PLC for dummies

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PLC- Overview

- **Programmable Logic Controller**
  - Designed for industrial processes.
  - Works under severe conditions.
  - Real time system.
  - Handles sensors and actuators (I/O).
PLC - Functions

- Process control
  - Collects inputs (digital, analog)
  - Runs the process control
    - Basic logic functions
    - Complex algorithms (PID...)
    - Safety functions
  - Produces actions (outputs)
  - Provides data to the supervision layer
PLC - Strength

- Reliable. Used for safety systems.
- Robust. Resistant to electrical noise, vibration, impact, dust, heat.
- Extensive range of inputs/outputs.
- Extensive range of functionalities.
- Long term support by suppliers.
- Long service life, around 20 years.
PLC - Weak points

- Limited memory.
- Low performance.
- Dedicated programming environment.
- Different programming languages from different manufacturers.
PLC - Hardware Overview

Supervisory Control And Data Acquisition (SCADA)

ETHERNET TCP/IP

INDUSTRIAL FIELD BUS

REMOTE I/O

PLC

DIRECT WIRING

SENSORS/ACTUATORS
Device which converts the signal from one form to another.

**Sensors**
- Analog: Temperature, pressure, humidity, level, flow, weight...
- Digital: Level, pushbutton (emergency stop), position switch, photoelectric sensor...

**Actuators**
- Analog: valve, pump, heater, power supply...
- Digital: Signaling column, contactor, electro valve, switch, OnOff pump...
PLC - Periphery stations

- Communication modules.

- I/O Modules.
  - Convert physical value into numeric value and vice versa.

- Function modules.
PLC - Communication modules

- Ethernet
- Profibus
- Profinet
- Modbus
- Ethernet IP
- CAN
- Serial, Point to Point
- AS-Interface
PLC- Input / Output modules

- **Analog**
  - 16-bit signed from -32768 to 32767.
  - Inputs: Resistance, Current, Voltage, thermocouple...
  - Outputs: Current, voltage.

- **Digital**
  - 1-bit
  - Inputs: 120v-230v AC, 24v DC
  - Outputs: Relay, 120v-230v AC, 24v-48v-125v DC.
PLC- Function modules

- PID control
- Flow
- Camera controllers
- Numerical controllers
- Counters, positioners.
- Motor VFD or Soft Starter
PLC - Hardware Overview

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ETHERNET TCP/IP

PLC

INDUSTRIAL FIELD BUS

REMOTE I/O

DIRECT WIRING

SENSORS/ACTUATORS
PLC- FieldBus. Overview

- Industrial Network System
- Provides the PLC with I/Os
- Time deterministic
PLC- FieldBus. Strength

- Controls multiple I/Os
- Saves cabling costs
- Allows distributed layouts and topologies
- Safety compliant
PLC- FieldBus. Weak points

- Sensitive to electromagnetic noise.
- Installation constraints (specific installation guidelines).
- Several different (incompatible) fieldbus standards.
PLC - FieldBus. Standards

- Profibus
  - Industry leader (56.1 million nodes)
- WorldFip
  - Robust (radiation resistant)
- CAN, CANOpen, CANBus
  - Low cost, Easy to implement
  - Used for ELMB at CERN
- Over Industrial Ethernet:
  - Profinet (16.4 million nodes)
  - EtherNet/IP
  - Powerlink
  - EtherCAT
PLC- FieldBus. Market share

Fieldbus: 42% (48)
Annual growth: 6% (4)

Wireless 6% (6)
Annual growth: 32% (32)

EtherCAT 7%
EtherNet/IP 15%
PROFINET 12%
EtherNet/DC 4%
Modbus-TCP 4%
POWERLINK 4%
Other Ethernet 10%
WLAN 4%
Bluetooth 1%
Other Wireless 1%
Modbus-RTU 6%
CC-Link 6%
CANopen 4%
DeviceNet 4%
Other Fieldbus 10%

Industrial Ethernet: 52% (46)
Annual growth: 22% (22)
<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>PROFIBUS EN 50 170</td>
</tr>
<tr>
<td>Access</td>
<td>Token ring. Master-Slave</td>
</tr>
<tr>
<td>Transmission rate</td>
<td>9.6 kbit/s - 12 Mbit/s</td>
</tr>
<tr>
<td>Transmission technology</td>
<td>electric: Shielded cooper pair twisted cable</td>
</tr>
<tr>
<td></td>
<td>optic: fiberoptics (crystal and plastic)</td>
</tr>
<tr>
<td></td>
<td>wireless: infrared and radio</td>
</tr>
<tr>
<td>Nodes</td>
<td>127 maximum</td>
</tr>
<tr>
<td>Network length</td>
<td>electric: 9.6 km maximum</td>
</tr>
<tr>
<td></td>
<td>optic: 150 km maximum</td>
</tr>
<tr>
<td>Topology</td>
<td>Daisy Chain, tree, star, ring, redundant ring</td>
</tr>
<tr>
<td>Used for</td>
<td>Process communication, data transfer</td>
</tr>
</tbody>
</table>
PLC- Profibus

Token ring

Active nodes. Master

Passive nodes. Slaves.

