INSTRUMENTATION LABORATORY MANUAL

MECHANICAL ENGINEERING DEPARTMENT

(ISO 9001:2008 Certified)

MES COLLEGE OF ENGINEERING, KUTTIPPURAM

Instrumentation Laboratory Manual

MECHANICAL ENGINEERING DEPARTMENT

Revision	Date	Prepared by			Approved by		
		Name	Designation	Signature	Name	Designation	Signature
Rev1.0					Dr.Rahmathunza. I	Prof. & HoD ME Dept.	

VISION

To develop the Department into a premier destination of international level for advanced learning in Mechanical Engineering and to mould quality engineers to serve the society through creative solutions.

MISSION

- To mould engineers who would be able to apply the basic science and mathematics with confidence in professional activities for the benefit of all.
- To make our graduates experts in practical problem solving with abstract thinking skills.
- To make our students life-long learners capable of building their careers upon a solid foundation of knowledge and competent in communicating technical materials and concepts in individual group situations

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

After 3-4 years of graduation, our students will be able to

- Demonstrate their skills in technical profession and/or higher education by using the acquired knowledge in Mathematics, Science and Engineering fundamentals.
- Analyze the real life problems and propose sustainable design solutions for specific needs through applications of Engineering principles.
- Recognize the ethical responsibility as engineers and judiciously serve their peers, employers & society for the benefit of all.
- Practice life-long learning by continuing up gradation of possessed skills.

PROGRAM SPECIFIC OUTCOMES (PSOs)

At the end of four year programme the students (graduates) will be able to:

- Demonstrate basic knowledge in mathematics, science and engineering.
- Design, manufacture and analyze a Mechanical system using modern engineering software tools and measurement systems.
- Cognize concepts involved in thermal and fluid energy systems.
- Utilize self education to develop lifelong learning to appraise and adapt global and societal contexts to propose Engineering solutions.

PROGRAM OUTCOMES (POs)

Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analy**sis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

TABLE OF CONTENTS

Course Outcomes (CO's)

Course Outcomes (COs)

ME09 708(P): INSTRUMENTATION LAB (C408)	
Course objectives 1. To provide knowledge of uncertainties involved in any measurement. 2. To train the students in the calibration and use of different measuring instruments.	
Course Outcome	
C408.1	Able to evaluate the uncertainties involved in any measurement
C408.2	Able to perceive expertise on various calibration methods and measuring instruments for various applications.

ME14 603(P): INSTRUMENTATION LAB (C318)	
Course objectives 1. To provide knowledge of uncertainties involved in any measurement. 2. To train the students in the calibration and use of different measuring instruments.	
Course Outcome	
C318.1	Able to evaluate the uncertainties involved in any measurement
C318.2	Able to perceive expertise on various calibration methods and measuring instruments for various applications.

ME334-MANUFACTURING TECHNOLOGY LAB II (C 319)	
C319.1	Able to demonstrate programming practice on CNC machine tools
C319.2	Able to develop knowledge on the fundamental concepts and principles of metrology
C319.3	Able to explain the need of various modern measuring instruments and precision measurement techniques

1. CALIBRATION OF LOAD CELL

AIM

(a) To calibrate the Load Cell by plotting the graph between o/p voltage vs. load.
(b) To determine the static sensitivity and Impression of the Load Cell.

APPARATUS

1. Load Cell apparatus
2. A set of weights
3. A multimeter

SPECIFICATIONS

1. Maximum load – 5 kg
2. Exciting voltage – 10 V DC

DESCRIPTION OF THE APPARATUS

The experimental set up of the strain gauge load cell consists of a loading arrangement, D.C. exciting power supply, controls for adjusting exciting voltage, balancing the bridge and jacks for the measurement of bridge output.

PRINCIPLE

Four strain gauges forming a Wheatstone bridge circuit are bonded to a cantilever beam of the Load Cell. Since the strain gauge load cell is a passive transducer, an exciting voltage of 10 V is applied to the bridge. When no load is applied, the bridge is balanced and the bridge output voltage is zero. Load applied to the load cell produces compressive and tensile stresses in the cantilever beam. This causes strain in the gauges bonded to it and the bridge gets unbalanced. The resulting bridge output is a measure of the load applied to the load cell.

PRECAUTIONS

1. The bridge must be in balanced condition under no load.
2. The exciting voltage should not exceed 10 V.

PROCEDURE

An exciting voltage (10 V) was applied to the Wheatstone bridge circuit. The bridge was brought to balanced position by rotating the bridge offset knob. The loads were added in steps to the maximum load and at each step the bridge output voltage is noted down. Then the loads were reduced to zero in steps and at each step the bridge output voltage is noted down. The values were tabulated. Average of these two is used as output quantity (q_o) in the calculations. To calibrate the load cell a graph is plotted between o/p voltage (milli volts) and load (kg).

CALCULATIONS:

(a) Static sensitivity = ${}^{\Delta q_o}/_{\Delta q_i}$ (from graph)

Where Δq_o= increment in o/p voltage (mV)
Δq_i = corresponding increment in load (kilograms)

a) Standard deviation, σ

$$\sigma = \sqrt{1}/\text{N}\sum \quad \left[\left(q_o - \frac{b}{m}\right) - (q_i)\right]^2 \quad \text{kg}$$

Where, q_o = Output voltage

b = Intercept

m = Slope

N = Number of observations

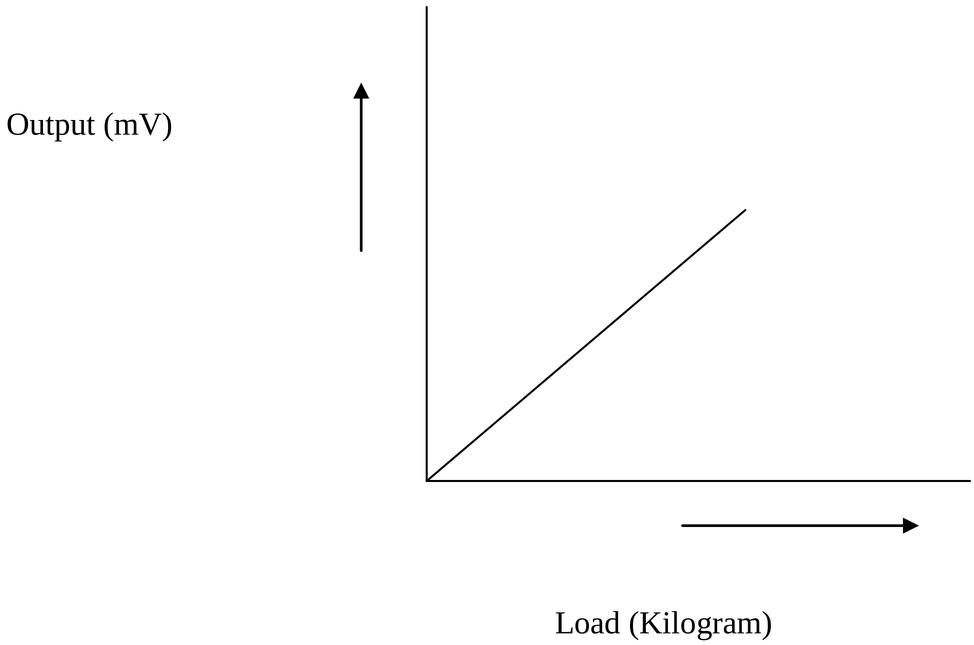
$$m = \frac{\text{N}\sum q_i\, q_{o-} \sum q_o\, q_i}{\text{N}\sum q_i^2 - (\sum q_i)^2} \qquad b = \frac{\sum q_o \sum q_i^2 - \sum q_i\, q_o \sum q_i}{\text{N}\sum q_i^2 - (\sum q_i)^2}$$

