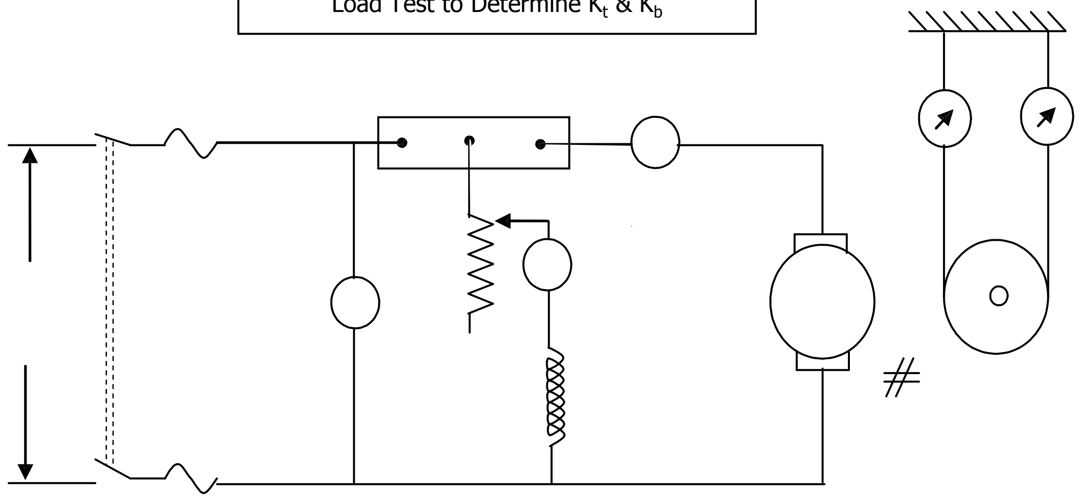
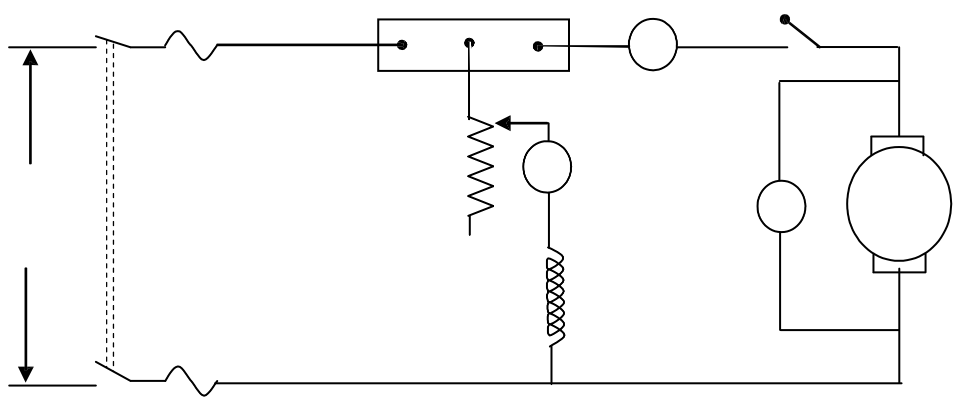
CONTENTS

Exp. No.	Date	Name of the Experiment	Page No.	Signature

Load Test to Determine K_t & K_b



Retardation Test to Find J & F



Exp. No.: **Date:**

Transfer Function of Armature Controlled DC Motor

Aim:

To determine the transfer function of an armature controlled dc shunt motor.

Name Plate Details:

Power :
Voltage :
Current :
Speed :

Apparatus Required:

Sl.No	Name of the Apparatus	Range	Type	Qty
1.	Voltmeter			
2.	Ammeter			
3.	Rheostat			
4.	Techometer			
5.	Lamp Load			

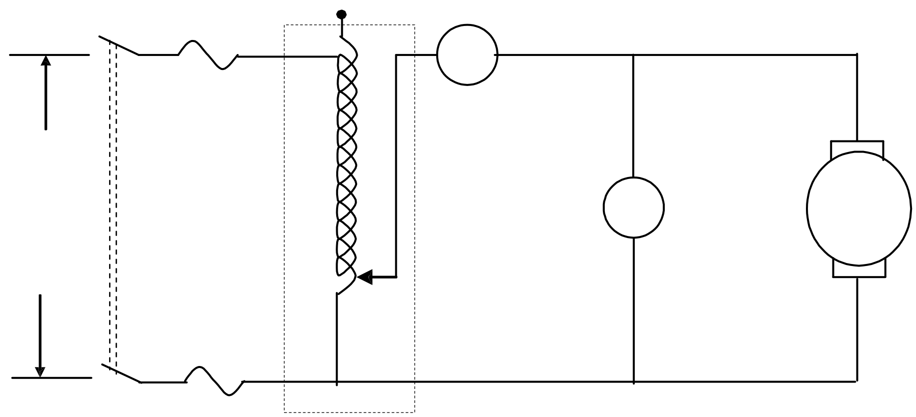
Theory:

The transfer function is defined as the ratio of Laplace transformation of the output variable to the Laplace transformer of input variable. The DC motor converts electrical energy into mechanical energy. The electrical energy supplied at the armature terminals converted into controlled mechanical energy.

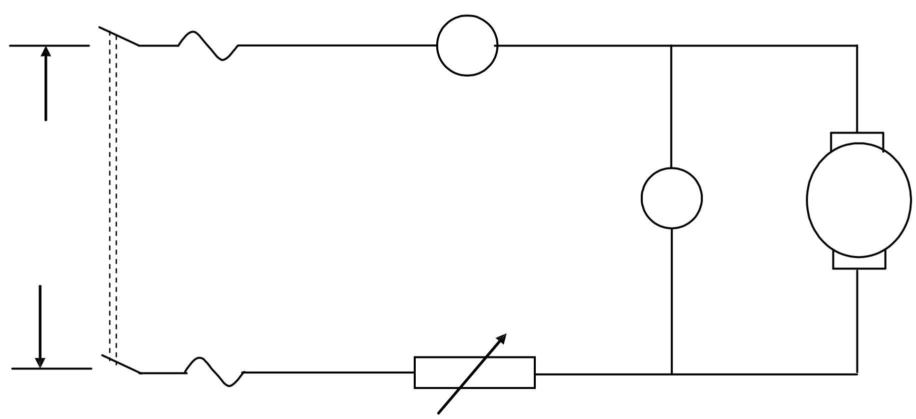
(i) Armature controlled DC shunt motor

In armature control, the field current is kept constant and the armature voltage is varied and hence the speed is varied. The field current I_f (t) is maintained constant by keeping the V $_t$(t) to a constant value V_f and the armature current I_a(t) is varied to change the torque T_m(t) of

To Find Z_a:-



To Find R_a:-



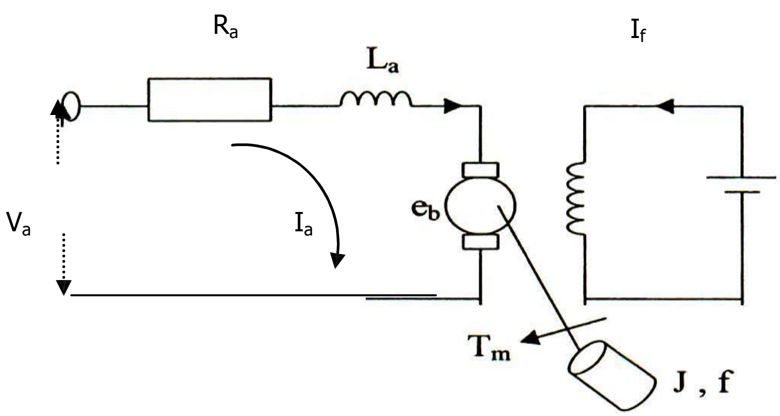
the load connected to the motor shaft. Thus the input variable of the motor is the armature voltage $V_a(t)$ and the output variable is the torque $T_m(t)$. The speed of the DC motor is directly proportional to the armature voltage and inversely proportional to the flux in the armature.

i.e. $N \alpha V_a / \varphi$

In the armature controlled DC motor, the desired speed is obtained by varying the armature voltage.

Transfer Function by Kirchoff's law,

$V_a = I_a R_a + L_a \, dI_a(t)/dt + Eb\,(t)$...................... (1)



Taking Laplace transform of equation (1), we have

$V_a(s) = [R_a+sL_a]\, I_a(s) + E_b(S)$

=> $I_a(s) = [V_a(s) - E_b(S)] / [R_a+sL_a]$.................(2)

Since the field current is kept constant, the torque developed is proportional to the armature current, i.e., the flux developed $\varphi \alpha I_f(t)$, I_f is constant

Hence torque developed $T \alpha I_a$, $T \alpha I_a$ => $T = K_t I_a$.................. (3)

Taking Laplace transform of equation (3), T (s) = Kt Ia (s) .... (4)

Where K =Torque constant, $K_t = \Delta T / \Delta I_a$ N-m / A .... (5)

Tabulations:-

To Find K_t & K_b:-

I_f	I_a	V_a	N (rpm)	$\omega=2\Pi N/60$ (Rad/sec)	$E_b=V_a-I_aR_a$	$T=E_bI_a/\omega$ (N-m)
Rated Value (0.5A)						

To Find J & F:-

Retardation Test For	Range of Speed (Rpm)	Time (Sec)
J only	1500 to 225	
Both J & F	1500 to 225	

To Find R_a:-

v_a (V)	I_a (A)	$R_a = V_f/I_f$

The torque equation is given by,

$T(t) = J_d{}^2\theta/d_t^2 + f\, d\theta/d_t$ ....(6)

Taking Laplace transform of equation (6),

$T(s) = Js^2\,\theta(s) + f\, s\theta(s)$. ....(7)

Substituting equation (4) in (7),

$K_t\, I_a\,(s) = Js^2\theta(s) + f\, s\theta(s)$

$s\theta(s)\,[Js+f] = K_t\, I_a\,(s)$ ....(8)

Substituting equation (2) in (8),

$s\theta(s)\,[Js+f] = Kt\,[Va(s) - Eb(S)] / [Ra+sLa]$..........(9)

Motor back emf is proportional to speed,i.e.,

$E_b(t) = K_b\, d\theta/dt = K_b\,\omega(t)$..........(10)

Where Kb = back emf constant.

