PLC Programming Basics

Studio 5000 Logix Designer and CompactLogix Controllers

Order No: *****

First Edition

Revision level: 08/2023

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Printed in United States

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CompactLogix Controllers

CompactLogix Controllers are a series of programmable logic controllers (PLCs) offered by Allen-Bradley, a brand within Rockwell Automation. These controllers are designed for industrial automation and control applications. The CompactLogix line of controllers is known for its compact size, versatility, and performance, making them suitable for a wide range of applications in various industries.

CompactLogix Controllers are a part of Rockwell Automation's Logix platform, which encompasses multiple PLC families, including ControlLogix and SoftLogix. The CompactLogix controllers provide a mid-range solution, offering a balance between features and scalability.

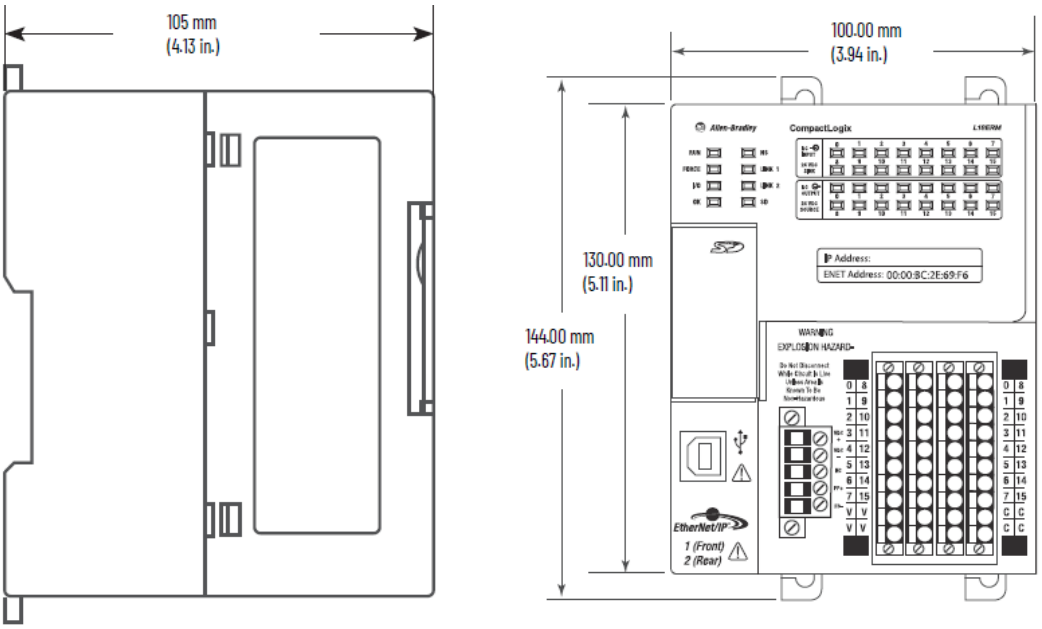
Key features and characteristics of CompactLogix Controllers include:

1. **Compact Design:** As the name suggests, these controllers are relatively compact, making them suitable for applications with limited space.
2. **Scalability:** CompactLogix Controllers come in various models with different processing capabilities, allowing users to choose the appropriate level of performance for their application.
3. **Integrated Communication:** They support various communication protocols, including Ethernet/IP, allowing seamless integration with other devices and systems within the automation network.
4. **Built-in I/O:** Some models offer built-in I/O modules, simplifying the setup and reducing the need for additional external I/O modules.
5. **Programming and Development:** CompactLogix Controllers are programmed using Rockwell Automation's programming software, such as Studio 5000 Logix Designer (formerly known as RSLogix 5000). This software provides a user-friendly environment for ladder logic, function block diagram, and structured text programming.
6. **Diagnostics and Troubleshooting:** These controllers offer advanced diagnostics and troubleshooting capabilities, helping users identify and resolve issues efficiently.
7. **Modular Expansion:** In addition to built-in I/O, CompactLogix Controllers support the addition of expansion I/O modules and communication modules, allowing users to customize their controller's capabilities as needed.
8. **Motion Control:** Some models of CompactLogix Controllers also offer integrated motion control capabilities, making them suitable for applications that require precise control of motion processes.

CompactLogix Controllers are commonly used in applications such as packaging machinery, material handling systems, automotive assembly lines, and more. Their versatility, combined with the robustness of the Rockwell Automation ecosystem, makes them a popular choice for industrial automation projects that require a balance between performance, features, and cost.

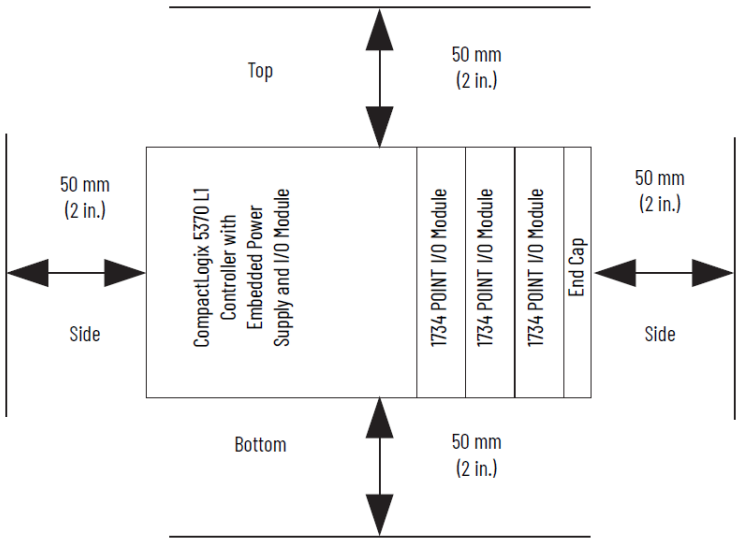
System Dimensions

CompactLogix 5370 L1 Control System Dimensions



Minimum Spacing

Maintain spacing from enclosure walls, wireways, and adjacent equipment. Allow 50 mm (2 in.) of space on all sides, as shown. This spacing provides ventilation and electrical isolation.