b) Imprecision of the instrument = $\pm 3\sigma$ kg

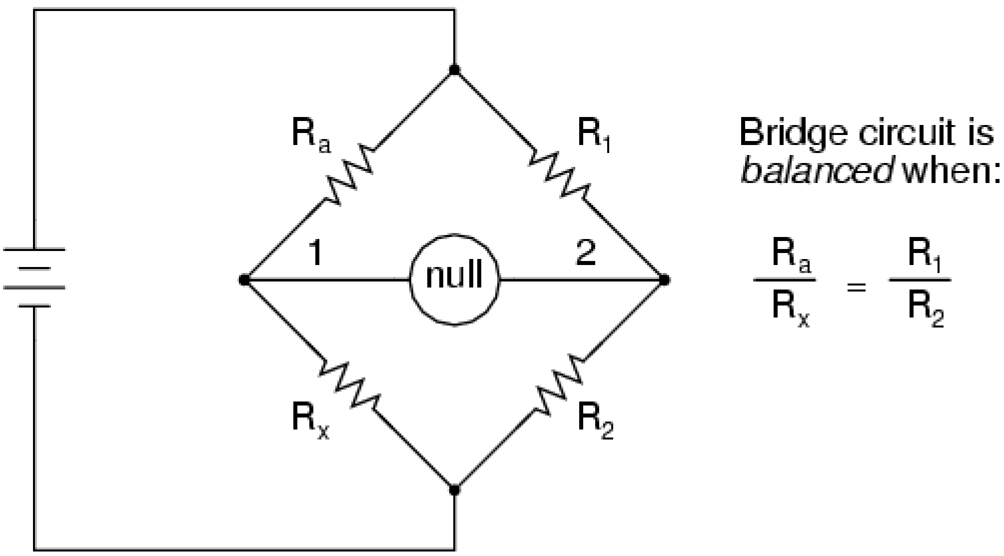
OBSERVATIONS

Sl. No.	Input (q_i) kilograms	Output (q_o) (mV)			qi x q_o	qi^2	$\frac{q_o - b}{m}$	$[(q_o - b/m) - (q_i)]^2$	Sensitivity $\Delta q_o/\Delta q_i$ (mV/kg)
		q_1	q_2	q_0					
1	1								
2	2								
3	3								
4	4								
5	5								

EXPECTED GRAPH



WheatStone Bridge Circuit



RESULT & INFERENCE

The given load cell is calibrated and the load v/s output voltage graph is plotted

1. Sensitivity from calculations (m) = -------------------------- mV/kg
2. Sensitivity from graph = -------------------------- mV/kg
3. Imprecision = -------------------------- kg

2. CALIBRATION OF LINEAR VARIABLE DIFFERENTIAL TRANSFORMER [LVDT]

AIM

To calibrate the given LVDT.

APPARATUS

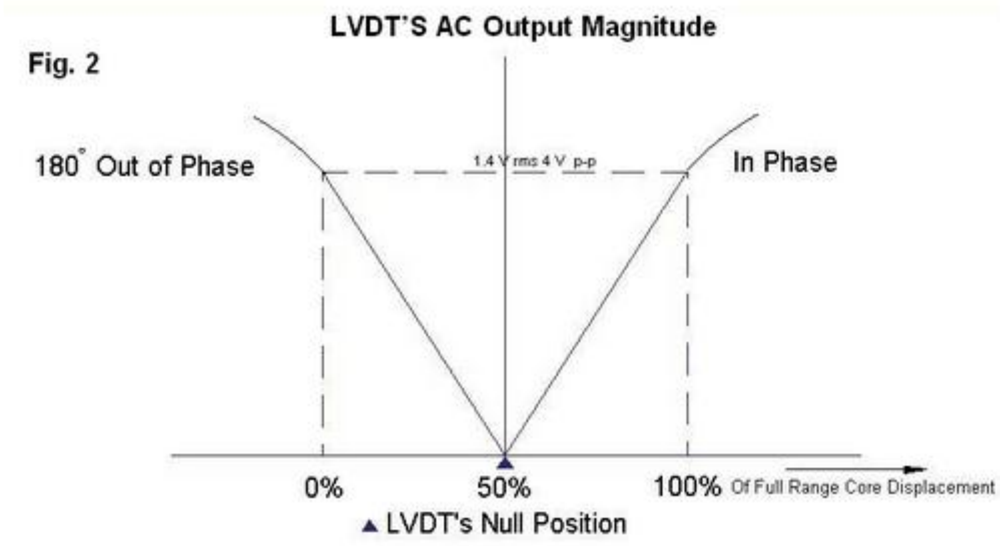
1. LVDT
2. Multimeter

PRINCIPLE

LVDT is a variable reluctance type displacement transducer, where a moving coil is used to vary the magnetic flux coupling the two coils. It consists of a primary winding, two secondary windings and a movable core. When the core is in the null position, the voltage in the two secondaries will be equal and the output voltage will be zero.

LVDT is constructed with an iron core with a non magnetic rod moving freely inside the windings. The iron core is responsible for the flux linkage.

With the two identical secondary coils, sinusoidal voltages of same frequency are produced the amplitude varies with the position of the iron core when the secondary coils are connected. In series opposition null output is obtained at the null position motion of the core from the null position causes a large mutual inductance for one coil and a small mutual inductance for another coil and the amplitude of the output voltage becomes a linear function of the core position.



AC Output of Conventional LVDT Versus Core Displacement

PROCEDURE

1. The power supply of the LVDT module is switched ON.
2. The LVDT is placed at the null position (12.5mm) and the offset is adjusted to read zero on the DVM calibrated in terms of the displacement of the core.
3. The core is gradually moved to the +ve direction (25mm) and gain is adjusted
4. The above steps are repeated in the opposite direction. Corresponding millivolt readings are taken.
5. To calibrate the LVDT, a graph is plotted taking displacement along X- axis and voltage along Y- axis.

OBSERVATIONS

POSITIVE DISPLACEMENT

Sl. No.	Displacement q_i (mm)	Voltage, q_o (mV)	q_i x q_o mV mm	q_i^2 mm^2	$\frac{qo-b}{m}$	$[\frac{qo-b}{m}-qi]^2$	Sensitivity mV/mm

NEGATIVE DISPLACEMENT

Sl. No.	Displacement q_i (mm)	Voltage, q_o (mV)	q_i x q_o mv mm	q_i^2 mm^2	$\frac{qo-b}{m}$	$[\frac{qo-b}{m}-qi]^2$	Sensitivity mV/mm

The calculations involved are:

(b) Static sensitivity = $\Delta q_o / \Delta q_i$ (from graph)

Where Δq_o= increment in o/p voltage (mV)

Δq_i = corresponding increment in load (mm)

c) Standard deviation, σ

$$\sigma = \sqrt{1/N\sum} \quad \left[\left(q_o - \frac{b}{m}\right) - (q_i)\right]^2 \quad \text{mm}$$

