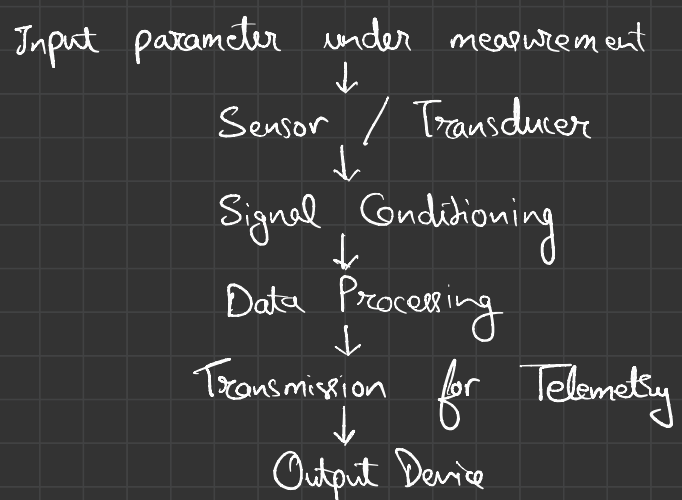
Sensors and Transducers

Minor Project
→ PT Cells
→ Microprocessor based temperature compensation

Generalized Measuring System



Q. Discuss with neat diagram the concept of generalised measuring system.

Transducers :- A device that is used to convert one form of energy to another form.

All sensors are transducers but all transducers are not sensors.

Q. Classify sensors based on i) Activity, ii) Position of measurement, iii) Signals, iv) Principle of operation

Transducer Classification :-

1) According to activity

i) Energy Converter (Active)
   a) magnetic induction
   b) Thermoelectric
   c) photoelectric
   d) Piezoelectric

ii) Energy Controller (Passive)
   a) Resistive
   b) Inductive
   c) Capacitive

2) According to Output Signal

i) Analog

ii) Digital

3) According to working principle

i) Mechanical
ii) Thermal
iii) Magnetic
iv) Radiation

4) According to position of measurement

i) Primary
ii) Secondary

Q. State different factors to be considered for selecting sensors in mechatronics application.
Q. Conceptual → Block Diagram

Factors influencing choice of Transducers

* Size & Weight
  Ex:- Aerial drones (Need to be light & small)

* Shape
  Ex:- Underwater / Underground pipes.

* Sensitivity
  Ex:- For accurate measurements

* Accuracy

* Frequency response

* Transient response (Step change or sudden change)
  T_d, T_r, T_s, Peak Overshoot

* Static characteristics
  Resolution :- Clarity (Smallest change input detected)
  Accuracy :- Error (Giving 10V, 10.1V, 10.2V ...)
  Precision :- Repetability (Giving 10V again & again)

* Ruggedness
  Shock absorber

* Reliability (MTBF, MTTR)
  Mean Time Before Failure
  Mean Time To Repair
  Repairing incase of failure

* Stability
  Oscillations

* Environmental Capability
  Military Grade (withstand huge variations of temperature, pressure, humidity etc.)

Measurement

Pressure Transducers :-

* $P = F/A$

* Inferentially measure variables like Flow & level. (indirect)
* Determines boiling point of liquids.
* Fluids exert pressure on walls of vessels equally in all directions.

* Following considerations during pressure measurement
  i) Pressure influenced by position within a static fluid but at a given position is independent of direction.

ii) Pressure is unaffected by the shape of the enclosing boundaries.

* Units :- N/m² (Pascal)
  Psi (Pounds per square inches)
  bar

* Vaccum pressure measurement (Below atmosphere)
  Ionization gauges

* Gauge pressure measurement (Above atmosphere)

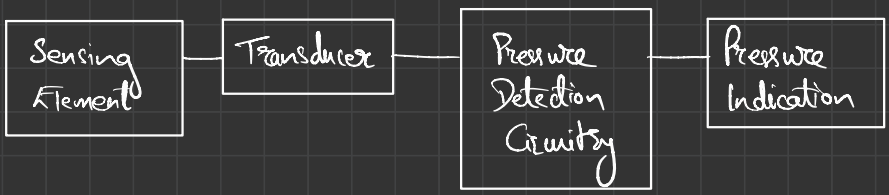
Gauge Pressure + Atomospheric Pressure = Pressure due to fluid itself = Absolute fluid pressure

where 1 atm = 14.696 psi = 101.325 KPa

* Pressure measurement methods

i) Elastic pressure transducers
ii) Primary pressure transducers (Physical → Physical)
  Ex:- pressure → displacement
iii) Manometer method
iv) Pressure measurement by measuring vaccum
v) Electric pressure transducer
vi) Pressure measurement by balancing forces produced on a known area by a measured force.