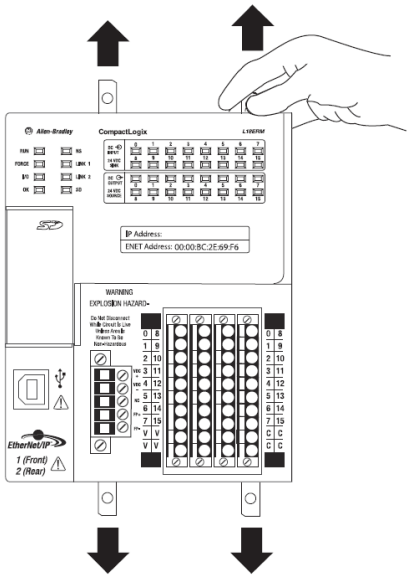


Mounting the Controller

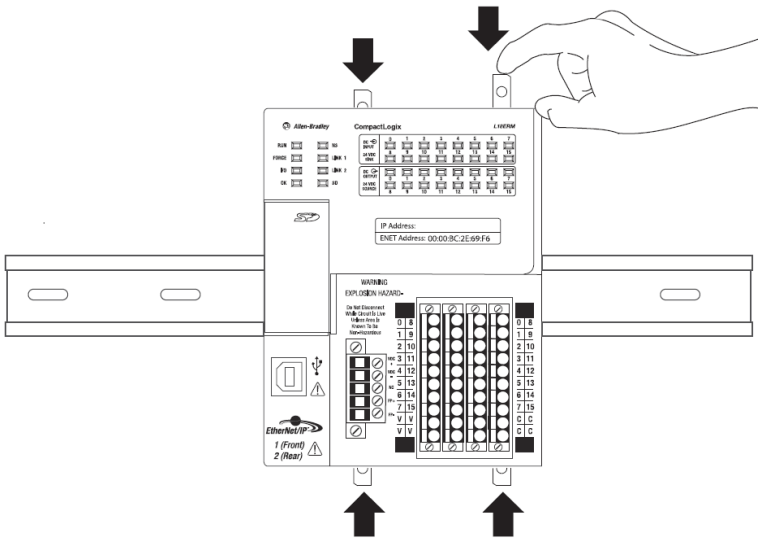
You mount a CompactLogix 5370 L1 control system on a DIN rail. Before you complete the steps that are required to install the system, install a DIN rail. This product is grounded through the DIN rail to chassis ground.

Installation of the Controller

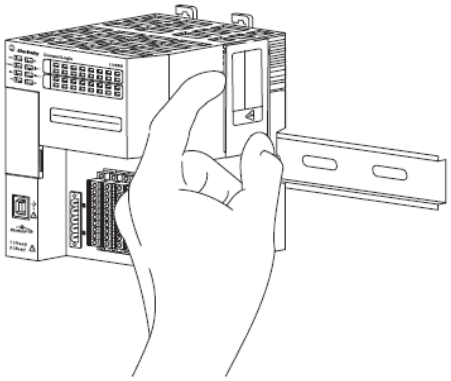
1. Pull out the locking tabs.



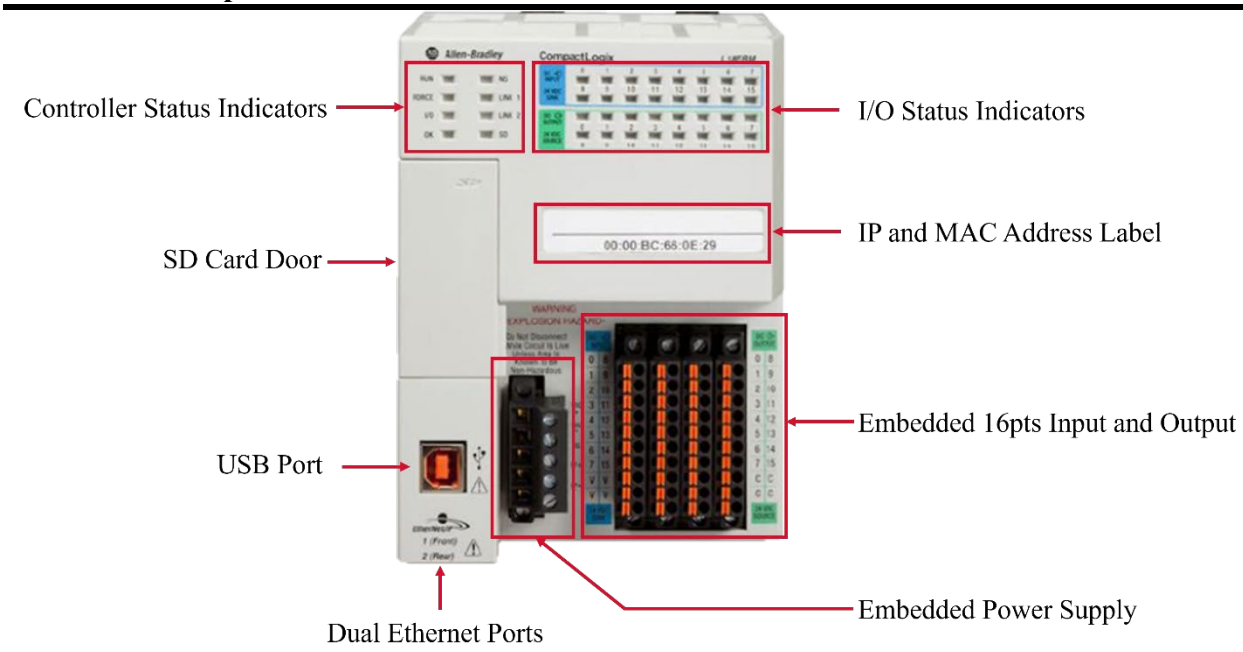
2. Slide the controller into position on the DIN rail and push the locking tabs in



3. If you aren't using the local expansion modules, use the tongue and groove slots on the right side of the controller to slide a protective covering onto the controller. The protective cover ships with the controller.
   The covering covers the exposed interconnections on the right side of the controller. Failure to use a protective covering can result in equipment damage or injury from electric shock.



Controller Components



CompactLogix 5370 Controller Status Indicators

RUN Status Indicator

Indicates the operating mode of the controller.

Controller Mode (RUN) Status Indicator	
Status	**Description**
Off	The controller is in Program or Test Mode.
Green	The controller is in Run mode.

FORCE Status Indicator

Indicates the force state.

Force State (FORCE) Status Indicator	
Status	**Description**
Off	No tags contain I/O force values. I/O forces are inactive (disabled).
Yellow	I/O forces are active (enabled). I/O force values can exist.
Flashing Yellow	One or more input or output addresses have been forced to an On or Off condition, but the forces haven't been enabled.

I/O Status Indicator

Indicates the current state of communication between the controller and I/O modules.

I/O Status IndicatorI/O State (I/O) Status Indicator	
Status	**Description**
Off	One of the following conditions exists: • There are no devices in the I/O configuration of the controller. ○ Applies to only CompactLogix 5370 L3 controllers. • The controller does not contain a project.
Green	The controller is communicating with all devices in its I/O configuration.
Flashing Green	One or more devices in the I/O configuration of the controller aren't responding.
Flashing Red	One of the following conditions exists: • The controller isn't communicating with any devices. • A fault has occurred on the controller. ○ Only CompactLogix 5370 L1 and L2 controllers.

OK Status Indicator

Indicates the state of the controller.

Controller Status (OK) Status Indicator	
Status	**Description**
Off	No power is applied.
Green	The controller is OK.
Flashing Green	The controller is storing a project to or loading a project from the SD card.
Red	The controller detected a nonrecoverable major fault and cleared the project from memory.
Flashing Red	One of the following: • The controller requires a firmware update. • A major recoverable fault occurred on the controller. • A nonrecoverable major fault occurred on the controller and cleared the program from memory. • A controller firmware update is in process. • An embedded I/O module firmware update is in process. o Only CompactLogix 5370 L1 controllers.
Dim Green to Red	Save to Flash at power-down.

