



LABORATORY MANUAL

B.Tech. Semester- VI

CONTROL SYSTEM LAB

Subject code: LC-ECE-324G

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**DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING
DRONACHARYA COLLEGE OF ENGINEERING
KHENTAWAS, FARRUKH NAGAR, GURUGRAM (HARYANA)**

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Vision and Mission of the Institute

Vision:

To impart Quality Education, to give an enviable growth to seekers of learning, to groom them as World Class Engineers and managers competent to match the expending expectations of the Corporate World has been ever enlarging vision extending to new horizons of Dronacharya College of Engineering

Mission:

1. To prepare students for full and ethical participation in a diverse society and encourage lifelong learning by following the principle of 'Shiksha evam Sahayata' i.e. Education & Help.
2. To impart high-quality education, knowledge and technology through rigorous academic programs, cutting-edge research, & Industry collaborations, with a focus on producing engineers& managers who are socially responsible, globally aware, & equipped to address complex challenges.
3. Educate students in the best practices of the field as well as integrate the latest research into the academics.
4. Provide quality learning experiences through effective classroom practices, innovative teaching practices and opportunities for meaningful interactions between students and faculty.
5. To devise and implement programmes of education in technology that are relevant to the changing needs of society, in terms of breadth of diversity and depth of specialization.

Vision and Mission of the Department

VISION

“ To be a Centre of Excellence for producing high quality engineers and scientists capable of providing sustainable solutions to complex problems and promoting cost effective indigenous technology in the area of Electronics, Communication & Control Engineering for Industry, Research Organizations, Academia and all sections of society.”

MISSION

M1: To frame a well-balanced curriculum with an emphasis on basic theoretical knowledge as well the requirements of the industry.

M2: To motivate students to develop innovative solutions to the existing problems for betterment of the society.

M3: Collaboration with the industry, research establishments and other academic institutions to bolster the research and development activities in department.

M4: To provide infrastructure and support for culmination of novel ideas into useful prototypes.

M5: To promote research in emerging and interdisciplinary areas and act as a facilitator for knowledge generation and dissemination through Research, Institute – Industry and Institute-Institute interaction.

Program Educational Objectives (PEOs)

- PEO1: Engineers will practice the profession of engineering using a systems perspective and analyze, design, develop, optimize & implement engineering solutions and work productively as engineers, including supportive and leadership roles on multidisciplinary teams.
- PEO2: Continue their education in leading graduate programs in engineering & interdisciplinary areas to emerge as researchers, experts, educators & entrepreneurs and recognize the need for, and an ability to engage in continuing professional development and life-long learning.
- PEO3: Engineers, guided by the principles of sustainable development and global interconnectedness, will understand how engineering projects affect society and the environment.
- PEO4: Promote Design, Research, and implementation of products and services in the field of Engineering through Strong Communication and Entrepreneurial Skills.
- PEO5: Re-learn and innovate in ever-changing global economic and technological environments of the 21st century.

Program Outcomes (POs)

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5 : Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6 :The engineer and society: Apply reasoning informed by the contextual knowledge to Assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7 : Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9 : Individual and teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12: Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

PSO1: Equip themselves to potentially rich & employable field of Engineering. Analyse and design electronic systems for signal processing, communications and other applications.

PSO2: Pursue higher studies in the contemporary Technologies and multidisciplinary fields with an inclination towards continuous learning. area of Electronics, Telecommunication ,VLSI or Instrumentation.

PSO3: Design, implement and evaluate processes, components and/or programs using modern techniques, skills and tools of core Information Technologies to effectively integrate effective communication-based solutions into using Electronic components.

PSO4: Develop impactful solutions by using research-based knowledge and methods in the fields of integration and implementation, alongside Meeting the requirements of the Industrial standard.

University Syllabus

LIST OF EXPERIMENTS:

Hands-on experiments related to the course contents PCC-ECE-307G

S.NO	NAME OF THE EXPERIMENT
1.	(a) To study a.c servo motor and plot its torque speed characteristics. (b) To study d.c servo motor and plot its torque speed characteristics.
2.	To study the magnetic amplifier and plot its load current v/s control current characteristic for series and parallel mode.
3.	To plot the load current v/s control current characteristics for self excited mode of the magnetic amplifier.
4.	To study PID controller for level control of a pilot plant
5.	To study lead lag compensator and draw magnitude and phase plots.
6.	To study the basic open loop and closed loop control system.
7.	Determine transpose, inverse values of given matrix
8.	Plot bode plot of a given transfer function.
9.	Plot unit step response of given transfer function and find peak overshoot, peak time.
10.	Plot the pole-zero configurations in s-plane for the given transfer function.

Course Outcomes (COs)

After completion of this course, students will be able to:

CO1 Understands servo motor, magnetic amplifier, compensator.

CO2 Understand MATLAB evaluate the poles and zeros on s-plane along with transfer function of a given system.

CO3 Construct state space model of a linear continuous system.

CO4 Evaluate the various specifications of time domain response of a given system.

CO5 to understand and analyze the impact of PID controllers on linear system

CO6 Examine the relative stability of a given transfer function using various methods such as root locus, Bode plot and Nyquist plot

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	2	2	3	-	-	-	-	1	1	3
CO2	3	2	3	2	3	-	-	-	-	1	1	3
CO3	3	3	2	3	2	-	-	-	-	-	1	3
CO4	3	2	3	1	3	-	-	-	-	1	1	1
CO5	3	2	2	2	2	-	-	-	-	-	1	1
CO6	1	1	1	1	1	-	-	-	-	-	1	1

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4
CO1	2	1		1
CO2	3	3	3	3
CO3	3	3		1
CO4	2	2		2
CO5	3	3	3	3
CO6	2	2	2	2

Course Overview

The objective of the lab is to design a system and calculate the transfer function, analyzing the stability of the system (both open and closed loop, with positive and negative feedback) with time domain approach and frequency response analysis, using MATLAB and also developing the system which is dynamic in nature with state space analysis approach.

Practical Exam: 25 Marks

Lab work : 25 Marks

Total: 50 Marks

Duration of Exam: 3 Hour

Control system lab experiments are done using hardware and software tools which provide path towards the engineering applications.

List of Experiments mapped with Cos

S.NO	NAME OF THE EXPERIMENT	COURSE OUTCOMES
1.	(a) To study a.c servo motor and plot its torque speed characteristics. (b) To study d.c servo motor and plot its torque speed characteristics.	CO1
2.	To study the magnetic amplifier and plot its load current v/s control current characteristic for series and parallel mode.	CO1
3.	To plot the load current v/s control current characteristics for self excited mode of the magnetic amplifier.	CO1
4.	To study PID controller for level control of a pilot plant	CO5
5.	To study lead lag compensator and draw magnitude and phase plots.	CO1
6.	To study the basic open loop and closed loop control system.	CO4
7.	Determine transpose, inverse values of given matrix	CO2
8.	Plot bode plot of a given transfer function.	CO6
9.	Plot unit step response of given transfer function and find peak overshoot, peak time.	CO4
10.	Plot the pole-zero configurations in s-plane for the given transfer function.	CO2

DOs and DON'Ts

DOs

1. Login-on with your username and password.
2. Log off the Computer every time when you leave the Lab.
3. Arrange your chair properly when you are leaving the lab.
4. Put your bags in the designated area.
5. Ask permission to print.

DON'Ts

1. Do not share your username and password.
2. Do not remove or disconnect cables or hardware parts.
3. Do not personalize the computer setting.
4. Do not run programs that continue to execute after you log off.
5. Do not download or install any programs, games or music on computer in Lab.
6. Personal Internet use chat room for Instant Messaging (IM) and Sites is strictly prohibited.
7. No Internet gaming activities allowed.
8. Tea, Coffee, Water & Eatables are not allowed in the Computer Lab.

General Safety Precautions

Precautions (In case of Injury or Electric Shock)

1. To break the victim with live electric source, use an insulator such as fire wood or plastic to break the contact. Do not touch the victim with bare hands to avoid the risk of electrifying yourself.
2. Unplug the risk of faulty equipment. If main circuit breaker is accessible, turn the circuit off.
3. If the victim is unconscious, start resuscitation immediately, use your hands to press the chest in and out to continue breathing function. Use mouth-to-mouth resuscitation if necessary.
4. Immediately call medical emergency and security. Remember! Time is critical; be best.

