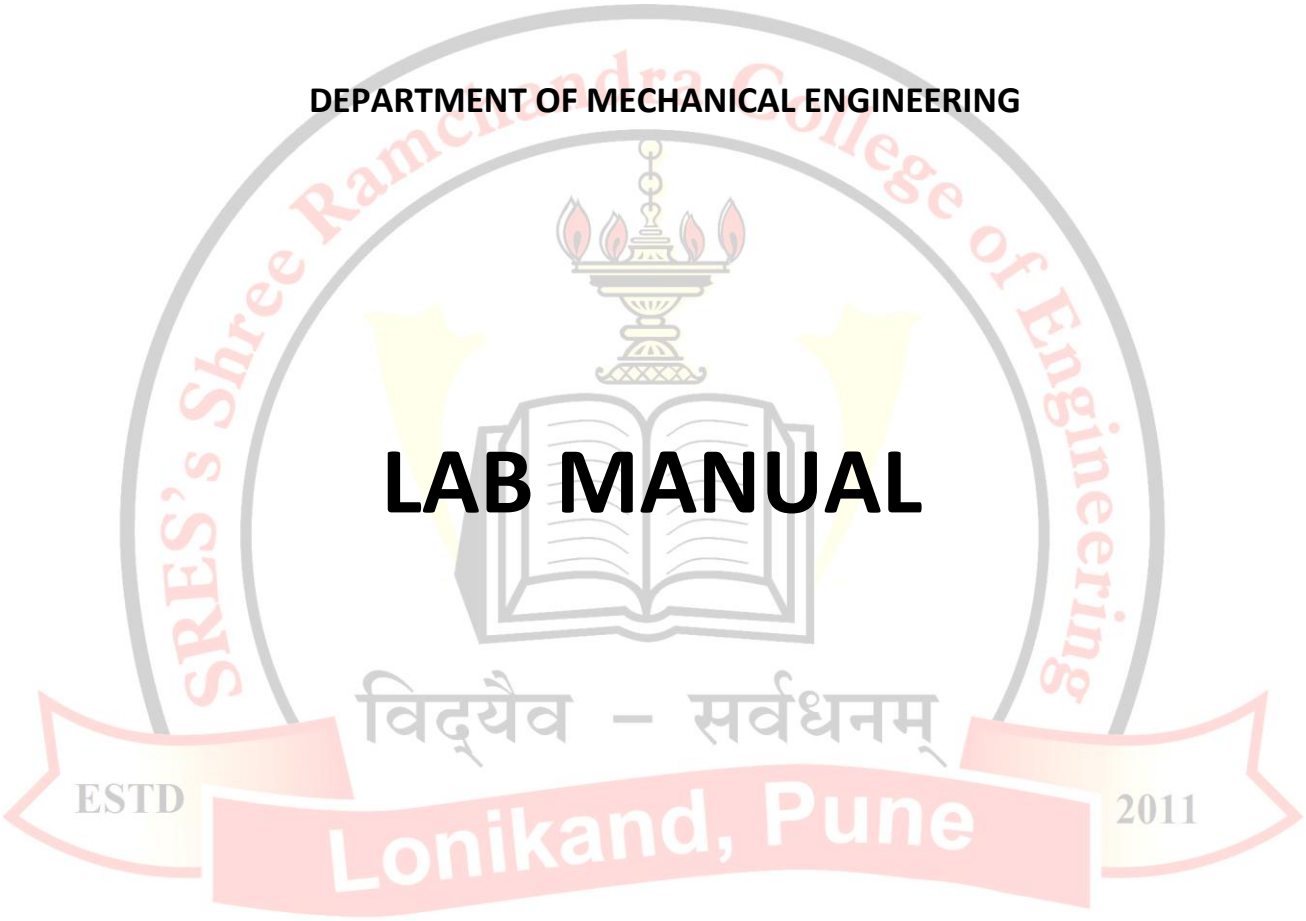
SHREE RAMCHANDRA EDUCATION SOCIETY'S

SHREE RAMCHANDRA COLLEGE OF ENGINEERING,

LONIKAND, PUNE – 412 216

DEPARTMENT OF MECHANICAL ENGINEERING



LAB MANUAL

MECHATRONICS(MTX)TE (ME) Semester-VI

Prepared by

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List of Experiments (S.P.UNIPUNE SYLLABUS)

Note: - 1.Eleven experiments from below list should be performed; out of which at least nine trials should be conducted

2.Data from any trial performed should be analyzed by using any suitable software