Taking laplace transform of equation (10),

$E_b(s) = K_b\,\omega(s)$..............................(11)

Substituting equation (11) in (9),

$s\theta(s)\,[Js+f] = K_t\,[V_a(s) - K_b\omega(s)] / [R_a+sL_a]$

$\omega(s)\,[Js+f] = K_t\,[V_a(s) - Kb\omega(s)] / [R_a+sL_a]$, since $d\theta/dt = \omega(s)$ & $s\theta\,(s) = \omega(s)$

$$\boldsymbol{\omega(s) / V_a(s) = K_t / K_t\, K_b + (sJ+f)\,(R_a+sL_a)}$$

Where, R_a = Armature resistance; Ω

L_a = Armature Inductance; Hendry

K_t = Torque constant = $\Delta T / \Delta I_a$; N-m / A

K_b= Back emf constant = ~Eb / ~ N ; Volts/(rad/sec)

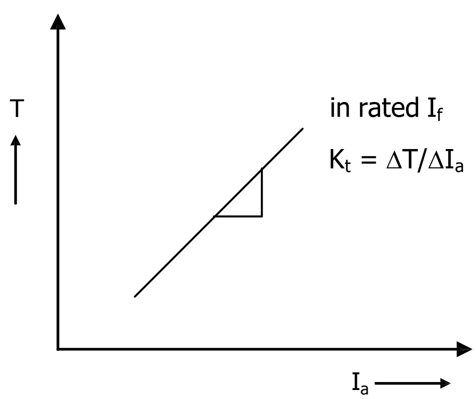
f= Frictional constant; N-m/(rad/sec)

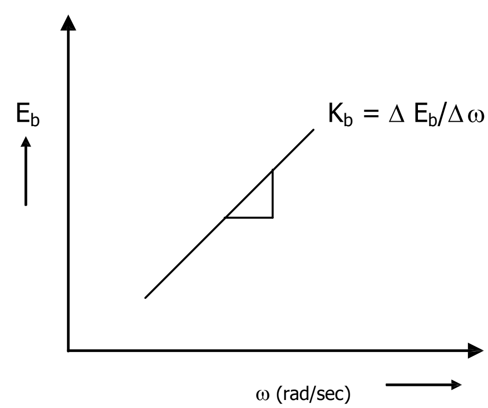
J = moment of Inertia; kg-m^2

To Find Z_a:-

V_a (V)	I_a (A)	$Z_a = V_f/I_f$

Model Graph: [to find K_t & K_b]





Formulae:

Total losses in a circuit = $V (I_a+I_f) - Ia^2R - VI_f$

Energy = (Losses * t) = $\frac{1}{2} J (\omega_1^2 - \omega_2^2)$

N_1 =1500 rpm; N_2 = 225 rpm; $\omega = 2\Pi N/60$

$J = (Losses * t * 2) / (\omega_1^2 - \omega_2^2)$

$f = J/\sum m$

$L_a = \sqrt{Z_a^2 - R_a^2} / 2\P f$

f = frequency

$\omega(s) / V_a(s) = K_t / K_t K_b + (sL+f)(R_a+sL_a)$

Procedure:

(i) Load test to determine K_t & K_f

- Conduct the load test with normal rated value of field currents.
- Give the connections as per circuit diagram.
- Keep the field rheostat in minimum position & switch on 230 V supply.
- Adjust the field rheostat to rated speed & consider the corresponding field current as rated field current.
- For different loads note down I_a,V_a & speed
- Calculate the torque developed.
- Plot a graph between T(Y -axis) and Ia (X-axis) for both the cases.
- From this graph, obtain K_t.
- Plot the graph between E_b Vs ω.
- From this graph, obtain K_b.

(ii) Retardation Test to find J & f

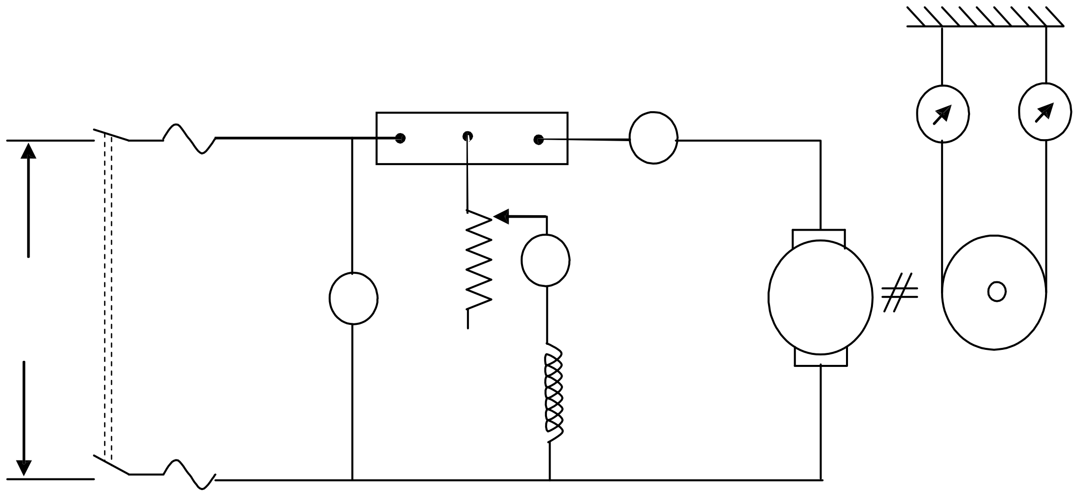
The total losses can be divided into two parts,viz., constant losses and variable losses. The constant losses include frictional & inertia losses.

- Give the connections as per circuit diagram.
- By closing the switch, make the measurement of V ,I_a and I_f.
- Make the motor to run at a speed greater than 1600 RPM.
- Open the switch suddenly.
- Using stopwatch, note down the time taken for the speed of the motor to fall down from (ω_1 =1500 rpm, ω_2 =225 rpm)
- The moment of inertia, J is obtained from the relation between loss, time and ω
- The friction constant, f is obtained using the exponential relation between speed, time and time constant. ζ m = t1~ t2/ ln (N1- ln N2) ☞ natural log
- Calculate no load input power using the values read by ammeter & voltmeter connected to armature circuitry.

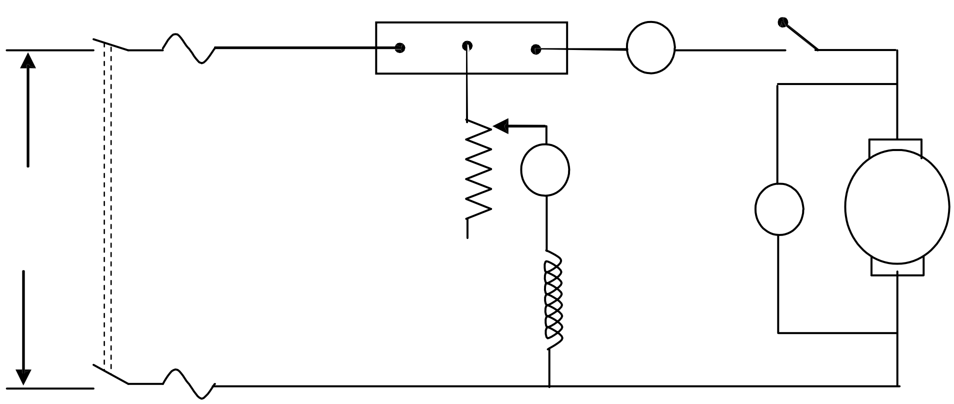
Result:

Thus the transfer function of dc shunt motor by armature control is determined.

Load Test to Determine K_t & K_b



Retardation Test to Find J & F



Exp. No.: **Date:**

Transfer Function of Field Controlled DC Motor

Aim:

To determine the transfer function of a field controlled dc shunt motor.

Name Plate Details:

Power :
Voltage :
Current :
Speed :

Apparatus Required:

Sl.No	Name of the Apparatus	Range	Type	Qty
1.	Voltmeter			
2.	Ammeter			
3.	Rheostat			
4.	Techometer			
5.	Lamp Load			

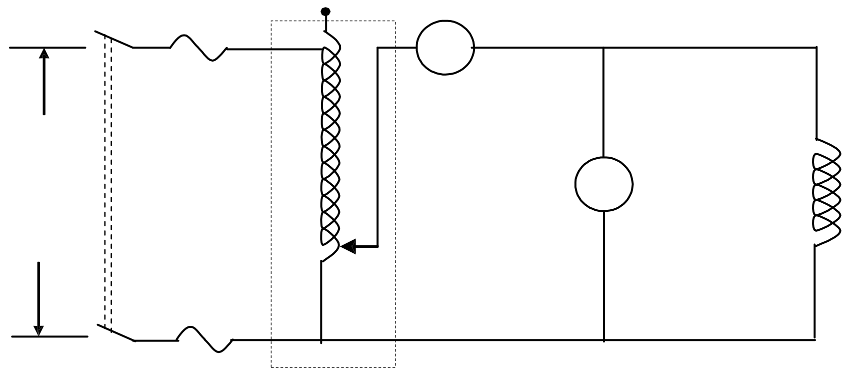
Theory:

The transfer function is defined as the ratio of Laplace transform of the output variable to the Laplace transform of input variable. The DC motor converts electrical energy into mechanical energy. The electrical energy supplied at the armature terminals converted into controlled mechanical energy.

