000000000000FDST000000000000000000

ERROR =C

**HIGH SPEED FAN**

X

Y

Y

X

SET TEMPERATURE =C

TIME

% OF POWER

DEVIATION IN CCC00000000000000000000000000FDST000000000000000000

TIME

LOWSPEED FANC ERROR

HIGH SPEED FANC ERROR

OFF SET ERROR = C

**LOW SPEED FAN**

ERROR =C

**EXPERIMENT No.2.**

**PROPORTIONAL + INTEGRAL (P+I)**

**Aim:-** To show the effect of integral action in eliminating the offset To observe that the integral action has destabilizing effect on the process when the load changes occur.

**CIRCUIT DIAGRAM:**

ISOLATOR

**PROPORTIONAL + INTEGRAL CONTROL (SCHEMATIC DIAGRAM)**

A

V

**CONNECTIONS AND TYPICAL SETTING**

ADJUST

PROPORTIONAL

SET

RTD sensor

PROPORTIONAL BAND

5

2.5

10

COARSE

RESET

3

2

1

INTEGRAL

**RESET BUTTON MUST BE PUSHED BEFORE STARTING**

**FIGURE - 3**

**PROCEDURE:**

1. Establish the connection as per fig. 5 with the help of patch cards. Get the indicated settings for the various controls.
2. SET =18 OHMS (i.e. 45 degree centigrade)
3. PB = 10%
4. Coarse control for integral action = 10 seconds
5. Fine control = Midway.
6. Turn on the fan with control on low position.
7. Wait until the process stabilizes with almost zero deviation.
8. Now suddenly increase the fan speed to high position with help of stop watch record the deviation meter readings at an interval of 15 seconds. Continue the process until the deviation meter almost stabilizes at zero deviation. There might be negligible error(around 0.2 degree centigrade or so )
9. You can ob serve that the integral action gives zero offset but transient response is hampered.

**DERIVATIVE ACTION:-**

A derivative control action may be added to proportional control and continued P+D control action is obtained.

Derivative control action may be defined as a control action in which the magnitude of the manipulated variable is proportional to the rate of change of deviation.

The controller response anticipates. Derivative time is defined as amount of lead, expressed in minutes of time that control action is given.

Refer. Fig No.8 Consider the system shown in fig.8 the signal feedback is ……

\*

Where “S” is the Laplace operator. The transfer equation will be:

(0+ \* ) A =V

If A>>K1, V = K1(1+SCR)0

And transforming

V =-(K10+K1CR\*do/dt)=-(K10+K3\*do/dt)

CR is the derivative action time td r K3=derivative action factor=K1CR.

The advantage of derivative action is that the proportional gain may be made large without producing excessive oscillations.

This in turn reduces offset. It is sometimes possible through the use of P+D reduces offset to such a small value that integral action would not required. The P+D action improves the transient under larger load changes.

**PROPORTIONAL +INTEGRAL(P+I) ACTION:-**

**MODEL GRAPH:**

TIME

ERROR

DEVIATION C

CHANGE FROM HIGH TO LOW DISTURBANCE

**CONCLUSION: ALMOST ZERO ERROR**

**SLUGGISH TIME RESPONSE**

**P.I.D CONTROLLER (TYPICAL READING)**

**PROPORTIONAL + INTEGRAL**

**Low Disturbance ( Fan Low speed)**

**Tabular Column:**

|  |  |  |  |
| --- | --- | --- | --- |
| **SI. No.** | **Time in Seconds** | **Deviation Degree C** | **% of Power** |
| 1 |  |  |  |
| 2 |  |  |  |
| 3 |  |  |  |
| 4 |  |  |  |
| 5 |  |  |  |
| 6 |  |  |  |
| 7 |  |  |  |
| 8 |  |  |  |
| 9 |  |  |  |
| 10 |  |  |  |
| 11 |  |  |  |
| 12 |  |  |  |