Precautions (In case of Fire)

1. Turn the equipment off. If power switch is not immediately accessible, take plug off.
2. If fire continues, try to curb the fire, if possible, by using the fire extinguisher or by covering it with a heavy cloth if possible isolate the burning equipment from the other surrounding equipment.
3. Sound the fire alarm by activating the nearest alarm switch located in the hallway.
4. Call security and emergency department immediately:

Emergency : Reception
Security : Gate No.1

Guidelines to students for report preparation

All students are required to maintain a record of the experiments conducted by them. Guidelines for its preparation are as follows:-

- 1) All files must contain a title page followed by an index page. **The files will not be signed by the faculty without an entry in the index page.**
- 2) Student's Name, Roll number and date of conduction of experiment must be written on all pages.
- 3) For each experiment, the record must contain the following :
 - (i) Aim/Objective of the experiment .
 - (ii) Pre-experiment work (as given by the faculty) .
 - (iii) Lab assignment questions and their solutions.
 - (iv) Test Cases (if applicable to the course) .
 - (v) Results/ output.

Note:

1. Students must bring their lab record along with them whenever they come for the lab.
2. Students must ensure that their lab record is regularly evaluated.

Lab Assessment Criteria

An estimated 10 lab classes are conducted in a semester for each lab course. These lab classes are assessed continuously. Each lab experiment is evaluated based on 5 assessment criteria as shown in following table. Assessed performance in each experiment is used to compute CO attainment as well as internal marks in the lab course.

Grading Criteria	Exemplary (4)	Competent (3)	Needs Improvement (2)	Poor (1)
AC1: Pre-Lab written work (this may be assessed through viva)	Complete procedure with underlined concept is properly written	Underlined concept is written but procedure is incomplete	Not able to write concept and procedure	Underlined concept is not clearly understood
AC2: Program Writing/ Circuit connection	Assigned problem is properly analyzed, correct solution designed, appropriate language constructs/ tools are applied, Program/solution written is readable	Assigned problem is properly analyzed, correct solution designed, appropriate language constructs/ tools are applied	Assigned problem is properly analyzed & correct solution designed	Assigned problem is properly analyzed
AC3: Identification & Removal of Error / Troubleshooting	Able to identify errors/hardwiring and remove them	Able to identify errors/ circuit based errors and remove them with little bit of guidance	Is dependent totally on someone for identification of errors and their removal	Unable to understand the reason for errors even after they are explicitly pointed out
AC4: Execution & Demonstration	All variants of input /output are tested, Solution is well demonstrated and implemented concept is clearly explained	All variants of input /output are not tested, However, solution is well demonstrated and implemented concept is clearly explained	Only few variants of input /output are tested, Solution is well demonstrated but implemented concept is not clearly explained	Solution is not well demonstrated and implemented concept is not clearly explained
AC5: Lab Record Assessment	All assigned problems are well recorded with objective, design constructs and solution along with Performance analysis using all variants of input and output	More than 70 % of the assigned problems are well recorded with objective, design constructs and solution along with Performance analysis is done with all variants of input and output	Less than 70 % of the assigned problems are well recorded with objective, design contracts and solution along with Performance analysis is done with all variants of input and output	

LAB EXPERIMENTS

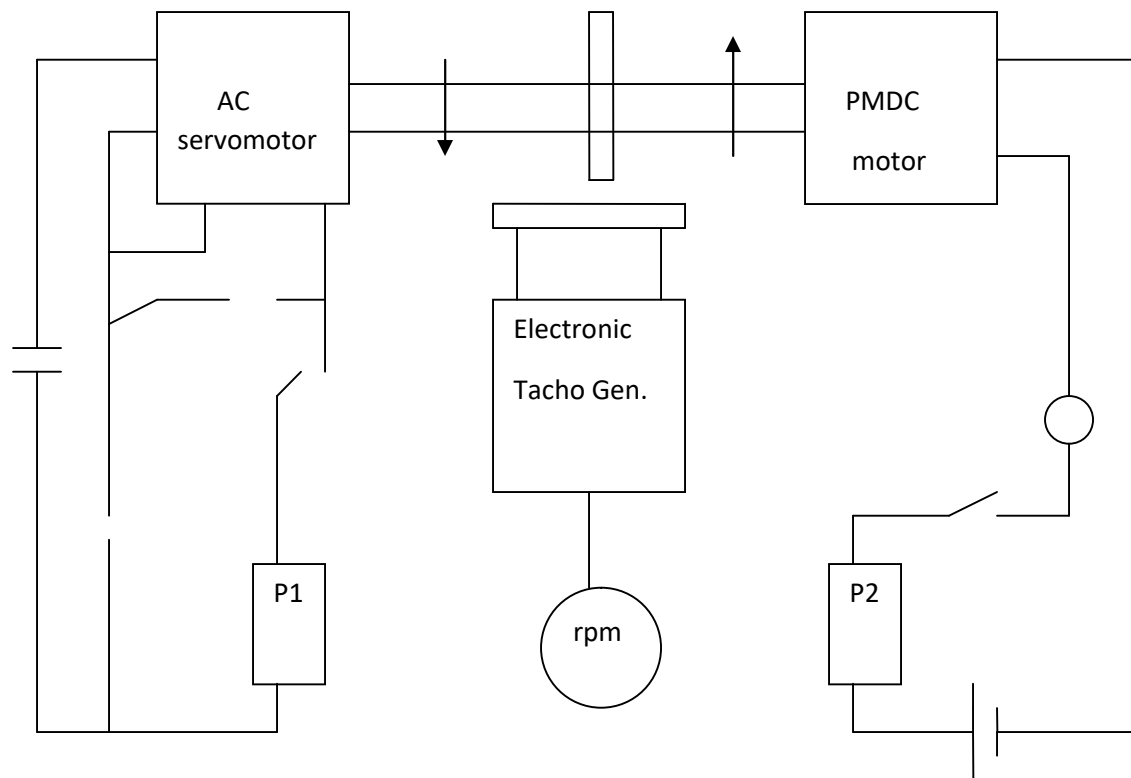
EXPERIMENT NO: 1(a)

OBJECTIVE: - To study AC servo motor and note its speed torque Characteristics.

APPARATUS REQUIRED: - AC Servo Motor Setup, Digital Multimeter and Connecting Leads.

BRIEF DESCRIPTION: - AC servomotor has best use for low power control applications. Its important parameters are speed – torque characteristics. An AC servomotor is basically a two phase induction motor. Which consist of two stator winding oriented 90° electrically apart. In feedback application phase A is energised with fixed voltage known as “Reference” and phase B is energised with variable voltage called “Control voltage”. In this setup AC servomotor is mounted and mechanically coupled a small PMDC motor loading purpose. When DC supply is fed to DC motor it runs in reverse direction of servomotor direction to impose load on servomotor. The resultant torque developed by DC motor to overcome it increase the current through it which is indicated by panel meter.

CIRCUIT DIAGRAM:-



PROCEDURE: -

1. Switch ON the power supply, switch ON S1. Slowly increase control P1 so that AC servomotor starts rotating. Connect DVM across DC motor sockets (red & black). Vary the speed of servomotor gradually and note the speed N rpm and corresponding back emf Eb across DC motor.
2. Connect DVM across servo motor control winding socket (yellow) and adjust AC servomotor voltage to 70V and note speed N rpm in table.
3. Switch On S2 to impose load on the motor due to which the speed of AC motor decreases. Increase the load current by means of P2 slowly and note corresponding speed N rpm and Ia. Calculate $P=I_a \cdot E_b$ and $Torque = \frac{P \cdot 60}{2.2 \cdot 14 \cdot N} \text{ Nm/cm}$.

OBSERVATION TABLE:-

TABLE-1

S.NO	SPEED N rpm	Eb volts
1.		
2.		
3.		
4.		