Where, q_o = Output voltage

b = Intercept

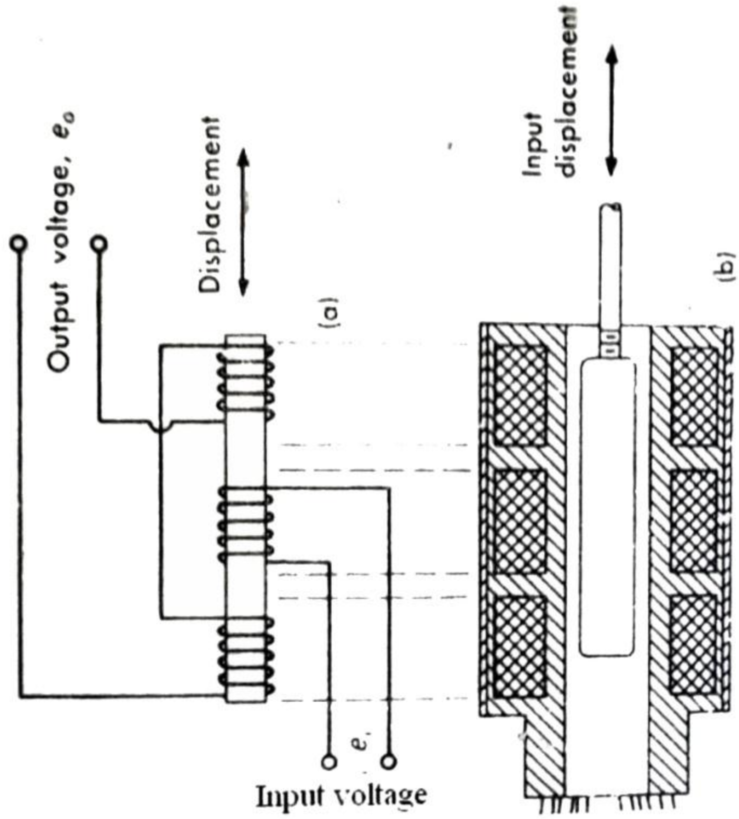
m = Slope

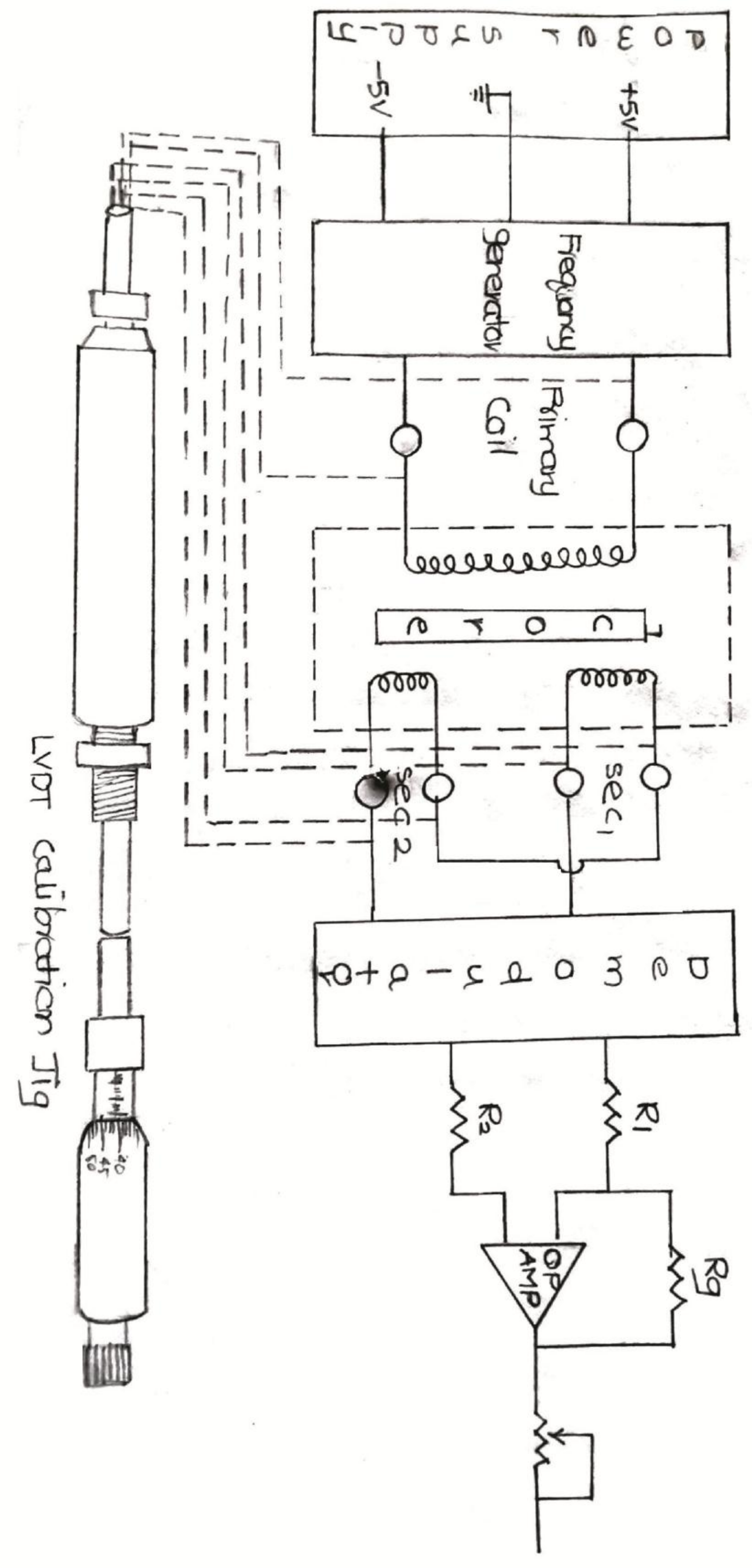
N = Number of observations

$$m = \frac{N\sum q_i\, q_{o-} \sum q_o\, q_i}{N\sum q_i^2 - (\sum q_i)^2} \qquad b = \frac{\sum q_o \sum q_i^2 - \sum q_i\, q_o \sum q_i}{N\sum q_i^2 - (\sum q_i)^2}$$

d) Imprecision of the instrument = $\pm 3\sigma$ mm

SCHEMATIC DIAGRAM OF LVDT




Power supply
+5V
-5V
Frequancy Generator
Primary Coil
core
sec 1
sec 2
Demodulator
R1
R2
Rg
OP AMP
LVDT Calibration Jig

RESULT

Positive displacement

a) Sensitivity from observation =
b) Sensitivity from graph =
c) Imprecision =

Positive displacement

a) Sensitivity from observation =
b) Sensitivity from graph =
c) Standard deviation =
d) Imprecision =

3. CALIBRATION OF TORQUE MEASUREMENT CELL

Aim

(a) To calibrate the torque sensor by plotting the graph o/p v/s input moment.

(b) To determine the static sensitivity of the torque sensor

Apparatus

1. Strain gauge torque sensor module.
2. A set of weights.
3. Multimeter

Specifications

1. Length of lever arm – 1 m
2. Weight of'the strip - 50gm
3. Maximum moment - 98 Nm
4. Exciting voltage – 10 V
5. Maximum amplifier voltage: -2 V

Description of the Apparatus

The experimental set up of the strain gauge torque sensor consists of a loading arrangement. D.C exciting power supply, signal conditioner and amplifier, controls for adjusting exciting voltage balancing the bridge and gain or the amplifier and jacks for the measurement of bridge output and amplifier output.

Principle

Four strain gauges forming a whetstone bridge circuit are bonded to the sensor shaft as shown in Fig. I Since the strain gauge torque sensor is a passive transducer an exciting voltage of 10 V is applied to the bridge. When no momentt is applied, the bridge is balanced and the bridge output voltage is zero. Moment applied to the sensor produces angular deformation in its shaft. This causes strain on the gauges bonded to it and the bridge gets unbalanced. The resulting bridge output, which is conditioned and amplified, is a measure of the moment applied to the sensor. Static sensitivity and gain can be determined from the slope of graphs bridge o/p voltage v/ s moment applied and bridge output voltage v/s amplified voltage, respectively.

Static sensitivity

Static sensitivity $=\Delta V/\Delta M$ where

ΔV is the increment in o/p voltage (V)

ΔM is the corresponding increment in moment (Nm)

Precautions

1. The bridge must be in balanced condition under no moment state
2. The exciting voltage should not exceed 10 V
3. The maximum amplified voltage should not exceed ≈2.5 V
4. The loading should not produce any bending or axial stress in the shaft or the sensor.

Procedure

An excitation voltage (10V) was applied to the Wheatstone bridge circuit. The bridge was brought to balanced position by rotating the bridge offset knob. The amplifier output was made to zero by rotating the amplifier offset knob. Then full load was applied on the lever and the amplifier voltage was set to 2 V. The load was then reduced to zero in steps and at each step the bridge output is noted down. After completely unloading the lever arm the loads were added in steps to the maximum load and at each step the bridge output is again noted down. The values were tabulated.

Calculations

a) Static sensitivity = $\Delta q_o/q_i$ (from graph)

where q_o = increment in o/p voltage (mV)

q_i = corresponding increment in moment (Nm)

b) standard deviation, σ

$$\sigma = \sqrt{1}/N \sum[(\mathbf{q_0 - b/m}) - (\mathbf{q_i})]^2$$

Where, q_o = Output voltage

b = Intercept

m = Slope (sensitivity from calculations)

N = Number of observations

$$m = \frac{N\sum q_i\, q_{o-} \sum q_o\, q_i}{N\sum q_i^2 - (\sum q_i)^2} \qquad b = \frac{\sum q_o \sum q_i^2 - \sum q_i\, q_o \sum q_i}{N\sum q_i^2 - (\sum q_i)^2}$$

c) Imprecision of the instrument = $\pm 3\sigma$ Nm

OBSERVATIONS

Sl. No.	Input (q_i) (N-m)	Output (q_o) (mV)			qi x q_o	qi^2	$\frac{q_o - b}{m}$	**$[(q_o – b/m) – (q_i)]^2$**	Sensitivity $\Delta q_o/\Delta q_i$
		q_1	q_2	q_0					
1	0								
2	1 x 9.81								
3	2 x 9.81								
4	3 x 9.81								
5	4 x 9.81								
6	5 x 9.81								
7	6 x 9.81								
8	7 x 9.81								
9	8 x 9.81								
10	9 x 9.81								
11	10 x 9.81								
12	11 x 9.81								

$\sum q_i =$ $\sum q_o =$ $\sum q_i \sum q_o =$ $\sum q_i^2$ $\sum$ **$[(q_o – b/m) – (q_i)]^2$**

RESULT

4. Sensitivity from calculations (m) = -------------------------- mV/Nm
5. Sensitivity from graph = -------------------------- mV/Nm
6. Imprecision of the instrument = -------------------------- Nm

4. CATHODE RAY OSCILLOSCOPE

AIM

To familiarize with the panel of CRO and to study the measurements using it and also the same about signal generator

CATHODE RAY OSCILLOSCOPE

Cathode ray oscilloscope is an instrument which gives the visual representation of electrical signals. It is one among the most versatile tool used for the research and study of electronic circuits and systems. It displays the signal on a screen in X and Y axis used in the conventional graph construction. X-axis represents the time and Y-axis the amplitude of the signal. Oscilloscopes are capable of displaying voltage variations which take place over a period of micro seconds and nanoseconds. The controls and sockets of front panel of a typical Cathode Ray Oscilloscope are explained below.