**REMANIS STABLE AT TIME INTERVAL**

**High Disturbance (Fan high speed)**

|  |  |  |  |
| --- | --- | --- | --- |
| **SI. No.** | **Time in Seconds** | **Deviation Degree C** | **% of Power** |
| 1 |  |  |  |
| 2 |  |  |  |
| 3 |  |  |  |
| 4 |  |  |  |
| 5 |  |  |  |
| 6 |  |  |  |
| 7 |  |  |  |
| 8 |  |  |  |
| 9 |  |  |  |
| 10 |  |  |  |
| 11 |  |  |  |
| 12 |  |  |  |

**REMANIS STABLE AT TIME INTERVAL 60 SEC’S**

**EXPERIMENT No.3.**

**PROPORTIONAL+DERIVATIVE (P+D)**

**Aim:-** To observe the stabilizing of the derivative action.

**CIRCUIT DIAGRAM:**

ADJUST

PROPORTIONAL

SET

RTD sensor

PROPORTIONAL BAND

5

2.5

10

COARSE

RESET

1

2

3

DERIVATIVE

ISOLATOR

A

V

C

R

**PROPORTIONAL + DERIVATIVE CONTROL (SCHEMATIC DIAGRAM)**

**RESET BUTTON BE PUSHED BEFORE STARTING EXPT**

**FIGURE - 4**

**CONNECTIONS AND TYPICAL SETTINGS**

**PROCEDURE:-**

1. Establish the connection as per f.g.8 with the help of patch cards. Get the indicated settings for the various controls.

a).SET= 18 ohms 9i..e.45 degree centigrade)

b).PB= 10%

c).Coarse control for derivative action= 5 seconds.

d).Fine control = Midway.

2. Turn on the with control on low position.

3. Wait until the process stabilizes.

4. Now introduce the load change by moving the fan control to high position with the help of a

stop watch record the deviation meter readings at an interval of 5 to 10 seconds. You may

observe that the process comes to almost zero deviation point quickly. In fact in this process

the performance of P+D and P+I+D are almost identical.

5. You may perform experiments for other settings of derivative time and PB.

**P+I+D ACTION:-**

Proportional + Integral + derivative action procedure smallest Max. derivations and offset is eliminated, because of integral action.

The derivative action tries to improve the transient response to a greater extent.

The P+I+D action is more effective for control of process with many energy strong elements than the P+I action used alone.

**P.I.D CONTROLLER (TYPICAL READING)**

**PROPORTIONAL + DERIVATIVE**

**Low Disturbance ( Fan Low speed)**

**Tabular Column:**

|  |  |  |  |
| --- | --- | --- | --- |
| **SI. No.** | **Time in Seconds** | **Deviation Degree C** | **% of Power** |
| 1 |  |  |  |
| 2 |  |  |  |
| 3 |  |  |  |
| 4 |  |  |  |
| 5 |  |  |  |
| 6 |  |  |  |
| 7 |  |  |  |
| 8 |  |  |  |
| 9 |  |  |  |
| 10 |  |  |  |

**REMANIS STABLE AT TIME INTERVAL**

**High Disturbance (Fan high speed)**

|  |  |  |  |
| --- | --- | --- | --- |
| **SI. No.** | **Time in Seconds** | **Deviation Degree C** | **% of Power** |
| 1 |  |  |  |
| 2 |  |  |  |
| 3 |  |  |  |
| 4 |  |  |  |
| 5 |  |  |  |
| 6 |  |  |  |
| 7 |  |  |  |
| 8 |  |  |  |
| 9 |  |  |  |
| 10 |  |  |  |

**REMANIS STABLE AT TIME INTERVAL**

**PROPORTIONAL + DERIVATIVE (P+D):-**

**MODEL GRAPH:**

**DEVIATION**

**1. CHANGE FOR P TO P+D**

**2. CHANCE FROM HIGH TO LOW DISTURBANCE**

**TIME (SEC)**

(a)

**DEVIATION**

**CHANGE FROM LOW TO HIGH DISTURBANCE**

**TIME (SEC**)

(b)