Electric Pressure Transducers



Analog signal transmission is in standard current range of 4mA to 20mA.

Standard pneumatic range is 3Psi to 15Psi.

Types of Electric Pressure Transducer :-

→ Strain gauge

→ Piezoelectric

Strain gauge

→ Compressive (length less)
→ Tensile (length more)

→ Strain :- amount of deformation of a body due to applied force

→ Use wheatstone bridge or voltage divider

working
Q. Discuss the principle of strain gauges and derive the equation for gauge factor.

Gauge Factor :- (Derivation Class Participation)

$$\frac{\text{Change in Resistance}}{\text{Change in dimension}}$$

(Kalsi's Book page 415 - 418)

$$G = \frac{\Delta R/R}{\Delta L/L} = 1 + 2\mu + \frac{\Delta \rho/\rho}{\Delta L/L}$$

$$G = \frac{\Delta R/R}{\Delta L/L} = \boxed{1 + 2\mu}$$

Gauge factor for metal is low.

Gauge factor for semiconductor is high.

Inbuilt temperature compensation circuit is required for Germanium & Silicon types of strain gauges.

→ Unbonded strain gauge transducers can be corroded and can be affected by environment causing errors.

Semiconductor strain Gauges

→ Silicon is used more because :
i) easily available
ii) Thermal stability
iii) easy doping

For Temperature Compensation :-

Single gauge :- Active Gauge
Dummy Gauge

For 2, 4, 6 .... gauges not needed.

(ε) Strain → Input
Vo → Output

$V_o \propto \varepsilon$

Application of Strain gauges

- → Force, Torque, Pressure transducers
- → Stress analysis
- → Bathroom & Kitchen scales
- → Load cells in Commercial scales, Tank & vessel weighing
- → Measurement of deflection angles of control surfaces (Helicopter blades, wing flaps, elevators etc.)

Q. Explain the construction & working of various electric pressure transducers.

Piezoelectric Transducers

→ Apply force to generate voltage
→ Universal sensor
→ Piezoelectric Accelerometer

Piezoelectric materials

→ Natural (Quartz, Topaz)
→ Synthetic (Barium Titanate $BaTiO_3$, Lead Zirconate $PbZiO_3$, PVDF Polyvinylidine Fluoride)

Q. Classify different types of piezoelectric materials

Applications :—

→ Low Frequency Devices (Force, position, spark generator, acceleration)
→ RF Devices (Radio Frequency) / High Frequency (Ultrasonic generator / receiver / Scanner)
→ Audio Devices (Mic heads, Loud speaker)

→ Non Destructive Testing
  ↳ Ultrasonic testing : To check internal irregularities, cracks in materials.

Differential Pressure Cell (DP Cell)

→ measures differential pressure btw two inputs.

Q. Measure vaccum pressure
A. Ionization Gauge
Pirani Gauge

→ Q. Discuss the different techniques of vaccum pressure measurement.

Pirani Gauge

→ heated wire is placed in chamber of gas, thermal conductivity of the gas depends on its pressure.

→ pressure measurement converted to temperature measurement

→ Or, Temperature change causes change in resistance.

Flow Measurement

→ Flow rate = $\frac{\text{volume of substance}}{\text{unit time}}$

→ Turbines, filling a bottle in factory.

Thermistors vs RTD

i) Non linear characteristics – Thermistors
Linear characteristics – RTD

ii) Thermistors have high sensitivity

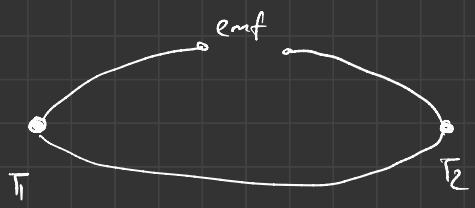
iii) Thermistors have low range of measurement.

iv) Cost and size of thermistors is very less as compared to RTD.

v) Customized fabrication of thermistors is possible.

Thermocoupling

Thermoelectric effect :- i) Seebek effect
ii) Peltier effect



* Insulation in RTD to prevent corrosion and noise immunity

Q. State the need of temperature compensation in thermocouples and discuss different methods of temperature compensation.