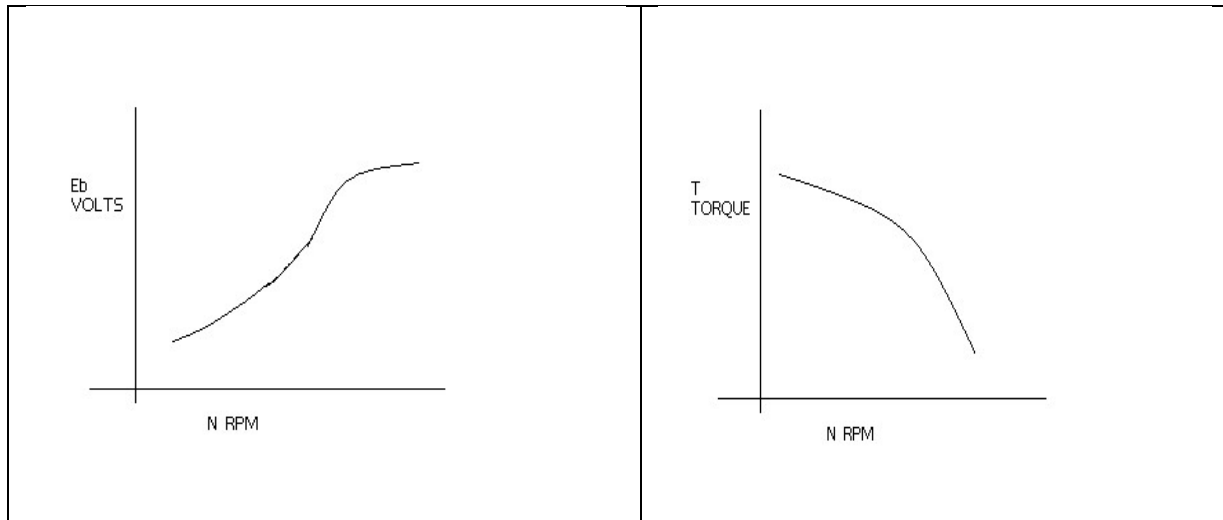
TABLE-2

S.NO	Ia amp	Eb (Tab 1)	Speed N rpm	P watt	Torque
1.					
2.					
3.					
4.					

PRECAUTIONS: -

1. Apply voltage to servomotor slowly to avoid errors.
2. Impose load by DC motor slowly.
3. Take the reading accurately as the meter fluctuates.
4. Switch OFF the setup when not in use.

GRAPH:-



DISCUSSION:-

The graph is plotted between speed and torque. As we reduce the speed of the motor the torque goes on increasing therefore the graph starts with a low value and rises to a high value approximately linearly. This rise in the graph is due to the rising speed- torque characteristics of AC servo motor.

QUIZ:-

- Q 1. What is AC servo motor ?
- Q.2 What is the use of AC servo motor ?
- Q.3 What are the advantages of AC servo motor ?
- Q4. What is the important parameter of AC servo motor ?
- Q.5 On what factor does the direction of rotation of AC servo motor depends
- Q6. What is the drawback of AC servo motor ?
- Q.7 How the drawback of positive in AC servo motor is overcome ?
- Q.8 What is the input of AC servo motor in feedback control application ?
- Q.9 What is the phase relationship between reference voltage and control Voltage?
- Q.10 What are the types of AC servo motor ?

EXPERIMENT NO: 1(b)

OBJECTIVE:- To study dc servo motor and plot its speed torque characteristics.

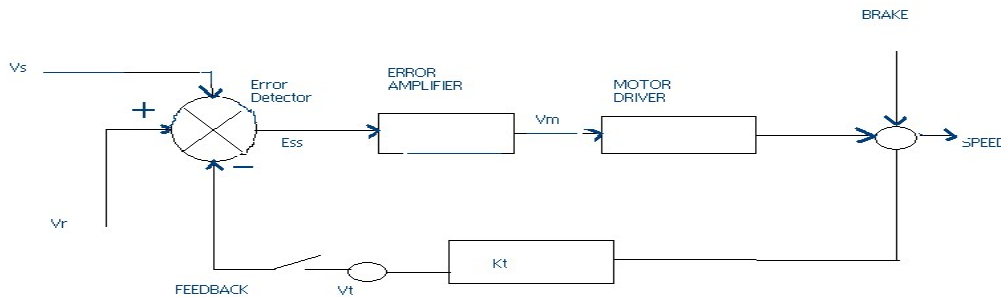
APPARATUS:- DC servo motor kit and digital volt meter.

BRIEF DESCRIPTION:- The experiment is carried out in two steps.

1. open loop performance
2. close loop performance.

In first case the motor is run without feedback. The amplifier gain factor is kept at minimum gain = 3. motor is connected with main unit by 9 pin D Type socket. Step signal is kept off.

CIRCUIT DIAGRAM:-



PROCEDURE:-

OPEN LOOP PERFORMANCE:- Connect the main unit to the supply. Keep the gain switch off. Set $V_r = 0.7$ or 0.8 . connect DVM with feedback signal socket V_t . Note the speed N rpm from display and tacho output V_t in volts from DVM. Record N rpm and V_t volts for successive gain 4-10 in observation table. Calculate $V_m = V_r * K_a$. Where K_a is the gain set from control 3 – 10.

$$V_r = 0.7 \text{ V.}$$

$$V_m \text{ at gain 3} = 0.7 * 3$$

$$= 2.1 \text{ V.}$$

Plot N vs V_t and N Vs V_m graph.

CLOSED LOOP PERFORMANCE:- In this case the gain switch is kept in on position thus feedback voltage gets subtracted from reference voltage. Which is observed by decreased motor speed. Record the result between gain factor K_a and speed N . draw the graph between techo voltage V_t and speed N .

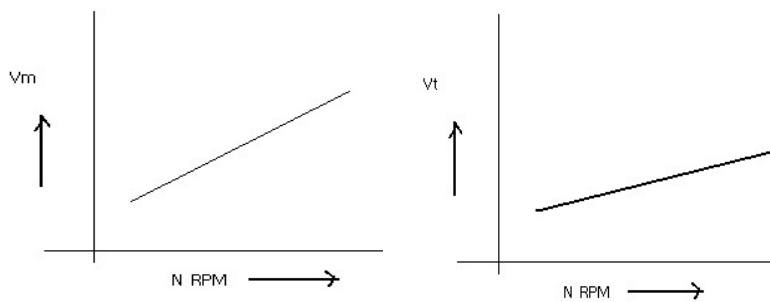
OBSERVATION TABLE:-

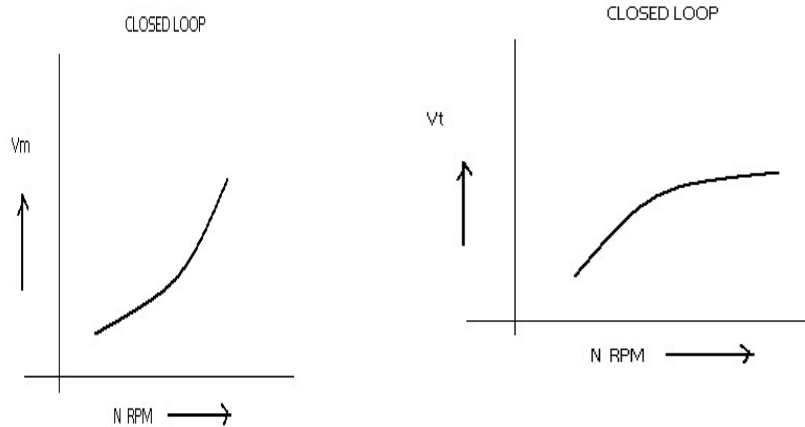
S.NO.	GAIN(K_a)	V_t (volts)	N (rpm)	$V_m=V_r \times K_a$

PRECAUTIONS:-1. Apply the voltage slowly to start the motor

- 2. Take the reading properly.
- 3. Do not apply breaks for long time as the coil may get heated up.
- 4. Switch OFF the main power when not in use.

GRAPH:-





DISCUSSION:-

The graph is plotted between N (RPM) and V_t (techo voltage) and N (rpm) & V_m (motor voltage).the tacho voltage increases linearly as the RPM of

DC servo motor increases. Similarly the motor voltage increases with RPM .in open loopThe slope is less but in close loop the slope is sharp . this is due to the feed back gain .

QUIZ:-

- Q.1 What are the uses of DC servo motor ?
- Q.2. What are the types of DC servo motors ?
- Q.3. How the speed of DC servo motor is controlled ?
- Q.4. What is the relation between torque and speed of DC servo motor ?
- Q.5. Why the speed torque characteristics of DC servo motor has large negative Slope ?
- Q.6. What is the effect of negative slope ?
- Q.7. In which wattage the DC servo motors are available ?
- Q.8. What are the special features of DC SERVO MOTORS ?
- Q.9. How the direction of rotation of DC servo motor can be changed?
- Q.10. What is transfer function of DC SERVO MOTOR?

