SRM VALLIAMMAI ENGINEERING COLLEGE
(An Autonomous Institution)

SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF
ELECTRONICS AND INSTRUMENTATION ENGINEERING

Lab Manual

IV SEMESTER

EI3466 ELECTRICAL MACHINES AND CONTROL SYSTEMS LABORATORY

Regulation – 2023

Academic Year 2024-2025

EVEN SEMESTER

Prepared by

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SYLLABUS

EI3466 ELECTRICAL MACHINES AND CONTROL SYSTEMS LABORATORY

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COURSE OBJECTIVES

1. To expose the students to the operation of D.C. machines.
2. To expose the students to the operation of transformers.
3. To expose the students to the operation of generators and induction motors.
4. To impart knowledge about modelling of the system and the design of controllers.
5. To understand the performance of the system.

LIST OF EXPERIMENTS

1. Determination of Open circuit and Load characteristics of a self-excited D.C. shunt generator.
2. Load test on DC shunt motor.
3. Load test on DC series motor.
4. Load test on single phase induction motor.
5. Load test on single phase transformer.
6. Speed control of DC shunt motor.
7. Determination of Transfer function of DC motor.
8. Study of characteristics of Synchros.
9. Determination of time and frequency responses of a Second order system.
10. Stability analysis of LTI system.
11. Design, Analysis and implementation of lag, lead and lag-lead compensators.
12. Effect of P, PD, PI, PID controller on a second order system (open loop stable and open loop unstable system).

TOTAL : 45 PERIODS

COURSE OUTCOMES

At the end of the course, the student should have the:

1. To understand and analyze DC Machine.
2. To understand and analyze AC Machine.
3. To identify the model of the system using various techniques.
4. To design and implementation of control techniques for various control application.
5. To obtain the performance of the system.

LIST OF EQUIPMENTS FOR A BATCH OF 30 STUDENTS

1. DC Shunt Motor with Loading Arrangement – 3 nos
2. Single Phase Transformer – 4 nos
3. DC Series Motor with Loading Arrangement – 1 No.
4. Single Phase Induction Motor with Loading Arrangement – 1 No.
5. DC Shunt Motor Coupled with DC Shunt Generator – 1 No.
6. Tachometer -Digital/Analog – 8 nos
7. Single Phase Auto Transformer – 2 nos
8. Single Phase Resistive Loading Bank – 2 nos
9. SPST switch – 2 nos
10. DC Motor Transfer Function Module – 2nos
11. Synchro Transmitter and Receive module – 2nos

MAPPING OF COs WITH POs AND PSOs

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1	3	3	2	1	1	1	-	-	-	-	-	1	2	1	-	1
2	3	3	2	2	1	1	-	-	-	-	-	1	3	3	-	1
3	3	3	3	2	3	2	-	-	-	-	-	1	2	2	3	2
4	3	3	3	2	3	2	-	-	-	-	-	1	2	2	3	2
5	3	3	2	1	3	-	-	-	-	-	-	1	2	2	3	-
Avg.	3	3	2.4	1.6	2.2	1.2	-	-	-	-	-	1	2.2	2	1.8	1.2

LIST OF EXPERIMENTS

Exp. No	Experiments
CYCLE 1	
1	Determination of Open circuit and Load characteristics of a self-excited D.C. shunt generator.
2	Load test on DC shunt motor.
3	Load test on DC series motor.
4	Load test on single phase induction motor.
5	Load test on single phase transformer.
6	Speed control of DC shunt motor.
CYCLE 2	
1	Determination of Transfer function of DC motor.
2	Study of characteristics of Synchros.
3	Determination of time and frequency responses of a Second order system.
4	Stability analysis of LTI system.
5	Design, Analysis and implementation of lag, lead and lag-lead compensators.
6	Effect of P, PD, PI, PID controller on a second order system (open loop stable and open loop unstable system).

Ex. No: 1a **Determination of Open circuit characteristics of a self-excited D.C. shunt generator**

Date:

Aim:

To obtain the open circuit characteristics of a self-excited DC shunt generator and hence deduce the critical field resistance and critical speed.

Apparatus required:

Sl. No.	Name of the apparatus	Range	Type	Quantity
1.	Ammeter	(0 - 2A)	MC	1
2.	Ammeter	(0 - 10A)	MC	1
3.	Voltmeter	(0 - 300V)	MC	1
4.	Rheostat	400 Ω/1.1 A, 800 Ω/0.8 A	Wire wound	1 each
5.	Tachometer	(0 -9999 rpm)	Digital	1

THEORY

The voltage equation for DC shunt generator is given by $V_L=E_g-I_aR_a$. In separately excited DC Generator, the field winding is excited by separate external DC source. The induced EMF is directly proportional to the field current when speed is maintained constant. The plot between the induced EMF and the field current is known as open circuit characteristics of the DC generator. The typical shape of these characteristics is shown in model graph. The induced EMF when the field current is zero is known as residual voltage (R_V). This EMF is due to the presence of a small amount of flux retained in the field poles during previous process of the generator called residual flux.

PROCEDURE

Open Circuit Characteristics:-

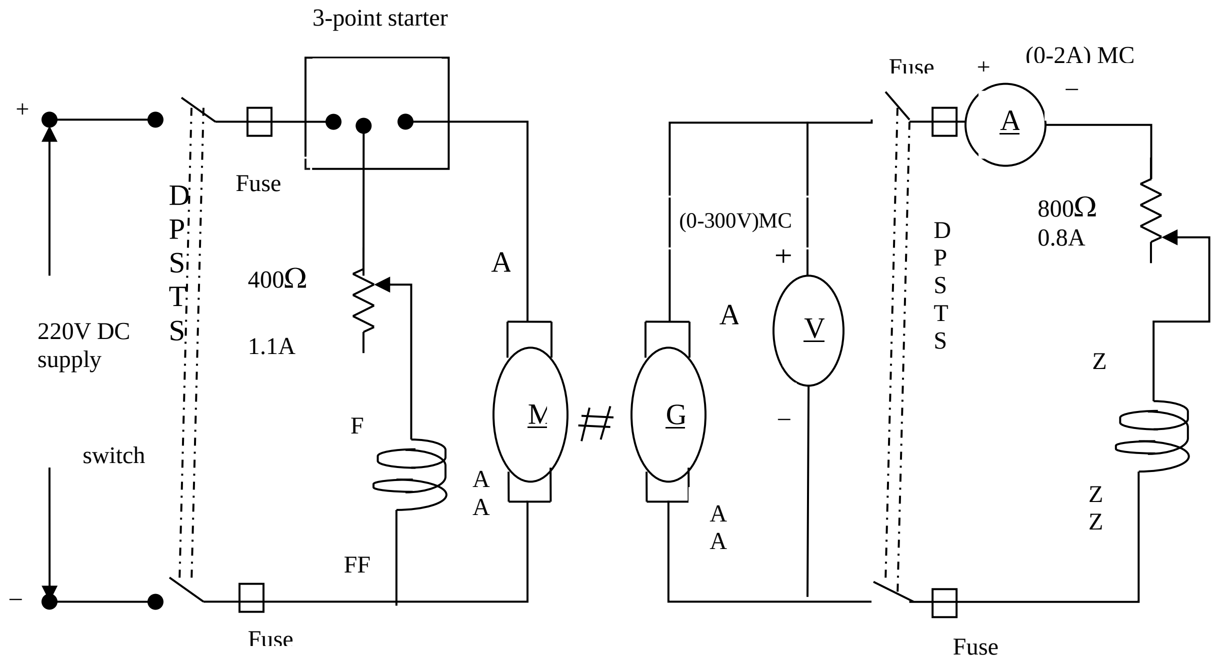
- The connections are made as per the circuit diagram.
- After checking minimum position of motor field rheostat, maximum position of generator held rheostat, The DPST switch is closed and starting resistance is gradually removed.
- The motor is started using three point starter.
- By varying the field rheostat of the motor, the speed of the motor is adjusted to the rated speed of the generator.

- By varying the generator field rheostat, voltmeter and ammeter readings are taken in steps upto 120% of rated voltage.
- After bringing the generator rheostat to maximum position, field rheostat of motor to minimum position, the DPST switch is closed.
- Draw R_c line, such that it is tangent to the initial portion of O.C.C. at rated speed and passes through origin

PRECAUTION

- All the switches are kept open initially.
- The motor field rheostat is kept at minimum resistance position.
- The generator field rheostat is kept at maximum resistance position.

CIRCUIT DIAGRAM



Motor Specifications	
Voltage	
Line Current	
Speed	
Capacity	

Generator Specifications	
Voltage	
Line Current	
Speed	
Capacity	

Fuse Ratings:
Motor side
Fuse rating= 125% of rated current

TABULAR COLOUMN FOR OPEN CIRCUIT CHARACTERISTICS

Sl. No.	Voltage in Volts	Current in A
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

MODEL GRAPH:-

Model Calculation:

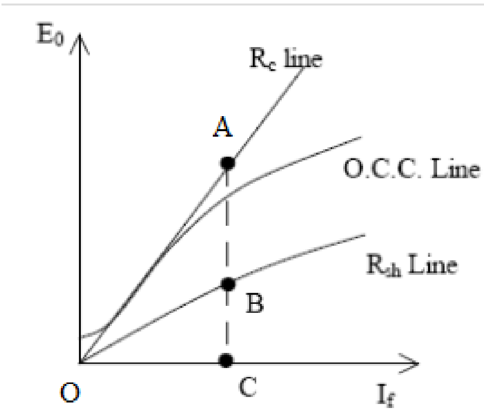
$E_0 \alpha N$

So, for different speeds, O.C.C. can be deduced from the O.C.C.at rated speed.

$N_1/N_2 = E_1/E_2$

Critical field resistance, $\mathbf{R_c}$ = the slope of R_c line= OA/OC
Critical speed, $\mathbf{N_c}$= BC/AC X $N_{R(N)}$
Where N_R is the Rated speed.

Model Graphs:



Result:

Thus the O.C.C. characteristics of self excited D.C. shunt generator were drawn

Review Question

1. How the emf are build up in generator?
2. What is meant by residual magnetism?
3. What is meant by open circuit characteristics?
4. What is meant by critical resistance?
5. The occ of a dc shunt generator starts a little above the origin. Give reasons
6. At the time of rheostat in the field winding side of the generator should be in maximum position.why?
7. Explain the building up phenomena ina dc shunt generator.
8. What is meant by torque? or Define torque?
9. How can we reduce the eddy current loss in the electrical machine?
10. Explain its applications.

Ex. No: 1b **Determination of Load Characteristics of a self-excited D.C. Shunt Generator**

Date:

Aim:

To obtain the load characteristics of a self-excited DC shunt generator.

Apparatus required:

Sl. No.	Name of the apparatus	Range	Type	Quantity
1.	Ammeter	(0 - 20A)	MC	1
3.	Voltmeter	(0 - 300V)	MC	1
4.	Rheostat	400 Ω/1.1 A, 800 Ω/0.8 A	Wire wound	1 each
5.	Tachometer	(0 -9999 rpm)	Digital	1

THEORY

The voltage equation for DC shunt generator is given by $V_L=E_g-I_aR_a$. Since $I_a$is negligibly small, from the above equation, the terminal voltage(V_L) is the no load induced EMF(E_g).As the load on the generator increases, the load current causes increase in $I_aR_a$drop. Hence the terminal voltage decreases with increasing load. The plot between terminal voltage (V_L) and load current (I_L)is known as the external or load characteristics. The plot between induced EMF (E_g) and the armature current causes increase in I_aR_a drop. Hence the terminal voltage decreases with increasing load. Typical graph of internal and external characteristics in shown in model graph.

PROCEDURE:

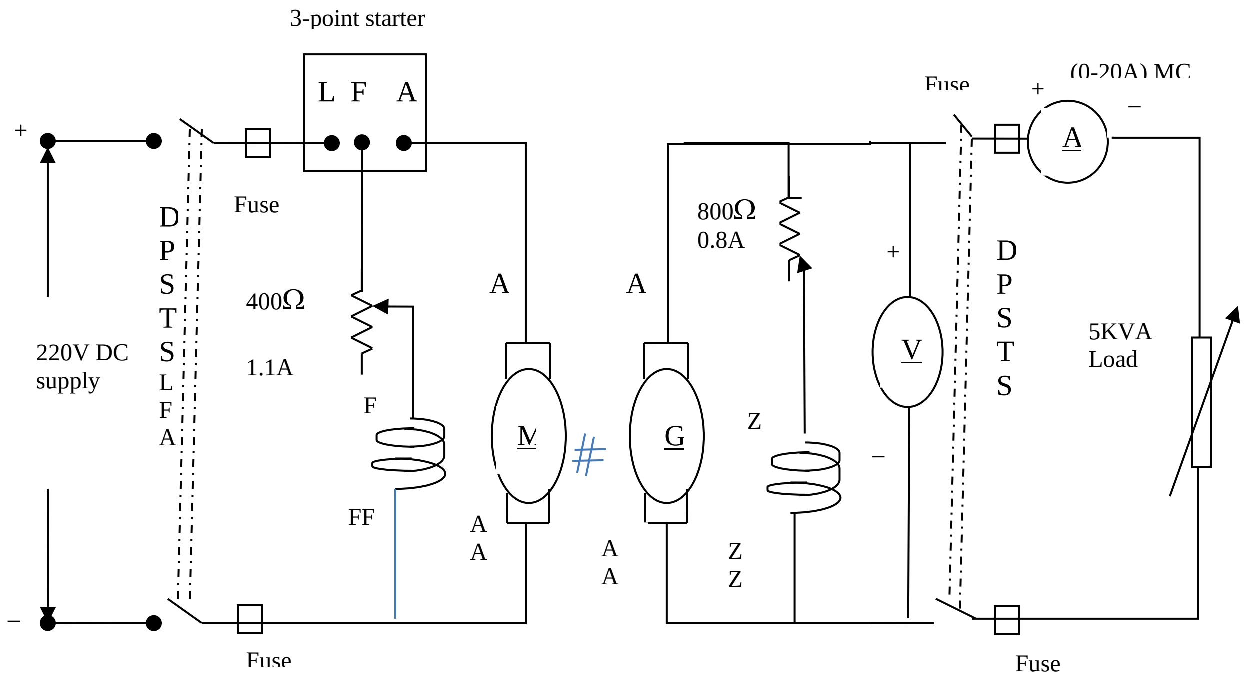
Load test:

- The connections are made as per the circuit diagram.
- The motor is started using three point starter.
- Run the MG set at rated speed
- Excite the Generator to its rated voltage after closing the SPSTS, and observe the readings on no load.
- Close the DPSTS on load side, vary the load for convenient steps of load current andobserve the meter readings.
- Note that on each loading the speed should be rated speed.
- Load the Generator upto its rated capacity.

PRECAUTION

- ❖ All the switches are kept open initially.
- ❖ The motor field rheostat is kept at minimum resistance position.
- ❖ The generator field rheostat is kept at maximum resistance position.
- ❖ Ensure that no load is connected, while switching on and switching off the supply side DPST switch.

Circuit Diagram



TABULAR COLOUMN FOR LOAD CHARACTERISTICS

Speed = __________________ rpm

S.No.	Voltage (V) Volts	Current (I_L) Amps	No Load Voltage

Model Calculation:

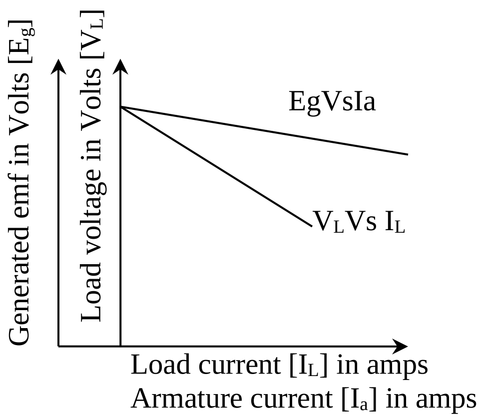
Load test:

For self excitation $I_a = IL + I_f$

So, induced emf on load, $E_g = V + I_aR_a$

Model Graphs:

Internal (EgVsIa) and External (V_LVs I_L) characteristics



Result:

Thus the load characteristics of self excited D.C. shunt generator were drawn.