NS Status Indicator

Indicates the EtherNet/IP network status regarding the controller operating on the network.

Ethernet Network Status (NS) Status Indicator	
Status	**Description**
Off	The port isn't initialized; it does not have an IP address and is operating in BOOTP or DHCP mode.
Green	The port has an IP address and CIM connections are established.
Flashing Green	The port has an IP address, but no CIP connections are established.
Red	The port has detected that the assigned IP address is in use.
Flashing Red/Green	The port is performing its power-up self-test.

LINK 1/LINK 2 Status Indicator

Indicates the EtherNet/IP link status for Port 1 and Port 2 of the controller.

Ethernet Link Status (LINK 1/LINK 2) Status Indicator	
Status	**Description**
Off	One of the following conditions exists: • No link. • Port administratively disabled. • Port disabled because rapid ring fault condition was detected (LINK2).
Green	One of the following conditions exists: • A 100 Mbps link (half- or full-duplex) exists, no activity. • A 10 Mbps link (half- or full-duplex) exists, no activity. • Ring network is operating normally and the controller is the active supervisor. • Ring network has encountered a rare partial network fault and the controller is the active supervisor.
Flashing Green	One of the following conditions exists: • A 100 Mbps link exists and there's activity. • A 10 Mbps link exists and there's activity.

SD Status Indicator
Indicates if there's activity on the SD card.

CompactLogix 5370 controllers support nonvolatile storage through the following SD cards:

- 1784-SD1 - Ships with CompactLogix 5370 controller and offers 1 GB of memory. You can order more 1784-SD1 cards if desired.
- 1784-SD2 cards - Available for separate purchase and offer 2 GB of memory.

It is recommended that you leave the SD card installed in the controller and the card unlocked. The SD card saves extended diagnostic information that you can send to Rockwell Automation that provides enhanced diagnostics of your application and firmware revision if circumstances require this data.

However, you can complete other tasks by using the SD card, such as the following:

- Store and load a project.
- Change the image that is loaded from the card.
- Check for a load that was completed.
- Clear an image from the memory card.
- Store an empty image.
- Change load parameters.
- Read/write application data to the card.

For more detailed information on how to use the SD card, consult the operator's manual.

SD Card Activity (SD) Status Indicator	
Status	**Description**
Off	There's no activity to the SD card.
Flashing Green	The controller is reading from or writing to the SD card.
Flashing Red	The SD card does not have a file system.

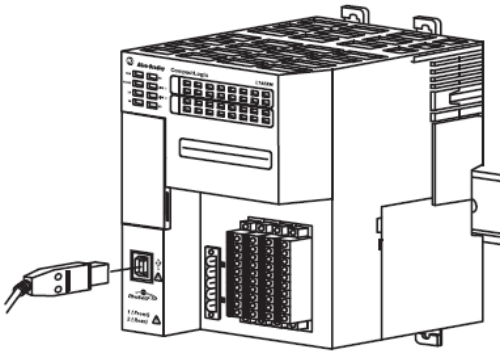
Communications

The CompactLogix 5370 L1 Controllers have two communication network components.

- USB connection only for programming and firmware updates
- EtherNet/IP network via built-in EtherNet/IP network ports

USB Port

The controller has a USB port that uses a Type B receptacle. The port is USB 2.0 compatible and operates at 12 Mbps. Use a USB cable to connect your computer to the USB port. With this connection, you can update firmware and download programs to the controller directly from your computer.



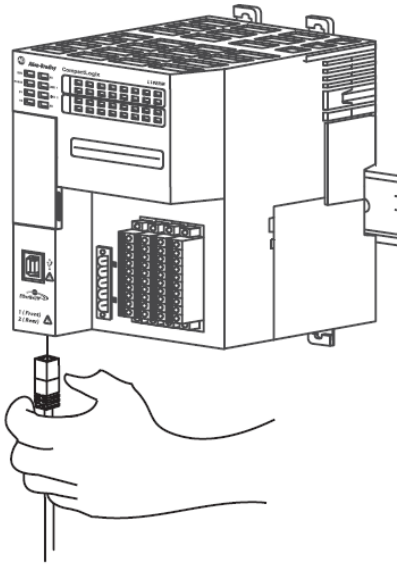
The USB port is intended only for temporary local programming purposes and not intended for permanent connection.

Dual Ethernet Ports

CompactLogix 5370 L1 controllers have embedded switch technology and two EtherNet/IP ports that let you use it in various EtherNet/IP network topologies:

- Device Level Ring network topology - Both ports on the controller are connected to the network.
- Linear network topology - Both ports on the controller are connected to the network.
- Star network topology - One port on the controller is connected to the network.

There are connection and configuration requirements for each EtherNet/IP network topology.



Embedded IO Modules and Sensors

The CompactLogix 5370 L1 Controllers provide 16 embedded sinking digital input points and 16 embedded sourcing digital output points. You wire the input and output points via a removable connector.

Embedded Input Points

The embedded input points on the CompactLogix 5370 L1 controllers support 2-wire and 3-wire input devices. You can wire the input devices to be powered by one of the following methods:

- By using an **external power supply**
  - In this case, you can monitor the input devices even if field power is interrupted, for example, by the Master Control Relay (MCR).
  - This method is required if you must continue reading data from the input devices when the embedded output terminals are disabled, for example, when the use of an MCR disrupts output power.
- By using the **V terminal** on the embedded I/O module.
  - In this case, you can't monitor the input devices even if field power is interrupted, for example, by the MCR.

Embedded Output Points

The embedded output points on the CompactLogix 5370 L1 controllers support 2-wire systems. The embedded power supply in the controller powers the embedded output points over the POINTBus backplane.

I/O Status Indicators

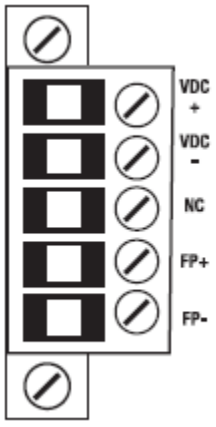
The I/O Status Indicators will be yellow when I/O is active.

Embedded Power Supply

The embedded power supply for the series C L18ERM controllers is a 24 DC nominal, isolated power supply. The input range of the power supply is 10…28.8V DC.

Connecting Power to the Controller

Connections to the **VDC+** and **VDC-** terminals **do not** provide power to input or output devices that are connected to the embedded I/O modules of the controller or local expansion modules.

