5^{th} Semester EE and EEE Control and Instrumentation laboratory Manual

Under BPUT Odisha

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EXPERIMENT-1(A)

<u>Whetstone's Bridge</u>

Introduction:

Bridge circuits are extensive use for measuring component values , such as resistance , inductance an of other circuit parameters directly derived from component values such as frequency, phase angle and temperature .Since the bridge circuit merely compares the value of the unknown component to that of an accurately known as component (a standard) its measurement accuracy can be very high indeed. This is so because the read out of this comparison measurements, based on null indication at bridge balance is essentially independent of the characteristics of the null director. The measurement accuracy is directly related to accuracy of the bridge components and not to that of the null indicator itself.

The AC bridge in its basic from can be used for measurement of unknown inductance or capacitance by comparing it with a known inductance or capacitance. Here a resistance measuring bridge is described as shown below in figure below.

<u>Aim of the Experiment</u>: To study the operation of the Wheatston's Bridge and to find the value of the unknown resistance.

<u>Apparatus Required:</u>

1. Adtron's Trainer Kit.
2. Oscilloscope.

<u>Procedure</u>:

1. Connect the required supply and switch ON the unit. See that the supply LED glows.
2. Observed the sine wav at the respective terminals.
3. Now connect the oscilloscope between the ground and the terminals marked "Detector".
4. Connect the unknown resistance to the terminal marked Rx.
5. Select one multiplier arm by the connecting link.
6. Vary R1 for minimum position i.e. where on either side it rises.
7. Similarly vary R_2 for minimum position.
8. If the selection of the multiplier is correct the balance point can be observed on the oscilloscope.
9. Repeat the above procedure for another value of the multiplier till you get the null point or the balance point.

10. On achieving balance remove the unknown resistance and then measure the value of R1 and R2 . Also note the value of multiplier arm R3.
11. Substitution the same in the formula and find the value of Rx.

Observation Table:-

SL.NO.	**R_1**	**R_2**	**R_3 Multiplier Arm**	**R_x Observed by Color**	**$R_x = \frac{R_2 R_3}{R_1}$ By Bridge**

EXPERIMENT-1(B)

Aim of the Experiment: To find the value of unknown capacitance and it's reactance with the help of shearing bridge.

Apparatus Required:-

1. Adtron's trainer kit
2. Unknown values of capacitors or Decade capacitance box
3. Patch Cords
4. Digital Multimeter DMM.

Theory: Bridge circuits are extensively used for measuring component values, such as resistance, inductance and capacitance, and of other circuit parameters directly derived form component values such as frequency, phase angle and temperature. The AC Bridge in its basic from can be used for measurement of unknown inductance or capacitance. A basic capacitance bridge is as shown in figure

One of the ratio arms has a variable resistance in parallel with a capacitance. The opposite arm is the unknown capacitance arm of the other two arms one is multiplier arm and the other has the fixed capacitor. The general bridge balance equation is.

$Zx = Z_2 Z_3 Y_1$

From the above bridge circuit

$Rx \times(-j / \omega Cx) = (R_2 - j / \omega C_2)\ (1/R_1 + j\ \omega C_2)$

Substitution of these values in the bridge balance equation gives

$Zx = Rx - j/wCx$, $Z_2=R_M$ $Z3=-j/Wc_2$, $Y= (1/R_1 +jwC_2)$

Where Rx= Ohmic resistance of capacitor Cx

R_M = Selected Multiplier

Separation of real and imaginary parts yields

$Rx = R_M \times (C_2/C_1)$

$Cx = C_2(R_1 /R_M)$ in farad

Where the resistance is expressed in ohms and capacitance in farads.

Procedure:

1. Connect jumper links to connect the KHz oscillator to the bridge
2. Connect unknown capacitance of say 0.01µF at the terminal marked CxRx.
3. Select any multiplier arm (R_M) for example says 1K.
4. Connect the required supply to the unit and switch ON the unit. See that the supply indicator glows.
5. Connect CRO at the other junction of the bridge i.e. GND of CRO at the junction of R_1C_1 and C_2 and input pin of CRO at the junctions of multipliers arm (R_M) and unknown capacitance CxRx.
6. Now study adjusts R_1 by moving it either clockwise or anti-clockwise as required, such that null points is achieved on CRO.