Review Question

1. What is Internal Characteristics?
2. What is External Characteristics?
3. What is the difference between the generating voltage and terminal voltage?
4. Write the derivation for generating voltage?
5. How the armature resistance are determined?
6. Principle of operation of a generator
7. What is the role of a Commutator?
8. What are the different types of generators?
9. Explain armature reaction?
10. What is the function of brushes

Ex. No: 2 **Load Test on D.C. Shunt Motor**

Date:

Aim:

To determine the efficiency of D.C shunt motor.

- To obtain the performance characteristics of shunt motor.

Apparatus required:

Sl. No.	Name of the apparatus	Range	Type	Quantity
1.	Ammeter	(0 - 2A)	MC	1
2.	Ammeter	(0 - 20A)	MC	1
3.	Voltmeter	(0 - 300V)	MC	1
4.	Rheostat	400 Ω/1.1A,	Wire wound	1
5.	Tachometer	(0 -9999 rpm)	Digital	1

Precautions:

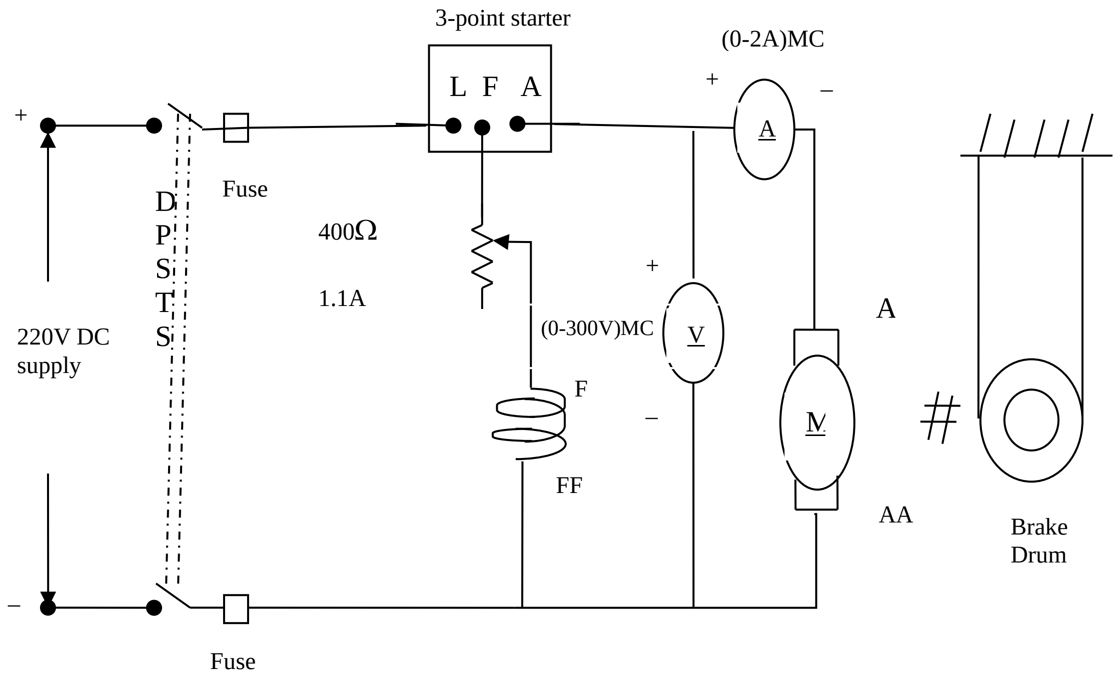
At the time of switching on and switching off the supply,

- The field rheostat should be at the **minimum resistance** position.
- There should not be any load on the motor.

Range fixing:

- The line Current of the shunt motor is IL = ________ A
- The current drawn by the shunt motor on load is 120% of full load current.
- The range of ammeter AL is (0 -   ) A
- The rated field current is ______ A
- Field circuit rheostat rating is ______ ; _____ A (the current rating should be slightly
- higher than the rated current)
- Rated voltage of motor V = ________ Volts
- The range of voltmeter V is (0 -   ) Volts

Circuit Diagram for Load Test on D.C. Shunt Motor:



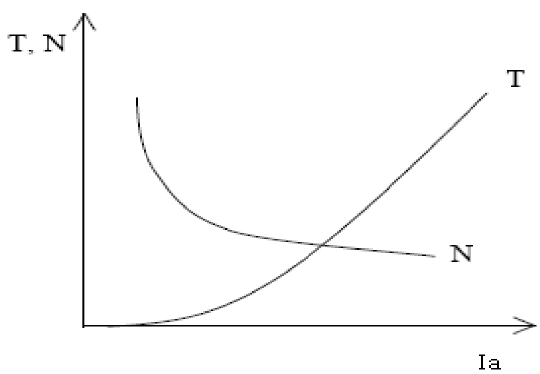
Motor Specifications	
Voltage	
Line Current	
Speed	
Capacity	

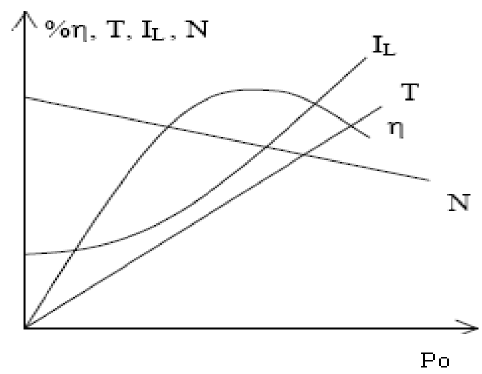
Observation:

S.No.	V (Volts)	I (Amps)	Spring Balance (Kg)			Speed N (rpm)	Torque T (Nm)	Output Power P_o (Watts)	Input Power P_i (Watts)	Efficiency η %
			F_1	F_2	$F_1 \sim F_2$					
1.										
2.										
3.										
4.										

Radius of brake drum, r = ___________ mts.

MODEL GRAPH:





Result:

Thus the performance characteristics of the DC shunt motor were drawn.

Review Question

1. Define torque.
2. What is meant by efficiency?
3. At the of starting of motor the field rheostat must be in minimum position. why?
4. If there is open circuit in the field circuit. What happen?
5. Name the different types of starters for DC motors.
6. How speed of the DC shunt motor can be increased?
7. Practical reason behind speed of DC shunt motor is proportional to back emf only is _____________
8. What is back e.m.f or counter e.m.f?

Ex. No: 3 **Load Test on D.C. Series Motor**

Date:

Aim:

- To determine efficiency of the D.C series motor.
- To obtain the performance characteristics of series motor.

Apparatus required:

Sl. No.	Name of the Apparatus	Range	Type	Quantity
1.	Ammeter	(0-15)A	MC	1
2.	Voltmeter	(0-300)V	MC	1
3.	Rheostat	400 Ω/1.14A,	Wire wound	1
4.	Tachometer	(0 -9999rpm)	Digital	1

Precaution:

- ❖ The motor should be started with some initial load.

Range fixing:

- ❖ The current drawn by the motor is 120% of full load current.
- ❖ Current drawn by the motor I_L =____A
- ❖ The range of ammeter A_L is (0-)A
- ❖ The rated supply voltage is__V
- ❖ The range of voltmeter V is (0-) V

Procedure:

- ❖ Connections are given as per circuit diagram.
- ❖ Before starting the motor some initial load is applied to the motor by using the brake drum with spring balance.
- ❖ Using two-point starter the motor is started to run. The meter readings are started at its initial condition.
- ❖ Gradually load the machine up to rated current and corresponding meter readings were noted.
- ❖ After the observation of all the readings the load is released gradually up to the initial load condition.

Formulae Used:

Circumference of the brake drum =________cms
Radius of the brake drum, r =_______m
Torque applied on the shaft of the rotor, T = (F1 ~ F2) r × 9.81 Nm

Output power, Po = $\frac{2\pi NT}{60}$ Watts

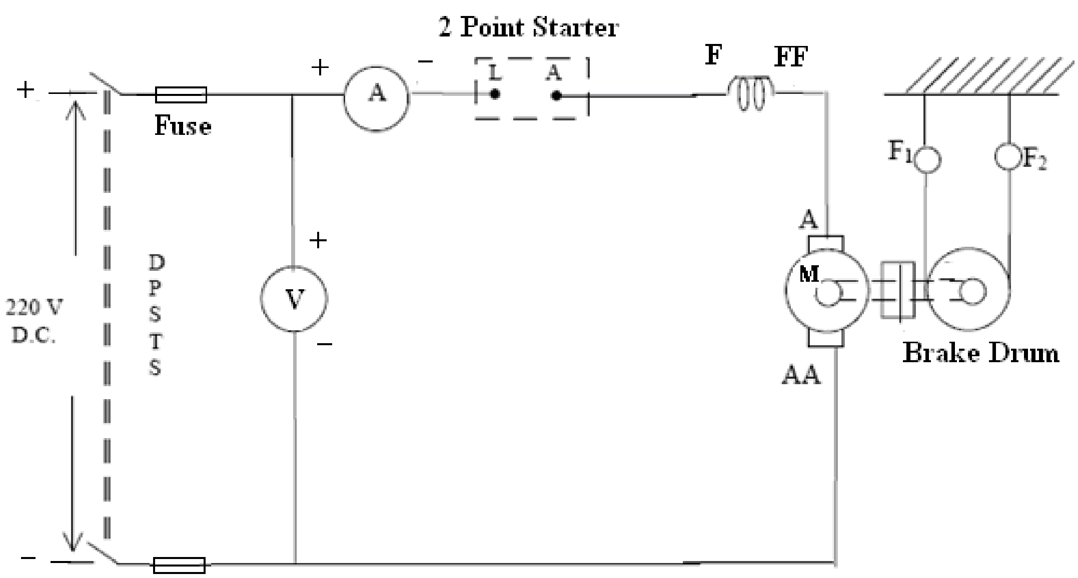
Input power Pi = V × IL Watts

% Efficiency, $= \frac{P_o}{P_i} \times 100$

Fuse Rating:

120% of rated current
The fuse rating is____A

Circuit Diagram for Brake Test on D.C. Series Motor:



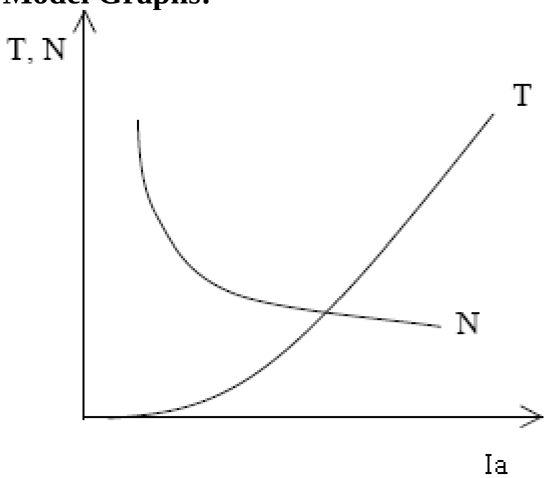
Motor Specifications	
Voltage	
Line Current	
Speed	
Capacity	

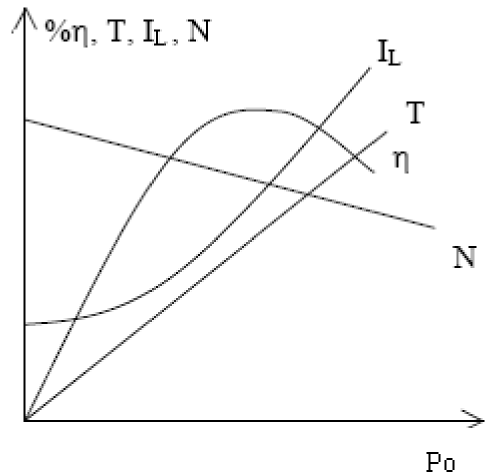
Observation:

Radius, r =__of brake drum _____mts.

S.No.	**Voltage V_L (Volts)**	**Current I_L (Amps)**	**Spring Balance (Kg)**			**Speed N (rpm)**	**Torque T (Nm)**	**Output Power P_o (Watts)**	**Input Power P_i (Watts)**	**Efficiency η%**
			F_1	**F_2**	**$F_1 \sim F_2$**					

Model Graphs:





Result:

Thus the performance characteristics of the DC series motor were drawn.

Review Question

1. How to reverse the direction of rotation of DC motor?
2. Explain why D.C series motor are started under no load.
3. Derive the torque equation.
4. Torque is directly proportional to the square of the current. Why and when?
5. State the difference between the shunt and series motor

Expt No : 4 LOAD TEST ON SINGLE PHASE INDUCTION MOTOR

Date:

AIM:

To conduct the load test on the given single phase induction motor and to plot its performance characteristics.

EQUIPMENTS REQUIRED:

SL NO	NAME OF THE EQUIPMENTS/INSTRUMENTS	TYPE	RANGE	QUANTITY
1.	Ammeter	MI	(0-10A)	1
2.	voltmeter	MI	(0-300V)	1
3	Wattmeter		300V,10A,UPF	1
4	Connecting Wires		As required	

PRECAUTIONS:

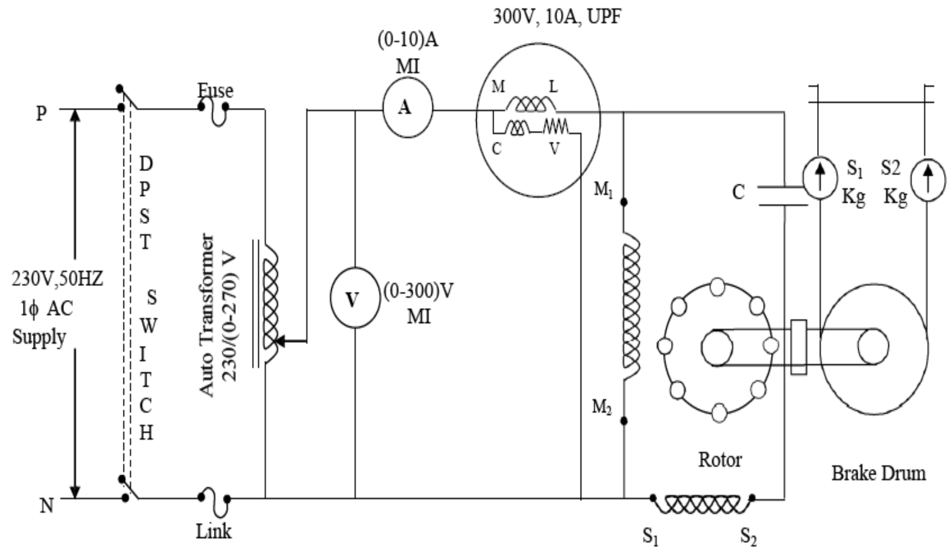
- Before starting the motor, release the load completely.
- Before providing a.c supply, the single phase variac must be in the minimum position.
- Handle the tachometer carefully.

PROCEDURE:

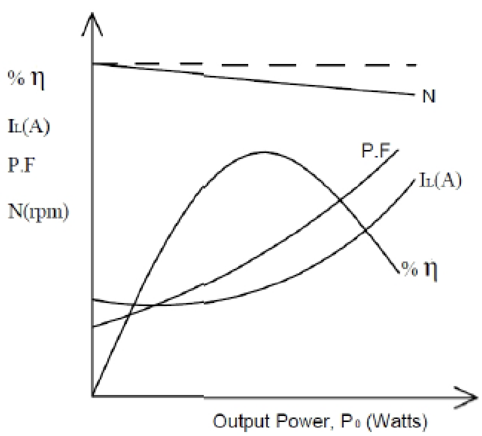
- Make the connections as per the circuit diagram. Release any load available on the motor. Switch ON the power supply by closing DPST switch.
- Vary the single phase auto transformer for rated input voltage.
- Initially when the motor is unloaded, note the readings of ammeter, voltmeter and wattmeter. Measure the speed using a tachometer at this no load condition.
- Load the motor in gradual steps up to the rated current. At each step, note down all the above mentioned readings.
- Add cooling water to the brake drum as and when required when the motor is loaded.
- Release the load on the motor and bring the auto transformer to initial position.
- Switch OFF the supply.
- Measure the circumferential length of the brake drum and use the same for calculation of the radius 'R' of the brake drum.