**DEVIATION**

**CHANGE FROM HIGH TO LOW DISTURBANCE**

**TIME (SEC)**

**CONCLUSION: NEGLEGIBLE ERROR**

**GOOD TIME RESPONSE**

(c)

**Experiment No.4**

**(PROPORTIONAL+INTEGRAL+DERIVATIVE)**

**AIM:-**To study the performance of P+I+D action.

ADJUST

PROPORTIONAL

SET

RTD sensor

PROPORTIONAL BAND

5

2.5

10

COARSE

RESET

1

2

3

INTEGRAL

DERIVATIVE

ISOLATOR

A

ISOLATOR

V

D

P

**CONNECTION AND TYPICAL SETTINGS FOR P + I +D ACTION**

**PUSH RESET BUTTONS BEFORE STARTING EXPT**

**FIGURE - 5**

**PROCEDURE:**

1. Establish the connection as per f.g.9 with the help of patch cards. Get the indicated settings for the various controls.
2. Turn on the fan with control on low position.
3. Wait until the process stabilizes.
4. Now introduce the load change by moving the fan control to high position. with the help of a

Stop watch record the deviation meter readings at an interval of 5 to 10 seconds. You may

Observe that the process comes to almost zero deviation point quickly. Thus the transient response is improved and offset is also avoided.

1. You may perform experiments with various other settings. You may also study the response of the system by change in set point by moving SET to 17 to25 ohms.

**PRECAUTIONS:-**

1. Operate SET control pot in a gentle fashion.
2. Study all the controls carefully before using the equipment.
3. “Adjust control is adjusted in proportional mode to get 50% of output power when deviation is zero. Then the adjust control is not disturbed in the entire expt.
4. Make or break the connection only after turning OFF the mains supply.

Note:- Heater lamps are of Philips make with reflector 3 Nos. with 100/150 watts.

1. During winter season in view of low ambient temp. you may have to adjust the process for low temperatures and vice versa for summer season.

**P.I.D CONTROLLER (TYPICAL READING)**

**PROPORTIONAL + INTEGRAL + DERIVATIVE**

**Low Disturbance ( Fan Low speed)**

**Tabular Column:**

|  |  |  |  |
| --- | --- | --- | --- |
| **SI. No.** | **Time in Seconds** | **Deviation Degree C** | **% of Power** |
| 1 |  |  |  |
| 2 |  |  |  |
| 3 |  |  |  |
| 4 |  |  |  |
| 5 |  |  |  |
| 6 |  |  |  |
| 7 |  |  |  |
| 8 |  |  |  |
| 9 |  |  |  |
| 10 |  |  |  |

**REMANIS STABLE AT TIME INTERVAL**

**High Disturbance (Fan high speed)**

|  |  |  |  |
| --- | --- | --- | --- |
| **SI. No.** | **Time in Seconds** | **Deviation Degree C** | **% of Power** |
| 1 |  |  |  |
| 2 |  |  |  |
| 3 |  |  |  |
| 4 |  |  |  |
| 5 |  |  |  |
| 6 |  |  |  |
| 7 |  |  |  |
| 8 |  |  |  |
| 9 |  |  |  |
| 10 |  |  |  |

**REMANIS STABLE AT TIME INTERVAL**

**RESULT:**

**EXPERIMENT – 7**

**CHARACTERISTICS OF MAGNETIC AMPLIFIER**

**AIM:**

To study the control characteristics of magnetic amplifier.

