

# **Understanding, Maintaining and Troubleshooting ControlLogix Systems** **—with The Studio 5000 Designer Software—**

## Training Program

Specially designed for Maintenance Personnel responsible for maintaining and troubleshooting a ControlLogix system in your plant.

- Module 1 Introduction to the ControlLogix—General Structure, Number Systems, and Basics of Boolean Logic
- Module 2 ControlLogix Hardware Composition, I/O Structure and Architecture—Introduction to Tags
- Module 3 Navigating the Studio 5000 Software and Creating, Opening and Understanding Projects
- Module 4 Connecting to the Controller—Establishing RSLinx Connection to the Network
- Module 5 ControlLogix Project Organization and Frequently Used Tag Structures
- Module 6 Troubleshooting Ladder Diagram Logic in the ControlLogix System
- Module 7 Creating and Editing Tags and Code—Documenting Troubleshooting Changes
- Module 8 Troubleshooting Using the Studio 5000 Software—Using I/O Forcing and Toggling Functions
- Module 9 Troubleshooting ControlLogix Hardware—Discrete and Analog I/O
- Module 10 Troubleshooting Remote I/O, Controller and Power Supply—Using the Trend and Compare Tools to Troubleshoot



No more excuses . . . no more . . . "I don't know how to troubleshoot this controller"...

**Make Everyone Count!**



## If you have a ControlLogix in your plant... this great product is for your maintenance personnel.

The Understanding and Troubleshooting ControlLogix Systems Training Series contains 10 modules which cover the most critical and fundamental ControlLogix skills that every maintenance technician needs to know, resulting in more efficient and effective troubleshooting and increased business competitiveness.

This training program was designed specifically for Maintenance personnel to sharpen their troubleshooting skills in a ControlLogix environment.



This is the most complete and comprehensive training program on the understanding and troubleshooting of a ControlLogix system, a series that provides approximately 40 hours of instructional material and assessments.

Just one troubleshooting solution of the many presented in the program can help your employees save several tens of thousands of dollars in downtime to the plant.

## We Know PLC Automation...We Know Training

At ITV (Industrial Text and Video) we have been publishing training materials for over 25 years. In fact, we wrote and published the best-selling textbook on programmable controllers with over 400,000 copies sold to industry and education.

We have also published other award winning PLCs, MicroLogix, and Electrical and Motor Controls multi-media training programs and made available to our worldwide customer base. We know how to set the standards for training, and this ControlLogix training program is no exception.

This ControlLogix series is the best training program on the market, delivering proven content and using top delivery technology not available anywhere.

## A New Paradigm in Course Delivery

The ControlLogix program is delivered via a powerful large-screen Microsoft Windows High Definition resolution Tablet that forms your company's personal ControlLogix Training Portal (includes detachable keyboard, stylus pen and earphones).

At the heart of the Training Portal is our proprietary built-in HD multi-media interactive software (Patent Pending) which makes the user's experience incredibly easy and seamless.

Not only is it easy for a technician learner to launch the training, but the system is also incredibly simple for the administrator—one touch and wallah... there you have the administrative report to see how everyone is doing and what they are learning!

### Secure & Off-Grid

No Internet communication, no connection to your company's network, no DVDs, no CD-ROMs...the Training Portal has everything built-in, keeping all your info and connections safe and secure. And best of all, the system is completely portable. A simple one second 'activation' through WiFi sets up the system, and from then it can remain off-grid— the Training Portal keeps all data and storage internal to the system.

### How Many People?

You can have as many people in your plant as you would like go through the training program. There are no limitations to the number of Learners you can have.

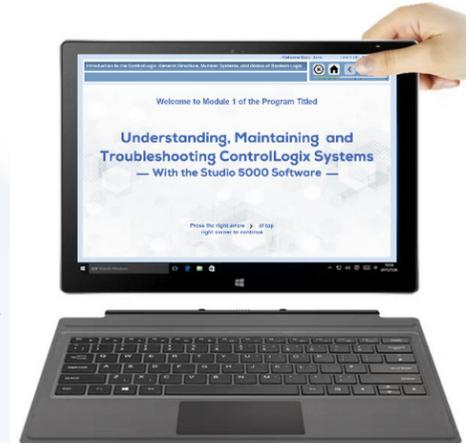
### Simple to Use Training Portal

To register employee learners...just give them the Tablet Portal, and they can self-register in less than a minute. Or they can be assigned courses by an administrator as needed, its as easy as just a few clicks.

Program Title	Lesson Title	Completed	Started	Finished	Final Exam Score
CLX Controller	1 Introduction...	100%	2/10/23	2/11/23	82
	2 Har_Composition	100%	3/10/23	3/11/23	93
	3 Navigating the...	50%	4/10/23		
	4 Connecting to...				
	5 Project Diagram...				
	6 Ladder Diagram...				
	7 Creating and...				
	8 Using the Studio...				
	9 Hardware...				
	10 Troubleshooting...				

To view employees' progress...just sign in as administrator and see how everyone is doing. The administrator's portal is clear and simple, with learner's listed alongside their Assigned Courses, Completion status and Final Exam scores.

Our easy set-up gives you more time, and accessing the dynamic content portal is a breeze! For Learners and Administrators alike, this Training Portal is your simple and easy to use solution for ControlLogix training.



Our trusted training includes:

- Windows tablet (Your Training Portal)
- Administrative and Interactive Training Content Software
- Handbook Collection
- Protective travel case



For an employee learner to open the training...simply login and click to launch the program. From there they can watch the instructional videos, answer interactive Review questions with ARM™, and complete the Final Exam. Their current place and answers are saved when they exit.