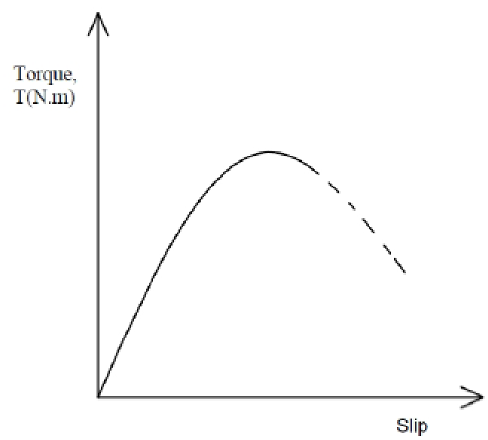
CIRCUIT DIAGRAM :

CIRCUIT DIAGRAM: LOAD TEST ON SINGLE PHASE INDUCTION MOTOR



MODEL GRAPHS:





TABULATION:

Sl. No.	V_L (V)	I_L (A)	Speed (rpm)	I/P Power (W)		Spring Balance reading			Torque (Nm)	O/P Power (W)	%slip	%η	cosφ
				Obs	Act	S1	S2	S1~S2					

CALCULATIONS:

1. Torque, T= 9.81 (S1 ~ S2) R (Nm)
   where R=(r + t /2) (m)
   R---effective radius of the brake drum (m)
   r--- Radius of the braked drum (m)
   t---thickness of the belt (m)
2. Output power, Po = 2πNT/60 (W)
   where N- actual speed of the motor (rpm)
3. Input power Pi = W (W)
   where W- actual reading of the wattmeter reading (W)
4. % Slip S= (Ns-N)/Ns x 100 (%)
   Where Ns-Synchronous speed (rpm), N=1500 rpm.
5. Power factor cosφ =Pi / (V * I)
   where V-line voltage (V)
   I-line current (A)
6. Efficiency %η = (Po/Pi) x 100 (%)
7. Multiplication Factor (MF) of the wattmeter:

MF= (Current Coil Rating * Pressure Coil Rating * Power Factor)/ Full Scale Deflection

8. Ns = 120 * f/ P
   Where f is the frequency of the supply (or) stator frequency
   P is the no. of poles of the motor

RESULT:

Thus the load test is performed in single phase Induction Motor and performance characteristics are drawn.

Review Question

1. What are the different types of single phase induction motors?
2. Explain why single phase induction motors are not self-starting?
3. Draw the phasor diagrams of Single phase induction motor indicating the starting winding and running winding current components.
4. Define slip.
5. List out the applications of single phase induction motor

EXP NO. 5 **Load test on single phase transformer**

Date :

Aim:

To perform load test on 1-phase transformer and determine the following:

a) Efficiency at different loads and to plot efficiency vs. load curve.

b) Regulation of the transformer and to plot regulation vs. load curve.

APPRATUS REQUIRED:

Sl. No.	Equipments	Type	Specification	Quantity
1.	Single Phase Transformer		1KVA, 230V/230V	1
2.	Wattmeter	Dynamometer	(0-300)V, 5/10 A 150/300/600 V	1
3.	Ammeter	MI	(0-5-10)A, AC	1
4.	Voltmeter	MI	(0-150-300) V, AC	1
5.	Lamp Bank Load	Resistive	Resistive 1 KW, 230 V	1

Precaution:

- The Variac should be kept in minimum position while switching on and switching off the supply side DPSTS.
- At the time of switching on the supply there should not be any load connected.

THEORY:

The transformer is a device which transfers energy from one electrical circuit to another electrical circuit through magnetic field as coupling medium. In this process it does not change the frequency of voltage or current. It works on the basic principle of electromagnetic induction (mutually induced e. m. f.). Being a static device it has a very high efficiency as compared to rotating machine of same rating as the losses are less.

Power input to the transformer,

$$\boldsymbol{P1 = reading\ of\ water * m.f.}$$

$$power\ output\ from\ the\ transformer\ P2 = V2 * I2$$

(cosØ being unity for lamp bank load)

Now percentage efficiency:

$$Percentage\ efficiency\ = \frac{P2}{P1} * 100$$

When primary winding of transformer is energized with source of voltage V_1 an e.m.f. E_2 is induced across the secondary winding and it is also equal to secondary terminal voltage V_2 till there is no load across secondary winding. As soon as load is applied across the secondary winding the terminal voltage is decreased from E_2 to V_2 this phenomenon of changing the voltage is called "voltage regulation". We can define voltage regulation in numerical term as "it is change in secondary terminal voltage from no load to full load with respect to the secondary no load voltage". Thus,

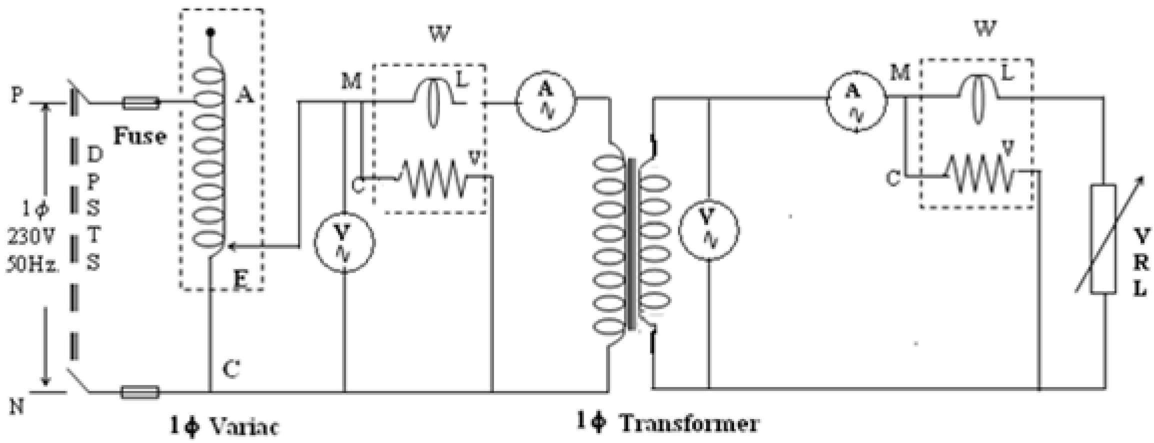
$$percentage\ voltage\ regulation = \frac{E2-V2}{E2} * 100$$

The voltage regulation should be as small as possible. Transformer being highly inductive device works on lagging power factor unless the load of highly capacitive nature is connected across the secondary winding to make overall circuit resistive purely or capacitive in nature.

PROCEDURE:

- Make the connections as per the circuit diagram.
- Keep the switch S on secondary side open so that load is zero to measure no load voltage. Also keep knob of auto transformer at zero output voltage position.
- Now increase the voltage through auto transformer until voltage in voltmeter V2 reads rated value of secondary winding & read no load voltage E2.
- Switch on certain lamps in the lamp in the bank load such that secondary winding current be approximately 10% of the rated current of secondary side.
- Take the readings from Wattmeter W2, Voltmeter V2, & Ammeter I2.
- Increase the load current in steps of 10% of the rated value by switching on few more lamps & take the readings of the Wattmeter, Ammeter & Voltmeter till it reaches 120-1255 of rated value.
- Reduce the load to zero by switching of the lamps one-by-one.
- Switch off the AC-Supply.

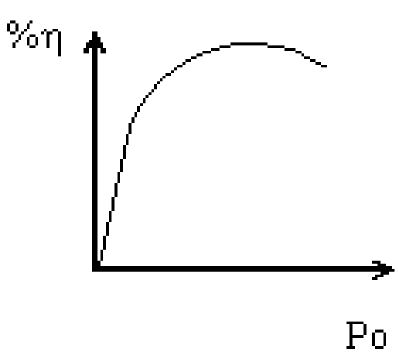
CIRCUIT DIAGRAM:

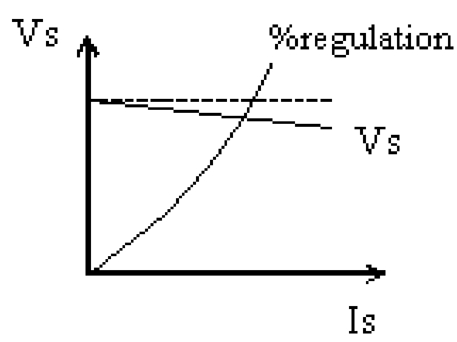


OBSERVATION TABLE:

Sl.No	V_P (Volts)	I_P (Amps)	W_P (Watts)		V_S (Volts)	I_S (Amps)	W_S (Watts)		% Efficiency	% Regulation
			Observed	Actual			Observed	Actual		

Model Graphs:





RESULT:

The efficiency of given Transformer is________________________.

The Voltage Regulation of the given Transformer is_____________.

Review Question

1. Define Regulation of a Transformer.
2. What is the effect of load p.f on regulation of Transformer?
3. What is the condition for maximum efficiency?
4. Determine the percentage load at which maximum efficiency occurred for the given single-phase transformer?
5. What is the effect of change in frequency on the efficiency of the transformer? 6.Why transformer rating is in KVA?

Ex. No: 6 **SPEED CONTROL OF D.C. SHUNT MOTOR**

Date:

Aim:

To draw the speed characteristics of DC shunt motor by

(1) Armature control method

(2) Field control method

APPARATUS REQUIRED:-

Sl. No.	Name of the apparatus	Range	Type	Quantity
1.	Ammeter	(0 -5A)	MC	1
2	Voltmeter	(0 – 300V)	MC	1
3.	Rheostat	400Ω, 1.1A, 50Ω,3.5A	Wire wound	1 each
4.	Tachometer		Digital	1

PROCEDURE

(1) Armature control method:-

- The connections are given as per the circuit diagram.
- The DPST switch is closed.
- The field current is varied in steps by varying the field rheostat.
- In each step of field current the armature voltage is varied in steps by varying the armature rheostat.
- In each step of armature rheostat variation the meter readings (Voltmeter & Tachometer) are noted.

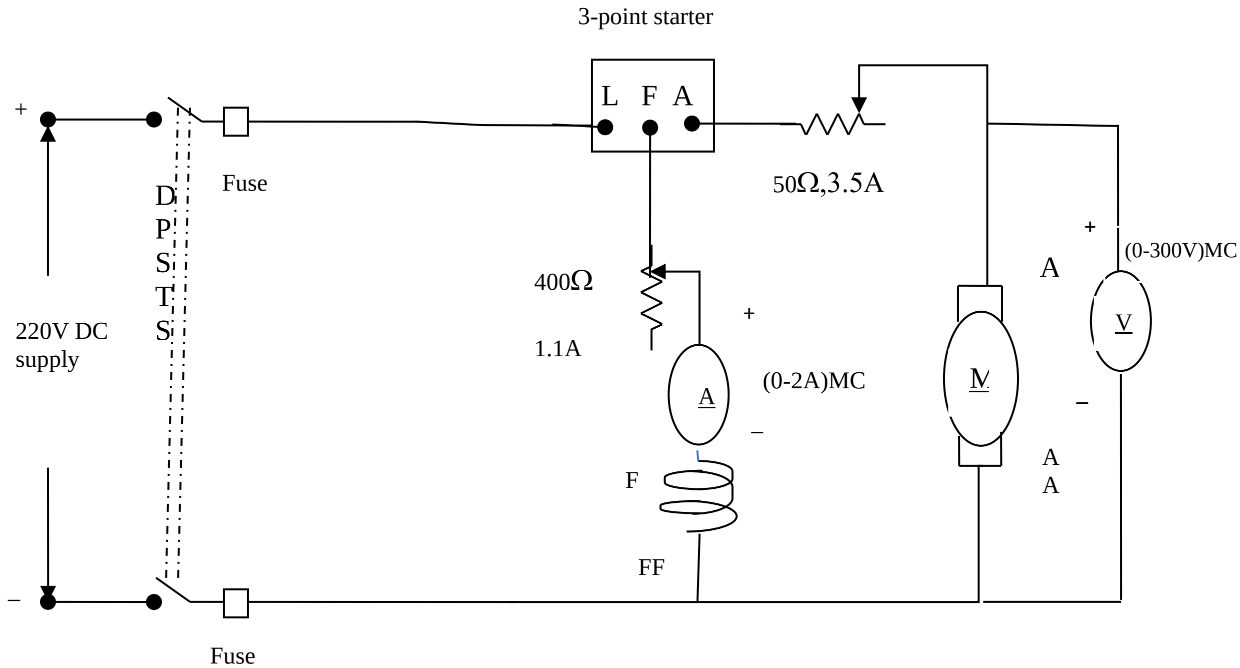
(2) Field control method:-

- The connections are given as per the circuit diagram.
- The DPST switch is closed.
- The armature voltage is varied in steps by varying the armature rheostat.
- In each step of armature voltage the field current in steps by varying the field rheostat.
- In each step of field rheostat the meter readings (Ammeter & tachometer) are noted.

PRECAUTION

- All the switches are kept open initially.
- The field rheostat should be kept at minimum resistance position.
- The armature rheostat should be kept at maximum resistance position.

Circuit Diagram



Name plate details:

Voltage :

Current :

Power :

Speed :

Fuse Rating

125 % of rated current

$= \frac{1.25}{100} \times$

Tabular Column

Armature voltage control:

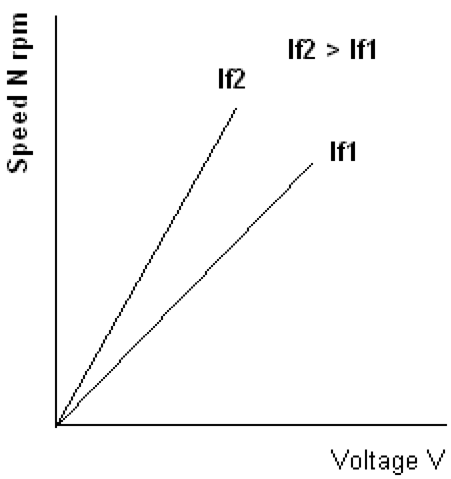
S.No	I_{F1} = A		I_{F2} = A	
	Voltage V	Speed N rpm	Voltage V	Speed N rpm

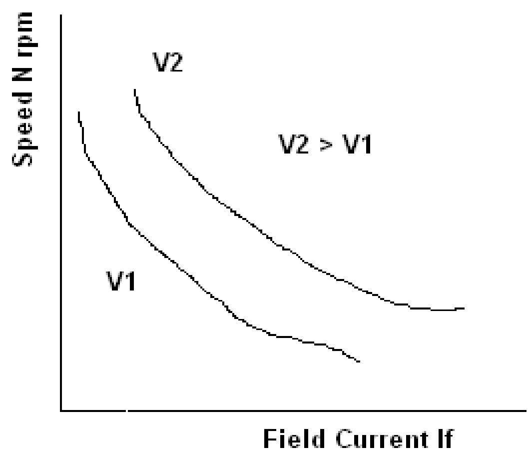
Field control:

S.No	Voltage V_1 = V		Voltage V_2 = V	
	Field current I_F A	Speed N rpm	Field current I_F A	Speed N rpm

Model Graph:

Armature voltage control **Field Control**





Result:

Thus the speed characteristics of the DC shunt motor were drawn.

Review Question

- what is the relationship between the voltage and speed?
- what is the relationship between the flux and speed?
- what are the methods for speed control of dc motors?
- which method of speed control can be used for above the rated speed control?
- which method of speed control can be used for below the rated speed control?
- explain different methods of speed control of d.c series motors
- how can you reverse the direction of rotation of a d.c motor?
- what are the different tests conducted on d.c machines?

Exp. No: 7. **Determination of transfer function of dc motor**

Date:

Aim:

1. To determine the transfer function of an armature-controlled DC motor.
2. To determine the transfer function of a field-controlled DC motor.