NULL POINT

The waveform observed on CRO decreases when pot moved in any one direction of example if it is moved in clockwise direction then the amplitude of the waveform on CRO decrease and a point is reached where it is maximum. If the pot is further isolated in the same direction then the amplitude increases again. The minimum point is called the null point.

7. If null point is not achieved with multiplier arm as 1K then change the multiplier arm till you get the exact null point.
8. Once null point position is achieved , switch OFF the unit, remove all connections, measure with DMM and note the following

R_1= _________________Ohms RM(multiplier arm)=__________

C_1=0.001µF C_2=0.001µF

9. Calculate the value of unknown capacitance and it reactance using the formula $Cx = C_2R_1/R_M$ and $Rx= R_M\, C_2/C_1$
10. Change the value of unknown capacitance and repeat the above procedure.
11. Instead of connecting the CRO for observing the null point, the dictator's circuit provided at the kit can also be used for finding the null point. To use the detector circuit make connectors as follows
    a. Locate the detector block on the panel
    b. Connect the headphone at the output socket of the detector block.

c. Connect the junction of multiplier are R3 and unknown capacitance CxRx to the input terminal. Other terminals ground, which is to be connected to the junction R_1C_1 and C_2.
d. Now adjust the null point following the above procedure and hear for the minimum sound position is the null point.
e. Then follow the above procedure to calculate the unknown capacitance Cx and it's reactance Rx.

Observation Table:

R_1	R_M	C_1	C_2	$Cx=C_2R_1 / R_M$	$Rx=R_MC_2 / C_1$	Value of Unknown Capacitance

Circuit Diagram:-

Conclusion:-

EXPERIMENT-1(C)

Aim Of The Experiment:-To study the operation of the Kelvin's Bridge and to find the value of the unknown resistance.

Appratus Required:

1. Adtron's trainer kit
2. Oscilloscope
3. Multimeter
4. Head phone
5. Unknown resistance

Theory: The AC Bridge into its basic form can be used for measurement of an unknown inductance or capacitance by comparing it with a known inductance or capacitance. Here a resistance measuring bridge is described as shown in the figure. The Kelvin's bridge is a modification of the Whetstone's Bridge and provides greatly increased accuracy in the measurement of low value resistances generally below 1Ohm.
The balance equation for this bridge is given by $Rx = R_2R_3 / R_1$
It being a purely resistive bridge at all the values are in Ohms and the value of unknown resistance is also available in Ohms.

Procedure:

1. Switch ON the unit and see that supply LED glows.

2. Observe the sine wave at the respective terminals.
3. Now connect the oscilloscope between the ground and the terminals marked "Detector".
4. Connect the unknown resistance to the terminal marked Rx.
5. Select one multiplier arm by the connecting link.
6. Vary R1 for minimum position i.e. where on either side it rises.
7. Similarly vary R2 for minimum position.
8. If the selection of the multiplier is correct the balance point can be observed on the oscilloscope.
9. Repeat the above procedure for another value of the multiplier till you get null point or the balance point.
10. On achieving balance remove the unknown resistance and then measure the value of R_1 and R_2 . Also note the value of multiplier arm R_3.
11. Substitute the same in the formula and find the value of Rx

Observation Table:-

R_1	R_2	R_3	Rx	$Rx = R_2R_3 / R_1$ by bridge

Experiment-2

Aim Of The Experiment:- Study of temperature voltage characteristic of J type thermocouple

Apparatus Required:

SL.NO	NAME	RANGE
1	Thermocouple sensor	100^o
2	Water heater	
3	Thermometer	
4	Multimeter	
5	Water pot	

Theory:- When two metals having different work function are placed together a voltage is generated at the junction which nearly proportional to the temperature. This junction is called a thermocouple. The thermocouple is a thermoelectric drive that converts thermal energy into electrical energy. The heat at the junction is produced by the electrical current flowing in the heater element while the thermocouple produces an emf at its ouput terminal. The emf produced is proportional to the temperature and hence to the rms value of the current. The thermocouple is used as a primary transducer for measurement of temperature. The temperature voltage characteristic of J type thermocouple is nonlinear.