Select Action	All Learner	Program(s) Assigned	Date Assigned	Completed
<input type="checkbox"/>	Smith, John	CL Controller	2/08/23	No
<input type="checkbox"/>	Hubbell, Chris	CL Controller	3/10/23	No
<input type="checkbox"/>	Miller, Mike	CL Controller	2/09/23	Yes

Program Title	Lesson Title	Completed	Started	Finished	Final Exam Score
ControlLogix	1 Introduction...	100%	2/10/23	2/11/23	82
	2 Har_Composition	100%	3/10/23	3/11/23	93
	3 Navigating the...	50%	4/10/23		
	4 Connecting to...				
	5 Project Diagram...				
	6 Ladder Diagram...				
	7 Creating and...				
	8 Using the Studio...				
	9 Hardware...				
	10 Troubleshooting...				

# PREVENTIVE MAINTENANCE!

... Starts with trained personnel



To order go to [www.clx.industrialtext.com](http://www.clx.industrialtext.com) or call 1-888-375-5334

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## CO\$T & Compare

### Your Personal Company Training Portal

The Training Portal Tablet introductory price is \$4956 and has a license for one-year at your plant. Optional subsequent years are at a discounted price (if not renewed...you keep the tablet). The Training Portal Software provides hands on interactive ARM™ (Automatic Reinforcement Mode) review feedback to enhance the learning.

### For As Many Users As You Want

The license allows you to train as many current as well as future (onboarding) maintenance personnel as you'd like, so that all can troubleshoot a ControlLogix system properly and save company money.

### Each Module Has Its Own Comprehensive Handbook.

Included with the Tablet Portal are also 10 comprehensive handbooks, one for each Module, with a total of 1,272 pages, 2400+ graphics and over 450+ Review Questions with explanatory ARM™ feedback. All illustrations, Studio 5000 software diagrams, and pictures are shown in full color. These sewn-bound Handbooks are made of recyclable materials and printed using nature and environmental sensitive soy ink. These



handbooks are packed in a handsome *Handbook Collection* Slip Case, a definite reference tool to keep on hand.

Your employees will use this powerful reference over and over. These handbooks are not just printed matter, these handbooks are a "tool of work". During the training they can write notes and comments in the handbooks relating to pertinent equipment in the plant and troubleshooting approaches. A great reference tool. Additional Handbook Collection sets are available at \$48.60 per handbook (\$486 for the complete 10-set collection in a protective slip case).

### Compare to Other Options... ...Besides Not Training at All



This program on the ControlLogix is the "best" proven training in the market. Compare it to going to a week training off-plant premises or out of town, not only travel expenses, a whole week out of work from the battle field (who is covering for your warrior?), and at a class fee cost of close to \$3000 per employee...and if lucky, you will receive a copy of the Power Points that were used in the class... and hopefully all is not forgotten after two weeks... *because there is no replay button.* Our program is simply the best option.

Your maintenance personnel will learn with this portal, and if needed they can always go back to review...it is a great tool to always have.

If For Some Reason Does Not Work For You...

...if in 30 days you find it is not for you, send it back for full refund, no questions asked.

To order go to [www.clx.industrialtext.com](http://www.clx.industrialtext.com)  
or call 1-888-375-5334

**Can the plant really afford  
for your maintenance  
people to be out for a  
week or more?**



## ControlLogix General Program Content

The ControlLogix Training Series has 10 courses that cover the most critical and fundamental skills that everyone who is involved with a ControlLogix system in a manufacturing plant maintenance department needs to know.

### Technicians going through the program will...

- Thoroughly understand the integrated architecture of the ControlLogix system so that we can troubleshoot the whole system
- Know how the Studio 5000 is also a great tool for troubleshooting a system
- ControlLogix hardware composition which provides a solid foundation on input and output addressing and "tag" referencing
- Create a project based on the fundamentals of the hardware composition and architecture and how it relates to the inputs and outputs that we troubleshoot in a control system,
- How we establish proper communication and connection with a controller to download a project and go on-line in order to troubleshoot any problems in the system.
- Project organization and the understanding of frequently used tag structures
- Ladder structure and basic instructions that we will need to understand to properly troubleshoot programming code
- Creating and editing tags and code and deal with the importance of documenting our troubleshooting changes in the system.
- Troubleshooting using the Studio 5000 software and learn how to use several special program control instructions for testing and troubleshooting sections of ControlLogix code.
- Troubleshooting discrete and analog I/O hardware components and the importance of understanding module configuration to avoid problems during troubleshooting.
- Remote I/O subsystems as well as troubleshooting the controller and power supply.
- Use of the forcing and toggling functions when troubleshooting.
- How to solve other potential problems that we can face during troubleshooting such as noise and interference in the system as well as heat.
- Use of the "Trending" function to troubleshoot a system.
- How to use the "Compare Projects" tool to compare two ControlLogix projects to find the differences.

...For an in-depth learning content see what each of the ten modules will give your technicians and you will agree that our ControlLogix solution is your best bet to get your personnel trained and solving problems in the plant floor.

## Complementary Support to OSHA

Because of the electrical nature of our training programs, they also help complement and support the employee's training requirements of OSHA 29 CFR 1090.332 and ISO 9000 Section 4.18 regulation.



To order go to [www.clx.industrialtext.com](http://www.clx.industrialtext.com) or call 1-888-375-5334

## Module 1

# Introduction to the ControlLogix—General Structure, Number Systems, and Basics of Boolean Logic

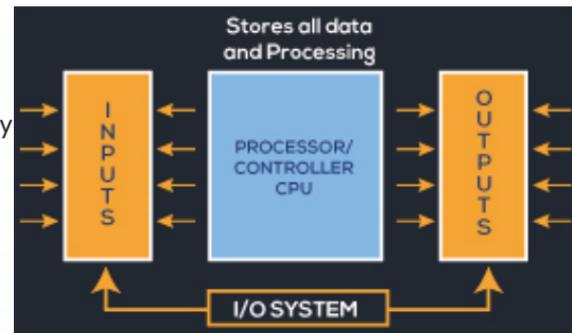
This module introduces you to the ControlLogix programmable controller from Rockwell Automation and you will thoroughly understand the integrated architecture of this wonderful product.