APPARATUS REQUIRED:

S.No	Name	Range	Qty	Type
1	Ammeter	(0-5A),(0-2A),(0-10A),(0-100mA)	Each 1	MC
2	Voltmeter	(0-300V),(0-300V) (0-300V),(0-150V)	Each1 Each1	MC MI
3	Auto transformer	1Φ,230V/(0-270V),5A	1	
4	Rheostat	400Ω/1.1A,50Ω/3.5A,250 Ω/1.5A.	Each1	
5	Tachometer		1	
6	Stopwatch		1	
7	Connecting Wires		12	

THEORY:

TRANSFER FUNCTION OF ARMATURE CONTROLLED DC MOTOR

The differential equations governing the armature controlled |DC motor speed control system are

$$V_a = I_a R_a + L_a \frac{di_a}{dt} + e_b \qquad (1)$$

$$T = K_t \, I_a \qquad (2)$$

$$T = J \frac{d^2 \theta}{dt^2} + B \frac{d\theta}{dt} \qquad (3)$$

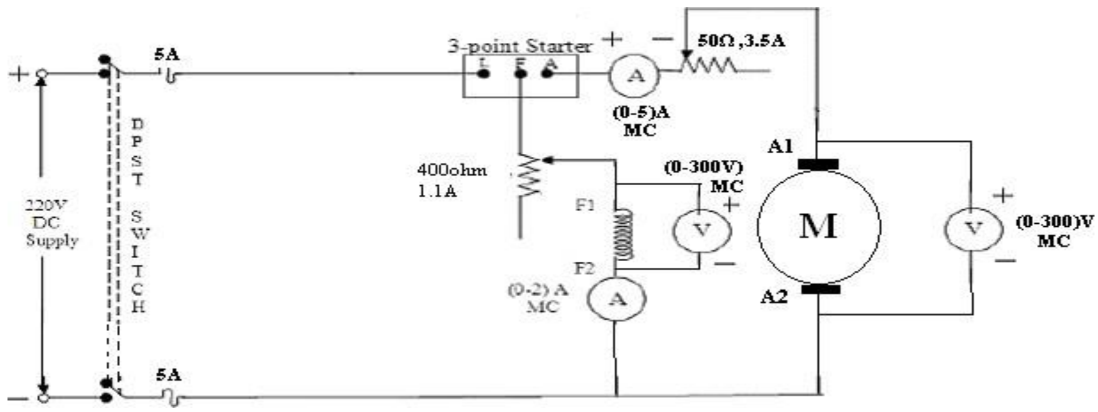
$$e_b = K_b \frac{d\theta}{dt} \qquad (4)$$

On taking Laplace transform of the system differential equations with zero initial conditions we get

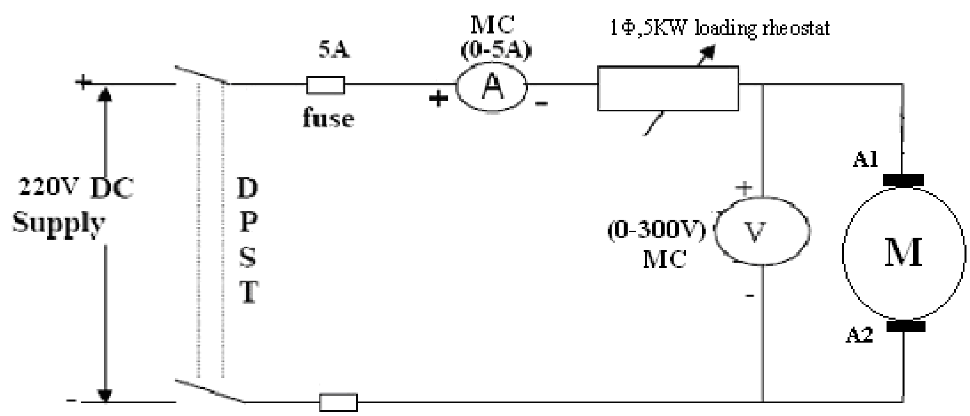
$$V_a(s) = I_a(s) R_a + L_a s I_a(s) + E_b(s) \qquad (5)$$

CIRCUIT DIAGRAM:

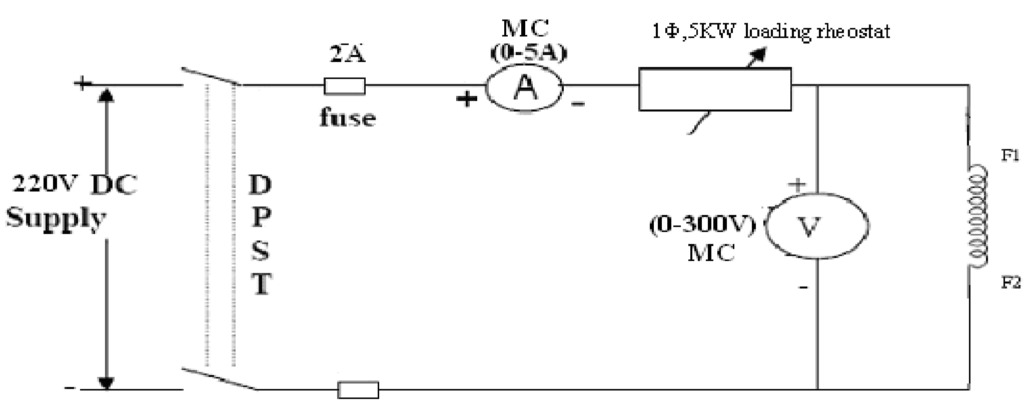
ARMATURE AND FIELD CONTROLLED DC MOTOR:



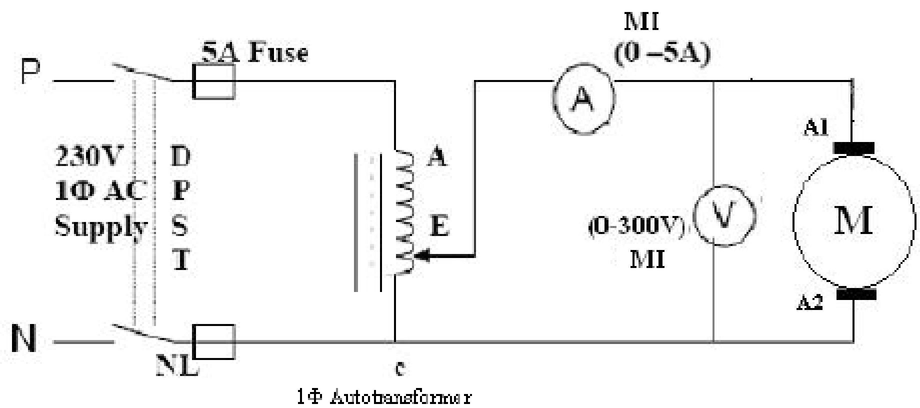
TO MEASURE ARMATURE RESISTANCE Ra:



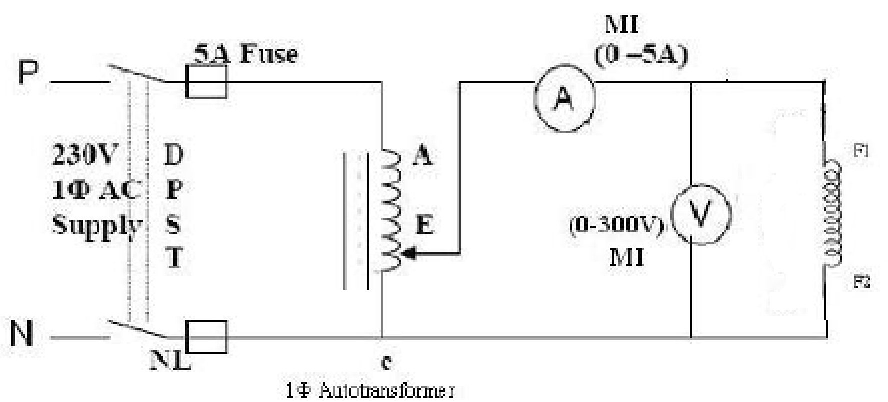
TO MEASURE FIELD RESISTANCE Rf:



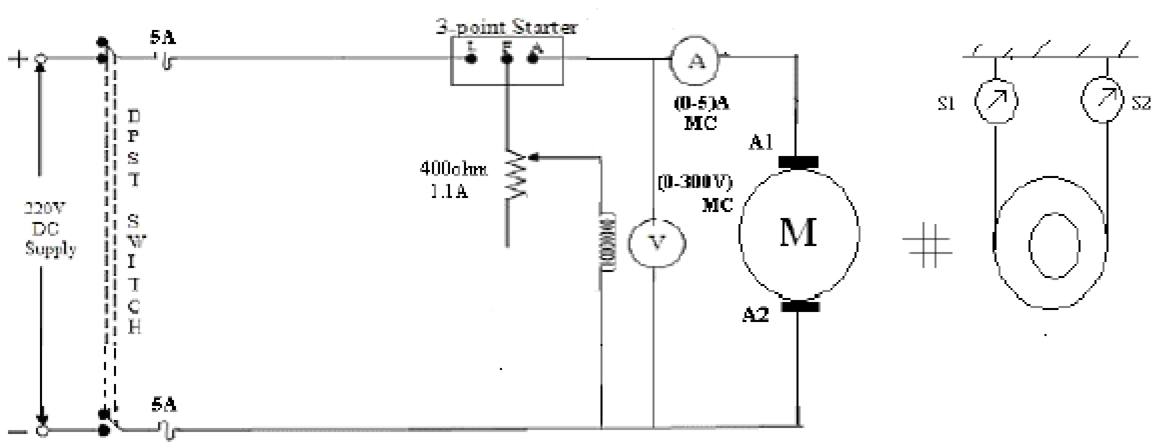
TO MEASURE ARMATURE INDUCTANCE(La):



TO MEASURE FIELD INDUCTANCE(LF):



TO MEASURE Ka



$$T(s) = K_t\, I_a(s) \qquad (6)$$

$$T(s) = Js^2\theta(s) + Bs\theta(s) \qquad (7)$$

$$E_b(s) = K_b s\theta(s) \qquad (8)$$

on equating equation (6) and (7)

$$I_a(s) = \frac{Js^2 + Bs}{K_t}\,\theta(s) \qquad (9)$$

Equation (5) can be written as

$$V_a(s) = (R_a + sL_a)I_a(s) + E_b(s) \qquad (10)$$

Substitute $E_b(s)$ and $I_a(s)$ from eqn (8),(9) respectively in equation 10

$$V_a(s) = \left[\frac{(R_a+sL_a)(Js^2+Bs)+K_b K_t s}{K_t}\right]\theta(s)$$

The required transfer function is

$$\frac{\theta(s)}{V_a(s)} = \frac{K_t}{(R_a+sL_a)(Js^2+Bs)+K_b K_t s}$$

$$\frac{\theta(s)}{V_a(s)} = \frac{K_t/R_a B}{s(1+sT_a)(1+sT_m)+\frac{K_b K_t}{R_a B}}$$

Where $L_a / R_a = T_a$= electrical time constant

$J/B = T_m$ =mechanical time constant

TRANSFER FUNCTION OF FIELD CONTROLLED DC MOTOR

The differential equations governing the field controlled DC motor speed control system are,

$$V_f = R_f\, I_f + L_f \frac{di_f}{dt} \qquad (11)$$

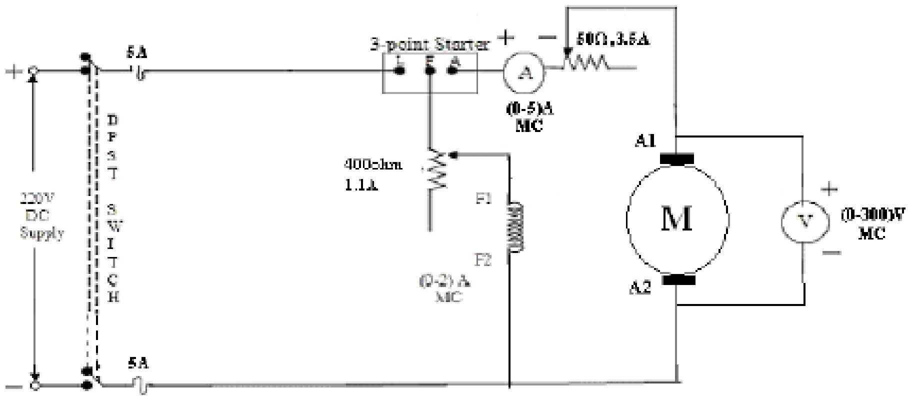
$$T(s) = K_{t_f} I_f(s) \qquad (12)$$

$$T(s) = Js^2\theta(s) + Bs\theta(s) \qquad (13)$$

Equation (12) and (13)

$$K_{t_f} I_f(s) = Js^2\theta(s) + Bs\theta(s) \qquad (14)$$

TO FIND K_b



TABULATION:

To find R_a:

V_a(V)	I_a(A)	R_a(Ω)

To find R_f:

V_f(V)	I_f(A)	R_f(Ω)

$$I_f(s) = \frac{s(Js+Bs)}{K_{t_f}}\theta(s)$$

(15)

The equation (4) becomes

$$V_f(s) = (R_f + sL_f)\, I_f(s) \qquad (16)$$

On substituting $I_f(s)$ from equation (7) and (8), we get

$$V_f(s) = (R_f + sL_f)\,\frac{s(Js+Bs)}{K_{t_f}}\,\theta(s) \qquad (17)$$

$$\frac{\theta(s)}{V_f(s)} = \frac{K_{t_f}}{s(R_f+sL_f)(B+sJ)} \qquad (18)$$

$$\frac{\theta(s)}{V_f(s)} = \frac{K_m}{s(1+sT_f)(1+sT_m)} \qquad (19)$$

Where

Motor gain constant $K_m = K_{tf}/R_{fb}$

Field time constant $T_f = L_f/R_f$

Mechanical time constant $T_m = J/B$

PROCEDURE:

To find armature resistance R_a:

1. Connections were given as per the circuit diagram.
2. By varying the loading rheostat take down the readings on ammeter and voltmeter.
3. Calculate the value of armature resistance by using the formula $R_a = V_a / I_a$.

To find armature resistance L_a:

1. Connections were given as per the circuit diagram.
2. By varying the AE positions values are noted.
3. The ratio of voltage and current gives the impedance Z_a of the armature reading. Inductance L_a is calculated as follows.

$$X_a = \sqrt{Z_a^2 - R_a}$$

$$L_a = \frac{X_a}{2\pi f}$$

To find La:

V_a(V)	I_a(A)	Z_a(Ω)	L_a(Ω)

To find L_f:

V_f(V)	I_f(A)	Z_f(Ω)	L_f(Ω)

ARMATURE CONTROLLED DC MOTOR:

V_a (V)	I_a (A)	N(RPM	T(NM)	Ω(Rad)	K_b	K_t	E_b

To find armature k_a:

1. Connections are made as per the circuit diagram.
2. Keep the rheostat in minimum position.
3. Switch on the power supply.
4. By gradually increasing the rheostat, increase the motor to its rated speed.
5. By applying the load note down the readings of voltmeter and ammeter.
6. Repeat the steps 4 to 5 times.

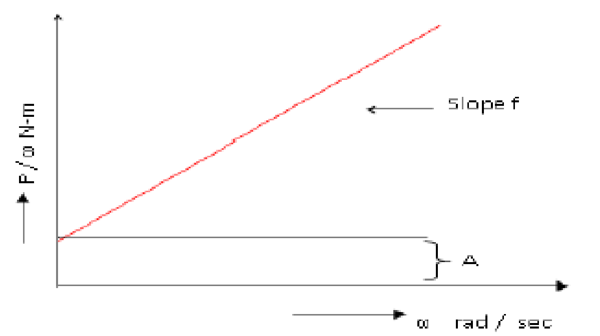
To find k_b:

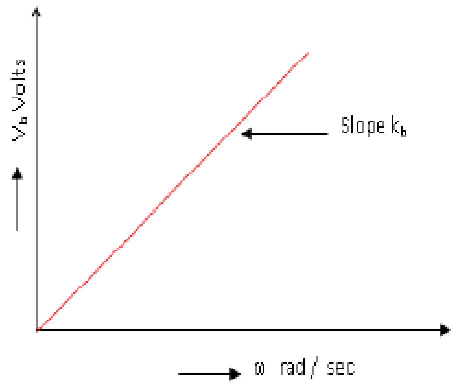
1. Connections are made as per the circuit diagram.
2. By observing the precautions switch on the supply.
3. Note down the current and speed values.
4. Calculate E_b and ω.