Control Pots:
0 degree (IC point) adjusts by zero trim pot.
100 degree (boiling point) adjusts by span trim pot.

Procedure:-

1. To connect the T/C sensor at the 9 pin connector.
2. Switch 'ON' the system the power indicator. The RED LED on the front panel will glow.
3. Give the 0 degree temperature to the T/C by keeping it into the ice, adjust the reading on the display by adjust through zero pot.
4. Keep the T/C into the boiling water and adjust the display reading 100 by adjusting through span pot 100º Celsius is calibrated.
5. Keep the T/C in room temperature. The indicator will display room temperature.

Observation Table:

SL.NO	TEMPERATURE	DISPLAY READING	ANALOGUE OUTPUT VOLTS	J TYPE T/C(mv)
1				
2				
3				
4				
5				

Precautions:

- To get the good performance from the tutor you have to maintain room temperature.
- To check the power source, it should be 230V + / - 10%. 50Hz to avoid over voltage hazards.
- To get best performance, you have to put the instrument at dust proof and humidity free environment.

Circuit Diagram:

EXPERIMENT-3

Aim Of The Experiment: To measure strain developed in a cantileger beam using strain gauges.

Apparatus Required: 1. ADTRON'S Trainer Kit.

2. Dead Weights

3. Digital Multimeter

Procedure:

1. Connect the required supply and switch ON the unit. See that the supply LED glows.
2. Connect the cantilever beam connector to the input jack provided on the panel.
3. Wait for five to ten minutes to stabilize the system.
4. Adjust with zero adjust potentiometer on the panel, such that meter reads micro constrains.
5. Now keep a load of 1 kg in the pan and note the reading.
6. Add 1kg in more loads in the pan and then observe the reading.
7. Repeat above procedure with different load. The maximum capacity of the cantilever beam is 10 Kg. (1000 micro constrains)

Note: Maximum weight to be applied is 10Kg.

Observation Table:

Load in the Pan(Cantilever beam) Kg	**Meter reading in micro constrains**

EXPERIMENT NO-4

Aim Of The Experiment: Measurement of temperature by using thermistor and study of different characteristics.

Apparatus Required:-

1. Water heater.
2. Water Pot.
3. Multimeter
4. Thermometer

Theory:- Thermister are generally composed of semiconductor materials . Most thermistors have a negative co-efficient of temperature resistance i.e. their resistance with increase in temperature. The negative temperature co-efficient of resistance can be as large as several percent per degree celcious. This allows the thermistor circuits to detect vary small changes in temperature, which could not be observed with a thermocouple. In some cases the resistance of thermistor at room temperature may decrease as much as 5 percent for each 1º rise in temperature. Thermistors are widely used in applications, which involve measurement in the range of 60 º c to 15º . The resistance of thermistors ranges from 0.5 Ohm to 0.75MΩ.

Procedure:-

1. Connect the thermistor at the 9 pin connector.
2. Switch 'ON' the system the power indicator. The RED LED on the front panel will glow.
3. Give the 0º C temperature to the thermister by keeping it into the ice, adjust the reading on the display by adjust through Zero-pot.
4. Keep the thermistor into the boiling water and adjust the display reading 100 by adjusting through span pot 100º is calibrated.
5. Keep the thermister in room temperature. The indicator will display room temperature. The indicator will display room temperature.

Observation Table:

SLNO	TEMPERATURE	DISPLAY READING	ANALOGUE OUTPUT(mv)	RESISTANCE
1				
2				
3				
4				

Precaution:

- To get the good performance form the tutor you have to maintain room temperature.

- To check the power source, it should be 230V + / - 10%, 50Hz to avoid over voltage hazards.
- To get best performance, you have to put the instrument at dust proof and humidity free environment.

