COLLEGE OF ENGINEERING BHUBANESWAR

DEPARTMENT OF ELECTRICAL ENGINEERING

CONTROL AND INSTRUMENTATION LABORATORY

LABORATORY RECORD

Name of the student: ____

Registration Number ________________________

Branch ______________Semester _____________Section ___________

Academic Year ____________________

INDEX

Exp. : Date:

KELVIN'S DOUBLE BRIDGE

AIM

To measure the given low resistance using Kelvin's Double bridge.

APPARATUS REQUIRED

Sl. No.	Name of the Trainer Kit/ Components	Quantity
1.	Kelvin's Double bridge trainer kit	1
2.	Unknown Resistors specimen	5
3.	Connecting wires	As required
4.	Galvanometer	1

CIRCUIT DIAGRAM

THEORY

Kelvin's double bridge is a modification of Wheatstone's bridge and provides more accuracy in measurement of low resistances It incorporates two sets of ratio arms and the use of four terminal resistors for the low resistance arms, as shown in figure. Rx is the resistance under test and S is the resistor of the same higher current rating than one under test. Two resistances Rx and S are connected in series with a short link of as low value of resistance r as possible. P, Q, p, q are four known non inductive resistances, one pair of each (P and p, Q and q) are variable. A sensitive galvanometer G is connected across dividing points PQ and pq. The ratio P/Q is kept the same as p/q, these ratios have been varied until the galvanometer reads zero.

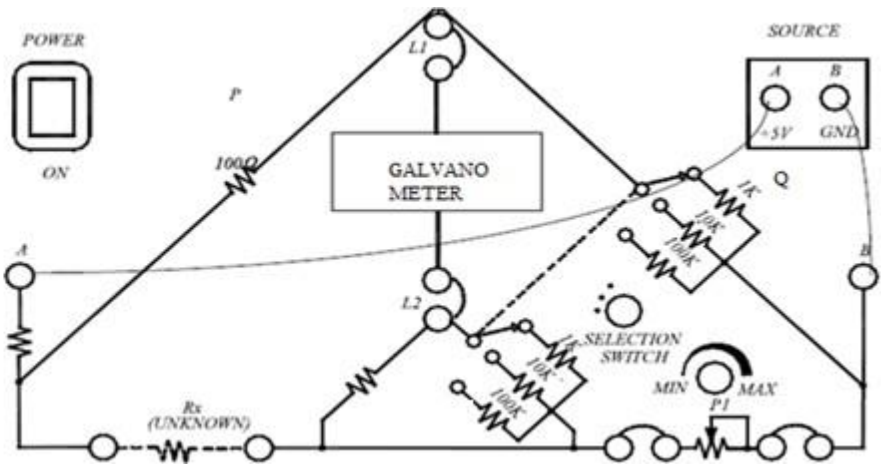
Balance Equation:

$\frac{P}{Q} = \frac{p}{q}$ then unknown resistance $R_x = \frac{P}{Q} P_1$

PROCEDURE:

1. The unknown resistance Rx was connected as marked on the trainer.
2. A galvanometer G was connected externally as indicated on the trainer.
3. The trainer was energized and the power was checked to be +5 V.
4. The values of P and Q were selected such that P/Q = p/q = 500/50000 = 0.01.
5. P_1 was adjusted for proper balance and then at balance, the value of P_1 was measured.

PANEL DIAGRAM



TABULATION

Sl. No.	P (Ω)	Q (Ω)	P_1(Ω)	R_x(Ω) (Actual)	R_x(Ω) (Observed)	%Error

CALCULATION

CONCLUSION

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MAXWELL'S BRIDGE

Exp.: Date:

AIM

To measure the unknown inductance of a given coil.

APPARATUS REQUIRED

Sl. No	Name of the Trainer Kit/ Components	Quantity
1.	Maxwell's inductance- capacitance bridge trainer kit	1
2.	Unknown inductance specimen	3 different values
3.	Connecting wires	Few
4.	Head phone/ CRO	1

CIRCUIT DIAGRAM

THEORY

In this bridge, an inductance is measured by comparison with a standard variable capacitance. The connection at the balanced condition is given in the circuit diagram.

Let L_1 = Unknown Inductance.

R_1 = effective resistance of Inductor L_1.

R_2, R_3 and R_4 = Known non-inductive resistances.

C_4 = Variable standard Capacitor.

Separating the real and imaginary terms, we have

$$R_1 = \frac{R_2 R_3}{R_4} \quad L_1 = R_2 R_3 C_4$$

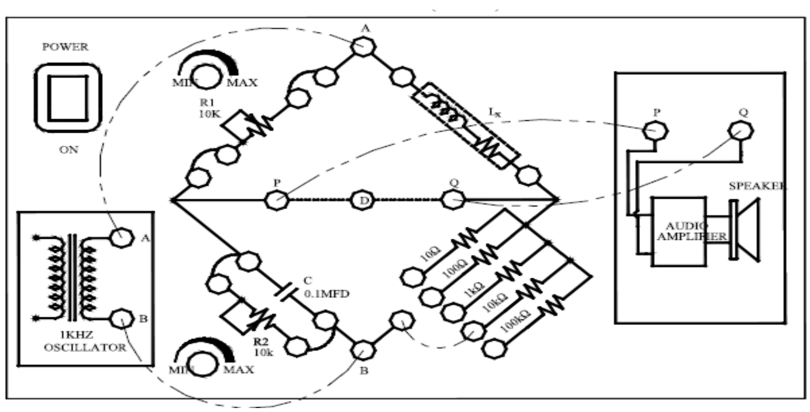
Thus we have two variables R4 and C4 which appear in one of the two balance equations and hence two equations are independent. The expression for Q factor is given by

$$Q = \frac{\omega L_1}{R_1} = \omega C_4 R_4$$
$$L_X = R_1 R_3 C$$
$$Q = \omega L_X R_X / R_X = \frac{R_1 R_3}{R_2}$$

PROCEDURE

1. Connections were made as per the circuit diagram.
2. Connect the unknown inductance was connected in the arm marked L_X .
3. The trainer kit was switched ON.
4. The sine wave at secondary of isolation transformer on CRO was observed.
5. R4 and C4 from minimum position was varied in the clockwise direction to obtain the bridge balancecondition.
6. The CRO was connected between ground and the output point to check the bridge balance.

