Allen-Bradley

Logix5000™ Controllers Common Procedures

1756 ControlLogix®, 1769 CompactLogix™, 1789 SoftLogix™, 1794 FlexLogix™, PowerFlex 700S with DriveLogix

Programming Manual

Rockwell Automation

Important User Information

Solid state equipment has operational characteristics differing from those of electromechanical equipment. *Safety Guidelines for the Application, Installation and Maintenance of Solid State Controls* (Publication SGI-1.1 available from your local Rockwell Automation sales office or online at http://www.ab.com/manuals/gi) describes some important differences between solid state equipment and hard-wired electromechanical devices. Because of this difference, and also because of the wide variety of uses for solid state equipment, all persons responsible for applying this equipment must satisfy themselves that each intended application of this equipment is acceptable.

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The examples and diagrams in this manual are included solely for illustrative purposes. Because of the many variables and requirements associated with any particular installation, Rockwell Automation, Inc. cannot assume responsibility or liability for actual use based on the examples and diagrams.

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Throughout this manual we use notes to make you aware of safety considerations.

WARNING

Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.

IMPORTANT

Identifies information that is critical for successful application and understanding of the product.

ATTENTION

Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss. Attentions help you:

- identify a hazard
- avoid a hazard
- recognize the consequence

SHOCK HAZARD

Labels may be located on or inside the drive to alert people that dangerous voltage may be present.

BURN HAZARD

Labels may be located on or inside the drive to alert people that surfaces may be dangerous temperatures.

Introduction

This release of this document contains new and updated information. To find new and updated information, look for change bars, as shown next to this paragraph.

Updated Information

The document contains the following changes:

Section:	Change:	Page:
Describe a User-Defined Data Type	Use the pass through of descriptions to reduce the time it takes to document a project.	3-21
Prioritize Periodic and Event Tasks	Corrections to the example of how tasks interrupt one another	4-7
Choose the Trigger for an Event Task	Addition of consumed tag trigger for CompactLogix, FlexLogix, and DriveLogix controllers	4-20
Export/Import Ladder Logic	Create a file that contains the ladder logic, tags, data types, parameter values, and documentation for a specific function, operation, or process.	8-14
Develop a Fault Routine	• Integration of the Power-Up Handler information into this section. This was done to clarify when a major fault occurs during power-up and how to handle it, if required. • Clarification regarding a fault due to a mode change	15-1
Clear a Major Fault During Prescan	Some controllers now automatically clear a fault that is due an array subscript that is beyond the range of the array (out of range) during prescan.	15-8
Create a User-Defined Major Fault	If you create a user-defined major fault, use a value between 990 to 999 for the fault code. These codes are reserved for user-defined faults.	15-13
Minor Fault Codes	Correction to missing fault codes for the GSV/SSV instructions	16-4
Choose a Controller That Has Nonvolatile Memory	Addition of the following controllers: • CompactLogix5331 • CompactLogix5332E • CompactLogix5335CR • ControlLogix5560M03SE • DriveLogix5730	17-3
Estimate Memory Information Offline	Estimate the free and used memory of a controller while still offline	19-2
View Run Time Memory Information	View the free and used memory of a controller while the controller is running	19-3

Purpose of this Manual

This manual guides the development of projects for Logix5000™ controllers. It provides step-by-step procedures on how to perform the following tasks, which are common to all Logix5000 controllers:

- Organize Tasks, Programs, and Routines
- Organize Tags
- Design a Sequential Function Chart
- Program Routines using ladder logic, function block diagram, sequential function chart, or structured text programming languages
- Communicate with Other Controllers
- Communicate and Process ASCII Information
- Handle Faults

The term *Logix5000 controller* refers to any controller that is based on the Logix5000 operating system, such as:

- CompactLogix™ controllers
- ControlLogix® controllers
- DriveLogix™ controllers
- FlexLogix™ controllers
- SoftLogix5800™ controllers

This manual works together with user manuals for your specific type of controller. The user manuals cover tasks such as:

- Place and configure I/O
- Communicate with devices over various networks
- Maintain the battery

Who Should Use this Manual

This manual is intended for those individuals who program applications that use Logix5000 controllers, such as:

- software engineers
- control engineers
- application engineers
- instrumentation technicians

When to Use this Manual

Use this manual when you perform these actions:

- develop the basic code for your application
- modify an existing application
- perform isolated tests of your application

As you integrate your application with the I/0 devices, controllers, and networks in your system:

- Refer to the user manual for your specific type of controller.
- Use this manual as a reference, when needed.

How to Use this Manual

This manual is divided into the basic tasks that you perform while programming a Logix5000 controller.

- Each chapter covers a task.
- The tasks are organized in the sequence that you will typically perform them.

As you use this manual, you will see some terms that are formatted differently from the rest of the text:

Text that is:	Identifies:	For example:	Means:
Italic	the actual name of an item that you see on your screen or in an example	Right-click *User-Defined* …	Right-click on the item that is named User-Defined.
bold	an entry in the "Glossary"	Type a **name** …	If you want additional information, refer to **name** in the "Glossary." If you are viewing the PDF file of the manual, click **name** to jump to the glossary entry.
`courier`	information that you must supply based on your application (a variable)	Right-click `name_of_program` …	You must identify the specific program in your application. Typically, it is a name or variable that you have defined.
enclosed in brackets	a keyboard key	Press [Enter].	Press the Enter key.

Chapter 5

Design a Sequential Function Chart

Chapter 7

Program Structured Text

Chapter 10

Communicate with Other Devices

Chapter 15

Handle a Major Fault

Appendix C

IEC61131-3 Compliance

Getting Started

Using This Chapter

This chapter provides preliminary information to help you get started with a project for Logix5000™ controller.

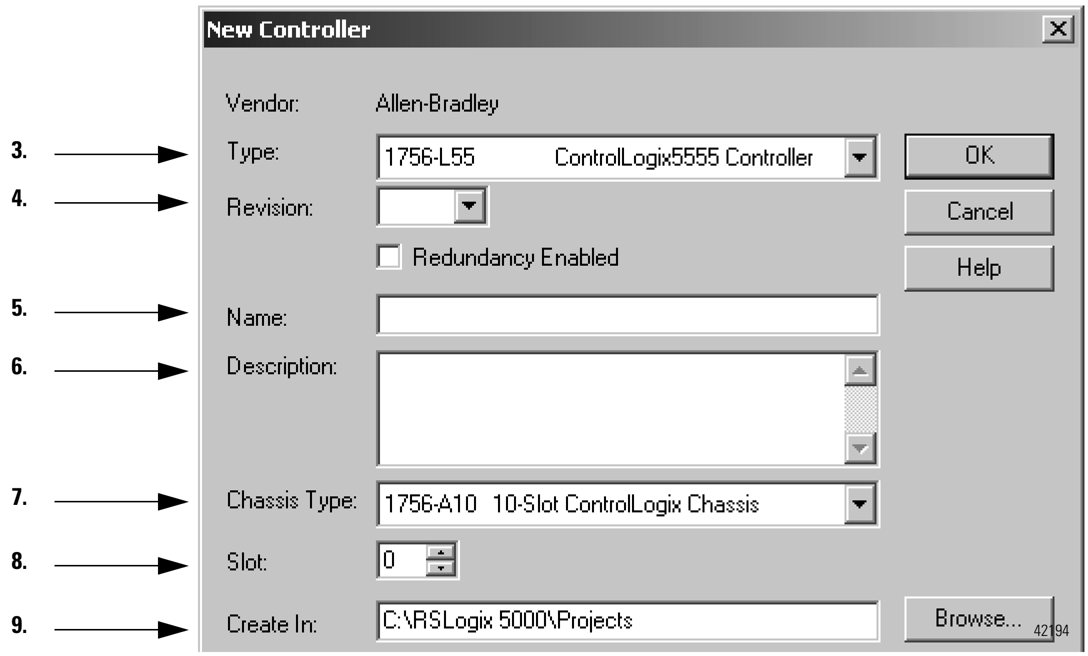
Create a Project

To configure and program a Logix5000 controller, you use RSLogix™ 5000 software to create and manage a project for the controller.

Term:	Definition:
project	The file on your workstation (or server) that stores the logic, configuration, data, and documentation for a controller. • The project file has an .ACD extension. • When you create a project file, the file name is the name of the controller. • The controller name is independent of the project file name. If you save a current project file as another name, the controller name is unchanged. • If the name of the controller is different than the name of the project file, the title bar of the RSLogix 5000 software displays both names.

Create a Project

1. Start the RSLogix 5000 software.
2. From the *File* menu, select *New*.



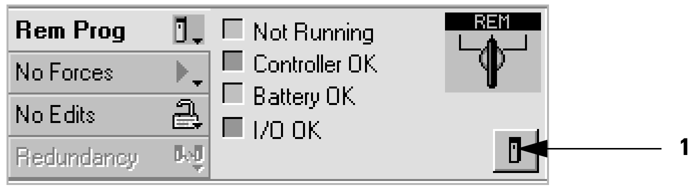
3. Select the type of controller.
4. Choose the major revision of firmware for this controller.
5. Type a **name** for the controller.
6. Type a description of the operations that the controller performs (optional).
7. Select the type of chassis (number of slots) that contains the controller (not applicable to some controllers).
8. Select or type the slot number where the controller is installed (not applicable to some controllers).
9. To store the file in a different folder (other than the default *Create In* path), click *Browse* and select a folder.
10. Choose 

Names:

- only alphabetic characters (A-Z or a-z), numeric characters (0-9), and underscores (_)
- must start with an alphabetic character or an underscore
- no more than 40 characters
- no consecutive or trailing underscore characters (_)
- *not* case sensitive

Configure a Project

To change the configuration of the controller, such as name, chassis size, or slot number, use the Controller Properties dialog box.



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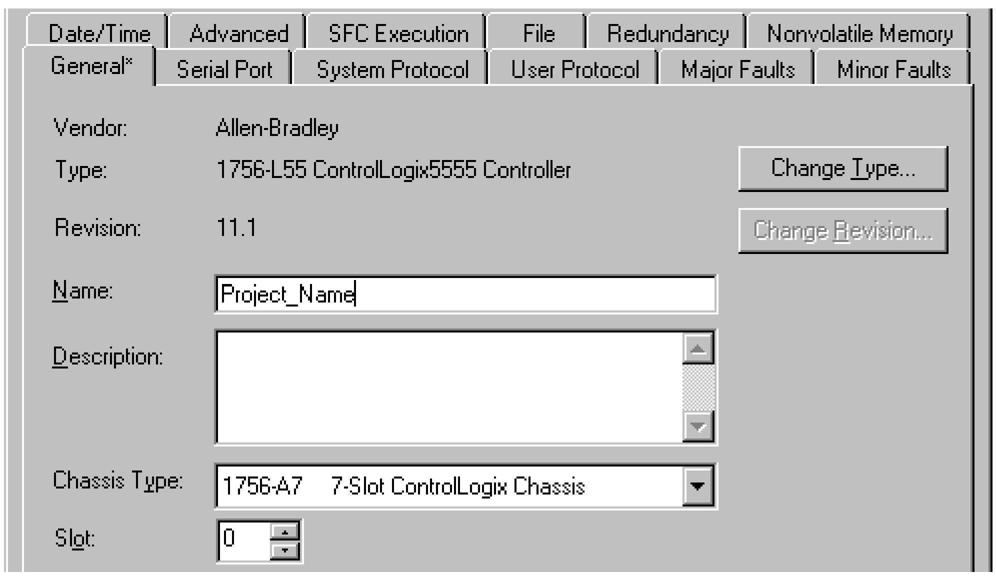
1. On the Online toolbar, click the controller properties button.



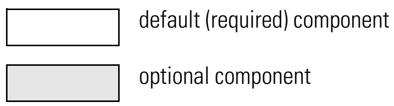
2. Make the required changes.

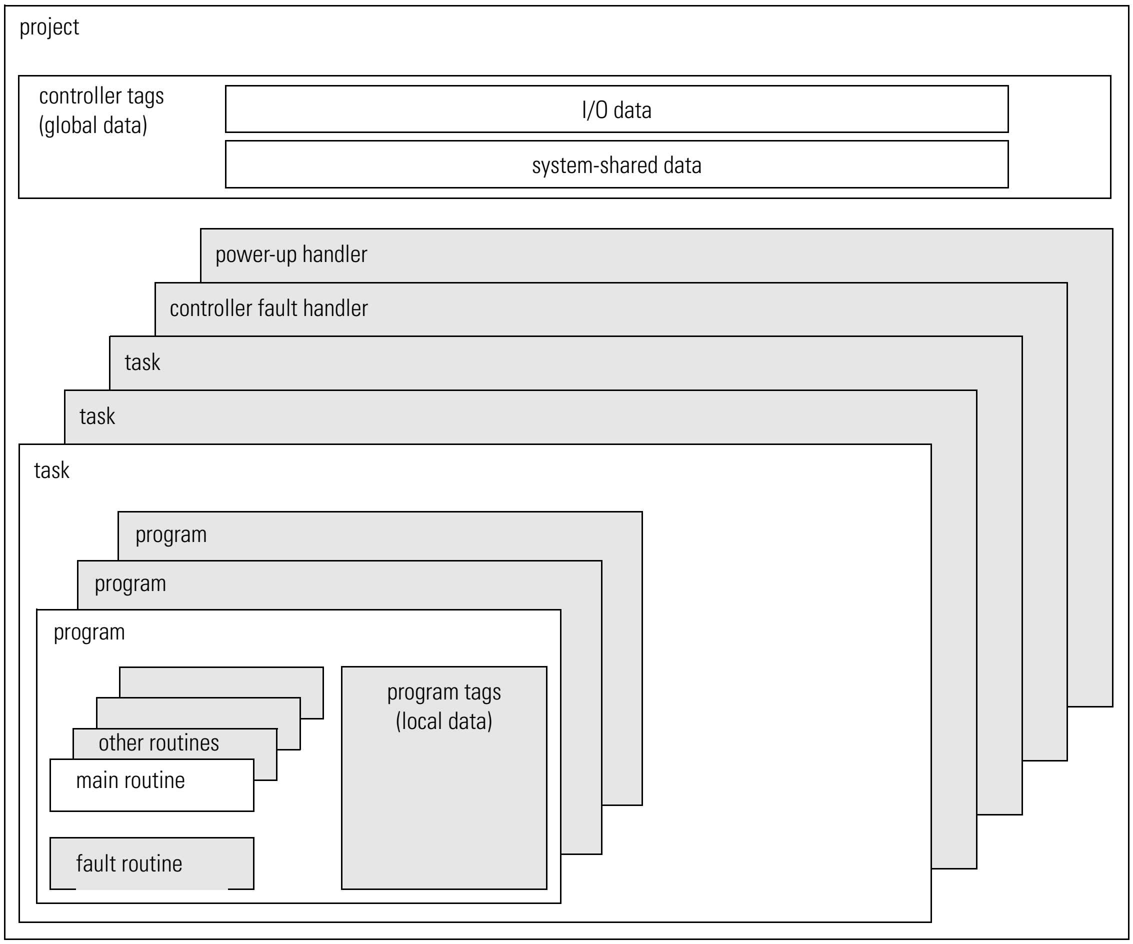
3. Choose OK

Explore a Project

A project includes the following basic components:

Legend





The components of a project work together as follows:

Project component:	Definition:
Task	A task provides scheduling and priority information for a set of one or more programs. When you create a new project, RSLogix 5000 software automatically creates an initial task that is configured to run all the time (continuous task). When the task completes a full scan, it restarts immediately.
Program	Each task requires at least one program. • A task can have as many as 32 separate programs, each with its own program tags, main routine, other routines, and an optional fault routine. • Once a task is triggered (activated), all the programs assigned (scheduled) to the task execute in the order in which they are displayed in the controller organizer. • You schedule a program in only one task and cannot share a program among multiple tasks.
Routine	Routines provide the executable code for the project in a controller (similar to a program file in a PLC or SLC controller). Each routine uses a specific programming language, such as ladder logic.
Main Routine	When a program executes, its main routine executes first. Use the main routine to call (execute) other routines (subroutines). To call another routine within the program, use a Jump to Subroutine (JSR) instruction.
Subroutine	Any routine other than the main routine or fault routine. To execute a subroutine, use a Jump to Subroutine (JSR) instruction in another routine, such as the main routine.

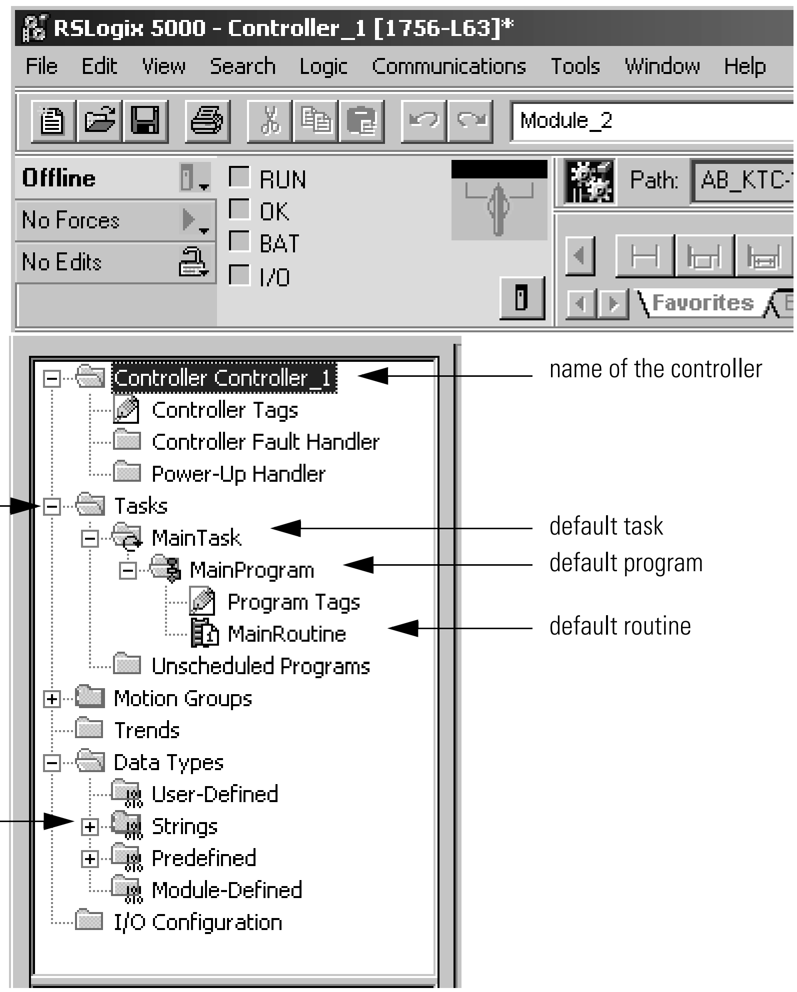
Controller Organizer

In RSLogix 5000 software, the controller organizer provides a graphical overview of a project. When you create a project, RSLogix5000 software automatically creates a default task, program, and routine.

When you create a project, the name of the project is the same as the name of the controller.

If you rename the project or controller, both names are shown.

controller organizer



name of the controller

default task

default program

default routine

To close a folder and hide its contents (collapse), do one of the following:

- Double-click the folder.
- Select the folder and press the [←] key.
- Click the – sign.

To open a folder and display its contents (expand), do one of the following:

- Double-click the folder.
- Select the folder and press the [→] key.
- Click the + sign.

Create Routines

Routines provide the executable code for the project in a controller.

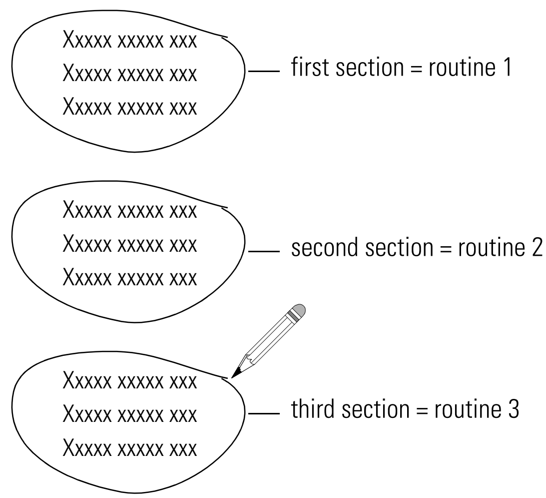
Define a Routine for Each Section of Your Machine or Process

To make your project easier to develop, test, and troubleshoot, divide it into routines (subroutines):

1. Identify each physical section of your machine or process.

2. Assign a routine for each of those sections.

Description of Your Machine or Process



Identify the Programming Languages That Are Installed

To determine which programming languages are installed on your version of RSLogix 5000 software:

1. Start RSLogix 5000 software.

2. From the *Help* menu, choose *About RSLogix 5000*.

To add a programming language, see *ControlLogix Selection Guide*, publication 1756-SG001.

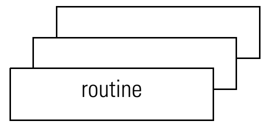
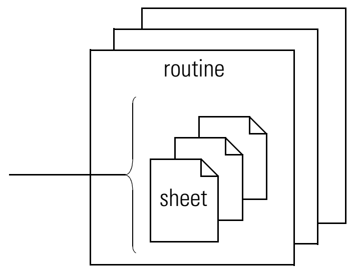
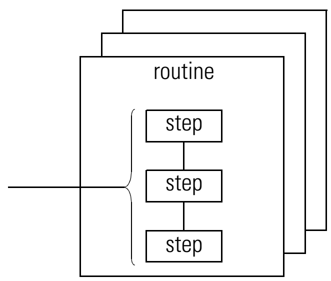
Choose a Programming Language for Each Section

For each section of your machine or process, choose an appropriate programming language.

- Logix5000 controllers let you use the following languages:
  - ladder logic
  - function block diagram
  - sequential function chart
  - structured text
- Use any combination of the languages in the same project.

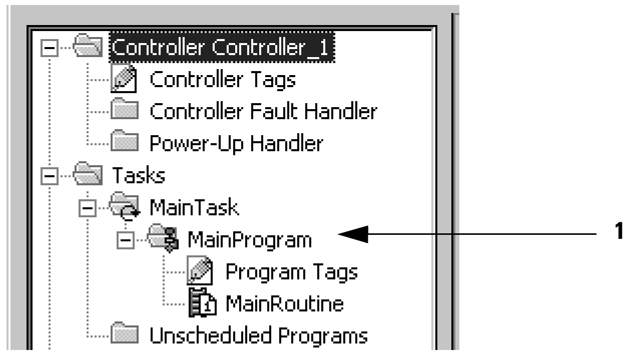
In general, if a section of your code represents:	Then use this language:
continuous or parallel execution of multiple operations (not sequenced)	ladder logic
boolean or bit-based operations	
complex logical operations	
message and communication processing	
machine interlocking	
operations that service or maintenance personnel may have to interpret in order to troubleshoot the machine or process.	
continuous process and drive control	function block diagram
loop control	
calculations in circuit flow	
high-level management of multiple operations	sequential function chart (SFC)
repetitive sequences of operations	
batch process	
motion control using structured text	
state machine operations	
complex mathematical operations	structured text
specialized array or table loop processing	
ASCII string handling or protocol processing	

Divide Each Routine Into More Meaningful Increments

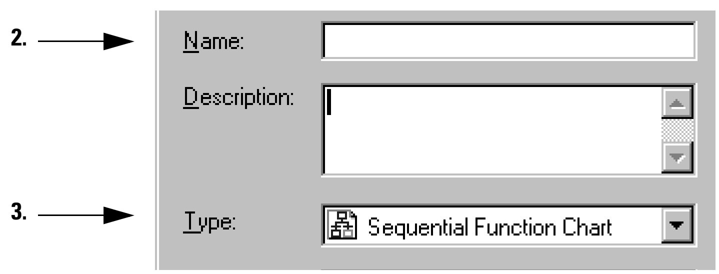
If a routine uses this language:	Then:	Example:
ladder logic structured text	Break up large routines into several smaller routines 	To continuously execute several complex boolean operations… …create a separate routine for each operation.
function block diagram (FBD)	Within the FBD routine, make a sheet for each functional loop for a device (motor, valve, etc.). 	To control 4 valves, where each valve requires feedback that it is in its commanded position… …make a separate sheet for each valve.
sequential function chart (SFC)	Break the SFC into steps. 	To perform the following sequence: 1. Fill a tank. 2. Mix the ingredients in the tank. 3. Empty the tank… …make each section (fill, mix, empty) a separate step.

Create a Routine

Each program requires at least one routine. Use a routine to execute your logic in a specific programming language.

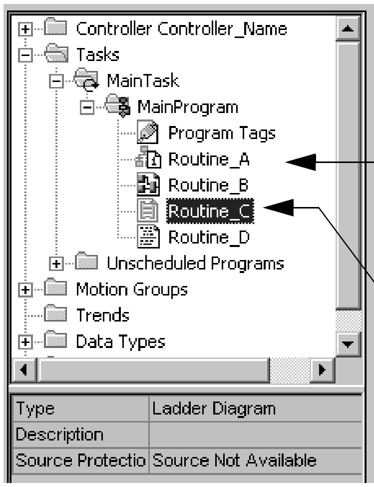


1. In the controller organizer, right-click the program that will execute the routine and choose *New Routine*.



2. In the *Name* text box, type a **name** for the routine.
3. From the *Type* list, choose the programming language for the routine
4. Choose 

Open a Routine



To open a folder and show its contents, either:

- Double-click the folder.
- Click the + sign.

To open a routine, double-click the routine. If a routine is grayed-out, you cannot open the routine.

source protection – The developer of the routine may have assigned a source key to the routine. The source key limits access to the routine.

If the controller organizer lists source protection for a routine, then a source key is assigned to the routine.

For this routine…

This is the protection status.

If:	Then:
Source Not Available	To open the routine, your computer requires the source key for the routine.
Source Not Available (Viewable)	• You can only open and view the routine. • You *cannot* make any changes or copy any of contents of the routine.
Source Available	You have full access to the routine.
Source Available (Viewable)	You have full access to the routine.

IMPORTANT

If the source of a routine is unavailable, *do not* export the project.

- An export file (.L5K) contains only routines where the source code is available.
- If you export a project where the source code is *not* available for all routines, you will *not* be able to restore the entire project.

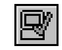
TIP

If a routine fails to open, your computer may not have the required programming language installed.

- To determine which programming languages are installed on your computer, choose *Help* ⇒ *About RSLogix 5000*.
- To add a programming language, see *ControlLogix Selection Guide*, publication 1756-SG001

Verify a Project

As you program your project, periodically verify your work:

1. In the top-most toolbar of the RSLogix 5000 window, click 
2. If any errors are listed at the bottom of the window:
   a. To go to the first error or warning, press [F4].
   b. Correct the error according to the description in the Results window.
   c. Go to step 1.
3. To close the Results window, press [Alt] + [1].

Save a Project

As you create logic and make configuration changes, save the project.

To:	Do this:
save your changes	From the *File* menu, select *Save*.
make a copy of the open project but keep the existing name of the controller	1. From the *File* menu, select *Save* As. 2. Type a name for the project file. Use underscores [_] in place of spaces. 3. Click *Save*.
make a copy of the project and assign a different name to the controller	1. From the *File* menu, select *Save* As. 2. Type a name for the project file. Use underscores [_] in place of spaces. 3. Click *Save*. 4. In the controller organizer, right-click *Controller* `name_of_controller` folder and select *Properties*. 5. Type a new name for the controller. 6. Click *OK*.

If you make changes to the project while **online**, save the project so that the offline project file matches the online project file:

If you want to:	Do this:
save online changes *and* data values	From the *File* menu, select *Save*.
save online changes but *not* online data values	1. From the *Communications* menu, select *Go Offline*. 2. From the *File* menu, select *Save*.

Configure a Communication Driver

The RSLogix 5000 software requires a communication driver to communicate with a controller. You configure communication drivers using RSLinx® software:

1. Start RSLinx software.
2. From the *Communications* menu, select *Configure Drivers*.
3. From the Available Driver Types drop-down list, select a driver:

For this network:	And this type of computer:	Select this driver:
serial	→	RS-232 DF1 Devices
DH+™	desktop computer	1784-KT/KTX(D)/PKTX(D)
	laptop computer	1784-PCMK
ControlNet™	desktop computer	1784-KTC(X)
	laptop computer	1784-PCC
EtherNet/IP	→	Ethernet devices
DeviceNet™	→	DeviceNet Drivers (1784-PCD/PCIDS, 1770-KFD, SDNPT drivers)

4. Choose *Add New*.
5. If you want to assign a descriptive name to the driver, change the default name.
6. Choose *OK*.
7. Configure the driver:

For this driver:	Do this:
serial	A. From the *Comm Port* drop-down list, select the serial port that the driver will use. B. From the Device drop-down list, select *Logix 5550-Serial Port.* C. Click *Auto-Configure*.
ControlNet	A. In the *Station Name* box, type a name that will identify the computer in the RSWho window. B. Select the interrupt value, memory address, and I/O base address. C. In the *Net Address* box, type the ControlNet node number that you want to assign to the computer.
DH+	A. From the *Value* drop-down list, select the type of interface card that the driver will use. B. In the *Property* list, select the next item. C. In the *Value* box, type or select the appropriate value. D. Repeat steps B. and C. for the remaining properties.
Ethernet	For each Ethernet device on this network with which you want to communicate (e.g., each 1756-ENB module or PLC-5E controller), add a map entry: A. In the *Host Name* column, type the IP address or host name of the Ethernet device. B. To communicate with another Ethernet device on this network, choose *Add New* and go to Step A.

8. Choose *OK*. and then choose *Close*.

Download a Project to the Controller

Use this procedure to download a project to the controller so you can execute its logic.

- When you download a project, you lose the project and data that is currently in the controller, if any.
- If the revision of the controller does not match the revision of the project, you are prompted to update the firmware of the controller. RSLogix 5000 software lets you update the firmware of the controller as part of the download sequence.

ATTENTION

When you download a project or update firmware, all active servo axes are turned off. Before you download a project or update firmware, make sure that this *will not* cause any unexpected movement of an axis.

IMPORTANT

To update the firmware of a controller, first install a firmware upgrade kit.

- An upgrade kit ships on a supplemental CD along with RSLogix 5000 software.
- To download an upgrade kit, go to www.ab.com. Choose *Product Support*. Choose *Firmware Updates*.

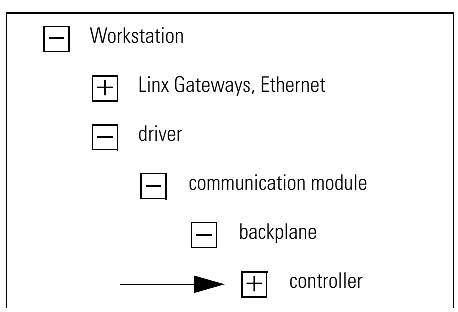
1. Open the RSLogix 5000 project that you want to download.

2. From the Communications menu, choose *Who Active*.

3. Expand the network until you see the controller.

To expand a network one level, do one of the following:

- Double-click the network.
- Select the network and press the → key.
- Click the + sign.



4. Select the controller.

5. Choose *Download*.

6. Which response did the software give:

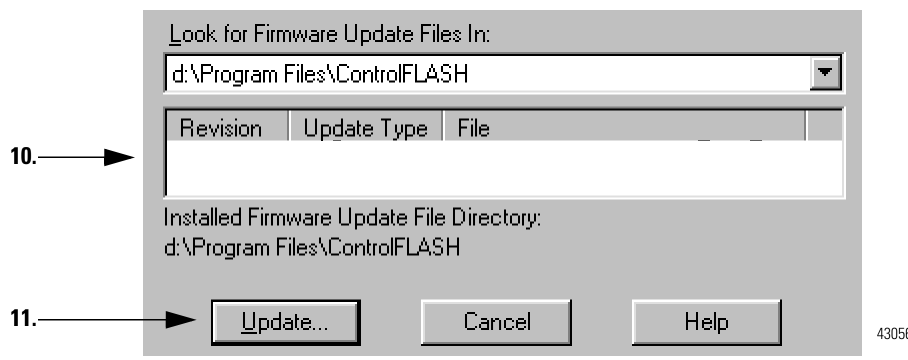
If the software indicates:	Then:
Download to the controller	Go to step 7.
Failed to download to the controller. The revision of the offline project and controller's firmware are not compatible.	Go to step 9.

7. Choose *Download*.

   The project downloads to the controller and RSLogix 5000 software goes online.

8. Skip the rest of this procedure.

9. Choose *Update Firmware*.



10. Select the required revision for the controller.

11. Choose *Update*.

    A dialog box asks you to confirm the update.

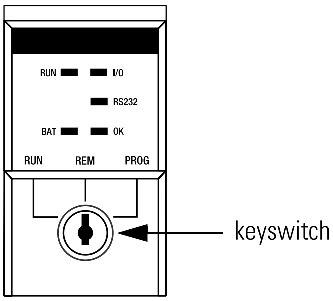
12. To update the controller, choose *Yes*.

    The following events occur:

    - The firmware of the controller is updated.
    - The project downloads to the controller.
    - RSLogix 5000 software goes online.

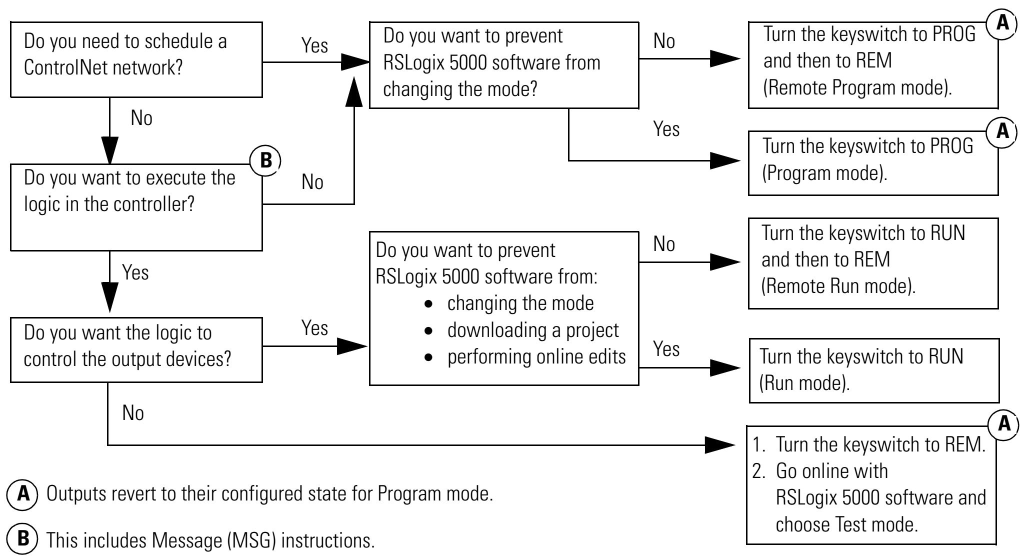
Select a Mode for the Controller

To change the operating mode of the controller, use the keyswitch on the front of the controller:



IMPORTANT

- All modes send and receive data in response to a message from another controller.
- All modes produce and consume tags.



You can also use RSLogix 5000 software to change the mode of the controller:

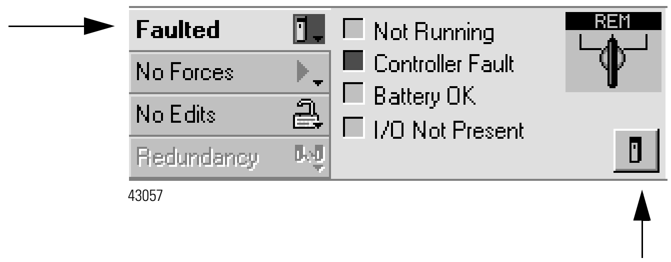
1. On the front of the controller, turn the keyswitch to REM.
2. Go online with the controller.

3. On the online toolbar, choose the desired mode.

Manually Clear a Major Fault

If the controller enters the **faulted mode**, a **major fault** occurred and the controller stopped executing the logic.

The controller is faulted. A major fault occurred and the controller is no longer executing its logic.



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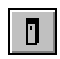
1.

To correct a major fault:

1. Click the  button.

2. Use the information in the *Recent faults list* to correct the cause of the fault. Refer to "Major Fault Codes" on page 15-15.

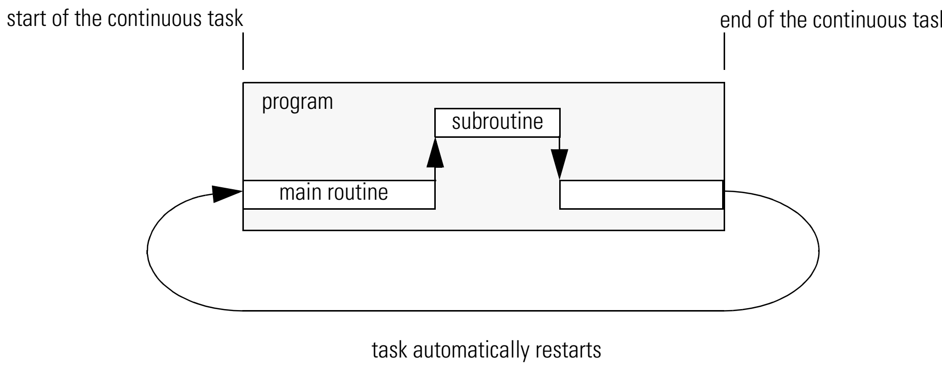
3. Click the *Clear Majors* button.

TIP You can also clear a major fault by using the keyswitch on the controller. Turn the keyswitch to *Prog*, then to *Run*, and then back to *Prog*.

Configure the Execution of a Task

When you create a new project, RSLogix 5000 software automatically creates an initial task that is configured to run all the time (continuous task). When the task completes a full scan, it restarts immediately.

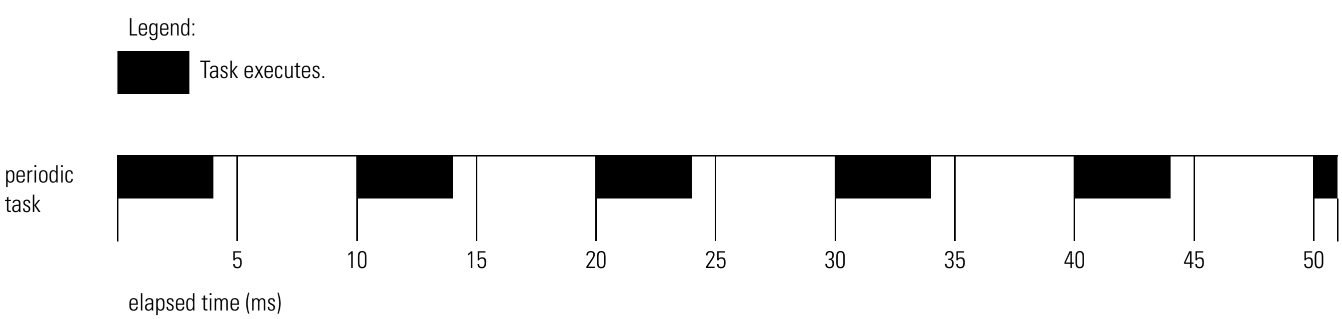
Figure 1.1 Execution of the Continuous Task



If you are familiar with a DCS application or plan to program your system using a function block diagram, you can configure the task to execute at a specific period (periodic task). This lets you update your function block diagram at a period that you specify.

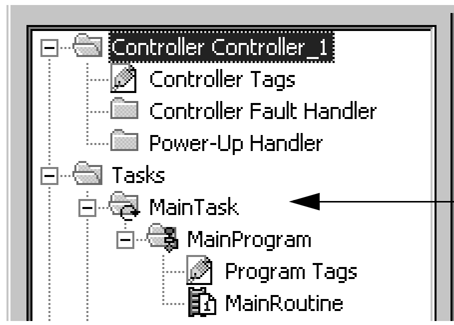
- Whenever the time period for the task expires, the task executes one time.
- You configure the period from 1 ms to 2000 s. The default is 10 ms.
- If you use a periodic task in addition to a continuous task, the periodic task interrupts the execution of the continuous task. When the periodic task is done, control returns to the continuous task. For more information on using multiple tasks, see chapter 4.

Figure 1.2 Example of a Periodic Task That Executes Every 10 ms.



Configure a Task

To configure the execution of a task, use the properties dialog box for the task.

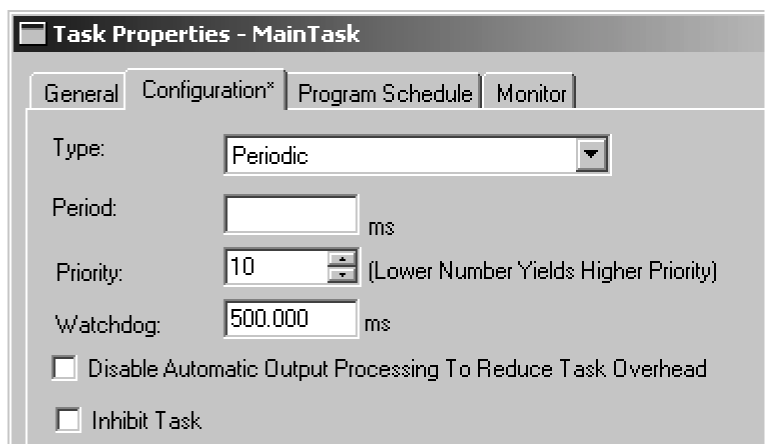


1.

1. In the controller organizer, right-click the task that you want to configure and choose *Properties*.

2. Click the *Configuration* tab.

3.
4.



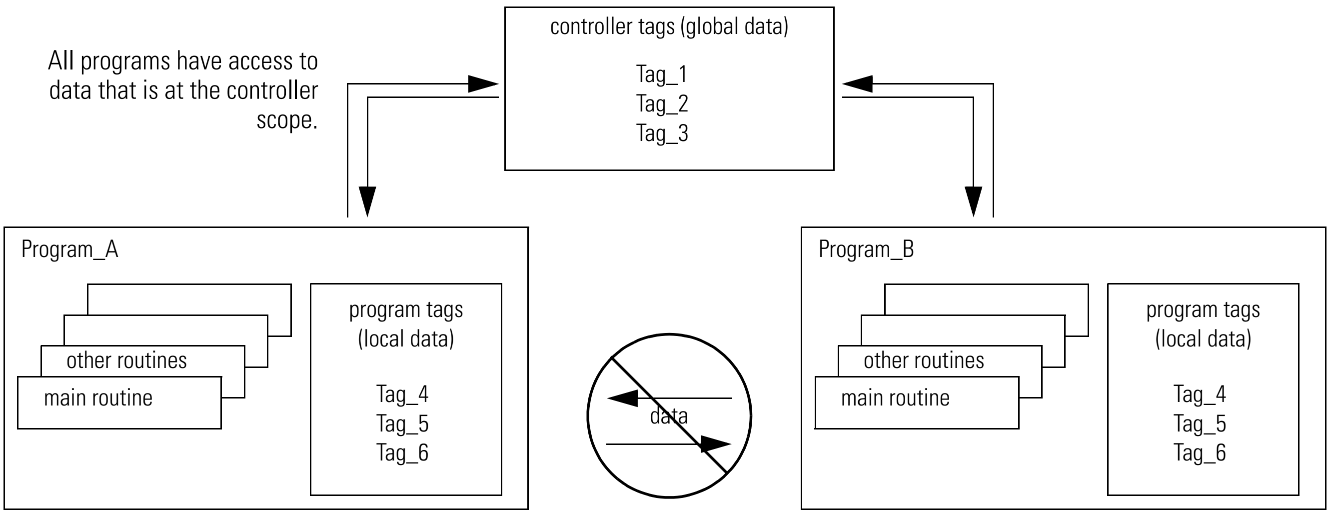
3. From the *Type* list, choose type of execution for the task. Only one continuous task is permitted.

4. If you chose Periodic in step 3, then type the rate at which you want the task to execute.

5. Choose 

Create Multiple Programs

A Logix5000 controller lets you divide your application into multiple programs, each with its own data. There is *no* need to manage conflicting tag names between programs. This makes it easier to re-use both code and tag names in multiple programs.



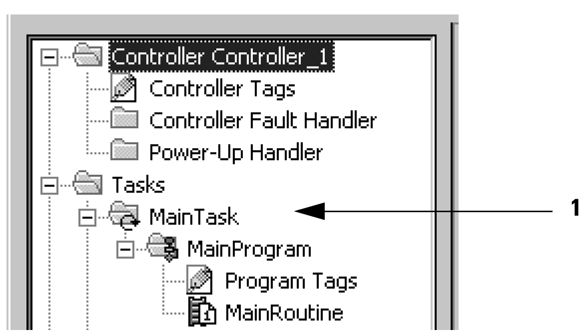
Data at the program scope is isolated from other programs:

- Routines cannot access data that is at the program scope of another program.
- You can re-use the tag name of a program-scoped tag in multiple programs.

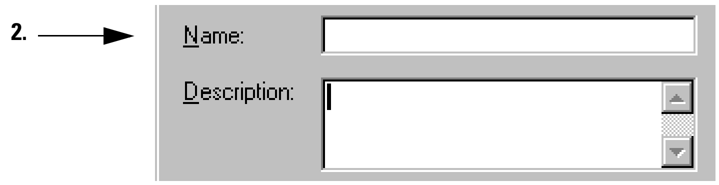
  For example, both Program_A and Program_B can have a program tag named Tag_4.

Create a Program

Each task requires at least one program. You can create multiple programs for a task.



1. In the controller organizer, right-click the task that will execute the program and choose *New Program*.

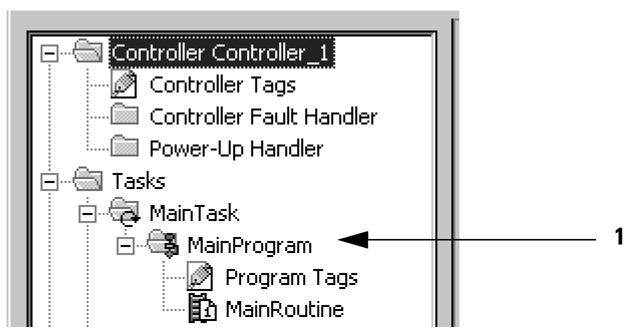


2. In the *Name* text box, type a **name** for the program.

3. Choose OK

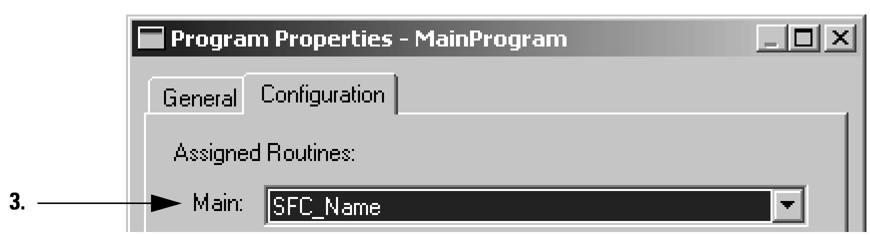
Configure a Program

Each program requires a main routine. The main routine executes whenever the program executes.



1. In the controller organizer, right-click the program that you want to configure and choose *Properties*.

2. Click the *Configuration* tab.



3. From the *Main* list, choose the name of the routine that you want to execute as the main routine.

4. Choose OK

Access Status Information

Logix5000 controllers do not have a status file, as in the PLC-5 controller. To access status information, you use a keyword or access a specific object.

If you want to:	See:
use specific key words in your logic to monitor specific events	"Monitor Status Flags" on page 1-22
get or set system values	"Get and Set System Data" on page 1-23

Monitor Status Flags

The controller supports status keywords you can use in your logic to monitor specific events:

- The status keywords are *not* case sensitive.
- Because the status flags can change so quickly, RSLogix 5000 software does *not* display the status of the flags. (I.e., Even when a status flag is set, an instruction that references that flag is *not* highlighted.)
- You *cannot* define a tag alias to a keyword.

You can use these key words:

To determine if:	Use:
the value you are storing cannot fit into the destination because it is either: • greater than the maximum value for the destination • less than the minimum value for the destination **Important:** Each time S:V goes from cleared to set, it generates a minor fault (type 4, code 4)	S: V
the instruction's destination value is 0	S:Z
the instruction's destination value is negative	S:N
an arithmetic operation causes a carry or borrow that tries to use bits that are outside of the data type For example: • adding 3 + 9 causes a carry of 1 • subtracting 25 - 18 causes a borrow of 10	S:C
this is the first, normal scan of the routines in the current program	S:FS
at least one minor fault has been generated: • The controller sets this bit when a minor fault occurs due to program execution. • The controller does not set this bit for minor faults that are not related to program execution, such as battery low.	S:MINOR

Get and Set System Data

The controller stores system data in objects. There is no status file, as in the PLC-5 controller. Use the GSV/SSV instructions get and set controller system data that is stored in objects:

- The GSV instruction retrieves the specified information and places it in the destination.
- The SSV instruction sets the specified attribute with data from the source.

ATTENTION

Use the SSV instruction carefully. Making changes to objects can cause unexpected controller operation or injury to personnel.

To get or set a system value:

1. Open the RSLogix 5000 project.
2. From the *Help* menu, select *Contents*.
3. Click the *Index* tab.
4. Type *gsv/ssv objects* and click *Display*.

5. Click the required object.

To get or set:	Click:
axis of a servo module	AXIS
system overhead timeslice	CONTROLLER
physical hardware of a controller	CONTROLLERDEVICE
coordinated system time for the devices in one chassis	CST
DF1 communication driver for the serial port	DF1
fault history for a controller	FAULTLOG
attributes of a message instruction	MESSAGE
status, faults, and mode of a module	MODULE
group of axes	MOTIONGROUP
fault information or scan time for a program	PROGRAM
instance number of a routine	ROUTINE
configuration of the serial port	SERIALPORT
properties or elapsed time of a task	TASK
wall clock time of a controller	WALLCLOCKTIME

6. In the list of attributes for the object, identify the attribute that you want to access.

7. Create a tag for the value of the attribute:

If the data type of the attribute is:	Then:
one element (e.g., DINT)	Create a tag for the attribute.
more than one element (e.g., DINT[7])	A. Create a user-defined data type that matches the organization of data that is used by the attribute. B. Create a tag for the attribute and use the data type from Step A..

8. In your ladder logic routine, enter the appropriate instruction:

To:	Enter this instruction:
get the value of an attribute	GSV
set the value of an attribute	SSV

9. Assign the required operands to the instruction:

For this operand:	Select:
Class name	name of the object
Instance name	name of the specific object (e.g., name of the required I/O module, task, message) • Not all objects require this entry. • To specify the current task, program, or routine, select *THIS*.
Attribute Name	name of the attribute
Dest (GSV)	tag that will store the retrieved value • If the tag is a user-defined data type or an array, select the first member or element.
Source (SSV)	tag that stores the value to be set • If the tag is a user-defined data type or an array, select the first member or element.

The following examples gets the current date and time.

EXAMPLE Get a system value

At the first scan, gets the *DateTime* attribute of the *WALLCLOCKTIME* object and stores it in the *wall_clock* tag, which is based on a user-defined data type.

42370

For more information, see the *Logix5000 Controllers General Instruction Set Reference Manual*, publication 1756-RM003.

Adjust the System Overhead Time Slice

A Logix5000 controller communicates with a other devices (I/O modules, controllers, HMI terminals, etc.) at either a specified rate (scheduled) or when there is processing time available to service the communication (unscheduled).

This type of communication:	Is:
update I/O data (not including block-transfers)	Scheduled Communication
produce or consume tags	
communicate with programming devices (e.g., RSLogix 5000 software)	Unscheduled Communication
communicate with HMI devices	
execute Message (MSG) instructions, including block-transfers	
respond to messages from other controllers	
synchronize the secondary controller of a redundant system	
re-establish and monitor I/O connections (such as Removal and Insertion Under Power conditions); this *does not* include normal I/O updates that occur during the execution of logic.	
bridge communications from the serial port of the controller to other ControlLogix devices via the ControlLogix backplane	

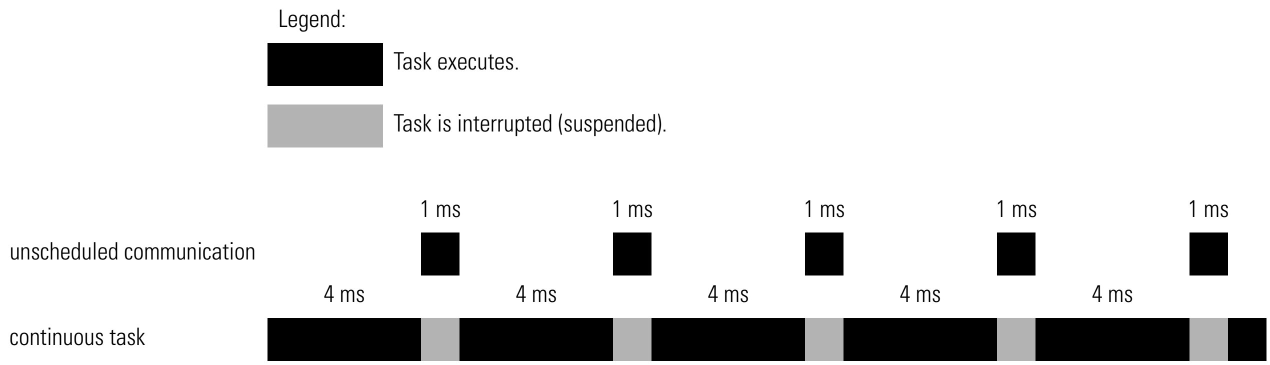
Unscheduled communication is any communication that you *do not* configure through the I/O configuration folder of the project.

- The **system overhead time slice** specifies the percentage of time (excluding the time for periodic or event tasks) that the controller devotes to unscheduled communication.
- The controller performs unscheduled communication for up to 1 ms at a time and then resumes the continuous task.

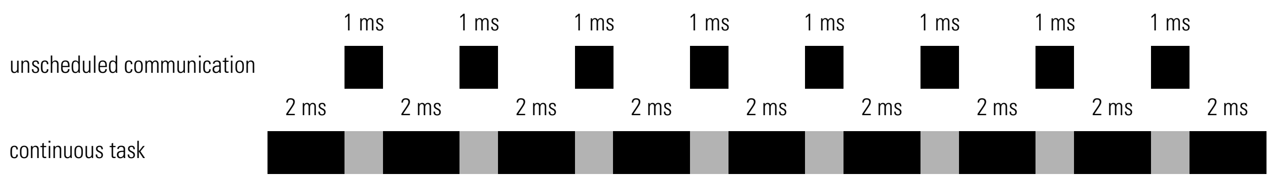
The following table shows the ratio between the continuos task and unscheduled communication at various system overhead time slices:

At this time slice:	The continuous tasks runs for:	And unscheduled communication occurs for up to:
10%	9 ms	1 ms
20%	4 ms	1 ms
33%	2 ms	1 ms
50%	1 ms	1 ms

At a system overhead time slice to 20 %, unscheduled communication occurs every 4 ms of continuous task time for 1 ms.

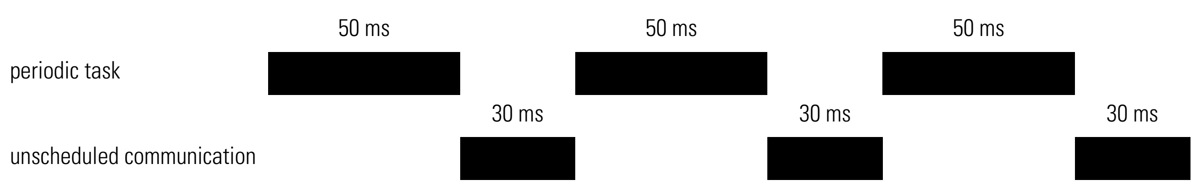


If you increase the system overhead time slice to 33 %, unscheduled communication occurs every 2 ms of continuous task time for 1 ms.

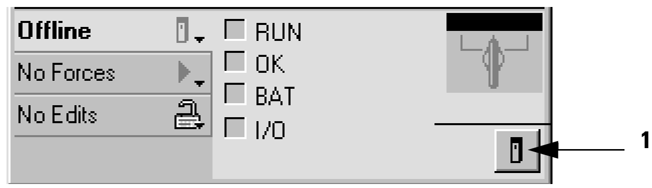


If the controller contains only a periodic task or tasks, the system overhead time slice value has no effect. Unscheduled communication occurs whenever a periodic task is not running.

For example, if your task takes 50 ms to execute and you configure its update rate to 80 ms, the controller has 30 ms out of every 80 ms for unscheduled communication.

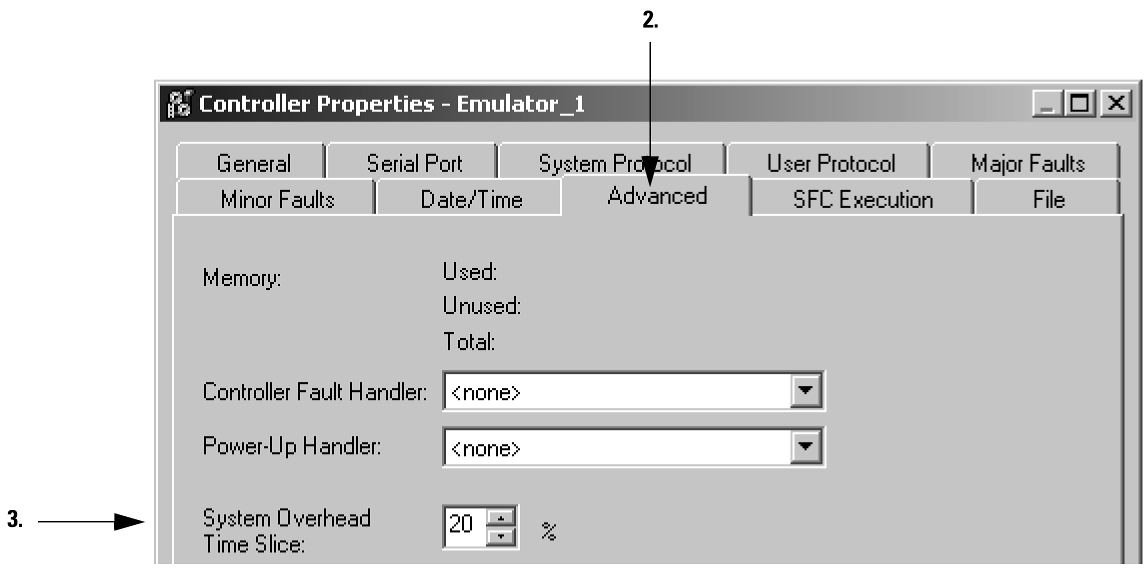


Adjust the System Overhead Time Slice



1. On the Online toolbar, click controller properties button.

2. Click the *Advanced* tab.



3. Type or select the system overhead time slice.

4. Choose OK

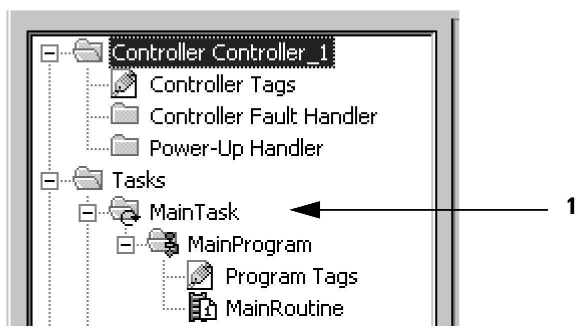
View Scan Time

A Logix5000 controller provides two types of scan times. Each serves a different purpose:

If you want to determine the:	Then:	Notes:
time that has elapsed from the start of a task to the end of the task, in milliseconds	View Task Scan Time	The scan time of a task includes the time that the task is interrupted to service communications or other tasks.
time to execute the logic of a program (its main routine and any subroutines that the main routine calls), in microseconds	View Program Scan Time	The scan time of a program includes only the execution time of the logic. It *does not* include any interrupts.

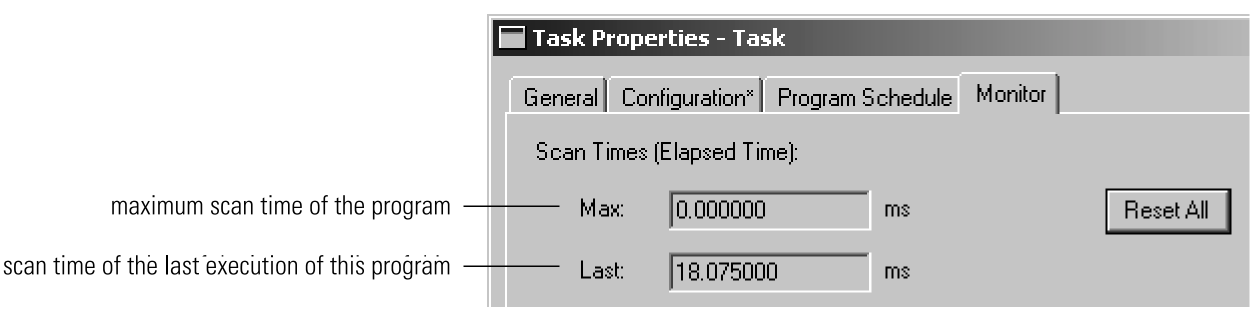
View Task Scan Time

To see the scan time of a task, display the properties for the task.



1. In the controller organizer, right-click the task whose scan time you want to view and choose *Properties*.

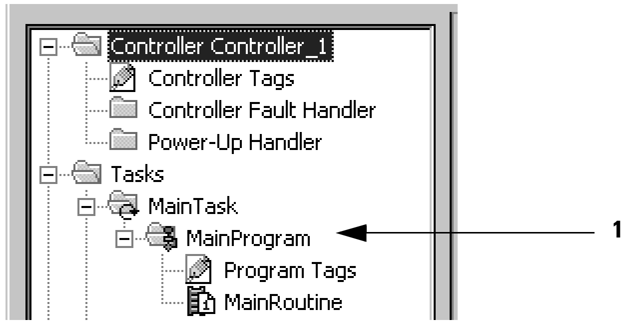
2. Click the *Monitor* tab.



3. To close the dialog box, choose OK

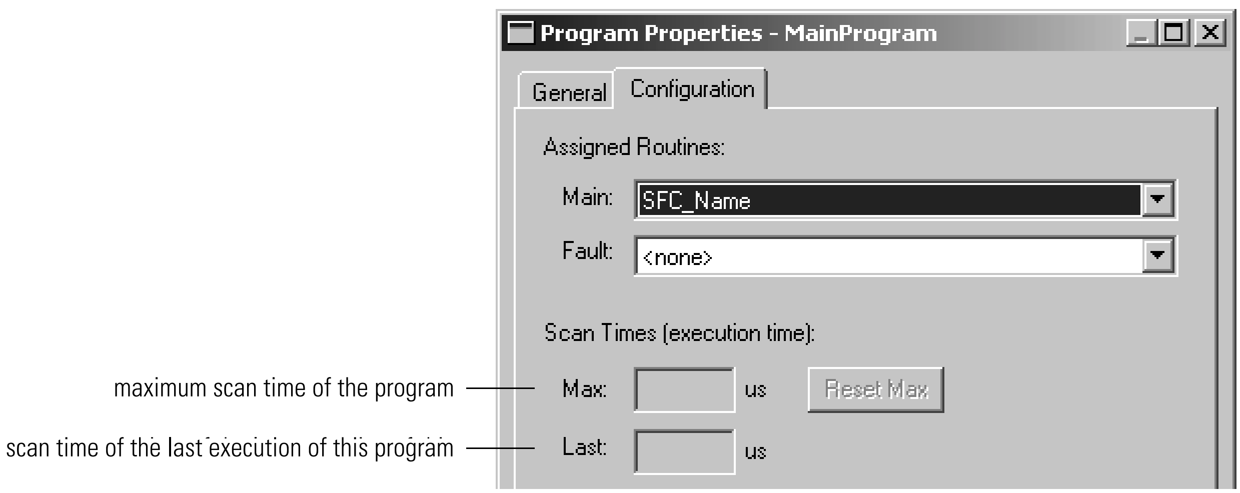
View Program Scan Time

To see the scan time of a program, display the properties for the program.



1. In the controller organizer, right-click the program whose scan time you want to view and choose *Properties*.

2. Click the *Configuration* tab.



3. To close the dialog box, choose OK

Adjust the Watchdog Time

Each task contains a watchdog timer that specifies how long a task can run before triggering a major fault.

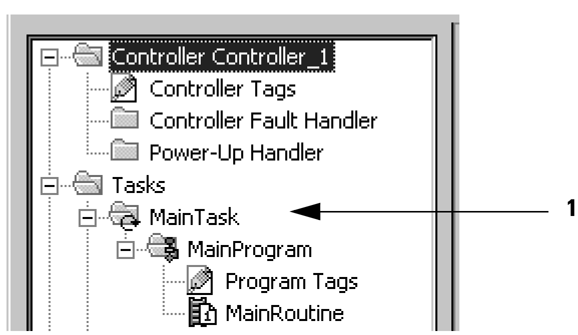
ATTENTION

If the watchdog timer reaches a configurable preset, a major fault occurs. Depending on the controller fault handler, the controller might shut down.

- A watchdog time can range from 1 ms to 2,000,000 ms (2000 seconds). The default is 500 ms.
- The watchdog timer begins to time when the task is initiated and stops when all the programs within the task have executed.
- If the task takes longer than the watchdog time, a major fault occurs. (The time includes interruptions by other tasks.)
- A watchdog time-out fault (major fault) also occurs if a task is triggered again while it is executing (task overlap). This can happen if a lower-priority task is interrupted by a higher-priority task, delaying completion of the lower-priority task.
- You can use the controller fault handler to clear a watchdog fault. If the same watchdog fault occurs a second time during the same logic scan, the controller enters faulted mode, regardless of whether the controller fault handler clears the watchdog fault.

Adjust the Watchdog Timer for a Task

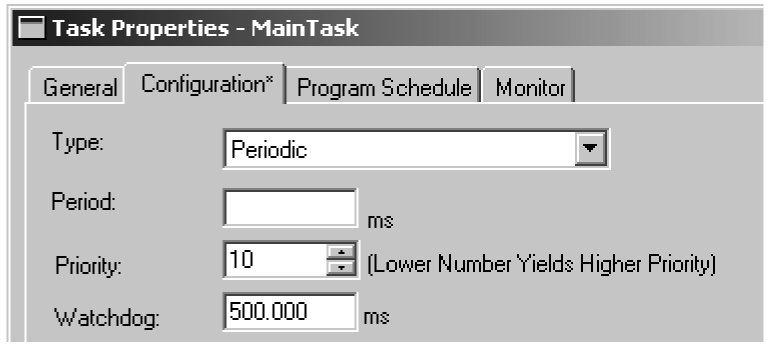
To change the watchdog time of a task, use the properties dialog box for the task.



1. In the controller organizer, right-click the task and choose *Properties*.

2. Click the *Configuration* tab.

3.



3. Type the watchdog time for the task, in milliseconds.

4. Choose 

Communicate with I/O

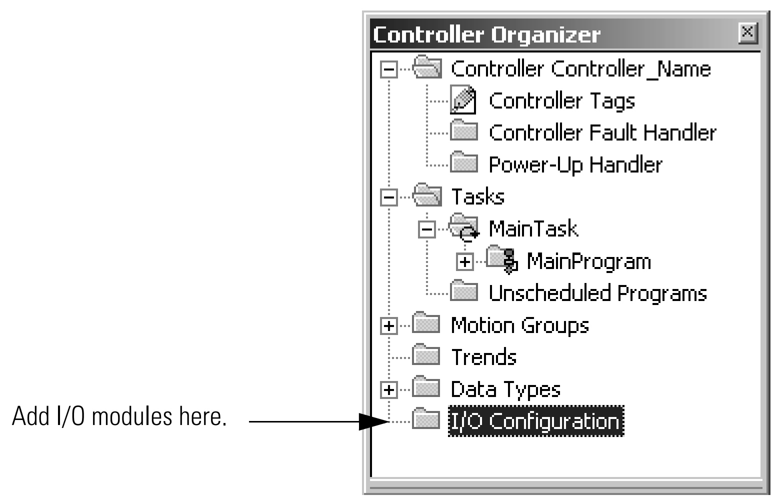
Using This Chapter

This chapter provides basic information on how a Logix5000 controller communicates with I/O modules.

For this information or procedure	See this page:
Configure an I/O Module	2-1
Address I/O Data	2-7
Buffer I/O	2-8

Configure an I/O Module

To communicate with an I/O module in your system, you add the module to the I/O Configuration folder of the controller.



When you add the module, you also define a specific configuration for the module. While the configuration options vary from module to module, there are some common options that you typically configure:

- Requested Packet Interval
- Communication Format
- Electronic Keying

Requested Packet Interval

The Logix5000 controller uses connections to transmit I/O data.

Term:	Definition:
Connection	A communication link between two devices, such as between a controller and an I/O module, PanelView terminal, or another controller. Connections are allocations of resources that provide more reliable communications between devices than unconnected messages. The number of connections that a single controller can have is limited. You indirectly determine the number of connections the controller uses by configuring the controller to communicate with other devices in the system. The following types of communication use connections: • I/O modules • produced and consumed tags • certain types of Message (MSG) instructions (not all types use a connection)
requested packet interval (RPI)	The RPI specifies the period at which data updates over a connection. For example, an input module sends data to a controller at the RPI that you assign to the module. • Typically, you configure an RPI in milliseconds (ms). The range is 0.2 ms (200 microseconds) to 750 ms. • If a ControlNet network connects the devices, the RPI reserves a slot in the stream of data flowing across the ControlNet network. The timing of this slot may not coincide with the exact value of the RPI, but the control system guarantees that the data transfers at least as often as the RPI.

In Logix5000 controllers, I/O values update at a period that you configure via the I/O configuration folder of the project. The values update asynchronous to the execution of logic. At the specified interval, the controller updates a value independently from the execution of logic.

ATTENTION

Take care to ensure that data memory contains the appropriate values throughout a task's execution. You can duplicate or buffer data at the beginning of the scan to provide reference values for your logic.

- Programs within a task access input and output data directly from controller-scoped memory.
- Logic within any task can modify controller-scoped data.
- Data and I/O values are asynchronous and can change during the course of a task's execution.
- An input value referenced at the beginning of a task's execution can be different when referenced later.
- To prevent an input value from changing during a scan, copy the value to another tag and use the data from there (buffer the values). To buffer your I/O values, see page 2-8.

Communication Format

The communication format that you choose determines the data structure for the tags that are associated with the module. Many I/O modules support different formats. Each format uses a different data structure. The communication format that you choose also determines:

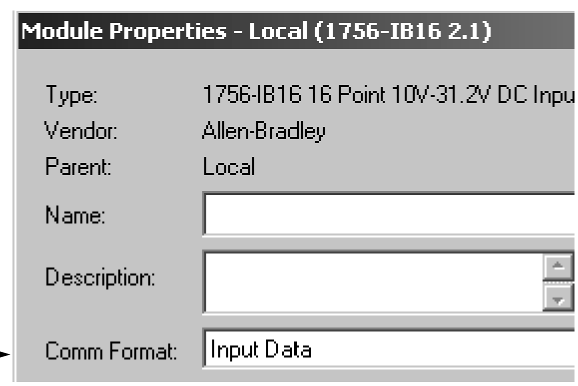
- Direct or Rack-Optimized Connection
- Ownership

Direct or Rack-Optimized Connection

The Logix5000 controller uses connections to transmit I/O data. These connections can be direct connections or rack-optimized connections.

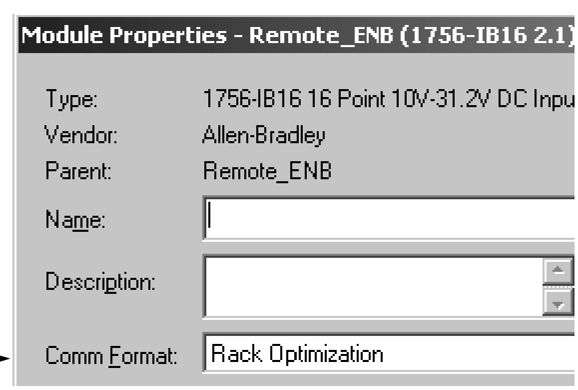
Term:	Definition:
direct connection	A direct connection is a real-time, data transfer link between the controller and an I/O module. The controller maintains and monitors the connection with the I/O module. Any break in the connection, such as a module fault or the removal of a module while under power, sets fault bits in the data area associated with the module.

A direct connection is any connection that *does not* use the Rack Optimization Comm Format.



Term:	Definition:
rack-optimized connection	For digital I/O modules, you can select rack-optimized communication. A rack-optimized connection consolidates connection usage between the controller and all the digital I/O modules in the chassis (or DIN rail). Rather than having individual, direct connections for each I/O module, there is one connection for the entire chassis (or DIN rail).

rack-optimized connection



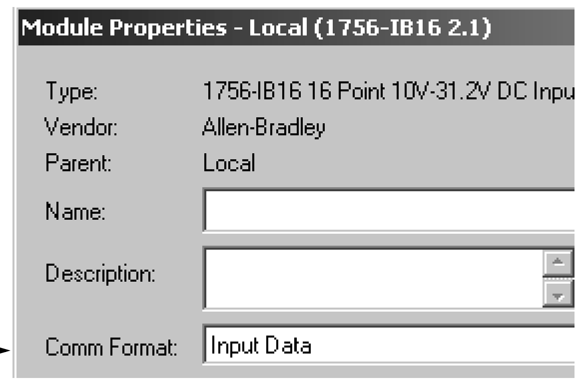
Ownership

In a Logix5000 system, modules multicast data. This means that multiple devices can receive the same data at the same time from a single device.

When you choose a communication format, you have to choose whether to establish an owner or listen-only relationship with the module.

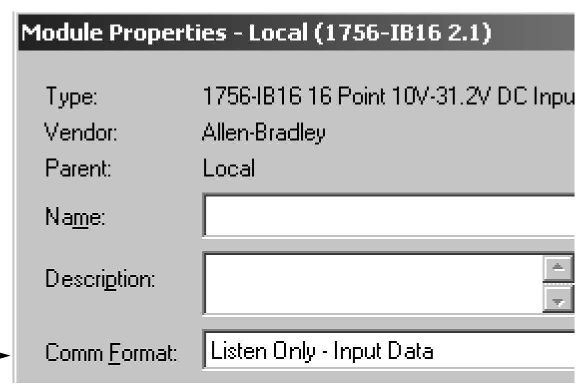
owner controller — The controller that creates the primary configuration and communication connection to a module. The owner controller writes configuration data and can establish a connection to the module.

An owner connection is any connection that *does not* include Listen-Only in its Comm Format.



listen-only connection — An I/O connection where another controller owns/provides the configuration data for the I/O module. A controller using a listen-only connection only monitors the module. It does not write configuration data and can only maintain a connection to the I/O module when the owner controller is actively controlling the I/O module.

listen-only connection



Use the following table to choose the type of ownership for a module:

If the module is an:	And another controller:	And you want to:	Then use this type of connection:
input module	*does not* own the module	→	owner (i.e., *not* listen-only)
	owns the module	maintain communication with the module if it loses communication with the other controller	owner (i.e., *not* listen-only) Use the same configuration as the other owner controller.
		stop communication with the module if it loses communication with the other controller	listen-only
output module	*does not* own the module	→	owner (i.e., *not* listen-only)
	owns the module	→	listen-only

There is a noted difference in controlling input modules versus controlling output modules.

Controlling:	This ownership:	Description:
input modules	owner	An input module is configured by a controller that establishes a connection as an owner. This configuring controller is the first controller to establish an owner connection. Once an input module has been configured (and owned by a controller), other controllers can establish owner connections to that module. This allows additional owners to continue to receive multicast data if the original owner controller breaks its connection to the module. All other additional owners must have the identical configuration data and identical communications format that the original owner controller has, otherwise the connection attempt is rejected.
	listen-only	Once an input module has been configured (and owned by a controller), other controllers can establish a listen-only connection to that module. These controllers can receive multicast data while another controller owns the module. If all owner controllers break their connections to the input module, all controllers with listen-only connections no longer receive multicast data.
output modules	owner	An output module is configured by a controller that establishes a connection as an owner. Only one owner connection is allowed for an output module. If another controller attempts to establish an owner connection, the connection attempt is rejected.
	listen-only	Once an output module has been configured (and owned by one controller), other controllers can establish listen-only connections to that module. These controllers can receive multicast data while another controller owns the module. If the owner controller breaks its connection to the output module, all controllers with listen-only connections no longer receive multicast data.

Electronic Keying

ATTENTION

Be careful when you disable electronic keying. If used incorrectly, this option can lead to personal injury or death, property damage, or economic loss.

When you configure a module, you specify the slot number for the module. However, it is possible to place a different module in that slot, either on purpose or accidently.

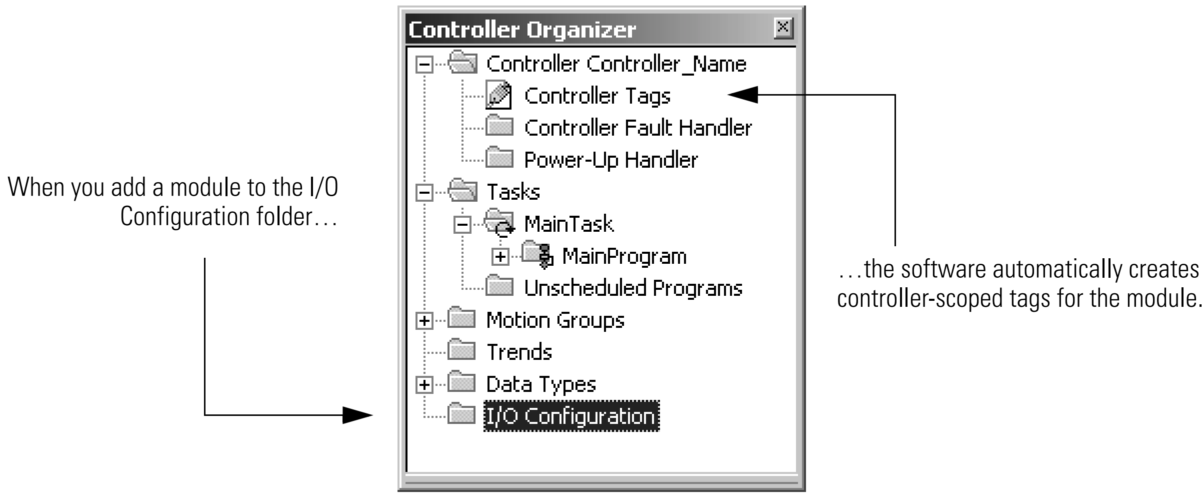
Electronic keying lets you protect your system against the accidental placement of the wrong module in a slot. The keying option you choose determines how closely any module in a slot must match the configuration for that slot.

If:	Then select:
all information must match: • type • catalog number • vendor • major and minor revision number	*Exact Match*
all information *except* the minor revision number	*Compatible Module*
no information must match	*Disable Keying*

Address I/O Data

I/O information is presented as a set of tags.

- Each tag uses a structure of data. The structure depends on the specific features of the I/O module.
- The name of the tags is based on the location of the I/O module in the system.



An I/O address follows this format:

`Location` `:Slot` `:Type` `.Member` `.SubMember` `.Bit`

(shaded box) = Optional

Where:	Is:
`Location`	Network location LOCAL = same chassis or DIN rail as the controller `ADAPTER_NAME` = identifies remote communication adapter or bridge module
`Slot`	Slot number of I/O module in its chassis or DIN rail
`Type`	Type of data I = input O = output C = configuration S = status
`Member`	Specific data from the I/O module; depends on what type of data the module can store. • For a digital module, a Data member usually stores the input or output bit values. • For an analog module, a Channel member (CH#) usually stores the data for a channel.
`SubMember`	Specific data related to a Member.
`Bit`	Specific point on a digital I/O module; depends on the size of the I/O module (0-31 for a 32-point module)

Buffer I/O

When to Buffer I/O

Buffering is a technique in which logic does not directly reference or manipulate the tags of real I/O devices. Instead, the logic uses a copy of the I/O data. Buffer I/O in the following situations:

- To prevent an input or output value from changing during the execution of a program. (I/O updates **asynchronous** to the execution of logic.)
- To copy an input or output tag to a member of a structure or element of an array.

Buffer I/O

To buffer I/O, perform these actions:

1. On the rung before the logic for the function (s), copy or move the data from the required input tags to their corresponding buffer tags.

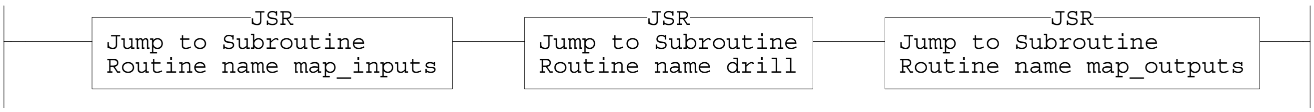
2. In the logic of the function (s), reference the buffer tags.

3. On the rung after the function (s), copy the data from the buffer tags to the corresponding output tags.

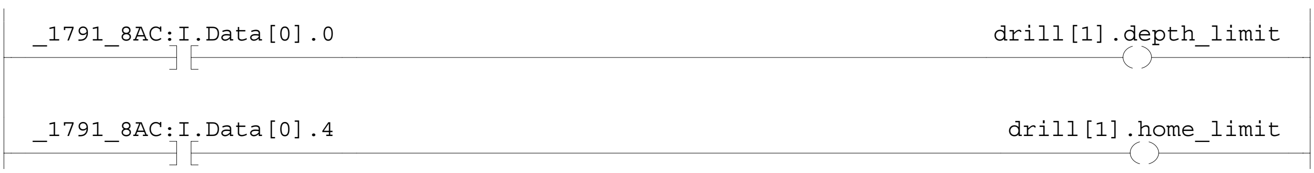
The following example copies inputs and outputs to the tags of a structure for a drill machine.

EXAMPLE Buffer I/O

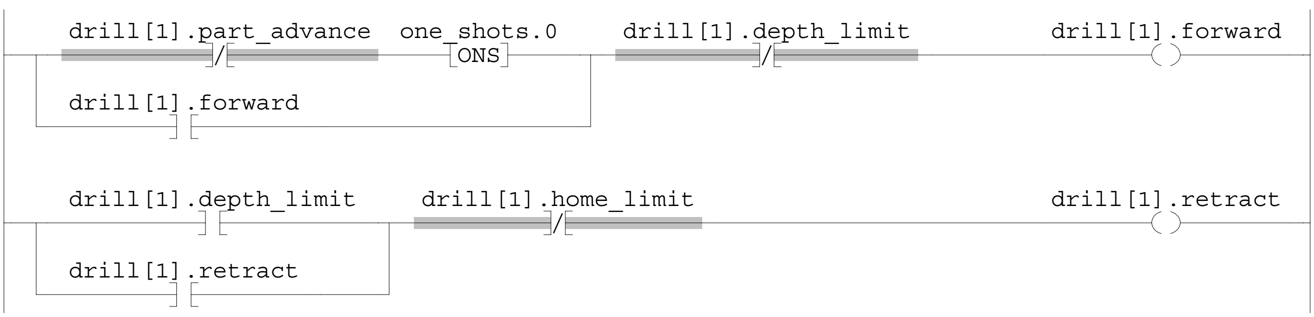
The main routine of the program executes the following subroutines in this sequence.