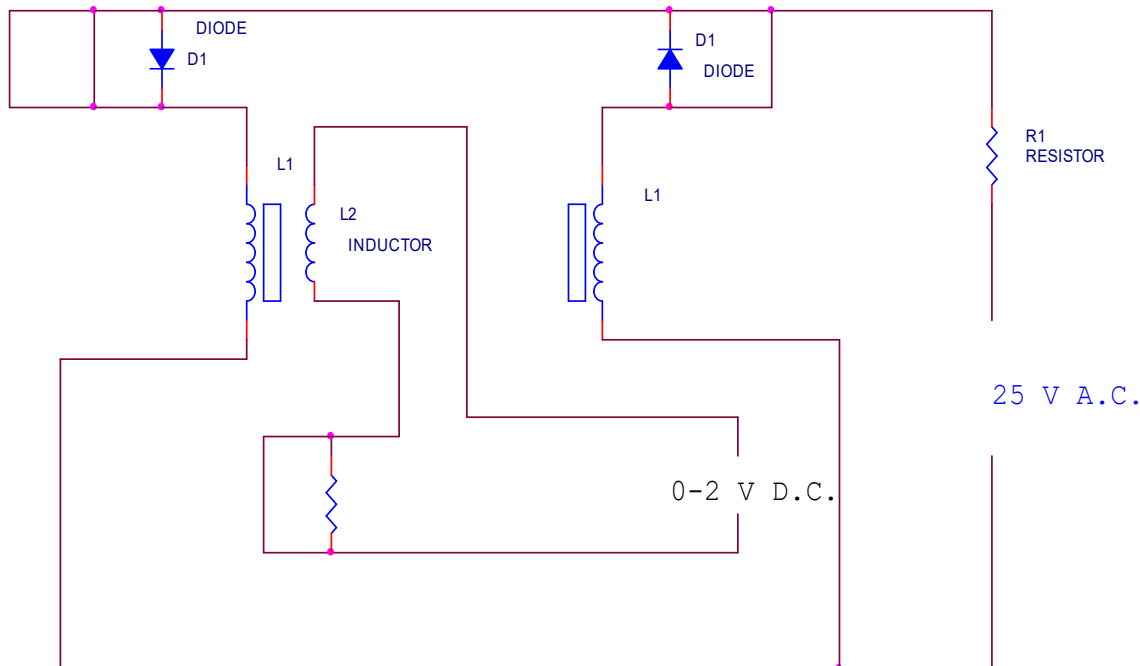
EXPERIMENT NO: 2

OBJECTIVE:- To study magnetic amplifier & plot its load current (IL) V/S control current (IC).
Characteristics for parallel mode.

APPARATUS REQUIRED:- Magnetic amplifier set up, digital multimeter & connecting leads.

BRIEF DESCRIPTION:- Amplification is the control of larger output by variation of a smaller input. Such amplification can be performed by a magnetic device called magnetic amplifier. This set up is designed to study basic characteristics of such amplifier. To set up consists of magnetic amplifier, A.C & D.C power supply, meters for load & control current & fixed value resistance of 50 ohms.

CIRCUIT DIAGRAM:-



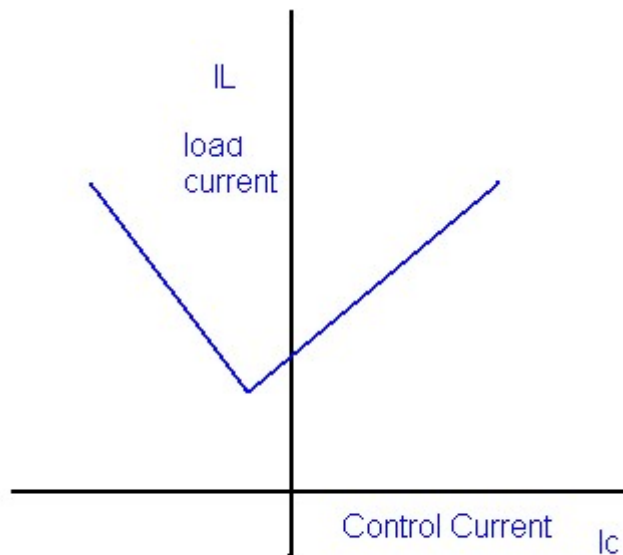
PROCEDURE: - Connect the circuit as shown in fig. keep D.C. supply to minimum. Selects positive direction. Connect DVM across D.C. input socket. Increase the D.C. voltage slowly & note IL, IC & VC in observation & repeat the experiment. Plot the characteristics curve between IL & IC in both direction. Calculate power gain = $p_{out}/p_{in} = \Delta I_L * R_L / \Delta I_C * V_C$.

OBSERVATION TABLE:-

SNO.	IC(mA)	IL(mA)	Vc(+ve)

- PRECAUTIONS:-**
1. Apply voltage slowly to control winding as the coil may get heated up & burn.
 2. Take the reading carefully & accurately.
 3. switch off the set up when not in use.

GRAPH:-



DISCUSSION:- - The graph is plotted between control current(IC) and load current (IL)For positive polarity the control current increases linearly with load current in forward Direction but for negative polarity the control current increases load current in reverse direction. This change in direction of control current is due to change in polarity of control voltage.

QUIZ:-

- Q.1. What is amplification?
- Q.2. What is magnetic amplification?
- Q.3. What is the working principle of magnetic amplifier?
- Q.4. What is magneto-motive force ?
- Q.5. What is the basis of selection of core of transformer and number of turns .
- Q.6. What is saturable reactor ?
- Q.7. What is drawback of a magnetic amplifier ?
- Q.8. How this problem is overcome in a magnetic amplifier ?
- Q.9. What is the nature of saturable reactor ?
- Q.10. What is effect of sudden current application to control winding ?

EXPERIMENT NO- 3

OBJECTIVE: To study magnetic amplifier and plot its load current and control current characteristics for self excited mode.

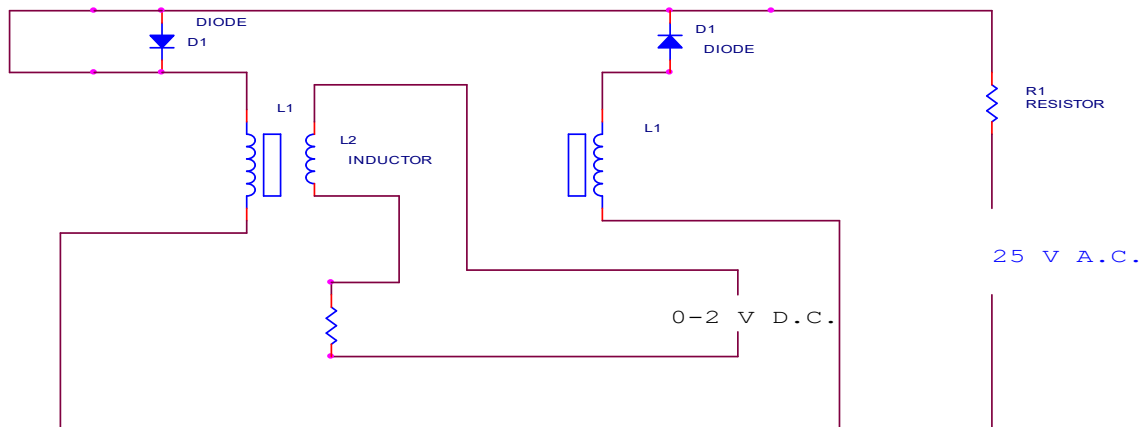
APPARATUS REQUIRED: Magnetic amplifier set up, digital multimeter and connecting leads.

BRIEF DESCRIPTION:: Self saturation of core is achieved by using two diodes D1 and D2 in series with L1 and L2 load coils. The successive rectified half wave saturates the core in opposite direction in few cycles. This leads to flow of current in RL greatly when control winding in open or there is no current flow. The core does not saturate completely but operates to bring the core out of saturation. DC current is made to flow in controlwinding. The control winding has more number of turns than load winding. Applying a small DC current which oppose the magnetic flux caused by self saturation tends to cut off produced mmf in load magnetic path. This causes to increase inductance in l load winding and the voltage drop across then tends to rise which result in decrease in AC current in RL.If the polarity of DC current is reversed then the saturation of core takes place in opposite direction.

