Industrial Automation (PLC)

COMMUNICATION BETWEEN PROGRAMMABLE LOGIC CONTROLLERS IN THE INDUSTRIAL DISTRIBUTION APPLICATIONS

1.1 Types of communication:

1.1.1 PC to PLC communication

1.1.2 PLC to PLC communication

1.1.3 Communication between different modules

1.2 Introduction

If the communication in the small applications is not critical than is sufficient to control these by one programmable logical controller (PLC). The role of the communication is exchanging of connection with a common computer in order to create and transmit the program to PLC and to transmit data to superior levels for operator’s control of technology. At the direct control it is possible to rely on the response specified by manufactures between input change and adequate reaction. This response ranges about 10 ms particularly with regard to needs of individual manufacturers of automation technologies and systems. Therefore their standardization was delayed and only after a certain period of time it is possible to monitor profiling of typical application service of industrial networks

1.3 Basic Network Characteristics:

The architecture of the Siemens-Net was designed with intention of creating an integrated environment for open communication of various automation systems (Total Integrated Automation) at all levels of industrial systems. Architecture of these networks integrates various network technologies so they ensure providing required communication services. Within the architecture are defined the follow in hierarchy levels with designated mode of communication:

✓ IT communication – allows integration of automation equipment with Enterprise Information System.

✓ Data communication – allows to communicate in real time on procedural level and control level, in which communication of PLCs, programming and controlling of performance components are dominant.
Procedural communication – allows I/O operations in real time and communication with sensors and sensor manufacturing process. As previously mentioned, in this case we are interested in data communication within industrial networks Simatic-Net, where we characterize basic types of industrial networks.

1.1.1 PC to PLC Communication:

PC to PLC communication communicates with PPI & MPI adaptor.

- PPI Adaptor for S7 200 module
- MPI Adaptor for S7 300, S7 400 module

MPI – Multi Point Interface:

MPI bus is designed for programming and data services on devices. It is not designed to collect data from decentralized peripherals. In a network there must be at least one Master, which manages data flow on the network. Network speed is optional, 9 kbit/s to 12 Mbit/s. In principle, transmission distance is not limited, but the network is primarily intended for local road length in tens to hundreds meters. Transmission technology is addressed through RS485 communication standard transmission and by fiber optic supplemented with converters, but this solution is not commonly used.
Disadvantages:

- limited amount of data transferred,
- longer response time,
- short range network.

1.1.2 PLC to PLC Communication:

PLC to PLC communication communicated by several items

- PROFIBUS
- PROFINET
- CAN BUS
- MOD BUS

Is an industrial field bus used for all areas of automation. At the level of physical layer Profibus is specified to suit the diverse needs and to support majority of industrial applications, such as linking remote controller peripherals to procedural controller (DP) or procedural automation.

Types and Versions of Profibus:

Profibus DP (Decentralized Periphery). This is the simplest and highly predominant variant of Profibus. It is suitable for fast transfer of decentralized peripherals and remote I/O units. Communication medium is either at wasted pair (standard RS-485) or optical fiber at speed of up to 12 Mbit/s.

Profibus PA (Proces Automation) uses enlarged standard Profibus DP and is designed to control slow processes, especially in potentially explosive atmospheres as it corresponds to intrinsically spark safety. Profibus FMS Profibus FMS provides communication standard for communication in heterogeneous environment with a large set of services for working with data, programs and alarms. Communication medium is a twisted pair (standard RS-485) or optical fiber. Speed is lower than the Profibus DP.

1.4 Disadvantages:

Comparing to Ethernet, Profibus is less powerful and flexible network. System architecture network Simatic – Net.
Industrial Ethernet:

Industrial Ethernet is based on standard IEEE 802.3. This protocol defines the physical layer and data link layer model. As a consequence, the standard IEEE 802.3 specifies characteristics of communication interface and a method of managing the access to transmission medium. Systems with industrial Ethernet can have different structures, i.e. network topology, logical structure of communication links but also methods of transmitting data. Topology: bus, tree, star, ring.

Bus topology Ethernet network. In the process of development and use of Ethernet in industrial practice were created many solutions. International Electro technical Commission (IEC) has recognized following Ethernet protocols:

- Profinet I/O – cyclic communication addressing through MAC (Device Name),
- ISO – acyclic communication addressing through MAC,
- ISO-on-TCP – acyclic communication addressing through IP,
- TCP/IP – reliable acyclic confirmed by communication addressing through IP,
- UDP/IP – acyclic datagram by uncertified communication addressing through IP

Communication among Several PLC:
Managing connections between remote PLC performs the data link layer with use.