1. **POWER ON/OFF**: puts the instrument to main supply with LED indication

2. **INTENS**: Controls the brightness of the display

3. **FOCUS: Controls the sharpness of the display**

4. **TIMEBASE**: Switch selects time base speeds

5. **TIME BASE VARIABLE: In calibrated position (CCW) the selected sweep speed holds indicated calibration. Clockwise it extends the sweep speed by 2.5 times approax., with LED indication**

6. **POSITION/X5**: Controls the horizontal position of the display. When this control is pulled, it magnifies the sweep 5 times, with LED indication.

7. **LEVEL**: Variable control, selects the trigger point on the displayed waveform

8. AT/NORM: In auto mode trace is displayed in absence of any input signal. The display is then automatically triggered for signals above 30Hz depending upon correct setting of Trigger LEVEL control.

9. **INT/EXT**: INT: Display triggers from signals derived from CH 1,CH2 or line.EXT: Triggering from any other external source fed through EXT TRIG BNC socket ·

10. **LINE**: Triggers from power line frequency.

11. **TV: Triggers from low frequency component of TV signal (TV-V or TV-H).**

12. +/-: Selects trigger point on either positive or Negative slop of the displayed wave form.

13. **CH1/CH2**: Selects trigger signal in INT mode derived from either CHI o·Cl-12 inputs.

14. **ac/dc**: Selects trigger signal coupling.

15. **HF Rej**: Introduces low pass filter (20K Hz) in trigger coupling

16. **SWP/X-Y**: When pressed converts CH2 input in to X-Channel and enable use of the scope as on x-y scope(Y- input via CHI)

17. **0.2V, IKHZ**: 200mV p-p I KHz square wave calibration signal

18. **POSITION/X5**: Controls the vertical position of the display. When this control is pulled, it magnifies the vertical sensitivity by 5 times with LED indication

19. **ac/dc/gnd**: selects input coupling/grounding (grounds the amplifier input signal is open circuited)

20. **EXT-TRIG**: input BNC for External trigger signal.
21. **INPUT BNC CH1/Y (CH2/X):** input terminals to CH I/Y, Cl-12/X inputs
22. **TRACE**: screwdriver controls to adjust horizontal till or the trace .
23. **CH1/CH2 ATTENUATOR**: 12 steps compensated attenuator from 5mV/div. to 20V/div. in 1,2,5 sequence
24. **VERTICAL MODES**
    a. **ALT/CHOP**: selects switching mode for the two channels while in DUAL operation
    b. **DUAL/CH I (X-Y):** when pressed CH 1 trace is selected. Also CH 1 becomes X input in X Y mode
    c. **DUAL/CH2**: when pressed CH2 trace is selected
    d. **CHANNEL ADDITION**: when both CH1 and CH2 are press signals from CH I and CH2 are algebraically added
    e. **CH2 INV**: when Cl-12 INV switch is pressed polarity of the signal to CH2 is inverted
    f. **CHANNEL SUBTRACTION**: when both CH I and CH2 and CH2 INV is pressed CH 2 signal is algebraically subtracted from CH I
25. **CT**: converts scope in to component tester
26. **CT TERMINAL**: Input terminal for component tester

FUNCTION GENERATOR

This is widely used laboratory equipment which will deliver different signals like sine, square, triangular etc. at different frequencies .The frequency control are available on front side of function generator. These signals are internally produced with help of Oscillators and Multivibrators.

FRONT PANNEL CONTROLS

I. FREQUENCY RANGE: Pushing one of the push button switches at a time selects the desired frequency from the function generator in decades

2 FREQUENCY COARSE AND FINE: Set the desired frequency of function between 0.1 to I times the frequency range value selected .User can accurately set the desired frequency using fine control knob

3 FUNCTION SWITCH: Three inter locking push button switches provide selection of the desired output wave form. Pressing one switch will release the switch previously pressed. When all switches are depressed then DC function is selected. Sine, square and triangle wave forms are provided.

4 DUTY CYCLE: Time symmetry of the output wave form, as well as the TTL Output is controlled by the duty cycle potentiometer

5 INVERT SWITCH: A push button switch is provided to invert the time symmetry set by the duty cycle pot

6 DC OFFSET: this is a knob with ON/OFF control. A DC OFFSET control is provided to allow the DC level of the output waveform to be set as desired

7 ATIN: There are n:or o output attenuation pushbutton switches providing attenuation of 20d8&40d8 .when both are pressed, it gives total attenuation of 60dB

8 LEVEL FINE: This level is used to set desired amplitude level of function output signal. The level control provides 20dB (approx.) of attenuation to the output wave form selected by the function switch

GENERATOR SETTINGS

After power on press the range switch to select desired frequency range. Each range has a typical control between 3% to 100% .The frequency can be set by using the frequency COARSE and FINE controls. The function switch selects the desired wave form. Any of the selected waveforms can be DC shifted by pressing the DC OFFSET switch to ON position and then adjusting DC level by the variable potentiometer. The generator output desired by the position of the LEVEL potentiometer. The variable level control has a range of approximate 20dB

PROCEDURE:

To analyze the amplitude and frequency of the signal

1. Switch on the CRO. Obtain a sharply defined trace of a horizontal line by using JNTENS and FOCUS knobs
2. Adjust the Y-position knob to make the trace to coincide with the centre line on the screen by keeping the AC-DC switch in GND position
3. Connect the function generator with the CRO using a probe and switch on the function generator
4. For amplitude measurement count the no. of divisions occupied by the signal from peak to peak
5. Multiply this by the scale indicated VOLT/DIV knob. This gives the peak to peak amplitude of the signal. Half of this will give the maximum (peak) value of voltage
6. For frequency measurement count the no.of divisions occupied by the signal in one cycle
7. Multiply this by the scale indicated on TIME/DIV. knob gives the time period of the signal. Then finding the reciprocal of this gives frequency of the signal
8. Repeat the same procedure for various setting of VOLT/DIV & TIME/DIV knob

OBSERVATIONS:

Voltage measurements

sl.no	No.of div.in Y-axis	V /div	Voltage
1	-		
2			
3			

Frequency Measurements

sl.no	No.of div.in X-axis (n)	Tim/div(c) in Sec.	Time period, T=n*c	Frequency, F=1/T in H_Z
1	-			
2				
3				

5. CALIBRATION OF J TYPE AND K TYPE THRMOCOUPLES

AIM

To study the characteristics of Temperature Vs emf developed by the K- type and J- type thermocouples and determine

i) Sensitivity and
ii) Imprecision

APPARATUS

Thermocouple (K- type),
Thermocouple (J-type),
Thermometer,
Water bath,
Multi meter

PRINCIPLE

Thermocouples are widely used sensors for the measurement or temperature. The sensing is based on the principle that current flows in a closed circuit made up of two types of metals when the joints are kept at two different temperatures. This phenomenon is called Seebeck effect. The magnitude of EMF generated will depend upon the magnitude of difference between the temperature of the two junctions and conductor materials.

PRECAUTIONS

The water in the bath must be at room temperature before the beginning of the experiment. The water used for second thermocouple should either be a different one at room temperature or if the bath used earlier is to be used again, it must be cooled to room temperature before use

PROCEDURE

Dip the K-type thermocouple in the water bath. A thermometer is also placed alongside the thermocouple. The bath will be initially at room temperature. Note down the voltage at room temperature using a multi meter. Now heat the water bath. There will be a rise in voltage value due to the increase in temperature. Note down the voltage value for every 10℃ rise in temperature. This is done for every 10C rise in temperature and is continued until boiling conditions are reached.

Repeat the same with J- type thermocouple. And record the observations. The experiment has thus been conducted and calculations were performed.