PANEL DIAGRAM



TABULATION

Sl. No.	$R_1(\Omega)$	$R_3\ (\Omega)$	C (μF)	L_x (mH) Actual	L_x(mH) Observed	Qualityfactor Q

CALCULATION

`CONCLUSION

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Exp: Date:

SCHERING BRIDGE

AIM

To measure the value of unknown capacitance using Schering's bridge & dissipation factor.

APPARATUS REQUIRED

S. No.	Components / Equipments	Quantity
1.	Schering's bridge trainer kit	1
2.	Decade Conductance Box	1
3.	Digital Multimeter	1
4.	CRO	1
5.	Connecting wires	As per requirements

CIRCUIT DIAGRAM

THEORY

In this bridge the arm BC consists of a parallel combination of resistor & a Capacitor and the arm AC contains capacitor. The arm BD consists of a set of resistors varying from 1Ω to 1 MΩ. In the arm AD the unknown capacitance is connected. The bridge consists of a built in power supply, 1 kHz oscillator and a detector.

BALANCE EQUATIONS:

Let C_1=Capacitor whose capacitance is to be measured.

R_1= a series resistance representing the loss in the capacitor C_1.

C_2= a standard capacitor.

R_3= a non-inductive resistance.

C_4= a variable capacitor.

R_4= a variable non-inductive resistance in parallel with variable capacitor C4.

At balance,

$$\left(r_1 + \frac{1}{j\omega C_1}\right)\left(\frac{R_4}{1+j\omega C_4 R_4}\right) = \frac{1}{j\omega C_2} R_3 \quad (1)$$

$$\left(r_1 + \frac{1}{j\omega C_1}\right) R_4 = \frac{1}{j\omega C_2} R_3 (1 + j\omega C_4 R_4) \quad (2)$$

$$r_1 R_4 - \frac{jR_4}{\omega C_1} = -j\frac{R_3}{\omega C_2} + \frac{R_3 R_4 C_4}{C_2} \quad (3)$$

Equating the real and imaginary terms, we obtain

$$r_1 = R_3 \frac{C_4}{C_2} \quad (4)$$

$$C_1 = C_2 \frac{R_4}{R_3} \quad (5)$$

PROCEDURE

1. The trainer board was switched on and the unknown capacitance was connected in the arm marked C_x.
2. The sine wave at the output of oscillator was observed and the circuit was patched by using the wiring diagram.
3. The sine wave at secondary of isolation transformer was observed on CRO. Some values of R_3 were selected.
4. The CRO was connected between ground and the output point of imbalance amplifier.
5. R_4 (500Ω potentiometer) was varied from minimum position in the clockwise direction.
6. For the correct selection of R_3, the balance point (DC line) was observed on CRO. (That is at balance the output waveform comes to a minimum voltage for a particular value of R_4 and then increases by varying R_3 in the same clockwise direction). Orelse another value of R_4 was selected.
7. Capacitor C_2 was also varied for fine balance adjustment. The balance of the bridge could be observed by using loud speaker.
8. The readings were tabulated and the unknown capacitance and dissipation factor were calculated.

TABULATION

Sl. No.	C_2 (μF)	R_3(Ω)	R_4(Ω)	C_x(μF)		Dissipationfactor (D_1)
				Truevalue	Measured Value	

CALCULATION

FORMULAE USED

$C_x = C_2 D_1 \frac{R_4}{R_3} = \omega C_4 R_4$ where C_4=C_x & R_4=R_x (6)

RESULT

CONCLUSION

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Exp: Date:

STUDY OF DISPLACEMENT TRANSDUCER – LVDT

AIM

To study the displacement transducer using LVDT and to obtain its characteristic

APPARATUS REQUIRED

Sl. No	**Name of the Trainer Kit/ Components**	**Quantity**
1.	LVDT trainer kit containing the signal conditioning unit	1
2.	LVDT calibration jig	1
3.	Multi meter	1
4.	Patch cards	As per requirements

THEORY

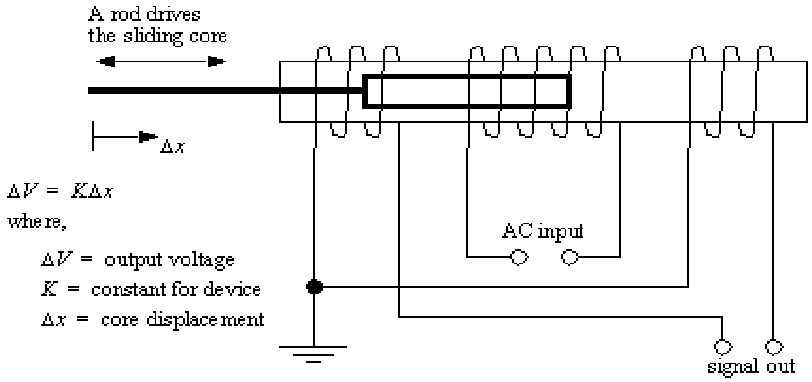
LVDT is the most commonly and extensively used transducer, for linear displacement measurement. The LVDT consists of three symmetrical spaced coils wound onto an insulated bobbin.