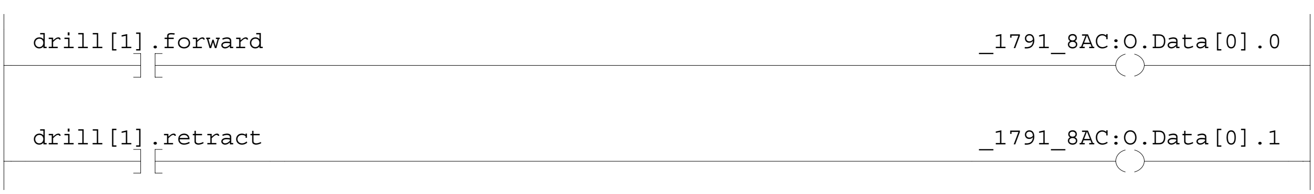
The *map_inputs* routine copies the values of input devices to their corresponding tags that are used in the *drill* routine.



The *drill* routine executes the logic for the drill machine.



The *map_outputs* routine copies the values of output tags in the *drill* routine to their corresponding output devices.



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The following example uses the CPS instruction to copy an array of data that represent the input devices of a DeviceNet network.

EXAMPLE Buffer I/O

Local:0:I.Data stores the input data for the DeviceNet network that is connected to the 1756-DNB module in slot 0. To synchronize the inputs with the application, the CPS instruction copies the input data to *input_buffer*.

- While the CPS instruction copies the data, no I/O updates can change the data.
- As the application executes, it uses for its inputs the input data in *input_buffer*.

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Organize Tags

Using this Chapter

Use this chapter to organize the data for your Logix5000 controller.

Defining Tags

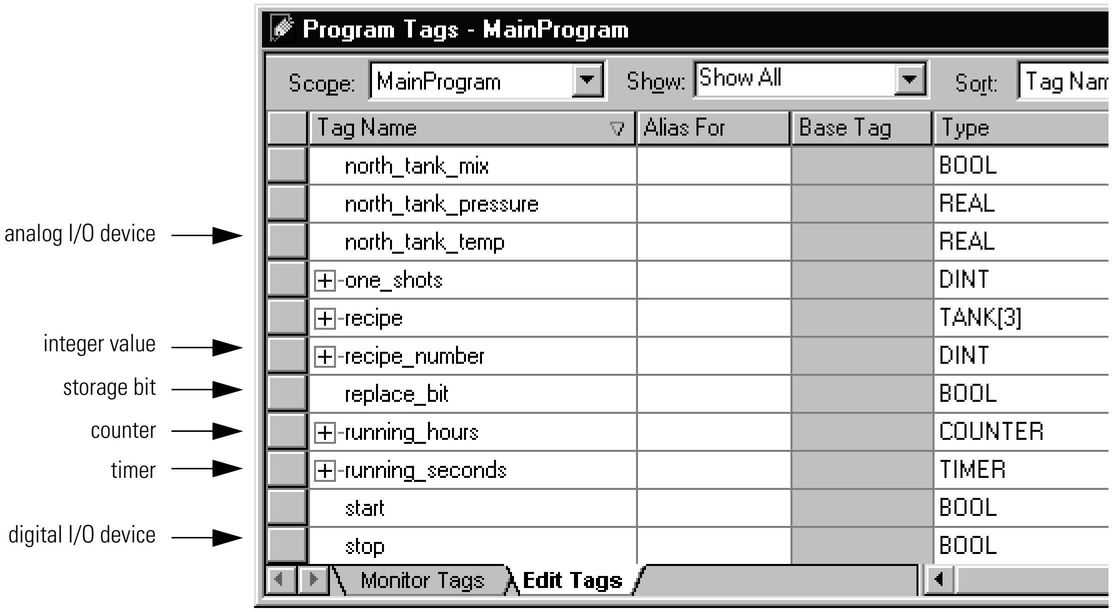
With a Logix5000 controller, you use a tag (alphanumeric name) to address data (variables).

Term:	Definition:
tag	A text-based name for an area of the controller's memory where data is stored. • Tags are the basic mechanism for allocating memory, referencing data from logic, and monitoring data. • The minimum memory allocation for a tag is four bytes. • When you create a tag that stores data that requires less than four bytes, the controller allocates four bytes, but the data only fills the part it needs.

The controller uses the tag name internally and doesn't need to cross-reference a physical address.

- In conventional PLCs, a physical address identifies each item of data.
  - Addresses follow a fixed, numeric format that depend on the type of data, such as N7:8, F8:3.
  - Symbols are required to make logic easier to interpret.
- In Logix5000 controllers, there is no fixed, numeric format. The tag name itself identifies the data. This lets you:
  - organize your data to mirror your machinery
  - document (through tag names) your application as you develop it

EXAMPLE Tags



When you create a tag, you assign the following properties to the tag:

- Tag Type
- Data Type
- Scope

Tag Type

The tag type defines how the tag operates within your project.

If you want the tag to:	Then choose this type:
store a value or values for use by logic within the project	Base
represent another tag.	Alias
send data to another controller	Produced
receive data from another controller	Consumed

If you plan to use produced or consumed tags, you must follow additional guidelines as you organize your tags. Refer to "Communicate with Other Devices" on page 10-1.

Data Type

Term:	Definition:
data type	The data type defines the type of data that a tag stores, such as a bit, integer, floating-point value, string, etc.
structure	A data type that is a combination of other data types. • A structure is formatted to create a unique data type that matches a specific need. • Within a structure, each individual data type is called a member. • Like tags, members have a name and data type. • A Logix5000 controller contains a set of predefined structures (data types) for use with specific instructions such as timers, counters, function blocks, etc. • You can create your own structures, called a user-defined data type.

The following table outlines the most common data types and when to use each.

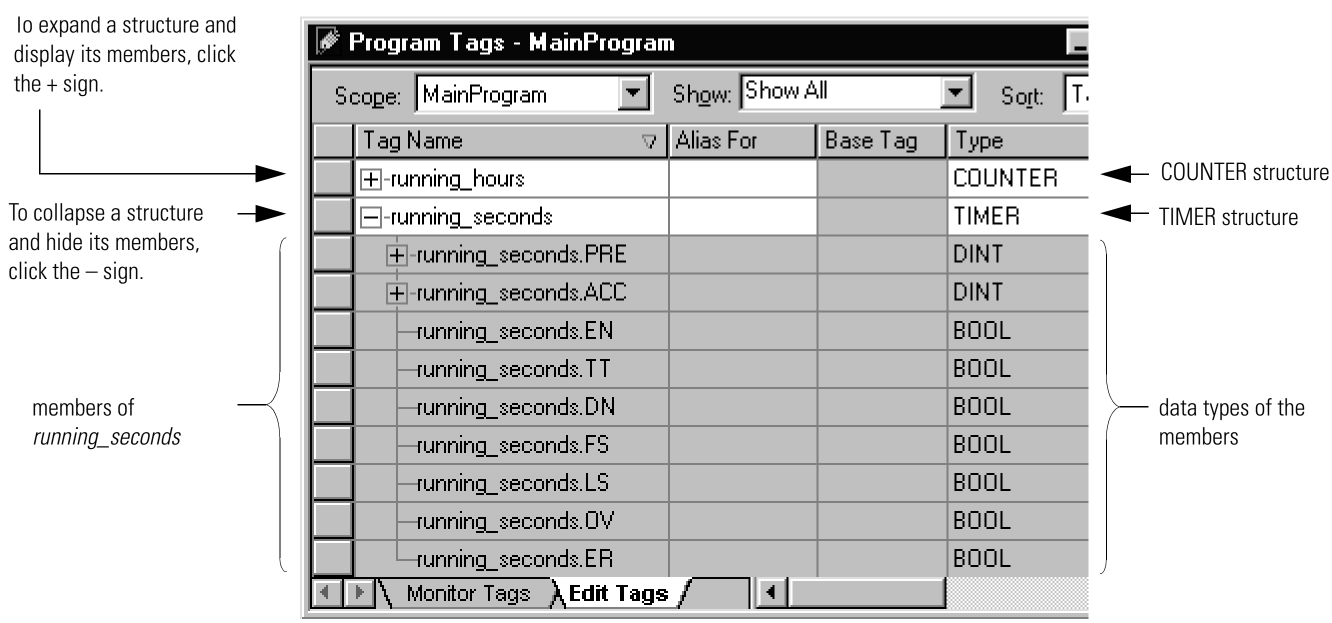
Table 3.1 Data Types

For:	Select:
analog device in floating-point mode	REAL
analog device in integer mode (for very fast sample rates)	INT
ASCII characters	string
bit	BOOL
counter	COUNTER
digital I/O point	BOOL
floating-point number	REAL
integer (whole number)	DINT
sequencer	CONTROL
timer	TIMER

The minimum memory allocation for a tag is 4 bytes. When you create a tag that stores data that requires less than four bytes, the controller allocates 4 bytes, but the data only fills the part it needs.

Data type	Bits			
	31 16	15 8	7 1	0
Bool	not used			0 or 1
Sint	not used		-128 to +127	
Int	not used	-32,768 to +32767		
Dint	-2,147,483,648 to +2,147,483,647			
Real	$-3.40282347E^{38}$ to $-1.17549435E^{-38}$ (negative values) 0 $1.17549435E^{-38}$ to $3.40282347E^{38}$ (positive values)			

The COUNTER and TIMER data types are examples of commonly used structures.



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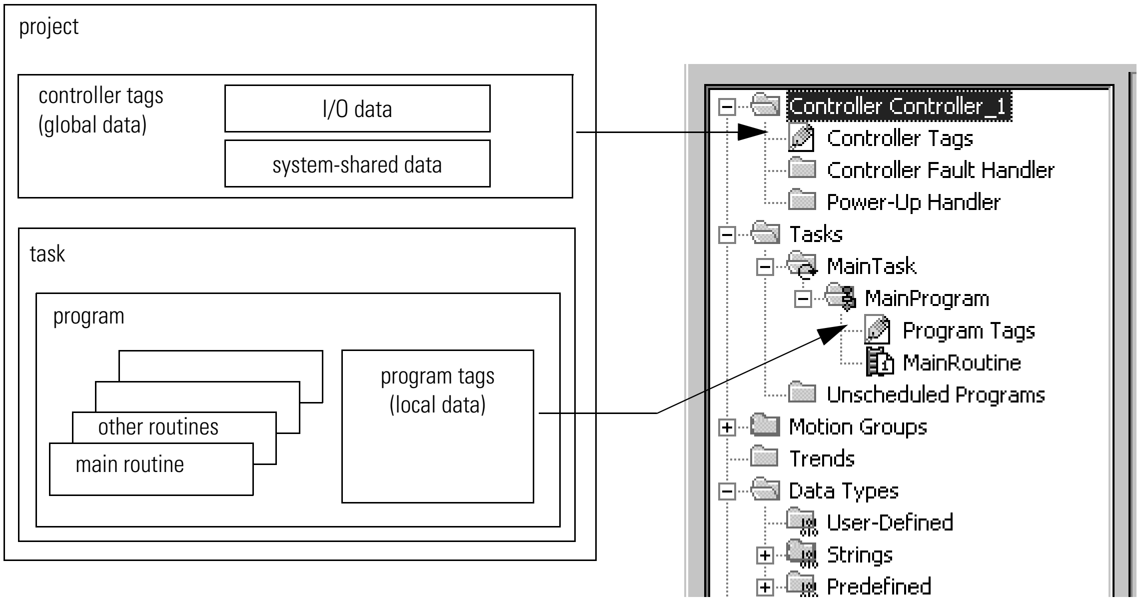
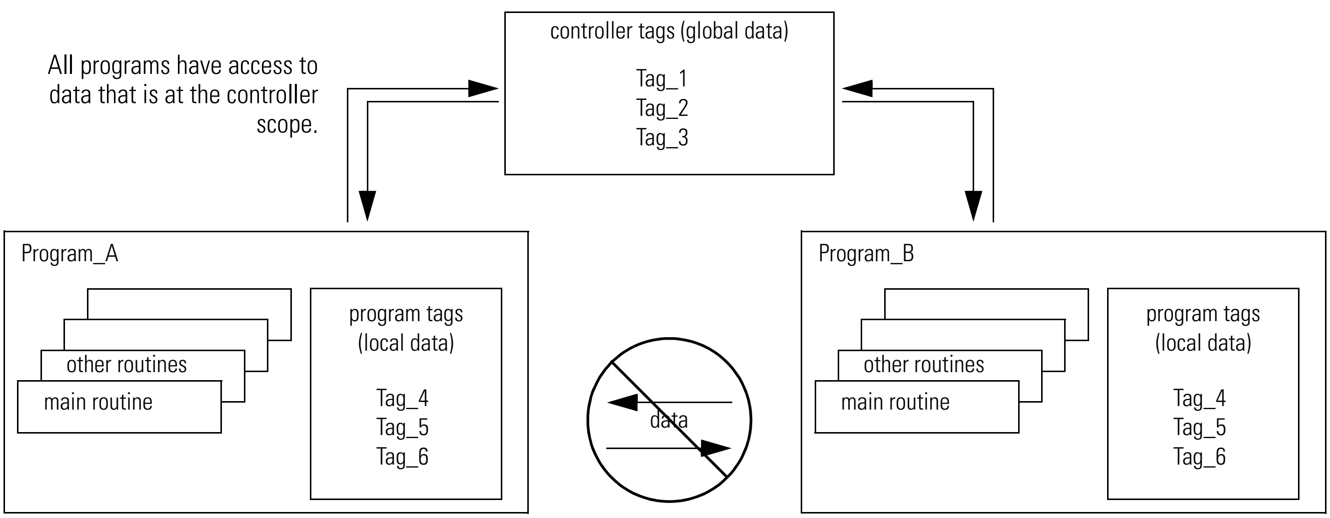
To copy data to a structure, use the COP instruction. See the *Logix5000 Controllers General Instruction Set Reference Manual*, publication 1756-RM003.

Scope

When you create a tag, you define it as either a controller tag (global data) or a program tag for a specific program (local data).



A Logix5000 controller lets you divide your application into multiple programs, each with its own data. There is *no* need to manage conflicting tag names between programs. This makes it easier to re-use both code and tag names in multiple programs.



Data at the program scope is isolated from other programs:

- Routines cannot access data that is at the program scope of another program.
- You can re-use the tag name of a program-scoped tag in multiple programs.

  For example, both Program_A and Program_B can have a program tag named Tag_4.

Avoid using the same name for a both controller tag and a program tag. Within a program, you cannot reference a controller tag if a tag of the same name exists as a program tag for that program.

Certain tags must be controller scope (controller tag).

If you want to use the tag:	Then assign this scope:
in more than one program in the project	controller scope (controller tags)
in a Message (MSG) instruction	
to produce or consume data	
to communicate with a PanelView terminal	
none of the above	program scope (program tags)

Guidelines for Tags

Use the following guidelines to create tags for a Logix5000 project:

<table>
<tr><th>Guideline:</th><th>Details:</th></tr>
<tr><td>❑ 1. Create user-defined data types.</td><td>User-defined data types (structures) let you organize your data to match your machine or process. A user-defined data type provides these advantages:
One tag contains all the data related to a specific aspect of your system. This keeps related data together and easy to locate, regardless of its data type.
Each individual piece of data (member) gets a descriptive name. This automatically creates an initial level of documentation for your logic.
You can use the data type to create multiple tags with the same data lay-out.
For example, use a user-defined data type to store all the parameters for a tank, including temperatures, pressures, valve positions, and preset values. Then create a tag for each of your tanks based on that data type.</td></tr>
<tr><td>❑ 2. Use arrays to quickly create a group of similar tags.</td><td>An array creates multiple instances of a data type under a common tag name.
Arrays let you organize a block of tags that use the same data type and perform a similar function.
You organize the data in 1, 2, or 3 dimensions to match what the data represents.
For example, use a 2 dimension array to organize the data for a tank farm. Each element of the array represents a single tank. The location of the element within the array represents the geographic location of the tank.

Important: Minimize the use of BOOL arrays. Many array instructions do not operate on BOOL arrays. This makes it more difficult to initialize and clear an array of BOOL data.
Typically, use a BOOL array for the bit-level objects of a PanelView screen.
Otherwise, use the individual bits of a DINT tag or an array of DINTs.</td></tr>
<tr><td>❑ 3. Take advantage of program-scoped tags.</td><td>If you want multiple tags with the same name, define each tag at the program scope (program tags) for a different program. This lets you re-use both logic and tag names in multiple programs.

Avoid using the same name for both a controller tag and a program tag. Within a program, you cannot reference a controller tag if a tag of the same name exists as a program tag for that program.

Certain tags must be controller scope (controller tag).<table><tr><th>If you want to use the tag:</th><th>Then assign this scope:</th></tr><tr><td>in more than one program in the project</td><td rowspan="4">controller scope (controller tags)</td></tr><tr><td>in a Message (MSG) instruction</td></tr><tr><td>to produce or consume data</td></tr><tr><td>to communicate with a PanelView terminal</td></tr><tr><td>none of the above</td><td>program scope (program tags)</td></tr></table></td></tr>
</table>

<table>
<tr><th></th><th>Guideline:</th><th>Details:</th></tr>
<tr><td>❑</td><td>4. For integers, use the DINT data type.</td><td>To increase the efficiency of your logic, minimize the use of SINT or INT data types. Whenever possible, use the DINT data type for integers.

A Logix5000 controller typically compares or manipulates values as 32-bit values (DINTs or REALs).
The controller typically converts a SINT or INT value to a DINT or REAL value before it uses the value.
If the destination is a SINT or INT tag, the controller typically converts the value back to a SINT or INT value.
The conversion to or from SINTs or INTs occurs automatically with no extra programming. But it takes extra execution time and memory.
</td></tr>
<tr><td>❑</td><td>5. Limit a tag name to 40 characters.</td><td>Here are the rules for a tag name:

only alphabetic characters (A-Z or a-z), numeric characters (0-9), and underscores (_)
must start with an alphabetic character or an underscore
no more than 40 characters
no consecutive or trailing underscore characters (_)
not case sensitive
</td></tr>
<tr><td>❑</td><td>6. Use mixed case.</td><td>Although tags are not case sensitive (upper case A is the same as lower case a), mixed case is easier to read.
<table>
<tr><th>These tags are easier to read:</th><th>Than these tags:</th></tr>
<tr><td>Tank_1</td><td>TANK_1</td></tr>
<tr><td>Tank1</td><td>TANK1</td></tr>
<tr><td></td><td>tank_1</td></tr>
<tr><td></td><td>tank1</td></tr>
</table></td></tr>
<tr><td>❑</td><td>7. Consider the alphabetical order of tags.</td><td>RSLogix 5000 software displays tags of the same scope in alphabetical order. To make it easier to monitor related tags, use similar starting characters for tags that you want to keep together.</td></tr>
</table>

Starting each tag for a tank with *Tank* keeps the tags together.

Tag Name
Tank_North
Tank_South
...

Otherwise, the tags may end up separated from each other.

Tag Name
North_Tank
...
...
...
South_Tank

other tags that start with the letters *o*, *p*, *q*, etc.

Create a Tag

IMPORTANT RSLogix 5000 software automatically creates tags when you:

- add an element to a sequential function chart (SFC)
- add a function block instruction to a function block diagram

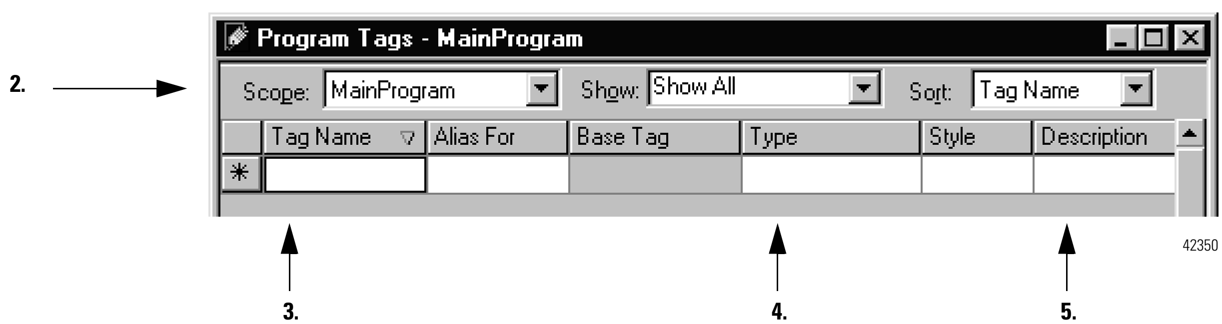
To create a tag, you have the following options:

- Create a Tag Using a Tags Window
- Create Tags Using Microsoft® Excel
- Create a Tag as You Enter Your Logic (See the corresponding chapter for the programming language that you are using.)

Create a Tag Using a Tags Window

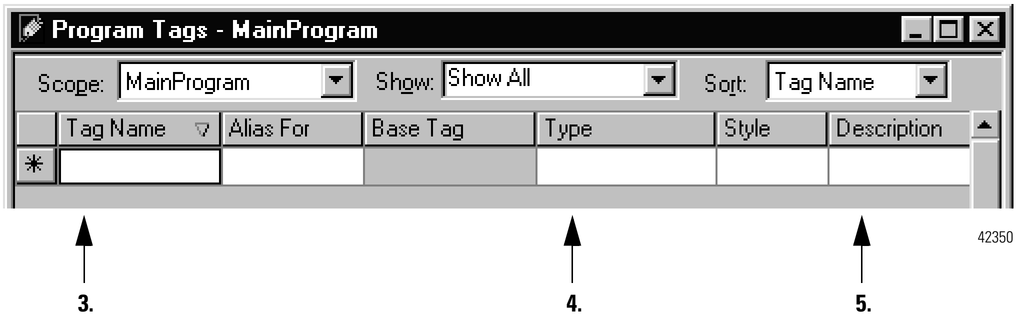
The Tags window lets you create and edit tags using a spreadsheet-style view of the tags.

1. From the *Logic* menu, select *Edit Tags*.



2. Select a **scope** for the tag:

If you will use the tag:	Then select:
in more than one program within the project	`name_of_controller`*(controller)*
as a producer or consumer	
in a message	
in only one program within the project	program that will use the tag



3. Type a **name** for the tag.

4. Type the **data type**:

5. Type a **description** (optional).

Create Tags Using Microsoft® Excel

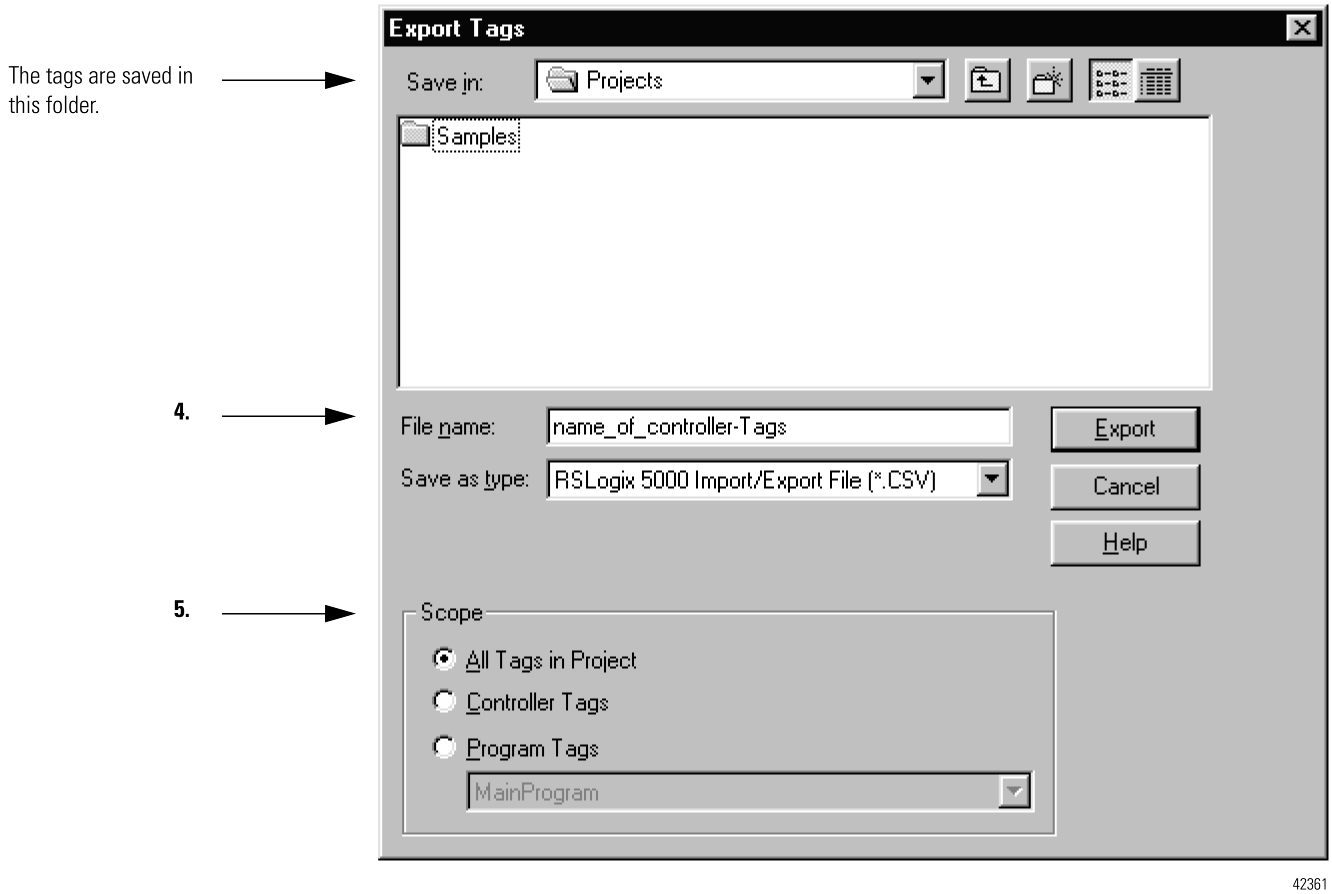
You can also use spreadsheet software such as Microsoft Excel to create and edit tags. This lets you take advantage of the editing features in the spreadsheet software.

Export the Existing Tags

1. Open the RSLogix 5000 project.

2. Create several tags. (This helps to format the Excel spreadsheet.)

3. From the *Tools* menu, select *Export Tags*.



4. Note the name of the export file (`project_name`-*Tags*).

5. Select the scope of tags to export. If you select *Program Tags*, select the program tags to export.

6. Click *Export*.

Edit the Export File

1. In Microsoft Excel software, open the export file.

TYPE	SCOPE	NAME	DESCRIPTION	DATATYPE
TAG		in_cycle		DINT
TYPE	SCOPE	NAME	DESCRIPTION	DATATYPE
TAG	MainProgram	conveyor_alarm		BOOL
TAG	MainProgram	conveyor_on		BOOL
TAG	MainProgram	drill_1		DRILL_STATION
TAG	MainProgram	hole_position		REAL[6,6]
TAG	MainProgram	machine_on		BOOL

2. 3. 4. 5.

2. Enter `TAG`

3. Identify the scope of the tag:

If the scope is:	Then:
controller	Leave this cell empty.
program	Enter the name of the program

4. Enter the name of the tag.

5. Enter the data type of the tag.

6. Repeat steps 2. to 5. for each additional tag.

7. Save and close the file. (Keep it as a .CSV format.)

Import the New Tags

1. In the RSLogix 5000 software, from the *Tools* menu, select *Import Tags*.

2. Select the file that contains the tags and click *Import*.

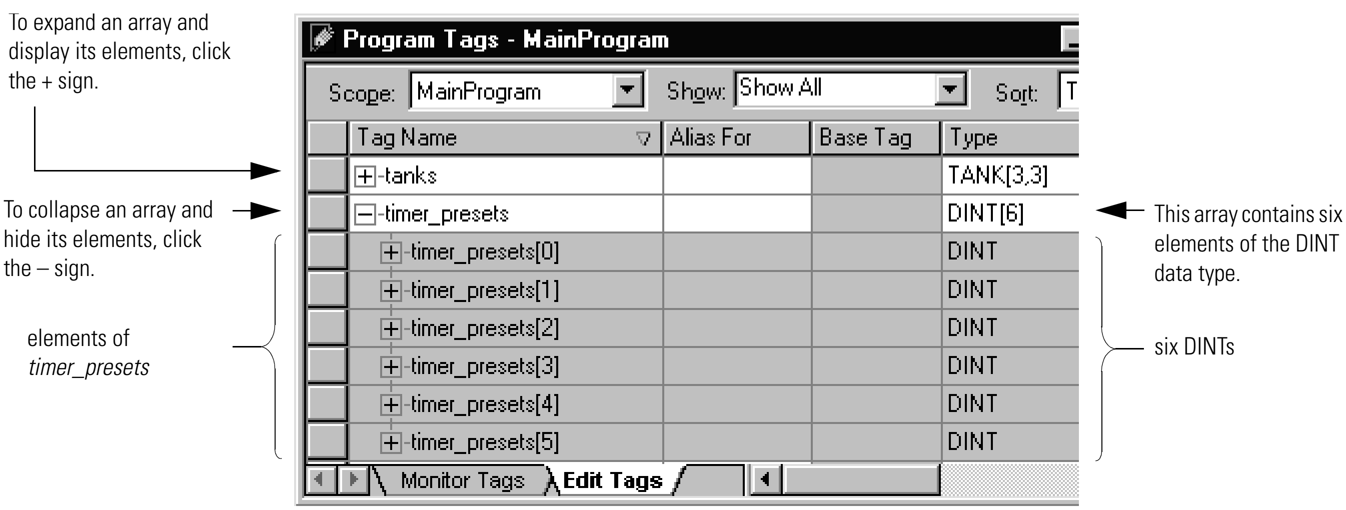
   The tags import into the project. The lower section of the RSLogix 5000 window displays the results.

Create an Array

Logix5000 controllers also let you use arrays to organize data.

Term:	Definition:
array	A tag that contains a block of multiple pieces of data. • An array is similar to a file. • Within an array, each individual piece of data is called an element. • Each element uses the same data type. • An array tag occupies a contiguous block of memory in the controller, each element in sequence. • You can use array and sequencer instructions to manipulate or index through the elements of an array • You organize the data into a block of 1, 2, or 3 dimensions.

A subscript (s) identifies each individual **element** within the array. A subscript starts at 0 and extends to the number of elements minus 1 (zero based).



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The following example compares a structure to an array:

This is a tag that uses the Timer structure (data type).

Tag Name	Data Type
Timer_1	TIMER
Timer_1.PRE	DINT
Timer_1.ACC	DINT
Timer_1.EN	BOOL
Timer_1.TT	BOOL
Timer_1.DN	BOOL

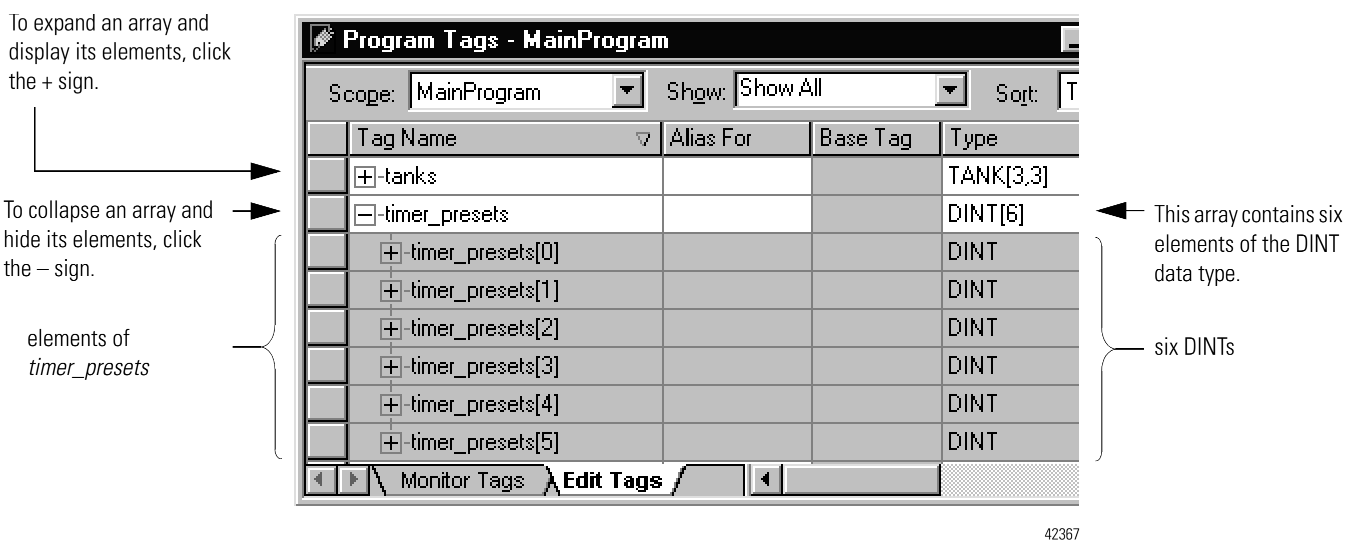
This is a tag that uses an array of the Timer data type.

Tag Name	Data Type
Timers	TIMER[3]
Timer[0]	TIMER
Timer[1]	TIMER
Timer[2]	TIMER

EXAMPLE

Single dimension array

In this example, a single timer instruction times the duration of several steps. Each step requires a different preset value. Because all the values are the same data type (DINTs) an array is used.



EXAMPLE

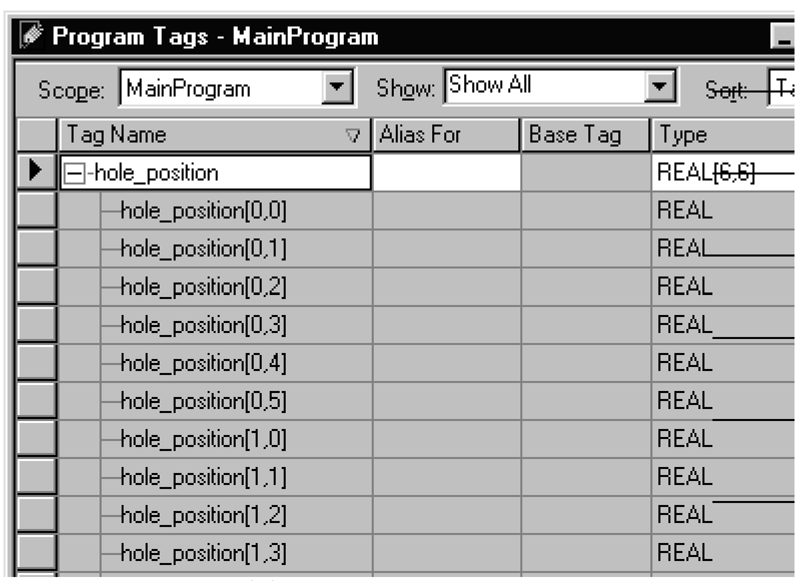
Two dimension array

A drill machine can drill one to five holes in a book. The machine requires a value for the position of each hole from the leading edge of the book. To organize the values into configurations, a two dimension array is used. The first subscript indicates the hole to which the value corresponds and the second subscript indications how many holes will be drilled (one to five).

subscript of second dimension

subscript of first dimension	0	1	2	3	4	5	Description
0							
1		1.5	2.5	1.25	1.25	1.25	Position of first hole from leading edge of book
2			8.0	5.5	3.5	3.5	Position of second hole from leading edge of book
3				9.75	7.5	5.5	Position of third hole from leading edge of book
4					9.75	7.5	Position of fourth hole from leading edge of book
5						9.75	Position of fifth hole from leading edge of book

In the Tags window, the elements are in the order depicted below.



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This array contains a two-dimensional grid of elements, six elements by six elements.

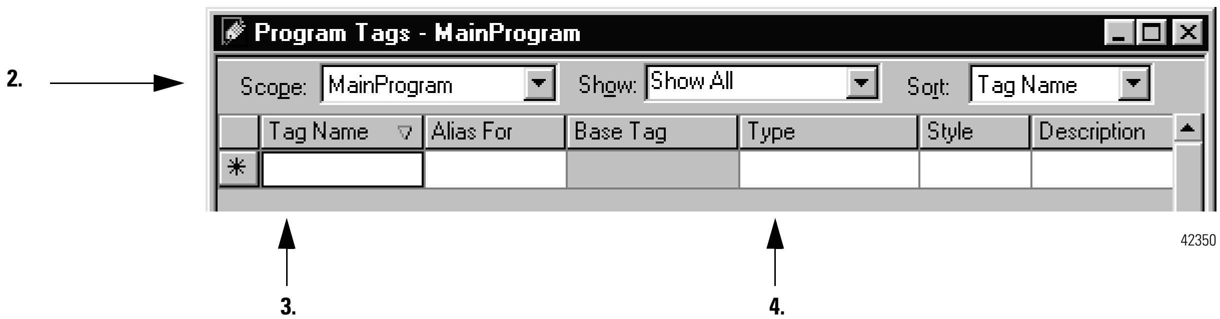
The right-most dimension increments to its maximum value then starts over.

When the right-most dimension starts over, the dimension to the left increments by one.

Create an Array

To create an array, you create a tag and assign dimensions to the data type:

1. From the *Logic* menu, select *Edit Tags*.



2. Select a **scope** for the tag:

If you will use the tag:	Then select:
in more than one program within the project	`name_of_controller`(controller)
as a producer or consumer	
in a message	
in only one program within the project	program that will use the tag

3. Type a **name** for the tag.

4. Assign the array dimensions:

If the tag is:	Then type:	Where:
one **dimension** array	`data_type[x]`	`data_type` is the type of data that the tag stores. `x` is the number of **elements** in the first dimension. `y` is the number of elements in the second dimension. `z` is the number of elements in the third dimension.
two dimension array	`data_type[x,y]`	
three dimension array	`data_type[x,y,z]`	

Create a User-Defined Data Type

User-defined data types (structures) let you organize your data to match your machine or process.

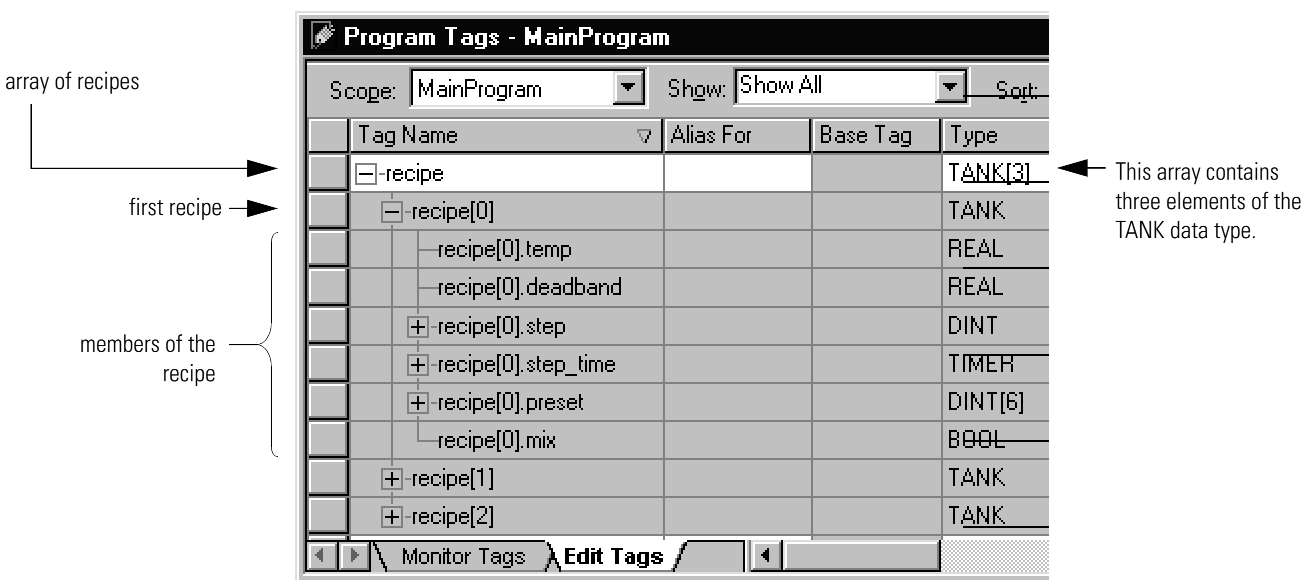
EXAMPLE

User-defined data type that stores a recipe

In a system of several tanks, each tank can run a variety of recipes. Because the recipe requires a mix of data types (REAL, DINT, BOOL, etc.) a user-defined data type is used.

Name (of data type): TANK	
Member Name	**Data Type**
temp	REAL
deadband	REAL
step	DINT
step_time	TIMER
preset	DINT[6]
mix	BOOL

An array that is based on this data type would look like this:



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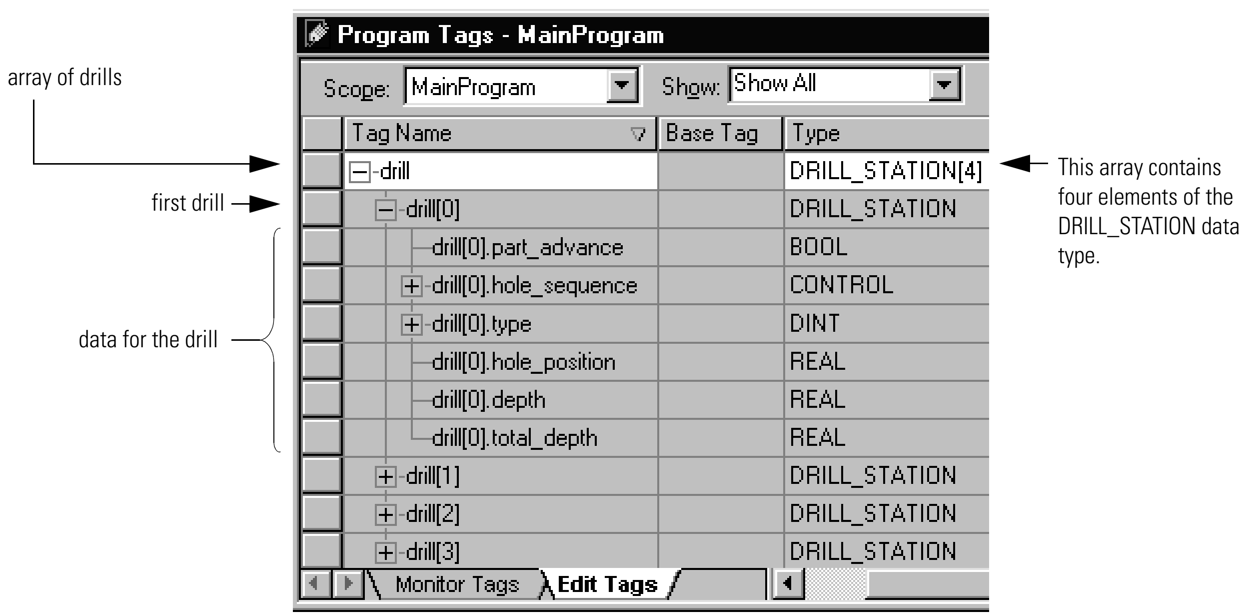
EXAMPLE

User-defined data type that stores the data that is required to run a machine

Because several drill stations require the following mix of data, a user-defined data type is created.

Name (of data type): DRILL_STATION	
Member Name	**Data Type**
part_advance	BOOL
hole_sequence	CONTROL
type	DINT
hole_position	REAL
depth	REAL
total_depth	REAL

An array that is based on this data type would look like this:



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Guidelines for User-Defined Data Types

When you create a user-defined data type, keep the following in mind:

- If you include members that represent I/O devices, you must use logic to copy the data between the members in the structure and the corresponding I/O tags. Refer to "Buffer I/O" on page 2-8.
- If you include an array as a member, limit the array to a single dimension. Multi-dimension arrays are *not* permitted in a user-defined data type.
- When you use the BOOL, SINT, or INT data types, place members that use the same data type in sequence:

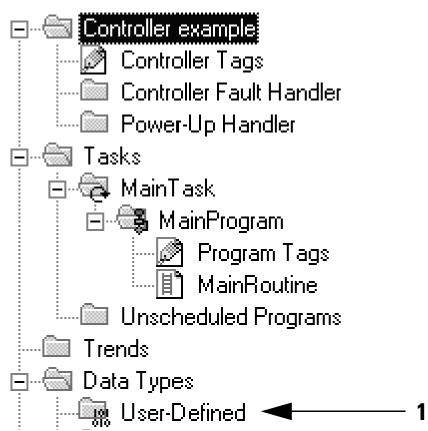
more efficient

BOOL
BOOL
BOOL
DINT
DINT

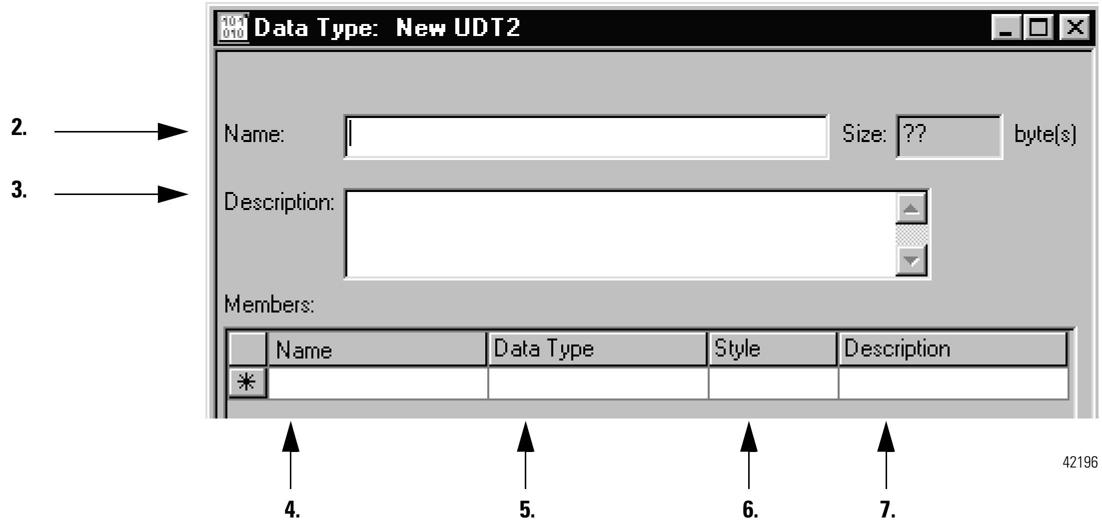
less efficient

BOOL
DINT
BOOL
DINT
BOOL

Create a User-Defined Data Type



1. Right-click *User-Defined* and select *New Data Type*.



2. Type a **name** for the data type.

3. Type a **description** (optional).

4. Type the name of the first **member**.

5. Specify the data type for the member.

   Limit any arrays to a single dimension.

6. To display the value (s) of the member in a different **style** (radix), select the style.

7. Type a description for the member (optional).

8. Click *Apply*.

9. More members?

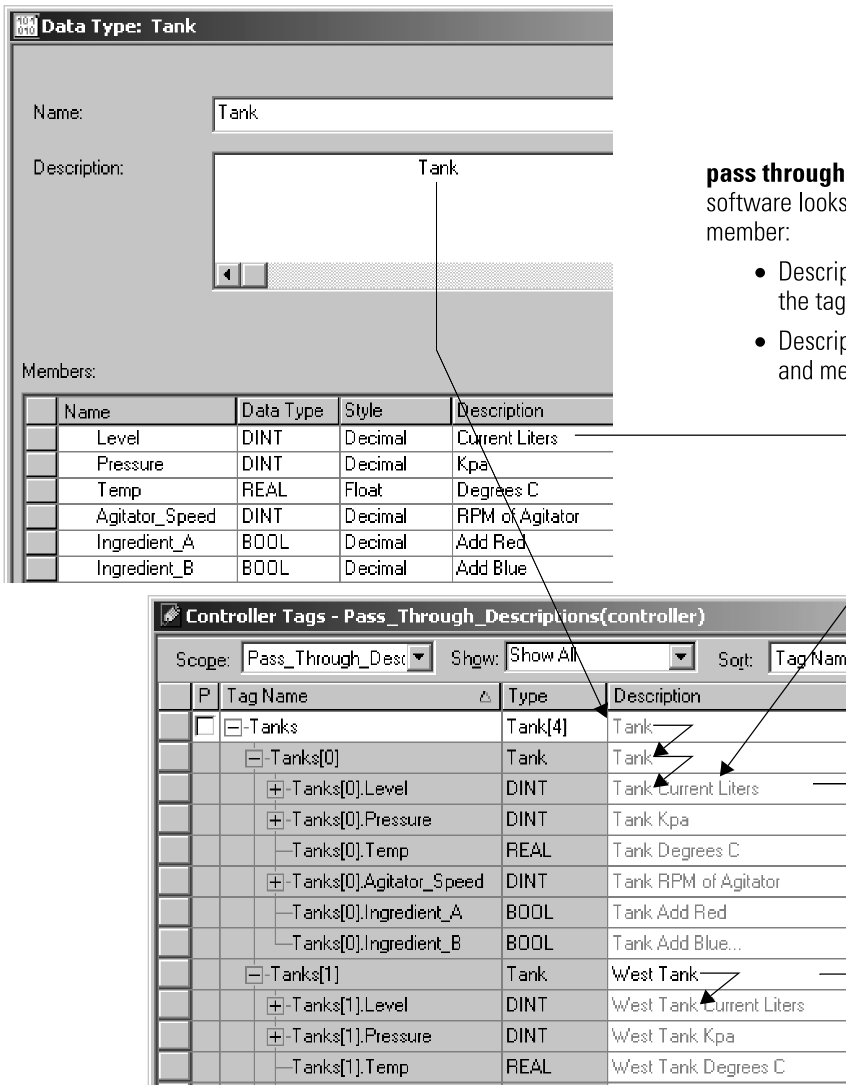
If:	Then:
Yes	Repeat steps 4. to 8.
No	Click *OK*.

Describe a User-Defined Data Type

RSLogix 5000 software
13.0 or later

RSLogix 5000 software lets you automatically build descriptions out of the descriptions in your user-defined data types. This greatly reduces the amount of time you have to spend documenting your project.

As you organize your user-defined data types, keep in mind the following features of RSLogix 5000 software:



pass through of descriptions – When possible, RSLogix 5000 software looks for an available description for a tag, element, or member:

- Descriptions in user-defined data types ripple through to the tags that use that data type.
- Description of an array tag ripples through to the elements and members of the array.

append description to base tag – RSLogix 5000 software automatically builds a description for each member of a tag that uses a user-defined data type. It starts with the description of the tag and then adds the description of the member from the data type.

paste pass-through description – Use the data type and array description as a basis for more specific descriptions.

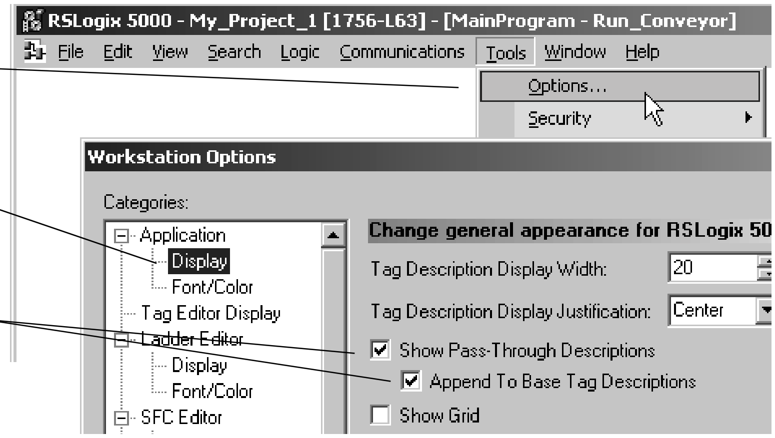
In this example, Tank became West Tank.

RSLogix 5000 software uses different colors for descriptions:

A description in this color:	Is a:
gray	pass-through description
black	manually entered description

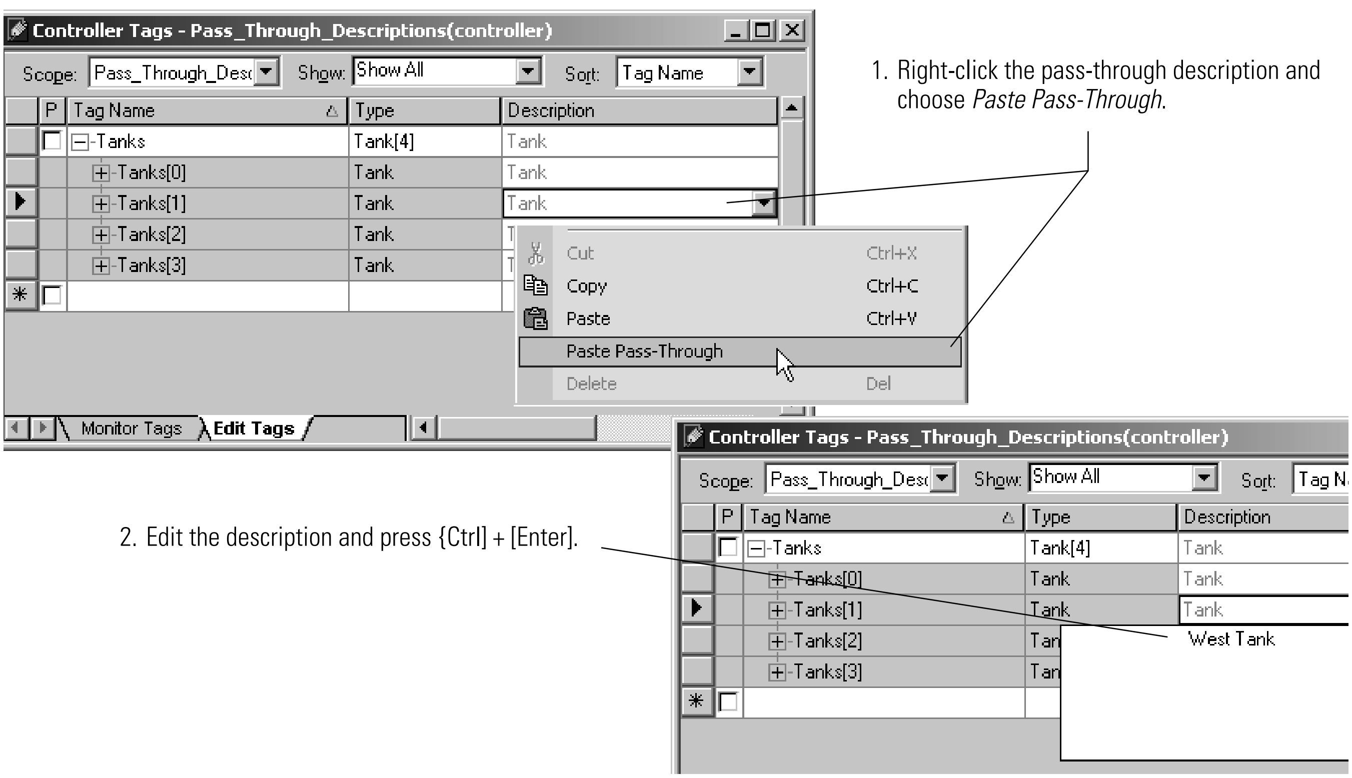
Turn Pass-Through and Append Descriptions On or Off

1. In RSLogix 5000 software, choose *Tools* ⇒ *Options*.
2. Select the *Application* ⇒ *Display*.
3. Turn on (check) or turn off (uncheck) the desired options.



Paste a Pass-Through Description

To use a pass-through description as the starting point for a more specific description:



1. Right-click the pass-through description and choose *Paste Pass-Through*.
2. Edit the description and press {Ctrl} + [Enter].

Address Tag Data

An tag name follows this format:

`Name` `[Element]` `.Member` `[Element]` `.Bit`
or
`.[Index]`

(shaded box) = Optional

Where:	Is:
Name	Name that identifies this specific tag.
Element	Subscript or subscripts that point to a specific element within an array. • Use the element identifier only if the tag or member is an array. • Use one subscript for each dimension of the array. For example: [5], [2,8], [3,2,7]. To indirectly (dynamically) reference an element, use a tag or numeric expression that provides the element number. • A numeric expression uses a combination of tags, constants, operators, and functions to calculate a value. For example, `Tag_1-Tag_2, Tag_3+4, ABS(Tag_4)`. • Keep the value of the tag or numeric expression within the dimensions of the array. For example, if a dimension of an array contains 10 elements, then the value of the tag or numeric expression must be 0 to 9 (10 elements).
Member	Specific member of a structure. • Use the member identifier only if the tag is a structure. • If the structure contains another structure as one of its members, use additional levels of the *.Member* format to identify the required member.
Bit	Specific bit of an integer data type (SINT, INT, or DINT).
Index	To indirectly (dynamically) reference a bit of an integer, use a tag or numeric expression that provides the bit number. • A numeric expression uses a combination of tags, constants, operators, and functions to calculate a value. For example, `Tag_1-Tag_2, Tag_3+4, ABS(Tag_4)`. • Keep the value of the tag or numeric expression within the range of bits of the integer tag. For example, if the integer tag is a Dint (32-bits), then the value of the index must be 0 to 31 (32-bits).

Assign Alias Tags

An alias tag lets you create one tag that represents another tag.

- Both tags share the same value (s).
- When the value (s) of one of the tags changes, the other tag reflects the change as well.

Use aliases in the following situations:

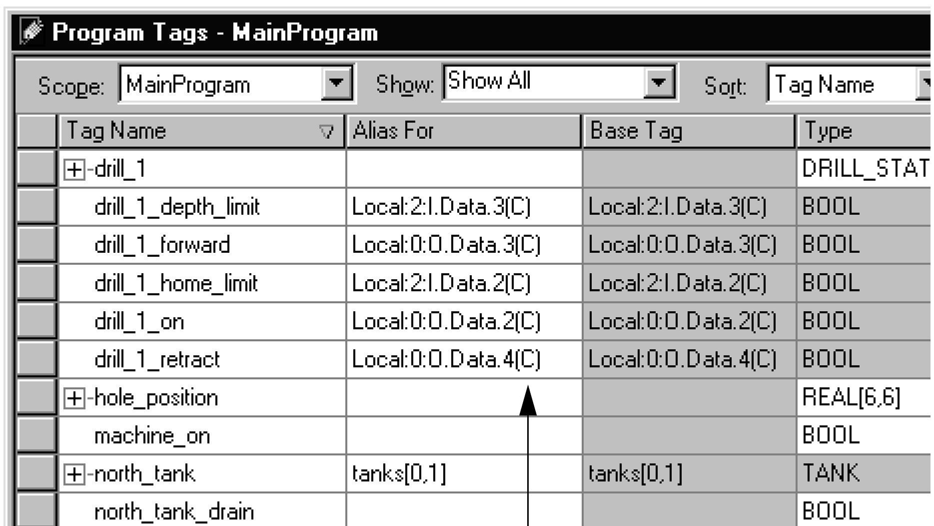
- program logic in advance of wiring diagrams
- assign a descriptive name to an I/O device
- provide a more simple name for a complex tag
- use a descriptive name for an element of an array

The tags window displays alias information.

drill_1_depth_limit is an alias for *Local:2:I.Data.3* (a digital input point). When the input turns on, the alias tag also turns on.

drill_1_on is an alias for *Local:0:O.Data.2* (a digital output point). When the alias tag turns on, the output tag also turns on.

north_tank is an alias for *tanks[0,1]*.



Program Tags - MainProgram

Scope: MainProgram Show: Show All Sort: Tag Name

Tag Name	Alias For	Base Tag	Type
+-drill_1			DRILL_STAT
drill_1_depth_limit	Local:2:I.Data.3(C)	Local:2:I.Data.3(C)	BOOL
drill_1_forward	Local:0:O.Data.3(C)	Local:0:O.Data.3(C)	BOOL
drill_1_home_limit	Local:2:I.Data.2(C)	Local:2:I.Data.2(C)	BOOL
drill_1_on	Local:0:O.Data.2(C)	Local:0:O.Data.2(C)	BOOL
drill_1_retract	Local:0:O.Data.4(C)	Local:0:O.Data.4(C)	BOOL
+-hole_position			REAL[6,6]
machine_on			BOOL
+-north_tank	tanks[0,1]	tanks[0,1]	TANK
north_tank_drain			BOOL

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The *(C)* indicates that the tag is at the controller scope.

A common use of alias tags is to program logic before wiring diagrams are available:

1. For each I/O device, create a tag with a name that describes the device, such as *conveyor* for the conveyor motor.

2. Program your logic using the descriptive tag names. (You can even test your logic without connecting to the I/O.)

3. Later, when wiring diagrams are available, add the I/O modules to the I/O configuration of the controller.

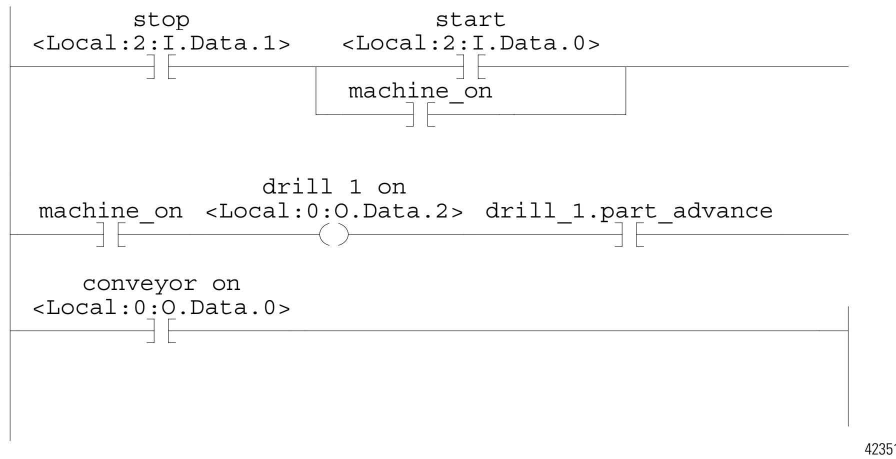
4. Finally, convert the descriptive tags to aliases for their respective I/O points or channels.

The following logic was initially programmed using descriptive tag names, such as *stop* and *conveyor_on*. Later, the tags were converted to aliases for the corresponding I/O devices.

stop is an alias for *Local:2:I.Data.1* (the stop button on the operator panel)

conveyor_on is an alias for *Local:0:O.Data.0*

(the starter contactor for the



Display Alias Information

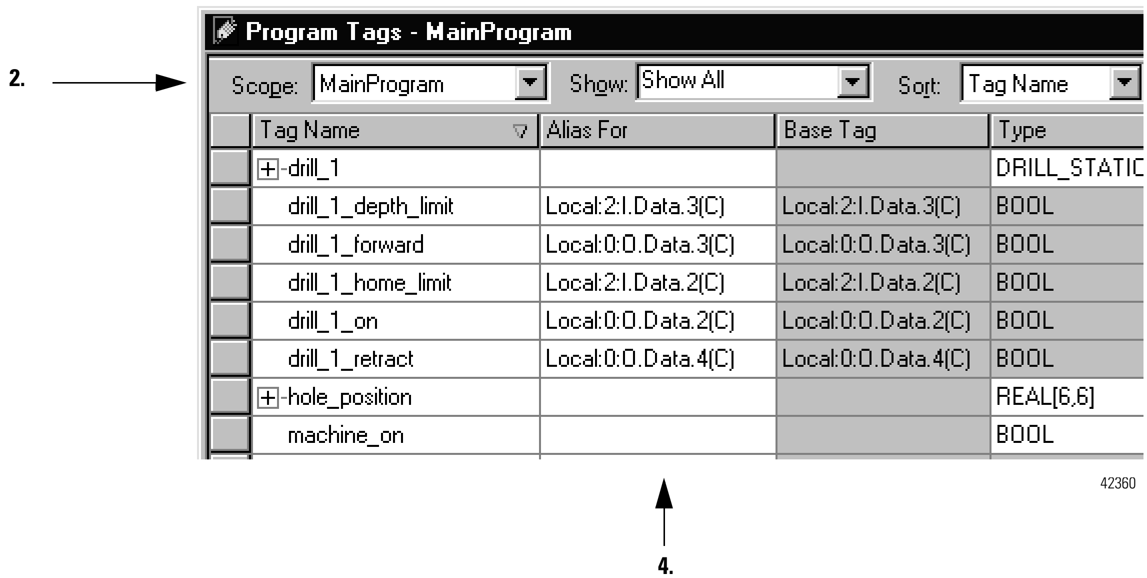
To show (in your logic) the tag to which an alias points:

1. From the *Tools* menu, select *Options*.
2. Click the *Ladder Display* tab.
3. Select the *Show Tag Alias Information* check box.
4. Click *OK*.

Assign an Alias

To assign a tag as an **alias tag** for another tag:

1. From the *Logic* menu, select *Edit Tags*.



2. Select the **scope** of the tag.

3. To the right of the tag name, click the *Alias For* cell.

   The cell displays a ▼

4. Click the ▼

5. Select the tag that the alias will represent:

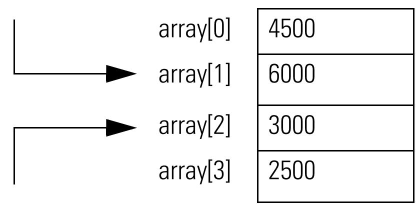
To:	Do this:
select a tag	Double-click the tag name.
select a bit number	A. Click the tag name. B. To the right of the tag name, click ▼ C. Click the required bit.

6. Press the *Enter* key or click another cell.

Assign an Indirect Address

If you want an instruction to access different elements in an array, use a tag in the subscript of the array (an indirect address). By changing the value of the tag, you change the element of the array that your logic references.

When *index* equals 1, *array[index]* points here.



When *index* equals 2, *array[index]* points here.

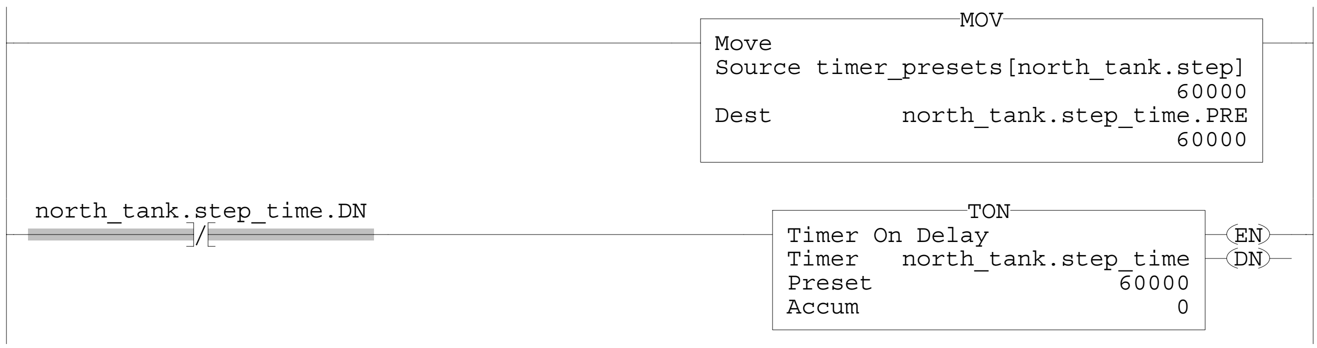
The following table outlines some common uses for an indirect address:

<table>
<tr><th>To:</th><th>Use a tag in the subscript and:</th></tr>
<tr><td>select a recipe from an array of recipes</td><td>Enter the number of the recipe in the tag.</td></tr>
<tr><td>load a specific machine setup from an array of possible setups</td><td>Enter the desired setup in the tag.</td></tr>
<tr><td>load parameters or states from an array, one element at a time</td><td rowspan="3">A. Perform the required action on the first element.
B. Use an ADD instruction to increment the tag value and point to the next element in the array.</td></tr>
<tr><td>log error codes</td></tr>
<tr><td>perform several actions on an array element and then index to the next element</td></tr>
</table>

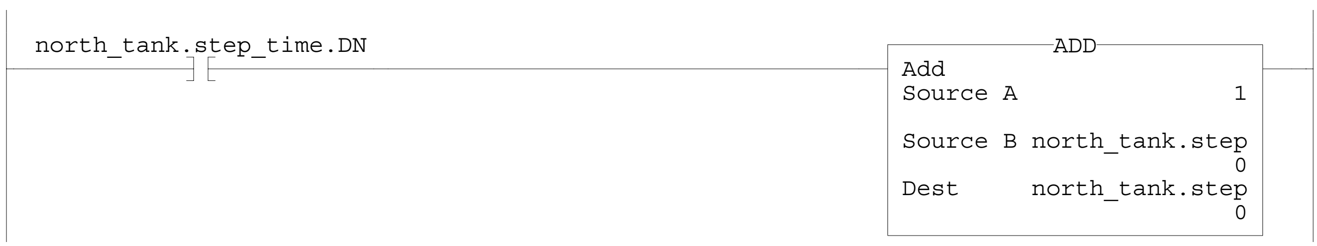
The following example loads a series of preset values into a timer, one value (array element) at a time.

EXAMPLE Step through an array

The *timer_presets* array stores a series of preset values for the timer in the next rung. The *north_tank.step* tag points to which element of the array to use. For example, when *north_tank.step* equals 0, the instruction loads *timer_presets[0]* into the timer (60,000 ms).



When *north_tank.step_time* is done, the rung increments *north_tank.step* to the next number and that element of the *timer_presets* array loads into the timer.



When *north_tank.step* exceeds the size of the array, the rung resets the tag to start at the first element in the array. (The array contains elements 0 to 3.)

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Expressions

You can also use an expression to specify the subscript of an array.

- An expression uses operators, such as + or -, to calculate a value.
- The controller computes the result of the expression and uses it as the array subscript.

You can use these operators to specify the subscript of an array:

Operator:	Description:
+	add
-	subtract/negate
*	multiply
/	divide
ABS	Absolute value
AND	AND
FRD	BCD to integer

Operator:	Description:
MOD	Modulo
NOT	complement
OR	OR
SQR	square root
TOD	integer to BCD
TRN	Truncate
XOR	exclusive OR

Format your expressions as follows:

If the operator requires:	Use this format:	Examples:
one value (tag or expression)	`operator(value)`	ABS(*tag_a*)
two values (tags, constants, or expressions)	`value_a operator value_b`	• *tag_b* + 5 • *tag_c* AND *tag_d* • (*tag_e* ** 2) MOD (*tag_f* / *tag_g*)

Manage Multiple Tasks

Using This Chapter

The default RSLogix 5000 project provides a single task for all your logic. While this is sufficient for many applications, some situations may require more than one task.

This chapter provides the following information to help you use multiple tasks in your project:

Select the Controller Tasks

A Logix5000 controller lets you use multiple tasks to schedule and prioritize the execution of your programs based on specific criteria. This balances the processing time of the controller among the different operations in your application.

- The controller executes only one task at one time.
- A different task can interrupt a task that is executing and take control.
- In any given task, only one program executes at one time.

A Logix5000 controller uses three types of tasks. Use the following table to choose the appropriate type of task for each section of your logic.

<table>
<tr><th>If you want to execute a section of your logic:</th><th>Then use this type of task:</th><th>Description:</th></tr>
<tr><td>all of the time</td><td>Continuous Task</td><td>The continuous task runs in the background. Any CPU time not allocated to other operations (such as motion, communications, and periodic or event tasks) is used to execute the programs within the continuous task.
The continuous task runs all the time. When the continuous task completes a full scan, it restarts immediately.
A project does not require a continuous task. If used, there can be only one continuous task.</td></tr>
<tr><td>at a constant period (e.g., every 100 ms)
multiple times within the scan of your other logic</td><td>Periodic Task</td><td>A periodic task performs a function at a specific period. Whenever the time for the periodic task expires, the periodic task:
interrupts any lower priority tasks
executes one time
returns control to where the previous task left off
You can configure the time period from 0.1 ms to 2000 s.
The default is 10 ms.
The performance of a periodic task depends on the type of Logix5000 controller and on the logic in the task.</td></tr>
<tr><td>immediately when an event occurs</td><td>Event Task</td><td>An event task performs a function only when a specific event (trigger) occurs. Whenever the trigger for the event task occurs, the event task:
interrupts any lower priority tasks
executes one time
returns control to where the previous task left off
The trigger can be:
change of a digital input
new sample of analog data
certain motion operations
consumed tag
EVENT instruction
Important: Some Logix5000 controllers do not support all triggers. See Table 4.1 on page 4-21.</td></tr>
</table>

Here are some example situations and the type of task that you could use:

For this example situation:	Use this type of task:
Fill a tank to its maximum level and then open a drain valve	continuous task
Collect and process system parameters and send them to a display	continuous task
Complete step 3 in a control sequence—reposition the bin diverter	continuous task
Your system must check the position of a field arm each 0.1 s and calculate the average rate of change in its position. This is used to determine braking pressure.	periodic task
Read the thickness of a paper roll every 20 ms.	periodic task
A packaging line glues boxes closed. When a box arrives at the gluing position, the controller must immediately execute the gluing routine.	event task
In a high-speed assembly operation, an optical sensor detects a certain type of reject. When the sensor detects a reject, the machine must immediately divert the reject.	event task
In an engine test stand, you want to capture and archive each analog data immediately after each sample of data	event task
Immediately after receiving new production data, load the data into the station	event task
In a line that packages candy bars, you have to make sure that the perforation occurs in the correct location on each bar. Each time the registration sensor detects the registration mark, check the accuracy of an axis and perform any required adjustment.	event task
A gluing station must adjust the amount of glue it applies to compensate for changes in the speed of the axis. After the motion planner executes, check the command speed of the axis and vary the amount of glue, if needed.	event task
In a production line, if any of the programs detect an unsafe condition the entire line must shut down. The shutdown procedure is the same regardless of the unsafe condition.	event task

The number of tasks supported depends on the controller:

This controller:	Supports this number of tasks:	Notes:
ControlLogix SoftLogix5800	32	Only one task can be continuous.
CompactLogix DriveLogix FlexLogix	8	

Use Caution in the Number of Tasks That You Use

Typically, each task takes controller time away from the other tasks. If you have too many tasks, then:

- The continuous task may take too long to complete.
- Other tasks may experience overlaps. If a task is interrupted too frequently or too long, it may not complete its execution before it is triggered again.

For more information, see "Avoid Overlaps" on page 4-9.

Prioritize Periodic and Event Tasks

Although a project can contain multiple tasks, the controller executes only one task at a time. If a periodic or event task is triggered while another task is currently executing, the priority of each task tells the controller what to do.

The number of priority levels depends on the controller:

This Logix5000 controller:	Has this many priority levels:
CompactLogix	15
ControlLogix	15
DriveLogix	15
FlexLogix	15
SoftLogix5800	3

To assign a priority to a task, use the following guidelines:

If you want:	Then	Notes:
this task to interrupt another task	Assign a priority number that is less than (higher priority) the priority number of the other task.	• A higher priority task interrupts all lower priority tasks. • A higher priority task can interrupt a lower priority task multiple times.
another task to interrupt this task	Assign a priority number that is greater than (lower priority) the priority number of the other task.	
this task to share controller time with another task	Assign the same priority number to both tasks.	The controller switches back and forth between each task and executes each one for 1 ms.

Additional Considerations

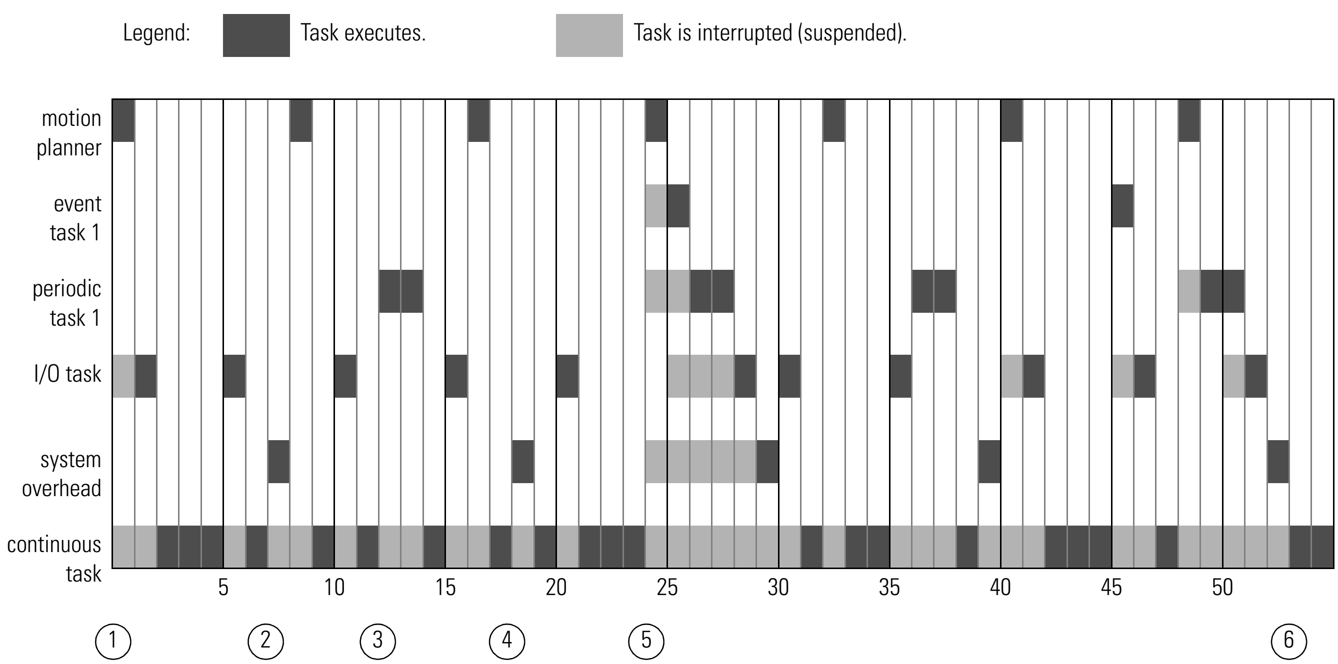
As you estimate the execution interrupts for a task, consider the following:

<table>
<tr><th>Consideration;</th><th>Description:</th></tr>
<tr><td>motion planner</td><td>The motion planner interrupts all other tasks, regardless of their priority.
The number of axes and coarse update period for the motion group effect how long and how often the motion planner executes.
If the motion planner is executing when a task is triggered, the task waits until the motion planner is done.
If the coarse update period occurs while a task is executing, the task pauses to let the motion planner execute.</td></tr>
<tr><td>I/O task</td><td>CompactLogix, FlexLogix, and DriveLogix controllers use a dedicated periodic task to process I/O data. This I/O task:
Does not show up in the Tasks folder of the controller.
Does not count toward the task limits for the controller.
Operates at priority 7.
Executes at the fastest RPI you have scheduled for the system.
Executes for as long as it takes to scan the configured I/O modules.
As you assign priorities to your tasks, consider the I/O task:<table><tr><th>If you want a task to:</th><th>Then assign one of these priorities:</th></tr><tr><td>interrupt or delay I/O processing</td><td>1 to 6</td></tr><tr><td>share controller time with I/O processing</td><td>7</td></tr><tr><td>let I/O processing interrupt or delay the task</td><td>8 to 15</td></tr></table></td></tr>
<tr><td>system overhead</td><td>System overhead is the time that the controller spends on unscheduled communication.
Unscheduled communication is any communication that you do not configure through the I/O configuration folder of the project, such as Message (MSG) instructions and communication with HMIs or workstations.
System overhead interrupts only the continuous task.
The system overhead time slice specifies the percentage of time (excluding the time for periodic or event tasks) that the controller devotes to unscheduled communication.
The controller performs unscheduled communication for up to 1 ms at a time and then resumes the continuous task.</td></tr>
<tr><td>continuous task</td><td>You do not assign a priority to the continuous task. It always runs at the lowest priority. All other tasks interrupt the continuous task.</td></tr>
</table>

EXAMPLE

The following example depicts the execution of a project with three user tasks.

Task:	Priority:	Period:	Execution time:	Duration:
motion planner	n/a	8 ms (course update rate)	1 ms	1 ms
event task 1	1	n/a	1 ms	1 to 2 ms
periodic task 1	2	12 ms	2 ms	2 to 4 ms
I/O task—n/a to ControlLogix and SoftLogix controllers. See page 4-6.	7	5 ms (fastest RPI)	1 ms	1 to 5 ms
system overhead	n/a	time slice = 20%	1 ms	1 to 6 ms
continuous task	n/a	n/a	20 ms	48 ms



Description:	
1	Initially, the controller executes the motion planner and the I/O task (if one exists).
2	After executing the continuous task for 4 ms, the controller triggers the system overhead.
3	The period for periodic task 1 expires (12 ms), so the task interrupts the continuous task.
4	After executing the continuous task again for 4 ms, the controller triggers the system overhead.
5	The triggers occurs for event task 1. Event task 1 waits until the motion planner is done. Lower priority tasks experience longer delays.
6	The continuous task automatically restarts.

Leave Enough Time for Unscheduled Communication

Unscheduled communication occurs only when a periodic or event task is not running. If you use multiple tasks, make sure that their scan times and execution intervals leave enough time for unscheduled communication.

If you have multiple tasks, follow these rules:

1. The execution time of a highest priority task is significantly less than its update rate.

2. The total execution time of all your tasks is significantly less than the update rate of the lowest priority tasks.

For example, in this configuration of tasks:

Task:	Priority:	Execution time:	Rate
1	higher	20 ms	80 ms
2	lower	30 ms	100 ms
	total execution time:	50 ms	

1. The execution time of the highest priority task (Task 1) is significantly less than its update rate (20 ms is less than 80 ms).

2. The total execution time of all tasks is significantly less than the update rate of the lowest priority task (50 ms is less than 100 ms).

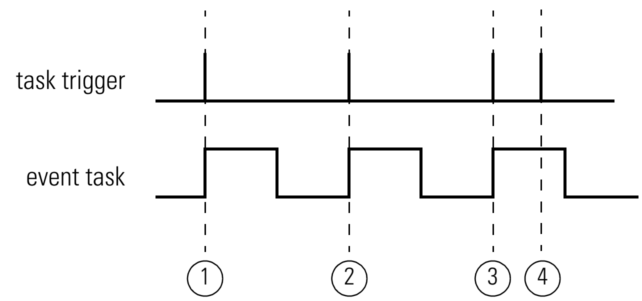
This generally leaves enough time for unscheduled communication.