Circuit Diagram:-

Conclusion:-

EXPERIMENT-5

Aim Of The Experiment: Measurement of torque by using Torque Transducer.

Apparatus Required: -

SLNO.	**NAME**	**RANGE**
1	Torque measurement tutor	-
2	Torque transducer	-
3	Weights	-
4	Multimeter	-

Theory:-

Torque transducer employ foil type strain bonded to the torque sensitive diaphragm. The design ensures high in inherent linearity whilst maintaining low hysterics and good ultimate safety factors. The design uses a full bridge strain gauge configuration. These transducers are will suited for static as well as dynamic Torque measurement.

Torque = Force × Distance
Force = 250gm = 0.0250Kg
Distance = 200mm =0.200m
Torque = Force × Distance
= 0.250× 0.200 = 0.050Kg-m.

Procedure:

1. To connect Torque Transducer at the 9 pin connector.
2. Power 'ON' the switch. The front RED LED glow with which indicated the power available on the instrument.
3. Give some time to stabilize the instrument for stabilization (warm up time)
4. Torque given both side.
5. Balancing the torque cell by through the corresponding "ZERO" ten turn trim pot.
6. Set the gain of load cell by "SPAN" ten turn trim pot.

7. Then to push the micro-switch to ascertain the reading position of CAL.
   The present CAL position in the instrument is _____________.
8. For example to apply the torque cell say 1KG-M. You will observe some reading on the Display says something like 0.92, 1.07 or so. Now we have to adjust this reading say 1.00 by rotating the span pot and to stop rotating with the desired 1.00 counts are visible .

Observation Table:-

Table-1:
Torque apply +ve direction

SLNO	**TORQUE APPLIED**	**DISPLAY READING**	**ANALOGUE OUTPUT**	**SIGNAL**
1	NO TORQUE	0.00gm	0.0 volt	0.00mv
2	250gms			
3	500gms			
4	750gms			
5	1000 gms			

Table-2:
Torque apply -ve direction

SLNO	**TORQUE APPLIED**	**DISPLAY READING**	**ANALOGUE OUTPUT**	**SIGNAL**
1	NO TORQUE	0.00gm	0.0 volt	0.00mv
2	250gms			
3	500gms			
4	750gms			
5	1000 gms			

Figure:

Precautions:
- To get good performance from the tutor you have to maintain room temperature.
- To check the power source, it should be 230V, +/- 10%, 50Hz tp avoid over voltage hazard.

- To get best performance, you have to put the instrument at dust proof and humidity free environment.

Conclusion:

EXPERIMENT -6

Aim of the Experiment: Study the characteristics of a relay and analyze the relay control system (Phase Plane)

Apparatus Required:

1. Relay control system kit
2. CRO
3. Multimeter
4. Patch cord

Theory:

Equipment Description

System: It is a second order type-1 system with parameters chosen appropriately for a proper CRO display. The system is simulated using operational amplifiers and passive components.

Relay: An electronic circuit simulates the relay. Its parameters are adjustable though panel controls as under,
Dead Zone (D) -0 to 500mV, Hysterics(H) – 0 to 600mV, Peak Output (M) - ±1V

Phase Plane Method:

In an autonomous second order system , whether linear or nonlinear, the complete performance may be depicted by a plot of x(t) and x·(t) as a function of time 't' where x(t) is most commonly the output of the system. If x(t) and x·(t) are taken as the two co-ordinates of a plane (the phase plane), the point { x(t), x·(t) represents the 'state' of the system at time t1. As 't' varies form zero to infinite, this point describes a 'trajectory' , which contains complete information about the dynamic performance of the system. Phase plane method is essentially a study and interpretation of the shape of the phase trajectory with regards to the stability and dynamic performance of the system. Obviously, the technique give the time response information in a direct manner, which is not possible though describing function method. The geometric interpretation of the trajectory, however is convenient for second order systems only.