PROCEDURE: Connect the circuit as shown in fig. keep DC voltage to minimum. Select positive direction and switch ON the power. Increase the control current slowly and note the IL, Ic and Vc in observation table. Bring DC voltage to minimum, select negative. direction and repeat the characteristics curve in both direction. Calculate power gain

$$P \text{ (gain)} = P(\text{out})/P(\text{in}) \text{ or } \Delta IL *RL/\Delta Ic *Vc$$

CIRCUIT DIAGRAM:



OBSERVATION TABLE

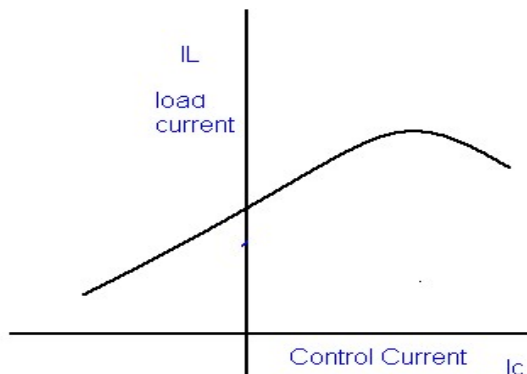
S.No	Ic(mA)	IL(mA)	Vc(+ve)
1.			
2.			
3.			
4.			
5.			

S.No	Ic(mA)	IL(mA)	Vc(-ve)
1.			
2.			
3.			
4.			
5.			

PRECAUTION

- : 1. Apply voltage slowly to control winding as the coil may get heated up and burn.
- 2. Take the reading carefully and accurately.
- 3. Switch off the set up when not in use.

GRAPH:-



DISCUSSION:-

The graph is plotted between load current and control current. for positive polarity the Control current rises in the forward direction with rise in load current where as for negative polarity the control current decreases in the reverse direction with rise in load current .This is due to the self saturation of the magnetic core .

QUIZ:-

- Q.1. What are the modes of operation of the magnetic amplifier?
- Q.2. What is the value load resistance R_L for magnetic amplifier ?
- Q.3. What is power gain in magnetic amplifier?
- Q.4. What is current gain in magnetic amplifier?
- Q.5. What is core saturation?
- Q.6. What is the direction of windings in the securable reactor?
- Q.7. How self saturation is achieved in a magnetic amplifier ?
- Q.8. How the magnetic core is brought out of saturation ?
- Q.9. Which winding has more number of turns ?
- Q.10. Between which parameter graph is plotted for magnetic amplifier?

EXPERIMENT:-4

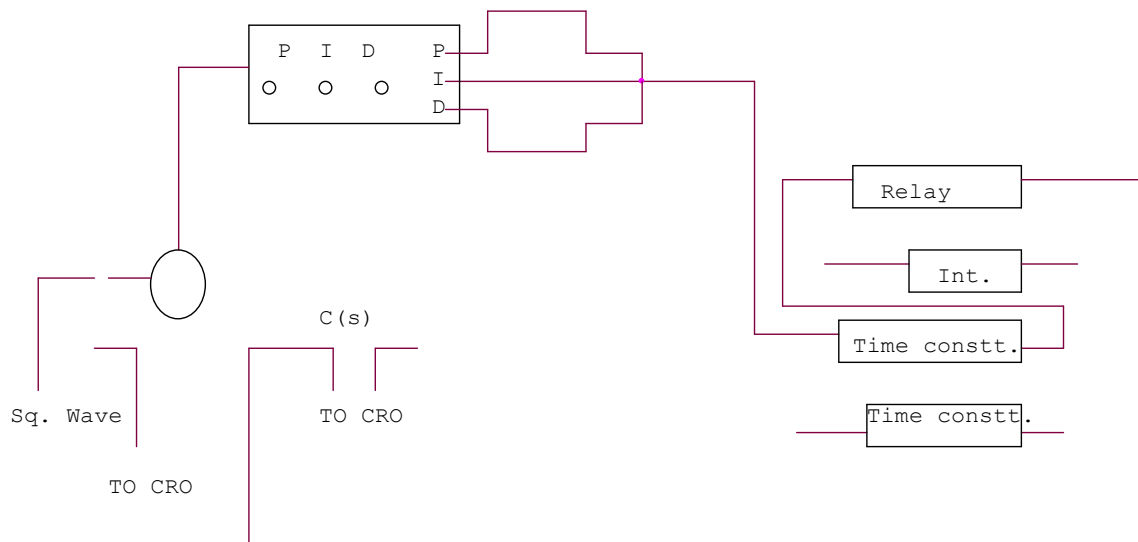
OBJECTIVE:-To study PID controller for level control of a plant.

- (a)To observe open loop performance of building block and calibration of PID controls
- (b)To study P, PI, PID controller with type 0 system with delay
- (c) To study P, PI, PID controller with type 1 system

APPARATUS REQUIRED: PID controller setup, CRO and connecting leads.

BRIEF DESCRIPTION:- - The setup is designed to study performance of analog PID controller with regulated system. The board has built in signal source, DVM, simulated process and three adjustable parameters as PID, P for proportional gain, I for integrated gain and D for derivative gain. three socket are given to add or out any parameter PI & D. there are two signal sources of square wave which is adjustable in frequency (10-40 Hz) and amplitude (0-2 Vpp) and other signal source in shape of triangular wave to sweep CRO in X-direction. One DC voltage output which is continuously variable between - 2V and +2V.

CIRCUIT DIAGRAM:-



PROCEDURE:

P control mode: connect the circuit as shown in the figure. Switch over CRO for XY mode. Adjust P control to 0.1 and note the X and Y values. Increase the value of P and note the results in table. Input 1.0 Vpp, square wave of 50ms. I not connected to adder and D control at 00. switch over CRO in trigger mode and find out period of oscillation. Switch over again in XY mode and find out percentage over shoot and steady state error

PI control mode : connect the circuit as shown in figure set K_p =reading of dial. $K_d=00$. input signal of square wave amplitude = 1Vpp at 20 Hz. Switch over CRO in XY mode. Increase I in steps and note the reading. find the result of K_i for 10-15 % over shoot with minimum E_{ss} .

CONTROL SYSTEM LAB (LC-ECE324G)

PID control mode : connect the circuit as shown in figure. Input =1Vpp square wave of same frequency adjust K_p and K_i as table 1 and 2 . increase K_d in steps and note the Y_{pp} and X_{pp} output from CRO. The equation of PID controller is

$$M(t) = K_p e(t) + K_i \int e(t) dt + K_d \frac{de}{dt}$$

OBSERVATION TABLE :

S NO.	K_p	X_{pp}	Y_{pp}	OSPP	ESSPP

PRECAUTIONS:

1. Do not keep CRO in XY mode for long time.
2. Take the reading carefully and accurately.
3. Apply the required signal to the kit to avoid error.
4. Switch off the kit when not in use.

DISCUSSION:-In open loop response the plots are performed between Magnitude/frequency and phase/frequency. The upper curve is for gain/Frequency raised to 9.35 db. The middle curve is for frequency and the Lower curve is for phase. This shift in gain-cross over frequency and phase Margin is due to applied gain K_A .

QUIZ:-

- Q.1. What for compensation networks are used?
- Q.2. What are the types of compensation networks?
- Q.3. What is the use of all pass filter?
- Q.4. What is use of inverting amplifier?
- Q.5. What are the responses of compensation network?
- Q.6. What is use of LEAD compensation?
- Q.7. What is the use effect of LEAD compensation on the system?
- Q.8. What is the effect of LAG compensator on the system?
- Q.9. What is use of LAG compensation?
- Q.10. What is process or plant?

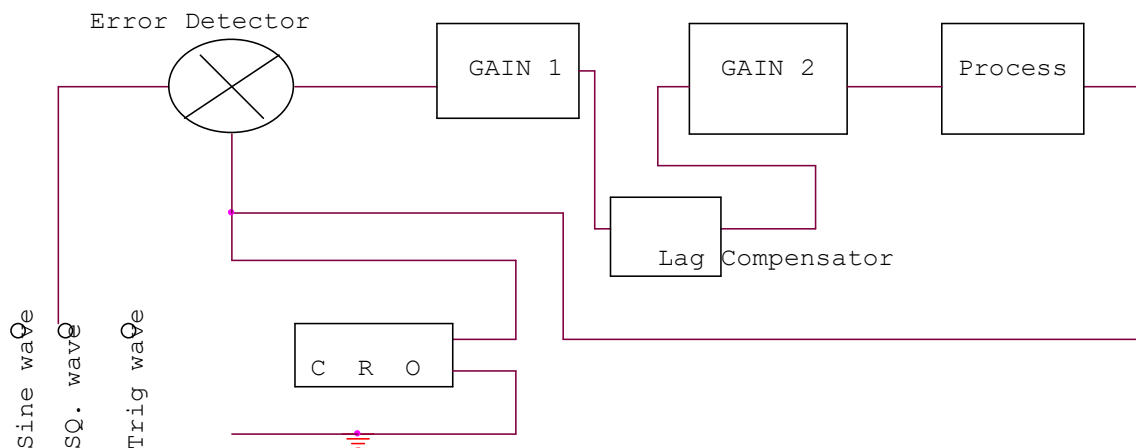
EXPERIMENT NO. 5

OBJECTIVE: To study LEAD LAG compensator and draw magnitude and phase plot.