A magnetic core, which moves through the bobbin without contact, provides a path for the magnetic flux linkage between the coils. The position of the magnetic core controls the mutual inductance between the primary coil and with the two outside or secondary coils. When an AC excitation is applied to the primary coil, the voltage is induced in secondary coils that are wired in a series opposing circuit. When the core is centred between two secondary coils, the voltage induced in the secondary coils are equal, but out of phase by 180°. The voltage in the two coils cancels and the output voltage will be zero.

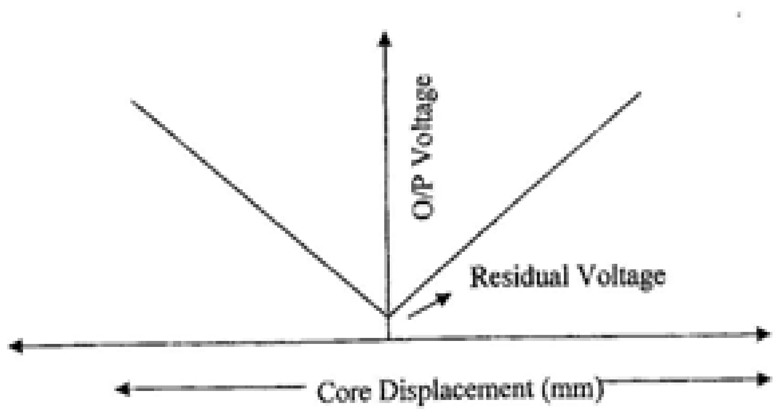
CIRCUIT DIAGRAM

CIRCUIT OPERATION:

The primary is supplied with an alternating voltage of amplitude between 5V to 25V with a frequency of 50 cycles per sec to 20 K cycles per sec. The two secondary coils are identical & for a centrally placed core the induced voltage in the secondaries Es1&Es2 are equal. The secondaries are connected in phase opposition. Initially the net o/p is zero. When the displacement is zero the core is centrally located. The output is linear with displacement over a wide range but undergoes a phaseshift of 180°. It occurs when the core passes through the zero displacement position.



MODEL GRAPH



PROCEDURE:

1. Power supply to the trainer kit was switched on.
2. The screw gauge was rotated in clock wise direction till the voltmeter reads zero volts.
3. The screw gauge was rotated in steps of 2mm in clockwise direction and the o/p voltage was noted down.
4. The same was repeated by rotating the screw gauge in the anticlockwise direction from null position.
5. The graph DC output voltage Vs Displacement was plotted.

TABULATION

S. No.	Displacement (mm)	Output voltage (mV)
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

CALCULATION

CONCLUSION

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Exp. : Date: Date

DC POSITION CONTROL SYSTEM

AIM:

To control the position of loading system using DC servo motor.

APPARATUS REQUIRED:

S.NO	APPARATUS	SPECIFICATION	QUANTITY
1.	DC Servo Motor Position Control Trainer	-	1
2.	Connecting Wires	-	As required
3.	Multimeter		1

THEORY:

DC Servo Motor Position Control Trainer has consisted various stages. They are Position set control (T_X), Position feedback control (R_X), buffer amplifiers, summing amplifiers, error detector and power driver circuits. All these stages are assembled in a separate PCB board. Apart from these, servo potentiometers and a dc servomotor are mounted in the separate assembly. By Jones plug these two assemblies are connected.

The servo potentiometers are different from conventional potentiometers by angle of rotation. The Normal potentiometers are rotating upto 270°. But the servo potentiometers are can be rotate upto 360°. For example, 1kΩ servo potentiometer give its value from 0 to 1 kΩ for one complete rotation (360°).

All the circuits involved in this trainer are constructed by operational amplifiers. For some stages quad operational amplifier is used. Mainly IC LM 324 and IC LM 310 are used. For the power driver circuit the power transistors like 2N 3055 and 2N 2955 are employed with suitable heat sinks.

Servo Potentiometers:

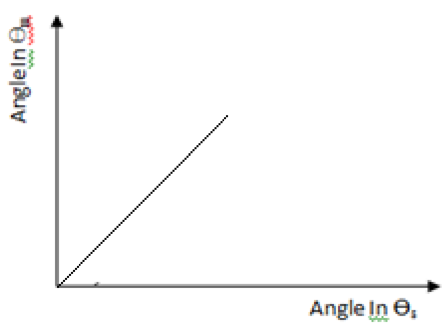
A 1 kΩ servo potentiometer is used in this stage. A + 5 V power supply is connected to this potentiometer. The feed point of this potentiometer is connected to the buffer amplifiers. A same value of another servo potentiometer is provided for position feedback control circuit. This potentiometer is mechanically mounted with DC servomotor through a proper gear arrangement. Feed point of this potentiometer is also connected to another buffer circuit. To measuring the angle of rotations, two dials are placed on the potentiometer shafts. When two feed point voltages are equal, there is no moving in the motor. If the positions set control voltages are higher than feedback point, the motor will be run in one direction and for lesser voltage it will run in another direction.

Buffer amplifier for transmitter and receiver and summing amplifier are constructed in one quad operational amplifier. The error detector is constructed in a single opamp IC LM 310. And another quad operational amplifier constructs other buffer stages.