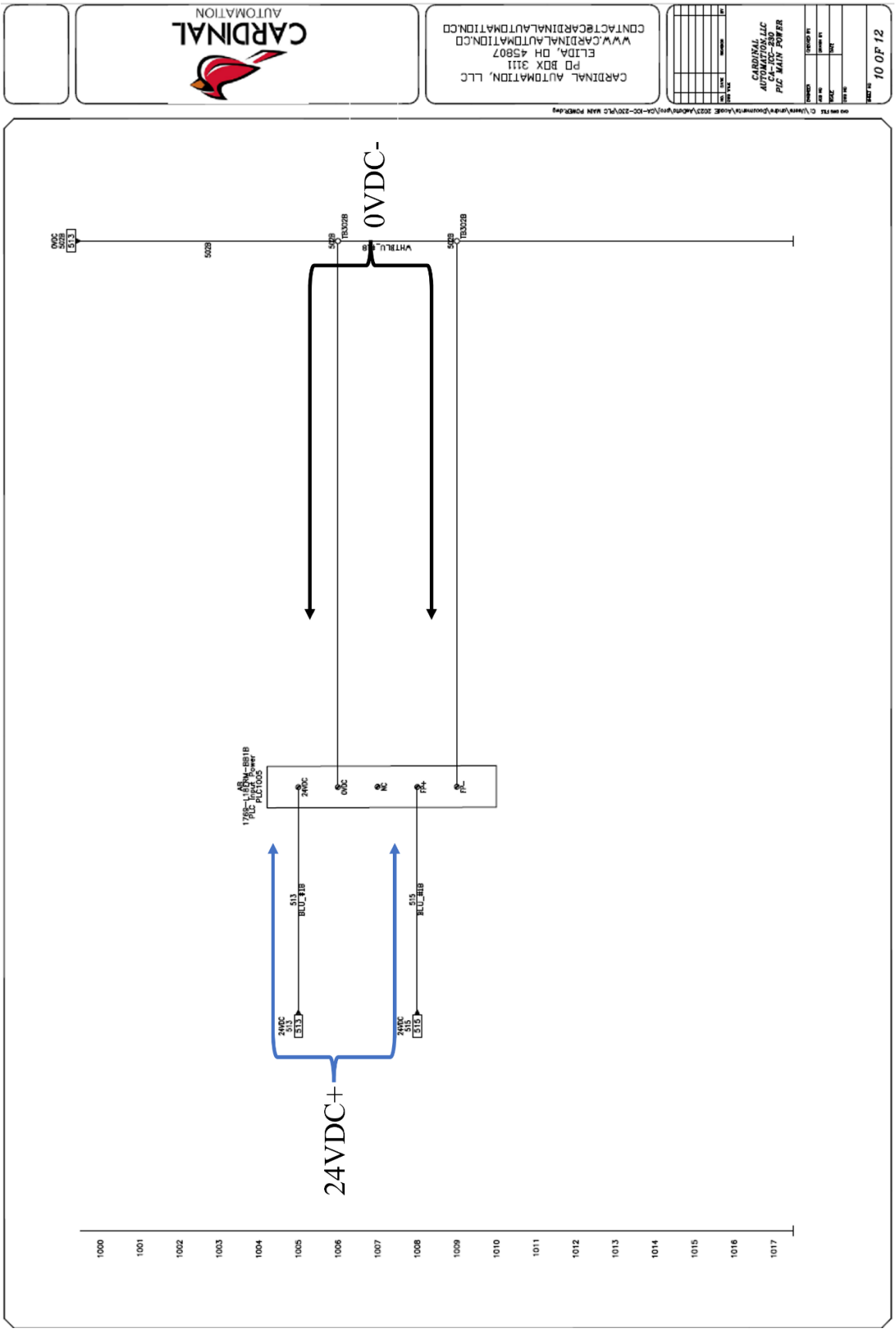


Power must be connected to the **FP+** and **FP- (Field Power)** terminals to provide power to input or output devices that are connected to the embedded I/O modules of the controller or local expansion modules.

The external power supply can be used to power both the VDC+/- and FP+/- terminals on the series C L1 controllers. Power is connected to the controller via a removable connector that is connected to the front of the controller.

Complete these steps to connect power and field power to the CompactLogix series C L18ERM controllers:

1. Verify that the external 24VDC power source isn’t powered.
2. Connect wires to the 24VDC+ and 24VDC- connections from the external 24VDC power source.
3. Connect wires to the FP+ and FP- connections from the external 24VDC power source.


0VDC-
24VDC+
24VDC
513
BLU_#18
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Wiring and Commissioning a PLC

Wiring and commissioning a programmable logic controller (PLC) involves connecting the input and output devices to the controller and configuring the software to read and process the signals from these devices. Here are the general steps for wiring a PLC:

1. **Plan the wiring layout:** Before starting the wiring process, it is important to create a wiring diagram or layout that shows the connections between the input and output devices and the PLC. This will help ensure that all the wiring is correct and reduce the likelihood of errors.
2. **Connect the power supply:** The first step in wiring a PLC is to connect the power supply. This involves connecting the positive and negative terminals of the power supply to the appropriate terminals on the PLC.
3. **Connect the input devices:** Next, connect the input devices to the PLC. This typically involves connecting the positive and negative wires from the input devices to the appropriate input terminals on the PLC. In addition, the devices may need to be configured to match the input type and voltage level of the PLC.
4. **Connect the output devices:** After the input devices are connected, connect the output devices to the PLC. This involves connecting the positive and negative wires from the output devices to the appropriate output terminals on the PLC. Like the input devices, the output devices may need to be configured to match the output type and voltage level of the PLC.
5. **Configure the PLC software:** Once the wiring is complete, configure the software that controls the PLC to read and process the signals from the input and output devices. This typically involves creating a ladder logic program that defines the logic of the system and assigns controller tags to the input and output signals.
6. **Test the system:** After the software is configured, test the system to ensure that the input and output devices are functioning correctly, and that the PLC is processing the signals as expected.

It is important to follow safety guidelines when wiring a PLC, including turning off power to the system before making any connections and using appropriate tools and protective equipment. Additionally, it is recommended to consult the manufacturer's wiring and installation manuals for specific instructions and guidelines.

Programming Timers

Timers serve many functions in logic. They can be used to control when events occur, can be used to delay actions in logic or they can also be used to keep track of elapsed time. Timers use milliseconds (ms) for the time base.

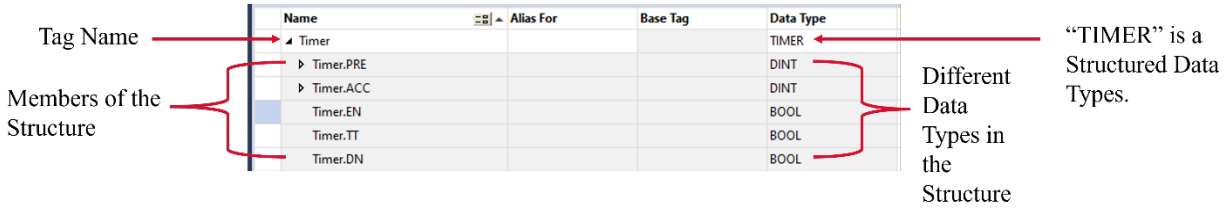
The ControlLogix family of PLCs have three timer instructions. The three types of instructions are the Timer-On Delay (TON), the Timer-Off Delay (TOF) and the Retentive Timer On-Delay (RTO). To reset a timer's accumulated values a Reset (RES) instruction is used.