Sr. No	Name of Experiment
1	Measurement of Load / Force using Load Cell*(Estimation of unknown weight using above voltage characteristics)
2	Measurement of Temperature : Thermocouple, Thermistor& RTD and comparative analysis (estimation of sensitivity)
3	Measurement of displacement using LVDT characteristics.
4	Interfacing of any Sensor with Data Acquisition System
5	PLC control system: -ladder logic implementation on real time system.
6	Ladder Diagram development for different types of Logic Gates using suitable Software
7	Real Time Temperature / Flow Control using PID Control system.
8	PID control Design, Tuning using suitable Simulation Software
9	PID Control Implementation on DC Motor Speed Control System
10	Demonstration of Bottle Filling System using PLC / Microcontroller / Relays System
11	Study of Modeling and Analysis of a typical Mechanical System (Estimation of poles, zeros, % overshoot, natural frequency, damping frequency, rise time,settling time)

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	PRACTICAL EXPERIMENT INSTRUCTION SHEET	
	EXPERIMENT TITLE: Measurement of Load / Force using Load Cell*(Estimation of unknown weight using above voltage characteristics)	
	DEPARTMENT OF MECHANICAL ENGINEERING	
EXPERIMENT NO. : SRCOE/MECH/TE/MTX/	SEMESTER : VI (TE)	PAGE:

EXPERIMENT NO-01

1. **Title :**Measurement of Load / Force using Load Cell*(Estimation of unknown weight using above voltage characteristics)

2. **Aim:**To study load cell trainer.

3. Equipment :

a) Load cell

b) Mechanical stand and pan with cantilever strip.

c) Electronics exciter with digital indicator.

d) Weight ranging from 20gm to 500grams.

4.Theory:

Transducers play very important role in the engineering applications. It is essential to measure parameters like weight, force, pressure, temperature and so on frequently, for which transducers are required. Strain gauge is one of the prime transducer widely used in industry for measurements of weight, load, force, pressure, displacement, indirectly for torque, stress and strain. The property of material used for strain gauges is, change in resistance when expose to mechanical or physical change in its shape. The strain gauge foils are available with different resistance values, different sizes and different gauge factors.

(Gauge factor is the ratio of change in resistance with elongation or strain). Normally strain gauges are available with 120Ω, 240Ω, 330Ω resistance values.

Resistance wire stain gauges are transducers applied to the surface of structural members under test in order to sense the elongation or strain due to applied loads. The setup consists of mild steel structural strip duly ground from both the side ensuring smooth surface rigidly mounted on a sturdy solid square bar supported on heavy stable base structure. The sturdy structure stand ensures better result.

Strain gauge sensor of plastic foil type with 120Ω resistance and 8mm gauge length, 5mm width, compensated for mild steel type are pasted to steel strip. The pasting procedure is very important as it is directly related to elongation of strain gauges when load is applied. Perfect surface contact shall give us better and consistent change in resistance linear to load applied on it. The strain gauges changes its resistance with variation of temperature. The change in resistance is too small in value which makes it difficult in sensing the change. In view of this the strain gauges are used in the form of bridge and electronic signal generated is processed by instrumentation amplifier. Bridge may have only one arm or two arms or four arms strain gauges as active element and balance resistances as passive element. Two arm strain gauge bridge is the option preferred on performance basis. We use two strain gauges as active bridge elements and other two 120Ω passive resistor. The strain gauges are pasted to steel strips in such a way that one strain gauge sensor is compressed while other is elongated, resulting in differential change in resistance, increasing the sensitivity. One strain gauge pasted from top to the strip and another exactly below from bottom, both the strain gauges are wired with passive resistors in the form of bridge and terminated at bottom plate on a connector ,makes it easy for connection. Small pan hooked up to the dead end cantilever with weights.

Types of load cells:

Hydraulic load cell: Figure shows the cross section of the hydraulicload cell. The cell uses the conventional piston and cylinder arrangement. The piston doesn't come actually in contact with the cylinder wall in the normal sense, but a thin elastic diaphragm or bridge ring, of steel is used as the positive cell, which allows small piston movement. Mechanical stop prevents the seal from being overstrained. The cell is filled with oil. When the force act on the piston, the resulting oil pressure is transmitted to some pressure sensing device like Bourdon gauge, electrical pressure transducers can also be used to obtain an electrical output. If the load cell is completely filled with oil, very small transfer or flow is required. Piston movements may be less than 0.05 mm at full capacity. This feature is responsible for good dynamic response for the system. However the overall response is largely determined by the response of the pressure sensing element. A problem with hydraulic cell using conventional piston and cylinder arrangement is that the friction between the piston and cylinder wall and required packing and seals is unpredictable.

Pneumatic load cell:A typical pneumatic cell is as shown in figure.This cell uses a diaphragm of a flexible material and is designed to automatically regulate the balancing pressure. The air pressure is supplied to one side of the diaphragm and is allowed to escape through position controlling bleed valve. Pressure under the diaphragm is therefore controlled both by the source pressure and bleed valve position. The diaphragm tries to take up the position that will result in just the proper air pressure to support the load. This naturally assumes that the supply pressure is large enough so that its value multiplied by effective area will at least equal to the load.

Piezoelectric load cell: In this type of cell, piezoelectric crystal isused for dynamic force measurement. Such transducers are very sensitive and used over a wide

range. They are used for measuring impact type of dynamic load.