TABULATION:

Sl. No.	Set Angle in degrees (set Θ_s)	Measured angle in degrees(Θ_m)	Error in degrees ($\Theta_s - \Theta_m$)	Error in % $[(\Theta_s - \Theta_m) / \Theta_s] \times 100$
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

MODEL GRAPH:



PROCEDURE:

1. The trainer kit was connected with motor setup through 9 pin D connector.
2. The trainer kit was switched on.
3. The angle in the transmitter was set by adjusting the position set control as Θ_s.
4. The motor started rotating and stopped at a particular angle which was tabulated as Θ_m.
5. Θ_m for was tabulated from different set angle Θ_s.
6. % error calculated using the formulae and the graph was plotted between $\Theta_s$vs Θ_m and $\Theta_s$vs % error.

FORMULA USED:

Error in degree $= \Theta_s - \Theta_m$

Error in percentage $= ((\Theta_s - \Theta_m) / \Theta_s) \times 100$

CALCULATION

CONCLUSION

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Exp. No: **AC POSITION CONTROL SYSTEM** Date:

AIM

To control the position of loading system using AC servo motor.

APPARATUS REQUIRED:

S.NO	APPARATUS	SPECIFICATION	QUANTITY
1.	AC Servo Motor Position Control Trainer	-	1
2.	Multimeter		1
3.	Connecting Wires	-	As required

THEORY

AC SERVOMOTOR POSITION CONTROL

It is attempted to position the shaft of a AC Synchronous Motor's (Receiver) shaft at any angle in the range of 10^0 to 350^0 as set by the Transmitter's angular position transducer (potentiometer), in the range of 10^0 to 350^0. This traineris intended to study angular position between two mechanical components (potentiometers), a Transmitter Pot and Receiver pot. The relation between these two parameters must be studied.

Any servo system has three blocks namely Command, Control and Monitor.

- ❖ The command is responsible for determining what angular position is desired.. This is corresponds to a Transmitter's angular position (Set Point- S_p) set by a potentiometer.
- ❖ The Control (servo) is an action, in accordance with the command issued and a control is initiated (Control Variable -C_v) which causes a change in the Motor's angular position. This corresponds to the receiver's angular position using a mechanically ganged potentiometer.
- ❖ Monitor is to identify whether the intended controlled action is executed properly or not. This is similar to feedback. This corresponds to Process Variable P_v. All the three actions together form a closed loop system.

PROCEDURE

1. The trainer kit was connected with motor setup through 9 pin D connector.
2. The trainer kit was switched on.
3. The angle in the transmitter was set by adjusting the position set control as Θ_s.
4. The motor was started rotating and stopped at a particular angle which was tabulated as Θ_m.
5. Θ_m value was tabulated for different set angle Θ_s.
6. % error was calculated using the formulae and the graph $\Theta_s$vs Θ_m was plotted.

CALCULATION

CONCLUSION

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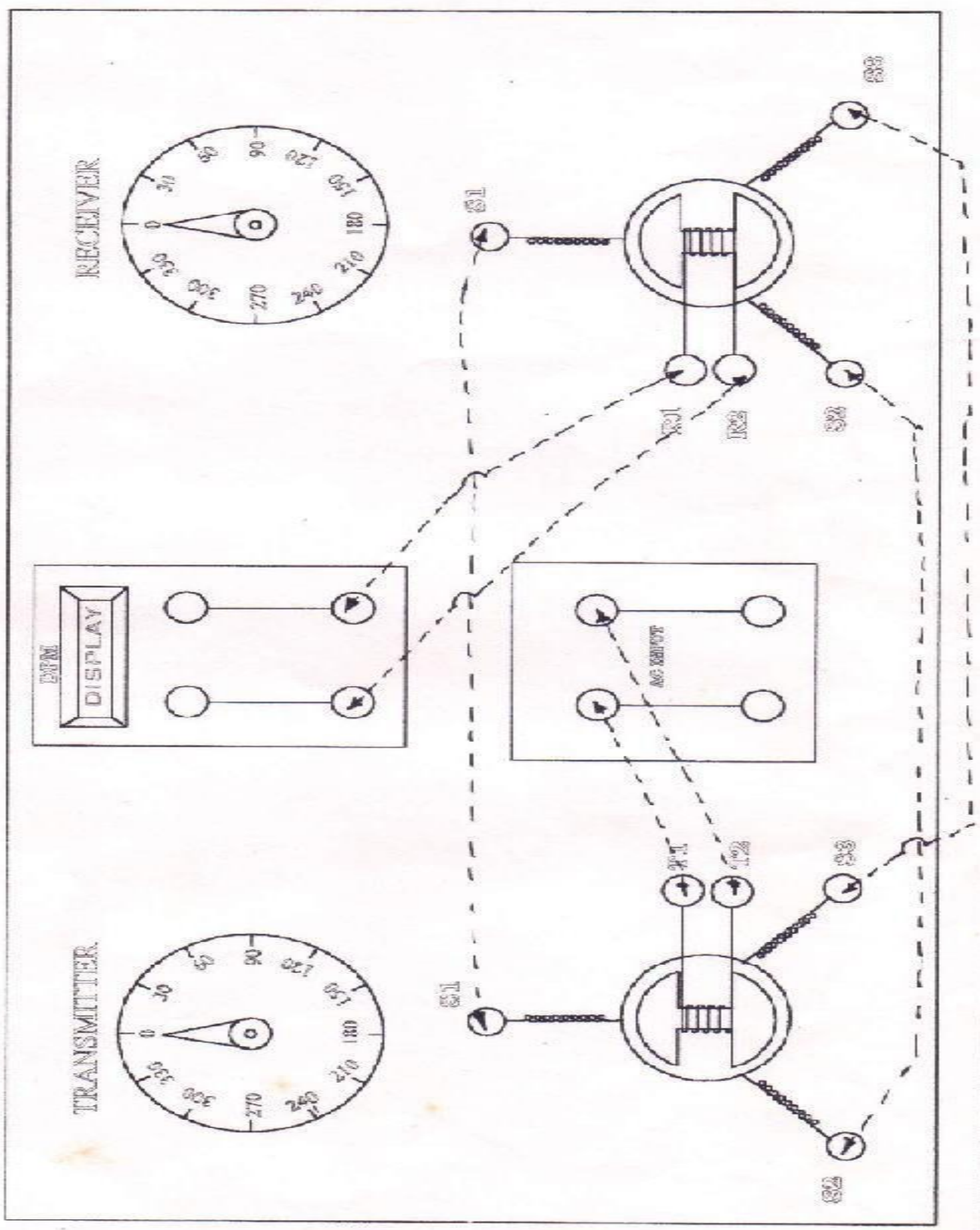
Synchro transmitter and receiver angle difference Vs output error voltage