**APPARATUS:**

|  |  |  |  |
| --- | --- | --- | --- |
| **SI.No** | **NAME OF THE EQUIPMENT** | **RANGE** | **QUANTITY** |
| 1 | Magnetic amplifier kit |  | 1 |
| 2 | Regulated power supply(RPS) | 30V/2A | 1 |
| 3 | Rheostat | 200 | 1 |
| 4 | Ammeter | 200mA (DC) | 1 |
| 5 | Ammeter | 2A (AC) | 1 |
| 4 | Connecting wires |  | Required |

**Theory:**

**CIRCUIT DIAGRAMS:**

**(I). SERIES CONNECTED MAGNETIC AMPLIFIER**

(0 - 2)

A.C

200Ώ/2A

100V

50V

0V

(0 -200)

D.C

C W

**Procedure:**

1. Connect the circuit as shown in the fig. externally with the help of patch cords. Take care of the polarity of the winding.
2. Connect DC Voltage supply (0 – 30)V/2A with DC current meter (0 – 200)mA in series with the control winding.
3. Connect a load resistor (preferably a Rheostat ) and load current meter (0 – 2A, AC)

As shown in the figure.

1. Vary control winding current in step and record corresponding load current .
2. Plot a graph of v/s in each case.
3. Repeat the above procedure for different values of
4. Connect (0 – 30)V/1A in series with the bias winding vary the bias voltage and that by the adjustment of bias voltage and p0larity the zero current point of the control winding can be moved to any desired point on the curve of the AC load current.

**Tabular column for series connected Magnetic amplifier:-**

|  |  |  |
| --- | --- | --- |
| **SI No.** | **(Control winding current)**  **DC in milliamps** | **(Load winding current)**  **AC in milliamps** |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |
| 6 |  |  |
| 7 |  |  |
| 8 |  |  |
| 9 |  |  |
| 10 |  |  |

**MODAL GRAPH :**

**(ii). PARALLEL CONNECTED MAGNETIC AMPLIFIER:-**

(0 -200)

D.C

C W

(0 - 2)

A.C

200Ώ/2A

100V

50V

0V

**Procedure:**

1. Connect the circuit as shown in the fig. externally with the help of patch cords. Take care of the polarity of the winding.
2. Connect DC Voltage supply (0 – 30)V/2A with DC current meter (0 – 200)mA in series with the control winding.
3. Connect a load resistor (preferably a Rheostat ) and load current meter (0 – 2A, AC)

As shown in the figure.

1. Vary control winding current in step and record corresponding load current .
2. Plot a graph of v/s in each case.
3. Repeat the above procedure for different values of
4. Connect (0 – 30)V/1A in series with the bias winding vary the bias voltage and that by the adjustment of bias voltage and p0larity the zero current point of the control winding can be moved to any desired point on the curve of the AC load current.

**Tabular column for parallel connected Magnetic amplifier:-**

|  |  |  |
| --- | --- | --- |
| **SI No.** | **(Control winding current)**  **DC in milliamps** | **(Load winding current)**  **AC in milliamps** |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |
| 6 |  |  |
| 7 |  |  |
| 8 |  |  |
| 9 |  |  |
| 10 |  |  |

**MODAL GRAPH :**

**(iii). SELF EXCITED MAGNETIC AMPLIFIER:**

C W

100V

50V

0V

200Ώ/2A

(0 - 2)

A.C

(0 -200)

D.C

**Procedure:**

1. Connect the circuit as shown in the fig. externally with the help of patch cords. Take care of the polarity of the winding.
2. Connect DC Voltage supply (0 – 30)V/2A with DC current meter (0 – 200)mA in series with the control winding.
3. Connect a load resistor (preferably a Rheostat ) and load current meter (0 – 2A, AC)

As shown in the figure.

1. Vary control winding current in step and record corresponding load current .
2. Reverse the polarity in the DC power supply to the control winding and vary control winding current in steps of 1mA and record corresponding load current .
3. Plot a graph of v/s in each case.
4. Repeat the above procedure for different values of
5. Connect (0 – 30)V/1A in series with the bias winding vary the bias voltage and that by the adjustment of bias voltage and p0larity the zero current point of the control winding can be moved to any desired point on the curve of the AC load current.