In this first module we are going to jump in and cover some basics of standard PLCs including operation and functionality and how standard PLCs differ slightly from the ControlLogix platform.

We will also cover the fundamentals of number systems which provide the basis for digital control systems. Then, we will move to the understanding of logic and binary concepts which are used as the foundation of not only PLCs, but also of computers in general.

## ControlLogix Operation—Know the Ins & Outs

- ❖ Point out the benefits of PLCs and ControlLogix in automation.
- ❖ Master the components of a ControlLogix system, Inputs and Outputs as well as the “main” controller.
- ❖ Understand the operation of standard PLCs and the operation of the ControlLogix platform—Synchronous vs Asynchronous.
- ❖ Know how the memory system of a PLC is arranged and why the memory system is “where things happen” in a system.
- ❖ Understand number systems and those used in a ControlLogix.
- ❖ Know about binary and word formats which define the ControlLogix “Data Types” used in the system.
- ❖ Use logic and binary concepts which are used as a foundation in control systems.
- ❖ Understand AND, OR and NOT Boolean logic and how these functions are used to implement from simple to complex control output decisions.



## Lessons in Module 1

- 1– Introduction to the ControlLogix System
  - About The Program
- 2– Basics of Standard PLCs
  - Components
- 3– Operation
  - Differences Between Standard PLCs and ControlLogix
- 4– Memory Structure
- 5– Number Systems
  - Basics of Number Systems
  - Decimal
  - Binary
  - Octal
  - Hexadecimal
  - ASCII
- 6– Binary and Word Formats
- 7– Logic Concepts and Principles of Boolean Algebra
  - Boolean Operators AND–OR–NOT



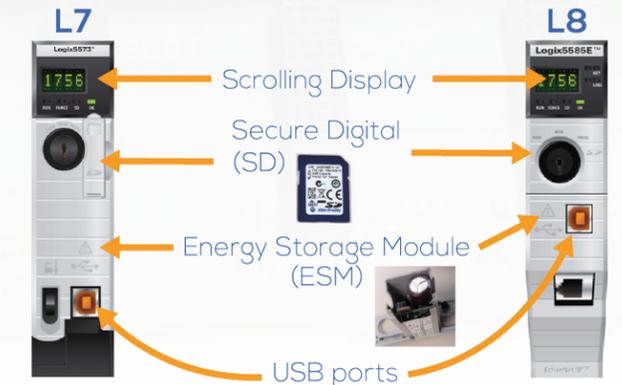
## Module 2

# ControlLogix Hardware Composition, I/O Structure and Architecture—Introduction to Tags

In the second module of the program, the ControlLogix hardware composition is covered which is critical to the understanding of the installation, configuration and troubleshooting of a ControlLogix system.

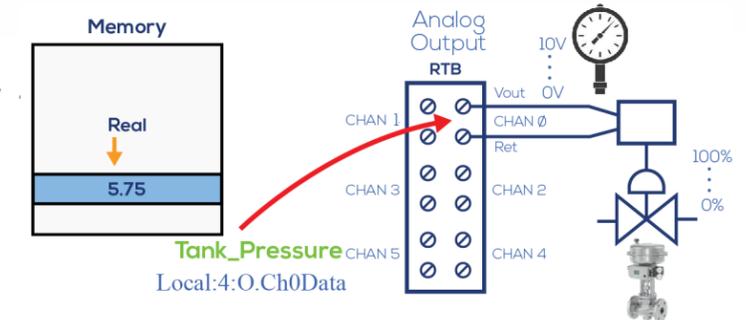
The hardware composition defines the *architecture* of the ControlLogix, the placement of the Input and Output (I/O) modules, and as we will see, defines the “addresses” of the field devices that will be connected to the input and output modules.

The different Logix controllers (L7 & L8) are covered along with power supply, chassis, and I/O and communication modules not only for “Local” chassis but also for Remote I/O subsystems.



## Master Installation, Configuration and Troubleshooting of I/O in a ControlLogix System Chassis

- ❖ How the chassis forms an integral part of the system and the different sizes available for the ControlLogix.
- ❖ The different types of ControlLogix controllers/processors.
- ❖ The different types of Power Supply available.
- ❖ How are the Inputs and Outputs modules inserted into slots of the chassis.
- ❖ What does the insertion of an I/O module mean in terms of memory addressing of the field devices wired to I/O modules.
- ❖ How to do the system configuration, and how the input and output modules are inserted into the chassis.
- ❖ Identify modules’ components such as diagnostics, status indicator, RTB connection and others.
- ❖ How the Remote I/O Subsystems and its I/O Placement and Configuration is done.
- ❖ Know what “Rack Optimization” is and how tags are shown for this type of Remote I/O configuration.
- ❖ Know what tradeoffs we have to make when using Rack Optimization.



## Lessons in Module 2

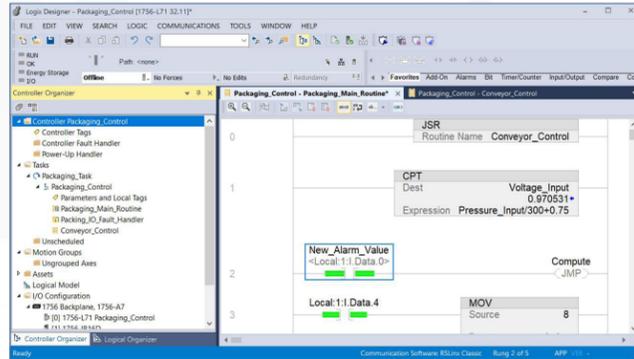
- 1– Introduction
  - Hardware Components
- 2– ControlLogix Controllers
  - Power Supply
- 3– I/O Modules
  - Communications Modules
- 4– I/O Module Placement and Configuration
  - I/O Placement in the Chassis
  - Tag Creation
  - Discrete Inputs
  - Discrete Outputs
  - Analog Inputs
  - Analog Outputs
- 5– Remote I/O Subsystems
  - I/O Placement and Configuration
  - Remote I/O
  - Rack Optimization