Exp.: **SYNCHRO TRANSMITTER & RECEIVER CHARACTERISTICS** Date

AIM

To study the operation of Synchro Transmitter and Receiver.

APPARATUS REQUIRED

S.NO	APPARATUS	SPECIFICATION	QUANTITY
1.	Synchro transmitter & receiver kit	-	1
2.	Multimeter		1
3.	Patch cords	-	As required

PROCEDURE

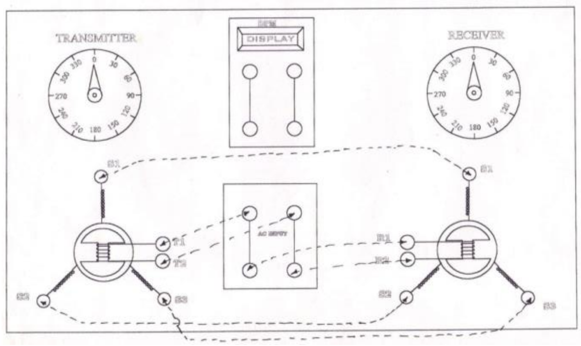
Synchro transmitter and receiver as an error detector

1. The R_1-R_2 terminals of transmitter was connected to power supply.
2. S_1-S_2, S_2-S_2, S_3-S_3 winding of transmitter and receiver was sorted.
3. The R_1-R_2 terminals of receiver was connected to digital panel meter.
4. After switching on the kit, transmitter and receiver shaft came to the same position on the dial.
5. The transmitter rotor was set in zero position and the receiver rotor was rotated.
6. Take the error voltage display was taken on the digital panel meter corresponding to the angle difference between transmitter and receiver.
7. The reading was tabulated as per the following table.

Tabulation for rotor angle versus receiver angle

Transmitter angular position (degrees)	Receiver angular position (degrees)

Synchro Transmitter stator angle Vs receiver rotor angle characteristics



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

Transmitter position (degrees)	Receiver position (degrees)	Error output voltage (Volts)	Angle of difference(degrees)

CALCULATION

CONCLUSION

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Exp.: **DESIGN OF LEAD, LAG COMPENSATORS** Date:

AIM

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

APPARATUS REQUIRED

Sl. NO	**APPARATUS**	**SPECIFICATION**	**QUANTITY**
1.	LEAD, LAG COMPENSATOR KIT	-	1
2.	CRO with probes		1
3	Multi meter	-	
4.	Patch cords	-	As required

CIRCUIT DIAGRAM

THEORY

Lead and lag compensators are important tools in control system design, used to modify the dynamic response of a system for improved performance or stability. Here's a brief overview of each.

Lead Compensator

A lead compensator is designed to improve the transient response of a system. It introduces a phase lead (hence the name) to the system's open-loop transfer function. This additional phase lead helps in increasing the phase margin and can improve the overall stability of the closed-loop system. Key characteristics of a lead compensator include:

- **Phase Lead:** It introduces a phase lead at high frequencies, which can help to counteract phase lag caused by the system dynamics or sensors.
- **Frequency Response:** Typically, a lead compensator boosts the high-frequency gain, which can improve the system's response speed.
- **Design Considerations:** Lead compensators are often used when the system needs faster response times or better phase margin, particularly in systems prone to oscillations or instability.

Lag Compensator

A lag compensator, on the other hand, is used to improve steady-state accuracy and reduce the steady-state error of a system. It introduces a phase lag into the system's open-loop transfer function. This phase lag can reduce the overall gain at high frequencies but improves the system's low-frequency performance. Key characteristics of a lag compensator include:

- **Phase Lag:** It introduces a phase lag at low frequencies, which improves the steady-state response and reduces the overall sensitivity of the system to disturbances.
- **Frequency Response:** Lag compensators typically attenuate high-frequency components, which can stabilize the system against noise or high-frequency disturbances.
- **Design Considerations:** Lag compensators are commonly employed when the primary goal is to reduce steady-state error, enhance system accuracy, or improve the system's ability to reject disturbances.

Comparison and Usage

- **Lead compensators** are used when the primary concern is to improve the transient response of the system, such as reducing settling time or increasing response speed.
- **Lag compensators** are used when the focus is on improving steady-state performance, such as reducing steady-state error or improving disturbance rejection.

In practical control system design, lead and lag compensators can be combined to achieve desired performance characteristics, striking a balance between transient response and steady-state accuracy according to the specific requirements of the application.

PROCEDURE

- The circuit connection was made as per the kit diagram.
- The ports marked with dotted line were sorted.
- The CRO probes were connected with both input and output port of the kit.
- 230V,50Hz supply was given to the kit. Switch on the kit and CRO as well.
- Now both the input and output waveforms can be seen in the CRO by making little CRO settings.
- Both the waveforms can be merged by using dual switch in the CRO.
- Different patterns of this Lissajous diagram can be obtained.
- Trace all the patterns using tracing paper.