The points in the phase plane where x·(t)= x(t) = 0, is called a singular point or an equilibrium point. If the system state is brought to this point it will stay there indefinitely since there is neither any forcing function nor any initial condition present in the system.

The shape and direction for the trajectory near the singular point determines the system's transient response and stability. However, the actual shapes depend on the nature and extent of the nonlinearity.

Driving s system with initial conditions alone is not very convenient, especially when the response needs to be displayed on a CRO . If a positive step input is used instead the equilibrium point will simply shift along the positive X-axis by and amount equal to the step magnitude. In the present setup, a low frequency (40-100Hz) square wave of amplitude ±R volt is used as input, the resulting display, shows two sets of trajectories, one corresponding to the positive step and the other to the negative step.

Procedure: In this experiment the phase plane trajectory of the system is viewed and studied for different nonlinearity and compared with the linear case.

(a) Linear System:

1. Connections are made for the closed loop system without the relay.
2. The two outputs, x and x are connected to the X and Y input of the CRO, which is kept in X-Y mode with D.C. Coupling.
3. Apply a square wave input of 1v p-p at 10-40 Hz and observe the equilibrium points on the CRO. Notice that the two trajectories and equilibrium points correspond to positive and negative step inputs.
4. Vary the gain K and observe how the equilibrium point is modified.

(b) **1.** Set K=10 ,11 and increase dead zone to make the system stable. This can be judged by the absence of a center on the CRO.

2. Apply a square wave of 10-40 Hz 1V p-p and observe the trajectory and equilibrium point.

3. Increase dead zone further and observe and record its effect on the singular point

4. Decrease dead zone counter to zero and set H= 0.2 (low)

5. Apply a square wave input of 10-40Hz, iV p-p . Observe the phase trajectory from the nature of the singular point comment on the stability of the system.

6. Repeat the above step for H= 0.4 (medium) and H=0.6 (high). Comment on the effect of increasing hysteresis.

Observation:

Relay Setting: Input since wave 100Hz, 2v p-p or more.

Dead Zone Only		Hysteresis only	
Knob Position	D, Volt	Knob Position	H2 Volt
1			
2			
3			

Circuit Diagram:

EXPERIMENT-7

D.C. SPEED CONTROL

Aim Of The Experiment:

To study the performance characteristics of a D.C. motor speed control system and determination of transfer function of a P.M.D.C. motor.

Apparatus Required:

1. D.C. speed control system kit
2. Patch cords

D.C. Motor: The 12-volt permanent magnet d.c. motor used in the system has the following specifications.
Rated voltage: 12 volt D.C. Rated current: 200 ma at no load , 290 ma at full load torque. 50gm-cm , maximum speed :2500 rpm

Theory:
In order to evaluate the system performance, it is necessary to compute the overall transfer function in terms of the transfer functions of the different blocks. To start with the transfer function of an armature controlled d.c. motor as

$$\theta(S) / V(S) = K_M / S(ST+1)$$

Where K_M is motor gain constant and T is the mechanical time constant. Considering motor speed ω rad/sec (=dθ /dt) as the output variable , the forward path transfer function may written as,

$G(s) = \omega(s) / V_E(s) = KA.KM / (sT+1)$………………………(eq -1)

Where KA is the gain of amplifier

Again the tachogenerator transfer function may written as,

$H(s) = V_T(s) / \omega(s) = K_T$

This yields the closed loop transfer function of the complete system as

$\Omega(s) / V_R(s) = K_A K_M / [S_T + K_A K_M K_T + 1]$

$= [K_A K_M / (K_A K_M K_T + 1)] / (K_A K_M K_T + 1)] + 1$ ………(eq -2)

In equation (2) the transfer function of the closed loop system is seen to be a first order type -0 functions.

Procedure:- The experiments suggested in this section start with a study of the open loop system and it's subsystems.

Note: - K_A may varied from 0 to 100 using a 10-turn potentiometer. Thus one turn of the potentiometer corresponds to gain variation from to 0 to 10.

(a) Signal and reference

- Set K_A =0 connect DVM to measure the range of variation of reference voltage V_R.