**Tabular column for parallel connected Magnetic amplifier:-**

|  |  |  |
| --- | --- | --- |
| **SI No.** | **(Control winding current)**  **DC in milliamps** | **(Load winding current)**  **AC in milliamps** |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |
| 6 |  |  |
| 7 |  |  |
| 8 |  |  |
| 9 |  |  |
| 10 |  |  |
| 11 |  |  |
| 12 |  |  |
| 13 |  |  |

**MODAL GRAPH :**

**(iv). Bridge type D.C OUTPUT WITH & WITHOUT FEED BACK**

(0 -200)

D.C

C W

100V

50V

0V

200Ώ/2A

(0 - 2)

A.C

**BRIDGE TYPE CONNECTED MAGNETIC AMMPLIFIER WITH OUT FEED BACK:-**

1. Connect the circuit as shown in the fig. Experimentally with the help of patch cords. Take care of the polarity of the windings. Connect the diodes as in circuit diagram.
2. Do not connect Feedback winding in the circuit.
3. Connect DC voltage supply 0-30 V/1A with DC current meter 0-200ma in series with the control winding.
4. Connect a load resistor (preferable a Rheostat) and load current meter (0-2A AC )as shown in the figure.
5. Vary control winding current IC in steps and record corresponding load current IL.
6. Reverse the polarity in the DC power supply to the control winding and Vary control winding current IC in steps of -1 ma and record corresponding load current IL.
7. Plot a graph of IC v/s IL in each case.
8. Repeat the above procedure for different values of RL.

**Tabular column for bridge type connected magnetic amplifier without feedback Magnetic amplifier:-**

|  |  |  |
| --- | --- | --- |
| **S.No.** | **IC (Control winding current) DC in milliamps** | **IL (Load winding current) AC in milliamps** |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |
| 6 |  |  |
| 7 |  |  |
| 8 |  |  |

**BRIDGE TYPE CONNECTED MAGNETIC AMMPLIFIER WITH POSITIVE FEED BACK:-**

1. Connect the circuit as shown in the fig. Experimentally with the help of patch cords. Take care of the polarity of the windings. Connect the diodes as in circuit diagram.
2. Do not connect Feedback winding in the circuit.
3. Connect DC voltage supply 0-30 V/1A with DC current meter 0-200ma in series with the control winding.
4. Connect a load resistor (preferable a Rheostat) and load current meter (0-2A AC )as shown in the figure.
5. Vary control winding current IC in steps and record corresponding load current IL.
6. Reverse the polarity in the DC power supply to the control winding and Vary control winding current IC in steps of -1 ma and record corresponding load current IL.
7. Plot a graph of IC v/s IL in each case.
8. Repeat the above procedure for different values of RL.

**TABULAR COLUMN FOR BRIDGE TYPE CONNECTED MAGNETIC AMPLIFIER WITH POSITIVE FEEDBACK MAGNETIC AMPLIFIER:-**

|  |  |  |
| --- | --- | --- |
| **S.No.** | **IC (Control winding current) DC in milliamps** | **IL (Load winding current) AC in milliamps** |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |
| 6 |  |  |
| 7 |  |  |
| 8 |  |  |

**BRIDGE TYPE CONNECTED MAGNETIC AMMPLIFIER WITH NEGATIVE FEED BACK:-**

1. Connect the circuit as shown in the fig. Experimentally with the help of patch cords. Take care of the polarity of the windings. Connect the diodes as in circuit diagram.
2. Do not connect Feedback winding in the circuit.
3. Connect DC voltage supply 0-30 V/1A with DC current meter 0-200ma in series with the control winding.
4. Connect a load resistor (preferable a Rheostat) and load current meter (0-2A AC )as shown in the figure.
5. Vary control winding current IC in steps and record corresponding load current IL.
6. Reverse the polarity in the DC power supply to the control winding and Vary control winding current IC in steps of -1 ma and record corresponding load current IL.
7. Plot a graph of IC v/s IL in each case.
8. Repeat the above procedure for different values of RL.