- Adjust the update rates of the tasks as needed to get the best trade-off between executing your logic and servicing unscheduled communication.
- If your project has a continuous task, unscheduled communication occurs as a percentage of controller time (excluding the time for periodic or event tasks). See “system overhead” on page 4-6.

Avoid Overlaps

An **overlap** is a condition where a task (periodic or event) is triggered while the task is still executing from the previous trigger.

IMPORTANT If an overlap occurs, the controller disregards the trigger that caused the overlap. In other words, you might miss an important execution of the task.



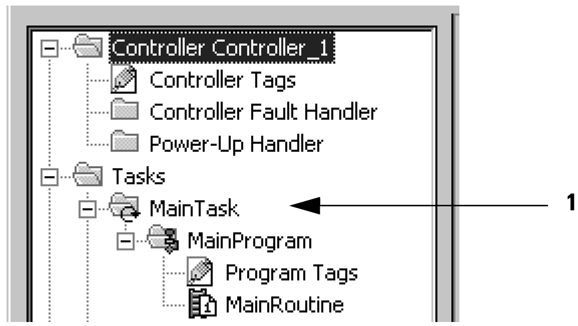
Description:	
1	Task trigger occurs. Task executes.
2	Task trigger occurs. Task executes.
3	Task trigger occurs. Task executes.
4	Overlap occurs. Task is triggered while it is still executing. The trigger does not restart the task. The trigger is ignored.

Each task requires enough time to finish before it is triggered again. Make sure that the scan time of the task is significantly less than the rate at which the trigger occurs. If an overlap occurs, reduce the frequency at which you trigger the task:

If the type of task is:	Then:
periodic	increase the period of the task
event	adjust the configuration of your system to trigger the task less frequently.

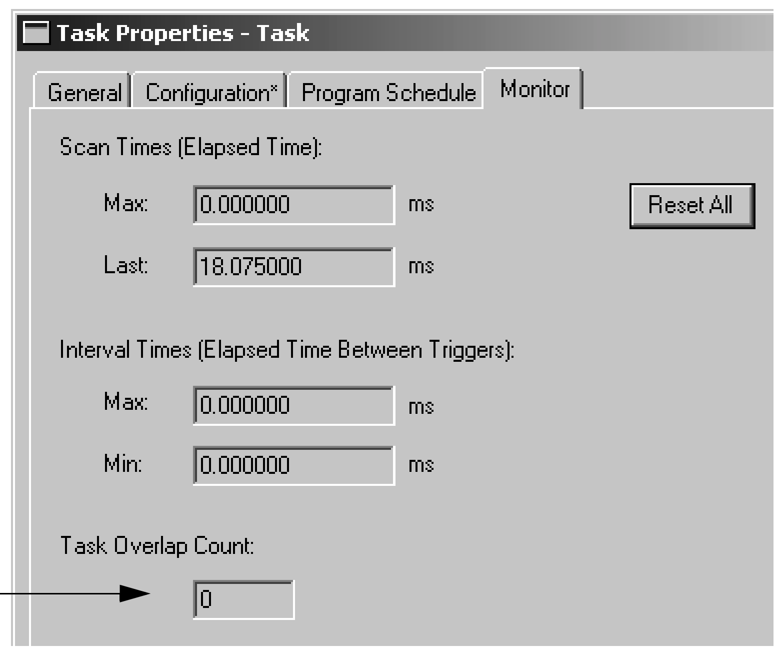
Manually Check for Overlaps

To manually see if overlaps are occurring for a task:



1. In the controller organizer, right-click the task and choose *Properties*.

2. Click the *Monitor* tab.



number of overlaps since the counter was last reset

3. To close the dialog box, choose OK

Programmatically Check for Overlaps

When an overlap occurs, the controller:

- logs a minor fault to the FAULTLOG object
- stores overlap information in the TASK object for the task

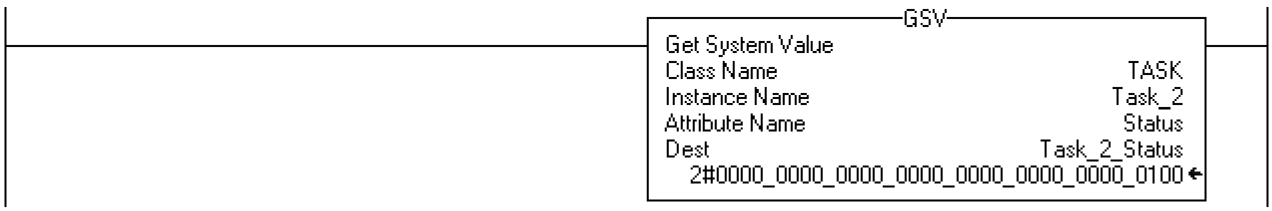
To write logic to check for an overlap, use a Get System Value (GSV) instruction to monitor either of the following objects:

If you want to:	**Then access the following object and attribute:**				
	Object:	**Attribute:**	**Data Type:**	**Description:**	
determine if an overlap occurred for any task	FAULTLOG	MinorFaultBits	DINT	Individual bits that indicate a minor fault:	
				To determine if:	**Examine this bit:**
				An instruction produced a minor fault.	4
				An overlap occurred for a task.	*6*
				The serial port produced a minor fault.	9
				The battery is not present or needs replacement.	10
determine if an overlap occurred for a specific task	TASK	Status	DINT	Status information about the task. Once the controller sets one of these bits, you must manually clear the bit.	
				To determine if:	**Examine this bit:**
				An EVENT instruction triggered the task (event task only).	0
				A timeout triggered the task (event task only).	1
				An overlap occurred for this task.	*2*
determine the number of times that an overlap occurred.	TASK	OverlapCount	DINT	Valid for an event or a periodic task. To clear the count, set the attribute to 0.	

EXAMPLE

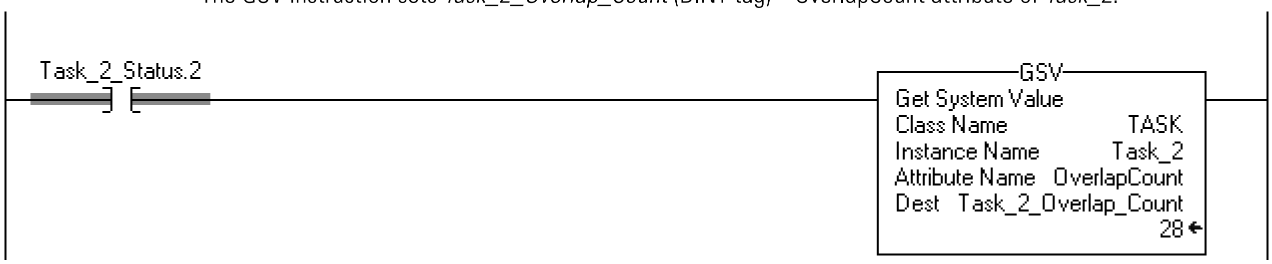
Programmatically Check for Overlaps

1. The GSV instruction sets *Task_2_Status* = Status attribute for *Task_2* (DINT value).



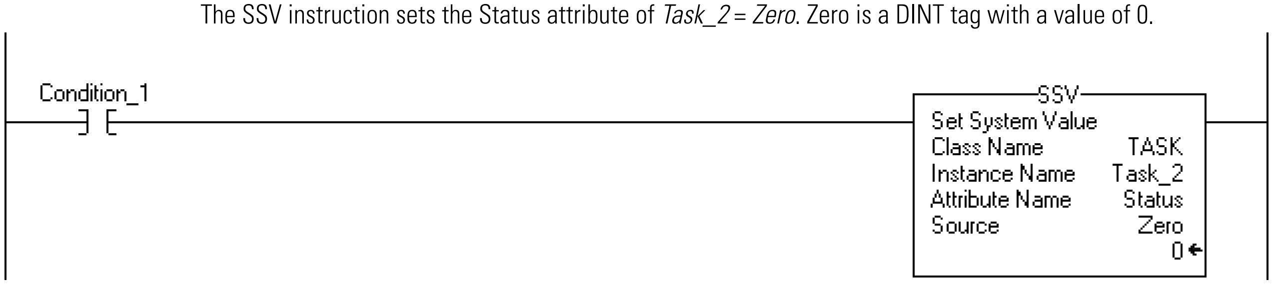
2. If *Task_2_Status.2* = 1, then an overlap occurred so get the count of overlaps:

   The GSV instruction sets *Task_2_Overlap_Count* (DINT tag) = OverlapCount attribute of *Task_2*.



3. If *Condition_1* = 1, then clear the bits of the Status attribute for *Task_2*:

   The SSV instruction sets the Status attribute of *Task_2* = *Zero*. Zero is a DINT tag with a value of 0.

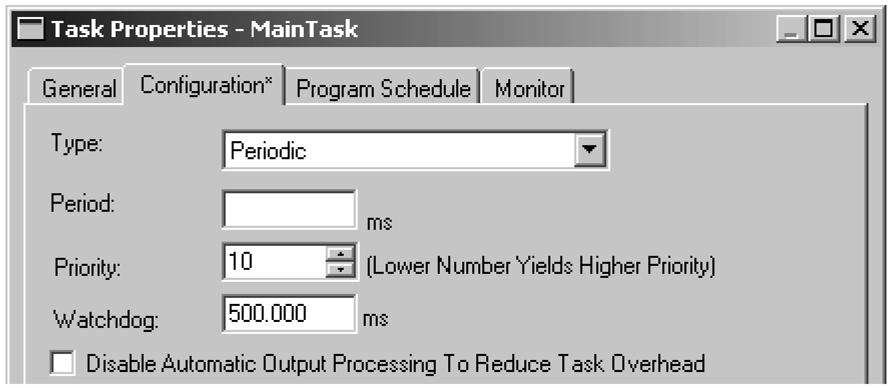


Configure Output Processing for a Task

At the end of a task, the controller performs overhead operations (output processing) for the I/O modules in your system. While *not* the same as updating the modules, this output processing may effect the update of the I/O modules in your system.

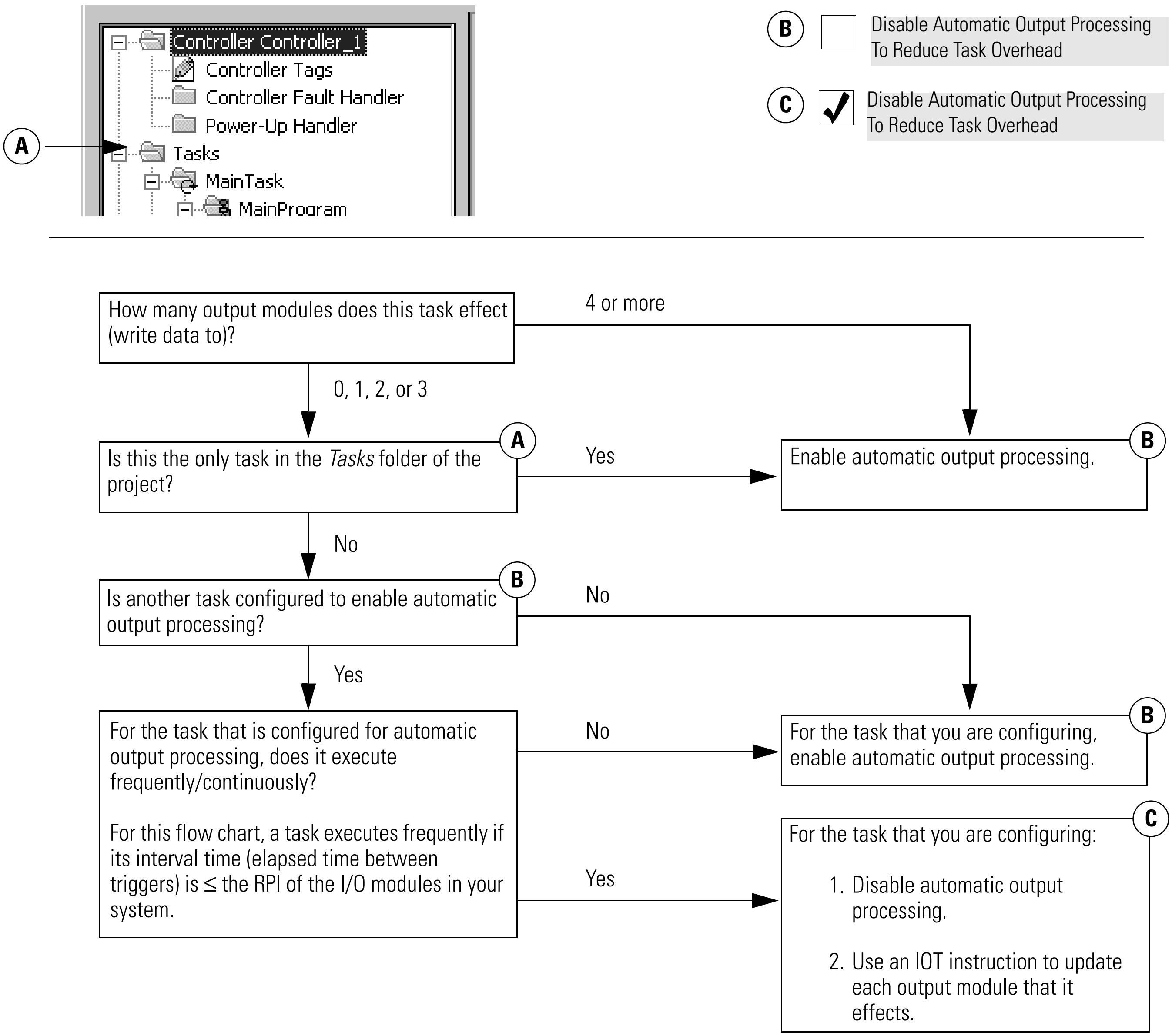
As an option, you can turn off this output processing for a specific task, which reduces the elapsed time of that task.

Enable or disable the processing of outputs at the end of the task

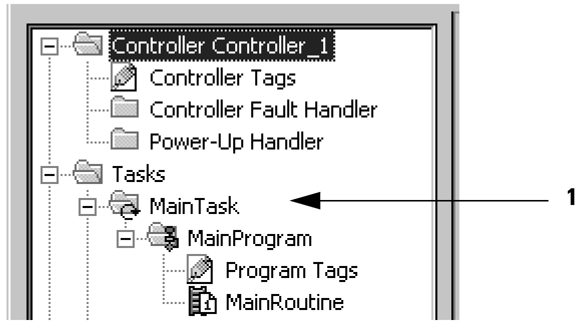


To choose how to configure output processing for a task, use the following flow chart

Figure 4.1 Choose how to configure output processing for a task.

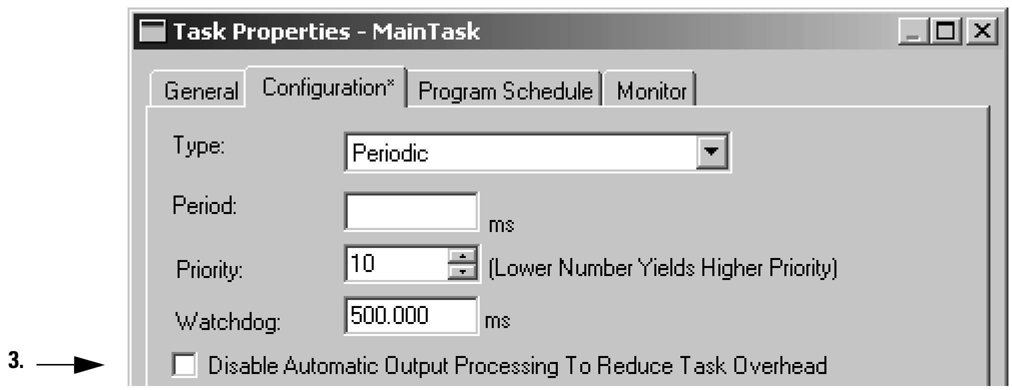


Manually Configure Output Processing



1. In the controller organizer, right-click the task and choose *Properties*.

2. Click the *Configuration* tab.



3. Configure output processing for the task:

If you want to:	Then:
enable the processing of outputs at the end of the task	Clear (uncheck) the *Disable Automatic Output Processing To Reduce Task Overhead* check box (default).
disable the processing of outputs at the end of the task	Select (check) the *Disable Automatic Output Processing To Reduce Task Overhead* check box.

4. Choose 

Programmatically Configure Output Processing

To write logic to configure output processing for a task, use a Set System Value (SSV) instruction. Access the following attribute of the TASK object for the task:

If you want to:	Then access this attribute:	Data Type:	Instruction:	Description: To:	Description: Set the attribute to:
enable or disable the processing of outputs at the end of a task	DisableUpdateOutputs	DINT	GSV SSV	enable the processing of outputs at the end of the task	0
				disable the processing of outputs at the end of the task	1 (or any non-zero value)

EXAMPLE Programmatically Configure Output Processing

If *Condition_1* = 0 then let *Task_2* process outputs when it is done.

1. The ONS instruction limits the true execution of the SSV instruction to one scan.
2. The SSV instruction sets the DisableUpdateOutputs attribute of *Task_2* = 0. This lets the task automatically process outputs when it finishes its execution.

If *Condition_1* = 1 then do not let *Task_2* process outputs when it is done.

1. The ONS instruction limits the true execution of the SSV instruction to one scan.
2. The SSV instruction sets the DisableUpdateOutputs attribute of *Task_2* = 1. This prevents the task from automatically processing outputs when it finishes its execution.

Inhibit a Task

By default, each task executes based on its trigger (event, periodic, or continuous). As an option, you can prevent a task from executing when its trigger occurs (i.e., inhibit the task). This is useful to test, diagnose, or start up your project.

If you want to:	Then:
let the task execute when its trigger occurs	Uninhibit the task (default).
prevent the task from executing when its trigger occurs	Inhibit the task.

EXAMPLE Inhibit a Task

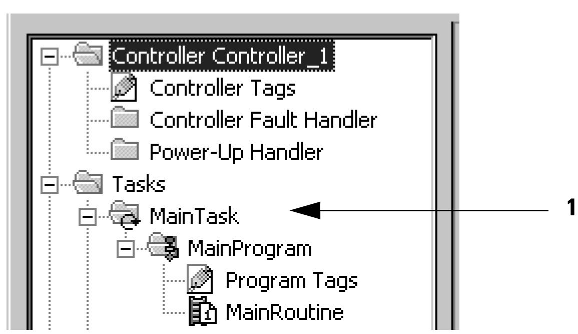
During the commissioning of a system that uses several task, you can first test each task individually.

1. Inhibit all the tasks except one, and then test that task.
2. Once the task meets your requirements, inhibit it and uninhibit a different task.
3. Continue this process until you have tested all your tasks.

If a task is inhibited, the controller still prescans the task when the controller transitions from program to run or test mode.

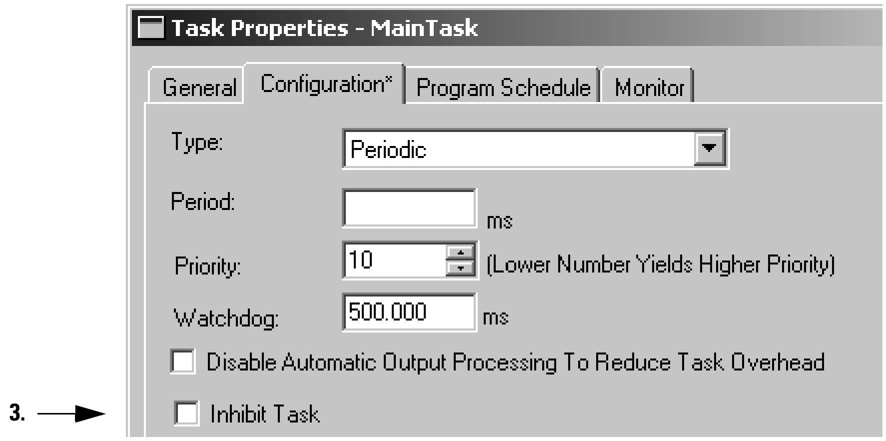
Manually Inhibit or Uninhibit a Task

To manually inhibit or uninhibit the execution of a task, use the properties dialog box for the task.



1. In the controller organizer, right-click the task and choose *Properties*.

2. Click the *Configuration* tab.



3. Inhibit or uninhibit the task:

If you want to:	Then:
let the task execute when its trigger occurs	Clear (uncheck) the *Inhibit Task* check box (default).
prevent the task from executing when its trigger occurs	Select (check) the *Inhibit Task* check box.

4. Choose 

Programmatically Inhibit or Uninhibit a Task

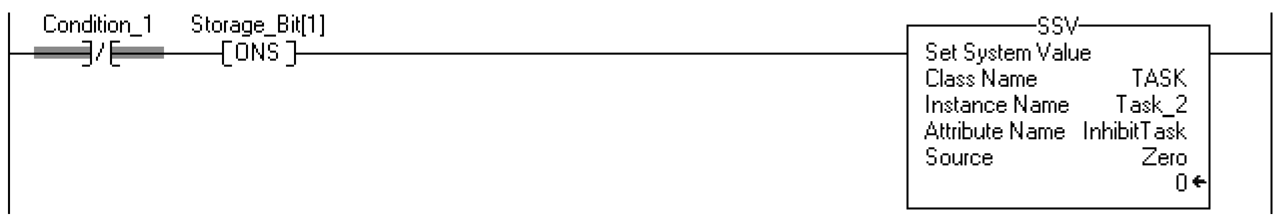
To write logic to inhibit or uninhibit a task, use a Set System Value (SSV) instruction to access the following attribute of the TASK object for the task:

Attribute:	Data Type:	Instruction:	Description:	
InhibitTask	DINT	GSV	Prevents the task from executing.	
		SSV	**To:**	**Set the attribute to:**
			enable the task	0 (default)
			inhibit (disable) the task	1 (or any non-zero value)

EXAMPLE Programmatically Inhibit or Uninhibit a Task

If *Condition_1* = 0 then let *Task_2* execute.

1. The ONS instruction limits the true execution of the SSV instruction to one scan.
2. The SSV instruction sets the InhibitTask attribute of *Task_2* = 0. This uninhibits the task.



If *Condition_1* = 1 then do not let *Task_2* execute.

1. The ONS instruction limits the true execution of the SSV instruction to one scan.
2. The SSV instruction sets the InhibitTask attribute of *Task_2* = 1. This inhibits the task.

Choose the Trigger for an Event Task

If configured correctly, an event task interrupts all other tasks for the minimum amount of time required to respond to the event. Each event task requires a specific trigger that defines when the task is to execute.

To trigger an event task when:	Use this trigger:	With these considerations:
digital input turns on or off	Module Input Data State Change	• Only one input module can trigger a specific event task. • The input module triggers the event task based on the change of state (COS) configuration for the module. The COS configuration defines which points prompt the module to produce data if they turn on or off. This production of data (due to COS) triggers the event task. • Typically, enable COS for only one point on the module. If you enable COS for multiple points, a task overlap of the event task may occur.
analog module samples data	Module Input Data State Change	• Only one input module can trigger a specific event task. • The analog module triggers the event task after each real time sample (RTS) of the channels. • All the channels of the module use the same RTS.
controller gets new data via a consumed tag	Consumed Tag	• Only one consumed can trigger a specific event task. • Typically, use an IOT instruction in the producing controller to signal the production of new data. The IOT instruction sets an event trigger in the producing tag. This trigger passes to the consumed tag and triggers the event task. • When a consumed tag triggers an event task, the event task waits for all the data to arrive before the event task executes.
registration input for an axis turns on (or off)	Axis Registration 1 or 2	• In order for the registration input to trigger the event task, first execute a Motion Arm Registration (MAR) instruction. This lets the axis detect the registration input and in turn trigger the event task. • Once the registration input triggers the event task, execute the MAR instruction again to re-arm the axis for the next registration input. • If the scan time of your normal logic is *not* fast enough to re-arm the axis for the next registration input, consider placing the MAR instruction within the event task.
axis reaches the position that is defined as the watch point	Axis Watch	• In order for the registration input to trigger the event task, first execute a Motion Arm Watch (MAW) instruction. This lets the axis detect the watch position and in turn trigger the event task. • Once the watch position triggers the event task, execute the MAW instruction again to re-arm the axis for the next watch position. • If the scan time of your normal logic is *not* fast enough to re-arm the axis for the next watch position, consider placing the MAW instruction within the event task
motion planner completes its execution	Motion Group Execution	• The coarse update period for the motion group triggers the execution of both the motion planner and the event task. • Because the motion planner interrupts all other tasks, it executes first. If you assign the event task as the highest priority task, it executes after the motion planner.
specific condition or conditions occur within the logic of a program	EVENT instruction	Multiple EVENT instructions can trigger the same task. This lets you execute a task from different programs.

Here are some example situations for event tasks and the corresponding triggers:

For this example situation:	Use an event task with this trigger:
A packaging line glues boxes closed. When a box arrives at the gluing position, the controller must immediately execute the gluing routine.	Module Input Data State Change
A production line uses a proximity sensor to detect the presence of a part. Because the proximity sensor is on for only a very short time (pulse), the continuous task might miss the off to on transition of the sensor.	Module Input Data State Change
In an engine test stand, you must capture and archive each sample of analog data.	Module Input Data State Change
Controller A produces an array of production data for Controller B. You want to make sure that Controller B doesn't use the values while Controller A is updating the array:	Consumed Tag
In a line that packages candy bars, you have to make sure that the perforation occurs in the correct location on each bar. Each time the registration sensor detects the registration mark, check the accuracy of an axis and perform any required adjustment.	Axis Registration 1 or 2
At the labeling station of a bottling line, you want to check the position of the label on the bottle. When the axis reaches the position that is defined as the watch point, check the label.	Axis Watch
A gluing station must adjust the amount of glue it applies to compensate for changes in the speed of the axis. After the motion planner executes, check the command speed of the axis and vary the amount of glue, if needed.	Motion Group Execution
In a production line, if any of the programs detect an unsafe condition the entire line must shut down. The shutdown procedure is the same regardless of the unsafe condition.	EVENT instruction

The triggers that you can use for an event task varies depending on your type of Logix5000 controller.

IMPORTANT RSLogix 5000 software may let you configure a trigger for an event task that your controller does not support. The project will verify and successfully download, but the event task will not execute.

Table 4.1 Use the following table to determine which Logix5000 controllers support each type of event trigger.

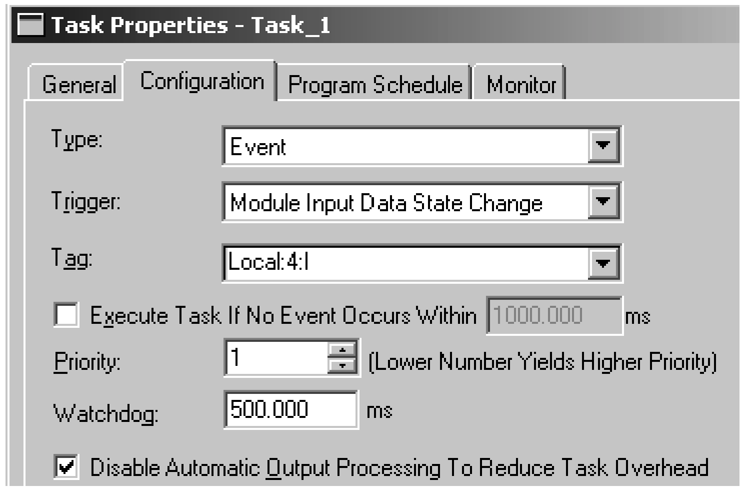
If you have this controller:	Then you can use these event task triggers:					
	Module Input Data State Change	Consumed Tag	Axis Registration 1 or 2	Axis Watch	Motion Group Execution	EVENT instruction
CompactLogix		✔				✔
FlexLogix		✔				✔
ControlLogix	✔	✔	✔	✔	✔	✔
DriveLogix		✔	✔	✔	✔	✔
SoftLogix5800	✔(1)	✔(2)	✔	✔	✔	✔

(1) Requires a 1756 I/O module or a virtual backplane.

(2) A SoftLogix5800 controller produces and consumes tags only over a ControlNet network.

Using the Module Input Data State Change Trigger

To trigger an event task based on data from an input module, use the *Module Input Data State Change* trigger.



Let an event trigger this task.

Let data from an input module trigger the task.

Let this input tag trigger the task.

When the task is done, do not update digital outputs in the local chassis.

How an I/O Module Triggers an Event Task

The following terms apply to the operation of an input module:

Term:	Definition:
multicast	A mechanism where a module sends data on a network that is simultaneously received by more that one listener (device). Describes the feature of the Logix5000 I/O line which supports multiple controllers receiving input data from the same I/O module at the same time.
requested packet interval (RPI)	The RPI specifies the interval at which a module multicasts its data. For example, an input module sends data to a controller at the RPI that you assign to the module. • The range is 0.2 ms (200 microseconds) to 750 ms. • When the specified time frame elapses, the module multicasts its data. This is also called a cyclic update.
real time sample (RTS)	The RTS specifies when an analog module scans its channels and multicasts the data (update the input data buffer then multicast). • The *RPI* specifies when the module multicasts the current contents of the input data buffer without scanning (updating) the channels. • The module resets the RPI timer each time and RTS transfer occurs.

Term:	Definition:
change of state (COS)	The COS parameter instructs a digital input module to multicast data whenever a specified input point transitions from On → Off or Off → On. • You enable COS on a per-point basis. • When any point that is enabled for COS receives the specified change, the module multicasts the data for all its points. • By default, COS is enabled for both On → Off and Off → On changes for all points. • You must specify an RPI regardless of whether you enable COS. If a change does not occur within the RPI, the module sends its data at the RPI.

The following table summarizes when an input module multicasts its data and triggers an event task *within its own chassis*.

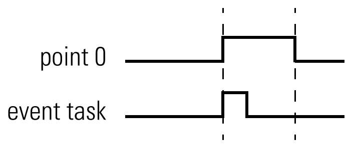
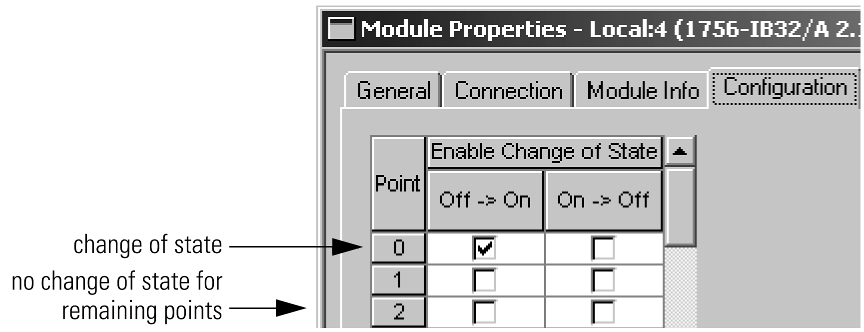
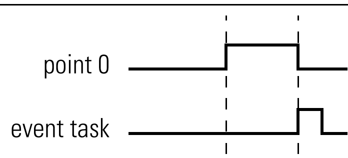
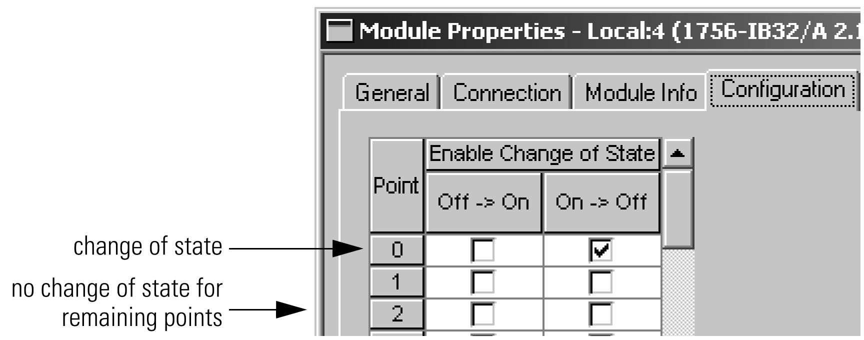
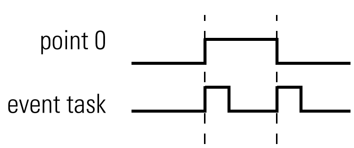
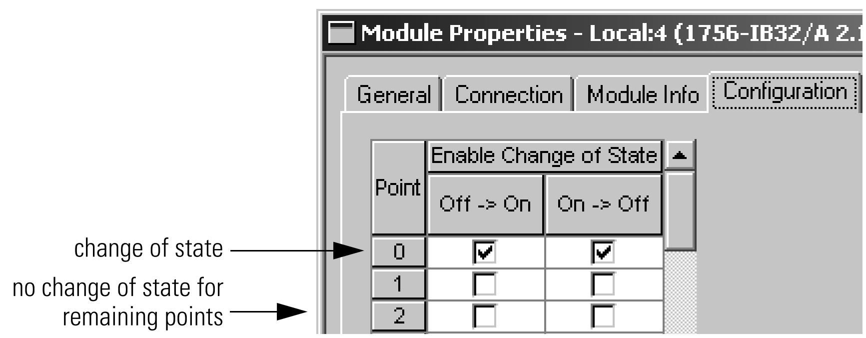
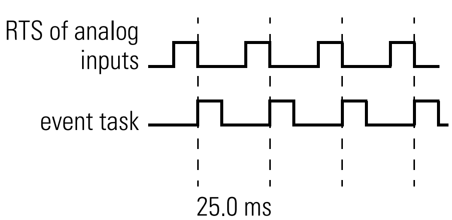
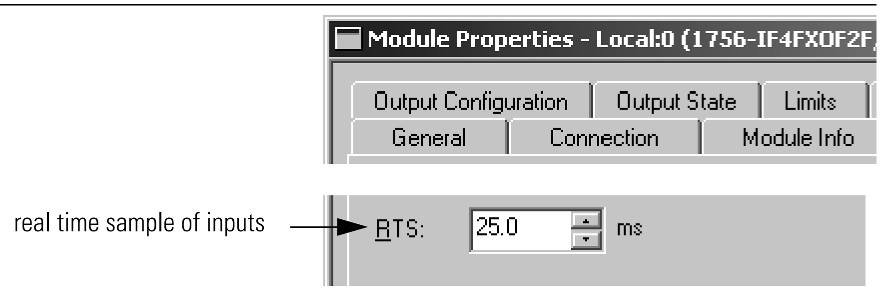
If the input module is:	And:	Then it multicasts data:	And it triggers an event task:
digital	COS is enabled for any point on the module	• when any point that is enabled for COS receives the specified change • at the RPI	when any point that is enabled for COS receives the specified change
	COS is not enabled for any point on the module	at the RPI	never
analog	RTS ≤ RPI	at the RTS (newly updated channel data)	at the RTS for the module
	RTS > RPI	• at the RTS (newly updated channel data) • at the RPI (does not contain updated data from the channels)	at the RTS for the module

If the module is in a remote chassis, only the RPI determines when the controller receives the data and event trigger over the network.

Over this network:	The controller receives the data:
EtherNet/IP	close to the RPI, on average
ControlNet	at the actual packet interval (≤ RPI)

Here are some examples that show COS and RTS configurations:

IMPORTANT If you use a digital module to trigger an event task, configure only one point on the module for COS. If you configure multiple points, a task overlap could occur.

If you want this:	Then configure the input module like this (point 0 is used as an example only):
	
	
	
	

Make Sure Your Module Can Trigger an Event Task

To use an input module to trigger an event task, the module must support event task triggering. If the module is in a remote location, the associated communication modules must also support event triggering.

The following table lists Rockwell Automation modules that we have tested for event task triggering. Some 3^{rd} party modules may also support event task triggering. Before you use a 3^{rd} party module, check with the supplier to validate the operation of the module.

Category	Module	Category	Module
1756 Discrete	1756-IA16	1756 Analog	1756-IF16
	1756-IA16I		1756-IF4FXOF2F/A
	1756-IA8D		1756-IF6CIS
	1756-IB16		1756-IF6I
	1756-IB16D		1756-IF8
	1756-IB16I		1756-IR6I
	1756-IB32/A		1756-IT6I
	1756-IB32/B		1756-IT6I2
	1756-IC16	1756 Generic	1756-MODULE
	1756-IH16I	1756 Communication	1756-CNB/A
	1756-IM16I		1756-CNB/B
	1756-IN16		1756-CNB/D
	1756-IV16/A		1756-CNBR/A
	1756-IV32/A		1756-CNBR/B
			1756-CNBR/D
			1756-DNB
			1756-ENBT/A
			1756-SYNCH/A
		SoftDNB	1784-PCIDS/A
		1789 Generic	1789-MODULE

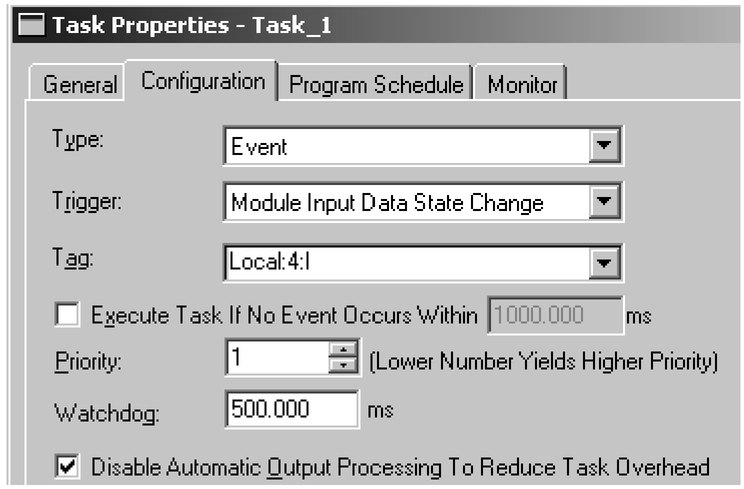
Checklist for an Input Event Task

For this:	Make sure you:
❑ 1. Input module type	For the fastest response, use the following modules: • For fastest digital response, use a 1756-IB32/B module. • For fastest analog response, use a 1756-IF4FXOF2F module.
❑ 2. I/O module location	Place the module that triggers the event and the modules that respond to the event (outputs) in the same chassis as the controller. Remote modules add network communications to the response time.
❑ 3. Number of local modules	Limit the number of modules in the local chassis. Additional modules increases the potential for backplane delays
❑ 4. Change of state (COS)	If a digital device triggers the event, enable COS for only the point that triggers the event task. • Enable change of state for the type of transition that triggers the task, either Off → On, On → Off, or both. • If you configure COS for both Off → On and On → Off, the point triggers an event task whenever the point turns on or off. Make sure the duration of the input is longer than the scan time of the task. Otherwise an overlap could occur. • Disable (clear) COS for the remaining points on the input module. If you configure multiple points on a module for COS, each point could trigger the event task. This could cause an overlap.
❑ 5. Task priority	Configure the event task as the highest priority task. If a periodic task has a higher priority, the event task may have to wait until the periodic task is done.
❑ 6. Motion planner	The motion planner interrupts all other tasks, regardless of their priority. • The number of axes and coarse update period for the motion group effect how long and how often the motion planner executes. • If the motion planner is executing when a task is triggered, the task waits until the motion planner is done. • If the coarse update period occurs while a task is executing, the task pauses to let the motion planner execute.
❑ 7. Number of event tasks	Limit the number of event tasks. Each additional task reduces the processing time that is available for other tasks. This could cause an overlap.
❑ 8. Automatic Output Processing	For an event task, you can typically disable automatic output processing (default). This reduces the elapsed time of the task. To verify this decision, see Figure 4.1 on page 4-14.
❑ 9. IOT instruction	Use an IOT instruction for each output module that you reference in the event task. The IOT instruction overrides the RPI for the module and immediately sends the data.

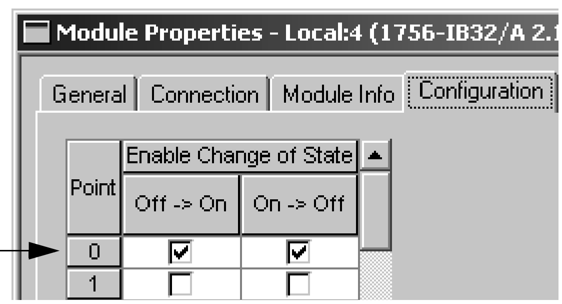
EXAMPLE

As parts move past a diverter location, the controller must decide whether or not to turn on the diverter. Once the diverter is on, the controller must also turn it off before the next part is in that position. Because of the speed of the line, an event task controls the diverter.

A photoeye at the diverter position indicates when a part is in the diverter position. The input is wired to the module in slot 4 of the local chassis.



The diverter photoeye (point 0) is configured for change of state for both Off and On. This lets the photoeye trigger the event task when it turns on and when it turns off.



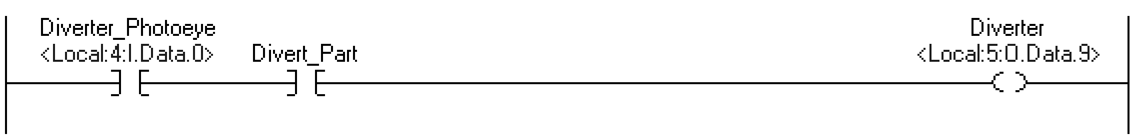
The event task uses the following logic to control the diverter.

If Diverter_Photoeye = 1 (part is in the diverter position)

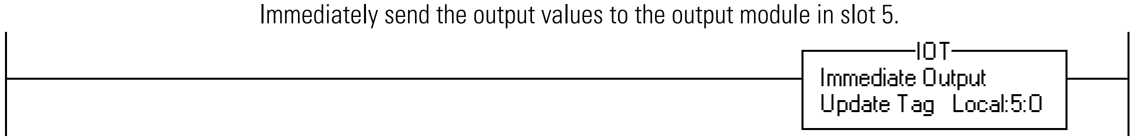
And Divert_Part = 1 (divert this part)

Then Diverter = 1 (turn on the diverter)

Otherwise Diverter = 0 (turn off the diverter)



Immediately send the output values to the output module in slot 5.



Estimate Throughput

To estimate the throughput time from input to output (screw to screw), use the following worksheet:

Consideration:	Value:
1. What is the input filter time of the module that triggers the event task? This is typically shown in milliseconds. Convert it to microseconds (μs).	μs
2. What is the hardware response time for the input module that triggers the event task? Make sure you use the appropriate type of transition (Off → On or On → Off). See Table 4.2 on page 4-29.	μs
3. What is the backplane communication time? **If the chassis size is:** / **Use this value (worst case):** 4 slot: 13 μs 7 slot: 22 μs 10 slot: 32 μs 13 slot: 42 μs 17 slot: 54 μs	μs
4. What is the total execution time of the programs of the event task?	μs
5. What is the backplane communication time? (Same value as step 3.)	μs
6. What is the hardware response time of the output module.	μs
7. Add steps 1 through 6. This is the minimum estimated throughput, where execution of the motion planner or other tasks do *not* delay or interrupt the event task.	μs
8. What is the scan time of the motion group?	μs
9. What is the total scan time of the tasks that have a higher priority than this event task (if any)?	μs
10. Add steps 7 through 9. This is the nominal estimated throughput, where execution of the motion planner or other tasks delay or interrupt the event task.	μs

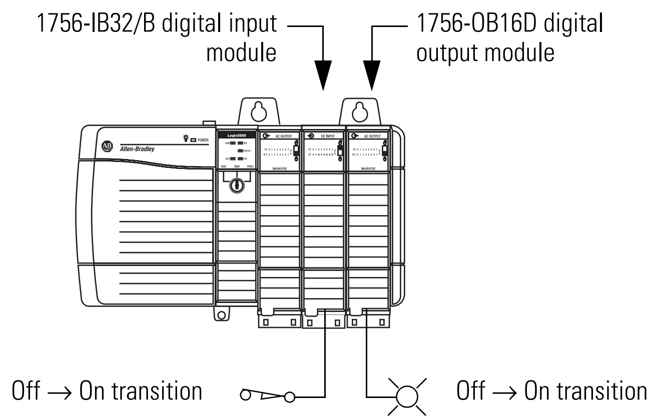
Table 4.2 Use the following table to determine the nominal hardware response times for selected 1756 I/O modules.

Module:	Nominal response time μs:			
	25° C		60° C	
	Off → On	On → Off	Off → On	On → Off
1756-IB16	265	582	265	638
1756-IB16D	303	613	305	673
1756-IB32/B	330	359	345	378
1756-IV16	257	435	254	489
1756-IV32	381	476	319	536
1756-OB16D	48	519	51	573
1756-OB16E	60	290	61	324
1756-OB32	38	160	49	179
1756-OV16E	67	260	65	326
1756-OV32E	65	174	66	210

EXAMPLE

Estimate Throughput

The following example shows the throughput considerations for the system shown below. In this example, the throughput is the time from when the input turns on to when the output turns on.



<table>
<tr><th>Consideration:</th><th>Value:</th></tr>
<tr><td>1. What is the input filter time of the module that triggers the event task?
This is typically shown in milliseconds. Convert it to microseconds (μs).</td><td>0 μs</td></tr>
<tr><td>2. What is the hardware response time for the input module that triggers the event task?
Make sure you use the appropriate type of transition (Off → On or On → Off). See Table 4.2 on page 4-29.</td><td>330 μs</td></tr>
<tr><td>3. What is the backplane communication time?
<table>
<tr><th>If the chassis size is:</th><th>Use this value (worst case):</th></tr>
<tr><td>4 slot</td><td>13 μs</td></tr>
<tr><td>7 slot</td><td>22 μs</td></tr>
<tr><td>10 slot</td><td>32 μs</td></tr>
<tr><td>13 slot</td><td>42 μs</td></tr>
<tr><td>17 slot</td><td>54 μs</td></tr>
</table></td><td>13 μs</td></tr>
<tr><td>4. What is the total execution time of the programs of the event task?</td><td>400 μs</td></tr>
<tr><td>5. What is the backplane communication time? (Same value as step 3.)</td><td>13 μs</td></tr>
<tr><td>6. What is the hardware response time of the output module.</td><td>51 μs</td></tr>
<tr><td>7. Add steps 1 through 6. This is the minimum estimated throughput, where execution of the motion planner or other tasks do not delay or interrupt the event task.</td><td>807 μs</td></tr>
<tr><td>8. What is the scan time of the motion group?</td><td>1130 μs</td></tr>
<tr><td>9. What is the total scan time of the tasks that have a higher priority than this event task (if any)?</td><td>0 μs</td></tr>
<tr><td>10. Add steps 7 through 9. This is the nominal estimated throughput, where execution of the motion planner or other tasks delay or interrupt the event task.</td><td>1937 μs</td></tr>
</table>

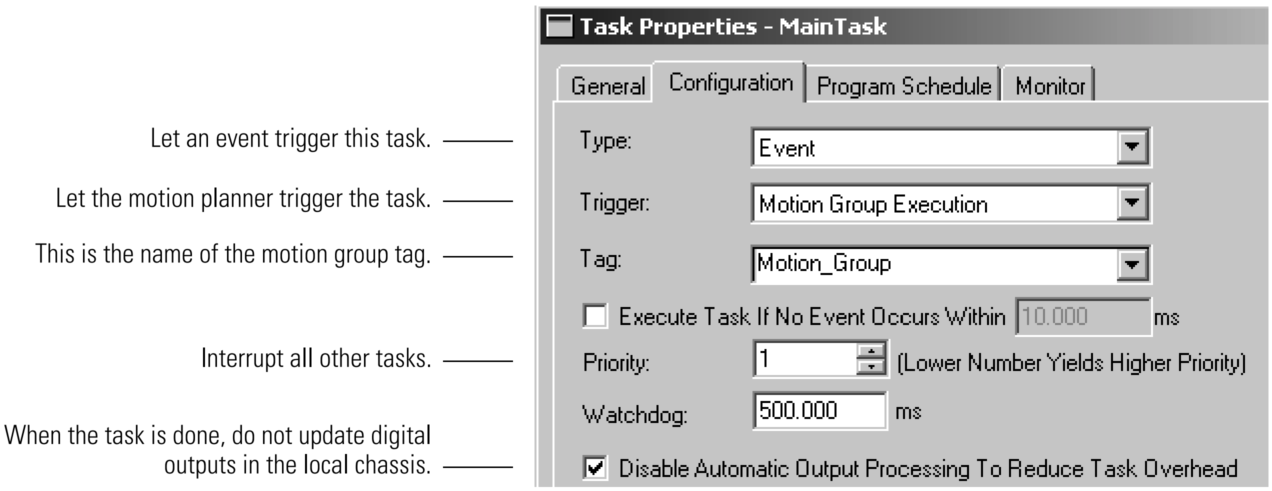
Additional Considerations

The following considerations effect the scan time of the event task, which effects the speed at which it can respond to the input signal.

Consideration:	Description:
amount of code in the event task	Each logic element (rung, instruction, structured text construct, etc…) adds scan time to the task.
task priority	If the event task is not the highest priority task, a higher priority task may delay or interrupt the execution of the event task.
CPS and UID instructions	If one of these instructions are active, the event task cannot interrupt the currently executing task. (The task with the CPS or UID.)
communication interrupts	The following actions of the controller interrupt a task, regardless of the priority of the task • communication with I/O modules Modules that have large data packets have a greater impact, such as the 1756-DNB module. • serial port communication

Using the Motion Group Trigger

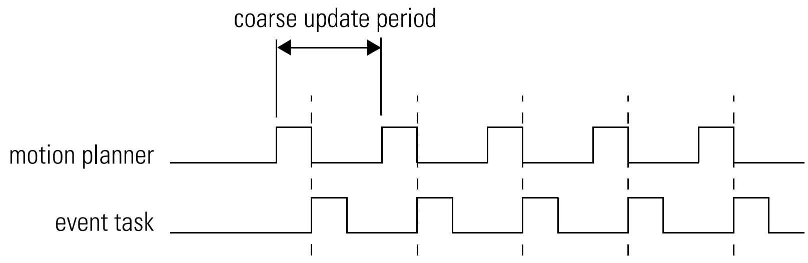
To couple the execution of an event task with the execution of the motion planner, use the *Motion Group Execution* trigger.

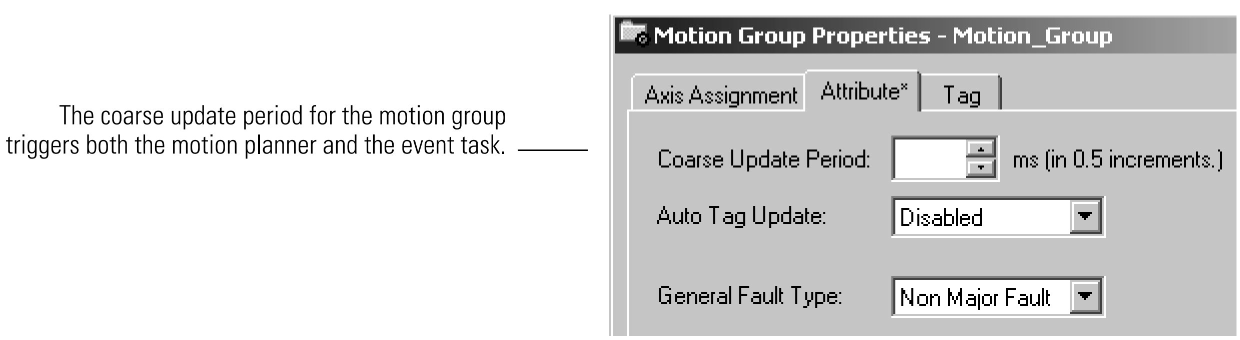


The *Motion Group Execution* trigger works as follows:

- The coarse update period for the motion group triggers the execution of both the motion planner and the event task.
- Because the motion planner interrupts all other tasks, it executes first. If you assign the event task as the highest priority task, it executes immediately after the motion planner.

The following timing diagram shows the relationship between the motion planner and the event task.



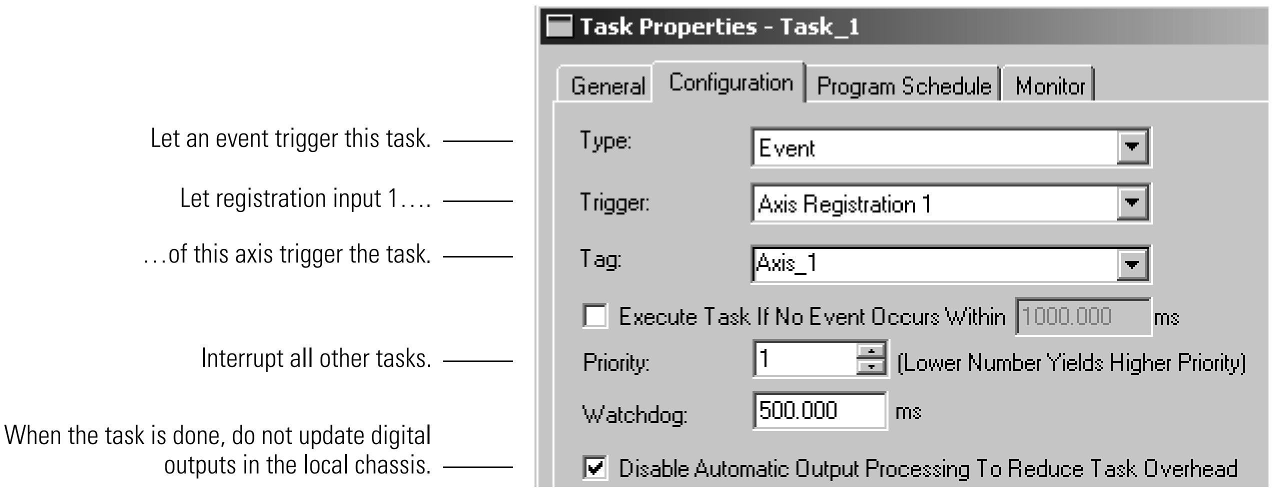


Checklist for a Motion Group Task

For this:		Make sure you:
❑	1. Scan time	Make sure the scan time of the event task is significantly less than the course update period of the motion group. Otherwise, a task overlap could occur.
❑	2. Task priority	Configure the event task as the highest priority task. If a periodic task has a higher priority, the event task may have to wait until the periodic task is done.
❑	3. Number of event tasks	Limit the number of event tasks. Each additional task reduces the processing time that is available for other tasks. This could cause an overlap.
❑	4. Automatic Output Processing	For an event task, you can typically disable automatic output processing (default). This reduces the elapsed time of the task. To verify this decision, see Figure 4.1 on page 4-14.

Using the Axis Registration Trigger

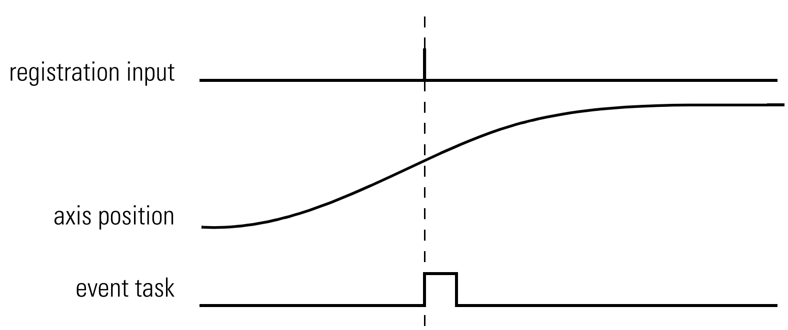
To let the registration input of an axis trigger an event task, use the *Axis Registration (1 or 2)* trigger.



When the specified registration input reaches its trigger condition, it triggers the event task.

- In the configuration of the event task, specify which registration input you want to trigger the task. Choose either *Axis Registration 1* or *Axis Registration 2*.
- You must first arm the registration input using a Motion Arm Registration (MAR) instruction.
- In the MAR instruction, the Trigger Condition operand defines which transition of the registration input (Off → On or On → Off) triggers the event task.
- Once the registration input triggers the task, you have to re-arm the registration input.

The following timing diagram shows the relationship between the registration input and the event task.



Checklist for an Axis Registration Task

<table>
<tr><th colspan="2">For this:</th><th colspan="2">Make sure you:</th></tr>
<tr><td rowspan="4">❑</td><td rowspan="4">1. Registration input</td><td colspan="2">Arm the registration input (MAR instruction). This lets the axis detect the registration input and trigger the event task.
• Initially, arm the registration input to detect the first trigger condition.
• Re-arm the registration input after each execution of the event task.
• Re-arm the registration input fast enough to detect each trigger condition.</td></tr>
<tr><td>If your normal logic is:</td><td>Then:</td></tr>
<tr><td>fast enough to re-arm the registration input between intervals of the trigger condition

E.g., Your normal logic always completes at least 2 scans between registration inputs.</td><td>Arm the registration input within your normal logic, if desired.</td></tr>
<tr><td>not fast enough to re-arm the registration input</td><td>Arm the registration input within the event task.</td></tr>
<tr><td>❑</td><td>2. Task priority</td><td colspan="2">Configure the event task as the highest priority task.

If a periodic task has a higher priority, the event task may have to wait until the periodic task is done.</td></tr>
<tr><td>❑</td><td>3. Number of event tasks</td><td colspan="2">Limit the number of event tasks.

Each additional task reduces the processing time that is available for other tasks. This could cause an overlap.</td></tr>
<tr><td>❑</td><td>4. Automatic Output Processing</td><td colspan="2">For an event task, you can typically disable automatic output processing (default). This reduces the elapsed time of the task.

To verify this decision, see Figure 4.1 on page 4-14.</td></tr>
</table>

EXAMPLE

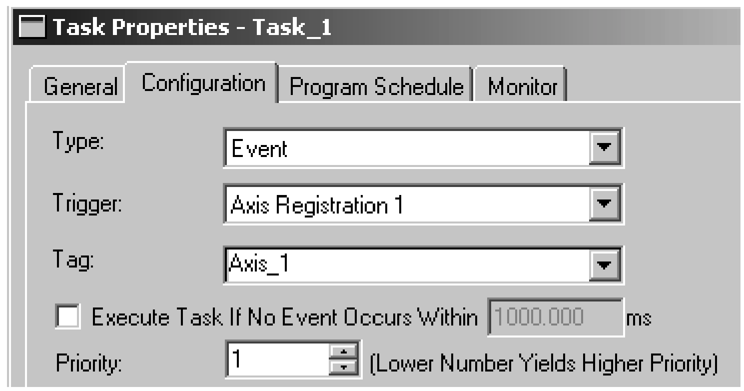
In a line that packages candy bars, you have to make sure that the perforation occurs in the correct location on each bar.

- Each time the registration sensor detects the registration mark, check the accuracy of an axis and perform any required adjustment.
- Due to the speed of the line, you have to arm the registration input within the event task.

A registration sensor is wired as registration input 1…

…for the axis named *Axis_1*.

This event task interrupts all other tasks.



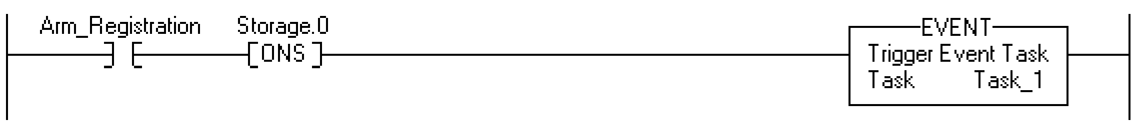
The following logic arms and re-arms the registration input.

Continuous task

If *Arm_Registration* = 1 (system is ready to look for the registration mark) then

The ONS instruction limits the execution of the EVENT instruction to one scan.

The EVENT instruction triggers an execution of *Task_1* (event task).



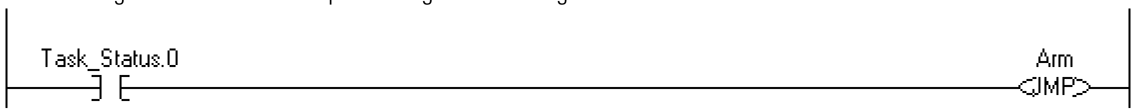
Task_1 (event task)

The GSV instruction sets *Task_Status* (DINT tag) = Status attribute for the event task. In the Instance Name attribute, THIS means the TASK object for the task that the instruction is in (i.e., *Task_1*).

continued on next page

If *Task_Status*.0 = 1 then an EVENT instruction triggered the event task. In the continuous task, the EVENT executes to arm registration for the first time.

The JMP instruction causes the controller to jump its execution to the *Arm* LBL instruction. This skips all the logic of the routine except the rung that arms registration for the axis.



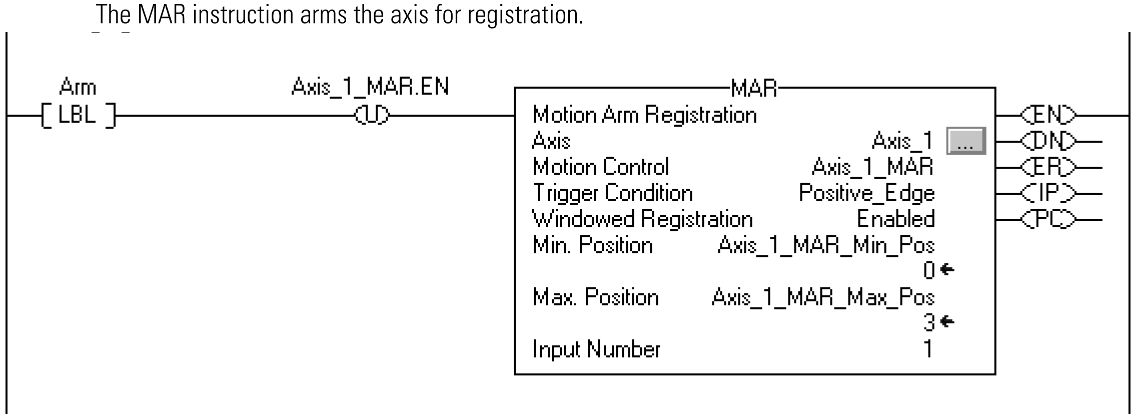
-
- Other logic
-

The MAR instruction executes each time the task executes and arms *Axis_1* for registration.

The OTU instruction sets the EN bit of the MAR instruction = 0.

- The MAR instruction is a transitional instruction.
- To execute the MAR instruction, its rung-condition-in must go from false to true.
- By first clearing the EN bit, the instruction responds as if its rung-condition-in changed from false to true.

The MAR instruction arms the axis for registration.

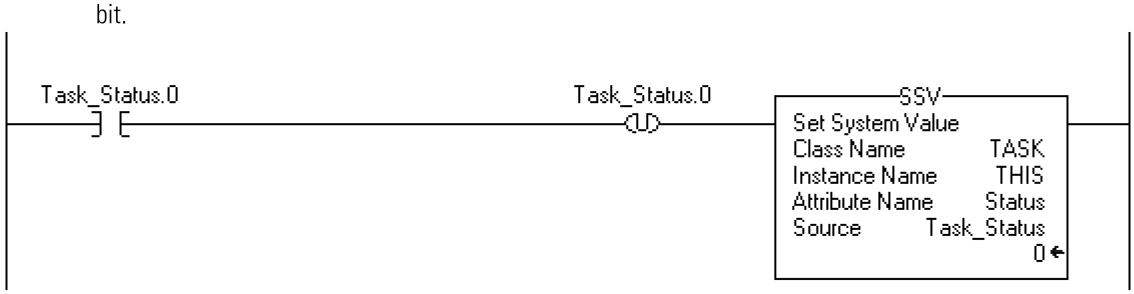


The controller does not clear the bits of the Status attribute once they are set. To use a bit for new status information, you must manually clear the bit.

If *Task_Status*.0 = 1 then clear that bit.

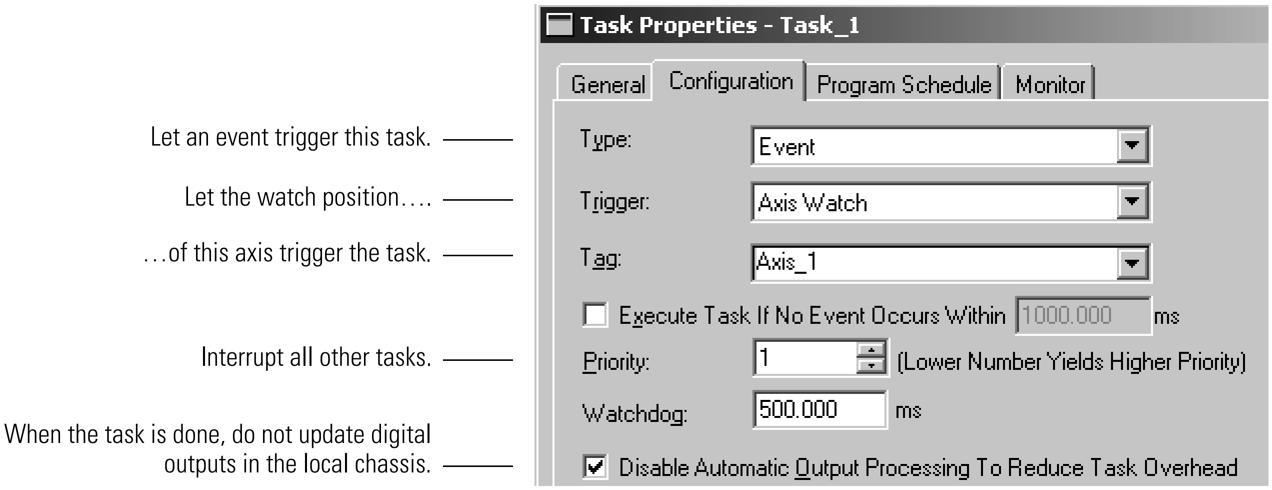
The OTU instruction sets *Task_Status*.0 = 0.

The SSV instruction sets the Status attribute of THIS task (*Task_1*) = *Task_Status*. This includes the cleared bit.



Using the Axis Watch Trigger

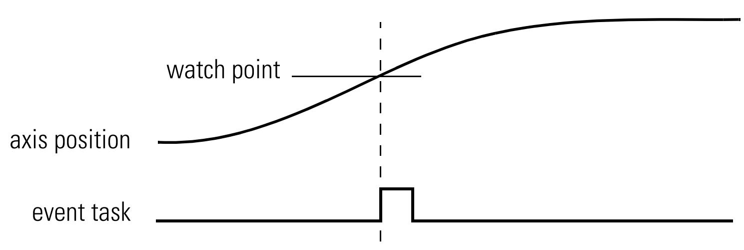
To let the watch position of an axis trigger an event task, use the *Axis Watch* trigger.



When the axis reaches the position that is specified as the watch position, it triggers the event task.

- You must first arm the axis for the watch position using a Motion Arm Watch (MAW) instruction.
- In the MAW instruction, the Trigger Condition operand defines the direction in which the axis must be moving to trigger the event task.
- Once the axis reaches the watch position and triggers the event task, you have to re-arm the axis for the next watch position.

The following timing diagram shows the relationship between the watch position and the event task.



Checklist for an Axis Watch Task

<table>
<tr><th></th><th>For this:</th><th>Make sure you:</th></tr>
<tr><td>❑</td><td>1. Watch position</td><td>Use a MAW instruction to set up a watch position. This lets the axis trigger the event task when it reaches the watch position.
Initially, arm the axis to detect the first watch position.
Once the axis reaches the watch position and triggers the event task, re-arm the axis for the next watch position.
Re-arm the axis fast enough to detect each watch position.
<table>
<tr><th>If your normal logic is:</th><th>Then:</th></tr>
<tr><td>fast enough to re-arm the axis between intervals of the watch position

E.g., Your normal logic always completes at least 2 scans between watch positions.</td><td>Arm the axis within your normal logic, if desired.</td></tr>
<tr><td>not fast enough to re-arm the axis</td><td>Arm the axis within the event task.</td></tr>
</table></td></tr>
<tr><td>❑</td><td>2. Task priority</td><td>Configure the event task as the highest priority task.

If a periodic task has a higher priority, the event task may have to wait until the periodic task is done.</td></tr>
<tr><td>❑</td><td>3. Number of event tasks</td><td>Limit the number of event tasks.

Each additional task reduces the processing time that is available for other tasks. This could cause an overlap.</td></tr>
<tr><td>❑</td><td>4. Automatic Output Processing</td><td>For an event task, you can typically disable automatic output processing (default). This reduces the elapsed time of the task.

To verify this decision, see Figure 4.1 on page 4-14.</td></tr>
</table>

EXAMPLE

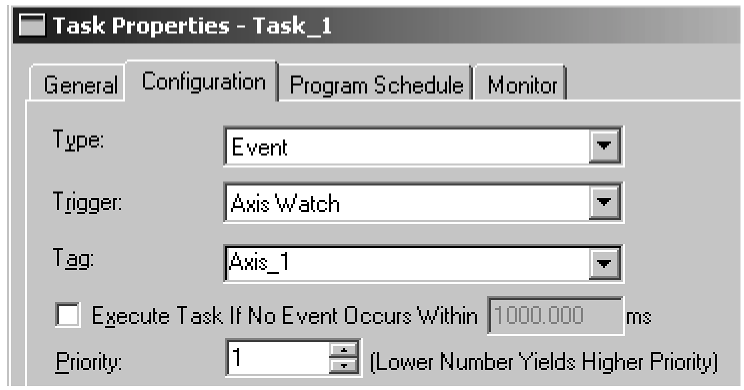
At the labeling station of a bottling line, you want to check the position of the label on the bottle.

- When the axis reaches the position that is defined as the watch point, check the label.and perform any required adjustment.
- Due to the speed of the line, you have to arm axis for the watch position within the event task.

Let the watch position…

…for the axis named *Axis_1* trigger the event task.

This event task interrupts all other tasks.



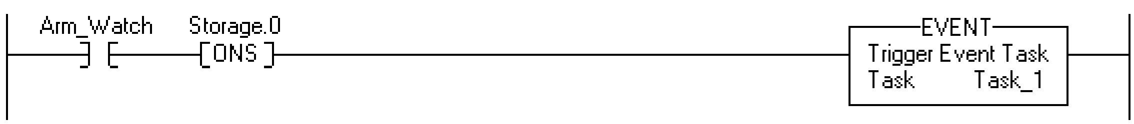
The following logic arms and re-arms the axis for the watch position.

Continuous task

If *Arm_Watch* = 1 (system is ready to set up a watch position) then

The ONS instruction limits the execution of the EVENT instruction to one scan.

The EVENT instruction triggers an execution of *Task_1* (event task).



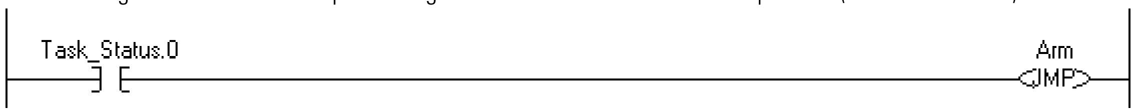
Task_1 (event task)

The GSV instruction sets *Task_Status* (DINT tag) = Status attribute for the event task. In the Instance Name attribute, THIS means the TASK object for the task that the instruction is in (i.e., *Task_1*).

continued on next page

If *Task_Status*.0 = 1 then an EVENT instruction triggered the event task. In the continuous task, the EVENT executes to set up the watch position for the first time.

The JMP instruction causes the controller to jump its execution to the *Arm* LBL instruction. This skips all the logic of the routine except the rung that arms the axis for the watch position (MAW instruction).



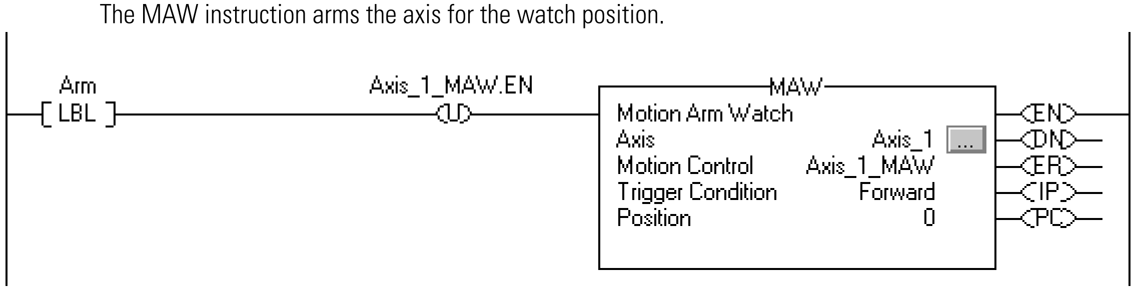
-
- Other logic
-

The MAW instruction executes each time the task executes and arms *Axis_1* for the watch position.

The OTU instruction sets the EN bit of the MAW instruction = 0.

- The MAW instruction is a transitional instruction.
- To execute the MAW instruction, its rung-condition-in must go from false to true.
- By first clearing the EN bit, the instruction responds as if its rung-condition-in changed from false to true.

The MAW instruction arms the axis for the watch position.

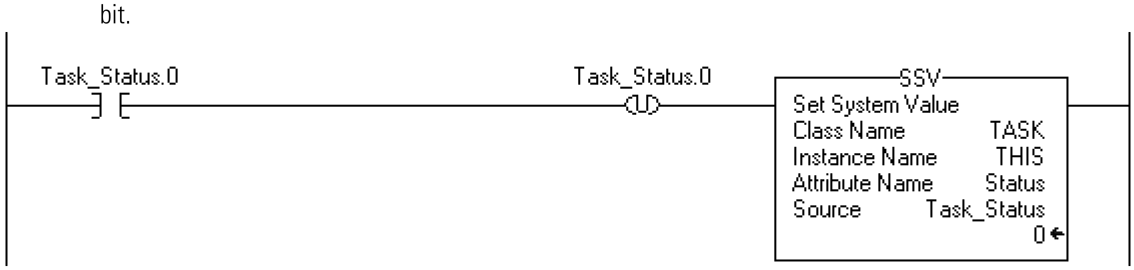


The controller does not clear the bits of the Status attribute once they are set. To use a bit for new status information, you must manually clear the bit.

If *Task_Status*.0 = 1 then clear that bit.

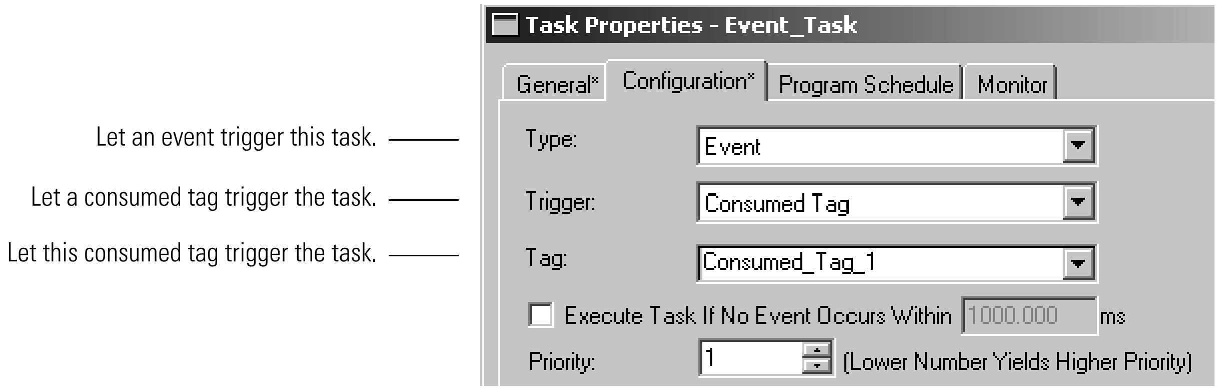
The OTU instruction sets *Task_Status*.0 = 0.

The SSV instruction sets the Status attribute of THIS task (*Task_1*) = *Task_Status*. This includes the cleared bit.

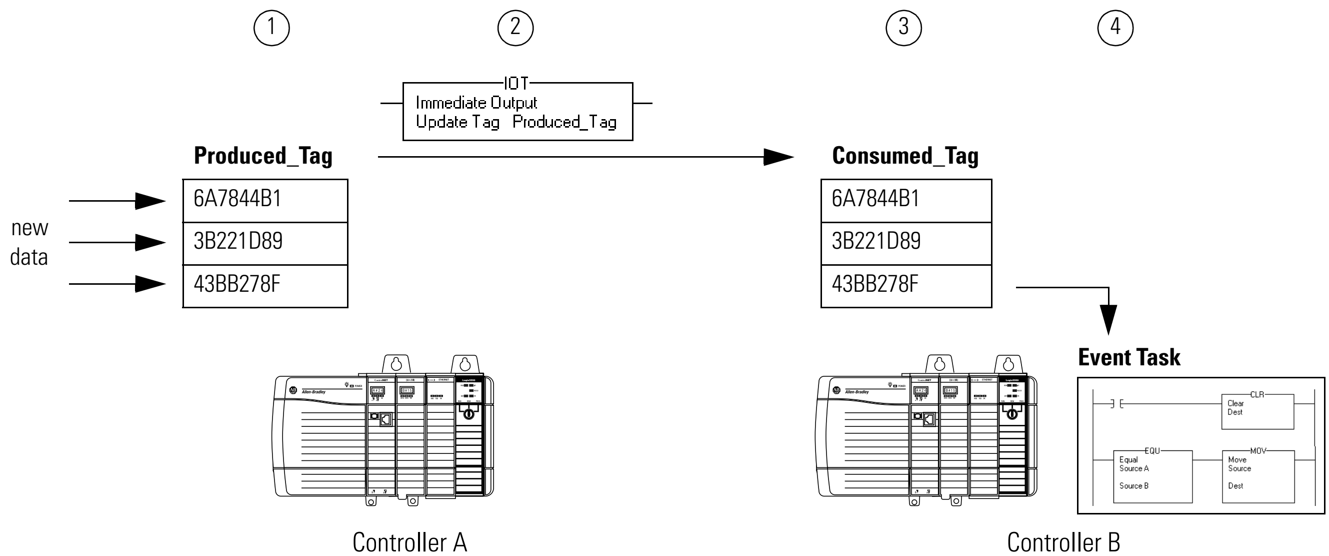


Using the Consumed Tag Trigger

To trigger an event task based on data from a consumed tag, use the *Consumed Tag* trigger.



A produced/consumed tag relationship can pass an event trigger along with data to a consumer controller. Typically, you use an Immediate Output (IOT) instruction to send the event trigger to the consumer controller.



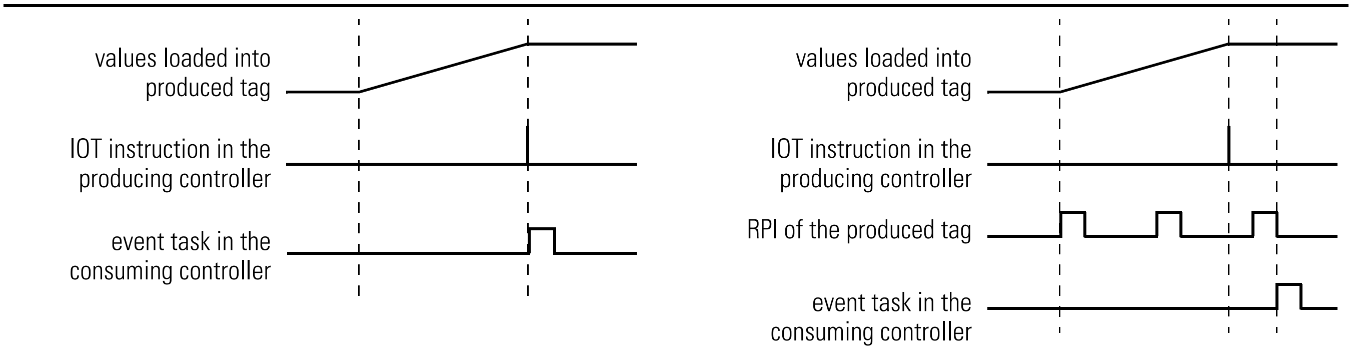
Description:	
1	In Controller A, logic updates the values of a produced tag.
2	Once the update is complete, the Controller A executes an IOT instruction to send the data and an event trigger to Controller B.
3	Controller B consumes the new data.
4	After Controller B updates the consumed tag, it executes the event task.

The type of network between the controllers determines when the consuming controller receives the new data and event trigger via the IOT instruction.

With this controller:	Over this network:	The consuming device receives the data and event trigger:
ControlLogix	backplane	immediately
	EtherNet/IP network	immediately
	ControlNet network	within the actual packet interval (API) of the consumed tag (connection)
SoftLogix5800	You can produce and consume tags only over a ControlNet network.	within the actual packet interval (API) of the consumed tag (connection)

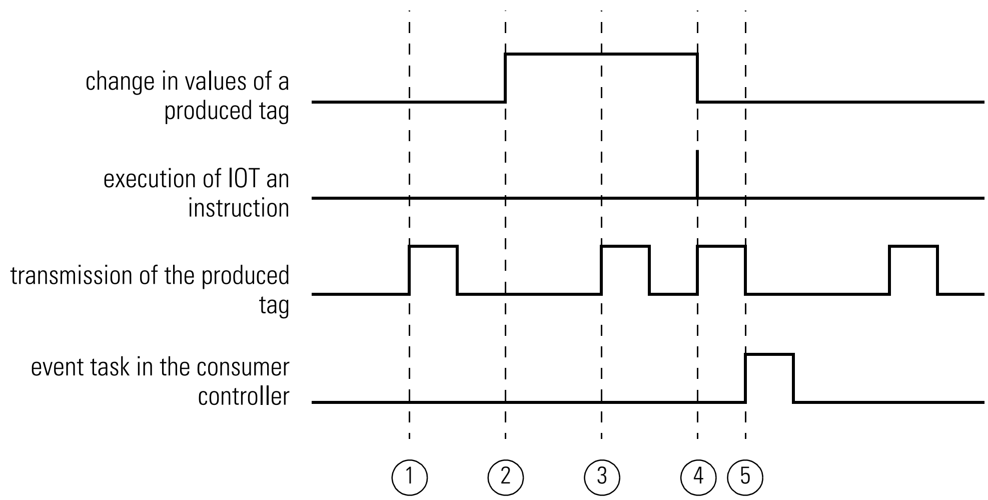
The following diagrams compare the receipt of data via an IOT instruction over EtherNet/IP and ControlNet networks.

EtherNet/IP network (ControlLogix controller) **ControlNet network**



Maintain the Integrity of Data

An event task with a consumed tag trigger provides a simple mechanism to pass data to a controller and ensure that the controller doesn't use the data while the data is changing.