PROFIBUS
PLC - Hardware Overview

- PLC
- Remote I/O
- Supervisory Control And Data Acquisition (SCADA)
- Ethernet TCP/IP
- Industrial Fieldbus
- Direct Wiring
- Sensors/Actuators
PLC- Supported at CERN

Siemens
CERN-SIEMENS  B1130A/GEN 31-12-1999

Schneider
CERN-SCHNEIDER. B1129/GEN 12-11-1999
PLC - Siemens

- S7 200 (low range)
  - Compact
  - Low cost
  - Small systems
PLC - Siemens

- S7 300 (medium range)
  - Modular
  - Wide range of IOs
  - Widely used
  - Limited memory
  - Limited range of fieldbuses
PLC- Siemens

- S7 400 (high range)
  - Redundant architecture
  - Large memory
  - High performance
PLC - Siemens – New CPUs

- S7 1500 (medium/high range)
  - Modular
  - Wide range of IO
  - Large memory
  - High performance
PLC - Schneider

- **Small range (M340)**
  - 4 Mb of memory
  - 1024 digital I/O
  - 256 analog I/O

- **Medium range (PREMIUM)**
  - 7 Mb of memory
  - 2040 Digital I/O max
  - 512 Analog I/O

- **High range (QUANTUM)**
  - 8 Mb of memory
  - 8 000 Digital I/O
  - 2500 Analog I/O
PLC- Schneider – New CPU

- High range (M580)
- Compact
- High performance
- Modular
PLC - Processor

Scan cycle 5-500 ms

- Executes user program
- Reads Inputs
- Writes Outputs
- OS functions Comm Diagnostics
**PLC- Memory access, IO access**

### Internal 16 bits

- **Data area**
  - 0
  - %MW120
  - 120
  - %MF137
  - 137
  - 138
  - N

- **Real**

### IO devices are mapped in a memory.

- **Input word**
  - %IW0.2.3
  - Access to The Module
  - Channel in The Module

- **Output word**
  - %QW0.2.3

- **Input Boolean**
  - %I0.6.3.1
  - Bit in the Channel

- **Output Boolean**
  - %Q0.7.3.6

---

%MW100 := 12;
%QW0.2.3 := 16#0F00;
%Q0.7.3.6 := TRUE;
PLC - Programming languages

- Languages defined in IEC 61131-3
  - Textual languages
    - Instruction List (IL)
    - Structure Text (ST)
  - Graphical Languages
    - Ladder (LD)
    - Functional Bloc Diagram (FBD)
  - Sequence (Stepper)
    - Sequential Function Chart (SFC)
PLC - Programming languages - IL

- IL: Instruction List
- Fastest possible logic execution.
- Low level language

```plaintext

Instruction List Start
(* example D = A - (B - C) *)
LD A
SUB ( LD B SUB C )
ST D
Instruction List End
```


PLC- Programming languages - ST

- **ST**: Structured Text
- High level language
- Equations, table manipulation
- Complex statements and nested instructions
  - Iteration loops (REPEAT-UNTIL; WHILE-DO)
  - Conditional execution (IF-THEN-ELSE; CASE)
  - Functions (SQRT(), SIN())

```plaintext
(* conditionnal if *)
IF (var1 = 12.45) THEN boolean1 := TRUE;
  else var2 := 56.78; boolean2 := 0;
END_IF;

(* simple PID controller *)
SIMPLE_CONTROLLER (PV := int_to_real(_integer) , SP := _real/56.78,
  PARA := para_PID,OUT := PID_Reg,
  OUTD => Out_PID);
```
PLC - Programming languages - LD

- Traditional *ladder logic* is an easy-to-use graphical programming language that implements relay-equivalent symbol.

- Intuitive.

- Limited functionalities.
PLC- Programming languages - FBD

- FBD: Function Block Diagram
- Easy way of programming (intuitive)
- Easy way of debugging
- Limited for complex algorithms
PLC - Programming languages - SFC

- **SFC**: Sequential Function Chart
- A graphical method of representing a sequential control system (stepper).
PLC- Programming software tools

- Siemens : Simatic Step7
  - Modular
  - Wide range of functionalities
  - Diagnostic tools
  - Network configuration

- Schneider : UNITY Pro V11.0
  - Easy to manage
  - Visualization facilities
PLC - Hardware Overview

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ETHERNET TCP/IP

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INDUSTRIAL FIELDBUS

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DIRECT WIRING

SENSORS/ACTUATORS

Supervisory Control And Data Acquisition (SCADA)
PLC- SCADA communication

- Ethernet TCP IP.
- Big amount of data transfer.
- Non deterministic.
- Big data transfer rates.
- S7 Driver on TCP IP. Siemens.
- Modbus Driver on TCP IP. Schneider.
- OPC.