## Basic of Industrial Automation

<table>
<thead>
<tr>
<th>What one will Learn?</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are the basic elements of Industrial Automation?</td>
</tr>
<tr>
<td>Why is automation relevant to industry?</td>
</tr>
<tr>
<td>What are the different technologies available?</td>
</tr>
<tr>
<td>Where can automation be applied purposefully?</td>
</tr>
<tr>
<td>What are the different kinds of controllers?</td>
</tr>
<tr>
<td>What is meant by visualization (HMI &amp; SCADA)?</td>
</tr>
</tbody>
</table>

### History
- Concept
- Automation Pyramid
- Controller
- Visualization
### Basic of Automation

<table>
<thead>
<tr>
<th>History</th>
<th>What is Automation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concept</td>
<td></td>
</tr>
<tr>
<td>Automation Pyramid</td>
<td></td>
</tr>
<tr>
<td>Controller</td>
<td></td>
</tr>
<tr>
<td>Visualization</td>
<td></td>
</tr>
</tbody>
</table>

**What is Automation**

- The dictionary defines automation as “The technique of making an apparatus, a process, or a system operate automatically.”

- Automation Federation define automation as “The creation & application of technology to monitor & control the production and delivery of products and services.”

- Automation Means use of available technologies to reduce the need of human work.

- Automation greatly decreases the need for human sensory and mental requirements as well.
Concept of Automation

Automation is basically the delegation of human control function to technical equipment for

- Total Automation
- Quality
- Productivity
- Plant

History
- Concept
- Automation Pyramid
- Controller
- Visualization

Manufacturing Competitiveness Solution

Manpower Cost
The Automation Pyramid

History
- Concept
- Automation Pyramid
- Controller
- Visualization

The Automation Pyramid:
- Level 0: Sensors and Actuators
- Level 1: Automation Control
- Level 2: Supervisory Control
- Level 3: Production Control
- Level 4: Enterprise

Industrial IT
Industrial Automation
## Basic of Automation

<table>
<thead>
<tr>
<th>History</th>
<th>The Automation Pyramid</th>
</tr>
</thead>
</table>
| Concept | **Sensors and Actuators Layer**  
  • Closest to the process and machines & field Signal |
| Automation Pyramid | **Automation Control Layer**  
  • Consists of automatic control & monitoring systems |
| Controller | **Supervisory Control Level**  
  • The automatic control system by setting target /goal to the controller |
| Visualization | **Production Control Layer**  
  • The decision problems like production targets, resource allocation, task allocation to machines, maintenance management |
| | **Enterprise control layer**  
  • This deals less technical and more commercial activities  
  • like supply, demand, cash flow, product marketing |
Basic of Automation

Types of Controller

- Manual Control
  - Option - 1
    - Machine / Process Control & Automation
      - Option - 2
        - Dedicated Electronic Control
          - Option - 3
            - Programmable Controller (PLC)
              - Option - 4
                - History
                  - Concept
                    - Automation Pyramid
                      - Controller
                        - Visualization

Hard Wired / Relay Logic Control
## Basic of Automation

### Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Manual</th>
<th>Relay/Wired</th>
<th>Dedicated Control</th>
<th>PLC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price per function</td>
<td>Lowest</td>
<td>Low</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Physical Size</td>
<td>Depend</td>
<td>Compact/ Bulky</td>
<td>Fairly Compact</td>
<td>Very Compact</td>
</tr>
<tr>
<td>Operating Speed</td>
<td>Low</td>
<td>Good</td>
<td>Fairly Fast</td>
<td>Fast</td>
</tr>
<tr>
<td>Electrical Noise Immunity</td>
<td>Low</td>
<td>Excellent/Low</td>
<td>Quit Good</td>
<td>Good</td>
</tr>
<tr>
<td>Installation</td>
<td>Time Consuming</td>
<td>Time Consuming design &amp; Installation</td>
<td>Programming is Time Consuming</td>
<td>Simple to Program and Install</td>
</tr>
<tr>
<td>Capability of Complex operation</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Ease of Changing Functions</td>
<td>Difficult</td>
<td>Difficult</td>
<td>Quite Simple</td>
<td>Very Simple</td>
</tr>
<tr>
<td>Ease of Maintenance</td>
<td>Poor , New Power Man</td>
<td>Poor- large number of contacts/Poor for Wiring Breakage</td>
<td>Poor- several custom boards</td>
<td>Good- few standard cards</td>
</tr>
<tr>
<td>Additional Functionality</td>
<td>No</td>
<td>Difficult</td>
<td>Not too much</td>
<td>Simple to add</td>
</tr>
</tbody>
</table>
Basic of Automation