Precautions:

1) Connect the electronic unit to main 230V AC and turn it ON.
2) Place the mechanical stand horizontal and on firm platform.
3) Connect the bridge wire to electronic unit.
4) Ensure proper connections.
5) Gently press the cantilever down and observe the change on electronics display, if change noted then unit is properly connected.
6) Wait to stabilize and warm up for five minutes.

5. Experimental Procedure:

1. Ensure that connections are proper and electronic display responds gentle pressure at cantilever.
2. Adjust '0.0' reading on display with empty pan hooked.
3. Measure bridge excitation voltage on DMM.
4. Observe bridge output on DMM.
5. Place calibration weight in pan and observe the display reading.
6. Keep on adding the weight and record the reading.
7. Reverse the procedure by removing the weight one by one.

6. Diagram

7. Observation Table:

Sr. No.	Load	Voltage
1		
2		
3		
4		
5		

8. Conclusion-

Experiment No-02

1. Title: Measurement of Temperature : Thermocouple, Thermistor& RTD and comparative analysis (estimation of sensitivity)

2. Aim: 1. To study the characteristics of RTD .
2. To study the characteristics of J , K and PT100 type of thermocouples.

3. Equipment :

1) Thermocouple & RTD characteristics trainer.
2) Digital Multi Meter.
3) J & K thermocouple, PT100 RTD.

4.Theory:

RTD Trainer

PT100 Thermocouple

RTD: It is resistance temperature detector. The resistance of a conductor changes withchange in temperature, this property is utilized for measurement of temperature. The variation of resistance with temperature is represented by following relationships for most of the metals.

$$R = R_0 [1+ \alpha_1 T + \alpha_2 T+\ldots\ldots..+ \alpha_n T] R_0$$

= Resistance at temperature T = 0

$\alpha_1, \alpha_2, \alpha_n$ = Constants

Platinum is especially suited for this purpose, as it can withstand the high temperatures while maintaining high stability. The requirements of a good conductor material to be used in RTD are

1. The change in the resistance of material per unit change in temperature should be less as large as possible.
2. The material should have a high value of resistively so that minimum volume of material should be used for the construction of RTD.

3. The resistance of the material should have a continuous and stable relationship with temperature.
4. The most common RTD's are made of platinum, nickel or nickel alloys. The economical nickel wires are used for a limited range of temperatures. Metals most commonly used for resistance thermometer along with their properties are listed below.

METAL	RESISTANCE TEMPERATURE COEFFICIENT	TEMPERATURE RANGE ^{o}C		MELTING POINT ^{O}C
		MIN	MAX	
PLATINUM	0.39	-260	110	1773
COPPER	0.39	0	180	1083
NICKEL	0.62	-220	300	1435
TUNGSTEN	0.45	-200	1000	3370

Thermocouple:

If two different metals are joined together, a potential difference occurs across one of the junction, if another junction is heated. The potential difference depends on the metals used and the temperature difference between the junctions. If both the junctions are at same temperature then there will not be net emf produced. Thermocouples are most important temperature sensors used in industries. Thermocouples are generally mounted on a sheath to give them mechanical and chemical protection. The type of sheath used depends on the temperature, at which the thermocouple is to be used. The best metal thermocouples are E, J, K & T; these are relatively cheap but deteriorate with the age.

Laws of thermocouple

LAW OF INTERMEDIATE TEMPERATURE: The emf generated in a thermocouple

with junctions at temperatures T1 & T3 is equal to the sum of emf generated by similar thermocouples one acting between T1 & T2 and other between T2 & T3, when T2 lies between T1 & T2.

Law of intermediate material: If a third wire introduced in between two conductors, the emf generated remains unaltered if the two new junctions are at same temperature.

Precautions: Ensure the following points for proper functioning of the trainer.

1) Mains supply is 1ϕ 230VAC ± 10% 50HZ.
2) Furnace is off and sensor is in place.
3) Fan is off and away from furnace
4) Sensor under calibration is removed from furnace.

5. Experimental Procedure:

1. Ensure mains supply is 1ϕ 230VAC ± 10% 50HZ.
2. Turn off the fan and furnace
3. Connect the trainer to mains and turn on the trainer
4. Ensure the digital temperature indicator displays room temperature or appropriate temperature i.e. furnace temp.
5. Give desired set point on digital temp controller
6. Turn the furnace on and note sensor output as per observation table.
7. Insert sensor in the furnace and connect it to the Digital Multi Meter on appropriate range.
8. If required to restrict furnace temperature, switch off the furnace at any point. Furnace temp shall latch with over shoot of around 60-80^{0}C
9. Also turn on the fan to reduce furnace temperature, if required.