CALCULATION

CONCLUSION

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Exp. No. **Determination of transfer function of AC Servomotor** Date:

AIM

To derive the transfer function of the given A.C Servo Motor and experimentally determine the transfer function parameters such as motor constant k_1 and k_2.

APPARATUS REQUIRED

Sl. No	Apparatus	Quantity
1	Transfer function of AC servomotor trainer kit	1
2	Two phase AC servomotor with load setup and loads	1
3	PC power chord	2
4	SP_6 patch chord	4
5	9 pin cable	1

Specifications of AC Servomotor

Main winding Voltage	-	230V
Control Winding Voltage	-	230V
No load current per phase	-	300 mA
Load current per phase	-	350 mA
Input power	-	100 W
Power Factor	-	0.8
No load speed	-	1400 rpm
Moment of inertia (J)	-	0.0155 kg m^2
Viscous friction co-efficient (B)	-	0.85 $\times 10^{-4}$ kg-m-sec

Formula Used:

Torque T = (9.18 × r × S) Nm

$$Motor\ constant\ K_1 = \frac{\triangle T}{\triangle V}\ Motor\ constant\ K_2 = \frac{\triangle T}{\triangle N}$$

Where,

r - Radius of the shaft, m = 0.0186 m

$\triangle T$ - Change in torque, Nm

$\triangle V$ - Change in control winding voltage , V

$\triangle N$ - Change in speed , rpm

S - Applied load in kg

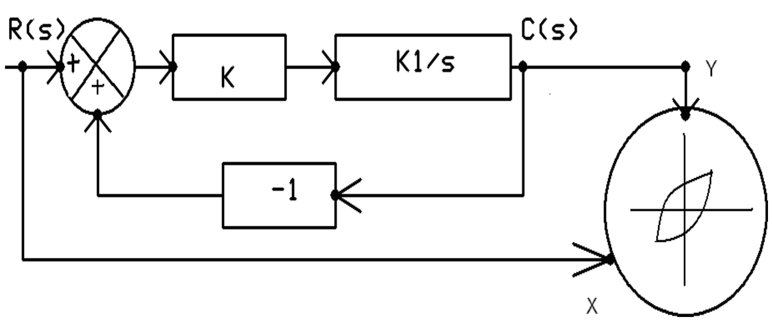
Theory:

It is basically a 2Φ induction motor except for certain special design features. AC servomotor differs in 2 ways from a normal induction motor. The servomotor rotor side is built in high resistance. So the X/R ratio is small, which results in linear mechanical characteristics. Another difference of AC servomotor is that excitation voltage applied to 2 stator of winding should have a phase difference of 90^o.

Working principle:

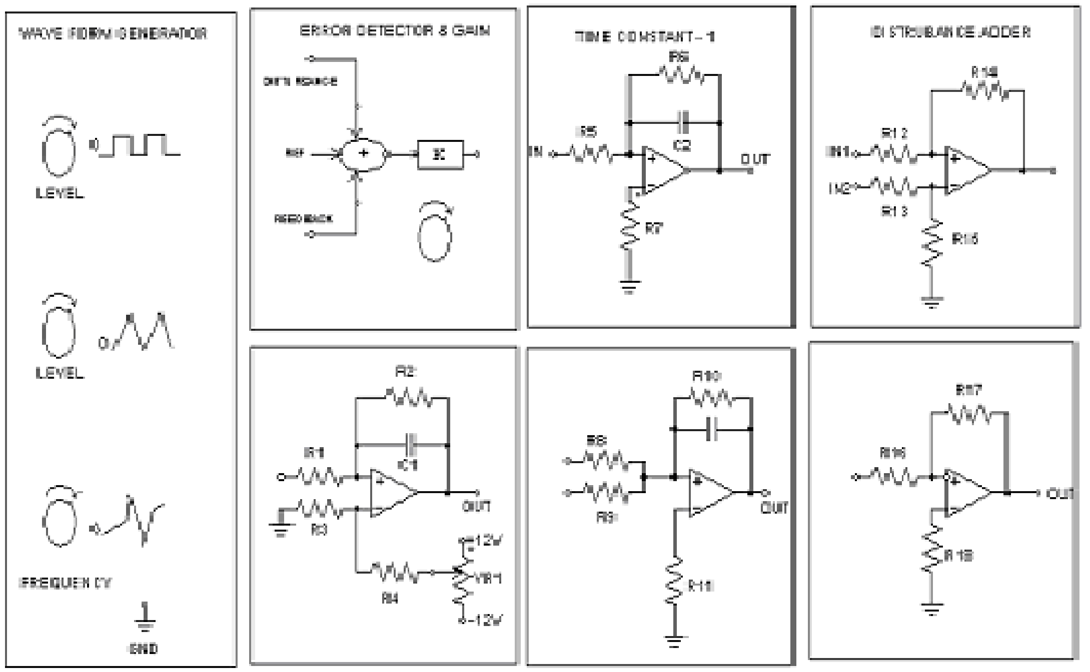
When the rotating magnetic field swaps over the rotor conductors, emf is induced in the rotor conductors. This induced emf circulates current in the short circuited rotor conductor. This rotor current generate a rotor flux a mechanical force is developed to the rotor and hence the rotor moving the same direction as that of the rotating magnetic field.

