25th Anniversary 周年紀念 EMSTF 機電工程營運基金

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Basic Theory of CCMS & SCADA System

Organized by	Mr. YEUNG Hon Fai, EnI/TS1/S
Presented by	Mr. LAW Piu Keung, Felix, AEnI/TS1/ES6
	Mr. TONG Chun Man, AEnI/ST1/2/2
Venue	Lecture Theatre, Room 7103A,
	7/F., EMSD Headquarters, 3 Kai Shing Street, Kowloon.
Date	8th November, 2021

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Agenda

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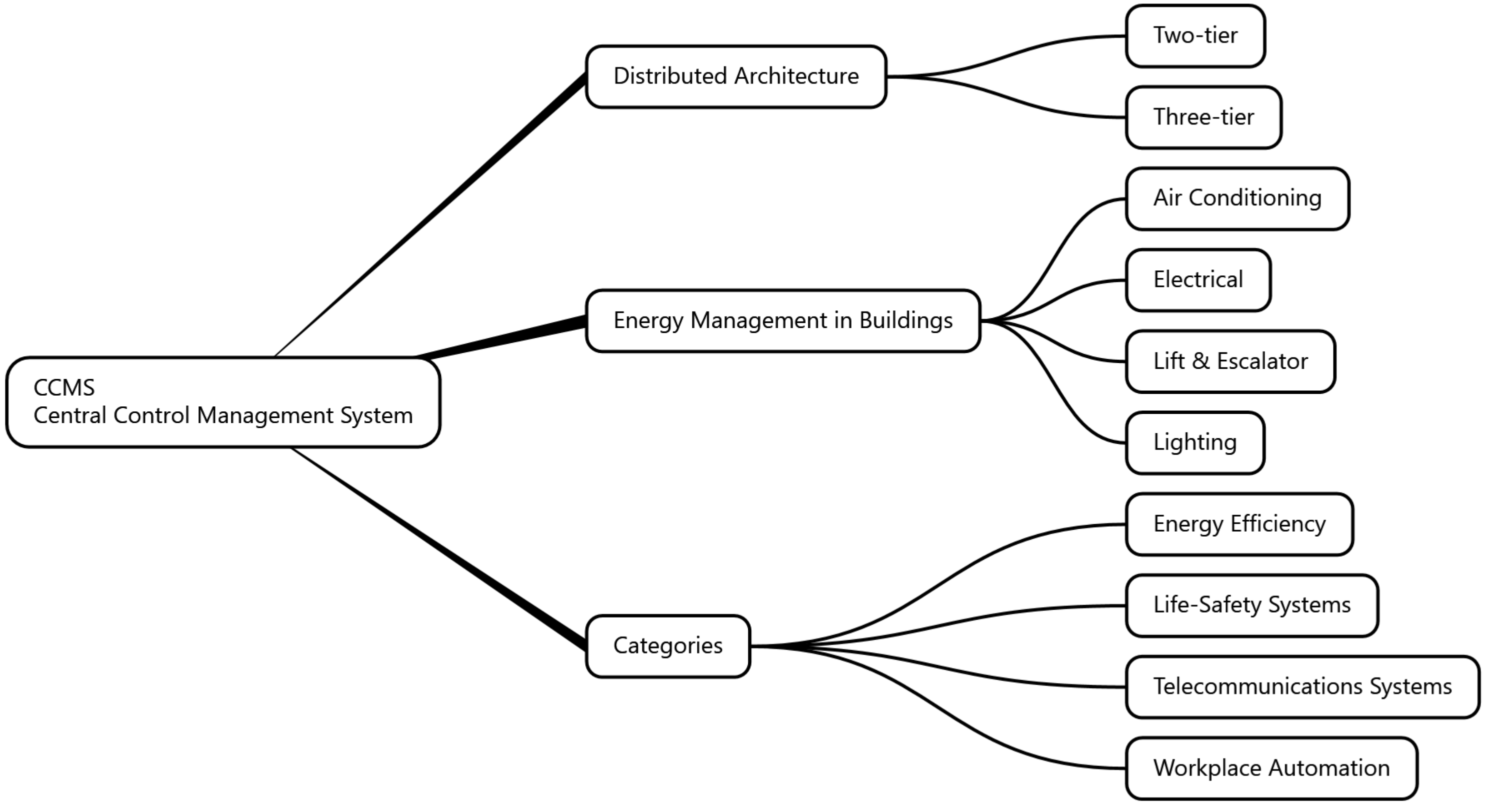
1. Basic Theory of CCMS

Central **C**ontrol and **M**onitoring **S**ystem



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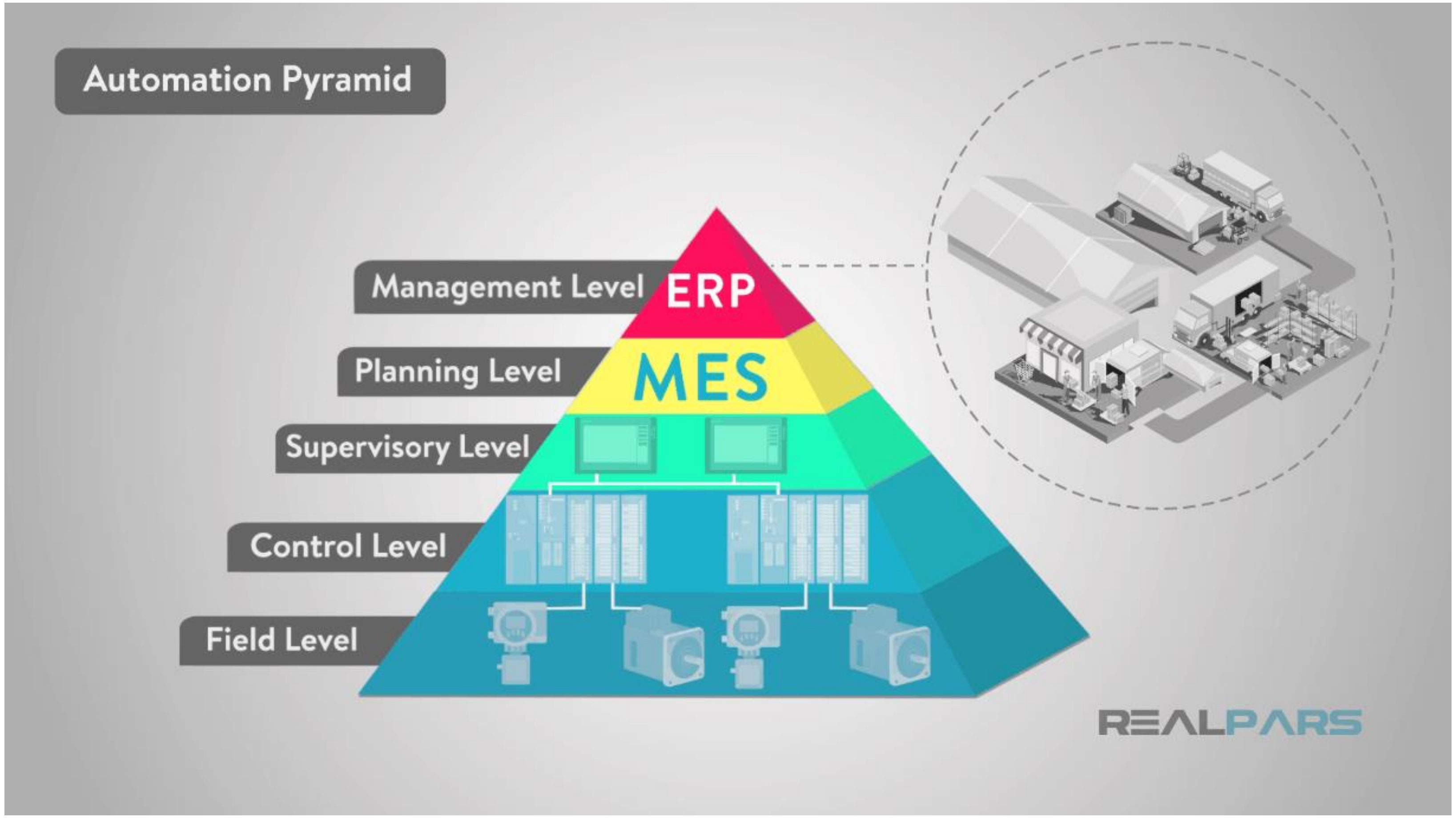
2. CCMS vs SCADA System

2. CCMS vs SCADA System Automation Pyramid



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2. CCMS vs SCADA System
b. What is CCMS in EMSD?

Central **C**ontrol and **M**onitoring **S**ystem

- Applications and functions
- Real time display
- Alarm status
- Management information, maintenance, fault attendance logging
- Simple and economic integration of CCMS
- Remote programming of DDC controller

2. CCMS vs SCADA System
b. What is CCMS in EMSD?

Features

- Open protocol and interoperability
- Web-based interface
- System integration
- Energy management strategies
- Inter-action between systems

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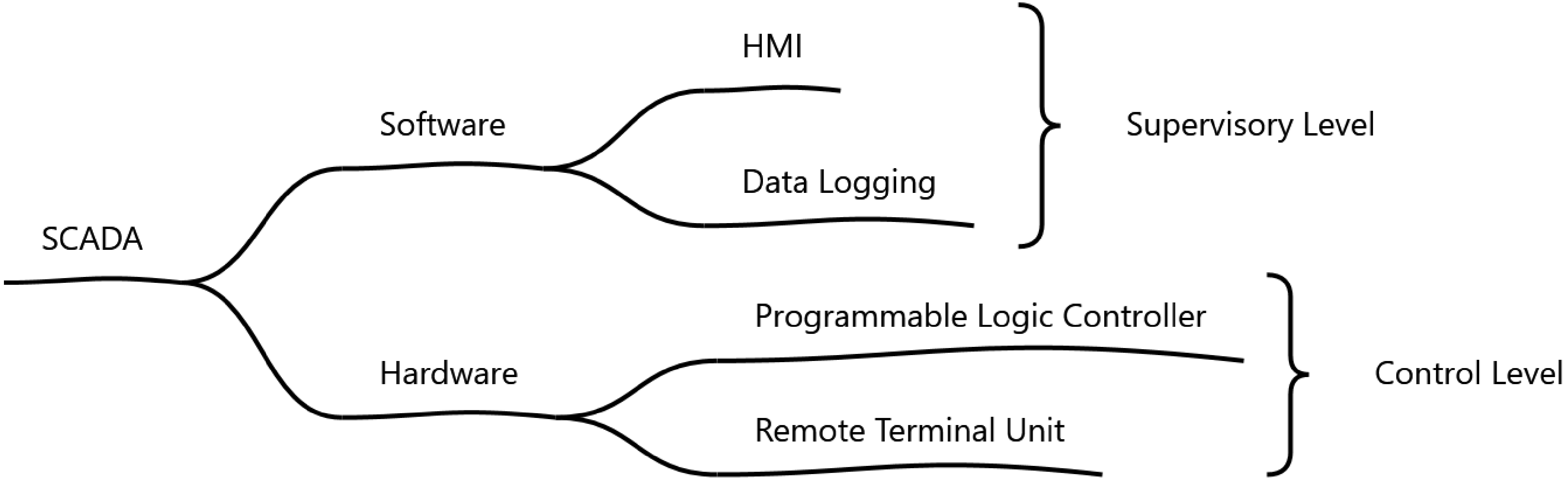
2. CCMS vs SCADA System
c. What is SCADA?

Supervisor **C**ontrol **A**nd **D**ata **A**cquisition



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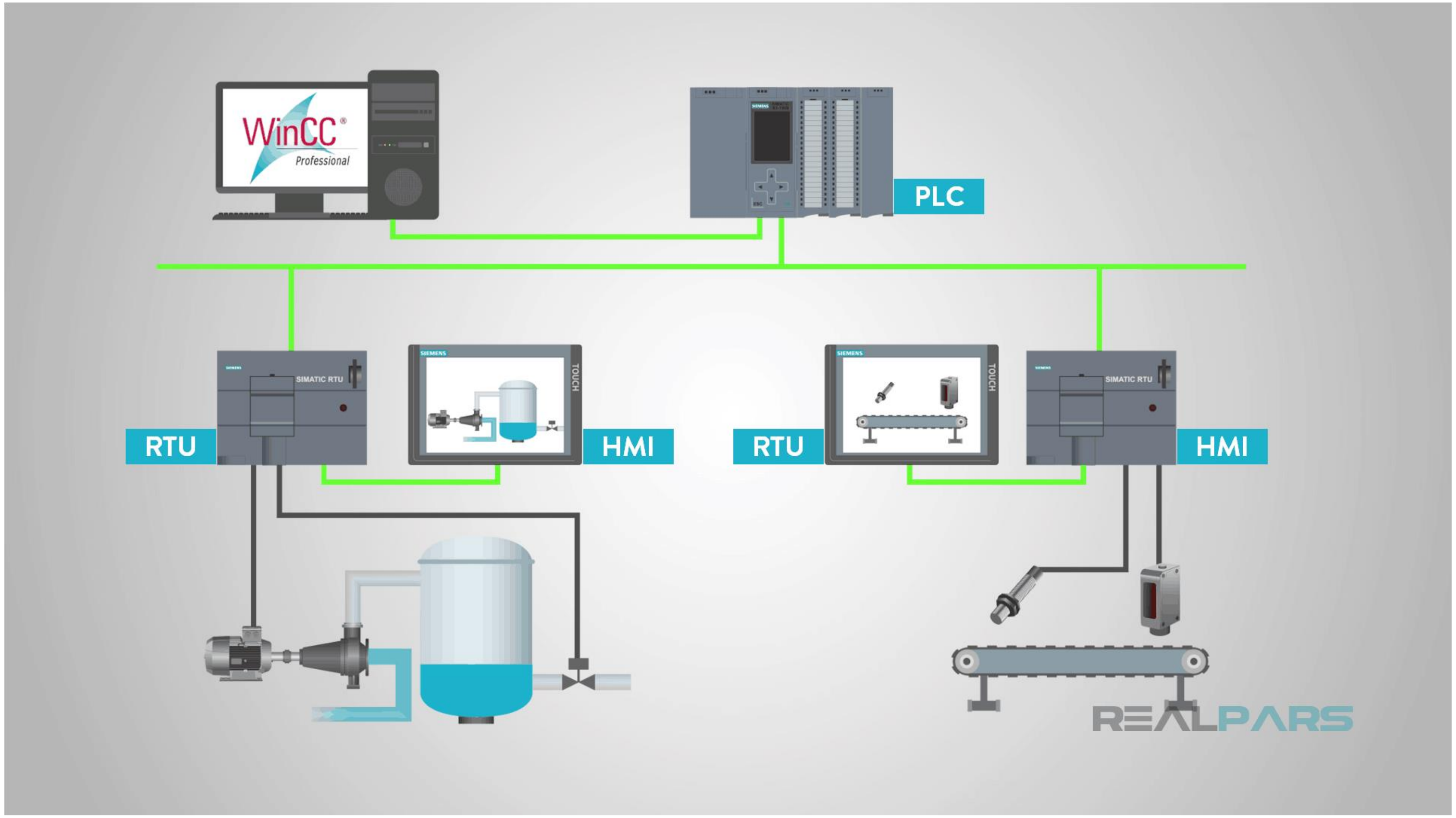

https://realpars.com/wp-content/uploads/2019/06/SCADA-System-Components.png

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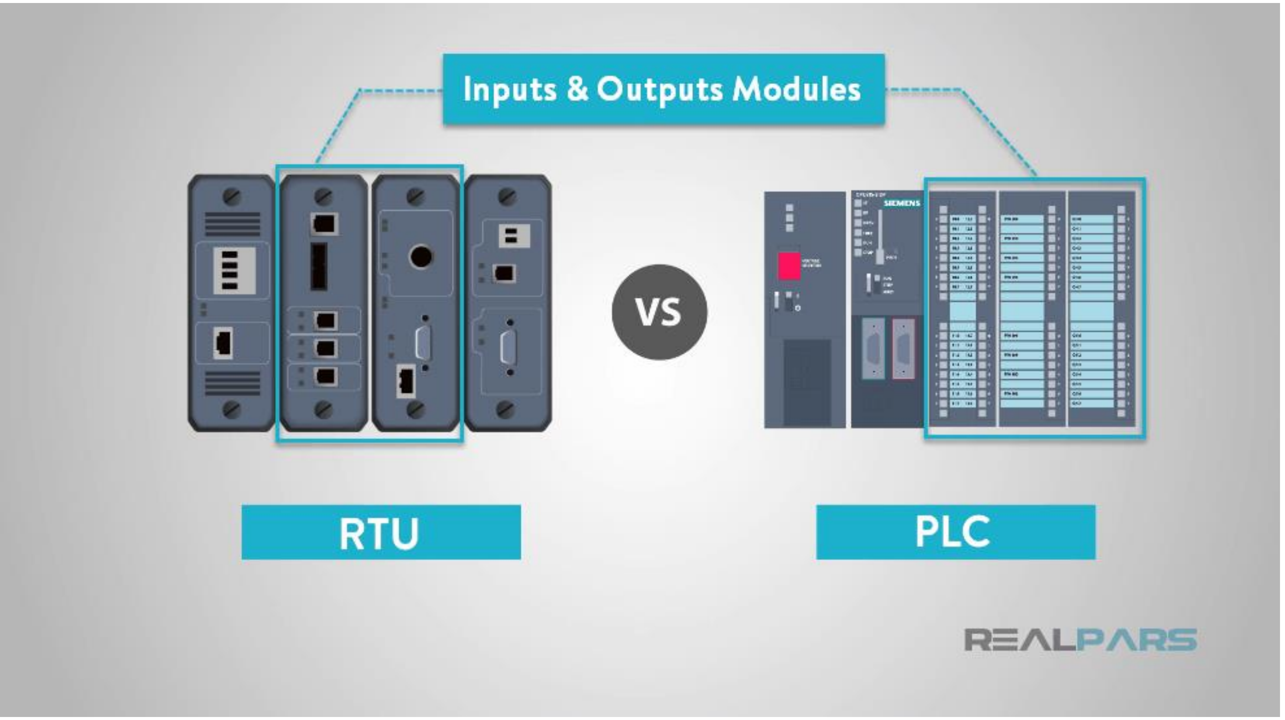
2. CCMS vs SCADA System
What is RTU?

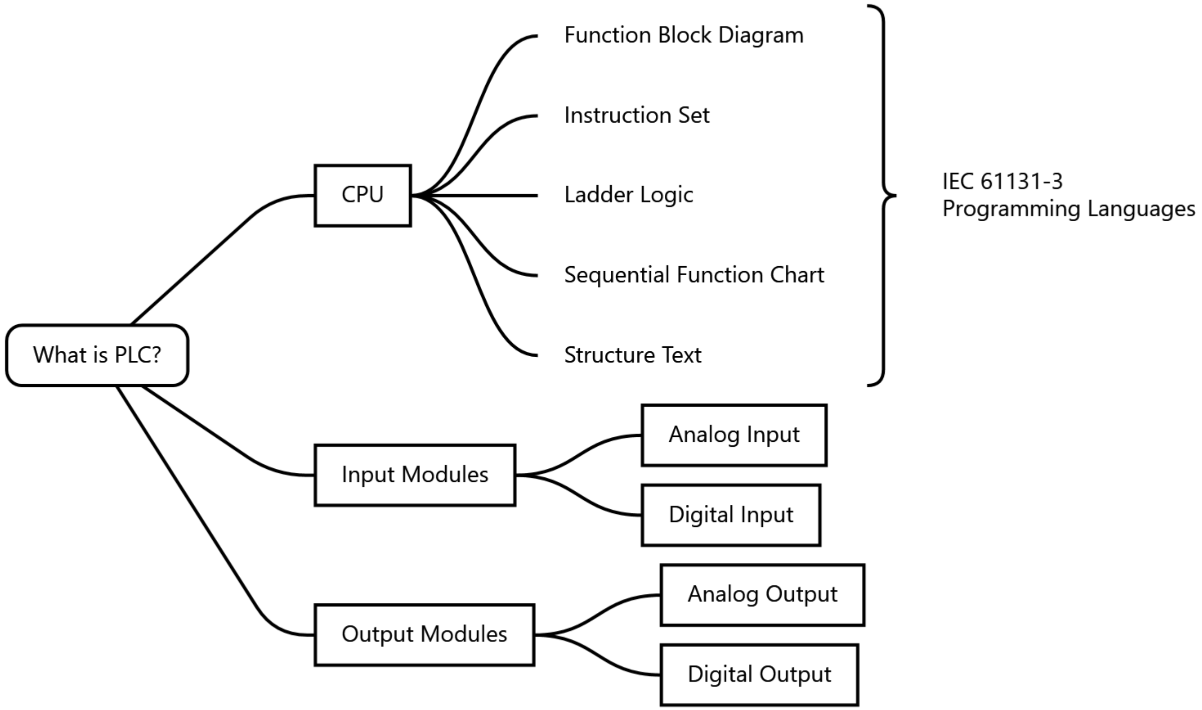


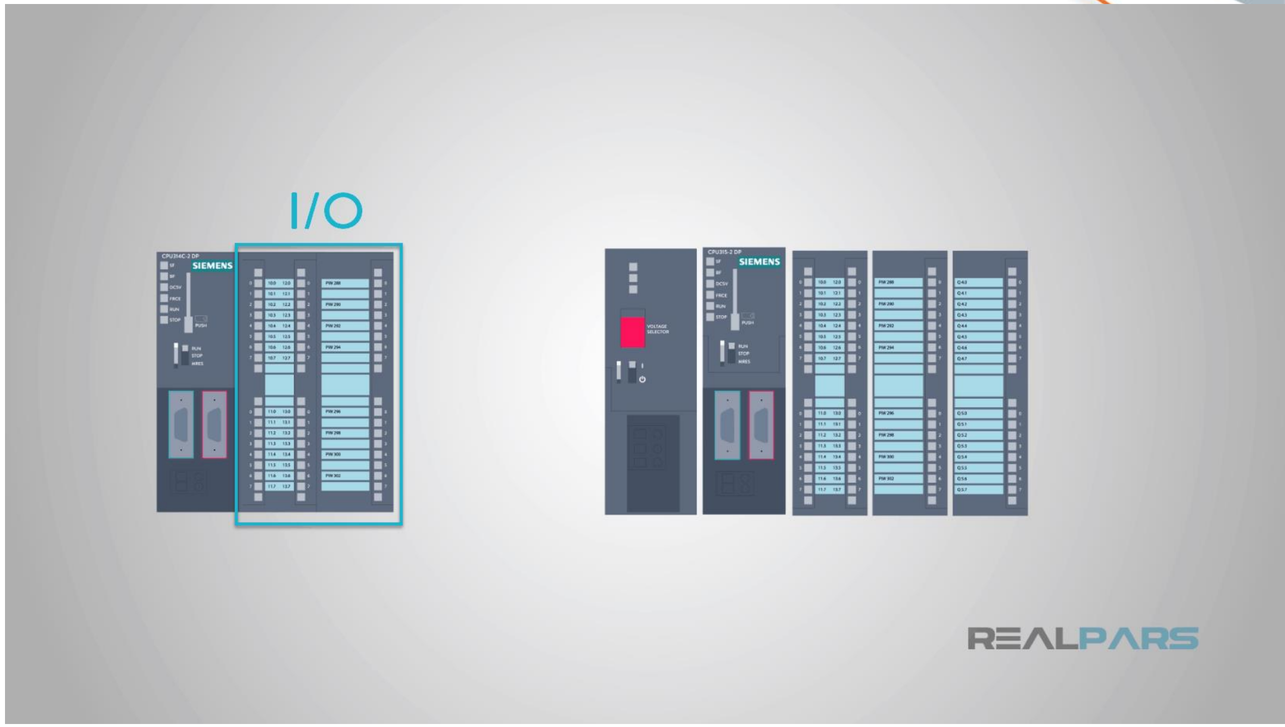
https://realpars.com/wp-content/uploads/2018/09/RTU-vs-PLC.png

Remote **T**erminal **U**nit

- Microprocessor based device
- Control level
- Web interface / setup software
  - Configuration for inputs, outputs and communication
- Basic, Visual Basic, C#, Ladder or Structure Test, etc.
- Environmental tolerances

2. CCMS vs SCADA System
What is PLC?





https://realpars.com/wp-content/uploads/2018/08/PLC-Basics-Part-of-the-CPU.png

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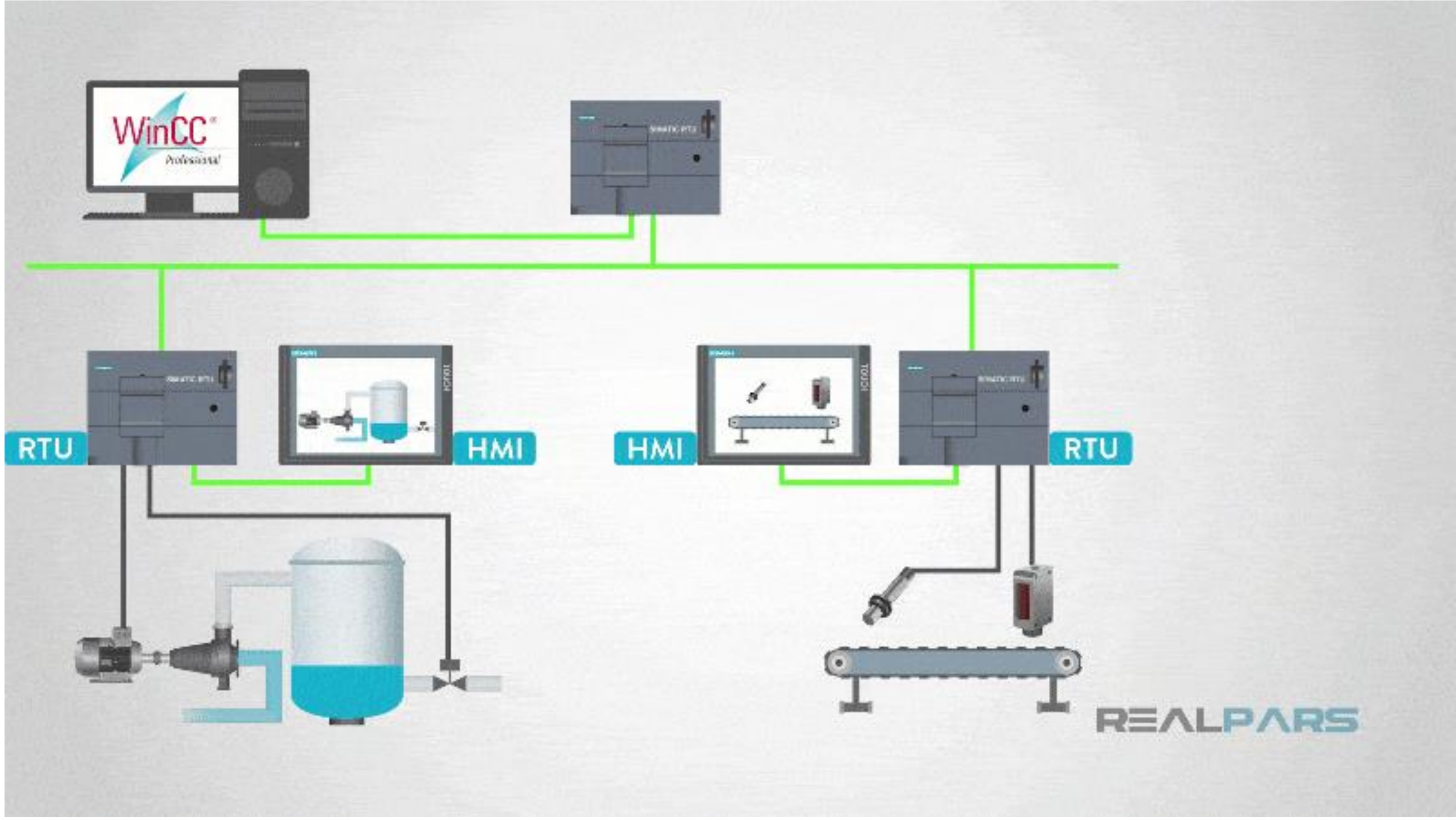
c. What is SCADA?



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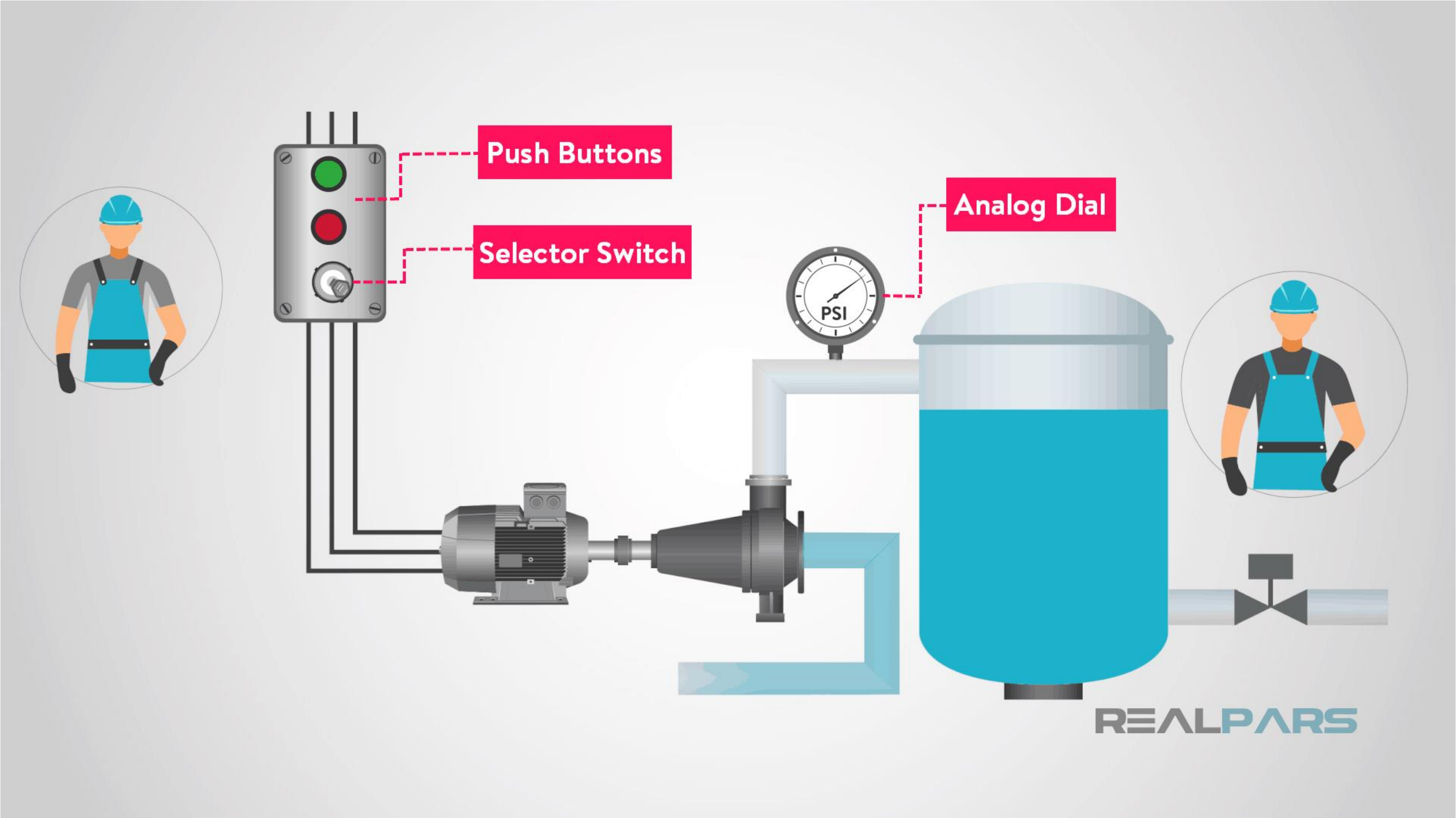
2. CCMS vs SCADA System
c. What is SCADA?



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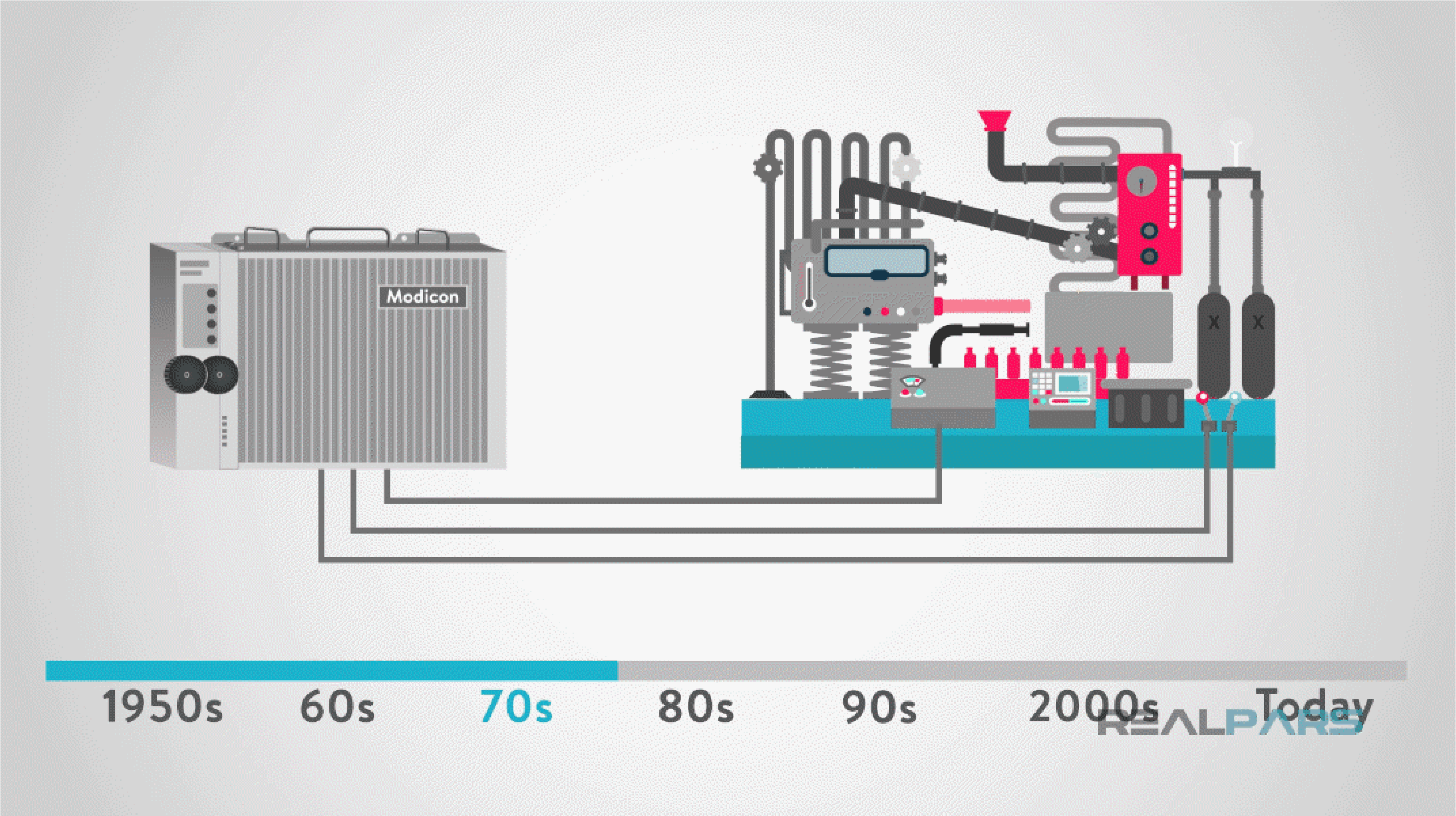
2. CCMS vs SCADA System
c. What is SCADA?



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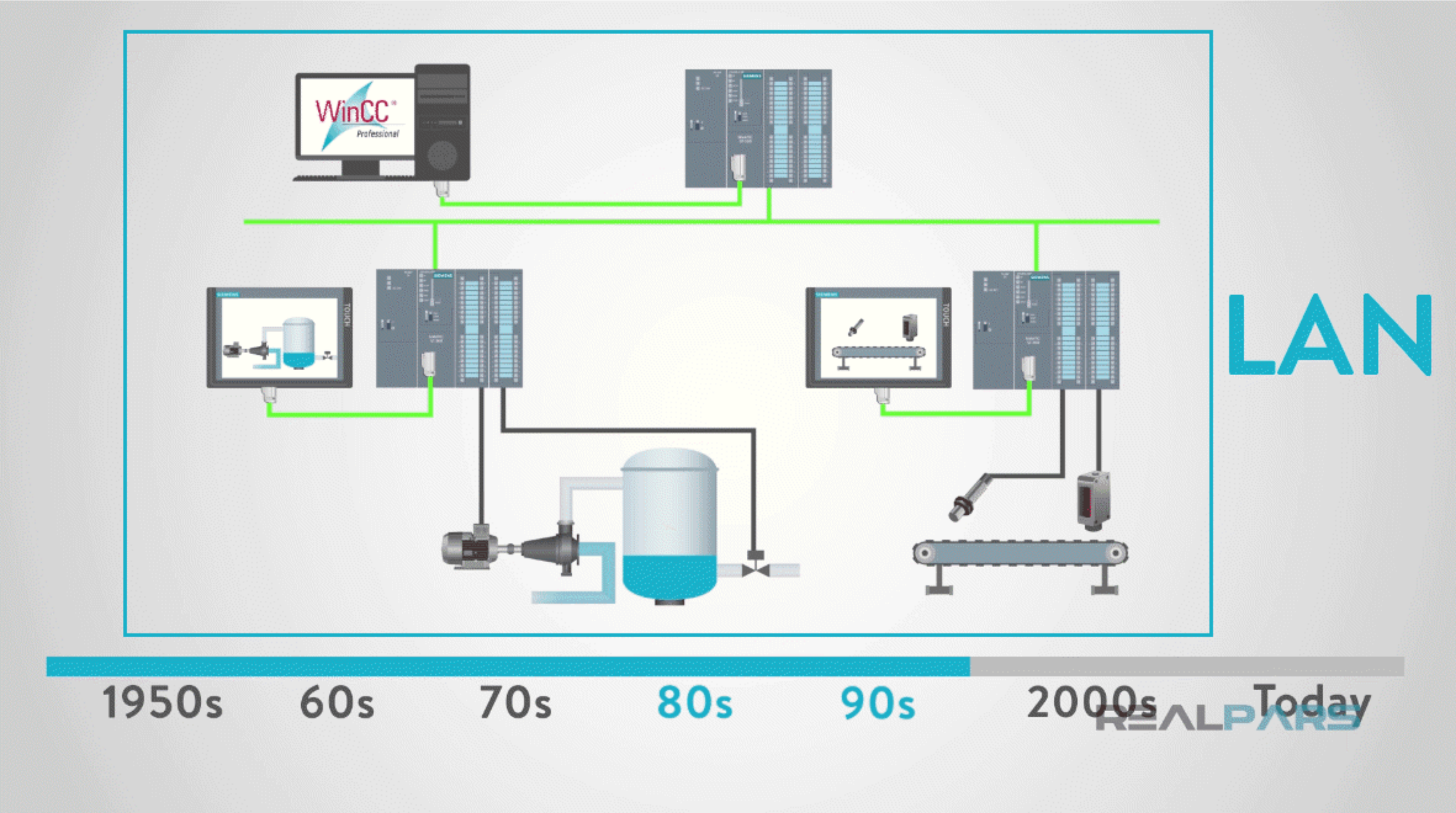

https://realpars.com/wp-content/uploads/2019/06/Local-Area-Network-in-SCADA-Systems.png

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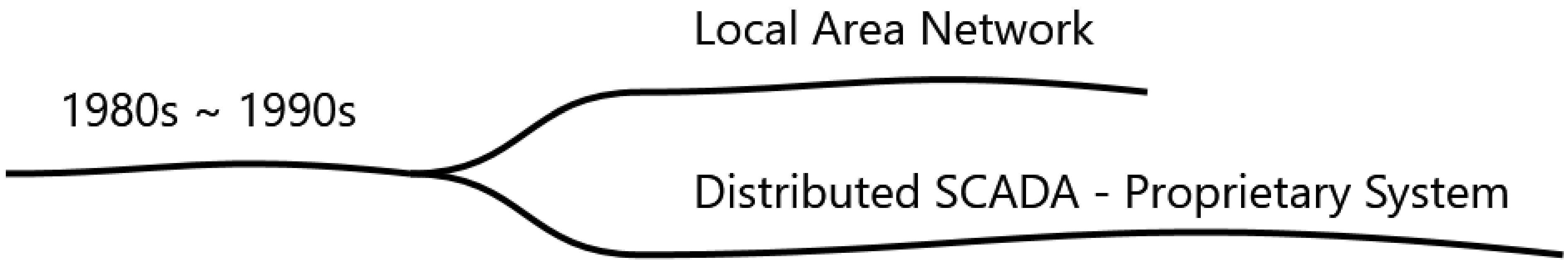

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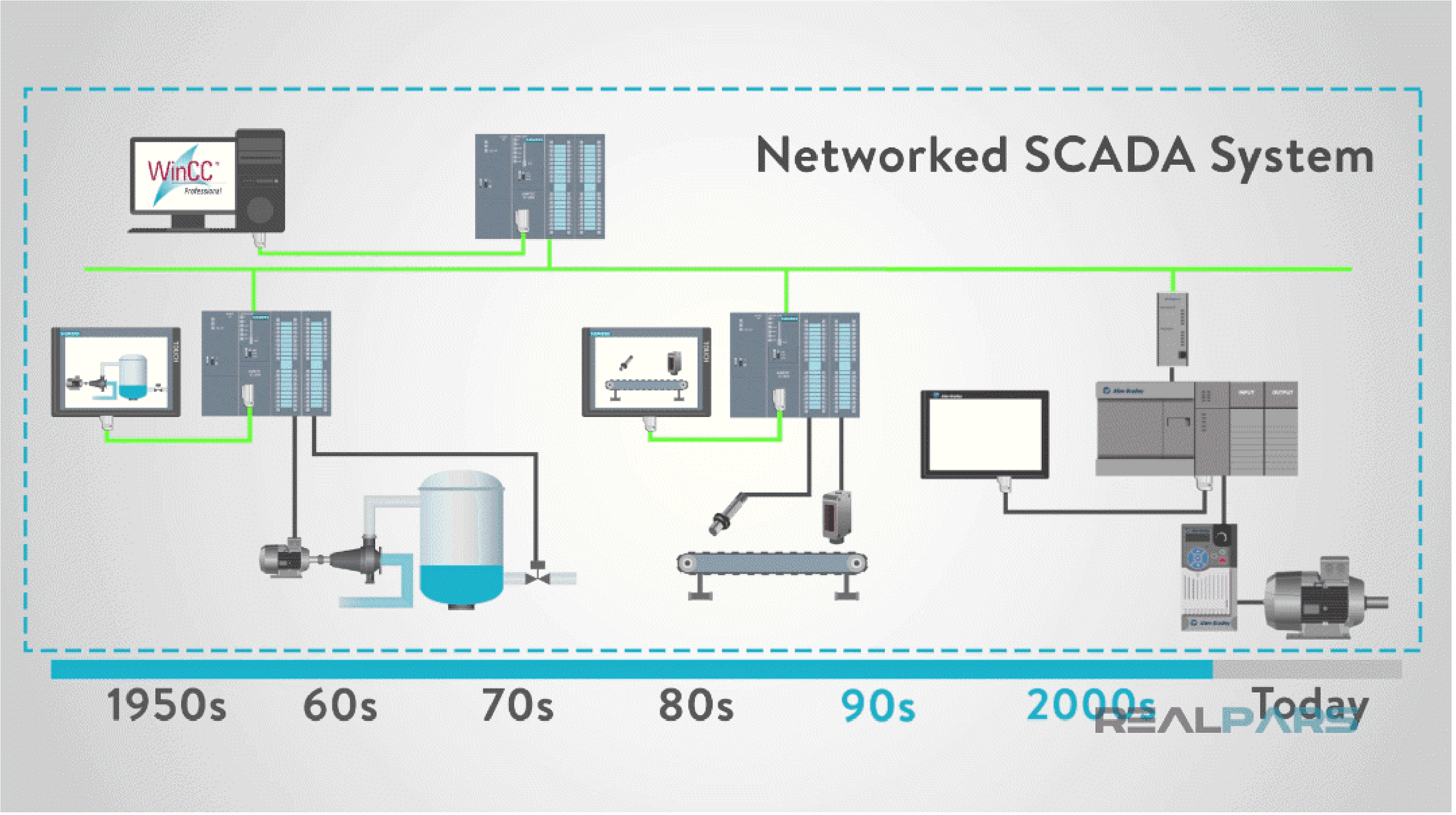

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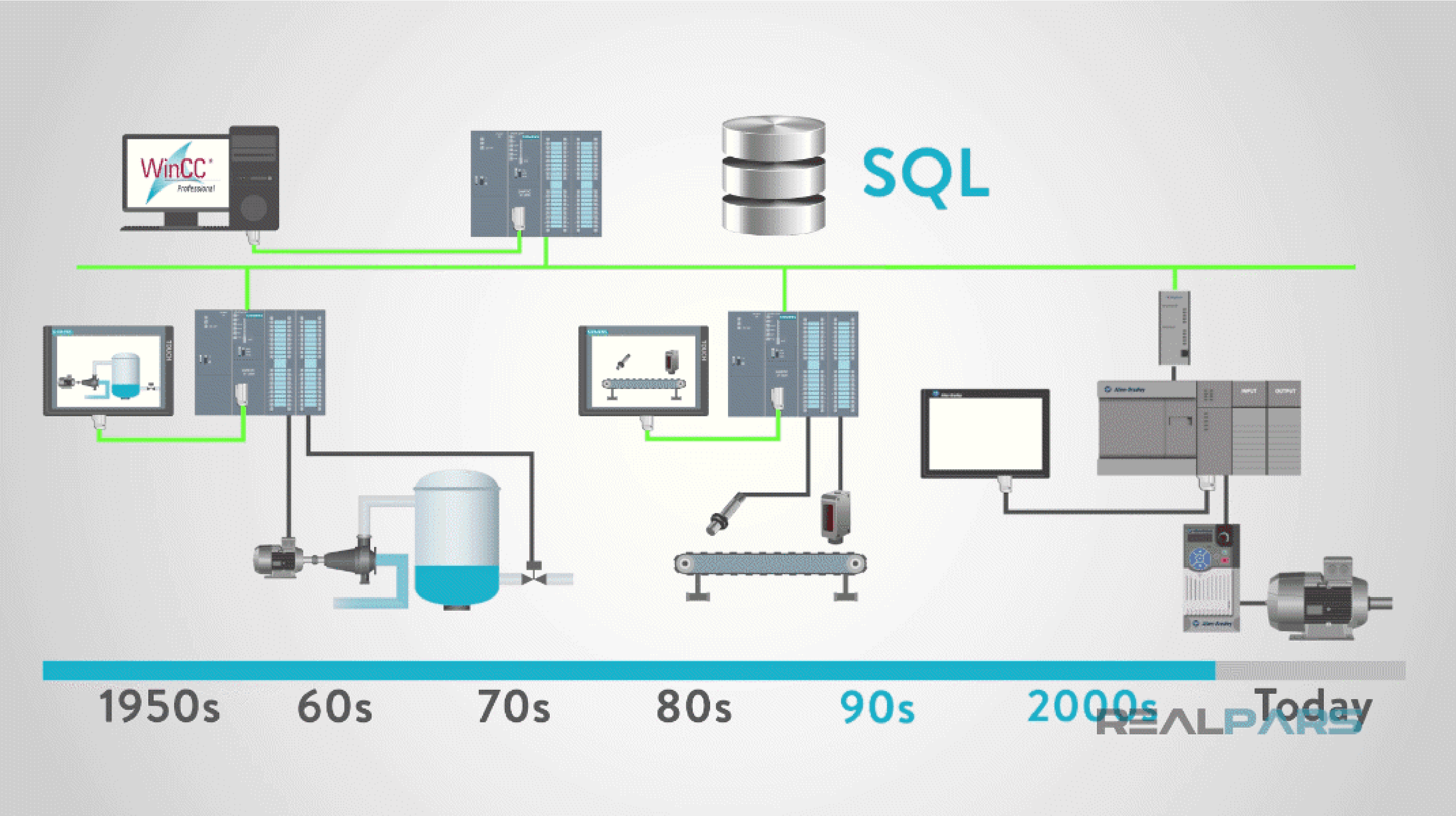
2. CCMS vs SCADA System
c. What is SCADA?



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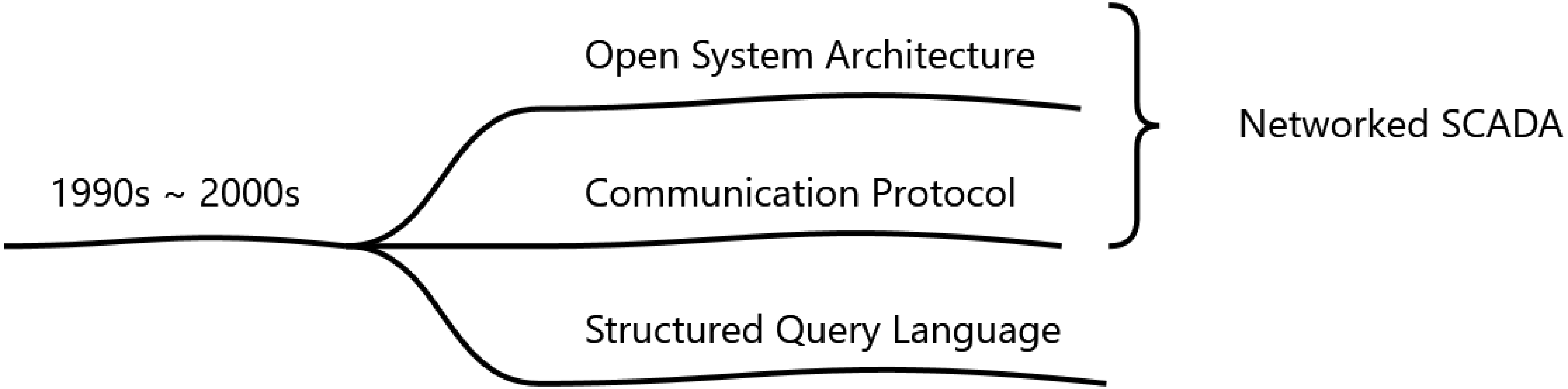
2. CCMS vs SCADA System
c. What is SCADA?