OBSERVATIONS

For K-type thermocouple

Sl.No.	qi (°C)	q_o (mV)	qi x q_o	qi^2	$\frac{q_o - b}{m}$	Sensitivity $\Delta q_o/\Delta q_i$
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						

For J-type thermocouple

Sl.No.	qi (°C)	q_o (mV)	qi x q_o	qi^2	$\frac{q_o - b}{m}$	Sensitivity $\Delta q_o/\Delta q_i$
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						

CALCULATIONS

d) Static sensitivity = $\Delta q_o/q_i$ (from graph)

Where q_o = increment in amplified voltage (mV)

q_i = corresponding increment in load (grams)

e) standard deviation, σ

$$\sigma = \sqrt{1}/N \sum[(q_o - b/m) - (q_i)]^2$$

Where, q_o = Output voltage

b = Y Intercept

m = Slope (sensitivity from calculations)

N = Number of observations

$$m = \frac{N\sum q_i q_o - \sum q_o}{N\sum q_i^2 - (\sum q_i)^2} \qquad b = \frac{\sum q_o \sum q_i^2 - \sum q_i q_o \sum q_i}{N\sum q_i^2 - (\sum q_i)^2}$$

f) Imprecision of the instrument = $\pm 3\sigma$ Nm

RESULT

7. Sensitivity (from table) = -------------------------- mV/Nm
8. Sensitivity (from graph) = -------------------------- mV/Nm
9. Imprecision of the instrument = -------------------------- Nm

6. DETERMINATION OF PSYCHROMETRIC PROPERTIES OF AIR USING SLING PSYCHROMETER

Aim

To determine the following properties of air and compare with the psychrometric chart

1) Specific humidity
2) Relative humidity
3) Vapour pressure
4) Density of water vapour in air
5) Density of dry air
6) Density of moist air
7) Dew point temperature
8) Enthalpy of moist air

Apparatus:

Sling type psychrometer

Specifications:

Thermometer range

Wet bulb temperature	: 0 – 100 °C
Dry bulb temperature	: 0—100 °C
Liquid used for wetting	: Water

Principle:

The sling type psychrometer has two thermometers. The bulb of one is covered with a wet cloth. When the psychrometer is rotated, the water from the wet bulb thermometer evaporates by absorbing heat from the thermometer bulb and hence mercury level in the thermometer falls. After some time the mercury level becomes constant. The readings of the thermometer are noted.

Calculation:

Carriers equation

$$P_V = \frac{(P_{VS})_{WBT} - [P_t - (P_{VS})_{WBT}] \times (T_{DB} - T_{WB})}{1547 - 1.44 T_{WB}} \text{ bar}$$

Where, P_V = Vapour pressure bar

$(P_{VS})_{WBT}$ = Vapour pressure at wet bulb temperature (from steam table)

Atmospheric pressure (P_t) = 1.01325

Properties of air

a)Specific humidity (ω) = $\dfrac{\text{Mass of water vapour}}{\text{Mass of dry air}} = \dfrac{0.622P_V}{(P_t - P_v)}$ kg/kg of dry air

b) Relative humidity, Q = $\dfrac{\text{Mass of water vapour in the given volume}}{\text{Mass of water vapour in the same volume of saturated air}}$

$$= \frac{PV}{(P_{VS})_{DBT}} \times 100 \quad \%$$

c) Density of water vapour in air (ρ_v) = $\dfrac{P_V \times 10^5}{Rv\,(T_{DB} + 273)}$ kg/m^3 Rv = $\dfrac{8.314 \times 10^3}{18}$ J/kg K

d) Density of air, (ρ_{air}) $= \dfrac{(Pt-Pv) \times 10^5}{R_{air}(T_{dbt} + 273)}$ kg/m^3 $R_{air} = \dfrac{8.314 \times 10^3}{29} = 287 J/kg\,K$

e) Density of moist air, $\rho_{moister}$ $= \rho_v + \rho_{air}$ kg/m^3

f) Dew point temperature, T dp = saturated temperature of water vapour at the existing partial pressure of water vapour.

= saturated temperature at Pv °C

g) Enthalpy of moist air, (h) $= Cp_{dry\ air} \times T_{DBT} + \omega(25006 + Cp_{moist\ air} \times T_{DBT})$

Where, $Cp_{dry\ air}$ = 1.005 kJ/kg K

$Cp_{moist\ air}$ = 1.88kJ/kg K

Procedure:

The sling psychrometer consists or a dry bulb and wet bulb thermometer mounted side by side in a protective case that is attached to a handle by a connection so that the case can be easily rotated .The dry bulb temperature measures the actual temperature of air.

The sling psychrorneter is rotated for about 5 minutes after which reading from both thermometers arc noted. The process is repeated for several times to assure that the lowest possible wet bulb temperature is recorded. The properties of air arc calculated using equations and compared with the values of psychrometric chart.

Observations:

Sl.no.	Dry bulb temperature(°C)	Wet bulb temperature(°C)
1		
2		
3		
4		

Results:

Properties of air	From equation	From chart
1)Specific humidity		
2) Relative humidity		
3) Vapour pressure		
4) Density of\water vapor in air		
5) Density of dry air		
6) Density of moist air		
7) Dew point temperature		
8) Enthalpy of moist air		

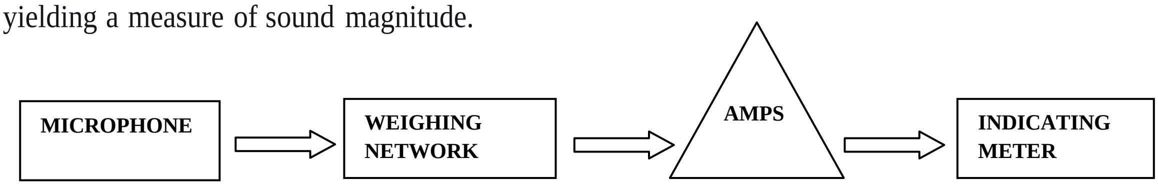
7. SOUND LEVEL METER

AIM

a) To measure the sound pressure level (S P L) of a single source.
b) To measure the S P L of a combination of sounds.

APPARATUS

Sound level meter- basic instrument t that senses the input sound and provides meter read out yielding a measure of sound magnitude.



PRINCIPLE

Sound pressure:

Instantaneous difference in air pressure and the average air pressure at a point is called sound pressure. The unit of measurement is N/m^2 or Pascal.

Sound pressure level:

Sound pressure level is represented in dB. It is a measure of power ratio ie $dB = 10\log_{10}$ (power 1/power2). Sound power is proportional to square of sound pressure. So dB will be equal to 10 $\log_{10}$ $(P_1^2/P_0^2$ which will be equal to $20\log_{10}(P_1/P_0)$. Decibel is not an absolute quantity but a comparative one. $P_0 = 0.00002\ N/m^2$. It is widely accepted as the standard reference for sound pressure level. This value takes on the significance when we note that it corresponds quite closely to the acute threshold of hearing.

S P L = $20\log_{10}(P / 0.00002)$

P = r m s pressure from the sound source in N/m^2

PROCEDURE

The weighing network is selected in C position and decibel range is noted in 80 – 130 dB range

(a) Measurement of sound from a single source:

The S P L of the lab without starting any source is measured and then started one sound source (twin cylinder texvel diesel engine)

(b) Measurement of S P L of combined source:

Measure S P L of lab by generating sound from two sources namely twin cylinder texvel diesel engine and single cylinder texvel diesel engine.

(c) Measure S P L of each source separately by working all sources at same distance:

OBSERVATIONS

Setti ngs on the meter

Posi tion weighing net work C

dB range = 80 – 130 dB

THERMAL LAB

(a) S P L of Hall = dB

(b) S P L measured from single cylinder texvel diesel engine = dB

(c) S P L measured from twin cylinder texvel diesel engine = dB

(d) S P L measured from both machines = dB

PRODUCTION ENGINEERING LAB

(a) S P L of Hall = dB

(b) S P L measured from machine lathe 1 = dB

(c) S P L measured from machine lathe 1 = dB

(d) S P L measured from both machines = dB

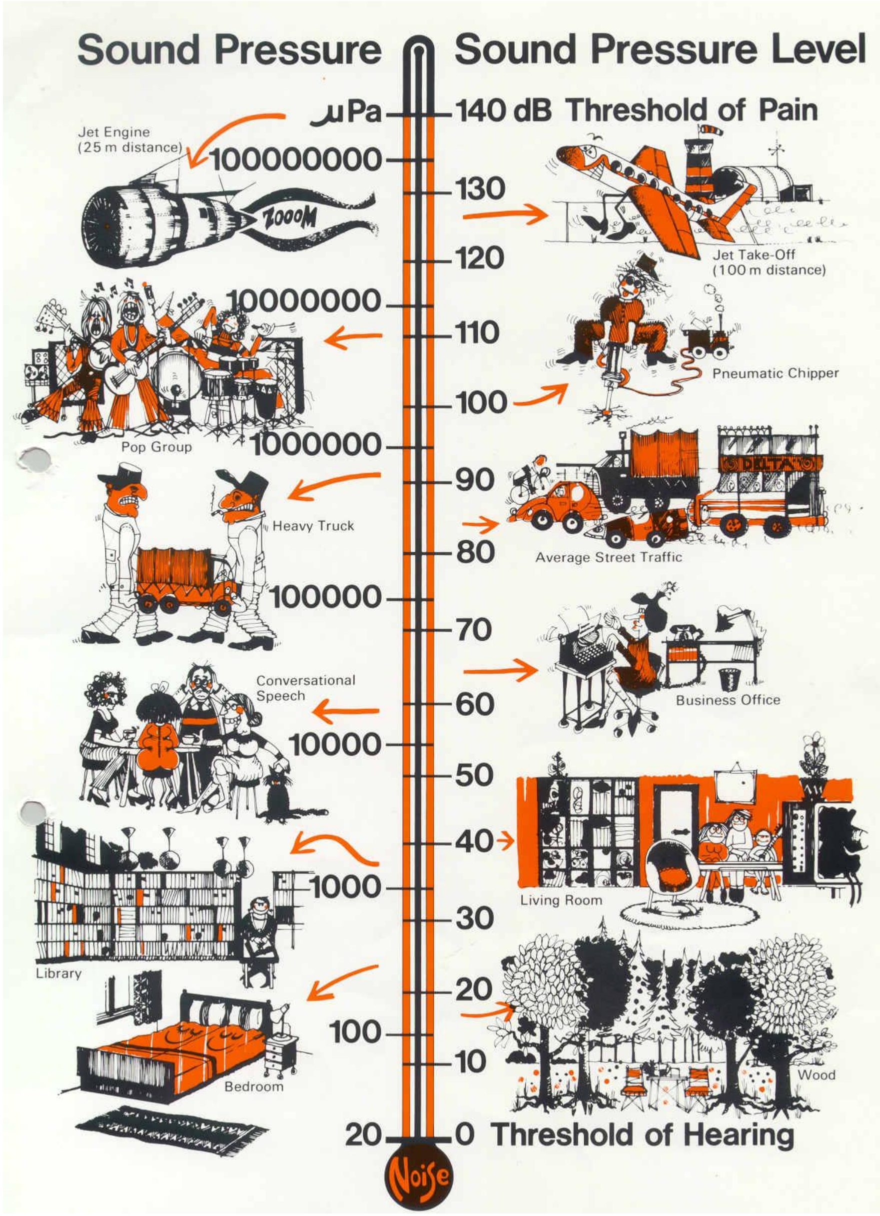
RESULT

Sl. No	Thermal Lab	Observed (dB)	Calculated (dB)
1	SPL of lab		
2	SPL of twin cylinder texvel diesel engine and hall		
3	SPL of twin cylinder texvel diesel engine alone		
4	SPL of single cylinder texvel diesel engine and hall		
5	SPL of single cylinder texvel diesel engine alone		
6	Combine SPL of lab, single cylinder and twin cylinder		

Sl. No	Production engineering lab	Observed (dB)	Calculated (dB)
1	SPL of Production engineering lab		
2	SPL of lathe 1 and hall		
3	SPL of lathe 1alone		
4	SPL of lathe 2 and hall		
5	SPL of lathe 2alone		
6	Combine SPL of Workshop, lathe 1 and lathe 2		

SOUND LEVEL METER

SOUND PRESSURE LEVEL



8.CALIBRATION OF PRESSURE GAUGE

AIM

(a) To calibrate a pressure gauge using a dead weight pressure gauge calibrator and to plot the linearity graph.
(b) To determine the % linearity and % Hysteresis.

APPARATUS

Dead weight pressure gauge calibrator with weights.

SPECIFICATIONS

Capacity	=	0.1 to 10 Kg/cm^2
Plunger weight	=	0.2 Kg/ cm^2
Test gauge	=	40 Kg/ cm^2
Dead weight	=	1 ATA (5 no.)

PRINCIPLE

Dead weight tester owns the principle of Pascal's Law. The hand operated piston is fully drawn out and the oil is allowed in to the system through the reservoir needle valve. This valve is then closed and the gauge is connected by a suitable adapter. A suitable the measuring piston and pumping lever is used to apply force on the piston. The gauge tube is filled with oil and pressure is developed in the hydraulic system of the tester. The piston is just lifted for balancing of the weight. This is then kept revolving by hand for minimizing the friction.

PRECAUTIONS

1. The pressure gauge calibrator should be leveled using a spirit level

2. There should be sufficient oil in the chamber

3. Air entrapped in the chamber is to be removed by opening the needle valve and moving the plunger to and fro a few times until no air bubble escape through the pouring cup

4 · Once the air bubbles are removed from the chamber the needle valve should be in the closed position through out the experiment.

5. The effect of static frictional force is to be eliminated by rotating the weights while pressurizing the system.

PROCEDURE

1. Fill the oil tank with sufficientt oil (Castrol Grade 40 oil)
2. Release the air valve provided at the bottom till the oil starts dripping continuously (about 10 to 12 drops) and then tight the valve.
3. Release the control valve and pump the oil so that the oil circulates through the tubes. Pump for a while about a minute so that all the tubes will be filled with the oil and any air bubble inside the tube will be removed.
4. Now close the control valve and pump the oil to the plunger which starts flouting. Pump till the line on the plunger is visible. Rotate the plunger gently. The pressure built inside the chamber is proportional to the weight on the plunger. The gauge fixed to be tested will start showing the pressure.
5. Add 1 ATA dead weight on the plunger and pump once again till the line on the plunger is clearly visible. The pressure inside the chamber increases by 1Kg/cm^2
6. Add the weights on the plunger and pump till the linne on the plunger is clearly visible.
7. The Bourdon pressure gauge will read the pressure corresponding to the dead weights on the plunger. Note down the readings on the pressure gauge and tabulate the readings with the corresponding readins of the dead weight.
8. Pressure gauge readings are noted for different loads in the ascending and descending order.
9. Plot the graph for actual pressure Vs pressure gauge readings. Calculate the accuracy, linearity and Hysteresis of the pressure gauge.
10. **CALCULATIONS**

%Linearity = (Maximum Error/Maximum Pressure) x 100
%Hysteresis = (Maximum Deviation/Maximum Pressure) x 100

OBSEERVATIONS

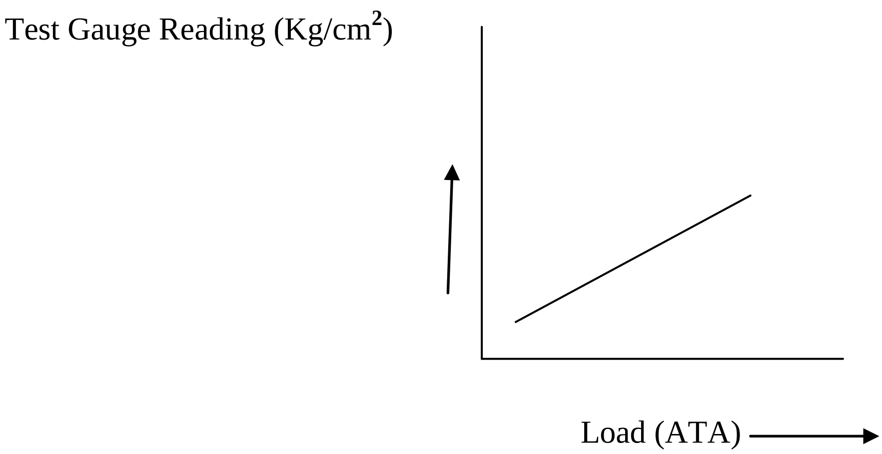
To Determine % Linearity

Sl.NO.	Laod Applied (ATA)	Actual Pressure (Kg/cm^2)	Test Gauge Reading (Kg/cm^2)	Error
1.				
2.				
3.				
4.				
5.				
6.				

To Determine % Hysteresis

Sl.NO.	Laod Applied (ATA)	Gauge pressure reading (bar)		
		Ascending test	Descending test	Deviation
1.				
2.				
3.				
4.				
5.				
6.				

Expected curve



RESULT

%Linearity =

%Hysteresis =

9.CALIBRATTON OF ORIFICEMETER

AIM

To draw the calibration curve of the given orifice meter to determine

a) Sensitivity
b) Imprecision

APPARATUS

The experimental set up consists of orifice meter with measuring tank.
Tank dimension (L X B) is 50X50 cm^2.
The diameter of the pipe is 25mm.
The diameter of orifice is 15mm. [$C_d = 0.62$]

PRINCIPLE

Here the discharge obtained from the measuring tank is considered as standard value and the orifice meter is calibrated for it. The theoretical value is given as:

$$Q_{cal} = \frac{C_d\, a_1 a_2 \sqrt{2_g H_w}}{\sqrt{a1^2 - a2^2}}$$

Where, H_w = Head of water

= 12.9 x h m,

a_1 = Cross sectional area of pipe

a_2 = Cross sectional area of orifice

h = difference in manometer reading in m

The discharge obtained in the collecting tank is taken as the actual one

Q_{act} = (A.L) / t

Where A = area of the tank

L = 10 cm,

T = time for 10 cm rise of water in the collecting tank.