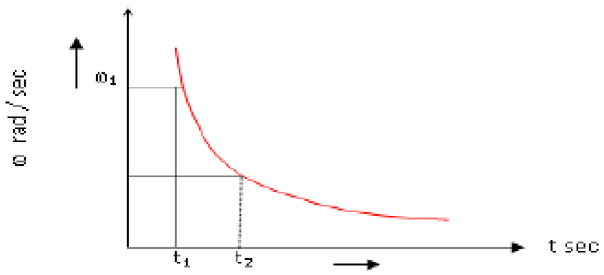
FIELD CONTROLLED DC MOTOR:

V_a (V)	I_a (A)	N(RPM)	T_m(NM)	ω(Rad)	E_b(V)	K_m	T(NM)	K_{tf}	T_f(NM)

MODEL GRAPH:







MODEL CALCULATION

RESULT:

Exp. No: 8 **Study of characteristics of Synchros**

Date:

Aim:

1. To study the operation of synchro transmitter and receiver as a error detector
2. To study the operation of Synchro Transmitter and Receiver.

Apparatus Required:

- Synchro transmitter and receiver kit
- Patch cords

Procedure:

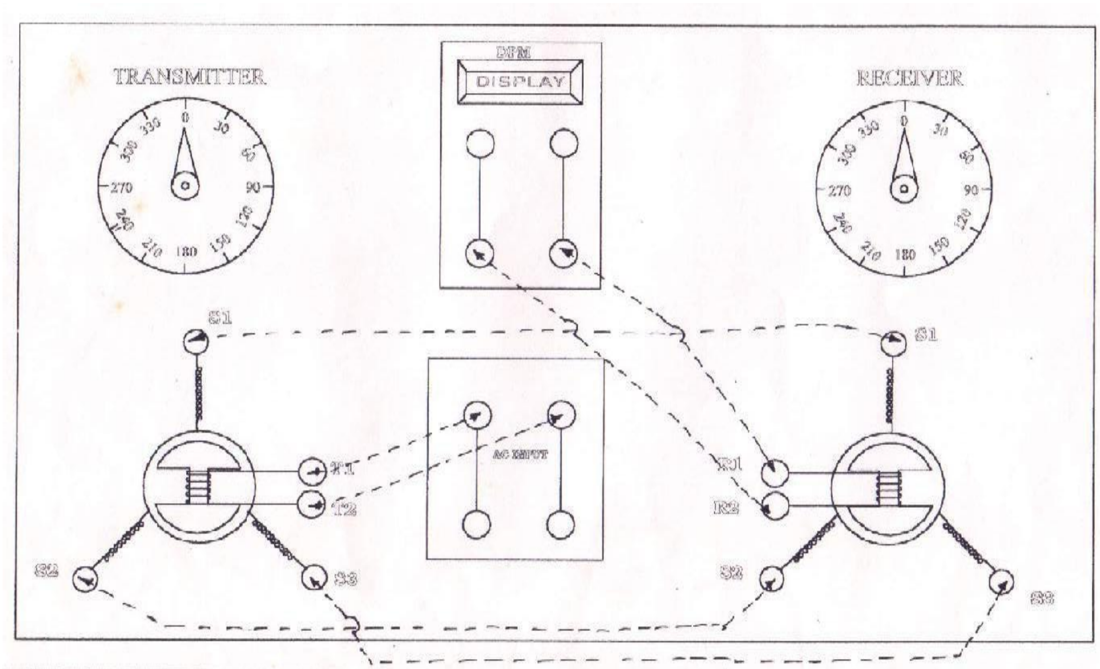
Synchro transmitter and receiver as an error detector

- Connect the R1-R2 terminals of transmitter to power supply.
- Short S1-S2, S2-S2, S3-S3 winding of transmitter and receiver.
- Connect the R1-R2 terminals of receiver to digital panel meter.
- As the power is switched ON transmitter and receiver shaft will come to the same position on the dial.
- Set the transmitter rotor in zero position and rotate the receiver rotor.
- Take the error voltage display on the digital panel meter corresponding to the angle difference between transmitter and receiver.
- Tabulate the reading as per the following table.

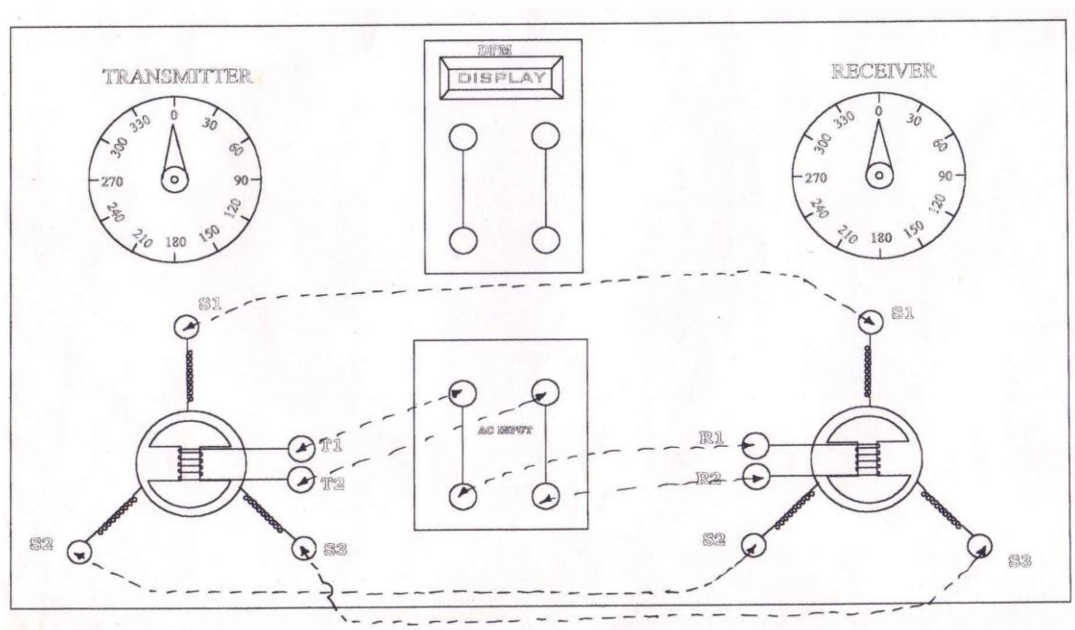
Synchro Transmitter and Receiver

- Arrange power supply, synchro transmitter and synchro receiver near to each other.
- Connect power supply output to R1-R2 terminals of the transmitter and receiver.
- Short S1-S2, S2-S2, and S3-S3 winding of transmitter and receiver with the help of patch cords.
- Switch on the unit, supply neon will glow on.
- As the power is switched on transmitter and receiver shaft will come to the same position on the dial.
- Vary the shaft position of the transmitter and observe the corresponding change in the shaft position of the receiver.
- Repeat the above steps for different angles of the shaft of the transmitter, you should have observed that the receiver shaft move by an equal amount as that of a transmitter.

Synchro transmitter and receiver angle difference Vs output error voltage



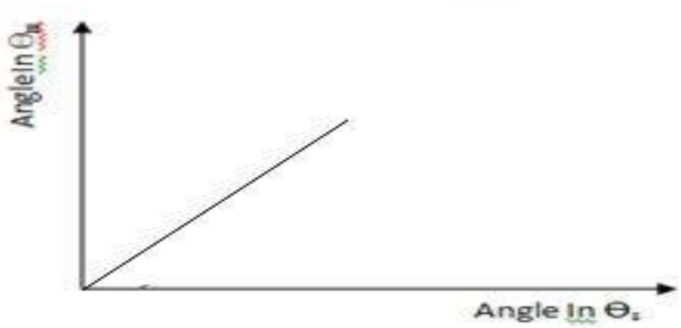
Synchro Transmitter stator angle Vs receiver rotor angle characteristics



Tabulation for rotor angle versus receiver angle:

S.No	Transmitter angular position (degrees)	Receiver angular position (degrees)

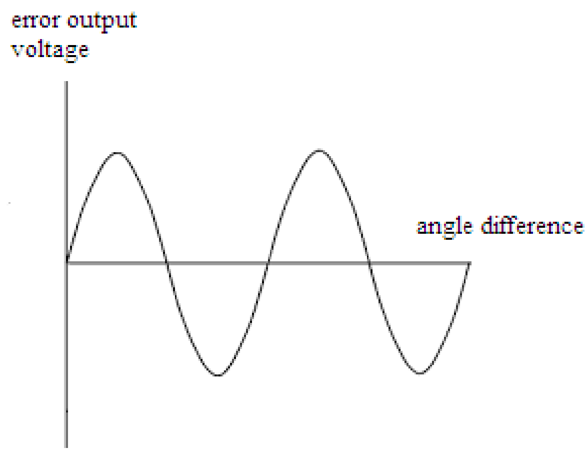
Model Graph:



Tabulation for error voltage Vs difference between transmitter and receiver rotor angle

S.No	Transmitter position (degrees)	Receiver position (degrees)	Error output Voltage (Volts)	Angle of Difference (degrees)

Model Graph



MODEL CALCULATION

RESULT:

Transfer function:

100

----

s^2 + 15 s

Transfer function:

100

----

s^2 + 15 s + 100

(i) Wn = 10.0000

10.0000

Z = 0.7500

0.7500

P = -7.5000 + 6.6144i

-7.5000 - 6.6144i

(ii) Kp = Inf Kv = 6.6667

Ka = 0

(iii)Wd = 6.6144

Theta= 0.7227

(iv) Td = 0.1525

(v) Tr = 0.3655

(vi) Tp = 0.4747

(vii)MpPercentage = 2.8427

(viii) Ts = 0.5333 Ts = 0.4000

Exp. No: 9 Determination of time and frequency responses of a Second order system
Date:

Aim

To obtain the time domain and Frequency Domain Specifications for the given system using MATLAB Software.

Apparatus Required

- MATLAB Software

Design Procedure :

1. The open loop transfer function G(s)=100/s(s+15) has a unity feedback. Find (i) Natural Frequency and Damping Ratio (ii)Position, Velocity, Acceleration Error Constants (iii)Damped Frequency and Theta (iv)Delay Time (v) Rise Time (vi)Peak Time (vii)Maximum Peak over shoot percentage (viii) Settling Time for 2% and 5% and Calculate the same results using MATLAB Software.

Solution

```
% Time Domain Specifications num=[100];
den=[1 15 0];
%Transfer Function Form
G=tf(num,den)
% Unity Feedback System
C=feedback(G,1)
% (i)Natural frequency and Damping Ratio
[Wn Z P] = damp(C)
Wn=Wn(1);
Z=Z(1);
%(ii)Position,Velocity,Acceleration Error Constants
% Position Error Constant
Kp=dcgain(G)
%Differentiator  Part
num1=[1 0];den1=[1];G1=tf(num1,den1);
%Velocity Error Constant
Gv=G1*G;
Kv=dcgain(Gv)

% Acceleration Error Constant
Ga=Gv*G1;
Ka=dcgain(Ga)
%(iii) Damped Frequency and Theta
```

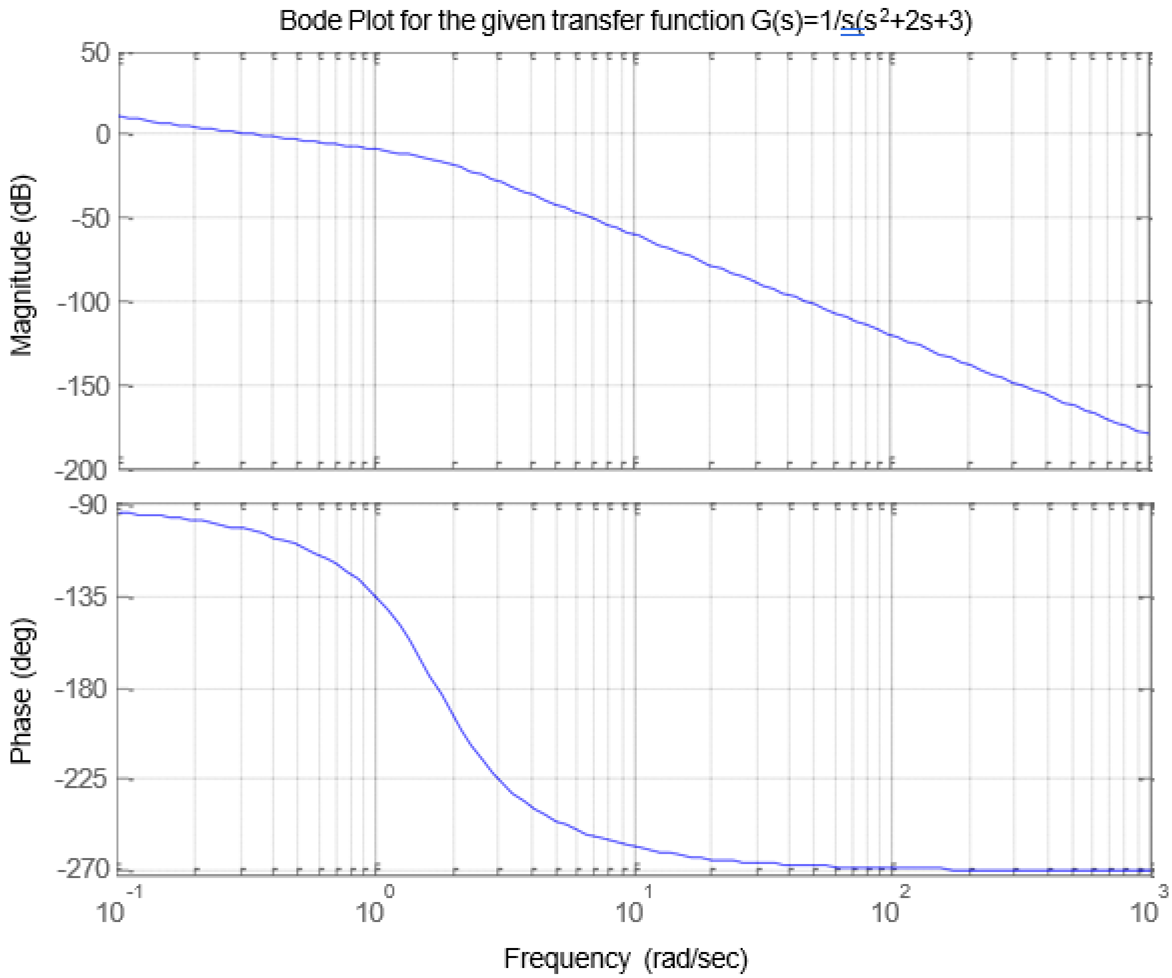
```
% Damped Frequency of oscillation
Wd=Wn*sqrt(1-(Z^2))
%Angle of Theta
Theta=atan((sqrt(1-(Z^2)))/Z)
%(iv)Delay Time(Td)
Td=(1+0.7*Z)/Wn
%(v)Rise Time
Tr=(3.14-Theta)/Wd
%(vi)Peak Time
Tp=3.14/Wd
%(vii)Percentage of Peak over shoot
MpPercentage=exp((-3.14*Z)/(sqrt(1-Z^2)))*100
%(viii) Settling Time
%    For    2%
Ts=4/(Z*Wn)
%    For    5%
Ts=3/(Z*Wn)
```

2. The open loop transfer function of a unity feedback system G(s)=K/s(s^2+2s+3) Draw the Bode Plot manually Find (i)Gain Margin (ii)Phase Margin (iii)Gain cross over frequency (iv)Phase cross over frequency (v) Resonant Peak (vi)Resonant Frequency (vii)Bandwidth and Check the same results using MATLAB Software. (Assume K=1)

