Programmable Logic Controllers, Industrial Field Buses and SCADA.

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Outline

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8.	SCADA and its Applications
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Significance of topic…

- **Programmable Logic Controllers, Industrial buses and SCADA are key areas for Automation solutions.**
- **Solutions for factory automation, process automation, safety applications, and the entire range of drive technology are available with PLC, SCADA and buses.**

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…Significance of topic

- The current trend is Totally Integrated Automation

- Totally Integrated Automation allows a perfect interplay of all integrated automation components

- This presentation will focus on practical aspects of PLCs, SCADA and Industrial buses

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Three Parts of Presentation

1. Programmable Logic Controllers

2. Industrial Field Buses and PROFINET

3. Supervisory Control and Data Acquisition (SCADA)

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Programmable Logic Controllers

- A Programmable Logic Controller [1] is a micro-controller based device which is specifically designed to operate in the industrial environment that can be rather harsh.
- A PLC package is capable of monitoring status of inputs connected with it to take decisions according to the control program, and manipulates its outputs to achieve Automation.
- Basically it is an alternate solution to the previously under taken Wired Logic Control (WLC) technology but it can accommodate more advanced options.
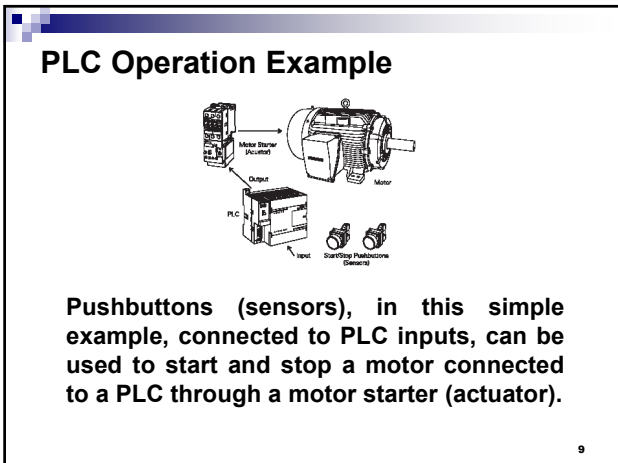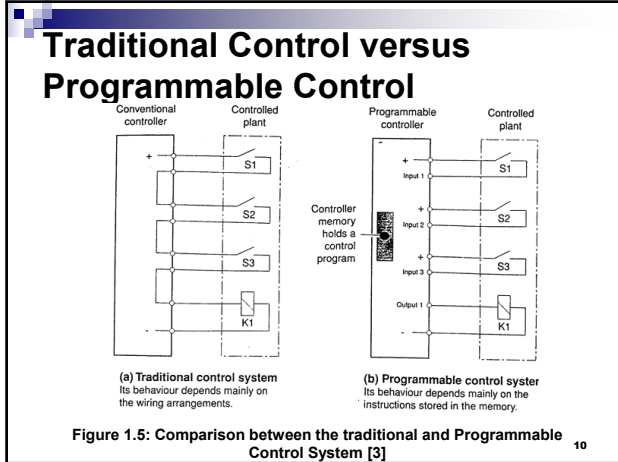
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Basic PLC operation…

Figure 1.1: Basic PLC Operation [2]
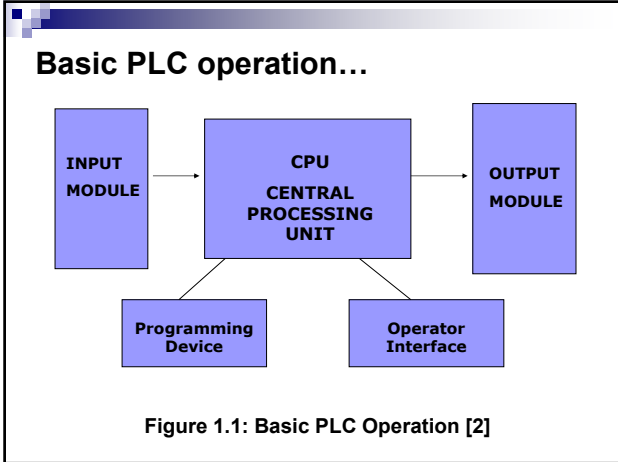
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…Basic PLC operation

- **Output modules convert control instructions from the CPU into a digital or analog signal that can be used to control various field devices (actuators).**
- **A programming device is used to input the desired instructions.**
- **These instructions determine what the PLC will do for a specific input.**
- **An operator interface device allows process information to be displayed and new control parameters to be entered.**

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PLC Operation Example

Pushbuttons (sensors), in this simple example, connected to PLC inputs, can be used to start and stop a motor connected to a PLC through a motor starter (actuator).