CALCULATIONS

Let q_i be the calculated discharge and q_o be the actual discharge.

a) Static sensitivity = $\Delta q_o / \Delta q_i$ (from graph)

Where Δq_o = increment in actual discharge (m^3/sec)

Δq_i = corresponding increment in calculated discharge (m^3/sec)

b) standard deviation, σ

$$\sigma = \sqrt{(1/N)\sum[\ (q_o\text{-}b/m) - (q_i)]^2}$$

Where, q_o = actual discharge

b = Intercept

m = Slope

N = Number of observations

$$m = \frac{N\sum q_i\, q_{o-}\ \sum q_i}{N\sum q_i^{\,2} - (\sum q_i)^2} \qquad b = \frac{\sum q_o \sum q_i^{\,2} - \sum q_i\, q_o \sum q_i}{N\sum q_i^{\,2} - (\sum q_i)^2}$$

c) Imprecision of the instrument = $\pm 3\sigma$ Nm

PROCEDURE

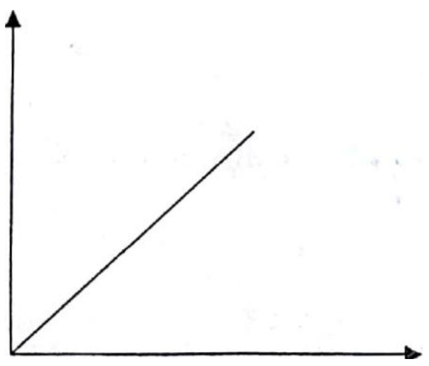
The supply valve was opened to full discharge position. There is another valve which can be adjusted for discharge. Discharge is varied in steps and the corresponding time for l0cm rise of water in the measuring tank is noted. The head difference in manometer is also noted. The experiment is repeated for different values or discharge.

OBSERVATIONS

Sl. No	Manometer reading h (cm)	Head of water Hw =12.6h (m)	Time for 10 cm rise Of water t(s)	Qact (m^3 / s)	Qcal (m^3 / s)
1.					
2.					
3.					
4.					
5.					

EXPECTED GRAPH

Output (q_o) m^3 / sec



Input (q_i) m^3 / sec

RESULT

Sensitivity from the graph =

Sensitivity (calculated) =

Imprecision = (m^3 / sec)

10. STRAIN MEASUREMENT WITH DATA ACQUISITION SYSTEM

AIM

a) Calibrate the load cell by using data acquisition system.
b) Determine the static sensitivity by plotting graph micro strain Vs laod.

APPARATUS

1. Data acquisition system
2. Load cell arrangement
3. A set of weights

SPECIFICATION

Number of channels	= 32
Measuring range	= strain gauge ± 32000 micro strains per transducer
Resolution for strain gauges	= 1 micro strain
Number of samples	= up to 4000 sample

PRINCIPLE

Four strain gauges forming a Wheatstone bridge are located on a cantilever beam. Since a strain gauge is passive transducer an exciting voltage of 5V is applied to the bridge. At no load, the bridge is balanced and the compressive and tensile stresses are also equal. This set up measures strain in gauges bonded to it and the bridge gets balanced. The resulting bridge output is conducted and amplified. Static sensitivity and gain are determined from the slope of the graph of bridge voltage Vs amplified voltage.

PROCEDURE

Connections of the load cell were arranged in full bridge condition. The Wires are connected to the pipe pin connectors on rear panel of the data acquisition module. Pin no.1 is connected to the excitation voltage +5V. Pin 2 is connected to the ground. Pin 4 and 5 are connected to the signal on front panel of data acquisition system. Two main control components are available, that is keyboard and alphanumeric LCD.

LCD - this is a 20*4 alphanumeric LCD, where all the data and message will appear.

KEYBOARD - the keyboard is used for monitoring the system, edit channel number and for recording.

Add weights on the load cell in steps 0f 1Kg. Measure the corresponding micro strain from the LCD of the data acquisition system.

OBSERVATIONS

Sl.No.	Input (q_i) (Kg)	Output (q_o) (μ $strain$)	qi x q_o	qi^2	$\frac{q_o - b}{m}$	**[(q_o–b/m) – (q_i)]^2**	Sensitivity $\Delta q_o/\Delta q_i$ (μ $strain$) / Kg
1.							
2.							
3.							
4.							
5.							

Calculations

g) Static sensitivity = $\Delta q_o/q_i$ (from graph)

where q_o= increment in micro strain (μ $strain$)

q_i= corresponding increment in load (Kg)

h) standard deviation, σ

$$\sigma = \sqrt{1}/N \sum[(q_0 - b/m) - (q_i)]^2$$

Where, q_o = Output strain

b = Y Intercept

m = Slope

N = Number of observations

$$m = \frac{N\sum q_i\, q_o - \sum q_i}{N\sum q_i^2 - (\sum q_i)^2} \qquad b = \frac{\sum q_o \sum q_i^2 - \sum q_i\, q_o \sum q_i}{N\sum q_i^2 - (\sum q_i)^2}$$

i) Imprecision of the instrument = $\pm 3\sigma$ Nm

RESULT

10. Sensitivity from observation (m) = -------------------------- micro strain/Kg
11. Sensitivity from graph = -------------------------- micro strain/Kg
12. Imprecision of the instrument = -------------------------- kg

11. LADDER PROGRAMMING ON PLC

Automation of Car parking garage and product packaging

Aim

Implement ladder diagram for,

1. Automation of car parking garage
2. Automation of product packaging.

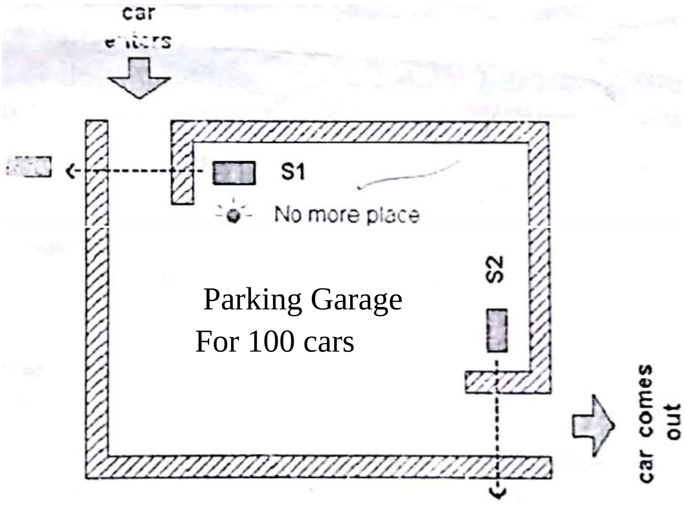
Apparatus required

PLC Trainer, Patch cords, RS232 cable

Principle

1. Automation of parking garage:

In this automation system we can control 100 Car at the max mum. Each time a car enters, PLC automatically adds it to a total sum of other cars found in the garage. Each car that comes out will automatically be taken off. When 100 cars park, a signal will turn on signalizing that a garage is full and notifying other drivers not to enter because there is no space available.



Automation parking garage

Signal from a sensor at the garage entrance sets bit IR200.00. The DIFFERENTIATE UP (DIFU) instruction Turns ON a bit for one cycle when the execution condition goes from OFF to ON. This bit is a condition for execution of the following two instructions in a program. First instruction resets carry bit CY (it is always done before some other calculation that would inflounce it), and the other instruction adds one to n number of cars in word HR00, and a sum total is again stored in HR00. HR memory space is selected for storing a total number of cars because this keeps the status even after supply stops.