Solution

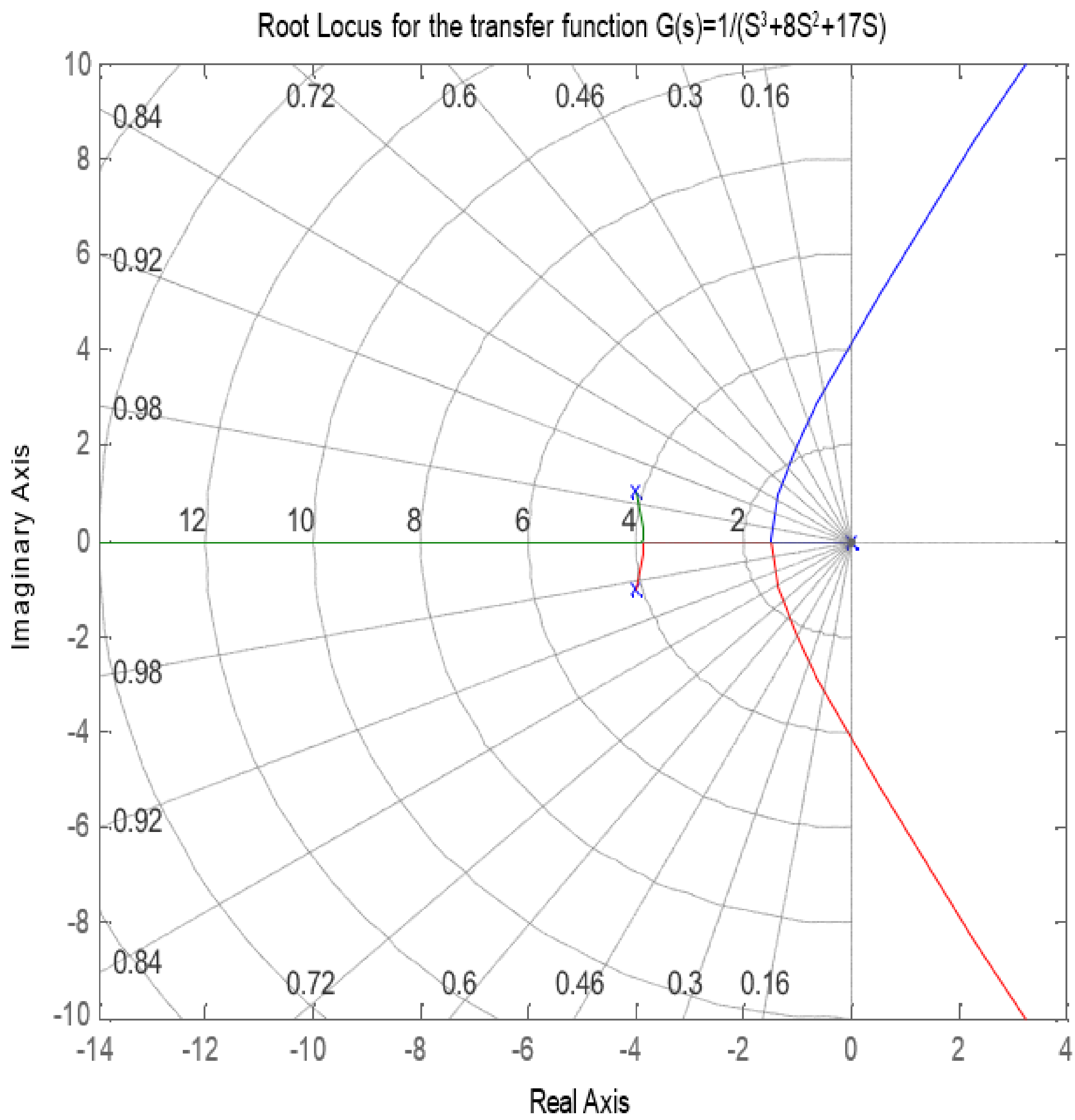
```
%Draw the Bode Plot for the given transfer functionG(S)=1/S(S2+2S+3) %Find (i)Gain Margin
%(ii) Phase Margin (iii) Gain Cross over Frequency %(iv) Phase Cross over Frequency
%(v)Resonant Peak (vi)Resonant %Frequency  (vii)Bandwidth
num=[1 ];
den=[1 2 3 0];
w=logspace(-1,3,100);
figure(1);
bode(num,den,w);
title('Bode Plot for the given transfer function G(s)=1/s(s^2+2s+3)')
grid;
[Gm Pm Wcg Wcp] =margin(num,den);
Gain_Margin_dB=20*log10(Gm) Phase_Margin=Pm
Gaincrossover_Frequency=Wcp Phasecrossover_Frequency=Wcg
[M P w]=bode(num,den);
[Mp i]=max(M);
Resonant_PeakdB=20*log10(Mp)
Wp=w(i);
```

```
Resonant_Frequency=Wp
for i=1:1:length(M);
if M(i)<=1/(sqrt(2));
Bandwidth=w(i)
break; end;
end;
```



Gain_Margin_dB =15.5630
Phase_Margin = 76.8410
Gaincrossover_Frequency = 0.3374
Phasecrossover_Frequency= 1.7321
Resonant_PeakdB = 10.4672
Resonant_Frequency = 0.1000
Bandwidth = 0.5356

RESULT


Root Locus for the transfer function G(s)=1/(S3+8S2+17S)
Imaginary Axis
Real Axis
0.84
0.72
0.6
0.46
0.3
0.16
0.92
0.98
12
10
8
6
4
2

Exp. No: 10 **Stability Analysis of LTI System**

Date:

Aim:-

To check the stability analysis of the given system or transfer function using MATLAB Software.

Apparatus Required

- MATLAB Software

Design Procedure :

1. Root Locus : The open loop transfer function of a unity feedback system $G(s)=K/s(s^2+8s+17)$ Draw the root locus manually and Check the same results using MATLAB Software. (Assume K=1)

Solution

```
% Rootlocus of the transfer function G(s)=1/(S^3+8S^2+17S)
num=[1];
den=[1 8 17 0];
figure(1); rlocus(num,den);
Title('Root Locus for the transfer function G(s)=1/(S^3+8S^2+17S)')
 grid;
```

2. BODE PLOT : The open loop transfer function of a unity feedback system $G(s)=K/s(s^2+2s+3)$ Draw the Bode Plot manually Find (i)Gain Margin (ii)Phase Margin (iii)Gain cross over frequency (iv)Phase cross over frequency (v) Resonant Peak (vi)Resonant Frequency (vii)Bandwidth and Check the same results using MATLAB Software. (Assume K=1)

Solution

```
%Draw the Bode Plot for the given transfer functionG(S)=1/S(S2+2S+3) %Find (i)Gain Margin
(ii) Phase Margin (iii) Gain Cross over Frequency %(iv) Phase Cross over Frequency (v)Resonant Peak (vi)Resonant %Frequency (vii)Bandwidth

num=[1 ]; den=[1 2 3 0];

w=logspace(-1,3,100); figure(1); bode(num,den,w);

title('Bode Plot for the given transfer function G(s)=1/s(s^2+2s+3)') grid;

[Gm Pm Wcg Wcp] =margin(num,den); Gain_Margin_dB=20*log10(Gm)

Phase_Margin=Pm Gaincrossover_Frequency=Wcp Phasecrossover_Frequency=Wcg
```

```
[M P w]=bode(num,den); [Mp i]=max(M);

Resonant_PeakdB=20*log10(Mp) Wp=w(i);

Resonant_Frequency=Wp for i=1:1:length(M);

if M(i)<=1/(sqrt(2)); Bandwidth=w(i)

break; end; end;
```

Answer

Gain_Margin_dB =15.5630

Phase_Margin = 76.8410

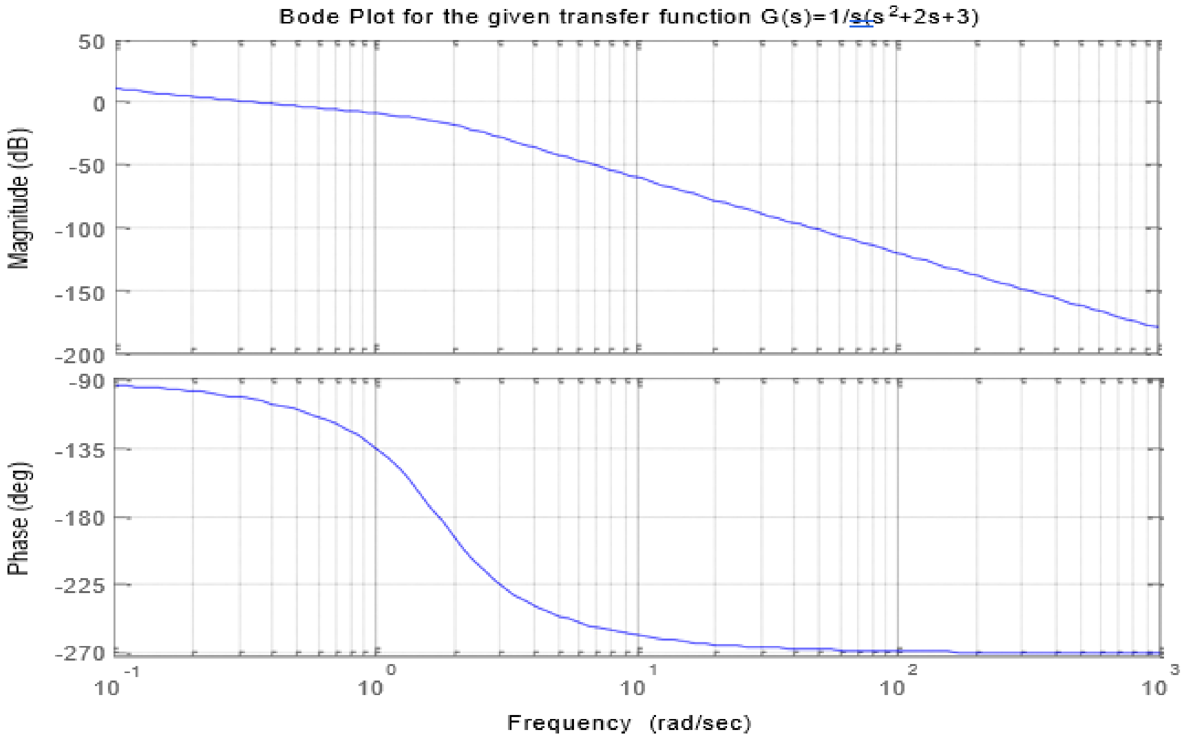
Gaincrossover_Frequency = 0.3374

Phasecrossover_Frequency= 1.7321

Resonant_PeakdB = 10.4672

Resonant_Frequency = 0.1000

Bandwidth = 0.5356

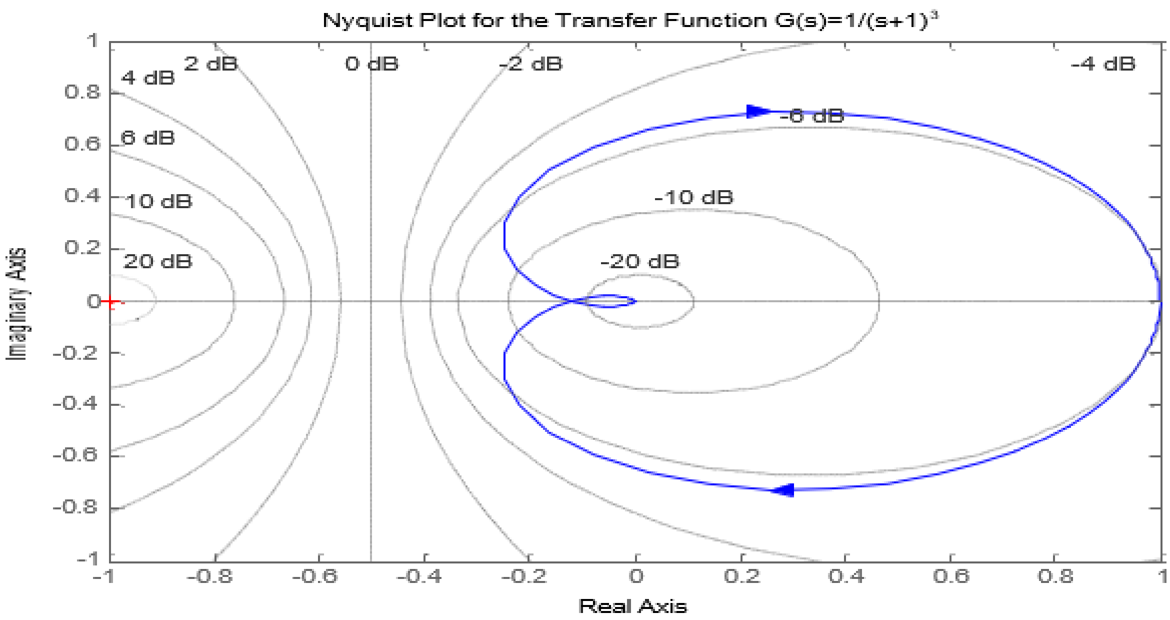


3. Nyquist Plot : The open loop transfer function of a unity feedback system

$G(s)=K/s(s^2+2s+3)$ Draw the Nyquist Plot manually Find (i)Gain Margin (ii)Phase Margin (iii)Gain cross over frequency (iv)Phase cross over frequency and Check the same results using MATLAB Software. (Assume K=1)

Solution

```
%Nyquist Plot for the Transfer Function G(s)=1/(s+1)^3

num=[1];

den=[1 3  3 1];

figure(1
);
nyquist(
num,de
n)

Title('Nyquist Plot for the Transfer Function
G(s)=1/(s+1)^3') [Gm,Pm,Wcg,Wcp]
=margin(num,den)

grid;

[Gm,Pm,Wcg,Wcp]
=margin(num,den);
Gain_Margin=Gm

Phase_Margin=Pm
PhaseCrossover_Frequency=
Wcg
GainCrossover_Frequency=
Wcp
```



Answer

Gain_Margin = 8.0011

Phase_Margin = -180

PhaseCrossover_Frequency = 1.7322

GainCrossover_Frequency = 0

4. **Nichols Chart : The open loop transfer function of a unity feedback system G(s)=60/s(s+2)(s+3) Draw the Nichol's Chart manually Find (i)Gain Margin (ii)Phase Margin (iii)Gain cross over frequency (iv)Phase cross over frequency (v) Resonant Peak (vi)Resonant Frequency (vii)Bandwidth and Check the results using MATLAB Software. (Assume K=1)**

num=[60]; den=[1 8 12 0];

Solution

figure(1); nichols(num,den)

Title('Nichols Plot for the Transfer Function G(s)=60/s(s+2)(s+6)') grid;

[Mag,Ph,w] =bode(num,den);

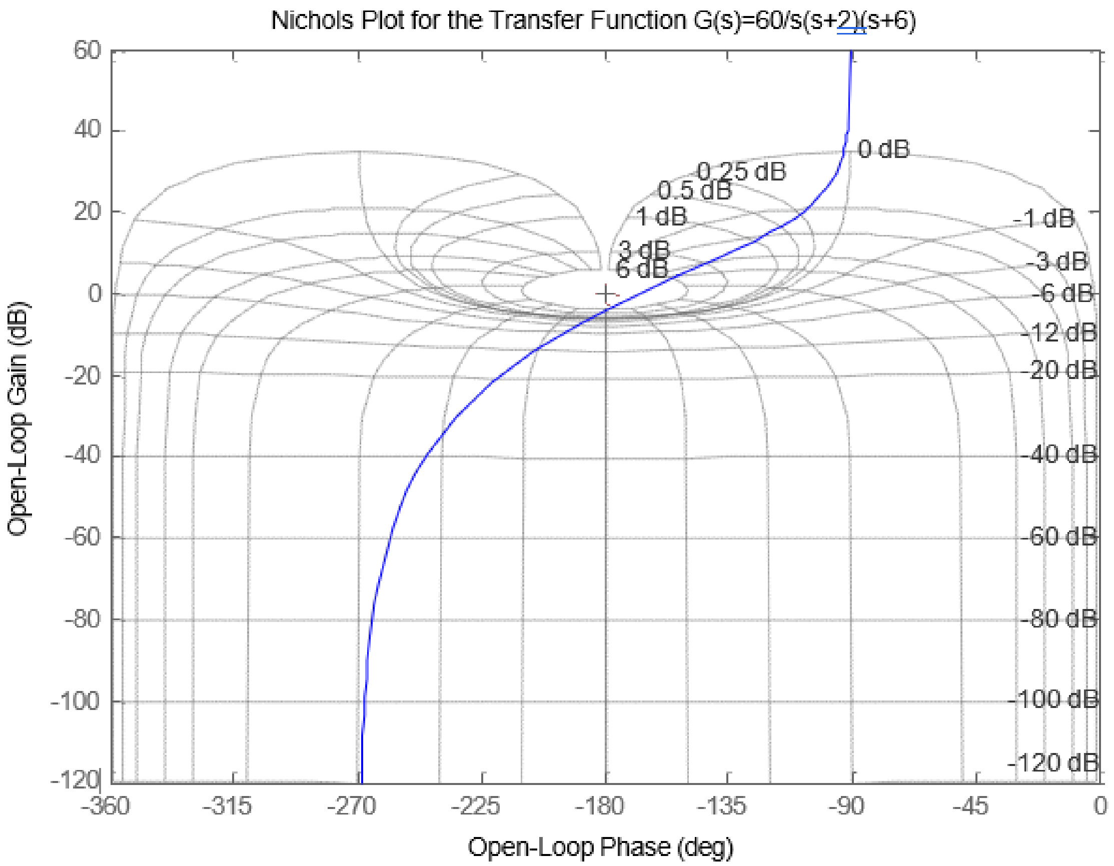
[Gm,Pm,Wcg,Wcp] =margin(num,den);