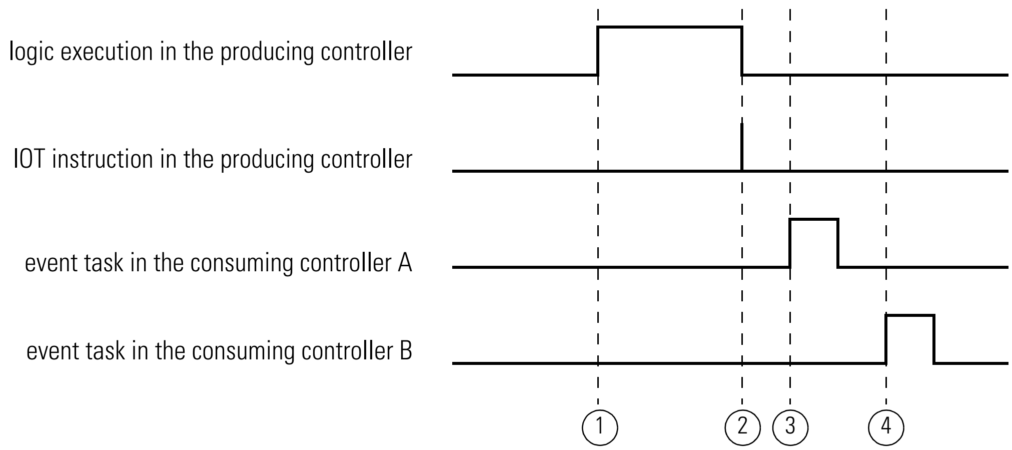


Description:	
1	RPI occurs for the produced tag. The produced tag transfers old data to the consuming controller.
2	The producer controller starts to update the values of the produced tag.
3	RPI occurs again for the produced tag. The produced tag transfers a mix of old and new data to the consuming controller.
4	The producer controller finishes updating the values of the produced tag. The producer controller executes an Immediate Output (IOT) instruction. The produced tag immediately transfers all the new data to the consuming controller.
5	When the consumer controller receives all the data, it executes its event task.

Although the producing controller executes the IOT instruction immediately after it loads new data, the event task is not triggered (in the consuming controller) until the consuming controller has received all the new data. This ensures that the controller operates on a complete packet of new data.

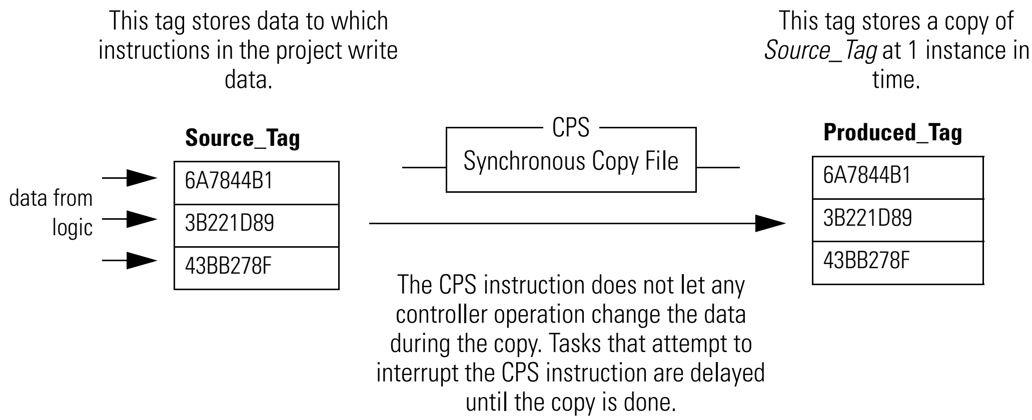
Synchronize Multiple Controllers

You can also use the produced/consumed tag relationship to synchronize controllers. In this case, the produced/consumed tag serves only as a triggering mechanism.



Description:	
1	The first controller executes an action with which other controllers need to stay synchronized.
2	When the action is done, the controller executes an IOT instruction. The IOT instruction uses a produced tag as its target.
3	When controller A receives the produced tag, it executes its event task.
4	When controller B receives the produced tag, it executes its event task.

Checklist for the Producer Controller

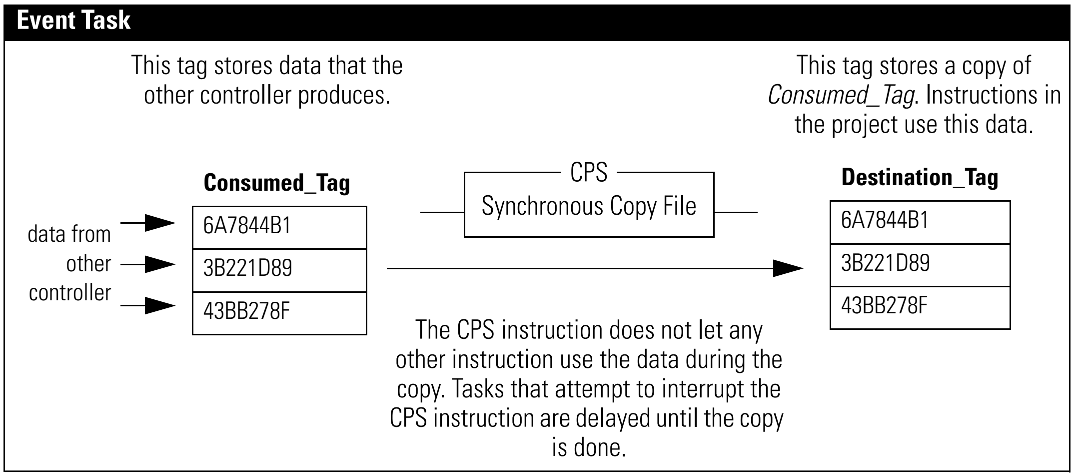
<table>
<tr><th></th><th>For this:</th><th>Make sure you:</th></tr>
<tr><td>❑</td><td>1. Buffer of data</td><td>If you want to send a complete image of data at one instance in time, then produce a copy of the data, as shown below:

</td></tr>
<tr><td>❑</td><td>2. Produced tag properties</td><td>In the Connection properties of the produced tag, select (check) the following check box:
Check this check box.


If you leave this box cleared (unchecked), the producing controller triggers the event task at the end of any task that automatically updates local outputs. In other words, the task scan will trigger the event in addition to the IOT instruction.</td></tr>
<tr><td>❑</td><td>3. IOT instruction</td><td>Use an IOT instruction at the point in your logic where you want to trigger the event task.

The IOT instruction overrides the RPI for the tag and immediately sends the event trigger and the data of the tag.</td></tr>
</table>

Checklist for the Consumer Controller

	For this:	Make sure you:
❑	1. Buffer of data	If you want to make sure that the controller does not use data from the consumed tag while the data is changing, use a copy of the consumed tag. Use the event task to copy the data, as shown below:



❑	2. Task priority	Configure the event task as the highest priority task. If a periodic task has a higher priority, the event task may have to wait until the periodic task is done.
❑	3. Number of event tasks	Limit the number of event tasks. Each additional task reduces the processing time that is available for other tasks. This could cause an overlap.
❑	4. Automatic Output Processing	For an event task, you can typically disable automatic output processing (default). This reduces the elapsed time of the task. To verify this decision, see Figure 4.1 on page 4-14.

EXAMPLE

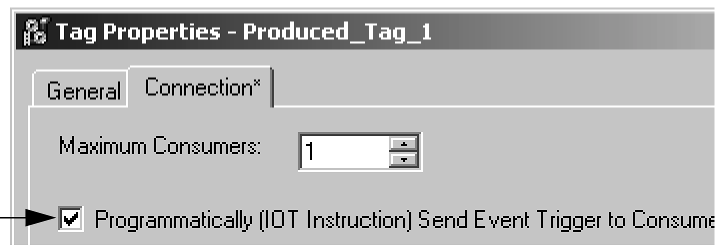
As parts move along a production line, each station requires production specifications for the part at its station. To make sure that a station doesn't act on old data, an event task signals the arrival of new data for the next part.

Producer Controller

This controller controls station 24 and produces data for the next station (station 25). To signal the transmission of new data, the controller uses the following elements:

Produced Tag Properties

Produced_Tag is configured to update its event trigger via an IOT instruction.

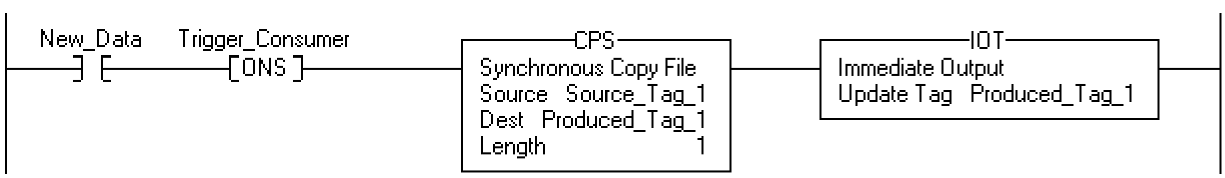


Ladder Logic

If *New_Data* = on, then the following occurs for one scan:

The CPS instruction sets *Produced_Tag_1* = *Source_Tag_1*.

The IOT instruction updates *Produced_Tag_1* and sends this update to the consuming controller (station 25). When the consuming controller receives this update, it triggers the associated event task in that controller.



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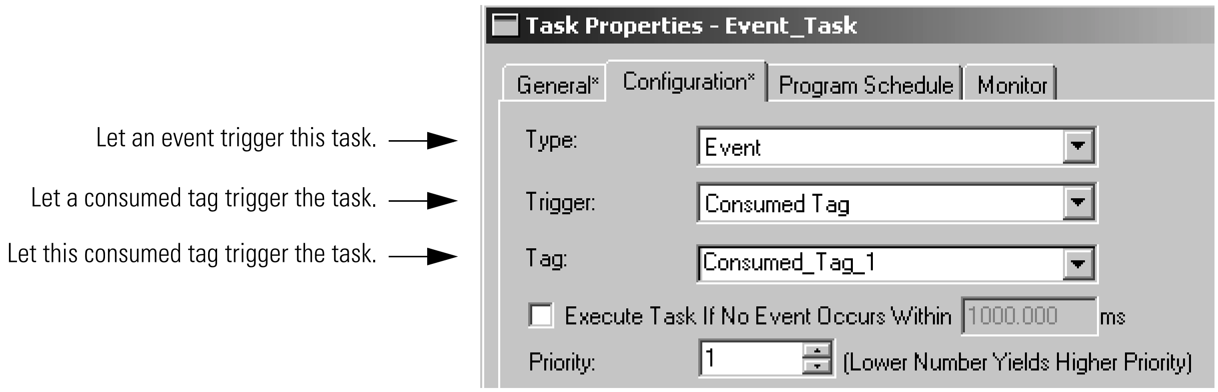
Consumer Controller

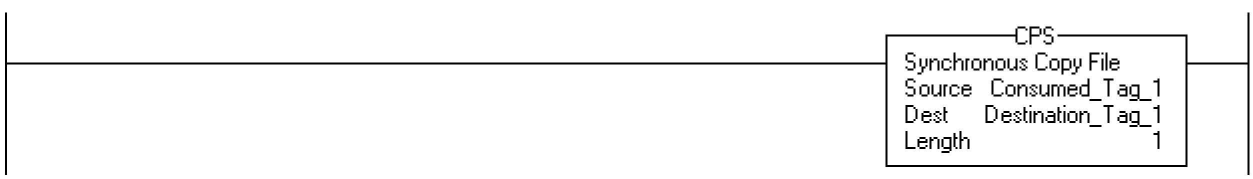
The controller at station 25 uses the data produced by station 24. To determine when new data has arrived, the controller uses an event task.

Event Task Properties



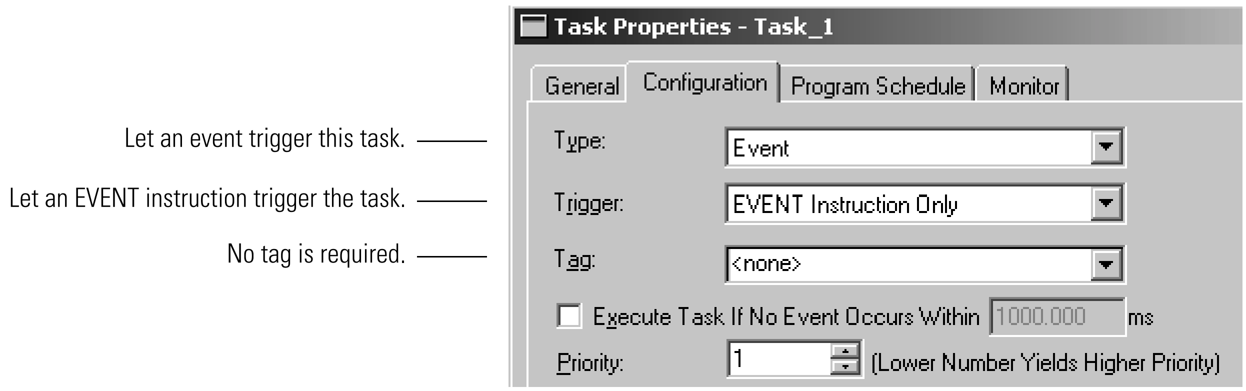
Ladder Logic in the Event Task

When the event task executes, the CPS instruction sets *Destination_Tag_1 = Consumed_Tag_1* (the values from the producing controller). The remaining logic in this controller uses the values from *Destination_Tag_1*.

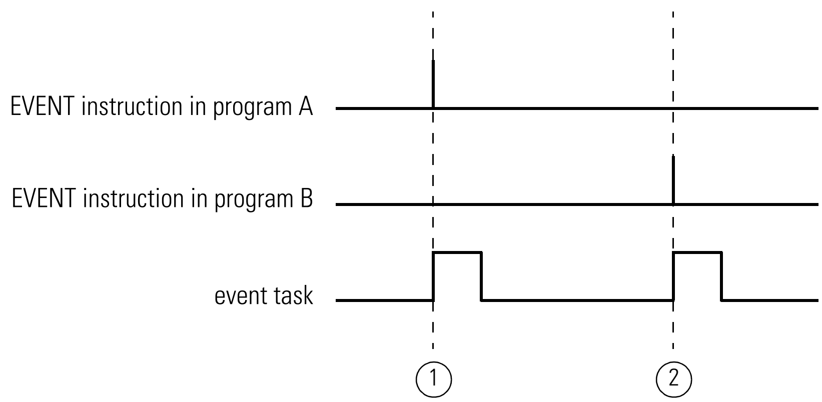


Using the EVENT Instruction Trigger

To trigger an event task based on conditions in your logic, use the *EVENT Instruction Only* trigger.



The *EVENT Instruction Only* trigger requires that you use a Trigger Event Task (EVENT) instruction to trigger the task. You can use an EVENT instruction from multiple points in your project. Each time the instruction executes, it triggers the specified event task.



Description:	
1	Program A executes an EVENT instruction. The event task that is specified by the EVENT instruction executes one time.
2	Program B executes an EVENT instruction. The event task that is specified by the EVENT instruction executes one time.

Programmatically Determine if an EVENT Instruction Triggered a Task

To determine if an EVENT instruction triggered an event task, use a Get System Value (GSV) instruction to monitor the Status attribute of the task.

Table 4.3 Status Attribute of the TASK Object

<table>
<tr><th>Attribute:</th><th>Data Type:</th><th>Instruction:</th><th colspan="2">Description:</th></tr>
<tr><td rowspan="5">Status</td><td rowspan="5">DINT</td><td rowspan="5">GSV

SSV</td><td colspan="2">Provides status information about the task. Once the controller sets a bit, you must manually clear the bit to determine if another fault of that type occurred.</td></tr>
<tr><td>To determine if:</td><td>Examine this bit:</td></tr>
<tr><td>An EVENT instruction triggered the task (event task only).</td><td>0</td></tr>
<tr><td>A timeout triggered the task (event task only).</td><td>1</td></tr>
<tr><td>An overlap occurred for this task.</td><td>2</td></tr>
</table>

The controller does not clear the bits of the Status attribute once they are set.

- To use a bit for new status information, you must manually clear the bit.
- Use a Set System Value (SSV) instruction to set the attribute to a different value.

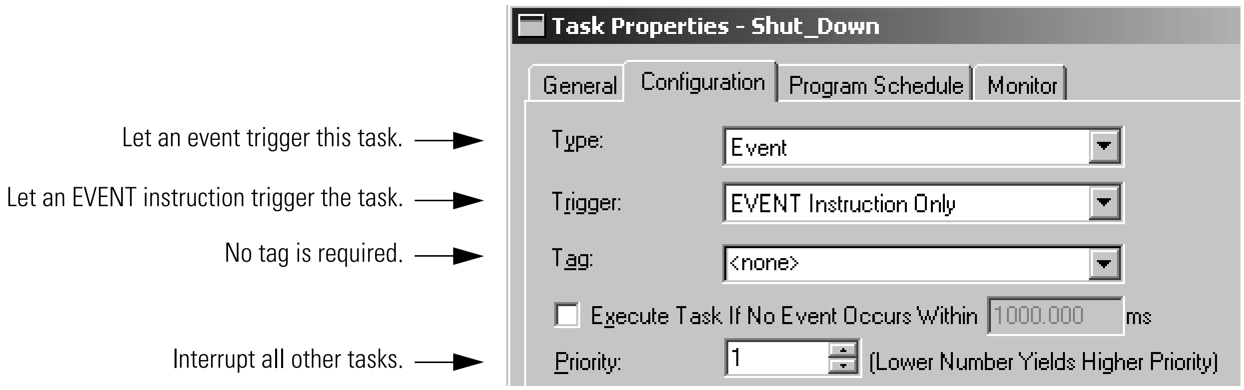
Checklist for an EVENT Instruction Task

For this:		Make sure you:
❑	1. EVENT instruction	Use a Trigger Event Task (EVNT) instruction at each point in your logic that you want to trigger the event task.
❑	2. Task priority	Configure the event task as the highest priority task. If a periodic task has a higher priority, the event task may have to wait until the periodic task is done.
❑	3. Number of event tasks	Limit the number of event tasks. Each additional task reduces the processing time that is available for other tasks. This could cause an overlap.
❑	4. Automatic Output Processing	For an event task, you can typically disable automatic output processing (default). This reduces the elapsed time of the task. To verify this decision, see Figure 4.1 on page 4-14.

EXAMPLE

A controller uses multiple programs but a common shut down procedure. Each program uses a program-scoped tag named *Shut_Down_Line* that turns on if the program detects a condition that requires a shut down.

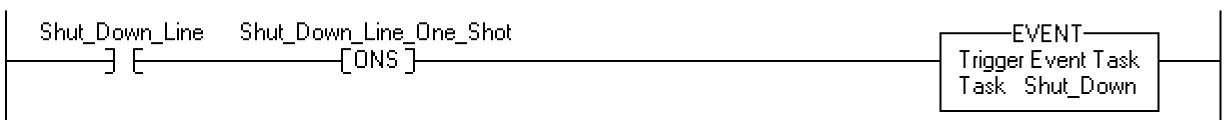
Event Task Properties



Ladder Logic in Program_A

If *Shut_Down_Line* = on (conditions require a shut down) then

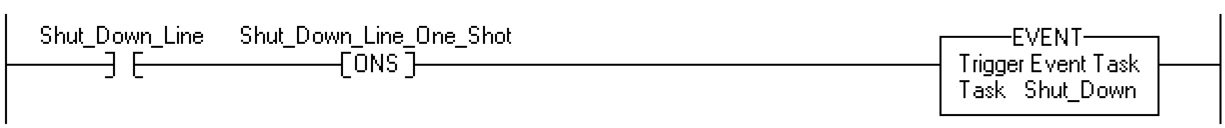
Execute the *Shut_Down* task one time



Ladder Logic in Program_B

If *Shut_Down_Line* = on (conditions require a shut down) then

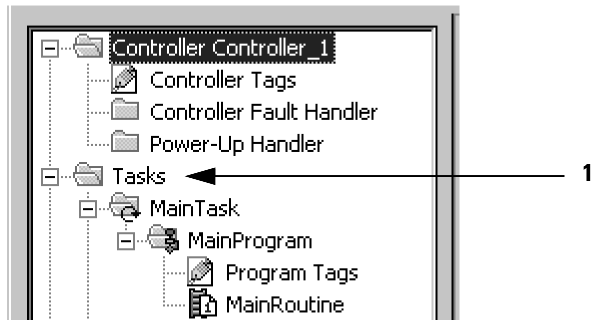
Execute the *Shut_Down* task one time



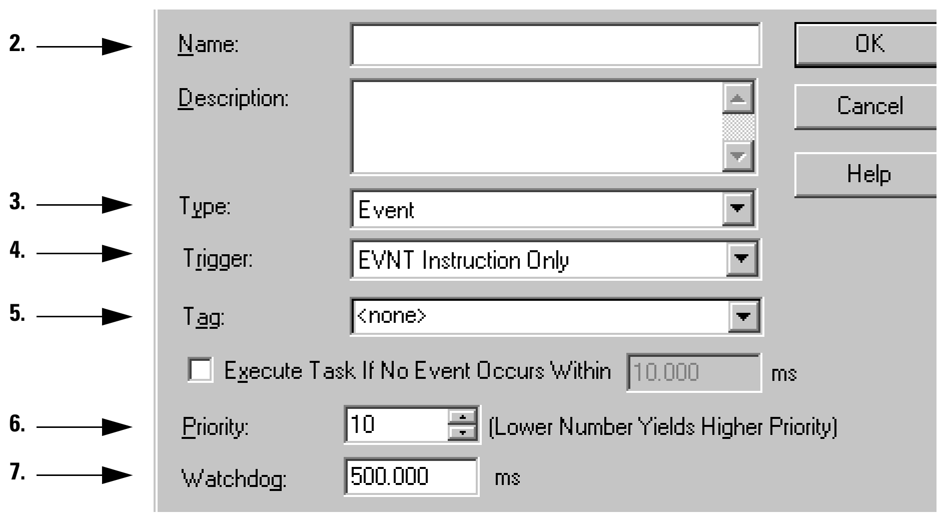
Create a Task

Create an Event Task

To create an event task:



1. In the controller organizer, right-click the *Tasks* folder and choose *New Task*.



2. In the *Name* text box, type a **name** for the task.

3. From the *Type* list, choose *Event*.

4. From the *Trigger* list, choose the trigger for the task.

5. From the *Tag* list, choose the tag that contains the triggering data.

6. In the *Priority* text box, type the **priority** for the task.

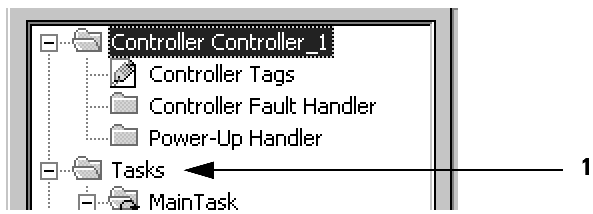
7. In the *Watchdog* text box, type the **watchdog** time for the task.

8. Choose 

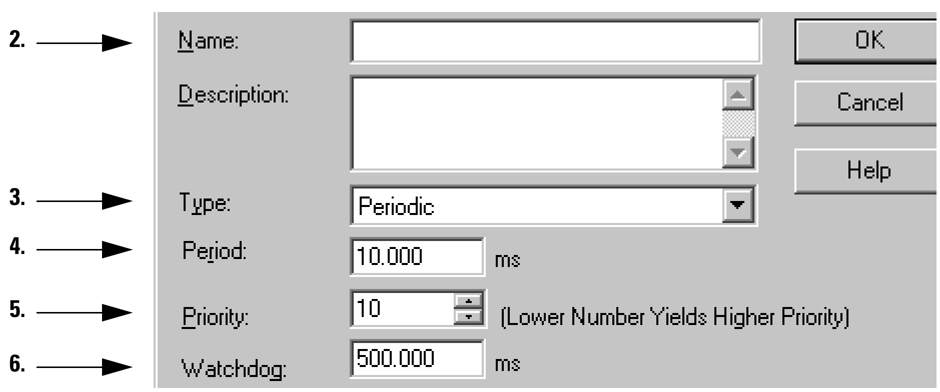
Create a Periodic Task

A periodic task performs a function or functions at a specific rate.

IMPORTANT	Ensure that the time period is longer than the sum of the execution times of all the programs assigned to the task. • If the controller detects that a periodic task trigger occurs for a task that is already operating, a minor fault occurs (overlap). • Priorities and execution times of other tasks may also cause an overlap.



1. In the controller organizer, right-click the *Tasks* folder and choose *New Task*.



2. In the *Name* text box, type a **name** for the task.

3. From the *Type* list, choose *Periodic* (default).

4. In the *Period* text box, type the period at which you want the task to execute.

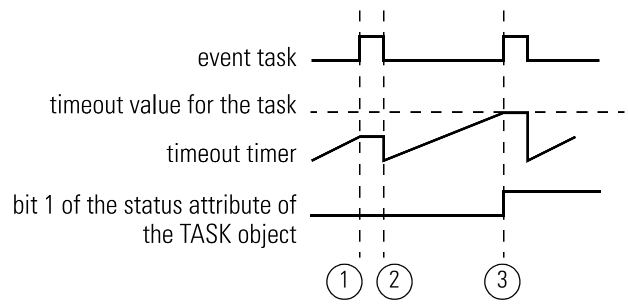
5. In the *Priority* text box, type the **priority** for the task.

6. In the *Watchdog* text box, type the **watchdog** time for the task.

7. Choose OK

Define a Timeout Value for an Event Task

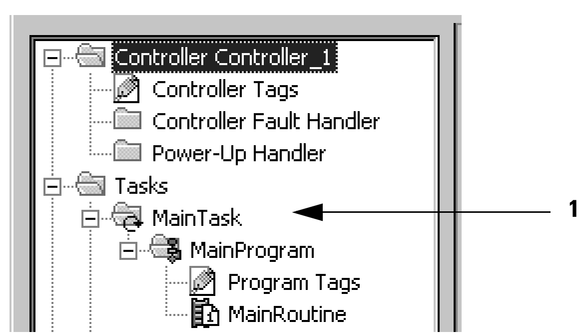
If you want your event task to automatically execute if the trigger fails to occur within a certain time, assign a timeout value to the task. When the event task is done, its timeout timer begins to increment. If the timer reaches its preset value before the event task is triggered, the event task automatically executes.



Description:	
1	Event task executes. Timeout time stops incrementing.
2	Event task is done. Timeout timer resets and begins incrementing.
3	Timeout timer reaches the timeout value. Event task automatically executes. In the Status attribute of the TASK object, bit 1 turns on.

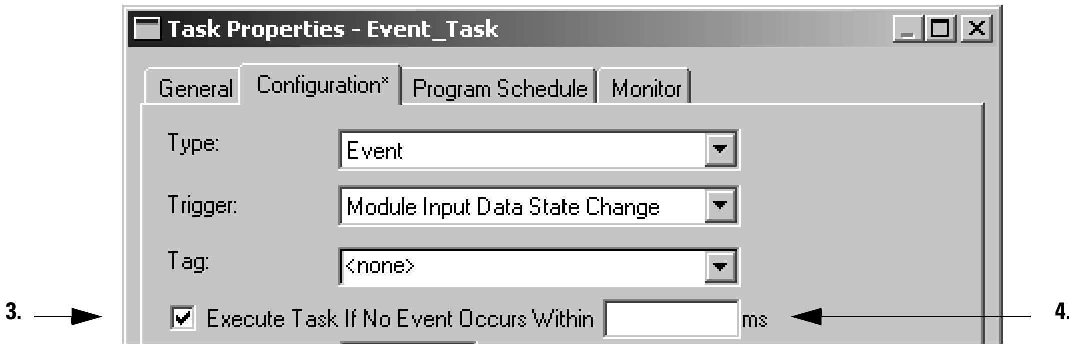
Assign a Timeout Value to an Event Task

To assign a timeout value to an event task:



1. In the controller organizer, right-click the event task and choose *Properties*.

2. Click the *Configuration* tab.



3. Check the *Execute Task If No Event Occurs Within* check box.

4. Type the timeout value, in milliseconds.

5. Choose OK

Programmatically Configure a Timeout

To programmatically configure a timeout, use a Get System Value (GSV) instruction to access the following attributes of the task.

Table 4.4 Status Attribute of the TASK Object

Attribute:	Data Type:	Instruction:	Description:	
Rate	DINT	GSV SSV	**If the task type is:**	**Then the Rate attribute specifies the:**
			periodic	Period for the task. Time is in microseconds.
			event	The timeout value for the task. Time is in microseconds.
EnableTimeOut	DINT	GSV SSV	Enables or disables the timeout function of an event task.	
			To:	**Set the attribute to:**
			disable the timeout function	0 (default)
			enable the timeout function	1 (or any non-zero value)

EXAMPLE

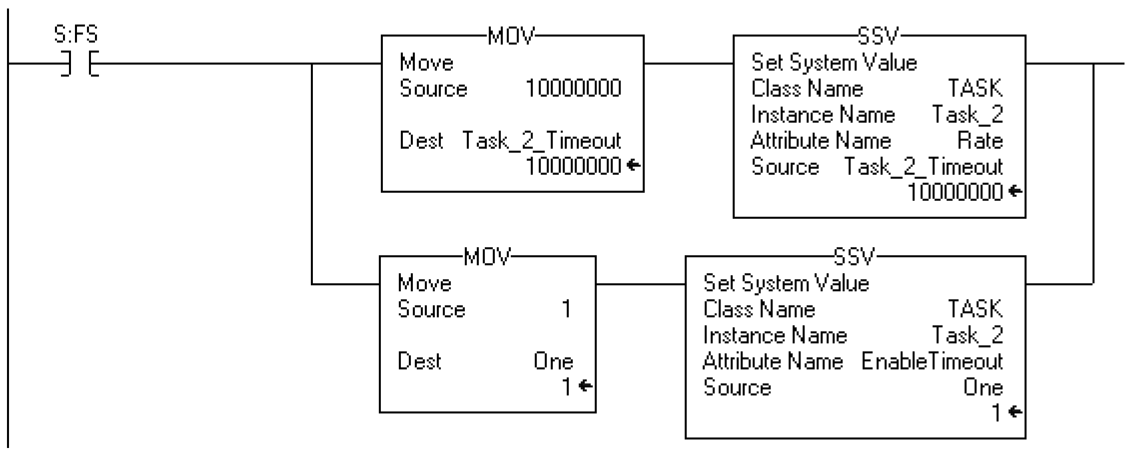
Programmatically Configure a Timeout

To make sure that a timeout value is always defined and enabled for an event task, the following logic configures the timeout when the controller enters the run mode.

If S:FS = 1 (first scan) then set the timeout value for *Task_2* and enable the timeout function:

1. The first MOV instruction sets *Task_2_Timeout* = 10000000 µs (DINT value). Then the SSV instruction sets the Rate attribute for *Task_2* = *Task_2_Timeout*. This configures the timeout value for the task.

2. The second MOV instruction sets *One* = 1 (DINT value). Then the SSV instruction sets the EnableTimeout attribute for *Task_2* = *One*. This enables the timeout function for the task.



Programmatically Determine if a Timeout Occurs

To determine if an event task executed due to a timeout, use a Get System Value (GSV) instruction to monitor the Status attribute of the task.

Table 4.5 Status Attribute of the TASK Object

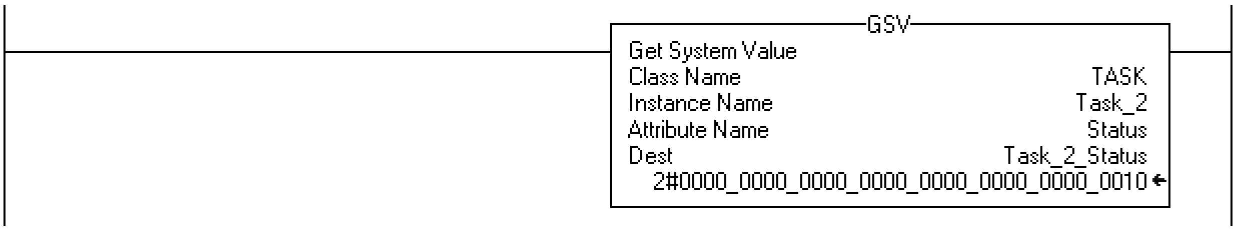
Attribute:	Data Type:	Instruction:	Description:	
Status	DINT	GSV SSV	Provides status information about the task. Once the controller sets a bit, you must manually clear the bit to determine if another fault of that type occurred.	
			To determine if:	**Examine this bit:**
			An EVENT instruction triggered the task (event task only).	0
			A timeout triggered the task (event task only).	*1*
			An overlap occurred for this task.	2

EXAMPLE

Define a Timeout Value for an Event Task

If a timeout occurs for the event task, communication with the triggering device might have failed. This requires the process to shut down. To shut down the controller, the event task calls the fault routine for the program and supplies a user-defined fault code (999 in this example).

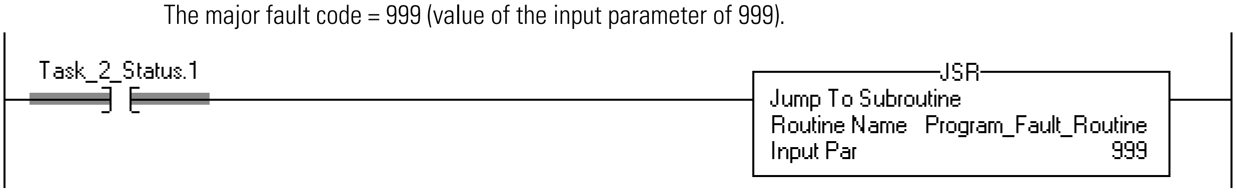
1. The GSV instruction sets *Task_2_Status* = Status attribute for *Task_2* (DINT value).



2. If *Task_2_Status.1* = 1, then a timeout occurred so shut down the controller and set the major fault code to 999:

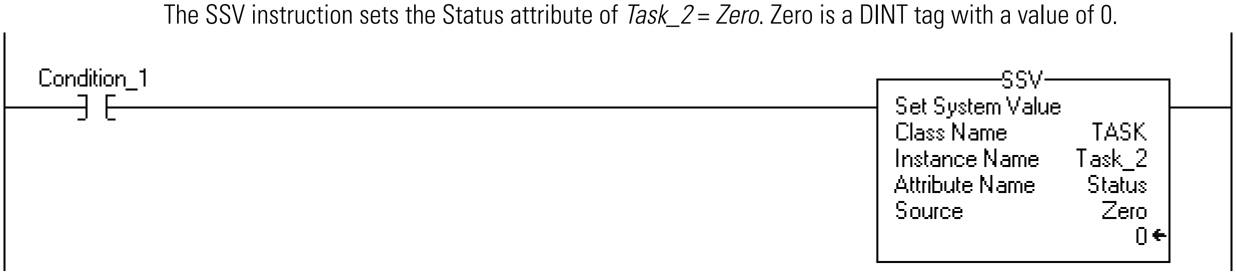
   The JSR instruction calls the fault routine for the program. This produces a major fault.

   The major fault code = 999 (value of the input parameter of 999).



3. If *Condition_1* = 1, then clear the bits of the Status attribute for *Task_2*:

   The SSV instruction sets the Status attribute of *Task_2* = *Zero*. Zero is a DINT tag with a value of 0.



For more information on shutting down the controller, see "Create a User-Defined Major Fault"on page 15-13.

Notes:

Design a Sequential Function Chart

When to Use This Procedure

Use this procedure to design a **sequential function chart (SFC)** for your process or system. An SFC is similar to a flowchart of your process. It defines the steps or states through which your system progresses. Use the SFC to:

- organize the functional specification for your system
- program and control your system as a series of steps and transitions

By using an SFC to specify your process, you gain these advantages:

- Since an SFC is a graphical representation of your process, it is easier to organize and read than a textual version. In addition, RSLogix 5000 software lets you:
  - add notes that clarify steps or capture important information for use later on
  - print the SFC to share the information with other individuals
- Since Logix5000 controllers support SFCs, you do not have to enter the specification a second time. You are programming your system as you specify it.

By using an SFC to program your process, you gain these advantages:

- graphical division of processes into its major logic pieces (steps)
- faster repeated execution of individual pieces of your logic
- simpler screen display
- reduced time to design and debug your program
- faster and easier troubleshooting
- direct access to the point in the logic where a machine faulted
- easy updates and enhancements

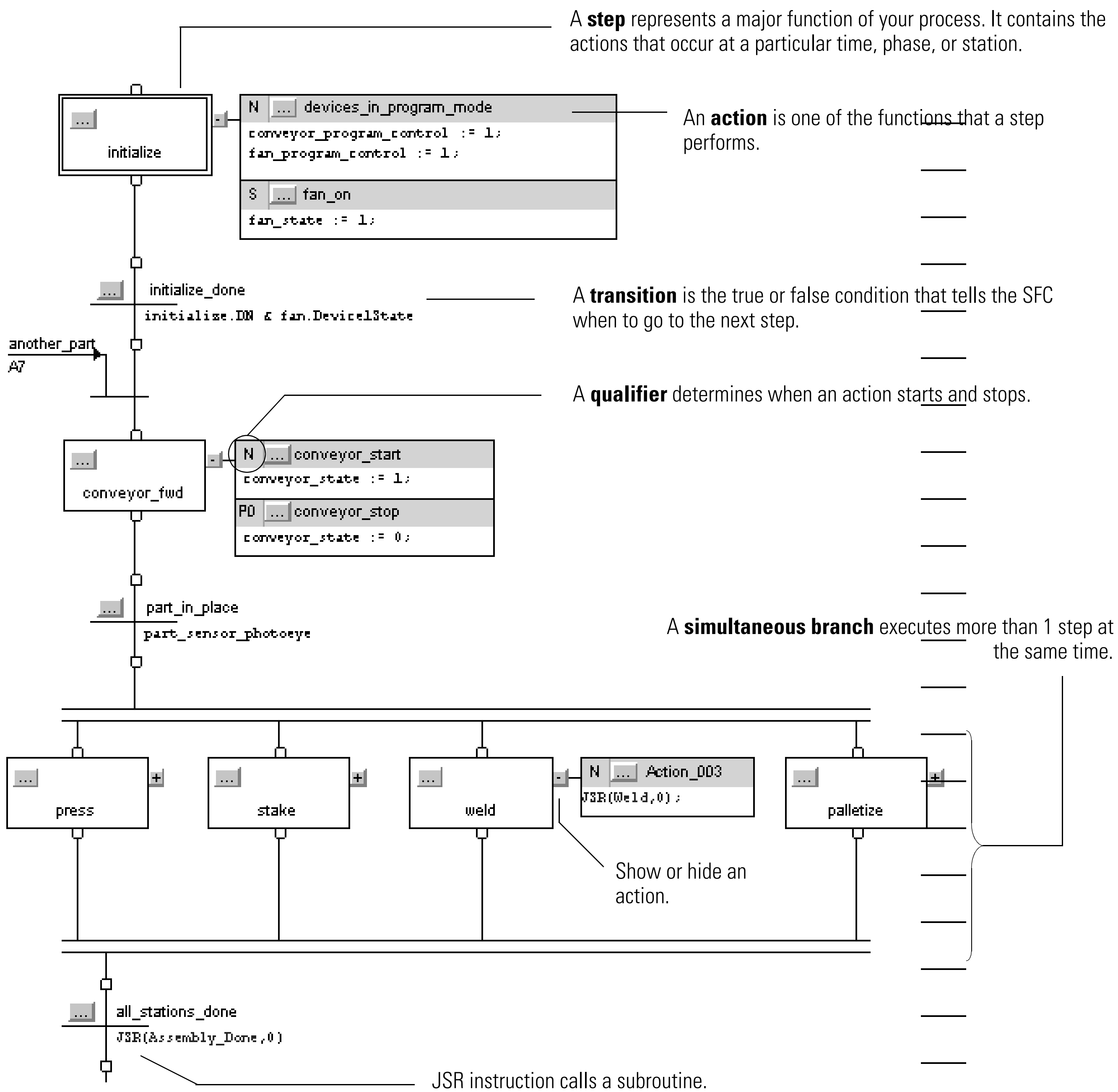
How to Use This Procedure

Typically, the development of an SFC is an iterative process. If you prefer, you can use RSLogix 5000 software to draft and refine your SFC. For specific procedures on how to enter an SFC, see “Program a Sequential Function Chart” on page 6-1.

What is a Sequential Function Chart?

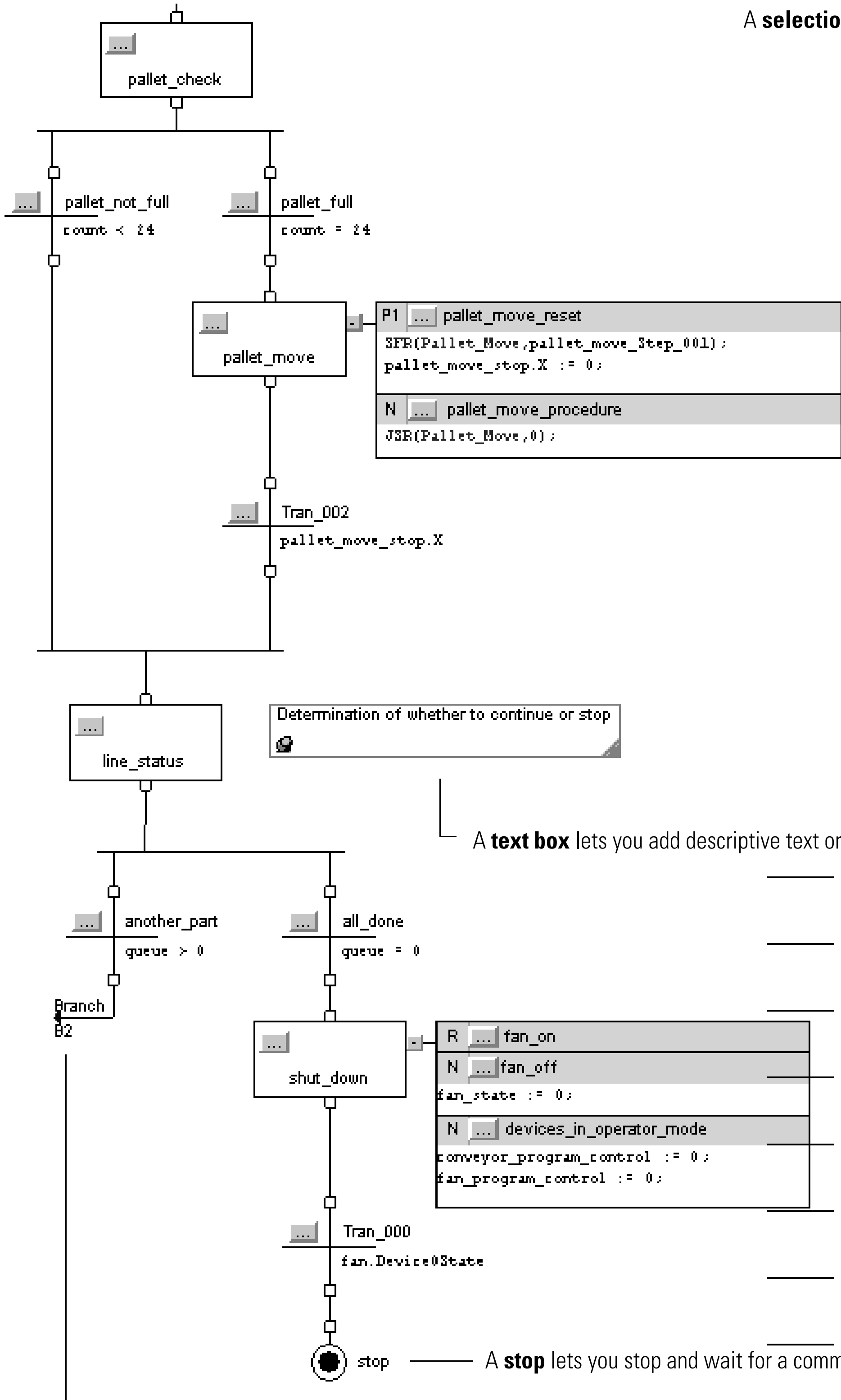
A **sequential function chart** (SFC) is similar to a flowchart. It uses steps and transitions to perform specific operations or actions. Figure 5.1 and Figure 5.2 is an example that shows the elements of an SFC:

Figure 5.1 SFC Example



(continued on next page)

Figure 5.2 SFC Example (continued from previous page)



A **selection branch** chooses between different execution paths.

A **text box** lets you add descriptive text or notes to your SFC.

A **stop** lets you stop and wait for a command to restart.

A **wire** connects one element to another element anywhere on the chart. This wire takes you to the *conveyor* step on Figure 5.1 on the previous page.

How to Design an SFC: Overview

To design an SFC, you perform these tasks:

- ☐ Define the Tasks
- ☐ Choose How to Execute the SFC
- ☐ Define the Steps of the Process
- ☐ Organize the Steps
- ☐ Add Actions for Each Step
- ☐ Describe Each Action in Pseudocode
- ☐ Choose a Qualifier for an Action
- ☐ Define the Transition Conditions
- ☐ Transition After a Specified Time
- ☐ Turn Off a Device at the End of a Step
- ☐ Keep Something On From Step-to-Step
- ☐ End the SFC
- ☐ Nest an SFC
- ☐ Configure When to Return to the OS/JSR
- ☐ Pause or Reset an SFC

The remaining sections of this chapter describe in detail how to perform each task.

Define the Tasks

The first step in the development of an SFC is to separate the configuration and regulation of devices from the commands to those devices. Logix5000 controllers let you divide your project into one **continuous task** and multiple **periodic tasks** and **event tasks**.

1. Organize your project as follows:

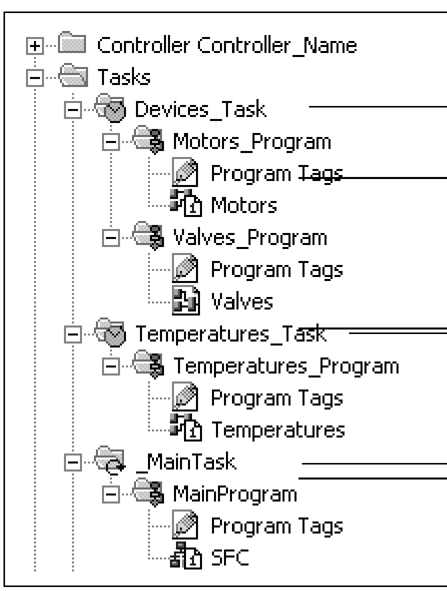
These functions:	Go here:
configure and regulate devices	periodic task
command a device to a specific state	SFC in the continuous task
sequence the execution of your process	

2. For those functions that go in a periodic task, group the functions according to similar update rates. Create a periodic task for each update rate.

   For example, your 2-state devices may require faster updates than your PID loops. Use separate periodic tasks for each.

The following example shows a project that uses two periodic tasks to regulate motors, valves, and temperature loops. The project uses an SFC to control the process.

EXAMPLE Define the Tasks



This task (periodic) uses function block diagrams to turn on or off motors and open or close valves. The SFC in *MainTask* commands the state for each device. The function block diagrams set and maintain that state.

This task (periodic) uses function block diagrams to configure and regulate temperature loops. The SFC in *MainTask* commands the temperatures. The function block diagrams set and maintain those temperatures.

This task (continuous) executes the sequential function chart (SFC). The SFC commands the specific state or temperature for each device or temperature loop.

Choose How to Execute the SFC

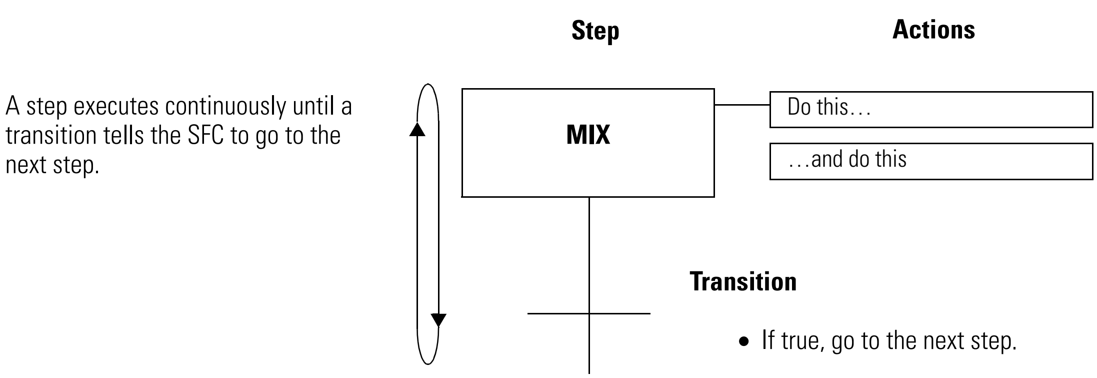
To execute an SFC, either configure it as the main routine for a program or call it as a subroutine.

If:	Then:
The SFC is the only routine in the program.	Configure the SFC as the main routine for the program.
The SFC calls *all* the other routines of the program.	
The program requires other routines to execute independent of the SFC.	1. Configure another routine as the main routine for the program. 2. Use the main routine to call the SFC as a subroutine.
The SFC uses boolean actions.	

If the SFC uses boolean actions, then other logic must run independent of the SFC and monitor status bits of the SFC.

Define the Steps of the Process

A **step** represents a major function of your process. It contains the actions that occur at a particular time, phase, or station.

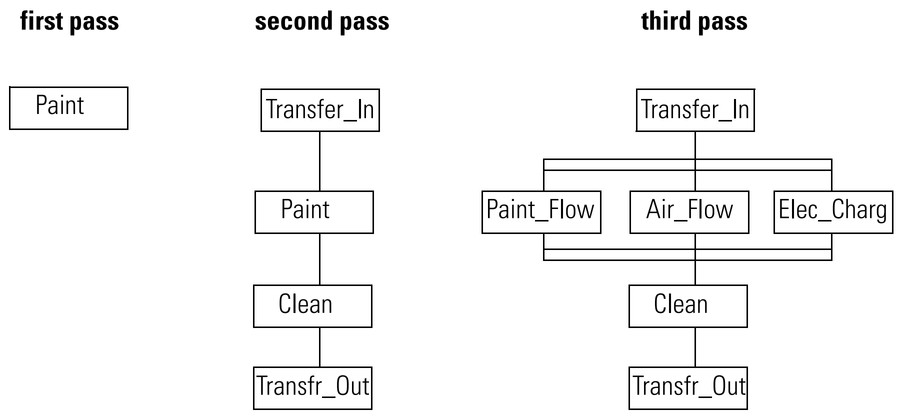


A **transition** ends a step. The transition defines the physical conditions that must occur or change in order to go to the next step.

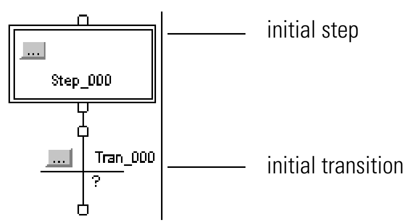
Follow These Guidelines

As you define the steps of your process, follow these guidelines:

- Start with large steps and refine the steps in several passes.



- When you first open an SFC routine, it contains an initial step and transition. Use this step to initialize your process.



- To identify a step, look for a physical change in your system, such as new part that is in position, a temperature that is reached, a preset time that is reached, or a recipe selection that occurs. The step is the actions that take place before that change.

- Stop when your steps are in meaningful increments. For example:

This organization of steps:	Is:
produce_solution	probably too large
set_mode, close_outlet, set_temperature, open_inlet_a, close_inlet_a, set_timer, reset_temperature, open_outlet, reset_mode	probably too small
preset_tank, add_ingredient_a, cook, drain	probably about right

SFC_STEP Structure

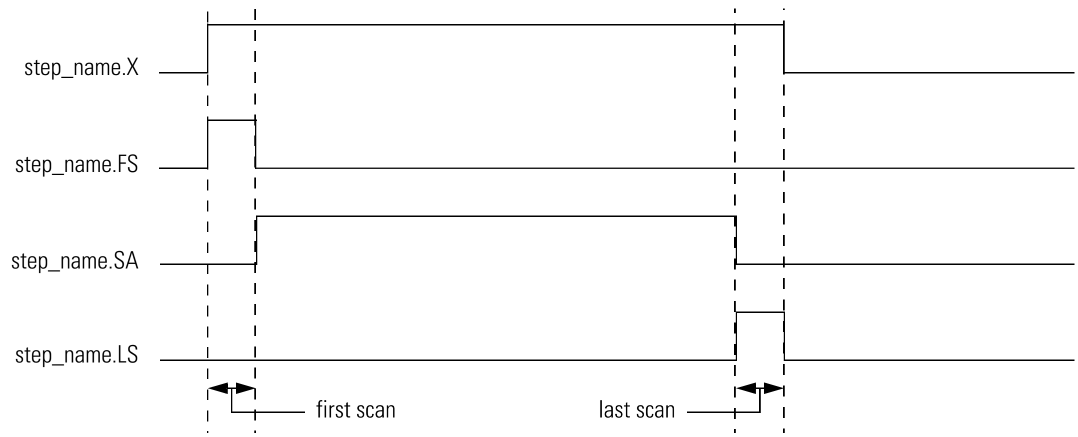
Each step uses a tag to provide information about the step. Access this information via either the *Step Properties* dialog box or the *Monitor Tags* tab of the *Tags* window:

If you want to:	Then check or set this member:	Data type:	Details:
determine how long a step has been active (milliseconds)	T	DINT	When a step becomes active, the Timer (T) value resets and then starts to count up in milliseconds. The timer continues to count up until the step goes inactive, regardless of the Preset (PRE) value.
flag when the step has been active for a specific length of time (milliseconds)	PRE	DINT	Enter the time in the Preset (PRE) member. When the Timer (T) reaches the Preset value, the Done (DN) bit turns on and stays on until the step becomes active again. As an option, enter a numeric expression that calculates the time at runtime.
	DN	BOOL	When the Timer (T) reaches the Preset (PRE) value, the Done (DN) bit turns on and stays on until the step becomes active again.
flag if a step did not execute long enough	LimitLow	DINT	Enter the time in the LimitLow member (milliseconds). • If the step goes inactive before the Timer (T) reaches the LimitLow value, the AlarmLow bit turns on. • The AlarmLow bit stays on until you reset it. • To use this alarm function, turn on (check) the AlarmEnable (AlarmEn) bit. As an option, enter a numeric expression that calculates the time at runtime.
	AlarmEn	BOOL	To use the alarm bits, turn on (check) the AlarmEnable (AlarmEn) bit.
	AlarmLow	BOOL	If the step goes inactive before the Timer (T) reaches the LimitLow value, the AlarmLow bit turns on. • The bit stays on until you reset it. • To use this alarm function, turn on (check) the AlarmEnable (AlarmEn) bit.

If you want to:	Then check or set this member:	Data type:	Details:
flag if a step is executing too long	LimitHigh	DINT	Enter the time in the LimitHigh member (milliseconds). • If the Timer (T) reaches the LimitHigh value, the AlarmHigh bit turns on. • The AlarmHigh bit stays on until you reset it. • To use this alarm function, turn on (check) the AlarmEnable (AlarmEn) bit. As an option, enter a numeric expression that calculates the time at runtime.
	AlarmEn	BOOL	To use the alarm bits, turn on (check) the AlarmEnable (AlarmEn) bit.
	AlarmHigh	BOOL	If the Timer (T) reaches the LimitHigh value, the AlarmHigh bit turns on. • The bit stays on until you reset it. • To use this alarm function, turn on (check) the AlarmEnable (AlarmEn) bit.
do something while the step is active (including first and last scan)	X	BOOL	The X bit is on the entire time the step is active (executing). Typically, we recommend that you use an action with a *N Non-Stored* qualifier to accomplish this.
do something one time when the step becomes active	FS	BOOL	The FS bit is on during the first scan of the step. Typically, we recommend that you use an action with a *P1 Pulse (Rising Edge)* qualifier to accomplish this.
do something while the step is active, *except* on the first and last scan	SA	BOOL	The SA bit is on when the step is active except during the first and last scan of the step.
do something one time on the last scan of the step	LS	BOOL	The LS bit is on during the last scan of the step. Use this bit only if you do the following: On the *Controller Properties* dialog box, *SFC Execution* tab, set the *Last Scan of Active Step* to *Don't Scan* or *Programmatic reset*. Typically, we recommend that you use an action with a *P0 Pulse (Falling Edge)* qualifier to accomplish this.

If you want to:	Then check or set this member:	Data type:	Details:	
determine the target of an SFC Reset (SFR) instruction	Reset	BOOL	An SFC Reset (SFR) instruction resets the SFC to a step or stop that the instruction specifies. • The Reset bit indicates to which step or stop the SFC will go to begin executing again. • Once the SFC executes, the Reset bit clears.	
determine the maximum time that a step has been active during any of its executions	TMax	DINT	Use this for diagnostic purposes. The controller clears this value only when you choose the *Restart Position* of *Restart at initial step* and the controller changes modes or experiences a power cycle.	
determine if the Timer (T) value rolls over to a negative value	OV	BOOL	Use this for diagnostic purposes.	
determine how many times a step has become active	Count	DINT	This is *not* a count of scans of the step. • The count increments each time the step becomes active. • It increments again only after the step goes inactive and then active again. • The count resets only if you configure the SFC to restart at the initial step. With that configuration, it resets when the controller changes from program mode to run mode.	
use one tag for the various status bits of this step	Status	DINT	**For this member:**	**Use this bit:**
			Reset	22
			AlarmHigh	23
			AlarmLow	24
			AlarmEn	25
			OV	26
			DN	27
			LS	28
			SA	29
			FS	30
			X	31

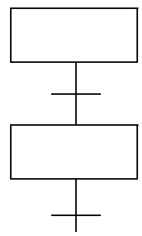
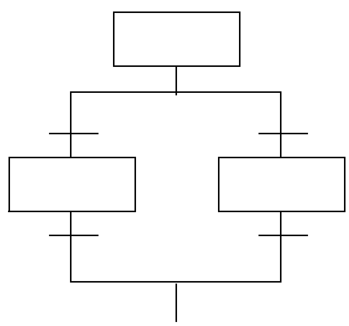
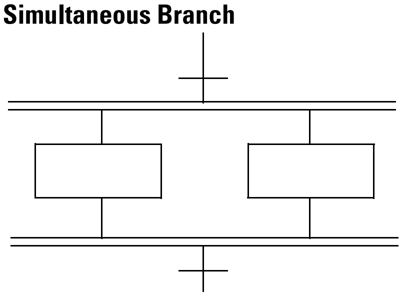
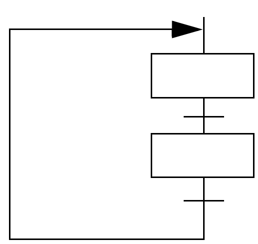
The following diagram shows the relationship of the X, FS, SA, and LS bits.


step_name.X
step_name.FS
step_name.SA
step_name.LS
first scan
last scan

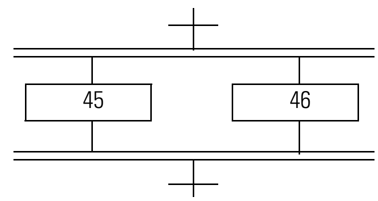
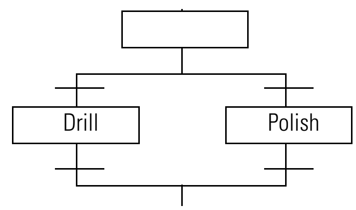
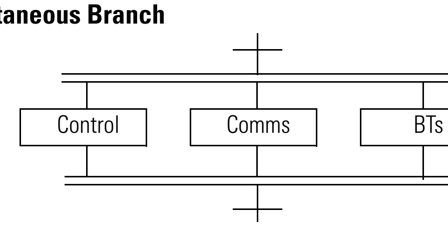
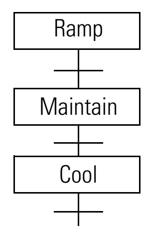
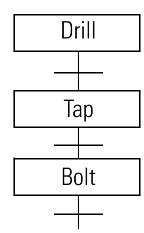
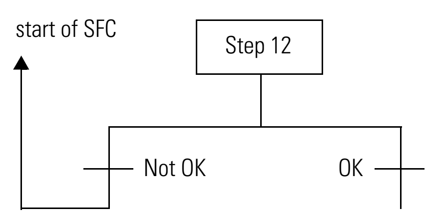
Organize the Steps

Once you define the steps of your process, organize them into sequences, simultaneous branches, selection branches, or loops.

Overview

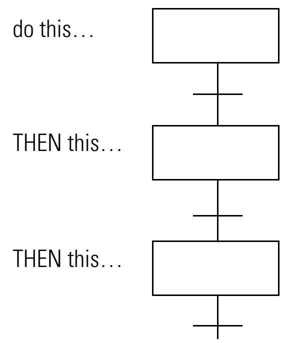
To:	Use this structure:	With these considerations:
Execute 1 or more steps in sequence: • One executes repeatedly. • Then the next executes repeatedly.	**Sequence** 	The SFC checks the transition at the end of the step: • If true, the SFC goes to the next step. • If false, the SFC repeats the step.
• Choose between alternative steps or groups of steps depending on logic conditions • Execute a step or steps or skip the step or steps depending on logic conditions	**Selection Branch** 	• It is OK for a path to have no steps and only a transition. This lets the SFC skip the selection branch. • By default, the SFC checks from left to right the transitions that start each path. It takes the first true path. • If no transitions are true, the SFC repeats the previous step. • RSLogix 5000 software lets you change the order in which the SFC checks the transitions.
Execute 2 or more steps at the same time. All paths must finish before continuing the SFC	**Simultaneous Branch** 	• A single transition ends the branch. • The SFC checks the ending transition after the last step in each path has executed at least once. If the transition is false, the SFC repeats the previous step.
Loop back to a previous step	**Wire to a Previous Step** 	• Connect the wire to the step or simultaneous branch to which you want to go. • *Do not* wire into, out of, or between a simultaneous branch.

Here are some examples of SFC structures for different situations:

Example situation:	Example solution:
Station 45 and 46 of an assembly line work on parts simultaneously. When both stations are done, the parts move down 1 station.	**Simultaneous Branch** 
Depending on the build code, a station either drills or polishes.	**Selection Branch** 
To simplify my programming, I want to separate communications and block transfers from other control logic. All occur at the same time.	**Simultaneous Branch** 
In a heat treating area, the temperature ramps up at a specific rate, maintains that temperature for a specific duration, and then cools at a specific rate.	**Sequence** 
At station 12, the machine drills, taps, and bolts a part. The steps occur one after the other.	**Sequence** 
Step 12 inspects a process for the correct mix of chemicals. • If OK, then continue with the remaining steps. • If not OK, go to the top of the SFC and purge the system.	**Wire** 

Sequence

A sequence is a group of steps that execute one after the other.



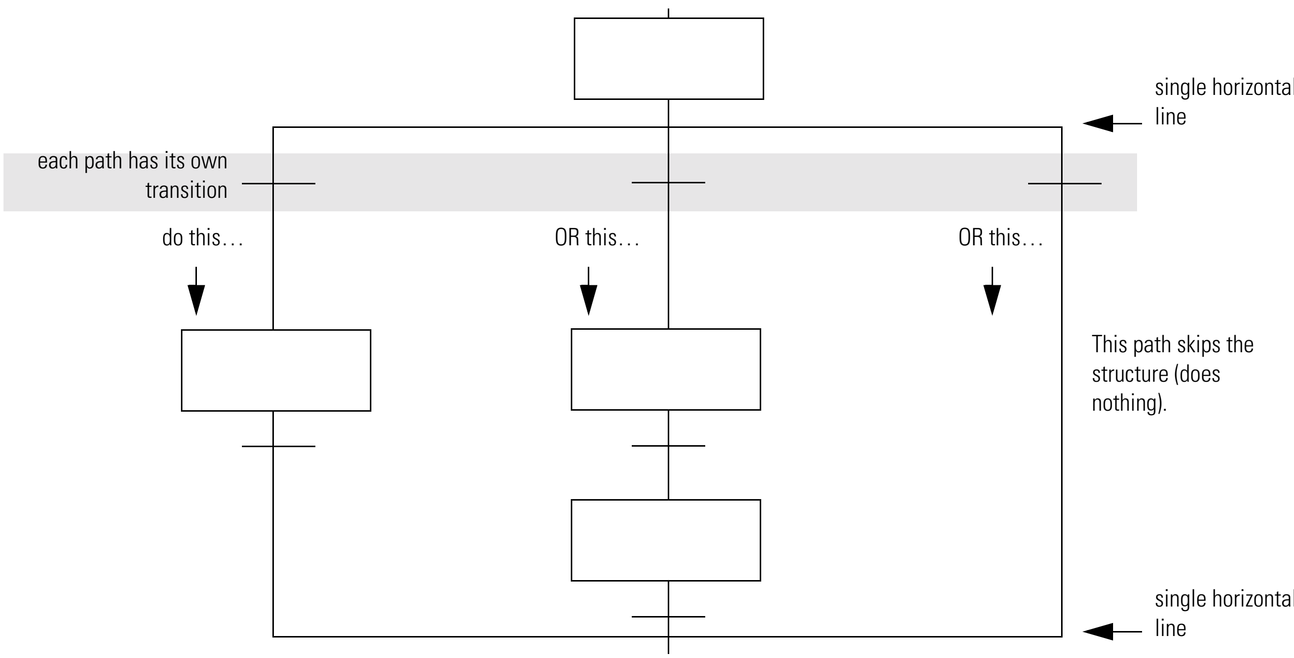
For a detailed diagram of the execution of a sequence of steps, see Figure 5.5 on page 5-52.

To override the state of a transition, see "Force Logic Elements" on page 14-1.

Selection Branch

A selection branch represents a choice between one path (step or group of steps) or another path (i.e., an OR structure).

- Only one path executes.
- By default the SFC checks the transitions from left to right.
  - The SFC takes the first true path.
  - RSLogix 5000 software lets you change the order in which the SFC checks the transitions. See “Program a Sequential Function Chart” on page 6-1.



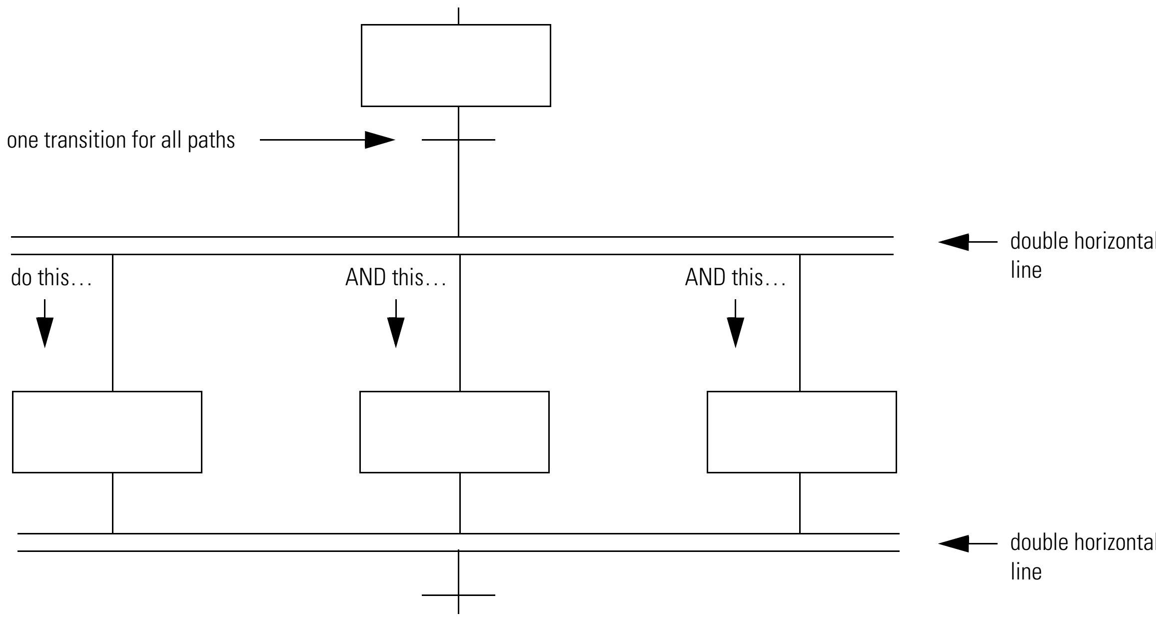
For a detailed diagram of the execution of a selection branch, see Figure 5.7 on page 5-54.

To override the state of a transition, see “Force Logic Elements” on page 14-1.

Simultaneous Branch

A simultaneous branch represents paths (steps or group of steps) that occur at the same time (i.e., an AND structure).

- All paths execute.
- All paths must finish before continuing with the SFC.
- The SFC checks the transition after the last step of each path has executed at least once.



For a detailed diagram of the execution of a simultaneous branch, see Figure 5.6 on page 5-53.

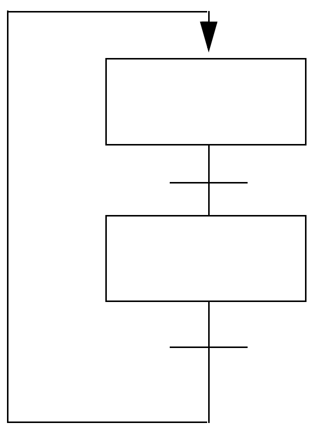
To override the branch and prevent a path from executing, see “Force Logic Elements” on page 14-1.

Wire to a Previous Step

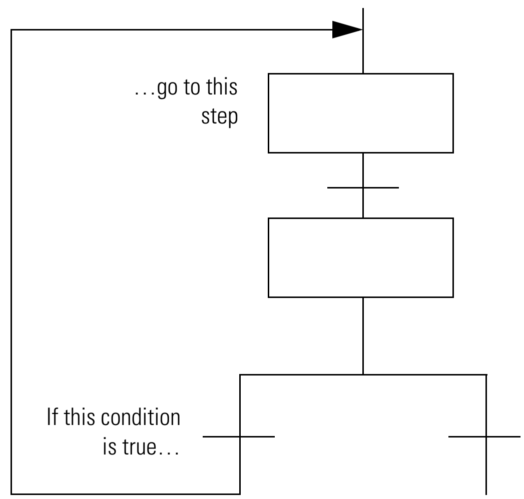
In addition to connecting steps in sequences, simultaneous branches, and selection branches, you can connect a step to a previous point in your SFC. This lets you:

- loop back and repeat steps
- return to the beginning of the SFC and start over

For example:



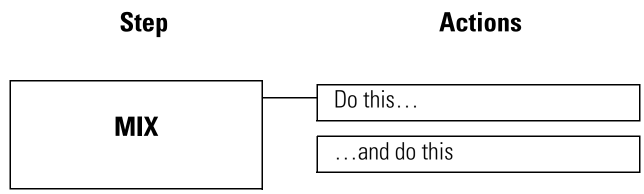
simple loop that repeats the entire SFC



path of a selection branch that returns to a previous step

Add Actions for Each Step

Use **actions** to divide a step into the different functions that the step performs, such as commanding a motor, setting the state of a valve, or placing a group of devices in a specific mode.



How Do You Want to Use the Action?

There are two types of actions:

If you want to:	Then:
execute structured text directly in the SFC	Use a Non-Boolean Action
call a subroutine	
use the automatic reset option to reset data upon leaving a step	
only set a bit and program other logic to monitor the bit to determine when to execute.	Use a Boolean Action

Use a Non-Boolean Action

A non-boolean action contains the logic for the action. It uses structured text to execute assignments and instructions or call a subroutine.

With non-boolean actions, you also have the option to **postscan** (automatically reset) the assignments and instructions before leaving a step:

- During postscan the controller executes the assignments and instructions as if all conditions are false.
- The controller postscans both embedded structured text and any subroutine that the action calls.

To automatically reset assignments and instructions, see “Turn Off a Device at the End of a Step” on page 5-32.

To program a non-boolean action, you have the following options:

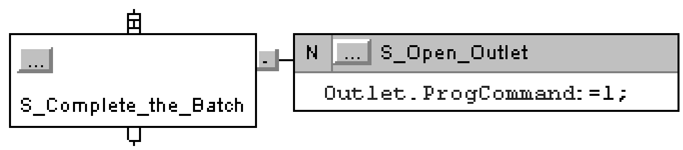
<table>
<tr><th>If you want to:</th><th>Then:</th></tr>
<tr><td>

- execute your logic without additional routines
- use structured text assignments, constructs, and instructions

</td><td>

Embed structured text.

For example:



When the *S_Complete_the_Batch* step is active, the *S_Open_Outlet* action executes. The action sets the *Outlet.ProgCommand* tag equal to 1, which opens the outlet valve.

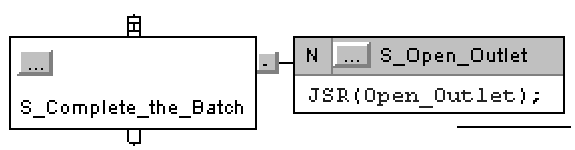
</td></tr>
<tr><td>

- re-use logic in multiple steps
- use another language to program the action, such as ladder logic
- nest an SFC

</td><td>

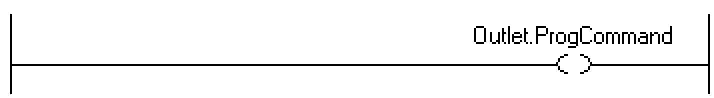
Call a subroutine.

For example:



When the *S_Complete_the_Batch* step is active, the *S_Open_Outlet* action executes. The action calls the *Open_Outlet* routine.

Open_Outlet Routine



When the *Open_Outlet* routine executes, the OTE instruction sets the *Outlet.ProgCommand* tag equal to 1, which opens the outlet valve.

</td></tr>
</table>

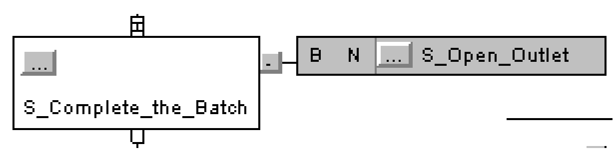
You *cannot* reuse a non-boolean action within the same SFC except to reset a stored action. Only one instance of a specific non-boolean action is permitted per SFC.

Use a Boolean Action

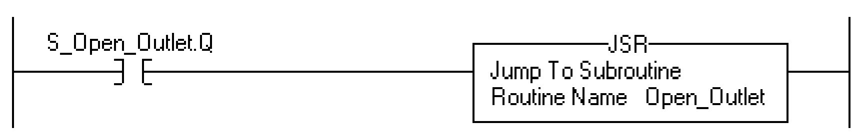
A boolean action contains no logic for the action. It simply sets a bit in its tag (SFC_ACTION structure). To do the action, other logic must monitor the bit and execute when the bit is on.

With boolean actions, you have to manually reset the assignments and instructions that are associated with the action. Since there is no link between the action and the logic that performs the action, the automatic reset option does not effect boolean actions.

Here is an example:



When the *S_Complete_the_Batch* step is active, the *S_Open_Outlet* action executes. When the action is active, its Q bit turns on.



A ladder logic routine monitors the Q bit (*S_Open_Outlet.Q*). When the Q bit is on, the JSR instruction executes and opens the outlet valve.

You can reuse a boolean action multiple times within the same SFC.

SFC_ACTION Structure

Each action (non-boolean and boolean) uses a tag to provide information about the action. Access this information via either the

Action Properties dialog box or the *Monitor Tags* tab of the *Tags* window:

<table>
<tr><th>If you want to:</th><th>Then check or set this member:</th><th>Data type:</th><th colspan="2">Details:</th></tr>
<tr><td rowspan="6">determine when the action is active</td><td rowspan="5">Q</td><td rowspan="5">BOOL</td><td colspan="2">The status of the Q bit depends on whether the action is a boolean action or non-boolean action:</td></tr>
<tr><td>If the action is:</td><td>Then the Q bit is:</td></tr>
<tr><td>boolean</td><td>on (1) the entire time the action is active, including the last scan of the action</td></tr>
<tr><td>non-boolean</td><td>on (1) while the action is active but

off (0) at the last scan of the action</td></tr>
<tr><td colspan="2">To use a bit to determine when an action is active, use the Q bit.</td></tr>
<tr><td>A</td><td>BOOL</td><td colspan="2">The A bit is on the entire time the action is active.</td></tr>
<tr><td>determine how long an action has been active (milliseconds)</td><td>T</td><td>DINT</td><td colspan="2">When an action becomes active, the Timer (T) value resets and then starts to count up in milliseconds. The timer continues to count up until the action goes inactive, regardless of the Preset (PRE) value.</td></tr>
<tr><td>use one of these time-based qualifiers: L, SL, D, DS, SD</td><td>PRE</td><td>DINT</td><td colspan="2">Enter the time limit or delay in the Preset (PRE) member. The action starts or stops when the Timer (T) reaches the Preset value.

As an option, enter a numeric expression that calculates the time at runtime.</td></tr>
<tr><td>determine how many times an action has become active</td><td>Count</td><td>DINT</td><td colspan="2">This is not a count of scans of the action.
The count increments each time the action becomes active.
It increments again only after the action goes inactive and then active again.
The count resets only if you configure the SFC to restart at the initial step. With that configuration, it resets when the controller changes from program mode to run mode.</td></tr>
<tr><td rowspan="3">use one tag for the various status bits of this action</td><td rowspan="3">Status</td><td rowspan="3">DINT</td><td>For this member:</td><td>Use this bit:</td></tr>
<tr><td>Q</td><td>30</td></tr>
<tr><td>A</td><td>31</td></tr>
</table>

Describe Each Action in Pseudocode

To organize the logic for an action, first describe the action in pseudocode. If you are unfamiliar with pseudocode, follow these guidelines:

- Use a series of short statements that describe exactly what should happen.

- Use terms or symbols such as: if, then, otherwise, until, and, or, =, >, <.
- Sequence the statements in the order that they should execute.
- If necessary, name the conditions to check first (when 1st) and then the action to take second (what 2nd).

Enter the pseudocode into the body of the action. After you enter the pseudocode, you can:

- Refine the pseudocode so it executes as structured text.
- Use the pseudocode to design your logic and leave the pseudocode as comments. Since all structured text comments download to the controller, your pseudocode is always available as documentation for the action.

To convert the pseudocode to structured text comments, add the following comment symbols:

For a comment:	Use one of these formats:
on a single line	`//comment`

that spans more than one line	`(*start of comment . . . end of comment*)`
	
	`/*start of comment . . . end of comment*/`

Choose a Qualifier for an Action

Each action (non-boolean and boolean) uses a **qualifier** to determine when it starts and stops.

The default qualifier is *Non-Stored*. The action starts when the step is activated and stops when the step is deactivated.

To change when an action starts or stops, assign a different qualifier:

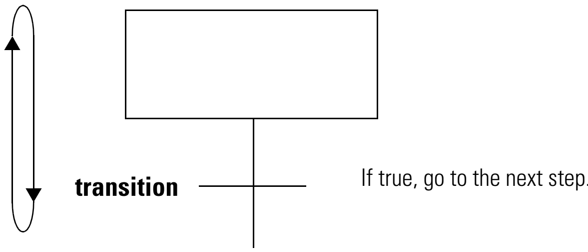
Table 5.1 Choose a Qualifier for an Action

If you want the action to:	And:	Then assign this qualifier:	Which means:
start when the step is activated	stop when the step is deactivated	N	Non-Stored
	execute only once	P1	Pulse (Rising Edge)
	stop before the step is deactivated or when the step is deactivated	L	Time Limited
	stay active until a *Reset* action turns off this action	S	Stored
	stay active until a *Reset* action turns off this action or a specific time expires, even if the step is deactivated	SL	Stored and Time Limited
start a specific time after the step is activated *and* the step is still active	stop when the step is deactivated	D	Time Delayed
	stay active until a *Reset* action turns off this action	DS	Delayed and Stored
start a specific time after the step is activated, even if the step is deactivated before this time	stay active until a *Reset* action turns off this action	SD	Stored and Time Delayed
execute once when the step is activated	execute once when the step is deactivated	P	Pulse
start when the step is deactivated	execute only once	P0	Pulse (Falling Edge)
turn off (reset) a stored action: • S Stored • SL Stored and Time Limited • DS Delayed and Stored • SD Stored and Time Delayed	→	R	Reset

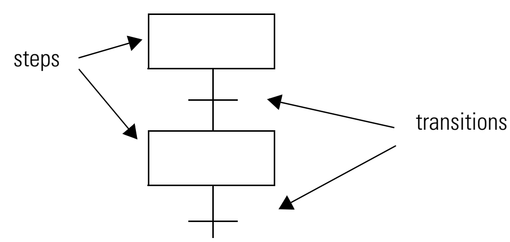
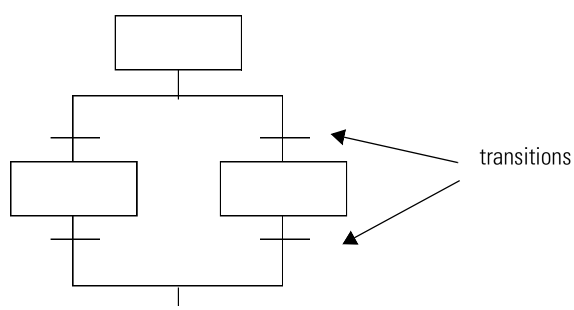
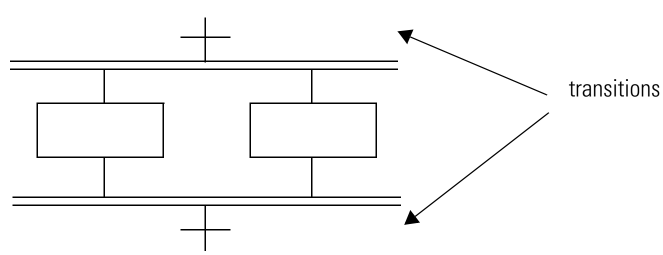
Define the Transition Conditions

The transition is the physical conditions that must occur or change in order to go to the next step.

The transition tells the SFC when to go to the next step.



Transitions occur in the following places:

<table>
<tr><th>For this structure:</th><th>Make sure that:</th></tr>
<tr><td>sequence</td><td>A transition is between each step.
</td></tr>
<tr><td>selection branch</td><td>Transitions are inside the horizontal lines.
</td></tr>
<tr><td>simultaneous branch</td><td>Transitions are outside the horizontal lines.
</td></tr>
</table>

Here are two examples of transitions:

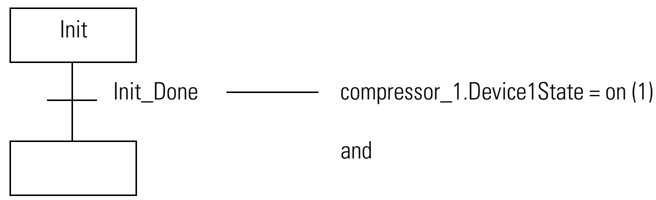
EXAMPLE

You want to:

a. Turn on 2 compressors. When a compressor is on, the Device1State bit is on.

b. When both compressors are on, go to the next step.

Solution:



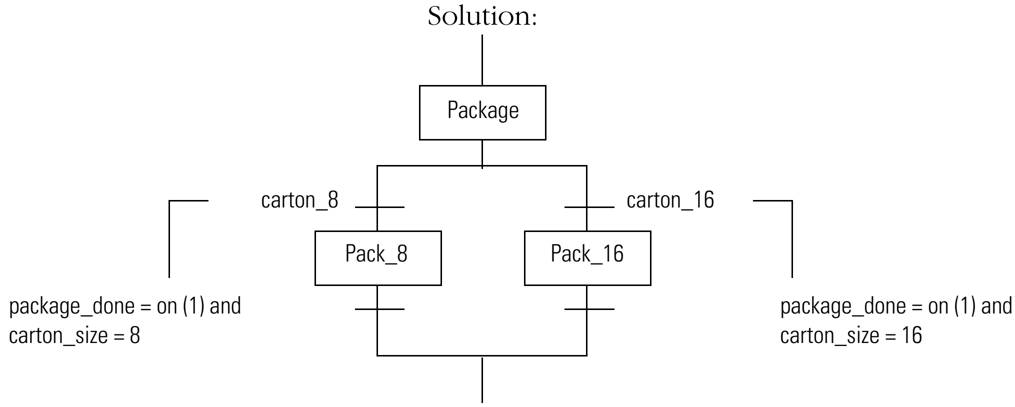
EXAMPLE

You want to:

a. Package the product. When the product is in the package, the *package_done* bit turns on.

b. Pack the product either 8 per carton or 16 per carton.