Timer Instructions

Instruction	Mnemonic	How Instruction is Used	Functional Example Description
Timer On-Delay	TON	Program a time delay before an instruction becomes true.	Use a Timer On-Delay to begin a manufacturing process 15 seconds after a signal is received from an input sensor.
Timer Off-Delay	TOF	Program a time delay after the input instructions become false.	Use a Timer-Off Delay for an external cooling fan to start running for 30 seconds once the motor has turned OFF.
Retentive Timer On-Delay	RTO	Retain the accumulated value through power loss, controller mode change, or rung state goes from true to false.	Use a Retentive Timer-On Delay to keep track of how long the machine has been running for maintenance purposes. Every time the machine is turned OFF, the timer will remember the running time.
Reset	RES	Resets the accumulated value of a timer to 0.	After the RTO has reached the accumulated value, maintenance must be performed. After maintenance has been completed, reset the RTO accumulated value to 0 to restart the maintenance schedule.

Timer Structure and Timer Status Bits

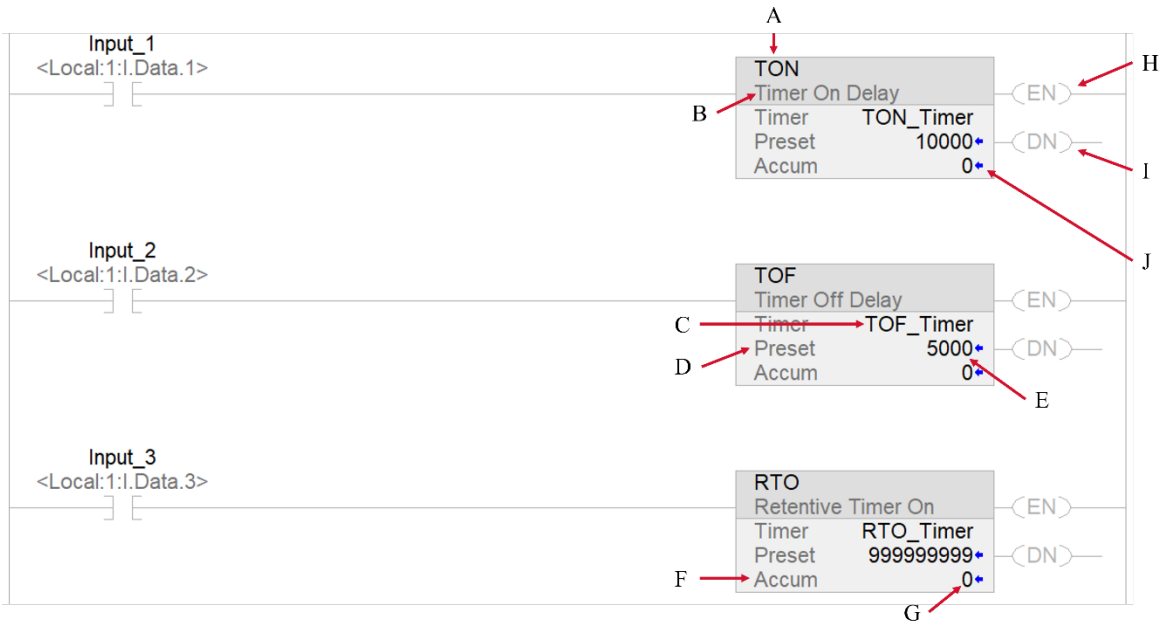
A ControlLogix Timer is a structure data type of TIMER. A structure is a more complex data type that is made up of several pieces of data. A timer structure contains two DINTS and three BOOLS.



Each member of the structure is referred to as Status Bits. Status Bits are used by the PLC and operator to monitor the current timer status. The following is the Status Bits for a timer and their use.

Timer Status Bits				
Status Bit	**Identifier**	**Data Type**	**Example Tag**	**Functional Description**
Preset Value	PRE	DINT	Timer.PRE	The number of units or time base in milliseconds to be timed. (Valid range from 0 to +2,147,483,647)
Accumulated Value	ACC	DINT	Timer.ACC	The total time elapsed since the timer has been enabled in milliseconds.
Enable	EN	BOOL	Timer.EN	Bit is true when timer instruction is true or enabled.
Done	DN	BOOL	Timer.DN	The done bit is true when the accumulated value and present value are equal.
Timer Timing	TT	BOOL	Timer.TT	The timer timing bit is true when the timer is timing. The timer is enabled but not done and the accumulated value is incrementing.

Timer Instructions Overview

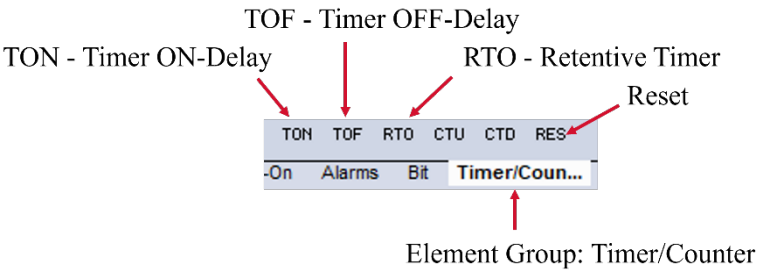


Timer Instructions Overview	
Letter	Meaning
A	Timer Mnemonic – Three letter abbreviation to identify the timer instruction.
B	Timer instruction identification
C	Timer Parameter – Identifies the tag where the timer is stored and its associated status information.
D	Timer Preset Value
E	Timer Preset Value in Milliseconds
F	Timer Accumulated Value
G	Timer Accumulated Value in Milliseconds
H	Enable Bit
I	Done Bit
J	Blue Arrow

Selecting Timer Instructions from the Language Element Toolbar

Timer instructions can be selected from the Timer/Counter tab on the Language Element Toolbar.

The desired instruction can be selected by clicking it or dragging and dropping it into the desired position on the ladder rung.