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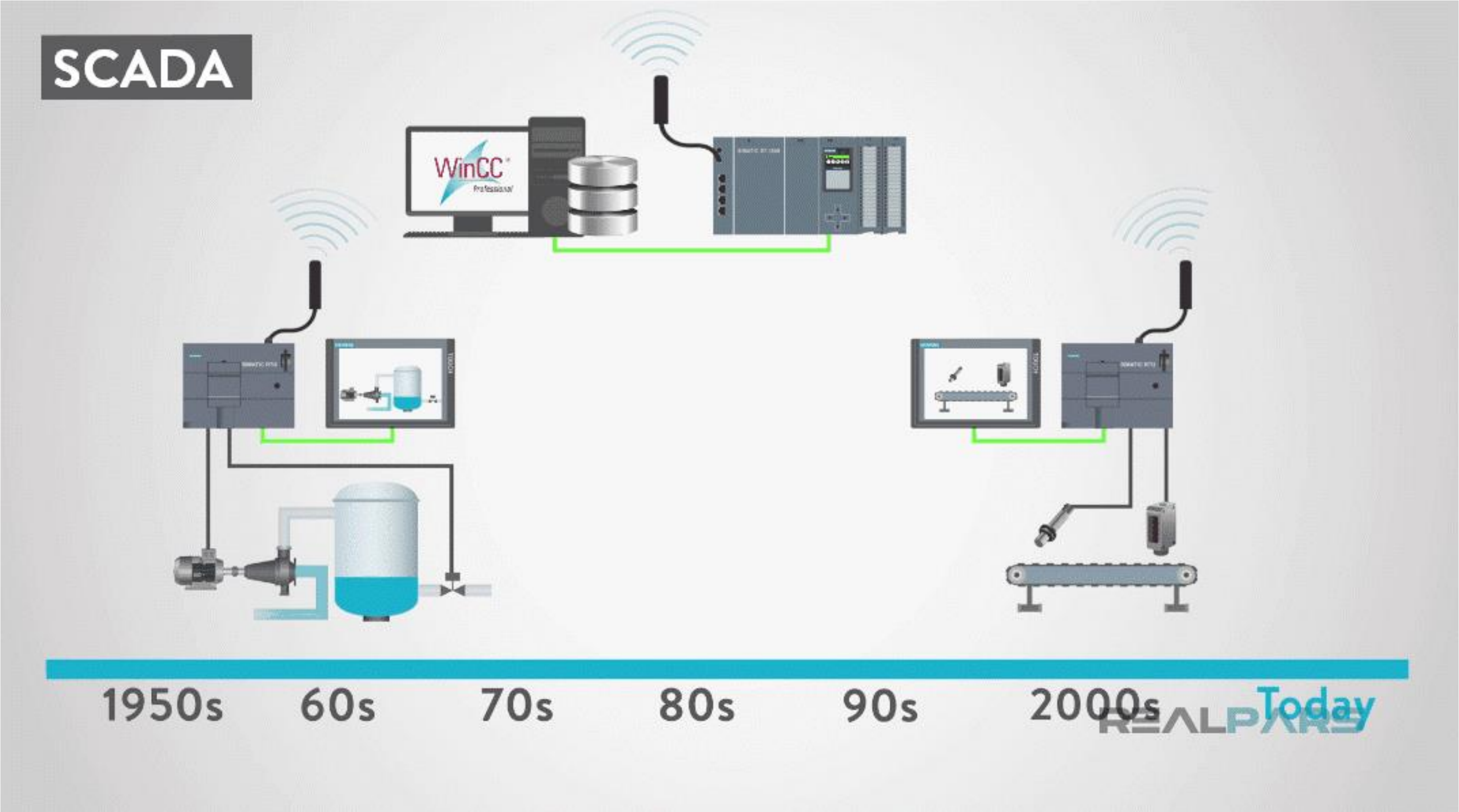

https://realpars.com/wp-content/uploads/2019/06/Today-SCADA-Technologies.png

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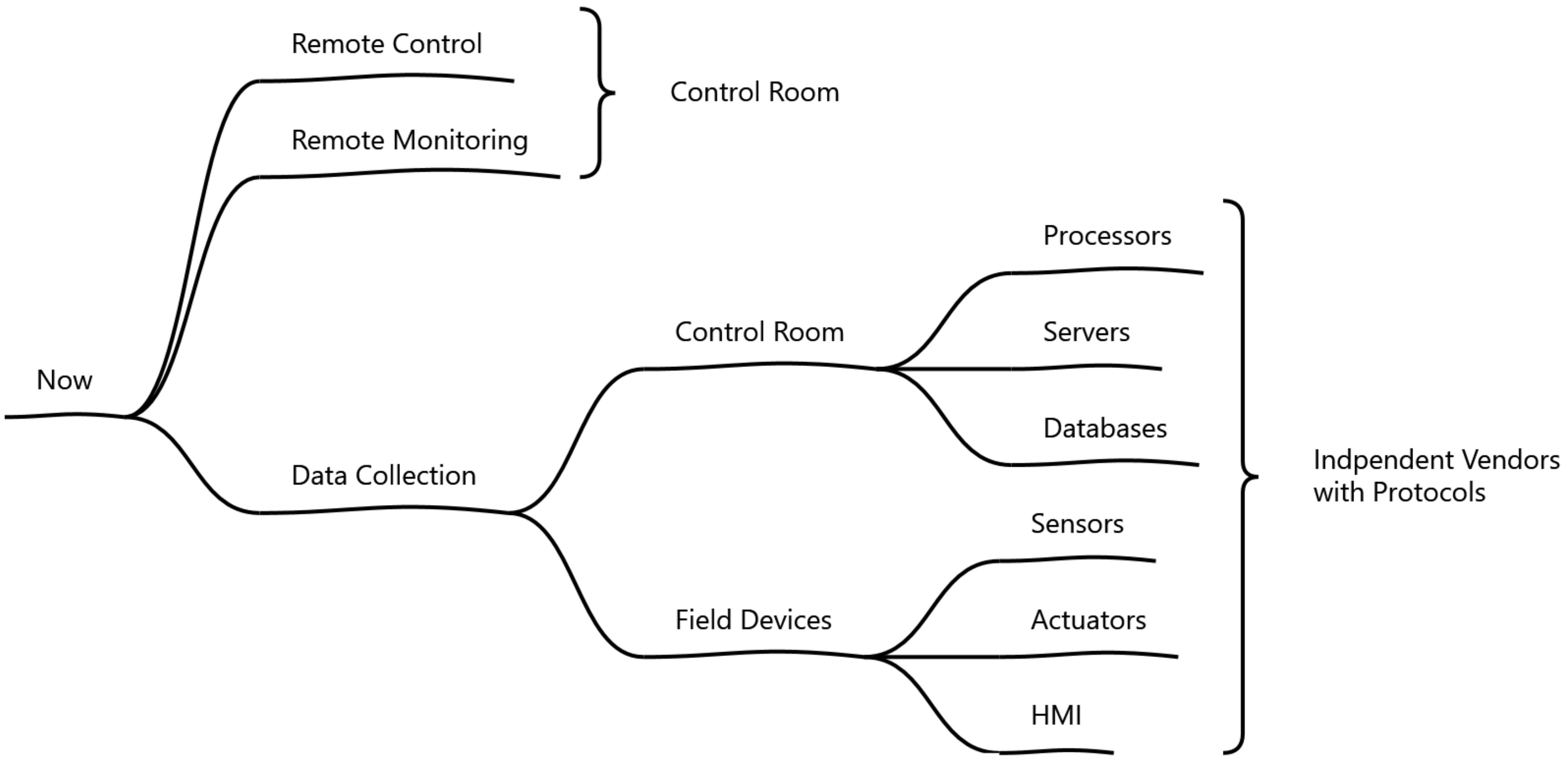
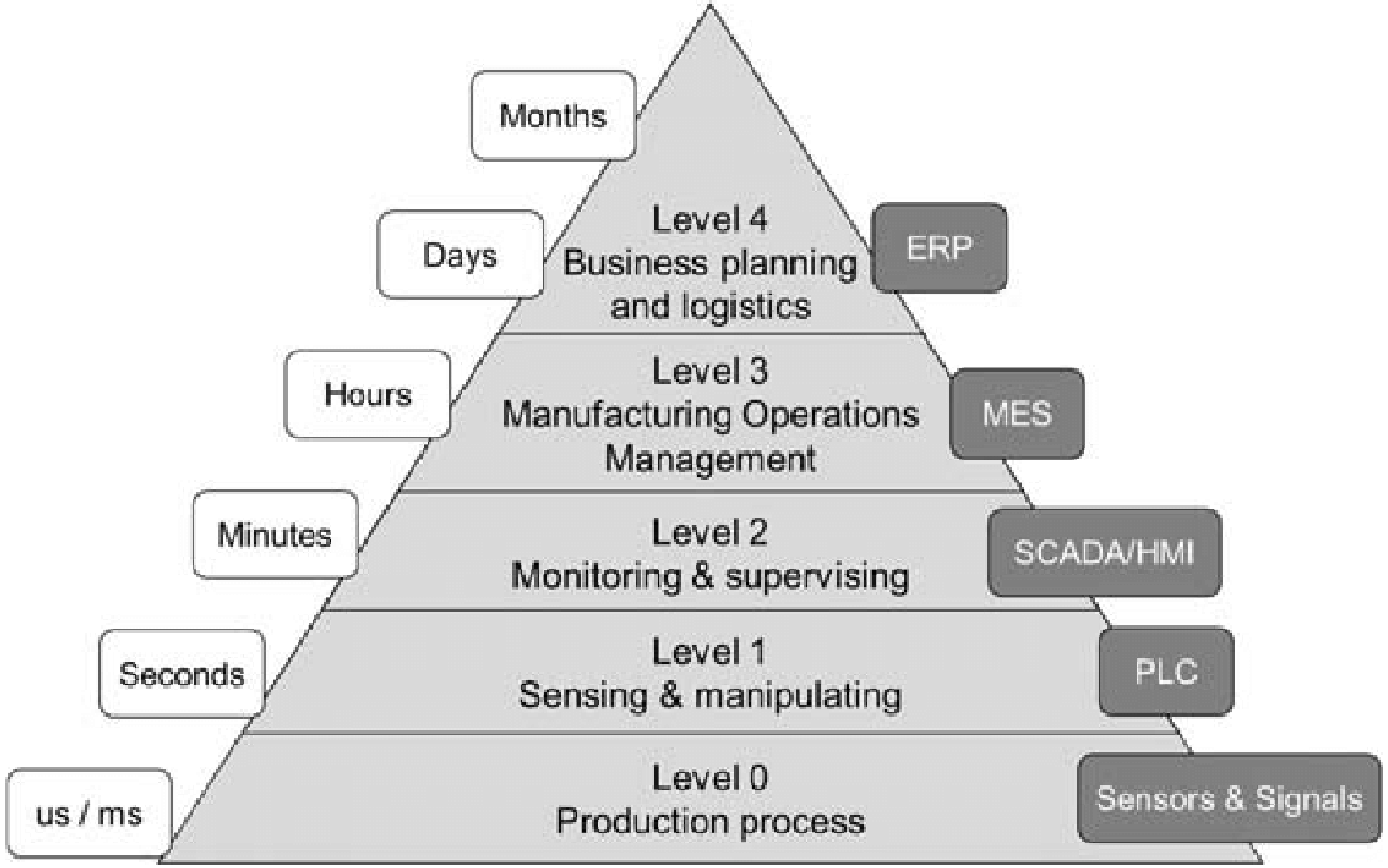


2. CCMS vs SCADA System
Automation Pyramid



https://www.researchgate.net/profile/Magnus-Akerman/publication/326224890/figure/fig2/AS:645309810094091@1530865256320/The-automation-pyramid-according-to-the-ISA-95-model-The-five-levels-0-5-are-defined.png

3. Process Measurement Devices

3. Process Measurement Devices
a. Definitions

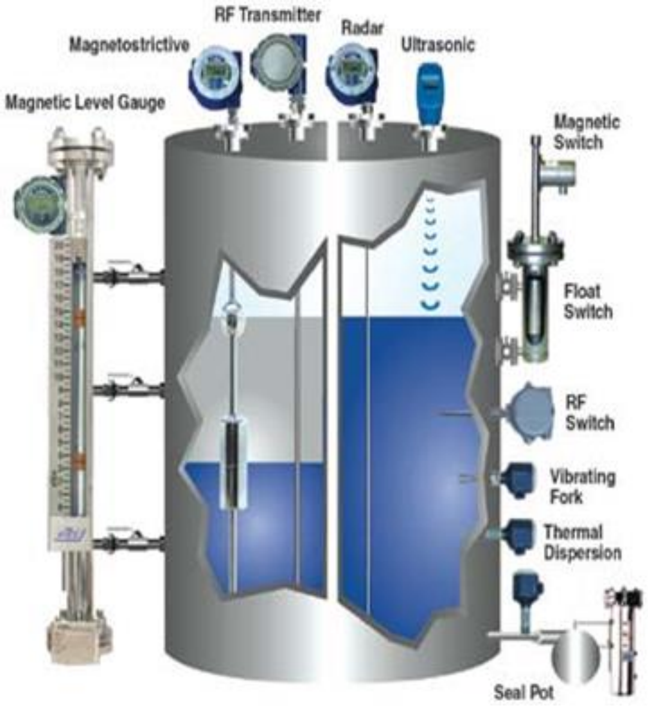
Terms	Description
Measurement	Assignment to an object which can be compared
Instrument	A device for measuring physical quantity
Sensor	A device for detecting events or environment
Transducer	A device for converting energy from one form to another
Transmitter	A device for sending out information
Range	The extent of measurement
Span	The absolute value of the range
Scale	Categorize and quantify variables, units, magnitude, intervals, and zero point
Accuracy	Trueness of measurement or observational error

3. Process Measurement Devices
b. Sensors

- A sensitive element and conversion element
- Sense the measured variables
- Convert the sensed variables into non-standard electrical signals or other forms of output signals
- Output signal of a sensor is non-standard

3. Process Measurement Devices
c. Different Types of Measurement Devices

- Flow
- Level
- Pressure
- Temperature
- Displacement
- Vibration
- Speed
- Chemicals



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3. Process Measurement Devices
c. Different Types of Measurement Devices
Flow

Type	Industrial Application
Positive Displacement	
Inferential	• Fuel oil flow, town water flow
Variable Area	• Chemical sampling system
Electromagnetic	• Chemical & waste water flow
Ultrasonic	• Gas flow in air duct
Coriolis Mass	• Natural gas flow
Differential Pressure	• Generic air, water and steam flow
Thermal Mass Flow	• Gas flow in air duct
Open Channel Flow	• Waster water flow

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3. Process Measurement Devices
c. Different Types of Measurement Devices
Level

Type	Industrial Application
Slight Glass Gauge	• Local level indication in open tanks
Float	• Local indication for large tanks • Fixed installation of level switches
Displacer	• Pneumatic level controller
Hydrostatic Pressure / Weight	• Generic type of level transducer for liquid / particles
Vibration Damping	• For ash (particles) level switch
Rotation Suppression	• For ash (particles) or liquid level switch
Conductive / Capacitive	• Convert level to electrical in transducers • For chemical liquid only
Ultrasonic	• Modern tank level transducer for liquid / particles

3. Process Measurement Devices
c. Different Types of Measurement Devices
Pressure

Type	Industrial Application
Manometer	• Slightly pressure • usually used in laboratory or workshop
Bourdon Tube	• Generic sensor for pressure gauges and transmitters • Medium and high pressure ranges
Diaphragm	• Low pressure gauges and transmitters, differential pressure • Good for corrosive fluid applications
Bellow	• Low pressure transmitter and controllers
Strain Gauge	• Convert pressure to electrical signal in transducers • Medium and high pressure ranges
Capacitive / Conductive	• Convert pressure to electrical signals in transducers • Low and differential pressure gauges
Piezoelectric	• Convert pressure to electrical signal in transducers • Portable equipment

3. Process Measurement Devices
c. Different Types of Measurement Devices
Temperature

Type	Industrial Application
Thermocouple	• General plant application
Resistance Temperature Detector	• Used in reducing atmosphere and corrosive fluid
Thermistor	• Within electronics
Bimetallic Strip	• Temperature Switch
Glass Bulb Thermometer	• Laboratory and workshop as standard
Bourdon Tube Thermometer	• Local temperature indicator
Temperature Sensitive Label	• For maintenance purpose, usually used in motor temperature recording
Infra-red Thermometer	• Portable to measure plant objects

3. Process Measurement Devices
c. Different Types of Measurement Devices
Displacement

Type	Industrial Application
Ultrasonic Displacement	• Transmitter sends ultrasonic waves towards an object • Determines the distance by calculating the relationship between the time required for the wave to be sent and received.
Linear Variable Differential Transformer	• Moving core moves away from the center of coil creating a gap • Impedance of both coils excited depends on the gap • Displacement is output linearly as differential voltage of the coils

3. Process Measurement Devices
c. Different Types of Measurement Devices
Vibration

Type	Industrial Application
Proximity Probe	• For displacement measurement
Velocity Sensor	• To be mounted at casing
Accelerometers	• To be mounted at casing

3. Process Measurement Devices
c. Different Types of Measurement Devices
Speed

Type	Industrial Application
Hall Effect	• Uses notches or shutter blades on rotating disc disrupt a magnetic field in the Hall Effect Sensor Window • Switch on and off, producing a digital signal
Optical Sensor	• Generates pulses at a frequency corresponding to the rotor rotation • Optical sensor measures either reflected light or light allowed to pass through slits. • Rotor either has light or dark marks for the optical sensors, or • A series of slits that allows light from an infrared source to pass through and be detected by a phototransistor on the other side.

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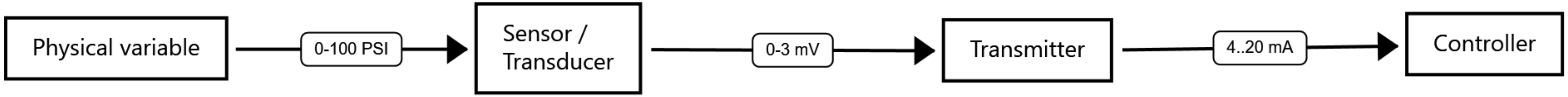
3. Process Measurement Devices
c. Different Types of Measurement Devices
Chemical

Type	Industrial Application
Ion Selective Electrode	• Some kind of barrier between two solutions • Difference in concentration of ion across the two sides of the barrier, potential difference is up. • Electrode can be designed to react to particular ion only
Colorimetry	• Determine the concentration of colored chemicals • To measure absorbance of specific wavelength of light • Known concentration must be used as reference for comparison
Conductivity	
pH	• A measure of the acidity or basicity • Acid: pH < 7 • Alkaline or basic: pH > 7
Sodium	To monitor sea water leakage of condenser
Calcium	To monitor any deposit salt in feed water

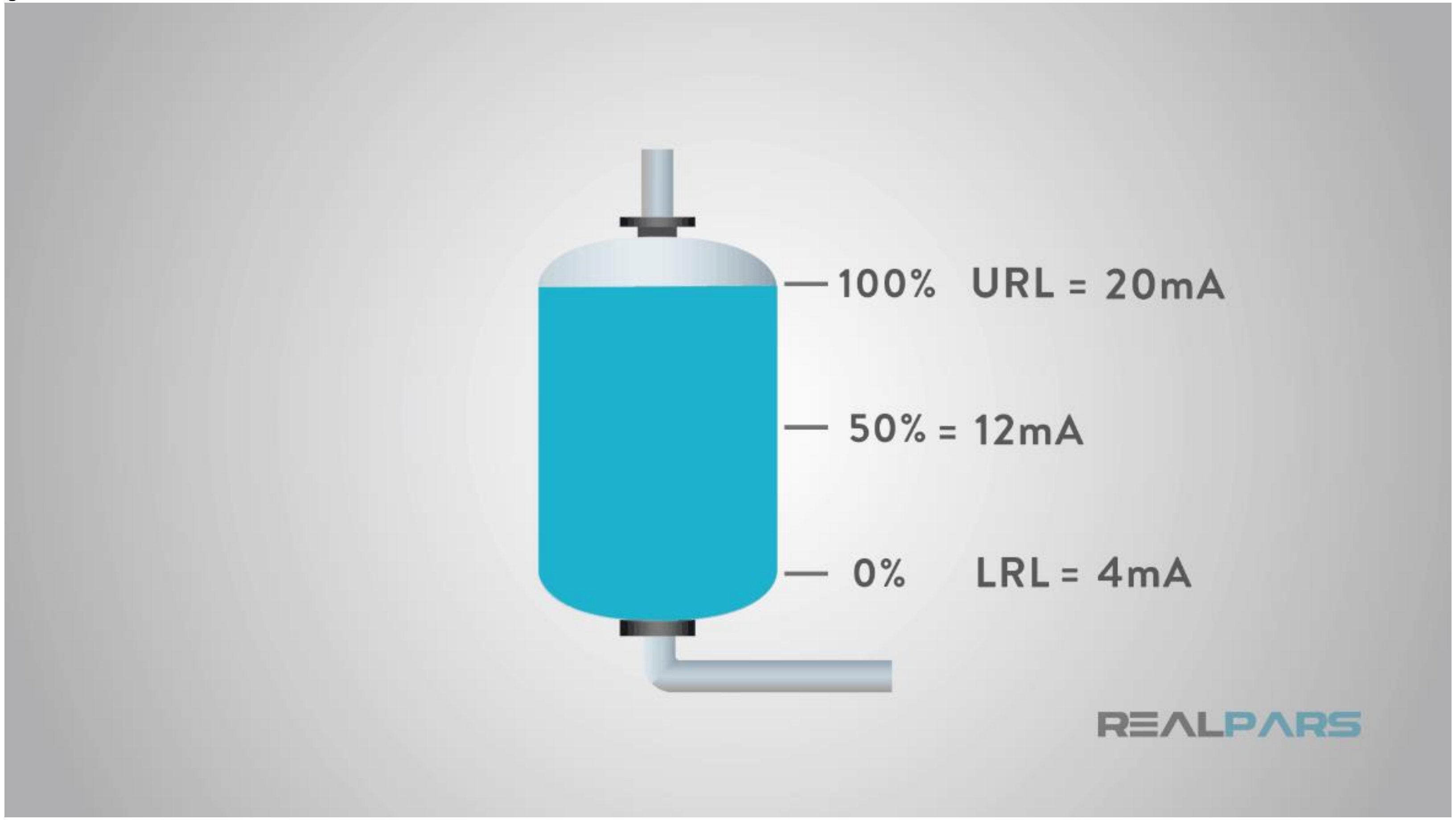
3. Process Measurement Devices
d. Transmitter

- Can’t sense the measured variables
- To convert the non-standard electrical signal outputted by the sensor into a measurable electric signal
  - 4- to 20 mA current signal
  - 1- to 5 V DC voltage signal
- To amplify the signal for subsequent receiving instrument

3. Process Measurement Devices
d. Transmitter

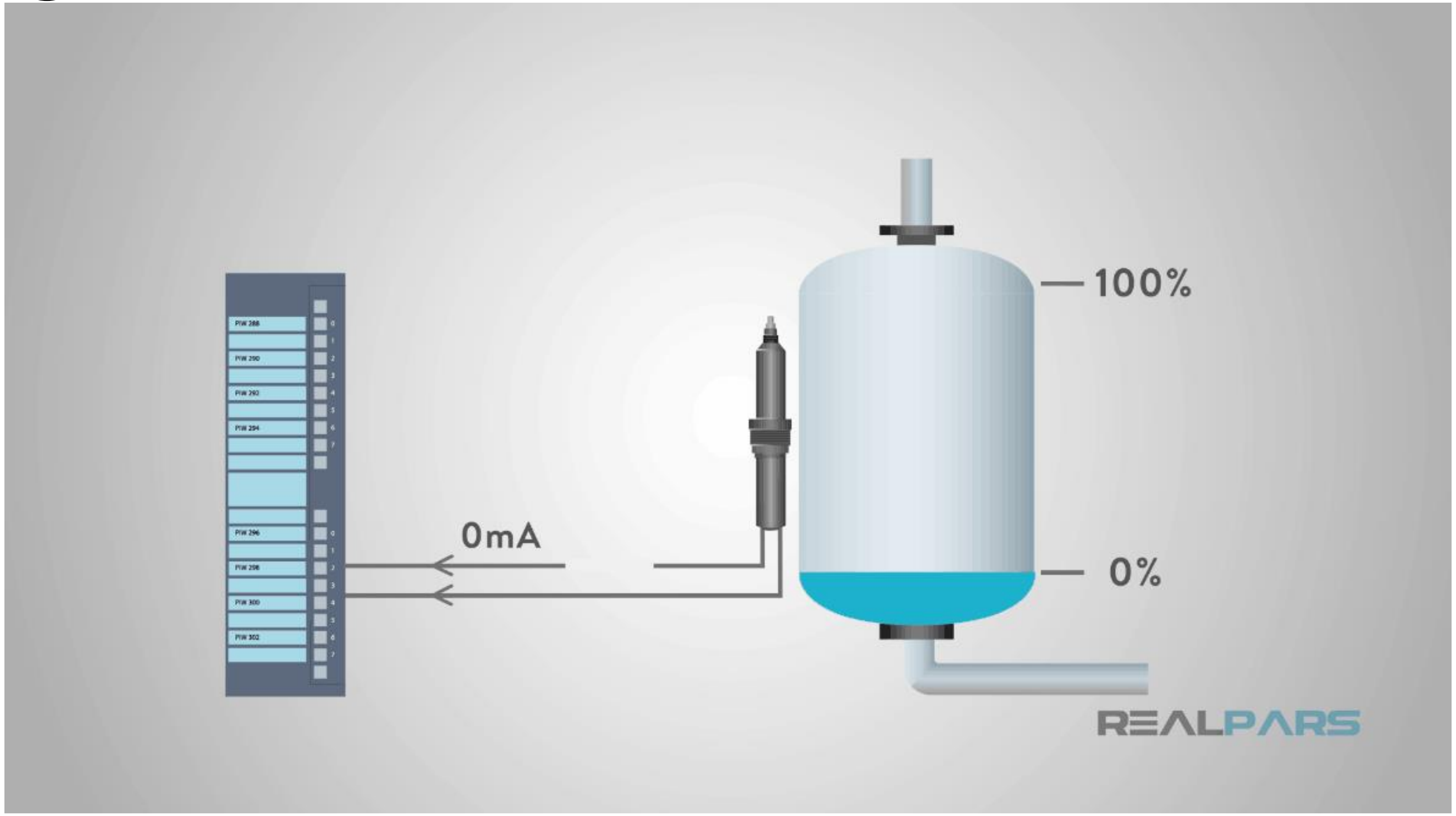


3. Process Measurement Devices
d. Transmitter
Application



https://realpars.com/wp-content/uploads/2018/06/hart-analog-sensor-different-sensors-different-prices-1080x604.png

3. Process Measurement Devices
d. Transmitter
Diagnostic



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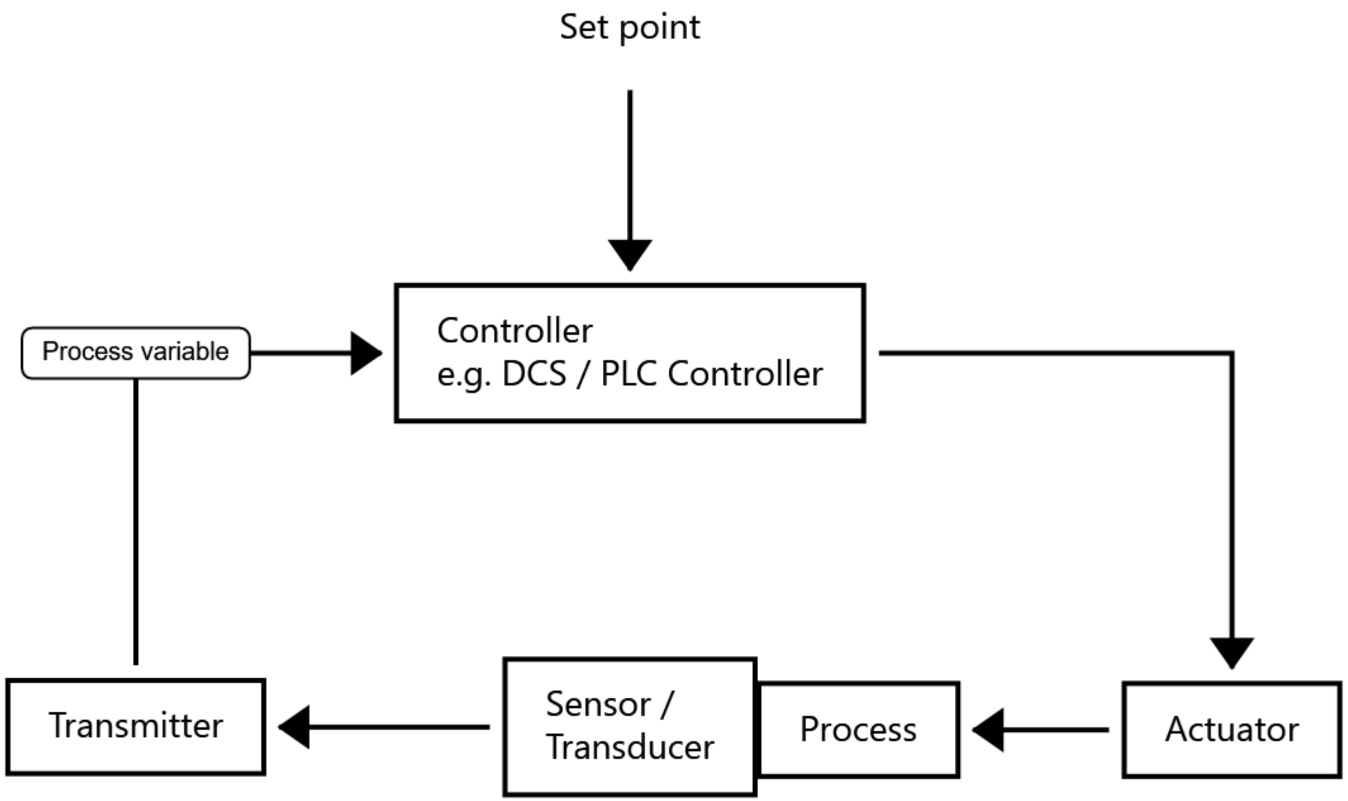
3. Process Measurement Devices
d. Transmitter
Process Control



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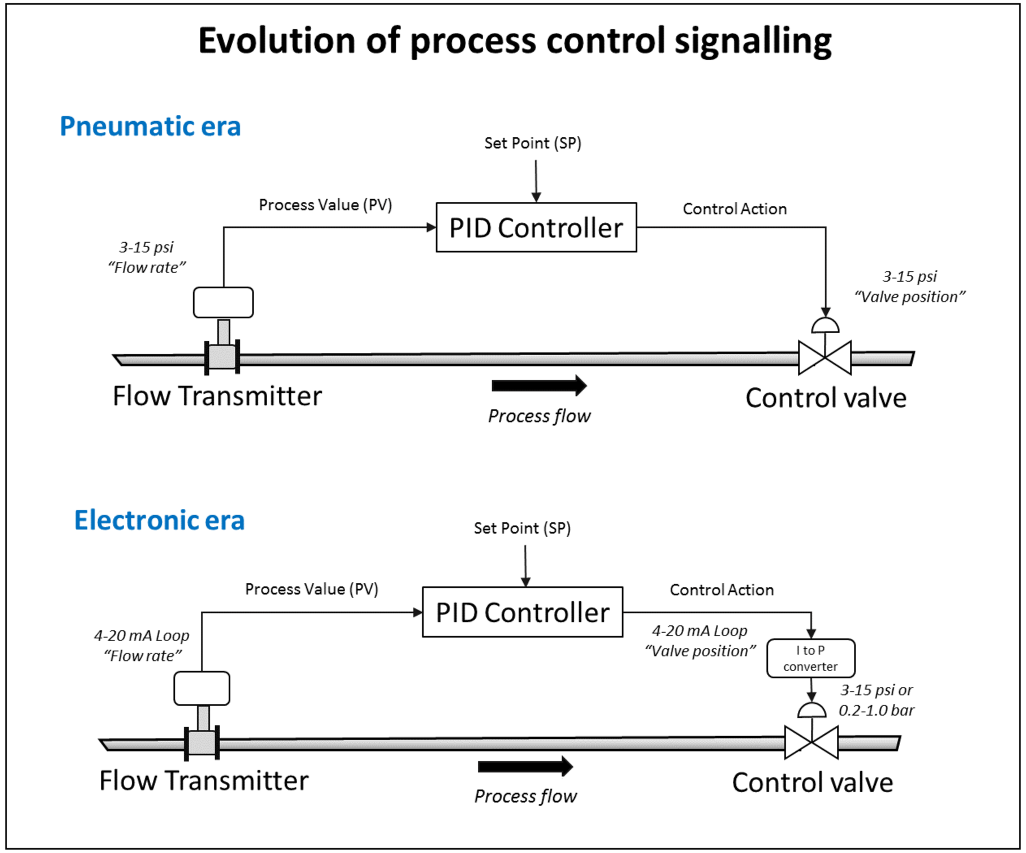
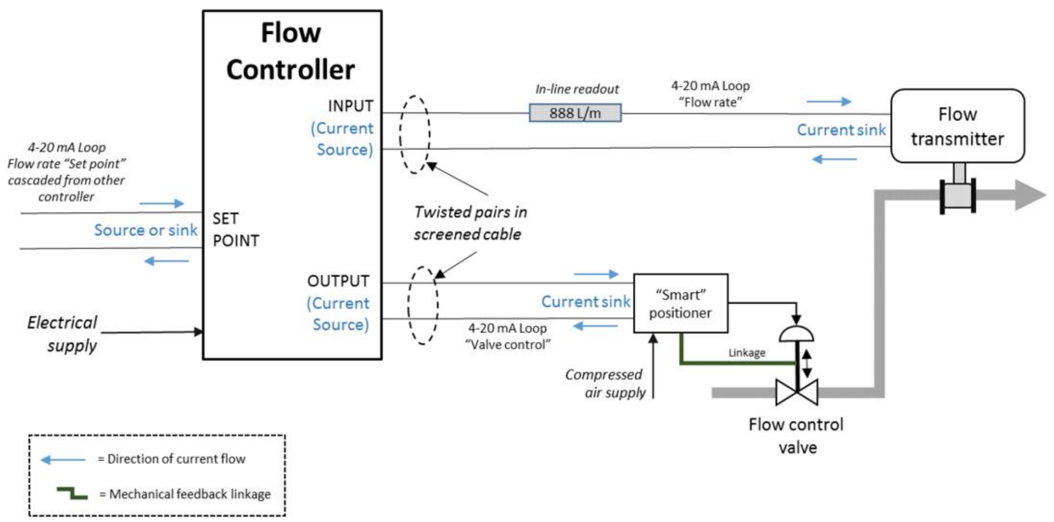
3. Process Measurement Devices
d. Transmitter
Process Control





This example shows the versatility of the 4-20 mA current loop system in multiple applications. It can be used to cascade a set point from another controller, and it can both control and supply power to passive field devices which "sink" the current. In each loop there has to be one source of current, usually the controller.
Here a current loop is connected directly to a modern "smart" valve positioner. This is a local servo-controller that ensures the valve goes to the required position using a mechanical feedback linkage..

https://en.wikipediorg/wiki/Current_loop

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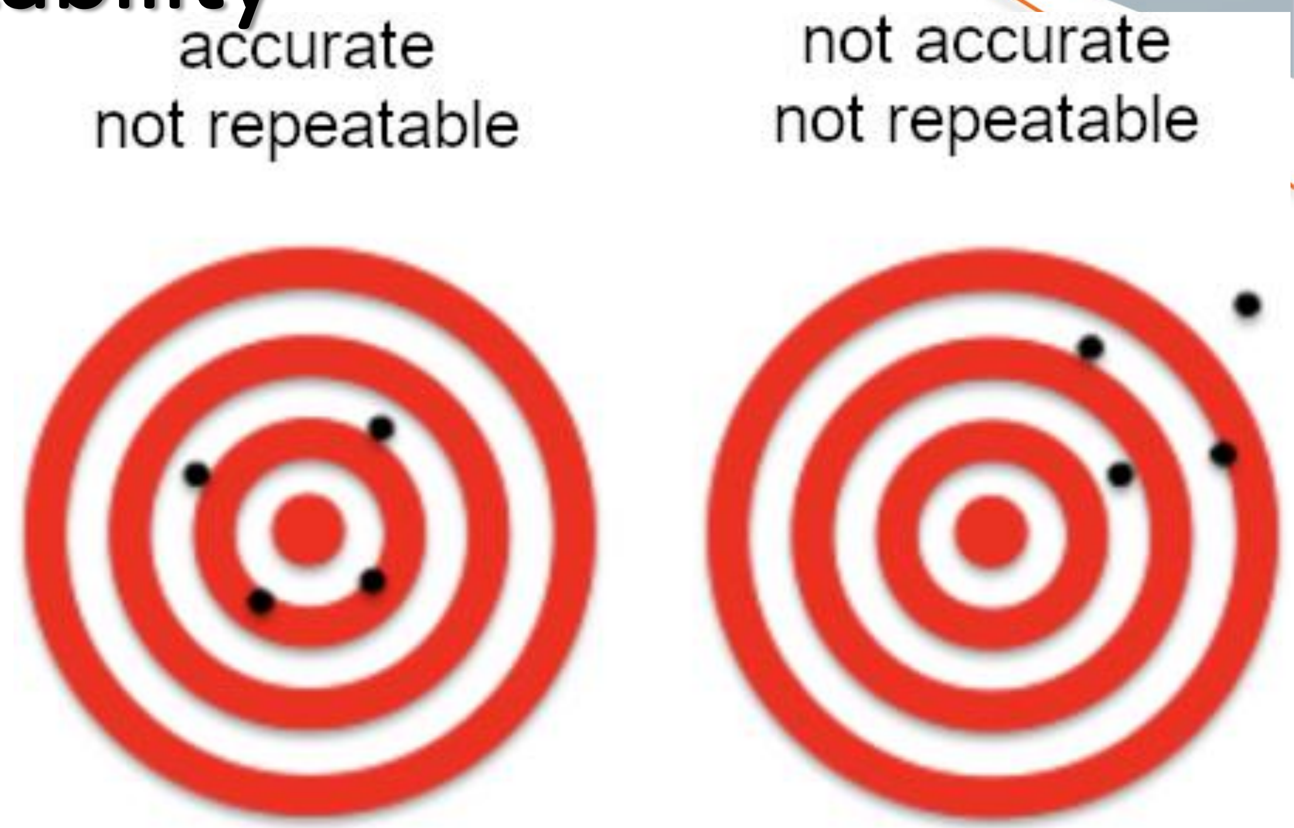
4. Application and Calibration of the Sensor Accuracy vs. Repeatability

- **Repeatability** is defined as the range of positions attained when the stage is repeatedly commanded to one specific location under identical conditions.



https://xeryon.com/wp-content/uploads/2019/07/accuracy_vs_repeatability.png

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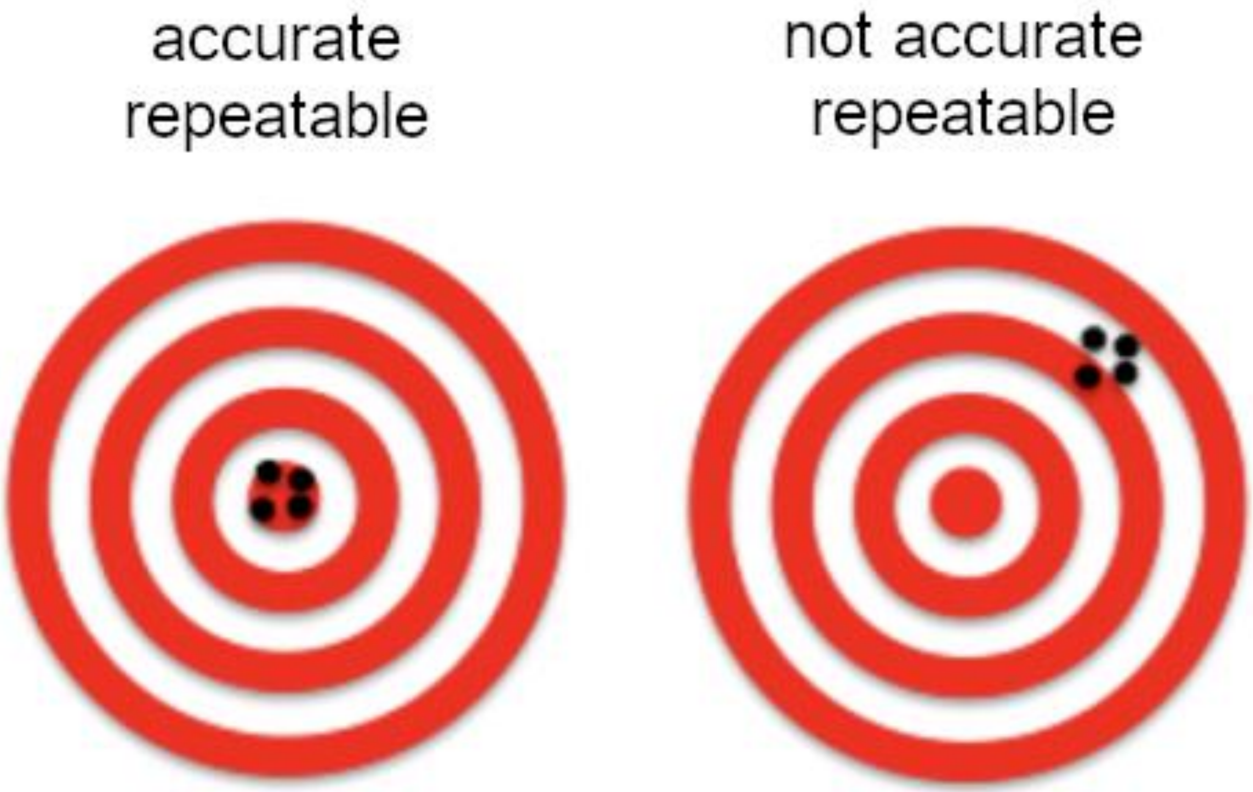
4. Application and Calibration of the Sensor Accuracy vs. Repeatability



- The **accuracy** of a position sensor represents the absolute deviation with respect to a calibrated, metrologically traceable standard. Sensor accuracy does not necessarily relate to sensor resolution.

https://xeryon.com/wp-content/uploads/2019/07/accuracy_vs_repeatability.png

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https://en.wikipediorg/wiki/Current_loop

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4. Application and Calibration of the Sensor Current Loop Basics

1. Power Supply (2-wire)
   36, 24, 15 and 12 VDC
2. Transmitter (flow, level, pressure, temperature, etc.)
   4-20mA
3. Receiver Resistor (precision)
   250Ω
4. Wire
   Sending current through wire produces voltage drops proportional to the wire length

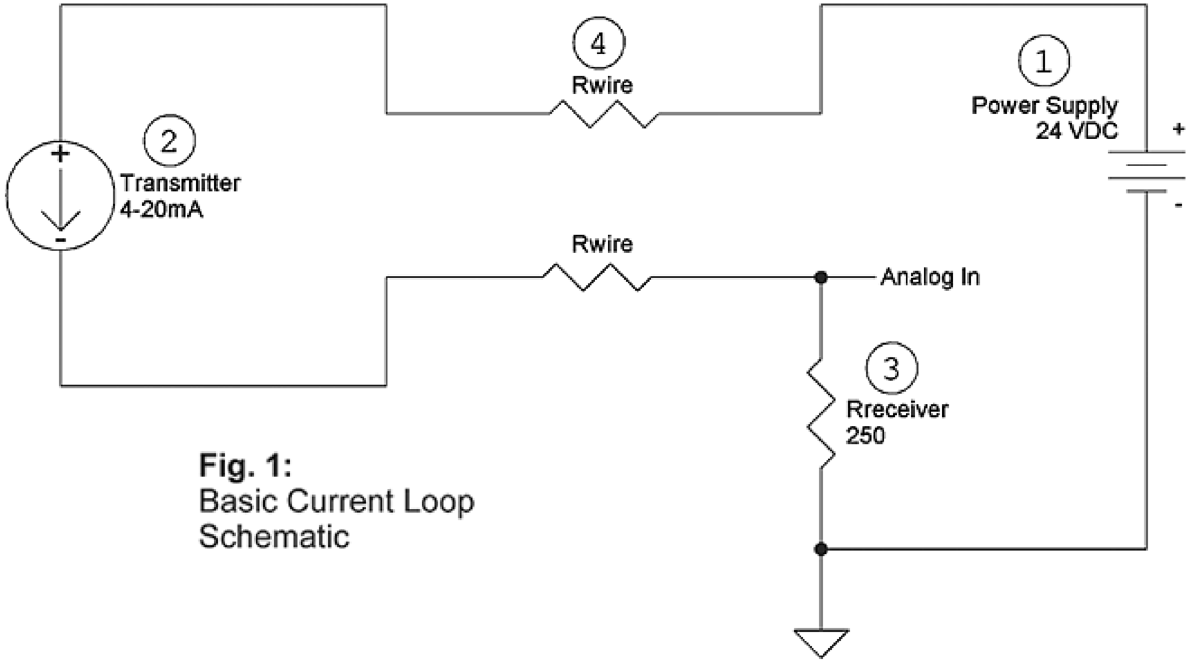
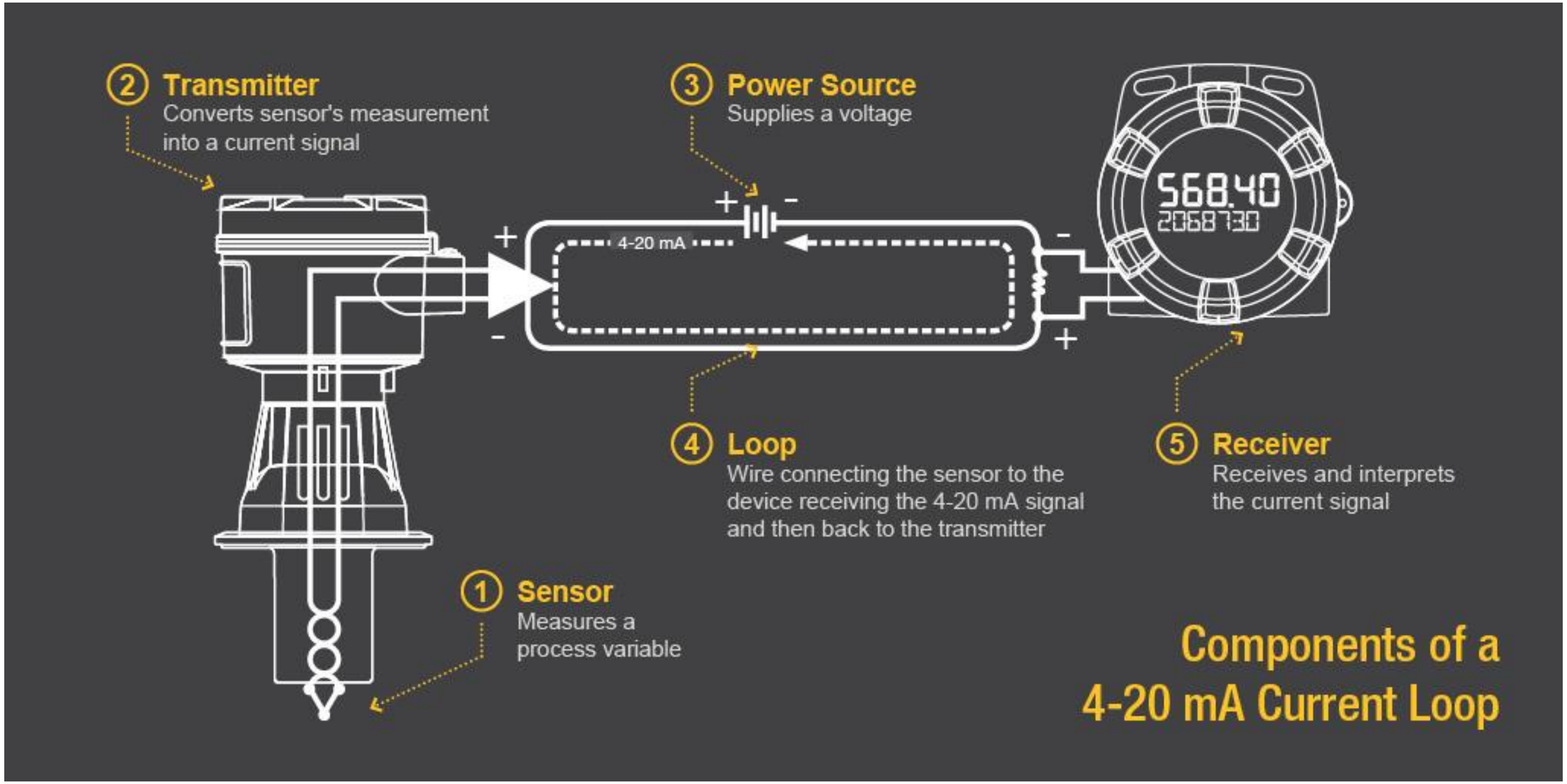


Fig. 1:
Basic Current Loop Schematic

https://www.bapihvac.com/wp-content/uploads/Science_of_4_20_Loops_Fig1.png

4. Application and Calibration of the Sensor Current Loop Basics



https://www.predig.com/sites/default/files/images/Indicator/back_to_basics/4-20mA_Current_Loops/4-20mA_current_loop_components.jpg

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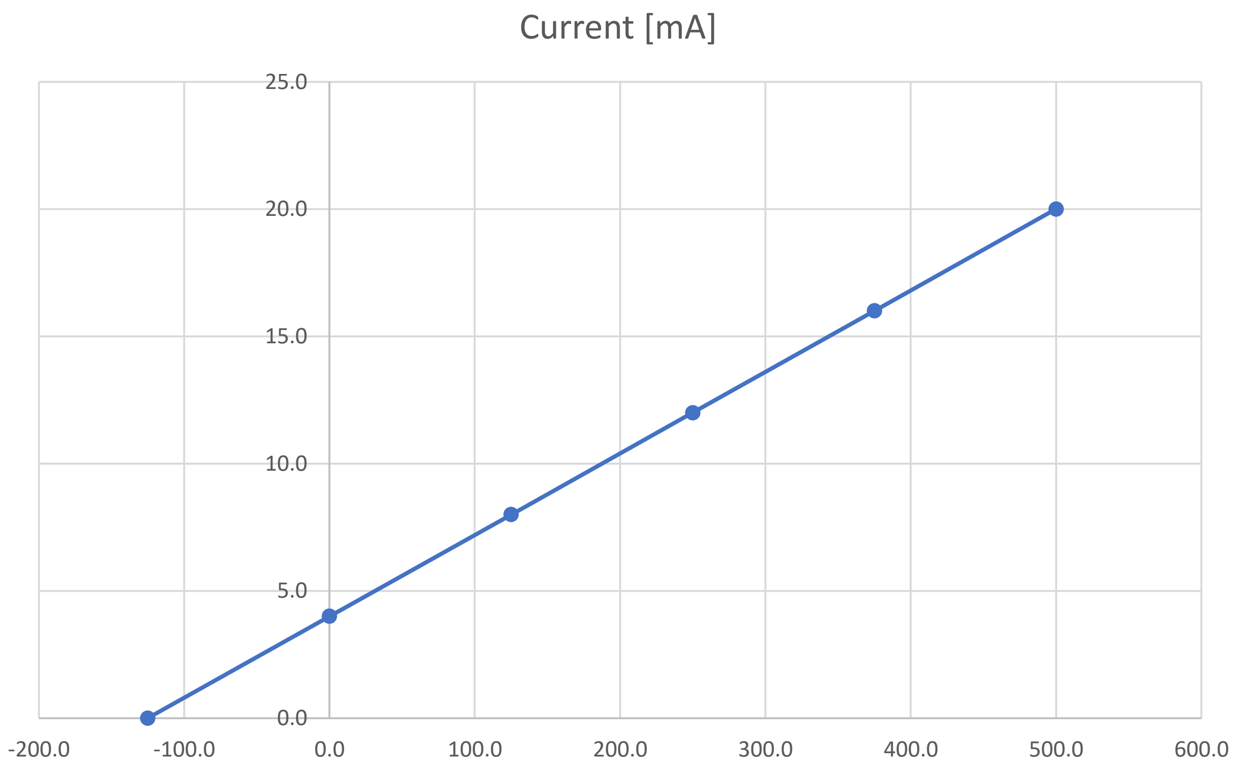
4. Application and Calibration of the Sensor Current Loop Basics

Example:

- Span = 0 .. 500 PSI
- Current Output = 4 .. 20 mA

$$Current = 4 + (20 - 4) \times \frac{Value}{Span} [mA]$$

Engineering Unit [PSI]	%	Current [mA]
500.0	100%	20.0
375.0	75%	16.0
250.0	50%	12.0
125.0	25%	8.0
0.0	0%	4.0
-125.0	-25%	0.0



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4. Application and Calibration of the Sensor Errors in Sensor Measurement

$$Error = Actual\,Value\; - Indicated\,Value$$

1. Error due to Improper Zero Reference
2. Shift in Sensor’s Range
3. Mechanical Wear or Damage

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4. Application and Calibration of the Sensor Errors in Sensor Measurement

Input Values	Output Values						
% of Span	Ideal Values	Measured Value		% Deviation (Error)		Calibration	
		↓	↑	↓	↑	↓	↑
0%	4 mA	4.01	4.01				
25%	8 mA	8.03	8.02				
50%	12 mA	12.03	12.04				
75%	16 mA	16.05	16.04				
100%	20 mA	20.06	20.06				