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Traditional Control versus Programmable Control

Figure 1.5: Comparison between the traditional and Programmable Control System [3]

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Solutions Communities

Solutions Communities are:

- Automotive
- Cement
- Chemical
- Food & Beverage
- Glass
- Machine Tools
- Marine
- MES
- Metals
- Mining
- Oil & Gas
- Pharmaceutical
- Production Machines
- Pulp & Paper
- Semiconductor

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Advantages of PLCs…

- The same (WLC) and even additional complicated tasks can be done with a PLC.
- Wiring to connect field devices and contacts of relays/contactors is made in the control program saved in the memory of PLC.
- Transforming the functions and rectifying errors are much easier to work out.
- It is more simple and easy to develop and modify a control program in a PLC than making a circuit by wiring then re-wiring it for modifications.
- Another significant advantage is smaller physical size as compared to hard-wire based solutions.

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…Advantages of PLCs

- **Speed of operation is quite fast so it is much more easy and fast to cater modifications.**
- **PLCs are incorporated with diagnostics and priority functions**
- **Diagnostics are accessible from a central location**
- **Applications can be instantaneously recognized and documented**
- **Applications can be reproduced faster and relatively lower cost than WLC based systems.**

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PLC Programming Packages

- A PLC program may contain at least one or more user written instructions which are used to accomplish a task. Developing a PLC program is equivalent to build a set of instructions to obtain desired sequence of operation.
- There are several programming packages available including:
1. Ladder logic 2. Statement list and 3. Function block diagrams [7].

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Industrial Field Buses

Some widely used Field bus standards are:

- CAN (The Controller Area Network)
- DeviceNet
- Foundation Field Bus
- ModBus
- Profibus (Profibus PA, Profibus DP)

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CAN (The Controller Area Network)…

Supporters	Automotive industry, Honeywell, Allen-Bradley, Late 1980s
Standard	ISO 11898 (High Speed), ISO 11519 (Low Speed)
Topology	Bus terminated on both sides.
Access Medium	twisted -pair cable.
Distance	40m @ 1 Mb/s (A); 400m @ 100kb/s (B); 1000m @ 25kb/s (B)
Repeaters	unspecified (useless)
Encoding	NRZ, bit stuffing
User bits in frame	64
Mastership	multi-master, 12-bit bisection, bit-wise arbitration
Mastership redundancy	none (use device redundancy)
Link layer control	connectionless (command/reply/acknowledgement)
Upper layers	no transport, no session, implicit presentation
Application Protocols	CAL, SDS, DeviceNet (profiles)
Chips	comes free with processor
	(Intel: 82527, 8xC196CA; Philips: 82C200, 8xC592; Motorola: 68HC05X4, 68HC705X32; Siemens: SAB-C167

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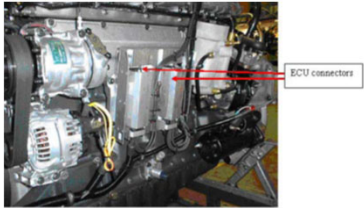
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…CAN (The Controller Area Network)

Figure 3.1: An ECU mounted directly on a diesel engine of a Scania truck. The arrows indicate the ECU connectors, which are interfaced to the CAN. (Courtesy of Scania)

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DeviceNet…

- **DeviceNet offers links between simple industrial field devices (such as sensors and actuators) and other higher end devices (such as programmable Logic controllers and computers)**
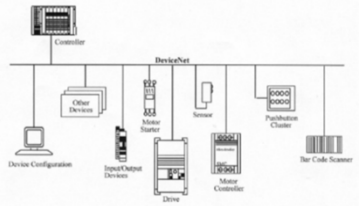

Figure 3.2: Typical connection link between different devices using DeviceNet

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…DeviceNet

- Originally formulated by Allen-Bradley
- DeviceNet is supervised by the Open DeviceNet Vendors Association (ODVA)
- Basic Bus topology.
- A twisted-pair bus for signal and another twisted-pair bus for power distribution, with signal and power carried in the same cable (protected cable).
- Live placement of devices without terminating power from the network.
- Optically isolated design so externally-powered devices can share bus cable with bus-powered devices.
- Data rates 125kbps (up to 500m), 250kbps (up to 250m), and 500kbps (up to 100m).
- Maximum drop length is 6 meters.
- Up to 64 node addresses on a single network.
- Prioritized, Peer-to-Peer communication based on the non-destructive bit-wise arranged format of CAN protocol.
- Manufacturer-Customer Model for transfer of data

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Foundation Field Bus…

- The Foundation Fieldbus criterion describes the method of adding more devices into the network adjust and configure them.
- Foundation Fieldbus is an industrial network particularly planned for distributed process control applications.