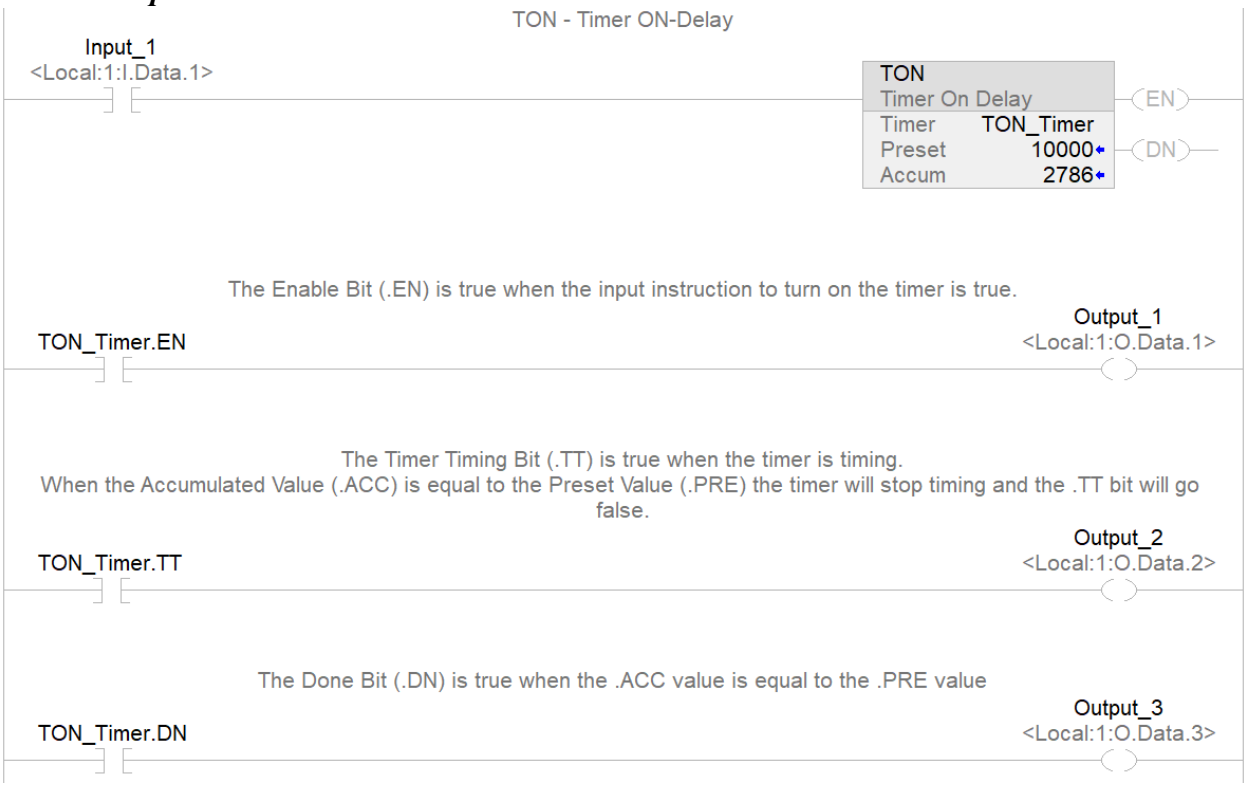
TON Instruction Operation Example

A TON instruction is used to delay the ON state of its DN bit. When the logic for the instruction becomes true, the timer begins accumulating time. After the preset time has been reached, the DN bit will energize and remain ON until the rung logic goes false.

The TON is a non-retentive instruction. If the logic goes false before the accumulated value reaches the preset value, the timer accumulated value will not be retained and will be reset to 0.

There are two common ways the time timer instructions status bits, DN and TT, can control outputs. The TT bit will be set to true when the timer is enabled, and the accumulated value has not reached the preset value. The TT bit will remain true until the rung goes false or the accumulated value reaches the preset value. When the accumulated value is equal to or greater than the preset value, the DN bit will be set to a 1. The DN bit remains true until the rung goes false or a reset instruction resets the timer. The DN bit is the most commonly used timer status bit.

TON Example



TOF Timer Operation Example

A TOF instruction is used for a timer that needs to time when it is false and reset when true.

When the logic for the instruction becomes true, unlike the TON instruction, the DN bit comes on immediately. When the input logic goes false, the TOF timer begins accumulating time until the preset value is reached.

Never use an RES instruction to reset a TOF instruction because the RES clears the status bits as well as the accumulated value.

TOF Examples

RTO Timer Operation Example

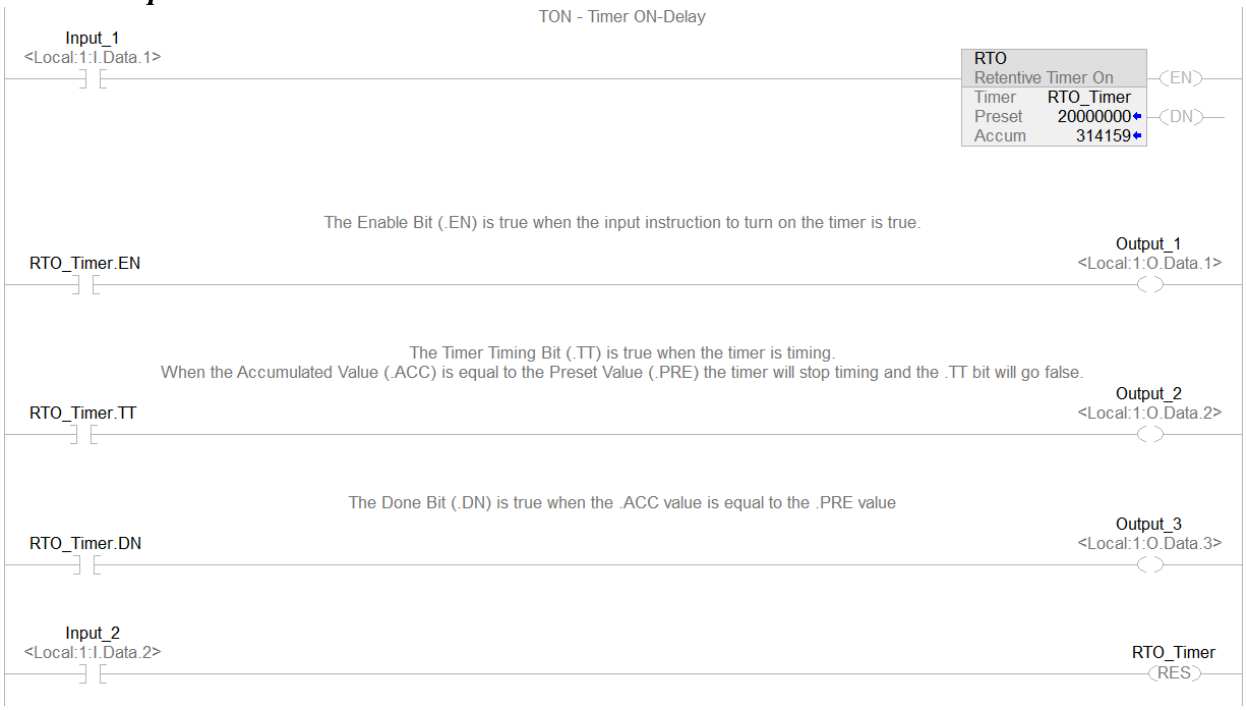
The Retentive (RTO) Timer works the same as a TON except the accumulated value will be retained once the rung on which the RTO instruction goes false. If the power is lost to the PLC and the battery is good, the RTO will still retain its accumulated value.