Block diagram of Type- 1 First order system



PATCHING DIAGRAM TO OBTAIN THE STEADY STATE ERROR OF

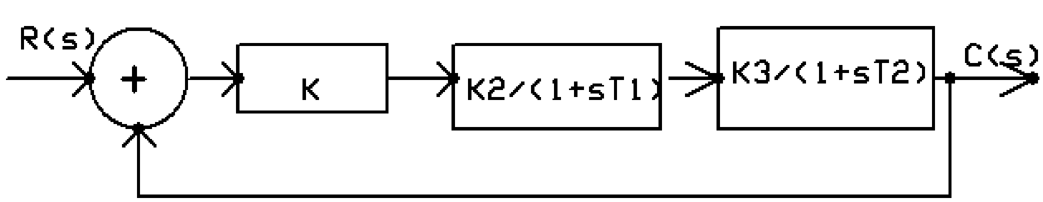
TYPE – 1 FIRST ORDER SYSTEM



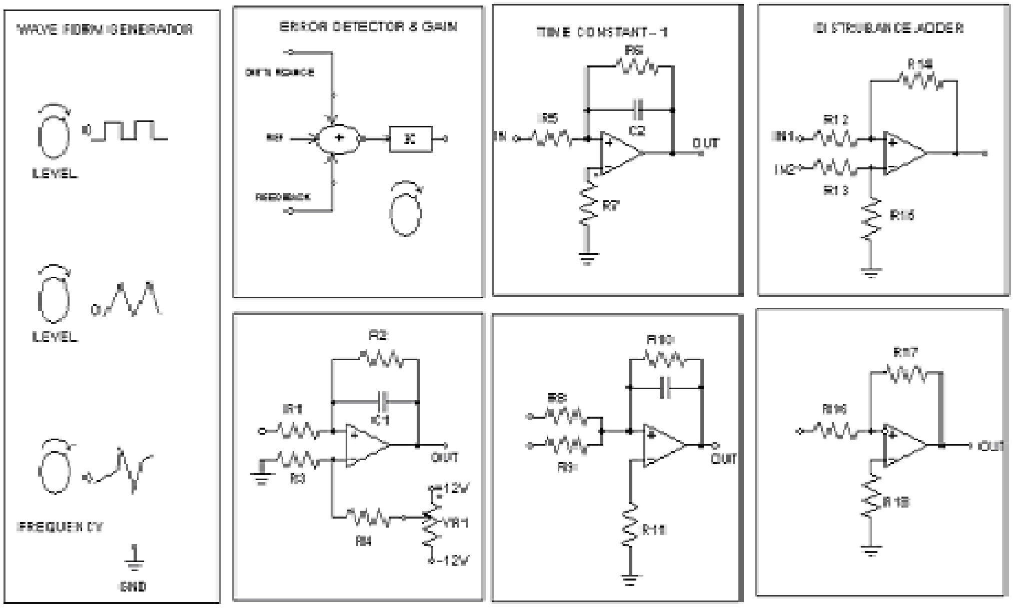
OBSERVATIONS:

S. No.	Gain, K	Steady state error, ess
1		
2		
3		

Block diagram to obtain closed loop response of Type-0 second order system



PATCHING DIAGRAM TO OBTAIN THE CLOSED LOOP RESPONSE OF TYPE – 0 SECOND ORDER SYSTEM



Transfer function of a AC servomotor

Let

T_m – Torque developed by the motor (Nm)

T_1 Torque developed by the load (Nm)

k_1 – Slope of control phase voltage versus torque characteristics

k_2 – Slope of speed torque characteristics

km – Motor gain constant τm – Motor time constant

g – Moment of inertia (Kgm^{-2})

B – Viscous friction co-efficient (N/m/sec)

e_c – Rated input voltage, volt

$\frac{d\omega}{dt}$ = Angular Speed

Transfer function of AC servomotor:

$$\textbf{Torque developed by motor } T_m = K_1 e_c - K_2 \frac{d\theta}{dt}$$

$$\text{Load Torque } T_L = J\frac{d^2\theta}{dt^2} + B\frac{d\theta}{dt}$$

At equilibrium, the motor torque is equal to the load torque.

$$J\frac{d^2\theta}{dt^2} + B\frac{d\theta}{dt} = K_1 e_c - K_2\frac{d\theta}{dt}$$

On taking laplace transform of above equation, with zero initial conditions, we get

$$Js^2\theta(s) + Bs\theta(s) \ = \ K_1E_c(s) - K_2s\theta(s)$$

$$(Js^2 + Bs + K_2s)\theta(s) \ = K_1E_c(s)$$

$$\frac{\theta(s)}{E_c(s)} = \frac{K_1}{(Js^2 + Bs + K_2s)} = \frac{K_1}{(Js + B + K_2)s}$$

$$\frac{\theta(s)}{E_c(s)} = \frac{\frac{K_1}{(B + K_2)}}{s\left[\frac{J}{B + K_2}s + 1\right]}$$

$$\frac{\theta(s)}{E_c(s)} = \frac{k_m}{s(\tau_m s + 1)}$$

$$k_m = \frac{K_2}{B + K_2} = \text{Motor gain constant}$$

$$\tau_m = \frac{J}{B + K_2} = \text{Motor time constant}$$

CONNECTION PROCEDURE

1. Initially all the switches were kept in OFF position
2. Banana connector P_{out} to P_{in} and N_{out} to N_{in} were connected.
3. Banana connector P_{in} terminal is also connected with motor control winding Pterminal and the banana connector N_{in} terminal was also connected with motor control winding N terminal.
4. The 9 pin D connector from AC servomotor to module trainer kit was connected.
5. The variable AC source was kept in minimum position.

Experimental Procedure to find K_1

1. 3-phase AC supply was given to 3-phase input banana connectors at the back side of the module.