**TABULAR COLUMN FOR BRIDGE TYPE CONNECTED MAGNETIC AMPLIFIER WITH NEGATIVE FEEDBACK MAGNETIC AMPLIFIER:-**

|  |  |  |
| --- | --- | --- |
| **S.No.** | **IC (Control winding current) DC in milliamps** | **IL (Load winding current) AC in milliamps** |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |
| 6 |  |  |
| 7 |  |  |
| 8 |  |  |
| 9 |  |  |
| 10 |  |  |

**MODEL GRAPH:**

without F.B

With – ve F.B

With + ve F.B

A.C

D.C

**RESULT**

**EXPERIMENT - 8**

**CHARACTERISTICS OF A.C SERVO MOTOR**

**Aim:** To observe the speed torque characteristics of two phase A.C servo motor.

**APPARATUS:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SI.NO** | **NAME OF THE EQUIPMENT** | **RANGE** | **TYPE** | **QUANTITY** |
| 1 | Speed torque characteristics of two phase ac servo motor kit |  |  | 1 |
| 2 | Multimeter |  |  | 1 |

**CIRCUIT DIAGRAM:**

REFERENCE WINDING

R

C

ON

OFF

ON

OFF

SERVO MOTOR

CONTROL VOLTAGE

LOAD

POWER

SPEED (RPM)

AMMETER (AMPS)

R

**SPEED V/S TORQUE STUDY UNIT**

D.C -MOTOR

**Front panel details:-**

**1. POWER**  : mains ON/OFF switch to the unit with built in indicator.

**2. RPM**  : tachometer to display the RPM.

**3. AMMETER** : ammeter to measure the DC motor armature current.

**4. SERVO MOTOR ON/OFF** : AC supply ON/OFF switch to the servo motor.

**5. LOAD ON/OFF** : ON/OFF switch to load the motor.

**6. R** : potentiometer to vary the load -2500 ohms/100watts.

**7.** : 12v unregulated DC supply to DC MOTOR.

**8.**  : terminals measure the back EMF.

**9. CONTROL WINDING** : control winding terminals of AC servomotors.

**10. REFFERANCE WINDING** : reference winding of AC servomotor.

**11. CONTROL VOLTAGE** : auto transformer to vary the AC supply to the control winding.

**THEORY:**

An AC servo motor is basically a two phase induction motor except for certain special design features. A two phase induction motor consisting of two stator windings oriented 90 degrees electrically apart in space excited by AC voltages which differ in time phase by 90 degrees. Generally a voltages of equal magnitude & 90 degrees phase difference is applied to the two stator phases thus making their respective fields 90 degrees apart in both & space at the synchronous speed as there field sweeps over a rotor, voltages are induced in it producing current in the short circuited rotor. The rotating magnetic field interacts with these currents Producing a torque on the rotor in the direction of the field rotation.

The shape of the characteristics depends upon the ratio of the rotor reactance (x) to the rotor resistance (R) In normal inductions motors X/R ratio is generally Kept high so as to obtain the maximum torque close to operating region which is usually around 5% slip.

A two phase servo motor differs in two ways from normal induction motor.

1. The rotor of the servo motor is built with high resistance so that its X/R ratio is small & the torque speed characteristics is as shown in the figure(2). Curve (B) is nearly Linear in contrast to the non linear characteristics with large X/r. It must be emphasized that if a conventional induction motor with high X/r is used for servo application, then because of the positive slope for the part of the characteristics, the system using such a motor becomes unstable. The motor construction is usually squirrel cage or drag cup type. The diameter of the rotor is kept small in order to reduce inertia & thus to obtain good accelerating characteristics. Drag sup construction is used for a very low inertia operation.
2. In servo applications, the voltages applied to the two stator windings are seldom balanced, One of the phases known as the reference phase is excited by constant voltage & the other phase is excited constant voltage supplied to the reference windings & it has a variable magnitude & polarity. The control winding voltage is supplied because they are light weight, rugged & there are no brush contacts to maintain.

Both the control and reference windings are similar and we can interchange them. During forward direction the control winding is taken as control winding and reference winding as reference winding and during reverse direction control winding is taken as reference winding and reference winding as control winding.