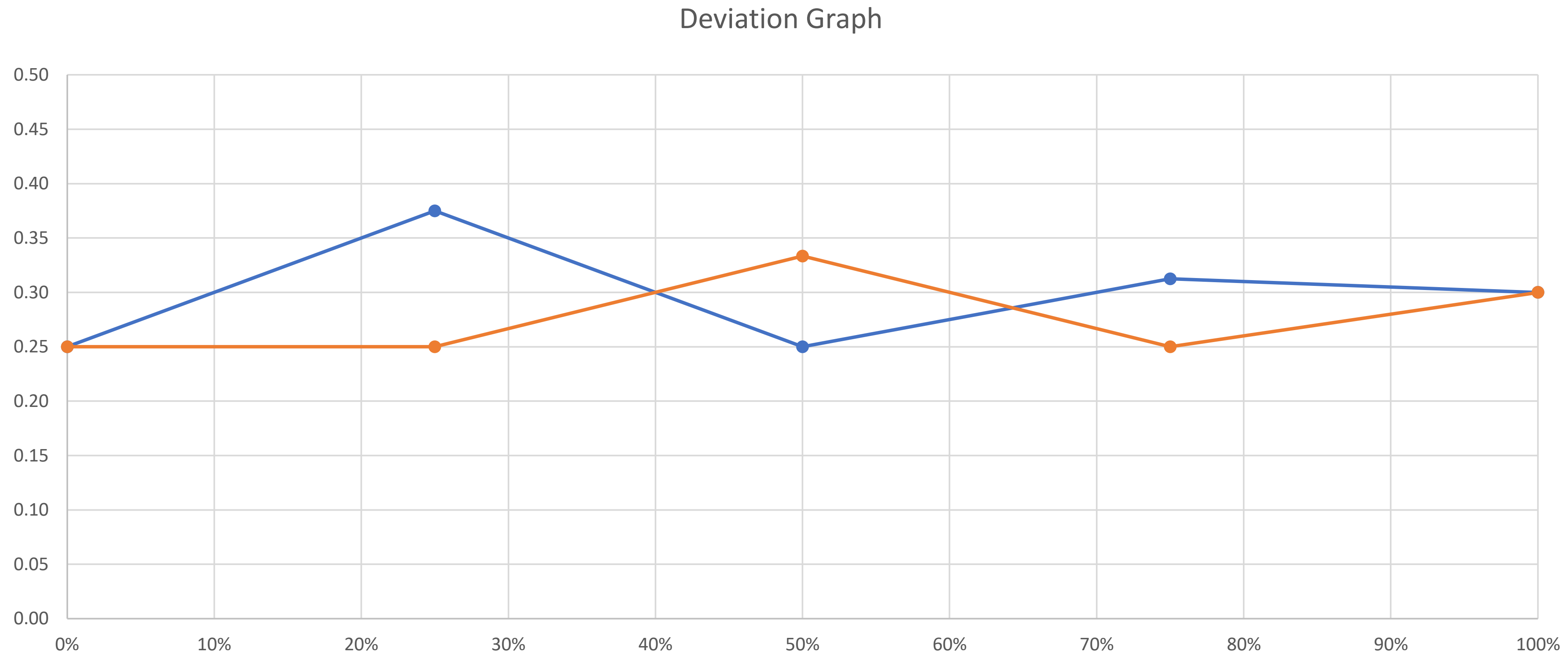
Area to record "As Found" Values

4. Application and Calibration of the Sensor Errors in Sensor Measurement

$$\% \, Deviation = \frac{As\ Found\ Value\ - Ideal\ Value}{Ideal\ Value} \times 100$$

Input Values	Output Values						
% of Span	Ideal Values	Measured Value		% Deviation (Error)		Calibration	
		↓	↑	↓	↑	↓	↑
0%	4 mA	4.01	4.01	0.250	0.250		
25%	8 mA	8.03	8.02	0.375	0.250		
50%	12 mA	12.03	12.04	0.250	0.333		
75%	16 mA	16.05	16.04	0.313	0.250		
100%	20 mA	20.06	20.06	0.300	0.300		

4. Application and Calibration of the Sensor Errors in Sensor Measurement



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4. Application and Calibration of the Sensor Errors in Sensor Measurement

$$\% \ Deviation = \frac{As\ Found\ Value\ - Ideal\ Value}{Ideal\ Value} \times 100$$

Input Values	Output Values							
% of Span	Ideal Values	Measured Value		% Deviation (Error)		Calibration		
		↓	↑	↓	↑	↓	↑
0%	4 mA	4.01	4.01	0.250	0.250	4.00	4.00
25%	8 mA	8.03	8.02	0.375	0.250	8.01	8.00
50%	12 mA	12.03	12.04	0.250	0.333	12.02	12.02
75%	16 mA	16.05	16.04	0.313	0.250	16.03	16.02
100%	20 mA	20.06	20.06	0.300	0.300	20.00	20.00

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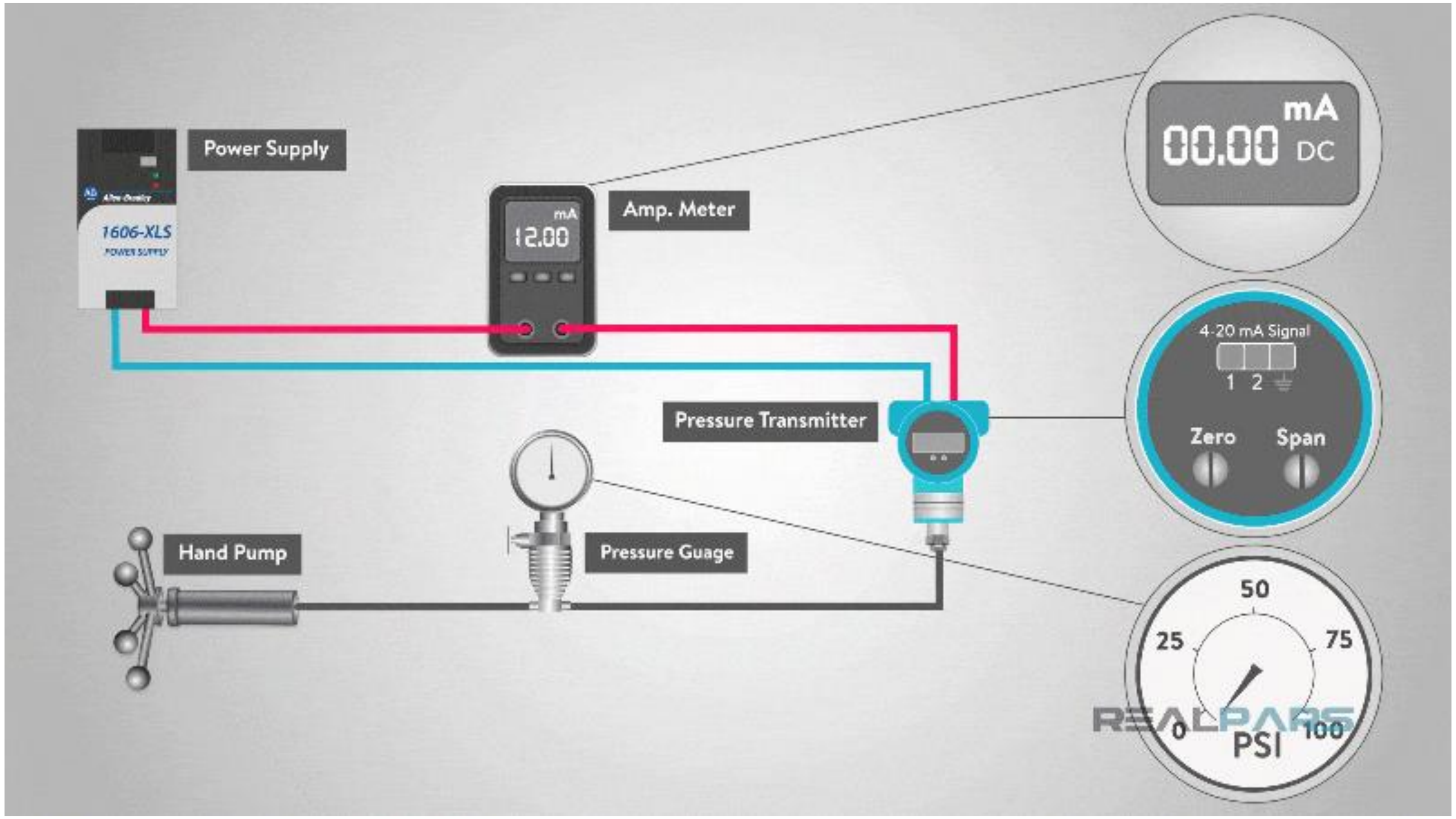
4. Application and Calibration of the Sensor
Sensor Calibration



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4. Application and Calibration of the Sensor Diagnostic Tool

Fluke 773 Milliamp Process Clamp Meter

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https://sydneytools.com.au/assets/images/products/1/8/5/5/18557/84C880B4092F83914D8DE44EF9A75D0FA2F9ED1308D0A2B9C74C03E228E5D02F.jpeg

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5. Backbone and Core Networking Network Topology

1. Point-to-point Topology
2. Bus Topology
3. Star Topology
4. Ring Topology
5. Tree Topology
6. Mesh Topology
7. Hybrid Topology

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5. Backbone and Core Networking
Point-to-point Topology

https://www.myworkingnet.com/wp-content/uploads/2021/02/Point-to-Point-topology-1024x593.png

Network Topology

1. Point-to-point Topology
2. Bus Topology
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6. Mesh Topology
7. Hybrid Topology

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5. Backbone and Core Networking Point-to-point Topology

Advantages	Disadvantages
• Because only two nodes have the complete bandwidth of a link, it has the highest bandwidth.	• This topology is only usable in small areas with nearby nodes.
• As it can only contact two nodes, it is quite quick compared to other network topologies.	• The entire network is dependent on the common cable; if the link fails, the entire network will be down.
• It has low latency.	• As there are only two nodes, data cannot be sent across the network if one of them fails.
• Connectivity is really simple.	
• Simple to use and maintain.	
• In a couple of seconds, a node can be replaced.	

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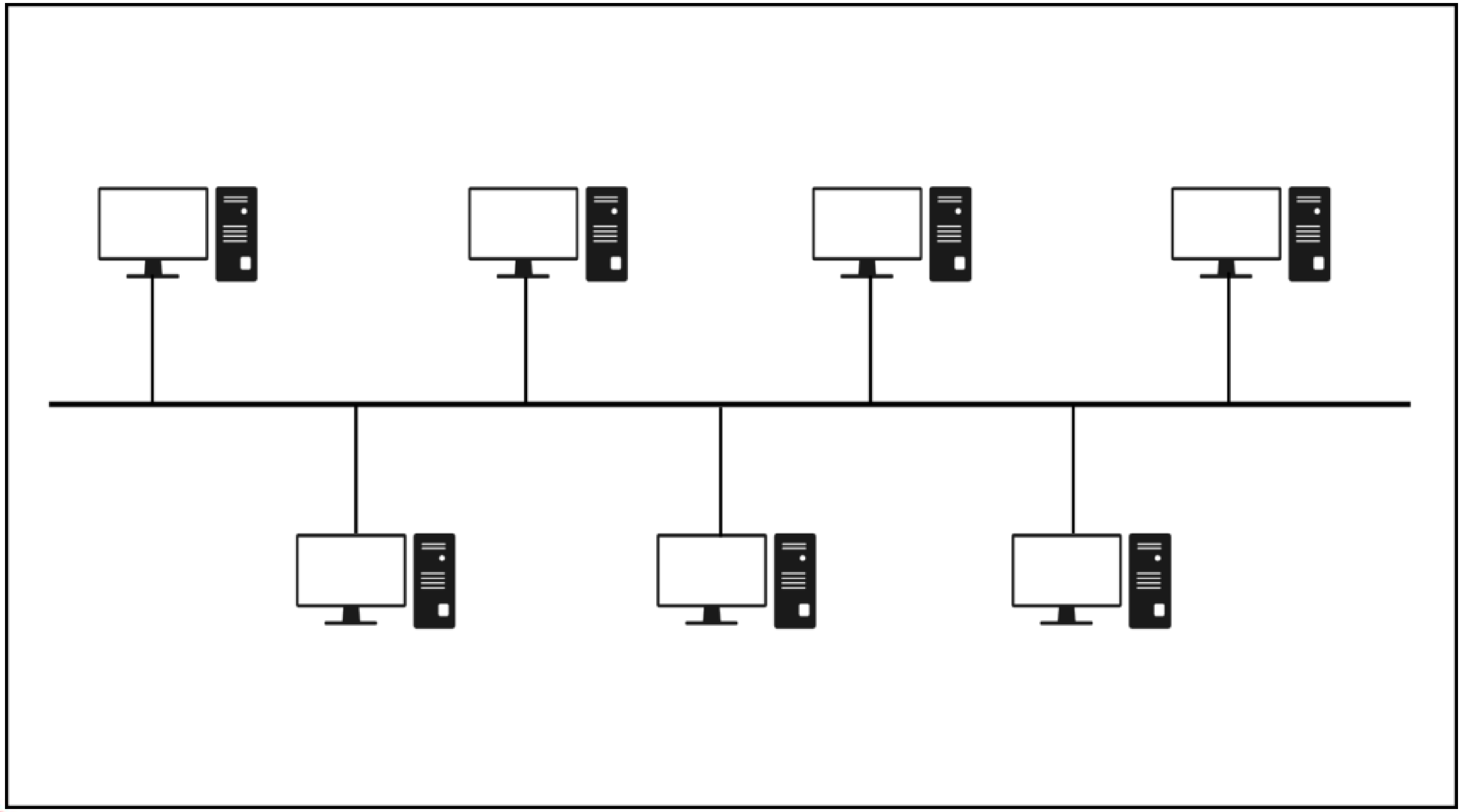
5. Backbone and Core Networking
Bus Topology



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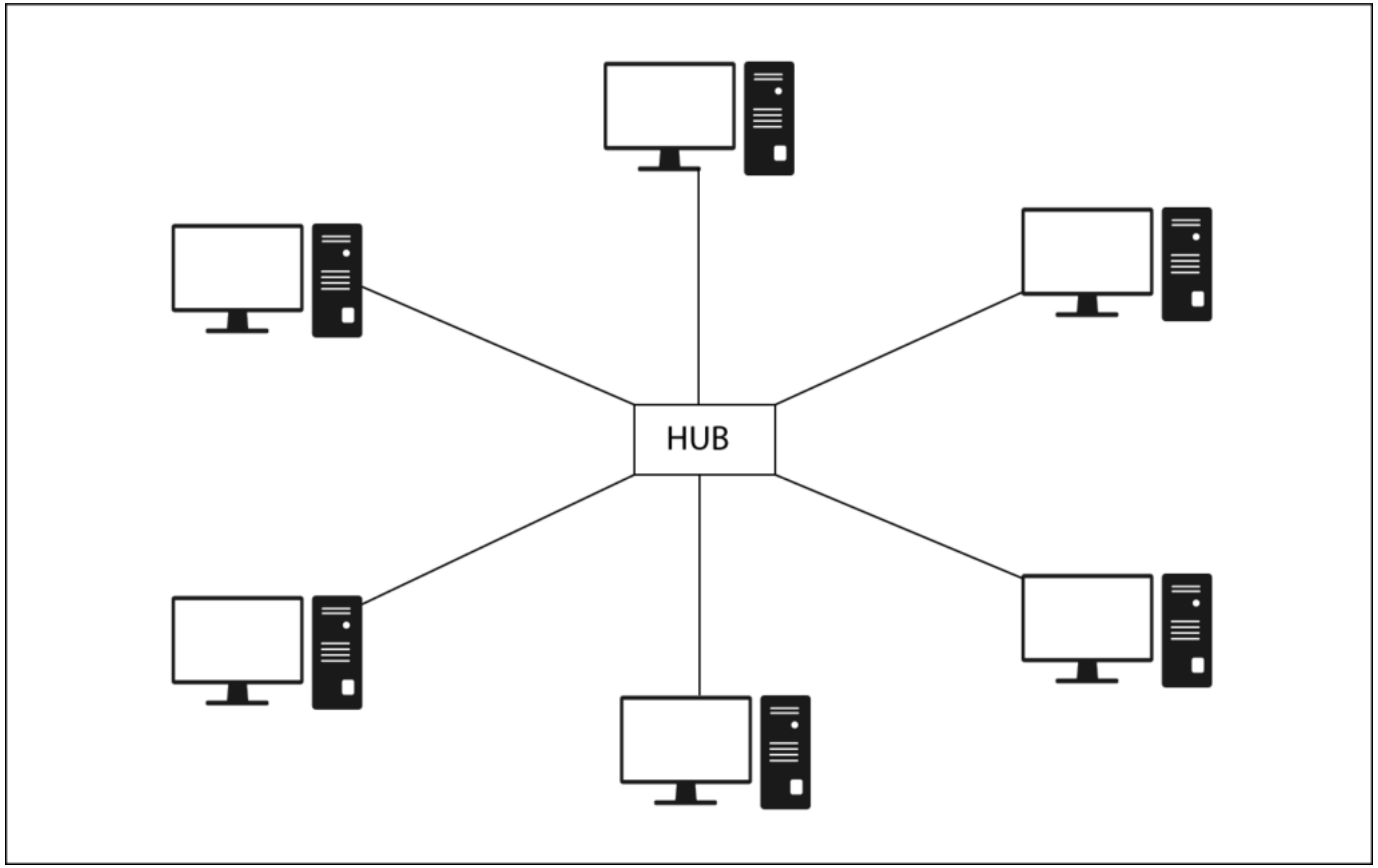
Network Topology

1. Point-to-point Topology
2. Bus Topology
3. Star Topology
4. Ring Topology
5. Tree Topology
6. Mesh Topology
7. Hybrid Topology

5. Backbone and Core Networking
Bus Topology

Advantages	Disadvantages
• Simple installation procedure.	• Slow data transferring process
• Bus topology systems are available at a low cost!	• Not appropriate for more extensive networks
• It can be useful to use in a small network system.	• The whole network system fails to function if the central cable gets damaged.
• It needs fewer cables.	• Difficult to detect network problems
• Can develop without interrupting other network topology systems and devices	• Hard-to-detect individual device issues
• Easiest network topology	• Limitations of cables and nodes

5. Backbone and Core Networking
Star Topology



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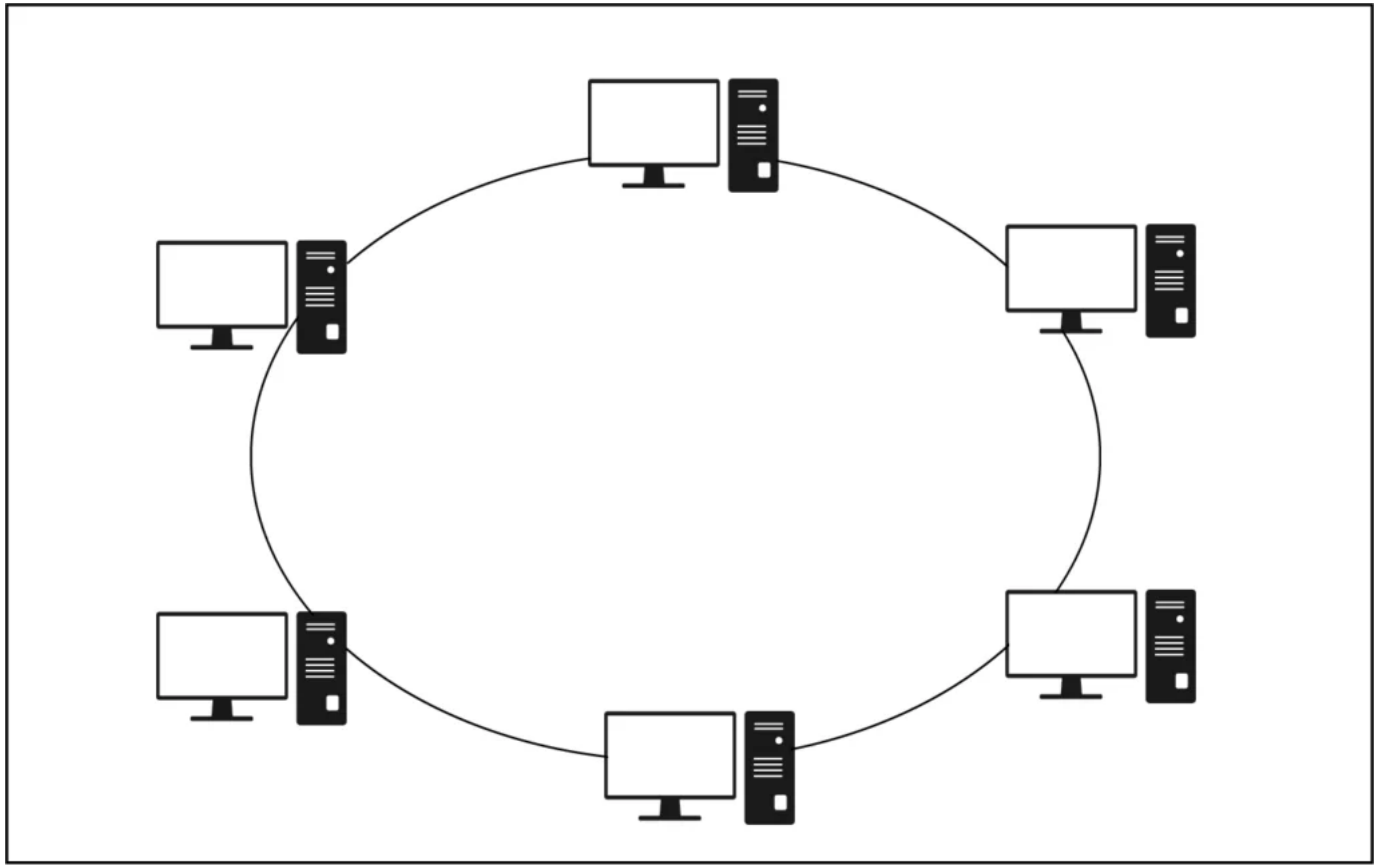
Network Topology

1. Point-to-point Topology
2. Bus Topology
3. Star Topology
4. Ring Topology
5. Tree Topology
6. Mesh Topology
7. Hybrid Topology

5. Backbone and Core Networking
Star Topology

Advantages	Disadvantages
• Because each node requires a separate cable, the network is simple to operate and maintain.	• The network's whole performance is based on a single device hub.
• Problems are easier to identify because cable failure only affects one user.	• The entire network will be inactive if the hub device fails.
• Extending the network is simple and does not disturb the entire network.	• In comparison to the ring and bus topologies, the star topology requires more wires.
• Controlling and managing a network is very easier with a Hub device.	
• It's simple to find faults and remove nodes from a network.	
• It has a high fast data transfer rate.	

5. Backbone and Core Networking
Ring Topology



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Network Topology

1. Point-to-point Topology
2. Bus Topology
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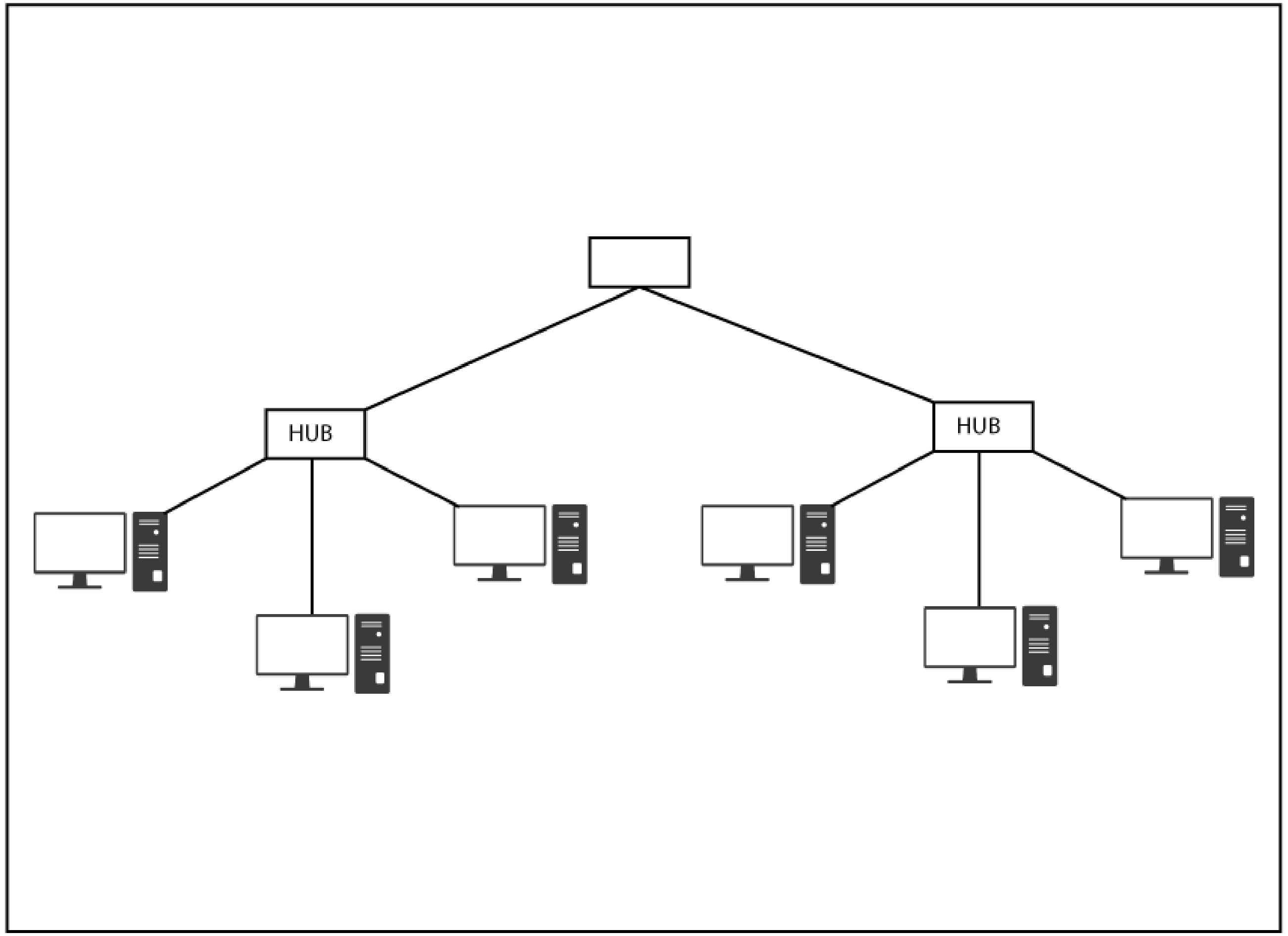
5. Backbone and Core Networking Ring Topology

Advantages	Disadvantages
• There are no packet collisions because all data goes in one direction.	• If one workstation fails, it will affect the entire network.
• You can add additional workstations later without affecting network performance in this design.	• When compared to the bus topology, it performs slower.
• High-speed data communication between workstations is possible.	• The cost of the hardware required to connect each workstation to the network is higher.
	• Troubleshooting is difficult.
	• The entire network is dependent on a single cable.

5. Backbone and Core Networking
Tree Topology



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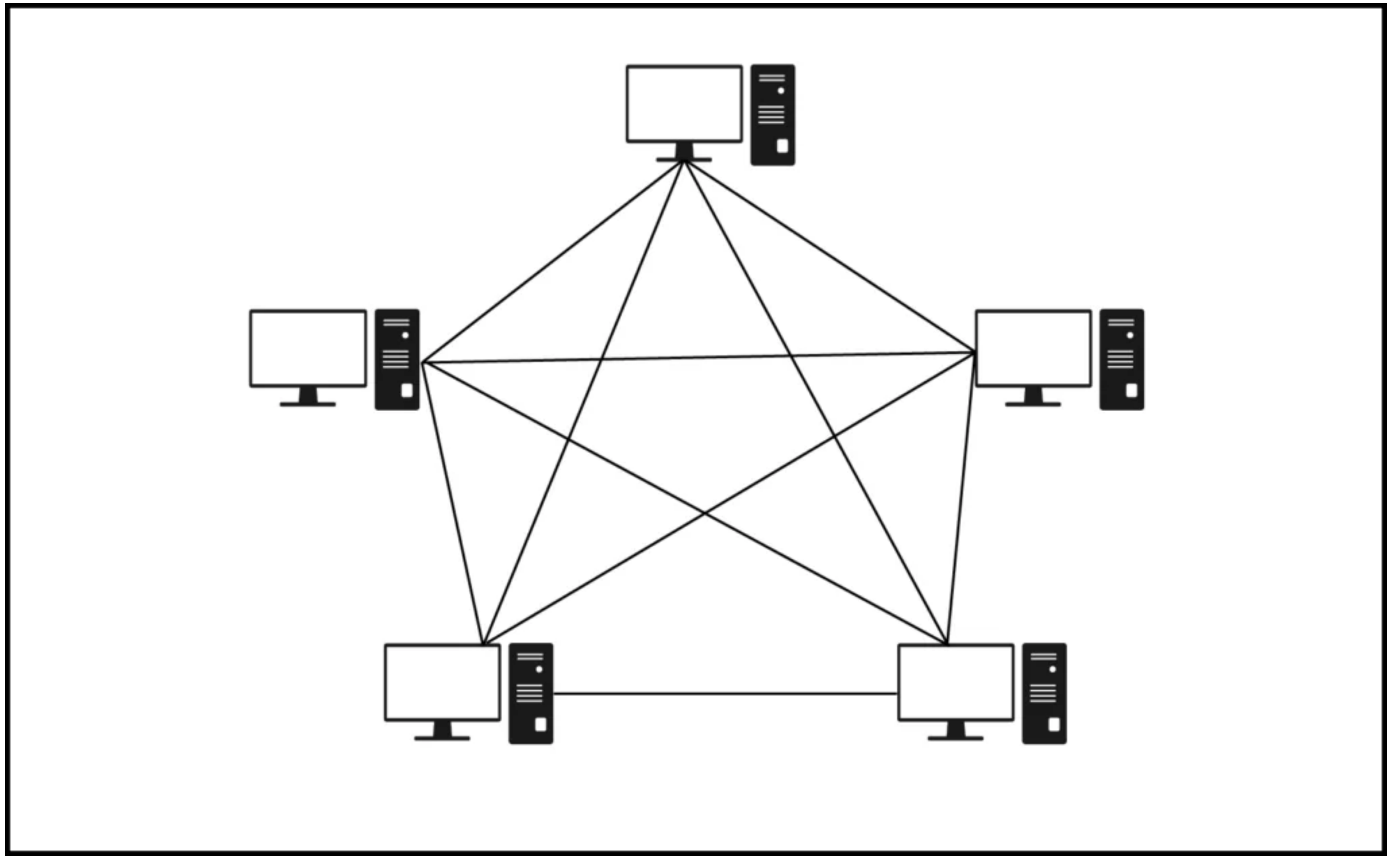
Network Topology

1. Point-to-point Topology
2. Bus Topology
3. Star Topology
4. Ring Topology
5. Tree Topology
6. Mesh Topology
7. Hybrid Topology

5. Backbone and Core Networking

Advantages	Disadvantages
• This topology combines the bus and star topologies.	• In comparison to other network topologies, this network is complicated to configure.
• This architecture gives the nodes a hierarchical and central data layout.	• A segment's length is limited, and the length limit is determined by the type of cabling used.
• If one of the nodes in a network is destroyed or stops working, the remaining nodes in the network are unaffected.	• If the first-level computer is faulty, the second-level computer will have problems as well.
• This topology provides excellent scalability because the leaf nodes can add one or more nodes to the hierarchical chain.	• The network performance of tree topology becomes a little slow due to the huge number of nodes.
• The tree topology allows for easy Maintenance and defect diagnosis.	• In comparison to star and ring topologies, tree topology necessitates a considerable number of wires.
• More nodes can be stored in leaf nodes.	• The Backbone appears to be the single point of failure for the entire network section.
	• Because the data must travel from the central wire, there is a lot of network traffic.
	• The Maintenance of topology is somewhat difficult.
	• The establishment costs very high.
	• If a large number of nodes are added to this network, Maintenance will become more difficult.

5. Backbone and Core Networking
Mesh Topology



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Network Topology

1. Point-to-point Topology
2. Bus Topology
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7. Hybrid Topology

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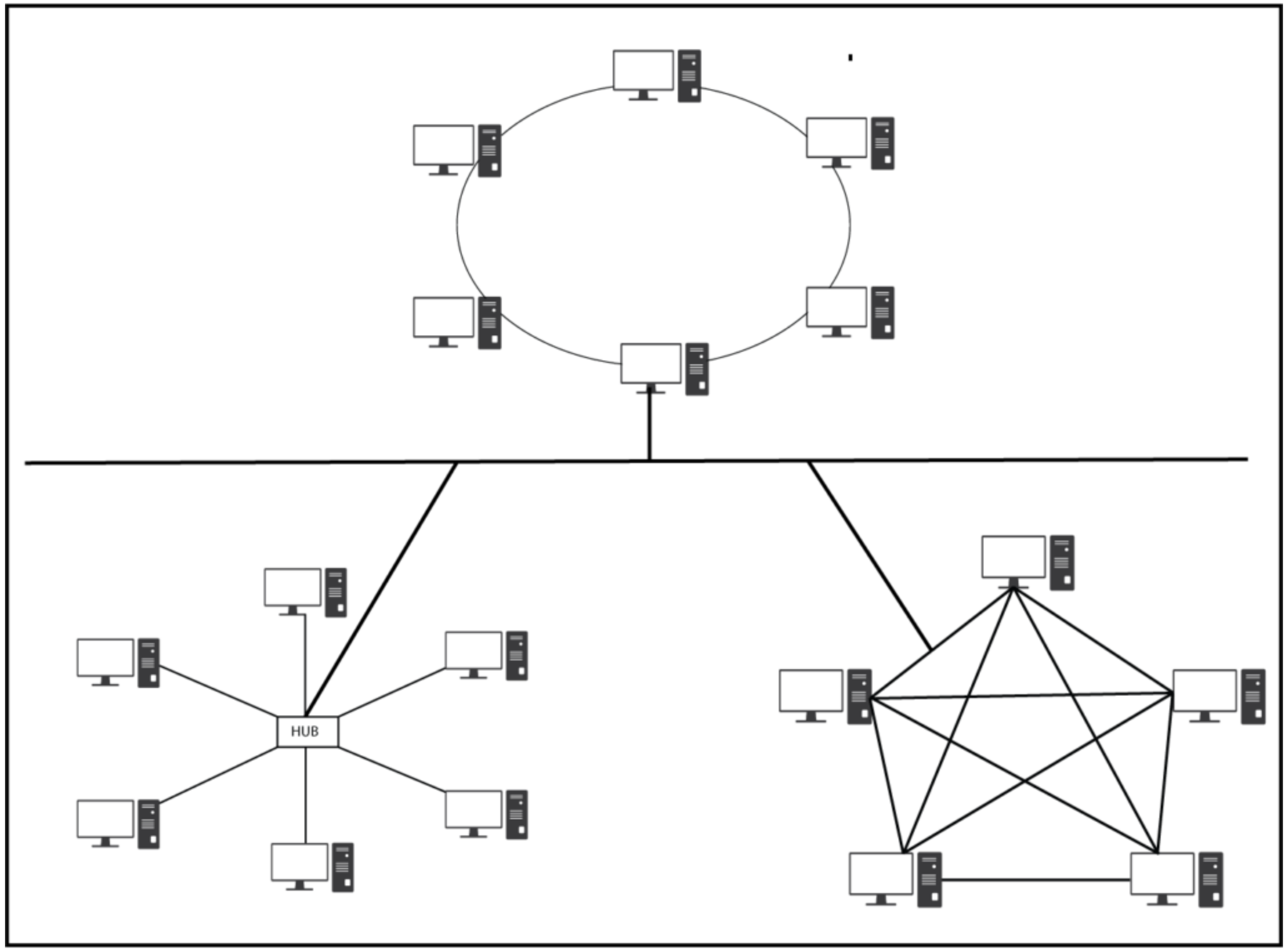
5. Backbone and Core Networking Mesh Topology

Advantages	Disadvantages
• The network will not be broken if a single device fails.	• When compared to other network topologies, it is more expensive.
• There is no traffic congestion because each computer has its own dedicated point-to-point link.	• Installation is quite difficult.
• It has a higher level of privacy and security.	• The power need is larger since all of the nodes must be operational at all times and share the load.
• Because failure does not disturb its processes, data transmission is more consistent.	• Mesh implementation is more expensive than other options.
• The process of identifying a fault is simple.	• In a mesh topology, it's difficult to keep up with maintenance.
• The addition of new devices is not disrupting data transmissions.	
• This topology can withstand any condition.	

5. Backbone and Core Networking
Hybrid Topology



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Network Topology

1. Point-to-point Topology
2. Bus Topology
3. Star Topology
4. Ring Topology
5. Tree Topology
6. Mesh Topology
7. Hybrid Topology

5. Backbone and Core Networking Hybrid Topology

Advantages	Disadvantages
•Reliable	•Complexity
•Scalable	•Expensive
•Effective	
•A hybrid network is created by integrating many networks that use a variety of approaches to associate points for devices such as personal computers and other hardware components that are connected to servers. They also provide other advantages, including data communication, signal strength, throughput, and high-end equipment.	
•It offers the capacity to easily transport data between many types of networks.	

6. Fieldbus Protocols Introduction

IEC 61784 / IEC 61158

- Fieldbuses for Manufacturing Automation
    a. Modbus
    b. Profibus-DP
    c. HART
    d. Interbus
    e. Canbus

- Fieldbus for Building Automation
    d. BACNet
    e. LonWorks
    f. Modbus

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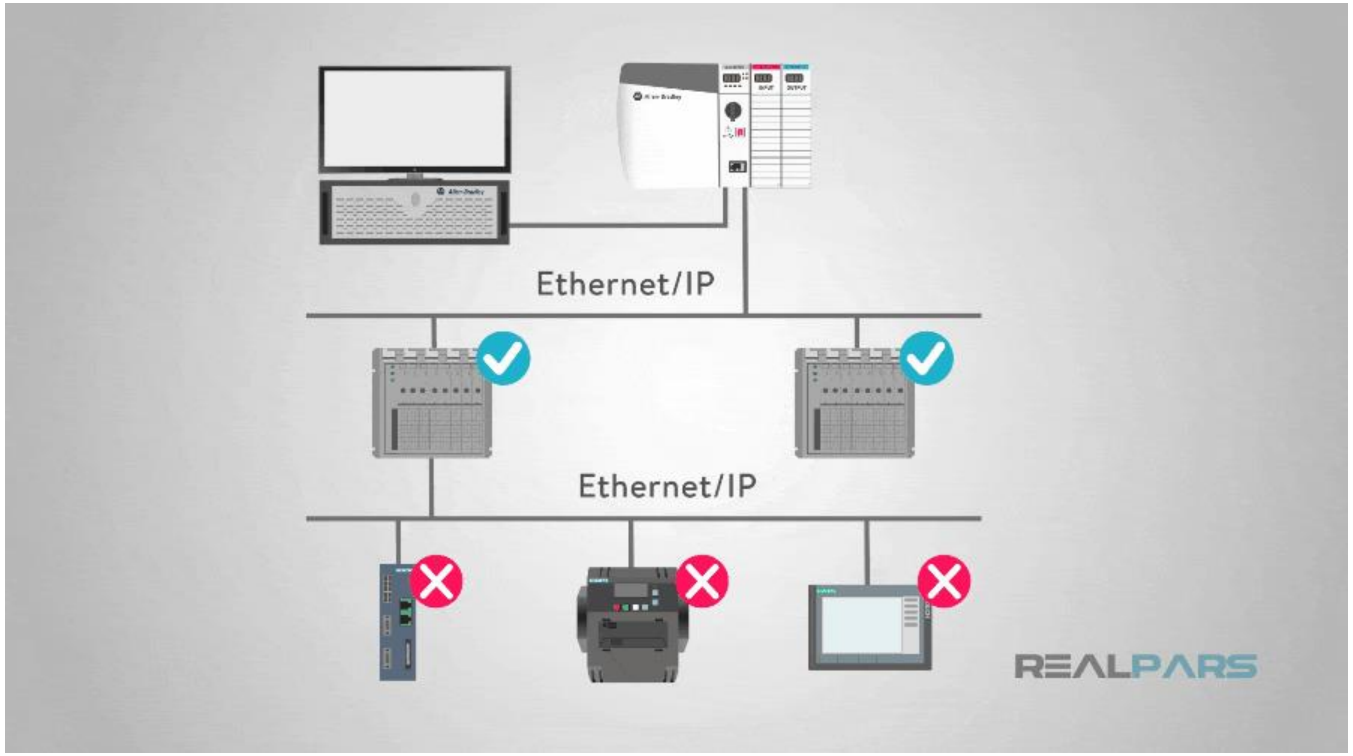
6. Fieldbus Protocols
a. What is Modbus?

- Modbus as an “Open Protocol”
  - The specifications are published and may be used by anyone freely or by license.



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6. Fieldbus Protocols
a. What is Modbus?

- Modbus is a communication protocol published by Modicon in 1979.
- Modicon is now owned by Schneider Electric.
- Modbus provides a common language for devices and equipment to communicate with one and another.

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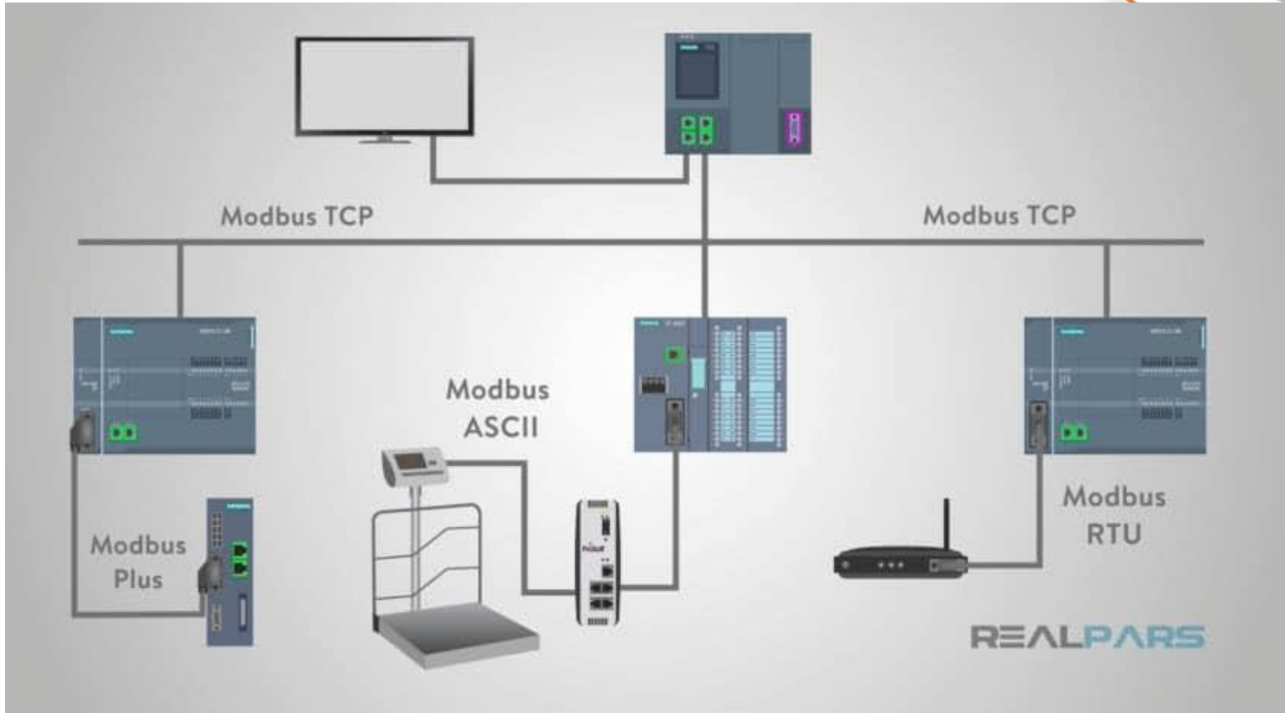
6. Fieldbus Protocols
a. What is Modbus?
Types of Modbus Communication Protocol

- Modbus communication interface for a multidrop network based on a Master-Slave architecture.
- Send request and read response type messages.



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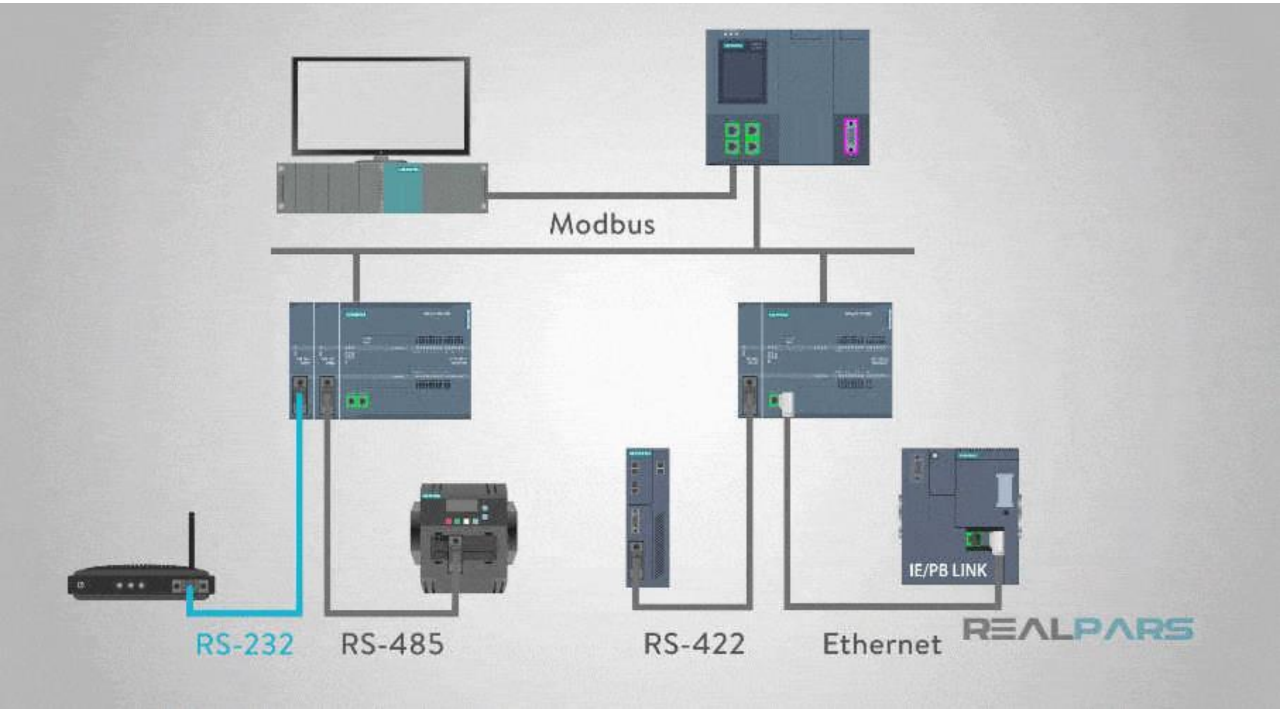
6. Fieldbus Protocols
a. What is Modbus?
Modbus Protocol and its Physical Media

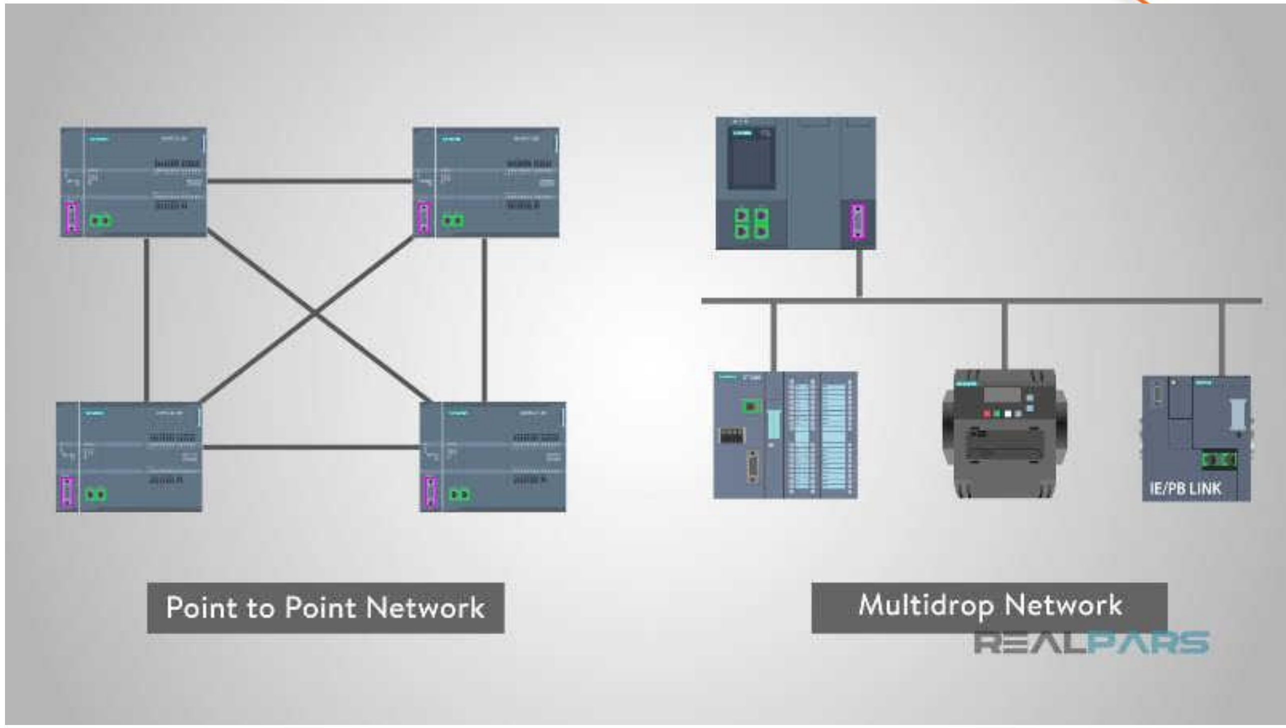


https://realpars.com/wp-content/uploads/2018/12/Modbus-Communication-Physical-Medigif

- Serial RS-232
- Serial RS-485
  - Longer distances
  - Higher speeds
  - Multiple devices on a single multi-drop network
- Serial RS-422
- Ethernet

6. Fieldbus Protocols
a. What is Modbus?
Modbus Message Structure

- Peer-to-Peer
- Point-to-Point and Multidrop Networks
- Master-Slave (Client-Server for Ethernet) technique
- Only one device (the Master/Server) can initiate transactions (called queries).
- The other devices (Slaves/Clients) respond by supplying the requested data to the master, or by taking the action requested in the query.



https://realpars.com/wp-content/uploads/2018/12/Modbus-Message-Architecture.jpg

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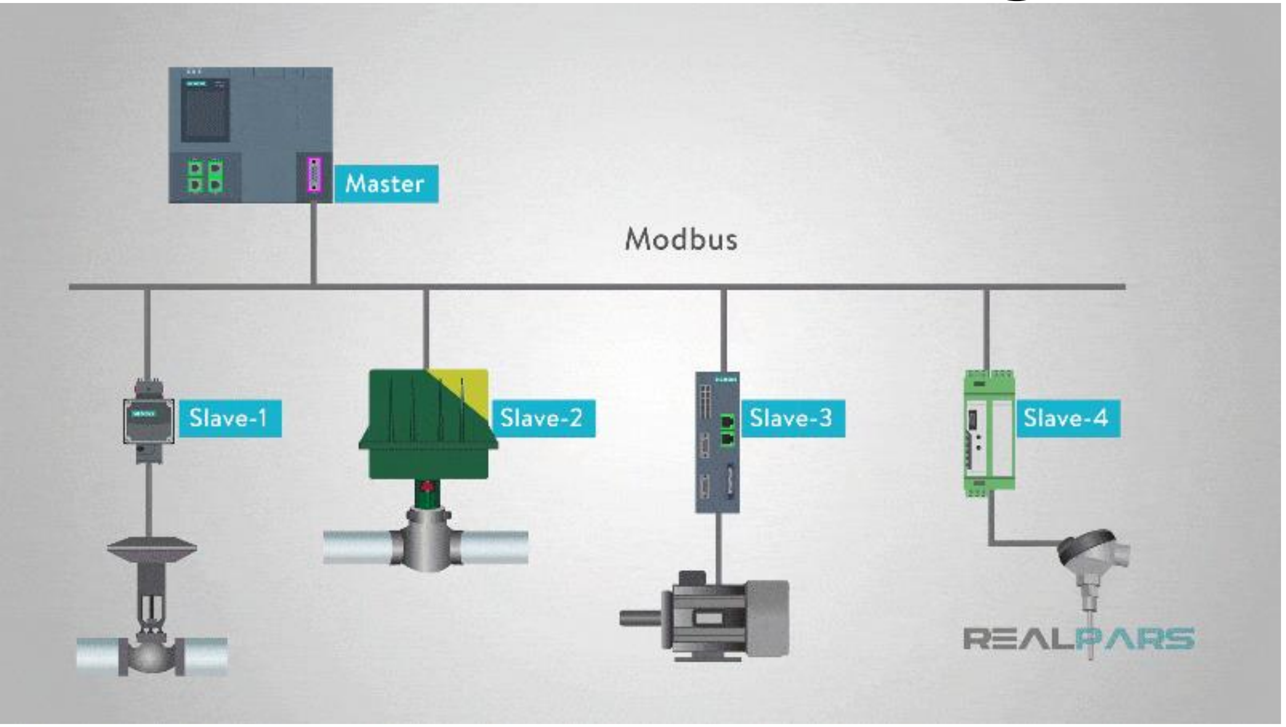
6. Fieldbus Protocols
a. What is Modbus?
Modbus Message Structure



- Slave is any peripheral device such as an I/O transducer, valve, network drive, or other measuring types of devices
- Processes information and sends its response message to the master using Modbus

https://realpars.com/wp-content/uploads/2018/12/Modbus-Master-Query-and-Reply.gif

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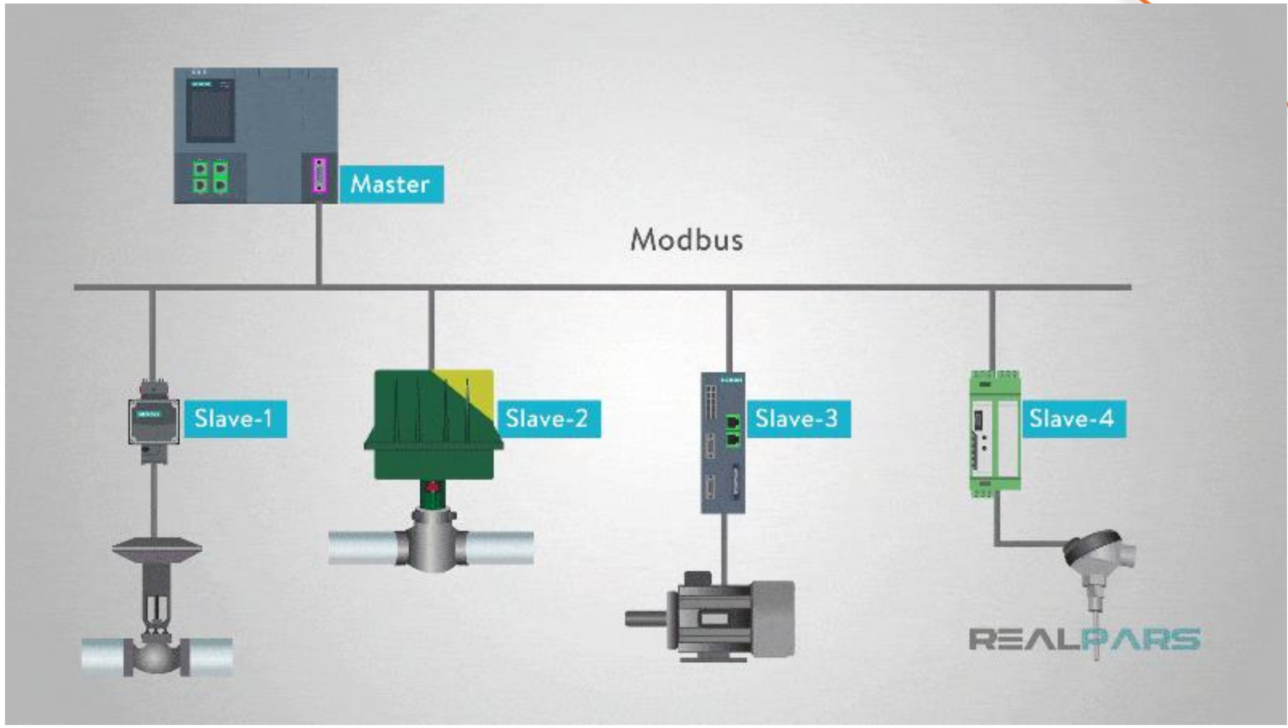
6. Fieldbus Protocols
a. What is Modbus?
Modbus Message Structure

- Masters can address individual slaves or initiate a broadcast message to all slaves. Slaves return a response to all message queries addressed to them individually, but do not respond to broadcast messages.
- Slaves do not initiate messages on their own and only respond to message queries transmitted from the master.