Figure 3.3: Structure of the Foundation Fieldbus
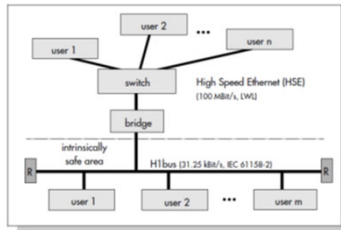
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… Foundation Field Bus

- Integrated safety to operate in hazardous environments
- Bus-powered field devices
- Topologies can be line or tree
- Capable of multi-master communication
- Predictable dynamic behavior
- Distributed data transfer (DDT)
- Standard block model for uniform device interfaces i.e. interoperability and interchangeability.
- Flexible options for extension based on device descriptions
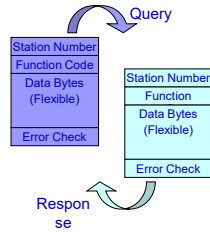
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ModBus…

- **MODBUS Protocol is a messaging arrangement developed by Modicon in 1979.**
- **It is used to set up master-slave/client-server communication between intelligent field devices.**
- **It is a by default standard which is purely open and the mainly used network protocol used for industrial manufacturing.**
- **MODBUS devices communicate using a master-slave method in which only master can initiate queries.**
- **Standard MODBUS networks utilize one of two types of transmission modes:**

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…ModBus

Query-Response Cycle

Query

| Station Number |
| Function Code |
| Data Bytes (Flexible) |
| Error Check |

| Station Number |
| Function |
| Data Bytes (Flexible) |
| Error Check |

Response

- **MODBUS includes communication of intelligent devices with sensors and instruments.**
- **It also offers monitoring of field devices using PCs and HMIs.**
- **MODBUS also served as an ideal protocol for RTU applications where wireless communication is required**

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Profibus Family…

PROFIBUS-DP (Distributed Processing)

Designed for communication between programmable logic controllers and decentralized I/O, basically under the control of a single master
Replaces parallel signal transmission with 24 V or 0 to 20 mA by " intelligent DIN rail"
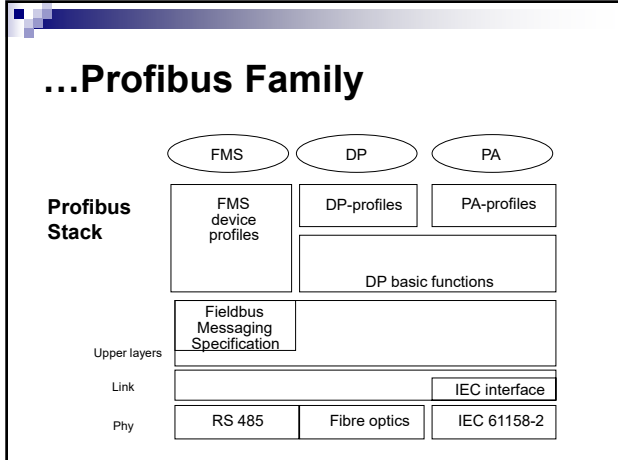
PROFIBUS-PA (Process Automation)

Permits data communication and power over the bus using 2-wire
Connects sensors and actors on one common bus line even in intrinsically-safe areas (chemical industry)
Physical Layer according to international standard IEC 61158-2.

PROFIBUS-FMS (Field Messaging Specification)

General-purpose for peer-to-peer communication at the cell level.
Can be used for extensive and complex communication tasks.
Academic approach (layer 7 services based on MMS, ISO 9506).
Disappearing

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…Profibus Family

	FMS	DP	PA
Profibus Stack	FMS device profiles	DP-profiles	PA-profiles
		DP basic functions	
Upper layers	Fieldbus Messaging Specification		
Link			IEC interface
Phy	RS 485	Fibre optics	IEC 61158-2

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ProfiNet…

- **PROFINET is the open Industrial Ethernet standard**
- **This standard is specified in IEC 61158 [18] and IEC 61784 [19] compatible with Ethernet (IEEE802.3)**
- **It allows existing fieldbus systems such as PROFIBUS PA, PROFIBUS DP, AS-Interface, INTERBUS, and DeviceNet to be included without modifying existing field devices.**
- **This characteristic insures that the investments of plant operators, machine and plant manufacturers, and device manufacturers are all protected.**

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…ProfiNet

The PROFINET model is based on a modular concept which permits the user to select the required functionality.

- **PROFINET CBA** is appropriate for component based machine-to-machine communication using TCP/IP and also for real time communication in modular plant manufacturing.

- **PROFINET I/O** illustrates an I/O data view on distributed I/O. PROFINET I/O features Real Time (RT) communication and Isochronous Time real-time (IRT) communication with the distributed Input/Output.