- Switch ON the square wave signal Vs and measure it's amplitude and frequency using a calibrated CRO. The frequency of this signal is about 1 Hz, which makes the CRO display very in convert for measurements. It is suggested that the amplitude may measured with time-base switched OFF and for frequency simply count the number of pulses, in say 60 secs using a watch.

(b) Motor and tachogenerator

- Set V_R =1 volt and K_A=3 the motor may be running at a low speed N is rpm and the tachogenerator output V_T.
- Repeat with V_R =1 and K_A =4, 5 …..10 and tabulate measured motor voltage V_M (=$V_R.K_A$), steady state motor speed N in rpm (or ωss=N.2 /60 in radian /sec) and tachogenerator output V_T.
- Plot N vs V_M and V_T vs N. Obtain K_M form the linear region of the curves.
- Motor gain constant, K_M = (shaft speed in rad /sec , ωss) / (Motor voltage , V_M) and tachogenerator gain K_T= [V_T / ωss] , volt-sec /rad.
- To calculate motor time constant with squire wave signal Vs on set Vr and KA show that the peak-to-peak variation of VM lies between 3-8V. This would ensure a reasonably linear operation of the motor.
- Obtain the motor transfer function using G(s) = Km /(sT +1)

Observation Table:-

(a) Motor and tachogenerator characteristics:

SLNO	K_A SETTING	N IN RPM	V_T VOLT	V_M VOLT	EXPERIMENTAL K_A= V_M /V_R
1					
2					

Draw the graphs of N vs Vm and Vt vs N. From the linear region, find out Km and Kt Time Constant, T= (1/2f)* [1/1n(1-V_T(p-p) / (V_M(p-p) / (VM(p-p) * $K_M K_T$)]

Where f=0.82Hz, VM=K_A-Vs (p-p) =0.8V (p-p), V_T=40mv (p-p)
The motor speed voltage characteristic rather non linear. This is because the motor fails to start at very low voltage and at higher voltages it's speed saturates due to its internal speed limiter.

EXPERIMENT-8

Aim Of The Experiment:- Study of P, PI, PID and relay type ON-OFF controllers in feedback system.

Apparatus Required:-

1. Thermal process for temperature control
2. Digital multimeter
3. Patch cords.

Description of the Thermal Process:-

The plant is an electric oven, the temperature of the plant is to be controlled in a closed loop feedback system. It is an example of 1^{st} order system described by Q=C×dT +I / R×T……(equ-1)

Where Q= rate of heat flow in Joule /Sec.
R= Thermal resistance defined by
C= Thermal Capacitance
=ΔQ(ΔT /dt) = Rate of heat flow / Rate of temp change.
Taking Laplace Transform of both sides of (equ-1)
R.Q(s) =(1+RCS)T(S)
Or, T(s) / Q(s) = R/ (1+RCS)×R/ (1+Ts)….(equ-2)
Where T=RC sec= time constant
Equ(2) which is a first order system , in closed loop operation.(see in fig 3)

With an amplifier of gain A, Kp =AR & steady state error is produced in the output.
Ess = Tref / 1+Kp = Tref/(1+AR)
From physical , practical considerations, a proportional controller with high gain and can not be used to reduce temperature error.
CONTROLLERS:-
Practical controllers used are of the following types

1. Proportional controllers
2. ON-OFF type
3. Proportional plus integral controller(PI)
4. Proportional – integral derivative (PID)

ON-OFF (RELAY) CONTROLLER:-
In a pure ON-OFF (relay) if the error is positive (Tref>Tc), the controller output is maximum. Heat flow rate Qmax .In other situation if e is negative (R<C) the controller output can be maximum negative.

Hysteresis is inherit in practical relays. It enables the controller output to remain at present value (say 0) till the input (error) has increase to beyond the hysteresis band h.
PROPORTIONAL CONTROLLER (P): fig 4(c)
It is an amplifier of gain A within s<e<s, where s is the input saturation level, output Q=Ae. If input(error) increases beyond or falls below s , the output of the amplifier is at +- Qmax.