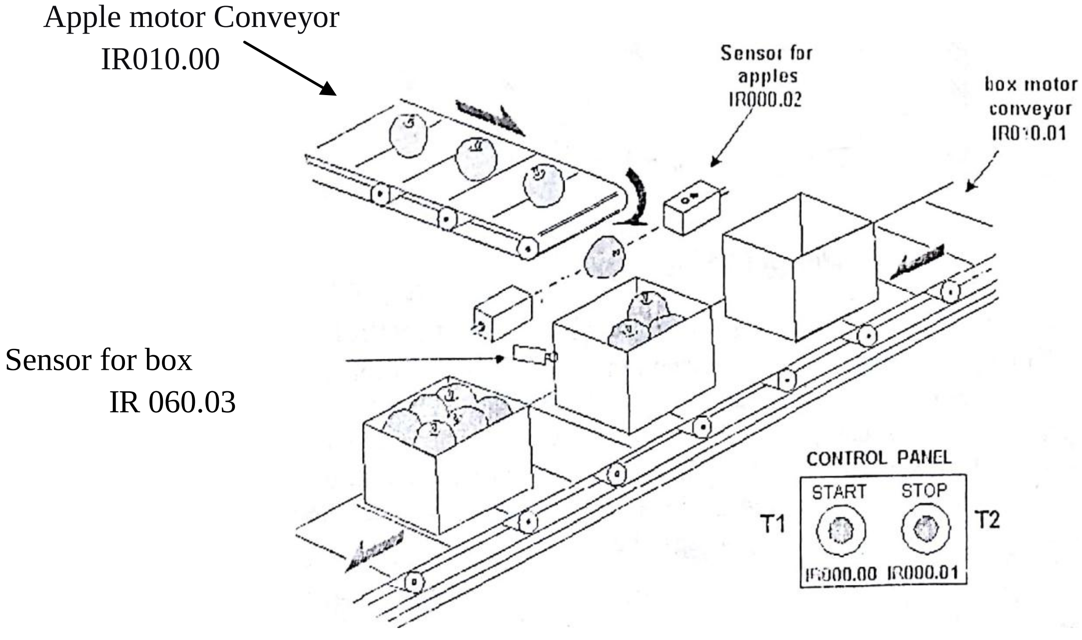
Symbol "#" in addition and subtraction instructions defines decimal constant that is being added or subtracted from a number of cars already in the garage. Condition for executing comparison instruction CPM is always executed because bit SR253.13 is always set; this practically means that comparison will be done in each cycle regardless whether car has entered or left the garage.

Signal lamp for "garage full" is connected to an output JRO I 0.00.Working of the lamp is controlled by EQ (equal) flag at address SR.255.06 and GR (greater than) flag at address SR255.05. Both bits arc in OR connection with an out put IR01 0.00 where the Automation of Car parking garage.

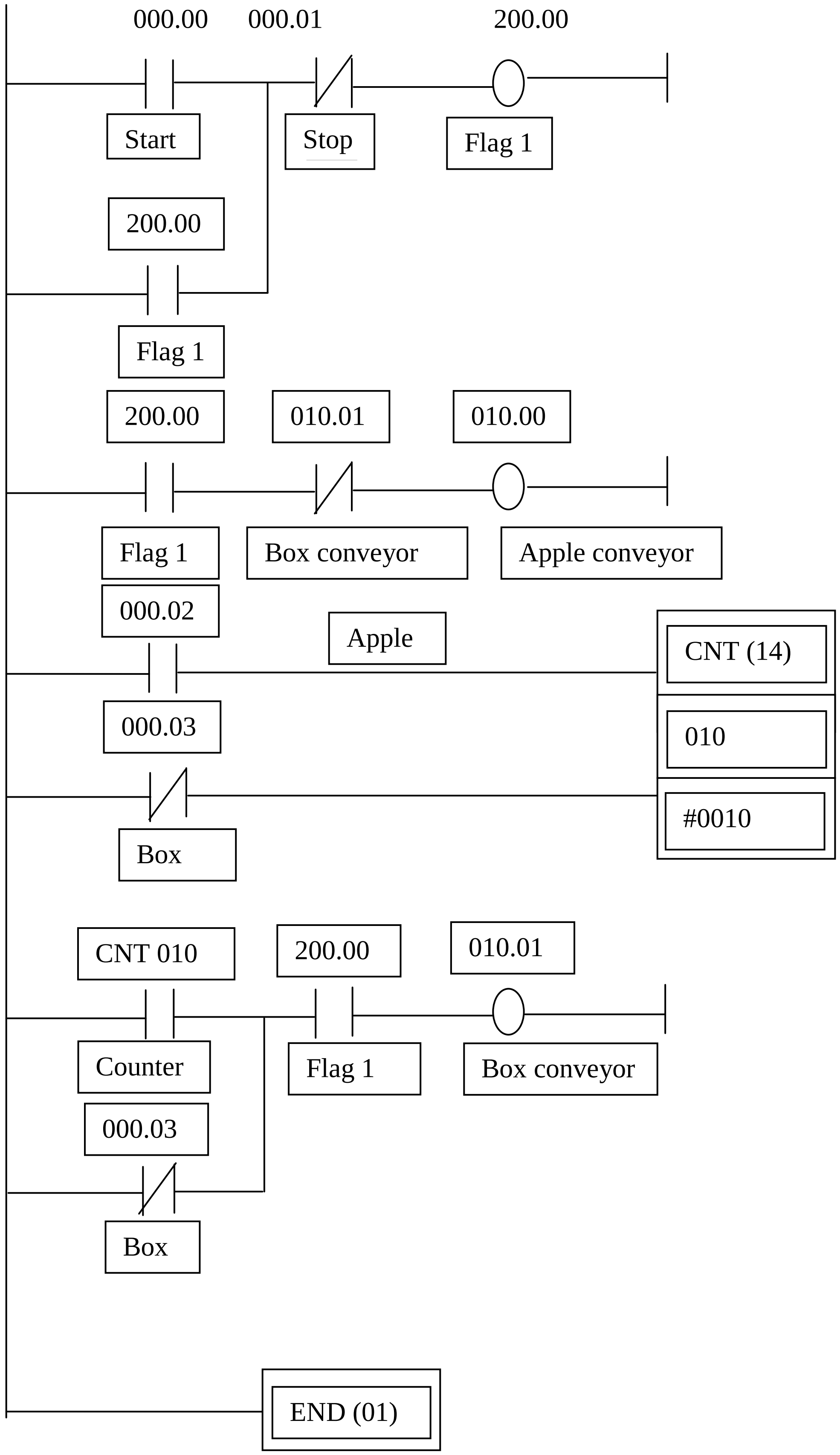
Automation of product packaging signal lamp is. This way lamp will emit light when a number of cars is greater than or equal to 100. Number of cars in a real setting can really be greater than 100 because some untrusting driver may decide to check whether there is any space left, and so a current number of cars can increase from a 100 to 101. When he leaves the garage, a number of cars goes down to 100 which is how many parking spots there are in fact.

2. Automation of product packaging

By pushing START key we activate Flag1 which represents an assisting flag (Segment 1) that comes up as a condition in further program (resetting depends only on a STOP key). When started, motor of an conveyor for boxes is activated. The conveyor takes a box up to the limit switch and a motor stops then (Segment 4). Condition for starting a conveyor with apples is actually a limit switch for a box. When a box is detected, a conveyor with apples starts moving (Segment 2). Presence of the box allows counter to count 10 apples through a sensor used for apples and to generate counter CNT 010 flag which is a condition for new activation of a conveyor with boxes (Segment 3). When the conveyor with boxes has been activated, limit switch resets counter which is again ready to count 10 apples. Operation repeat until STOP key is pressed when condition for setting Flag1 is lost. Picture below gives a time diagram for a packaging line signal.



Automation of Product Packaging



Ladder Diagram for Product Packaging

PROCEDURE

1. Switch on power to the unit
2. Interface the PLC with PC by using RS 232 cable.
3. Draw the ladder diagram for automation of product packaging.
4. Configure the PLC operation.

RESULT

Implemented the ladder diagram for Automation of product packaging were done and observed the simulation.

12.Logic Gates using PLC

Aim

Implement logic gates using PLC

Apparatus Required

PLC trainer, Patch chords, RS232 cable.

Principle

A programmable logic controller (PLC) is a digital computer used for automation of electromechanical processes. Unlike general-purpose computers, the PLC is designed for multiple inputs and output arrangements. A PLC is an example of a hard real time system since output results must be produced in response to input conditions within a bounded time, otherwise unintended operation will result. PLCs were programmed in "ladder logic", which strongly resembles a schematic diagram of relay logic. Programs to control machine operation are typically stored in batte1y-backed or non-volatile memory. More recently PLCs are programmed using application software on personal computers. The computer is connected to the PLC through Ethernet, RS-232, RS-485 or RS- 422 cabling.

Simulation of logic gates can be done by programming a PLC. Logic gate process one or more input in a logic fashion. Depending on the input value or voltage, the logic gate will either output a value of '1' for ON or value of 'O' for OFF. Logic gates allow simplification of circuit operation. The five common logic gate used in wiring diagrams are the AND,OR, NOT, NAND and NOR.

Procedure

1. Switch ON power to the unit.
2. Interface the PLC with PC by using RB 232 cable.
3. Draw the ladder logic diagram for logic gates.
4. Configure the PLC operation.

Result

Different types of logic gates are implemented by using PLC.