**PROCEDURE:**

1. study all the control carefully on the front panel
2. initially that the control switch at OFF position, indicating that the armature circuit of dc machine is not connected to auxiliary DC supply -12v DC keep servomotor supply switch also at OFF position.
3. Ensure load potentiometer and control voltage auto transformer at minimum position.
4. Now switch on mains supply. Vary the control voltage transformer. You can observe that the AC servomotor will starts rotating and the speed will be indicated by the tachometer in front panel.
5. With load switch in OFF position vary the speed of the AC servomotor by moving the control voltage and note down back emf generated by the DC machine.

(now working as DC generator or tacho) entre the result in the table.

**OBSERVATION TABLE: -1**

|  |  |  |
| --- | --- | --- |
| **Si.no** | **Speed N**  **( rpm)** | **Back e.m.f**  **V**  **(volts)** |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |
| 6 |  |  |
| 7 |  |  |
| 8 |  |  |
| 9 |  |  |
| 10 |  |  |

1. Now with the load switch at OFF position. Switch on AC servo motor and keep the speed in the maximum position. You can observe that the AC servo motor starts moving with speed being indicated by the tachometer, now vary the control winding voltage by varying the auto transformer (230) and set the speed for maximum speed, now switch ON the load switch and start loading AC servomotor by varying the load potentiometer slowly. Note down the corresponding values of and speed and then entre these readings in the table and note down control voltage.
2. Repeat the above procedure for different control voltage 200V, 180V also and plot the graph of speed v/s torque.

**OBSERVATION TABLE: - 2**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **SI.NO** | **Ammeter reading**  **()** | **Speed**  **(** | **Back e.m.f**  **(volts)** | **Power**  **P**  **(watts)** | **Torque**  **T =**  **(N-m)** |
| **1** |  |  |  |  |  |
| **2** |  |  |  |  |  |
| **3** |  |  |  |  |  |
| **4** |  |  |  |  |  |
| **5** |  |  |  |  |  |
| **6** |  |  |  |  |  |
| **7** |  |  |  |  |  |
| **8** |  |  |  |  |  |
| **9** |  |  |  |  |  |
| **10** |  |  |  |  |  |

1. measured by ammeter which is connected in series with the power supply and variable resistance (LOAD CONTROL). This method does not take into the account the no load torque developed by the AC servomotor. Rotor to measure torque developed at no load (i.e. torque just required to rotate rotor of AC servomotor) is switched OFF , rotor of DC motor) the AC servomotor is switched OFF. Now the DC machine runs as the motor with the help of DC power supply. Speed will be connected controlled by variable resistance, again we have to effect the measurement of ia, for a given speed. From the product of (back e.m.f developed by the motor) and the armature current take, we can find the mechanical power developed at the motor shaft. Again we must use the formula

P = power in watts , T = torque

Torque

N = speed in rpm,

For various speeds we can note down the no load torque required to be developed by the motor. This torque is negligible and may not be taken into account for normal testing.

**Model graph – 1:**

**Back E.M.F v/s SPEED:-**

(Volts)

Speed (N) rpm

**Model graph – 2:**

**SPEED v/s TORQUE :-**

Speed

(N) RPM

TORQUE (T) N-m

= 230V

= 200V

= 180V

= 150V

**Result:**

**EXPERIMENT - 1**

**LINEAR SYSTEM ANALYSIS (TIME DOMAIN ANALYSIS, ERROR ANALYSIS) USING MATLAB**

**AIM:** To find time domain analysis at given linear system using MAT LAB.

**APPARATUS:**

desktop with MATLAB software.

**PROCEDURE:**

* Open the **‘’ MATLAB ‘’** software.
* Then open the **FILE** menu and enter.
* Select **NEW** then select the **BLANK – M file** and enter.
* Entre the programme code.
* And click **RUN and SAVE** and enter.
* Note down the output after executing the programme.
* Compare the theoretical and practical values.