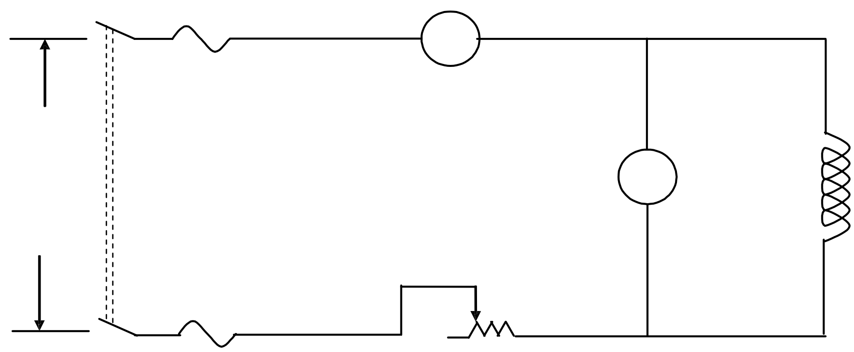
(ii) Field Controlled DC Shunt Motor

In field control method, the armature current Ia(t) is maintained to a constant value Ia while the field voltage V.(t) is varied to control the speed or torque of the motor. Thus the input of the motor is field voltage V.(t) and the output is the motor speed and the load displacement.

To Find Z_f :-

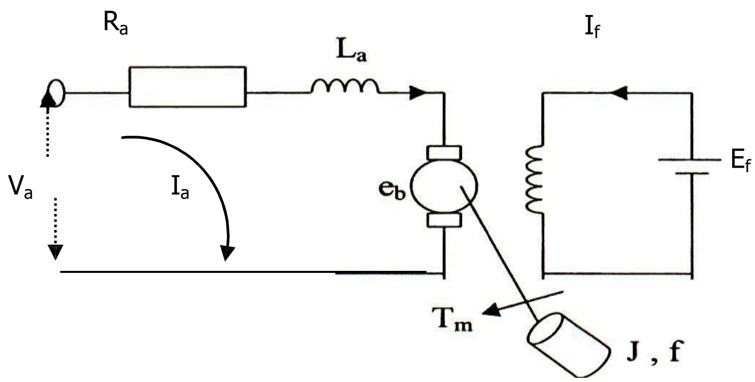


To Find R_f :-



Transfer Function:

The circuit for field controlled dc shunt motor is given in figure.



Where, R_f = Resistance of field circuit ;Ω
L_f = Inductance of field circuit; Henry
E_f = Excitation voltage; Volts
I_f = Excitation current; Amperes
J = Moment of Inertia; kg-m^2

f= Co efficient of friction ;N-m / (rad/sec)
ω = Angular velocity = $d\theta/dt$ in rad/sec
Applying Kirchoffs law,
$E_f(t) = R_f I_f(t) + L_f dI_f(t)/dt$ ....(1)
Taking Laplace transform of equation (1)
$E_f(s) = R_f I_f(s) + L_f s I_f(s)$, which implies $I_f(s) = E_f(s) / [R_f+sL_f]$ ....(2)
The torque developed is proportional to the field current, since the armature current is constant i.e.

$\varphi \; \alpha \; I_f$ & $T \; \alpha \varphi \; I_a$ as I_a is constant, $T \; \alpha \; \varphi$, which implies $T \; \alpha \; I_f$

$T = K_f \; I_f(t)$............(3)

Where $K_f = \Delta T / \Delta I_f$= Constant in N-m /amperes................(4)

Taking laplace transform of equation (3), $T(s) = K_f \, I_f(s)$..............(5)

The torque equation is given by,

$T(t) = Jd^2\theta/dt^2 + fd\theta/dt = Jd\omega/dt + f\omega$

Taking laplace of the above equation,

$T(s) = Js\omega(s) + f\omega(s)$..............(6)

Substituting equation (5) in (6),

$K_f I_f(s) = Js\omega(s) + f\omega(s)$, which implies $\omega(s) = K_f \, I_f(s)/[Js+f]$.........(7)

Substituting equation (2) in (7),

$$\omega(s)/E_f(s) = K_f/\{[sJ+f][R_f+SL_f]\}$$

Tabulations:-

To Find K_f:-

I_f	I_a	V_a	N (rpm)	$\omega=2\Pi N/60$ (Rad/sec)	$E_b=V_a-I_aR_a$	$T=E_bI_a/\omega$ (N-m)
Rated Value (0.5A)						
80 % Rated Value						

To Find J & F:-

Retardation Test For	Range of Speed (Rpm)	Time (Sec)
J only	1500 to 225	
Both J & F	1500 to 225	

Procedure:

(i) Load test to determine K_f

- Conduct the load test with two constants normal (rated value) & sub normal (say 80% of rated field current) values of field currents.
- Give the connections as per circuit diagram. .
- Keep the field rheostat in minimum position & switch on 230 V supply.
- Adjust the field rheostat to rated speed & consider the corresponding field current as rated field current.
- For different loads note down Ia,Va & speed
- Calculate the torque developed.
- Repeat the same for 80% of excitation current.
- Plot a graph between T (Y-axis) and Ia (X-axis) for both the cases.
- From the graph deduce two points (T_1,I_{f1} and (T_2,I_{f2}) for the same armature current (I_a = rated or maximum value).
- Plot the graph between T Vs I_f
- From this graph, obtain K_f.

(ii) Retardation Test to find J & f

The total losses can be divided into two parts,viz., constant losses and variable losses. The constant losses include frictional & inertia losses.

- Give the connections as per circuit diagram.
- By closing the switch, make the measurement of V ,I_a and I_f.
- Make the motor to run at a speed greater than 1600 RPM.
- Open the switch suddenly.
- Using stopwatch, note down the time taken for the speed of the motor to fall down from (ω_1 =1500 rpm, ω_2 =225 rpm)
- The moment of inertia, J is obtained from the relation between loss, time and ω
- The friction constant, f is obtained using the exponential relation between speed, time and time constant. ζ m = t1~ t2/ ln (N1- ln N2)
- Calculate no load input power using the values read by ammeter & voltmeter connected to armature circuitry.

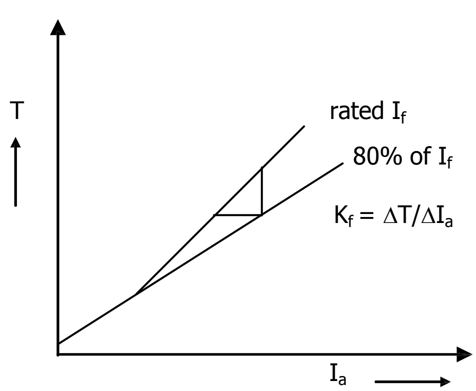
To Find R_f:-

V_f (V)	I_f (A)	$R_f = V_f/I_f$

To Find Z_f:-

V_f (V)	I_f (mA)	$Z_f = V_f/I_f$ (KΩ)

Model Graph: [to find K_t & K_b]



Formulae:

Total losses in a circuit = $V (I_a+I_f) - Ia^2R - VI_f$

Energy = (Losses * t) = ½ J $(\omega_1^2 - \omega_2^2)$

N_1 =1500 rpm; N_2 = 225 rpm; $\omega = 2\Pi N/60$

J = (Losses * t *2) / $(\omega_1^2 - \omega_2^2)$

f = J/ ζ m

$L_f = \sqrt{Z_f^2 - R_f^2}$ / 2¶f

$\omega(s)/ E_f(s) = K_f / \{ [sJ+ f] [R_f+ sL_f]\}$

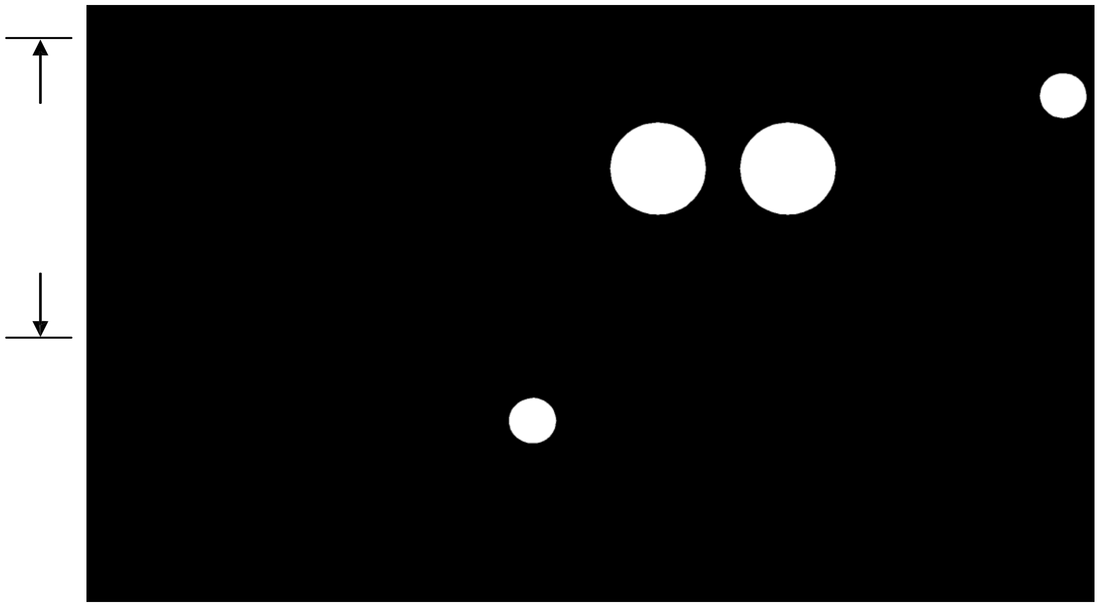
(iii) V-A method to obtain L_f

- Give the connections as per circuit diagram.
- Measure R_a & R_f. [As the field winding resistance is of the order of 250-3000hms and it can withstand a current of 1A,the circuit shown can be used for measurement of R_f Similarly, as the armature resistance is of order of 0.2 - 1 ohms and it can be measured using the circuit shown]
- To measure L_f & L_a, give the connections as shown.
- Apply an ac voltage & measure the field reactance Zr & armature reactance Za.
- Calculate X_f =Square root of $Z_f^2 - R_f^2$ and L_f = Square root of $(Z_f^2 - R_f^2)/ 2\Pi f$