## Module 3

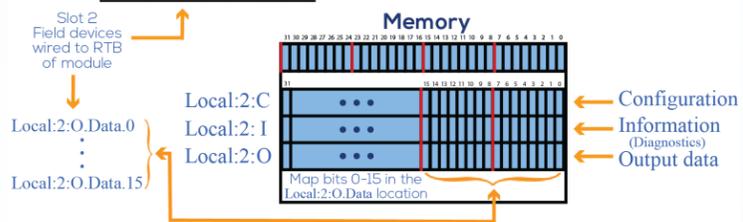
# Navigating the Studio 5000 Software and Creating, Opening and Understanding Projects

In this module of the program, a ControlLogix project is created in order to explore the Studio 5000 by navigating through the different sections of this powerful software. Also cover in detail is the functionality of the toolbars in the software which assist while troubleshooting.

Furthermore, I/O modules are added to the project and explore the relationship of the I/O field devices connected to the I/O system and their "tag" representation in the controller. This important navigation of the Studio 5000 software will be invaluable during its use when troubleshooting a ControlLogix system.



## Master a ControlLogix Troubleshooting Problem Knowing The Studio 5000 Software



### Lessons in Module 3

- 1- Introduction–Studio 5000
- 2- Opening the Studio 5000 Software  
Creating a New Project
- 3- Opening the Studio 5000 Software –“Screen Zones”  
Controller Organizer  
Logical Organizer
- 4- Studio 5000 Navigation  
Main Window  
Routine Editor  
Output window–Errors–Search Results–Watch  
Quick View
- 5- Floating and Docking Windows  
A Floating Window Beware–Note of Caution in the Classic
- 6- Navigation and Functionality of the Studio 5000 Toolbars  
Standard Toolbars  
Online Bar Toolbar
- 7- Studio 5000–The Other Toolbars  
Path Toolbar  
New Component Toolbar  
Language Element Toolbar  
Documentation Languages Toolbar  
Bookmark Toolbar  
Ladder Common Logic Toolbar  
Custom Tools Toolbar
- 8- Creation of a Project

- 9- Adding More I/O Modules  
Basics of Tag Creation  
Creating a Tag–On-The-Fly  
Creating a Tag–At the Controller Tags  
Creating a Tag–At the Controller Tags Tab

## Module 4

# Connecting to the Controller Establishing RSLinx Connection to the Network

This module covers how to establish communication with the ControlLogix processor in a chassis via the Ethernet communications network. The course shows how via RSLinx, Allen Bradley’s communication software, different types of drives can be created to communicate in the network and what precautions we have to take during the driver creation.

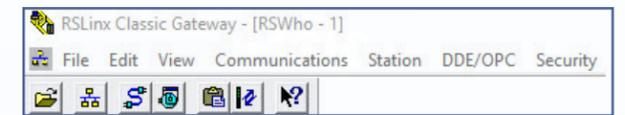


Important information is covered about networks which is necessary to know during troubleshooting of a project. Establish organization on IP addresses and how they can be assigned and managed to avoid confusion.

The Downloading, going Online and Uploading of projects is thoroughly covered and as well as things that users must be aware when doing these procedures. In depth detail about the controller’s operating modes is covered as well as how we go about during troubleshooting to monitor the status of tags for both discrete and analog field devices (analog scaled and non-scaled).

## Save Time During Troubleshooting—Connect Correctly To The Network

- ❖ Know what is required in order to establish communication between the Studio 5000 in a computer and a ControlLogix in a network.
- ❖ Set up a computer’s network configuration to be ready to create a driver.
- ❖ Understand IP addresses, network subnet masks, gateways and how these parameters are important during the setting and troubleshooting of network components.
- ❖ Device a proper way to distribute and use IP addresses in your plant to avoid problems.
- ❖ Learn about RSLinx and why we refer to it as “The Communicator”
- ❖ Know how to set up the two types of Ethernet drivers required to communicate with the network.
- ❖ Backup and Restore drivers by using the RSLinx utility.
- ❖ Know how to download a project properly using created drivers and go online.
- ❖ Know how to upload a project and some “precautions” we have to take during uploading to avoid overwriting on an existing project.
- ❖ Understand thoroughly the operating modes of the ControlLogix and what is needed to keep a Remote control of the operating modes at the Studio 5000.
- ❖ Monitor discrete and analog tags in the ladder editor as well as in the tags display monitoring.
- ❖ Understand the basics of discrete and analog I/O module configuration including scaling of analog I/O (more detail configuration information later in later modules).



### Lessons in Module 4

- 1- Introduction  
Connecting to the Controller  
Establishing RSLinx Connection to the Network  
Basics of Networks  
IP Address  
Subnet  
Default Gateway
- 2- More on IP Addresses and How They Are Assigned
- 3- RSLinx–The Communicator  
Creating the Driver
- 4- Setting Up RSLinx Drivers  
Ethernet/IP Driver Set Up  
Ethernet Devices Driver Set Up  
RSLinx Back-Up and Restore Drivers  
Point-to-Point Connection
- 5- Downloading a Project and Going Online  
Changing Controller Versions Downloading a Project  
Discovery Method–Adding I/O Modules
- 6- ControlLogix Operating Modes
- 7- Monitoring Tags  
Binary-Decimal Style Monitoring  
Add Analog Tag and Monitor Its Data  
Analog I/O Module Configuration Basics  
Monitor a Scaled Pressure Input
- 8- Uploading a Project

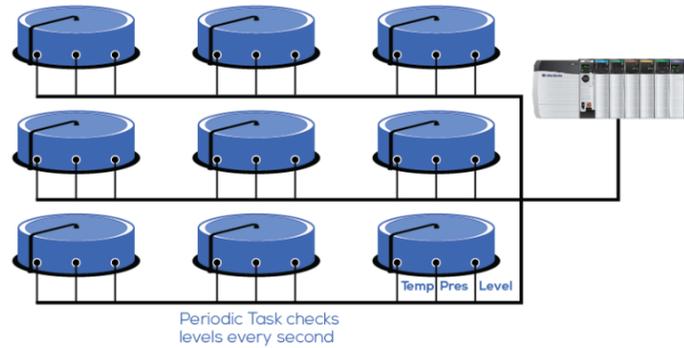
## Module 5

### ControlLogix Project Organization and Frequently Used Tag Structures

This module covers the project organization of a ControlLogix and also some of the frequently used structures that programmers use when creating code and that we are likely to encounter during troubleshooting.