Solution:



To override the state of a transition, see "Force Logic Elements" on page 14-1.

Transition Tag

Each transition uses a BOOL tag to represent the true or false state of the transition.

If the transition is:	The value is:	And:
true	1	The SFC goes to the next step.
false	0	The SFC continues to execute the current step.

How Do You Want to Program the Transition?

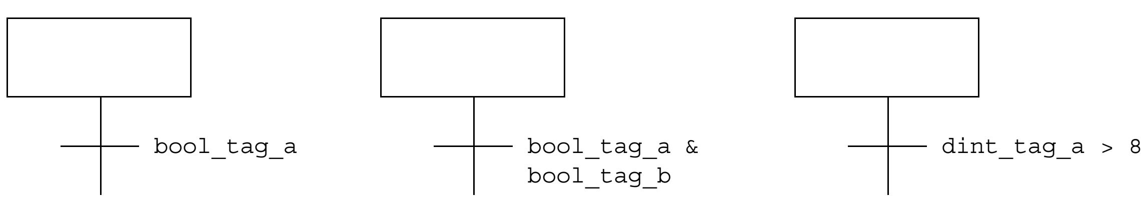
To program the transition, you have these options:

If you want to:	Then:
enter the conditions as an expression in structured text	Use a BOOL Expression
enter the conditions as instructions in another routine	Call a Subroutine
use the same logic for multiple transitions	

Use a BOOL Expression

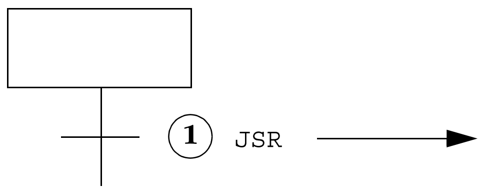
The simplest way to program the transition is to enter the conditions as a **BOOL expression** in structured text. A BOOL expression uses bool tags, relational operators, and logical operators to compare values or check if conditions are true or false. For example, `tag1>65`.

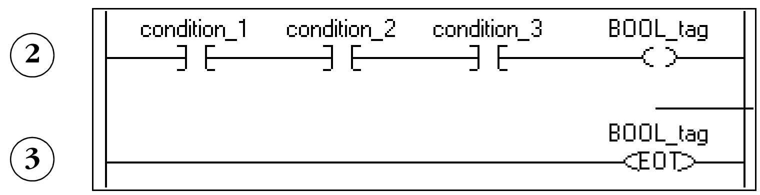
Here are some examples of BOOL expressions.



Call a Subroutine

To use a subroutine to control a transition, include an End Of Transition (EOT) instruction in the subroutine. The EOT instruction returns the state of the conditions to the transition, as shown below.





- or -

2

```
If condition_1 & condition_2 &
condition_3 then
     BOOL_tag := 1;
Else
     BOOL_tag := 0;
End_if;
EOT(BOOL_tag);
```

3

1. Call a subroutine.

2. Check for the required conditions. When those conditions are true, turn on a BOOL tag.

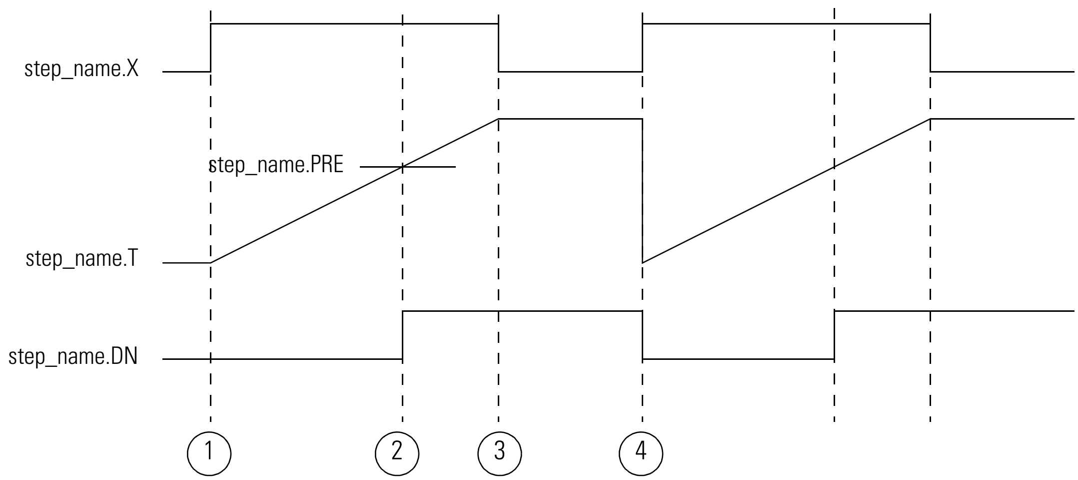
3. Use an EOT instruction to set the state of the transition equal to the value of the BOOL tag. When the BOOL tag is on (true), the transition is true.

Transition After a Specified Time

Each step of the SFC includes a millisecond timer that runs whenever the step is active. Use the timer to:

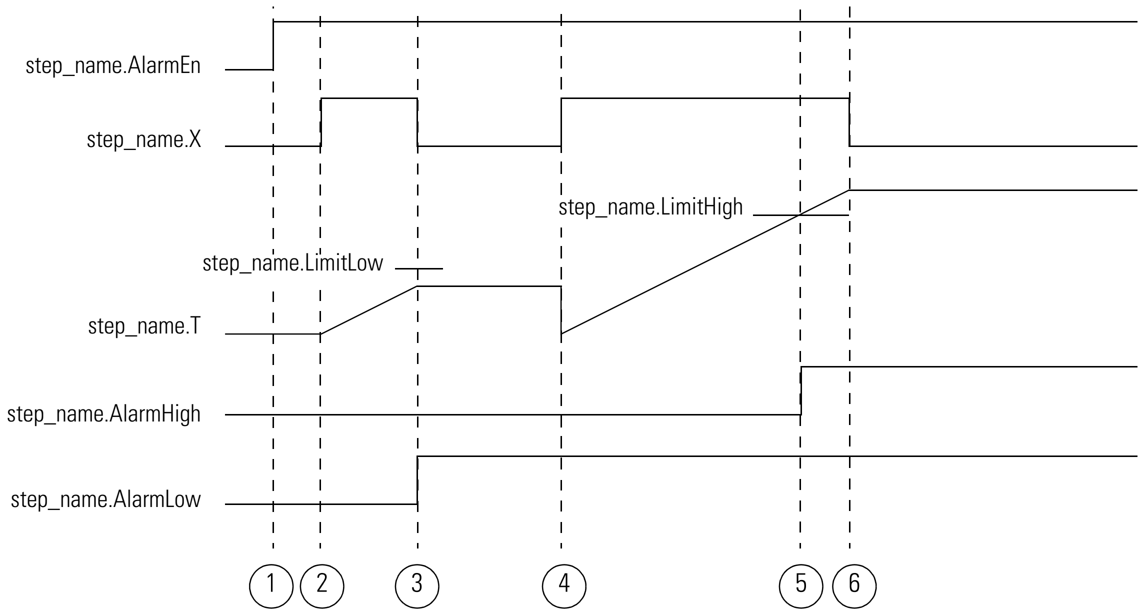
- signal when the step has run for the required time and the SFC should go to the next step
- signal when the step has run too long and the SFC should go to an error step

Figure 5.3 The following diagram shows the action of the timer and associated bits of a step:



Description:
1. Step becomes active. X bit turns on. Timer (T) begins to increment.
2. Timer reaches the Preset (PRE) value of the step. DN bit turns on. Timer continues to increment.
3. Step becomes inactive. X bit turns off. Timer retains its value. DN remains on.
4. Step becomes active. X bit turns on. Timer clears and then begins to increment. DN bit turns off.

Figure 5.4 The following diagram shows the action of the low and high alarms for a step:



Description:
1. AlarmEn is on. To use the low and high alarms turn this bit on. Turn the bit on via the properties dialog box or the tag for the step.
2. Step becomes active. X bit turns on. Timer (T) begins to increment.
3. Step becomes inactive. X bit turns off. Timer retains its value. Since Timer is less than LimitLow, AlarmLow bit turns on.

Description:
4. Step becomes active. X bit turns on. Timer clears and then begins to increment. AlarmLow stays on. (You have to manually turn it off.)
5. Timer reaches the LimitHigh value of the step. AlarmHigh bit turns on. Timer continues to increment.
6. Step becomes inactive. X bit turns off. Timer retains its value. AlarmHigh stays on. (You have to manually turn it off.)

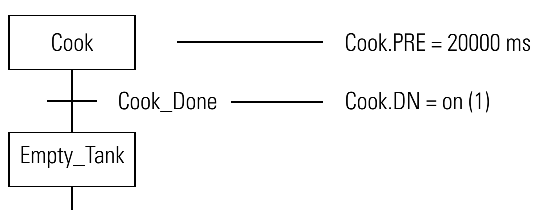
Here is an example of the use of the Preset time of a step.

EXAMPLE

Functional specification says:

a. Cook the ingredients in the tank for 20 seconds.
b. Empty the tank.

Solution:



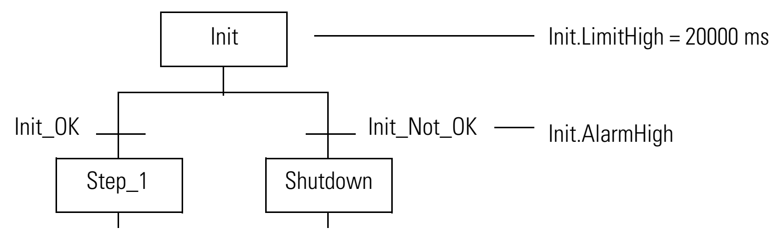
Here is an example of the use of the high alarm of a step.

EXAMPLE

Functional specification says:

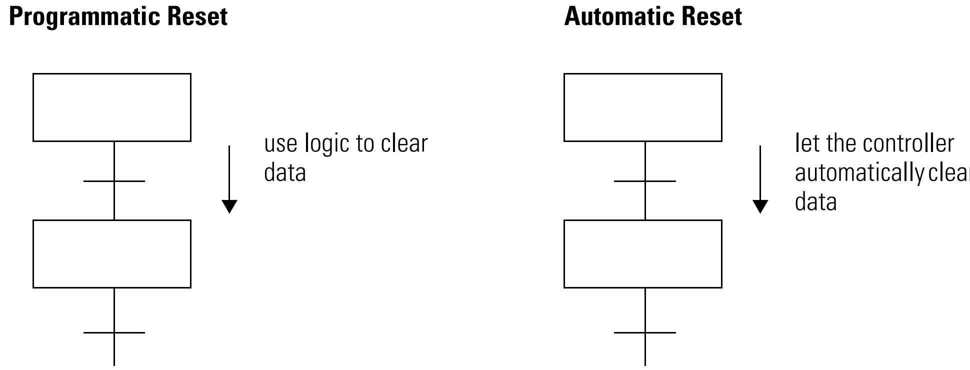
a. Home 8 devices.
b. If all 8 devices are not home within 20 seconds, then shutdown the system.

Solution:



Turn Off a Device at the End of a Step

When the SFC leaves a step, you have several options on how to turn off devices that the step turned on.



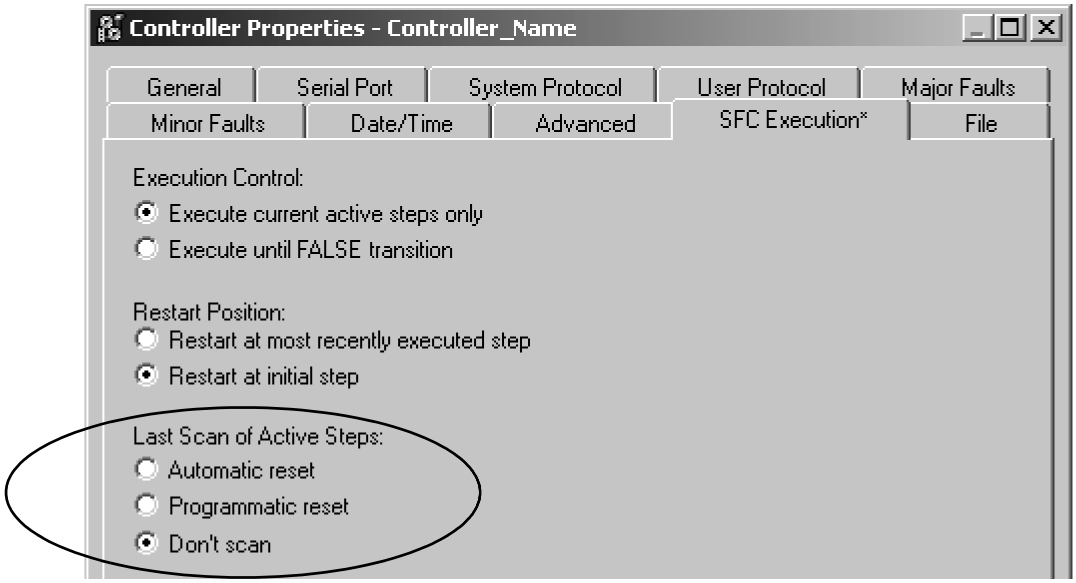
Each option requires you to make the following choices:

1. Choose a last scan option.
2. Based on the last scan option, develop your logic so that the last scan returns data to the desired values.

Choose a Last Scan Option

On the last scan of each step, you have the following options. The option that you choose applies to all steps in all SFCs of this controller.

If you want to:	And on the last scan of a step:	Then:	See:
control which data to clear	Execute *only* P and P0 actions and use them to clear the required data.	Use the Don't Scan Option	page 5-34
	Execute *all* actions and use either of these options to clear the required data: • status bits of the step or action to condition logic • P and P0 actions	Use the Programmatic Reset Option	page 5-35
let the controller clear data	→	Use the Automatic Reset Option	page 5-38


Controller Properties - Controller_Name
General
Serial Port
System Protocol
User Protocol
Major Faults
Minor Faults
Date/Time
Advanced
SFC Execution*
File
Execution Control:
Execute current active steps only
Execute until FALSE transition
Restart Position:
Restart at most recently executed step
Restart at initial step
Last Scan of Active Steps:
Automatic reset
Programmatic reset
Don't scan

The following table compares the different options for handling the last scan of a step:

Characteristic:	During the last scan of a step, this option does the following:		
	Don't scan	**Programmatic reset**	**Automatic reset**
execution actions	Only P and P0 actions execute. They execute according to their logic.	All actions execute according to their logic.	• P and P0 actions execute according to their logic. • All other actions execute in postscan mode. • On the next scan of the routine, the P and P0 actions execute in postscan mode.
retention of data values	All data keeps its current values.	All data keeps its current values.	• Data reverts to its values for postscan. • Tags to the left of [:=] assignments clear to zero.
method for clearing data	Use P and P0 actions.	Use either: • status bits of the step or action to condition logic • P and P0 actions	Use either: • [:=] assignment (non-retentive assignment) • instructions that clear their data during postscan
reset of a nested SFC	A nested SFCs remains at its current step.	A nested SFCs remains at its current step.	For the *Restart Position* property, if you choose the *Restart at initial step* option, then: • A nested SFC resets to its initial step. • The X bit of a stop element in a nested SFC clears to zero.

Use the Don't Scan Option

The default option for handling the last scan of a step is *Don't scan*. With this option, all data keeps its current values when the SFC leaves a step. This requires you to use additional assignments or instructions to clear any data that you want to turn off at the end of a step.

To turn off a device at the end of a step:

1. Make sure that the *Last Scan of Active Steps* property is set to the *Don't scan* option (default).

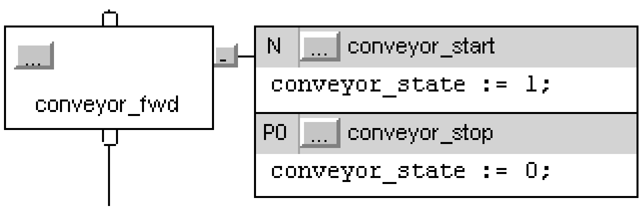
2. Use a *P0 Pulse (Falling Edge)* action to clear the required data. Make sure that the P0 action or actions are last in the order of actions for the step.

During the last scan of the step, the *Don't scan* option executes only P and P0 actions. The assignments and instructions of the actions execute according to their logic conditions.

- The controller *does not* execute a **postscan** of assignments or instructions.
- When the SFC leaves the step, all data keeps its current values.

The following example uses an action to turn on a conveyor at the start of a step. A different action turns off the conveyor at the end of the step.

EXAMPLE Use the Don't Scan Option



This action turns on the conveyor. When *conveyor_state* turns on, the conveyor turns on.

Before the SFC leaves the step, the P0 action turns off the conveyor. On the last scan of the step, *conveyor_state* turns off. This turns off the conveyor.

Use the Programmatic Reset Option

An optional method to programmatically turn off (clear) devices at the end of a step is to execute all actions on the last scan of the step. This lets you execute your normal logic as well as turn off (clear) devices at the end of a step.

1. In the *Last Scan of Active Steps* property, choose the *Programmatic reset* option:

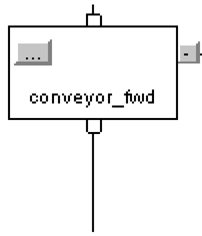
2. Clear the required data using any of the following methods:
   - To your normal logic, add logic that clears the required data. Use the LS bit of the step or the Q bit of the action to condition the execution of the logic.
   - Use a *P0 Pulse (Falling Edge)* action to clear the required data. Make sure that the P0 action or actions are last in the order of actions for the step.

During the last scan of the step, the *Programmatic reset* option executes all assignments and instructions according to logic conditions.

- The controller *does not* **postscan** the assignments or instructions.
- When the SFC leaves the step, all data keeps its current value.

The following example uses a single action to turn on and off a conveyor. The LS bit of the step conditions the execution of the logic. See “SFC_STEP Structure” on page 5-8.

EXAMPLE Use the Programmatic Reset Option and the LS Bit



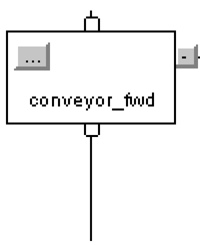

```
N  ...  conveyor_start
If NOT(conveyor_fwd.LS) then
    conveyor_state:=1;
Else
    conveyor_state:=0;
End_if;
```

When the step is not on its last scan (*conveyor_fwd.LS* = 0), this statement turns on *conveyor_state*. When *conveyor_state* turns on, the conveyor turns on.

On the last scan of the step (*conveyor_fwd.LS* =1), this statement turns off *conveyor_state*. When *conveyor_state* turns off, the conveyor turns off.

For an action that uses one of the stored qualifiers, use the Q bit of the action to condition your logic. See “SFC_ACTION Structure” on page 5-20.

EXAMPLE Use the Programmatic Reset Option and the Q Bit



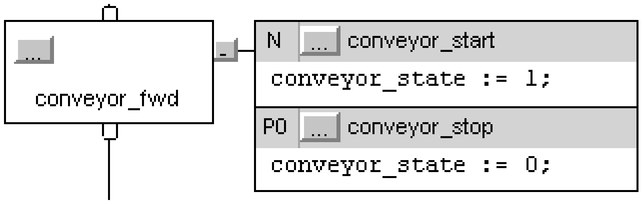

```
S  ...  conveyor_start
If conveyor_start.Q then
    conveyor_state:=1;
Else
    conveyor_state:=0;
End_if;
```

When the action is not on its last scan (*conveyor_start.Q* =1), this statement turns on *conveyor_state*. When *conveyor_state* turns on, the conveyor turns on.

On the last scan of the action (*conveyor_start.Q* =0), this statement turns off *conveyor_state*. When *conveyor_state* turns off, the conveyor turns off.

You can also use a *P0 Pulse (Falling Edge)* action to clear data. The following example uses an action to turn on a conveyor at the start of a step. A different action turns off the conveyor at the end of the step.

EXAMPLE Use the Programmatic Reset Option and a P0 Action



This action turns on the conveyor. When *conveyor_state* turns on, the conveyor turns on.

Before the SFC leaves the step, the P0 action turns off the conveyor. On the last scan of the step, *conveyor_state* turns off. This turns off the conveyor.

Use the Automatic Reset Option

To automatically turn off (clear) devices at the end of a step:

1. In the *Last Scan of Active Steps* property, choose the *Automatic reset* option:

2. To turn off a device at the end of the step, control the state of the device with an assignment or instruction such as:
   - [:=] assignment (non-retentive assignment)
   - Output Energize (OTE) instruction in a subroutine

During the last scan of each step, the *Automatic reset* option does the following:

- execute P and P0 actions according to their logic conditions
- clear tags to the left of [:=] assignments
- execute a **postscan** of embedded structured text
- execute a postscan of any subroutine that an action calls via a Jump to Subroutine (JSR) instruction
- reset any nested SFC (SFC that an action calls as a subroutine)

IMPORTANT The postscan of an action actually occurs when the action goes from active to inactive. Depending on the qualifier of the action, the postscan could occur before or after the last scan of the step.

As a general rule, the postscan executes instructions as if all conditions are false. For example, the Output Energize (OTE) instruction clears its data during postscan.

Some instructions *do not* follow the general rule during postscan. For a description of how a specific instruction executes during postscan, see the following manuals:

- *Logix5000 Controllers General Instructions Reference Manual*, publication 1756-RM003
- *Logix5000 Controllers Process and Drives Instructions Reference Manual*, publication 1756-RM006
- *Logix5000 Controllers Motion Instruction Set Reference Manual*, publication 1756-RM007

Here is an example that uses a non-retentive assignment to control a conveyor. It turns on a conveyor at the start of a step and automatically turns off the conveyor when the step is done.

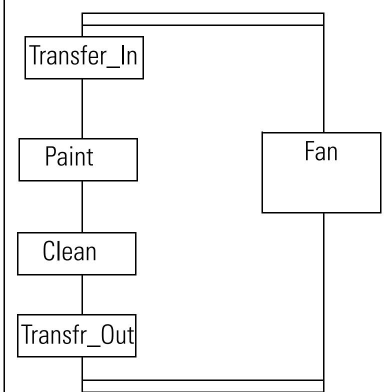
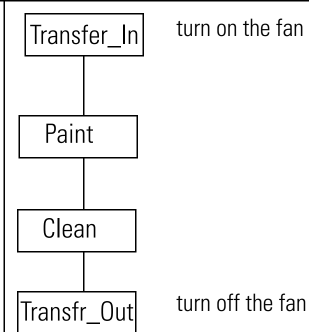
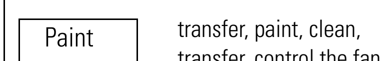
EXAMPLE Automatically Clear Data

This action turns on the conveyor. When *conveyor_state* turns on, the conveyor turns on.

Keep Something On From Step-to-Step

How Do You Want to Control the Device?

To provide bumpless control of a device during more than one time or phase (step), do one of the following:

Option:	Example:
Use a Simultaneous Branch Make a separate step that controls the device.	
Store and Reset an Action Note the step that turns on the device and the step that turns off the device. Later, define a Stored and Reset Action pair to control the device.	
Use One Large Step Use one large step that contains all the actions that occur while the device is on.	

Use a Simultaneous Branch

A simple way to control a device or devices during one or more steps is to create a separate step for the devices. Then use a simultaneous branch to execute the step during the rest of the process.

Here is an example:

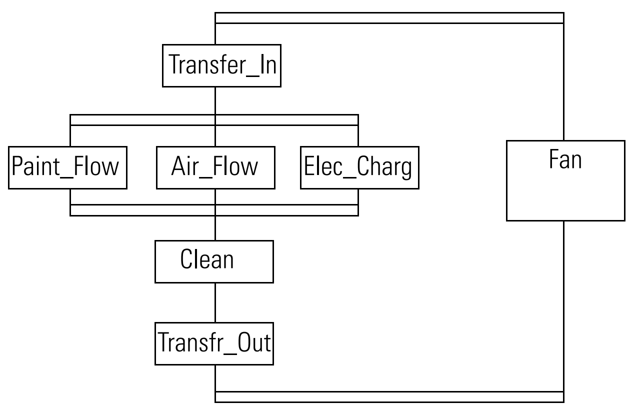
EXAMPLE

A paint operation does the following:

1. Transfer the product into the paint shop.
2. Paint the product using 3 separate paint guns.
3. Clean the guns.
4. Transfer the product to the paint ovens.

During the entire process, the system must control the shop fans.

Solution:



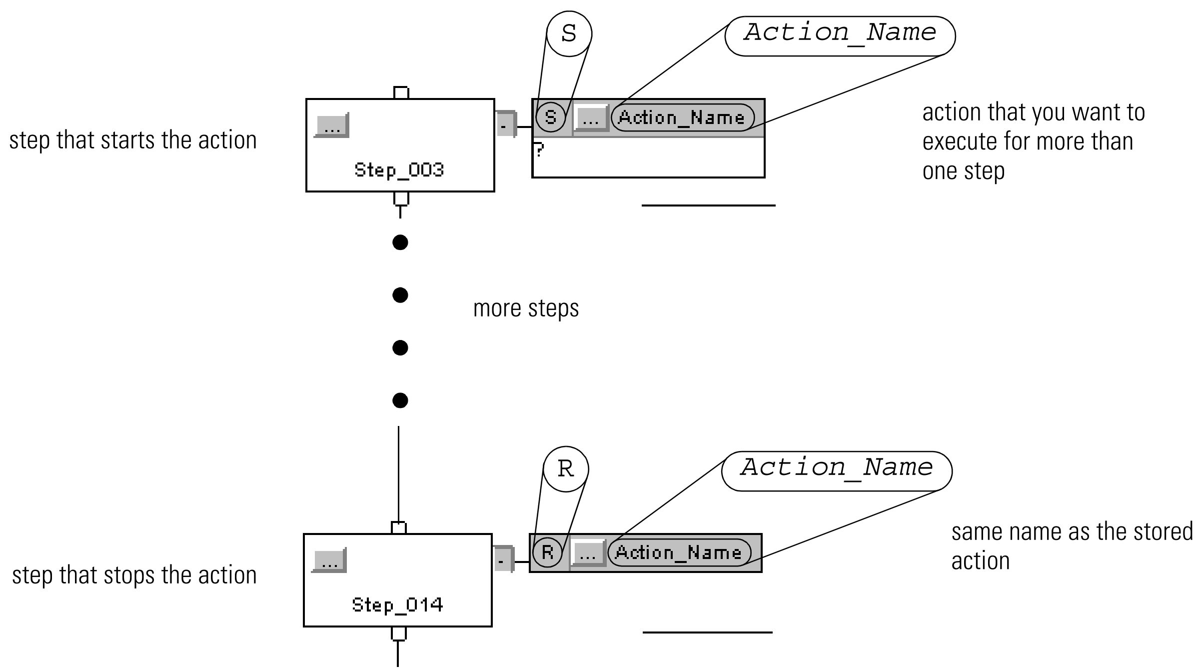
Store and Reset an Action

Typically, an action turns off (stops executing) when the SFC goes to the next step. To keep a device on from step to step without a bump, store the action that controls the device:

1. In the step that turns on the device, assign a stored qualifier to the action that controls the device. For a list of stored qualifiers, see Table 5.1 on page 5-23.

2. In the step that turns off the device, use a *Reset* action.

The following figure shows the use of a stored action.

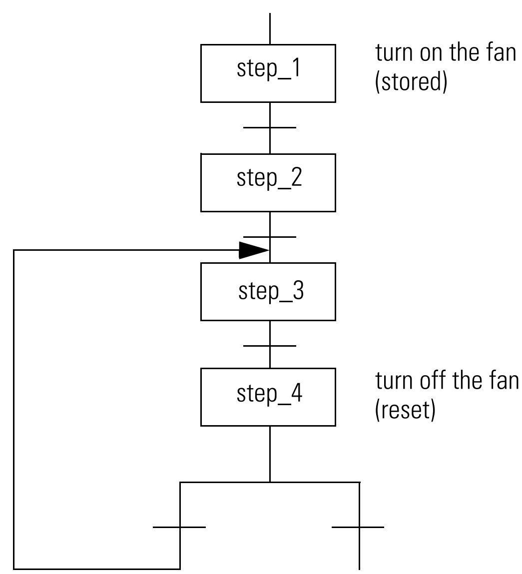


When the SFC leaves the step that stores the action, RSLogix 5000 software continues to show the stored action as active. (By default, a green border displays around the action.) This lets you know that the SFC is executing the logic of that action.

To use a stored action, follow these guidelines:

- The *Reset* action only turns off the stored action. It *does not* automatically turn off the devices of the action. To turn off the device, follow the *Reset* action with another action that turns off the device. Or use the *Automatic reset* option described on page 5-38.
- Before the SFC reaches a stop element, reset any stored actions that you *do not* want to execute at the stop. An active stored action remains active even if the SFC reaches a stop.
- Use caution when you jump in between a step that stores an action and a step that resets the action. Once you reset an action, it only starts when you execute the step that stores the action.

  In the following example, steps 1 - 4 require a fan to be on. At the end of *step_4*, the fan is reset (turned off). When the SFC jumps back to *step_3*, the fan remains off.



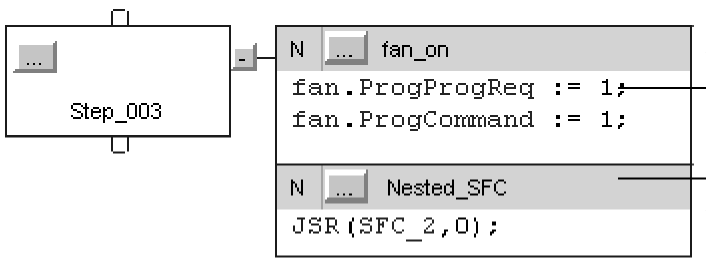
  To turn the fan back on, the SFC has to jump back to *step_1*.

Use One Large Step

If you use one large step for multiple functions, then use additional logic to sequence the functions. One option is to nest an SFC within the large step.

In the following example, a step turns on a fan and then calls another SFC. The nested SFC sequences the remaining functions of the step. The fan stays on throughout the steps of the nested SFC.

EXAMPLE Use a Large Step



This action turns on a fan:

- *fan.ProgProgReq* lets the SFC command the state of the fan.
- *fan.ProgCommand* turns on the fan.

This action calls another SFC. The SFC sequences the remaining functions of the step.

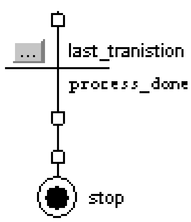
For additional information on how to nest an SFC, see "Nest an SFC" on page 5-49.

End the SFC

Once an SFC completes its last step, it *does not* automatically restart at the first step. You must tell the SFC what to do when it finishes the last step.

At the End of the SFC, What Do You Want to Do?

To:	Do this:
automatically loop back to an earlier step	Wire the last transition to the top of the step to which you want to go. See “Wire to a Previous Step“on page 5-17.
stop and wait for a command to restart	Use a Stop Element. See “Use a Stop Element” on page 5-45.



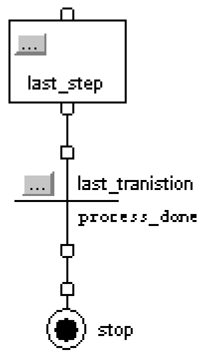
Use a Stop Element

The stop element lets you stop the execution of an entire SFC or a path of a simultaneous branch and wait to restart. When an SFC reaches a stop element, the following occurs:

- The X bit of the stop element turns on. This signals that the SFC is at the stop element.
- Stored actions remain active.
- Execution stops for part or all of the SFC:

If the stop element is at the end of a:	Then:
sequence	entire SFC stops
selection branch	
path within a simultaneous branch	only that path stops while the rest of the SFC continues to execute.

EXAMPLE Use a Stop Element



When the SFC reaches *last_step* and *process_done* is true, the execution of the SFC stops.

Restart (Reset) the SFC

Once at the stop element, you have several options to restart the SFC:

<table>
<tr><th>If the SFC is:</th><th>And the Last Scan of Active Steps option is:</th><th>Then:</th></tr>
<tr><td rowspan="3">nested (i.e., another SFC calls this SFC as a subroutine)</td><td>Automatic reset</td><td>At the end of the step that calls the nested SFC, the nested SFC automatically resets:
• The nested SFC resets to the initial step.
• The X bit of the stop element in the nested SFC clears to zero.</td></tr>
<tr><td>Programmatic reset</td><td rowspan="2">1. Use an SFC Reset (SFR) instruction to restart the SFC at the required step.
2. Use logic to clear the X bit of the stop element.</td></tr>
<tr><td>Don’t scan</td></tr>
<tr><td>NOT nested (i.e., no SFC calls this SFC as a subroutine)</td><td>→</td><td>1. Use an SFC Reset (SFR) instruction to restart the SFC at the required step.
2. Use logic to clear the X bit of the stop element.</td></tr>
</table>

The following example shows the use of the SFC Reset (SFR) instruction to restart the SFC and clear the X bit of the stop element.

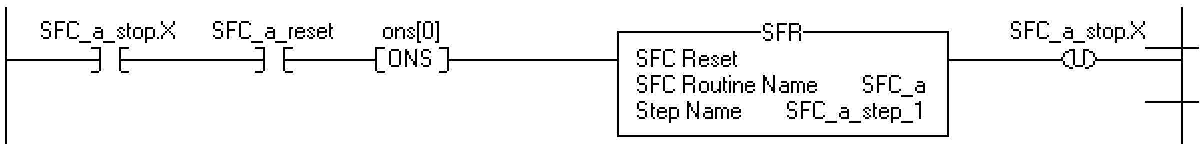
EXAMPLE

Restart (Reset) the SFC

If SFC_a_stop.X = on (SFC_a is at the stop) and SFC_a_reset = on (time to reset the SFC) then for one scan (ons[0] = on):

Reset SFC_a to SFC_a_Step_1

SFC_a_stop.X = 0



SFC_STOP Structure

Each stop uses a tag to provide the following information about the stop element:

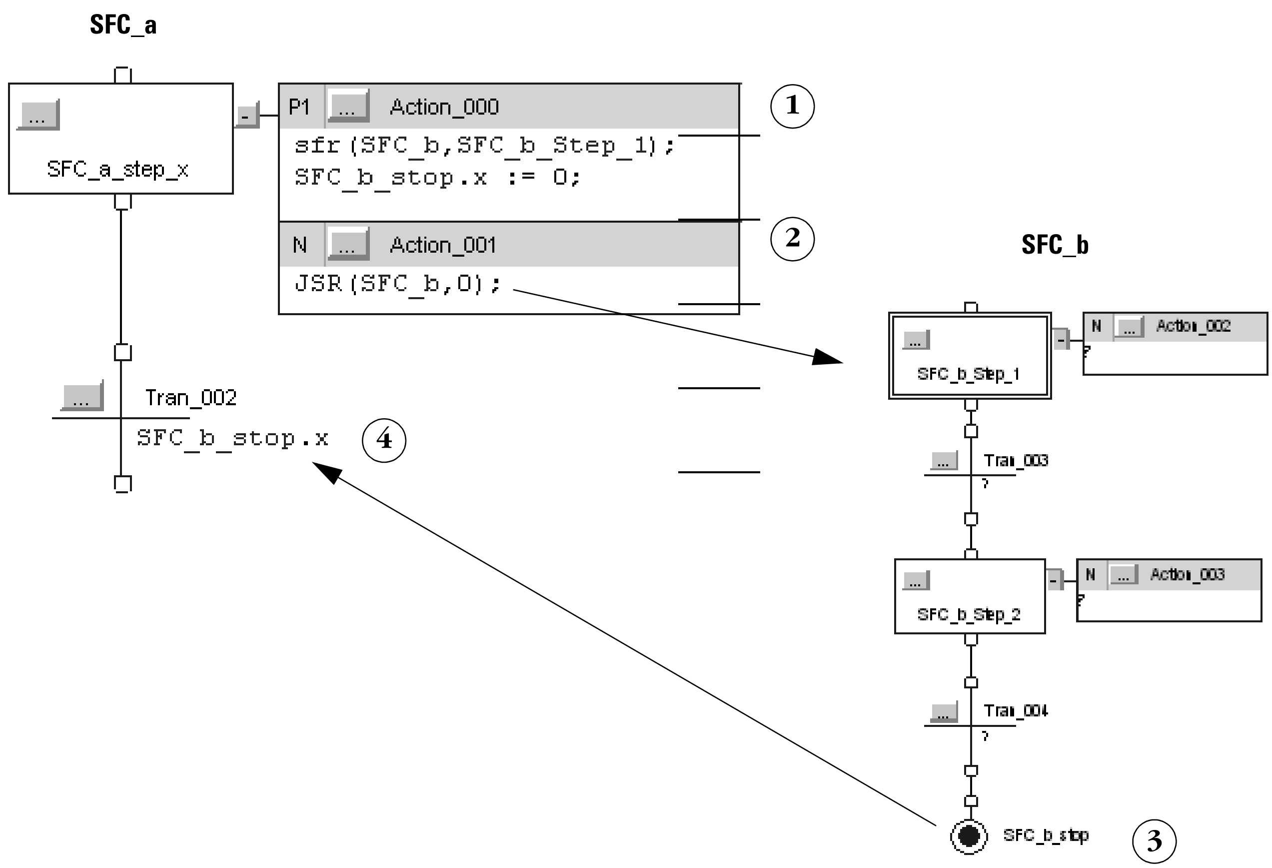
If you want to:	Then check or set this member:	Data type:	Details:
determine when the SFC is at the stop	X	BOOL	• When the SFC reaches the stop, the X bit turns on. • The X bit clears if you configure the SFCs to restart at the initial step and the controller changes from program to run mode. • In a nested SFC, the X bit also clears if you configure the SFCs for automatic reset and the SFC leaves the step that calls the nested SFC.
determine the target of an SFC Reset (SFR) instruction	Reset	BOOL	An SFC Reset (SFR) instruction resets the SFC to a step or stop that the instruction specifies. • The Reset bit indicates to which step or stop the SFC will go to begin executing again. • Once the SFC executes, the Reset bit clears.
determine how many times a stop has become active	Count	DINT	This is *not* a count of scans of the stop. • The count increments each time the stop becomes active. • It increments again only after the stop goes inactive and then active again. • The count resets only if you configure the SFC to restart at the initial step. With that configuration, it resets when the controller changes from program mode to run mode.

If you want to:	Then check or set this member:	Data type:	Details:	
use one tag for the various status bits of this stop	Status	DINT	**For this member:**	**Use this bit:**
			Reset	22
			X	31

Nest an SFC

One method for organizing your project is to create one SFC that provides a high-level view of your process. Each step of that SFC calls another SFC that performs the detailed procedures of the step (nested SFC).

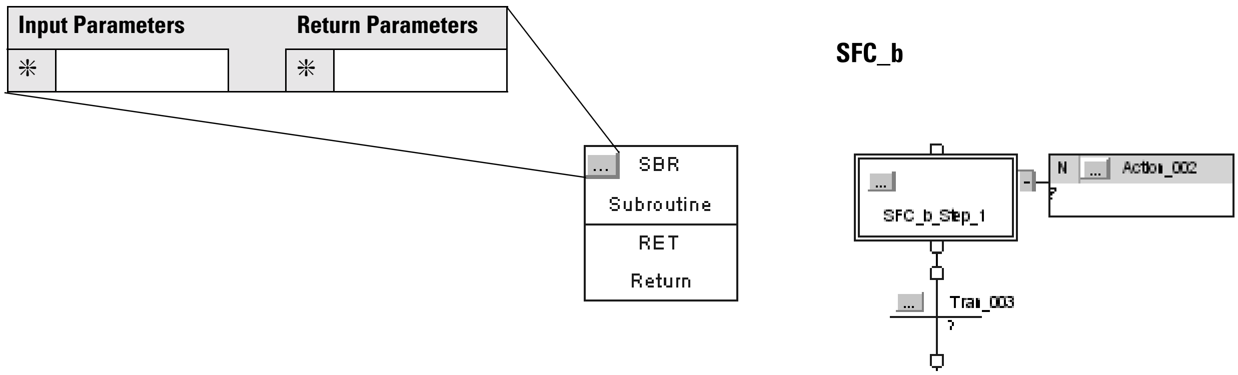
The following figure shows one way to nest an SFC. In this method, the last scan option of the SFC is configured for either *Programmatic reset* or *Don't scan*. If you configure the SFC for *Automatic reset*, then step 1 is unnecessary.



1. Reset the nested SFC:
   - The SFR instruction restarts the *SFC_b* at *SFC_b_Step_1*. Each time the *SFC_a* leaves this step and then returns, you have to reset the *SFC_b*.
   - The action also clears the X bit of the stop element.
2. Call the *SFC_b*.
3. Stop the *SFC_b*. This sets the X bit of the stop element.
4. Use the X bit of the stop element to signal that the *SFC_b* is done and it is time to go to the next step.

Pass Parameters

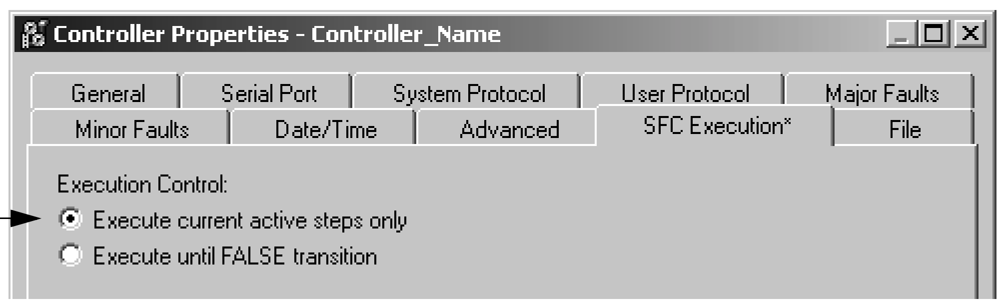
To pass parameters to or from an SFC, place a Subroutine/Return element in the SFC.



Configure When to Return to the OS/JSR

By default, an SFC executes a step or group of simultaneous steps and then returns to the operating system (OS) or the calling routine (JSR).

default



You have the option of letting the SFC execute until it reaches a false transition. If several transitions are true at the same time, this option reduces the time to get to the desired step.

Use the *Execute until FALSE transition* option only when:

1. You don't have to update JSR parameters before each step. Parameters update only when the SFC returns to the JSR. See "Pass Parameters" on page 5-50.

2. A false transition occurs within the watchdog timer for the task. If the time that it takes to return to a JSR and complete the rest of the task is greater than the watchdog timer, a major fault occurs.

For a detailed diagram of the execution of each option, see Figure 5.9 on page 5-55.

Pause or Reset an SFC

Two optional instructions are available that give you further control over the execution of your SFC:

If you want to:	Then use this instruction:
pause an SFC	Pause SFC (SFP)
reset an SFC to a specific step or stop	Reset SFC (SFR)

Both instructions are available in the ladder logic and structured text programming languages.

For more information, use either of the following resources:

- In RSLogix 5000 software, from the *Help* menu, choose *Instruction Help*. Look in the *Program Control Instructions* category.
- See *Logix5000 Controllers General Instructions Reference Manual*, publication 1756-RM003.

Execution Diagrams

The following diagrams show the execution of an SFC with different organizations of steps or different selections of execution options. Use the diagrams if you require a more detailed understanding of how your SFC executes.

Figure 5.5 Execution of a Sequence

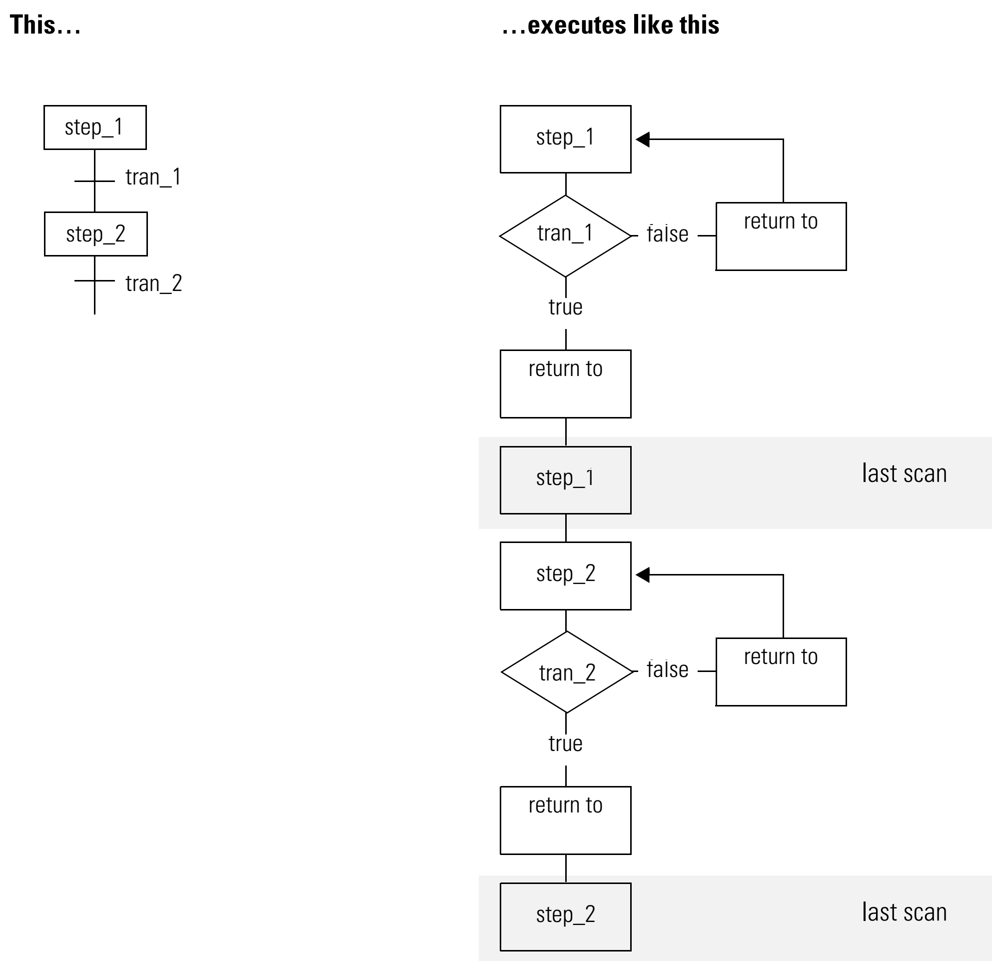


Figure 5.6 Execution of a Simultaneous Branch

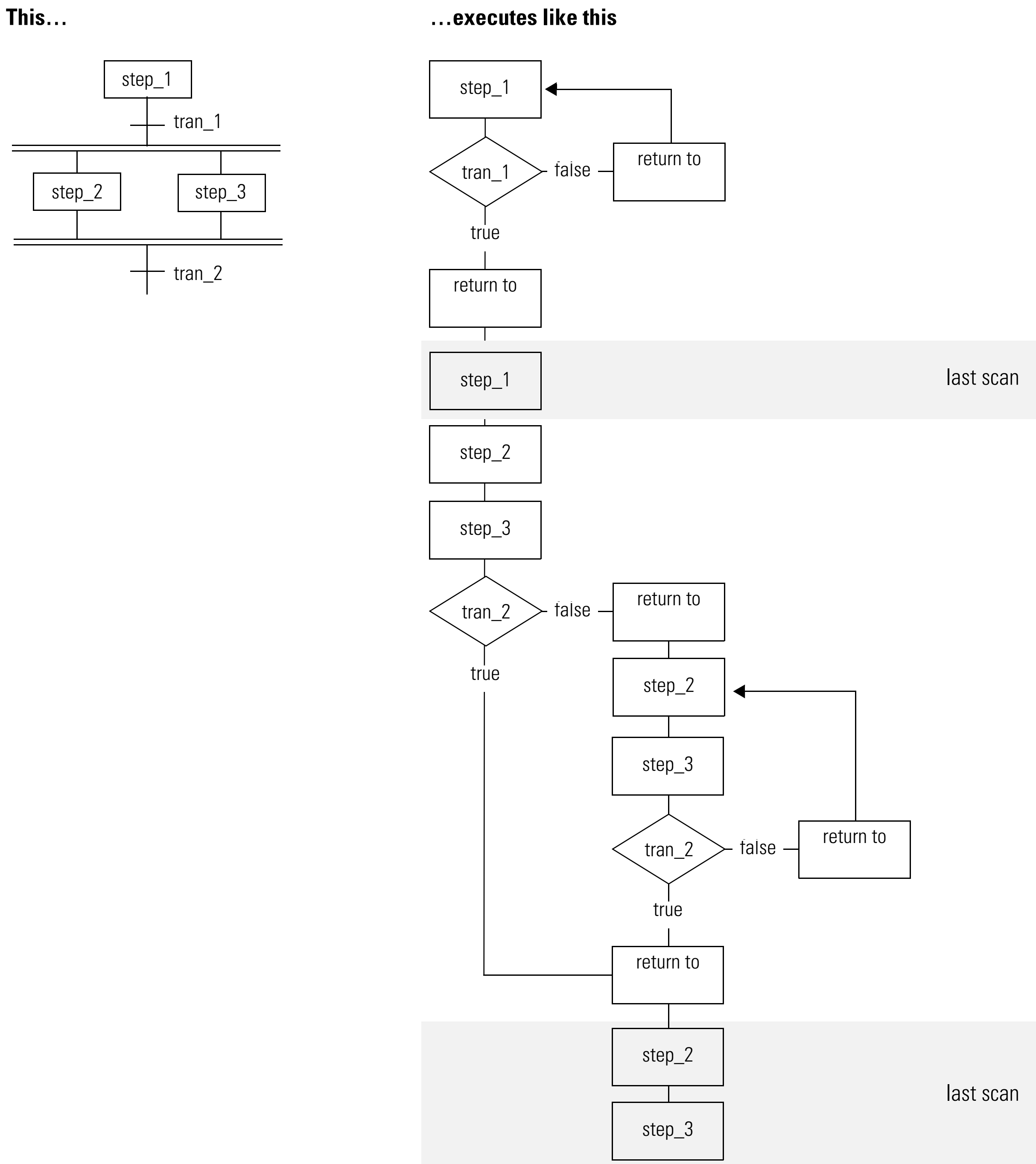


Figure 5.7 Execution of a Selection Branch

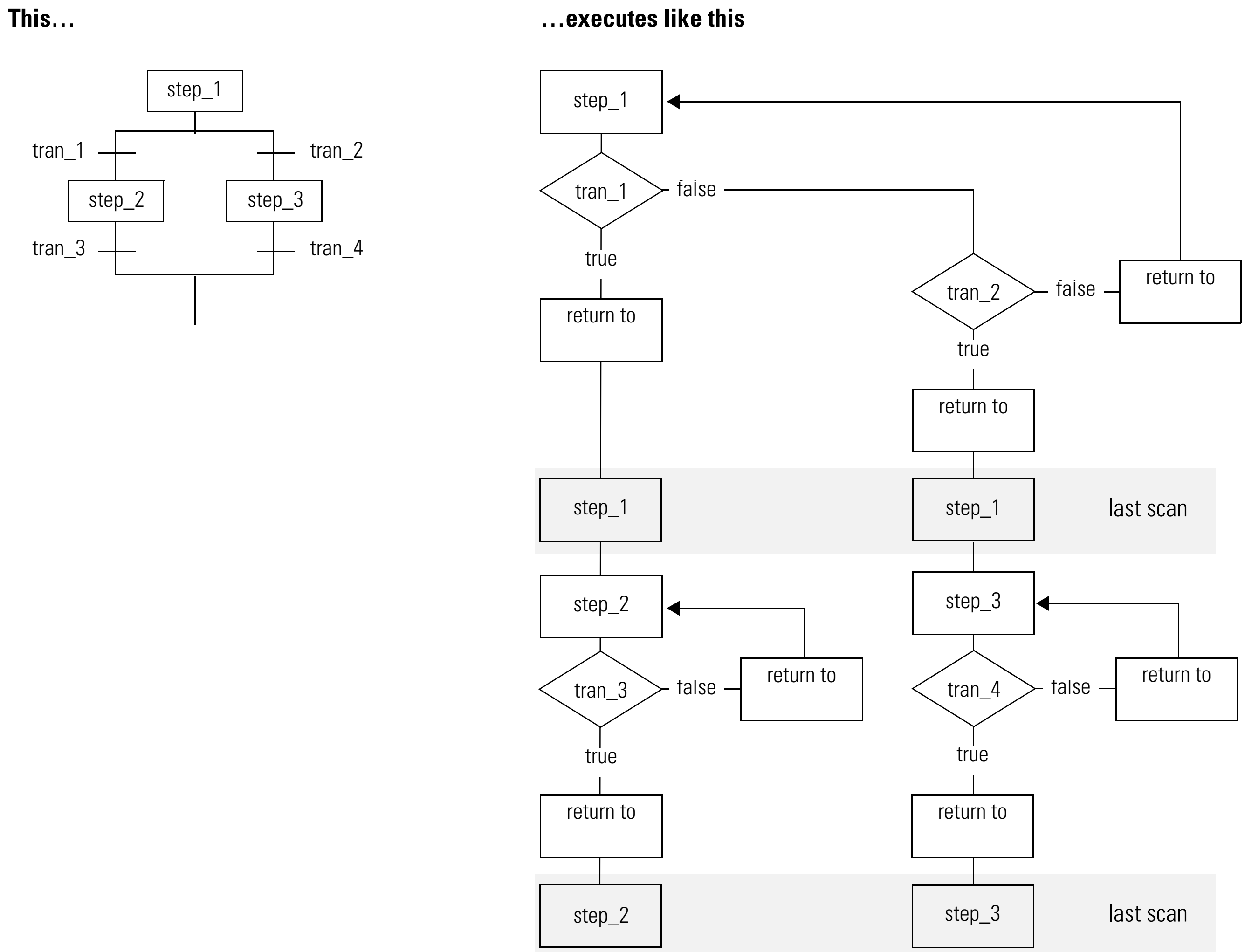


Figure 5.8 When parameters enter and exit an SFC

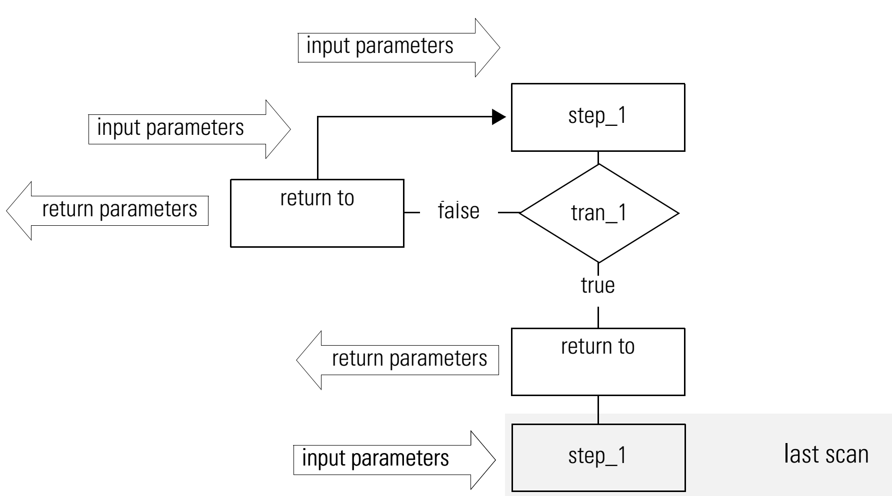
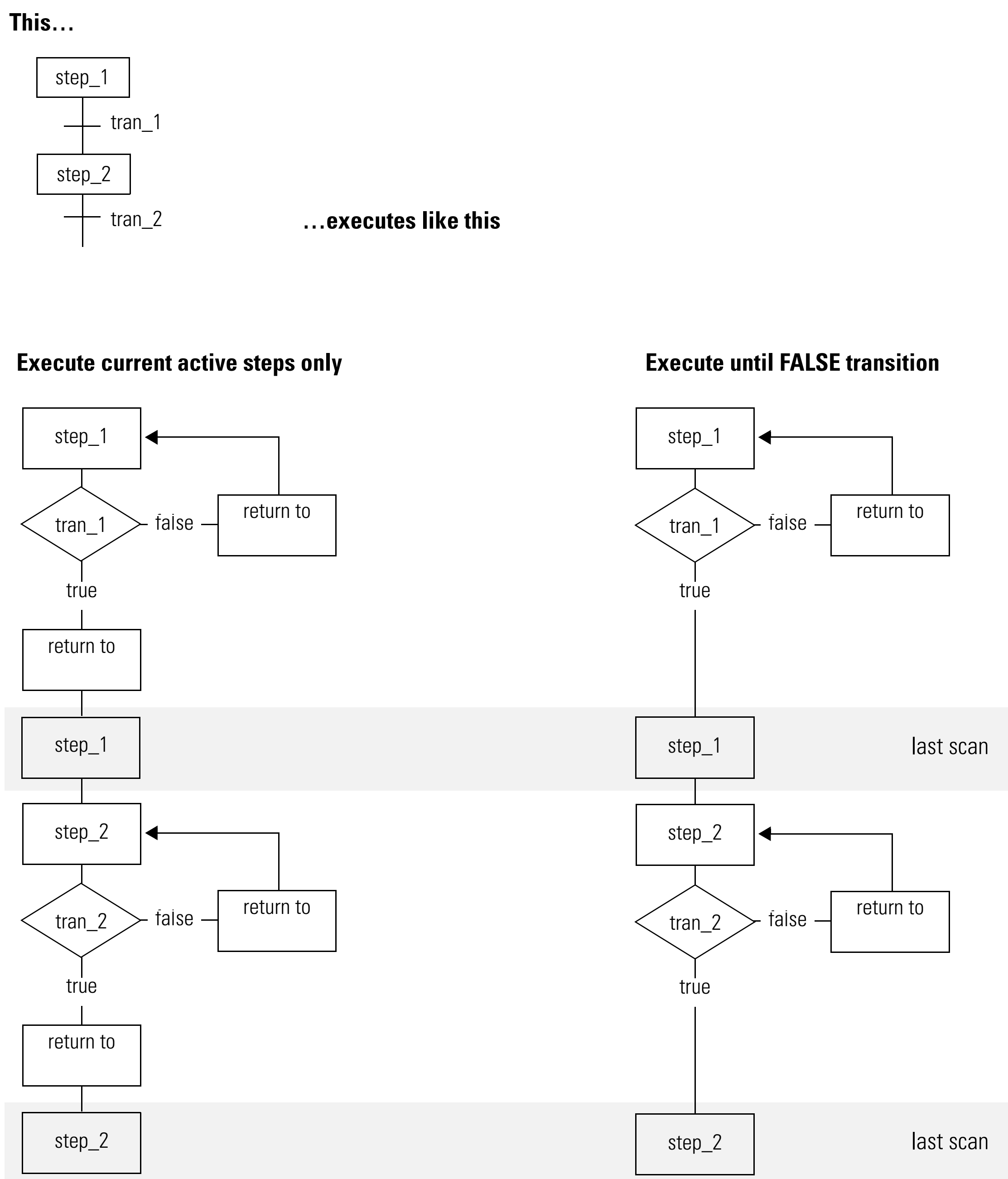


Figure 5.9 Options for Execution Control



Notes:

Program a Sequential Function Chart

When to Use This Procedure

Use this procedure to enter a **sequential function chart** (SFC) into RSLogix 5000 software. Enter the SFC as you design it. Or first design the SFC and then enter it. To design the SFC, see “Design a Sequential Function Chart” on page 5-1.

Before You Use This Procedure

Before you use this procedure, make sure you are able to perform the following tasks:

- ☑ Navigate the Controller Organizer
- ☑ Identify the Programming Languages That Are Installed

For more information on any of those tasks, see “Getting Started” on page 1-1.

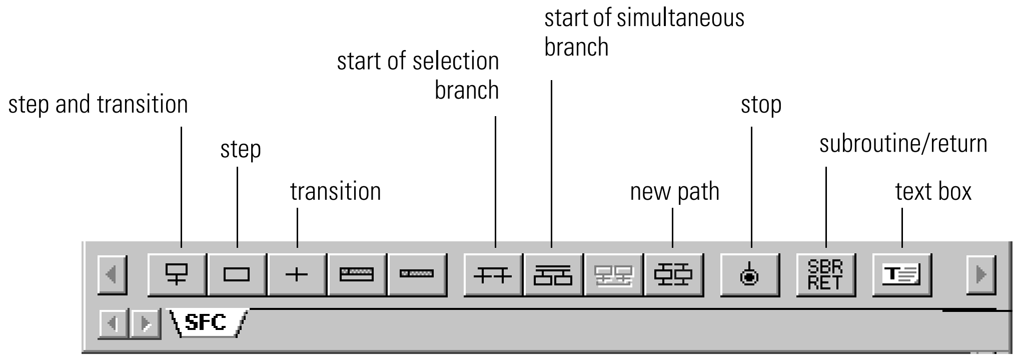
How to Use This Procedure

To program an SFC:

- [ ] Add an SFC Element
- [ ] Create a Simultaneous Branch
- [ ] Create a Selection Branch
- [ ] Set the Priorities of a Selection Branch
- [ ] Return to a Previous Step
- [ ] Rename a Step
- [ ] Configure a Step
- [ ] Rename a Transition
- [ ] Program a Transition
- [ ] Add an Action
- [ ] Rename an Action
- [ ] Configure an Action
- [ ] Program an Action
- [ ] Assign the Execution Order of Actions
- [ ] Document the SFC
- [ ] Show or Hide Text Boxes or Tag Descriptions
- [ ] Configure the Execution of the SFC
- [ ] Verify the Routine

Add an SFC Element

To add SFC elements, use the SFC toolbar.



To add an element to your SFC, you have these options:

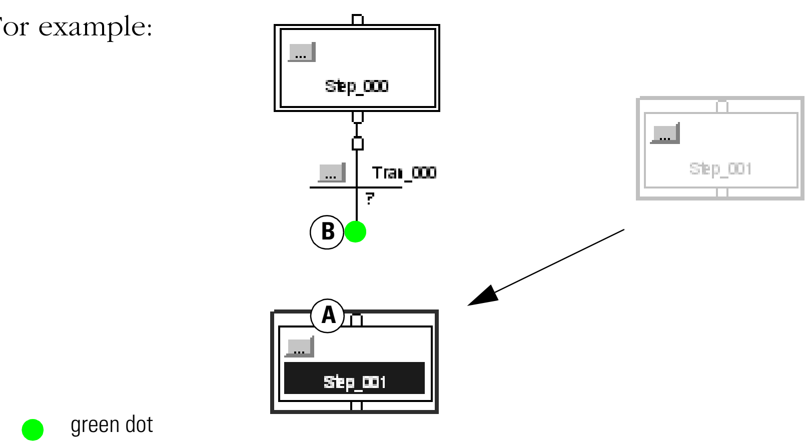
- ☐ Add and Manually Connect Elements
- ☐ Add and Automatically Connect Elements
- ☐ Drag and Drop Elements

Add and Manually Connect Elements

1. On the SFC toolbar, click the button for the item that you want to add.

2. Drag the element to the required location on the SFC.

   For example:



3. To wire (connect) two elements together, click a pin on one of the elements A and then click the pin on the other element B. A green dot shows a valid connection point.

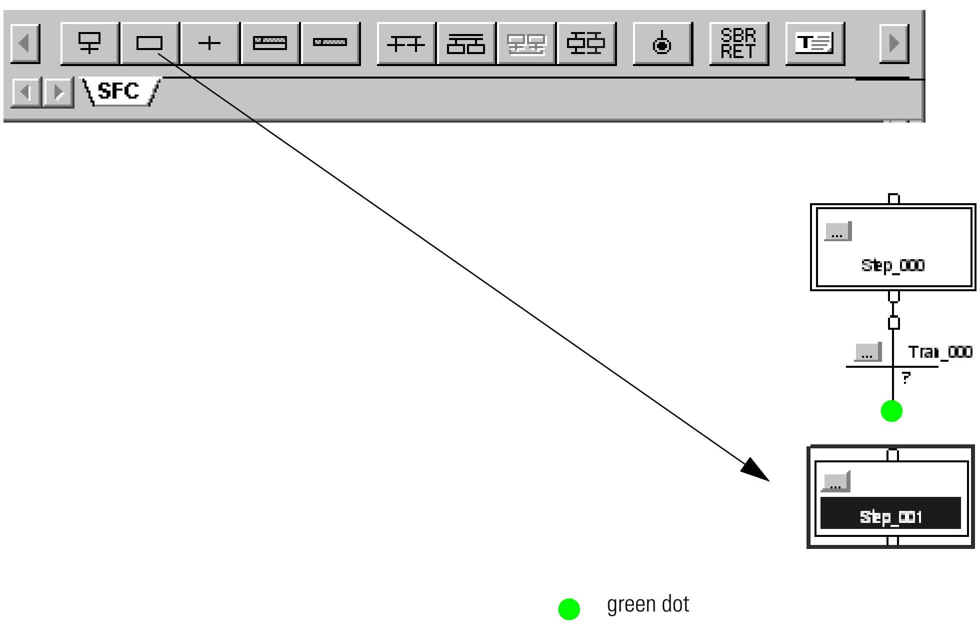
Add and Automatically Connect Elements

1. Select (click) the element to which you want to connect a new element.

2. With the element still selected, click the toolbar button for the next element.

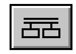
Drag and Drop Elements

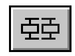
From the SFC toolbar, drag the button for the required element to the desired connection point on the SFC. A green dot shows a valid connection point.

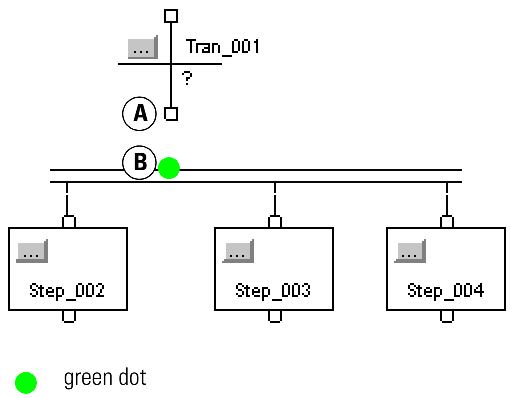


Create a Simultaneous Branch

Start a Simultaneous Branch

1. On the SFC toolbar, click the  button. Then drag the new branch to the desired location.

2. To add a path to the branch, select (click) the first step of the path that is to the left of where you want to add the new path. Then click the  button.

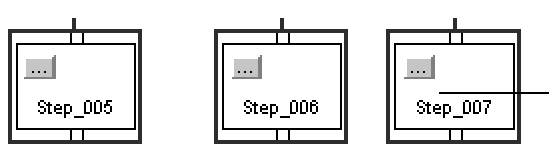


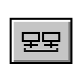
3. To wire the simultaneous branch to the preceding transition, click the bottom pin of the transition A and then click the horizontal line of the branch B. A green dot shows a valid connection point.

End a Simultaneous Branch

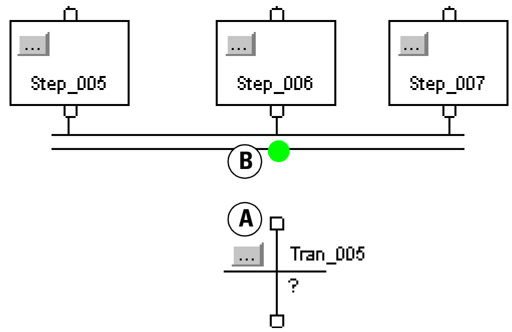
1. Select the last step of each path in the branch. To select the steps, you can either:

   - Click and drag the pointer around the steps that you want to select.
   - Click the first step. Then press and hold [Shift] and click the rest of the steps that you want to select.



2. On the SFC toolbar, click the  button.

3. Add the transition that follows the simultaneous branch.

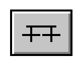


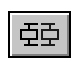
green dot

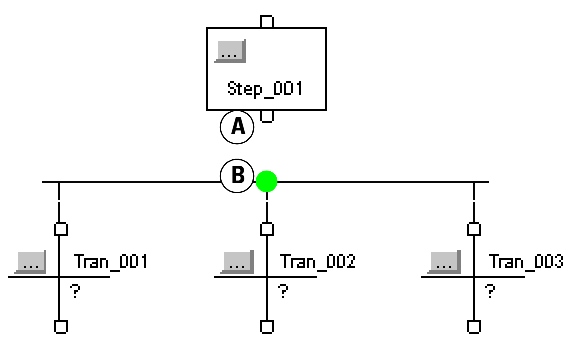
4. To wire the simultaneous branch to the transition, click the top pin of the transition (A) and then click the horizontal line of the branch (B). A green dot shows a valid connection point.

Create a Selection Branch

Start a Selection Branch

1. On the SFC toolbar, click the  button. Then drag the new branch to the desired location.

2. To add a path to the branch, select (click) the first transition of the path that is to the left of where you want to add the new path. Then click the  button.



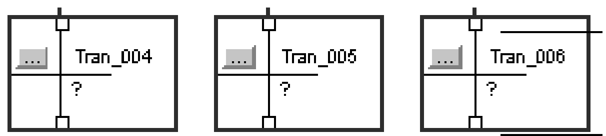
green dot

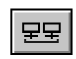
3. To wire the selection branch to the preceding step, click the bottom pin of the step (A) and then click the horizontal line of the branch (B). A green dot shows a valid connection point.

End a Selection Branch

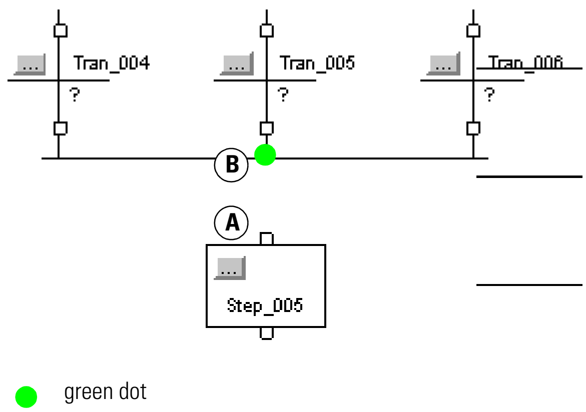
1. Select the last transition of each path in the branch. To select the transitions, you can either:

   - Click and drag the pointer around the transitions that you want to select.
   - Click the first transition. Then press and hold [Shift] and click the rest of the transitions that you want to select.



2. On the SFC toolbar, click the  button.

3. Add the step that follows the selection branch.



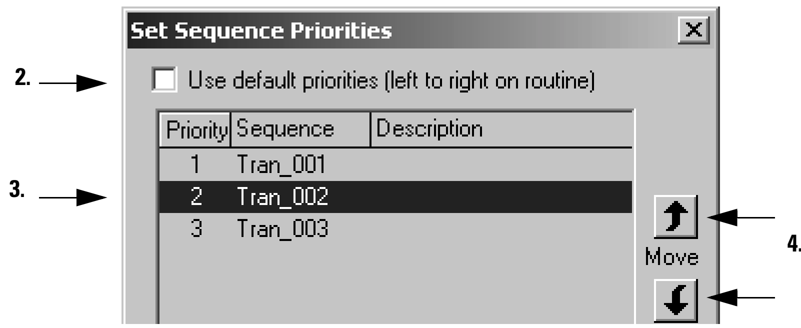
4. To wire the selection branch to the step, click the top pin of the step A and then click the horizontal line of the branch B. A green dot shows a valid connection point.

Set the Priorities of a Selection Branch

By default, the SFC checks the transitions that start a selection branch from left to right. If you want to check a different transition first, assign a priority to each path of the selection branch. For example, it is a good practice to check for error conditions first. Then check for normal conditions.

To assign priorities to a selection branch:

1. Right click the horizontal line that starts the branch and choose *Set Sequence Priorities*.



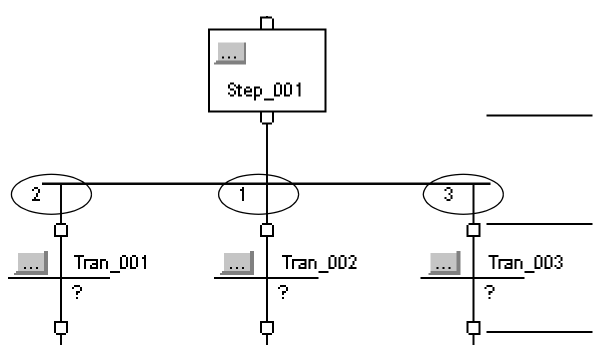
2. Clear (uncheck) the *Use default priorities* check box.

3. Select a transition.

4. Use the *Move* buttons to raise or lower the priority of the transition.

5. When all the transitions have the desired priority, choose OK

When you clear (uncheck) the *Use default priorities* check box, numbers show the priority of each transition.



Return to a Previous Step

To jump to a different step in your SFC:

- Connect a Wire to the Step
- Hide a Wire
- Show a Hidden Wire

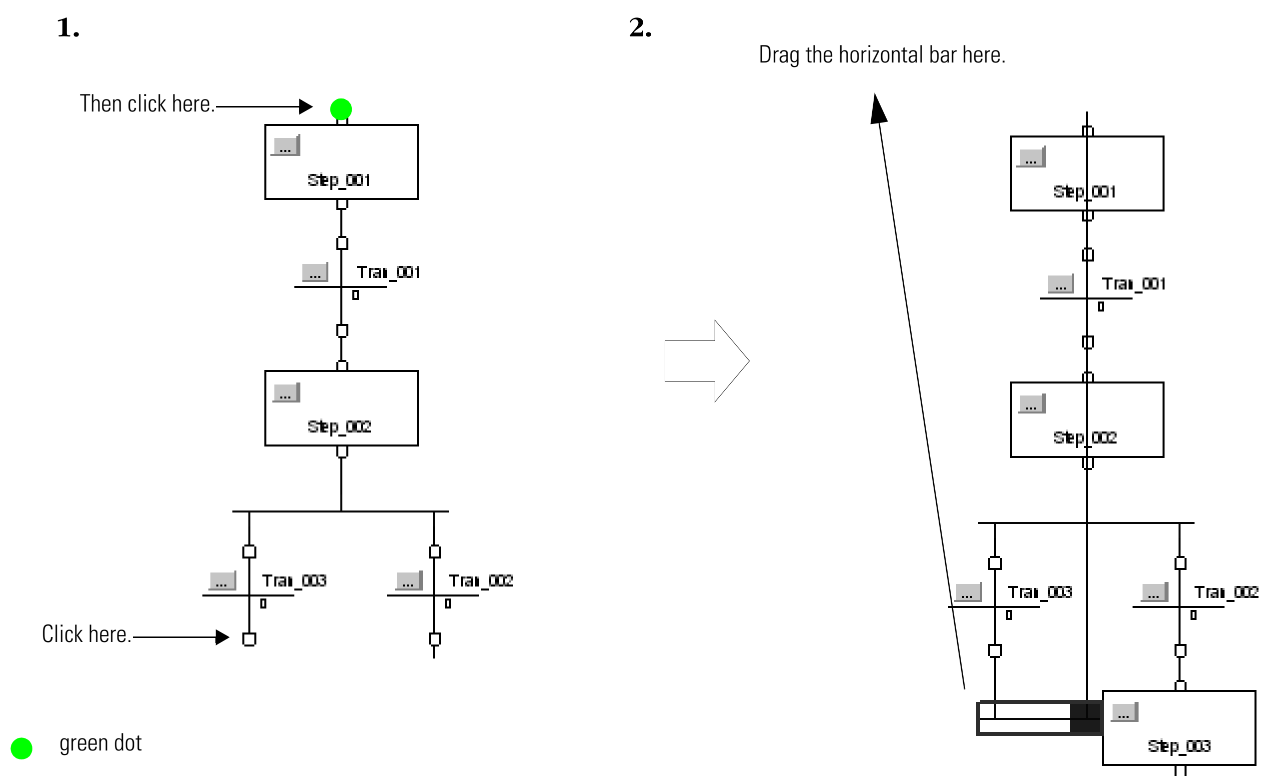
Connect a Wire to the Step

1. Click the lower pin of the transition that signals the jump. Then click the top pin of the step to which you want to go. A green dot shows a valid connection point.

   Typically, the resulting connection orients itself along the center of the flowchart and is hard to see.

2. To make the jump easier to read, drag its horizontal bar above the step to which the jump goes. You may also have to reposition some of the SFC elements.

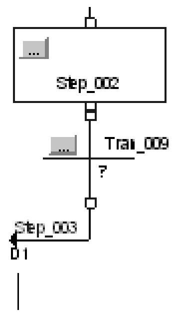
For example, to go to *Step_001* from *Tran_003*:



Hide a Wire

If a wire gets in the way of other parts of your SFC, hide the wire to make the SFC easier to read.

To hide a wire, right-click the wire and choose *Hide Wire*.

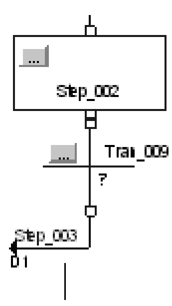


location to which the wire goes

To see the SFC element to which the wire goes, click the grid location on the wire.

Show a Hidden Wire

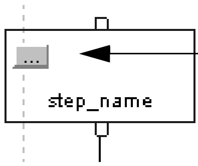
To show a wire that is hidden, right-click a visible part of the wire and choose *Show Wire*.



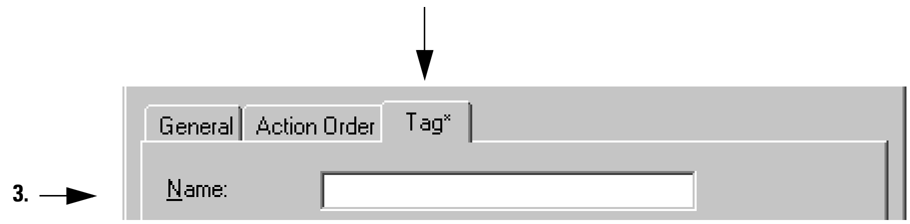
hidden wire

Rename a Step

Each step uses a tag to store configuration and status information about the step. To rename the tag of the step:



1. Click the ... button of the step.
2. Click the *Tag* tab.



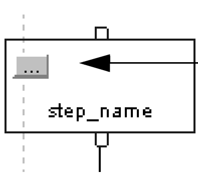
3. Type the new name for the step (tag).
4. Choose OK

Configure a Step

To configure a step, you have these options:

- Assign the Preset Time for a Step
- Configure Alarms for a Step
- Use an Expression to Calculate a Time

Assign the Preset Time for a Step



1. Click the ... button of the step.

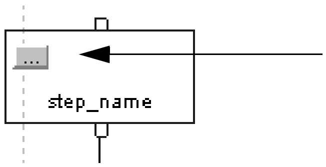
2. Type the time for the step, in milliseconds.
3. Choose OK

When the step is active for the preset time (Timer = Preset), the DN bit of the step turns on.

To calculate the preset time for a step at runtime, see “Use an Expression to Calculate a Time” on page 6-12.

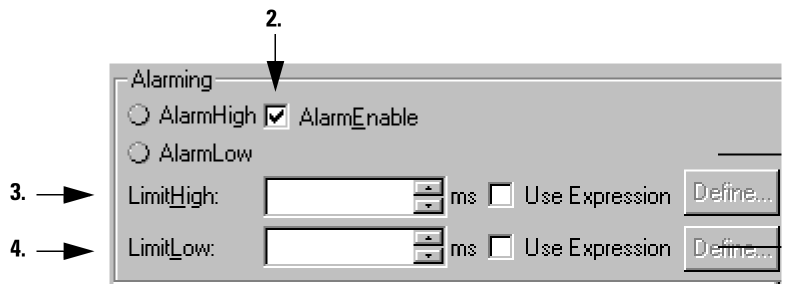
Configure Alarms for a Step

To turn on an alarm if a step executes too long or not long enough:



1. Click the ... button of the step.

2. Check the *AlarmEnable* check box.



3. Type the time for the high alarm, in milliseconds.

4. Type the time for the low alarm, in milliseconds.

5. Choose OK

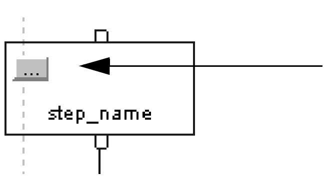
To calculate the time for an alarm at runtime, see “Use an Expression to Calculate a Time” on page 6-12.

Use an Expression to Calculate a Time

To calculate a time based on tags in your project, enter the time as a **numeric expression**. You can use an expression to calculate the following times:

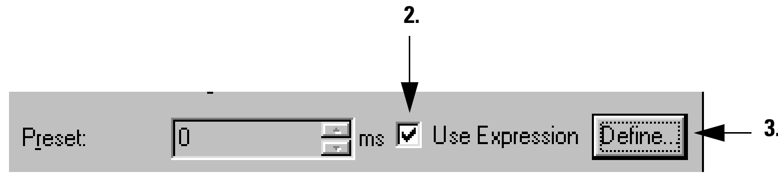
- Preset
- LimitHigh
- LimitLow

To enter a time as an expression:

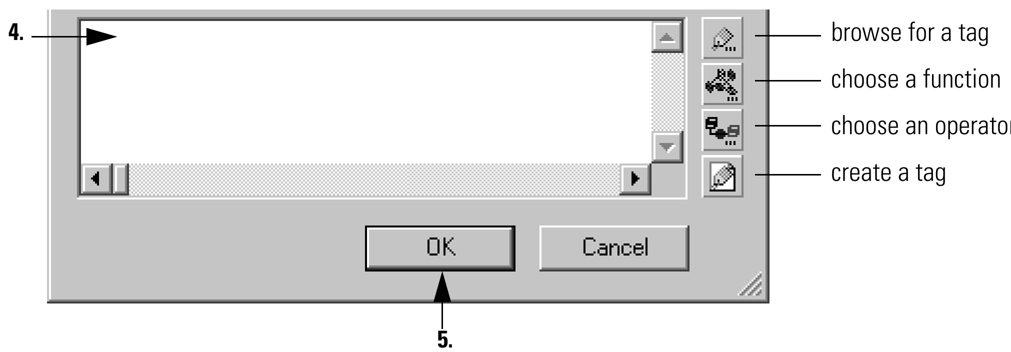


1. Click the ... button of the step.

2. Select (check) the *Use Expression* check box.



3. Click the *Define* button.

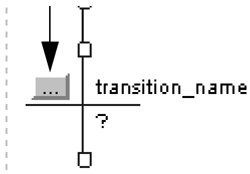


4. Type a **numeric expression** that defines the time.
- Use the buttons alongside the dialog box to help you complete the expression.
- For information on numeric expressions, see “Expressions” on page 7-4.

