CONCEPT

PLC Programming and SCADA Systems: IEC 61131-3, Networks, RTUs and Telemetry

PLC Programming and SCADA Systems: IEC 61131-3, Networks, RTUs and Telemetry

Introduction:

PLC programming and SCADA systems decide whether a plant runs to its control narrative or stops on an unexplained trip, a lost network link or an undocumented online edit. This Core Concept course takes automation engineers from PLC hardware, I/O and the IEC 61131-3 languages through timers, sequencing, interlocks and HMI screens, then into industrial networks, SCADA architecture, RTUs and telemetry, redundancy, diagnostics, change control and OT security basics. Participants produce an Automation Project Package: a tested PLC program, SCADA screens, network map and acceptance test record for a process from their own site.

Course Objectives:

- Write, structure and test PLC programs in ladder diagram, function block diagram, structured text and sequential function chart to the IEC 61131-3 software model
- Implement timers, counters, sequences, permissives and interlocks that make machine and process logic predictable and fault tolerant
- Scale analog signals, configure PID function blocks and build HMI screens and faceplates that operators can run without ambiguity
- Configure Modbus, Profibus, Profinet, EtherNet/IP and OPC UA links between PLCs, RTUs, HMI and SCADA servers
- Design SCADA and telemetry architectures with RTUs, DNP3 or IEC 60870-5-104, historian interfaces and redundant servers and controllers
- Diagnose controller, I/O and network faults and manage program changes, acceptance tests and basic IEC 62443 zone and conduit protection

Target Audience:

- Automation engineers responsible for writing and commissioning PLC programs on process and machine applications
- Control and electrical engineers responsible for panel I/O, controller hardware and plant network design
- SCADA engineers responsible for supervisory servers, HMI screens, telemetry links and historian interfaces
- Senior instrument and control technicians responsible for fault finding on PLC, RTU and communication equipment
- Maintenance engineers responsible for automation spares, program backups and change records

Course Outline:

Day 1: PLC Hardware, I/O Modules and the Scan Cycle

- Controller Architecture: Brick and Modular Rack PLCs, CPU, Power Supply and Memory
- Digital I/O Modules: Sinking and Sourcing Wiring, Isolation and Terminal Checks
- Analog I/O Modules: 4-20 mA and 0-10 V Channels, Resolution and Update Rate
- PLC Scan Cycle: Input Image, Program Execution, Output Update and Watchdog Timing
- I/O Allocation Table and Tag Naming Convention for a New Automation Project

Day 2: IEC 61131-3 Software Model and Programming Languages

- IEC 61131-3 Software Model: Configuration, Resource, Task and Program Organisation Units
- Ladder Diagram LD: Contacts, Coils, Set-Reset Latches and Rung Logic Patterns
- Function Block Diagram FBD: Standard Blocks and User-Defined Function Blocks
- Structured Text ST: IF, CASE and FOR Statements, Data Types and Arrays
- Sequential Function Chart SFC: Steps, Transitions, Actions and the Retirement of Instruction List

Day 3: Timers, Counters, Sequencing and Interlocks

- On-Delay, Off-Delay and Pulse Timers TON, TOF, TP in Motor and Valve Logic
- Up, Down and Up-Down Counters for Batching and Production Counting
- Start-Stop Seal-In Circuits, Permissives and Interlock Matrix Design
- State Machine Sequencing in SFC for a Tank Fill, Mix and Drain Batch
- First-Out Fault Capture and Equipment Trip Logic Lab

Day 4: Analog Handling, PID Function Blocks and HMI Design

- Analog Scaling to Engineering Units, Clamping and Out-of-Range Signal Detection
- PID Function Block Configuration in the PLC: Modes, Bumpless Transfer and Output Limits
- PLC Simulation Software and Offline Program Testing with Forced I/O
- HMI Screen Hierarchy, Navigation and Faceplate Design for Motors and Valves
- HMI Tag Binding, Operator Command Confirmation and User Access Levels