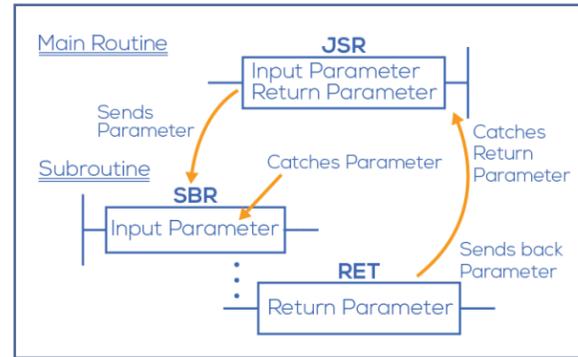
The organization of the project by the controller is very important because it tells us where everything is stored and located. In this section we will focus more where the code resides because that is where most of the troubleshooting occurs and the understanding of this project organization is critical and essential.

The frequently used structures involve the use of Subroutines and the instructions used to properly execute the code residing in the Subroutine. We will point out to some important situations that we can confront during troubleshooting.



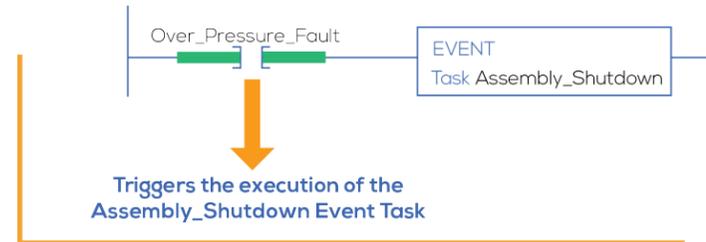
### Know Where Everything Is Stored Before Troubleshooting

- ❖ Thoroughly understand the hierarchical organization of the ControlLogix of Tasks-Programs-Routines and what each of these sections holds as content.
- ❖ Understand the order of execution of a project in a ControlLogix system and how to change this order if necessary and their implications.
- ❖ See what effects the "asynchronous" function of a ControlLogix has in the evaluation of code.
- ❖ How to add routines and Subroutines to a project if necessary.
- ❖ What are the different types of tasks and how to add programs and routines to these tasks.
- ❖ Understand Continuous, Periodic and Event task functions and how one task interrupts another one during the execution of code.
- ❖ Know how Periodic and Event task are triggered.
- ❖ Take into consideration certain aspects of task functionality during troubleshooting.
- ❖ Recognize Subroutine's potential problems during execution of code instructions and how this behavior can affect the ControlLogix project.
- ❖ How "parameters" are passed and work from the main routine to a Subroutine and what to look for when troubleshooting a project that has Subroutines passing parameters.



### Lessons in Module 5

- 1- Introduction
  - Task-Programs-Routines
  - Continuous Task
  - Periodic and Event Tasks
  - Task Interruption Examples
- 2- Program Order of Execution
  - Taking a Look at Programs and Routines
  - Adding a Routine to a Program
- 3- Adding a Program to a Task
  - Changing Program Execution Order
  - Unscheduled a Program
  - Watchdog in a Task



- 4- Creating Periodic and Event Tasks
  - Adding Event Task Trigger
  - Task Considerations During Troubleshooting
- 5- Routines and Subroutines
  - Adding a JSR Instruction
- 6- Passing Parameters in a Subroutine

## Module 6

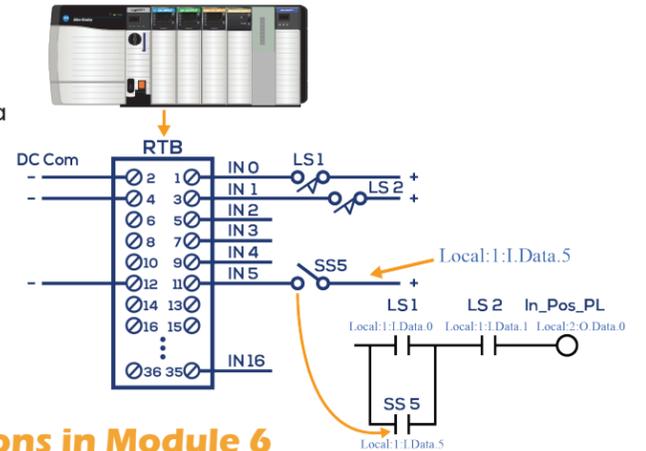
### Troubleshooting Ladder Diagram Logic in the ControlLogix System

This module goes over ladder logic diagrams interpretation and covers the function of ladder instructions, information that must be mastered during troubleshooting. Coverage of not only the "basic" ladder instructions, but also some of the frequently used instructions which are likely to be encountered during troubleshooting. Although some of the basic instructions have been covered, important "things to look for" are presented when using these instructions during troubleshooting.

This module presents the use of a trapping "Gotcha" method to detect very fast ladder diagram responses that we will not be able to see under the monitoring of the logic. These Gotcha situations are very handy during troubleshooting.

The programming of a normally closed input device is also presented— that is how to program a wired normally-closed input field device to behave like a normally closed, specially in fail-safe situations.