6. Diagram:

7.Observation table:

A] J & K THERMOCOUPLE SENSOR

Measure thermocouple output in mV on DMM range 0-200mV

[SAMPLE READINGS, ROOM TEMPERATURE $26^{O}C$]

SR. NO.	FURNACE TEMP $[^{0}C]$	J THERMO COUPLE OUTPUT IN [mV]	K THERMO COUPLE OUTPUT IN [mV]
1			
2			
3			
4			
5			

8. Calculations:

$$Rc = 100\ (1+ 0.00385[T-TO])$$

FOR SAMPLE READING AT T=120 R IS 125.58 AND T-TO IS 120-30 =90

SO $R_C = 100\ (1+0.00385\ [120-90]\ )$

$$R_C = 111.55$$

9.conclusion: Hence we have studied characteristics of J & K thermocouple andplatinum100 RTD.

Experiment No-03

Measurementof displacement using LVDT characteristics

1. **Title: Measurementof displacement using LVDT characteristics**
2. **Aim:** To study input output characteristics of Linear Variable Displacement Transformer
3. **Equipment:** Linear Variable Displacement Transformer.
4. **Theory:**

LVDT Trainer

Scientech LVDT Trainer ST2303 is designed to learn LVDT characterstics.LVDT(Linear variable Differential Transformer) is the most widely used inductive transducers for displacement measurement. LVDT is a secondary transducers which converts the displacement directly into electrical output proportional to the displacement. The trainer has seven segment LED display showing displacement in mm with sensitivity of 10mv/mm in the range of 10mm.ST2303 is self contained single box design and easy to use.

It is used for measurement of displacement. LVDTs operate on the principal of a transformer. LVDT consists of a coil assembly & a core. The coil assembly is typically mounted to a stationary form, while the cored is secured to the object whose position is being measured. The coil assembly consists of three coils of wire would on the hollow form. A core of permeable material can slide freely through the center of the form. The inner coil is the primary, which is excited by an AC source as shown. Magnetic flux produced by the primary is coupled to the two secondary coils, including an AC voltage in coil.

The main advantage of LVDT over the other types of displacement transducer is the high degree of robustness. Because there is no physical contact across sensing element, there is no wear in the sensing element. Because the device relies on the coupling of magnetic flux, an LVDT can have infinite resolution. Therefore the smallest fraction of movement

can be detected by suitable signal conditioning hardware, and the resolution of the transducer is solely determined by the resolution of the data acquisition system.

LVDT Measurement: LVDT measures displacement by associating a signal valuefor any given position of core. This association of signal value to a position occur through electromagnetic coupling of an AC excitation value signal on the primary winding to the core & back to the secondary winding. The position of the core determines how tightly the signal of the primary coil is coupled to each of the secondary coils. The two secondary coils are series-opposed, which means wound in series but in opposite directions. This results in the two signals on each secondary being 180^{o} out phase.

Fig .depicts a cross sectional view of LVDT. The core causes the magnetic field general by primary winding to be coupled to the secondary. When the core is centered perfectly between both secondary & the primary the voltage induced in each secondary is equal in amplitude & 180^{o}out of phase. Thus the LVDT output is zero because the voltages cancel each other.

Displacing the core to the left causes the first secondary to be more strongly coupled to the primary than the second secondary. The resulting higher voltage of the first secondary in relation to the second secondary causes an output voltage that is in phase with primary voltage likewise. Displacing the core to the right causes the secondary to be more strongly coupled to the primary than the first secondary. The greater voltage of the second secondary causes an output voltage to be out of phase with the primary voltage.

Features & application: Its features & benefits are as follows

1. **Friction free operation:** One of the most important features of an LVDTis its friction free operation. In normal use, there is no mechanical contact between the LVDT core & coil assembly so there is no rubbing, dragging, or other source of friction.
2. **Infinite resolution:** Since an LVDT operates on electromagnetic couplingprinciple in friction–free structure, it can measure infinitesimally small change in core position. This infinite resolution capability is limited only by the noise in an LVDT signal conditioner & the output display's resolution.

3. **Unlimited mechanical life:**This factor is especially important in highreliability applications such as air –craft, satellites & space vehicles & nuclear installations. It is also highly desirable in many industrial process control & factory automation systems.
4. **Single axis sensitivity:**An LVDT responds to motion of the core along thecoils axis but is generally insensitive to cross position thus on LVDT can usually function without observe effect in application involving misaligned or floating mooing member.

5. **New point repeatability:**The location of LVDT‘s intrinsic null point is extremely stable & repeatable, even over wide operating temperature range. This makes an LVDT perform well, as a null position sensors in closed –loop control system & high performance servo balance instruments.

6. **Fast dynamics response:**The absence of friction during ordinary operationpermits an LVDT to respond very fast to changes in core position. The dynamics response of an LVDT sensor itself is limited only by the inertial effect of the core’s slight mass.

7. **Absolute outputs**: An LVDT is an absolute output device, as opposed to anincremental output device. This means that in the event of loss of power, the position data being sent form the LVDT will not be lost.

Functional description of blocks:

1. Lvdt measurement: It is enclosed in M.S. enclose with arrangement oftwo hexagonal nuts that can be rotated clockwise or anti- clockwise to set the reading on display to 0.0 at 10mm position on micrometer. LVDT core is attached to the micrometer spindle.