5. Choose 

6. To close the *Step Properties* dialog box, choose 

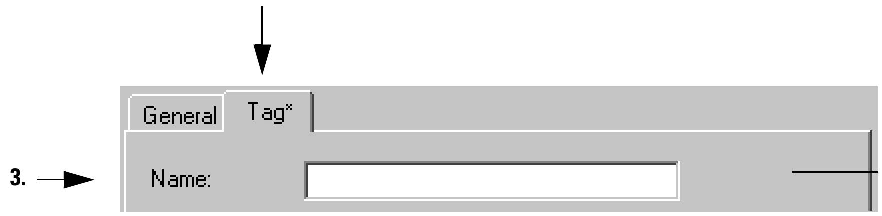
Rename a Transition



Each transition uses a tag to store the status of the transition. To rename the tag of the transition:

1. Click the ... button of the transition.

2. Click the *Tag* tab.



3. Type the new name for the transition (tag).

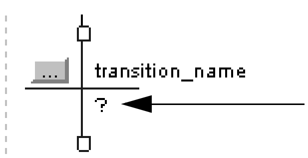
4. Choose OK

Program a Transition

To program a transition, you have these options:

- Enter a BOOL Expression
- Call a Subroutine

Enter a BOOL Expression

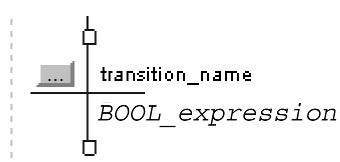


The simplest way to program the transition is to enter the conditions as a **BOOL expression** in structured text. For information on BOOL expressions, see “Expressions” on page 7-4.

1. Double-click the text area of the transition.

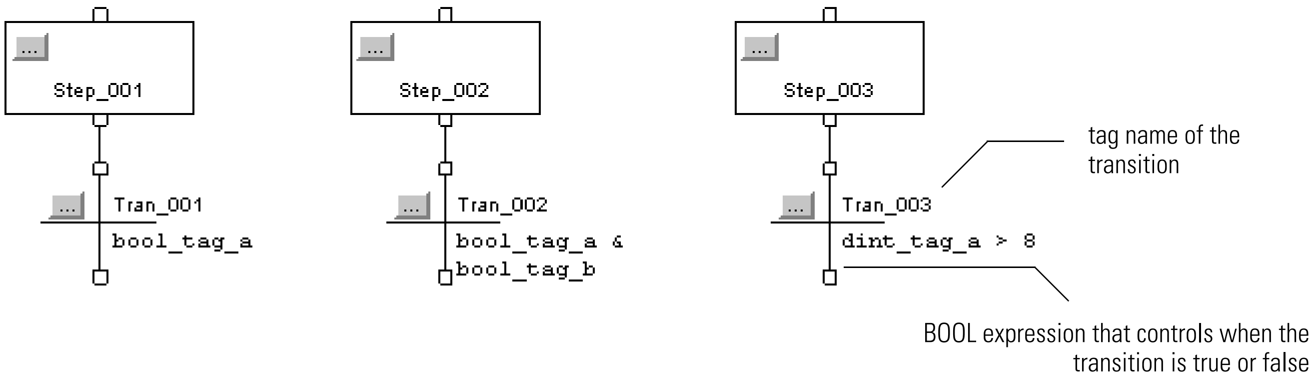
2. Type the BOOL expression that determines when the transition is true or false.

3. To close the text entry window, press [Ctrl] + [Enter].

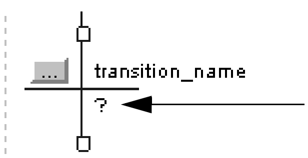


The following example shows three transitions that use a BOOL expression.

EXAMPLE Enter a BOOL Expression



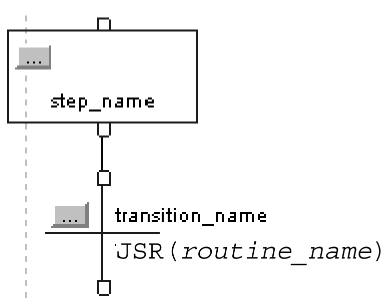
Call a Subroutine



1. Right-click the transition and choose *Set JSR*.

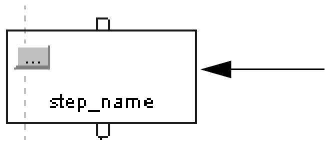
2. Choose the routine that contains the logic for the transition.

3. Choose OK

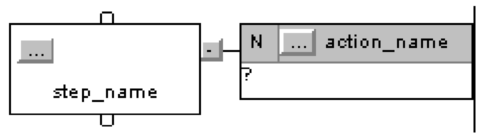


Add an Action

To add an action to a step:

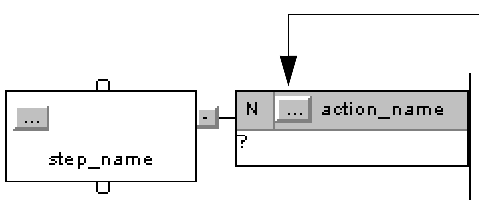


Right-click the step in which the action executes and choose *Add Action*.



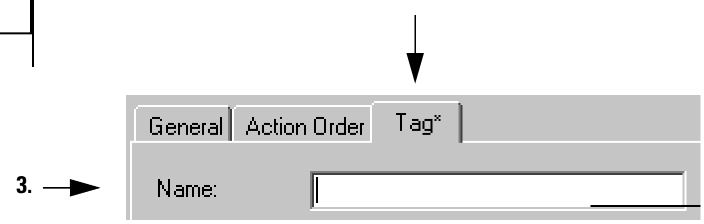
Rename an Action

To change the name of an action to something that is specific to your application:



1. Click the ... button of the action.

2. Click the *Tag* tab.



3. Type the new name for the action (tag).

4. Choose OK

Configure an Action

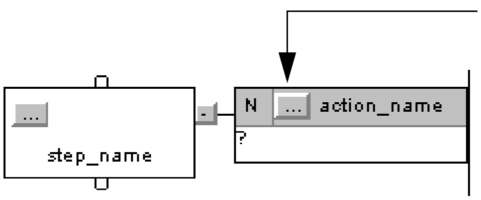
To configure an action, you have these options:

- Change the Qualifier of an Action
- Calculate a Preset Time at Runtime
- Mark an Action as a Boolean Action

Change the Qualifier of an Action

A qualifier determines when an action starts and stops. The default qualifier is *N Non-Stored*. The action starts when the step is activated and stops when the step is deactivated. For more information, see “Choose a Qualifier for an Action” on page 5-23.

1. Click the ... button of the action.



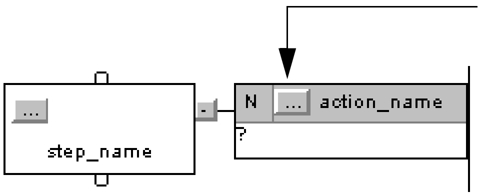
2. Assign the qualifier for the action.

3. If you chose a timed qualifier, type the time limit or delay for the action, in milliseconds. Timed qualifiers include:
   - L Time Limited
   - SL Stored and Time Limited
   - D Time Delayed
   - DS Delayed and Stored
   - SD Stored and Time Delayed

4. Choose OK

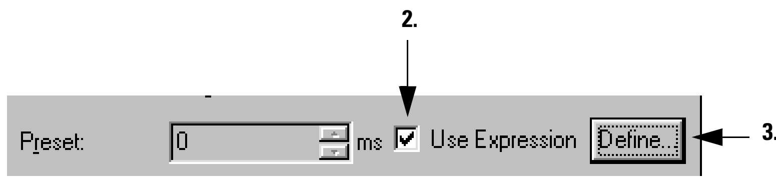
Calculate a Preset Time at Runtime

To calculate a preset value based on tags in your project, enter the value as a **numeric expression**.

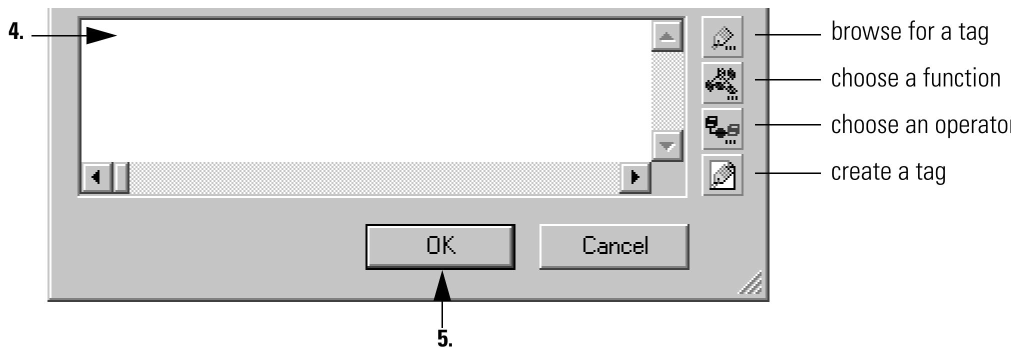


1. Click the [...] button of the action.

2. Select (check) the *Use Expression* check box.



3. Click the *Define* button.



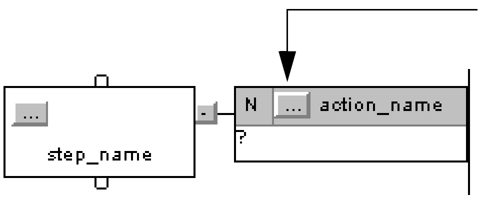
4. Type a **numeric expression** that defines the preset time.
   - Use the buttons alongside the dialog box to help you complete the expression.
   - For information on numeric expressions, see “Expressions” on page 7-4.

5. Choose [OK]

6. To close the *Action Properties* dialog box, choose [OK]

Mark an Action as a Boolean Action

Use a boolean action to only set a bit when the action executes. For more information, see “Use a Boolean Action” on page 5-20.



1. Click the ... button of the action.

2. Click the *Boolean* check box.

3. Choose OK

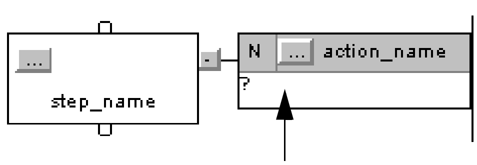
Program an Action

To program an action, you have these options:

- Enter Structured Text
- Call a Subroutine

Enter Structured Text

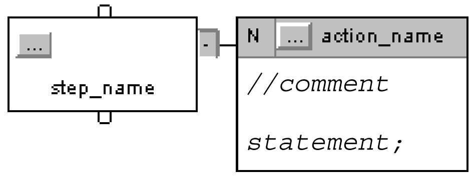
The easiest way to program an action is to write the logic as structured text within the body of the action. When the action turns on, the controller executes the structured text.



1. Double-click the text area of the action.

2. Type the required structured text.

3. To close the text entry window, press [Ctrl] + [Enter].

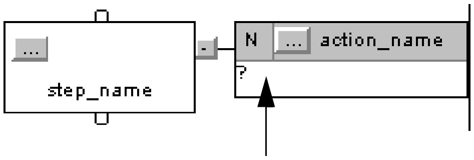


For information on structured text:

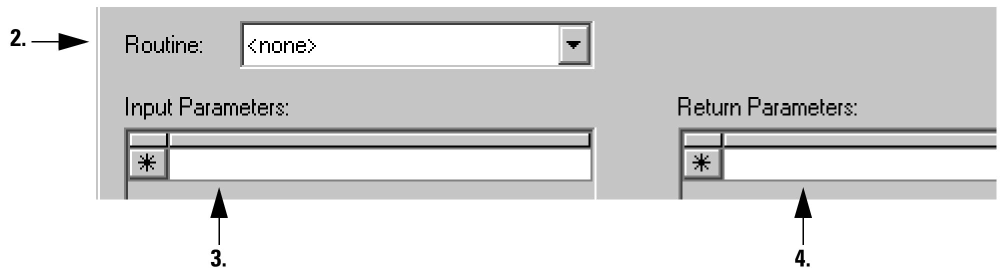
For this structured text information:	See:
general information about assignments, operators, functions, instructions, or comments	"Program Structured Text" on page 7-1
information about a specific instruction	• *Logix5000 Controllers General Instructions Reference Manual*, publication 1756-RM003 • *Logix5000 Controllers Process and Drives Instructions Reference Manual*, publication 1756-RM006 • *Logix5000 Controllers Motion Instruction Set Reference Manual*, publication 1756-RM007

Call a Subroutine

Use a Jump to Subroutine (JSR) instruction to execute a subroutine when the action is active.



1. In the SFC, right-click the text entry area of the action and choose *Set JSR*.

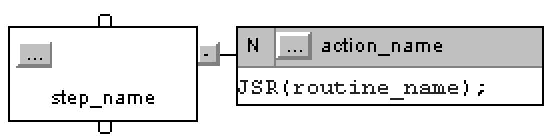


2. Choose the routine that you want to call.

3. To pass a parameter to the routine, click the empty *Input Parameters* text box. Then use the down arrow to choose the tag that contains the parameter.

4. To receive a parameter from the routine, click the empty *Return Parameters* text box. Then use the down arrow to choose the tag in which to store the parameter from the routine.

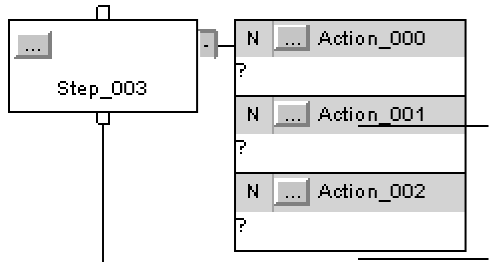
5. Choose 



Assign the Execution Order of Actions

Actions execute in the order in which they appear.

For example:

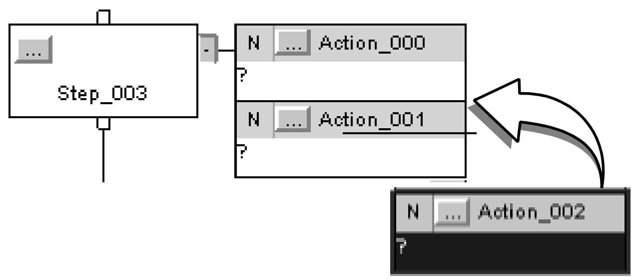


When *Step_003* is active, its actions execute in this order:

1. *Action_000*
2. *Action_001*
3. *Action_002*

To change the order in which an action executes, drag the action to the desired location in the sequence. A green bar shows a valid placement location.

For example:



Document the SFC

To document an SFC, you have the following options:

To document this:	And you want to:	Do this:
general information about the SFC	→	Add a Text Box
step	→	Add a Text Box -or- Add a Tag Description
transition	download the documentation to the controller	Add Structured Text Comments
	have the option of showing or hiding the documentation	Add a Text Box -or- Add a Tag Description
	position the documentation anywhere in the SFC	
action	download the documentation to the controller	Add Structured Text Comments
stop	→	Add a Text Box -or- Add a Tag Description
other element (e.g., selection branch)	→	

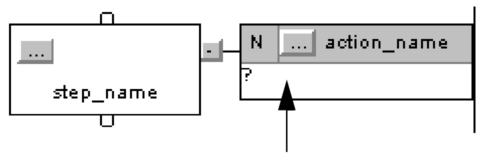
Add Structured Text Comments

Use the following table to format your comments:

To add a comment:	Use one of these formats:
on a single line	//*comment*
at the end of a line of structured text	(**comment**) /**comment**/
within a line of structured text	(**comment**) /**comment**/
that spans more than one line	(**start of comment . . . end of comment**) /**start of comment . . . end of comment**/

For more information, see "Comments" on page 7-28.

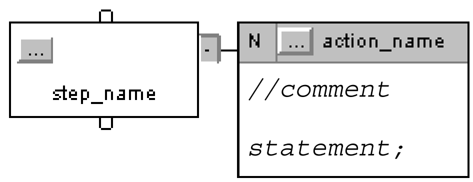
To enter the comments:



1. Double-click the text area of the action.

2. Type the comments.

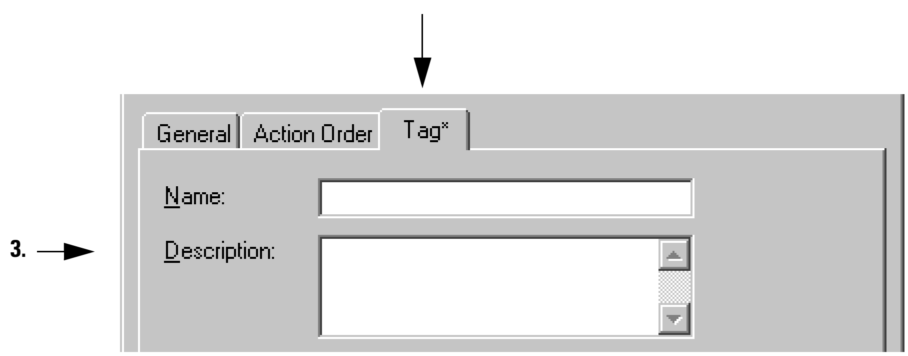
3. To close the text entry window, press [Ctrl] + [Enter].



Add a Tag Description

1. Click the ... button of the element.

2. Click the *Tag* tab.



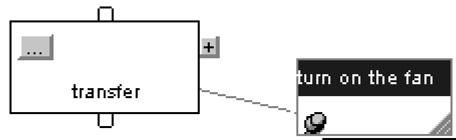
3. Type the description for the element (tag).

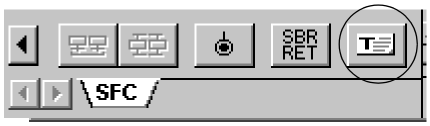
4. Choose OK

5. Drag the description box to the desired location on the SFC.

Add a Text Box

A text box lets you add notes that clarify the function of an SFC element (step, transition, stop, etc.). Or use a text box to capture information that you will use later on. For example:





1. Click 

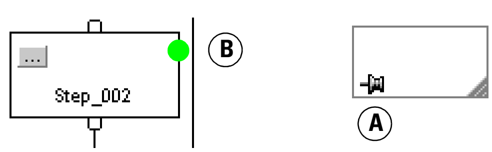
   A text box appears. 

2. Drag the text box to a location near the element to which it applies.

3. Double-click the text box and type the note. Then press [Ctrl] + [Enter].

4. As you move the element on the SFC, what do you want the text box to do?

If you the text box to:	Then:
stay in the same spot	Stop. You are done.
move with the element to which it applies	Go to step 5.



 green dot

5. Click the pin symbol in the text box and then click the SFC element to which you want to attach the text box. A green dot shows a valid connection point.

Show or Hide Text Boxes or Tag Descriptions

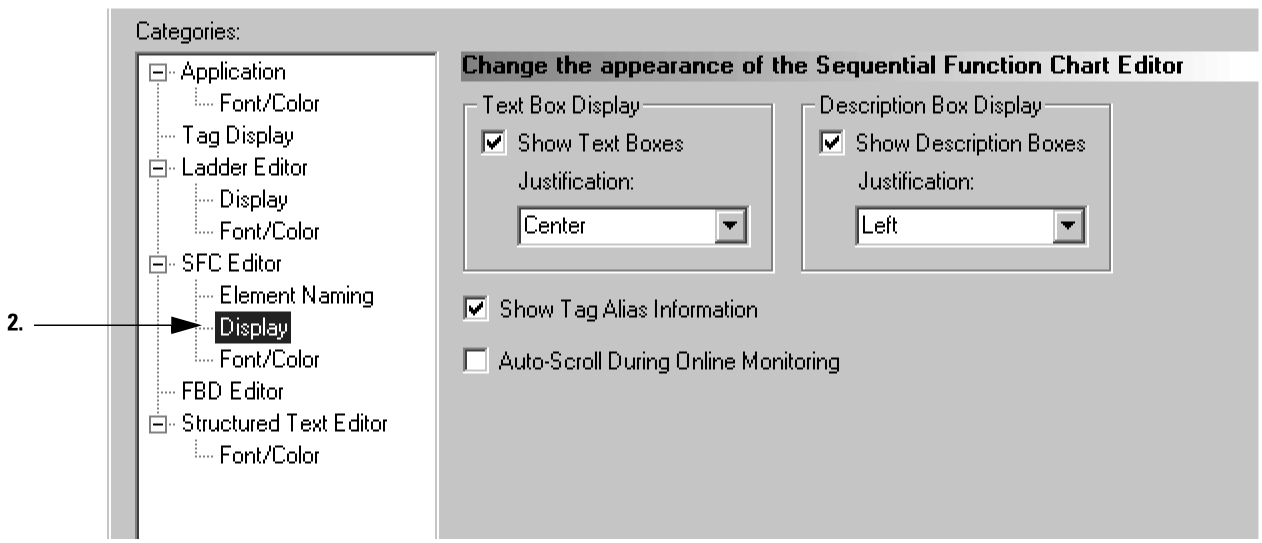
You have the option of showing or hiding both text boxes and tag descriptions. If you choose to show descriptions, the SFC window only shows the descriptions for steps, transitions, and stops (not actions).

To show or hide text boxes or descriptions, you have these options:

- Show or Hide Text Boxes or Descriptions
- Hide an Individual Tag Description

Show or Hide Text Boxes or Descriptions

1. From the *Tools* menu, choose *Options*.



2. Under *SFC Editor*, choose the *Display* category.

3. Choose the desired option.

If you want to:	Then:
show text boxes or descriptions	check the corresponding check box
hide text boxes or descriptions	clear (uncheck) the corresponding check box

4. Choose OK

Hide an Individual Tag Description

To hide the description of a specific element while showing other descriptions:

1. Click the [...] button of the element whose description you want to hide.

2. Check the *Never display description in routine* check box.

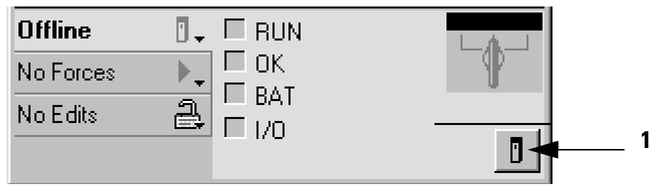
3. Choose [OK]

To show other descriptions, see “Show or Hide Text Boxes or Descriptions” on page 6-26.

Configure the Execution of the SFC

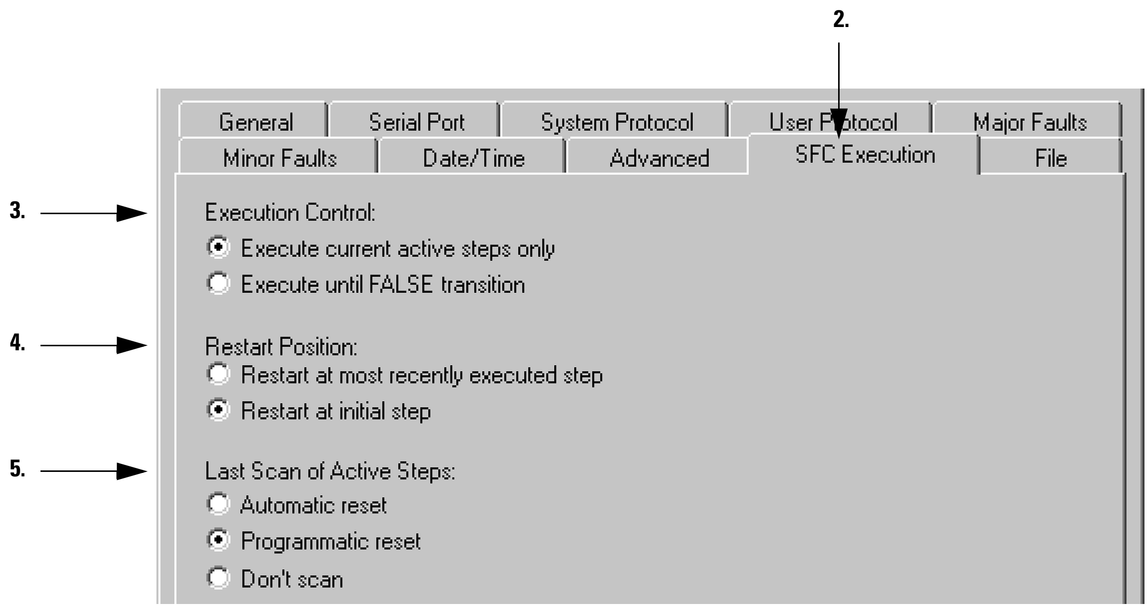
The SFC Execution tab of the controller properties lets you configure the following:

- what to do when a transition is true
- where to start after a transition to the run mode or recovery from a power loss
- what to do on the last scan of a step



1. On the Online toolbar, click controller properties button.

2. Click the *SFC Execution* tab.



3. Choose whether or not to return to the OS/JSR if a transition is true.

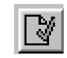
4. Choose where to restart the SFC after a transition to run mode or recovery from a power loss.

5. Choose what to do on the last scan of a step.

6. Choose OK

Verify the Routine

As you program your routine, periodically verify your work:

1. In the top-most toolbar of the RSLogix 5000 window, click 
2. If any errors are listed at the bottom of the window:
   a. To go to the first error or warning, press [F4].
   b. Correct the error according to the description in the Results window.
   c. Go to step 1.
3. To close the Results window, press [Alt] + [1].

Notes:

Notes:

Program Structured Text

When to Use This Chapter

Use this chapter to write and enter structured text for a:

- structured text routine
- action of a sequential function chart (SFC)
- transition of sequential function chart (SFC)

Structured Text Syntax

Structured text is a textual programming language that uses statements to define what to execute.

- Structured text is not case sensitive.
- Use tabs and carriage returns (separate lines) to make your structured text easier to read. They have no effect on the execution of the structured text.

Structured text can contain these components:

Term:	Definition:		Examples:
assignment (see page 7-2)	Use an assignment statement to assign values to tags. The := operator is the assignment operator. Terminate the assignment with a semi colon ";".		`tag := expression;`
expression (see page 7-4)	An expression is part of a complete assignment or construct statement. An expression evaluates to a number (numerical expression) or to a true or false state (BOOL expression). An expression contains:		
	tags	A named area of the memory where data is stored (BOOL, SINT,INT,DINT, REAL, string).	`value1`
	immediates	A constant value.	`4`
	operators	A symbol or mnemonic that specifies an operation within an expression.	`tag1 + tag2` `tag1 >= value1`
	functions	When executed, a function yields one value. Use parentheses to contain the operand of a function. Even though their syntax is similar, functions differ from instructions in that functions can only be used in expressions. Instructions cannot be used in expressions.	`function(tag1)`

Term:	Definition:	Examples:

instruction (see page 7-11)	An instruction is a standalone statement.
	An instruction uses parenthesis to contain its operands.
	Depending on the instruction, there can be zero, one, or multiple operands.
	When executed, an instruction yields one or more values that are part of a data structure.
	Terminate the instruction with a semi colon ";".
	
	Even though their syntax is similar, instructions differ from functions in that instructions cannot be used in expressions. Functions can only be used in expressions.
		`instruction();`
		
		`instruction(operand);`
		
		`instruction(operand1, operand2,operand3);`

construct (see page 7-12)	A conditional statement used to trigger structured text code (i.e, other statements).
	Terminate the construct with a semi colon ";".
		`IF...THEN`
		`CASE`
		`FOR...DO`
		`WHILE...DO`
		`REPEAT...UNTIL`
		`EXIT`

comment (see page 7-28)	Text that explains or clarifies what a section of structured text does.
	• Use comments to make it easier to interpret the structured text.
	• Comments do not affect the execution of the structured text.
	• Comments can appear anywhere in structured text.
		`//comment`
		
		`(*start of comment . . . end of comment*)`
		
		`/*start of comment . . . end of comment*/`

Assignments

Use an assignment to change the value stored within a tag. An assignment has this syntax:

tag := *expression* ;

where:

Component:	Description:	
tag	represents the tag that is getting the new value the tag must be a BOOL, SINT, INT, DINT, or REAL	
:=	is the assignment symbol	
expression	represents the new value to assign to the tag	
	If *tag* is this data type:	**Use this type of expression:**
	BOOL	BOOL expression
	SINT INT DINT REAL	numeric expression
;	ends the assignment	

The *tag* retains the assigned value until another assignment changes the value.

The expression can be simple, such as an immediate value or another tag name, or the expression can be complex and include several operators and/or functions. See the next section “Expressions“on page 7-4 for details.

Specify a non-retentive assignment

The non-retentive assignment is different from the regular assignment described above in that the tag in a non-retentive assignment is reset to zero each time the controller:

- enters the RUN mode
- leaves the step of an SFC if you configure the SFC for *Automatic reset* (This applies only if you embed the assignment in the action of the step or use the action to call a structured text routine via a JSR instruction.)

A non-retentive assignment has this syntax:

`tag` [:=] `expression` ;

where:

<table>
<tr><th>Component:</th><th colspan="2">Description:</th></tr>
<tr><td><code>tag</code></td><td colspan="2">represents the tag that is getting the new value
the tag must be a BOOL, SINT, INT, DINT, or REAL</td></tr>
<tr><td>[:=]</td><td colspan="2">is the non-retentive assignment symbol</td></tr>
<tr><td rowspan="4"><code>expression</code></td><td colspan="2">represents the new value to assign to the tag</td></tr>
<tr><td>If <code>tag</code> is this data type:</td><td>Use this type of expression:</td></tr>
<tr><td>BOOL</td><td>BOOL expression</td></tr>
<tr><td>SINT
INT
DINT
REAL</td><td>numeric expression</td></tr>
<tr><td>;</td><td colspan="2">ends the assignment</td></tr>
</table>

Assign an ASCII character to a string

Use the assignment operator to assign an ASCII character to an element of the DATA member of a string tag. To assign a character, specify the value of the character or specify the tag name, DATA member, and element of the character. For example:

This is OK:	**This is *not* OK.**
`string1.DATA[0]:= 65;`	`string1.DATA[0] := A;`
`string1.DATA[0]:= string2.DATA[0];`	`string1 := string2;`

To add or insert a string of characters to a string tag, use either of these ASCII string instructions:

To:	**Use this instruction:**
add characters to the end of a string	CONCAT
insert characters into a string	INSERT

Expressions

An expression is a tag name, equation, or comparison. To write an expression, use any of the following:

- tag name that stores the value (variable)
- number that you enter directly into the expression (immediate value)
- functions, such as: ABS, TRUNC
- operators, such as: +, -, <, >, And, Or

As you write expressions, follow these general rules:

- Use any combination of upper-case and lower-case letter. For example, these three variations of "AND" are acceptable: AND, And, and.
- For more complex requirements, use parentheses to group expressions within expressions. This makes the whole expression easier to read and ensures that the expression executes in the desired sequence. See “Determine the order of execution“on page 7-10.

In structured text, you use two types of expressions:

BOOL expression: An expression that produces either the BOOL value of 1 (true) or 0 (false).

- A bool expression uses bool tags, relational operators, and logical operators to compare values or check if conditions are true or false. For example, `tag1>65`.
- A simple bool expression can be a single BOOL tag.
- Typically, you use bool expressions to condition the execution of other logic.

Numeric expression: An expression that calculates an integer or floating-point value.

- A numeric expression uses arithmetic operators, arithmetic functions, and bitwise operators. For example, `tag1+5`.
- Often, you nest a numeric expression within a bool expression. For example, `(tag1+5)>65`.

Use the following table to choose operators for your expressions:

If you want to:	Then:
Calculate an arithmetic value	"Use arithmetic operators and functions"on page 7-6.
Compare two values or strings	"Use relational operators"on page 7-7.
Check if conditions are true or false	"Use logical operators"on page 7-9.
Compare the bits within values	"Use bitwise operators"on page 7-10.

Use arithmetic operators and functions

You can combine multiple operators and functions in arithmetic expressions.

Arithmetic operators calculate new values.

To:	Use this operator:	Optimal data type:
add	+	DINT, REAL
subtract/negate	-	DINT, REAL
multiply	*	DINT, REAL
exponent (x to the power of y)	**	DINT, REAL
divide	/	DINT, REAL
modulo-divide	MOD	DINT, REAL

Arithmetic functions perform math operations. Specify a constant, a non-boolean tag, or an expression for the function.

For:	Use this function:	Optimal data type:
absolute value	ABS (*numeric_expression*)	DINT, REAL
arc cosine	ACOS (*numeric_expression*)	REAL
arc sine	ASIN (*numeric_expression*)	REAL
arc tangent	ATAN (*numeric_expression*)	REAL
cosine	COS (*numeric_expression*)	REAL
radians to degrees	DEG (*numeric_expression)*	DINT, REAL
natural log	LN (*numeric_expression*)	REAL
log base 10	LOG (*numeric_expression*)	REAL
degrees to radians	RAD (*numeric_expression*)	DINT, REAL
sine	SIN (*numeric_expression*)	REAL
square root	SQRT (*numeric_expression*)	DINT, REAL
tangent	TAN (*numeric_expression*)	REAL
truncate	TRUNC (*numeric_expression*)	DINT, REAL

For example:

Use this format:	Example:	
	For this situation:	You'd write:
value1 operator value2	If *gain_4* and *gain_4_adj* are DINT tags and your specification says: "Add 15 to *gain_4* and store the result in *gain_4_adj*."	`gain_4_adj := gain_4+15;`
operator value1	If alarm and *high_alarm* are DINT tags and your specification says: "Negate *high_alarm* and store the result in *alarm*."	`alarm:= -high_alarm;`
function(numeric_expression)	If *overtravel* and *overtravel_POS* are DINT tags and your specification says: "Calculate the absolute value of *overtravel* and store the result in *overtravel_POS*."	`overtravel_POS := ABS(overtravel);`
value1 operator (function((value2+value3)/2)	If *adjustment* and *position* are DINT tags and *sensor1* and *sensor2* are REAL tags and your specification says: "Find the absolute value of the average of *sensor1* and *sensor2*, add the *adjustment*, and store the result in *position*."	`position := adjustment + ABS((sensor1 + sensor2)/2);`

Use relational operators

Relational operators compare two values or strings to provide a true or false result. The result of a relational operation is a BOOL value:

If the comparison is:	The result is:
true	1
false	0

Use the following relational operators:

For this comparison:	Use this operator:	Optimal Data Type:
equal	=	DINT, REAL, string
less than	<	DINT, REAL, string
less than or equal	<=	DINT, REAL, string
greater than	>	DINT, REAL, string
greater than or equal	>=	DINT, REAL, string
not equal	<>	DINT, REAL, string

For example:

Use this format:	Example:	
	For this situation:	**You'd write:**
`value1 operator value2`	If *temp* is a DINT tag and your specification says: "If *temp* is less than 100° then…"	`IF temp<100 THEN...`
`stringtag1 operator stringtag2`	If *bar_code* and *dest* are string tags and your specification says: "If *bar_code* equals *dest* then…"	`IF bar_code=dest THEN...`
`char1 operator char2` To enter an ASCII character directly into the expression, enter the decimal value of the character.	If *bar_code* is a string tag and your specification says: "If *bar_code.DATA[0]* equals 'A' then…"	`IF bar_code.DATA[0]=65 THEN...`
`bool_tag := bool_expressions`	If *count* and *length* are DINT tags, *done* is a BOOL tag, and your specification says "If *count* is greater than or equal to *length*, you are done counting."	`done := (count >= length);`

How Strings Are Evaluated

The hexadecimal values of the ASCII characters determine if one string is less than or greater than another string.

- When the two strings are sorted as in a telephone directory, the order of the strings determines which one is greater.

lesser ↑ greater ↓

ASCII Characters	Hex Codes	
1ab	$31$61$62	
1b	$31$62	
A	$41	
AB	$41$42	AB < B
B	$42	
a	$61	a > B
ab	$61$62	

- Strings are equal if their characters match.
- Characters are case sensitive. Upper case "A" ($41) is *not* equal to lower case "a" ($61).

For the decimal value and hex code of a character, see the back cover of this manual.

Use logical operators

Logical operators let you check if multiple conditions are true or false. The result of a logical operation is a BOOL value:

If the comparison is:	The result is:
true	1
false	0

Use the following logical operators:

For:	Use this operator:	Data Type:
logical AND	&, AND	BOOL
logical OR	OR	BOOL
logical exclusive OR	XOR	BOOL
logical complement	NOT	BOOL

For example:

Use this format:	Example:	
	For this situation:	**You'd write:**
`BOOLtag`	If *photoeye* is a BOOL tag and your specification says: "If *photoeye_1* is on then…"	`IF photoeye THEN...`
NOT `BOOLtag`	If *photoeye* is a BOOL tag and your specification says: "If *photoeye* is off then…"	`IF NOT photoeye THEN...`
`expression1` & `expression2`	If *photoeye* is a BOOL tag, *temp* is a DINT tag, and your specification says: "If *photoeye* is on and *temp* is less than 100° then…".	`IF photoeye & (temp<100) THEN...`
`expression1` OR `expression2`	If *photoeye* is a BOOL tag, *temp* is a DINT tag, and your specification says: "If *photoeye* is on or *temp* is less than 100° then…".	`IF photoeye OR (temp<100) THEN...`
`expression1` XOR `expression2`	If *photoeye1* and *photoeye2* are BOOL tags and your specification says: "If: • *photoeye1* is on while *photoeye2* is off or • *photoeye1* is off while *photoeye2* is on then…"	`IF photoeye1 XOR photoeye2 THEN...`
`BOOLtag := expression1 & expression2`	If *photoeye1* and *photoeye2* are BOOL tags, *open* is a BOOL tag, and your specification says: "If *photoeye*1 and *photoeye2* are both on, set *open* to true".	`open := photoeye1 & photoeye2;`

Use bitwise operators

Bitwise operators manipulate the bits within a value based on two values.

For:	Use this operator:	Optimal Data Type:
bitwise AND	&, AND	DINT
bitwise OR	OR	DINT
bitwise exclusive OR	XOR	DINT
bitwise complement	NOT	DINT

For example:

Use this format:	Example:	
	For this situation:	**You'd write:**
`value1 operator value2`	If *input1*, *input2*, and *result1* are DINT tags and your specification says: "Calculate the bitwise result of *input1* and *input2*. Store the result in *result1*."	`result1 := input1 AND input2;`

Determine the order of execution

The operations you write into an expression are performed in a prescribed order, not necessarily from left to right.

- Operations of equal order are performed from left to right.
- If an expression contains multiple operators or functions, group the conditions in parenthesis "( )" . This ensures the correct order of execution and makes it easier to read the expression.

Order:	Operation:
1.	( )
2.	function (…)
3.	**
4.	– (negate)
5.	NOT
6.	*, /, MOD
7.	+, - (subtract)
8.	<, <=, >, >=
9.	=, <>
10.	&, AND
11.	XOR
12.	OR

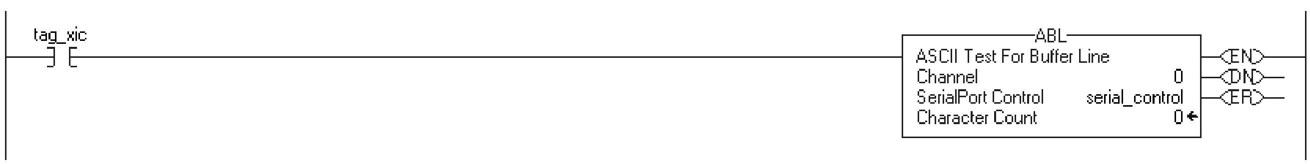
Instructions

Structured text statements can also be instructions. See the Locator Table at the beginning of this manual for a list of the instructions available in structured text. A structured text instruction executes each time it is scanned. A structured text instruction within a construct executes every time the conditions of the construct are true. If the conditions of the construct are false, the statements within the construct are not scanned. There is no rung-condition or state transition that triggers execution.

This differs from function block instructions that use EnableIn to trigger execution. Structured text instructions execute as if EnableIn is always set.

This also differs from relay ladder instructions that use rung-condition-in to trigger execution. Some relay ladder instructions only execute when rung-condition-in toggles from false to true. These are transitional relay ladder instructions. In structured text, instructions will execute each time they are scanned unless you pre-condition the execution of the structured text instruction.

For example, the ABL instruction is a transitional instruction in relay ladder. In this example, the ABL instruction only executes on a scan when *tag_xic* transitions from cleared to set. The ABL instruction does not execute when *tag_xic* stays set or when *tag_xic* is cleared.



In structured text, if you write this example as:

```
IF tag_xic THEN ABL(0,serial_control);

END_IF;
```

the ABL instruction will execute every scan that *tag_xic* is set, not just when *tag_xic* transitions from cleared to set.

If you want the ABL instruction to execute only when *tag_xic* transitions from cleared to set, you have to condition the structured text instruction. Use a one shot to trigger execution.

```
osri_1.InputBit := tag_xic;
OSRI(osri_1);

IF (osri_1.OutputBit) THEN
     ABL(0,serial_control);
END_IF;
```

Constructs

Constructs can be programmed singly or nested within other constructs.

If you want to:	Use this construct:	Available in these languages:	See page:
do something if or when specific conditions occur	IF...THEN	structured text	7-13
select what to do based on a numerical value	CASE...OF	structured text	7-16
do something a specific number of times before doing anything else	FOR...DO	structured text	7-19
keep doing something as long as certain conditions are true	WHILE...DO	structured text	7-22
keep doing something until a condition is true	REPEAT...UNTIL	structured text	7-25

IF...THEN

Use IF…THEN to do something if or when specific conditions occur.

Operands:

```
IF bool_expression THEN
    <statement>;
END_IF;
```

Structured Text

Operand:	Type:	Format:	Enter:
bool_ expression	BOOL	tag expression	BOOL tag or expression that evaluates to a BOOL value (BOOL expression)

Description:

The syntax is:

```
IF bool_expression1 THEN
    <statement >;
        .
        .
        .
```

statements to execute when *bool_expression1* is true

optional

```
ELSIF bool_expression2 THEN
    <statement>;
        .
        .
        .
```

statements to execute when *bool_expression2* is true

optional

```
ELSE
    <statement>;
        .
        .
        .
END_IF;
```

statements to execute when both expressions are false

To use ELSIF or ELSE, follow these guidelines:

1. To select from several possible groups of statements, add one or more ELSIF statements.
    - Each ELSIF represents an alternative path.
    - Specify as many ELSIF paths as you need.
    - The controller executes the first true IF or ELSIF and skips the rest of the ELSIFs and the ELSE.
2. To do something when all of the IF or ELSIF conditions are false, add an ELSE statement.

The following table summarizes different combinations of IF, THEN, ELSIF, and ELSE.

If you want to:	And:	Then use this construct
do something if or when conditions are true	do nothing if conditions are false	IF…THEN
	do something else if conditions are false	IF…THEN…ESLE
choose from alternative statements (or groups of statements) based on input conditions	do nothing if conditions are false	IF…THEN…ELSIF
	assign default statements if all conditions are false	IF…THEN…ELSIF…ELSE

Arithmetic Status Flags: not affected

Fault Conditions: none

Example 1: **IF…THEN**

If you want this:	Enter this structured text:
IF rejects > 3 then	`IF rejects > 3 THEN`
conveyor = off (0)	`conveyor := 0;`
alarm = on (1)	`alarm := 1;`
	`END_IF;`

Example 2: **IF…THEN…ELSE**

If you want this:	Enter this structured text:
If conveyor direction contact = forward (1) then	`IF conveyor_direction THEN`
light = off	`light := 0;`
Otherwise light = on	`ELSE`
	`light [:=] 1;`
	`END_IF;`

The [:=] tells the controller to clear *light* whenever the controller:

- enters the RUN mode
- leaves the step of an SFC if you configure the SFC for *Automatic reset* (This applies only if you embed the assignment in the action of the step or use the action to call a structured text routine via a JSR instruction.)

Example 3: IF...THEN...ELSIF

If you want this:	Enter this structured text:
If sugar low limit switch = low (on) and sugar high limit switch = not high (on) then	`IF Sugar.Low & Sugar.High THEN`
inlet valve = open (on)	`Sugar.Inlet [:=] 1;`
Until sugar high limit switch = high (off)	`ELSIF NOT(Sugar.High) THEN`
	`Sugar.Inlet := 0;`
	`END_IF;`

The [:=] tells the controller to clear *Sugar.Inlet* whenever the controller:

- enters the RUN mode
- leaves the step of an SFC if you configure the SFC for *Automatic reset* (This applies only if you embed the assignment in the action of the step or use the action to call a structured text routine via a JSR instruction.)

Example 4: IF...THEN...ELSIF...ELSE

If you want this:	Enter this structured text:
If tank temperature > 100	`IF tank.temp > 200 THEN`
then pump = slow	`pump.fast :=1; pump.slow :=0; pump.off :=0;`
If tank temperature > 200	`ELSIF tank.temp > 100 THEN`
then pump = fast	`pump.fast :=0; pump.slow :=1; pump.off :=0;`
otherwise pump = off	`ELSE`
	`pump.fast :=0; pump.slow :=0; pump.off :=1;`
	`END_IF;`

CASE...OF

Use CASE to select what to do based on a numerical value.

Operands:

```
CASE numeric_expression OF
    selector1: statement;
    selectorN: statement;
ELSE
    statement;
END_CASE;
```

Structured Text

Operand:	Type:	Format:	Enter:
numeric_expression	SINT INT DINT REAL	tag expression	tag or expression that evaluates to a number (numeric expression)
selector	SINT INT DINT REAL	immediate	same type as *numeric_expression*

IMPORTANT If you use REAL values, use a range of values for a selector because a REAL value is more likely to be within a range of values than an exact match of one, specific value.

Description:

The syntax is:

```
CASE numeric_expression OF
    selector1 :  <statement>;
                      .
                      .
                      .
    selector2 :  <statement>;
                      .
                      .
                      .
    selector3 :  <statement>;
                      .
                      .
                      .
ELSE
                 <statement>;
                      .
                      .
                      .
END_CASE;
```

specify as many alternative selector values (paths) as you need

statements to execute when *numeric_expression* = *selector1*

statements to execute when *numeric_expression* = *selector2*

statements to execute when *numeric_expression* = *selector3*

optional

statements to execute when *numeric_expression* ≠ any selector

See the table on the next page for valid selector values.

The syntax for entering the selector values is:

When selector is:	Enter:
one value	*value*: *statement*
multiple, distinct values	*value1*, *value2*, *valueN* : <*statement*> Use a comma (,) to separate each value.
a range of values	*value1*..*valueN* : <*statement*> Use two periods (..) to identify the range.
distinct values plus a range of values	*valuea, valueb, value1*..*valueN* : <*statement*>

The CASE construct is similar to a switch statement in the C or C++ programming languages. However, with the CASE construct the controller executes *only* the statements that are associated with the *first matching* selector value. Execution *always breaks after the statements of that selector* and goes to the END_CASE statement.

Arithmetic Status Flags: not affected

Fault Conditions: none

Example

If you want this:	Enter this structured text:
If recipe number = 1 then	CASE recipe_number OF
Ingredient A outlet 1 = open (1)	1: Ingredient_A.Outlet_1 :=1;
Ingredient B outlet 4 = open (1)	Ingredient_B.Outlet_4 :=1;
If recipe number = 2 or 3 then	2,3: Ingredient_A.Outlet_4 :=1;
Ingredient A outlet 4 = open (1)	Ingredient_B.Outlet_2 :=1;
Ingredient B outlet 2 = open (1)	
If recipe number = 4, 5, 6, or 7 then	4..7: Ingredient_A.Outlet_4 :=1;
Ingredient A outlet 4 = open (1)	Ingredient_B.Outlet_2 :=1;
Ingredient B outlet 2 = open (1)	
If recipe number = 8, 11, 12, or 13 then	8,11..13 Ingredient_A.Outlet_1 :=1;
Ingredient A outlet 1 = open (1)	Ingredient_B.Outlet_4 :=1;
Ingredient B outlet 4 = open (1)	
Otherwise all outlets = closed (0)	ELSE
	Ingredient_A.Outlet_1 [:=]0;
	Ingredient_A.Outlet_4 [:=]0;
	Ingredient_B.Outlet_2 [:=]0;
	Ingredient_B.Outlet_4 [:=]0;
	END_CASE;

The [:=] tells the controller to also clear the outlet tags whenever the controller:

- enters the RUN mode
- leaves the step of an SFC if you configure the SFC for *Automatic reset* (This applies only if you embed the assignment in the action of the step or use the action to call a structured text routine via a JSR instruction.)

FOR…DO

Use the FOR…DO loop to do something a specific number of times before doing anything else.

Operands:

```
FOR count:= initial_value TO
final_value BY increment DO

    <statement>;

END_FOR;
```

Structured Text

Operand:	Type:	Format:	Description:
count	SINT INT DINT	tag	tag to store count position as the FOR…DO executes
initial_ value	SINT INT DINT	tag expression immediate	must evaluate to a number specifies initial value for count
final_ value	SINT INT DINT	tag expression immediate	specifies final value for count, which determines when to exit the loop
increment	SINT INT DINT	tag expression immediate	(*optional*) amount to increment count each time through the loop If you don't specify an increment, the count increments by 1.

IMPORTANT Make sure that you *do not* iterate within the loop too many times in a single scan.

- The controller *does not* execute any other statements in the routine until it completes the loop.
- If the time that it takes to complete the loop is greater than the watchdog timer for the task, a major fault occurs.
- Consider using a different construct, such as IF...THEN.

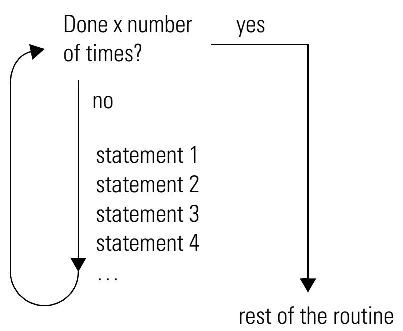
Description: The syntax is:

```
FOR count := initial_value
   TO final_value
   BY increment
   DO
   <statement>;
   IF bool_expression THEN
       EXIT;
   END_IF;
END_FOR;
```

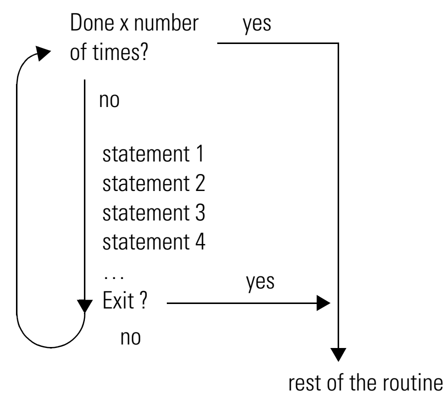
optional { BY *increment* — If you don't specify an increment, the loop increments by 1.

optional { IF … END_IF; — If there are conditions when you want to exit the loop early, use other statements, such as an IF...THEN construct, to condition an EXIT statement.

The following diagrams show how a FOR...DO loop executes and how an EXIT statement leaves the loop early.



The FOR…DO loop executes a specific number of times.



To stop the loop before the count reaches the last value, use an EXIT statement.

Arithmetic Status Flags: not affected

Fault Conditions:

A major fault will occur if:	Fault type:	Fault code:
the construct loops too long	6	1

Example 1:

If you want this:	Enter this structured text:

Clear bits 0 - 31 in an array of BOOLs:
1. Initialize the *subscript* tag to 0.
2. Clear *array[subscript]* . For example, when *subscript* = 5, clear *array[5].*
3. Add 1 to *subscript*.
4. If *subscript* is ≤ to 31, repeat 2 and 3. Otherwise, stop.
	`For subscript:=0 to 31 by 1 do`
	`    array[subscript] := 0;`
	`End_for;`

Example 2:

<table>
<tr><th>If you want this:</th><th>Enter this structured text:</th></tr>
<tr><td>A user-defined data type (structure) stores the following information about an item in your inventory:
• Barcode ID of the item (string data type)
• Quantity in stock of the item (DINT data type)
An array of the above structure contains an element for each different item in your inventory. You want to search the array for a specific product (use its bar code) and determine the quantity that is in stock.
1. Get the size (number of items) of the Inventory array and store the result in Inventory_Items (DINT tag).
2. Initialize the position tag to 0.
3. If Barcode matches the ID of an item in the array, then:
a. Set the Quantity tag = Inventory[position].Qty. This produces the quantity in stock of the item.
b. Stop.
Barcode is a string tag that stores the bar code of the item for which you are searching. For example, when position = 5, compare Barcode to Inventory[5].ID.
4. Add 1 to position.
5. If position is ≤ to (Inventory_Items -1), repeat 3 and 4. Since element numbers start at 0, the last element is 1 less than the number of elements in the array. Otherwise, stop.</td><td><pre>SIZE(Inventory,0,Inventory_Items);
For position:=0 to Inventory_Items - 1 do
    If Barcode = Inventory[position].ID then
        Quantity := Inventory[position].Qty;
        Exit;
    End_if;
End_for;</pre></td></tr>
</table>

WHILE…DO

Use the WHILE…DO loop to keep doing something as long as certain conditions are true.

Operands:

```
WHILE bool_expression DO
    <statement>;
END_WHILE;
```

Structured Text

Operand:	Type:	Format:	Enter:
bool_ expression	BOOL	tag expression	BOOL tag or expression that evaluates to a BOOL value

IMPORTANT Make sure that you *do not* iterate within the loop too many times in a single scan.

- The controller *does not* execute any other statements in the routine until it completes the loop.
- If the time that it takes to complete the loop is greater than the watchdog timer for the task, a major fault occurs.
- Consider using a different construct, such as IF...THEN.

Description:

The syntax is:

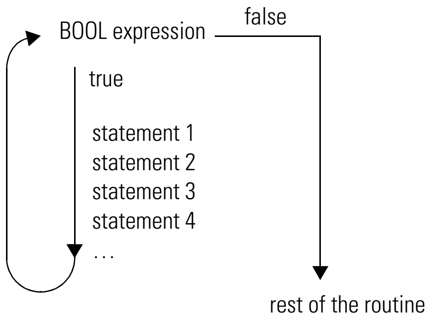
```
WHILE bool_expression1 DO
   <statement>;

   IF bool_expression2 THEN
     EXIT;
   END_IF;

END_WHILE;
```

statements to execute while *bool_expression1* is true

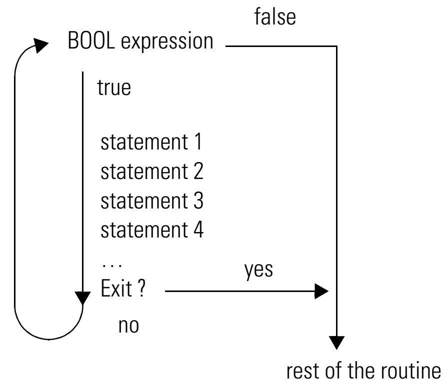
optional

If there are conditions when you want to exit the loop early, use other statements, such as an IF...THEN construct, to condition an EXIT statement.

The following diagrams show how a WHILE...DO loop executes and how an EXIT statement leaves the loop early.



While the *`bool_expression`* is true, the controller executes only the statements within the WHILE…DO loop.



To stop the loop before the conditions are true, use an EXIT statement.

Arithmetic Status Flags: not affected

Fault Conditions:

A major fault will occur if:	Fault type:	Fault code:
the construct loops too long	6	1

Example 1:

If you want this:	Enter this structured text:

The WHILE...DO loop evaluates its conditions first. If the conditions are true, the controller then executes the statements within the loop.
 	
This differs from the REPEAT...UNTIL loop because the REPEAT...UNTIL loop executes the statements in the construct and then determines if the conditions are true before executing the statements again. The statements in a REPEAT...UNTIL loop are always executed at least once. The statements in a WHILE...DO loop might never be executed.
	`pos := 0;`
	
	`While ((pos <= 100) & structarray[pos].value`
	`<> targetvalue)) do`
	
	`    pos := pos + 2;`
	
	`    String_tag.DATA[pos] := SINT_array[pos];`
	
	`end_while;`

Example 2:

If you want this:	Enter this structured text:

Move ASCII characters from a SINT array into a string tag. (In a SINT array, each element holds one character.) Stop when you reach the carriage return.
1. Initialize *Element_number* to 0.
2. Count the number of elements in *SINT_array* (array that contains the ASCII characters) and store the result in *SINT_array_size* (DINT tag).
3. If the character at *SINT_array[element_number]* = 13 (decimal value of the carriage return), then stop.
4. Set *String_tag[element_number]* = the character at *SINT_array[element_number].*
5. Add 1 to *element_number*. This lets the controller check the next character in *SINT_array*.
6. Set the Length member of *String_tag* = *element_number*. (This records the number of characters in *String_tag* so far.)
7. If *element_number* = *SINT_array_size,* then stop. (You are at the end of the array and it does not contain a carriage return.)
8. Go to 3.
	`element_number := 0;`
	`SIZE(SINT_array, 0, SINT_array_size);`
	`While SINT_array[element_number] <> 13 do`
	    `String_tag.DATA[element_number] := SINT_array[element_number];`
	    `element_number := element_number + 1;`
	    `String_tag.LEN := element_number;`
	    `If element_number = SINT_array_size then`
	        `exit;`
	    `end_if;`
	`end_while;`

REPEAT…UNTIL

Use the REPEAT…UNTIL loop to keep doing something until conditions are true.

Operands:

```
REPEAT
    <statement>;
UNTIL bool_expression
END_REPEAT;
```

Structured Text

Operand:	Type:	Format:	Enter:
bool_ expression	BOOL	tag expression	BOOL tag or expression that evaluates to a BOOL value (BOOL expression)

IMPORTANT Make sure that you *do not* iterate within the loop too many times in a single scan.

- The controller *does not* execute any other statements in the routine until it completes the loop.
- If the time that it takes to complete the loop is greater than the watchdog timer for the task, a major fault occurs.
- Consider using a different construct, such as IF...THEN.

Description: The syntax is:

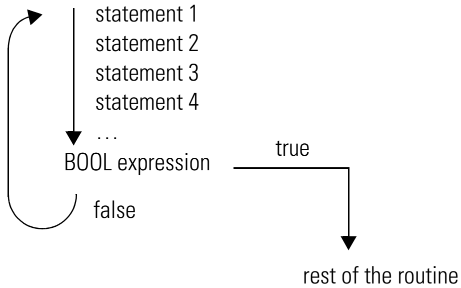
```
REPEAT
   <statement>;

   IF bool_expression2 THEN
     EXIT;
   END_IF;

UNTIL bool_expression1
END_REPEAT;
```

statements to execute while *bool_expression1* is false

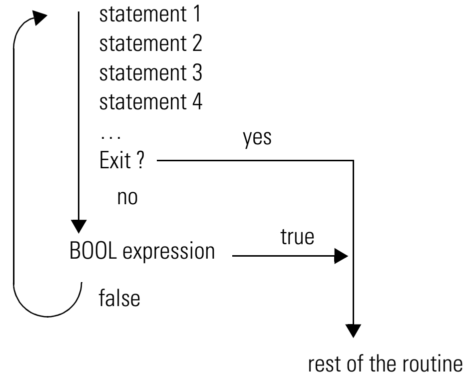
optional

If there are conditions when you want to exit the loop early, use other statements, such as an IF...THEN construct, to condition an EXIT statement.

The following diagrams show how a REPEAT...UNTIL loop executes and how an EXIT statement leaves the loop early.



While the *`bool_expression`* is false, the controller executes only the statements within the REPEAT…UNTIL loop.



To stop the loop before the conditions are false, use an EXIT statement.

Arithmetic Status Flags: not affected

Fault Conditions:

A major fault will occur if:	Fault type:	Fault code:
the construct loops too long	6	1

Example 1:

If you want this:	Enter this structured text:

The REPEAT...UNTIL loop executes the statements in the construct and then determines if the conditions are true before executing the statements again.
This differs from the WHILE...DO loop because the WHILE...DO The WHILE...DO loop evaluates its conditions first. If the conditions are true, the controller then executes the statements within the loop. The statements in a REPEAT...UNTIL loop are always executed at least once. The statements in a WHILE...DO loop might never be executed.
	`pos := -1;`
	`REPEAT`
	`    pos := pos + 2;`
	`UNTIL ((pos = 101) OR (structarray[pos].value = targetvalue))`
	`end_repeat;`

Example 2:

If you want this:	Enter this structured text:

Move ASCII characters from a SINT array into a string tag. (In a SINT array, each element holds one character.) Stop when you reach the carriage return.
1. Initialize *Element_number* to 0.
2. Count the number of elements in *SINT_array* (array that contains the ASCII characters) and store the result in *SINT_array_size* (DINT tag).
3. Set *String_tag[element_number]* = the character at *SINT_array[element_number].*
4. Add 1 to *element_number.* This lets the controller check the next character in *SINT_array.*
5. Set the Length member of *String_tag* = *element_number.* (This records the number of characters in *String_tag* so far.)
6. If *element_number* = *SINT_array_size,* then stop. (You are at the end of the array and it does not contain a carriage return.)
7. If the character at *SINT_array[element_number]* = 13 (decimal value of the carriage return), then stop. Otherwise, go to 3.
	`element_number := 0;`
	`SIZE(SINT_array, 0, SINT_array_size);`
	`Repeat`
	`    String_tag.DATA[element_number] := SINT_array[element_number];`
	`    element_number := element_number + 1;`
	`    String_tag.LEN := element_number;`
	`    If element_number = SINT_array_size then`
	`        exit;`
	`    end_if;`
	`Until SINT_array[element_number] = 13`
	`end_repeat;`

Comments

To make your structured text easier to interpret, add comments to it.

- Comments let you use plain language to describe how your structured text works.
- Comments do not affect the execution of the structured text.

To add comments to your structured text:

<table>
<tr><th>To add a comment:</th><th>Use one of these formats:</th></tr>
<tr><td>on a single line</td><td rowspan="2">//comment
(*comment*)
/*comment*/</td></tr>
<tr><td>at the end of a line of structured text</td></tr>
<tr><td>within a line of structured text</td><td>(*comment*)
/*comment*/</td></tr>
<tr><td>that spans more than one line</td><td>(*start of comment . . . end of comment*)
/*start of comment . . . end of comment*/</td></tr>
</table>

For example:

Format:	Example:

//*comment*	**At the beginning of a line**
	`//Check conveyor belt direction`
	`IF conveyor_direction THEN...`
	
	At the end of a line
	`ELSE //If conveyor isn't moving, set alarm light`
	`light := 1;`
	`END_IF;`

(**comment**)	`Sugar.Inlet[:=]1;(*open the inlet*)`
	
	`IF Sugar.Low (*low level LS*)& Sugar.High (*high level LS*)THEN...`
	
	`(*Controls the speed of the recirculation pump. The speed depends on the temperature in the tank.*)`
	`IF tank.temp > 200 THEN...`

/**comment**/	`Sugar.Inlet:=0;/*close the inlet*/`
	
	`IF bar_code=65 /*A*/ THEN...`
	
	`/*Gets the number of elements in the Inventory array and stores the value in the Inventory_Items tag*/`
	`SIZE(Inventory,0,Inventory_Items);`

Program Ladder Logic

When to Use This Procedure

Use this procedure to accomplish the following:

- develop the logic for a ladder logic routine
- enter the logic into the routine

Before You Use This Procedure

Before you use this procedure, make sure you are able to perform the following tasks:

☑ Navigate the Controller Organizer

☑ Identify the Programming Languages That Are Installed

For more information on any of those tasks, see "Getting Started" on page 1-1.

How to Use This Procedure

To program a ladder logic routine:

Definitions

Before you write or enter ladder logic, review the following terms:

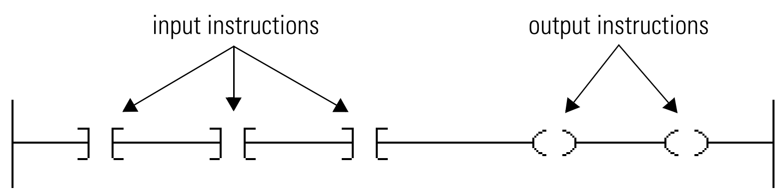
- Instruction
- Branch
- Rung Condition

Instruction

You organize ladder logic as rungs on a ladder and put instructions on each rung. There are two basic types of instructions:

Input instruction: An instruction that checks, compares, or examines specific conditions in your machine or process.

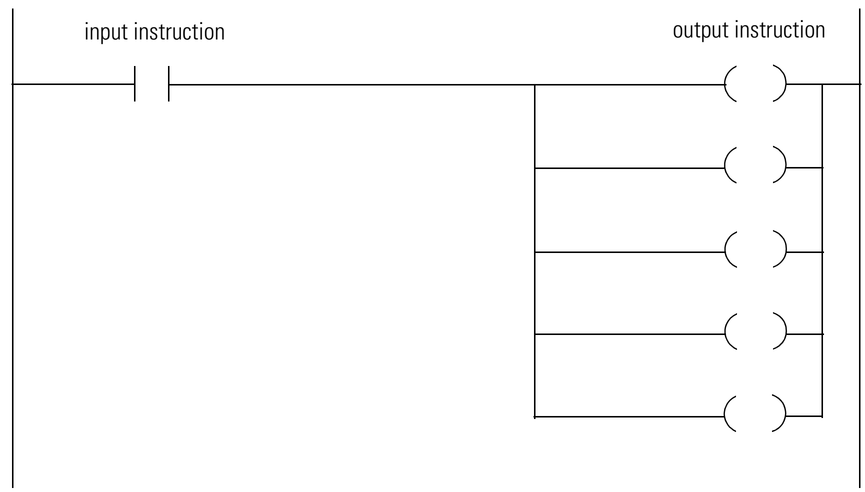
Output instruction: An instruction that takes some action, such as turn on a device, turn off a device, copy data, or calculate a value.



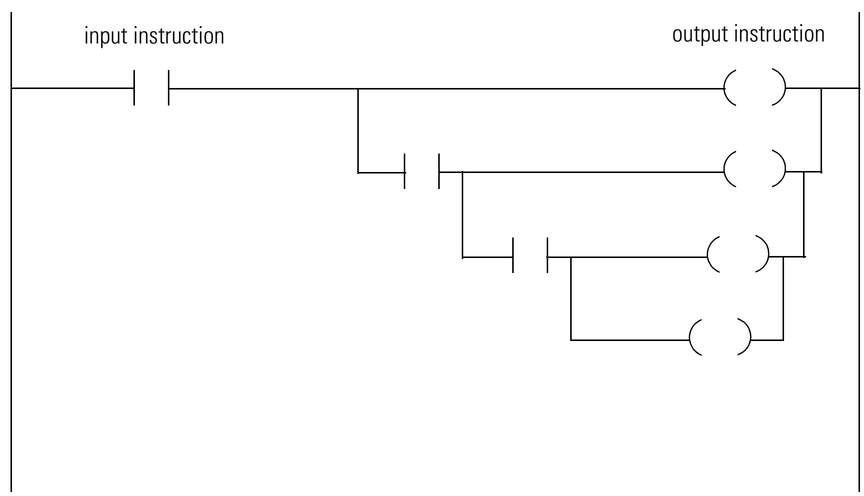
Branch

A branch is two or more instructions in parallel.

There is no limit to the number of parallel branch levels that you can enter. The following figure shows a parallel branch with five levels. The main rung is the first branch level, followed by four additional branches.

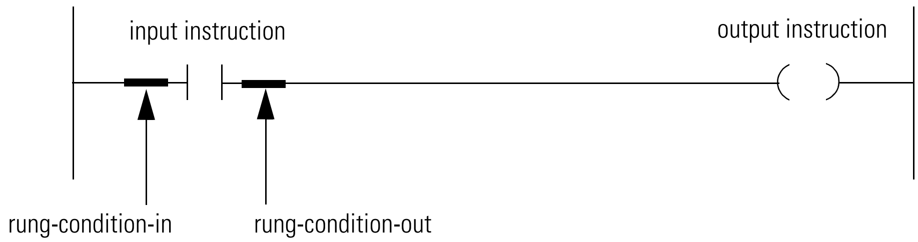


You can nest branches to as many as 6 levels. The following figure shows a nested branch. The bottom output instruction is on a nested branch that is three levels deep.



Rung Condition

The controller evaluates ladder instructions based on the rung condition preceding the instruction (rung-condition-in).



Only input instructions affect the rung-condition-in of subsequent instructions on the rung:

- If the rung-condition-in to an input instruction is true, the controller evaluates the instruction and sets the rung-condition-out to match the results of the evaluation.
  - If the instruction evaluates to true, the rung-condition-out is true.
  - If the instruction evaluates to false, the rung-condition-out is false.
- An output instruction does not change the rung-condition-out.
  - If the rung-condition-in to an output instruction is true, the rung-condition-out is set to true.
  - If the rung-condition-in to an output instruction is false, the rung-condition-out is set to false.

Write Ladder Logic

To develop your ladder logic, perform the following actions:

- ☐ Choose the Required Instructions
- ☐ Arrange the Input Instructions
- ☐ Arrange the Output Instructions
- ☐ Choose a Tag Name for an Operand

Choose the Required Instructions

1. Separate the conditions to check from the action to take.

2. Choose the appropriate input instruction for each condition and the appropriate output instruction for each action.

   To choose specific instructions, see the following manuals:

   - *Logix5000 Controllers General Instructions Reference Manual*, publication 1756-RM003
   - *Logix5000 Controllers Process and Drives Instructions Reference Manual*, publication 1756-RM006
   - *Logix5000 Controllers Motion Instruction Set Reference Manual*, publication 1756-RM007

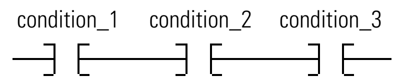
The examples in this chapter use two simple instructions to help you learn how to write ladder logic. The rules that you learn for these instructions apply to all other instructions.

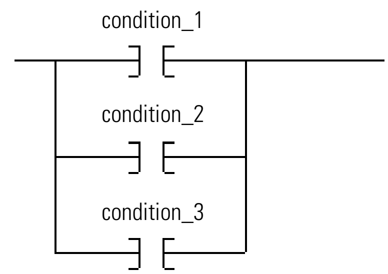
Symbol:	Name:	Mnemonic:	Description:	
—] [—	Examine If Closed	XIC	An input instruction that looks at one bit of data.	
			If the bit is:	**Then the instruction (rung-condition-out) is:**
			on (1)	true
			off (0)	false
—( )—	Output Energize	OTE	An output instruction that controls one bit of data.	
			If the instructions to the left (rung-condition-in) are:	**Then the instruction turns the bit:**
			true	on (1)
			false	off (0)

Arrange the Input Instructions

Arrange the input instructions on a rung using the following chart:

<table>
<tr><th>To check multiple input conditions when:</th><th>Arrange the input instructions:</th></tr>
<tr><td>all conditions must be met in order to take action

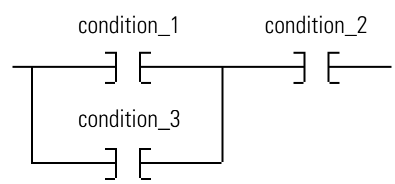
For example, If condition_1 AND condition_2 AND condition_3…</td><td>In series:
</td></tr>
<tr><td>any one of several conditions must be met in order to take action

For example, If condition_1 OR condition_2 OR condition_3…</td><td>In parallel:
</td></tr>
<tr><td>there is a combination of the above

For example,

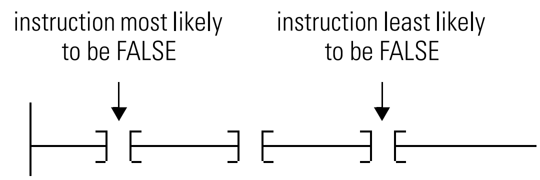
If condition_1 AND condition_2…

OR

If condition_3 AND condition_2…</td><td>In combination:
</td></tr>
</table>

TIP

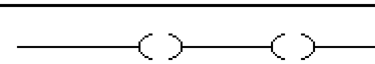
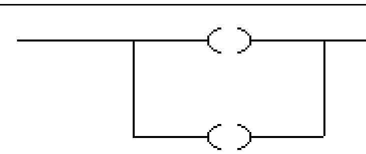
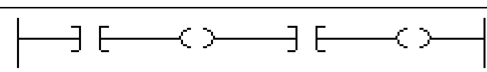
The controller executes all instructions on a rung regardless of their rung-condition-in. For optimal performance of a series of instructions, sequence the instructions from most likely to be false on the left to least likely to be false on the right.



When the controller finds a false instruction, it executes the remaining instructions in the series with their rung-condition-in set to false. Typically, an instruction executes faster when its rung-condition-in (rung) is false rather than true.

Arrange the Output Instructions

Place at least one output instruction to the right of the input instructions. You can enter multiple output instructions per rung of logic, as follows:

Option:	Example:
Place the output instructions in sequence on the rung (serial).	
Place the output instructions in branches (parallel).	
Place the output instructions between input instructions, as long as the last instruction on the rung is an output instruction.	

Choose a Tag Name for an Operand

Most instructions requires one or more of the following types of operands:

- tag name (variable)
- immediate value (constant)
- name of a routine, label, etc.

The following table outlines the format for a tag name:

For a:	Specify:
tag	*tag_name*
bit number of a larger data type	*tag_name.bit_number*
member of a structure	*tag_name.member_name*
element of a one dimension array	*tag_name[x]*
element of a two dimension array	*tag_name[x,y]*
element of a three dimension array	*tag_name[x,y,z]*
element of an array within a structure	*tag_name.member_name[x]*
member of an element of an array	*tag_name[x,y,z].member_name*

where:

x is the location of the element in the first dimension.

y is the location of the element in the second dimension.

z is the location of the element in the third dimension.

For a structure within a structure, add an additional *.member_name* .

EXAMPLE Choose a Tag Name for an Operand

To access:	The tag name looks like this:
machine_on tag	machine_on
bit number 1 of the *one_shots* tag	one_shots.1
DN member (bit) of the *running_seconds* timer	running_seconds.DN
mix member of the *north_tank* tag	north_tank.mix
element 2 in the *recipe* array and element 1,1 in the *tanks* array	COP Copy File Source recipe[2] Dest tanks[1,1] Length 1
element 2 in the *preset* array within the *north_tank* tag	CLR Clear Dest north_tank.preset[2] 0
part_advance member of element 1 in the *drill* array	drill[1].part_advance

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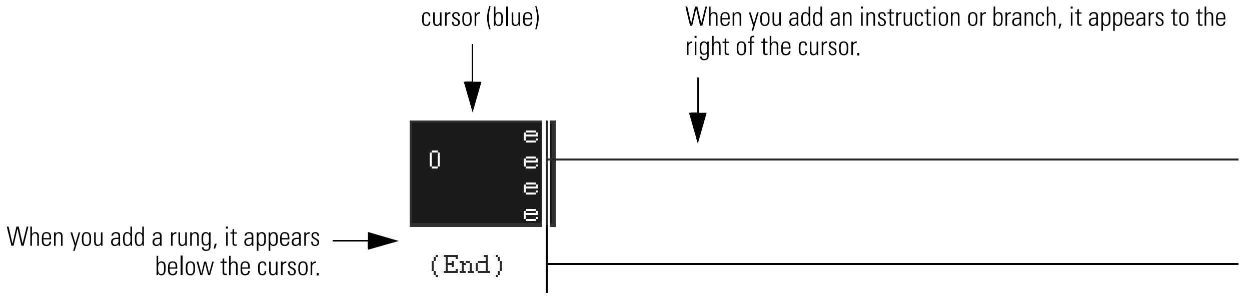
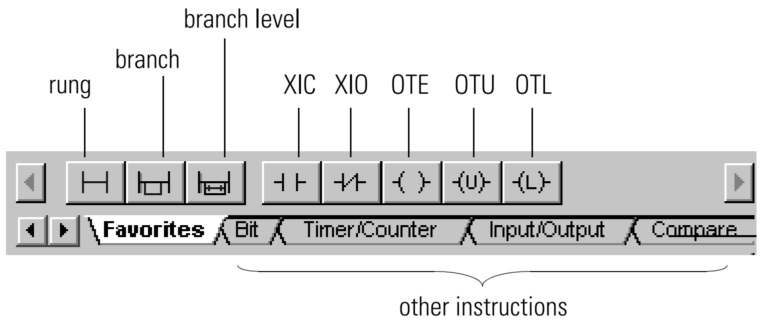
Enter Ladder Logic

A new routine contains a rung that is ready for instructions.



Use the Language Element toolbar to add a ladder logic element to your routine.



To add an element:

- ☐ Append an Element to the Cursor Location
- ☐ Drag and Drop an Element

Append an Element to the Cursor Location

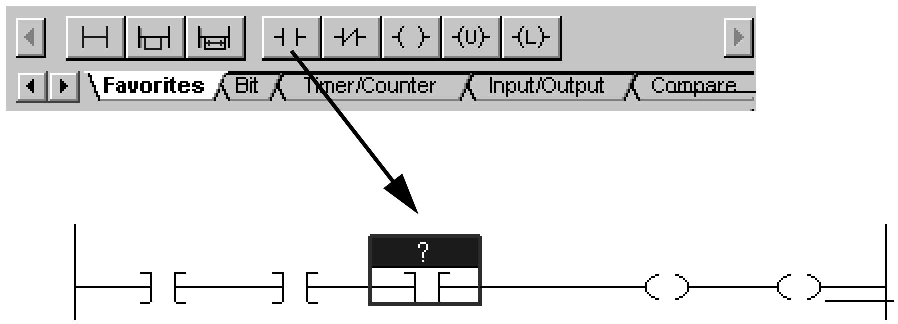
1. Click (select) the instruction, branch, or rung that is above or to the left of where you want to add an element.

2. On the Language Element toolbar, click the button for the element that you want to add.

Drag and Drop an Element

Drag the button for the element directly to the desired location. A green dot shows a valid placement location (drop point).

For example

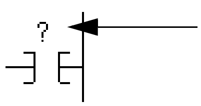


Assign Operands

To assign an operand you have these options:

- ☐ Create and Assign a New Tag
- ☐ Choose a Name or an Existing Tag
- ☐ Drag a Tag From the Tags Window
- ☐ Assign an Immediate (Constant) Value

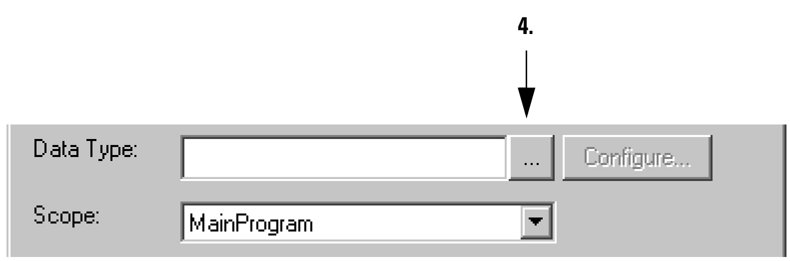
Create and Assign a New Tag



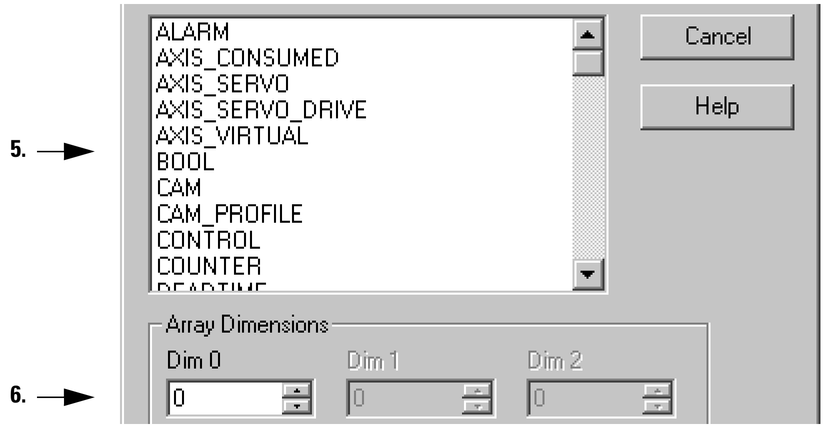
1. Click the operand area of the instruction.

2. Type a name for the tag and press [Enter].

3. Right-click the tag name and choose *New "tag_name"*.



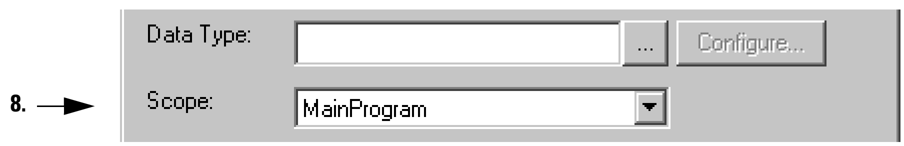
4. Click the ... button.



5. Select the data type for the tag.

6. If you want to define the tag as an array, type the number of elements in each dimension.

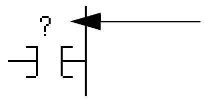
7. Choose 



8. Choose the scope for the tag.

9. Choose 

Choose a Name or an Existing Tag



1. Double-click the operand area.

   A text entry box opens.

2. Click the ▼

3. Select the name:

To select a:	Do this:
label, routine name, or similar type of name	Click the name.
tag	Double-click the tag name.
bit number	A. Click the tag name. B. To the right of the tag name, click ▼ C. Click the required bit.

4. Press [Enter] or click a different spot on the diagram.

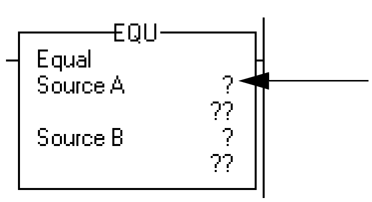
Drag a Tag From the Tags Window

1. Find the tag in the Tags window.

2. Click the tag two or three times until it highlights.

3. Drag the tag to its location on the instruction.

Assign an Immediate (Constant) Value



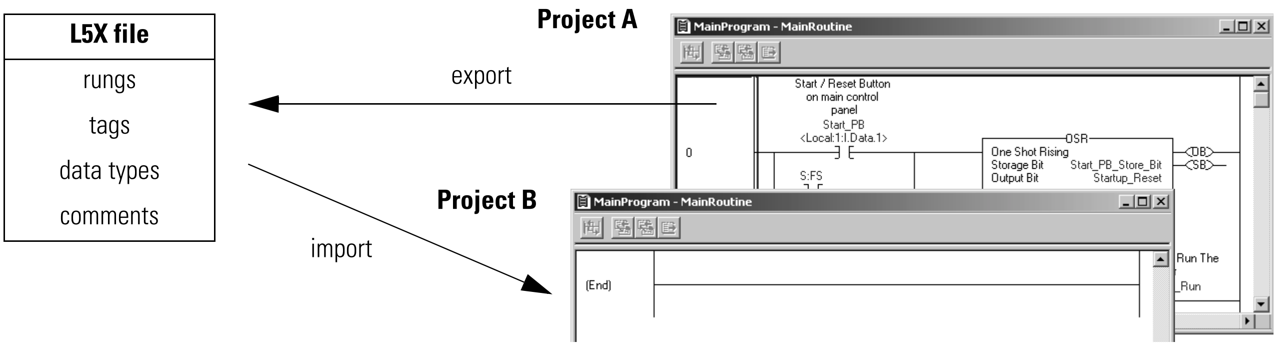
1. Click the operand area of the instruction.