Acid mixing Process using PLC

**History**
- Concept
- Automation Pyramid
- Controller
- Visualization

**Acid mixing Process using PLC**

- **V1 OPEN** → **SENSE LEVEL L1** → **V1 CLOSE**
- **V2 CLOSE** → **SENSE LEVEL L2** → **V2 OPEN**
- **MOTOR ON** → **MEASURE TIME** → **MOTOR OFF**
- **V3 CLOSE** → **SENSE LEVEL L0** → **V3 OPEN**
Basic of Automation

Benefits of PLC

- PLC CAPABILITIES
  - Logic Control
  - Timer
  - Counter
  - Analog Signal
  - PID Control
  - Arithmetic Functions
  - Communication
  - HMI - Operator Panel
  - Signalling & Listing
  - Real Time Function

History
- Concept
- Automation Pyramid
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### Basic of Automation

#### Advantages of PLC

**History**
- Concept
- Automation Pyramid
- Controller
- Visualization

**Advantages of Using PLC**

- Reduced Space
- Energy Saving
- Ease of Maintenance
- Economical
- Greater Life & Reliability
- Tremendous Flexibility
- Shorter Project Time
- Archiving & Documentation
### Basic of Automation

#### History
- Concept
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- Visualization

#### Evaluation of Visualization
- **Lamp/Indicators:**
  - A control might consist of hundreds of pushbuttons and LEDs performing different operations.
- **Alarm Annunciators:**
  - An Annunciator panel is a system to alert operators of alarm conditions in the plant.
- **Text Display:**
  - An electronic alphanumeric display that is mainly or only capable of showing text or extremely limited graphic characteristics.
- **Graphics:**
  - Schematic representation of process with variety of additional functionality like Alarm, Trend, Report, Script, User Admin, Recipes etc.
Basic of Automation

**History**
- Concept
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- Controller
- Visualization

**Lamp**

**Graphics**

**Alarm Annunciators**

**Indicators**

**Display**
# Programming Logic Controller

## Introduction
- The PLC processor, or controller
- Memory
- I/O (Input /Output) modules
- Chassis or backplane
- Power supply
- Programming software that runs in a PC

## PLC
- **Introduction**
- **Range of PLCs**
- **Architecture of PLCs**
- **Programming Techniques**

## Architecture
![Architecture Diagram](image-url)
# Range of PLCs

1) **Micro PLCs** - It covers units with up to 128 I/O’s and memories up to 2 Kbytes.
   (Small PLC) - these PLC’s are capable of providing simple to advance levels or machine controls.

2) **Mid Range PLCs** - This PLC have up to 2048 I/O’s and memories up to 32 Kbytes.

3) **Large PLCs**
   - The most sophisticated units of the PLC family.
   - They have up to 8192 I/O’s and memories up to 750 Kbytes.
   - It can control individual production processes or entire plant.

4) **Soft PLCs** - PC based Automation(PLC and HMI is integrated in one platform)
Programming Logic Controller

PLC

- Introduction
- Range of PLCs
- Architecture of PLCs
- Programming Techniques

Architecture of PLCs

PROCESSOR:
- Provides intelligence to command and govern the activities of the entire PLC systems.
Programming Logic Controller

**PLC**
- Introduction
- Range of PLCs
- Architecture of PLCs
- Programming Techniques

**Memory:**
- All PLC contain both RAM and ROM memory
  - **Executive Memory:** ROM memory. The operating system is a special machine language program that runs the PLC
  - **System Memory:** ROM memory. This area is allotted for use of the operating system only and is not available to the user for programming
  - **IO Status Memory:** RAM memory. This portion of RAM is allocated for the storage of current I/O status
  - **DATA Memory:** RAM memory. This portion of RAM is allocated for timers, counters, mathematics and process parameters are required, an area of memory must be set aside for data storage
  - **User Memory:** RAM/EPROM/EEPROM memory. The final area of memory in a PLC is allocated to the storage of the user program
Programming Logic Controller

I/O MODULES:
- Provides signal conversion and isolation between the internal logic level signals inside the PLC and the field’s high level signal.