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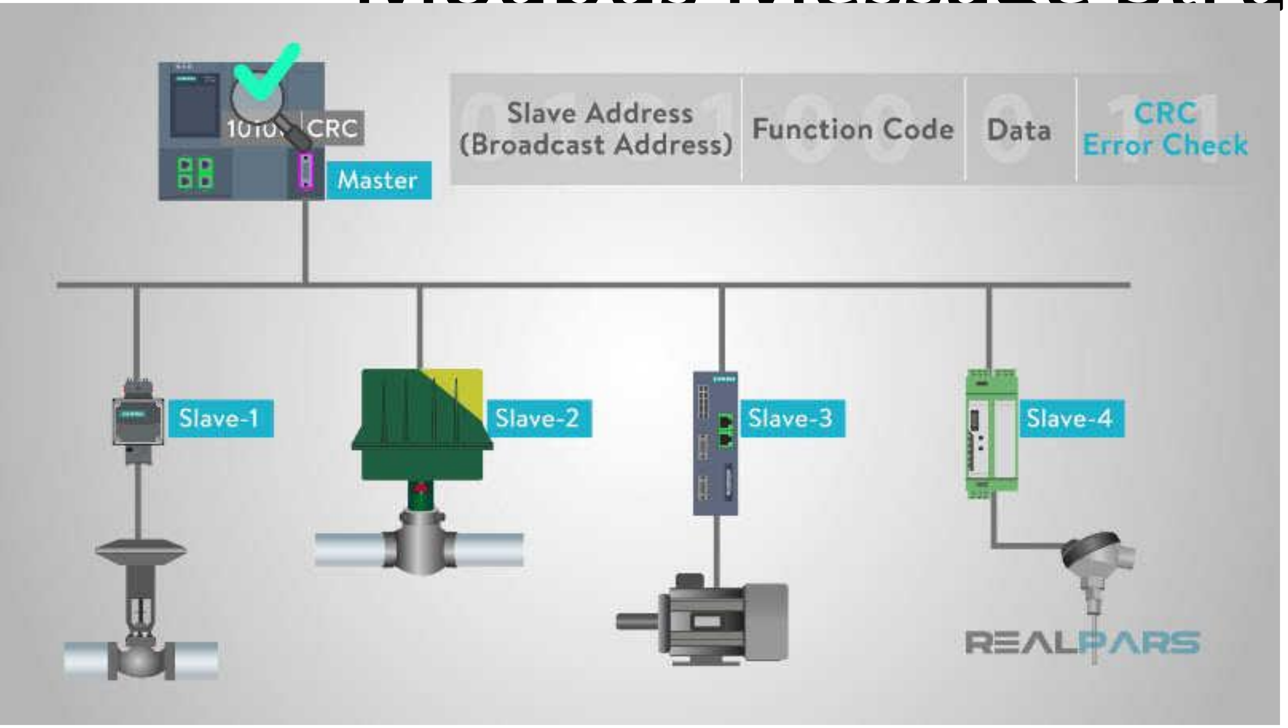
6. Fieldbus Protocols
a. What is Modbus?
Modbus Message Structure



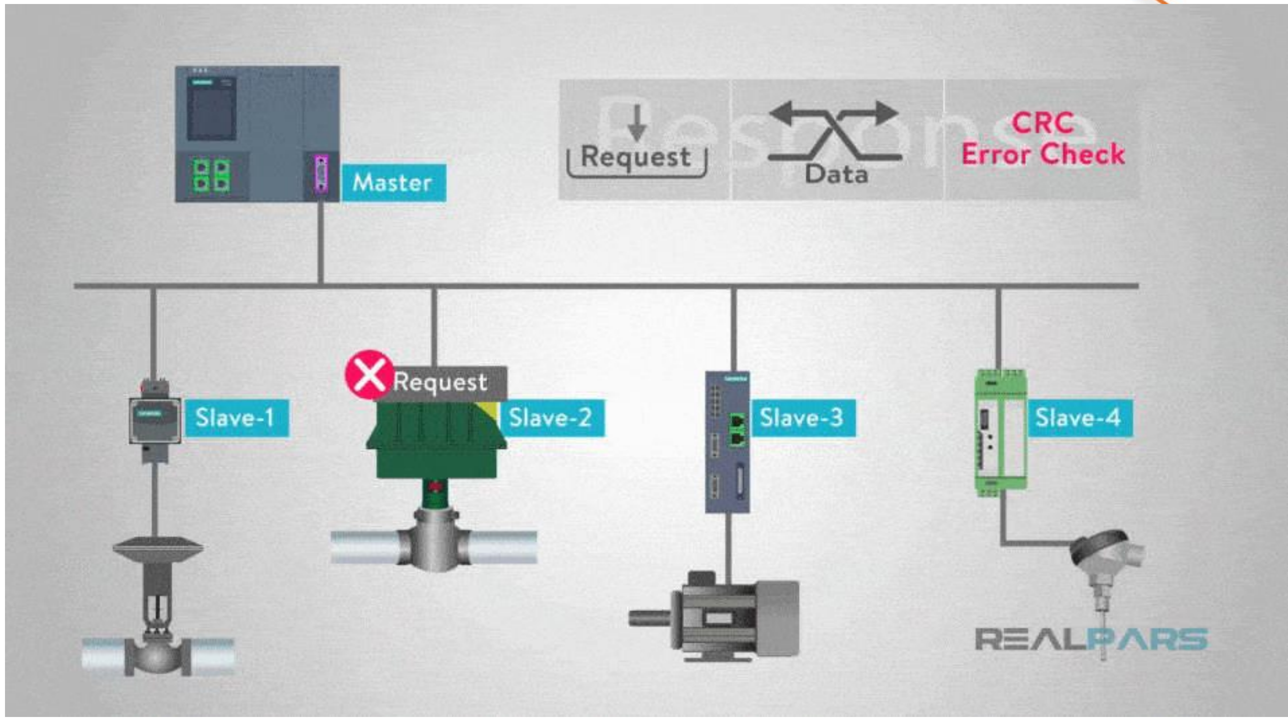
https://realpars.com/wp-content/uploads/2018/12/Modbus-Message-Structure.jpg

Master's query will consist of:

- Slave address (broadcast address).
- Function Code with a read or write data command to the slave.
- The write command "Data" if a write command was initiated by the master.
- Error checking field.

6. Fieldbus Protocols
a. What is Modbus?
Modbus Message Structure

- Slave's response consists of:
- Fields confirming it received the request.
- The data to be returned.
- Error checking dat
- If no error occurs, the slave's response contains the data as requested.



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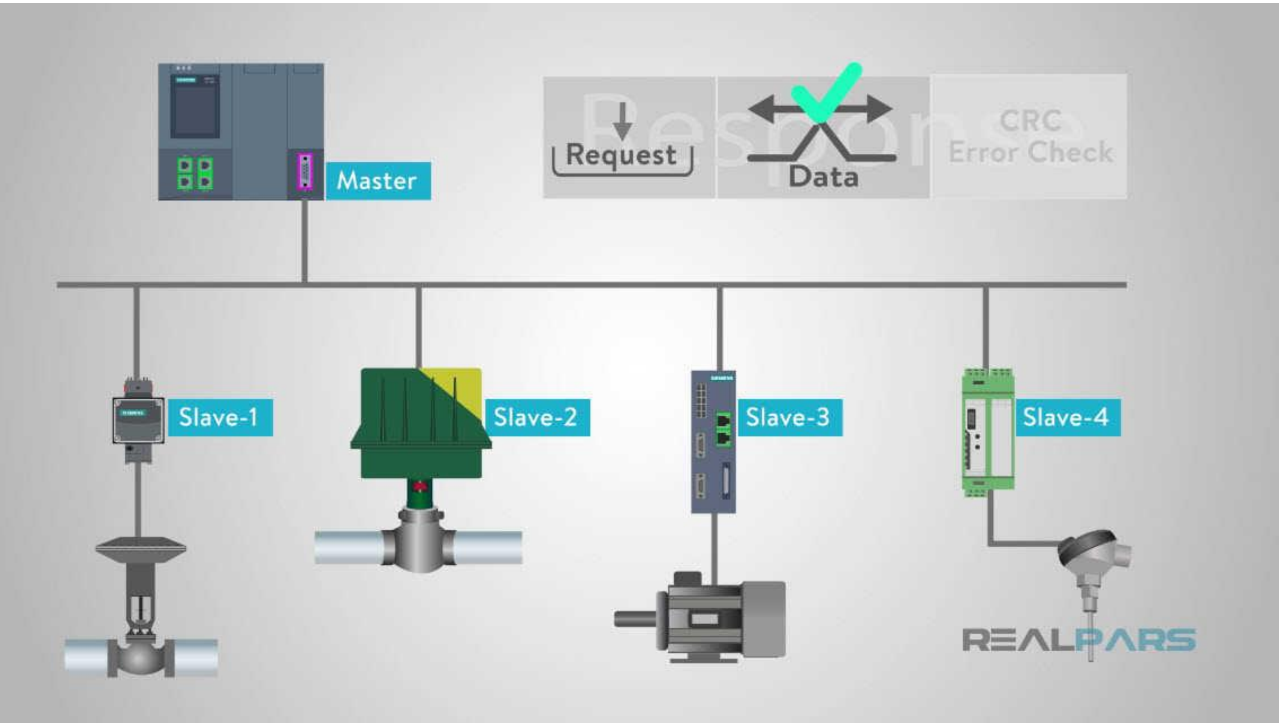
6. Fieldbus Protocols
a. What is Modbus?
Modbus Message Structure



https://realpars.com/wp-content/uploads/2018/12/Modbus-Slave-Response-Structure-1080x607.jpg

- If an error occurs in the message query received by the slave, or if the slave is unable to perform the action requested, the slave will return an exception message as its response.
- The error check field of the slave's message frame allows the master to confirm that the contents of the message are valid.

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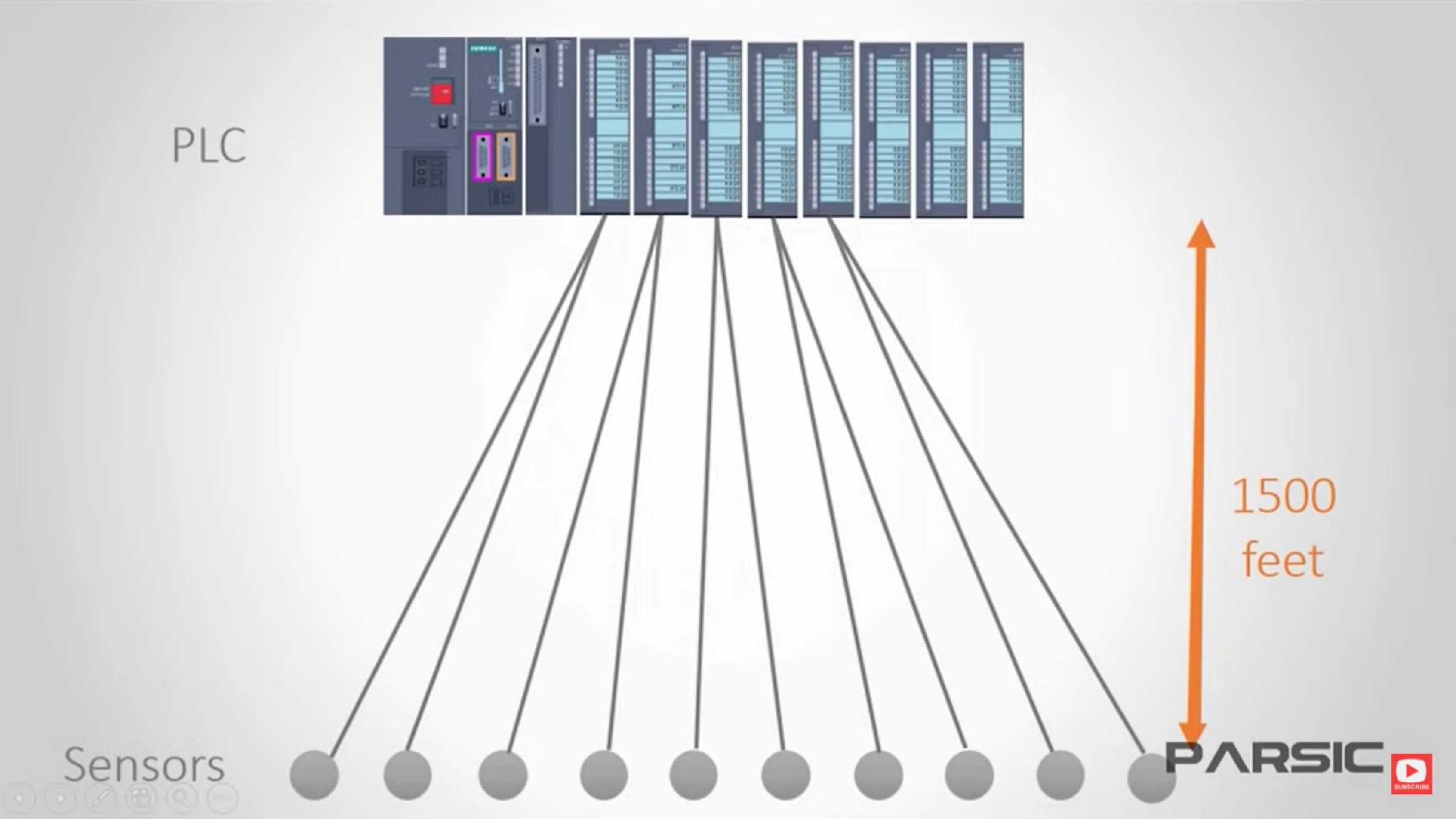
6. Fieldbus Protocols
b. Profibus-DP

- **Pro**cess **Fi**eldbus - **D**ecentralized **P**eripherals



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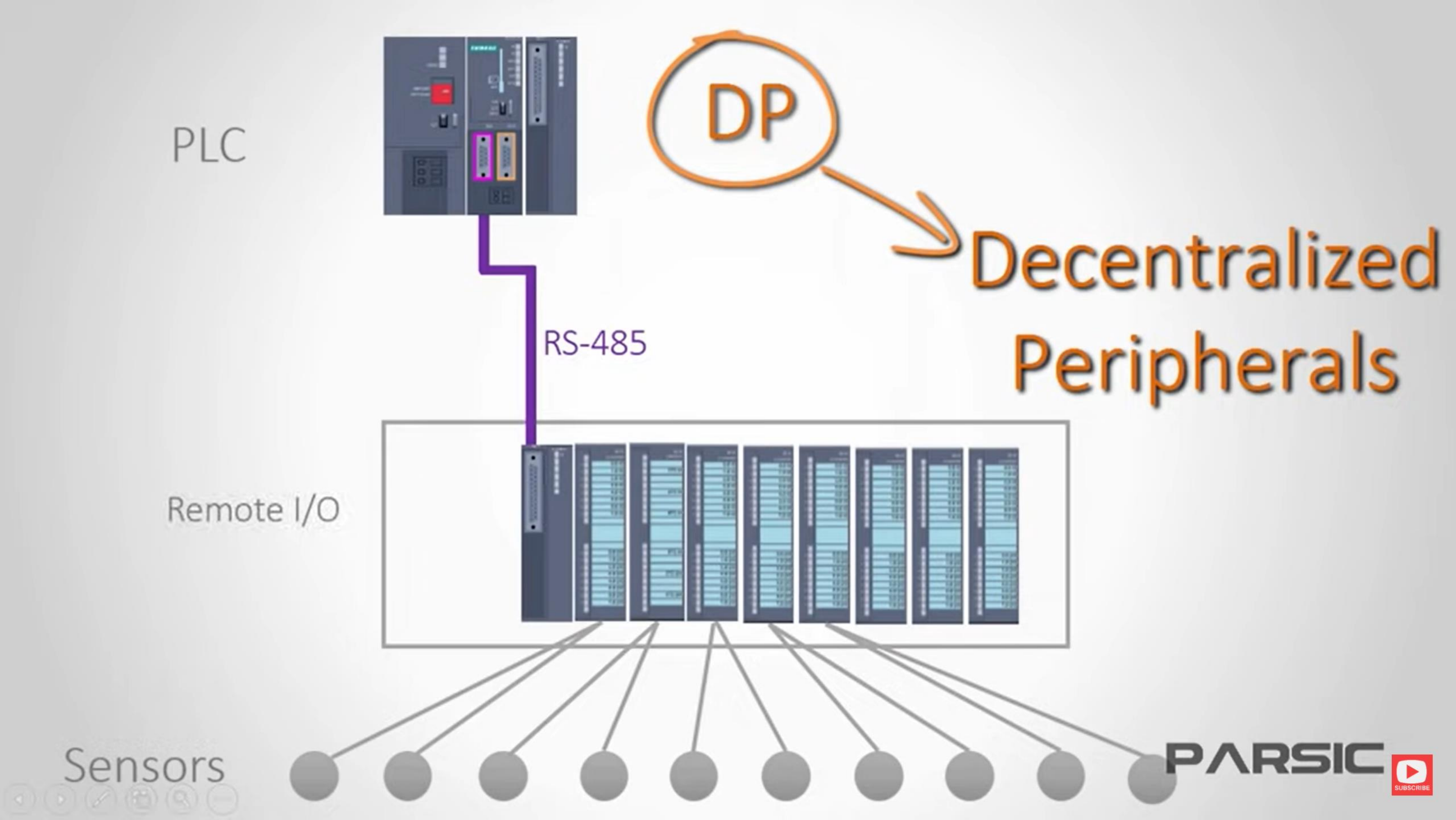
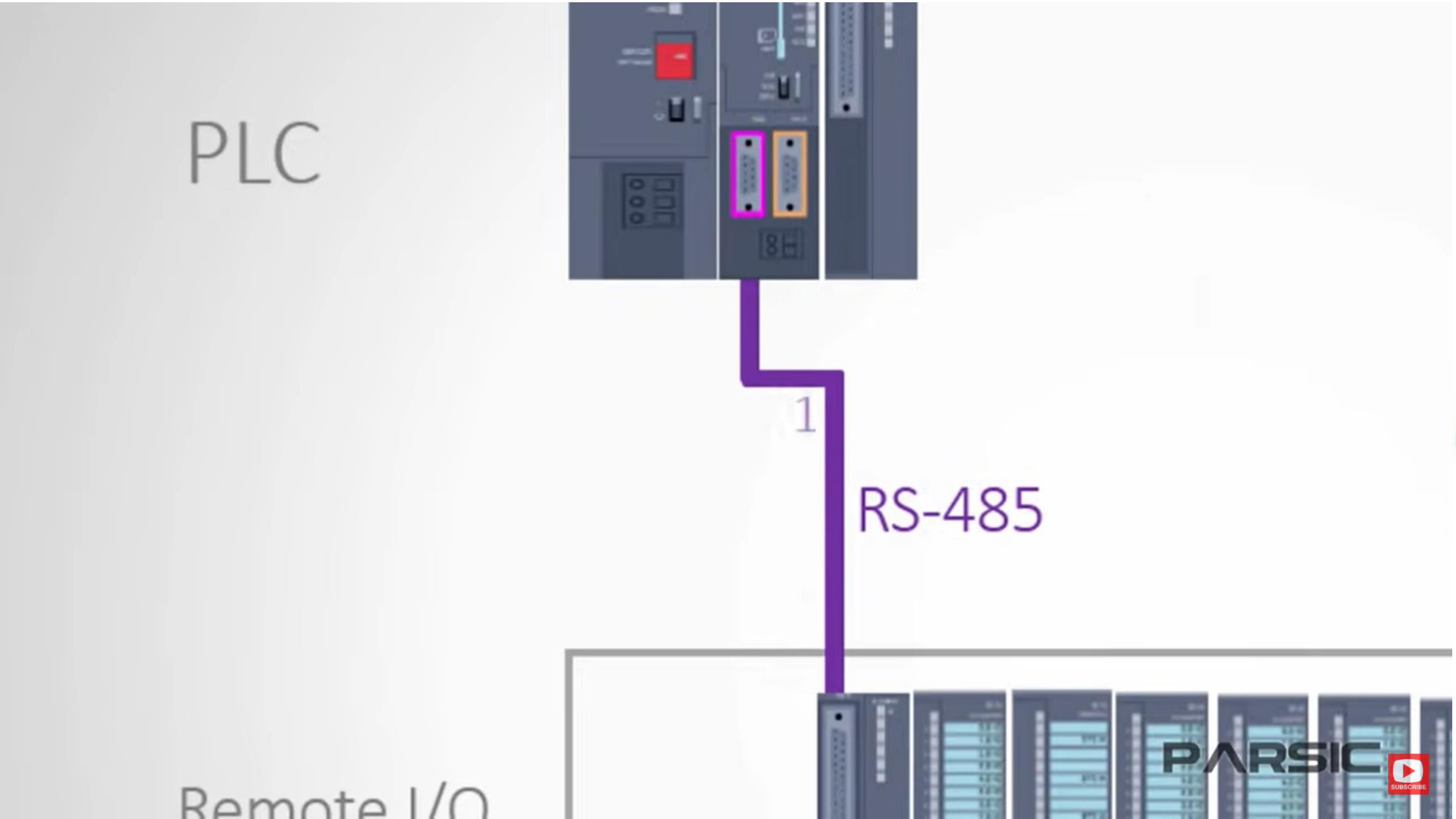
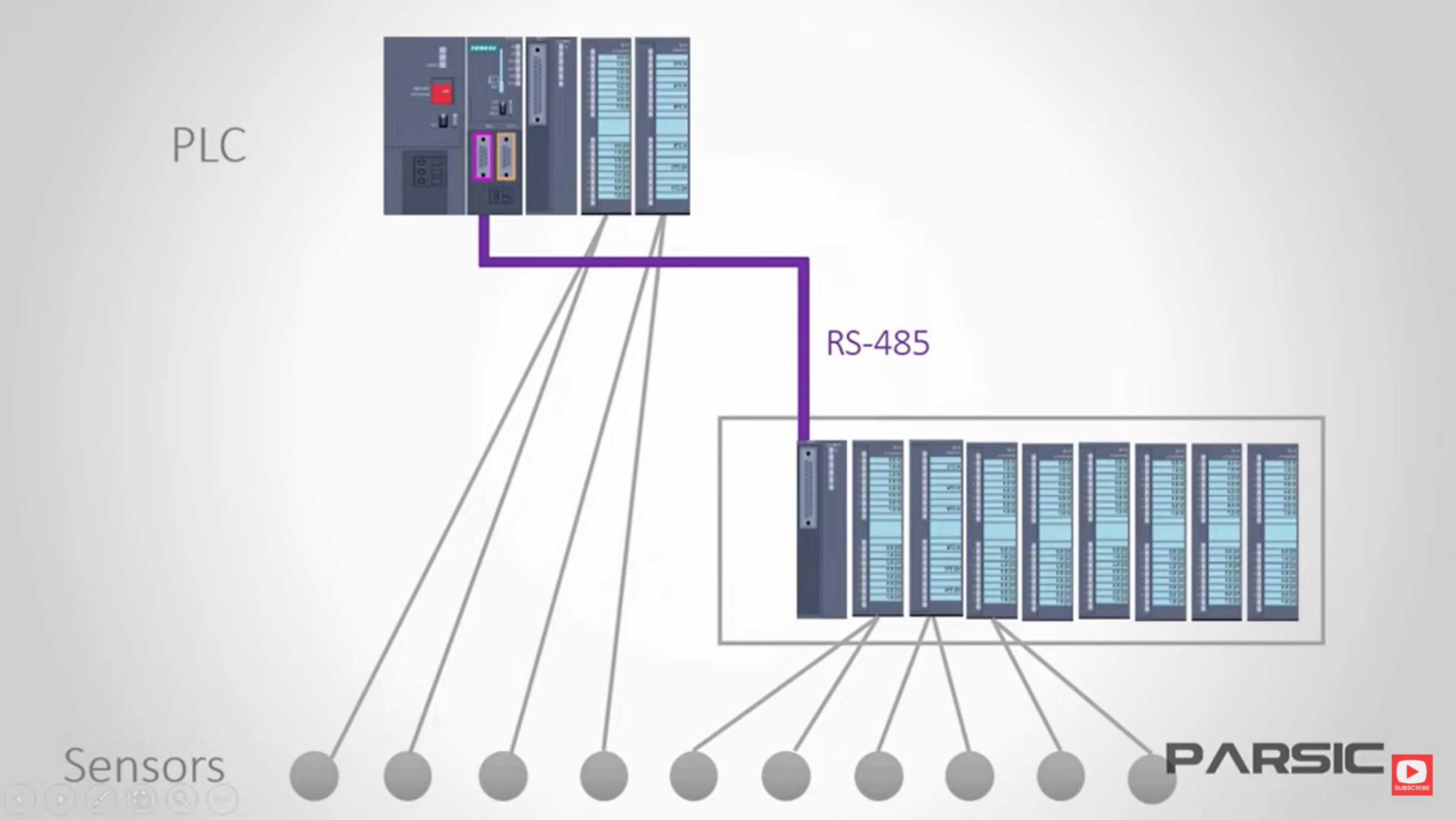
6. Fieldbus Protocols
b. Profibus-DP



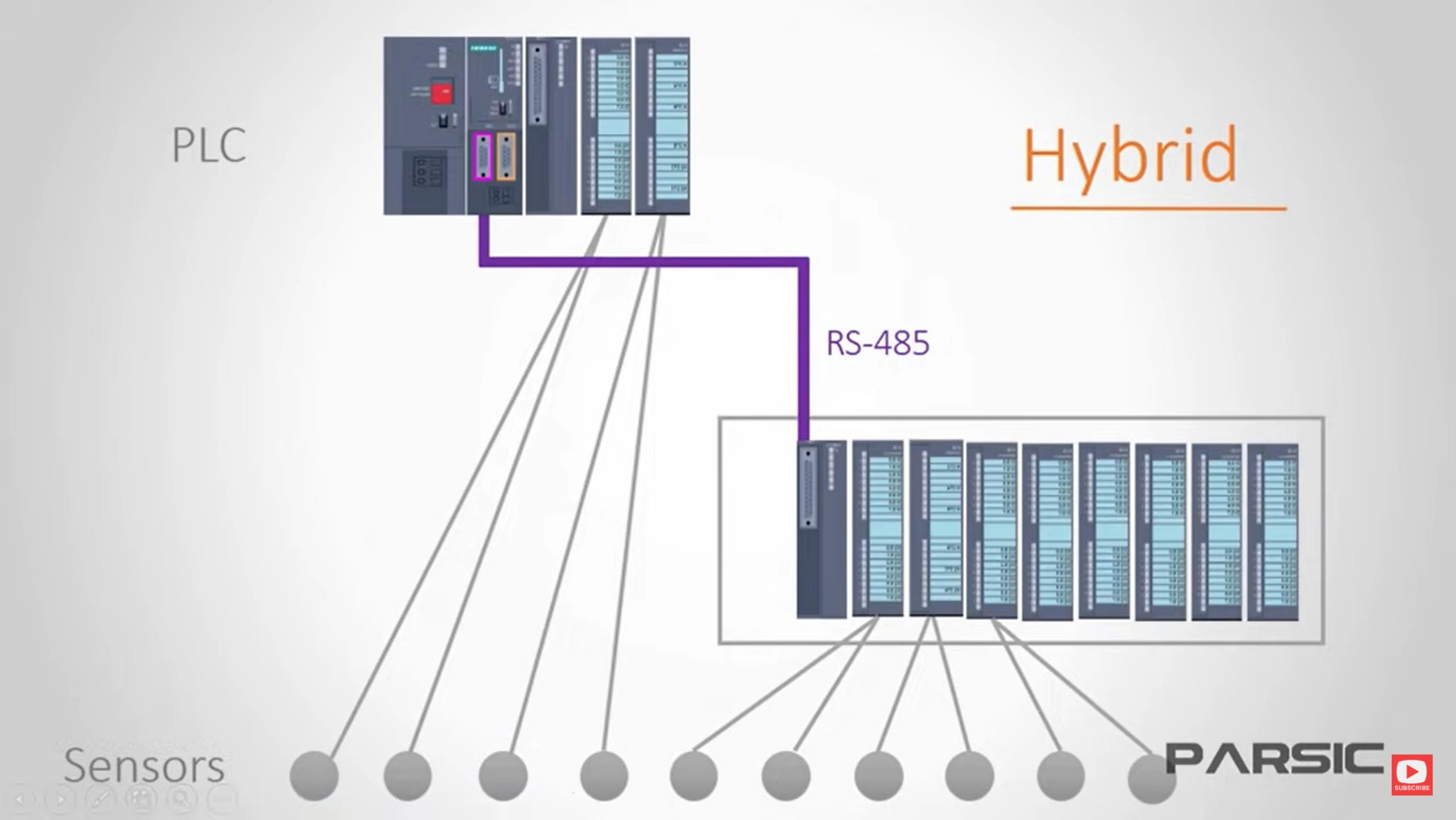
6. Fieldbus Protocols
b. Profibus-DP



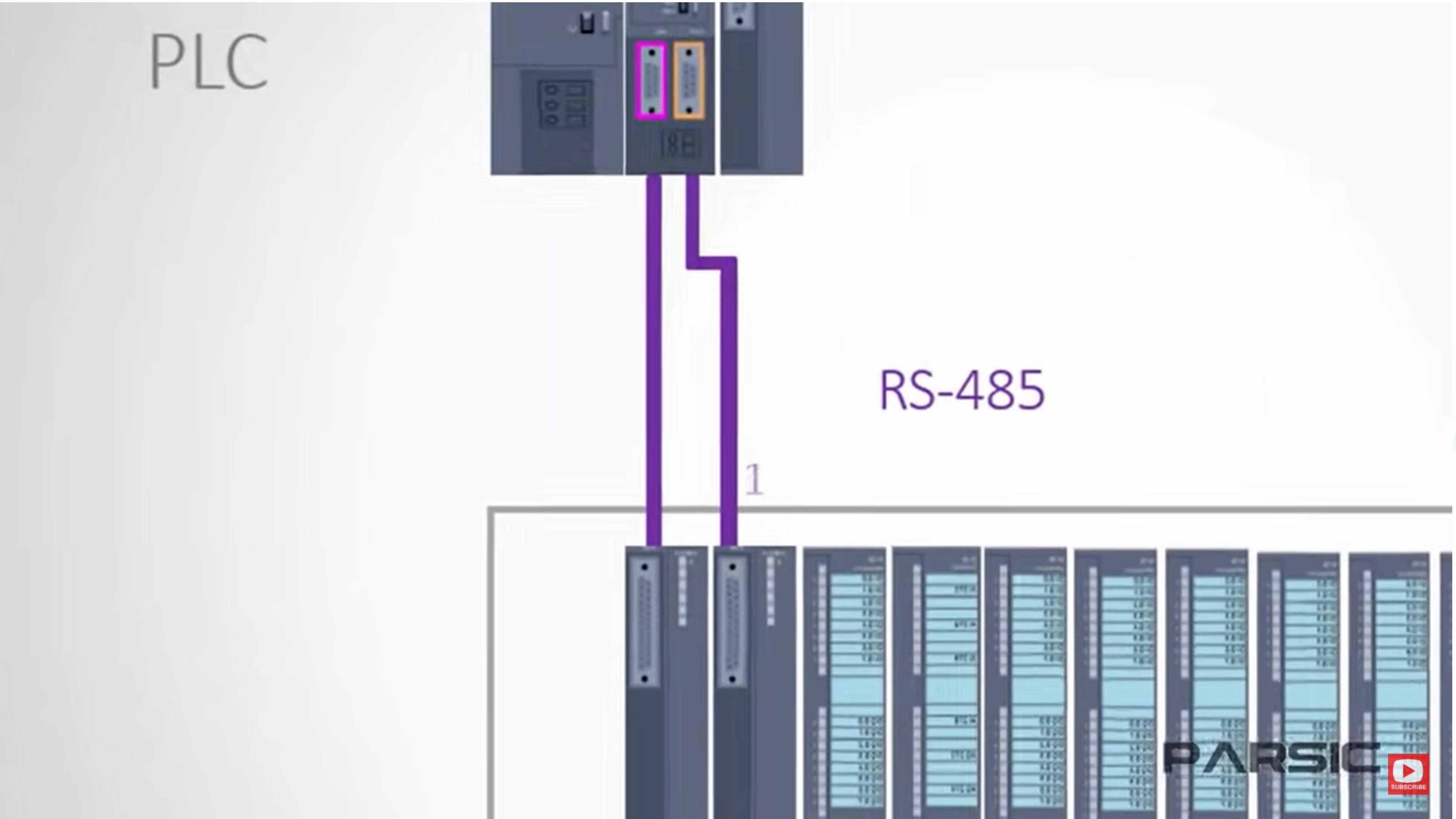
6. Fieldbus Protocols
b. Profibus-DP



6. Fieldbus Protocols
b. Profibus-DP



6. Fieldbus Protocols
b. Profibus-DP



6. Fieldbus Protocols
c. HART
What is HART?

- **H**ighway **A**ddressable **R**emote **T**ransducer
- Device Integration
  - Point-to-point connection of the 4...20 mA signal
  - Connection via a remote I/O or HART multiplexer to a superordinated bus system, e.g. PROFIBUS
  - On rare occasions, connection of a HART multidrop bus to a HART I/O card

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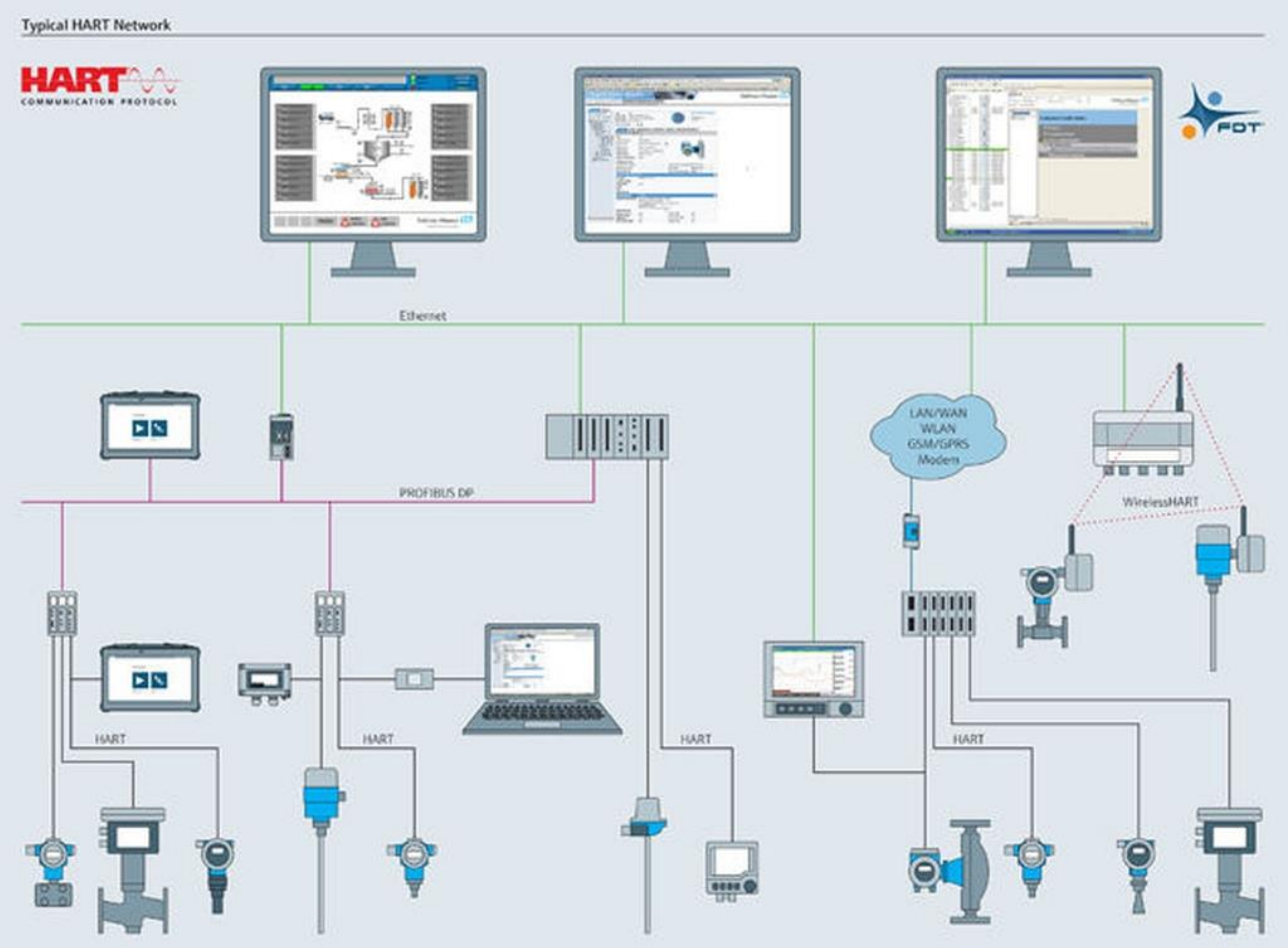
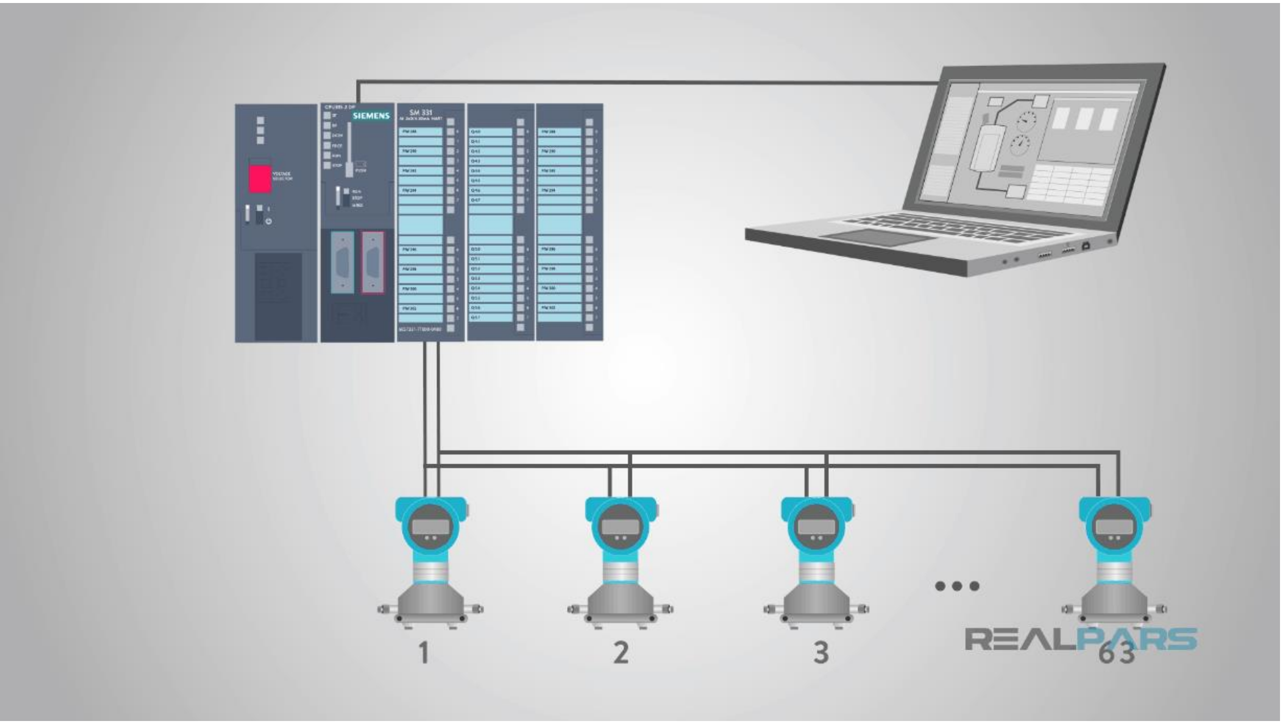


6. Fieldbus Protocols c. HART What is HART?



- Master requests HART sensor.
- Node# + Read Value + Process Value + Other Data + 16

https://realpars.com/wp-content/uploads/2018/06/hart-analog-sensor-access-data-from-control-room.png

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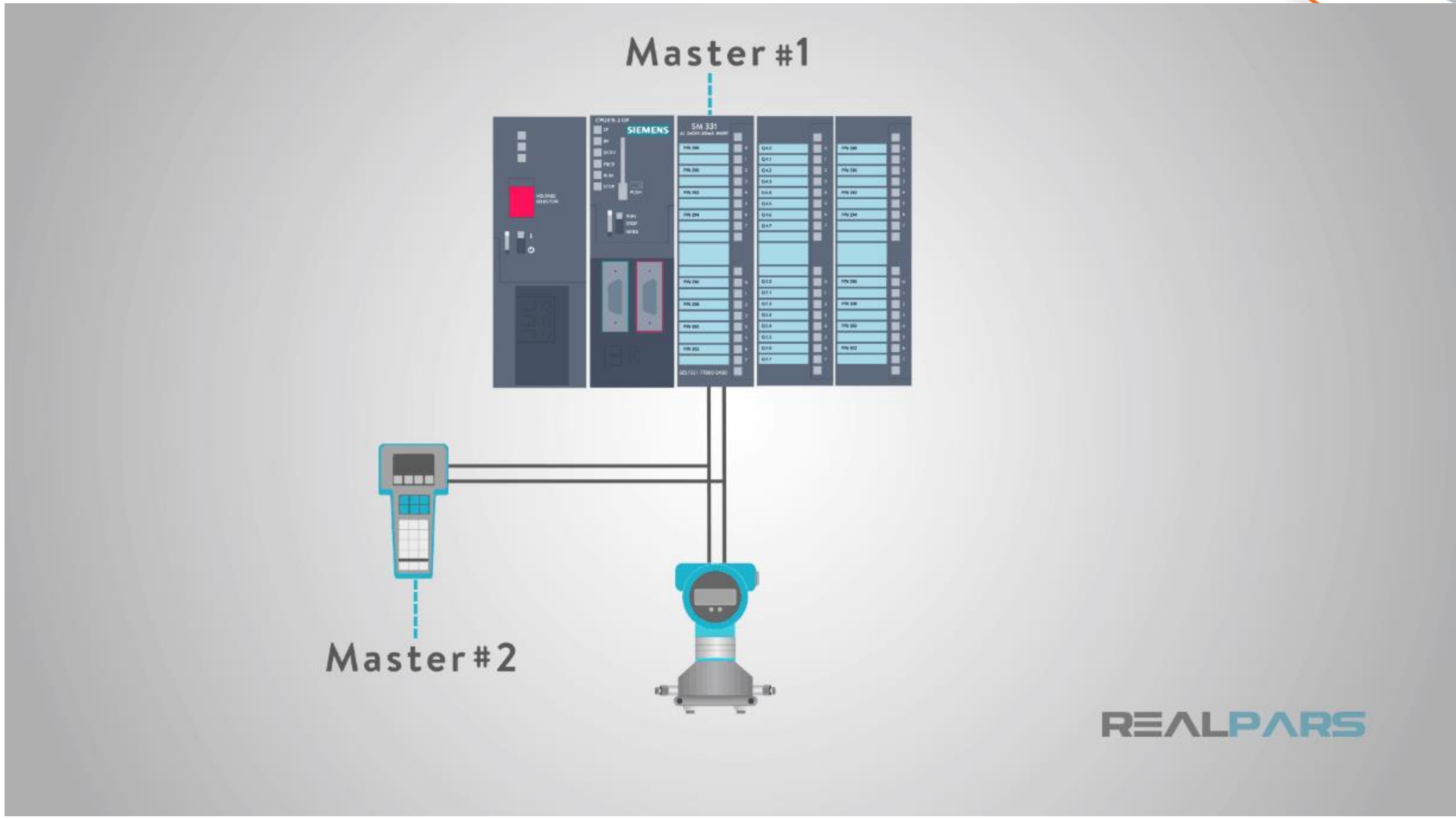
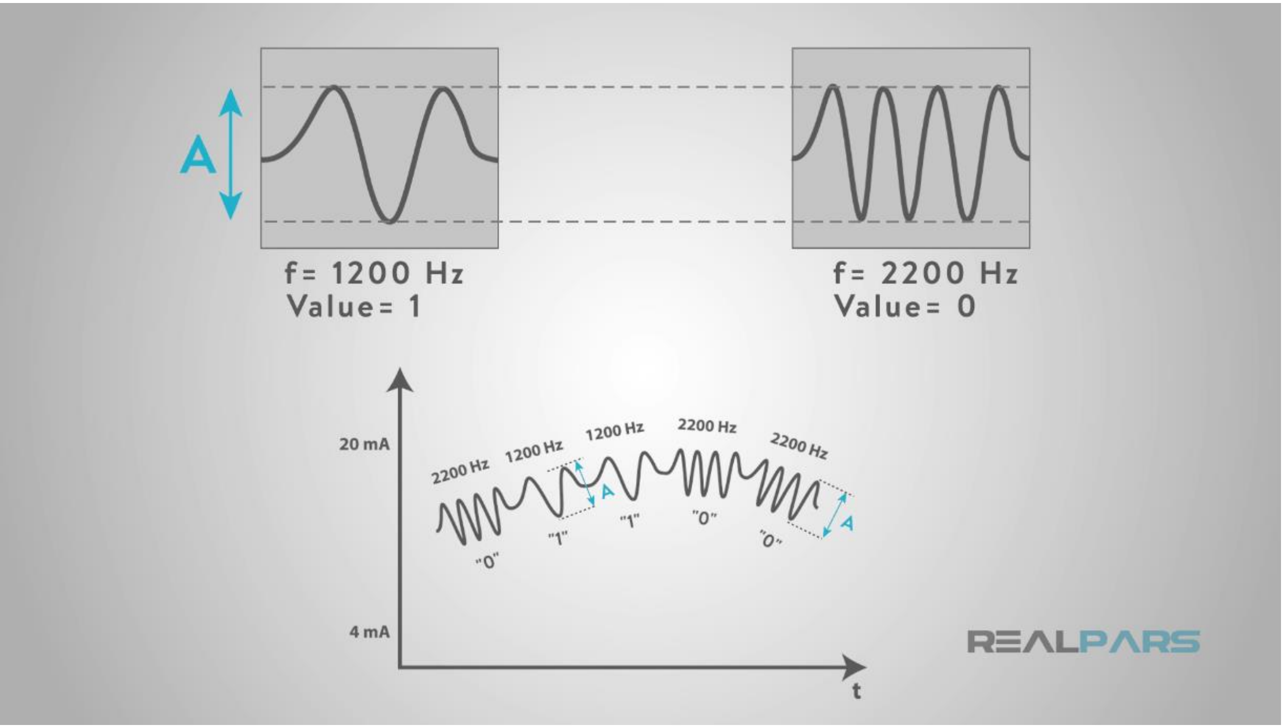
6. Fieldbus Protocols
c. HART
What is HART?