2. Type the value and press [Enter].

Export/Import Ladder Logic

RSLogix 5000 software 13.0 or later

If you want to re-use ladder logic from another project, simply export the logic to an L5X file and import it into the required project. The L5X file contains all that you need for the logic except I/O modules.



When You Import Rungs…

When you import rungs, RSLogix 5000 software shows a list of the tags and user-defined data types that go along with the rungs. Use the list to manage the tags and data types that are created during the import operation.

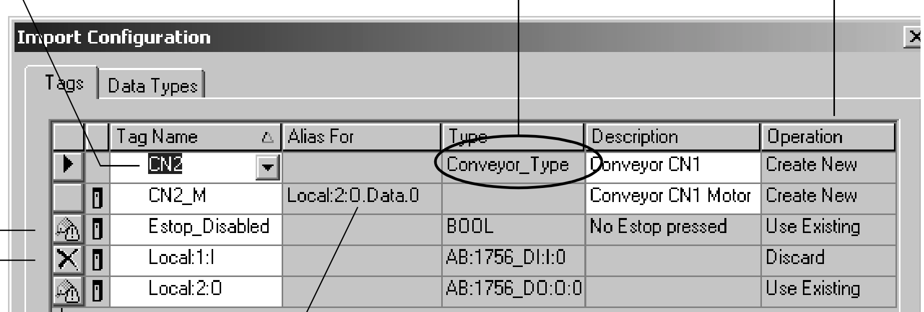
The *Operation* column shows what will happen to each tag and data type during the import. The software either creates it, uses an existing one in the project, or discards it (does not import it).

If desired, you can rename a tag.to make it fit the project better.

If you place the variables for the rungs in a user-defined data type, you have less tags to manage.

If a tag already exists in the project, you can either:

- Use the existing tag, which discards the tag in the library file and binds the logic to the existing tag.
- Rename the tag, which creates a new one.



No new I/O tags are created.

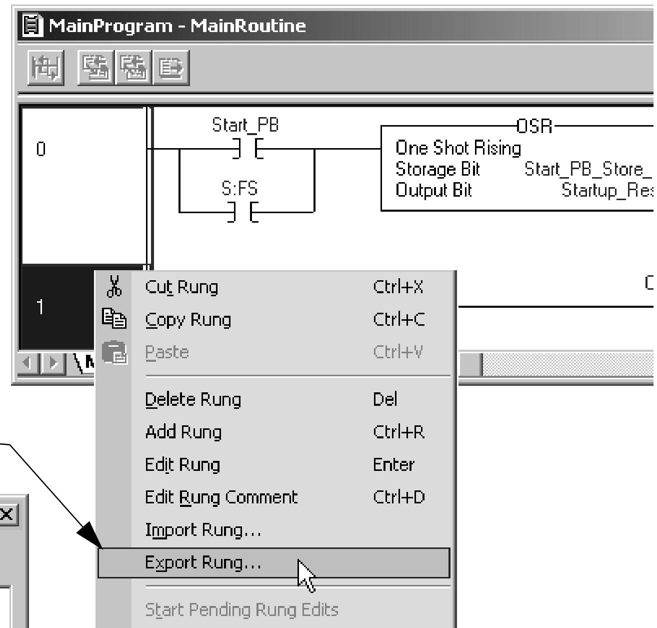
If an I/O tag already exists in the project, the import operation uses this tag for any aliases to that tag name. Once you import a project, make sure you check the alias tags for accuracy.

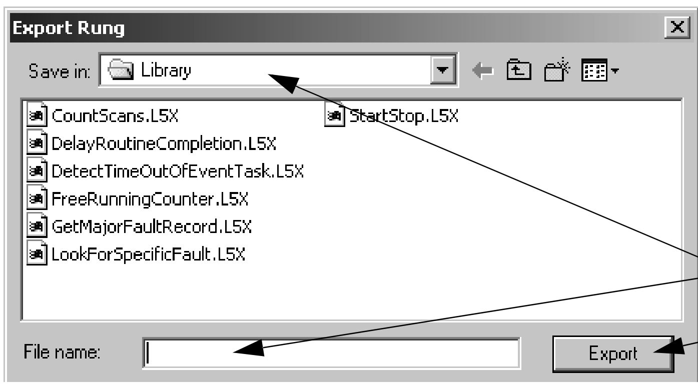
Export Rungs

1. Select the rungs to export:

If rungs are:	Do this:
in sequence	Click the first rung and then [Shift] + click the last rung.
out of sequence	Click the first rung and then [Ctrl] + click each additional rung.

2. Right-click the selection and choose *Export Rung*.

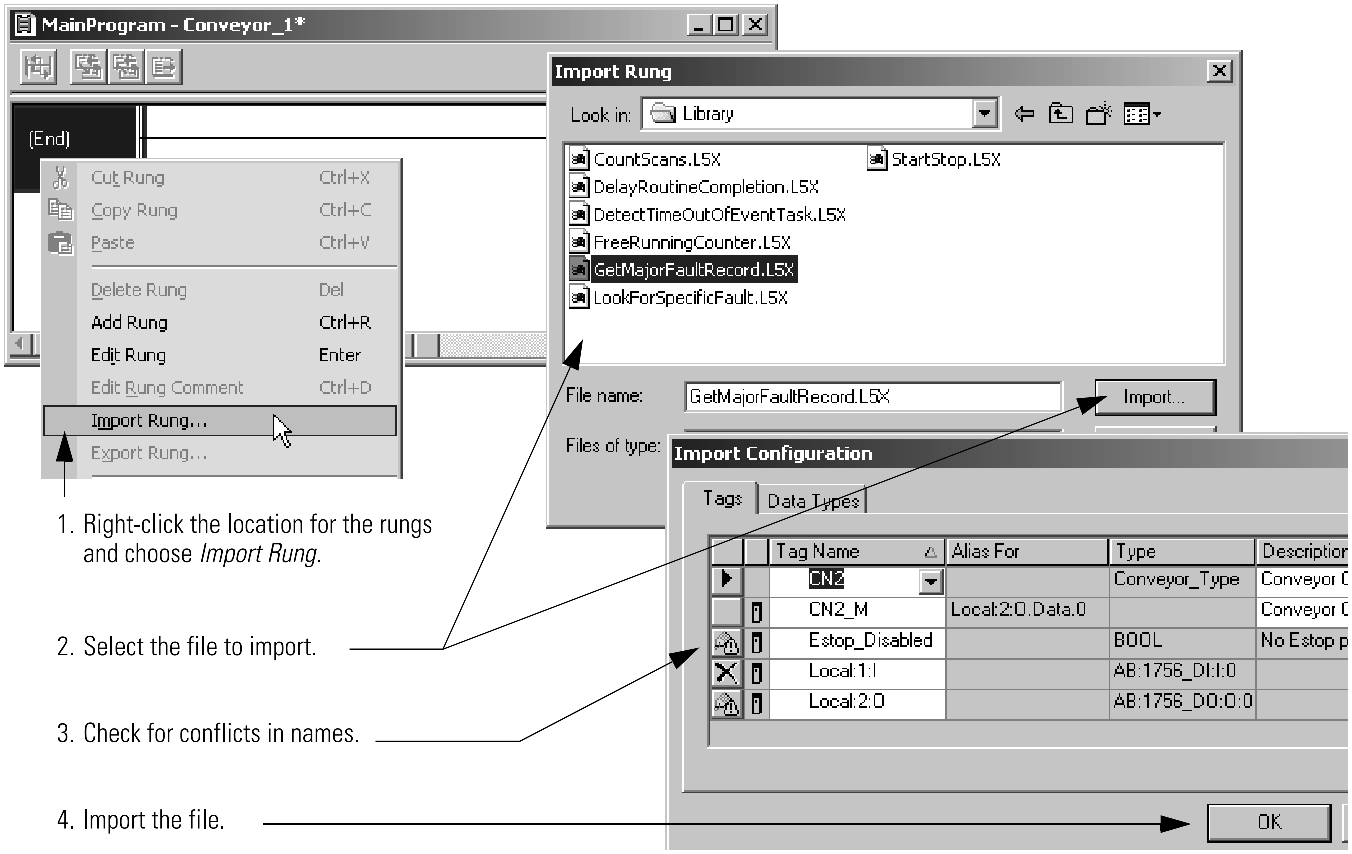




3. Choose a location and name for the file.

4. Create the file.

Import Rungs

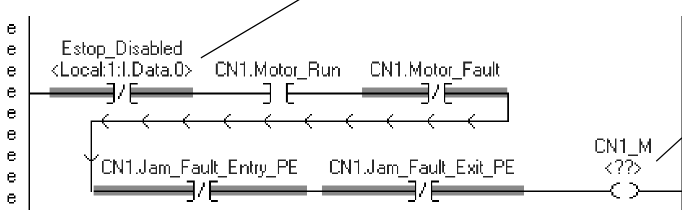


1. Right-click the location for the rungs and choose *Import Rung*.
2. Select the file to import.
3. Check for conflicts in names.
4. Import the file.

Check Alias Tags

rungs that you imported

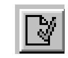
If you import an alias tag, make sure it points to the correct base tag. When a tag is an alias for a tag that already exists in the project, the software sets up the relationship between the alias and base tags.



If the project does not have the base tag, you have to either create the base tag or point the alias to a different base tag.

Verify the Routine

As you program your routine (s), periodically verify your work:

1. In the top-most toolbar of the RSLogix 5000 window, click 

2. If any errors are listed at the bottom of the window:
   a. To go to the first error or warning, press [F4].
   b. Correct the error according to the description in the Results window.
   c. Go to step 1.

3. To close the Results window, press [Alt] + [1].

Notes:

Program a Function Block Diagram

When to Use This Procedure

Use this procedure to accomplish the following:

- organize a function block routine
- develop one or more function block diagrams for the routine
- enter the function block diagrams into the routine

Before You Use This Procedure

Before you use this procedure, make sure you are able to perform the following tasks:

- [x] Navigate the Controller Organizer
- [x] Identify the Programming Languages That Are Installed

For more information on any of those tasks, see “Getting Started” on page 1-1.

How to Use This Procedure

To program a function block routine, do the following steps:

- [ ] Identify the Sheets for the Routine
- [ ] Choose the Function Block Elements
- [ ] Choose a Tag Name for an Element
- [ ] Define the Order of Execution
- [ ] Identify any Connectors
- [ ] Define Program/Operator Control
- [ ] Add a Sheet
- [ ] Add a Function Block Element
- [ ] Connect Elements
- [ ] Assign a Tag
- [ ] Assign an Immediate Value (Constant)
- [ ] Connect Blocks with an OCON and ICON
- [ ] Verify the Routine

Identify the Sheets for the Routine

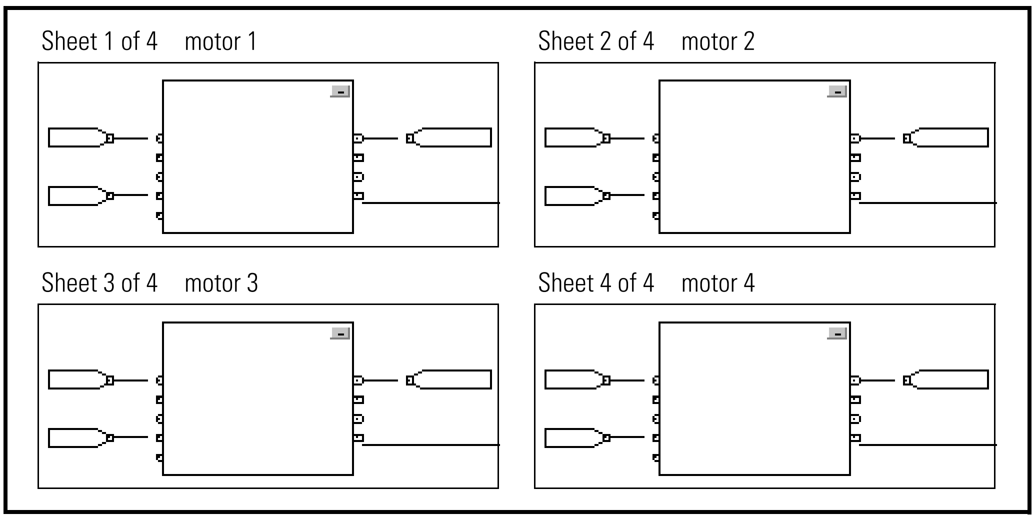
To make it easier to navigate through a function block routine, divide the routine into a series of sheets:

- Sheets help you organize and find your function blocks. They do not effect the order in which the function blocks execute.
- When the routine executes, all the sheets execute.
- In general, use one sheet for each device (motor, valve, etc.)

The following example shows a function block routine that controls 4 motors.

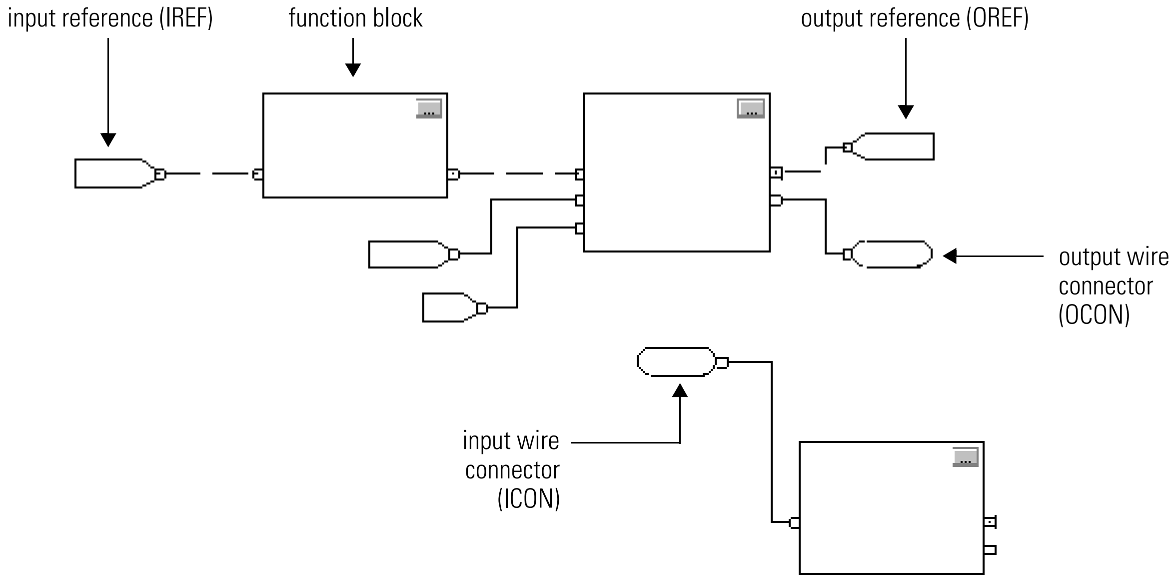
EXAMPLE Identify the Sheets for the Routine

Motor Control Routine



Choose the Function Block Elements

To control a device, use the following elements:



Use the following table to choose your function block elements:

If you want to:	Then use a:
supply a value from an input device or tag	input reference (IREF)
send a value to an output device or tag	output reference (OREF)
perform an operation on an input value or values and produce an output value or values	function block
transfer data between function blocks when they are: • far apart on the same sheet • on different sheets within the same routine	output wire connector (OCON) and an input wire connector (ICON)
disperse data to several points in the routine	single output wire connector (OCON) and multiple input wire connectors (ICON)

Choose a Tag Name for an Element

Each function block uses a tag to store configuration and status information about the instruction.

- When you add function block instruction, RSLogix 5000 software automatically creates a tag for the block. You can use this tag as is, rename the tag, or assign a different tag.
- For IREFs and OREFs, you have to create a tag or assign an existing tag.

The following table outlines the format for a tag name:

For a:	Specify:
tag	*tag_name*
bit number of a larger data type	*tag_name.bit_number*
member of a structure	*tag_name.member_name*
element of a one dimension array	*tag_name[x]*
element of a two dimension array	*tag_name[x,y]*
element of a three dimension array	*tag_name[x,y,z]*
element of an array within a structure	*tag_name.member_name[x]*
member of an element of an array	*tag_name[x,y,z].member_name*

where:

x is the location of the element in the first dimension.

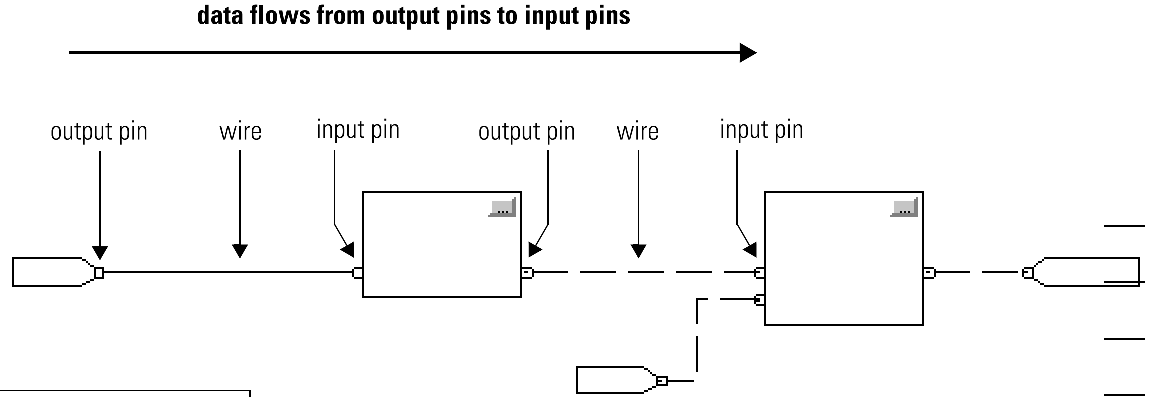
y is the location of the element in the second dimension.

z is the location of the element in the third dimension.

For a structure within a structure, add an additional *.member_name* .

Define the Order of Execution

You define execution order (flow of data) by wiring elements together and indicating any input (feedback) wires, if necessary. The location of a block does not affect the order in which the blocks execute.

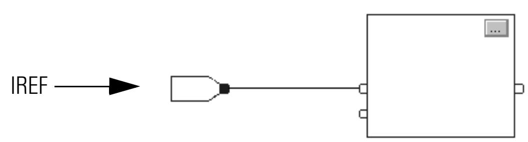


Wire symbols:

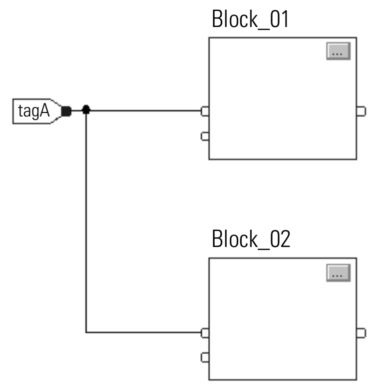
———————	SINT, INT, DINT, or REAL value
— — — —	BOOL value (0 or 1)

Data Latching

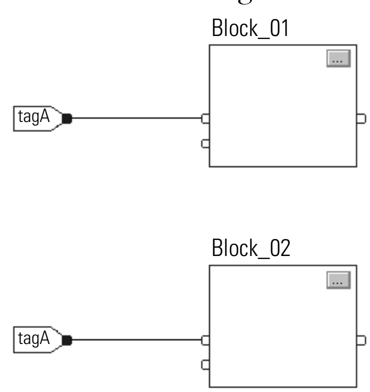
If you use an IREF to specify input data for a function block instruction, the data in that IREF is latched for the scan of the function block routine. The IREF latches data from program-scoped and controller-scoped tags. The controller updates all IREF data at the beginning of each scan.



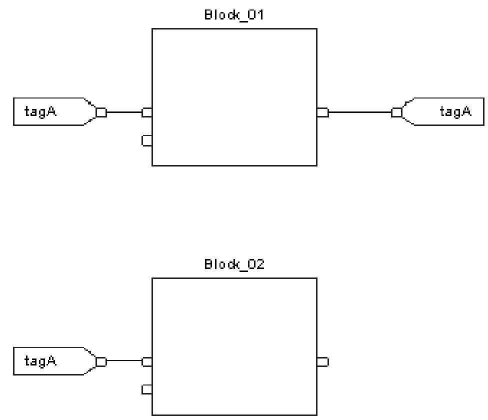
In this example, the value of tagA is stored at the beginning of the routine's execution. The stored value is used when Block_01 executes. The same stored value is also used when Blcock_02 executes. If the value of tagA changes during execution of the routine, the stored value of tagA in the IREF does not change until the next execution of the routine.



This example is the same as the one above. The value of tagA is stored only once at the beginning of the routine's execution. The routine uses this stored value throughout the routine.



Starting with RSLogix 5000 software, version 11, you can use the same tag in multiple IREFs and an OREF in the same routine. Because the values of tags in IREFs are latched every scan through the routine, all IREFs will use the same value, even if an OREF obtains a different tag value during execution of the routine. In this example, if tagA has a value of 25.4 when the routine starts executing this scan, and Block_01 changes the value of tagA to 50.9, the second IREF wired into Block_02 will still use a value of 25.4 when Block_02 executes this scan. The new tagA value of 50.9 will not be used by any IREFs in this routine until the start of the next scan.



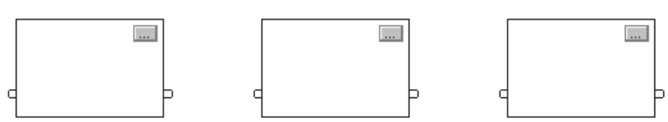
Order of Execution

The RSLogix 5000 programming software automatically determines the order of execution for the function blocks in a routine when you:

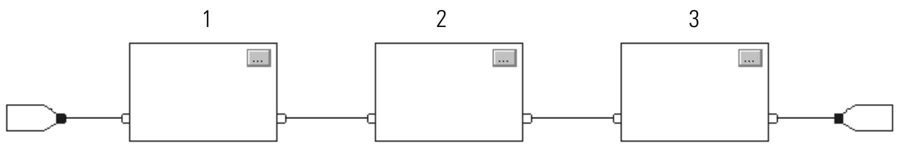
- verify a function block routine
- verify a project that contains a function block routine
- download a project that contains a function block routine

You define execution order by wiring function blocks together and indicating the data flow of any feedback wires, if necessary.

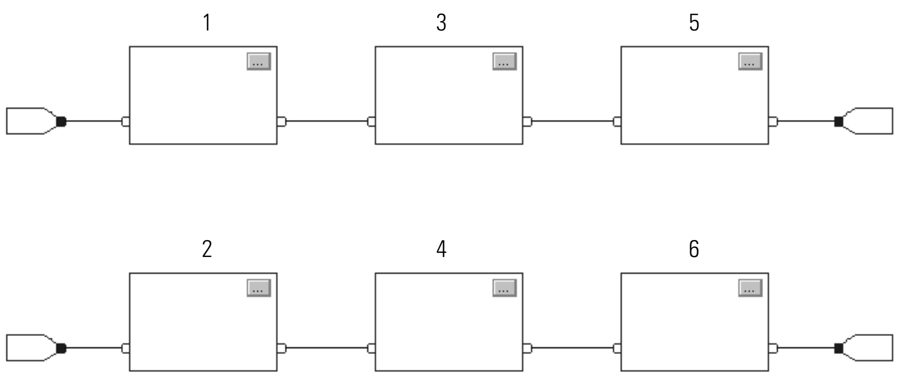
If function blocks are not wired together, it does not matter which block executes first. There is no data flow between the blocks.



If you wire the blocks sequentially, the execution order moves from input to output. The inputs of a block require data to be available before the controller can execute that block. For example, block 2 has to execute before block 3 because the outputs of block 2 feed the inputs of block 3.

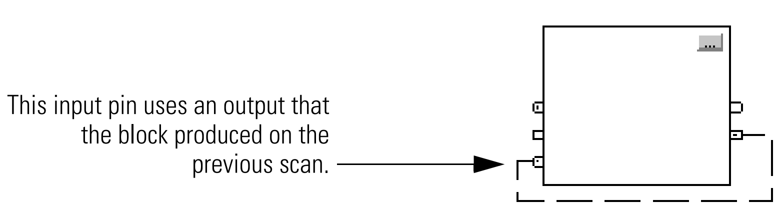


Execution order is only relative to the blocks that are wired together. The following example is fine because the two groups of blocks are not wired together. The blocks within a specific group execute in the appropriate order in relation to the blocks in that group.

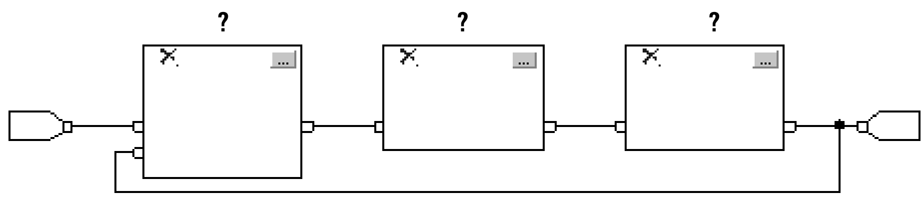


Resolve a Loop

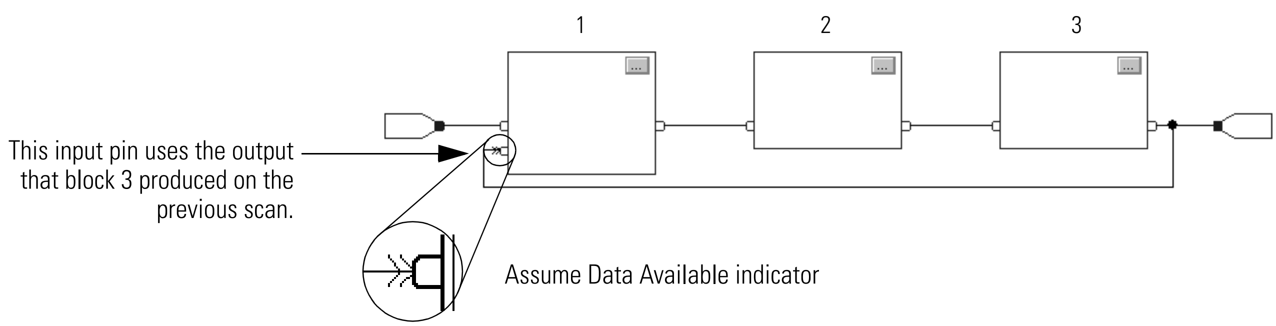
To create a feedback loop around a block, wire an output pin of the block to an input pin of the same block. The following example is OK. The loop contains only a single block, so execution order does not matter.



If a group of blocks are in a loop, the controller cannot determine which block to execute first. In other words, it cannot resolve the loop.

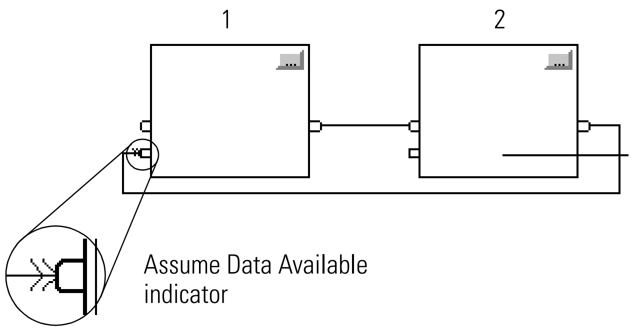
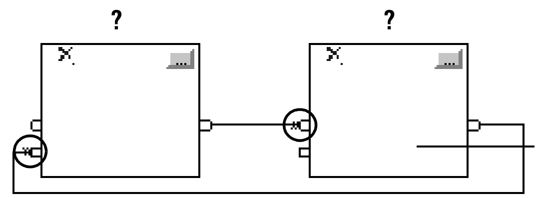


To identify which block to execute first, mark the input wire that creates the loop (the feedback wire) with the *Assume Data Available* indicator. In the following example, block 1 uses the output from block 3 that was produced in the previous execution of the routine.



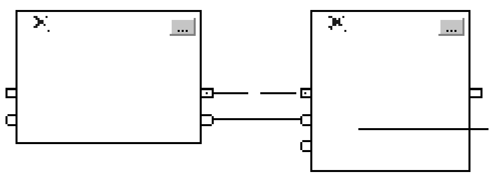
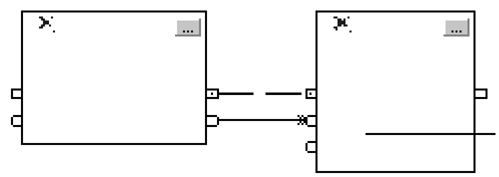
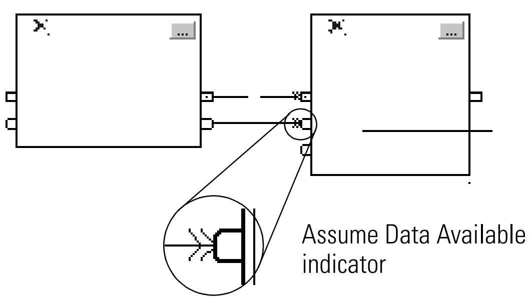
The *Assume Data Available* indicator defines the data flow within the loop. The arrow indicates that the data serves as input to the first block in the loop.

Do not mark all the wires of a loop with the *Assume Data Available* indicator.

This is OK	This is NOT OK
 The *Assume Data Available* indicator defines the data flow within the loop.	 The controller cannot resolve the loop because all the wires use the *Assume Data Available* indicator.

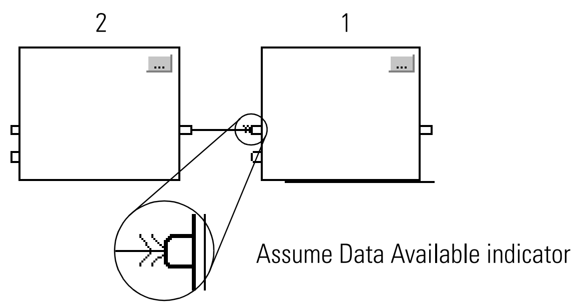
Resolve Data Flow Between Two Blocks

If you use two or more wires to connect two blocks, use the same data flow indicators for all of the wires between the two blocks.

This is OK	This is NOT OK
	
Neither wire uses the *Assume Data Available* indicator.	One wire uses the *Assume Data Available* indicator while the other wire does not.
	
Both wires use the *Assume Data Available* indicator.	

Create a One Scan Delay

To produce a one scan delay between blocks, use the *Assume Data Available* indicator. In the following example, block 1 executes first. It uses the output from block 2 that was produced in the previous scan of the routine.



Summary

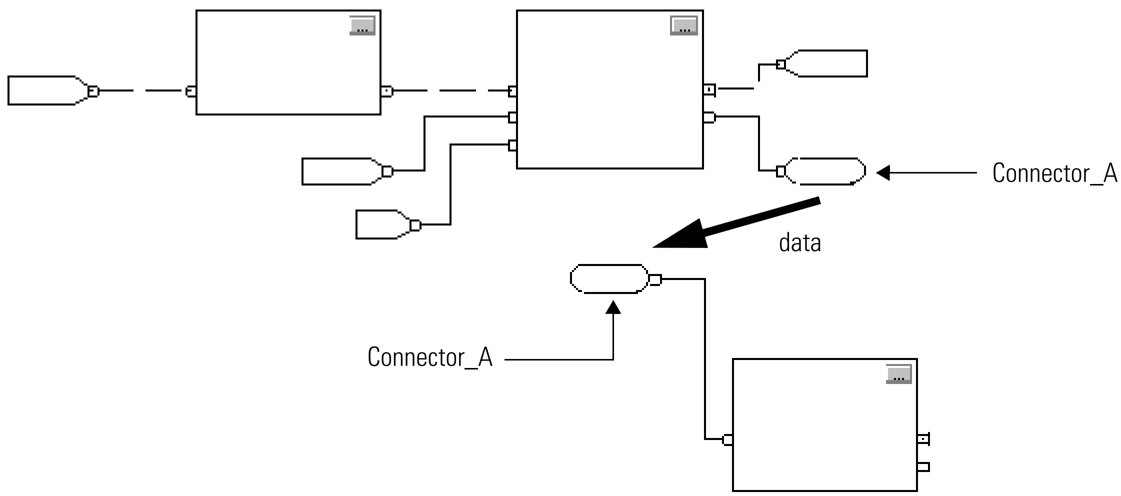
In summary, a function block routine executes in this order:

1. The controller latches all data values in IREFs.
2. The controller executes the other function blocks in the order determined by how they are wired.
3. The controller writes outputs in OREFs.

Identify any Connectors

Like wires, connectors transfer data from output pins to input pins. Use connectors when:

- the elements that you want to connect are on different sheets within the same routine
- a wire is difficult to route around other wires or elements
- you want to disperse data to several points in the routine



To use connectors, follow these rules:

- Each OCON requires a unique name.
- For each OCON, you must have at least one corresponding ICON (i.e., an ICON with the same name as the OCON).
- Multiple ICONs can reference the same OCON. This lets you disperse data to several points in your routine.

Define Program/Operator Control

Several instructions support the concept of Program/Operator control. These instructions include:

- Enhanced Select (ESEL)
- Totalizer (TOT)
- Enhanced PID (PIDE)
- Ramp/Soak (RMPS)
- Discrete 2-State Device (D2SD)
- Discrete 3-State Device (D3SD)

Program/Operator control lets you control these instructions simultaneously from both your user program and from an operator interface device. When in Program control, the instruction is controlled by the Program inputs to the instruction; when in Operator control, the instruction is controlled by the Operator inputs to the instruction.

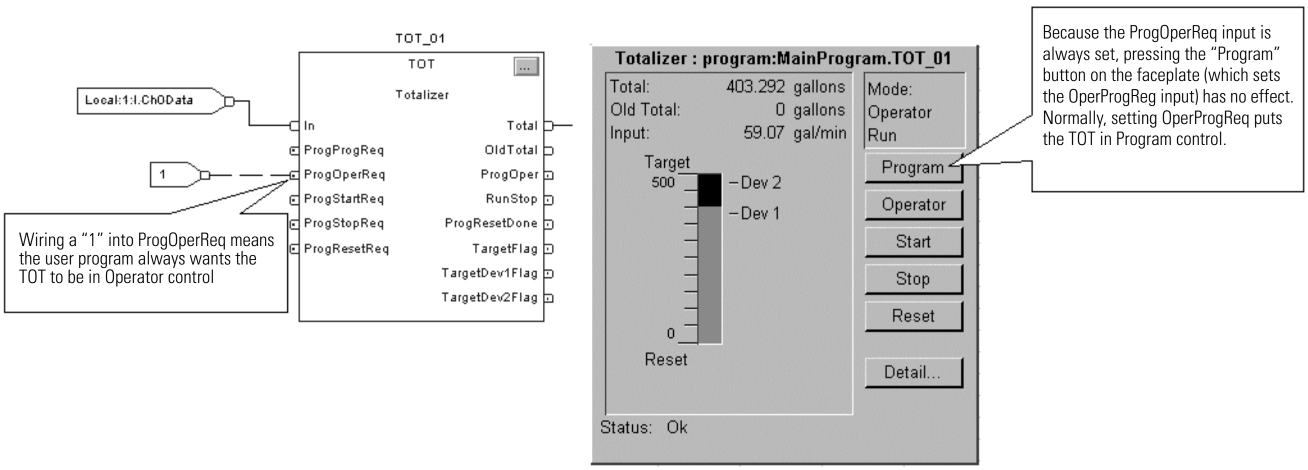
Program or Operator control is determined by using these inputs:

Input:	Description:
.ProgProgReq	A program request to go to Program control.
.ProgOperReq	A program request to go to Operator control.
.OperProgReq	An operator request to go to Program control.
.OperOperReq	An operator request to go to Operator control.

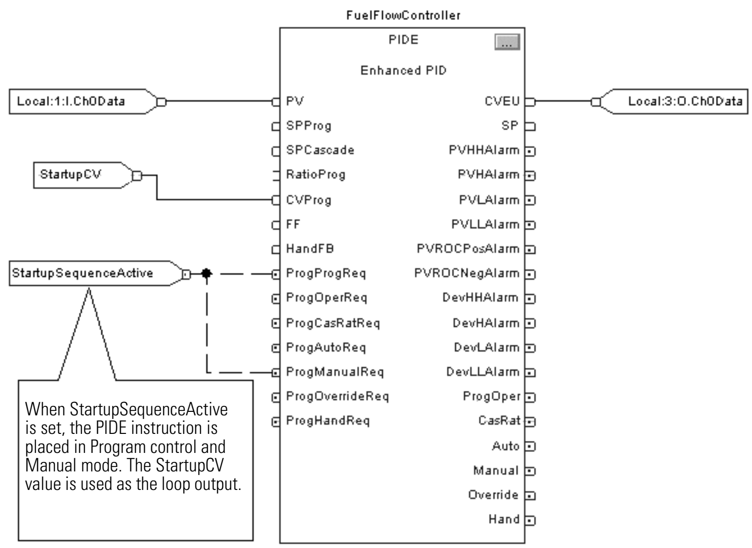
To determine whether an instruction is in Program or Control control, examine the ProgOper output. If ProgOper is set, the instruction is in Program control; if ProgOper is cleared, the instruction is in Operator control.

Operator control takes precedence over Program control if both input request bits are set. For example, if ProgProgReq and ProgOperReq are both set, the instruction goes to Operator control.

The Program request inputs take precedence over the Operator request inputs. This provides the capability to use the ProgProgReq and ProgOperReq inputs to "lock" an instruction in a desired control. For example, let's assume that a Totalizer instruction will always be used in Operator control, and your user program will never control the running or stopping of the Totalizer. In this case, you could wire a literal value of 1 into the ProgOperReq. This would prevent the operator from ever putting the Totalizer into Program control by setting the OperProgReq from an operator interface device.



Likewise, constantly setting the ProgProgReq can “lock” the instruction into Program control. This is useful for automatic startup sequences when you want the program to control the action of the instruction without worrying about an operator inadvertently taking control of the instruction. In this example, you have the program set the ProgProgReq input during the startup, and then clear the ProgProgReq input once the startup was complete. Once the ProgProgReq input is cleared, the instruction remains in Program control until it receives a request to change. For example, the operator could set the OperOperReq input from a faceplate to take over control of that instruction. The following example shows how to lock an instruction into Program control.



Operator request inputs to an instruction are always cleared by the instruction when it executes. This allows operator interfaces to work with these instructions by merely setting the desired mode request bit. You don’t have to program the operator interface to reset the request bits. For example, if an operator interface sets the OperAutoReq input to a PIDE instruction, when the PIDE instruction executes, it determines what the appropriate response should be and clears the OperAutoReq.

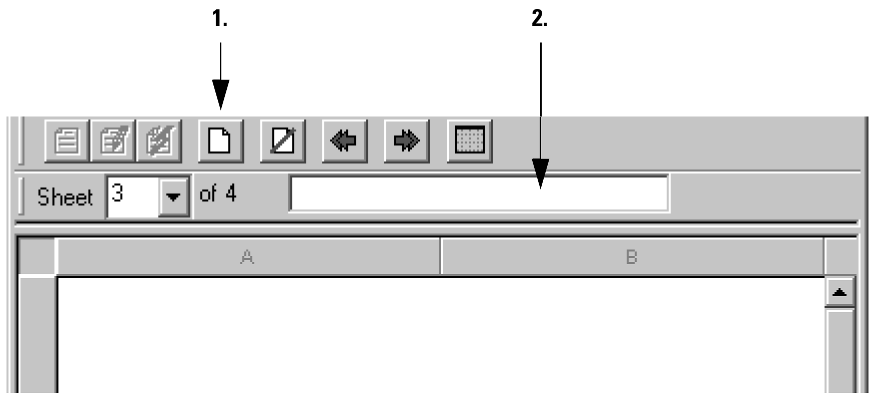
Program request inputs are not normally cleared by the instruction because these are normally wired as inputs into the instruction. If the instruction clears these inputs, the input would just get set again by the wired input. There might be situations where you want to use other logic to set the Program requests in such a manner that you want the Program requests to be cleared by the instruction. In this case, you can set the ProgValueReset input and the instruction will always clear the Program mode request inputs when it executes.

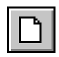
In this example, a rung of ladder logic in another routine is used to one-shot latch a ProgAutoReq to a PIDE instruction when a pushbutton is pushed. Because the PIDE instruction automatically clears the Program mode requests, you don't have to write any ladder logic to clear the ProgAutoReq after the routine executes, and the PIDE instruction will receive only one request to go to Auto every time the pushbutton is pressed.

When the TIC101AutoReq Pushbutton is pressed, one-shot latch ProgAutoReq for the PIDE instruction TIC101. TIC101 has been configured with the ProgValueReset input set, so when the PIDE instruction executes, it automatically clears ProgAutoReq.

Add a Sheet

To add a sheet to a function block routine:

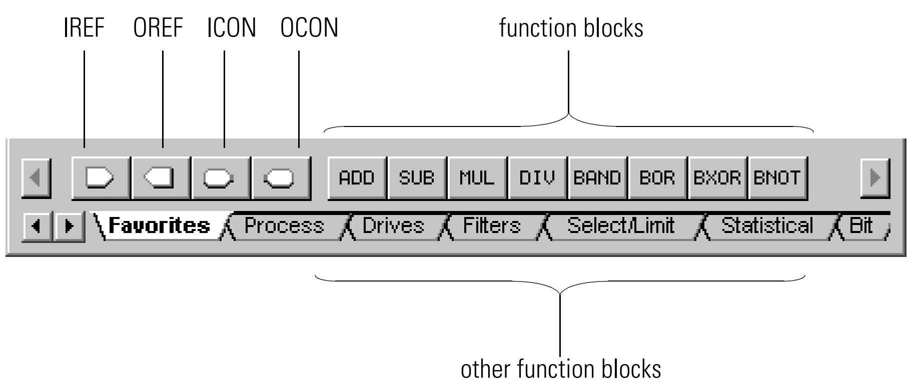


1. Click 

2. Type a description of the sheet (up to 50 characters).

Add a Function Block Element

Use the Language Element toolbar to add a function block element to your routine.

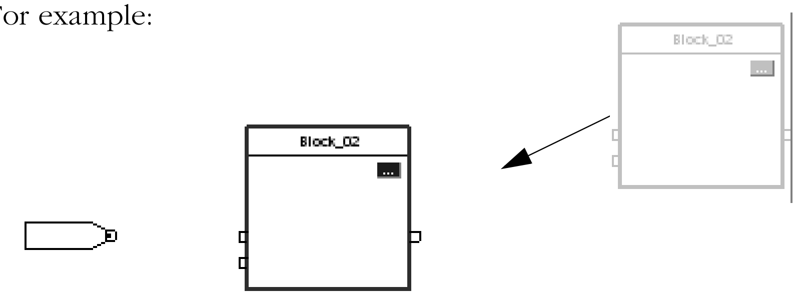


To add an element:

1. On the Language Element toolbar, click the button for the element that you want to add.

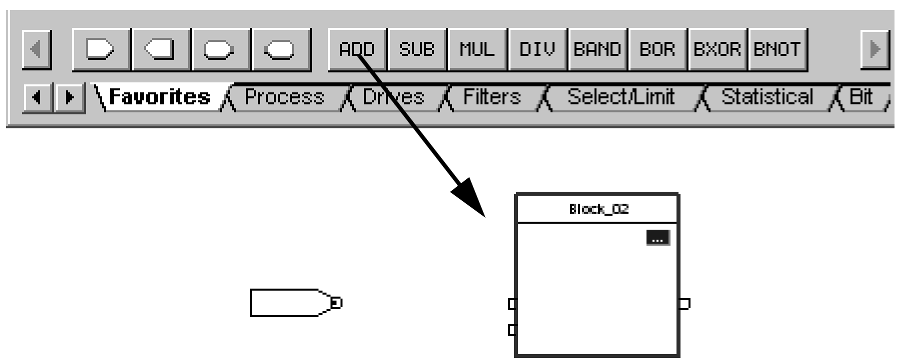
2. Drag the element to the desired location.

   For example:



You can also drag the button for the element directly to the desired location.

For example



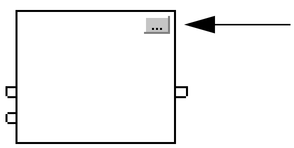
Connect Elements

To define the flow of data:

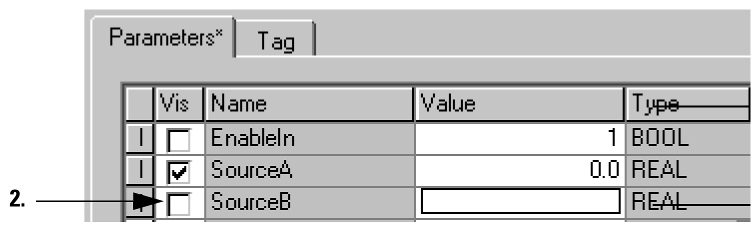
- ☐ Show or Hide a Pin
- ☐ Wire Elements Together
- ☐ Mark a Wire with the Assume Data Available Indicator

Show or Hide a Pin

When you add a function block instruction, a default set of pins for the parameters are shown. The rest of the pins are hidden. To show or hide a pin:



1. Click the [...] button of the block.



2. Clear or check the *Vis* check box of the pin:

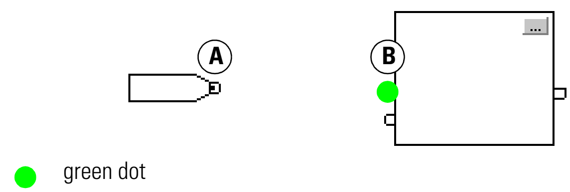
If you want to:	Then;
hide a pin	Clear (uncheck) its *Vis* check box.
show a pin	Check its *Vis* check box.

3. Choose [OK]

Wire Elements Together

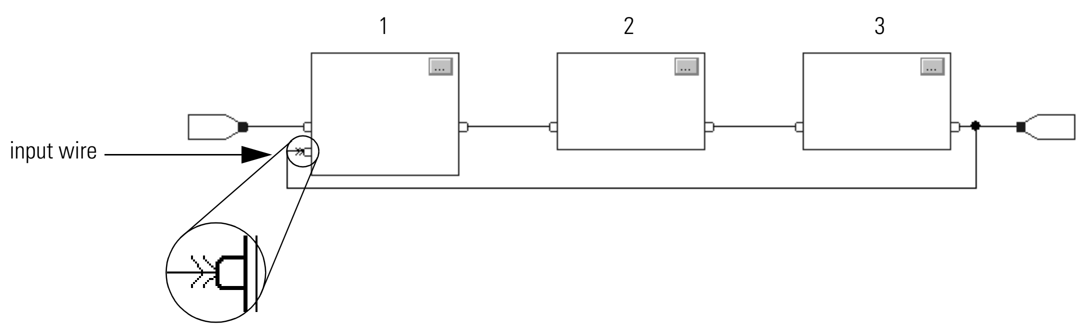
To wire (connect) two elements together, click the output pin of the first element and then click the input pin of the other element. A green dot shows a valid connection point.

For example:



Mark a Wire with the Assume Data Available Indicator

To define a wire as an input, right-click the wire and choose *Assume Data Available*.

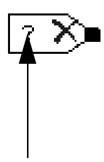


Assign a Tag

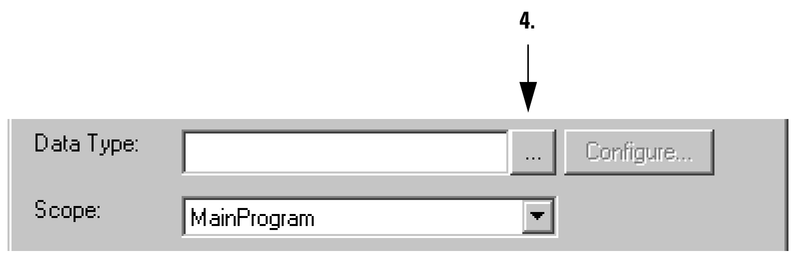
To assign a tag to a function block element, you have these options:

- Create and Assign a New Tag
- Rename the Tag of a Function Block
- Assign an Existing Tag

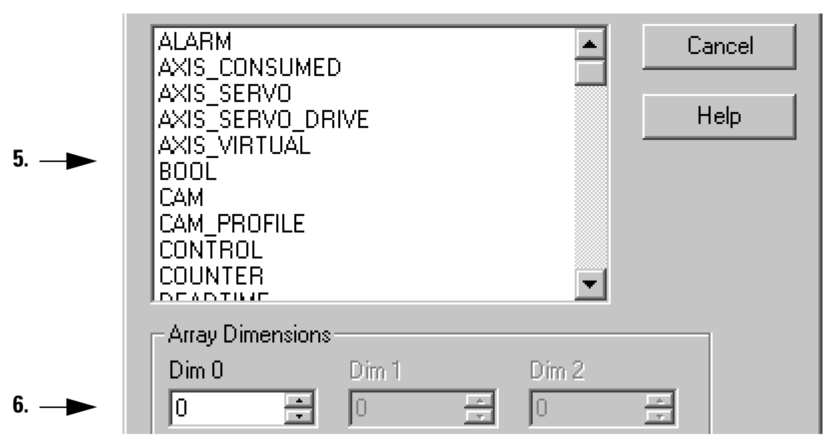
Create and Assign a New Tag



1. Double-click the operand area.
2. Type a name for the tag and press the *Enter* key.
3. Right-click the tag name and choose *New "tag_name"*.

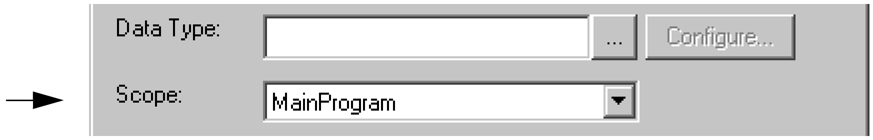


4. Click the ... button.



5. Select the data type for the tag.
6. If you want to define the tag as an array, type the number of elements in each dimension.
7. Choose OK

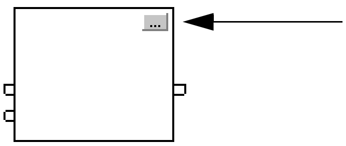
8.



8. Choose the scope for the tag.

9. Choose OK

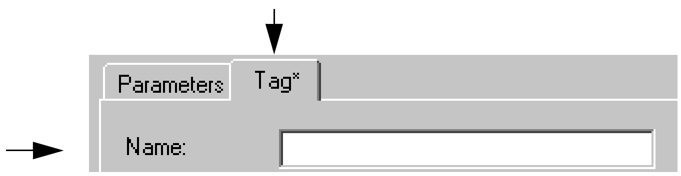
Rename the Tag of a Function Block



1. Click the ... button of the block.

2. Click the *Tag* tab.

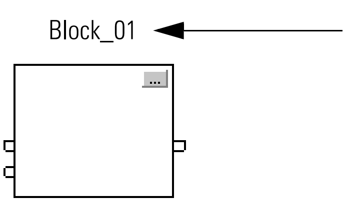
3.



3. Type the new tag name for the block.

4. Choose OK

Assign an Existing Tag



1. Double-click the operand area.

2. Click the ▼

3. Select the tag:

To select a:	Do this:
tag	Double-click the tag name.
bit number	A. Click the tag name. B. To the right of the tag name, click ▼ C. Click the required bit.

4. Press [Enter] or click a different spot on the diagram.

Assign an Immediate Value (Constant)

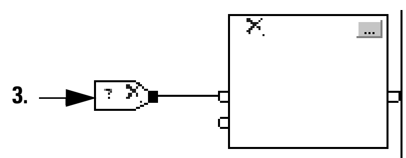
To assign a constant value instead of a tag value to an input parameter, you have these options:

If you want to:	Then:
make the value visible on the diagram and reports	Use an IREF
be able to change the value online without editing the routine	Enter a Value in the Tag of a Block

Use an IREF

1. Add an IREF.

2. Wire the IREF to the input pin that gets the value.

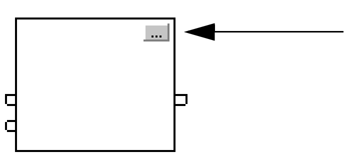


3. Double-click the operand area of the IREF.

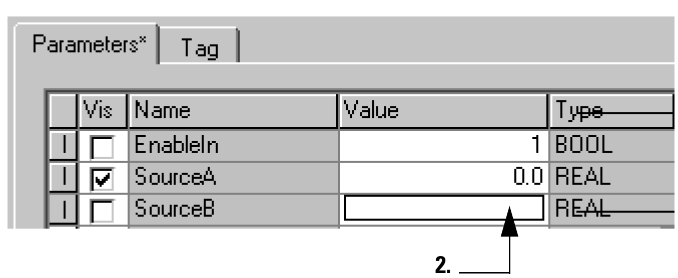
4. Type the value and press the *Enter* key.

Enter a Value in the Tag of a Block

To assign a value to a parameter when on wire connects to its pin:



1. Click the ... button of the block.



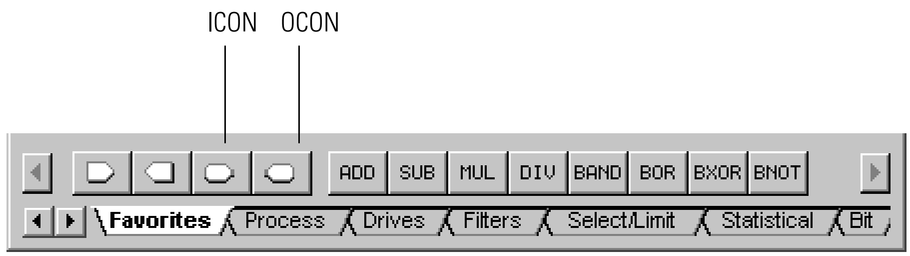
2. Type the value.

3. Choose OK

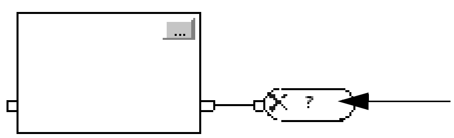
Connect Blocks with an OCON and ICON

To transfer data between sheets or in complex wiring situations:

- ☐ Add an OCON
- ☐ Add an ICON

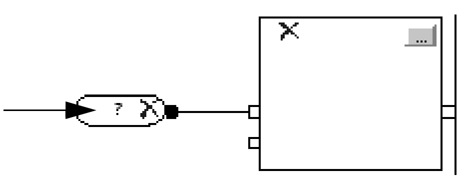


Add an OCON



1. Add an output wire connector (OCON) and place it near the output pin that supplies the value.
2. Wire the OCON to the output pin.
3. Double-click the operand area of the OCON.
4. Type a name that identifies the connector and press [Enter].

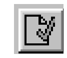
Add an ICON



1. Add an input wire connector (ICON) and place it near the input pin that gets the value from the corresponding OCON.
2. Wire the ICON to the input pin.
3. Double-click the operand area of the ICON.
4. Select the name of the OCON that supplies the value to this connector and then click a blank spot on the diagram

Verify the Routine

As you program your routine, periodically verify your work:

1. In the top-most toolbar of the RSLogix 5000 window, click 

2. If any errors are listed at the bottom of the window:
   a. To go to the first error or warning, press [F4].
   b. Correct the error according to the description in the Results window.
   c. Go to step 1.

3. To close the Results window, press [Alt] + [1].

Communicate with Other Devices

Using This Chapter

Use this chapter to plan your communication between the controller and I/O modules or other controllers.

Connections

A Logix5000 controller uses **connections** for many, but not all, of its communication with other devices.

Term:	Definition:
connection	A communication link between two devices, such as between a controller and an I/O module, PanelView terminal, or another controller. Connections are allocations of resources that provide more reliable communications between devices than unconnected messages. The number of connections that a single controller can have is limited. You indirectly determine the number of connections the controller uses by configuring the controller to communicate with other devices in the system. The following types of communication use connections: • I/O modules • produced and consumed tags • certain types of Message (MSG) instructions (not all types use a connection)

Term:	Definition:
requested packet interval (RPI)	The RPI specifies the period at which data updates over a connection. For example, an input module sends data to a controller at the RPI that you assign to the module. • Typically, you configure an RPI in milliseconds (ms). The range is 0.2 ms (200 microseconds) to 750 ms. • If a ControlNet network connects the devices, the RPI reserves a slot in the stream of data flowing across the ControlNet network. The timing of this slot may not coincide with the exact value of the RPI, but the control system guarantees that the data transfers at least as often as the RPI.
path	The path describes the route that a connection takes to get to the destination. Typically, you automatically define the path for a connection when you add the devices to the I/O Configuration folder of the controller. I/O Configuration [0] 1756-CNB/x Local_CNB 2 [0] 1756-CNB/x chassis_b [1] 1756-L55/x peer_controller

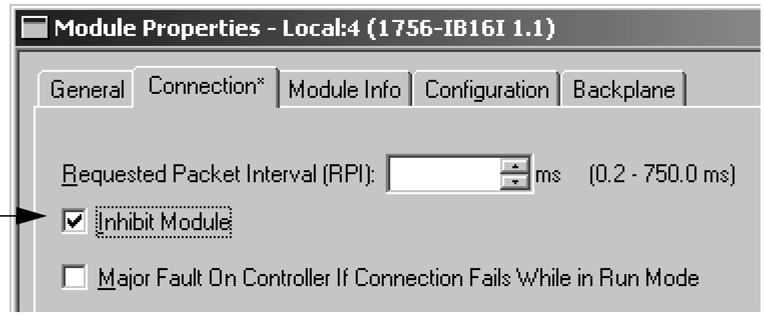
Inhibit a Connection

ATTENTION

Inhibiting a module breaks the connection to the module and prevents communication of I/O data.

In some situations, such as when initially commissioning a system, it is useful to disable portions of a control system and enable them as you wire up the control system. The controller lets you inhibit individual modules or groups of modules, which prevents the controller from trying to communicate with the modules.

Inhibit communication with the module.



When you configure an I/O module, it defaults to being not inhibited. You can change an individual module's properties to inhibit a module.

If you want to:	Then:
communicate with the module	do not inhibit the module
prevent communication with the module	inhibit the module

When you inhibit a communication bridge module, such as a 1756-CNB or 1756-DHRIO module, the controller shuts down the connections to the bridge module and to all the modules that depend on that bridge module. Inhibiting a communication bridge module lets you disable an entire branch of the I/O network.

When you select to inhibit the module, the controller organizer displays a yellow attention symbol ⚠ over the module.

If you are:	And you:	And:	Then:
offline	→	→	The inhibit status is stored in the project. When you download the project, the module is still inhibited.
online	inhibit a module while you are connected to the module	→	The connection to the module is closed. The modules' outputs go to the last configured program mode.
	inhibit a module but a connection to the module was *not* established (perhaps due to an error condition or fault)	→	The module is inhibited. The module status information changes to indicate that the module is inhibited and not faulted.
	uninhibit a module (clear the check box)	no fault occurs	A connection is made to the module and the module is dynamically reconfigured (if the controller is the owner controller) with the configuration you created for that module. If the controller is configured for listen-only, it cannot reconfigure the module.
		fault occurs	A connection is *not* made to the module. The module status information changes to indicate the fault condition.

To inhibit or uninhibit a module from logic:

1. Use a Get System Value (GSV) instruction to read the Mode attribute for the module.

2. Set or clear bit 2:

If you want to:	Then:
inhibit the module	Set bit 2.
uninhibit the module	Clear bit 2

3. Use a Set System Value (SSV) instruction to write the Mode attribute back to the module.

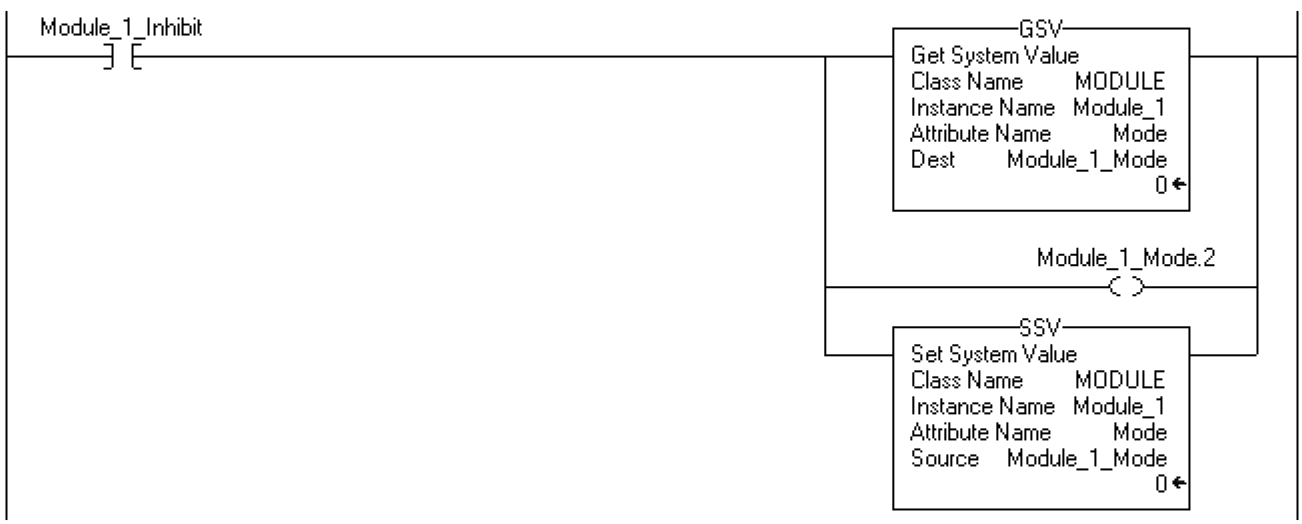
EXAMPLE Inhibit a Connection

If *Module_1_Inhibit* = 1, then inhibit the operation of the I/O module named *Module_1*:

1. The GSV instruction sets *Module_1_Mode* = value of the Mode attribute for the module.

2. The OTE instruction sets bit 2 of *Module_1_Mode* = 1. This means inhibit the connection.

3. The SSV instruction sets the Mode attribute for the module = *Module_1_Mode.*



Manage a Connection Failure

ATTENTION

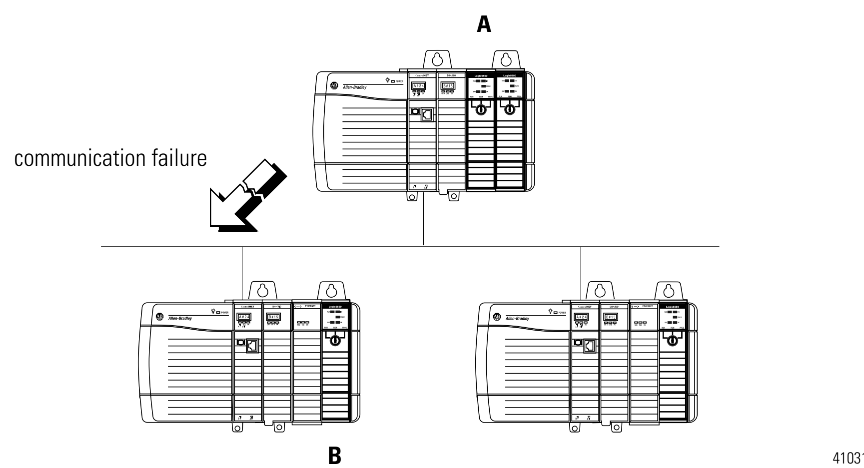
Outputs respond to the last, non-faulted state of the controlling inputs. To avoid potential injury and damage to machinery, make sure this does not create unsafe operation. Configure critical I/O modules to generate a controller major fault when they lose their connections to the controller. Or, monitor the status of I/O modules.

If the controller loses communication with a module, data from that device does not update. When this occurs, the logic makes decisions on data that may or may not be correct.

EXAMPLE

Loss of communication

Controller B requires data from controller A. If communication fails between the controllers, then controller B continues to act on the last data that it received from controller A.



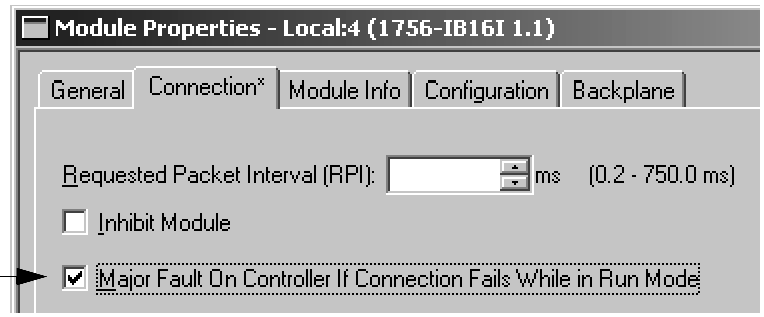
If communication with a device in the I/O configuration of the controller does not occur for 100 ms, the communication times out. If this occurs, you have the following options:

If you want the controller to:	Then:
fault (major fault)	Configure a Major Fault to Occur
continue operating	Monitor the Health of a Module

Configure a Major Fault to Occur

You can configure modules to generate a major fault in the controller if they lose their connection with the controller. This interrupts the execution of logic and executes the Controller Fault Handler. If the Controller Fault Handler does not clear the fault, then the controller shuts down.

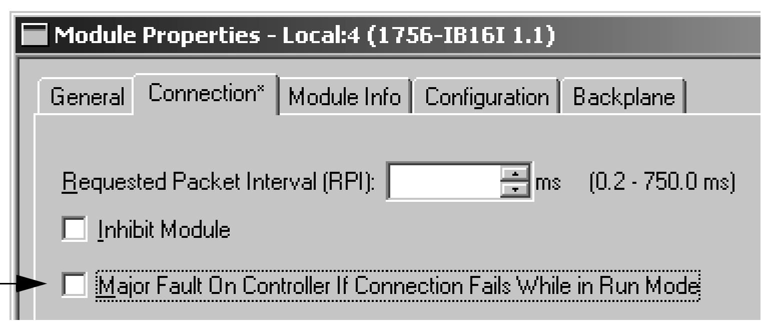
If the connection times out, produce a major fault in the controller.



Monitor the Health of a Module

If you do not configure the major fault to occur, you should monitor the module status. If a module loses its connection to the controller, outputs go to their configured faulted state. The controller and other I/O modules continue to operate based on old data from the module.

If the connection times out, continue operation without invoking a major fault on the controller.



If communication with a module times out, the controller produces the following warnings:

- The I/O LED on the front of the controller flashes green.
- A ⚠ shows over the I/O configuration folder and over the device (s) that has timed out.
- A module fault code is produced, which you can access through:
  - Module Properties window for the module
  - GSV instruction

To monitor the health of your connections, use a Get System Value (GSV) instruction to monitor the MODULE object for either the controller or a specific module:

<table>
<tr><th>If you want to:</th><th>Get this attribute:</th><th>Data Type:</th><th colspan="2">Description:</th></tr>
<tr><td rowspan="6">determine if communication has timed out with any device</td><td rowspan="6">LEDStatus</td><td rowspan="6">INT

For efficiency, use a DINT as the destination data type.</td><td colspan="2">Specifies the current state of the I/O LED on the front of the controller.

Note: You do not enter an instance name with this attribute. This attribute applies to the entire collection of modules.</td></tr>
<tr><td>Value:</td><td>Meaning:</td></tr>
<tr><td>0</td><td>LED off: No MODULE objects are configured for the controller (there are no modules in the I/O Configuration section of the controller organizer).</td></tr>
<tr><td>1</td><td>Flashing red: None of the MODULE objects are Running.</td></tr>
<tr><td>2</td><td>Flashing green: At least one MODULE object is not Running.</td></tr>
<tr><td>3</td><td>Solid green: All the Module objects are Running.</td></tr>
<tr><td>determine if communication has timed out with a specific device</td><td>FaultCode</td><td>INT

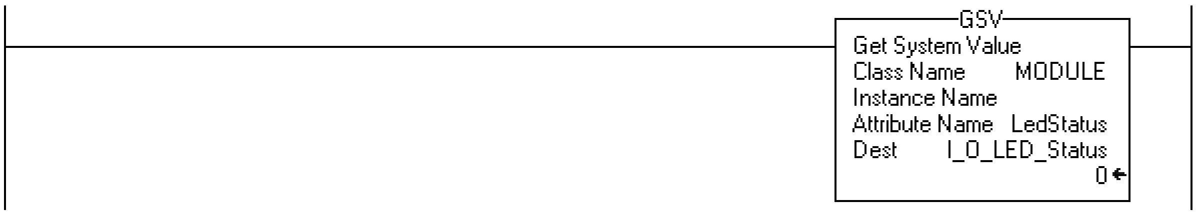
For efficiency, use a DINT as the destination data type.</td><td colspan="2">A number which identifies a module fault, if one occurs.

In the Instance Name, choose the device whose connection you want to monitor. Make sure to assign a name to the device in the I/O Configuration folder of the project.</td></tr>
</table>

EXAMPLE Monitor the Health of a Module

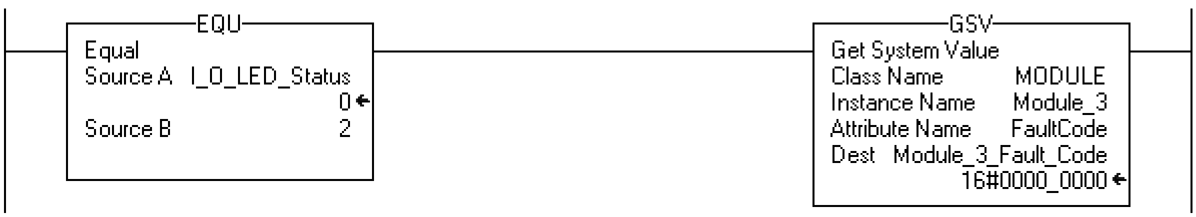
The GSV instruction continuously sets *I_O_LED_Status* (DINT tag) = status of the I/O LED of the controller.

1



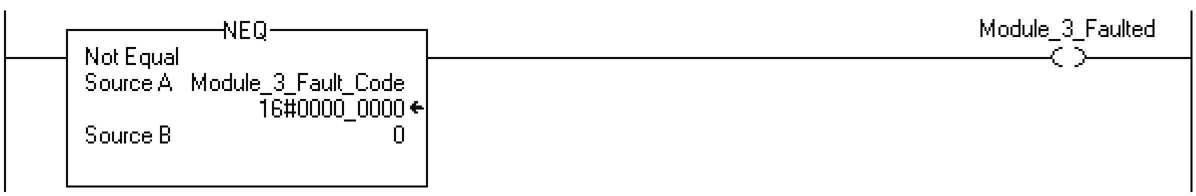
If *I_O_LED_Status* = 2, then communication has timed out (faulted) with at least one module. The GSV instruction sets *Module_3_Fault_Code* = fault code for *Module_3*.

2



If *Module_3_Fault_Code*. is NOT equal to 0, then communication has timed out (faulted) with *Module_3*. The OTE instruction sets *Module_3_Faulted* = 1.

3

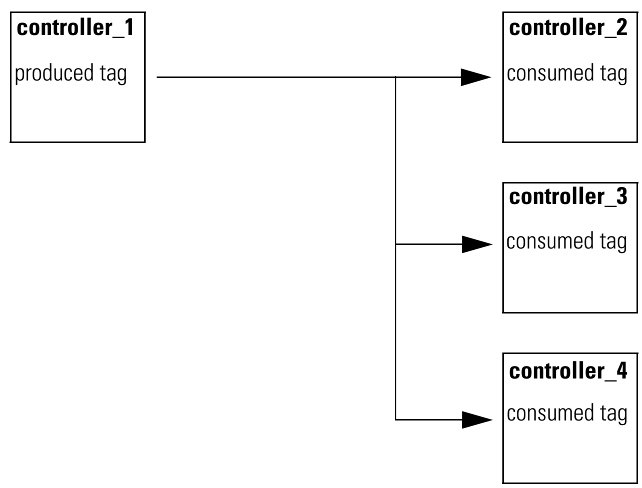


Produce and Consume a Tag

To transfer data between controllers (send or receive data), you have the following options:

If the data:	Then:	See:
needs regular delivery at an interval that you specify (i.e., deterministic)	Produce and Consume a Tag	This section
is sent when a specific condition occurs in your application	Execute a Message (MSG) Instruction	Page 10-19

A Logix5000 controller lets you produce (broadcast) and consume (receive) system-shared tags.



Term:	Definition
produced tag	A tag that a controller makes available for use by other controllers. Multiple controllers can simultaneously consume (receive) the data. A produced tag sends its data to one or more consumed tags (consumers) without using logic. The produced tag sends its data at the RPI of the consuming tag.
consumed tag	A tag that receives the data of a produced tag. The data type of the consumed tag must match the data type (including any array dimensions) of the produced tag. The RPI of the consumed tag determines the period at which the data updates.

Controllers and Networks that Support Produced/Consumed Tags

Use the following table to see the controller and network combinations that let you produce and consume tags.

This controller:	Can produce and consume tags over this network:		
	Backplane	ControlNet	EtherNet/IP
SLC 500		✔	
PLC-5		✔	
CompactLogix[1]			✔
ControlLogix	✔	✔	✔
DriveLogix			
FlexLogix		✔	
SoftLogix5800		✔	

(1) Use a CompactLogix5335 controller, catalog number 1769-L35E.

For two controllers to share produced or consumed tags, both controllers must be attached to the same network (such as a ControlNet or Ethernet/IP network). You cannot bridge produced and consumed tags over two networks.

Connection Requirements of a Produced or Consumed Tag

IMPORTANT If a consumed-tag connection fails, all of the other tags being consumed from that remote controller stop receiving new data.

Produced and consumed tags each require connections. As you increase the number of controllers that can consume a produced tag, you also reduce the number of connections the controller has available for other operations, like communications and I/O.

Each produced or consumed tag uses the following number of connections:

This controller:	And this type of tag:	Uses this many connections
ControlLogix SoftLogix5800	produced tag	`number_of_consumers` +1
	consumed tag	1
CompactLogix DriveLogix FlexLogix	produced tag	`number_of_consumers`
	consumed tag	1

EXAMPLE

Connection Requirements of a Produced or Consumed Tag

- A FlexLogix controller producing a tag for 5 controllers (consumers) uses 5 connections.
- A ControlLogix controller producing 4 tags for 1 controller uses 8 connections:
  - Each tag uses 2 connections (1 consumer + 1 = 2).
  - 2 connections per tag x 4 tags = 8 connections
- Consuming 4 tags from a controller uses 4 connections (1 connection per tag x 4 tags = 4 connections).

Organize Tags for Produced or Consumed Data

As you organize your tags for produced or consumed data (shared data), follow these guidelines:

<table>
<tr><th>Guideline:</th><th colspan="4">Details:</th></tr>
<tr><td>Create the tags at the controller scope.</td><td colspan="4">You can share only controller-scoped tags.</td></tr>
<tr><td>Use one of these data types:
• DINT
• REAL
• array of DINTs or REALs
• user-defined</td><td colspan="4">• To share other data types, create a user-defined data type that contains the required data.
• Use the same data type for the produced tag and corresponding consumed tag or tags.</td></tr>
<tr><td rowspan="8">To share tags with a PLC-5C controller, use a user-defined data type.</td><td>To:</td><td>This:</td><td colspan="2">Then:</td></tr>
<tr><td rowspan="3">produce</td><td>integers</td><td colspan="2">Create a user-defined data type that contains an array of INTs with an even number of elements, such as INT[2]. (When you produce INTs, you must produce two or more.)</td></tr>
<tr><td>only one REAL value</td><td colspan="2">Use the REAL data type.</td></tr>
<tr><td>more than one REAL value</td><td colspan="2">Create a user-defined data type that contains an array of REALs.</td></tr>
<tr><td rowspan="4">consume</td><td rowspan="4">integers</td><td colspan="2">Create a user-defined data type that contains the following members:</td></tr>
<tr><td>Data type:</td><td>Description:</td></tr>
<tr><td>DINT</td><td>Status</td></tr>
<tr><td>INT[x], where x is the output size of the data from the PLC-5C controller. (If you are consuming only one INT, omit x.)</td><td>Data produced by a PLC-5C controller</td></tr>
<tr><td>Limit the size of the tag to ≤ 500 bytes.</td><td colspan="4">• If you must transfer more than 500 bytes, create logic to transfer the data in packets. See chapter 11.
• If you produce the tag over a ControlNet network, the tag may need to be less than 500 bytes. Refer to "Adjust for Bandwidth Limitations" on page 10-13.</td></tr>
<tr><td>Use the highest permissible RPI for your application.</td><td colspan="4">If the controller consumes the tag over a ControlNet network, use a binary multiple of the ControlNet network update time (NUT). For example, if the NUT is 5 ms, use an RPI of 5, 10, 20, 40 ms, etc.</td></tr>
<tr><td>Combine data this goes to the same controller.</td><td colspan="4">If you are producing several tags for the same controller:
• Group the data into one or more user-defined data types. (This uses less connections than producing each tag separately.)
• Group the data according to similar update intervals. (To conserve network bandwidth, use a greater RPI for less critical data.)
For example, you could create one tag for data that is critical and another tag for data that is not as critical.</td></tr>
</table>

Adjust for Bandwidth Limitations

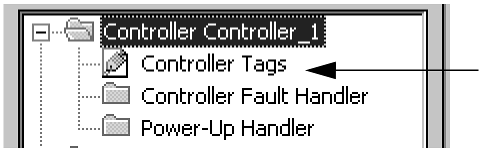
When you share a tag over a ControlNet network, the tag must fit within the bandwidth of the network:

- As the number of connections over a ControlNet network increases, several connections, including produced or consumed tags, may need to share a network update time (NUT).
- Since a ControlNet network can only pass 500 bytes in one NUT, the data of each connection must be less then 500 bytes to fit into the NUT.

Depending on the size of your system, you may not have enough bandwidth on your ControlNet network for a tag of 500 bytes. If a tag is too large for your ControlNet network, make one or more of the following adjustments:

<table>
<tr><th>Adjustment:</th><th colspan="2">Description:</th></tr>
<tr><td>Reduce your network update time (NUT).</td><td colspan="2">At a faster NUT, less connections have to share an update slot.</td></tr>
<tr><td>Increase the requested packet interval (RPI) of your connections.</td><td colspan="2">At higher RPIs, connections can take turns sending data during an update slot.</td></tr>
<tr><td rowspan="4">For a ControlNet bridge module (CNB) in a remote chassis, select the most efficient communication format for that chassis:</td><td>Are most of the modules in the chassis non-diagnostic, digital I/O modules?</td><td>Then select this communication format for the remote CNB module:</td></tr>
<tr><td>Yes</td><td>Rack Optimization</td></tr>
<tr><td>No</td><td>None</td></tr>
<tr><td colspan="2">The Rack Optimization format uses an additional 8 bytes for each slot in its chassis. Analog modules or modules that are sending or getting diagnostic, fuse, timestamp, or schedule data require direct connections and cannot take advantage of the rack optimized form. Selecting “None” frees up the 8 bytes per slot for other uses, such as produced or consumed tags.</td></tr>
<tr><td>Separate the tag into two or more smaller tags.</td><td colspan="2">1. Group the data according to similar update rates. For example, you could create one tag for data that is critical and another tag for data that is not as critical.
2. Assign a different RPI to each tag.</td></tr>
<tr><td>Create logic to transfer the data in smaller sections (packets).</td><td colspan="2">Refer to "Produce a Large Array" on page 11-1.</td></tr>
</table>

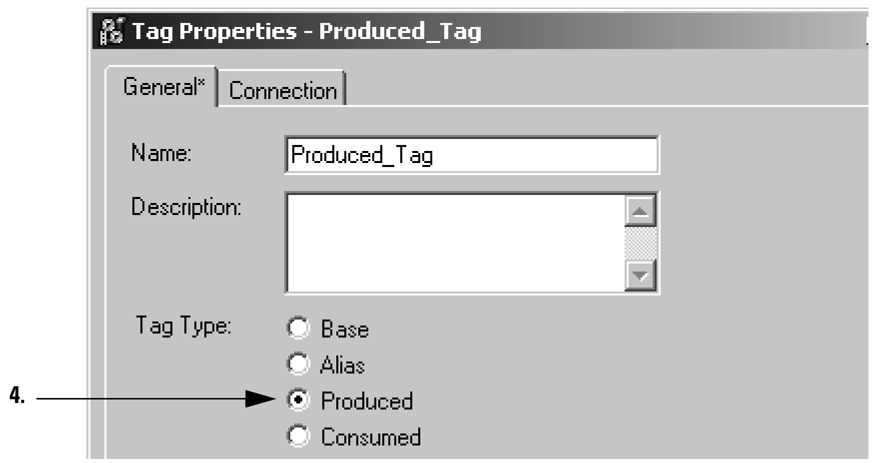
Produce a Tag



1. Open the RSLogix 5000 project that contains the tag that you want to produce.

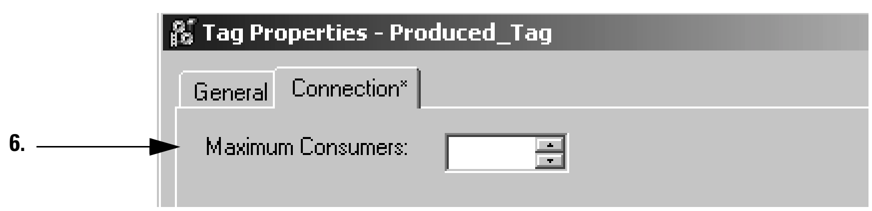
2. In the controller organizer, right-click the *Controller Tags* folder and choose *Edit Tags*. (You can produce only controller-scoped tags.)

3. In the Controller Tags window, right-click the tag that you want to produce and choose *Edit Tag Properties*.



4. Select the *Produced* option button.

5. Click the *Connection* tab.



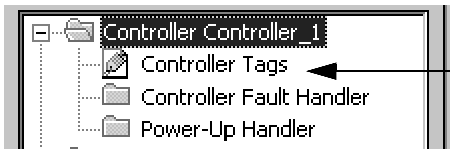
6. Type or select the number of controllers that will consume (receive) the tag.

7. Choose 

Consume Data That Is Produced by Another Controller

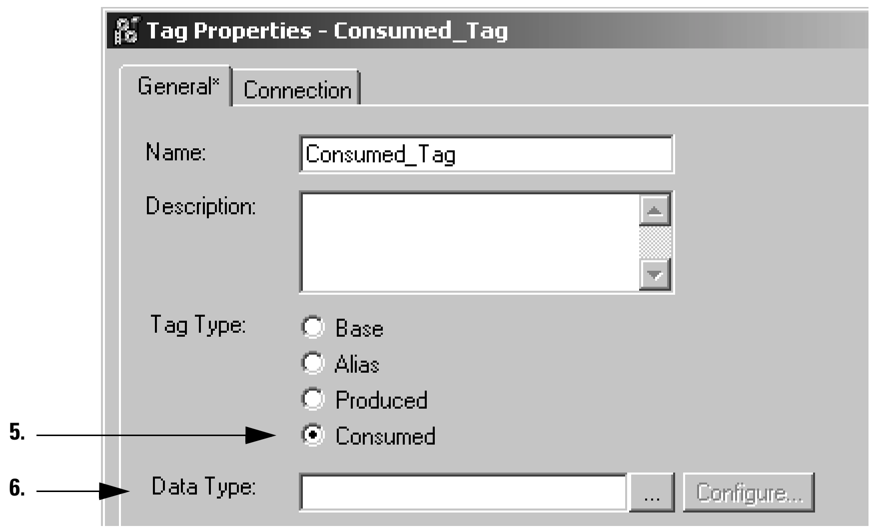
1. Open the RSLogix 5000 project that will consume the data.