SCANNING:
- Input Scan + Program Scan + Output Scan.

POWER SUPPLY:
- Provides the voltage needed to run the primary PLC components.

PROGRAMMING DEVICE:
- Used to enter the desired program that will determine the sequence of operation and control of process equipment or driven machine.
Programming Logic Controller

1) Standalone PLCs

- Introduction
- Range of PLCs
- Architecture of PLCs
- Programming Techniques
Programming Logic Controller

2) Distributed PLCs

PLC
- Introduction
- Range of PLCs
- Architecture of PLCs
- Programming Techniques
3) Redundant PLCs

- Hardware Redundancy
- Software Redundancy
Programming Logic Controller

**A) Basic Types of Programming**

1) Linear Programming

- Main Blocks for whole program
- Simple Program
- Simple Operation

**PLC**
- Introduction
- Range of PLCs
- Architecture of PLCs
- Programming Techniques
2) Structured Programming

- Complex Programming, Simple and clear programming, even for large programs
- Program parts can be standardized, Easy alterations
- Simple program test, Simple start-ups
- Subroutine techniques (block call from different locations)
- Debugging is simplified since
- Separate sections can be tested.
# Programming Logic Controller

## Programming Languages

1) **Ladder Language**
- Scanning of each rung
- Easy and simple for programming
- Easy for diagnosis

### PLC
- Introduction
- Range of PLCs
- Architecture of PLCs
- Programming Techniques

![Ladder Diagram]
Programming Logic Controller

2) Functional Block diagram (FBD)
- Graphical Blocks for Programming
- Simple for Programming
- Many Input but Single output

3) Statement List Programming
- Statement List Operations
  * Load (LD) instruction.
  * And (A) instruction.
  * Or (O) instruction.
  * Output (=) instruction.
# Programming Logic Controller

## PLC
- Introduction
- Range of PLCs
- Architecture of PLCs
- Programming Techniques

## 2) Functional Block diagram (FBD)
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- Statement List Operations
  - Load (LD) instruction.
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<thead>
<tr>
<th>History</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concept</td>
<td>Frequent new versions</td>
</tr>
<tr>
<td>Automation Pyramid</td>
<td>From “tag/ channel-based” to “device oriented”</td>
</tr>
<tr>
<td>Controller</td>
<td>Multi-team development</td>
</tr>
<tr>
<td>Visulization</td>
<td>Web technology, Active X, Java, etc.</td>
</tr>
<tr>
<td></td>
<td>OPC for internal communication</td>
</tr>
<tr>
<td></td>
<td>Different third party PLC driver</td>
</tr>
<tr>
<td></td>
<td>Modbus Communication</td>
</tr>
</tbody>
</table>
## SCADA/HMI

<table>
<thead>
<tr>
<th>SCADA/HMI</th>
<th>Architecture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Various process busses (Profinet, Modbus, Profibus, Ethernet, …)</td>
</tr>
<tr>
<td></td>
<td>- Non-proprietary channels (PROFIBUS, FMS)</td>
</tr>
<tr>
<td></td>
<td>- Communication to 3rd-party PLC’s via OPC, OPC Data Access, OPC Data Access XML</td>
</tr>
<tr>
<td></td>
<td>- More channels available as</td>
</tr>
<tr>
<td></td>
<td>- Add-Ons</td>
</tr>
</tbody>
</table>

### Architecture Diagram

- **PLC_1**
- **PLC_2**
- **Rack PLC**
- **SCADA OPC client**
- **3rd-party OPC server**

---

**Intrduction**

**Architecture**

**Functions**

**Applications**
Areas Of Application

- SCADA/HMI
  - Introduction
  - Architecture
  - Functions
  - Applications
# SCADA/HMI

## SCADA/HMI Functionality

<table>
<thead>
<tr>
<th>SCADA/HMI</th>
<th>SCADA/HMI Functionality</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Introduction</strong></td>
<td>Graphics System</td>
</tr>
<tr>
<td><strong>Architecture</strong></td>
<td>Message System</td>
</tr>
<tr>
<td><strong>Functions</strong></td>
<td>Archiving System</td>
</tr>
<tr>
<td><strong>Applications</strong></td>
<td>Report System</td>
</tr>
</tbody>
</table>