2. Micrometer: The micrometer provides displacement to the LVDT core. Thedisplacement suffered by core is indicated by 3 1\2 digit LED display in mm. It will be same as read on micrometer. The main scale of micrometer is at 25mm. Least count of main scale is 1mm. Circular scale on thimble is of 1mm with least count 0.01mm. On one circular rotation of thimble, the spindle will display LVDT core 1mm.

3.Excitation generator: The output of excitation generator is 4 KHz sinewave of variable amplitude. It is used to excite primary coils of LVDT. The max input given to primary of LVDT is 4V p-p, which can be set by an amplifier preset given in the Excitation generator block.

4.Buffer: It is used to improve current driving capacity of excitation generator so thatexcitation generator can drive low impedance primary coil of LVDT.

5.Signal conditioner:- It is used to process the form or mode of a signals so asto make it intelligible to, or compatible with, a given devices, including such a manipulation as pulse shaping, pulse clipping, compensating digitalizing etc. It consists of rectifier & filter section for each secondary coil.

6.Differential amplifier: It is OPAMP based differential amplifier block. Itconverts the differential output of signal conditioner block to the single ended output, which can be used as input to some recording stage to record the data. The output is same as indicated by display.

7.Display: It is 3 1\2 digit LED display. It shows displacement of core in mm withpolarity indication. +ve sign shows, core is moved inside & -ve sign shows it is moved outside the LVDT.

5.Experimental Procedure:

1. Switch on the trainer. Make micrometer to read 10mm i.e. rotate thimble till 0 of the circular scale coincides with 10 of main scale
2. Display will indicate 0.0 this is the position when core is at the center i.e. equal flux linking to both the secondary.
3. If display is not 0.0 then adjust display reading 0.0 then adjust display reading to 0.0 with the help of hexagonal arrangement given with the LVDT.
4. Rotate thimble clockwise so that micrometer read 9.9mm. It will move core 0.1 mm inside the LVDT and simultaneously observe reading on display. It will indicate displacement from 10 mm position in positive direction. The reading will be positive it indicates that secondary - I is at higher voltage than secondary-II.
5. Repeat above step by rotating thimble again clockwise by 0.1mm. Reading will be taken after each 0.1 mm rotation until micrometer read 0 mm. This is positive end.
6. Rotate thimble anticlockwise so that micrometer read 10mm. The display will be 0.0

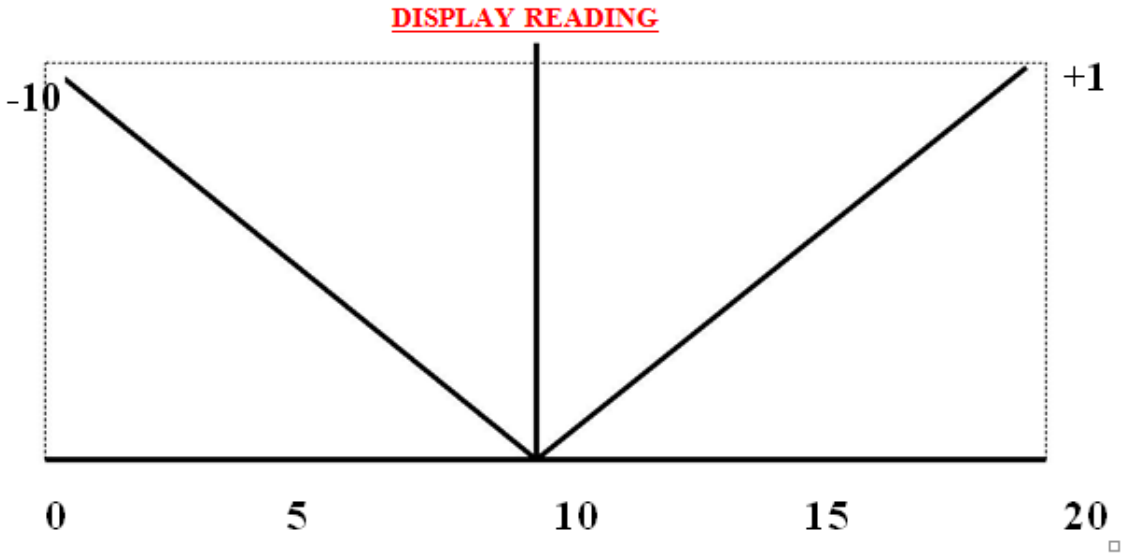
(center).

7. Rotate thimble anticlockwise so that micrometer read 10.1mm. It will move core 0.1 mm outside the LVDT and simultaneously observe reading on display. It will indicate displacement from 10 mm position in negative direction. The reading will be negative.
8. Repeat above steps by rotating thimble again anticlockwise by 0.1 mm. Reading will be taken after each 0.1 mm rotation until micrometer is 20mm. This is negative end.
9. Compare above results with the observation table
10. Plot the graph between displacement (mm) indicated by micrometer & display reading (mm) the graph will be linear as shown in diagram.