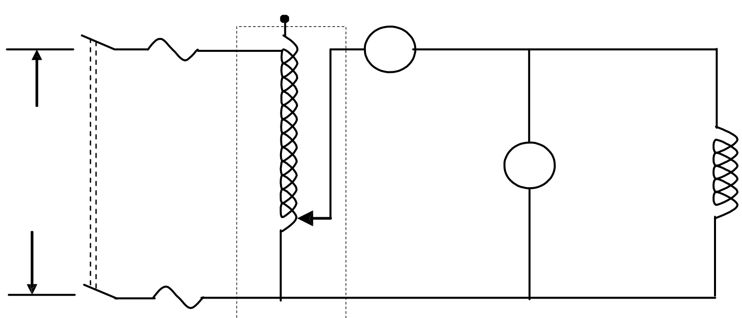
RESULT:

Thus the transfer function of dc shunt motor by field-control method is determined.

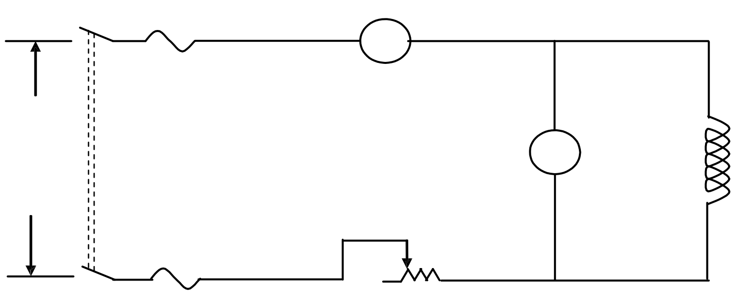
Transfer function of separately excited dc shunt generator on load



To Find Z_f :-



To Find R_f :-



Exp.No.: **Date:**

Transfer function of separately excited dc shunt generator on load

Aim:-

To determine the transfer function of Separately Excited DC generator on load condition.

Name Plate Details:

Power :
Voltage :
Current :
Speed :

Apparatus Required:

Sl.No	Name of the Apparatus	Range	Type	Qty
1.	Voltmeter			
2.	Ammeter			
3.	Rheostat			
4.	Techometer			
5.	Lamp Load			

Precautions:-

1. Field rheostat at motor side should be at minimum resistance position.
2. Potential divider must be kept at minimum potential position.
3. Starter handle should be at OFF position.
4. DPST switch should be in open.

Procedure:-

1. Connections are made as per the circuit diagram.
2. Close the DPST switch.
3. Start the motor with the help of 3 point starter.
4. By adjusting the field rheostat in the motor side the machine is made to run in the rated speed of the generator.

Tabulations:-

To find R_L:-

S.No	Generated voltage (I_g)	Generated current I_g	$R_L = E_g/I_g$

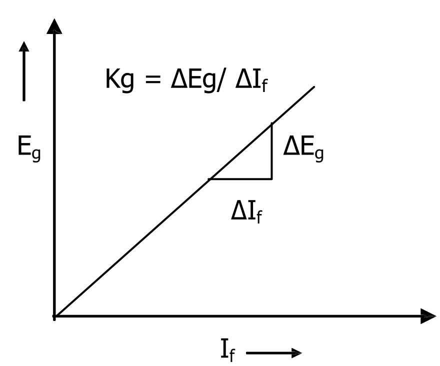
To find Z_f:-

S.No	V_f	I_f	$Z_f = V_f/I_f$	$X_f = \sqrt{(Z_f^2 - R_f^2)}$	$L_f = X_f/2\pi_f$

To find R_f:-

S.No	V_f	I_f	$R_f = V_f / I_f$

Model graph:



5. Note the value of field current, field voltage generated voltage when the field current is zero.
6. By varying the potential divider find out If, E_g, V_g, which are used to calculated R_L, R_f.
7. To find the R_{eff}, find the armature resistance of the generator.
8. Auto transformer is used to find field impedance, field reactance and field inductance.

Formulae:

Transfer function: $$\frac{E_o(s)}{E_f(s)} = \frac{K}{1+sT}$$

Where,

$K = K_g/R_f$ (no unit)

K_g = Generated emf constant

R_f = Field resistance

$K_g = \Delta E_g / \Delta I_f$

Where,

ΔE_g = Voltage generated

ΔI_f = Field Current

$T = L_f/R_f$

Where,

T = Time constant

L_f = Field Inductance

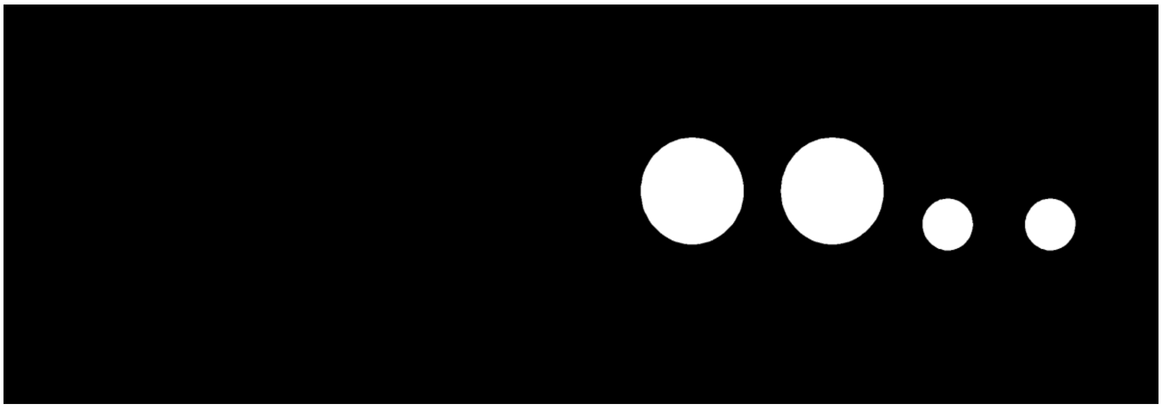
R_f = Field Resistance

Result:-

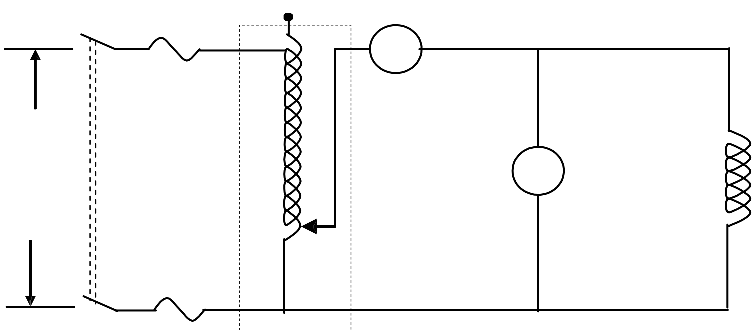
Thus the transfer function of Separately Excited DC generator on load condition is successfully determined.

The transfer function is $$\frac{E_o(s)}{E_i(s)} =$$

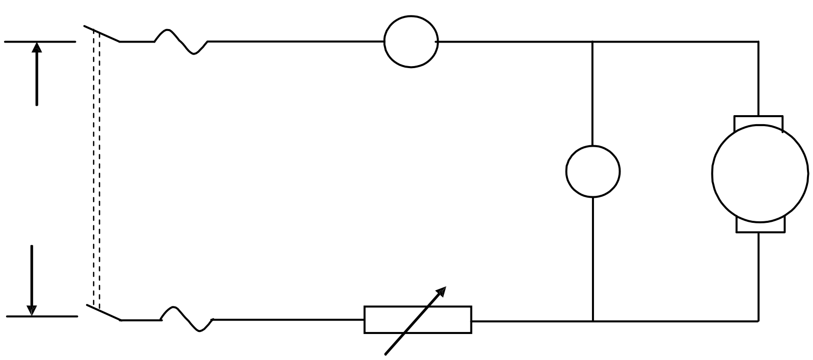
Transfer function of self excited DC shunt generator on load condition



To Find L_f :-



To Find R_a:-



Exp.No.: **Date:**

Transfer function of self excited DC shunt generator on load condition

Aim:-

To determine the transfer function of self excited DC shunt generator on load condition.

Name Plate Details:

Power :
Voltage :
Current :
Speed :

Apparatus Required:

Sl.No	Name of the Apparatus	Range	Type	Qty
1.	Voltmeter			
2.	Ammeter			
3.	Rheostat			
4.	Techometer			
5.	Lamp Load			

Precautions:-

1. Field rheostat of motor should be kept at minimum resistance position.
2. Potential divider must be kept at minimum potential position.
3. Starter handle should be at OFF position.
4. DPST switch should be kept at OFF before starting the motor.

Procedure:-

1. Connections are made as per the circuit diagram.
2. Close the DPST and start the motor with the help of the three point starter.
3. By adjusting the field rheostat on the motor side the machine is made to run at rated speed.