Because the RTO is retentive, the accumulated value will not reset to 0 when the rung instruction goes false. To reset the RTO, a RES instruction is used with the associated RTO timer tag to reset the accumulated value to 0.

When an RES instruction is true, the accumulated value and the bits of either a timer or counter instruction of the referenced tag data type are cleared to 0 (reset).

An RES instruction is an output instruction used to reset timer and counter instructions. It will typically reference either a TON, RTO, CTU, or CTD instruction by its tag.

RTO Examples



Interlocking Timers

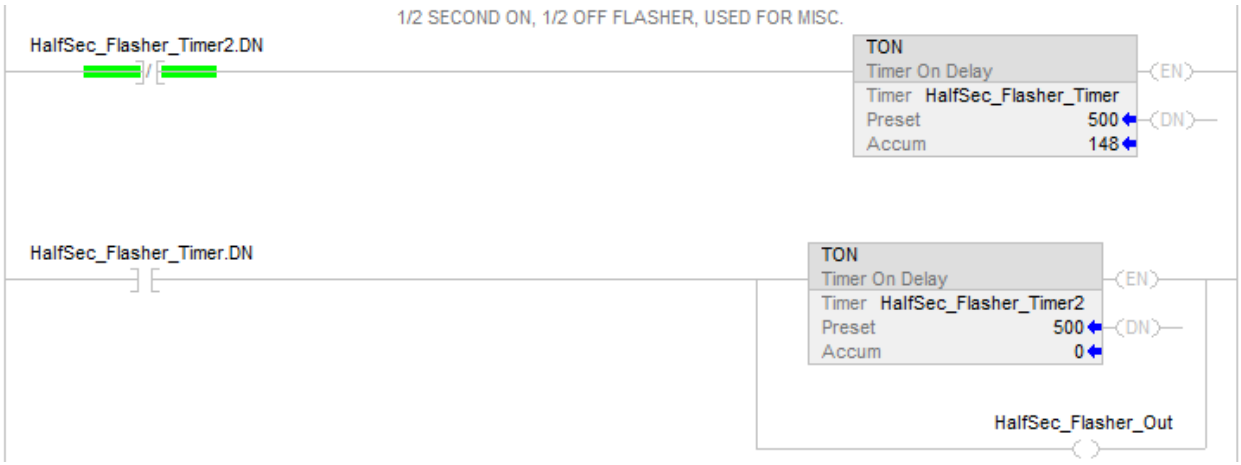
In the previous sections, timer instructions were used to create PLC ladder logic diagrams that turns outputs on or off. In this section, you will learn how to interlock the operations of two timers to control an output. Interlocked timers turn an output on and off sequentially.

Interlocking Timers Example

Note that both timers are non-retentive On-Delay (TON) timers. They reset their accumulated values when the proceeding logic if false. In this example, we have two TON timers, "HalfSec_Flasher_Timer" and "HalfSec_Flasher_Timer2". We are going to interlock these timers to control an output, "HalfSec_Flasher_Out".

The first rung has the XIO instruction with the tag "HalfSec_Flasher_Timer2.DN". This mean that when "HalfSec_Flasher_Timer" is **not done**, it will start the first timer "HalfSec_Flasher_Timer". When the "HalfSec_Flasher_Timer" reaches it preset value of 500ms (.5sec), the "HalfSec_Flasher_Timer" **done bit** (.DN) will be **true**. Using the "HalfSec_Flasher_Timer.DN" tag, we will start the "HalfSec_Flasher_Timer2" timer. This will now make the logic for "HalfSec_Flasher_Timer2.DN" false.

In this example, one timer will be on for 500ms (.5 sec) and the other time will be off for the same amount of time. We can now use this to control an output, "HalfSec_Flasher_Out", that will be on for 500ms then be off for 500ms. The creation of a pulsing output can be used with various times and multiple applications.



Lab 16 – Programming TON Instructions in a Studio 5000 Logix Designer Project

Objective:

The objective of this lab is to guide students through the process of building Timer-ON Delay (TON) logic using Studio 5000 Logix Designer for an Allen-Bradley CompactLogix PLC. Students will learn how to implement these timer types to control device operations in industrial automation.

Equipment and Software:

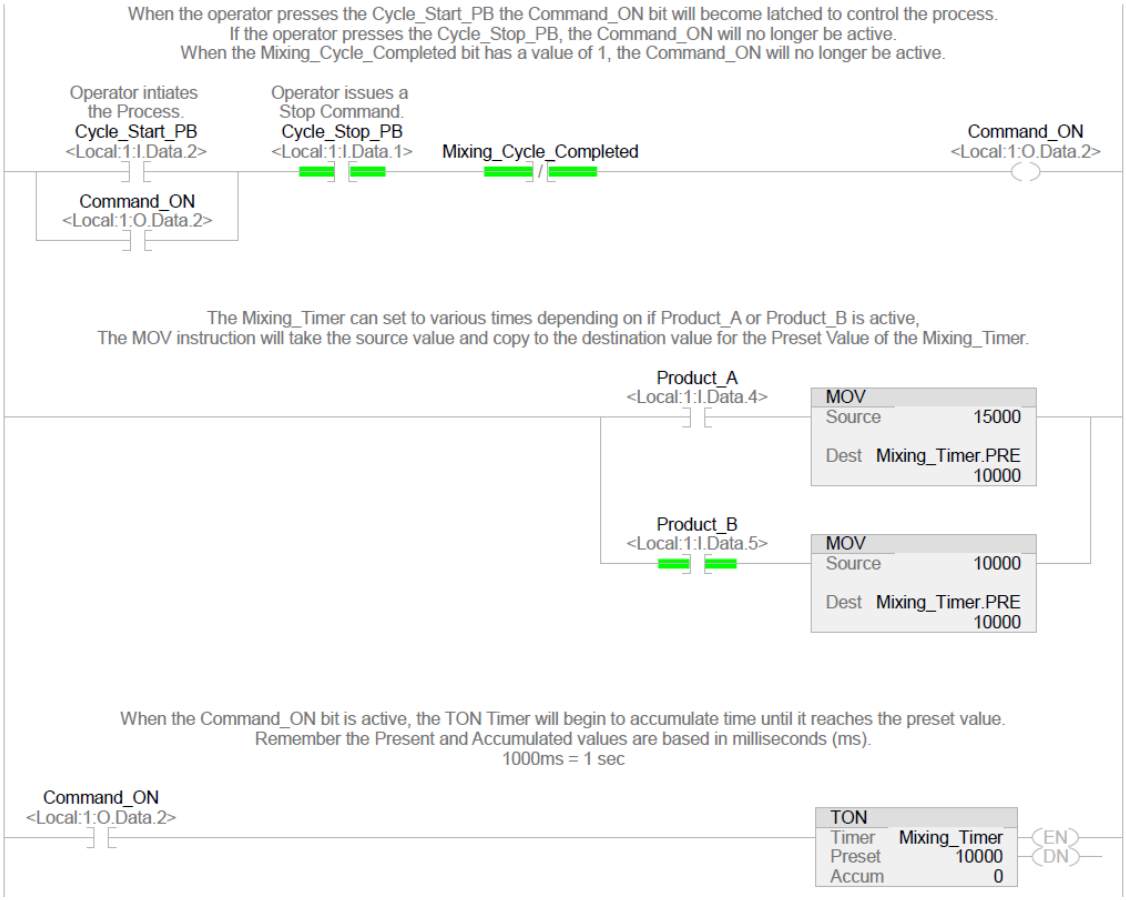
- Allen-Bradley CompactLogix PLC
- Studio 5000 Logix Designer Programming Software
- Simulated or Real-World Input Devices (Pushbuttons, Sensors)
- Simulated or Real-World Ouput Devices (Indicators)