- HART Communicator
- Anywhere in the loop
- Hazardous area?
- Multiple masters



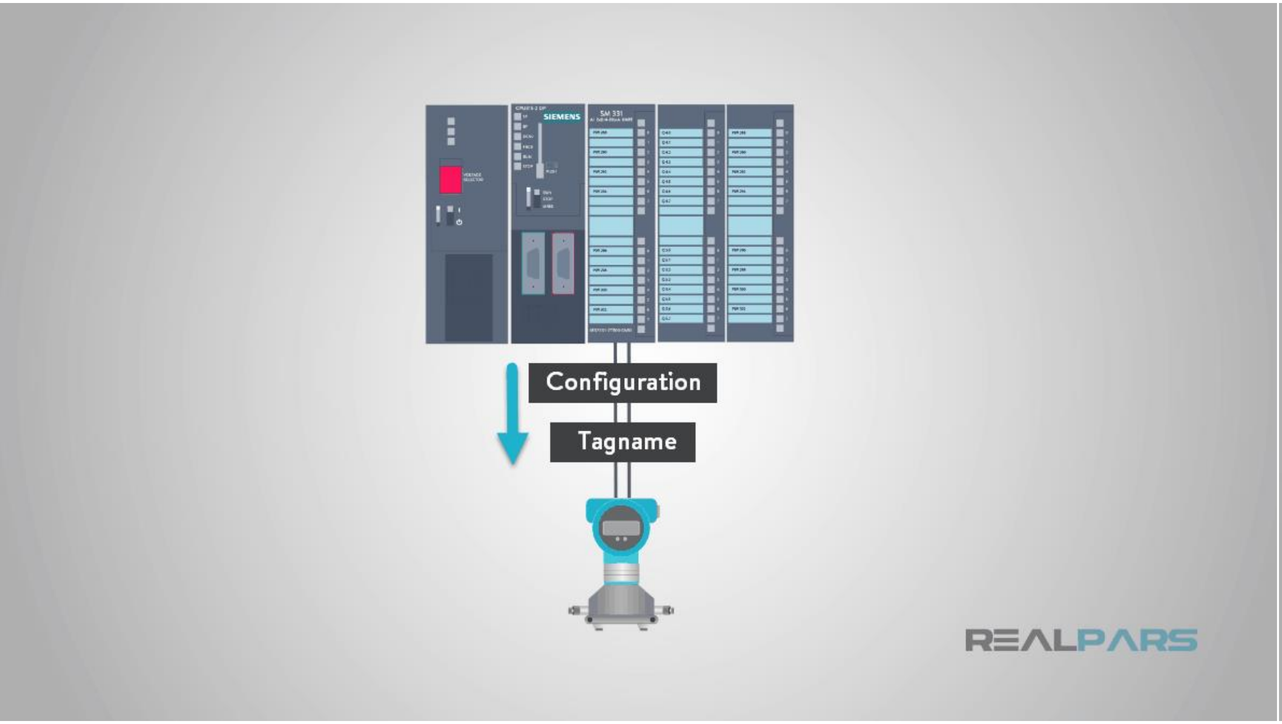
6. Fieldbus Protocols
c. HART
What is HART?

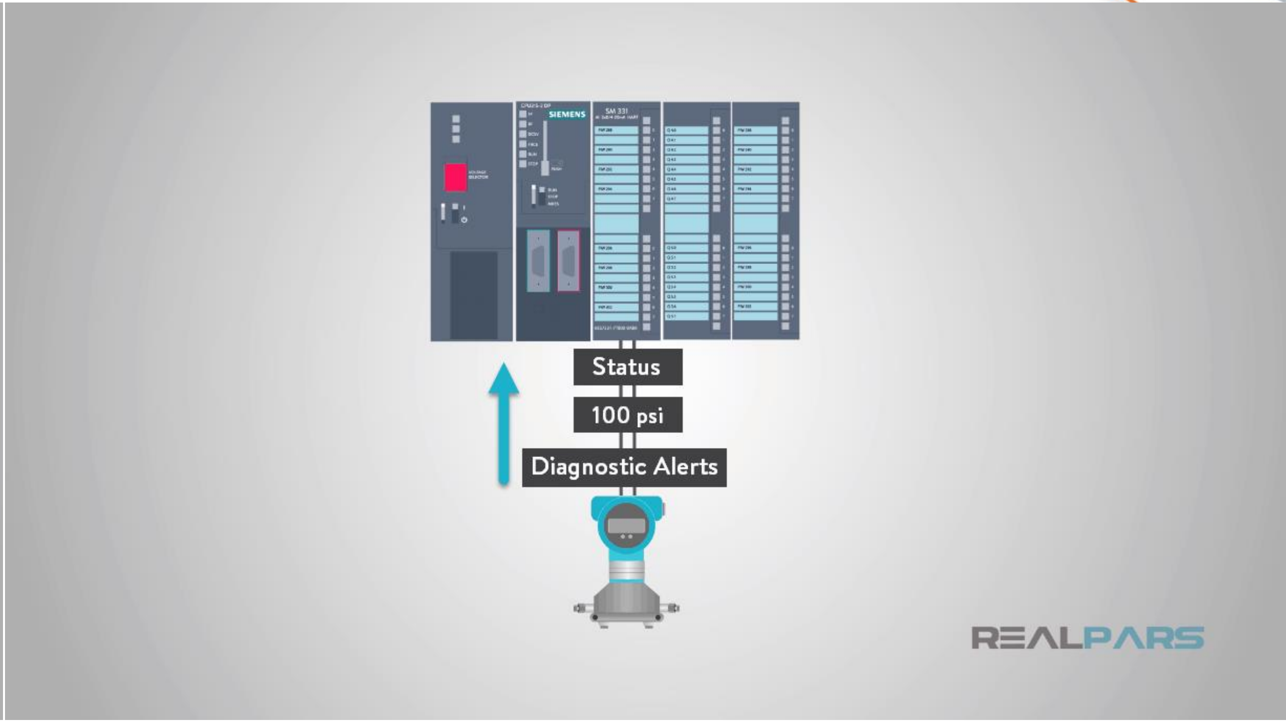


- AC sine wave
- 1 = 1200 Hz
- 0 = 2200 Hz
- Same amplitude
- Net effect is zero
- 4..20mA is not affected by HART.

https://en.wikipediorg/wiki/Current_loop

6. Fieldbus Protocols
c. HART
What is HART?





6. Fieldbus Protocols
d. BACnet

- **B**uilding **A**utomation and **C**ontrol **net**work
- Building automation for
  - **H**eating, **V**entilation, **A**ir-Conditioning **C**ontrol
  - Lighting Control
  - Access Control
  - Fire Detection
  - Associated equipment, etc.

6. Fieldbus Protocols
d. BACnet

- The BACnet protocol defines a number of services that are used to communicate between building devices.
- The protocol services include Who-Is, I-Am, Who-Has, I-Have, which are used for Device and Object discovery.
- Services such as Read-Property and Write-Property are used for data sharing.

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6. Fieldbus Protocols
d. BACnet

- Protocol Implementation Conformance Statements (PICS) Specifying :
  - Communication levels
  - Communication properties
  - System objects

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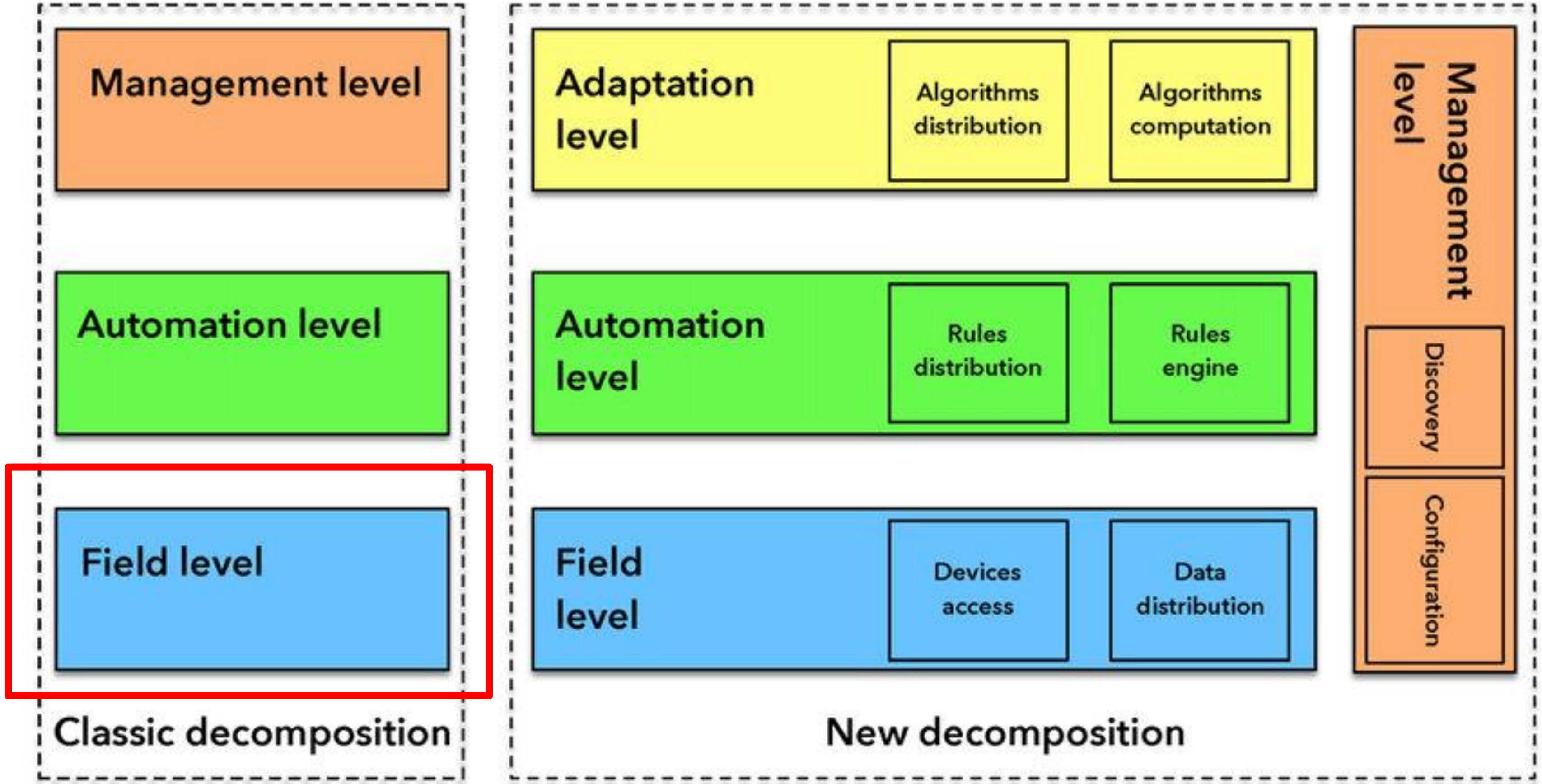
7. Basic Software Application and Operation

Levels of Control (CCMS)



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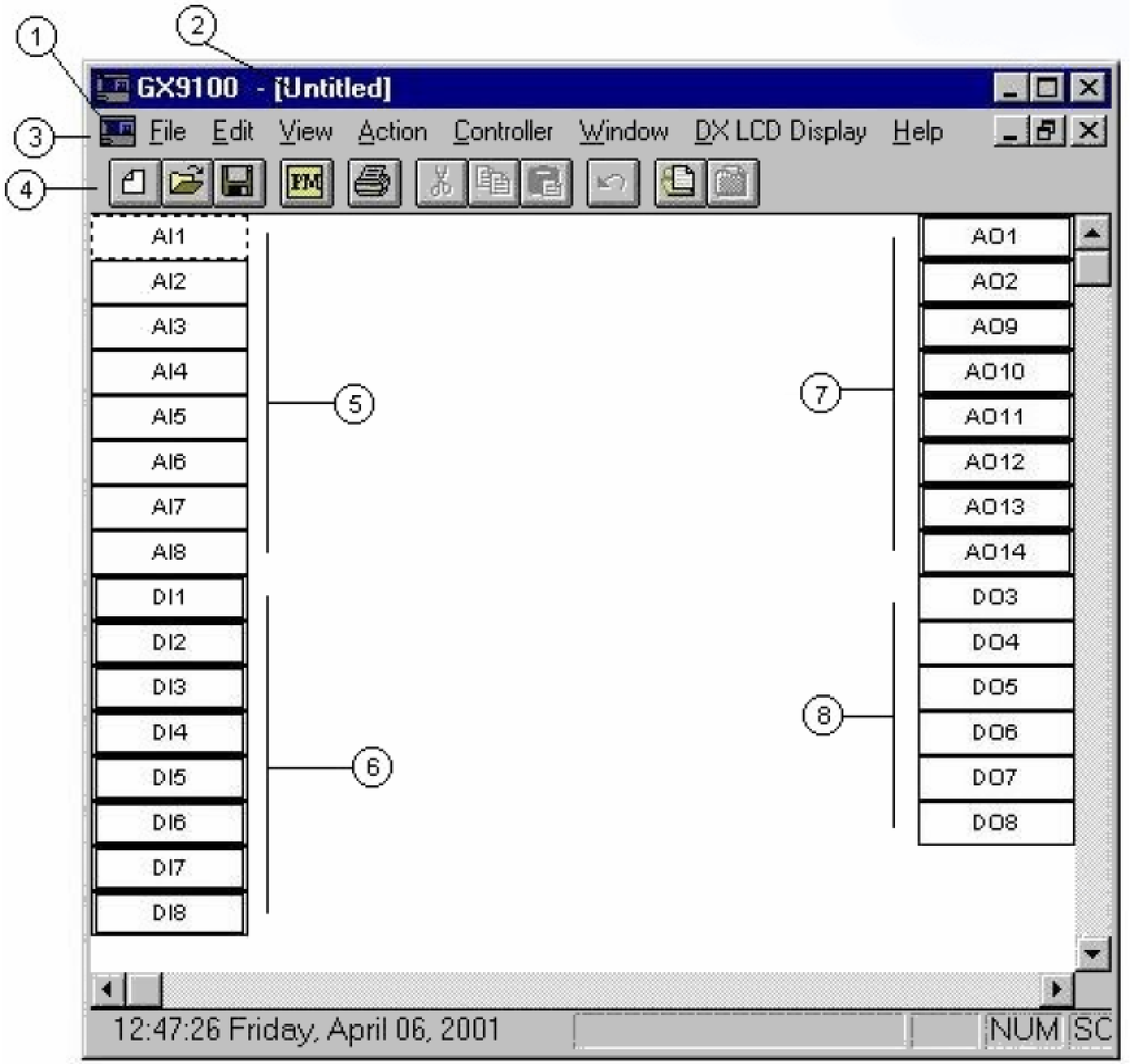
7. Basic Software Application and Operation

Levels of Control - Field Level (CCMS)

- Example 1 - GX-9100 Graphic Configuration Software Tool (GX Tool)
  - Configure the DX series of extended digital plant controllers
  - Configure the XT-9100 and XTM-905 extension modules

7. Basic Software Application and Operation

Levels of Control - Field Level (CCMS)



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7. Basic Software Application and Operation

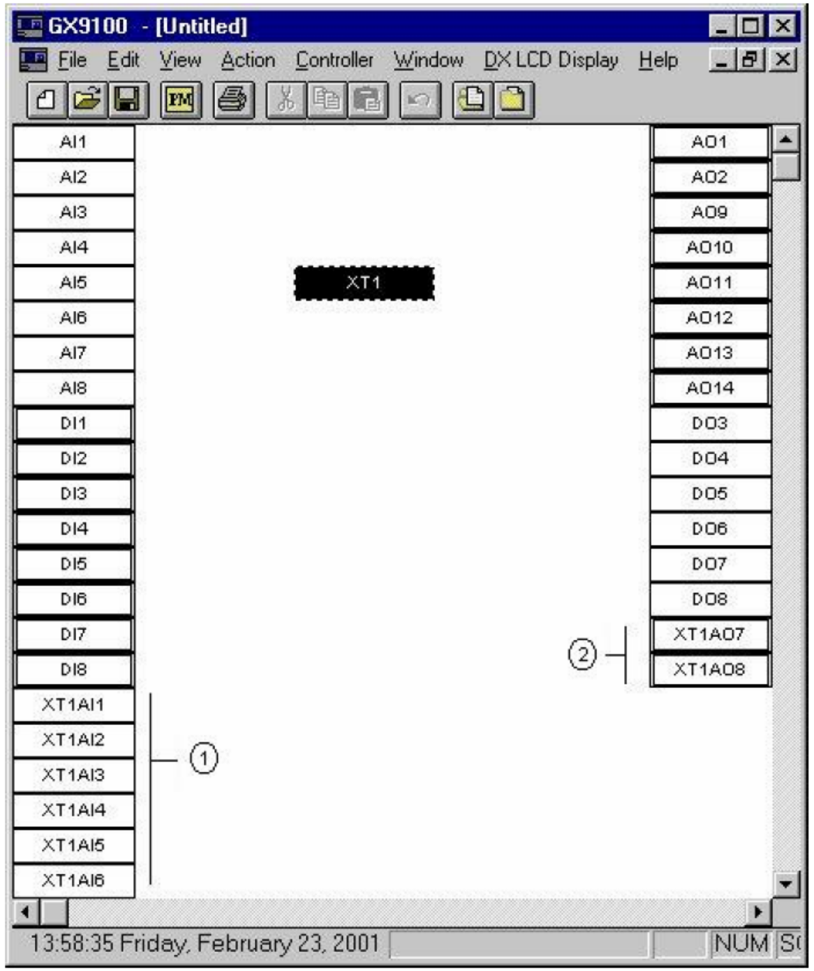
Levels of Control - Field Level (CCMS)

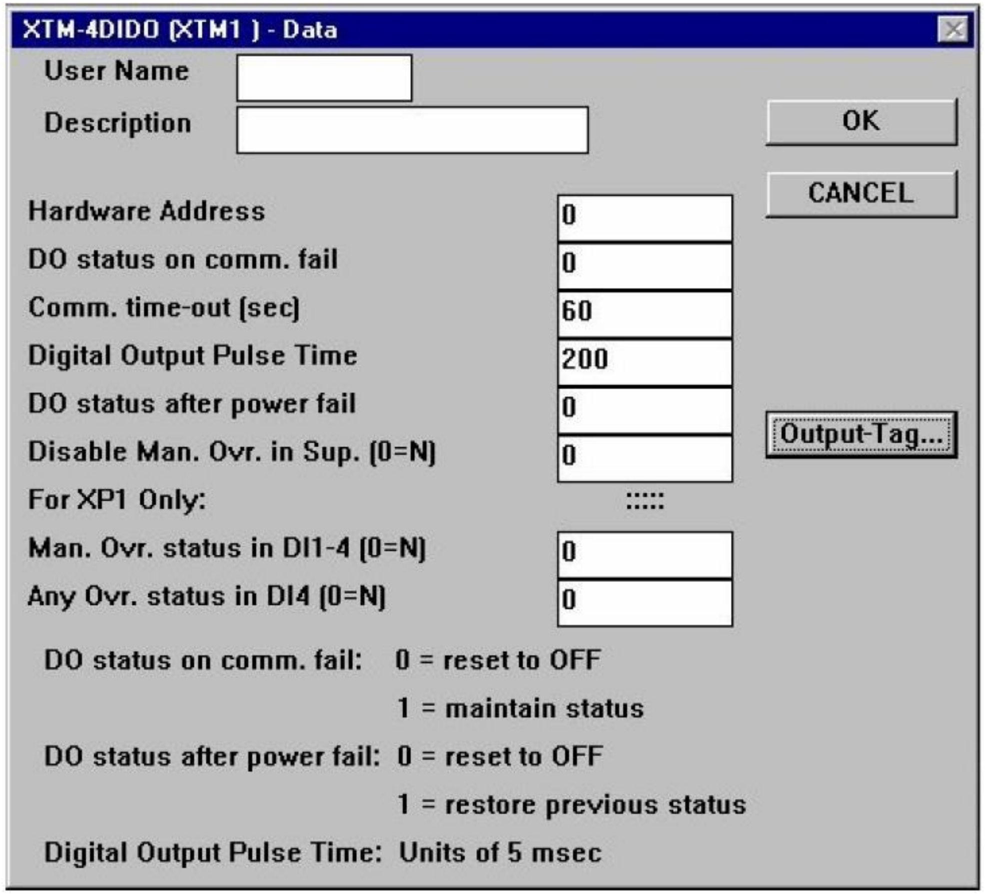
Table 3-6: Action Menu Options

Menu Option	Description
Upload	Uploads a configuration from a DX controller.
Download	Downloads a configuration to a DX controller.
Upload via N30	Uploads a configuration from a DX controller to the PC via an N30 Supervisory Controller. Only appears if enabled in the GX9100.INI file.
Download via N30	Downloads a configuration to a DX controller from the PC via an N30. Only appears if enabled in the GX9100.INI file.

7. Basic Software Application and Operation

Levels of Control - Field Level (CCMS)





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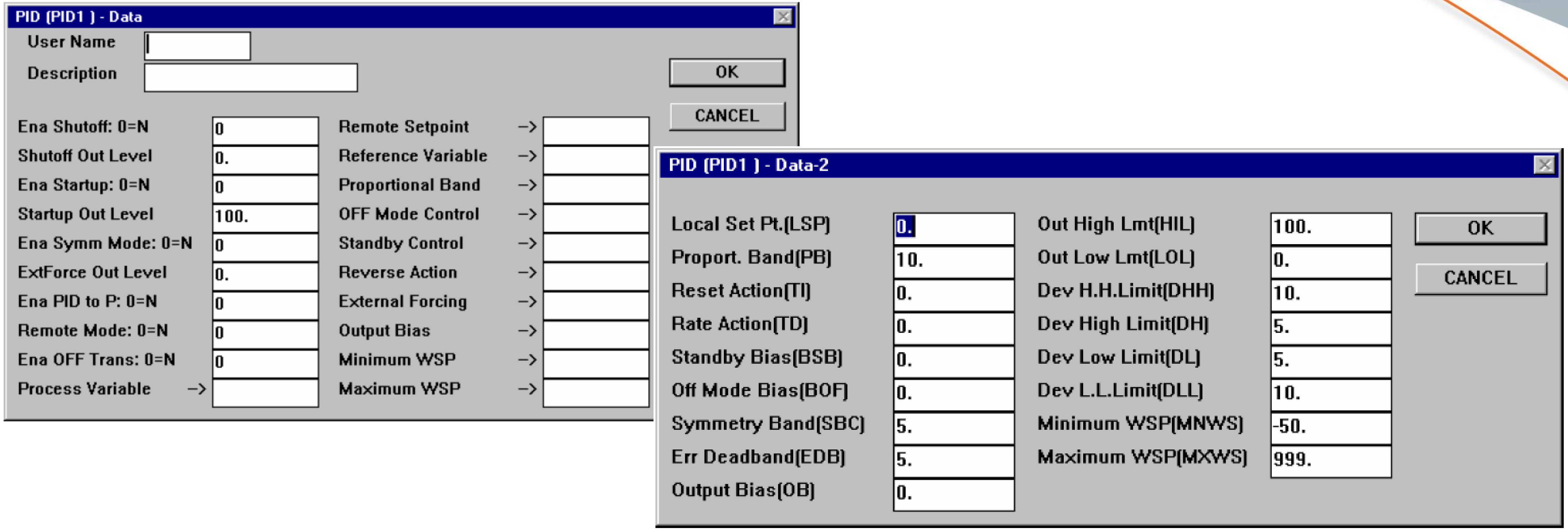
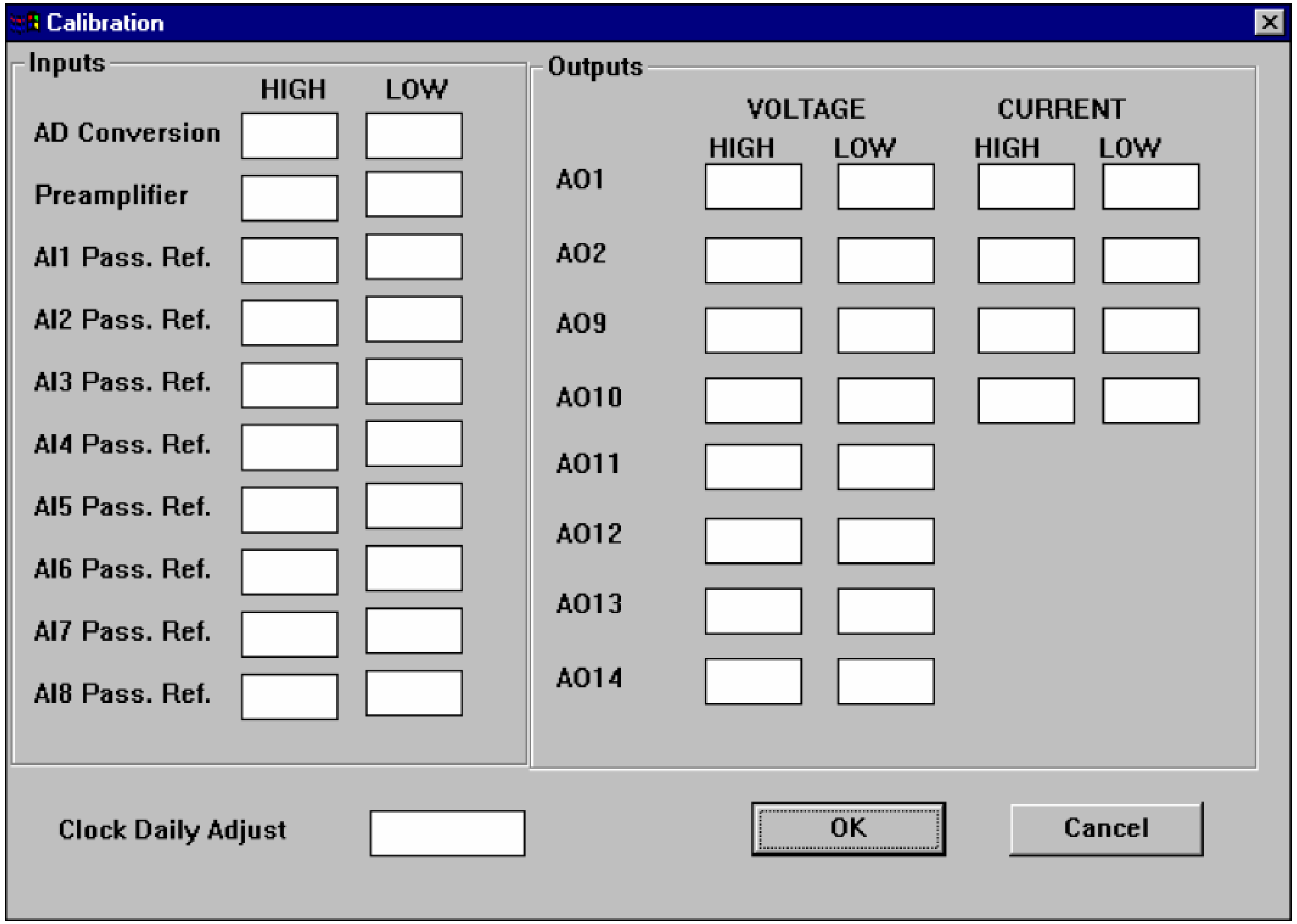
7. Basic Software Application and Operation

Levels of Control - Field Level (CCMS)



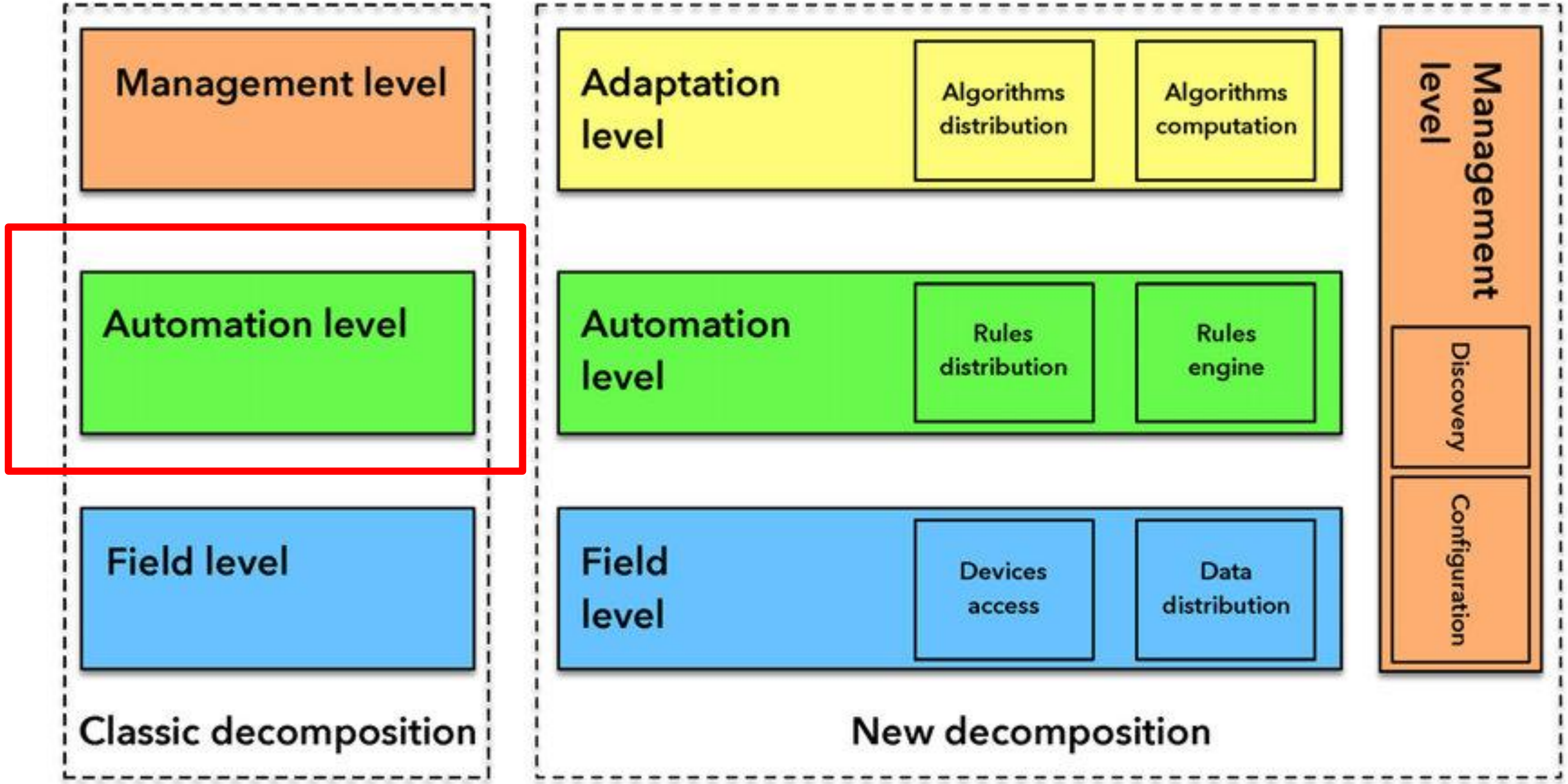
7. Basic Software Application and Operation

Levels of Control - Field Level (CCMS)



7. Basic Software Application and Operation

Levels of Control (CCMS) - Automation



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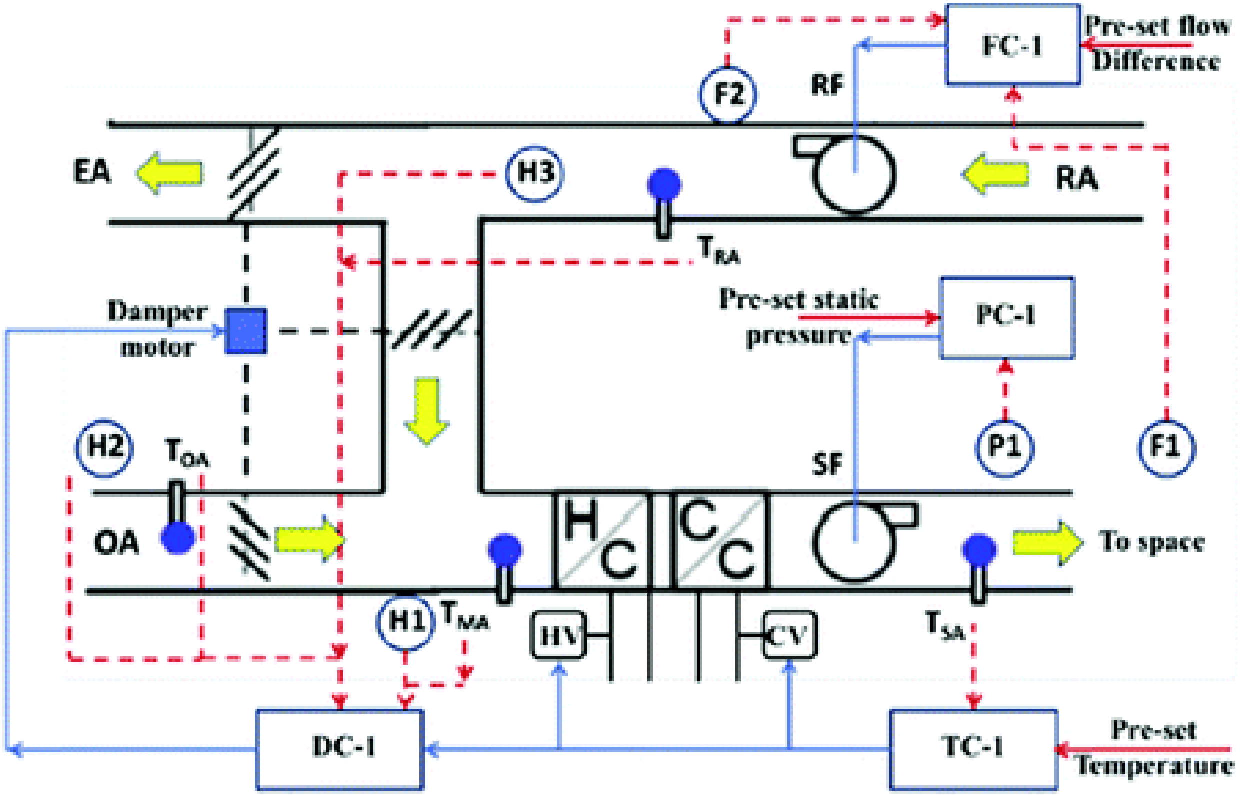
7. Basic Software Application and Operation

Levels of Control (CCMS) - Automation



TC-1: Supply air temperature controller
DC-1: Damper controller
PC-1: Supply air static pressure controller
FC-1: Return air flow rate controller
HV: Heating coil valve
CV: Cooling coil valve
SF: Supply fan
RF: Return fan
T: Temperature sensor; H: Humidity sensor; P: Pressure sensor; F: Flow sensor.

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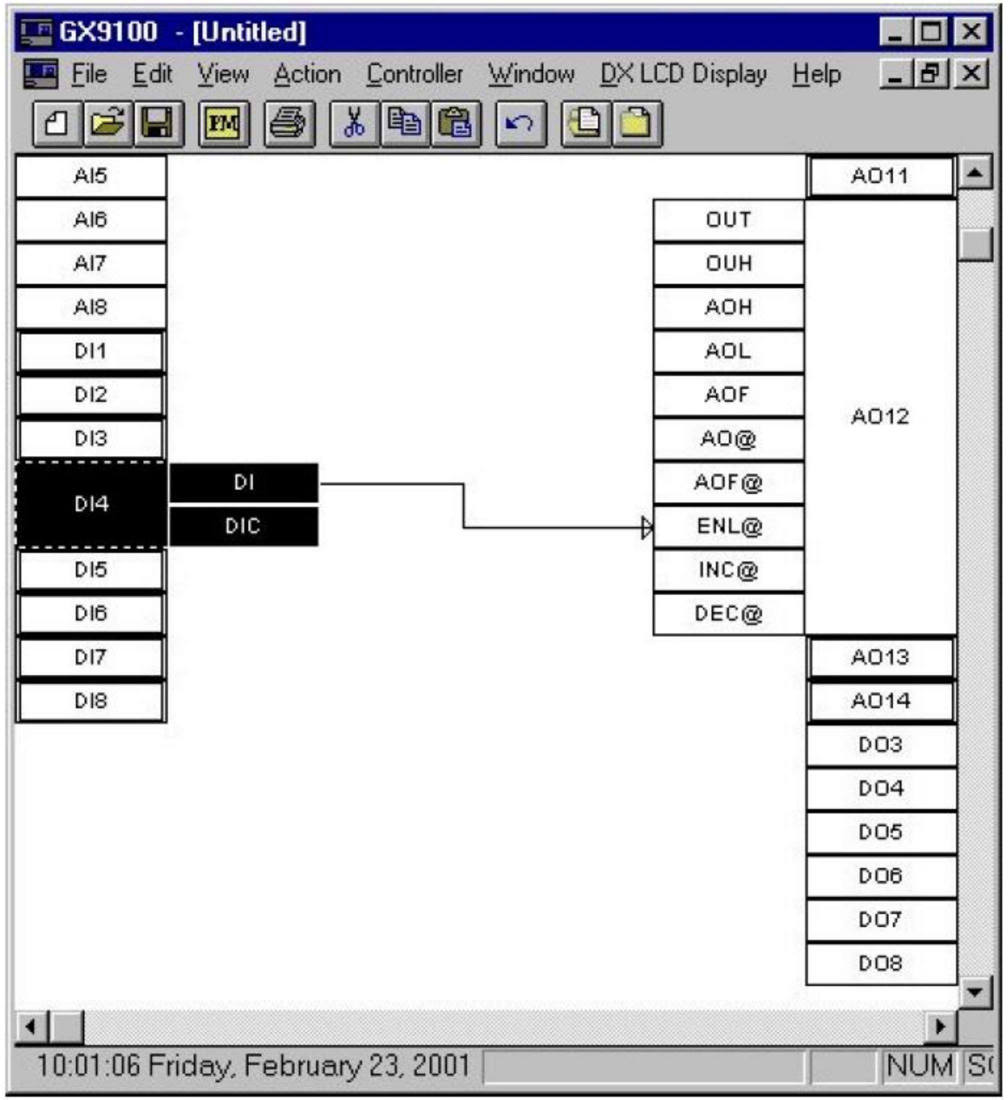
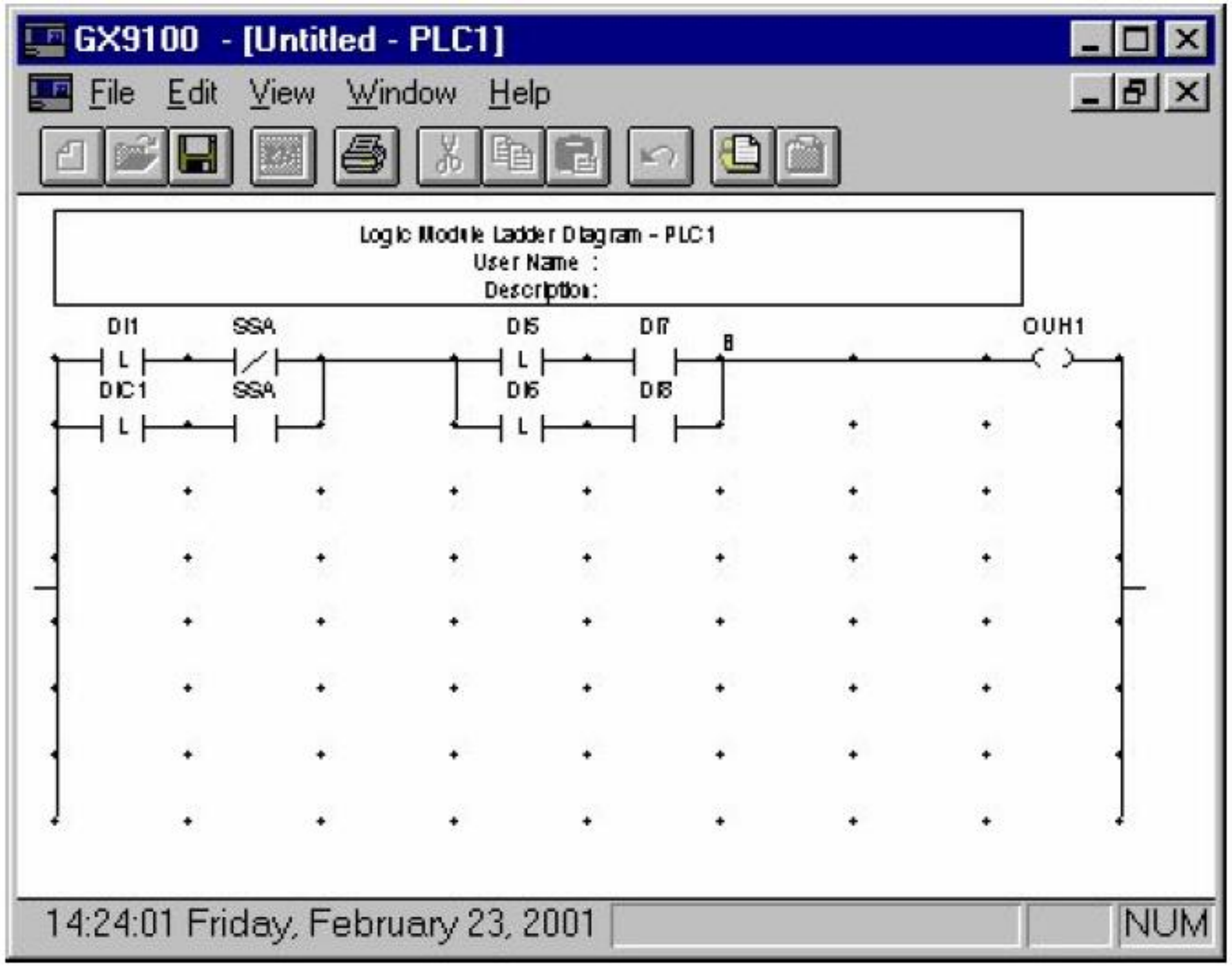
7. Basic Software Application and Operation

Levels of Control - Field Level (CCMS)



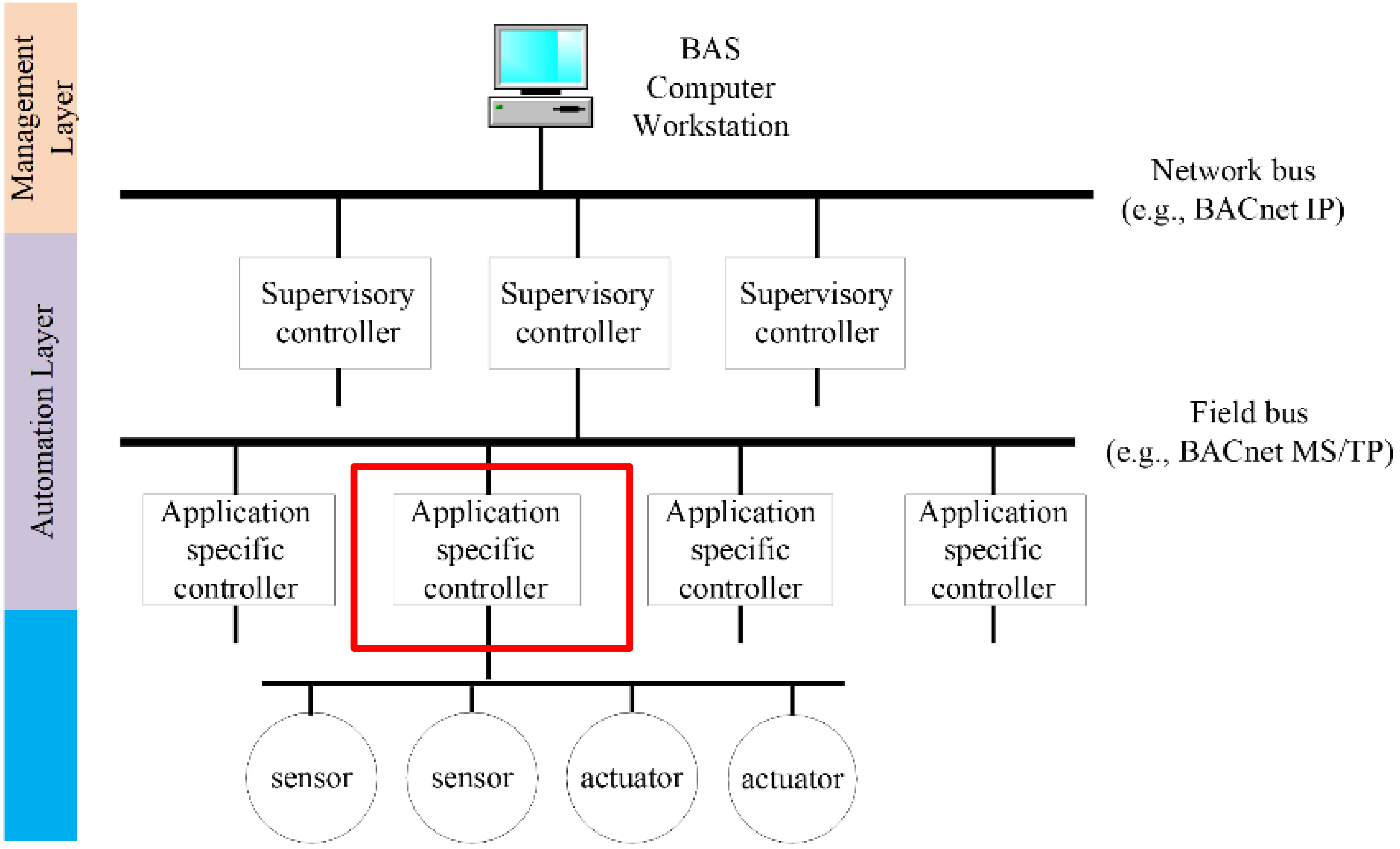
7. Basic Software Application and Operation

Levels of Control - Field Level (CCMS)



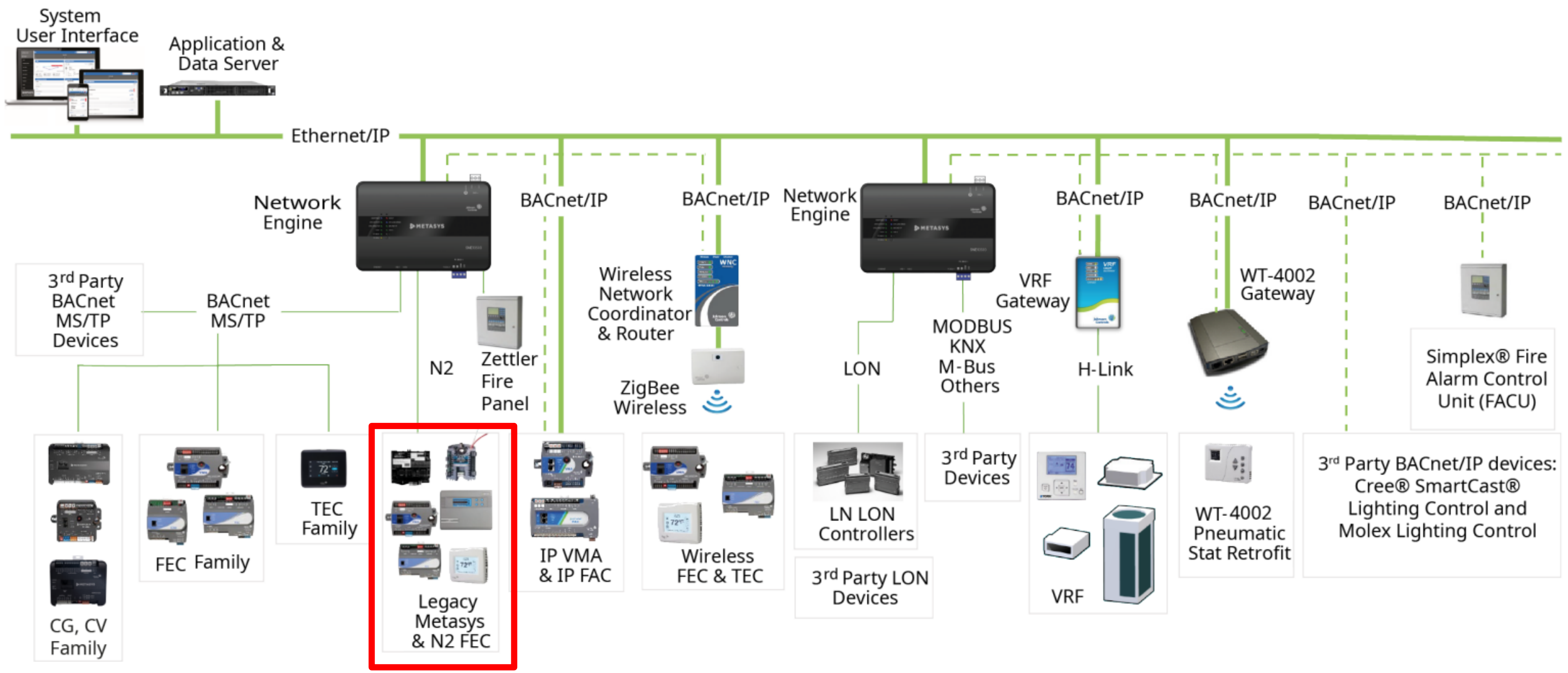
7. Basic Software Application and Operation

Levels of Control (CCMS) - Field Level



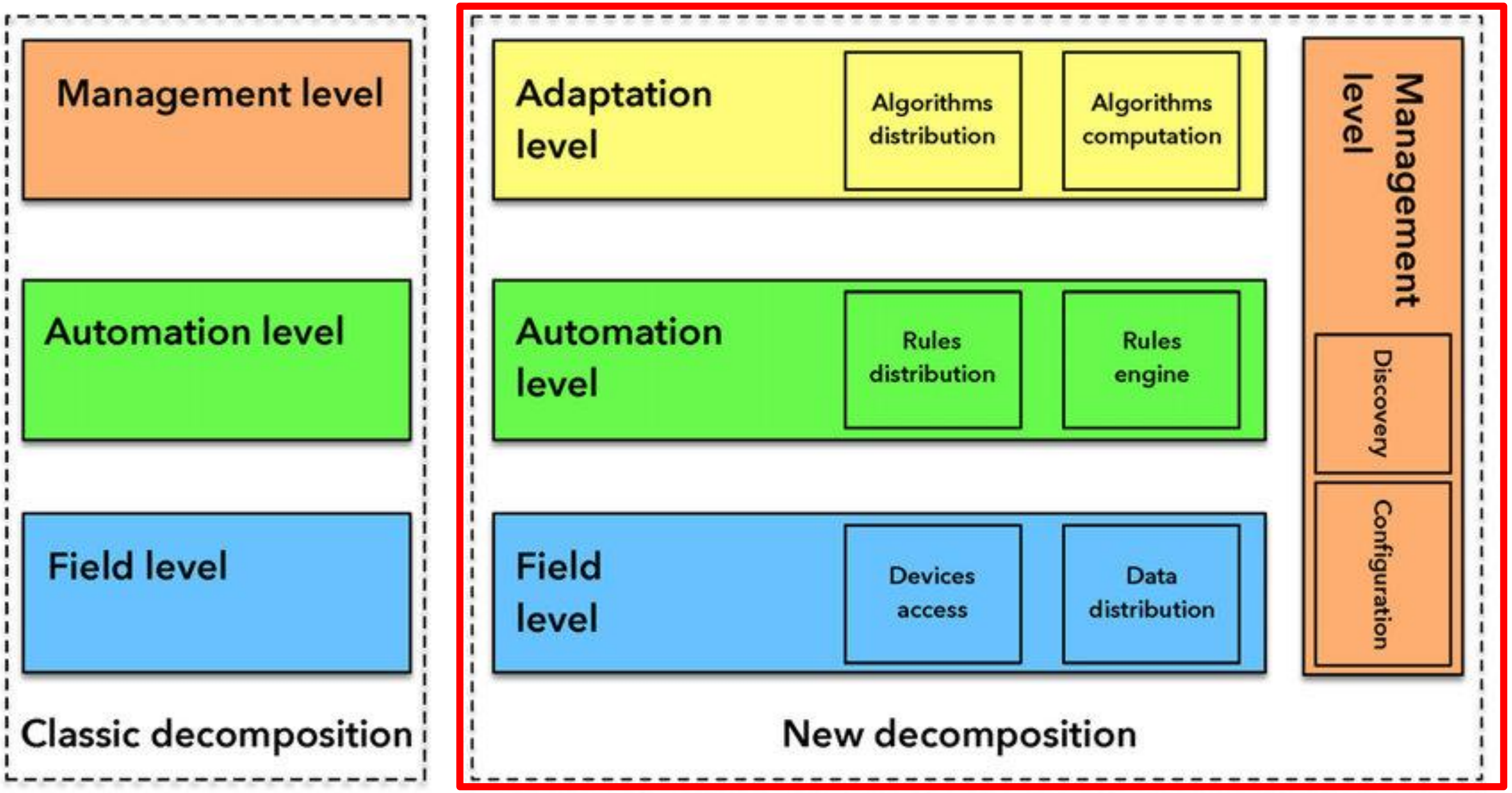
7. Basic Software Application and Operation