Tabulations:-

To find K_g & R_f.

S.No	V_f (volts)	I_f (A)	I_L (A)	E_g (V)	$R_f = V_f/I_f$	$R_L = E_g/I_L$

To find R_a

S.No	V_a (volts)	I_a (amp)	$R_a = V_a/I_a$

To find Lf:-

S.No	V_f (volts)	I_f (mA)	$Z_f = V_f/I_f$	$X_f = \sqrt{(Z_f^2 - R_f^2}$	$L_f = X_f/2\pi_f$

4. Note down the value of field current and voltage generated voltage the field current at zero.
5. By varying the loading rheostat the corresponding values of ammeter and voltmeter readings are noted.

Formula :-

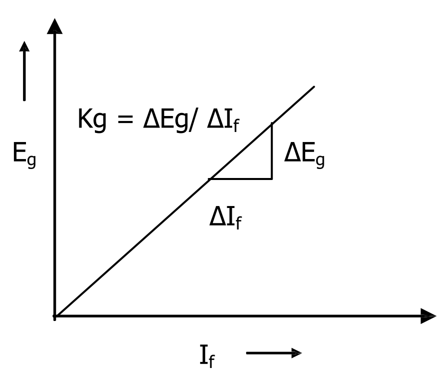
Transfer function $T(s) = \frac{K}{1+sT}$

Where, $K = \frac{K_g R_L}{R_f (R_a+R_L)}$

$Kg = \Delta E_g / \Delta I_f$

$T = Lf/Rf$

Model graph:

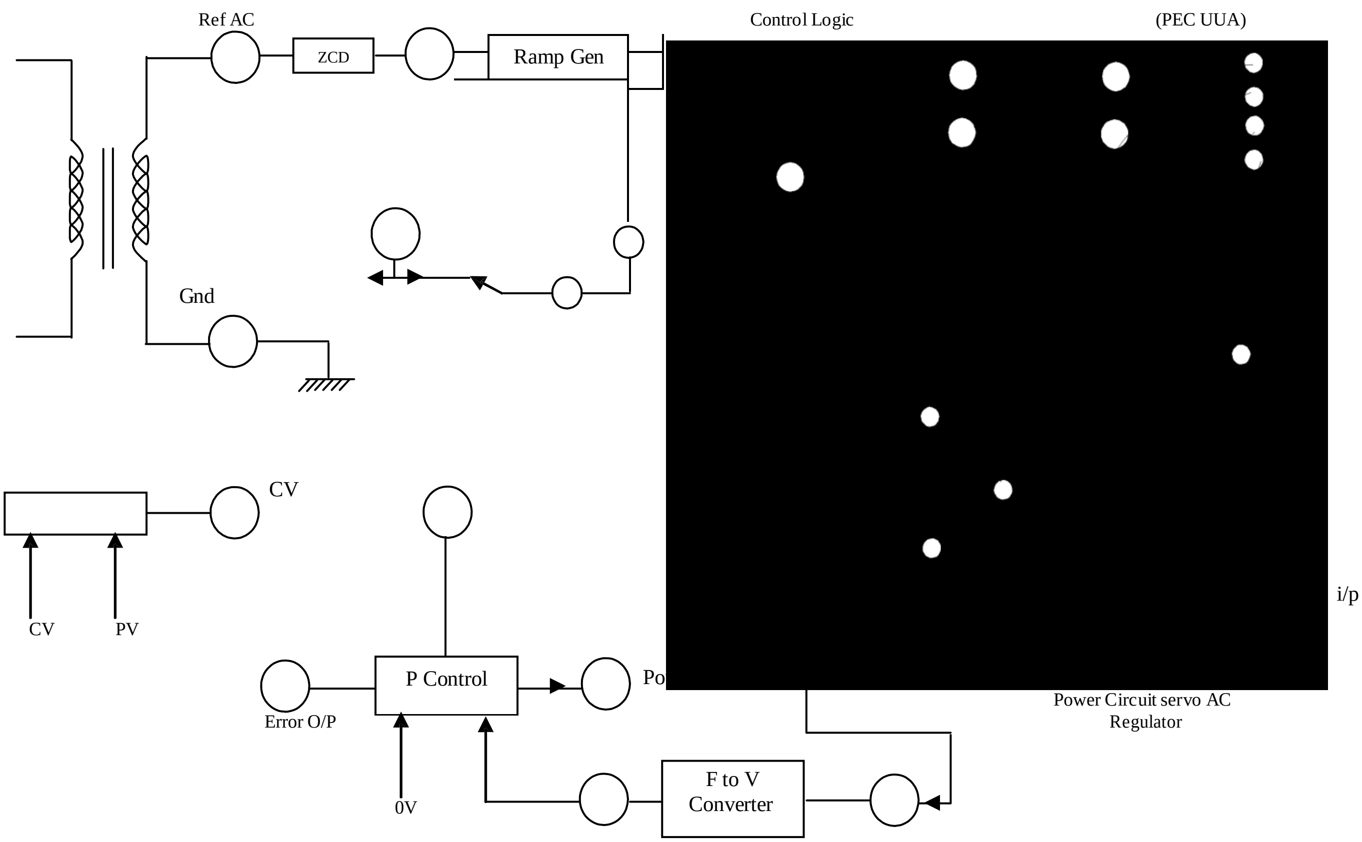


Result:-

Thus the transfer function of self excited DC shunt generator on load condition is determined and is found to be,

$T(s) = K/(1+sT)$

Measurement of Transfer Function Parameters of AC servomotor



Exp.No: **Date:**

Measurement of Transfer Function Parameters of AC servomotor

Aim:

To determine the motor constants K_u and K_z and to find transfer function of motor.

Apparatus Required:

1. Voltmeter (0- 20) V Mc
2. Patch chards
3. Single phase AC servomotor speed control and transfer function study trainer kit.

Procedure:

To determine value of k_z : -

1. Connect G_1K_1 of pulse isolation output to G_1K_1 of SCR.
2. Connect G_2K_2 of pulse isolation output to G_2K_2 of SCR
3. To operate open loop control mode using switch S_1.
4. 9 – pin - D connector is connected from over setup to back side of trainer.
5. Keep speed indicator switch in PV mode.
6. Connect AC voltmeter (0 – 20)V or Multimeter across the control phase winding C_1 and C_2.

Experimental Procedure:-

1. Switch on 230V AC supply to winding reluctance.
2. Switch on 230V AC supply to motor setup.
3. Switch on pulse on/off switch S_2.
4. Vary control voltage pot and set the rated voltage (11.4) to control phase winding.
5. Apply load on motor step by step to motor upto zero rpm.
6. For each step, note readings (load, speed) as shown.
7. Calculate torque value.
8. Plot graph speed vs torque.
9. Slope of speed torque curve gives K_2.

To determine the value of K_1

1. Connects G_1K_1 of pulse isolation output to G_1K_1 of SCR_1.
2. Connects G_1K_1 of pulse isolation output to G_2K_2 of SCR_2.
3. To operate open loop control mode using switch S_1.

TABULATION:-

Control voltage = Rated voltage.

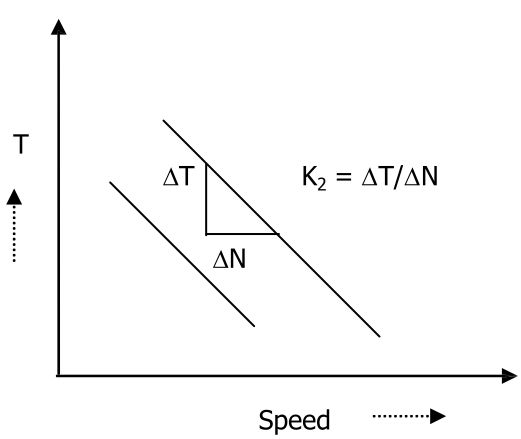
For K_2 :-

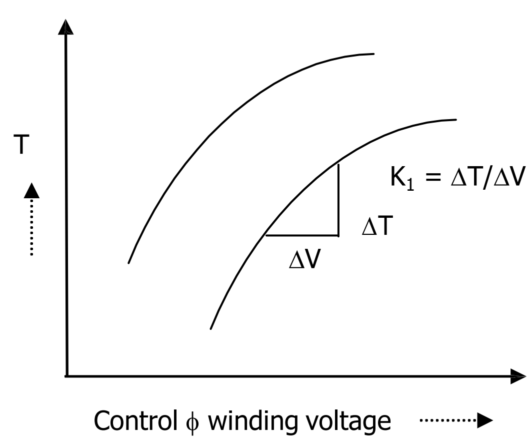
Speed (rpm)	Load (K_g)	Torque (nm)

For K_1:-

Load (K_g)	Control Voltage (V)	Torque (nm)

Model Graph:-





4. 9 pin D connector is connected from motor setup to back side of trainer.
5. Keep speed indicator switch in PV mode.
6. Connects AC Voltmeter (0-20)V of Multimeter across control phase winding.

Experimental procedure:-

1. Switch ON the 230V AC supply to reference winding.
2. Switch ON the 230V AC supply to motor setup.
3. Switch ON the pulse ON/OFF switch S_2.
4. Vary control voltage pot or and set the rated voltage to control phase winding.
5. Apply load on motor, step by step up to zero rpm.
6. For each step, note down load and voltmeter readings.
7. Calculate torque and the plot graph torque vs control voltage.
8. A slope of torque vs control voltage curve gives motor constant K_2.