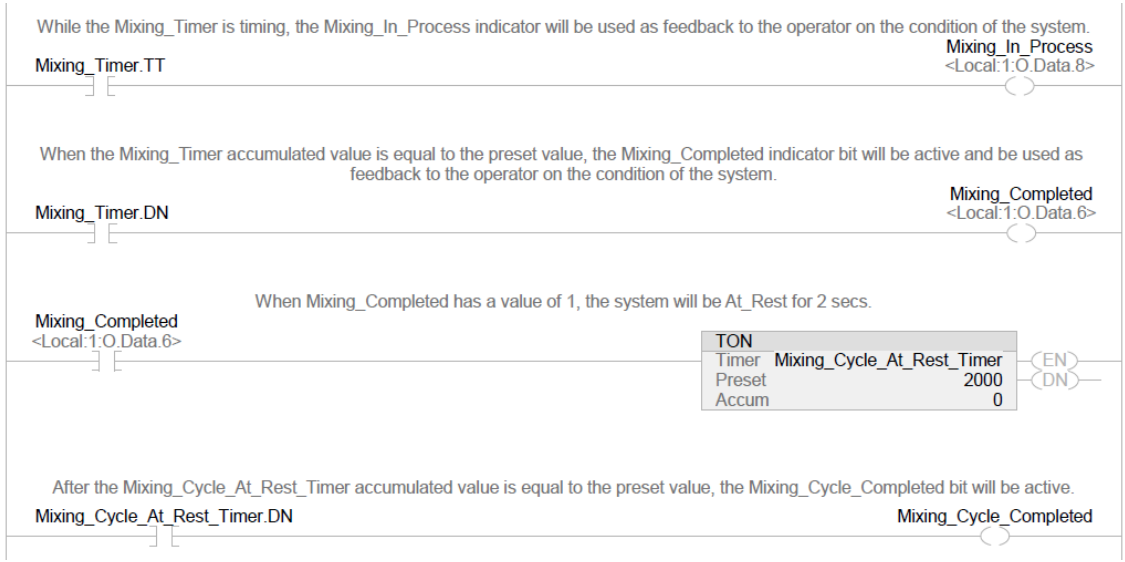
Lab Task:

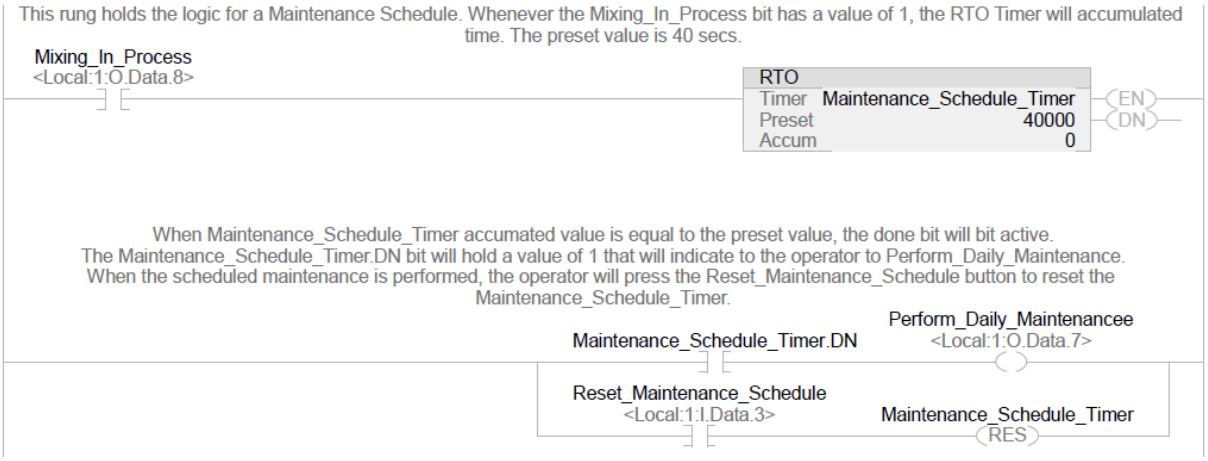
1. Create a new project called "**TON_Project**".
2. Create the following controller-scoped tags:

Alias Tag	IO Address	Physical Device	Tag Description	Data Type
Cycle_Start_PB	Local:1:I.Data.2	Green PB	Operator initiates the process.	BOOL
Cycle_Stop_PB	Local:1:I.Data.1	Red PB	Operator issues a Stop Command	BOOL
Mixing_Cycle_Completed	-	-	-	BOOL
Command_ON	Local:1:O.Data.2	Green PB Indicator	-	BOOL
Product_A	Local:1:I.Data.4	Selector Switch	-	BOOL
Product_B	Local:1:I.Data.5	Selector Switch	-	BOOL
Mixing_Timer	-	-	-	TIMER
Mixing_In_Process	Local:1:O.Data.8	Red Signal Tower	-	BOOL
Mixing_Completed	Local:1:O.Data.6	Green Signal Tower	-	BOOL
Mixing_Cycle_At_Rest_Timer	-	-	-	TIMER
Maintenance_Schedule_Timer	-	-	-	TIMER
Perform_Daily_Maintenance	Local:1:O.Data.7	Yellow Signal Tower	-	-
Reset_Maintenance_Schedule	Local:1:I.Data.3	Yellow PB	-	BOOL

3. **MainRoutine** - The purpose of this routine is to house the logic for a **Mixing Process Application**. Read the rung descriptions for further information on the purpose of each rung.







4. This is the **end of the lab exercise. Check with your instructor** to verify the completion of the lab. Save your completed project as "**TON_Project**" to a known location. **Download and Go Online** with the controller to **verify operation**.

Notes

Cardinal Automation, LLC

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About Us

Cardinal Automation, LLC was created by former university instructors and industry professionals to provide custom automation training and equipment to meet the needs of your program.

Cardinal Automation, LLC is committed to providing a quality training platform to those looking to expand their knowledge in industrial automation.

- Our courses offer a concise curriculum taught online and in-person through step-by-step guides to teach real-world industrial equipment.
- We provide custom training options to assist the employees in your facility.
- The automation trainers we build are constructed with industrial grade components that will bridge the gap to industry.

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