UNIT-3

PROGRAMMABLE LOGIC CONTROLLER

Q. Compare PLC with RLC
or
List advantages of PLC over RLC

Q. Compare PC with PLC
(computer)

Q. Classify PLC based on structure and types.

Q. Compare continuous process with discrete process.

* Watch the PLC experiments from VLabs ... for M2

engineertech.org → PLC

Q. Architecture of PLC (Long Question)

Q. State the important functions of PLC I/O modules.

UNIT- 4

Q. Discuss in detail the memory organization of PLC.

Q. Explain with example how the memory in the PLC is arranged

Q. How the program is executed in PLC

Q. Discuss the steps involved in PLC program execution. State the factors on which the program execution time depends.

or

Explain the steps involved in processor scan cycle.

Q. Discuss in details the program scanning process in PLC

or

Define scan time. State the factors which influence scan time.

Q. Explain with working analog input and output.

Q. State the criteria for selecting PLC for the particular application.

Q. Discuss with example the I/O addressing scheme in PLC.

Programming a PLC

Exp 5

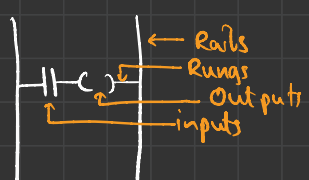
Software :- IndiraWorks Engineering

Steps :-

1. File → new project
   Name , Compatibility :- 14V22 PS , Folder

2. Add Controller
   Library → MLC → L2S → Drag it to project explorer
   Name ← Comment ← Next
   Need <u>modding</u> firmware (otherwise communication error)
   Here Firmware version : MLC 13VRS
   Firmware release : FWA - CML2S*- ML* - 13V24.3
   Next
   Extended Settings
   Programming language :- LD (Ladder Diagram)

Ladder Diagram



Execution :- Left → Right Top ↓ Bottom

Graphic Based

FBD (Function Block Diagram)
Blocks

CFC (Continuous Flow charts)

SFC (Sequential Flow charts)
Chemical industries

Text Based

ST (Structured Text)
Text based

IL (Instruction List)
Text based

function package → next → Interfaces (Additional components) → Finished

3. Inline → right click → Add → module × 4

RIBIL24D116

RIBIL24D016

RIBILA12SF

RIBILA02UBP

Exp 6

AIM :- a) Demonstrate the working of PLC relay logic instructions.

b) To implement the ladder logic program for different types of logic gates & to verify their operations

a) Relay Logic Instruction

b) 1. Right click Indra Motion MLC 1
↓
Simulation

2. To remove error

Project → compile version
↓
3.4.5.127 (13V16 P9)
↓
Build

3. Expand Logic → Expand Application
↓
Plc Prog
↓
Put logic

Variable

→ Name shouldn't be similar to any standard function block (Ex: Ton, Toff, STOP ...)

→ Select proper Type of Variable. (Bool, Time, Int)

→ Name in sequential order

→ Local Variable, Global Variable

Var Window

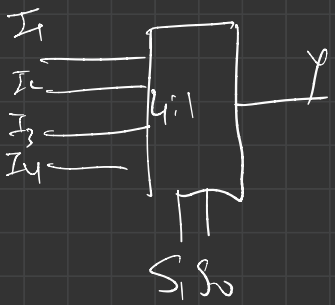
Scope :- Var_ Glbal : Global
Var : Local
Var_ Input
Var_ Output

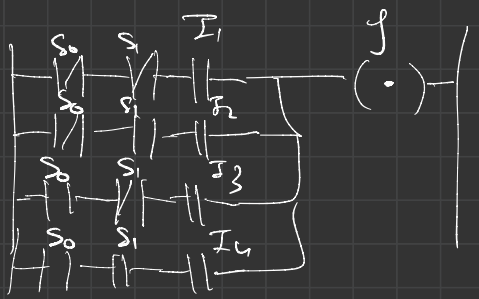
Name → Type (Bool, Int, Byte)

(False) Initialization ← (Plc Prog) Object

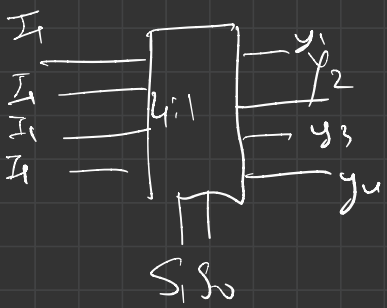
→ Address (%IX0.0)