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Integration of ProfiNet with Profibus

- PROFINET specifies a model to integrate existing PROFIBUS with other fieldbus systems for instance INTERBUS and DeviceNet.

Figure 4.3 Fieldbus systems can be easily integrated in PROFINET

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Advantages of ProfiNet

- Bring plant online faster
- Easily integrate machines
- Real-time production management
- Remote access
- Accurate motion control
- Faster troubleshooting
- Predictive maintenance
- Wireless connectivity
- Connect legacy buses
- Provision of plant safety
- Reduction in energy consumption

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SCADA

- SCADA is a short form for Supervisory Control and Data Acquisition.
- SCADA systems are utilized to monitor and control a plant or equipment in industries
- Major application areas include energy, oil and gas refining, telecommunications, water and waste control, and transportation.
- These systems include the transfer of data between a SCADA Master Terminal Unit (MTU) and a number of Remote Terminal Units (RTUs) and/or Programmable Logic Controllers (PLCs), and the MTU to the operator workstation.

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Components of SCADA…

SCADA systems consist of:

- One or more field data interface devices which are usually termed as RTUs, or PLCs
- A communications system (means of telemetry) utilized to transmit data between field data interface devices and control units and the computers in the MTU of SCADA.
- A central host computer server or collection of servers, sometimes called a SCADA Center, master station, or Master Terminal Unit (MTU)
- A collection of standard and/or custom software, sometimes called Human Machine Interface (HMI) software
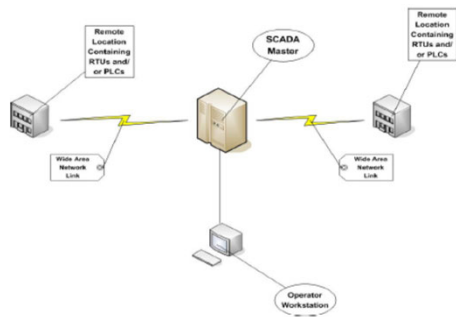
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…Components of SCADA

Figure 5.1 Typical SCADA System

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SCADA Architectures

- SCADA systems have evolved in parallel with the development and sophisticated intelligence of modern computing technology.
- Three Generations of SCADA include:
1. **First Generation – Monolithic**
2. **Second Generation – Distributed**
3. **Third Generation – Networked**

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SCADA Applications…

Public or Private Infrastructure:

- Water treatment and distribution
- Waste water collection and treatment
- Electrical power transmission and distribution
- Oil and gas pipeline monitoring and control

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…SCADA Applications

Industrial Processes (continuous, batch, or repetitive):

- Remote monitoring and control of oil and gas production, pumping, and storage at refineries from both offshore platforms and onshore wells
- Electrical power distribution from nuclear, gas-fired, coal, or renewable resources
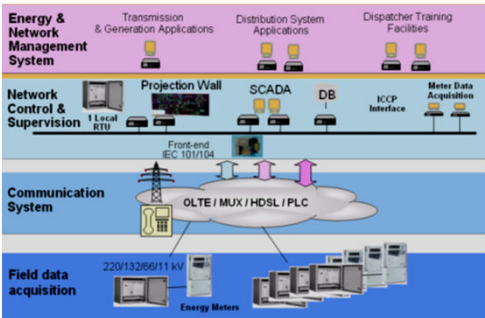
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SCADA Examples…

Figure 5.7 Energy and Network Management System using SCADA [28]
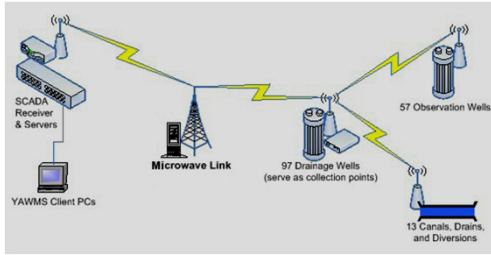
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SCADA Examples…

Figure 5.8 Water Management system using SCADA
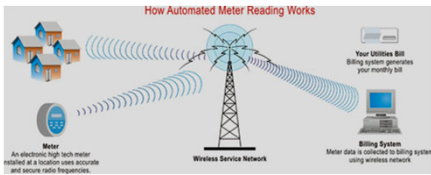
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…SCADA Examples

Figure 5.9 Automated Meter Reading using SCADA (Source: CIMCON Software)

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Conclusion

- **A synopsis of PLC, Industrial Field Buses and SCADA is presented.**

- **The presentation delivered practical aspects of current trend in automation technology.**

- **Optimization in the field of automation can be achieved by careful system design.**

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Discussion Session

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Thank You

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