Frequently used instructions that employ tag structures that we are bound to encounter when we are troubleshooting a system are thoroughly covered— an understanding of these tag structures is very important. These include timers, counters, math, compare. Additionally we will also apply the use of program control instructions during troubleshooting.



### Lessons in Module 6

- 1- Introduction-Ladder Diagram Logic
  - Basic Bit Instructions
  - Examine If Closed
  - Examine If Open
  - Output Energize
  - AND Generated Output Logic
  - OR Generated Output Logic
  - AND/OR Generated Output Logic
  - Adding a Branch in Studio 5000-OR Condition
- 2- Retentive Output Bit Instructions
  - Latch Output
  - Unlatch Output
  - One-Shot Instruction
  - Troubleshooting Situation-One-Shot Solution
  - Trapping-Inserting a "Gotcha"
  - Order of Evaluation-Review
- 3- Programming a Normally Closed Input Device
- 4- Other Frequently Used Instructions
  - Timer Instructions
  - Timer Tag Structures
  - Timer On-Delay-TON
  - Retentive Timer On-Delay-RTO
  - Timer Off-Delay-TOF
  - Creating Timer Circuits in ControlLogix
  - TON-TOF-RTO (RES)
  - Things to Watch During Troubleshooting RTOs
- 5- Counters and Math Instructions
  - Counter Instructions
  - Math Instructions
  - Troubleshooting Math Instructions-Things to Consider
- 6- Compare and Move Instructions
  - Compare Instructions
  - Limit
  - Compare Expression
  - Move Instructions

### Implement Best Practices During Troubleshooting

- ❖ Master ladder diagram code execution in a ControlLogix system.
- ❖ Understand the functionality of "Bit" instructions and know how to troubleshoot code that utilizes these instructions.
- ❖ Know the difference between Retentive and Non-Retentive outputs and what to watch for during troubleshooting.
- ❖ The use of One-Shot instructions and when and why they are used extensively in ladder diagrams.
- ❖ The use of "Gotcha" circuits to capture very fast signals—this is a great troubleshooting technique.
- ❖ How to program a normally closed input field device (like a Stop PB) and why it is programmed normally open.
- ❖ Master the different types of Timers (TON, TOF, RTO) and things to watch for during the examination of code.
- ❖ Know how to troubleshoot code that used Counters, Math, Compare instructions.
- ❖ How to use program control instructions during troubleshooting to disable sections of code in a ladder diagram.

## Module 7

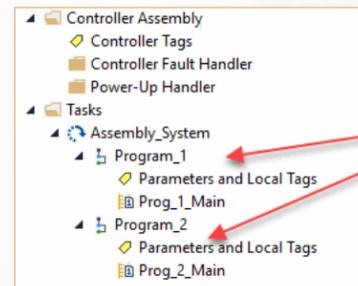
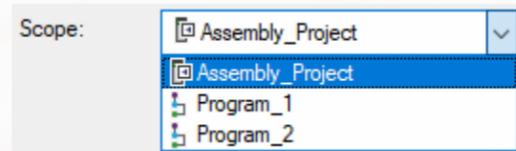
# Creating and Editing Tags and Code— Documenting Troubleshooting Changes

This module goes over the two types of “tag scopes” which are Controller or Global and Local or Program-scope. The understanding of these tag usages is very important when we are troubleshooting code and the state of tags in a ControlLogix. We will cover all the properties of Local or Program-scope tags and how we can change the “parameter usage” in order for the tags to be used in other programs.

Tag monitoring and editing is covered extensively since use these techniques extensively during the troubleshooting of a system and the topics presented are an invaluable resource needed to properly address system problems. The monitoring and editing if signals is presented for both discrete and analog systems.

Editing online during troubleshooting is covered in detail to identify and modify field device’s wiring, code and test operational status using the Studio 5000 software. Presented in detail is how to make changes to code if it is necessary to satisfy certain production requirements and how to properly document changes made.

Arrays and User-defined Data Types (UDTs) are thoroughly discussed and examples are presented for troubleshooting potential problems that can shutdown the system.



Tags can be used in other programs when Usage is changed.



### Know What This Tag Means: \Main\_Control.LS\_1

- ❖ Determine by looking at a tag if it is Global or Local, and if local what is the parameter usage and if there are any connections made.
- ❖ Assign “connections” to Local tags with Input or Output parameter usage.
- ❖ See how connected Input/Output parameter Local tags are represented in the code and how to make changes to these tags.
- ❖ Edit and monitor any type of tag (Global or Local) and make changes if necessary.
- ❖ Make changes online while the controller is running and know how to use the “test” mode to check code changes.
- ❖ Use “best practices” for documenting changes made, techniques that will be very useful during collaborative troubleshooting a ControlLogix-based system.
- ❖ Understand the functionality of Arrays which are used extensively in applications and what to look for when an Array creates a Major Recoverable Fault and shuts down the system.
- ❖ Troubleshoot a system that uses User-defined Data Types or UDTs and thoroughly understand how UDTs are created and represented in tags in the code.