Levels of Control - Field Level (CCMS)



7. Basic Software Application and Operation

Levels of Control in New decomposition



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7. Basic Software Application and Operation

Levels of Control - Field Level (CCMS)

- Example 2 - Controller Configuration Tool (CCT)
  - Configure FEC (Field Equipment Controllers) and IOM (I/O Modules)
  - Simulate the program logic before downloading the controllers
  - Commission FEC family controllers to upload and download program

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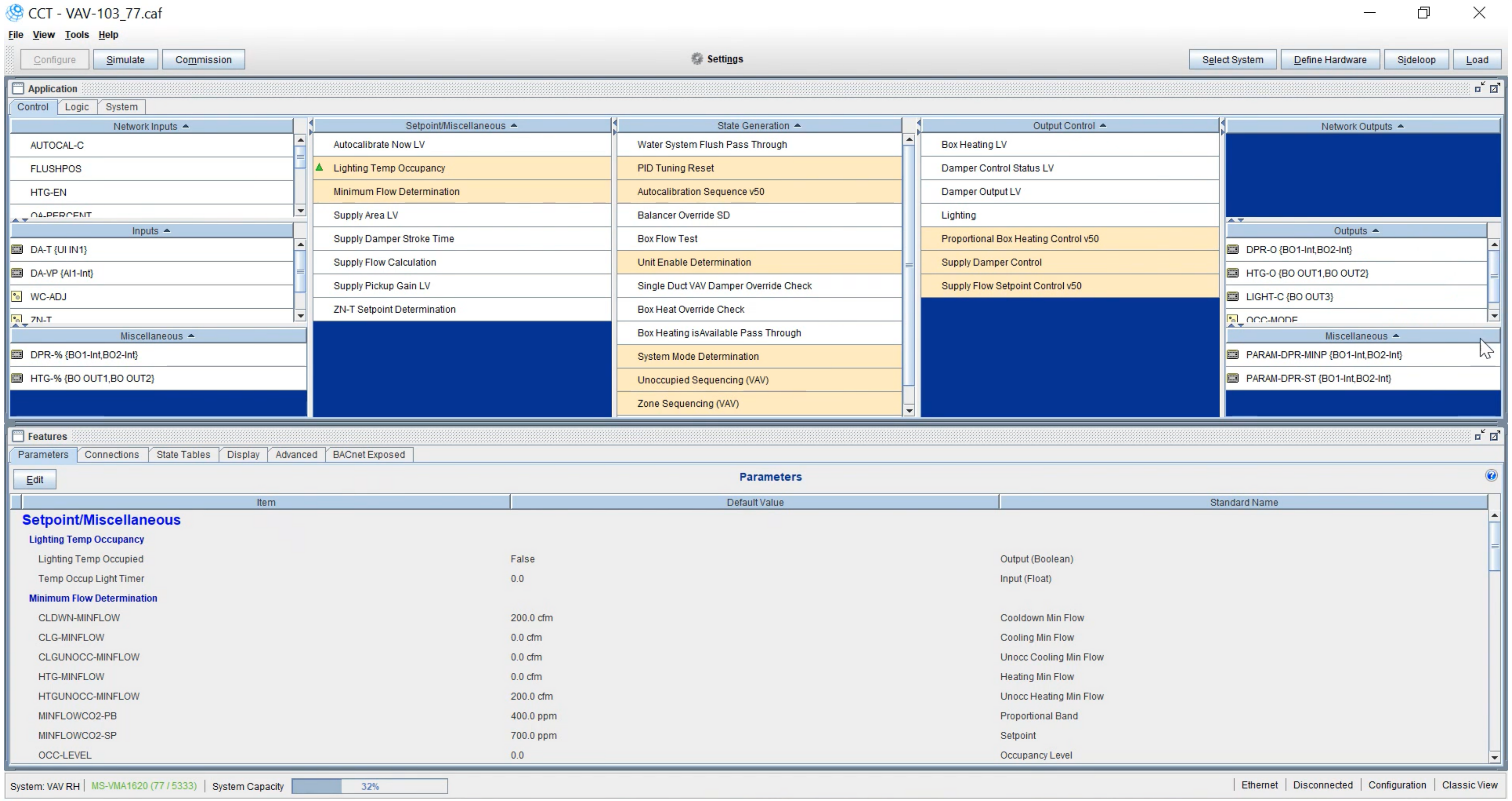
Levels of Control - Field Level (CCMS)



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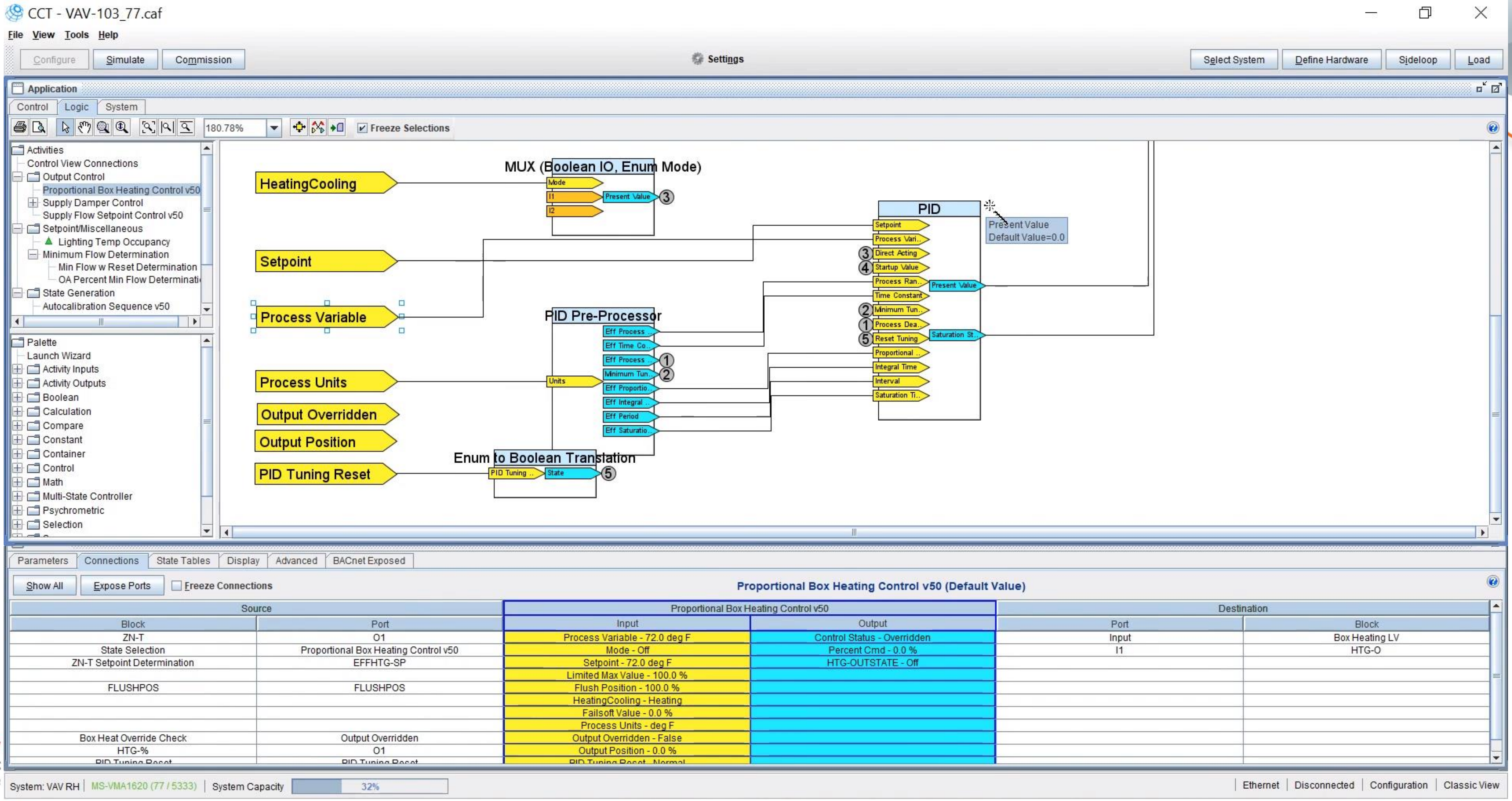
7. Basic Software Application and Operation



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7. Basic Software Application and Operation

Levels of Control - Field Level (CCMS)

Edit

PID

Attribute	Value
Object	
Name	
Object Identifier	PID:10036
Setup	
Manual Tuning	False
Setpoint Differential	1.0
Staged Output	False
Operational Data	
Tuning Updated	False
PRAC Prop Band	16.0
PRAC Integral Time	729.0

Inputs

Name	Standard Name	Default Value	Units	Display Precision	BACnet Exposed
Process Variable	Use Attribute String	0.0		10ths	False
Setpoint	Use Attribute String	0.0		10ths	False
Minimum Tune Band	Use Attribute String	0.9		10ths	False
Startup Value	Use Attribute String	0.0		10ths	False
Low Limit	Use Attribute String	0.0		10ths	False
High Limit	Use Attribute String	100.0		10ths	False
Offset	Use Attribute String	0.0		10ths	False
Direct Acting	Use Attribute String	True			False
Adaptive Tuning	Use Attribute String	True			False
Process Range	Use Attribute String	22.0		10ths	False
Time Constant	Use Attribute String	720.0	seconds	10ths	False
Process Dead Time	Use Attribute String	72.0	seconds	10ths	False
Proportional Band	Use Attribute String	28.8		10ths	False

Outputs

Name	Standard Name	Default Value	Units	Display Precision	BACnet Exposed
Present Value	Use Attribute String	0.0		10ths	False
Error	Use Attribute String	0.0		10ths	False
Saturation Status	Use Attribute String	Normal	Control Status		False
Absolute Effort EWMA	Use Attribute String	0.0	%	10ths	False
Absolute Error EWMA	Use Attribute String	0.0		10ths	False
Error EWMA	Use Attribute String	0.0		10ths	False
Present Value EWMA	Use Attribute String	0.0	%	10ths	False
Execution Count	Use Attribute String	0.0		10ths	False
PRAC Status	Use Attribute String	Normal	PRAC Status		False
Eff Proportional Band	Use Attribute String	16.0		10ths	False
Eff Integral Time	Use Attribute String	729.0	seconds	10ths	False

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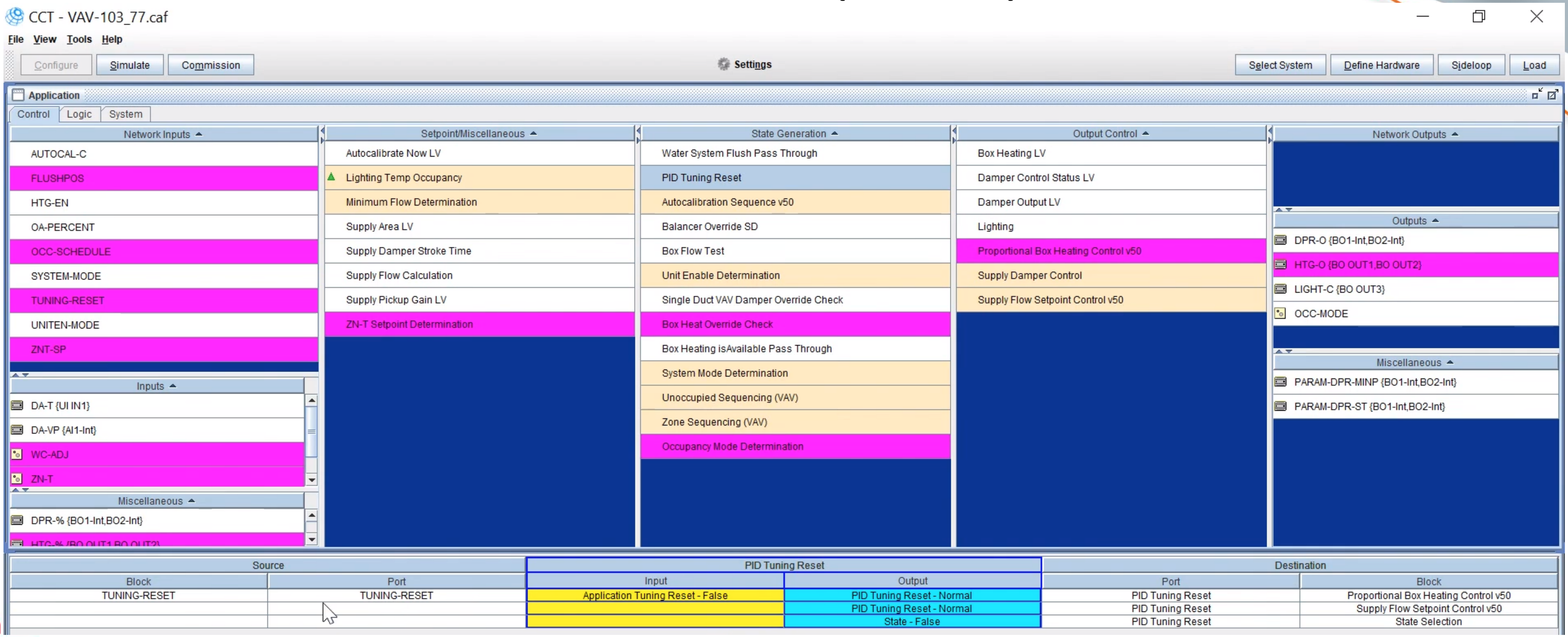
Levels of Control - Field Level (CCMS)



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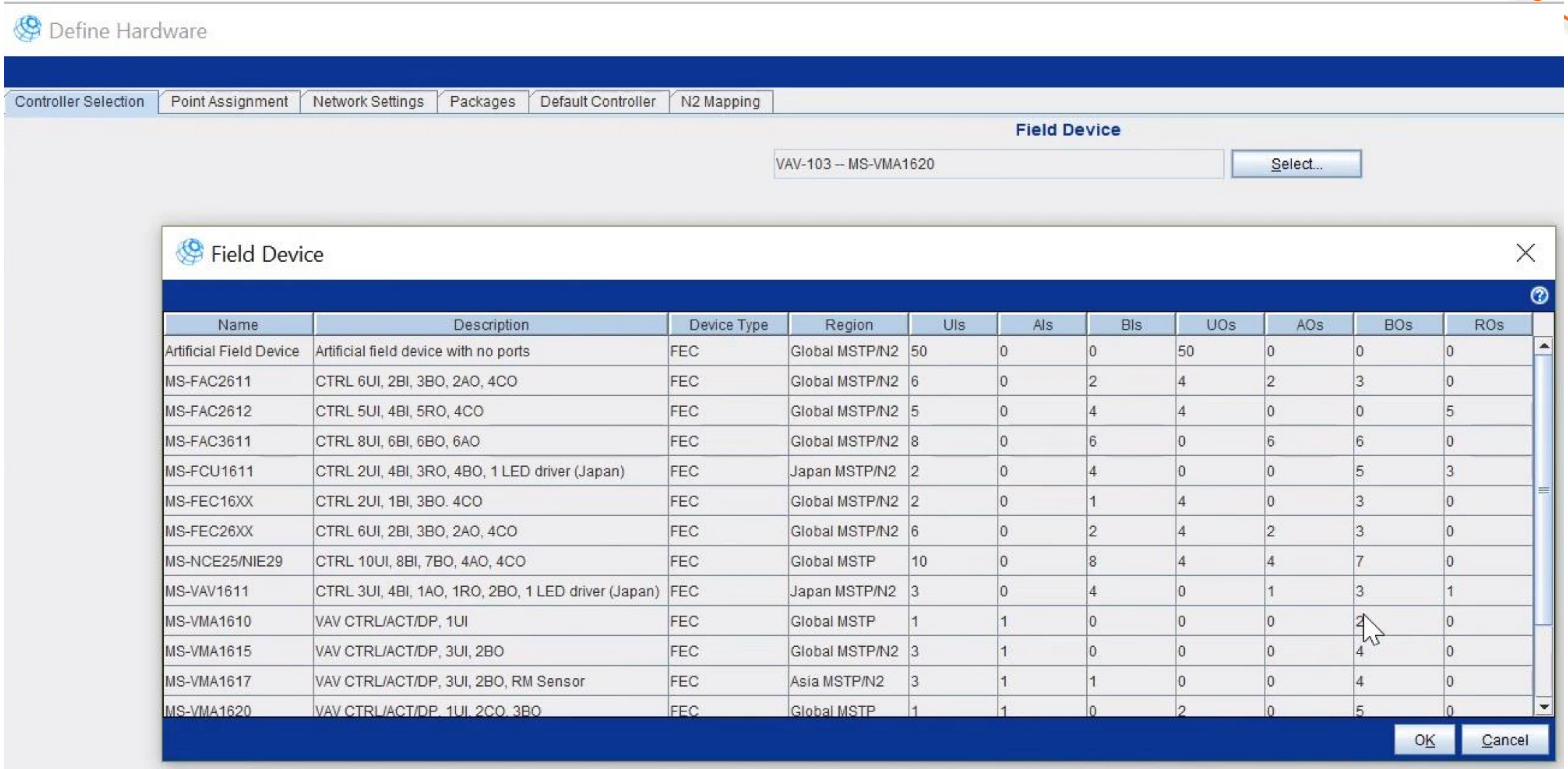
Levels of Control - Field Level (CCMS)



Name	Description	Device Type	Region	UIs	AIs	BIs	UOs	AOs	BOs	ROs
Artificial Field Device	Artificial field device with no ports	FEC	Global MSTP/N2	50	0	0	50	0	0	0
MS-FAC2611	CTRL 6UI, 2BI, 3BO, 2AO, 4CO	FEC	Global MSTP/N2	6	0	2	4	2	3	0
MS-FAC2612	CTRL 5UI, 4BI, 5RO, 4CO	FEC	Global MSTP/N2	5	0	4	4	0	0	5
MS-FAC3611	CTRL 8UI, 6BI, 6BO, 6AO	FEC	Global MSTP/N2	8	0	6	0	6	6	0
MS-FCU1611	CTRL 2UI, 4BI, 3RO, 4BO, 1 LED driver (Japan)	FEC	Japan MSTP/N2	2	0	4	0	0	5	3
MS-FEC16XX	CTRL 2UI, 1BI, 3BO. 4CO	FEC	Global MSTP/N2	2	0	1	4	0	3	0
MS-FEC26XX	CTRL 6UI, 2BI, 3BO, 2AO, 4CO	FEC	Global MSTP/N2	6	0	2	4	2	3	0
MS-NCE25/NIE29	CTRL 10UI, 8BI, 7BO, 4AO, 4CO	FEC	Global MSTP	10	0	8	4	4	7	0
MS-VAV1611	CTRL 3UI, 4BI, 1AO, 1RO, 2BO, 1 LED driver (Japan)	FEC	Japan MSTP/N2	3	0	4	0	1	3	1
MS-VMA1610	VAV CTRL/ACT/DP, 1UI	FEC	Global MSTP	1	1	0	0	0	2	0
MS-VMA1615	VAV CTRL/ACT/DP, 3UI, 2BO	FEC	Global MSTP/N2	3	1	0	0	0	4	0
MS-VMA1617	VAV CTRL/ACT/DP, 3UI, 2BO, RM Sensor	FEC	Asia MSTP/N2	3	1	1	0	0	4	0
MS-VMA1620	VAV CTRL/ACT/DP, 1UI, 2CO, 3BO	FEC	Global MSTP	1	1	0	2	0	5	0

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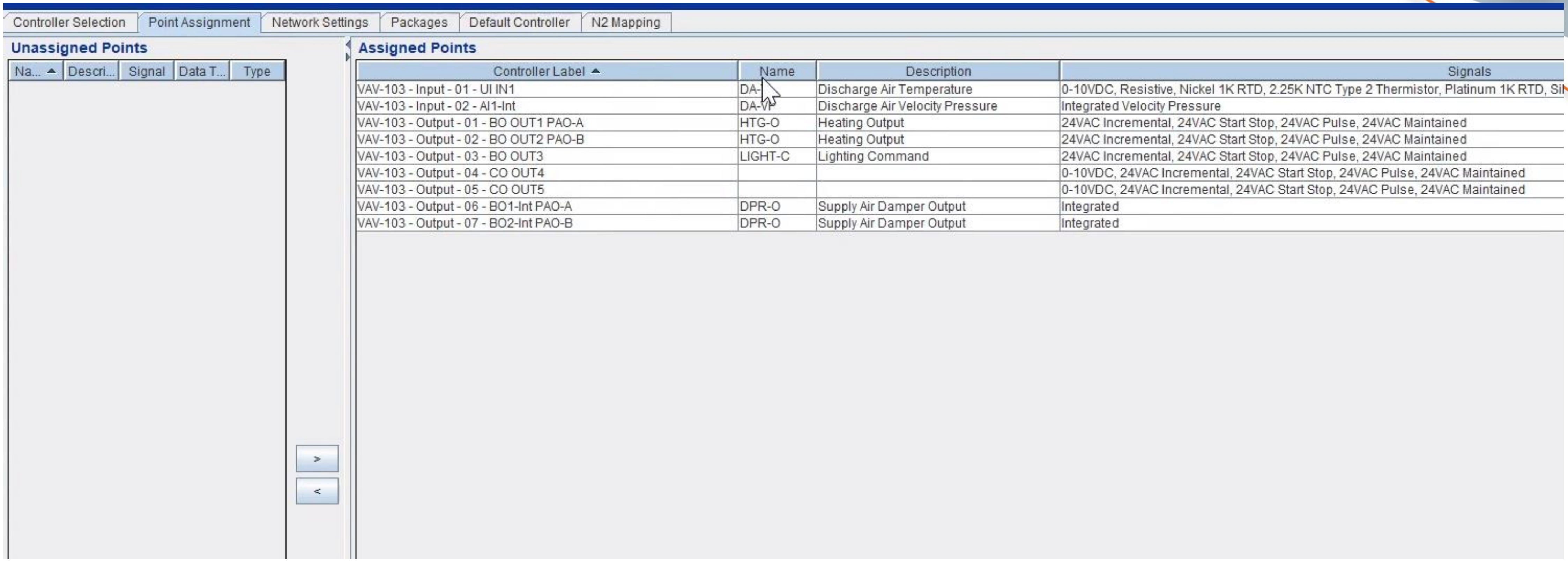
7. Basic Software Application and Operation

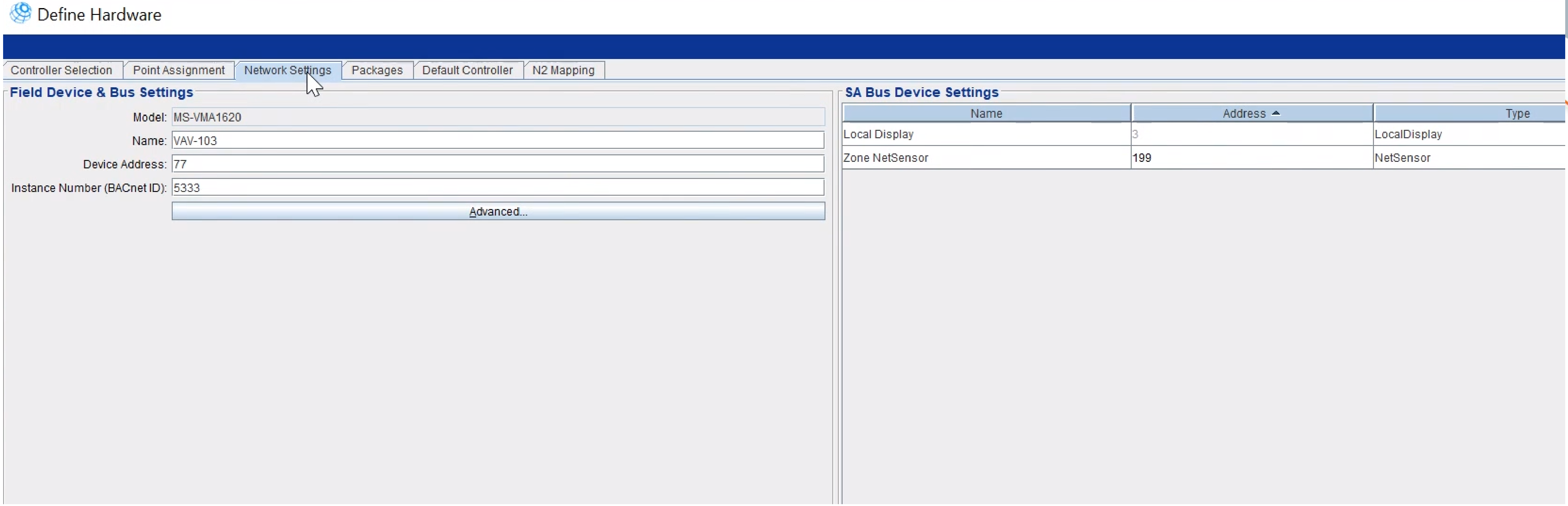
Levels of Control - Field Level (CCMS)



Controller Label	Name	Description	Signals
VAV-103 - Input - 01 - UI IN1	DA-	Discharge Air Temperature	0-10VDC, Resistive, Nickel 1K RTD, 2.25K NTC Type 2 Thermistor, Platinum 1K RTD, Si
VAV-103 - Input - 02 - AI1-Int	DA-VP	Discharge Air Velocity Pressure	Integrated Velocity Pressure
VAV-103 - Output - 01 - BO OUT1 PAO-A	HTG-O	Heating Output	24VAC Incremental, 24VAC Start Stop, 24VAC Pulse, 24VAC Maintained
VAV-103 - Output - 02 - BO OUT2 PAO-B	HTG-O	Heating Output	24VAC Incremental, 24VAC Start Stop, 24VAC Pulse, 24VAC Maintained
VAV-103 - Output - 03 - BO OUT3	LIGHT-C	Lighting Command	24VAC Incremental, 24VAC Start Stop, 24VAC Pulse, 24VAC Maintained
VAV-103 - Output - 04 - CO OUT4			0-10VDC, 24VAC Incremental, 24VAC Start Stop, 24VAC Pulse, 24VAC Maintained
VAV-103 - Output - 05 - CO OUT5			0-10VDC, 24VAC Incremental, 24VAC Start Stop, 24VAC Pulse, 24VAC Maintained
VAV-103 - Output - 06 - BO1-Int PAO-A	DPR-O	Supply Air Damper Output	Integrated
VAV-103 - Output - 07 - BO2-Int PAO-B	DPR-O	Supply Air Damper Output	Integrated

7. Basic Software Application and Operation

Levels of Control - Field Level (CCMS)



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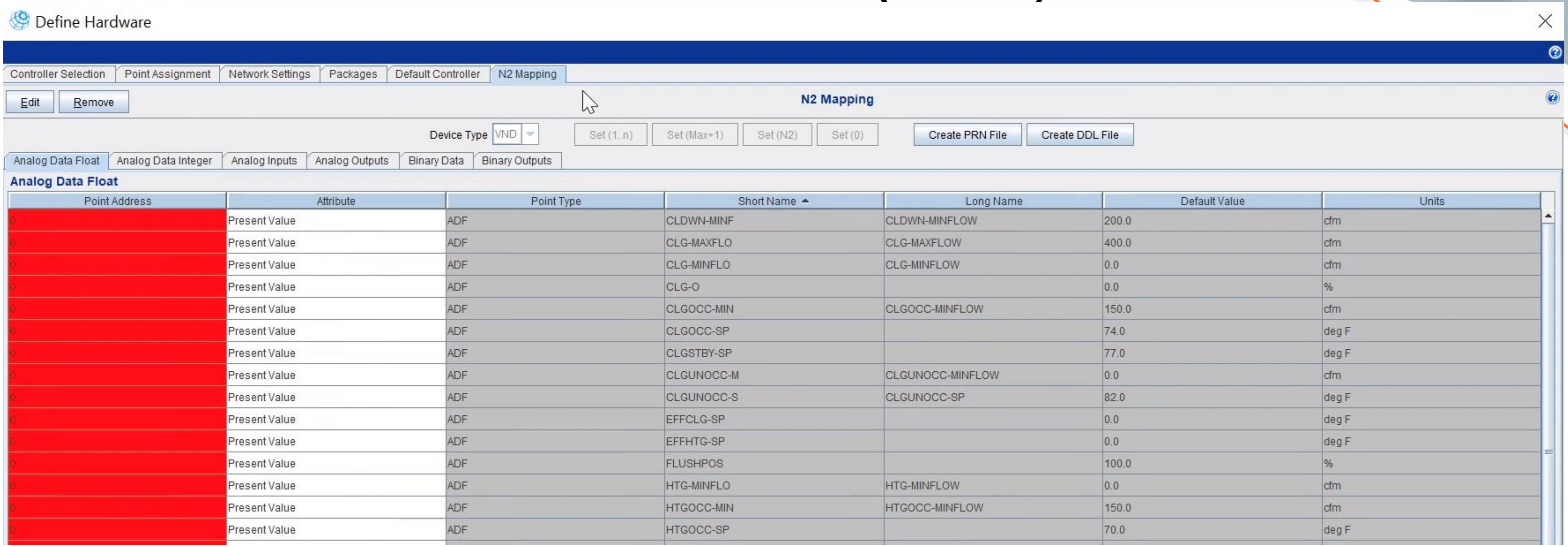
Levels of Control - Field Level (CCMS)



Point Address	Attribute	Point Type	Short Name	Long Name	Default Value	Units
0	Present Value	ADF	CLDWN-MINF	CLDWN-MINFLOW	200.0	cfm
0	Present Value	ADF	CLG-MAXFLO	CLG-MAXFLOW	400.0	cfm
0	Present Value	ADF	CLG-MINFLO	CLG-MINFLOW	0.0	cfm
0	Present Value	ADF	CLG-O		0.0	%
0	Present Value	ADF	CLGOCC-MIN	CLGOCC-MINFLOW	150.0	cfm
0	Present Value	ADF	CLGOCC-SP		74.0	deg F
0	Present Value	ADF	CLGSTBY-SP		77.0	deg F
0	Present Value	ADF	CLGUNOCC-M	CLGUNOCC-MINFLOW	0.0	cfm
0	Present Value	ADF	CLGUNOCC-S	CLGUNOCC-SP	82.0	deg F
0	Present Value	ADF	EFFCLG-SP		0.0	deg F
0	Present Value	ADF	EFFHTG-SP		0.0	deg F
0	Present Value	ADF	FLUSHPOS		100.0	%
0	Present Value	ADF	HTG-MINFLO	HTG-MINFLOW	0.0	cfm
0	Present Value	ADF	HTGOCC-MIN	HTGOCC-MINFLOW	150.0	cfm
0	Present Value	ADF	HTGOCC-SP		70.0	deg F

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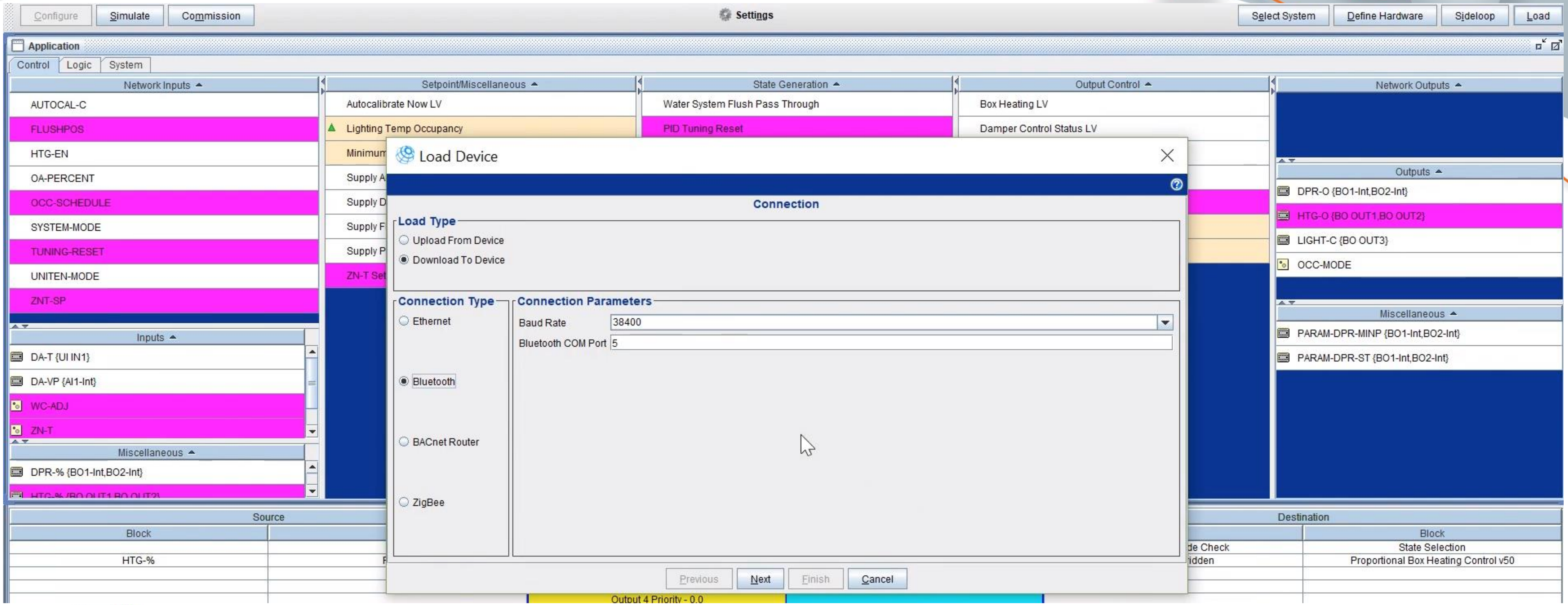
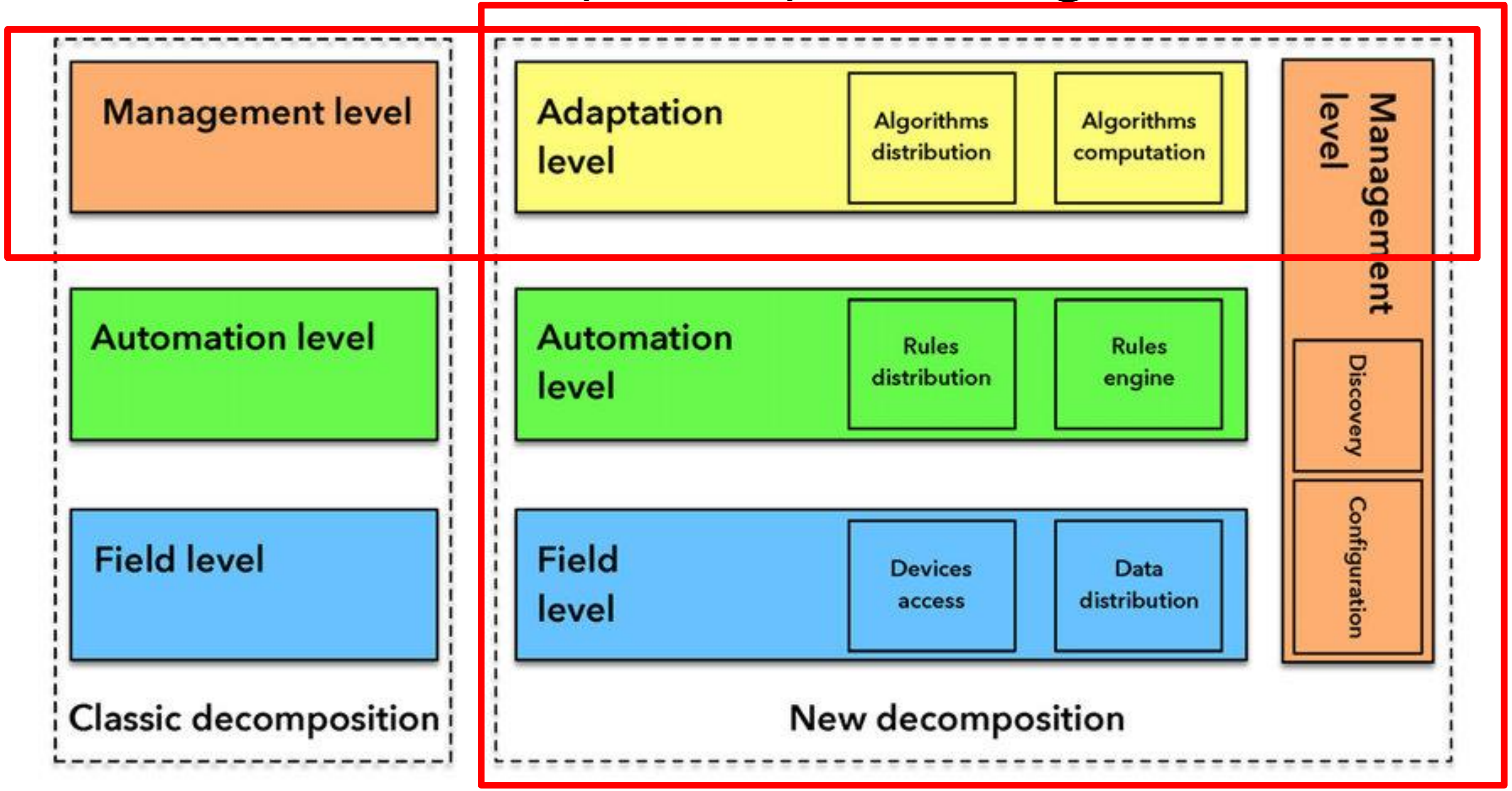


7. Basic Software Application and Operation
c. Levels of Control (CCMS) - Management Level



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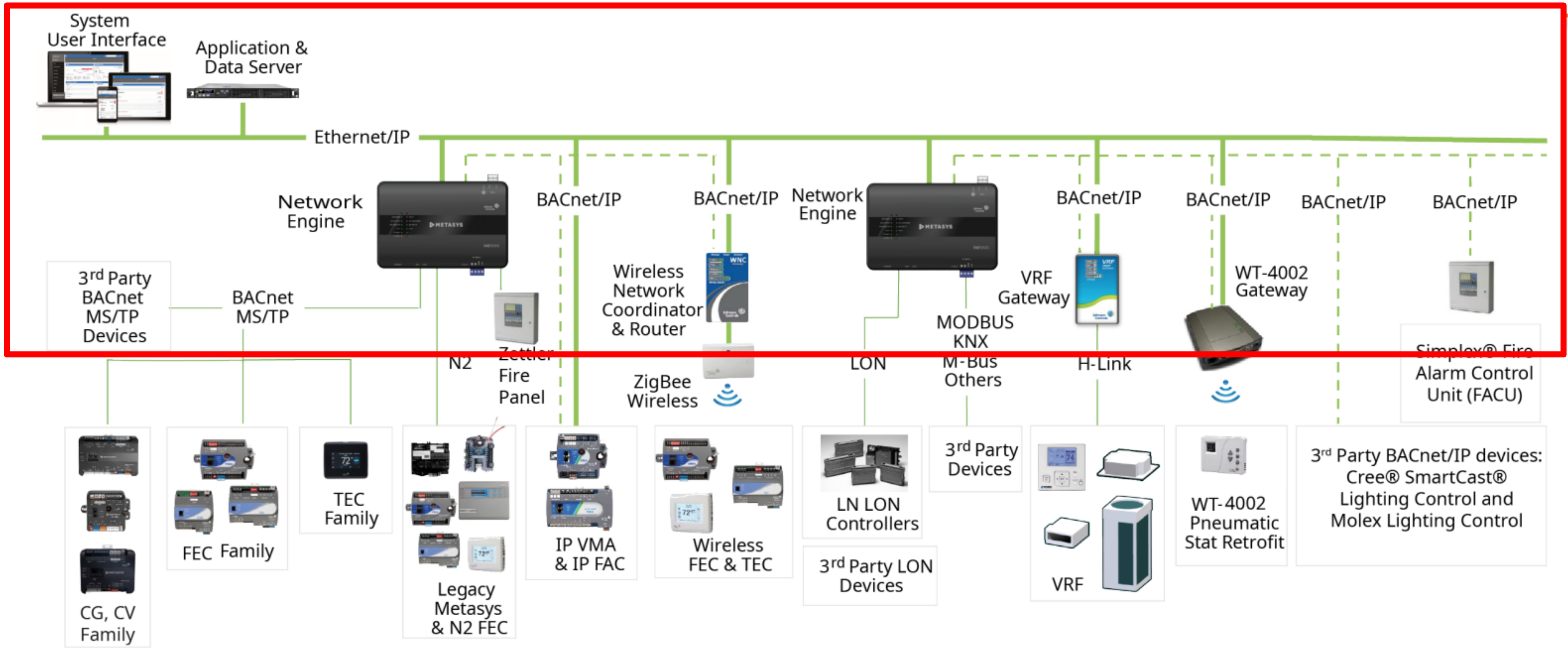
Levels of Control - Field Level (CCMS)



7. Basic Software Application and Operation

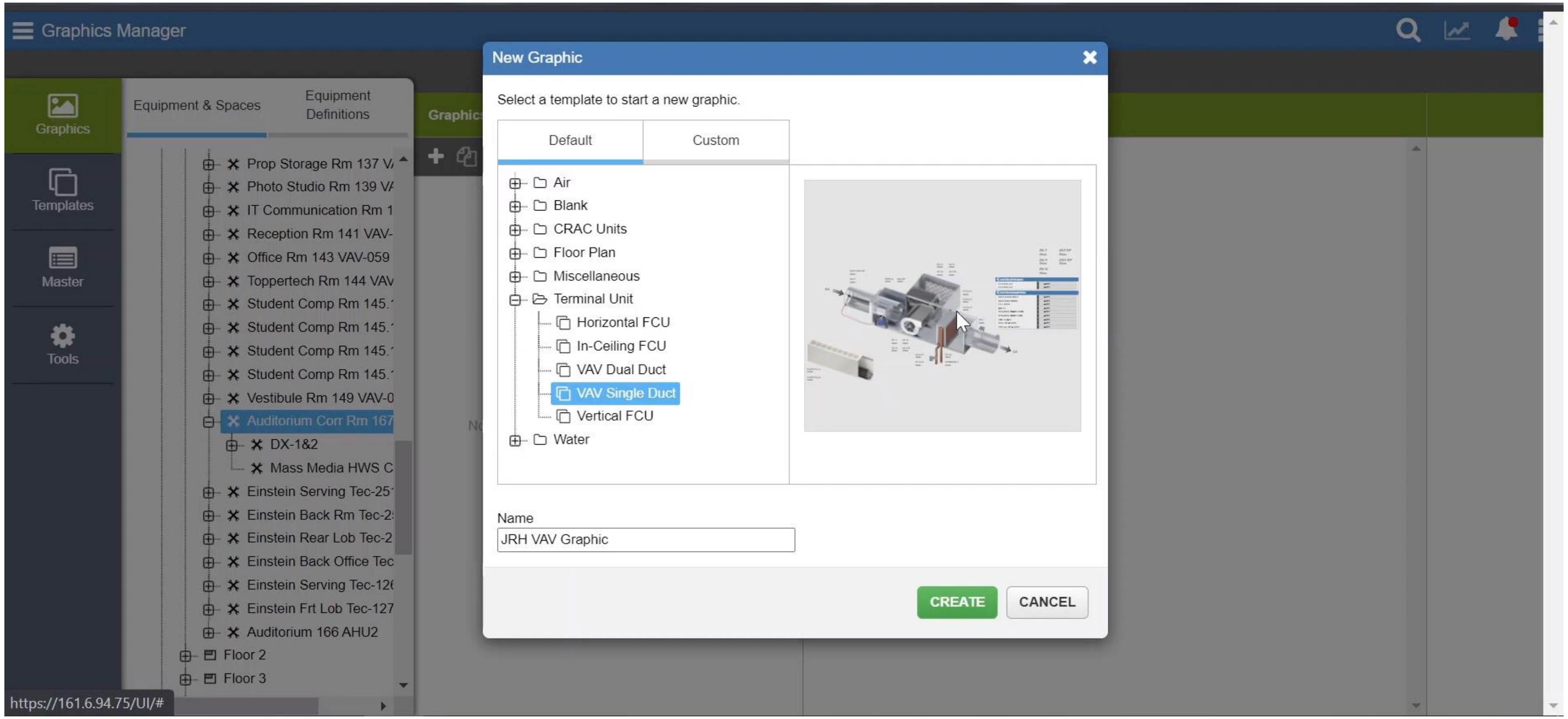
c. Levels of Control - Management Level(CCMS)

System Configuration Tool (SCT)

- https://jcpublic.kzoplatform.com/player/medium/120790531917113 4481?secs=38

7. Basic Software Application and Operation

CCMS Human Machine interface (HMI)



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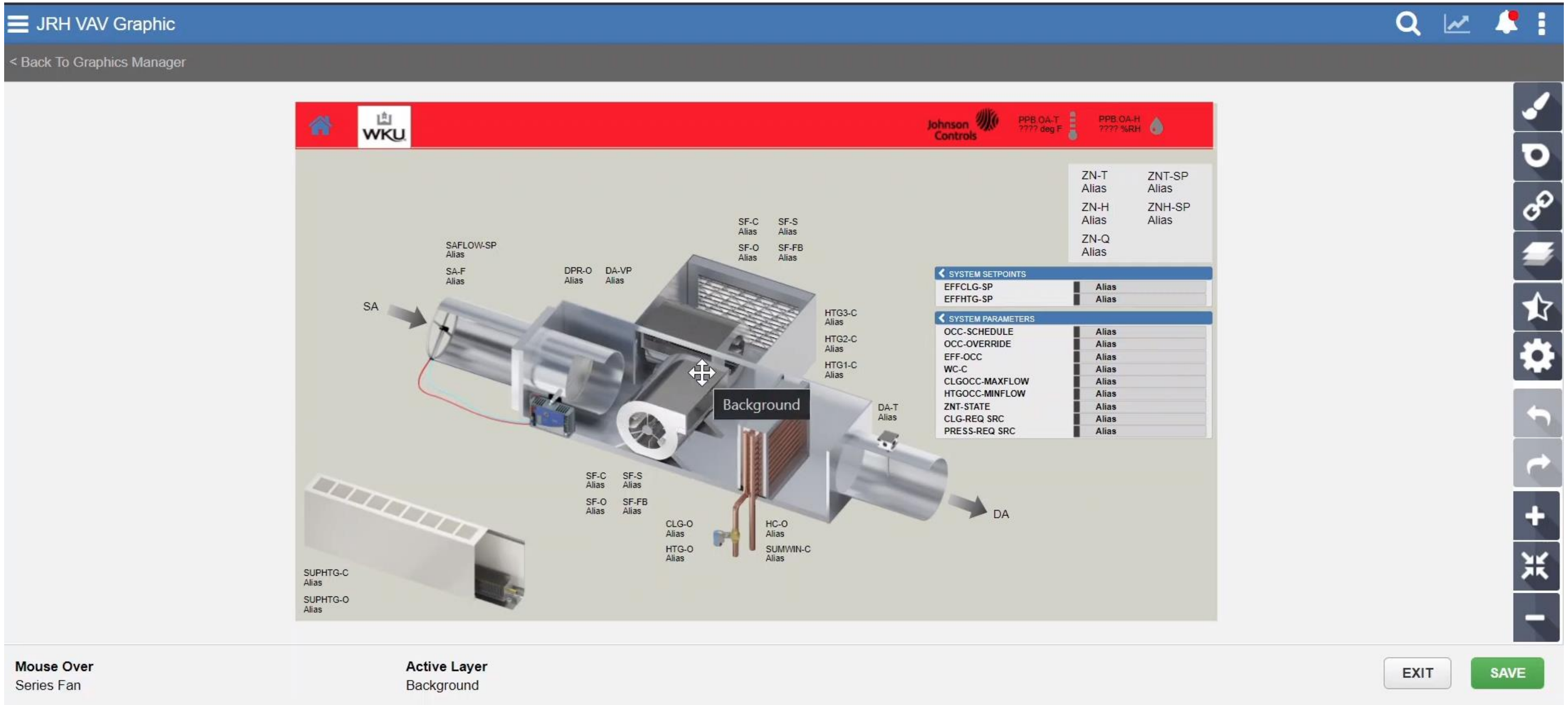
7. Basic Software Application and Operation
CCMS Human Machine interface (HMI)



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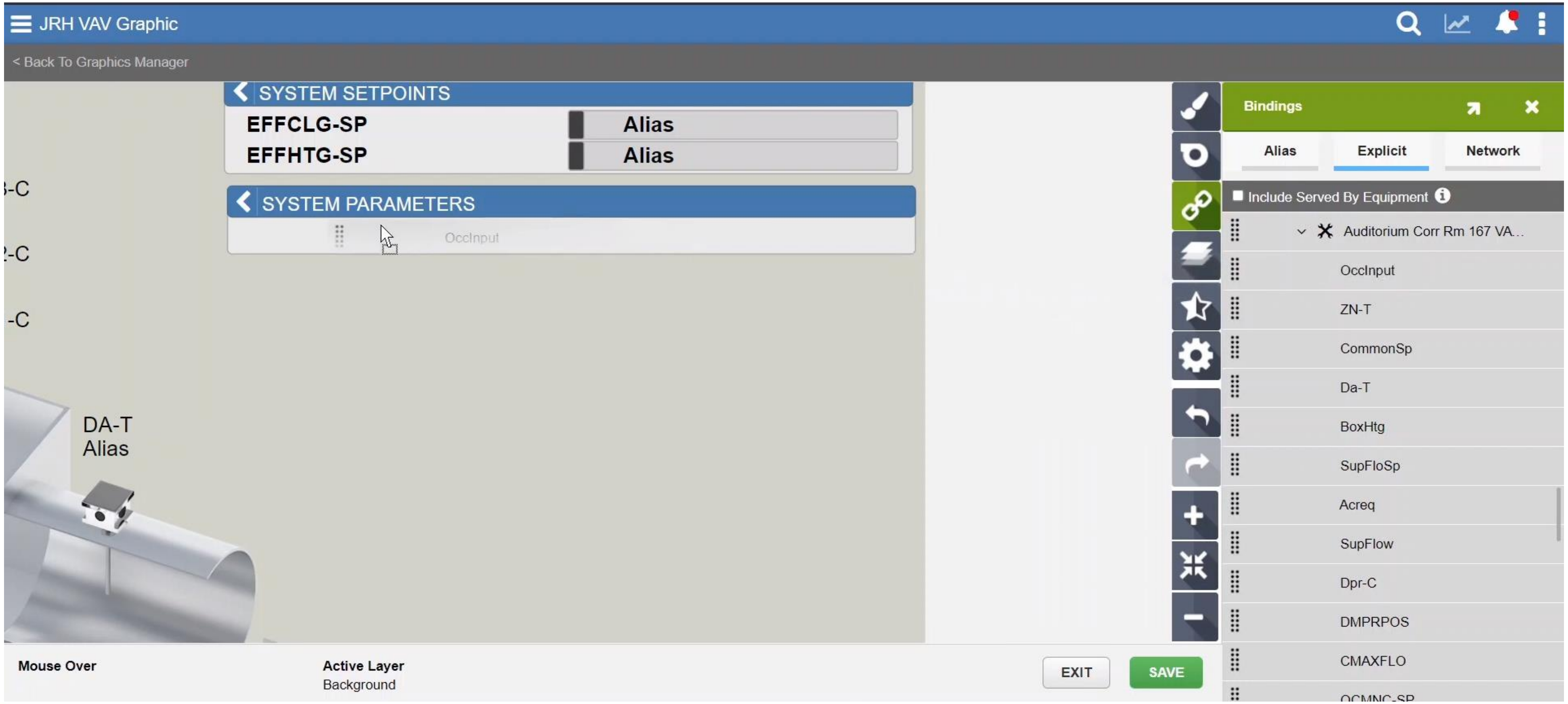
CCMS Human Machine interface (HMI)