**Creating Project of Communication between PLC:**

For practical verification of communication among various PLC, we used the communication model consisting of the following parts.

### 1.5 PLC Programme:

After setting communication between processors (CPUs) of the both PLCs, we could access to creation of the user program. It is possible to choose from the following programming languages in programming environment of Step 7:

- **STL (Statement List Programming Language):** a text-based programming language with a structure similar to machine code. Each statement represents a program processing operation of the CPU.

- **LAD (Ladder Logic):** a programming language that represents a program by a graphical diagram based on the circuit diagrams of relay-based logic hardware.

- **FBD (Function Block Diagram):** a graphical language that allows the user to program elements in "blocks". These program languages are equivalent. We could change them while programming.

User program structure is declared by organization block (OB 1), which operates cyclically. Operation system S7 CPU periodically initializes the block OB1. OB1 consists of separately programmable function blocks (FBs). FB contains memory, which makes it possible to save internal variables to this block by declaration table.

For the most frequently used routines we use function – FC blocks. Data blocks (DBs) are used for saving user data, which could but need not to couple with particular function block FB. Program Step 7 uses System.

Function Blocks SFBs and System Functions SFCs. These are directly integrated in the S7 processor (CPU) and enable entry to some special system functions. It is necessary to call programmed blocks FB, FC, DB by appropriate OB.
INTERFACING OF PLC WITH DIFFERENT ELECTRICAL DEVICES

INTERFACING WITH PHYSICAL DEVICE

Hardware I/O Interfaces

INTERFACES TYPES

Different connection possibilities are available:

- USB, Serial or Parallel ports.
- PCI/ISA Cards.
- Ethernet, TCP/IP Protocol.
- Software / OPC / Others...

SERIAL PORT CONFIGURATIONS

To connect a serial port input/output device you will need to make a device based on a microcontroller, this is because it will manage the serial port to send the communication messages to the diverse actuators that you connect (relays, up to isolators, etc..)

Easy PLC allows two different protocol types; byte protocol (with this option you can only use 8 inputs and 8 outputs) or ASCII protocol, where a number is sent followed by a control character to indicate the end of the transmission (control character 13), you can get in this way a maximum of 31 inputs and 31 outputs.

I recommend that you to look at the Easy PLC help to obtain more information.

PARALLEL PORT CONFIGURATIONS

You can develop your own interface following the standard characteristics of the parallel port

USB PORT CONFIGURATIONS

- **USB OPTO RLY88**, 8 optically Isolated Inputs and 8 Relay Outputs.

  This card is ideal for interface in all type of PLC (sink or source 24Vdc voltage). Totally compatible with Easy PLC and Machines Simulator.

Easy PLC is compatible with input/output devices from diverse makers, and with different system of data capture, using the Easy PLC External drivers.
For example:
Easy PLC is compatible with Phidget™ I/O interface cards like:
Phidget Interface Kit 0/0/4: 4 outputs (digitals).
Phidget InterfaceKit 0/16/16: 16 inputs / 16 outputs (digitals).
Phidgt InterfaceKit 8/8/8: 8 inputs / 8 outputs (digitals) / 8 analog inputs.
And all Phidgets™ analogic-digital interfaces.
(Phidgets™ and Phidget InterfaceKit are trademarked and registered by Phidget™).

• Or develop your own USB digital I/O card for your PC:
TCP/IP DRIVER

With the Easy PLC TCP/IP external driver you can connect two remote computers, for example one in California and the other in Tokyo, and send the sensors/actuators information between them. This way you can manage electronic devices over long distances.

Siemens Simatic S7 - PLCSIM DRIVER

With this Driver you will be able to communicate your Step 7 logic programs directly with Easy PLC and Machines Simulator without any additional hardware. More info

GENERIC OPC DRIVER

Using this driver will be possible to communicate with Real or Simulated PLC's using the standar OPC protocol specifications. For example use it to dialogue with Rockwell RSLogix software. And is included in the registered version!.

COMPATIBLE I/O DEVICES

Easy PLC can be compatible with any I/O analagical/digital device designed for Windows XP / Vista / Windows 7. With any device compatible with Windows .NET Framework or ActiveX/COM technology can be connected. If you need a specific driver.

VIRTUAL INTERFACE

Easy PLC has another important characteristic, the Simulated Virtual Interface. With this option it is possible to carry out and to check the programs without the necessity of connecting any hardware.

This modality has multiple applications:

- Create programs to verify their operation without having concluded the hardware.
- Verify the programs of other systems.
- As method of learning PLC languages.
- Approach to industrial automation.