...Tag LS1 is a Program-scope tag with Input Parameter Usage created in the Program Main\_Control being used in the code in another Program represented as \Main\_Control.LS\_1...when troubleshooting, we need to know and understand this addressing representation...LS1 *will not* be listed in the Controllers Tags

### Lessons in Module 7

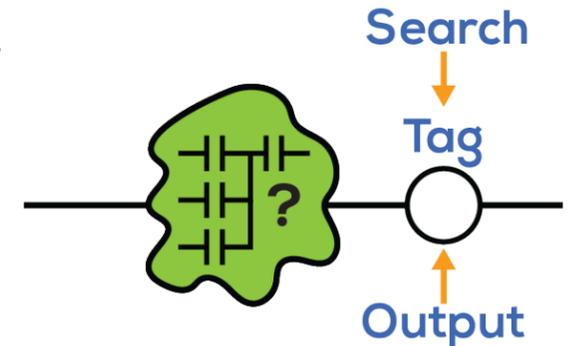
- 1- Introduction-Tag Scopes
  - General Tag Scope Types
  - Scope-Based Tag Creation
- 2- Local Tag Example
  - Parameter Functionality
  - Same Tag Name-Connectivity
- 3- Tag Monitoring and Editing
  - Tag Monitor View of System I/O
  - Tags Monitoring-Description and Style
  - ControlLogix Tags Editing
- 4- Editing Code Online During Troubleshooting
  - Documenting Changes During Troubleshooting
- 5- Tag Structures-Arrays and UDTs
  - Arrays
  - Array Addressing
- 6- Troubleshooting Array Faults-
  - Going Beyond the Boundary
  - Other Array Indirect Addressing
- 7- User-defined Data Types-UDTs
  - Mapping UDTs To I/O Field Devices
  - UDT Array Using Program-scope Tags

## Module 8

# Troubleshooting Using the Studio 5000 Software— Applying I/O Forcing and Toggling Functions

This module covers some of the best software tools available for troubleshooting ControlLogix systems. The Studio 5000 software, in addition to be used for programming and documenting a system, also has some magnificent tools that are used for troubleshooting a project. These tools include under *Search*, the *Find*, *Find and Replace*, *Go To*, *Browse Logic* and *Cross Reference*. These tools are also complemented by the Bookmark Toolbar capabilities.

Additionally, this module also goes over some Program Control instructions that are mostly used in troubleshooting to by-pass testing sections rather than as code to alter the control flow of a Routine. Also presented are several important situations that we must be aware when using Program Control instructions over other instructions in the code. Also explored are other ControlLogix tools used during troubleshooting that helps us get the system back online and find the solution to problems. These tools include the *Forcing* and *Toggling* functions used with I/O devices and internals.



### Know How To Use the Studio 5000 Tools in Troubleshooting

- ❖ Understand and apply the searching tools: Find, Find and Replace, Go To, Browse Logic and Cross Reference.
- ❖ Implement the searching and finding of tags and trace back what it takes for the rung being troubleshooted achieve continuity.
- ❖ Use and apply the Cross Reference tool to tags to find continuity problems in the code and properly apply bookmarks during the troubleshooting of several rungs.
- ❖ Know what “Destructive” is during cross referencing tags and how to use this information to find and trace back power continuity in a rung.
- ❖ Master the use of Bookmarks during the use of the Cross Reference tool so that we can easily find the rungs we are troubleshooting.
- ❖ Use Program Control instructions to facilitate troubleshooting and temporary end of code execution, and implement by-passes of code in routines.
- ❖ How to use the Forcing tool for Discrete as well as Analog I/O and things to look for during forcing.
- ❖ Understand the two phases of Forcing-Installing the force and Enabling the force.
- ❖ Understand that the “logic” follows the input devices forcing and that the “logic” does not follow the output devices forcing.
- ❖ How to apply Toggling of internal tags during troubleshooting.

### Lessons in Module 8

- 1- Introduction-Troubleshooting Software Tools
  - Using the Searching Tools
  - Find, ind and Replace, Go To, Browse Logic
- 2- Using the Searching Tools-continued
  - Cross Reference
  - Bookmarking Rungs-A Good Idea and Practice
- 3- Troubleshooting Using Program Control Instructions
  - NOP-No Operation
  - Output Use of NOP in Output Branch
  - Removing NOPs and Shorted Branches Before Downloading
  - TND-Temporary End
  - JMP & LBL-Jump & Label
  - MCR-Master Control Reset
  - Important Considerations When Using Program Control Instructions During Troubleshooting
  - Timers in MCR Testing Zone
  - Timers in Jump Testing Zone
  - Jumps Over MCR Zone
- 4- Troubleshooting Using Discrete I/O Forcing and Toggling
  - Basics of Forcing Function
  - Basic Forcing Procedures
  - Discrete I/O Forcing
  - Input Forcing
  - Output Forcing
  - Removing Discrete I/O Forces
  - Toggling I/O
- 5- Troubleshooting Using Analog I/O Forcing
  - Forcing an Analog Input
  - Forcing an Analog Output
  - Removing Analog I/O Forces
  - Input and Output Forcing Behavior
  - Summary.

## Module 9

### Troubleshooting ControlLogix Hardware—Discrete and Analog I/O



In this module, the troubleshooting of the hardware components that make up a ControlLogix system is thoroughly covered. These components include the discrete and analog I/O modules and in both of these cases we will also look at the important configurations of the modules to achieve proper operation.

In order to properly troubleshoot the discrete and analog I/O modules it is a good idea to understand in more detail the operation of the modules themselves. This involves how the communication between the processor and the I/O modules takes place and some common communication problems that are applicable to all modules.

This section of the training program also covers in depth the communication between modules and controller which is necessary for the understanding of the asynchronous operation of the ControlLogix.

#### Master a ControlLogix System Troubleshooting of Discrete and Analog I/O

- ❖ Identify important safety situations in ControlLogix applications and know what to do to be safe.
- ❖ Prevent potential arcing conditions which can create critical safety situations.
- ❖ Thoroughly understand what is the Requested Packet Interval (RPI) communication.
- ❖ Know what Change of State is in the input settings and how this setting operates.
- ❖ Understand what "Ownership" of a module is and what are the implications in the module's configuration.
- ❖ Know the difference between "Data" and "Listen Only" communication settings.
- ❖ Know "why" output modules have an "I" base tag not to be confused with the input module's "I" base tag.
- ❖ Deal with ownership problems during troubleshooting of a system and how to fix it.
- ❖ Know exactly what to do when replacing I/O modules during troubleshooting and how to correct revision problems caused by configuration mismatches.
- ❖ How module diagnostics operate and when their functionality takes place, when the bit is ON or OFF.
- ❖ Use diagnostic I/O statuses and indicators to pinpoint problems quickly along with the Studio 5000 software.
- ❖ Properly set and configure diagnostics in discrete and analog I/O modules.
- ❖ Understand analog I/O configurations needed for troubleshooting, including scaling, alarms, dead-bands, limits and proper wiring connections necessary for proper analog I/O operations.
- ❖ Know how to detect non-linearities in analog readings due to disturbances in the system and suggest possible solutions to programming personnel.