From observation:-

$K_2 = 2*10^{-5}$; $K_1 = 7.5*10^{-3}$

$$T.F = \frac{W(S)}{E_c(S)} = \frac{K_1}{SJ+K2+B} = \frac{K_m}{1+ST_m}$$

$K_m = K_1/ K_2+B$ => Motor gain Constant

$T_m = J/ K_2+B$ => Motor time Constant

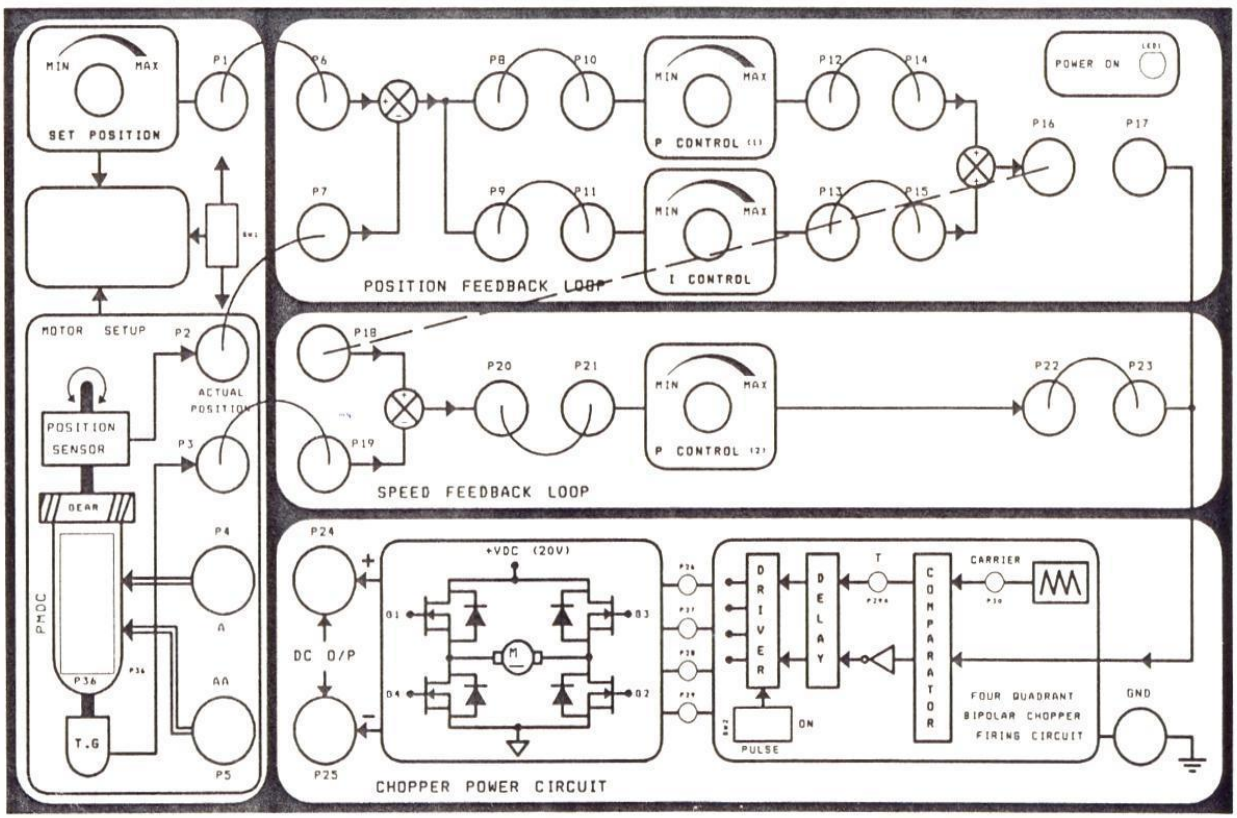
$J= 52gm/cm^2$ B= 0.01875

Result:-

Thus motor constants K_1 and K_2 are obtained and AC servo motor T.F is:-

$$\frac{W(s)}{E(s)} = \frac{K_1}{SJ+K_2+B} = \frac{K_m}{1+ST_M} =$$

Dc Servomotor Position Controller



Exp. No: **Date:**

DC Servomotor Position Controller

Aim:-

To study the DC servomotor position controller with PI control.

Apparatus Required:-

1. PEC – 01
2. Connecting Wires
3. Motor setup

Procedure:-

1. Connections are given as per circuit diagram.
2. Checks whether the pulse release switch is in OFF position.
3. If it is in ON position by varying the set position.
4. Switch on the unit.
5. Set the motor at any position by varying the set position.
6. Notice the input position in digital display.
7. Now release the pulse and release the switch alos, so at the same time there is no voltage.
8. Note output position in digital display.
9. Tabulate the input and output position voltage at S_p and P_r.

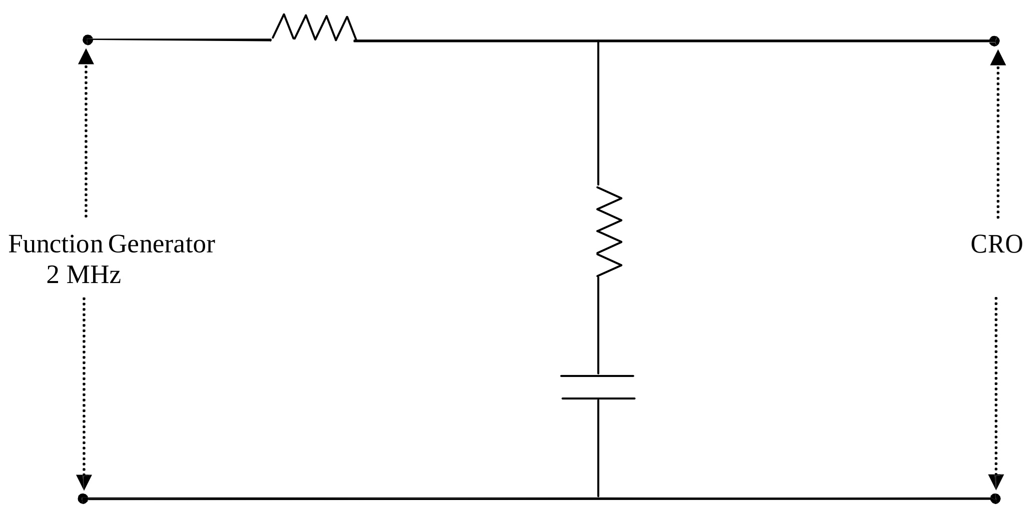
Tabulation:-

Set Point (Sp)		Motor Position Variables (Pr)				Error	
		Before		After			
Q (deg)	V (volts)	Q (deg)	V (volts)	Q (deg)	V (volts)	Before (v)	After (v)

Result:-

DC Servomotor position controller was studied with PI controller.

LAG NETWORK



Exp. No: **Date:**

STUDY OF LAG NETWORK

Aim:-

To obtain the transfer function and hence identify the components of LAG network.

Apparatus Required:-

Sl.No	Name of the apparatus	Range	Type	Qty

Procedure:-

1. The resistor values are choosen and the connections are made as per the circuit diagram.
2. The input voltage of required volt is given from function generator.
3. The frequency range is choosen for the corresponding frequency of the out put $v_{o\,,}$ a and b component are notoed.
4. For various frequency this steps are repeated.
5. The gain is $_{20}$ log vo/vin in db.

Theory:-

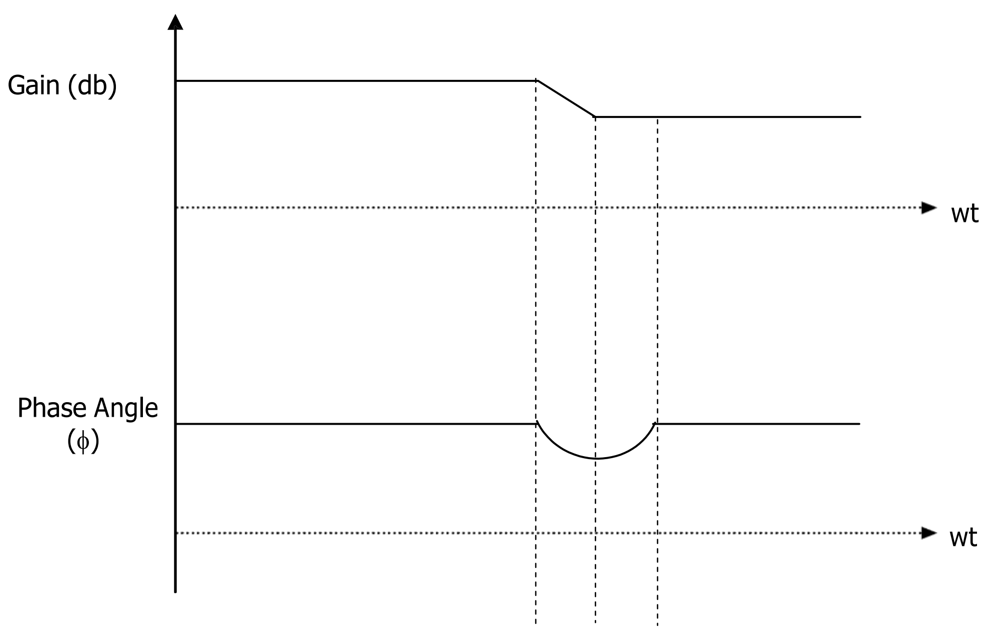
This consists of inserting an extra pole into the transfer function at a lesser frequency than the existing poles. This introduces a phase lag into the amplifier. Hence the loop gain becomes o db with a slope of 6 db per of frequency where the poles of Av contribute negligible phase shift.

The additional of dominant frequency may be easily realised by adding simple Rc network.