Day 5: Week-One Guided Case: Pump Station and Conveyor Control

- Guided Case: Duty-Standby Pump Station Logic Written in LD and ST
- Guided Case: Conveyor Sequence with Jam Detection and Restart Interlocks
- Guided Case: HMI Mimic and Faceplate Screens for the Pump Station
- PLC Code Review Checklist: Structure, Comments, Unused Tags and Scan Load
- Week-One Program Test Record and Functional Walkthrough

Day 6: Industrial Networks and Communication Protocols

- Modbus RTU and Modbus TCP: Register Map Design and Master Polling Configuration
- Profibus DP and Profinet Device Configuration with Device Description Files
- EtherNet/IP Implicit I/O Connections and Explicit Messaging Between Controllers
- OPC UA Server and Client Setup: Address Space, Subscriptions and Security Modes
- RS-485 and Industrial Ethernet Topologies: Line, Star and Ring with Switch Settings

Day 7: SCADA Architecture, RTUs and Telemetry

- SCADA Generations from Monolithic to Web-Based Systems and Supervisory Server Roles
- RTU Functions: Autonomous Local Logic, Time-Stamping and Store-and-Forward Buffers
- Telemetry Protocols: DNP3 and IEC 60870-5-104 Event Reporting and Polling Cycles
- Radio, Cellular and Fibre Telemetry Links: Bandwidth and Latency Budget
- SCADA Tag Database, Historian Interface and Alarm Summary Page Configuration

Day 8: Redundancy, Diagnostics and OT Security Basics

- Hot-Standby Controllers, Redundant CPUs and Redundant I/O Configuration
- Redundant SCADA Servers and Network Ring Recovery Switchover Tests
- Controller and Module Diagnostics: Fault Codes, Status Words and Event Logs
- IEC 62443 at Overview: Zones, Conduits and Security Levels for PLC and SCADA Networks
- Hardening PLC and SCADA Hosts: User Accounts, Remote Access and Backup Images

Day 9: Troubleshooting, Change Management and Automation Performance

- Structured Troubleshooting: Symptom Isolation, Signal Trace and Online Logic Monitoring
- Communication Fault Diagnosis with Protocol Analysers and Diagnostic Counters
- Program Version Control, Online Edits and Change Approval Records
- Factory and Site Acceptance Test Protocols for Automation Changes
- Automation Performance Indicators: Scan Time, Network Load, Controller Availability and Downtime Causes

Day 10: Capstone: Automation Project Package

- Capstone Brief: Process Description, I/O List and Control Narrative
- Capstone Build: PLC Program with Sequences and Interlocks Across Four Languages
- Capstone Build: SCADA Screens, Historian Tags and Modbus or OPC UA Link
- Capstone Test: Simulated Faults, Redundancy Switchover and Change Record
- Automation Project Package Presentation and Peer Technical Review

Skills You Will Gain:

- Ladder and Structured Text Programming
- Sequential Function Chart Design
- Interlock and Permissive Logic
- HMI Faceplate Design
- Industrial Protocol Configuration
- RTU and Telemetry Integration
- Controller Redundancy Testing
- Automation Change Control

Why Attend This Course:

- Return with an Automation Project Package: a tested PLC program, SCADA screens, network map and acceptance test record for a process on your own site
- Move in week two from writing controller logic to connecting it: networks, SCADA servers, RTUs, telemetry, redundancy and diagnostics
- Shorten fault finding on trips and lost communications by working through controller, I/O and network diagnostics in a set order
- Compare automation practice with engineers from oil and gas, water, power, utilities and manufacturing plants

Conclusion:

A PLC program only earns trust when its logic is readable, its I/O is documented, its networks are diagnosable and every change is recorded. The first week builds programming capability in the IEC 61131-3 languages, sequencing, interlocks and HMI design. The second week adds industrial protocols, SCADA architecture, RTUs and telemetry, redundancy, diagnostics, change control and IEC 62443 basics. The capstone turns both weeks into an Automation Project Package ready for review at the participant's own site.