APPARATUS REQUIRED: lead lag compensator kit, CRO, and connecting leads.

BRIEF DESCRIPTION::

Compensation network are often used to make improvement in transient response and small change in steady state accuracy. The set up is divided in to three parts. Signal source: It has sine wave of 10-1200 Hz. Of 0-8 Vpp, Square wave of 20, 40 and 80 Hz of 0-2 Vpp. Trigger is available for trigger of CRO in external trigger mode. The amplitude is 1.2 Vpp. There are three compensation circuits as lag, Lead and Lag-Lead with transfer function. The set up has two DC regulated power supply for signal source and systems.

CIRCUIT DIAGRAM

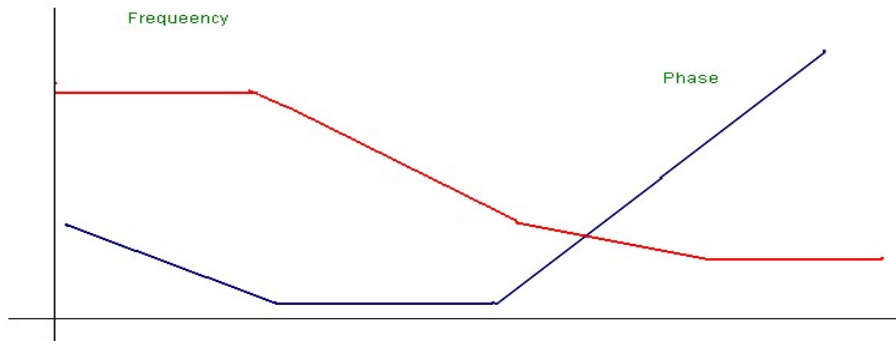
PROCEDURE: The experiment is divided in two parts.

1. Open Loop Response: Connect square wave to gain and CRO across input and output. Select frequency to 80 Hz at 0.2 Vpp. Measure input amplitude Vpp as A and output as amplitude as B. Calculate gain factor= B/A . Connect sine wave with process input, CRO across input and output. Set input voltage =8Vpp. From low frequency end 10Hz note output voltage Vpp as B. Note the phase difference for each test frequency. Connect the sine wave with lag input .connect CRO across input and output. Note the output voltage, phase difference for each test frequency. Prepare a table between input/output voltage, gain magnitude in db and phase angle in degrees. Plot a graph accordingly.
2. Close loop response: connect the square wave signal of 20Hz, 1Vpp at input of error detector. Adjust gain to the value found from plot for required shape of response and sketch it 0 the paper. From the transient response measure maximum over shoot Mp, steady state error Ess and peak time Tp. Select wave frequency to 40Hz, 1Vpp and adjust gain control to 60%. Not gain control setting. Trace wave form on paper with record of Ess, Mp, and Tp. Select frequency to 80Hz and adjust gain control for minimum Ess 0. Trace wave form with Mp and Tp. connect process with lag compensator and gain 2. Set square wave frequency to 20Hz, 1Vpp at error detector input . Adjunct gain control to for similar Ess. Note gain to from dial setting. Trace the wave form on paper with record of Mp, Tp and Ess.

OBSERVATION TABLE :

S.NO.	A V _{pp}	B V _{pp}	GAIN dB	PHASE ANGLE

GRAPH:



QUIZ:

- Q.1 What is use of LAG compensation?
- Q.2. What are the responses of compensation network?
- Q.3. What is use of LEAD compensation?
- Q.4. What is the use effect of LEAD compensation on the system?
- Q.5. What is the effect of LAG compensator on the system?

EXPERIMENT NO. 6

OBJECTIVE: To study basic open loop and close loop control systems.

BRIEF DESCRIPTION::

Control System :-

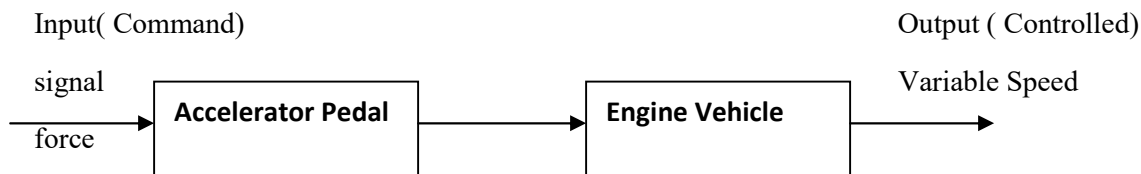
A control system is a combination of elements intended to act together to accomplish an objective. Control systems are classified into two general categories. Open loop and closed loop control system. The distinction is determined by the control action, which is that quantity responsible for activating the system to produce the output.

Open loop control system:-

An open loop control system is one in which the control action is independent of the output. The important features of open loop control system are:-

- (1) Their ability to perform accurately is determined by their calibration, which implies to establish the input-output relation to obtain a desired system accuracy.
- (2) They are not generally troubled with problems of instability.

BLOCK DIAGRAM:-



Examples of open loop control system:-

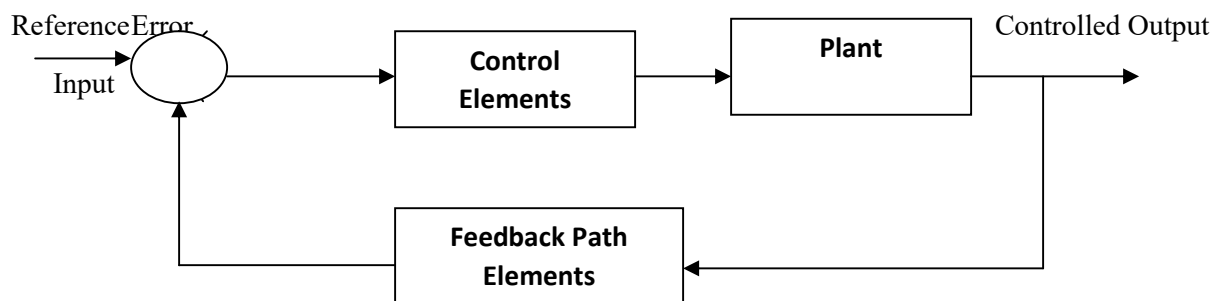
1. A man working on a road with his eyes closed is an example of open loop control system. The major components in walking are the brain, the eyes and the feet. The input may be chosen as desired work direction and the output actual work direction. The control action is determined by the eyes which detect the difference between input and output and send information to brain. Since the eyes are closed therefore the system is open loop.
2. Another example of open loop control system is an electric automatic coffee maker. One possible input for coffee maker is amount of coffee used. In addition most coffee makers have a dial which can be set for weak, medium or strong coffee. This setting usually regulates a timing mechanism. There for brewing time of coffee is another possible input and the output of any coffee maker can be chosen as coffee strength.

CLOSE LOOP CONTROL SYSTEM:-

A close loop control system is one in which the control action is some how dependent of the output. Close loop control systems are commonly called feedback control system. Feedback is that characteristics of close loop control system which differentiates it from open loop. It is the property of closed loop system which permits the output to be compared with the input. So that appropriate control action maybe formed as a function of input and output.

Important features of feedback are:-

1. Reduced effects of non linearities and distortion.
2. Increased accuracy.
3. Increased bandwidth.
4. Reduced sensitivity of the ratio of output to input to variations in system characteristics.
5. Tendency towards oscillation or instability.

BLOCK DIAGRAM:-

Examples of closed loop control system:-

1. A man working on a road with his eyes open is an example of closed loop control system. As eyes can distinguish between the desired walk direction and actual walk direction and make the necessary correction therefore the system is closed loop.
2. Another example of closed loop control system is an automatic toaster. In which each heating element supplies same amount of heat to both sides of the bread. And toast quality can be determined by its color. The toaster is initially calibrated for a desired toast quality which needs no re-adjustment. The toaster is automatically switched off when the sensor sees the desired color with the help of feedback linkage which may be electrical or mechanical. Since the output (color of toast) is dependent on input (temperature setting) there for the system is closed loop.