**PROGRAM CODE:**

t=[0; 15; 30];

num1=[0 8];

den1 =[1 4 8];

c1=step(num1,den1,t);

plot(t,c1);

x- label(‘time in sec’);

y- label (‘c (t)’);

**OUTPUT:**

**Model graph;**

Time in (sec) t

**RESULT:**

**EXPERIMENT – 2(A)**

**BODE PLOT**

**AIM:** To draw The bode plot for the given transfer function using MATLAB.

**APPARATUS:**

desktop with MATLAB software.

**PROCEDURE:**

* Open the **‘’ MATLAB ‘’** software.
* Then open the **FILE** menu and enter.
* Select **NEW** then select the **BLANK – M file** and enter.
* Entre the programme code.
* And click **RUN and SAVE** and enter.
* Note down the output after executing the programme.
* Compare the theoretical and practical values.

**PROGRAM CODE:**

% g(s) = ;

num = [10 5];

den = conv([4 1],[0.25 1]);

g = tf (num,den);

bode (g);

**OUTPUT:**

**Model graph:**

-20

0

10

20

Frequency

Magnitude

(d B)

0

-45

-90

Frequency(rad / sec)

phase

(deg)

**RESULT:**

**EXPERIMENT - 2 – (B)**

**STABILITY ANALYSIS (ROOT LOCUS) OF LINEAR TIME INVARIANT SYSTEM USING MATLAB**

**AIM:** To draw the root locus plot for the given transfer function using MATLAB.

**APPARATUS:**

Desktop with MATLAB software.

**PROCEDURE:**

* Open the **‘’ MATLAB ‘’** software.
* Then open the **FILE** menu and enter.
* Select **NEW** then select the **BLANK – M file** and enter.
* Entre the programme code.
* And click **RUN and SAVE** and enter.
* Note down the output after executing the programme.
* Compare the theoretical and practical values.

**PROGRAM CODE:**

% g(s) = ;

num = [10 5];

den = conv([4 1],[0.25 1]);

g = tf (num,den);

rlocus (g);

**OUTPUT:**

**Model graph:**

-2

-3

-4

j

S

**RESULT:**

**EXPERIMENT – 2 –(C)**

**NYQUIST PLOT**

**AIM:** To draw the nyquist plot for the given transfer function using MATLAB.

**APPARATUS:**

desktop with MATLAB software.

**PROCEDURE:**

* Open the **‘’ MATLAB ‘’** software.
* Then open the **FILE** menu and enter.
* Select **NEW** then select the **BLANK – M file** and enter.
* Entre the programme code.
* And click **RUN and SAVE** and enter.
* Note down the output after executing the programme.
* Compare the theoretical and practical values.

**PROGRAM CODE:**

% g(s) = ;

num = [10 5];

den = conv([4 1],[0.25 1]);

g = tf (num,den);

nyquist (g);

**OUTPUT:**

**Model graph**:

Real axis

Imaginary axis

**RESULT:**

**EXPERIMENT - 3**

**STATE SPACE MODEL FOR CLASSICAL TRANSFER FUNCTION USING MATLAB VERIFICATION**

**AIM:** To determine the state space model for classical transfer function using MATLAB.

**APPARATUS:**

Desktop with **MATLAB** software.

**PROCEDURE:**

* Open the **‘’ MATLAB ‘’** software.
* Then open the **FILE** menu and enter.
* Select **NEW** then select the **BLANK – M file** and enter.
* Entre the programme code.
* And click **RUN and SAVE** and enter.
* Note down the output after executing the programme.
* Compare the theoretical and practical values.

**PROGRAMME CODE:**

A=[-2 1 0;0 -3 1;-3 -4 -5];

B=[0; 0; 1];

C=[0 10 10];

D=[0];

[num,den] = ss2tf(A,B,C,D);

print sys = [num,den]

g=tf(num,den);

poles=roots(den);

**OUTPUT:**

Transfer function =

= -3.693j1.4359.

**RESULT:**