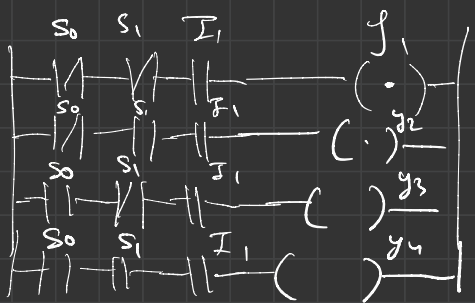
Multiplexer (1:4)





Demultiplexer (4:1)



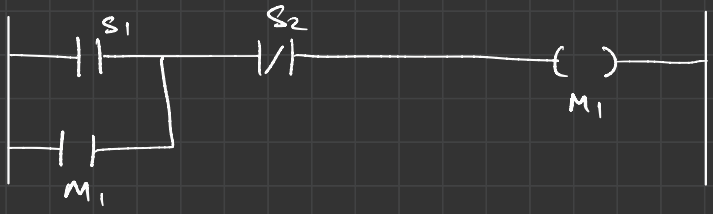


Q. State various rules to be followed for writing the PLC ladder logic program.

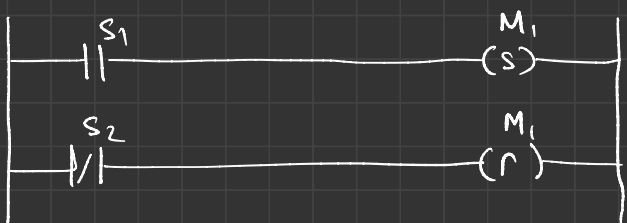
Q. State the steps to be followed for designing PLC ladder program.

Q. List different types of PLC ladder logic instruction

Latching (Start - stop mechanism)



Set - Reset Latching

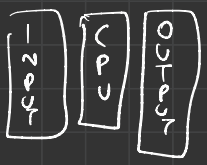


Class Participation

Q. Industrial Electric Drive → Application → 5 Applications
(Change program to Bosch Rexroth)

PLC Ladder Logic Question

1. Addressing table (I/O Ports)
2. Program
3. Interfacing diagram
4. Very short description



Q. Timer, Counter, Arithmetic Operations

Q. Application & Clarify Timers in PLC
↳ functions

Q. Discuss with neat timing diagram ON Delay Timer, OFF Delay Timer, Pulse Timer.

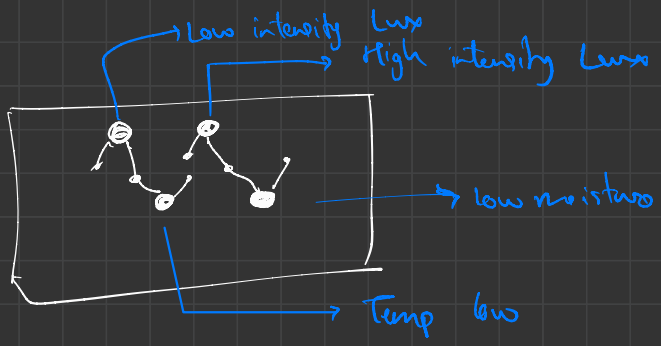
Q. Compare PLC timer instructions with counters.

Basket 1

1. Industrial Robotics & Motion Control
   modelling, simulation, speed, motion, torque, simulations (Pid Control)

2. Micro electromechanical Systems
   Fabrications

3. Fluid Power Automation
   Pneumatic systems, hydraulic actuation systems



Dark → High

Light → low (650 - 700)

600

TL → 11

BL → 10

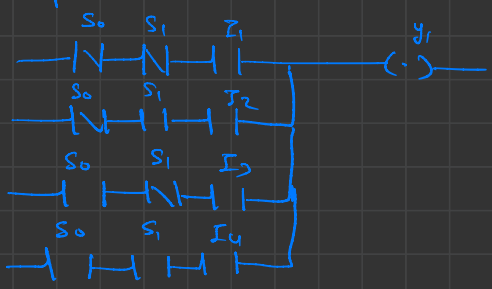
TR → 9

BR → 6

LADDER DIAGRAM

N	N	O
N	O	O
O	N	O
O	O	O

Multiplexer



Demultiplexer