QUIZ:-

Q.1 What is control system?

Q.2 How control system is classified?

Q.3 What is open loop control system?

Q.4 What is closed loop control system?

Q.5 What are the main features of open loop control system?

Q.6 What are the main features of close loop control system?

EXPERIMENT NO:-7

OBJECTIVE: Determine transpose, inverse values of a given matrix.

APPARATUS REQUIRED: MATLAB SOFTWARE ,PC.

PROGRAM:

```
%Program to find transpose and inverse of given matrix%
clc
A= input('Enter the value of matrix A :')
Inverse_A=inv(A)
Transpose_A=A'
```

Input:-

Enter the value of matrix A :[2 6 8; 4 8 16; 4 8 22]

Output:- A =

```
2 6 8
4 8 16
4 8 22
```

Inverse_A =

```
-1.0000 1.4167 -0.6667
0.5000 -0.2500 0
0 -0.1667 0.1667
```

Transpose_A =

```
2 4 4
6 8 8
8 16 22
```

COMMAND DETAILS:**1. Inv = Matrix inverse**

Syntax:-Y = inv(X)

Description

Y = inv(X) returns the inverse of the square matrix X. A warning message is printed if X is badly scaled or nearly singular. In practice, it is seldom necessary to form the explicit inverse of a matrix. A frequent misuse of inv arises when solving the system of linear equations $Ax = b$. One way to solve this is with $x = \text{inv}(A)*b$. A better way, from both an execution time and numerical accuracy standpoint, is to use the matrix division operator $x = A \setminus b$. This produces the solution using Gaussian.

2. Input = Request user input**Syntax:-**

evalResponse = input(prompt) strResponse = input(prompt, 's')

Description

evalResponse = input(prompt) displays the prompt string on the screen, waits for input from the keyboard, evaluates any expressions in the input, and returns the value in evalResponse. To evaluate expressions, the input function accesses variables in the current workspace.

strResponse = input(prompt, 's') returns the entered text as a MATLAB string, without evaluating expressions.

3. Clc = Clear Command Window

Alternatives

As an alternative to the `clc` function, select Edit > Clear Command Window in the MATLAB desktop.

Syntax:-`clc`

Description

`clc` clears all input and output from the Command Window display, giving you a "clean screen."

After using `clc`, you cannot use the scroll bar to see the history of functions, but you still can use the up arrow to recall statements from the command history.

EXPERIMENTNO.8

OBJECTIVE: Plot bode plot of a given transfer function.

APPARATUS REQUIRED: MATLAB SOFTWARE, PC.

PROGRAM:

```
%Program to find bode plot %
clc
num= input('Enter the value numerator :')
den= input('Enter the value denominator :')
fun=tf(num,den)
bode(fun)
gridon
```

Input:-

Enter the value numerator :[1 4]

num =

1 4

Enter the value denominator :[4 6 8]

den =

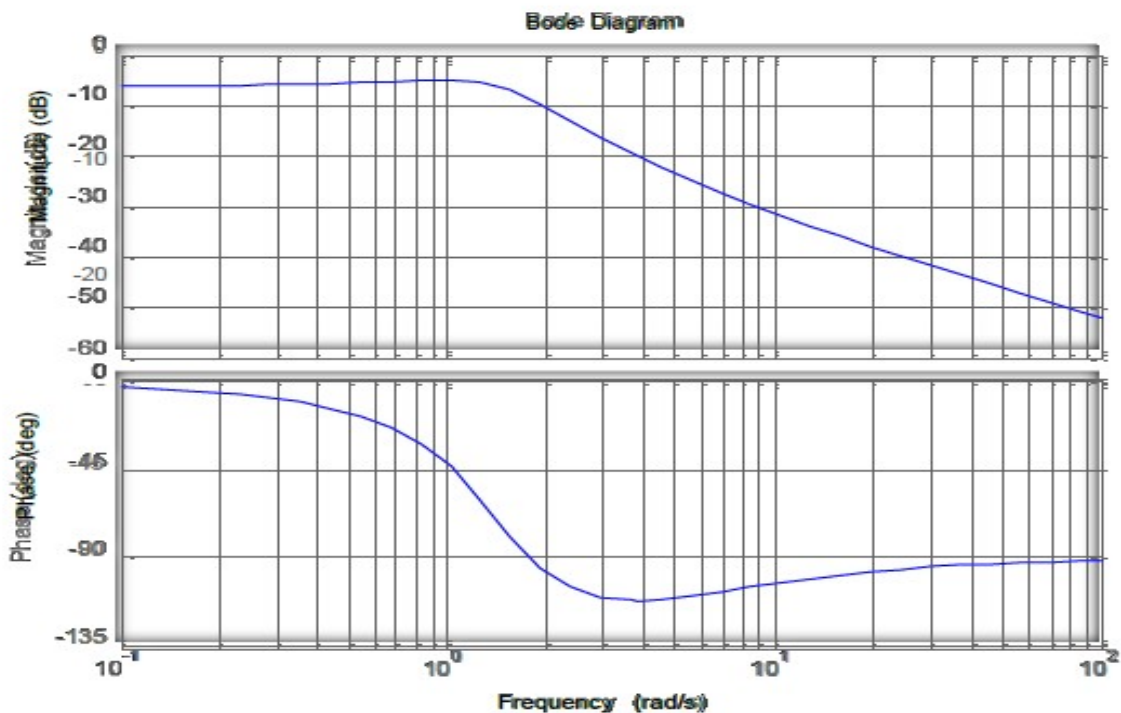
4 6 8

Output:-

$$\text{fun} = s + 4$$

$$4 s^2 + 6 s + 8$$

Continuous-time transfer function.



Command details:-

4. tf= Create transfer function model, convert to transfer function model

Syntax:-tf

```
sys = tf(num,den) sys
      = tf(num,den,Ts)
sys = tf(M)
sys = tf(num,den,ltsys)

tfsys = tf(sys)
tfsys = tf(sys)
tfsys = tf(sys, 'measured')
tfsys = tf(sys, 'augmented')
```

Description

Use tf to create real- or complex-valued transfer function models (TF objects) or to convert state-space or zero-pole-gain models to transfer function form. You can also use tf to create Generalized state-space (genss) models.

5. bode = Bode plot of frequency response, magnitude and phase of frequency response

```
Syntax:- bode(sys)
           bode(sys1,...,sysN)
           bode(sys1,PlotStyle1,...,sysN,PlotStyleN)
           bode(...,w)
           [mag,phase] = bode(sys,w)
           [mag,phase,wout] = bode(sys)
           [mag,phase,wout,sdmag,sdphase] = bode(sys)
```

Description

bode(sys) creates a Bode plot of the frequency response of a dynamic system model sys. The plot displays the magnitude (in dB) and phase (in degrees) of the system response as a function of frequency.

When sys is a multi-input, multi-output (MIMO) model, bode produces an array of Bode plots, each plot showing the frequency response of one I/O pair. bode automatically determines the plot frequency range based on system dynamics.

6. grid = Grid lines for 2-D and 3-D plots

Alternatives

To control the presence and appearance of grid lines on a graph, use the Property Editor, one of the plotting tools. For details, see The Property Editor in the MATLAB Graphics documentation. Control

Syntax

grid on

grid off

grid

grid(axes_handle,...)

grid minor

Description

The grid function turns the current axes' grid lines on and off. grid on adds major grid lines to the current axes. grid off removes major and minor grid lines from the current axes. grid toggles the major grid visibility state grid(axes_handle,...) uses the axes specified by axes_handle instead of the current axes.

EXPERIMENT:9

OBJECTIVE: Plot unit step response of given transfer function and find peak overshoot, peak time.

APPARATUS REQUIRED: Computer with MATLAB

BRIEF DESCRIPTION:- Consider a higher-order system defined by

Using MATLAB, plot the unit-step response curve of this system. Using MATLAB, obtain the rise time, peak time, maximum overshoot, and settling time.

$$\frac{C(s)}{R(s)} = \frac{6.3223s^2 + 18s + 12.811}{s^4 + 6s^3 + 11.3223s^2 + 18s + 12.811}$$

PROGRAM

% ----- This program is to plot the unit-step response curve, as well as to find the rise time, peak time, maximum overshoot, and settling time.