PI CONTROLLER: fig.5 (a), 5(b), 5(c)
This illustrated in fig 5(a) which is block diagram, fig5(b) the response of the PI controller to a step input fig 5(c) is a circuit realization.

The input-output relation is Q(t) =Kpe(t) +Ki
e(t) = Kp [e(t) + 1/Ti
Where Kp= Proportional gain
Ki= integral time , sec= RC
Kp can be set by a potentiometer connected to integrator output.
The PI controller increases the type O system to a type 1 system. Makes
Kp= infinite and hence reduces the stedy state error to zero.

PID CONTROLLER:- fig 6(a) block diagram of the controller.

The circuit of a different is shown in fig6(b)
The PID output is given by
Q(s) = Kpe(s) +Kd /s e(s) +Kd se(s)
Or Q(s) =Kp [1+1/Tis + Tds] e(s)
Where Kp, Ki and the P-gain , I-gain & D-gains
Ti= integration time
Td= derivative time
The derivative block increases damping ration & thereby improve the dynamic performance by reducing the overshoot.
The integral block reduces steady state error.

Procedure:- Identification of oven parameters:-

1. The oven is driven through the P-amplifier set to gain of 10.
2. Keep switch S1 to wait, S2 to set & open feedback terminals.
3. Connect P, output to the driver input & switch on unit.
4. Set P potentiometer to 0.5 which gives Kp=10, this provides and input of 0.5 V to the driver.
5. Put switch S2 toe the measure position & note room temperature.
6. Put switch S1 to run position and note room temperature for every 15 sec till temperature becomes constant.
7. Plot temperature Vs time curve

ON-OFF Procedure:-

1. Keep switch S1 to the wait position and allow the oven to cool to room temperature short feed back terminals.
2. Keep switch S2 to the "Set" position and adjust reference potentiometer to the desired output temperature say 60.0 degree centigrade.

3. Connect R output to the driver input, outputs P,D and I must be disconnected from the driver input. Select “hi” of “low” value of hysteresis.
4. Switch S2 to measure and S1 to run position. Read and record oven temperature every 15/30 sec, for 20 minutes.
5. Plot a graph between temperature and time and observe the oscillation in the steady state.
6. Repeat the above steps with the

AIM OF THE EXPERIMENT:-

Measurement of linear displacement using LVDT

1) To plot a graph of displacement in mm v/s output (A.C mv) &find the residual voltage for different excitation signal
2) To plot a graph of displacement in mm v/s meter reading in mm.

APPARATUS REQUIRED:-

1) ADTRON’S Trainer kit
2) C.R.O
3) A.C. Milli voltmeter

PROCEDURE:-

a) Displacement in mm v/s output (A.C mv)
    1) Connect the required supply to the unit switch ON the unit and see that the supply indicator glows.
    2) Connect C.R.O at the primary of the LVDT and adjust with frequency pot, such that the frequency is 1 KHz at the amplitude pot be in maximum position.
    3) Connect the AC milli voltmeter at the secondary of the LVDT and note the reading for LVDT core displacement in steps of 1mm, in and out.
    4) Plot a graph of displacement in mm v/s A.C Milli voltmeter.
    5) Vary the excitation frequency and for each frequency repeat steps [1] to[4]
b) Displacement in mm v/s meter reading

    Again adjust excitation frequency at 1 khz and amplitude maximum

    6) Vary the core displacement (with micrometer) in steps of 1mm and read the mater reading.
    7) Plot a graph of displacement in mm(with micrometer reading) v/s meter reading in mv
    8) Vary the excitation frequency and for each frequency repeat steps [6]&[8]

OBSERVATION TABLE - 1:

Excitation frequency:------------------------- KHZ

SL NO	Input displacement in mm	Meter reading in mv

OBSERVATION TABLE - 2:

Excitation frequency:------------------------- KHZ

SL NO	Input displacement in mm	Meter reading in mv

CONCLUSION:-

From the above experiment I conclude that displacement of meter reading & plot a graph.