If this interface is selected, when the PLC is started the window will appear with the available inputs/outputs if it is selected from the Easy PLC notify icon. Pressing on inputs buttons it is
possible to force their state to ON/OFF as well as to visualize the state of the outputs.

**CONNECTION EXAMPLE**

In this example two serial devices with 8 I/O + Parallel port interface with 8 Out and 5 In + Phidget Interface Kit 0/16/16 are connected.

In total obtained with this configuration:

33 Inputs and
40 Outputs
**Input/Output Interfaces**

The Interface is the electronic device that is connected between the PC and the elements to be controlled (actuators, switches, push buttons, relays, circuits, etc.). Their mission will be to guarantee the correct isolation between the PC ports and the exterior devices, as well as to send/receive the information to the Easy PLC software about the state of the diverse connected elements. These interfaces are denominated Inputs/Outputs analogical-digital cards.

You can build your own input/output interfaces yourself or you can acquire commercial devices to connect to the PC ports and to use Easy PLC to manage them.
PLC Application For Speed Control of AC Motors With Variable Speed (VS) Drive

PLC Application For Speed Control of AC Motors With VSD (on photo: Quad flex panel that controls four total pumps, two 25HP and two 50HP pumps controlled by corresponding variable frequency drives with filters. The 460V 3ph4 wire 300A panel features a PLC based control system with back up floats and intrinsically safe barriers for level sensors. By D&B Custom Wiring

AC Motor Drive Interface:

A common PLC application is the speed control of AC motors with variable speed (VS) drives. The diagram in Figure 1 shows an operator station used to manually control a VS drive. The programmable controller implementation of this station will provide automatic motor speed control through an analog interface by varying the analog output voltage (0 to 10 VDC) to the drive.
The operator station consists of:

1. a speed potentiometer (speed regular).
2. a forward/reverse direction selector.
3. a run/jog switch, and start and stop push buttons.

The PLC program will contain all of these inputs except the potentiometer, which will be replaced by an analog output.

The required input field devices (i.e. start push button, stop push button, jog/run, and forward/reverse) will be added to the application and connected to input modules, rather than using the operator station’s components.

The PLC program will contain the logic to start, stop and interlock the forward/reverse commands.
The communication uses a contact o/p Interface to switch the forward/reverse signal, since the common must be switched. To activated the drive terminal must be receive 115 vac to Turn ON the inter relay cr1.

The drive terminal block supplies power to the plc l1 connection to turn the drive ON. the output module cr1 is connected to terminal tb1-6. the drives 115 vac signal is uses to control the motor speed so that the signal is in same circuit as the drive, avoiding the possibility of having different commons L2 in the drive.

In this configuration, the motor overload contact are wired & tb1-10, which are the drives power L1 connection and the o/p interface L1 connection. fault and load occurs the drive will turn OFF because the drive CR1 contact will not receive power from the module.

This configuration however does not provide low voltage protection, since the drive and motor will start immediately after the overload cool off and reclose.

To have a low voltage protection, the auxiliary contact from the drive CR1 in terminal TB1-7, must be used as an input in the PLC, so that it seals the START/STOP circuit.

Figure shows the PLC ladder program that will replace the manual operator station. The forward and reverse inputs are interlocked, so only one of them can be ON at any given time (i.e., they are mutually exclusive).

If the jog setting is selected the motor will run at the speed set by the analog output when the start push button is depressed. The analog output connection simply allows the output to be enabled when the drive stars. Register 4000 holds the value in courts for the analog output to the drive. Internal 1000, which is used in the block transfer the completion of the instruction.
*Selector switch is logic 1 (closed) in Fwd/Run position and logic 0 (open) in Rev/Jog position.
3.1 FBD & STL LANGUAGE PROGRAMMING IN PLC

Step-1

After open (OB) chose view option and set the language as FBD.

STEP-2
STEP-3

GIVE THE I/P AND O/P ADDRESS IN BLOCK
STEP-4

STEP-5

CLICK ON I/P ADDRESS:
Example of

And –or block in plc
understand the basic concept of PLC Valve Control Ladder Logic.

Target Users: Students, Technicians, Freshers, Trainee engineers.
Note: Barrier or Relay not shown in above figure.

Let's list out the required PLC digital inputs and digital output signals:

PLC Digital Inputs:
1. Valve Open Feedback
2. Valve Close Feedback

PLC Digital output:
1. Valve Energize command

PLC Valve Control Ladder Logic Programming

Any pneumatic valve requires instrument air supply for its operation. A air filter regulator is used to remove any liquid or particulate matter present in the instrument air supply and to set the required air supply to the valve.