Gain_Margin=Gm

GainMargin_dB=20*log10(Gm)

Phase_Margin=Pm Phase

```
Crossover_Frequency=Wcg

GainCrossover_Frequency=Wcp

[Mp,k] =max(Mag);

Resonant_Peak=Mp;

Resonant_PeakdB=20*log10(Gm)

Resonant_Frequency=w(k)

% In Nichol's Chart the bandwidth is obtained in -3dB n=1;

while 20*log10(Mag(n))>=-3 n=n+1;

end; Bandwidth=w(n)
```



GainMargin_dB = 4.0824

Phase_Margin = 12.1738

PhaseCrossover_Frequency = 3.4641

GainCrossover_Frequency = 2.7070

Resonant_PeakdB = 4.0824

Resonant_Frequency = 0.1000

Bandwidth = 3.4641

RESULT

Answers

num = 20

den = 1 5 4 0

Transfer function:

```
20
-----------
s^3 + 5 s^2 + 4 s
```

Gm = 1.0000

Pm = 7.3342e-006 Wcp = 2.0000

Wcp = 2.0000

PM = -135

Wg = 0.7016

beta = 5.7480

tau = 11.4025

Transfer function:

```
11.4   s + 1
-------
65.54 s + 1
```

Transfer function:

```
228 s + 20
---------------------------
65.54 s^4 + 328.7 s^3 + 267.2 s^2 + 4 s
```

Gm1 = 5.2261

Pm1 = 38.9569

Wcg1 = 1.9073

Wcp1 = 0.7053

Exp.No: 11 Design, Analysis and implementation of lag, lead and lag-lead compensators

Date:

Aim :

To Design the Lead, Lag and Lead-Lag compensator for the system using MATLAB Software.

Apparatus Required :

- MATLAB Software.

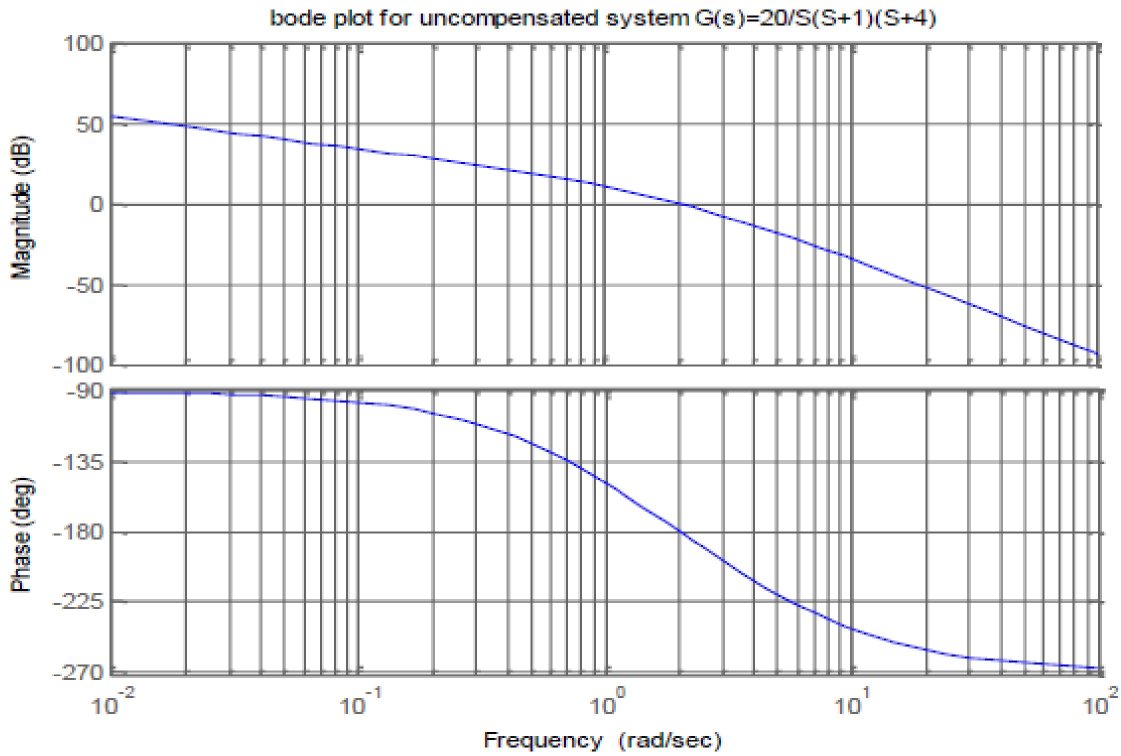
DESIGN PROCEDURE

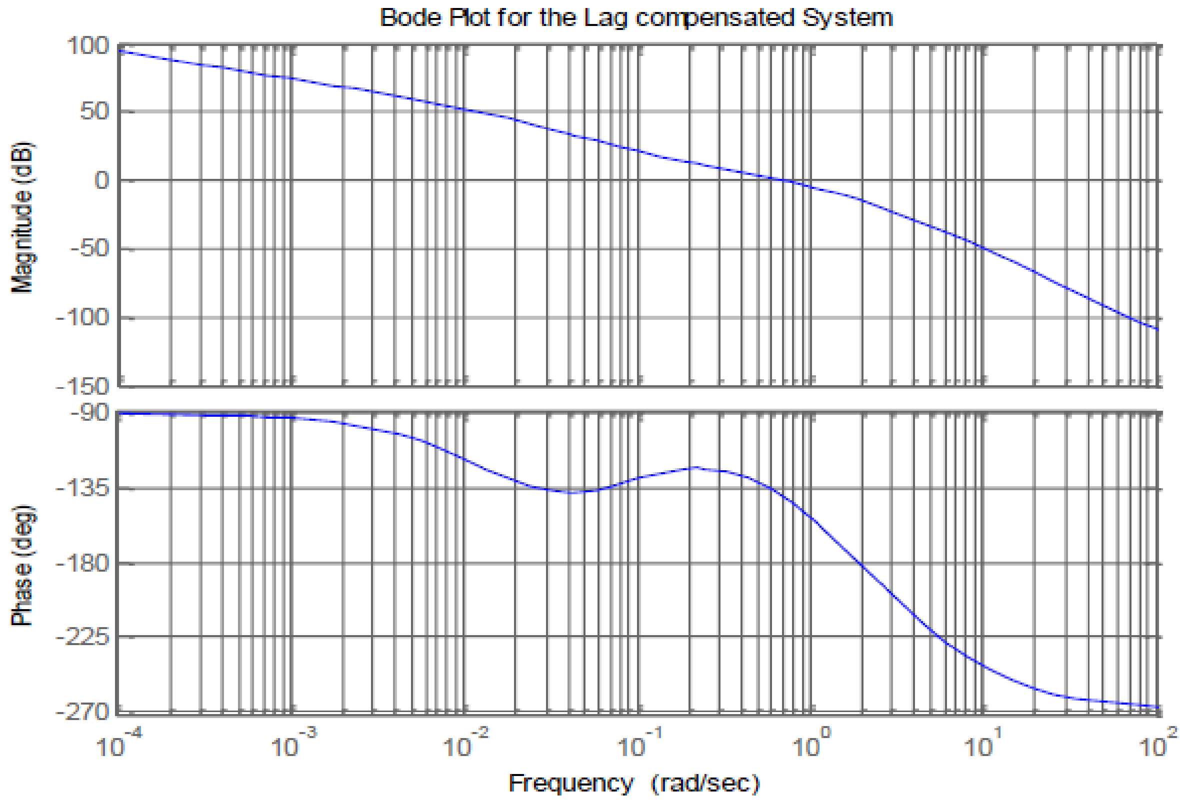
1. Design a Phase Lag compensator for the unity feedback transfer function G(s)=K /s(s+1)(s+4) has specifications : a. Phase Margin>_ 40^0 b. The steady state error for ramp input is less than or equal to 0.2 and check the results using MATLAB Software.

Solution

```
num=[20]

den=[1 5 4 0]

G=tf(num,den)

figure(1);

bode(num,den);

Title('bode plot for uncompensated system G(s)=20/S(S+1)(S+4)')

grid;

[Gm,Pm,Wcp,Wcp]=MARGIN(num,den)
```

```
Gmdb=20*log10(Gm);

W=logspace(-1,1,100)';

[mag,ph]=BODE(G,W);

ph=reshape(ph,100,1);

mag=reshape(mag,100,1);

PM=-180+40+5

Wg=interp1(ph,W,PM)

beta=interp1(ph,mag,PM)

tau=8/Wg

D=tf([tau 1],[beta*tau 1])

Gc=D*G

figure(2);

bode(Gc);

Title('Bode Plot for the Lag compensated System')

grid;

[Gm1,Pm1,Wcg1,Wcp1]=MARGIN(Gc)
```


bode plot for uncompensated system G(s)=20/S(S+1)(S+4)
Magnitude (dB)
Phase (deg)
Frequency (rad/sec)


Bode Plot for the Lag compensated System
Magnitude (dB)
Phase (deg)
Frequency (rad/sec)

2. Design a Phase Lead compensator for the unity feedback transfer function G(s)=K /s(s+2) has specifications : a. Phase Margin>_ 55⁰ b. The steady state error for ramp input is less than or equal to 0.33 and check the results using MATLAB Software. (Assume K=1)

Solution

```
num=[5]

den=[1 2 0]

G=tf(num,den)

figure(1);

bode(num,den);

Title('Bode Plot for uncompensated system G(s)=5/s(s+2)')

grid;

[Gm,Pm,Wcg,Wcp]=MARGIN(num,den)

GmdB=20*log10(Gm)

PM=55-Pm+3

alpha=(1-sin(PM*pi/180))/(1+sin(PM*pi/180))

Gm=-20*log10(1/sqrt(alpha))

w=logspace(-1,1,100)';

[mag1,phase1]=BODE(num,den,w);

mag=20*log10(mag1);

magdB=reshape(mag,100,1);

Wm=interp1(magdB,w,-20*log10(1/sqrt(alpha)))

tau=1/(Wm*sqrt(alpha))
```

```
D=tf([tau 1],[alpha*tau 1])

Gc=D*G

figure(2);

bode(Gc);

Title('Bode Plot for the Lead Compensated System')

grid;

[Gm1,Pm1,Wcg1,Wcp1]=MARGIN(Gc)
```

Answers

```
num =    5
den =    1    2    0
Transfer function:
    5
---------
s^2 + 2 s
Gm =   Inf
Pm =   47.3878
Wcg =   Inf
Wcp =  1.8399
GmdB =   Inf

PM =  10.6122

alpha =   0.6890

Gm =  -1.6181

Wm = 2.0853

tau =    0.5777

 Transfer function:

0.5777 s + 1

------------

0.398 s + 1

 Transfer function:

       2.889 s + 5
```

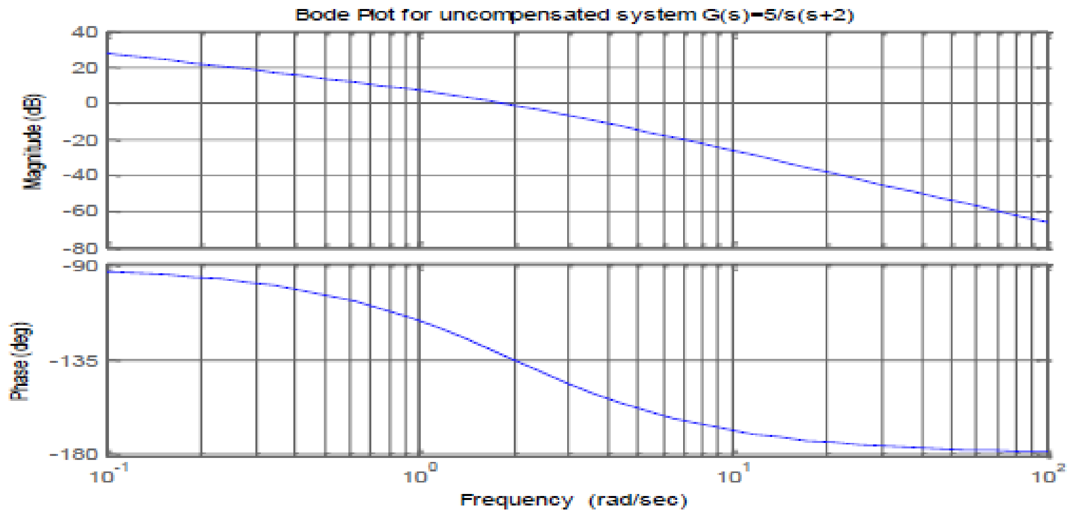
0.398 s^3 + 1.796 s^2 + 2 s

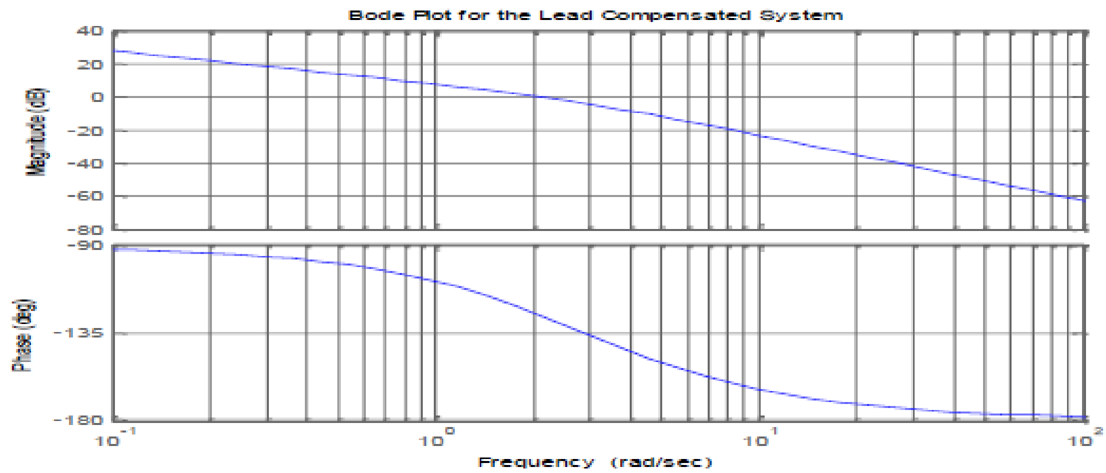
Gm1 =   Inf

Pm1 =   54.4212

Wcg1 =   Inf

Wcp1 =   2.0849





3. Design a Phase Lead-lag compensator for the unity feedback transfer function G(s)=K /s(s+1)(s+2) has specifications : a. Phase Margin>_ 50^0 b. The Velocity error constant Kv=10 sec^{-1} and check the results using MATLAB Software. (Assume K=1).