% In this program the rise time is calculated as the time required for the

% " response to rise from 10% to 90% of its final value. -----

```

num = [0 0 6.3223 18 12.811 1];
den = [1 6 11.3223 18 12.8111];
t = 0:0.02:20;
[y,x,t] = step(num,den,t);
plot(t,y)
grid
title('Unit-Step Response')
xlabel('t (set)')
ylabel('Output y(t)')
r1 = 1; while y(r1) < 0.1, r1= r1+ 1; end;
r2 = 1; while y(r2) < 0.9, r2 = r2+1; end;
rise-time = (r2-r1)*0.02
rise-time =
0.5800
[ymax,tp] = max(y);
peak-time = (tp-1)*0.02
    
```

peak-time =

max-overshoot = $y_{max}-1$

max_overshoot =

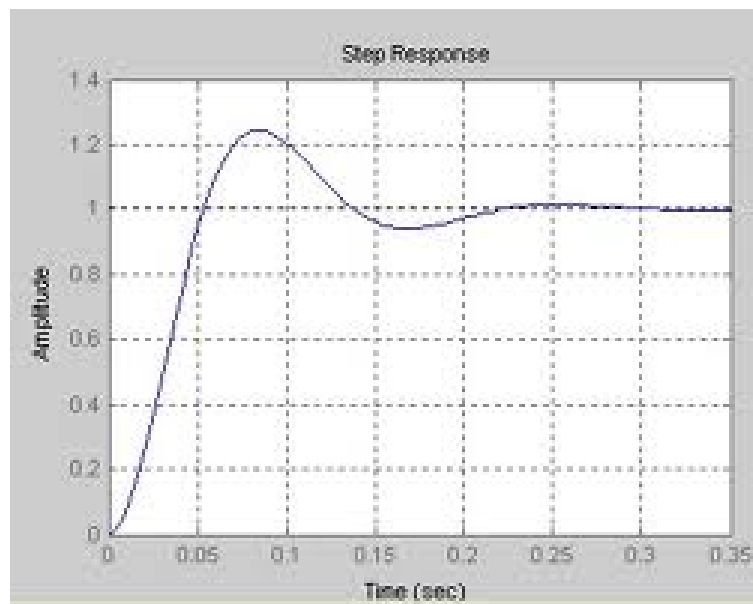
0.6182

$s = 1001$; while $y(s) > 0.98$ & $(y(s) < 1.02)$; $s = s-1$; end;

settlingtime = $(s-1)*0.02$

settling-time =

10.0200



EXPERIMENT NO:-10

OBJECTIVE: Plot the pole-zero configurations in s-plane for the given transfer function

APPARATUS REQUIRED: Computer with MATLAB

BRIEF DESCRIPTION:-**The S-Plane**

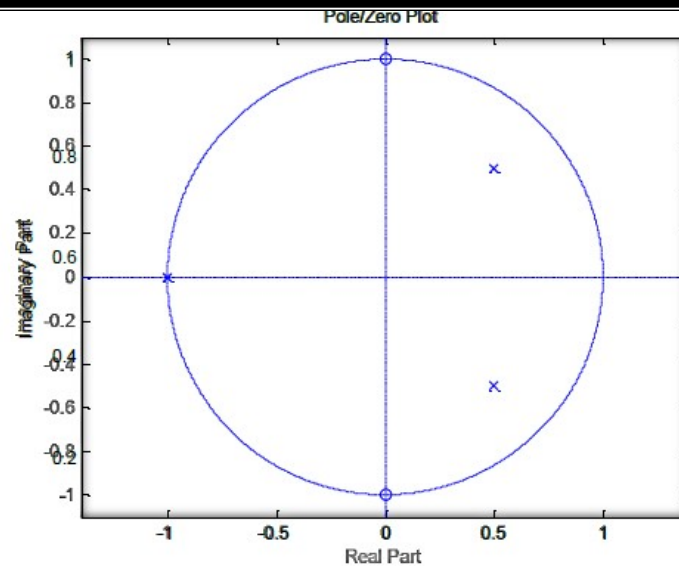
Once the poles and zeros have been found for a given Laplace Transform, they can be plotted onto the S-Plane. The S-plane is a complex plane with an imaginary and real axis referring to the complex-valued variable s . The position on the complex plane is given by σ and the angle from the positive, real axis around the plane is denoted by θ . When mapping poles and zeros onto the plane, poles are denoted by an "x" and zeros by an "o". The below figure shows the S-Plane, and examples of plotting zeros and poles onto the plane can be found in the following section.

PROGRAM:

```
%Program for pole-zero configuration in s-plane for the given transfer function %
clc
% Set up vector for zeros%
z
= [j ; -j]
% Set up vector for poles
p
= [-1 ; .5+.5j ; .5-.5j];
figure(1);
zplane(z,p);
title('Pole/Zero Plot')
```

Output:-

```
z =
0 + 1.0000i
0 - 1.0000i
p =
-1.0000
0.5000 + 0.5000i
0.5000 - 0.5000i
```



Command details:-

10. Zplane = Zero-pole plot for filter

Syntax:-

- zplane(Hq)
- zplane(Hq,plotoption)
- zplane(Hq,plotoption,plotoption2)
- zplane(Hq,Name,Value)
- [zq,pq,kq] = zplane(Hq)
- [zq,pq,kq,zr,pr,kr] = zplane(Hq)

Description

zplane(Hq) plots the zeros and poles of a quantized filter Hq in the current figure window. The poles and zeros of the quantized and unquantized filters are plotted by default. The symbol o represents a zero of the unquantized reference filter, and the symbol x represents a pole of that filter. The symbols and + are used to plot the zeros and poles of the quantized filter Hq. The plot includes the unit circle for reference.

zplane(Hq, plotoption) plots the poles and zeros associated with the quantized filter Hq according to one specified plot option. The string plotoption can be either of the following reference filters display options:

'on' to display the poles and zeros of both the quantized filter and the associated reference filter (default)

'off' to display the poles and zeros of only the quantized filter

zplane(Hq,plotoption,plotoption2) plots the poles and zeros associated with the quantized filter

Hq according to two specified plot options. The string plotoption can be selected from the reference filter display options listed in the previous syntax. The string plotoption2 can be selected from the section-by-section plotting style options described in the following list:

'individual' to display the poles and zeros of each section of the filter in a separate figure window

'overlay' to display the poles and zeros of all sections of the filter on the same plot

'tile' to display the poles and zeros of each section of the filter in a separate plot in the same figure window

zplane(Hq,Name,Value) returns a phase response with additional options specified by one or more Name,Value pair arguments. Name-value pair arguments are only available if Hq is a filter System object.

[zq,pq,kq] = zplane(Hq) returns the vectors of zeros zq, poles pq, and gains kq. If Hq has n sections, zq, pq, and kq are returned as 1-by-n cell arrays. If there are no zeros (or no poles), zq (or pq) is set to the empty matrix [].

[zq,pq,kq,zr,pr,kr] = zplane(Hq) returns the vectors of zeros zr, poles pr, and gains kr of the reference filter associated with the quantized filter Hq. It also returns the vectors of zeros zq, poles pq, and gains kq for the quantized filter Hq.

11. Figure = Create figure graphics object

Syntax:-

Figure

figure('PropertyName',propertyvalue,...)

figure(h)

h = figure(...)

Properties

For a list of properties, see Figure Properties.

Description

figure creates figure graphics objects. Figure objects are the individual windows on the screen in which the MATLAB software displays graphical output.

figure creates a new figure object using default property values. This automatically becomes the current figure and raises it above all other figures on the screen until a new figure is either created or called.

figure('PropertyName',propertyvalue,...) creates a new figure object using the values of the properties specified. For a description of the properties, see Figure Properties. MATLAB uses default values for any properties that you do not explicitly define as arguments.

figure(h) does one of two things, depending on whether or not a figure with handle h exists. If h is the handle to an existing figure, figure(h) makes the figure identified by h the current figure, makes it visible, and raises it above all other figures on the screen. The current figure is

the target for graphics output. If h is not the handle to an existing figure, but is an integer, figure(h) creates a figure and assigns it the handle h. figure(h) where h is not the handle to a figure, and is not an integer, is an error.

h = figure(...) returns the handle to the figure object.

QUIZ:

Q1: What do you understand by MATLAB software?

Q2. What does MATLAB stands for?

Q3. Where can we use MATLAB?

Q4. Name some tool boxes?

Q5. What is system requirement for MATLAB?

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