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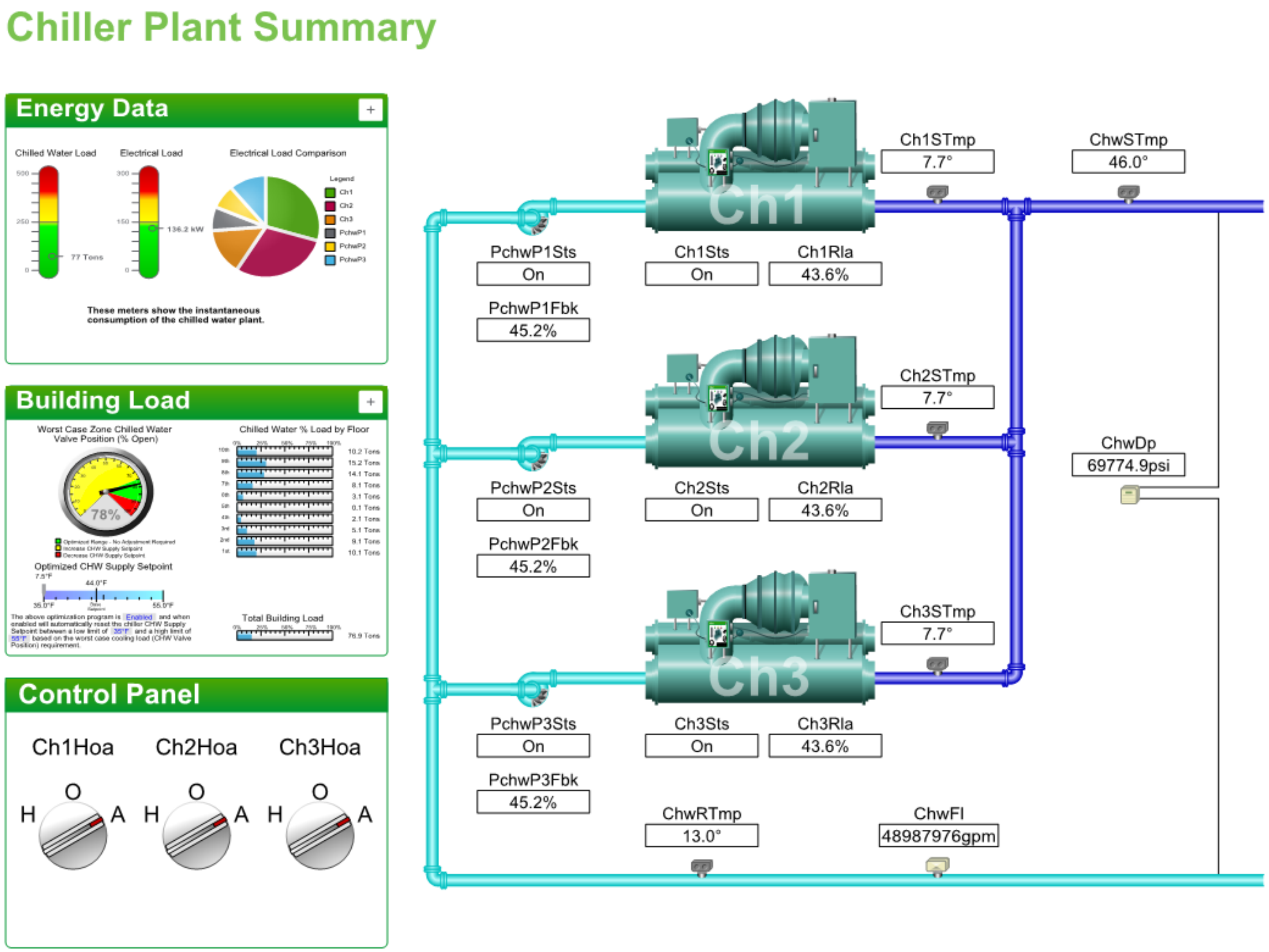
CCMS Human Machine interface (HMI)



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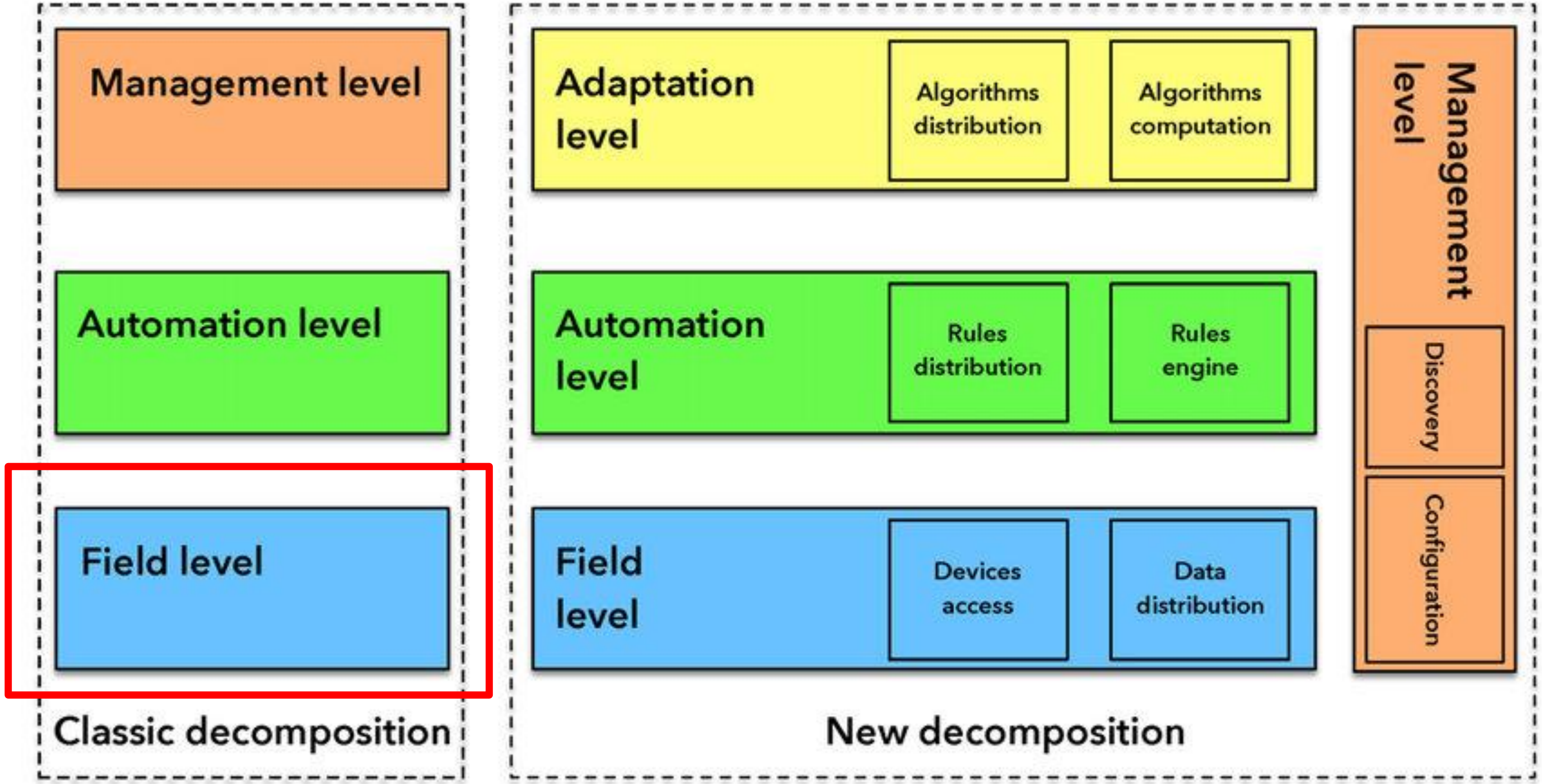
7. Basic Software Application and Operation
Levels of Control - Field Level (SCADA)



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7. Basic Software Application and Operation

Levels of Control - Field Level (SCADA)

Example : Allen-Bradley PLC

➢ RSLinx

- Configure communications drivers
- View nodes on a configured communication driver

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7. Basic Software Application and Operation

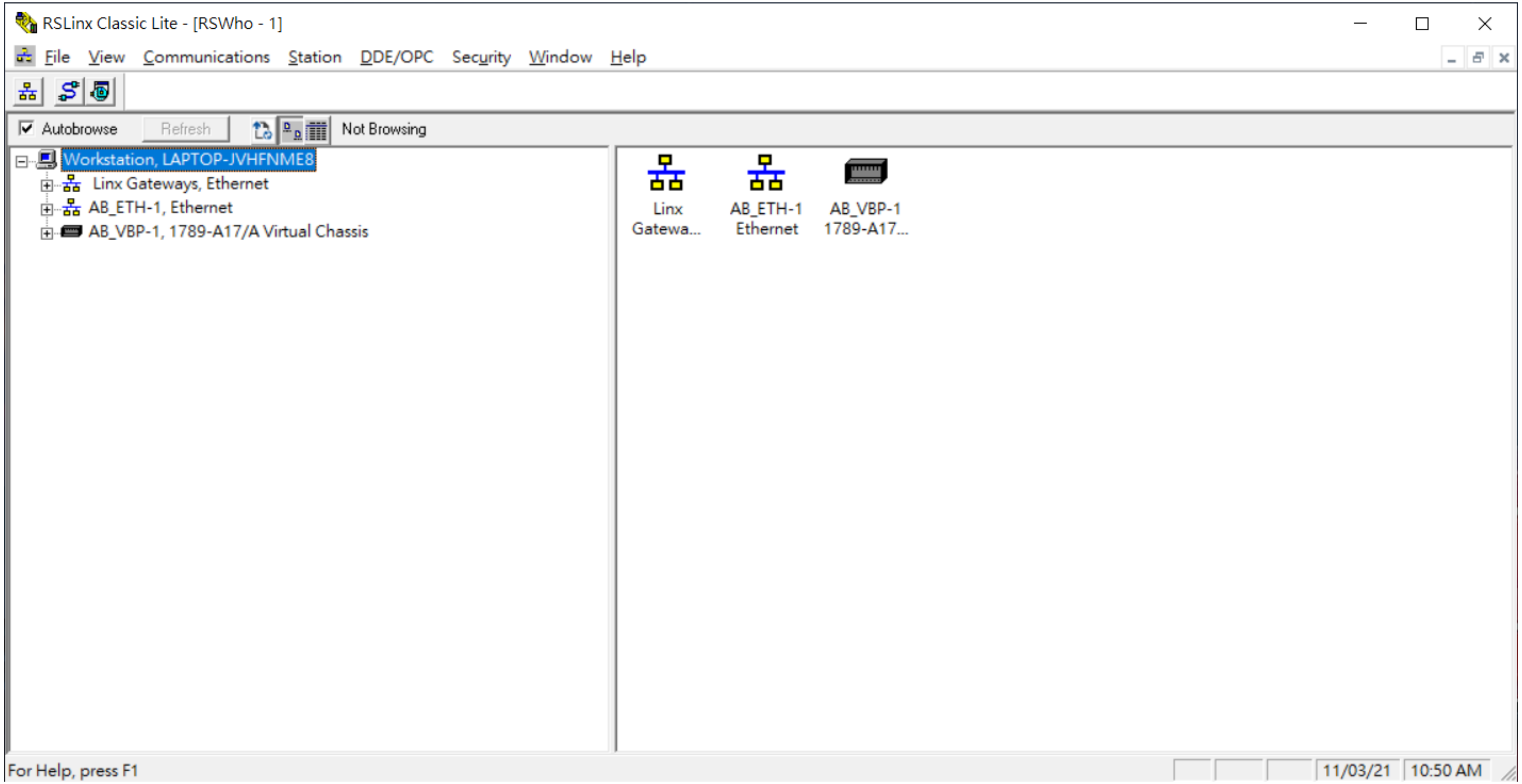
Levels of Control - Field Level (SCADA)

Example : Allen-Bradley PLC

- RSLogix 500
  - Uploading a project from a controller
  - Downloading a project to a controller
  - Going online with a controller
  - Updating a controller's firmware
  - Configuring Ethernet addressing for controllers and communication modules

7. Basic Software Application and Operation

Levels of Control - Field Level (SCADA)



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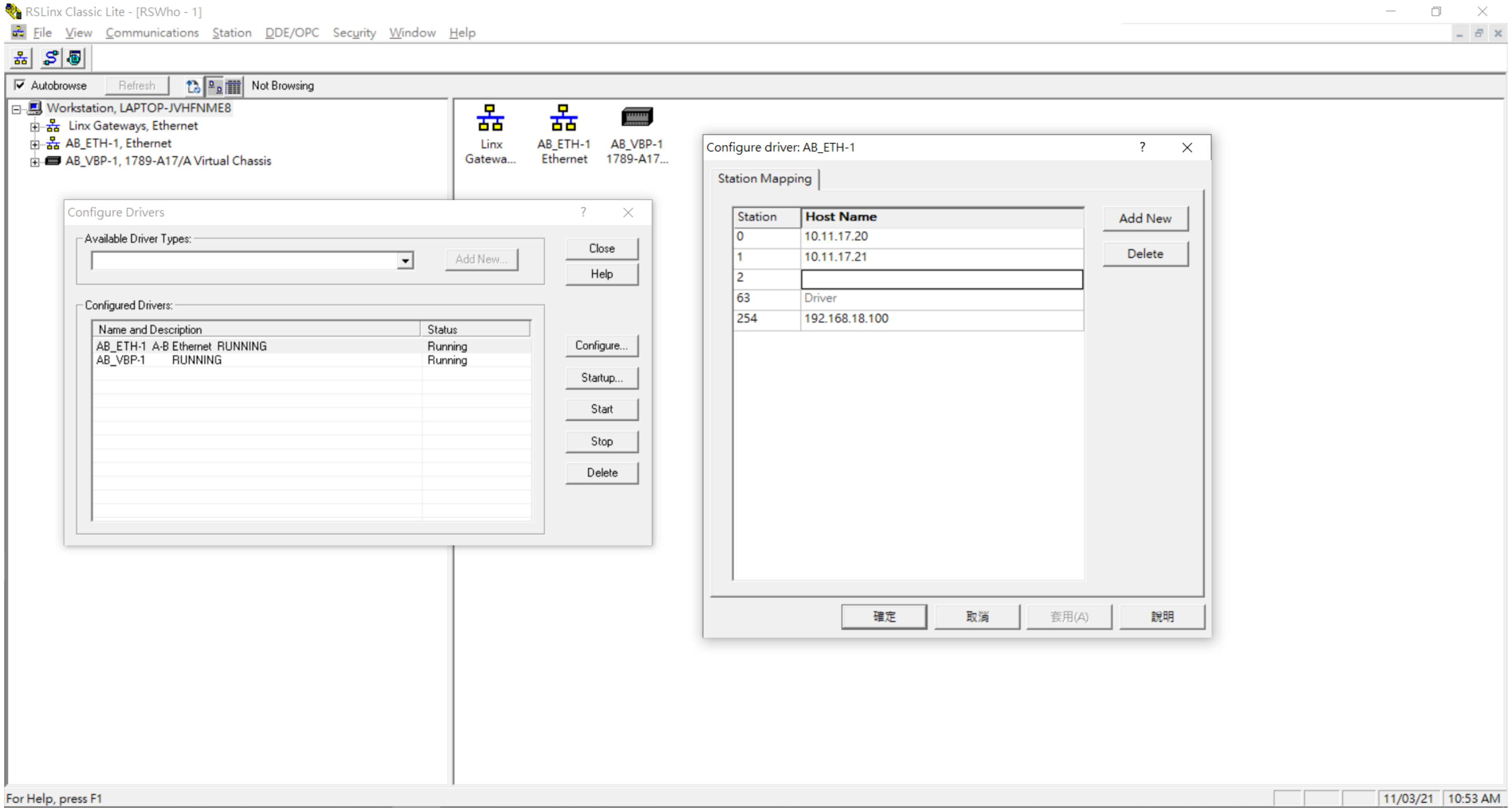

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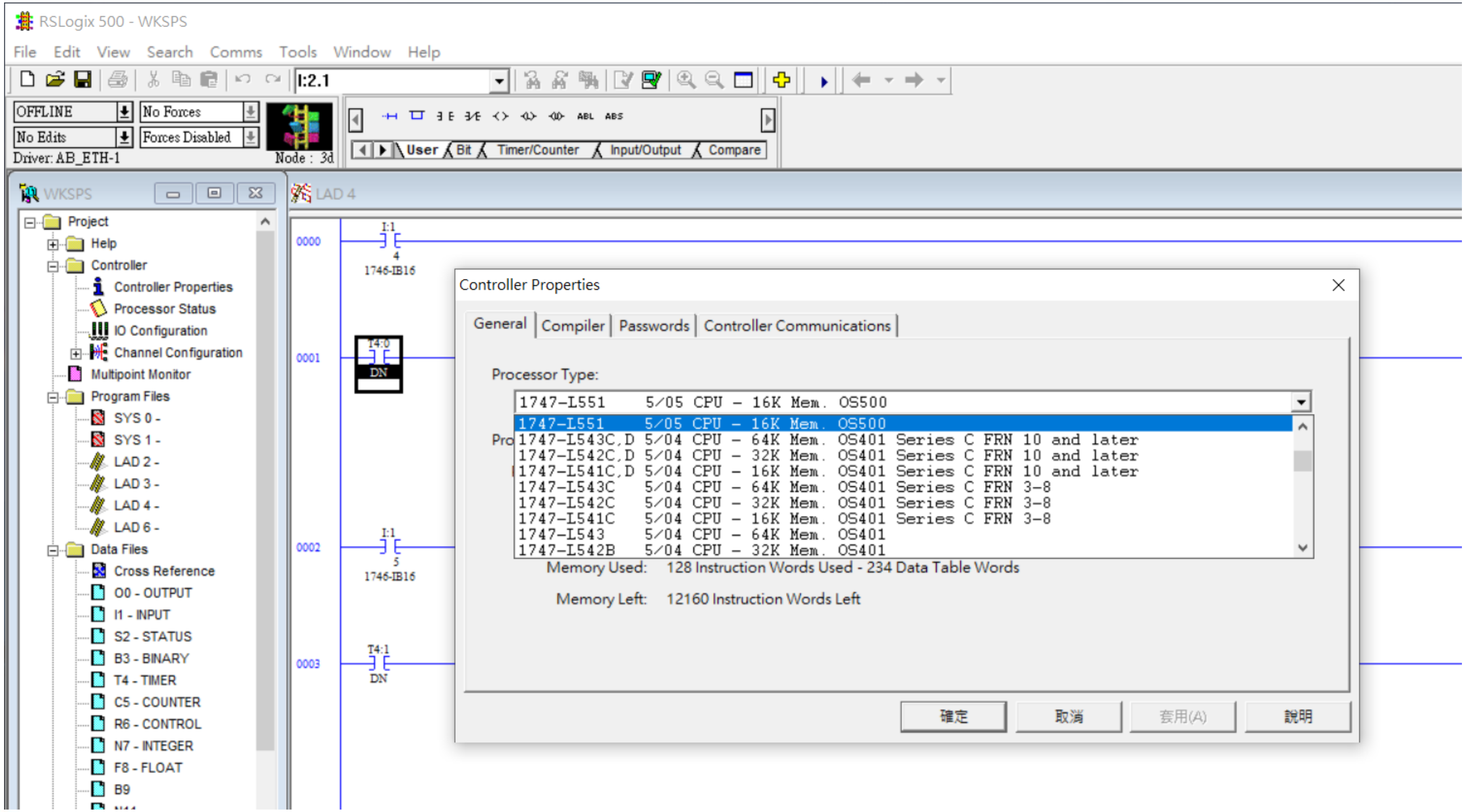
Levels of Control - Field Level (SCADA)



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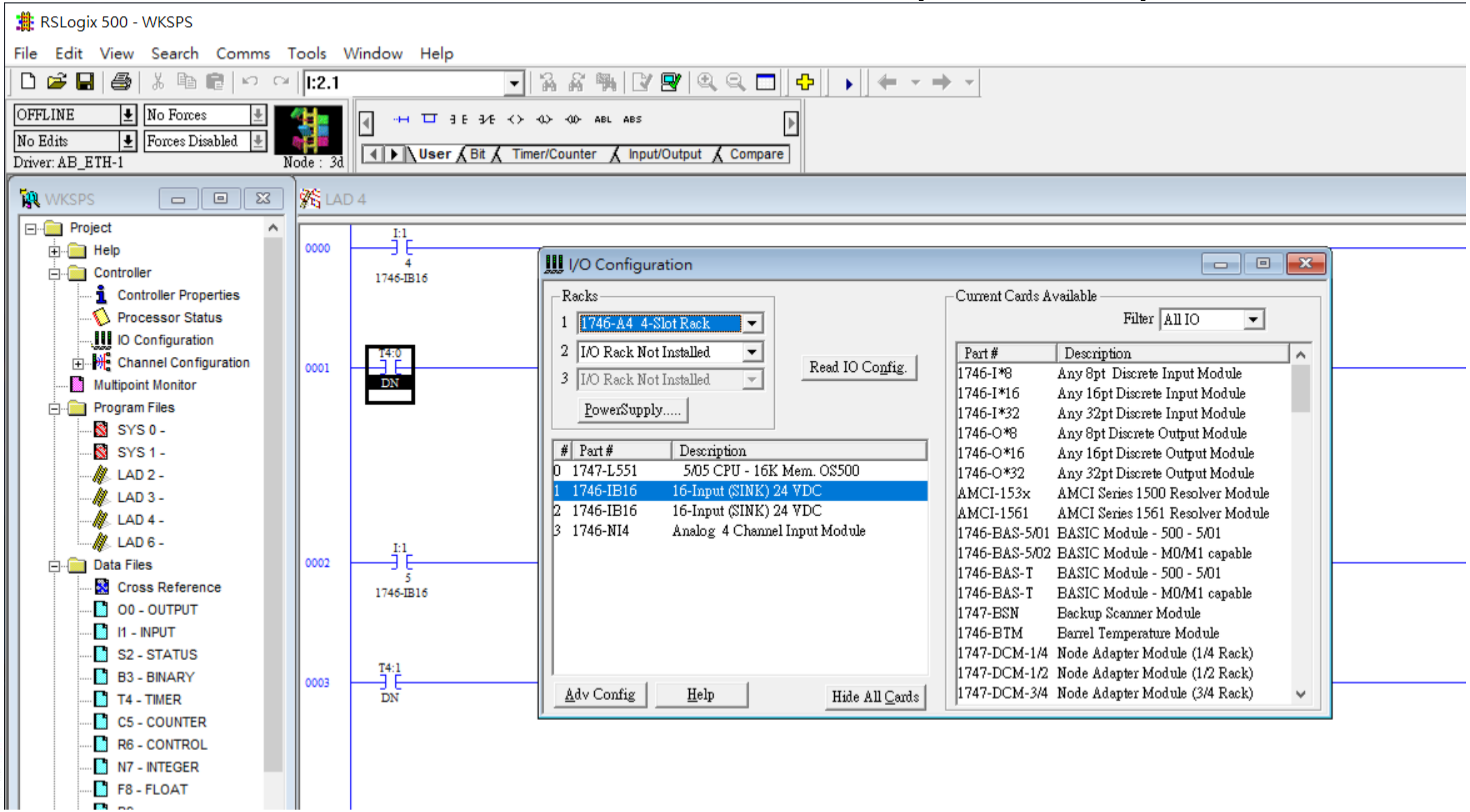
Levels of Control - Field Level (SCADA)



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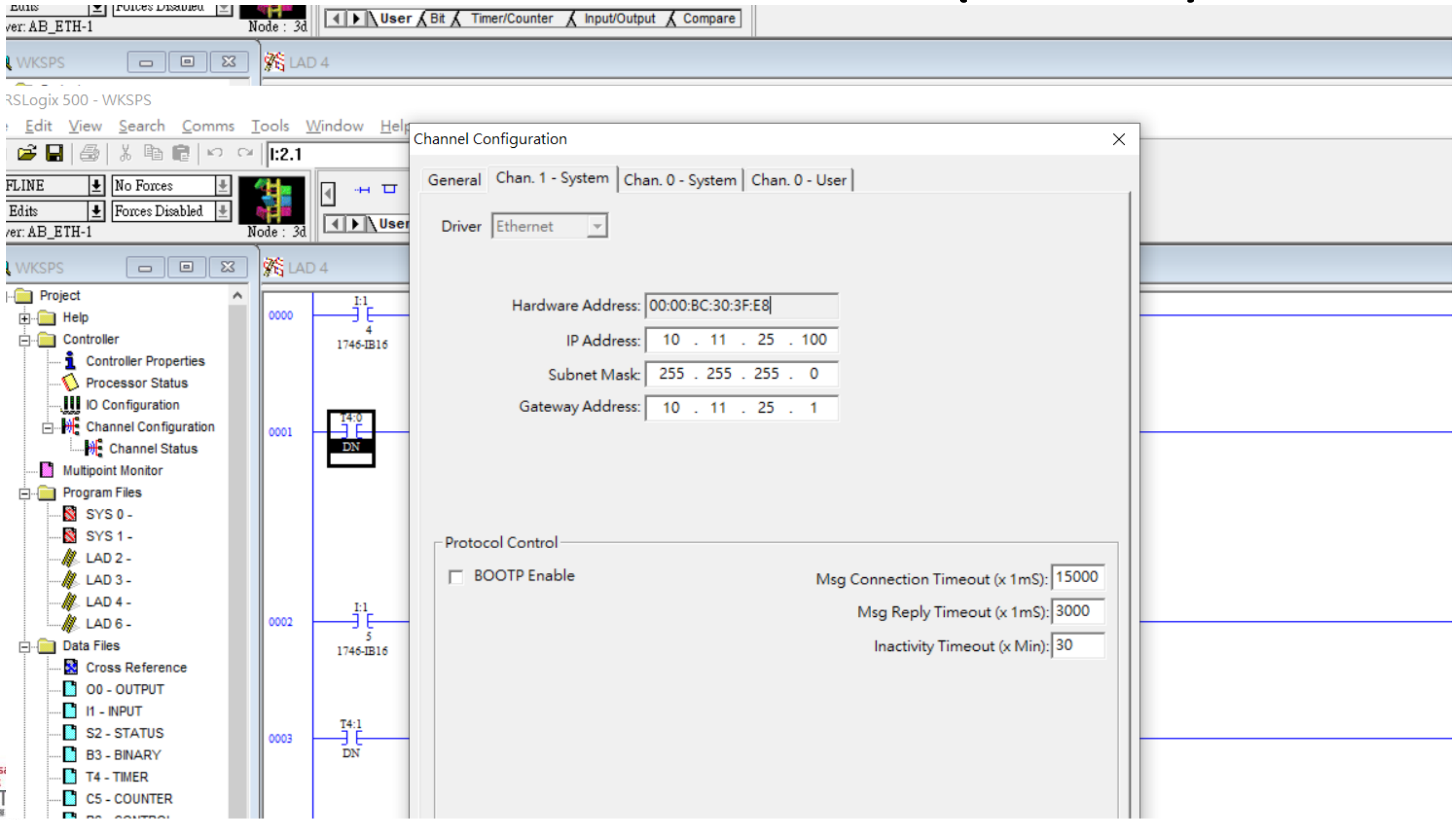
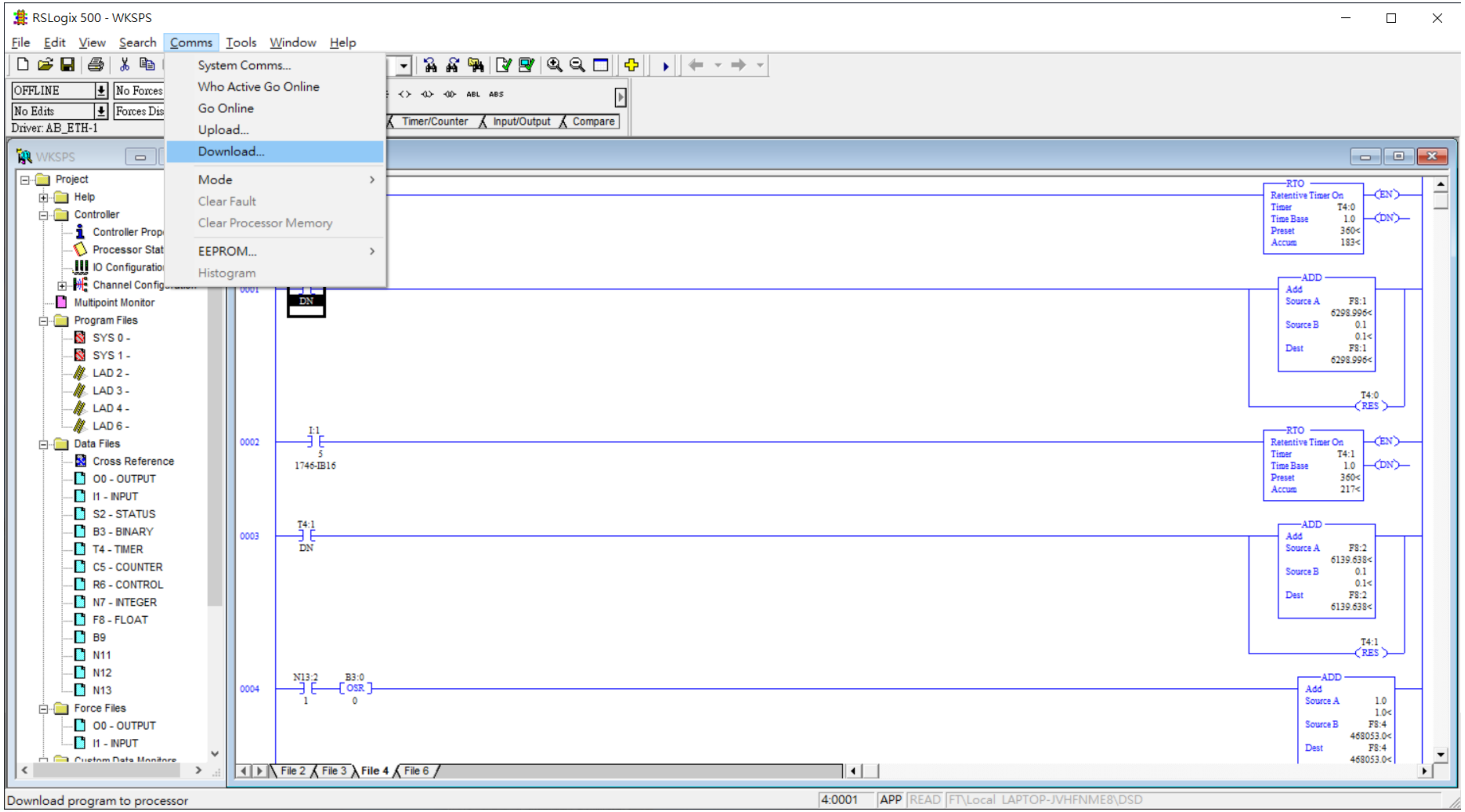
7. Basic Software Application and Operation

Levels of Control - Field Level (SCADA)



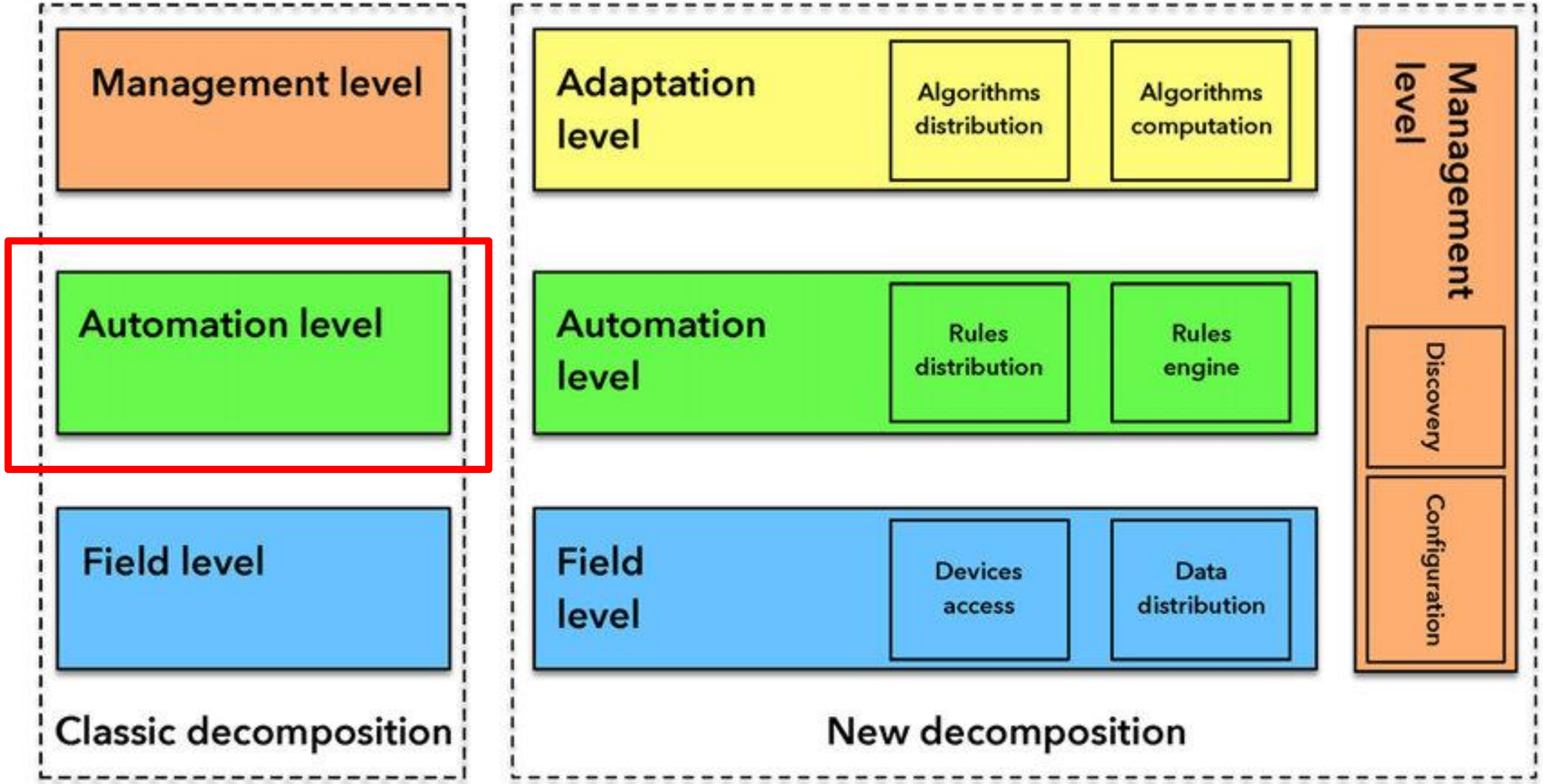
7. Basic Software Application and Operation

Levels of Control - Field Level (SCADA)

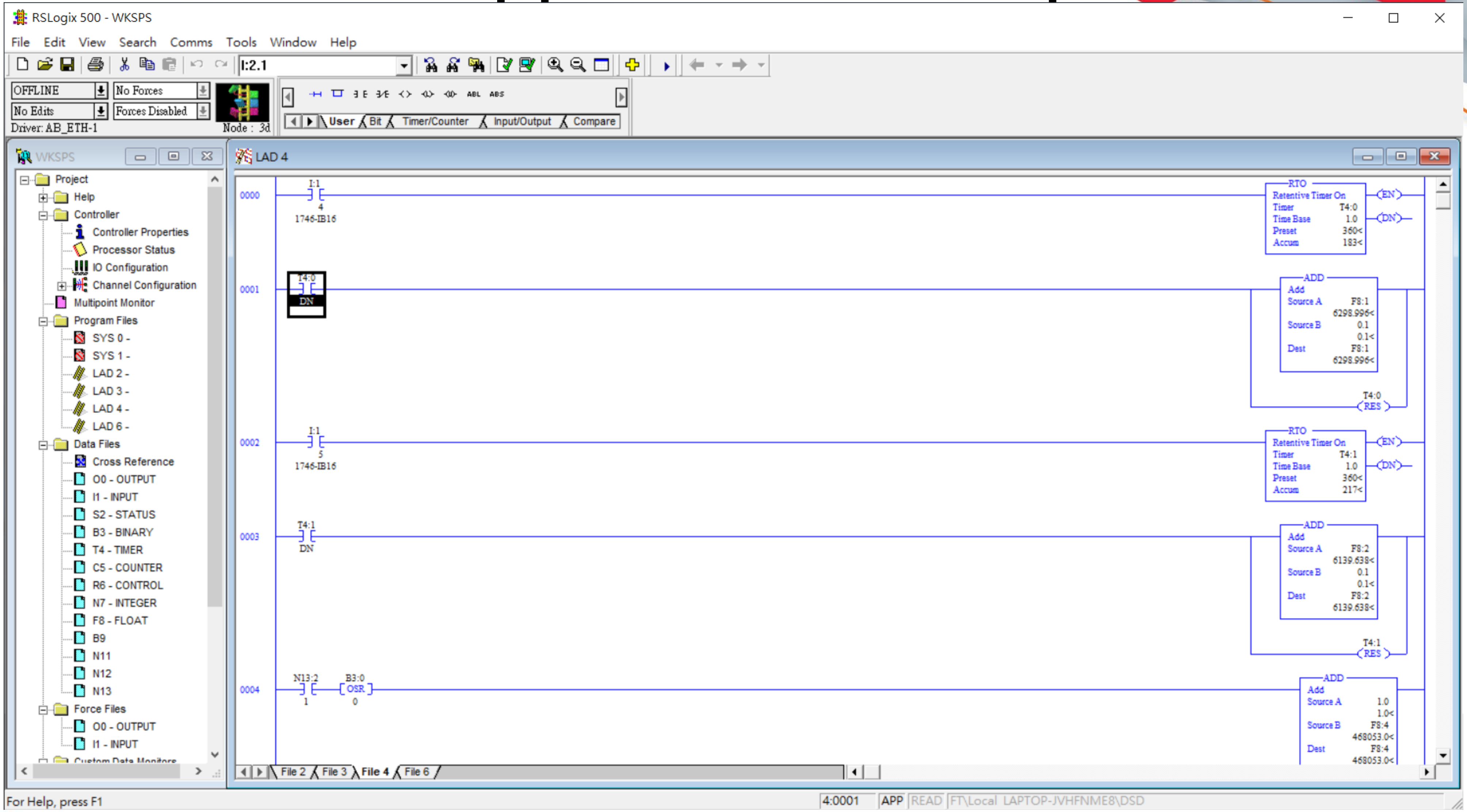


7. Basic Software Application and Operation

Levels of Control (SCADA) - Automation Level



7. Basic Software Application and Operation



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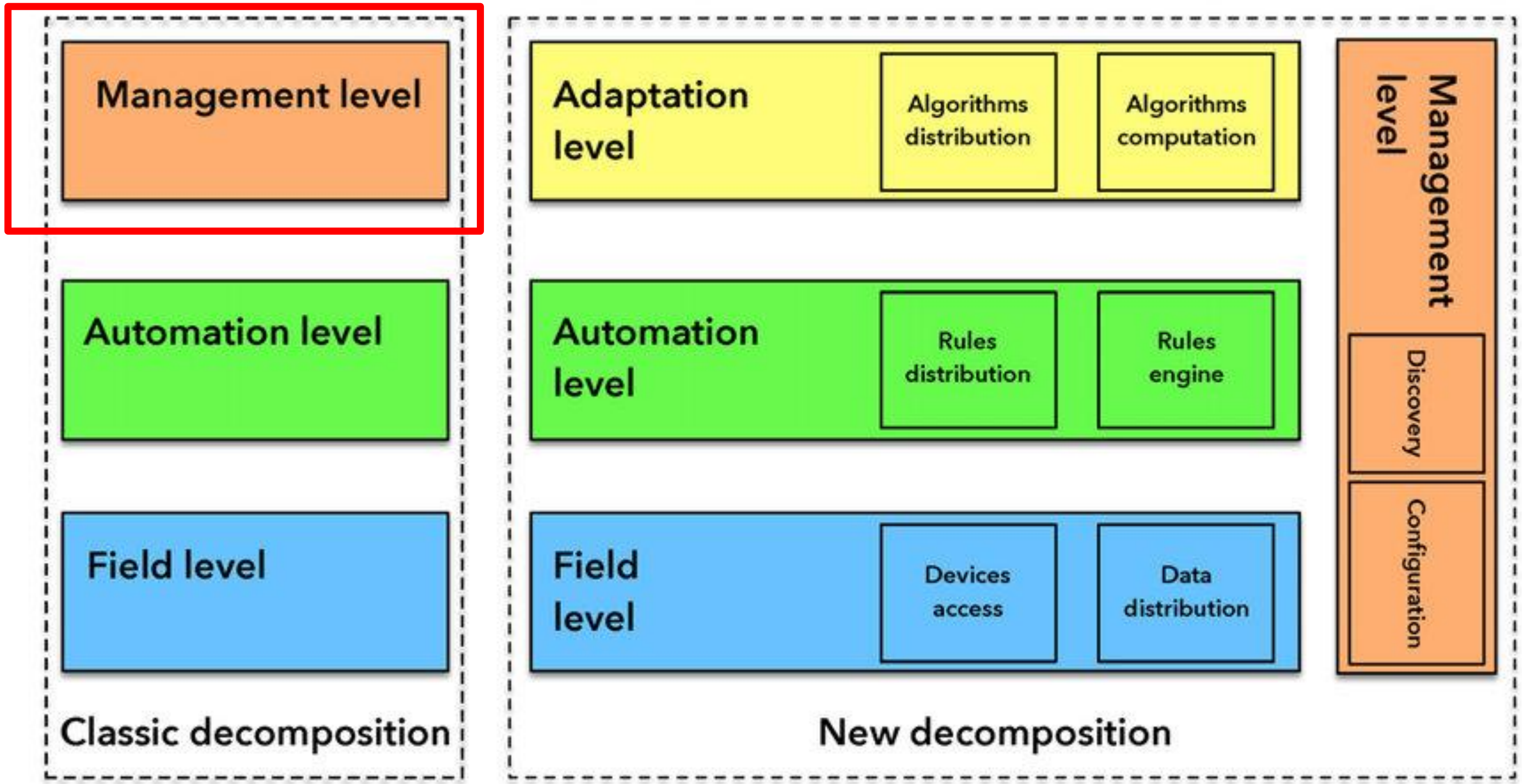
7. Basic Software Application and Operation

Levels of Control (SCADA) - Management Level



7. Basic Software Application and Operation

Levels of Control (SCADA) - Management Level

➢ Management level (SCADA) Software

- Supervisory Control
- Data Acquisition
- Example : Wonderware® InTouch
  - ✓InTouch HMI with Tag Server and Historian
  - ✓Top Server with PLC drivers

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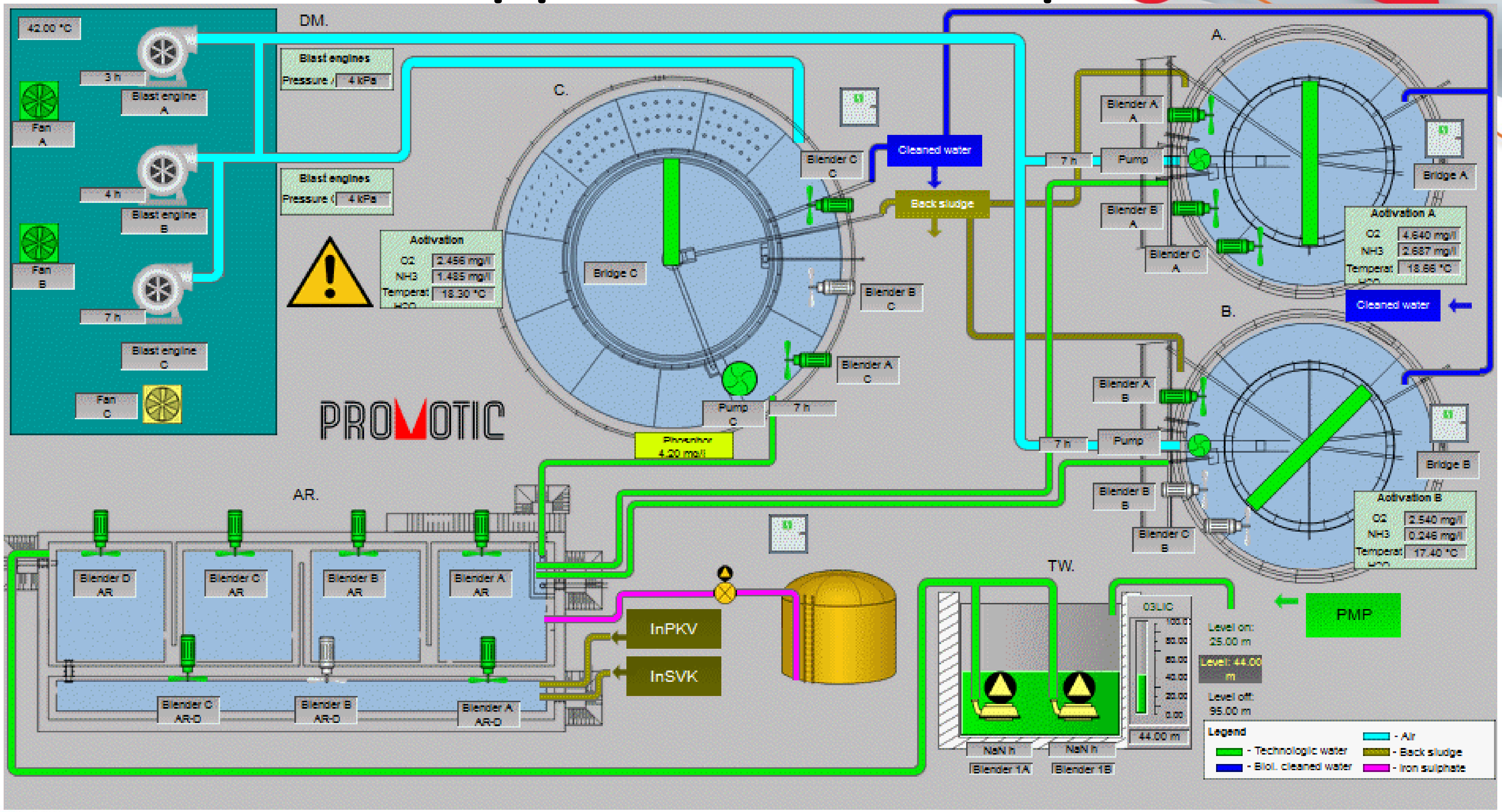
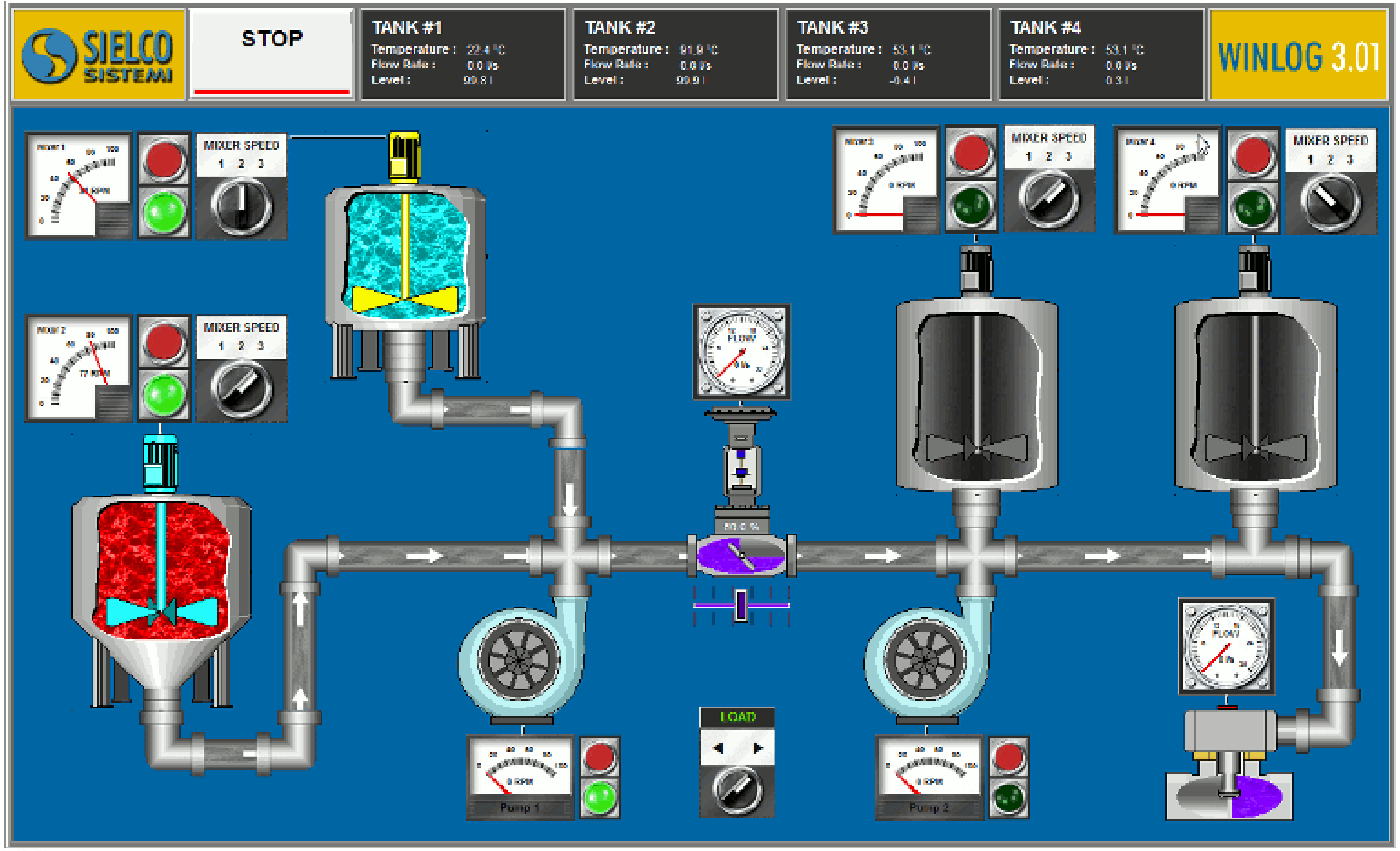
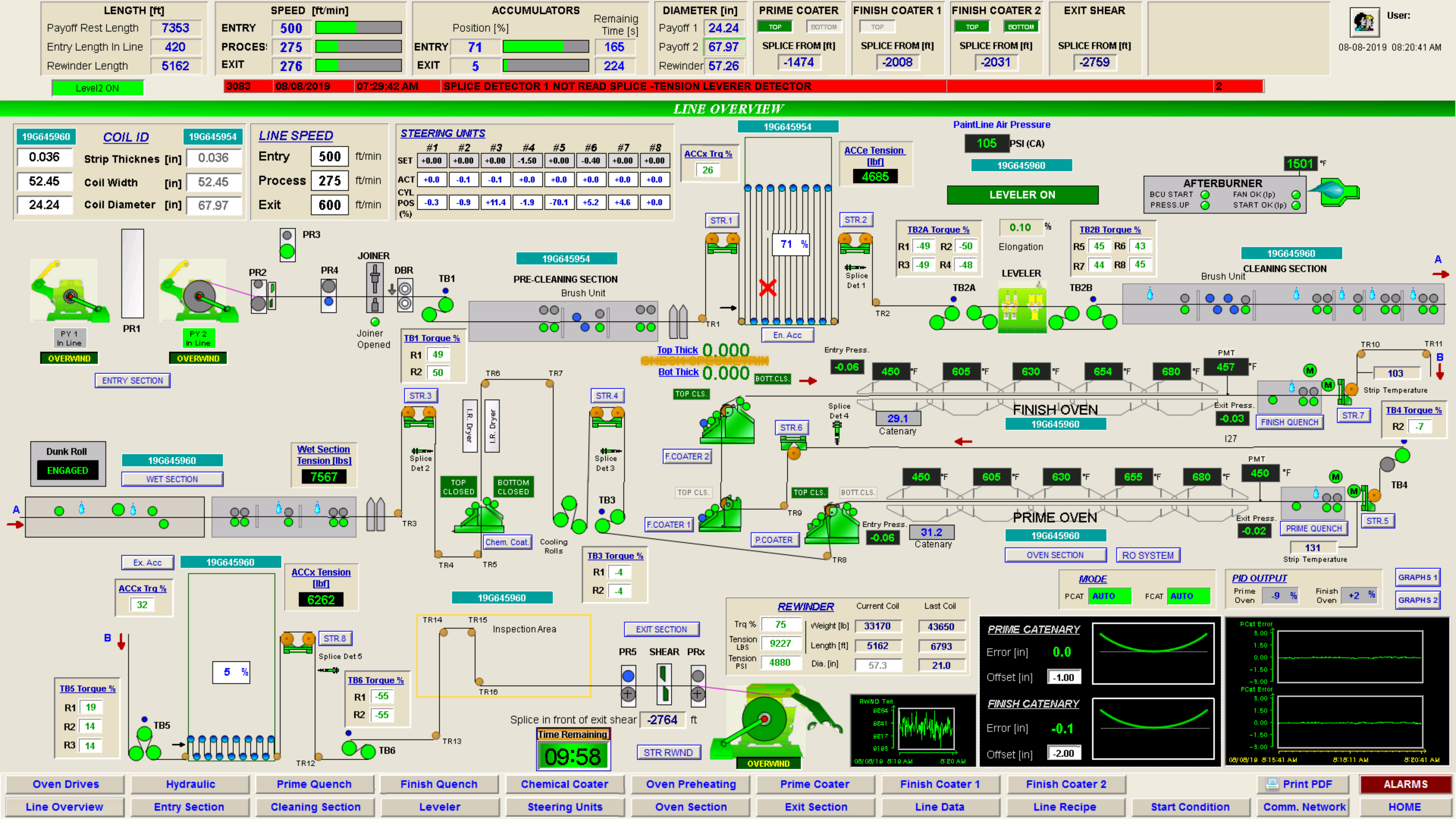