Solution

```
num=[20]

den=[1 3 2 0]

G=tf(num,den)

figure(1);

bode(num,den);

Title('bode Plot for Uncompensated System G(s)=20/S(S+1)(S+2)')

grid;

[Gm,Pm,Wcg,Wcp]=MARGIN(num,den)

GmdB=20*log10(Gm);

W=logspace(-1,1,100)';

%Bode Plot for Lag Section

[mag,ph]=BODE(G,W);

ph=reshape(ph,100,1);

mag=reshape(mag,100,1);

PM=-180+50+5

Wg=interp1(ph,W,PM)

beta=interp1(ph,mag,PM)

tau=8/Wg

D=tf([tau 1],[beta*tau 1])

%Bode Plot for Lead section

alpha=20/beta

mag=20*log10(mag)

Gm=-20*log10(1/sqrt(alpha))
```

```
Wm=interp1(mag,W,-20*log10(1/sqrt(alpha)))

tau=1/(Wm*sqrt(alpha))

E=tf([tau 1],[alpha*tau 1])

Gc1=D*E*G

figure(2);

bode(Gc1);

Title('Bode Plot for the Lag-lead compensated System')

grid;

 [Gm1,Pm1,Wcg1,Wcp1]=MARGIN(Gc1)
```

Answers

```
num =    20
den =     1     3     2     0
 Transfer function:
      20
-----------------
s^3 + 3 s^2 + 2 s
Gm = 0.3000
Pm = -28.0814
Wcg =  1.4142
Wcp =   2.4253
PM = -125
Wg =    0.4247
beta =   21.2032
tau =  18.8362
 Transfer function:
18.84 s + 1
-----------
399.4 s + 1
 alpha = 0.9433
Gm =   -0.2537
Wm = 2.4546
tau =  0.4195
Transfer function:
0.4195 s + 1
------------
0.3957 s + 1
  Transfer function:


          158 s^2 + 385.1 s + 20
```

----

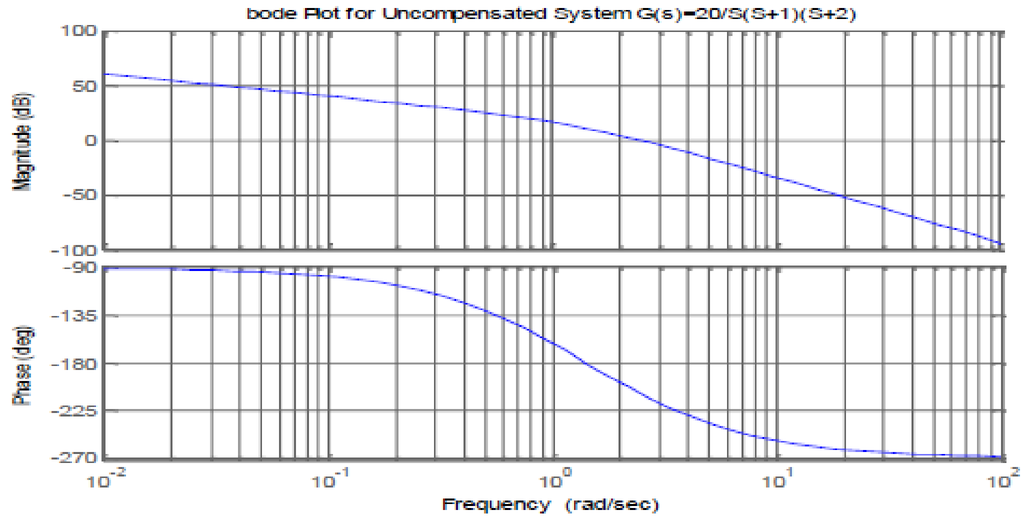
158 s^5 + 873.9 s^4 + 1516 s^3 + 802.6 s^2 + 2 s

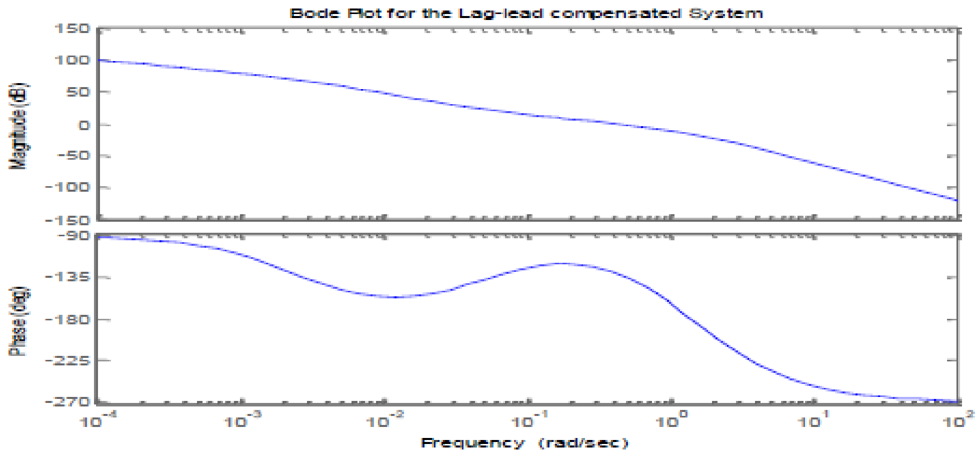
Gm1 = 6.1202

Pm1 = 48.5839

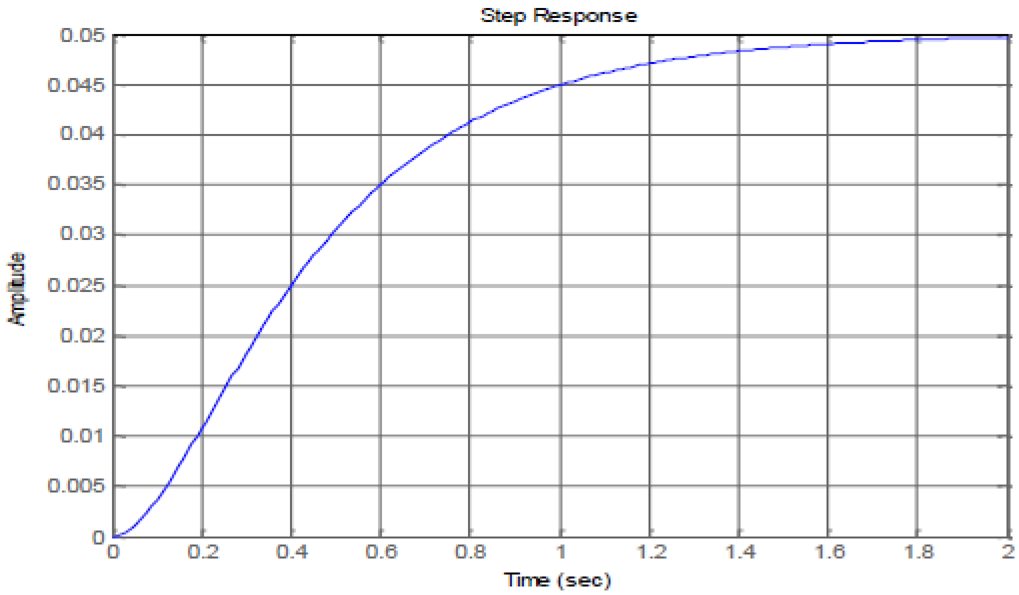
Wcg1 = 1.3976

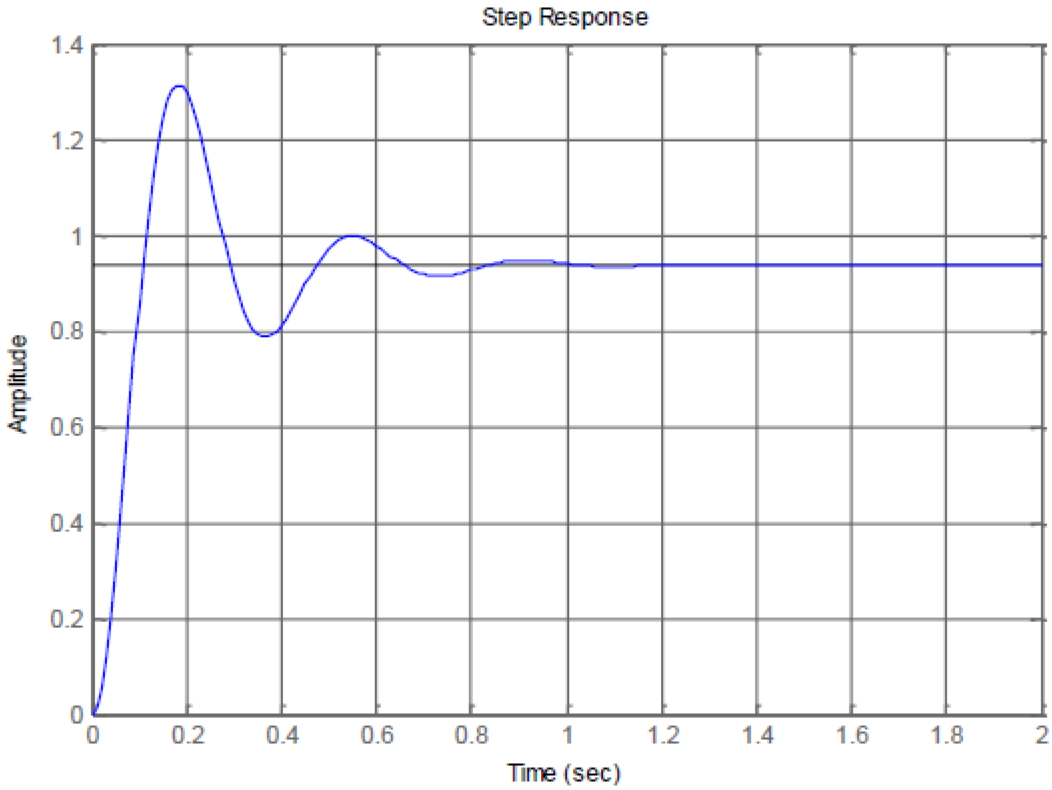
Wcp1 = 0.4279





RESULT


Step Response
Amplitude
Time (sec)
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2


Step Response
Amplitude
Time (sec)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2

Exp.No: 11 **Effect of P, PD, PI, PID controller on a second order system**

Date:

Aim :

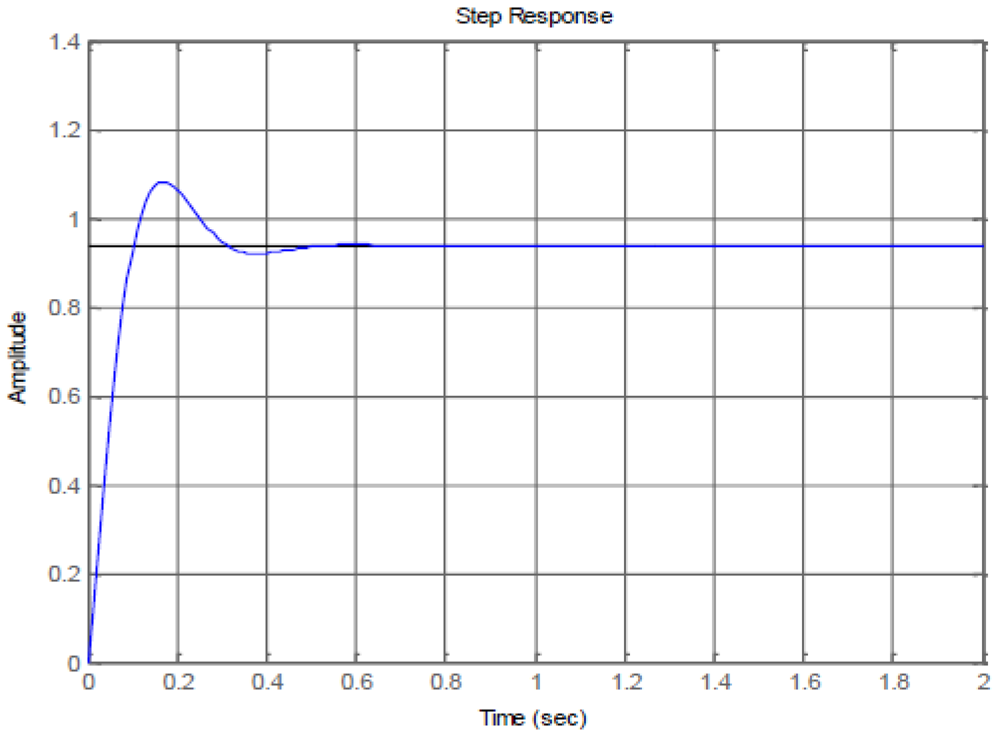
To obtain the response of the P, PI, PD, PID controller using MATLAB software.

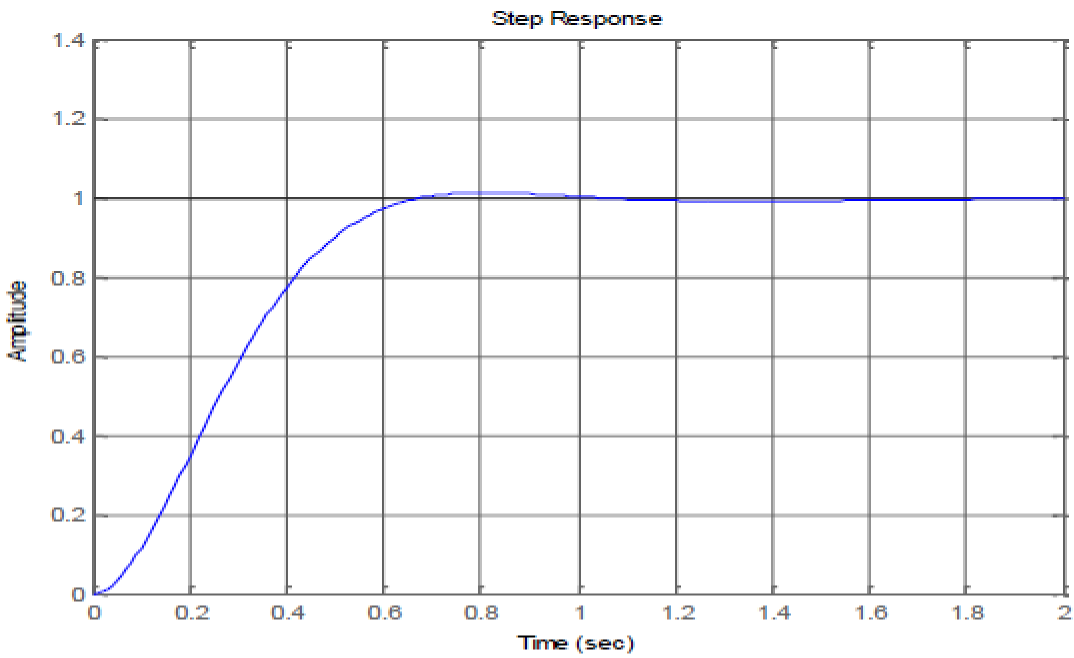
APPARATUS REQUIRED

1. MATLAB Software

PROGRAM

```
% Step Response for OLTF 1/(s^2+10s+20)

num=[1];

den=[1 10 20];

figure(1);

step(num,den)


% Proportional Controller

Kp=300;

num1=[Kp];

den1=[1 10 20+Kp];

t=0:0.01:2;

figure(2);

step(num1,den1,t)

grid;
```


Step Response
Amplitude
Time (sec)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2

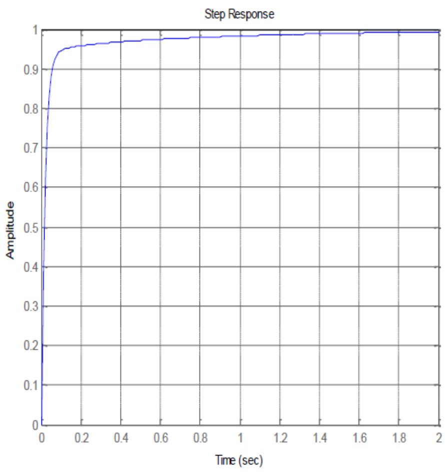

Step Response
Amplitude
Time (sec)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2

% Proportional Derivative Controller

```
Kp=300;
Kd=10;
num2=[Kd Kp];
den2=[1 10+Kd 20+Kp];
t=0:0.01:2;
figure(3);
step(num2,den2,t)
grid;
```

% Proportional Integral Controller

```
Kp1=30
Ki=70;
num3=[Kp1 Ki]
den3=[1 10 20+Kp1 Ki]
t=0:0.01:2;
figure(4);
step(num3,den3,t)
grid;
```



%Proportional Integral Derivative Controller

```
Kp2=350;

Kd2=50;

Ki2=300;

num4=[Kd2 Kp2 Ki2]

den4=[1 10+Kd2 20+Kp2 Ki2]

t=0:0.01:2;

figure(5);

step(num4,den4,t)

grid;
```

RESULT