6.Diagram:

7.**Observationtable:**

SR.NO.	DISPLACEMENT INDICATED BY MICROMETER (mm)	DISPLAY READING (mm)
01		
02		
03		
04		
05		



8.Conclusion: In this way we have studied input output characteristics of LVDT trainer.

Experiment No-04

Interfacing of any Sensor with Data Acquisition System

Title-Measurement of any pressure using data acquisition system

Aim- Interfacing of any Sensor with Data Acquisition System

Theory-Data acquisition systems (DAS) interface between the realworld of physical parameters, which are analog, and theartificial world of digital computation and control. Withcurrent emphasis on digital systems, the interfacing functionhas become an important one; digital systems are usedwidely because complex circuits are low cost, accurate, andrelatively simple to implement. In addition, there is rapidgrowth in the use of microcomputers to perform difficultdigital control and measurement functions.Computerized feedback control systems are used in manydifferent industries today in order to achieve greater pro-ductivity in our modern industrial societies. Industries thatpresently employ such automatic systems include steelmaking, food processing, paper production, oil refining,chemical manufacturing, textile production, cement manufacturing, and others.The devices that perform the interfacing function between analog and digital worlds are analog-to-digital (A/D)and digital-to-analog (D/A) converters, which togetherare known asdata converters. Some of the specificapplications in which data converters are used include datatelemetry systems, pulse code modulated communications,automatic test systems, computer display systems, videosignal processing systems, data logging systems, andsampled data control systems. In addition, every laboratorydigital multimeter or digital panel meter contains an A/Dconverter. Besides A/D and D/A converters, data acquisition and distribution systems may employ one or more of the following

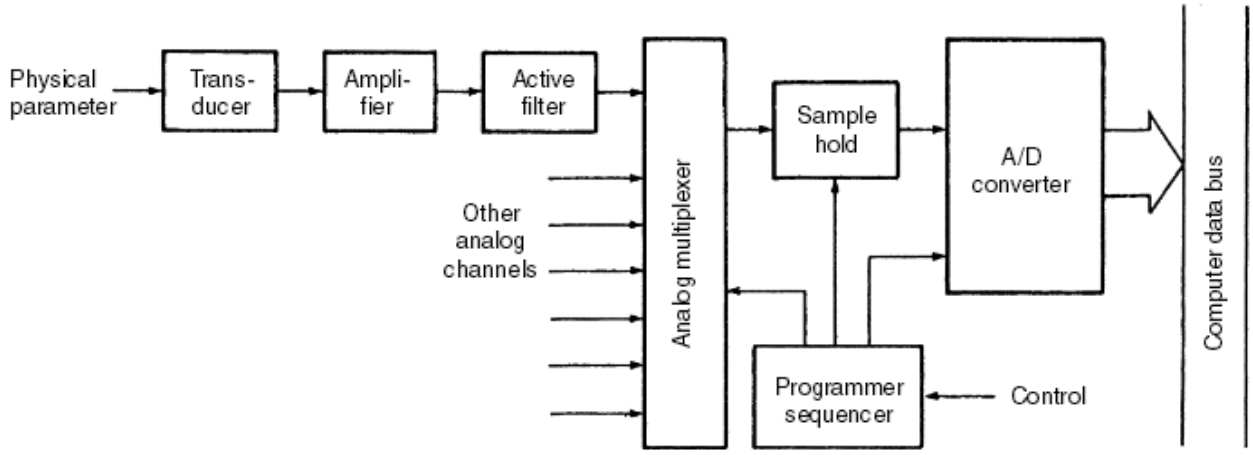
Circuit functions:

1. transducers
2. amplifiers
3. filters
4. nonlinear analog functions
5. analog multiplexers
6. sample-holds