Tabulation :-

Sl.No.	Frequency	Out put voltage (v)	Gain Av = 20 log vo/vin	Phase angle (Ø)

Model Graph:-



Formula :-

$Ø$ = tan-1 (R_2/ wc) - tan-1 (R_1+R_2)/ W_c)

Gain: A = 20 log ($v_{o/}$ v_{in}) db

Transfer function: $\dfrac{R_2 + SR_1 R_2 c}{(R_1+R_2) SR_1 R_2 c}$

Design theory:-

$E_i(t) = (z_1+z_2)\, i(t)$

$= (R_1+R_2)\, i(t) + 1/C\ \ i(t)\, dt$

$E_O(t) = z_2\, (t)$

$E_O(t) = R_2\, i(t) + 1/c\ \ i(t)\, dt$

Taking laplace transform (1) & (2) we get

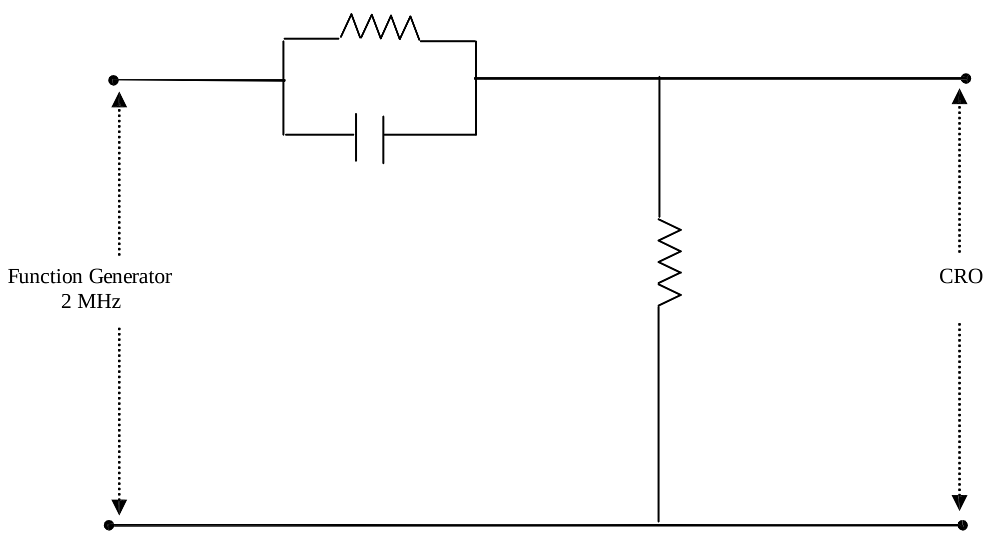
$E_i\,(s) = (R_1+R_2)\, I(S) + 1/CS\, I(S)$

$E_O(s) = R_2\, I(S) + 1/CS\, I(S)$

Result:-

Thus the lag compensator was analyzed and transfer function of lag compensator was determined.

LEAD NETWORK



Exp. No: **Date:**

STUDY OF LEAD NETWORK

Aim:-

To obtain the transfer function and hence identify the components of a lead network.

Apparatus Required:-

Sl.No	Name of the apparatus	Range	Type	Qty

Procedure:-

1. The resistor values are choosen and the connections are made as per the circuit diagram.
2. The input voltage of required volt is given from function generator.
3. The frequency range is choosen for the corresponding frequency of the out put v_o, a and b component are noted.
4. For various frequency this steps are repeated.
5. The gain is 20 log v_o/v_{in} in db.

Theory:-

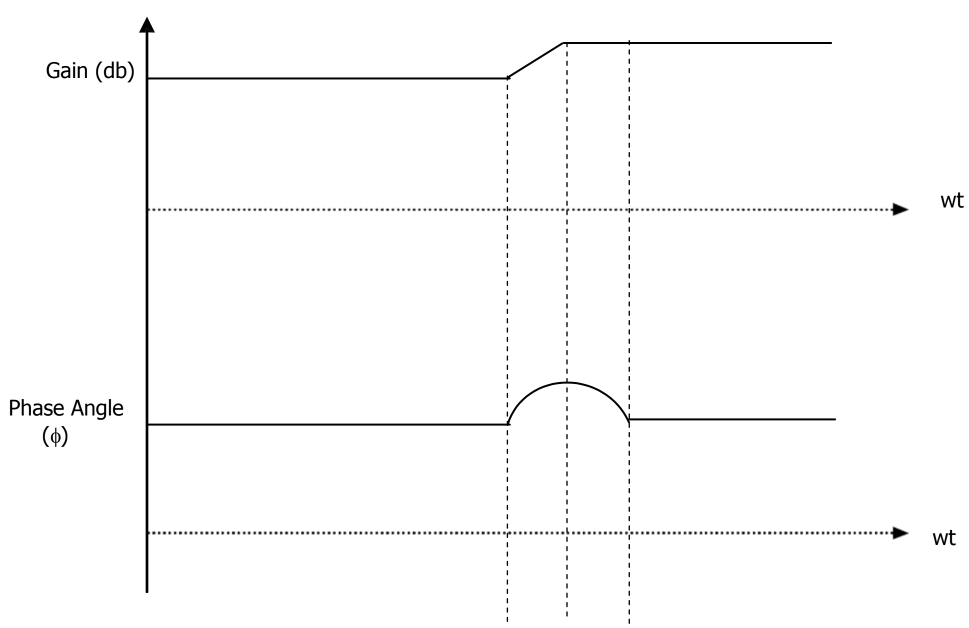
This consists in modifying the amplifier are the feed back network so as to add a zero to the transfer function there by increasing the phase. So that the magnitude of the gain remains unchanged and the phase margin gets increased.

This condition is achieved by placing a capacitor C in shunt connected with the resistor R. Now has an added positive phase shift in frequency range near the unity loop. Gain cross over point.

Tabulation :-

Sl.No.	Frequency	Output voltage (v)	Gain Av = 20 log vo/vin	Phase angle (Ø)

Model Graph:-



Formula :-

Ø = tan-1 (WR1C)- tan-1 (WR_1 R_2C/ R_1+R_2)

Gain : A = 20log (v_o/ v_{in}) db.

Transfer function: $$\frac{1+ S R_2 C}{1+SC (R_1+R_2)}$$

Design theory:-

E_i (t) = (Z_1+Z_2) i(t)

E_o (t)= Z_2 (t)

$$Z_i (S) = \frac{R_1 .1/CS}{1+R_1S}$$

Z_2 (S) = R_2

E_i (S) = (Z_1+Z_2) I(S)

E_o (S) = Z_2 I (S)

Put S = J_w

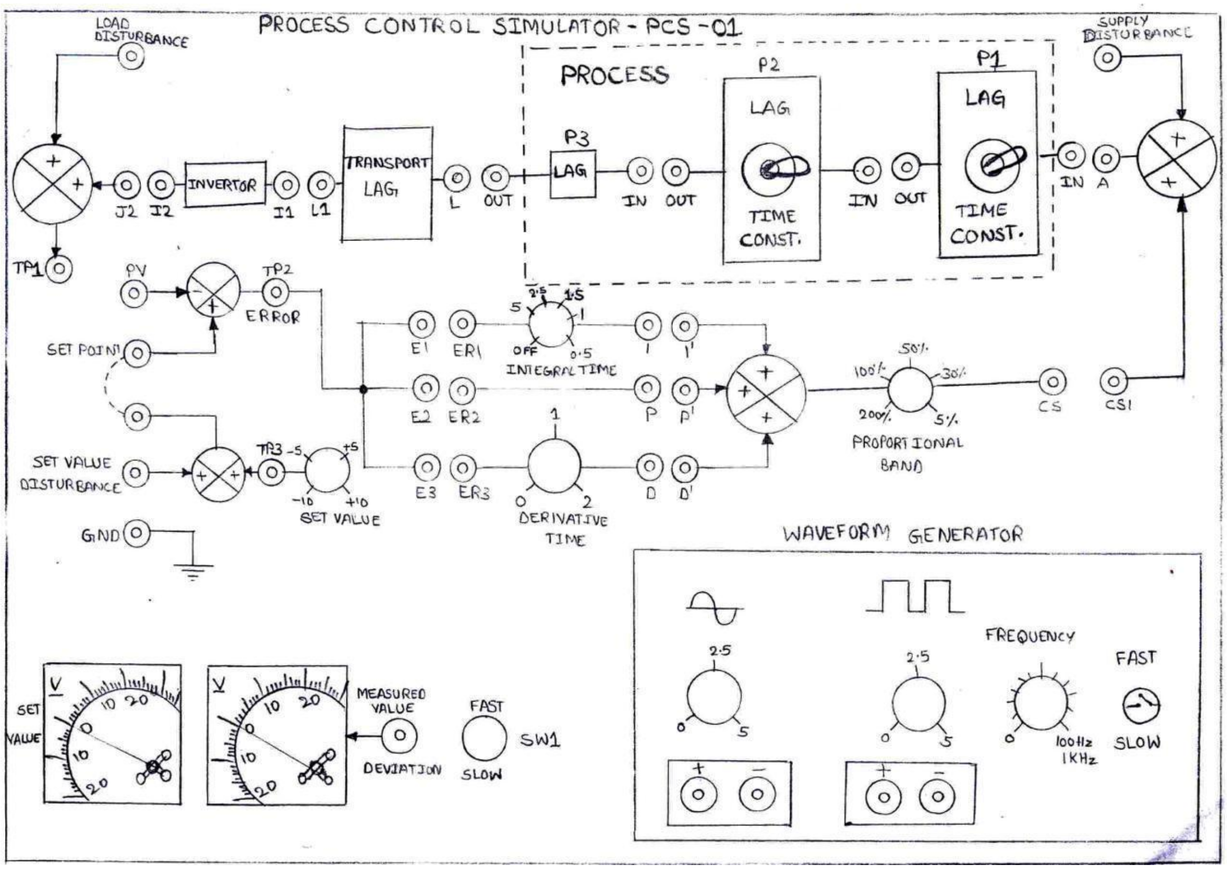
Transfer function:

$$T (S) = \frac{R_2+J WR_1 R_2C}{R_1+R_2+ J WR_1 R_2C}$$

Result:-

Thus the lead compensator was analyzed and transfer function of lead compensator was determined.