7. Basic Software Application and Operation

Levels of Control (SCADA) - Management Level

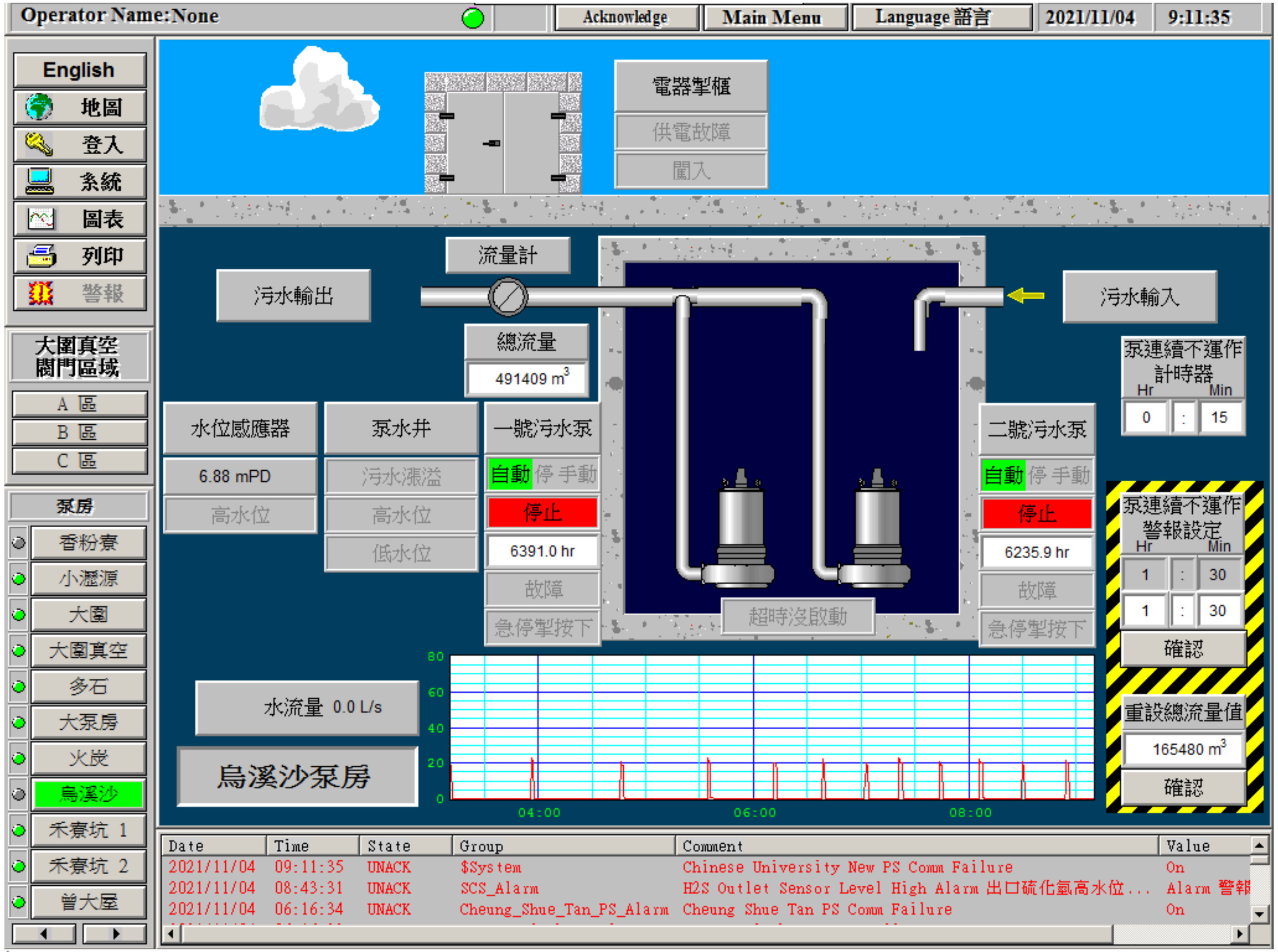




LENGTH [ft]
Payoff Rest Length 7353
Entry Length In Line 420
Rewinder Length 5162
SPEED [ft/min]
ENTRY 500
PROCESS 275
EXIT 276
ACCUMULATORS
Position [%]
Remaining Time [s]
ENTRY 71 165
EXIT 5 224
DIAMETER [in]
Payoff 1 24.24
Payoff 2 67.97
Rewinder 57.26
PRIME COATER
TOP BOTTOM
SPLICE FROM [ft] -1474
FINISH COATER 1
SPLICE FROM [ft] -2008
FINISH COATER 2
SPLICE FROM [ft] -2031
EXIT SHEAR
SPLICE FROM [ft] -2759
User:
08-08-2019 08:20:41 AM
Level2 ON
3083 08/08/2019 07:29:42 AM SPLICE DETECTOR 1 NOT READ SPLICE -TENSION LEVERER DETECTOR 2
LINE OVERVIEW
COIL ID
19G645960 19G645954
Strip Thicknes [in] 0.036 0.036
Coil Width [in] 52.45 52.45
Coil Diameter [in] 24.24 67.97
LINE SPEED
Entry 500 ft/min
Process 275 ft/min
Exit 600 ft/min
STEERING UNITS
#1 #2 #3 #4 #5 #6 #7 #8
SET +0.00 +0.00 +0.00 -1.50 +0.00 -0.40 +0.00 +0.00
ACT +0.0 -0.1 -0.1 +0.0 +0.0 +0.0 +0.0 +0.0
CYL POS (%) -0.3 -0.9 +11.4 -1.9 -70.1 +5.2 +4.6 +0.0
ACCx Trq % 26
ACCe Tension [lbf] 4685
PaintLine Air Pressure
105 PSI (CA)
LEVELER ON
AFTERBURNER
BCU START FAN OK (lp)
PRESS.UP START OK (lp)
1501 °F
PR3 PR2 PR4 JOINER DBR TB1 PR1
PY 1 In Line OVERWIND
PY 2 In Line OVERWIND
ENTRY SECTION
Joiner Opened
PRE-CLEANING SECTION
Brush Unit
TB1 Torque %
R1 49
R2 50
STR.1 STR.2 TR1 TR2
Splice Det 1
En. Acc
TB2A Torque %
R1 -49 R2 -50
R3 -49 R4 -48
0.10 % Elongation
LEVELER
TB2A TB2B
TB2B Torque %
R5 45 R6 43
R7 44 R8 45
CLEANING SECTION
Brush Unit
A
Top Thick 0.000
Bot Thick 0.000
BOTT.CLS. TOP CLS.
Entry Press. -0.06
450 °F 605 °F 630 °F 654 °F 680 °F
PMT 457 °F
TR10 TR11 B
103 Strip Temperature
FINISH OVEN
Exit Press. -0.03
FINISH QUENCH
STR.7
TB4 Torque %
R2 -7
Splice Det 4
29.1 Catenary
127
STR.3 STR.4 STR.6
TR6 TR7
I.R. Dryer I.R. Dryer
Splice Det 2
Splice Det 3
TOP CLOSED BOTTOM CLOSED
F.COATER 2
Dunk Roll ENGAGED
WET SECTION
Wet Section Tension [lbs] 7567
TR3 TR4 TR5
Chem. Coat.
Cooling Rolls
TB3
TB3 Torque %
R1 -4
R2 -4
F.COATER 1
TOP CLS. BOTT.CLS.
TR9 TR8
P.COATER
Entry Press. -0.06
31.2 Catenary
450 °F 605 °F 630 °F 655 °F 680 °F
PMT 450 °F
PRIME OVEN
Exit Press. -0.02
PRIME QUENCH
STR.5 TB4
131 Strip Temperature
OVEN SECTION RO SYSTEM
Ex. Acc
ACCx Trq % 32
ACCx Tension [lbf] 6262
B
5 %
STR.8
Splice Det 5
TB5 Torque %
R1 19
R2 14
R3 14
TB5 TR12
TB6 Torque %
R1 -55
R2 -55
TB6 TR13
TR14 TR15 TR16
Inspection Area
EXIT SECTION
PR5 SHEAR PRx
Splice in front of exit shear -2764 ft
Time Remaining 09:58
STR RWND
OVERWIND
REWINDER Current Coil Last Coil
Trq % 75 Weight [lb] 33170 43650
Tension LBS 9227 Length [ft] 5162 6793
Tension PSI 4880 Dia. [in] 57.3 21.0
MODE
PCAT AUTO FCAT AUTO
PID OUTPUT
Prime Oven -9 % Finish Oven +2 %
GRAPHS 1 GRAPHS 2
PRIME CATENARY
Error [in] 0.0
Offset [in] -1.00
FINISH CATENARY
Error [in] -0.1
Offset [in] -2.00
PCat Error
FCat Error
Oven Drives Hydraulic Prime Quench Finish Quench Chemical Coater Oven Preheating Prime Coater Finish Coater 1 Finish Coater 2 Print PDF ALARMS
Line Overview Entry Section Cleaning Section Leveler Steering Units Oven Section Exit Section Line Data Line Recipe Start Condition Comm. Network HOME

7. Basic Software Application and Operation

Levels of Control (SCADA) - Management Level



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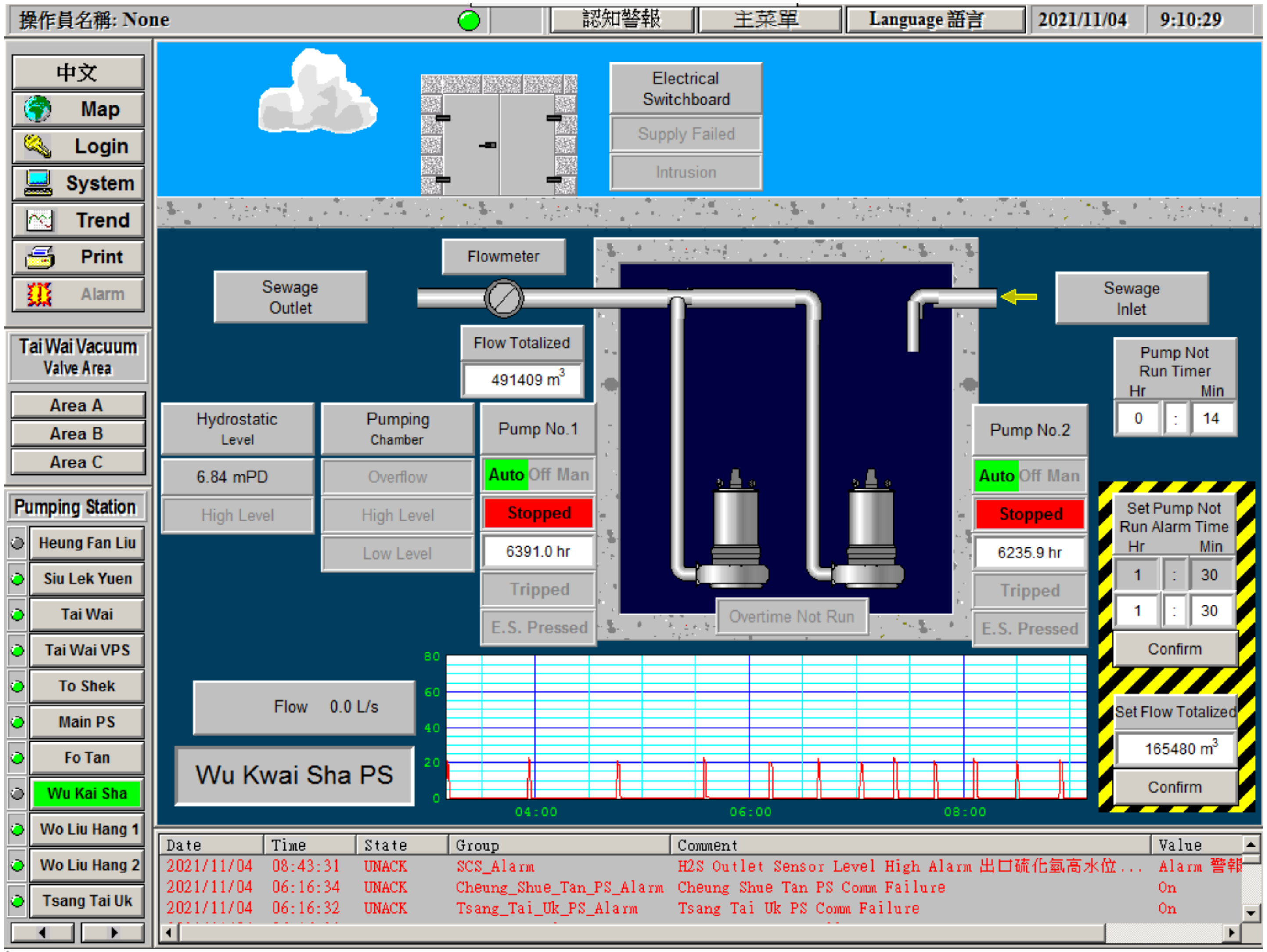
7. Basic Software Application and Operation

Levels of Control (SCADA) - Management Level



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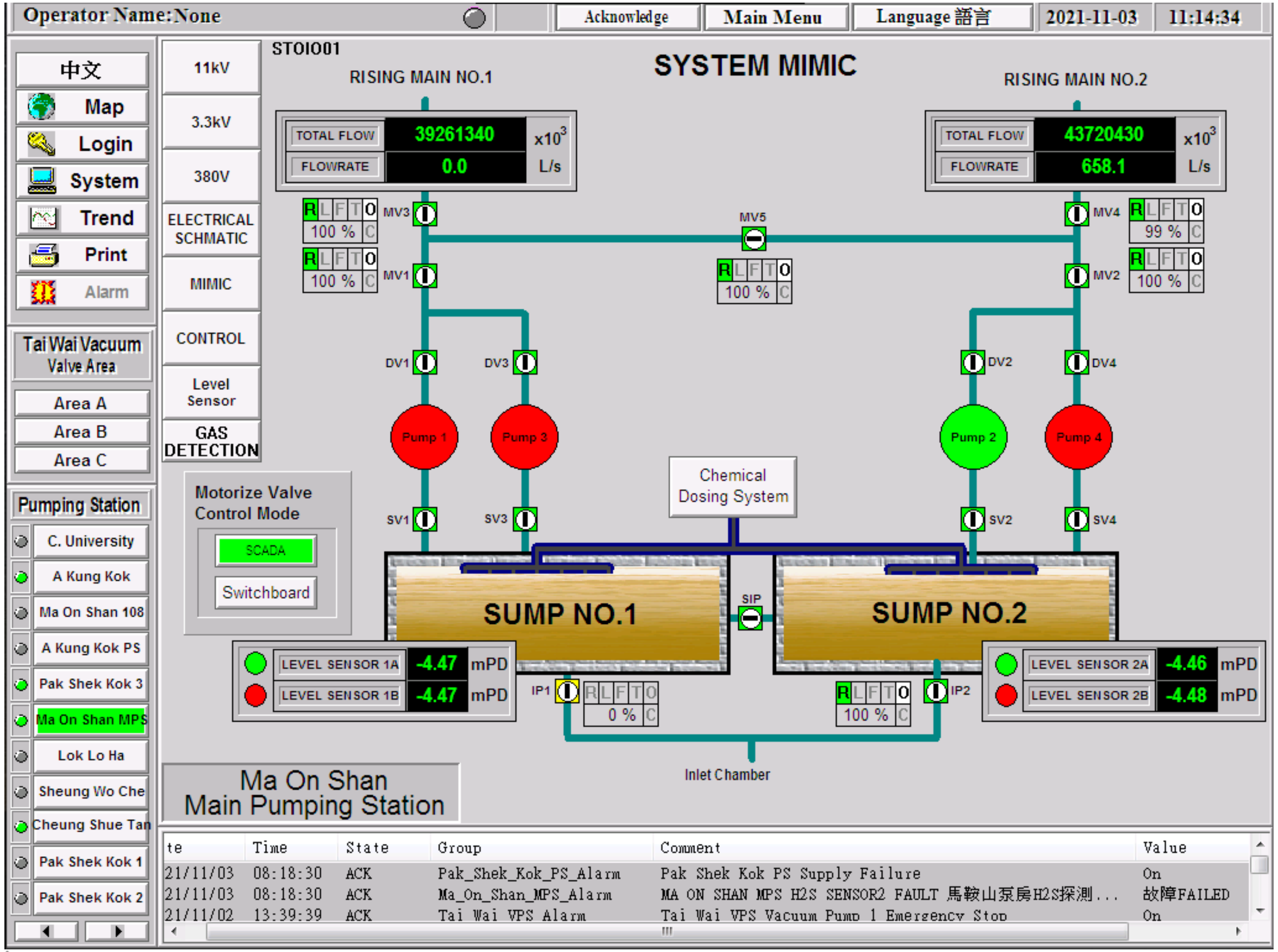
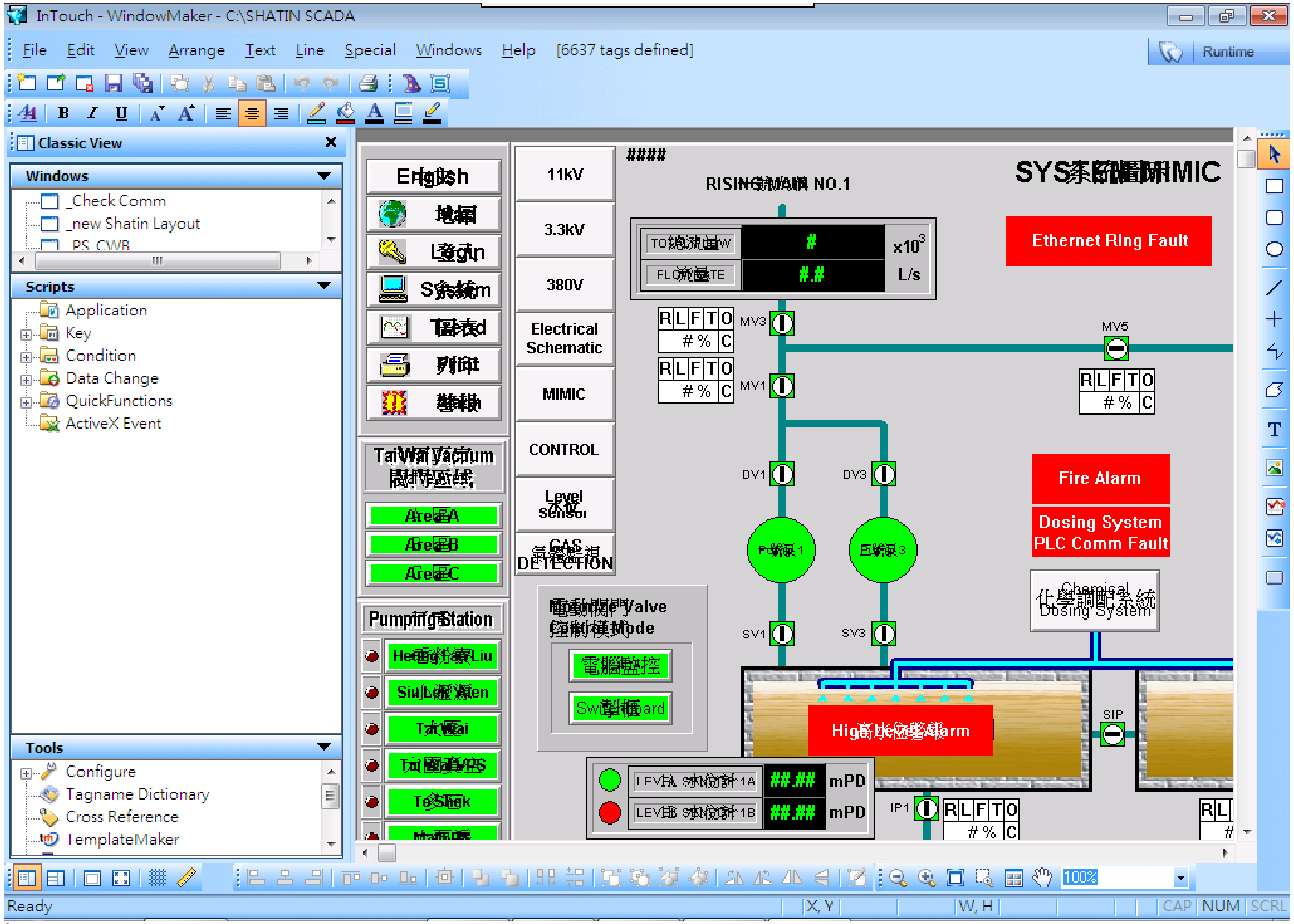
7. Basic Software Application and Operation

Levels of Control (SCADA) - Management Level



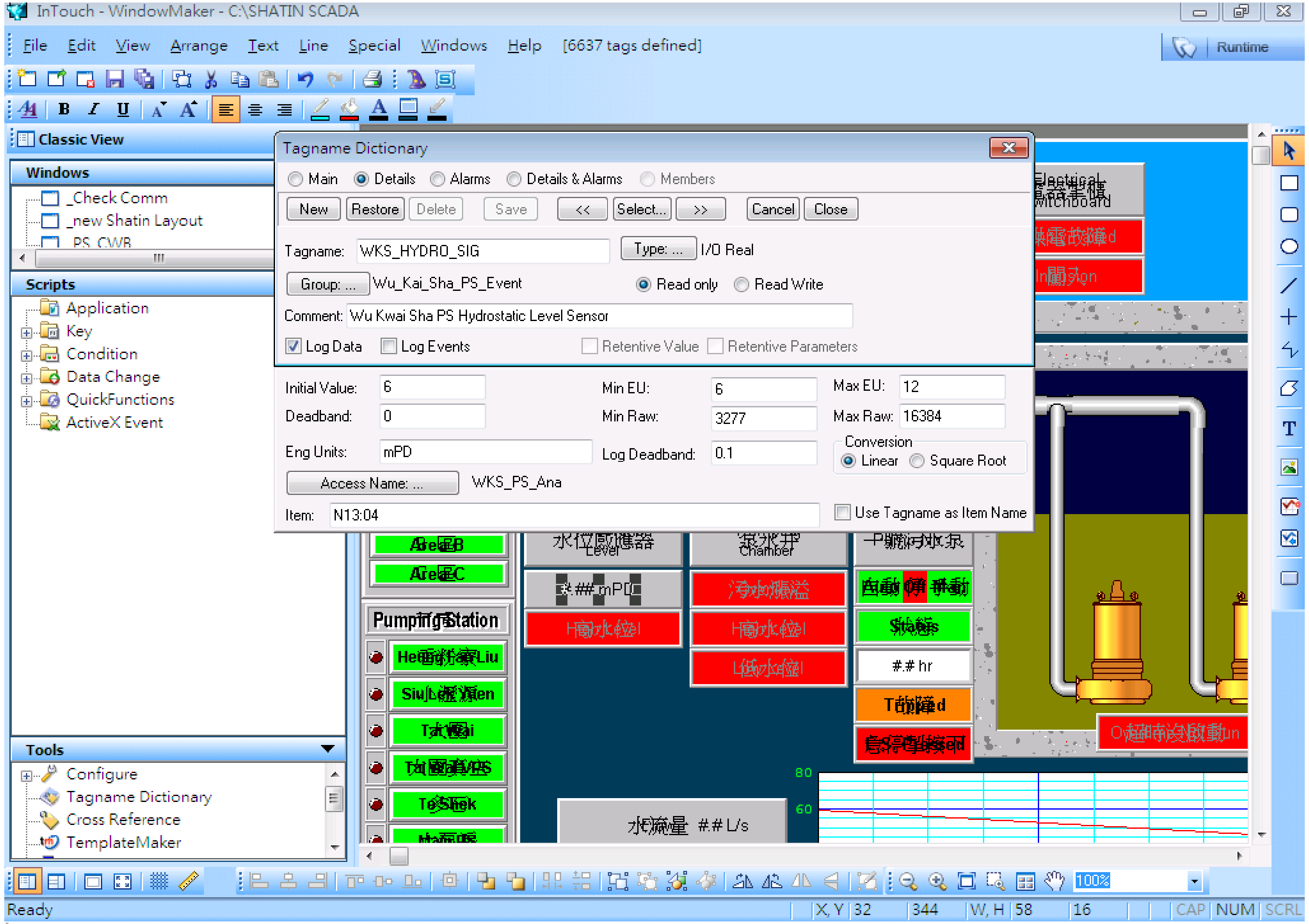
7. Basic Software Application and Operation

Levels of Control (SCADA) - Management Level



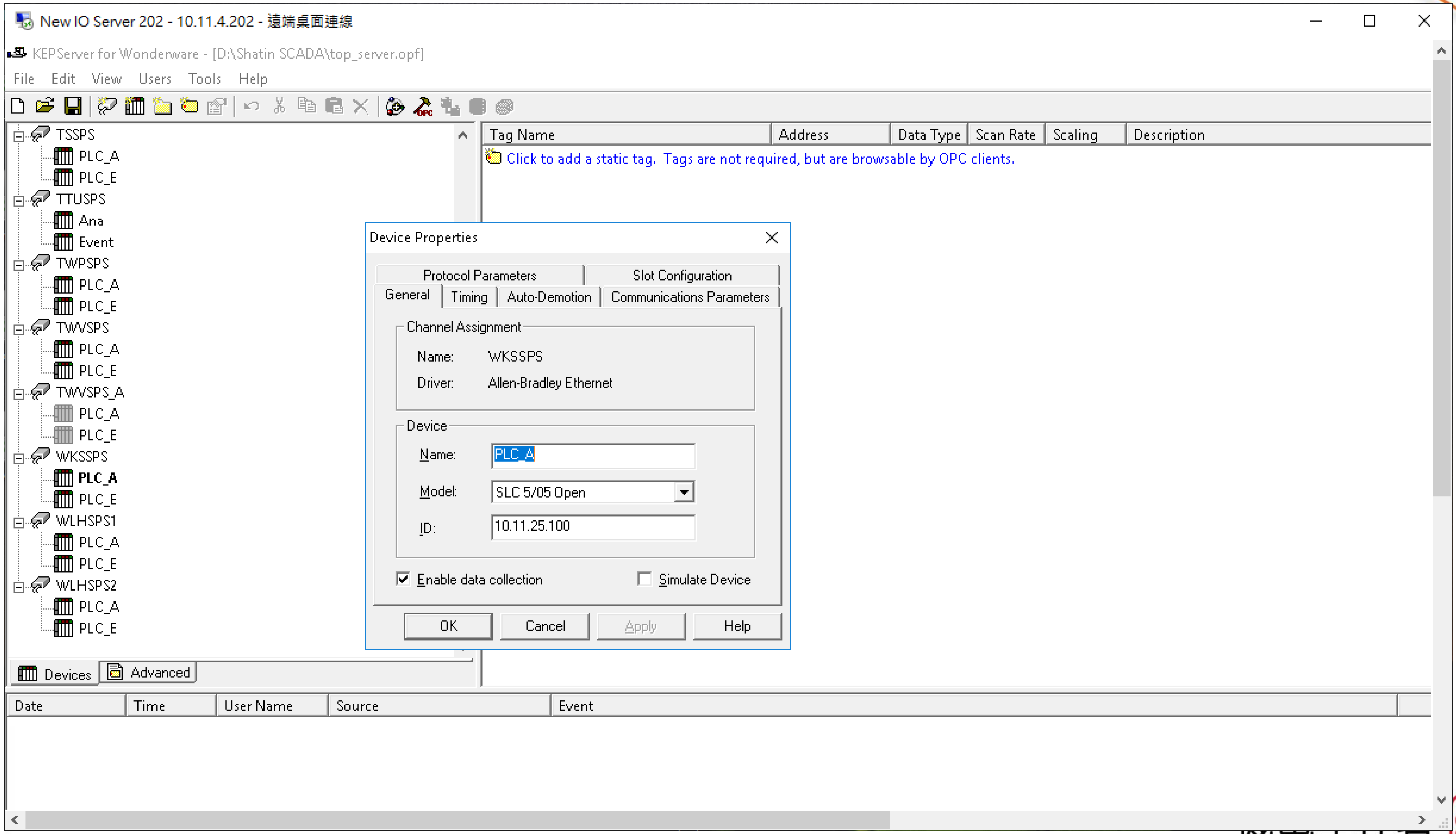
7. Basic Software Application and Operation

Levels of Control (SCADA) - Management Level



7. Basic Software Application and Operation

Levels of Control (SCADA) - Management Level



8. Hardware Practical and Troubleshooting

- PT1000 Sensor
- Signal Transmitter
- RTD, 4-20mA simulator
- Programmable Logic Controller (PLC)
- PLC commissioning Software

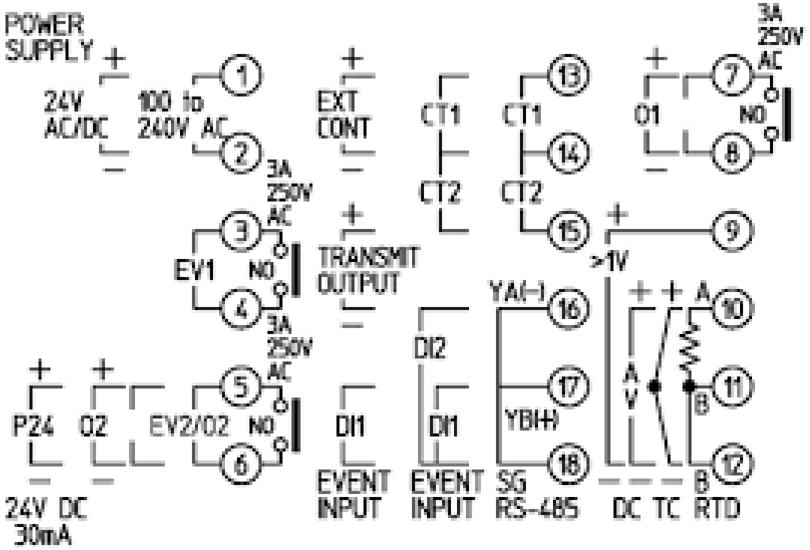
8. Hardware Practical and Troubleshooting

- PT1000 Sensor

Temp (°C)	0	1	2	3	4	5	6	7	8	9
-70	723.30	719.30	715.30	711.30	707.30	703.30	699.30	695.30	691.30	687.30
-60	763.30	759.30	755.30	751.30	747.30	743.30	739.30	735.30	731.30	727.30
-50	803.10	799.10	795.10	791.10	787.20	783.20	779.20	775.20	771.20	767.30
-40	842.70	838.70	834.80	830.80	826.90	822.90	818.90	815.00	811.00	807.00
-30	882.20	878.30	874.30	870.40	866.40	862.50	858.50	854.60	850.60	846.70
-20	921.60	917.70	913.70	909.80	905.90	901.90	898.00	894.00	890.10	886.20
-10	960.90	956.90	953.00	949.10	945.20	941.20	937.30	933.40	929.50	925.50
0	1000.00	996.10	992.20	988.30	984.40	980.40	976.50	972.60	968.70	964.80
	0	1	2	3	4	5	6	7	8	9
0	1000.00	1003.90	1007.80	1011.70	1015.60	1019.50	1023.40	1027.30	1031.20	1035.10
10	1039.00	1042.90	1046.80	1050.70	1054.60	1058.50	1062.40	1066.30	1070.20	1074.00
20	1077.90	1081.80	1085.70	1089.60	1093.50	1097.30	1101.20	1105.10	1109.00	1112.90
30	1116.70	1120.60	1124.50	1128.30	1132.20	1136.10	1140.00	1143.80	1147.70	1151.50
40	1155.40	1159.30	1163.10	1167.00	1170.80	1174.70	1178.60	1182.40	1186.30	1190.10
50	1194.00	1197.80	1201.70	1205.50	1209.40	1213.20	1217.10	1220.90	1224.70	1228.60
60	1232.40	1236.30	1240.10	1243.90	1247.80	1251.60	1255.40	1259.30	1263.10	1266.90
70	1270.80	1274.60	1278.40	1282.20	1286.10	1289.90	1293.70	1297.50	1301.30	1305.20
80	1309.00	1312.80	1316.60	1320.40	1324.20	1328.00	1331.80	1335.70	1339.50	1343.30
90	1347.10	1350.90	1354.70	1358.50	1362.30	1366.10	1369.90	1373.70	1377.50	1381.30
100	1385.10	1388.80	1392.60	1396.40	1400.20	1404.00	1407.80	1411.60	1415.40	1419.10
110	1422.90	1426.70	1430.50	1434.30	1438.00	1441.80	1445.60	1449.40	1453.10	1456.90
120	1460.70	1464.40	1468.20	1472.00	1475.70	1479.50	1483.30	1487.00	1490.80	1494.60
130	1498.30	1502.10	1505.80	1509.60	1513.30	1517.10	1520.80	1524.60	1528.30	1532.10
140	1535.80	1539.60	1543.30	1547.10	1550.80	1554.60	1558.30	1562.00	1565.80	1569.50
150	1573.30	1577.00	1580.70	1584.50	1588.20	1591.90	1595.60	1599.40	1603.10	1606.80

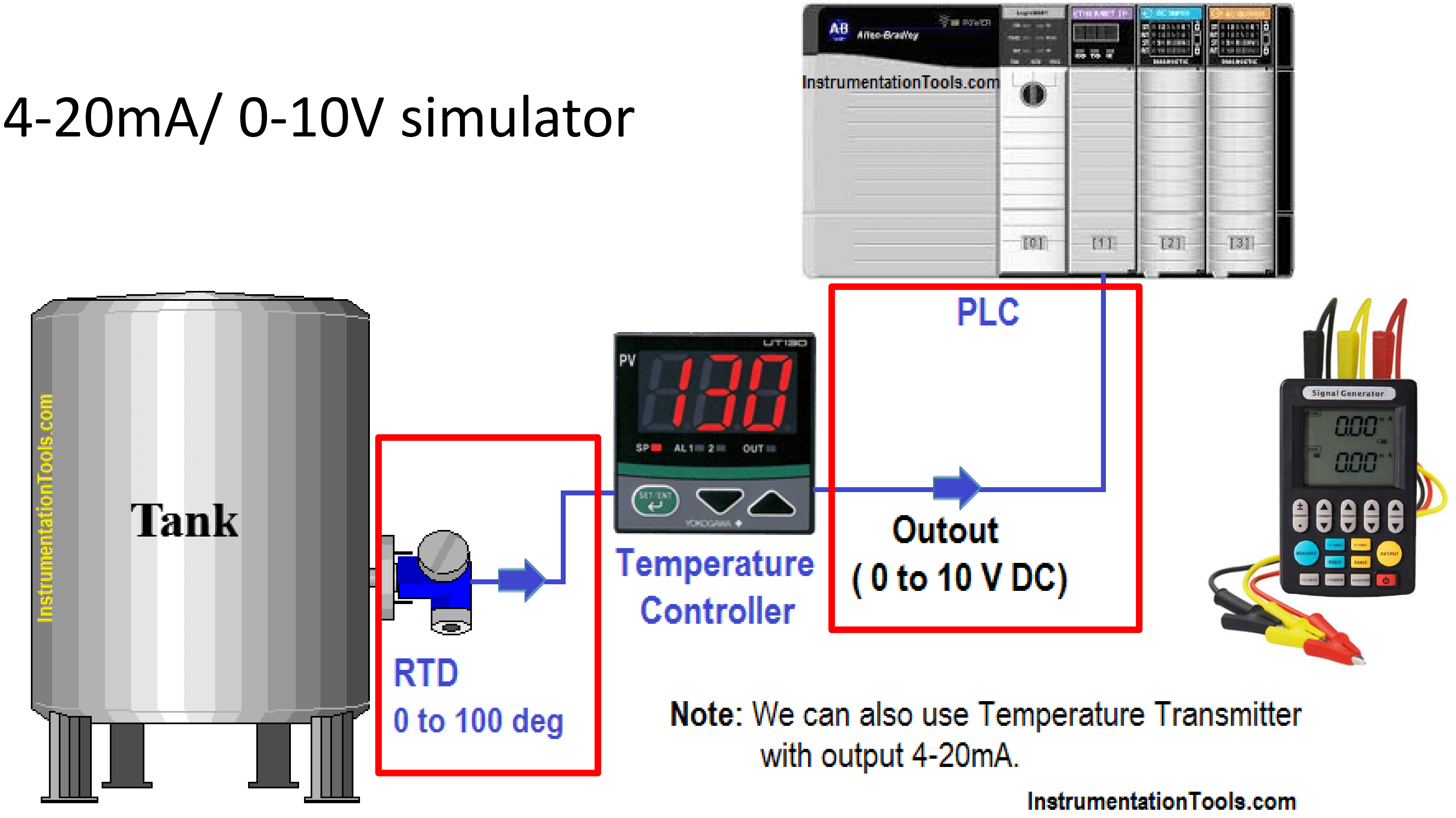
8. Hardware Practical and Troubleshooting

➢ Signal Transmitter



8. Hardware Practical and Troubleshooting

➢RTD, 4-20mA/ 0-10V simulator



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8. Hardware Practical and Troubleshooting

- Programmable Logic Controller (PLC)

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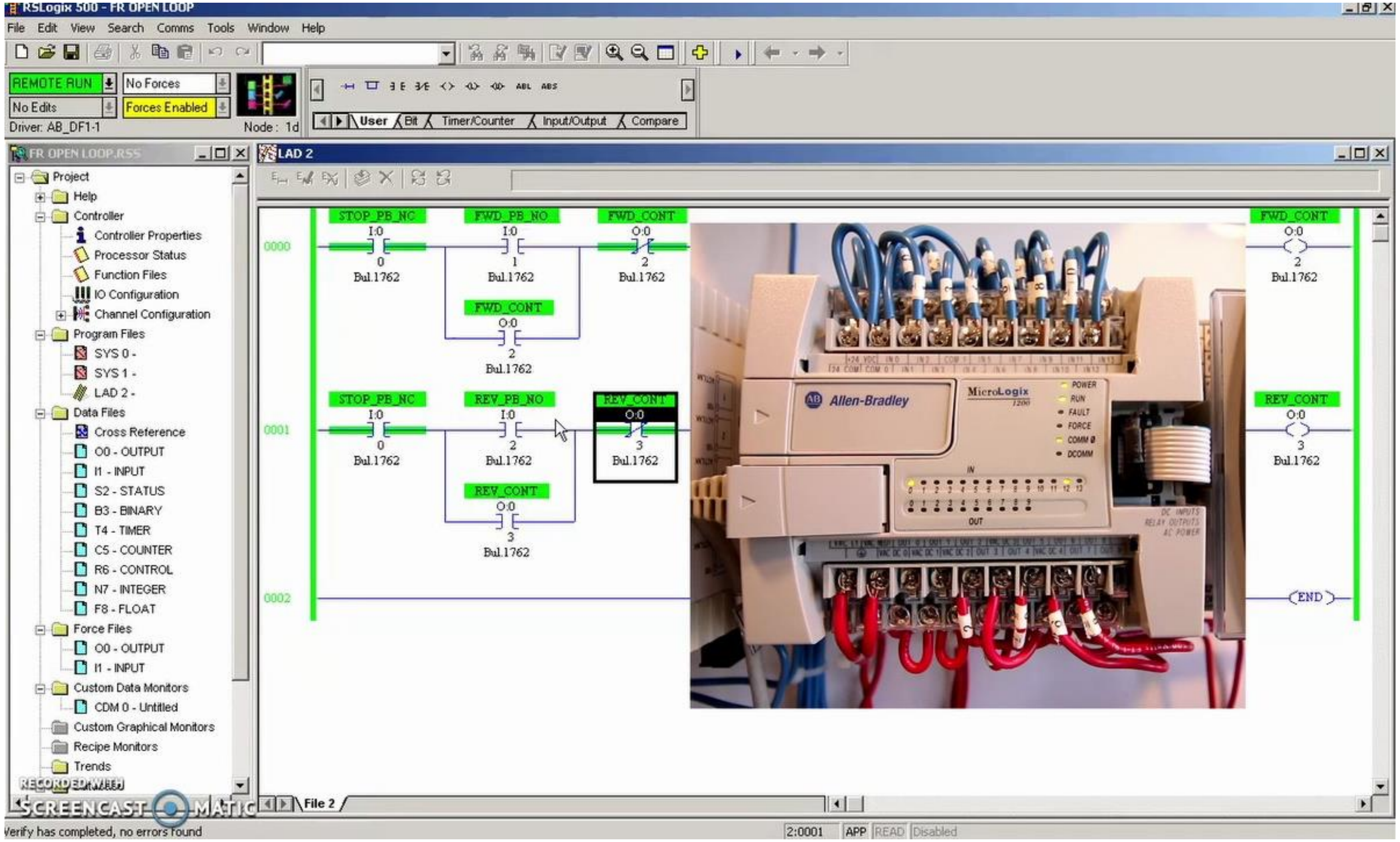
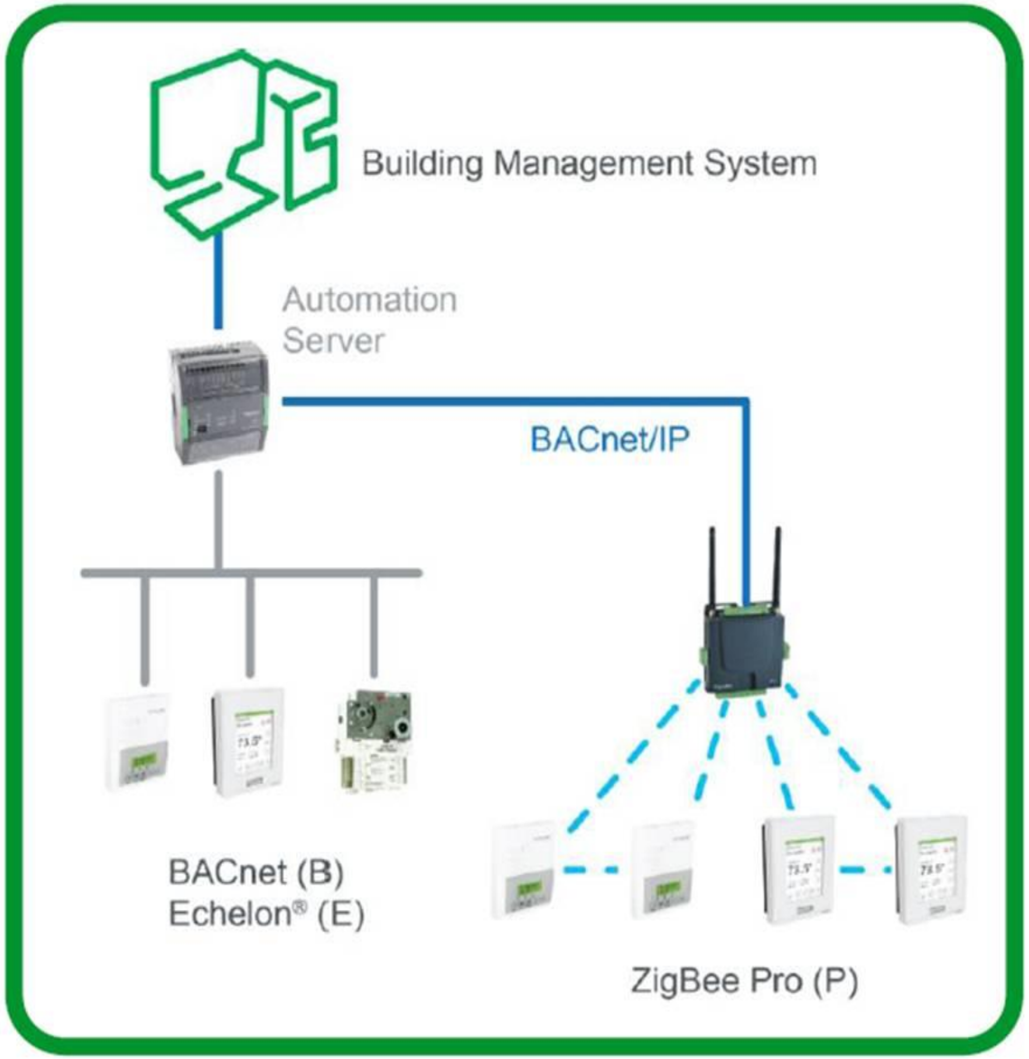
8. Hardware Practical and Troubleshooting

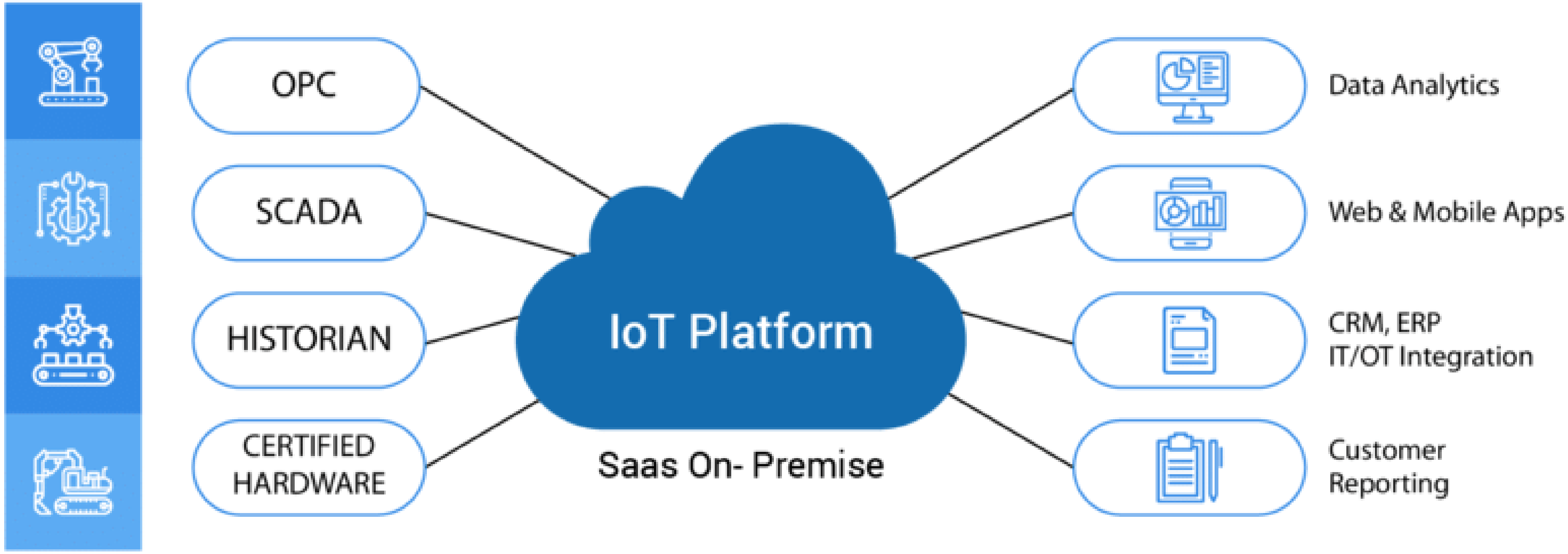
➢PLC commissioning



Additional information on new generation CCMS …



Additional information on new generation SCADA and CCMS …



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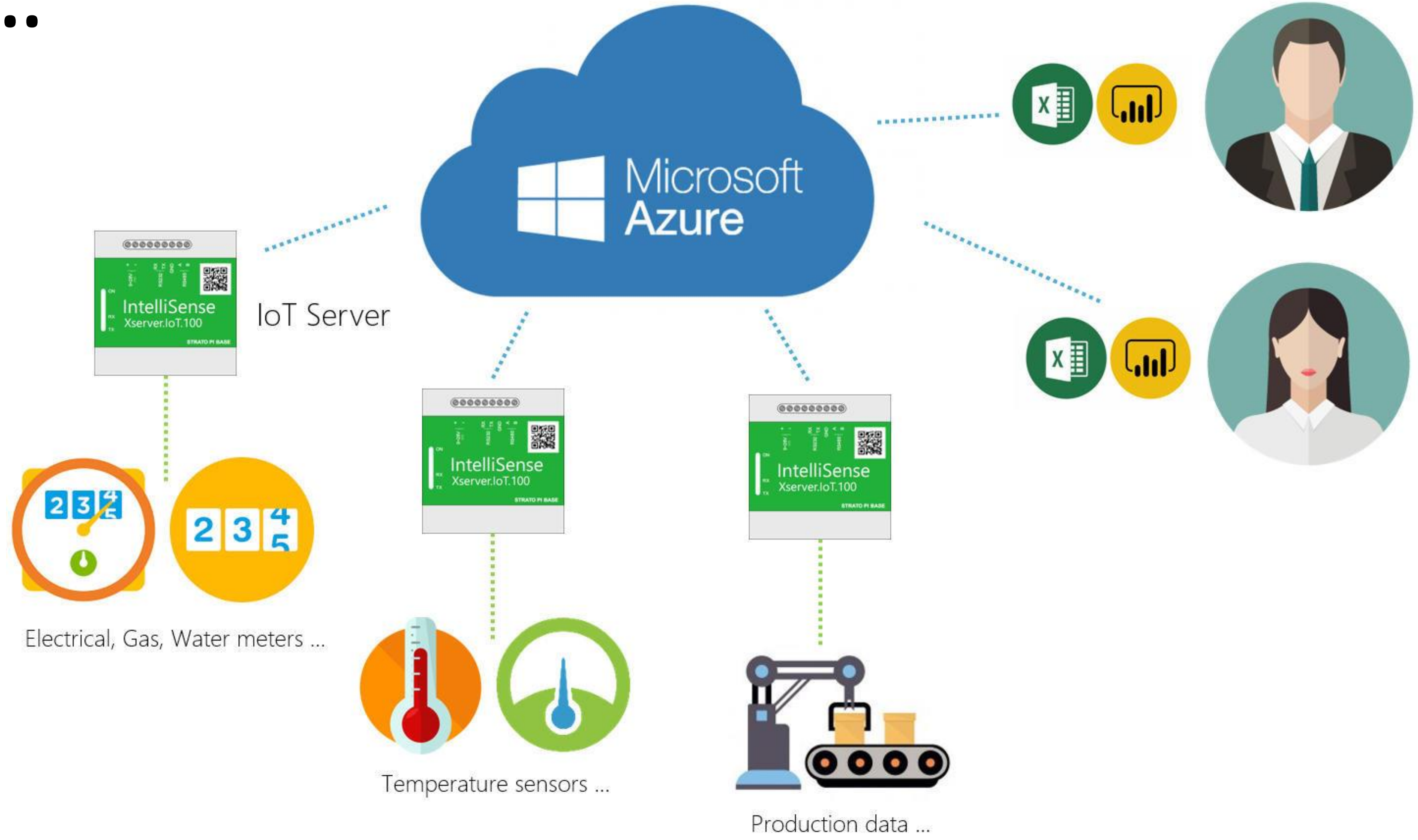
Additional information on new generation IoT ...



Questions & Answers

Thank You!

~ End ~