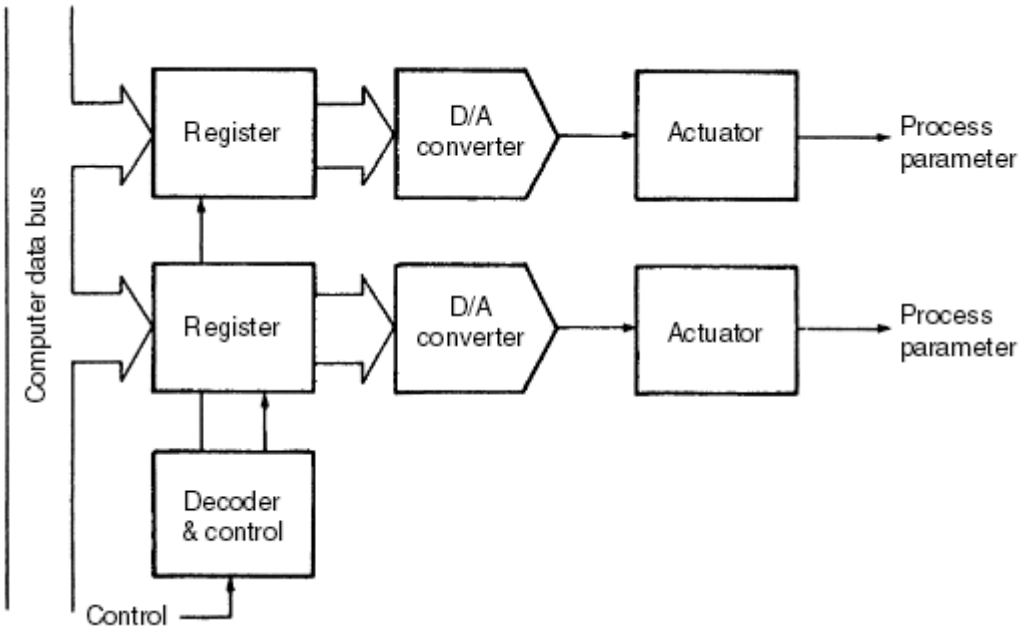
The interconnection of these components is shown in thediagram of the data acquisition portion of a computerizedfeedback control system in Figure. The input to the system is a physical parameter suchas temperature, pressure, flow, acceleration, and position,which are analog quantities. The parameter is first converted into an electrical signal by means of a transducer; once in electrical form, all further processing is done byelectronic circuits.Next, an amplifier boosts the amplitude of the transducer output signal to a useful level for further processing

Transducer outputs may be microvolt or millivolt level signals, which are then amplified to 1 to 10 Vlevels. Furthermore, the transducer output may be a high-impedance signal, a differential signal with common-modenoise, a current output, a signal superimposed on a high voltage, or a combination of these. The amplifier, in orderto convert such signals into a high-level voltage, may beone of several specialized types.

5.Diagram:-



Data acquisition system.



.The rotates

Data Distribution system

The amplifier is frequently followed by a low-pass active filter that reduces high -frequency signal components, unwanted electrical interference noise, or electronic noise from the signal The amplifier is sometimes also followed by a special nonlinear analog function circuit that performs a nonlinear operation on the high-level signal. Such operations include squaring, multiplication, division, rms conversion, log conversion, or linearization. The processed analog signal next goes to an analog multiplexer, which switches s equentially between a number of different analog input .Each input is in turn connected to the output of the multiplexer for a specified period of time by the multiplexer switch.

6.Conclusion:- Hence we have studied the interface of sensor like pressure, temperature, voltage, current etc. with DATA ACQUISITION SYSTEM.

Experiment No-05

PLC control system: - ladder logic implementation on real time system.

1.Title-Ladder diagram and PLC programming

2.Aim-Study of Mechatronics system with development of ladder diagram & PLCprogramming for bottle filling plant.

3.Equipment:- Bottle filling plant trainer model, Allen bradly make PLC loaded with programme.

4.Theory:-A] INTRODUCTIONTOPLC: Basic structure in beverage industries & petrochemicalindustries where the product is in the liquid form such as cold drinking, milk product etc. Depending upon the product different types of cans, glass bottles, paper cartoons are used for filling product. So it is necessary to design a plant comfortable for metallic & non metallic devices.

1]Conveyor belt driven with servomotor.

2] Proximity switches- inductive and capacitive to sense the metal and nonmetal. 3] Tank containing liquid which is to be filled by motor.

4] Output indicating LEDs

5] Load sensing devices (Circuit switches)

B] PLC(Allen Bradly): PLC uses both analog & digital input & gives the same output todifferent channels. For analog and digital input, output programming logic in PLC is supplied by ladder programming using software RD logos.

C] BOTTLEFILLINGPLANT: By changing the time of timers inbuilt in PLC it ispossible to fill different volumes of liquid into the bottles. A fast, accurate & steady filling is insured by properly setting time count in the timer by using the word accurate. It means that the liquid is delivered exactly into the bottle without spoilage of liquid outside the bottle. The operating parameter such as quantity of liquid, movement of bottle on the conveyor, filling head opening & filling speed for different bottle sizes can be taken care of by PLC interfacing with plant model. Auto protecting features as alignment & orientation of bottles passing on conveyor is important. Proximity sensor used in this model can also be used for

position sensing of bottles. The bottles are then placed & passed for position sensing. This would make, filled bottle is passed through conveyor by passing through filling programme, when presence of liquid in bottle is detected. The systems is timed, so that the bottle is moved on the conveyor to filling unit in fixed time & before filling unit it mainly consist of solenoid valve, submersible pump & floating sensor.

Solenoid valve opens & water beverage begins to flow through plastic fill nozzle. The bottle stays in position for programmed time. After bottle gets filled the conveyor moves & allows the next bottle to set into position.

1] CONVEYOR: It is belt connected to chassis of an AC 'servomotor' & it rotates withrotation of motor. Object is to be placed on the belt then it is moved towards filling section.