- **Programming Interfaces**: C-API, OLE-DB, COM Object Model via VBA & VBScript
- **Standard Interfaces**: WinCC
- **Process Communications**: Script Processing
<table>
<thead>
<tr>
<th>SCADA/HMI</th>
<th>Graphic Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>Support of tag structures</td>
</tr>
<tr>
<td>Architecture</td>
<td>Application of faceplate block technology</td>
</tr>
<tr>
<td>Functions</td>
<td>Creation of a specific project</td>
</tr>
<tr>
<td>Applications</td>
<td>And symbols library</td>
</tr>
</tbody>
</table>
Alarm Handling

- Based on limit and status checking
- More complicated expressions developed by creating derived parameters
- Alarms are time stamped and logically centralised
- Notifications (audible, visual, Email, GSM)
- Multiple alarm priority levels
- Grouping of alarms and handling of groups is possible
- Suppression and masking of alarms either individually or as a complete group
- Filtering of alarms is possible
Report

- Configurable layouts and Print
- Time or event driven reports
- Configuration, Runtime, Historical and external data (e.g. from databases)
User Administration

- Free configurable user groups and administration of rights
- Plant wide user management (scalable for Web-solutions)
- Integrated with the user management of Microsoft
### SCADA/HMI

<table>
<thead>
<tr>
<th>SCADA/HMI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trending</strong></td>
</tr>
<tr>
<td>➢ Multiple trending charts</td>
</tr>
<tr>
<td>➢ Charts are pre-defined or configured on-line</td>
</tr>
<tr>
<td>➢ Charts contain multiple pens,</td>
</tr>
<tr>
<td>➢ Zooming, scrolling, panning, ‘Hairline’</td>
</tr>
<tr>
<td>➢ Real-time and historical trending</td>
</tr>
<tr>
<td>➢ Write data to RDB</td>
</tr>
</tbody>
</table>

**SCADA/HMI**

- Introduction
- Architecture
- Functions
- Applications
## SCADA/HMI

<table>
<thead>
<tr>
<th>SCADA/HMI</th>
<th>Interfaces to H/W and S/W</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Hardware</strong></td>
</tr>
<tr>
<td></td>
<td>Multiple communication protocols supported in a single system (in particular CERN supported Field busses)</td>
</tr>
<tr>
<td></td>
<td>Support for major PLCs/DCSs but not VME</td>
</tr>
<tr>
<td></td>
<td><strong>Software</strong></td>
</tr>
<tr>
<td></td>
<td>API</td>
</tr>
<tr>
<td></td>
<td>ODBC, DDE and OLE I/F to PC Products</td>
</tr>
<tr>
<td></td>
<td>OPC Client and OPC Server</td>
</tr>
<tr>
<td></td>
<td>ActiveX Containers</td>
</tr>
<tr>
<td></td>
<td>Web clients</td>
</tr>
<tr>
<td>SCADA/HMI</td>
<td>Development Tool</td>
</tr>
<tr>
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<td>------------------</td>
</tr>
<tr>
<td></td>
<td>Project editor</td>
</tr>
<tr>
<td></td>
<td>Graphics editor</td>
</tr>
<tr>
<td></td>
<td>Configuration through parameter templates</td>
</tr>
<tr>
<td></td>
<td>Scripting language</td>
</tr>
<tr>
<td></td>
<td>Most processing tools based on IEC 1131</td>
</tr>
<tr>
<td></td>
<td>Batch configuration according to S88.1</td>
</tr>
<tr>
<td></td>
<td>Driver Development Tool Kit</td>
</tr>
</tbody>
</table>

**SCADA/HMI**

- Introduction
- Architecture
- Functions
- Applications
Areas Of Application of SCADA

**Electric power generation, transmission and distribution:** Electric utilities detect current flow and line voltage, to monitor the operation of circuit breakers, and to take sections of the power grid online or offline.

**Manufacturing:** manage parts inventories for just-in-time manufacturing, regulate industrial automation and robots, and monitor process and quality control.

**Mass transit:** regulate electricity to subways, trams and trolley buses; to automate traffic signals for rail systems; to track and locate trains and buses; and to control railroad crossing gates.

**Buildings, facilities and environments:** Facility managers use SCADA to control HVAC, refrigeration units, lighting and entry systems.

**Water and sewage:** State and municipal water utilities use SCADA to monitor and regulate water flow, reservoir levels, pipe pressure and other factors.
Thank you for your attention!

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