Study of PID Controller



Exp. No: **Date:**

STUDY OF PID CONTROLLER

Aim:-

To determine the time constant and the time response of first order system.

Apparatus required:-

1.controller unit
2.CRS
3.Pitch cords

Theory:-

Effect of proportional controller:-

The proportional controller produces an o/p signal. Which is proportional to error signal. The transfer function of proportional is Kp.The team Kp is called the gain of controller. Hence the gain of the controller implifies the error signal and increase the loop gain of the system behavior are improved by increased loop gain.

1. Steady state tracking accuracy
2 .Disturbance signal rejection
3. Relative stability

To increase in loop gain it decreases the sensitivity of the system. The drawback is proportional controller action is that it produces is constant steady state error.

Effect of PI controller:-

The proportional plus integral controller (PI) produces an o/p signal consisting of two term the one proportional to error signal and the other proportional to the integral of error signal.

Tr.function of PI controller = Kp(1+1/Tis)
= Kp(Tis+1/Tis)

Where Kp is equal to proportional gain and Ti is equal to integral time.

open loop Tr.function G(S)= wn^2/s(s+2ewn) closed loop Tr. Function

c(s)/R(s)=G(s)/1+G(S)

=Kp{[1+Ti's/Tis]Wn^2/s(s+ewn)}/{1+Kp[1+Kp[1+Tis/Tis]Wn^2/s(s+2ewn]}

={(Kp/Ti)Wn^2(1+Tis)}/S^2+2ewn^2+Kpwn^2stKp/Twn^2}

={(Kiwn^2(1+Tis)}/{s+2ewn^2+kpwn^2}

Ki=Kp/Ti

In the PI controller is used to reducing the steady state error and high order system less stable then lower order system.

Effect of PD controller:-

The proportional plus derivates controller produces an o/p signal consisting of two terms one proportional to error signal and other proportional to derivative of error signal.

The Tr.function of PD controller =Kp(1+Tds)

Kp=proportional gain

Td=derivative time let the open loop Tr,function G(s) be second order system with

Tr.function G(s) = Wn^2/s(s+2ewn)

C(S)/R(S) = G(s)/1+G(s)=Kp(Tds)Wn^2/[1+Kp(1+Tds)(Wn^2/S(S+2eWn)]

= Wn^2(Kp+Kds)/s^2+(2eWn+KdWn^2)S+KpWn^2

where Kp=KpTd.

From the closed loop tr.function it is observed that the PD controller .Introduces a zero in the system and increases the damping Ratio Reduces the peak over shoot.

PID CONTROLLER:-

A suitable combinational of the three basic modes,proportional Integral and derivative (PID) can improve an aspects of the system performance.

The proportional controller stabilize performance produces a steady state error. The integral controller reduces or eliminates the steady state error.The derivative controller reduces the rate of change of error. The combined effect of the three cannot be from the parameter Kp,Ki &Kd.

PROCEDURE:-

a) Make the ckt connection as per diagram.

b) Calculate the peak amplitude of input square wave signal.

c) Observe both input signal and output wave form on a cro.

d) Then calculate the time taken by output signal to reach 65.2% of finial value .

P - CONTROLLER:-

1. Make the connections as per fig.
2. Switch ON the power supply.
3. Square wave of amplitude 2Vpp is given as input with the optimum frequency setting and view the response on the CRO.
4. Adjust the proportional band knob.
5. From the response measure the peak over shoot from the setting value.
6. Note down the rise time,peak time,setting time for the given step input.
7. Repeat the above steps for various proportional bands.

P-I CONTROLLER:-

1. Make the connections as per fig.
2. Switch ON the power supply.
3. Square wave of amplitude 2Vpp is given as input with optimum frequency.
4. Adjust the value of the proportional and integral time knobs then view the response.
5. Repeat the above experiment for various proportional integral time and tabulate it .

PID CONTROLLER:-

1. Make the connections as per fig.
2. Switch ON the power supply .
3. Square wave of amplitude 2Vpp is given as input with the optimum frequency setting and view the response on the CRO.
4. Adjust the value of proportional band, integral time, and derivative knob and view the response on the CRO screen.
5. From the response measure the peak over shoot from the setting value.
6. Note down the rise time,peak time, setting time for the step input and note it .
7. Repeat the above steps for various proportional bands.

RESULT:-

Thus the time response of the first order system was determined.

Ex.No:

Date: **POLES AND ZEROS OF A TRANSFER FUNCTION**

AIM: To plot pole zero for a given transfer function in s-plane and z-plane using MATLAB

LIST OF EQUIPMENT/SOFTWARE:

Software : MATLAB

Category : soft experiment

THERORY PART :

PROBLEM: $T(s) = Y(s)/R(s)$

$= (8s^2+5s+1)/(s^2+2s+10)$

Zero's ➔ $(8s^2+5s+1)$, the roots are $s_1 = -0.3+j0.17$ & $s_2 = -0.3-j0.17$

Pole's ➔ $(s^2+2s+10)$, the roots are $s_3 = -1$ & $s_4 = -1$

PROGRAM PART :

```
x=[8 5 1];

y=[1 2 1];

h=tf(x,y)

Pzmap(h)
```

PROCEDURE :

1. Open the MATLAB software
2. Open the command window
3. Enter the values and implements the commands
4. Save the program & run it
5. Verify the MATLAB output with theoretical output

RESULT:

Thus plotted the poles and zeros of a given transfer function using MATLAB

Ex.No:

Date: **BLOCK DIAGRAM REDUCTION TECHNIC**

AIM: The aim of the experiment is to learn MATLAB command that would be used to reduce linear system block diagram using series, parallel and feedback configuration

LIST OF EQUIPMENT/SOFTWARE:

Software : MATLAB

Category : soft experiment

DELIVERABLES: A complete lab report including the following

- Summarized learning outcomes
- MATLAB scripts and their result for experiments

THEORETICAL PART :

Problem: $T_1(s) = 6/(s^2+3s+2)$ and $T_2(s) = 9/(s+5)$ for the given transfer function find the output for blocks in series, parallel & eliminate the feed back

PROGRAM PART:

```
num1= [6];
den1= [1 3 2];
num2= [9];
nen2= [1 5];
g1= tf(num1,den1)
g2= tf(num2,den2)
gs=series(g1,g2)
gp=parallel(g1,g2)
gf=feedback(g1,g2)
```

PROCEDURE :

1. Open the MATLAB software
2. Open the command window
3. Enter the values and implements the commands
4. Save the program & run it
5. Verify the MATLAB output with theoretical output

RESULT:

Thus the linear systems block diagram had been reduced theoretically and the same output was verified using MATLAB

Ex.No:

Date: **TIME DOMAIN ANALYSIS**

AIM: To compute and plot the unit step, ramp and impulse response using MATLAB

LIST OF EQUIPMENT/SOFTWARE:

Softwere : MATLAB

Category : soft experiment

THEORETICAL PART :

PROBLEM: Y(s)/R(s) = (2s+10)/(s2+5s+4)

PROGRAM PART:

(i) Unit Step input

```
num= [2 10];

den= [1 5 4];

g= tf(num,den)

step(g)
```

(ii) Impulse input

```
num= [2 10];

den= [1 5 4];

g= tf(num,den)

impulse(g)
```

(iii) Ramp input

```
num= [2 10];

den= [1 5 4 0];

g= tf(num,den)

step(g)
```

PROCEDURE :

1. Open the MATLAB software
2. Open the command window
3. Enter the values and implements the commands
4. Save the program & run it
5. Verify the MATLAB output with theoretical output

RESULT:

Thus the time domain analysis was made for the given transfer function and also output was verified both theoretically & simulation

Ex.No:

Date: **FREQUENCY DOMAIN ANALYSIS**

AIM: In this experiment concept of bode plot and its phase margin & gain margin will be addressed using MATLAB

LIST OF EQUIPMENT/SOFTWARE:

Software : MATLAB

Category : soft experiment

THEORETICAL PART:

PROBLEM: transfer function G(s) = 1250/s(s+5)(s+50) draw the bode plot obtain the frequency domain specification

PROGRAM PART:

```
num= [1250];

den= [1 55 250  0];

bode(num,den)

grid

title(‘bode plot  for the transfer function G(s) = 1250/s(s+5)(s+50)
```

PROCEDURE :

1. Open the MATLAB software
2. Open the command window
3. Enter the values and implements the commands
4. Save the program & run it
5. Verify the MATLAB output with theoretical output

RESULT:

Thus the concept of bode plot were studied using MATLAB

Ex.No:

Date: **STABILITY ANALYSIS USING ROOT LOCUS**

AIM: In this experiment concept of bode plot and its phase margin & gain margin will be addressed using MATLAB

LIST OF EQUIPMENT/SOFTWARE:

Software : MATLAB

Category : soft experiment

THEORETICAL PART:

PROGRAM : $G(s) = k(s+0.2)/s^2(s+3.6)$

PROGRAM PART :

```
num= [1 0.2];

den= [1 3.6 0 0];

rlocus (num,den)

axis(v)

grid

title('Root Locus  for the transfer function G(s) = k(s+0.2)/s^2(s+3.6) ')
```

PROCEDURE :

1. Open the MATLAB software
2. Open the command window
3. Enter the values and implements the commands
4. Save the program & run it
5. Verify the MATLAB output with theoretical output

RESULT:

Thus the concept of root locus were studied using MATLAB