2] PROXIMITY SWITCHES: To confirm that object is properly placed in perfect positionor not, proximity switches are used. It detects the appearance of subject in front of them. For metallic objects inductive switches are used & for non-metallic object capacitive switches are used.

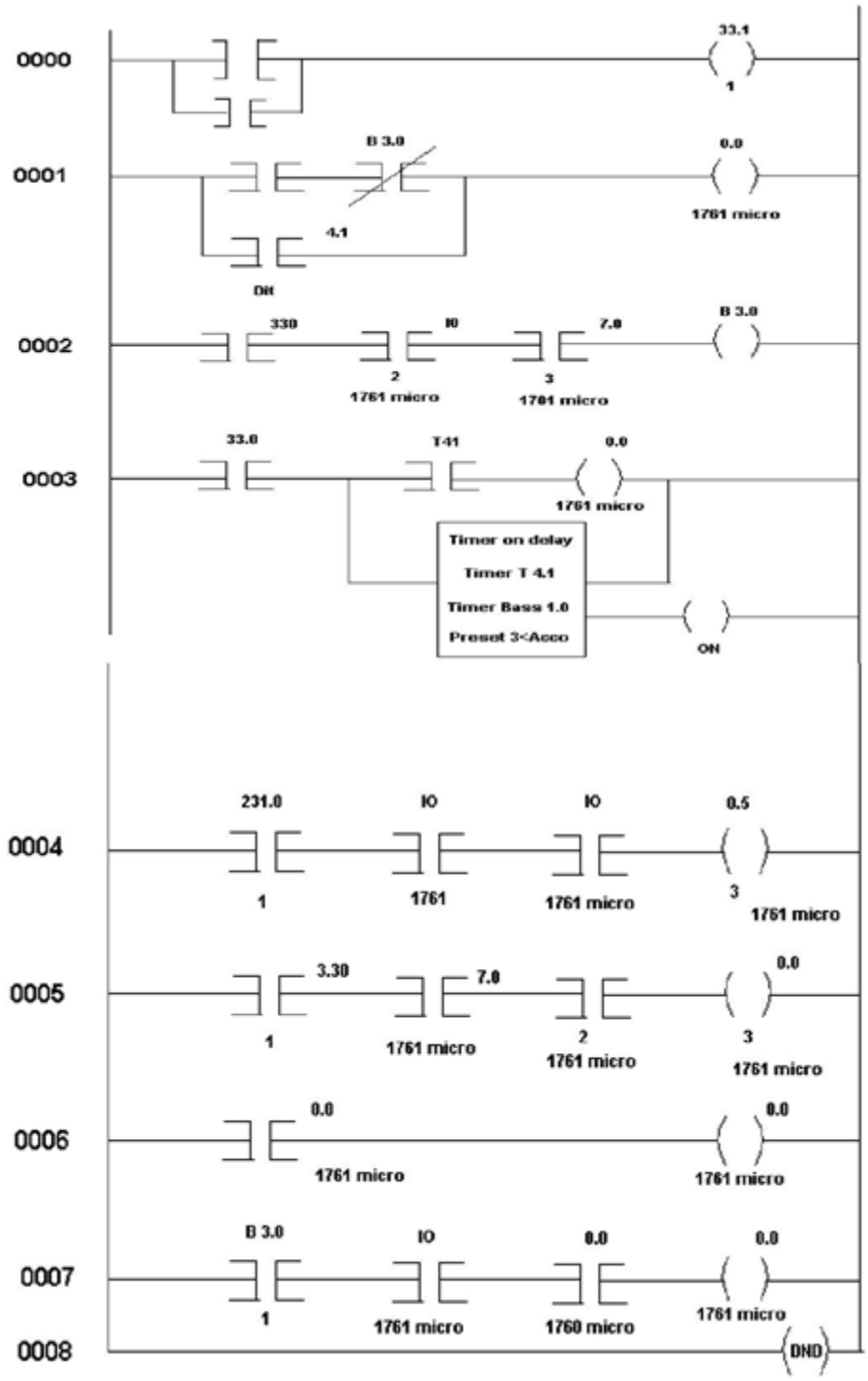
3] FILTERS: Filters are used on the top of AC pump assembly.

4] OUTPUT INDICATOR: LEDs used for identification of different operations such asfilling, fault finding etc.

5] LOAD SENSING DEVICES: In case of partially filled bottles comes on belt conveyor,that bottle is passes as it is, without filtering.

5. Experimental Procedure:-

1) Download program of filling on PLC.
2) Make input and output connections.
3) Keep bottle on conveyor and press start switch.
4) When bottle comes in front of proximity switch conveyor belt will stop.
5) The bottle filling will start up to predetermined time as per logic.
6) Same procedure is repeated further for each bottle.



LADDER DIAGRAM

6. Conclusion:- Hence we have studied Mechatronics system with development of Ladder diagram & PLC programming for bottle filling plant.