The output of air filter regulator is connected to valve actuator via a Solenoid valve. This solenoid valve is used to control i.e. ON/OFF the instrument air supply to the valve actuator.

Consider solenoid valve (SOV) is Normally Close (NC) type. In normal position, the SOV is in off position or de-energized state, so the instrument air supply will be blocked as SOV is Normally closed. If SOV is energized i.e. PLC sends the signal then SOV energizes and becomes normally open (NO), so allows instrument air supply through its.

**Normally Close type Solenoid Valve**

[Image of Normally Close type Solenoid Valve]

*When Solenoid valve OFF*  
*When Solenoid valve ON*
Some people often confuse about Solenoid valve and Valve actuator. These both are different, SOV controls (ON/OFF) the instrument air supply and Valve actuator controls the position of the valve either fully open or fully close.

ON/OFF valve are equipped with either proximity switches or limit switches to sense the valve position either fully open or fully close. So these are connected to the PLC digital inputs. So PLC can know the valve status in the field either fully open or fully close and displays to the operator via graphics.

Consider our ON/OFF valve is Normally Open type i.e. valve is in Open position. So by default Open Feedback will be sent to the PLC or we can say Open feedback limit switch or proximity switch will be energized and close feedback switch is in de-energize state.

Lets say PLC sends an Digital output command to the ON/OFF valve (via a barrier or a relay). Say we have 24V DC powered solenoid valve mounted on the ON/OFF valve.

How PLC controls a Motor?
Generally either a barrier or a relay is placed after the PLC digital output module. Consider we have a barrier, first barrier receives the PLC digital output module command (PLC command is Barrier input) then the barrier energizes its output (Barrier output) and barrier sends the 24V DC power to the respective ON/OFF valve.

The purpose of barrier or relay is used to isolate the PLC & Field signals or for safety purpose or to amplify the power/voltage signals.

Now ON/OFF valve receives the PLC command i.e. it received the 24V DC power to the solenoid valve from the barrier. So now solenoid valve will be energized and changes to Normally Open (NC) state. Now solenoid valve passes the instrument air supply to the valve actuator as it becomes Normally open.

The valve actuator receives the instrument air supply and moves the valve stem accordingly and the valve position will change from fully open state to full close state. When the ON/OFF valve starts the stem movement then immediately Open Feedback will be gone (proximity switch will not detect any object mounted on the stem).

After starts valve stem movement and before reaching close position, both open & close feedbacks will not be available to the PLC and we call this as transition state. After the ON/OFF valve fully closed then close feedback switch (proximity or limit) will be energized and close feedback signal will be sent to the PLC and displayed to the operator.

Note: Sometimes ON/OFF valve may stuck in between, so operator will not receive any feedback on the graphics, as both open & close feedback switches will only detect either fully open or fully close states of the valve. Its not possible to detect any Intermediate state of the valve. Say now PLC withdraws the Output command to the ON/OFF valve i.e. barrier input will be turned off, so barrier will de-energized or barrier output will be OFF, 24V DC power will be disconnected/removed to the Solenoid valve.
As solenoid valve power removed, SOV changes its state from NO to NC. Solenoid valve becomes Normally Closed i.e. Instrument air supply to the valve actuator will be stopped or disconnected. So ON/OFF valve also comes into its original state i.e. Open state.

PLC can send output command signal based on some logics or real time input signals. For example: if level of a drum reaches high alarm then drum feed ON/OFF valve has to be closed.

**Details of ON/OFF Valve:**
In our example we considered a pneumatic on/off valve. First we see the list of components in the valve & its purpose.

**a. Air Filter Regulator:**

Air Filters are used to remove liquid water and particulate matter from compressed air sources. These are ‘mechanical filters’ and do not remove oil vapors or chemical contaminants in vapor form. Click here for Principle & Animation.

**b. Solenoid Valve:**

A solenoid valve is an electro-mechanical controlled valve. The valve features a solenoid, which is an electric coil with a movable ferromagnetic core in its center. This core is called the plunger.

In rest position, the plunger closes off a small orifice. An electric current through the coil creates a magnetic field. The magnetic field exerts a force on the plunger. As a result, the plunger is pulled toward the center of the coil so that the orifice opens. This is the basic principle that is used to open and close solenoid valves.

Also Read:
1. Solenoid Valve Animation
2. Solenoid valve Types & Principles

**c. Open Feedback & Close Feedback:**

A proximity switch is one detecting the proximity (closeness) of some object.

By definition, these switches are non-contact sensors, using capacitive, inductive, magnetic, electric, or optical means to sense the proximity of the valve position either open or close.
Scada communication with plc to control loads.