2. The power switch was switched on.
3. The control winding and main winding switches S1 and S2 were switched on respectively.
4. Slowly the variable AC source to the control winding was varied till the motor reaches 300rpm.
5. The load was applied one by one till the motor stops.
6. The load values and control voltage were noted down.
7. The AC source was varied and voltage to control winding was applied till the motor reaches 300 rpm.
8. The loads were applied till the motor stops.
9. The above steps were repeated and the values were noted down and also tabulated.
10. The torque of the motor was calculated.
11. A graph between control voltage V_s torque was plotted.
12. From the graph the motor constant K_1 was obtained.

Experimental Procedure to find K_2:

1. The power supply was switched on.
2. The main winding power supply S_2 was switched on.
3. The power supply to the main winding was switched on and the control winding power supply switch S_1 was also on.
4. The control voltage was varied to set a rated voltage of the control winding (180V).
5. The load was applied in step by step upto the motor run at a zero rpm and note down the speedof the motor was noted down. Then the load was applied.
6. After taking the readings, the load was removed fully from the motor and the variable AC source was varied in minimum position.
7. The control winding switch S_1 was switched off.
8. Finally the main winding switch S_2 and power supply switch was switched off.
9. The speed and load values were tabulated and torque was calculated.
10. A graph of torque V_s speed was plotted and the motor constant K_2 was obtained.

TABULATION

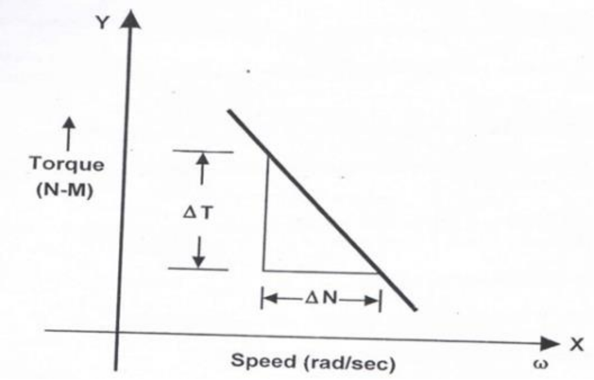
Sl. No.	Gain K	$\%M_P$	t_r(sec)	t_p(sec)	t_s(sec)	ξ	ω_n(rad/sec)

SL. NO.	Speed(N) rpm	Load(s) Kg	Torque(T) Nm

Motor Constant $K_2 = \frac{\Delta T}{\Delta N}$

CALCULATION

Model Graph



CONCLUSION

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Expt: Date:

AIM

To observe the time response of a second order process with P, PID and PI control and applyPID control to servomotor.

APPARATUS REQUIRED

Serial No.	Name of the Equipment	Ratings and Range	Quantity
1	Linear System Simulator	LSS-01	1
2	DSO	0-25MHz	1
3	Patch Cords	-	As per required
4	DSO Probes	-	As per required

THEORY

A second order control system is one where in the highest power of 's' in the denominator of its transfer function is equal to 2.Transfer function of second order closed loop system is given by

Rise time(t_r): Time required for response to rise from (10 – 90)% or (0-100)% of final value.

Delay time (t_d): Time required to reach 50% of final value.

Peak time (t_p): Time required to reach its first peak.

Peak overshoot (M_P): Maximum (+ve) deviation of output , with respect to its desiredsteady state value.

Controller

1) Proportional (P) controller:
   Actuating signal for the control action in a control system is proportional to the error signal.
2) Integral (I) controller:
   Also called as reset controller T_i & K_i are called as reset time and integral gain constant respectively. It has high settling time but required to reduce the steady state to zero.
3) Derivative (D) controller :
   It does not eliminate the steady state error properly but it improves the transient state characteristics of the system.

PROCEDURE

- Patch cords were connected as per the diagram.
- Switch (sw_4) was kept at first position and (sw_2) was kept in slow position.
- Proportional band settling was kept at 5% T_i at 1.5ms. T_d at 0.5 ms and the supply was givento trainer kit.
- Tracing for CRO for P, PI, PD, PID controller was taken by changing patch cords.
- Reading from CRO waveform was taken.

OBSERVATION

For PD controller				
Sl. no.	Rise time	Peak time	Settling time	Peak overshoot

For PI controller				
Sl. no.	Rise time	Peak time	Settling time	Peak overshoot

For P controller				
Sl. no.	Rise time	Peak time	Settling time	Peak overshoot

For PID Controller				
Sl. no.	Rise time	Peak time	Settling time	Peak overshoot

CONCLUSION

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AIM

To measure stress and strain using strain gauge mounted on a cantilever beam.

APPARATUS REQUIRED

Strain gauge Kit, cantilever beam weights, multimeter.

Formula Used: $M / I = f_s / y$

Where,

M = force × ⊥ distance (l)

b = ……mm, l = ……..mm, d = …….. mm

y = 1/2d

CIRCUIT DIAGRAM

THEORY

Strain gauges are sensitive resistance which is based on principle that resistance of a conductor increases with the increase in length and decreases with increase in area. Strain gauges are of three types.

1. Foil type
2. Wire type
3. Semi conductor type

Transducer

These are elements which convert desired input into more practical and convenient output.

PROCEDURE:

1. The cantilever beam, ammeter and voltmeter were arranged as shown in figure.
2. Then the weight was put on the rod of cantilever beam.
3. The digital display reading was measured for a particular weight.
4. The value of ammeter (along) and voltmeter reading (micro-volt) were noted.
5. The strength of weight was increased.
6. The steps were repeated for increased weight.
7. All dimensions of scale of cantilever were measured.

CALCULATION

CONCLUSION

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