#### Lessons in Module 9

- 1- Introduction–Troubleshooting Hardware Components  
General Characteristics and Safety Precautions  
When Dealing With I/O Modules  
General I/O Module Operation  
RPI–Requested Packet Interval  
COS–Change Of State  
I/O Module Ownership  
Data Connection  
Listen Only Connection
- 2- Troubleshooting Ownership Problems  
Ownership Rules  
Input Modules  
Output Modules  
Troubleshooting Common Problems (All Modules)
- 3- Discrete Input Configuration  
Discrete Input Properties  
Input Module Points Diagnostics Configuration Settings  
Input Module Filter Time Configuration Setting
- 4- Discrete Output Configuration  
No Load Diagnostics–Troubleshooting Example  
Output Verify Diagnostic Settings  
Output State During–Diagnostics Reset–Pulse Test
- 5- Troubleshooting Using Diagnostic I/O Modules  
Troubleshooting Using Diagnostic Inputs  
Troubleshooting Using Diagnostic Outputs
- 6- Analog Input Configuration  
Analog Input Configuration–Considerations  
Input Range–Input Signal–Scaling  
Filters–RTS–Sensor Offset  
Alarm Configurations  
Alarm Configuration Example  
Disable Alarms and Latch Process Alarms  
Deadband  
Rate Alarming
- 7- Analog I/O Module Indicators  
Status  
Calibration  
Analog Input Misreading or Non-Linearity?
- 8- Analog Output Configuration  
Scaling–Limits (Clamping)–Ramp Rate  
Analog I/O Troubleshooting–Other Problem Causes  
Analog Input  
Analog Outputs

## Module 10

### Troubleshooting Remote I/O, Controller and Power Supply—Using the Trend and Compare Tools to Troubleshoot

This module continues to troubleshoot the ControlLogix system hardware components like the Controller itself, the Power Supply and Remote I/O Subsystems.

Starts with Remote Subsystems and finding out what can go wrong in the communications with the controller in terms of communications modules, wiring and network switching and solving possible network interference. Discussions in detail about controller faults are covered as well as how to recover from these faults. And just in case we are faced during troubleshooting, we will also go over how the Fault Routines work and what we need to look for if when a fault is detected.

Not just your basic Power Supply problems are covered but also how to prevent possible loading problems during normal operation thus avoiding system shutdowns. Also we cover the important topic of how to deal with Noise and Heat problems when they occur as well as how to prevent them in the first place. This module finishes by taking an in-depth look at two useful tools that can be used during troubleshooting which are the "Trend" tool, used for Trending tags or signals like a histogram, and the "Compare" which compares two ControlLogix projects to determine differences.

#### Lessons in Module 10

- 1- Introduction–Troubleshooting ControlLogix Hardware  
Remote I/O Subsystems  
General Troubleshooting  
Remote I/O–Troubleshooting Interference
- 2- Troubleshooting Controller Problems and Faults  
Major Recoverable Faults  
Clearing a Major Recoverable Fault
- 3- Clearing Controller's Faults  
How the Fault Routine Works.  
Important–From Offline to a Faulted Controller  
Major Non-Recoverable Faults  
Minor Faults
- 4- Troubleshooting Power Supply Problems  
Short-Circuit Condition  
Input Power–Voltage Sags  
Overloading  
Grounding
- 5- Troubleshooting Noise and Heat Problems  
Noise Problems  
Noise Generators–Minimizing Noise and Crosstalk  
Analog I/O Wiring–Protect Low Level Signals  
Controller Location–Away From Noise  
Suppression of Loads  
Routing of Low Level Signals  
Ground Loop Noise Voltage  
Network Noise  
Heat Problems  
Controlling Humidity  
Condensation Problems
- 6- Troubleshooting Using The Trend Tool  
Creating a New Trend  
Display and Pen Settings  
X and Y Axis Settings  
Template and Sampling Settings  
Start and Stop Trigger  
Running the Trend  
Save Trend Information  
Starting and Stopping a Trend
- 7- Troubleshooting Using The Compare Tool  
Troubleshooting Scenario  
Saving Offline & Online Projects Before Comparison  
Start Comparison  
When Uploading–I/O Status Data is Also Uploaded

#### Taking ControlLogix Troubleshooting to the Next Level

- ❖ Know how to troubleshoot a ControlLogix system which has additional chassis in a subsystem configuration using a top-down strategy.
- ❖ Know how to solve network interference in remote subsystem and minimize wiring crosstalk.
- ❖ Understand Major Recoverable and Non-Recoverable faults that can occur in a controller and how to get back into operation by clearing the faults.
- ❖ Clear a Major Recoverable fault using the controller's front panel switch.
- ❖ Understand how the Fault Routine works so that troubleshooting can take place.
- ❖ Procedure to download to a previously faulted controller–what needs to be done.
- ❖ Know how to detect and clear Minor Faults in a system.
- ❖ Troubleshoot Power Supply problems as well as how to avoid potential problems.
- ❖ Understand how voltage sags affect controller voltages as well as I/O power.
- ❖ Deal with noise and heat problems in a control system, recognize it and how to fix the problem.
- ❖ Know how to use the Trend tool to troubleshoot a ControlLogix system.
- ❖ Use the Compare tool to find differences between two projects when troubleshooting.



# **Understanding, Maintaining and Troubleshooting ControlLogix Systems —with The Studio 5000 Designer Software—**

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the “luckier” we get during troubleshooting*