2. In the controller organizer, *I/O Configuration* folder, add the controller that is producing the data (the other Logix5000 controller or PLC-5C controller).



3. In the controller organizer, right-click the *Controller Tags* folder and choose *Edit Tags*. (Only controller-scoped tags can consume data.)

4. In the Controller Tags window, right-click the tag that will consume the data and choose *Edit Tag Properties*.

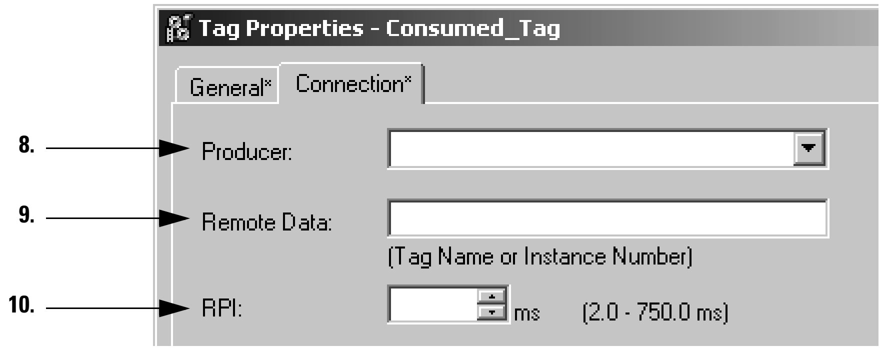


5. Select the *Consumed* option button.

6. Make sure the data type is as follows:

If the producing controller is:	Then the data type should be:	
Logix5000 controller	same data type as the produced tag	
PLC-5C controller	user-defined data type with the following members:	
	Data type:	**Description:**
	DINT	Status
	INT[x], where x is the output size of the data from the PLC-5C controller. (If you are consuming only one INT, omit x.)	Data produced by a PLC-5C controller

7. Click the *Connection* tab.



8. Select the controller that produces the data.

9. Type the name or instance number of the produced data.

If the producing controller is:	Then type or select:
Logix5000 controller	tag name of the produced tag
PLC-5C controller	message number from the ControlNet configuration of the PLC-5C controller

10. Type or select the requested packet interval (RPI) for the connection.

11. Choose 

12. If you consume the tag over a ControlNet network, use RSNetWorx for ControlNet software to schedule the network.

Additional Steps for a PLC-5C Controller

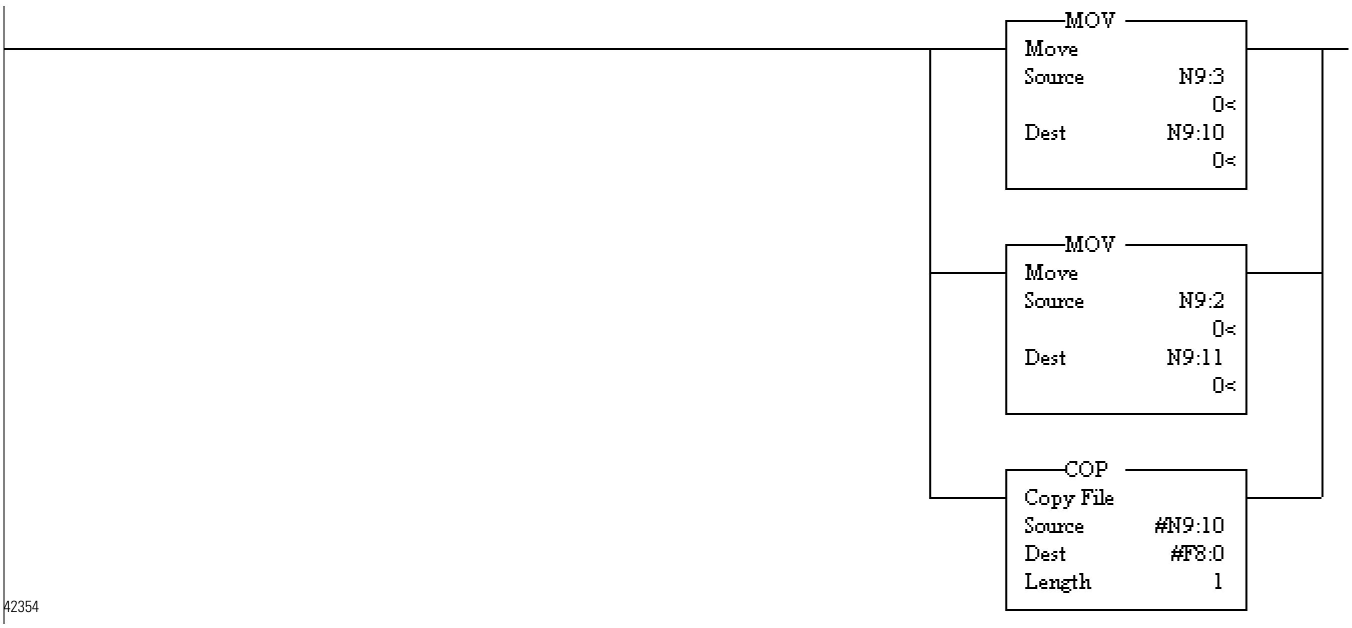
If you are sharing data with a PLC-5C controller, perform the following additional actions:

Action:	Details:		
In the ControlNet configuration of the PLC-5C controller, scheduled a message.	**If the PLC-5C:**	**This:**	**Then in RSNetWorx software:**
	produces	integers	In the ControlNet configuration of the PLC-5C controller, insert a Send Scheduled Message.
	consumes	integers	In the ControlNet configuration of the PLC-5C controller: A. Insert a Receive Scheduled Message. B. In the Message size, enter the number of integers in the produced tag.
		REALs	In the ControlNet configuration of the PLC-5C controller: A. Insert a Receive Scheduled Message. B. In the Message size, enter two times the number of REALs in the produced tag. For example, if the produced tag contains 10 REALs, enter 20 for the Message size.
If the PLC-5C controller consumes REALs, reconstruct the values.	When you produce REALs (32-bit floating-point values) for a PLC-5C controller, the PLC-5C stores the data in consecutive 16-bit integers: • The first integer contains the upper (left-most) bits of the value. • The second integer contains the lower (right-most) bits of the value. • This pattern continues for each floating-point value. See the following example on page 10-18.		

The following example shows how to re-construct a REAL (floating point value) in the PLC-5C controller

EXAMPLE Re-construct a floating point value

The two MOV instructions reverse the order of the integers as the integers move to a new location. Because the destination of the COP instruction is a floating-point address, it takes two consecutive integers, for a total of 32 bits, and converts them to a single floating-point value.



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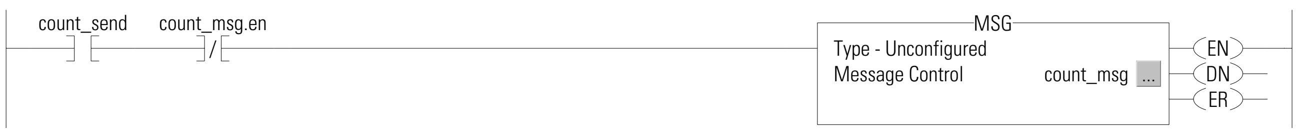
Execute a Message (MSG) Instruction

To transfer data between controllers (send or receive data), you have the following options:

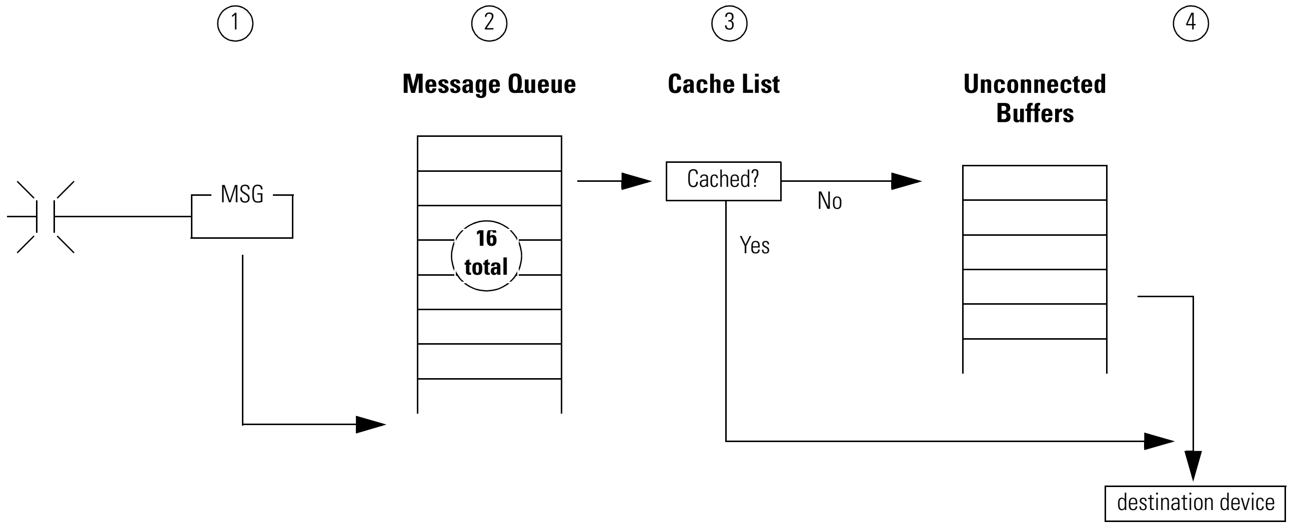
If the data:	Then:	See:
needs regular delivery at a rate that you specify (i.e., deterministic)	Produce and Consume a Tag	Page 10-9
is sent when a specific condition occurs in your application	Execute a Message (MSG) Instruction	This section

EXAMPLE Execute a Message (MSG) Instruction

If *count_send* = 1 and *count_msg.EN* = 0 (MSG instruction is not already enabled), then execute a MSG instruction that sends data to another controller.



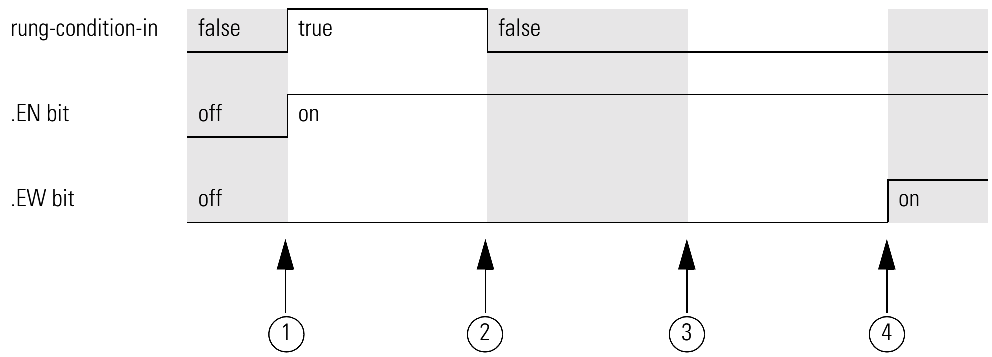
The following diagram shows how the controller processes Message (MSG) instructions.



Description:		
1	The controller scans the MSG instruction and its rung-condition-in goes true. The MSG instruction enters the message queue.	
2	The MSG instruction comes off the queue and is processed.	
3	**If the MSG instruction:**	**Then the MSG instruction:**
	does not use a connection or the connection was *not* previously cached.	uses an unconnected buffer to establish communication with the destination device
	uses a connection and the connection is cached	*does not* use an unconnected buffer
4	Communication occurs with the destination device.	

Message Queue

The message queue holds up to 16 MSG instructions, including those that you configure as a block-transfer read or block-transfer write. When the queue is full, an instruction tries to enter the queue on each subsequent scan of the instruction, as shown below:



Description:	
1	The controller scans the MSG instruction. The rung-condition-in for the MSG instruction is true. The EN bit is set. The MSG instruction attempts to enter the queue but the queue is full (16 MSG instructions are already enabled). The EW bit remains cleared.
2 & 3	The controller scans the MSG instruction. The rung-condition-in for the MSG instruction is false. The EN bit remains set. The MSG instruction attempts to enter the queue but the queue is full. The EW bit remains cleared.
4	The controller scans the MSG instruction. The MSG instruction attempts to enter the queue. The queue has room so the instruction enters the queue. The EW bit is set.

Cache List

Depending on how you configure a MSG instruction, it may use a connection to send or receive data.

This type of message:	And this communication method:	Uses a connection:
CIP data table read or write	⟶	✓
PLC2, PLC3, PLC5, or SLC (all types)	CIP	
	CIP with Source ID	
	DH+	✓
CIP generic	⟶	your option [1]
block-transfer read or write	⟶	✓

(1) You can connect CIP generic messages. But for most applications we recommend you leave CIP generic messages unconnected.

If a MSG instruction uses a connection, you have the option to leave the connection open (cache) or close the connection when the message is done transmitting.

If you:	Then:
Cache the connection	The connection stays open after the MSG instruction is done. This optimizes execution time. Opening a connection each time the message executes increases execution time.
Do not cache the connection	The connection closes after the MSG instruction is done. This frees up that connection for other uses.

The controller has the following limits on the number of connections that you can cache:

If you have this software and firmware revision:	Then you can cache:
11.x or earlier	• block transfer messages for up to 16 connections • other types of messages for up to 16 connections
12.x or later	up to 32 connections

If several messages go to the same device, the messages may be able to share a connection.

If the MSG instructions are to:	And they are:	Then:
different devices	⟶	Each MSG instruction uses 1 connection.
same device	enabled at the same time	Each MSG instruction uses 1 connection.
	NOT enabled at the same time	The MSG instructions share the connection. (I.e., Together they count as 1 connection.)

EXAMPLE

Share a Connection

If the controller alternates between sending a block-transfer read message and a block-transfer write message to the same module, then together both messages count as 1 connection. Caching both messages counts as 1 on the cache list.

Unconnected Buffers

To establish a connection or process unconnected messages, the controller uses an unconnected buffer.

Term:	Definition
unconnected buffer	An allocation of memory that the controller uses to process unconnected communication. The controller performs unconnected communication when it: • establishes a connection with a device, including an I/O module • executes a MSG instruction that does not use a connection The controller can have 10 - 40 unconnected buffers. • The default number is 10. • To increase the number of unconnected buffers, execute a MSG instruction that reconfigures the number of unconnected buffers. Refer to Get or Set the Number of Unconnected Buffers on page 10-25. • Each unconnected buffers uses 1.1K bytes of memory. • If all the unconnected buffers are in use when an instruction leaves the message queue, the instruction errors and data does not transfer.

If a MSG instruction uses a connection, the instruction uses an unconnected buffer when it first executes to establish a connection. If you configure the instruction to cache the connection, it no longer requires an unconnected buffer once the connection is established.

Guidelines

As you plan and program your MSG instructions, follow these guidelines:

Guideline:	Details:
1. For each MSG instruction, create a control tag.	Each MSG instruction requires its own control tag. • Data type = MESSAGE • Scope = controller • The tag *cannot* be part of an array or a user-defined data type.
2. Keep the source and/or destination data at the controller scope.	A MSG instruction can access only tags that are in the Controller Tags folder (controller scope).
3. If your MSG is to a device that uses 16-bit integers, use a buffer of INTs in the MSG and DINTs throughout the project.	If your message is to a device that uses 16-bit integers, such as a PLC-5® or SLC 500™ controller, and it transfers integers (not REALs), use a buffer of INTs in the message and DINTs throughout the project. This increases the efficiency of your project because Logix5000 controllers execute more efficiently and use less memory when working with 32-bit integers (DINTs). Refer to Convert Between INTs and DINTs on page 10-28.
4. Cache the connected MSGs that execute most frequently.	Cache the connection for those MSG instructions that execute most frequently, up to the maximum number permissible for your controller revision. This optimizes execution time because the controller does not have to open a connection each time the message executes.
5. If you want to enable more than 16 MSGs at one time, use some type of management strategy.	If you enable more than 16 MSGs at one time, some MSG instructions may experience delays in entering the queue. To guarantee the execution of each message, use one of these options: • Enable each message in sequence. • Enable the messages in groups. • Program a message to communicate with multiple devices. For more information, see Appendix B. • Program logic to coordinate the execution of messages. For more information, see Appendix A.
6. Keep the number of unconnected and uncached MSGs less than the number of unconnected buffers.	The controller can have 10 - 40 unconnected buffers. The default number is 10. • If all the unconnected buffers are in use when an instruction leaves the message queue, the instruction errors and does not transfer the data. • You can increase the number of unconnected buffers (40 max.), but continue to follow guideline 5. • To increase the number of unconnected buffers, see page 10-25.

Get or Set the Number of Unconnected Buffers

To determine or change the number of unconnected buffers, use a MSG instruction.

- The range is 10 - 40 unconnected buffers.
- The default number is 10.
- Each unconnected buffers uses 1.1K bytes of memory.

Get the Number of Unconnected Buffers

To determine the number of unconnected buffers that the controller currently has available, configure a Message (MSG) instruction as follows:

On this tab:	For this item:	Type or select:	
Configuration	Message Type	*CIP Generic*	
	Service Type	*Custom*	
	Service Code	3	
	Class	304	
	Instance	1	
	Attribute	0	
	Source Element	*source_array* where data type = SINT[4]	
		In this element:	**Enter:**
		source_array[0]	1
		source_array[1]	0
		source_array[2]	17
		source_array[3]	0
	Source Length (bytes)	4 (Write 4 SINTs.)	
	Destination	*destination_array* where data type = SINT[10] (Leave all the values = 0.)	
		destination_array[6] = current number of unconnected buffers	
Communication	Path	1, *slot_number_of_controller*	

Set the Number of Unconnected Buffers

As a starting value, set the number of unconnected buffers equal to the number of unconnected and uncached messages enabled at one time plus approximately 5. The additional 5 buffers provides a cushion in case you underestimate the number of messages that are enabled at one time.

To change the number of unconnected buffers of the controller, configure a Message (MSG) instruction as follows:

<table>
<tr><th>On this tab:</th><th>For this item:</th><th>Type or select:</th></tr>
<tr><td rowspan="10">Configuration</td><td>Message Type</td><td>CIP Generic</td></tr>
<tr><td>Service Type</td><td>Custom</td></tr>
<tr><td>Service Code</td><td>4</td></tr>
<tr><td>Class</td><td>304</td></tr>
<tr><td>Instance</td><td>1</td></tr>
<tr><td>Attribute</td><td>0</td></tr>
<tr><td>Source Element</td><td><code>source_array</code> where data type = SINT[8]
<table>
<tr><th>In this element:</th><th>Enter:</th></tr>
<tr><td>source_array[0]</td><td>1</td></tr>
<tr><td>source_array[1]</td><td>0</td></tr>
<tr><td>source_array[2]</td><td>17</td></tr>
<tr><td>source_array[3]</td><td>0</td></tr>
<tr><td>source_array[4]</td><td>Number of unconnected buffers that you want.</td></tr>
<tr><td>source_array[5]</td><td>0</td></tr>
<tr><td>source_array[6]</td><td>0</td></tr>
<tr><td>source_array[7]</td><td>0</td></tr>
</table></td></tr>
<tr><td>Source Length (bytes)</td><td>8 (Write 8 SINTs.)</td></tr>
<tr><td>Destination</td><td><code>destination_array</code> where data type = SINT[6] (Leave all the values = 0.)</td></tr>
<tr><td>Communication</td><td>Path</td><td>1, <code>slot_number_of_controller</code></td></tr>
</table>

EXAMPLE Set the Number of Unconnected Buffers

If *S:FS* = 1 (first scan), then set the number of unconnected buffers for the controller:

Source_Array[0] = 1

Source_Array[1] = 0

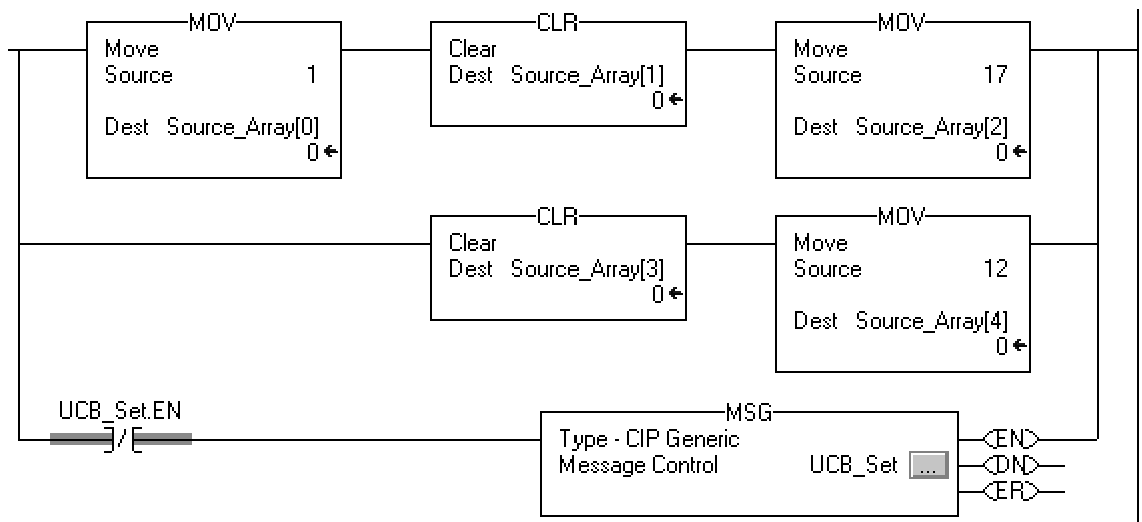
Source_Array[2] = 17

Source_Array[3] = 0

Source_Array[4] = *12* (The number of unconnected buffers that you want. In this example, we want 12 buffers.)

If *UCB_Set.EN* = 0 (MSG instruction is not already enabled) then:

MSG instruction sets the number of unconnected buffers = *Source_Array[4]*



where:

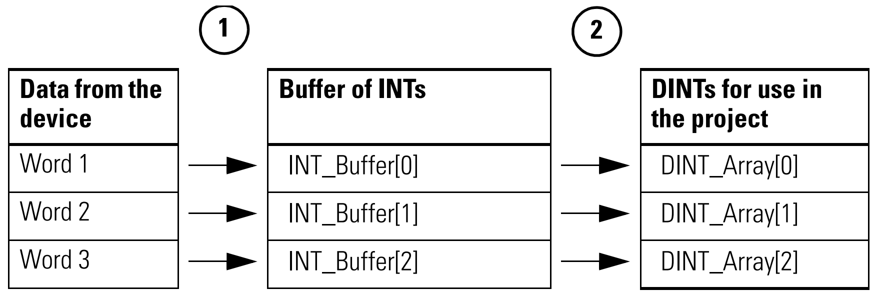
Tag Name	Type	Description
UCB_Set	MESSAGE	Control tag for the MSG instruction.
Source_Array	SINT[8]	Source values for the MSG instruction, including the number of unconnected buffers that you want.

Convert Between INTs and DINTs

In the Logix5000 controller, use the **DINT** data type for integers whenever possible. Logix5000 controllers execute more efficiently and use less memory when working with 32-bit integers (DINTs).

If your message is to a device that uses 16-bit integers, such as a PLC-5® or SLC 500™ controller, and it transfers integers (not REALs), use a buffer of INTs in the message and DINTs throughout the project. This increases the efficiency of your project.

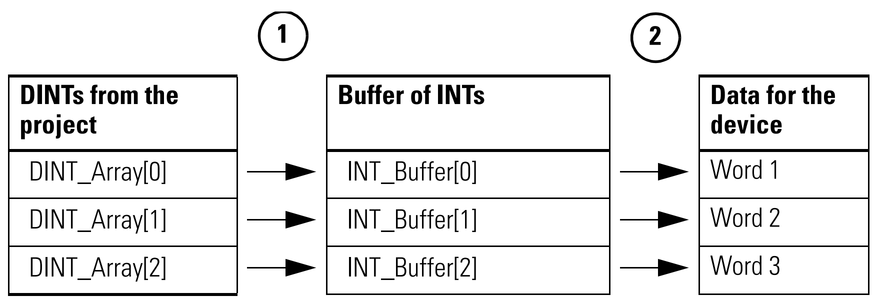
Read 16-Bit Integers



1. The Message (MSG) instruction reads 16-bit integers (INTs) from the device and stores them in a temporary array of INTs.

2. An File Arith/Logical (FAL) instruction converts the INTs to DINTs for use by other instructions in your project.

Write 16-Bit Integers



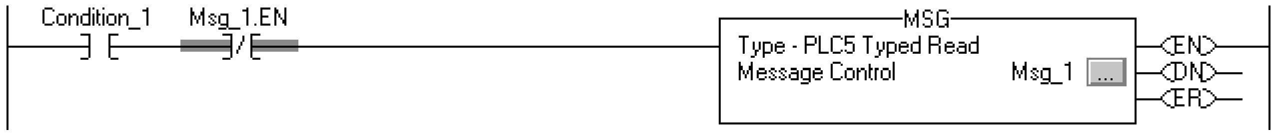
1. An FAL instruction converts the DINTs from the Logix5000 controller to INTs.

2. The MSG instruction writes the INTs from the temporary array to the device.

EXAMPLE Read integer values from a PLC-5 controller

If Condition_1 = 1 And Msg_1.EN = 0 (MSG instruction is not already enabled) then:

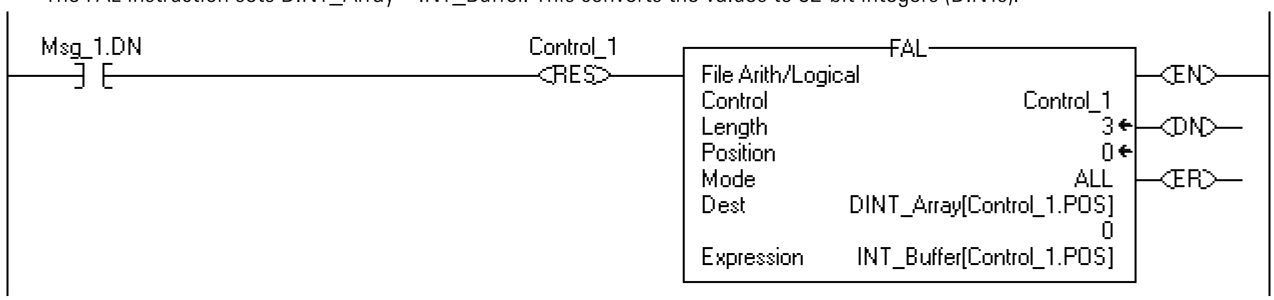
Read 3 integers from the PLC-5 controller and store them in INT_Buffer (3 INTs)



If Msg_1.DN =1 (MSG instruction has read the data.) then

Reset the FAL instruction.

The FAL instruction sets DINT_Array = INT_Buffer. This converts the values to 32-bit integers (DINTs).

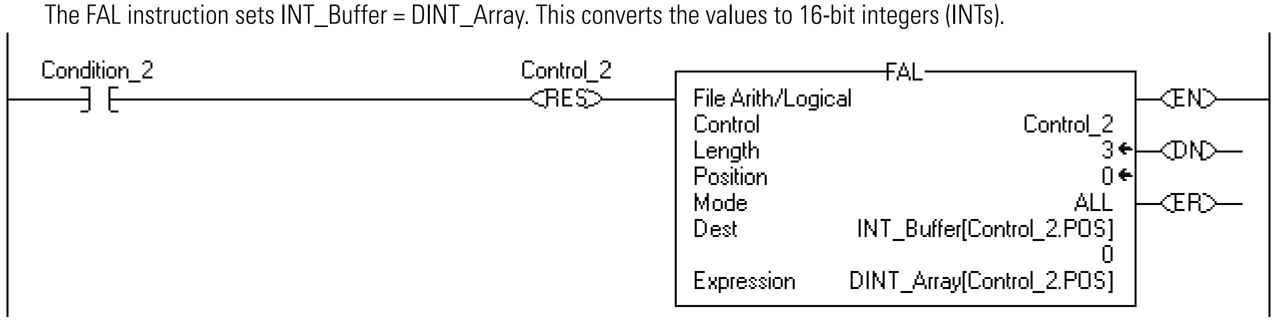


EXAMPLE Write integer values to a PLC-5 controller

If Condition_2 = 1 then:

Reset the FAL instruction.

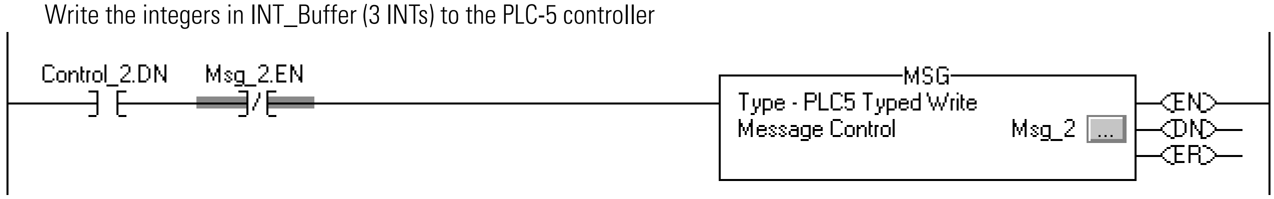
The FAL instruction sets INT_Buffer = DINT_Array. This converts the values to 16-bit integers (INTs).



If Control_2.DN = 1 (FAL instruction has converted the DINTs to INTs)

And Msg_2.EN = 0 (MSG instruction is not already enabled) then:

Write the integers in INT_Buffer (3 INTs) to the PLC-5 controller



Notes:

Produce a Large Array

When to Use this Procedure

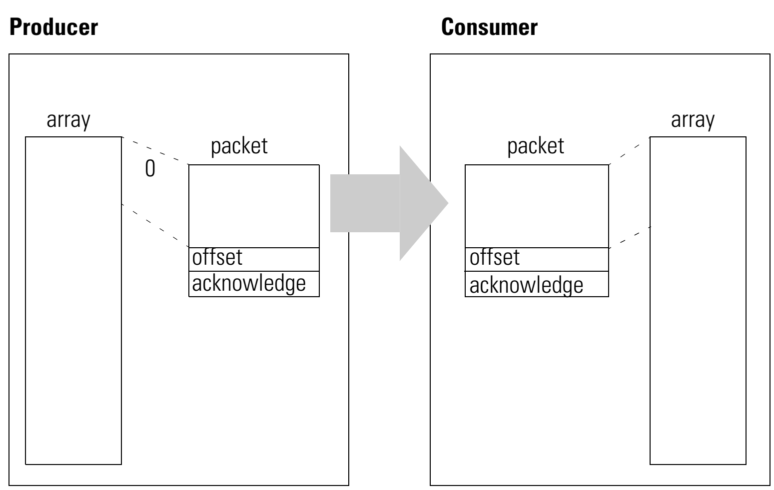
The Logix5000 controller can send as many as 500 bytes of data over a single scheduled connection. This corresponds to 125 DINT or REAL elements of an array. To transfer an array of more than 125 DINTs or REALs, use a produced/consumed tag of 125 elements to create a packet of data. You can then use the packet to send the array piecemeal to another controller.

When you send a large array of data in smaller packets, you must ensure that the transmission of a packet is complete before the data is moved into the destination array, for these reasons.

- Produced data over the ControlLogix backplane is sent in 50 byte segments.
- Data transmission occurs asynchronous to program scan.

The logic that this section includes uses an acknowledge word to make sure that each packet contains new data before the data moves to the destination array. The logic also uses an offset value to indicate the starting element of the packet within the array.

Because of the offset and acknowledge elements, each packet carries 123 elements of data from the array, as depicted below:



In addition, the array must contain an extra 122 elements. In other words, it must be 122 elements greater than the greatest number of elements that you want to transfer:

- These elements serve as a buffer.
- Since each packet contains the same number of elements, the buffer prevents the controller from copying beyond the boundaries of the array.
- Without the buffer, this would occur if the last packet contained fewer than 123 elements of actual data.

Produce a Large Array

1. Open the RSLogix 5000 project that will produce the array.
2. In the Controller Tags folder, create the following tags:

P	Tag Name	Type
	*array*_ack	DINT[2]
✓	*array*_packet	DINT[125]

where:

array is the name for the data that you are sending.

3. Convert *array_ack* to a consumed tag:

For:	Specify:
Controller	name of the controller that is receiving the packet
Remote Tag Name	*array_ack* Both controllers use the same name for this shared data.

Refer to "Consume Data That Is Produced by Another Controller" on page 10-15.

4. In either the Controller Tags folder or the tags folder of the program that will contain the logic for the transfer, create the following tags:

Tag Name	Type
array	DINT[x] where x equals the number of elements to transfer plus 122 elements
*array*_offset	DINT
*array*_size	DINT
*array*_transfer_time	DINT
*array*_transfer_time_max	DINT
*array*_transfer_timer	TIMER

where:

array is the name for the data that you are sending.

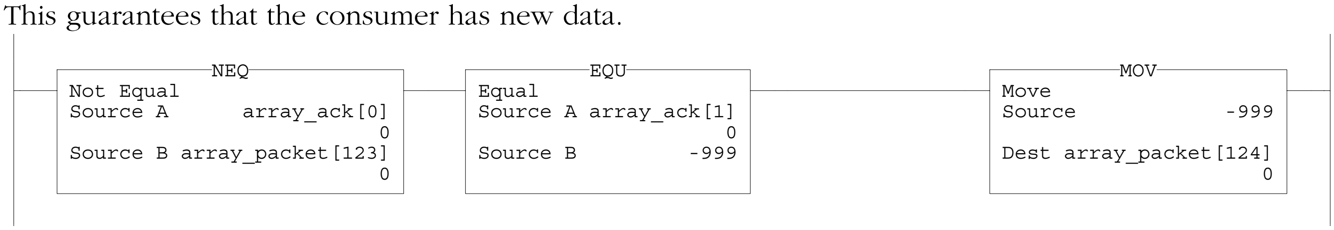
5. In the *array_size* tag, enter the number of elements of real data. (The value of *x* from step *4.* minus the 122 elements of buffer.)

6. Create or open a routine for the logic that will create packets of data.

7. Enter the following logic:

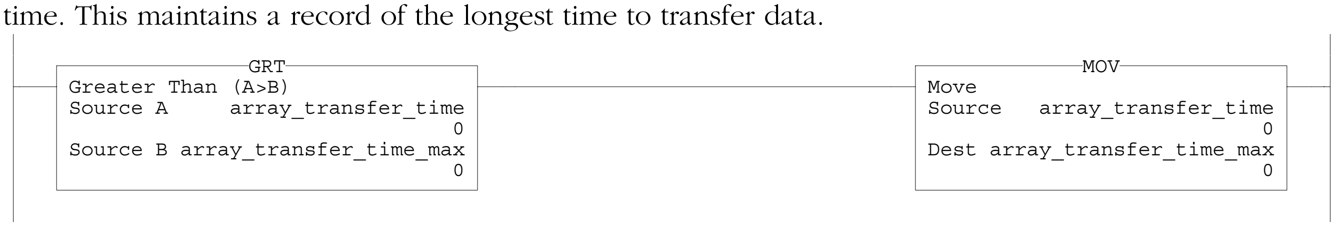
Times how long it takes to send the entire array

When the offset value in *array_ack[0]* is not equal to the current offset value but *array_ack[1]* equals -999, the consumer has begun to receive a new packet, so the rung moves -999 into the last element of the packet. The consumer waits until it receives the value -999 before it copies the packet to the array. This guarantees that the consumer has new data.



When the offset value in *array_ack[0]* is equal to the current offset value, the consumer has copied the packet to the array; so the rung checks for more data to transfer. If the offset value plus 123 is less than the size of the array, there is more data to transfer; so the rung increases the offset by 123. Otherwise, there is no more data to transfer; so the rung resets the offset value, logs the transfer time, and resets the timer. In either case, the rung uses the new offset value to create a new packet of data, appends the new offset value to the packet, and clears the acknowledge element of the packet (*packet[124]*).

If the current transfer time is greater than the maximum transfer time, updates the maximum transfer time. This maintains a record of the longest time to transfer data.



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8. Open the RSLogix 5000 project that will consume the array.

9. In the Controller Tags folder, create the following tags:

P	Tag Name	Type
✓	*array*_ack	DINT[2]
	*array*_packet	DINT[125]

where:

array is the name for the data that you are sending. Use the same name as in the producing controller (step 2.).

10. Convert *array_packet* to a consumed tag:

For:	Specify:
Controller	name of the controller that is sending the packet
Remote Tag Name	*array_packet* Both controllers use the same name for this shared data.

Refer to "Consume Data That Is Produced by Another Controller" on page 10-15.

11. In either the Controller Tags folder or the tags folder of the program that will contain the logic for the transfer, create the following tags:

Tag Name	Type
array	DINT[x] where x equals the number of elements to transfer plus 122 elements
*array*_offset	DINT

where:

array is the name for the data that you are sending.

12. Create or open a routine for the logic that will move the data from the packets to the destination array.

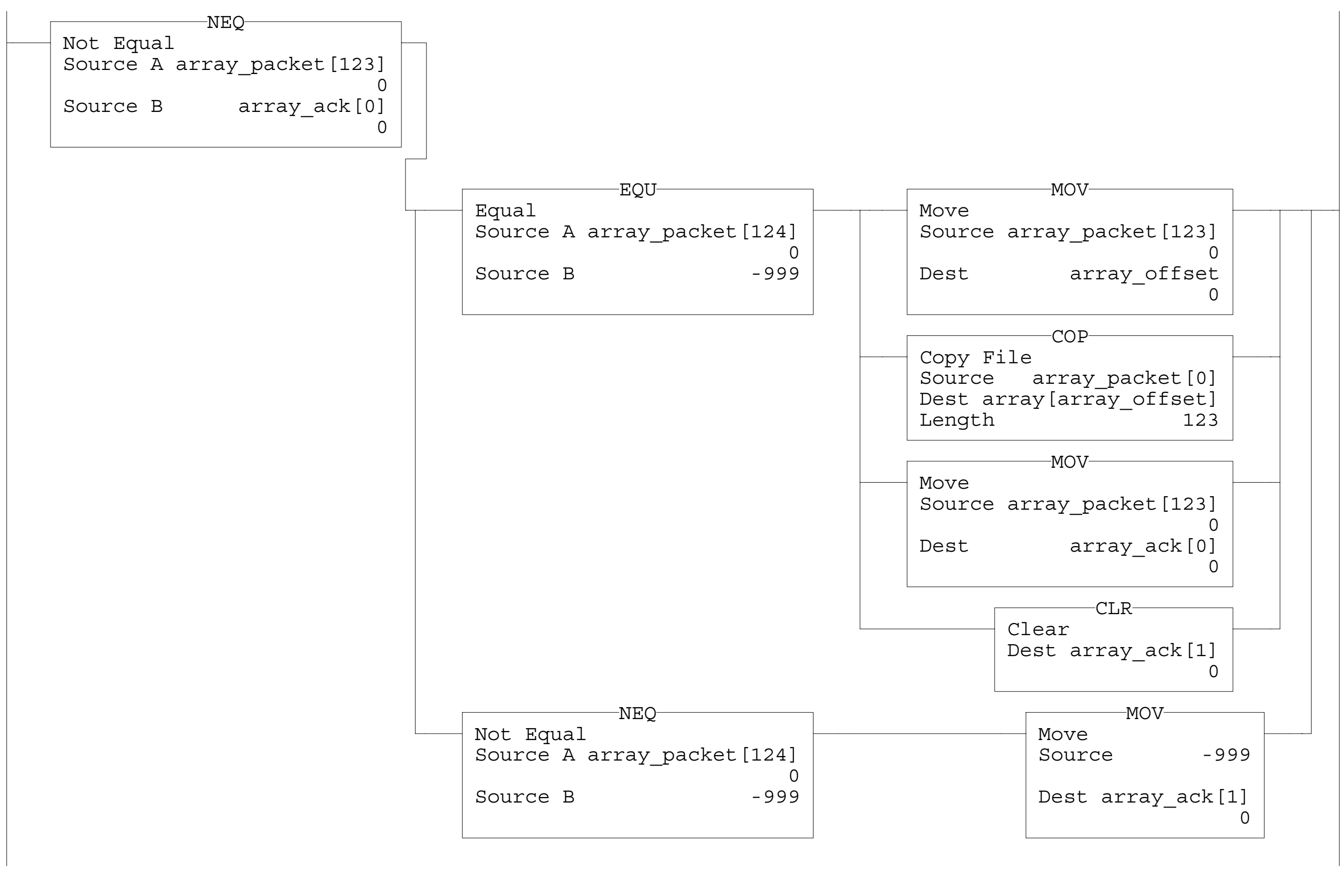
13. Enter the following logic:

When the offset value in *array_packet[123*] is different than the offset value in *array_ack[0]*, the controller has begun to receive a new packet of data; so the rung checks for the value of -999 in the last element of the packet.

If the last element of the packet equals -999, the controller has received an entire packet of new data and begins the copy operation:

- The offset value moves from the packet to array_offset.
- The COP instructions copies the data from the packet to the destination array, starting at the offset value.
- The offset value moves to *array_ack[0]*, which signals that the copy is complete.
- *Array_ack[1]* resets to zero and waits to signal the arrival of a new packet.

If the last element of the packet is not equal -999, the transfer of the packet to the controller may not be complete; so -999 moves to *array_ack[1]*. This signals the producer to return the value of -999 in the last element of the packet to verify the transmission of the packet.



42356

Transferring a large array as smaller packets improves system performance over other methods of transferring the data:

- Fewer connections are used than if you broke the data into multiple arrays and sent each as a produced tag. For example, an array with 5000 elements would take 40 connections (5000/125=40) using individual arrays.

- Faster transmission times are achieved than if you used a message instruction to send the entire array.

  - Messages are unscheduled and are executed only during the “system overhead” portion of the Logix5550 execution. Therefore, messages can take a fairly long time to complete the data transfer.
  - You can improve the transfer time by increasing system overhead time slice, but this diminishes the performance of the continuous task.

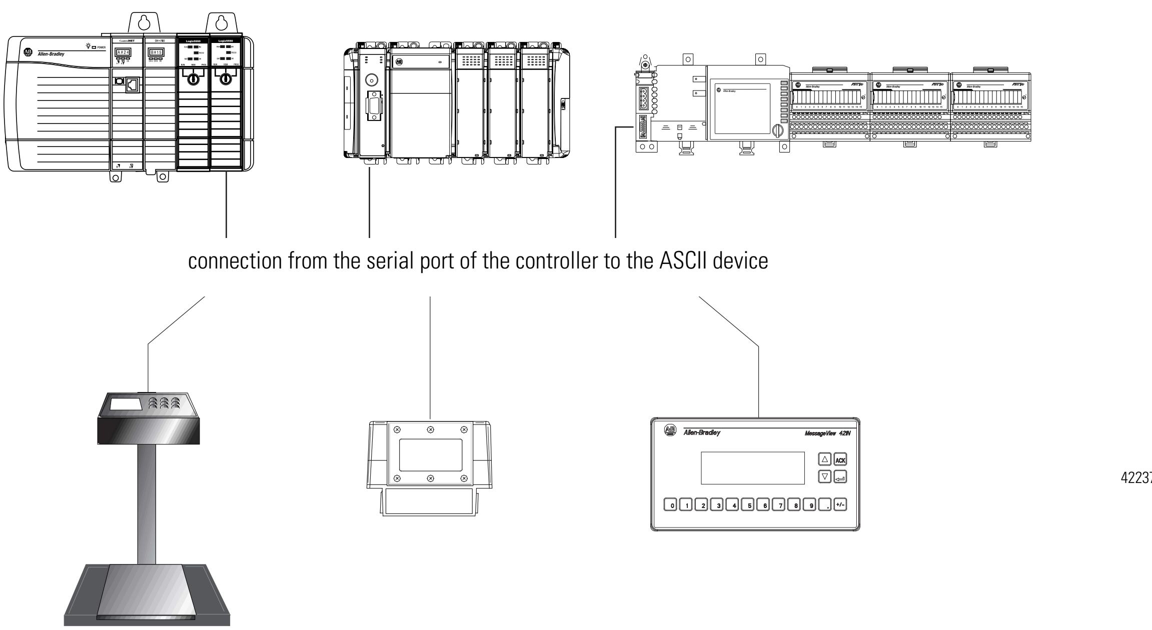
Notes:

Communicate with an ASCII Device

When to Use this Procedure

Use this procedure to exchange ASCII data with a device through the serial port of the controller. For example, you can use the serial port to:

- read ASCII characters from a weigh scale module or bar code reader
- send and receive messages from an ASCII triggered device, such as a MessageView terminal.



How to Use This Procedure

Before you use this procedure:

- Configure the ASCII Device for Your Application

To complete this procedure, do the following tasks:

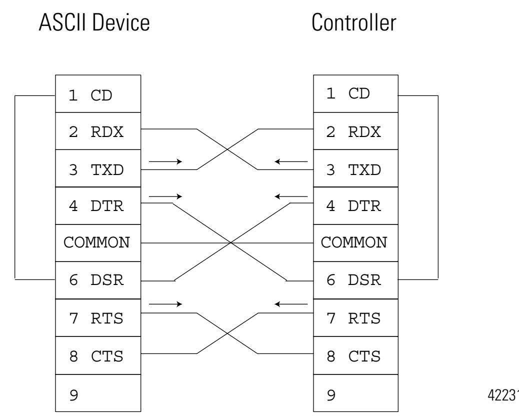
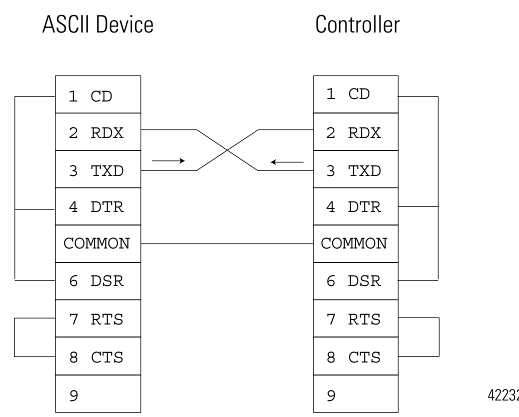
- Connect the ASCII Device
- Configure the Serial Port
- Configure the User Protocol
- Create String Data Types
- Read Characters from the Device

- Send Characters to the Device

Connect the ASCII Device

1. For the serial port of the ASCII device, determine which pins send signals and which pins receive signals.

2. Connect sending pins to corresponding receiving pins and attach jumpers:

If the communications:	Then wire the connectors as follows:
handshake	
do not handshake	

3. Attach the cable shield to both connectors.

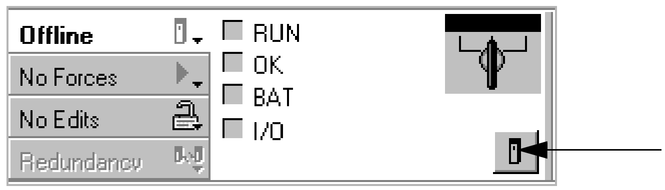
4. Connect the cable to the controller and the ASCII device.

Configure the Serial Port

1. Determine the following communication settings for the ASCII device:

   a. baud rate
   b. data bits
   c. parity
   d. stop bits

2. Open the RSLogix 5000™ project.



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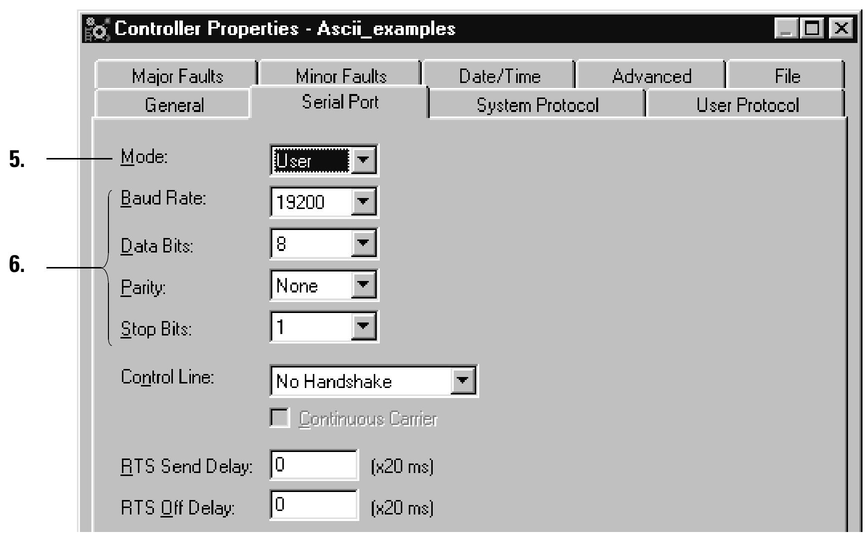
3. On the Online toolbar, click the controller button.

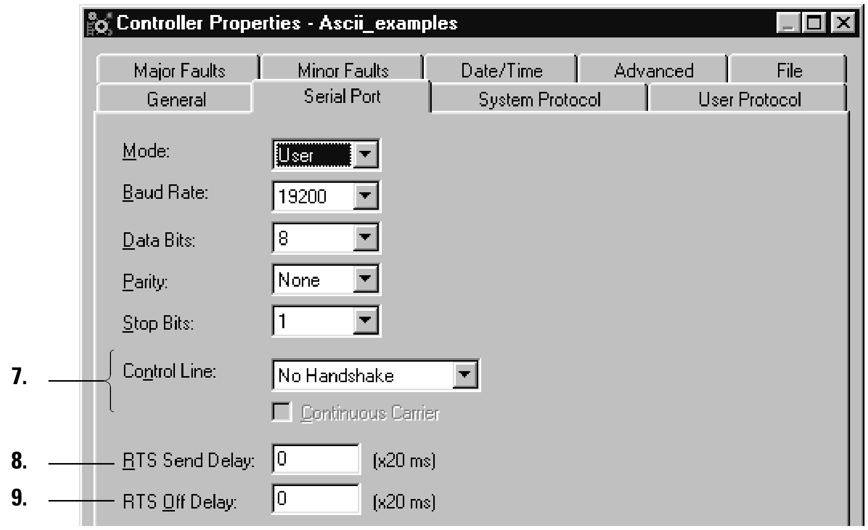
4. Click the *Serial Port* tab.



42251

5. Select *User*.

6. Select the settings for the ASCII device, from step 1.



42251

7. Select the Control Line option:

If:	**And:**	**And this is the:**	**Select:**	**Then:**
you are *not* using a modem	→	→	*No Handshaking*	Go to step 10.
you are using a modem	both modems in a point-to-point link are full-duplex	→	*Full Duplex*	
	master modem is full-duplex while slave modem is half-duplex	master controller.	*Full Duplex*	
		slave controller	*Half Duplex*	Select the *Continuous Carrier* check box.
	all modems in the system are half-duplex	→	*Half Duplex*	Clear the *Continuous Carrier* check box (default).

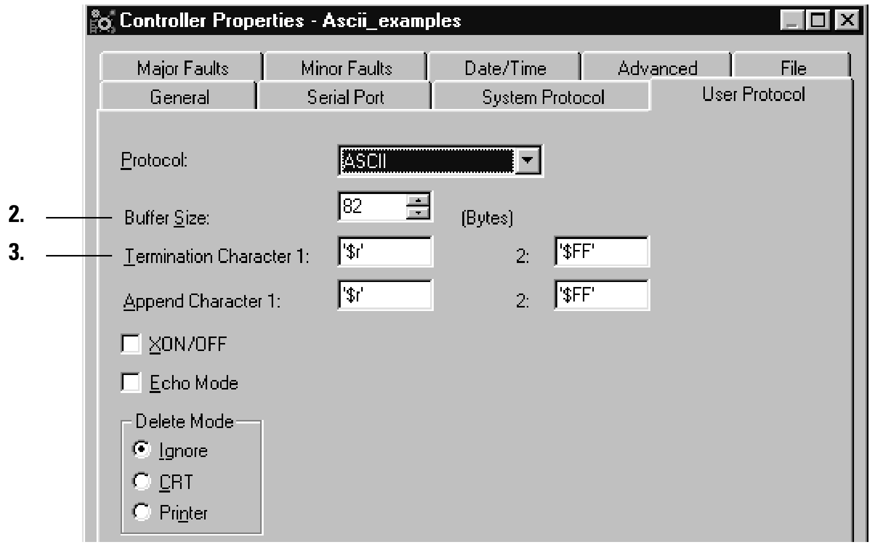
8. Type the amount of delay (20 ms units) between the time that the RTS signal turns on (high) and the time that data is sent. For example, a value of 4 produces an 80 ms delay.

9. Type the amount of delay (20 ms units) between the time that the last character is sent and the time that the RTS signal turns off (low).

10. Click *Apply*.

Configure the User Protocol

1. Click the *User Protocol* tab.



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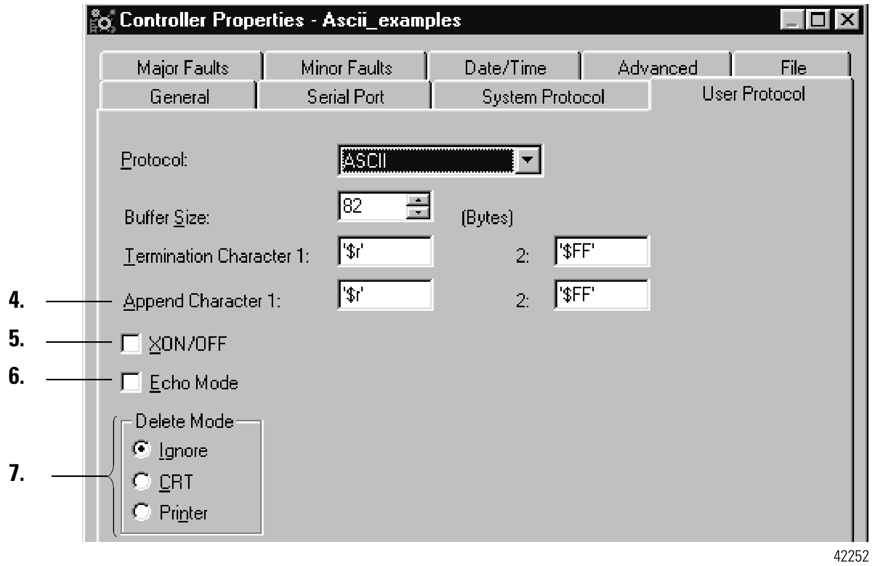
2. Select or type a number that is greater than or equal to the greatest number of characters in a transmission. (Twice the number of characters is a good guideline.)

3. If you are using ABL or ARL instructions, type the characters that mark the end of the data. For the ASCII code of a character, refer to the back cover of this manual.

If the device sends:	Then:	Notes:
one termination character	A. In the Termination Character 1 text box, type the hexadecimal ASCII code for the first character. B. In the Termination Character 2 text box, type $FF.	For printable characters, such as 1 or A, type the character.
two termination characters	In the Termination Character 1 and 2 text boxes, type the hexadecimal ASCII code for each character.	



4. If you are using the AWA instruction, type the character(s) to append to the data. For the ASCII code of a character, refer to the back cover of this manual.

To append:	Then:	Notes:
one character	A. In the Append Character 1 text box, type the hexadecimal ASCII code for the first character. B. In the Append Character 2 text box, type $FF.	For printable characters, such as 1 or A, type the character.
two characters	In the Append Character 1 and 2 text boxes, type the hexadecimal ASCII code for each character.	

5. If the ASCII device is configured for XON/XOFF flow control, select the *XON/XOFF* check box.

6. If the ASCII device is a CRT or is pre-configured for half duplex transmission, select the *Echo Mode* check box.

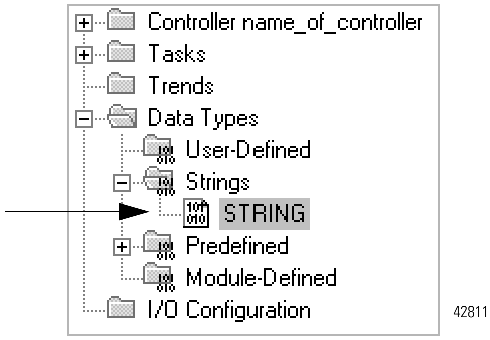
7. Select the Delete Mode:

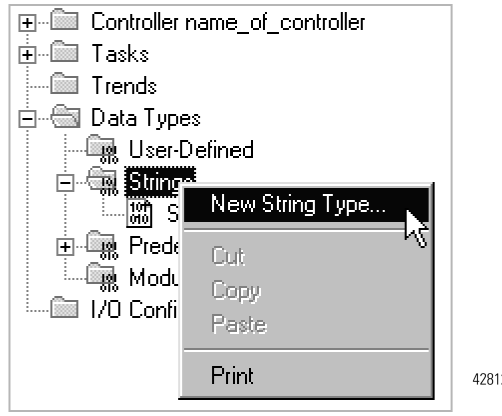
If the ASCII device is:	Select:	Notes:
CRT	*CRT*	• The DEL character ($7F) and the character that precedes the DEL character are *not* sent to the destination. • If echo mode is selected and an ASCII instruction reads the DEL character, the echo returns three characters: BACKSPACE SPACE BACKSPACE ($08 $20 $08).
printer	*Printer*	• The DEL character ($7F) and the character that precedes the DEL character are *not* sent to the destination. • If echo mode is selected and an ASCII instruction reads the DEL character, the echo returns two characters: / ($2F) followed by the character that was deleted.
None of the above	*Ignore*	The DEL character ($7F) is treated as any other character.

8. Click *OK*.

Create String Data Types

You store ASCII characters in tags that use a **string** data type.





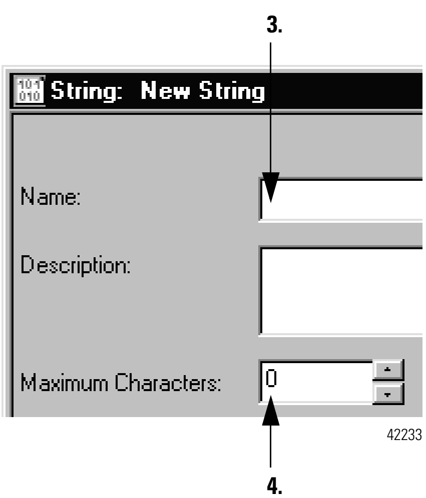
You can use the default STRING data type. It stores up to 82 characters.

or

You can create a new string data type to store the number of characters that you define.

IMPORTANT Use caution when you create a new string data type. If you later decide to change the size of the string data type, you may lose data in any tags that currently use that data type.

If you:	Then:
make a string data type smaller	• The data is truncated. • The LEN is unchanged.
make a string data type larger	The data and LEN is reset to zero.



1. Do you want to create a new string data type?

If:	Then:
no	Go to Read Characters from the Device on page 12-9.
yes	Go to step 2.

2. In the controller organizer, right-click *Strings* and choose *New String Type…*

3. Type a name for the data type.

4. Type the maximum number characters that this string data type will store.

5. Choose *OK*.

Read Characters from the Device

As a general rule, before you read the buffer use an ACB or ABL instruction to verify that the buffer contains the required characters:

- An ARD or ARL instruction continues to read the buffer until the instruction reads the required characters.
- While an ARD or ARL instruction is reading the buffer, no other ASCII Serial Port instructions, except the ACL, can execute.
- Verifying that the buffer contains the required characters prevents the ARD or ARL from holding up the execution of other ASCII Serial Port instructions while the input device sends its data.

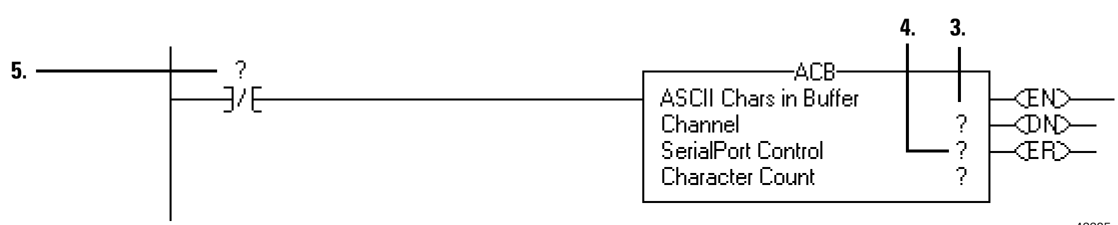
For additional information on ASCII Serial Port instructions, refer to *Logix5000 Controllers General Instruction Set Reference Manual*, publication 1756-RM003.

IMPORTANT If you are not familiar with how to enter ladder logic in an RSLogix 5000 project, first review “Program Ladder Logic” on page 8-1.

1. Which type of device are you reading?

If the device is a:	Then:
bar code reader	Go to step 2.
weigh scale that send a fixed number of characters	
message or display terminal	Go to step 14.
weigh scale that send a varying number of characters	

2. Enter the following rung:



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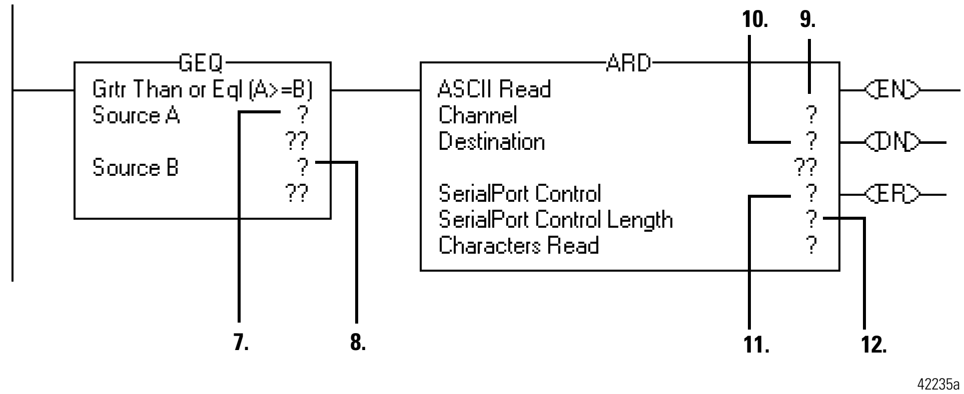
3. Enter 0. (The serial port is channel 0.)

4. Enter a tag name for the ACB instruction and define the data type as SERIAL_PORT_CONTROL.

5. Enter the EN bit of the ACB tag. (The tag from step 4.)

6. Enter the following rung:



7. Enter the POS member of the ACB tag. (The tag from step 4.)

8. Enter the number of characters in the data.

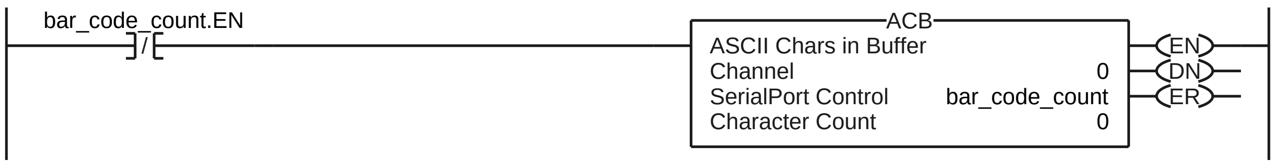
9. Enter 0.

10. Enter a tag name to store the ASCII characters. Define the data type as a **string**.

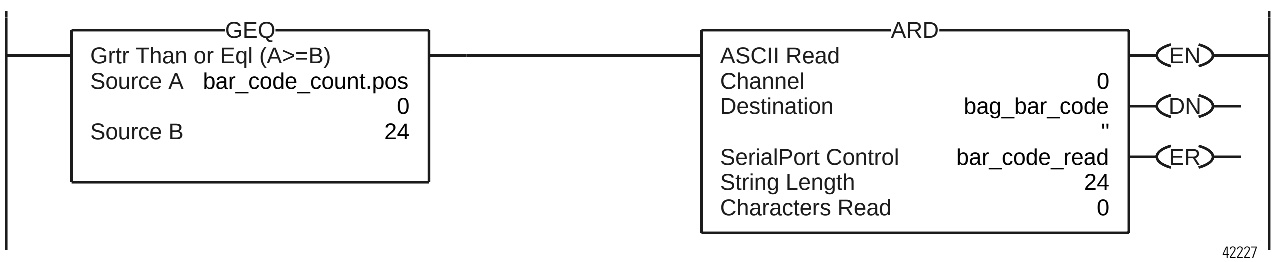
11. Enter a tag name for the ARD instruction and define the data type as SERIAL_PORT_CONTROL.

12. Enter the number of characters in the data.

EXAMPLE A bar code reader sends bar codes to the serial port (channel 0) of the controller. Each bar code contains 24 characters. To determine when the controller receives a bar code, the ACB instruction continuously counts the characters in the buffer.



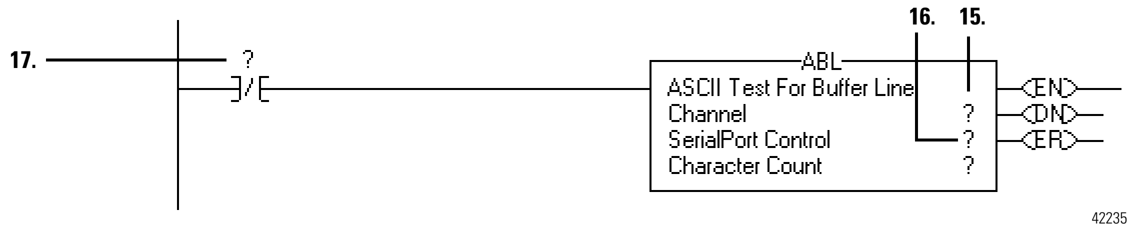
When the buffer contains at least 24 characters, the controller has received a bar code. The ARD instruction moves the bar code to the *bag_bar_code* tag.



13. Do you want to send data to the device?

If:	Then:
yes	Go to Send Characters to the Device on page 12-14.
no	Stop. You are done with this procedure. To use the data, go to “Process ASCII Characters” on page 13-1.

14. Enter the following rung:

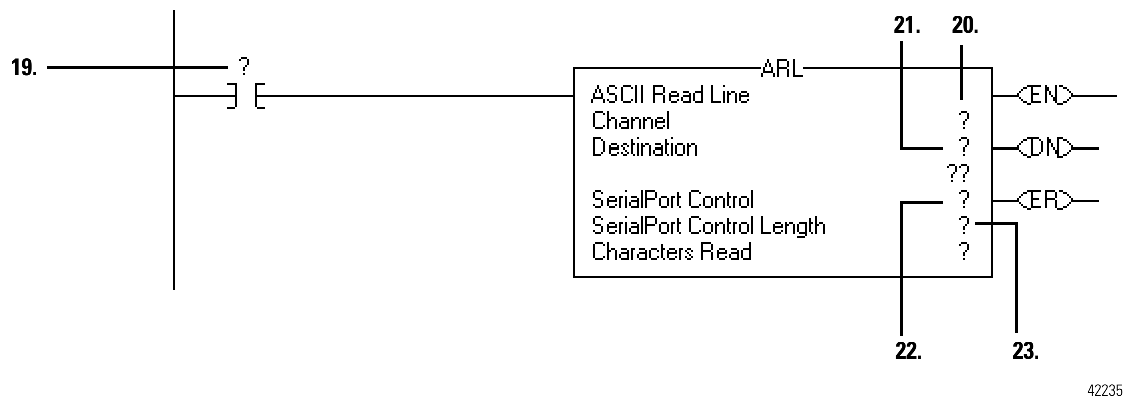


15. Enter 0.

16. Enter a tag name for the ABL instruction and define the data type as SERIAL_PORT_CONTROL.

17. Enter the EN bit of the ABL tag. (The tag from step 16.)

18. Enter the following rung:



19. Enter the FD bit of the ABL tag. (The tag from step 16.)

20. Enter 0.

21. Enter a tag name to store the ASCII characters. Define the data type as a **string**.

22. Enter a tag name for the ARL instruction and define the data type as SERIAL_PORT_CONTROL.

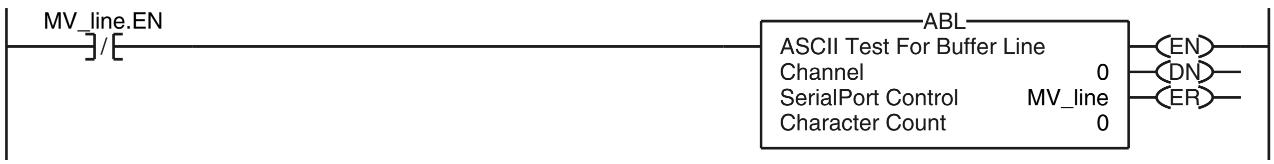
23. Enter 0.

This lets the instruction set the SerialPort Control Length equal to the size of the Destination.

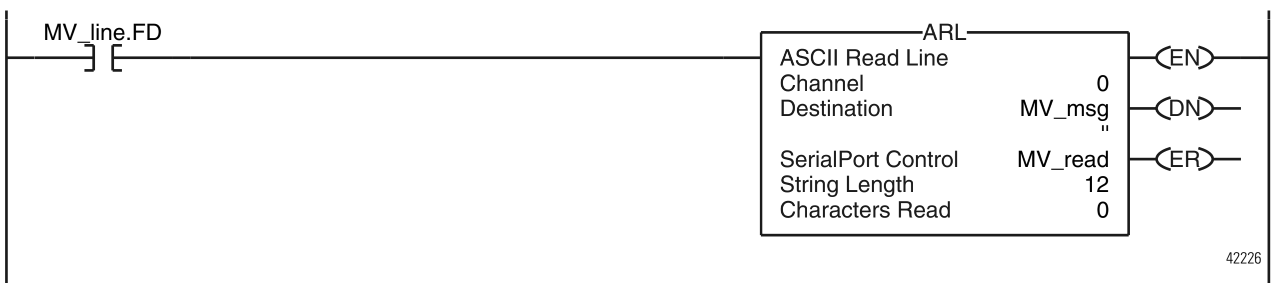
EXAMPLE

Continuously tests the buffer for a message from the MessageView terminal.

- Since each message ends in a carriage return ($0D), the carriage return is configured as the termination character in the Controller Properties dialog box, User Protocol tab.
- When the ABL finds a carriage return, its sets the FD bit.



When the ABL instruction finds the carriage return (MV_line.FD is set), the controller removes the characters from the buffer, up to and including the carriage return, and places them in the *MV_msg* tag.



24. Do you want to send data to the device?

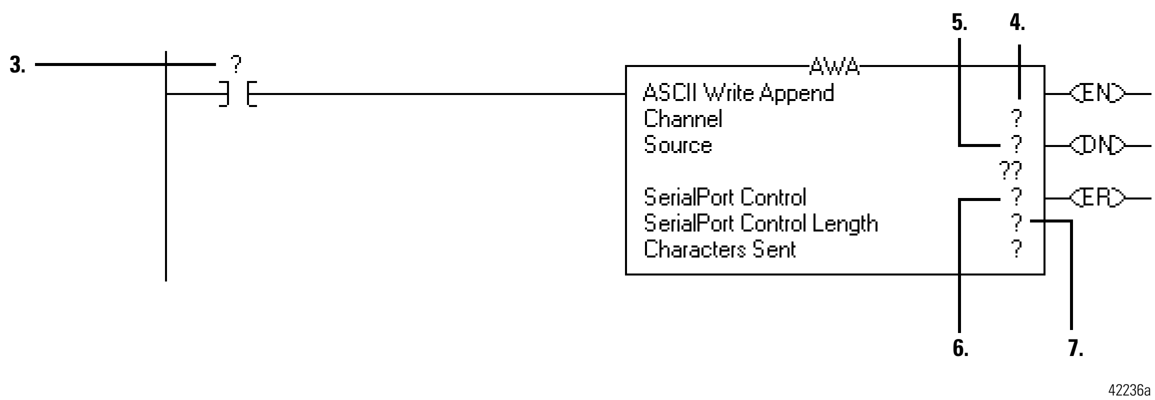
If:	Then:
yes	Go to Send Characters to the Device on page 12-14.
no	Stop. You are done with this procedure. To use the data, go to "Process ASCII Characters" on page 13-1.

Send Characters to the Device

1. Determine where to start:

If you:	And you:	Then:
always send the same number of characters	want to automatically append one or two characters to the end of the data	Go to step 2.
	do not want to append characters	Go to step 9.
send different numbers of characters	want to automatically append one or two characters to the end of the data	Go to step 16.
	do not want to append characters	Go to step 24.

2. Enter the following rung:



3. Enter the input condition (s) that determines when the characters are to be sent:
   - You can use any type of input instruction.
   - The instruction must change from false to true each time the characters are to be sent.

4. Enter 0.

5. Enter the tag name that stores the ASCII characters. Define the data type as a **string**.

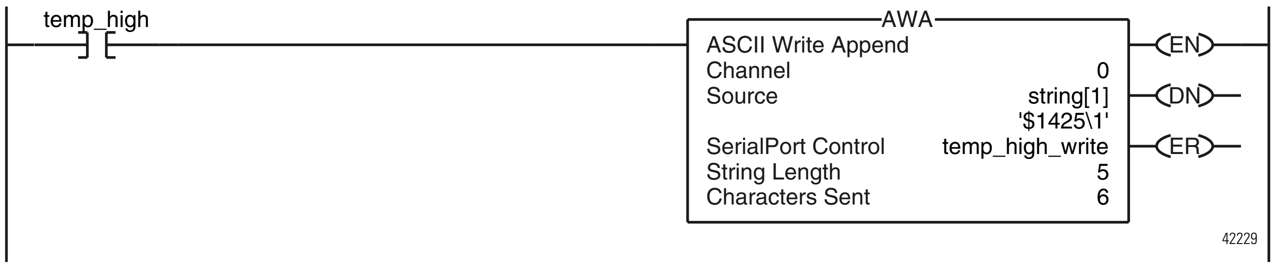
6. Enter a tag name for the AWA instruction and define the data type as SERIAL_PORT_CONTROL.

7. Enter the number of characters to send. Omit the characters that are appended by the instruction.

EXAMPLE

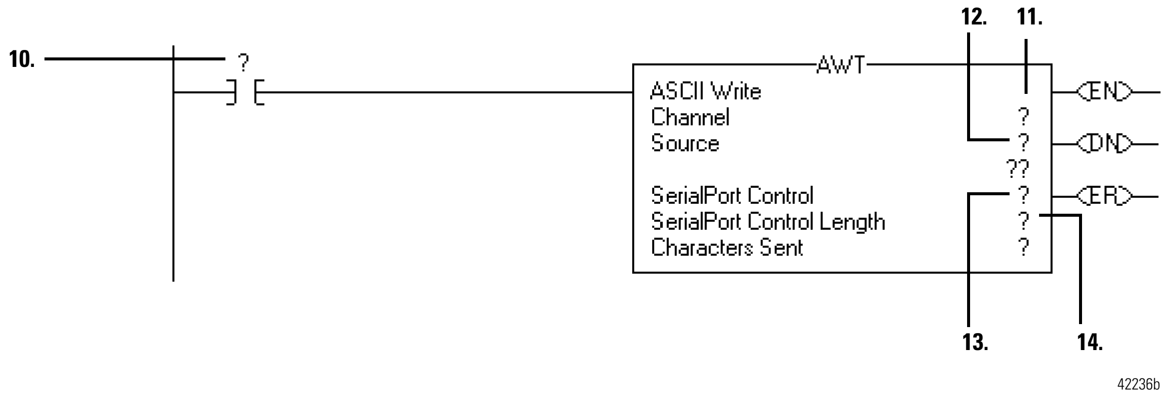
When the temperature exceeds the high limit (*temp_high* is on), the AWA instruction sends five characters from the *string[1]* tag to a MessageView terminal.

- The *$14* counts as one character. It is the hex code for the Ctrl-T character.
- The instruction also sends (appends) the characters defined in the user protocol. In this example, the AWA instruction sends a carriage return ($0D), which marks the end of the message.



8. Go to Enter ASCII Characters on page 12-21.

9. Enter the following rung:



10. Enter the input condition (s) that determines when the characters are to be sent:
    - You can use any type of input instruction.
    - The instruction must change from false to true each time the characters are to be sent.

11. Enter 0.

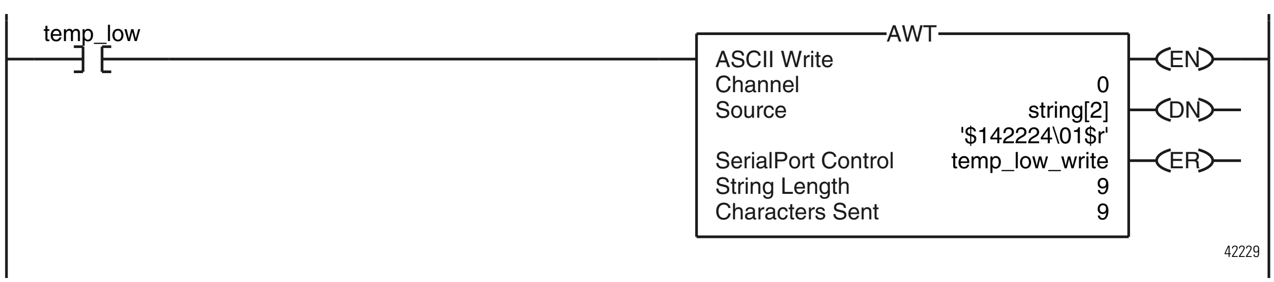
12. Enter the tag name that stores the ASCII characters. Define the data type as a **string**.

13. Enter a tag name for the AWT instruction and define the data type as SERIAL_PORT_CONTROL.

14. Enter the number of characters to send.

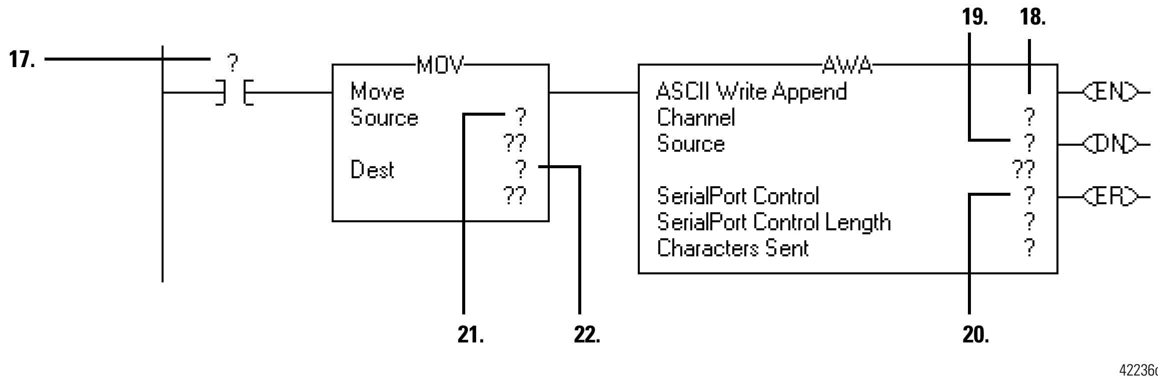
EXAMPLE

When the temperature reaches the low limit (*temp_low* is on), the AWT instruction sends nine characters from the *string[2]* tag to a MessageView terminal. (The *$14* counts as one character. It is the hex code for the Ctrl-T character.)



15. Go to Enter ASCII Characters on page 12-21.

16. Enter the following rung:



17. Enter the input condition (s) that determines when the characters are to be sent:

- You can use any type of input instruction.
- The instruction must change from false to true each time the characters are to be sent.

18. Enter 0.

19. Enter the tag name that stores the ASCII characters. Define the data type as a **string**.

20. Enter a tag name for the AWA instruction and define the data type as SERIAL_PORT_CONTROL.

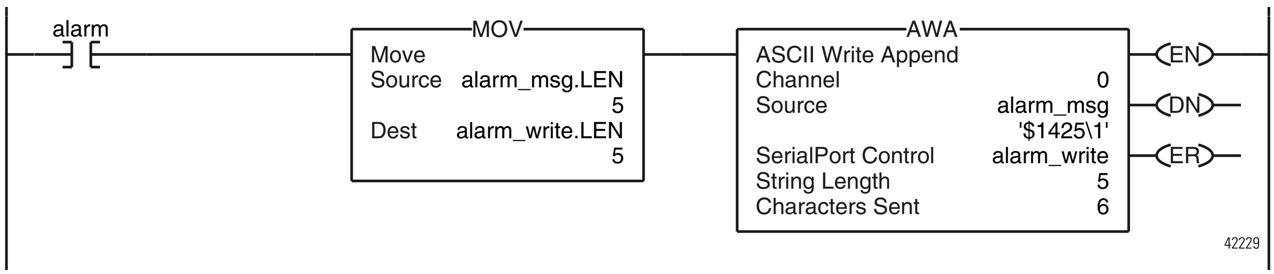
21. Enter the LEN member of the Source tag. (The tag from step 19.)

22. Enter the LEN member of the AWA instruction. (The tag from step 20.)

EXAMPLE

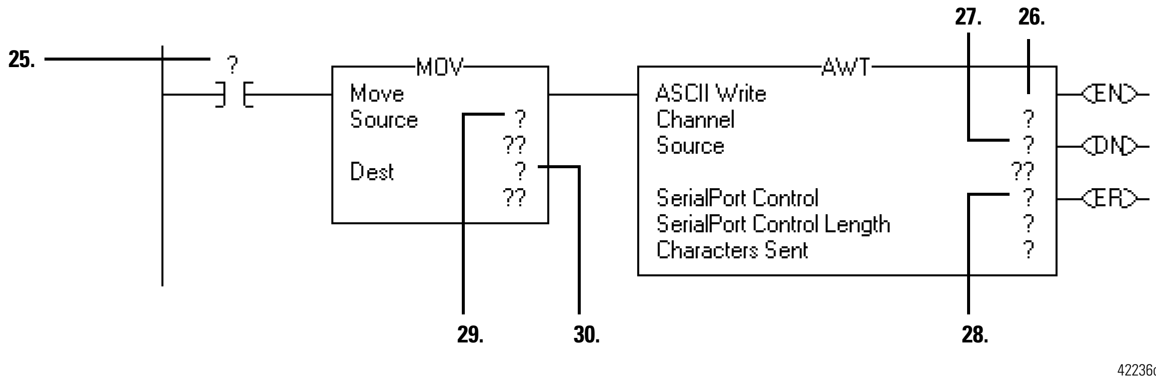
When *alarm* is on, the AWA instruction sends the characters in *alarm_msg* and appends a termination character.

- Because the number of characters in *alarm_msg* varies, the rung first moves the length of *alarm_msg* (*alarm_msg*.LEN) to the length of the AWA instruction (*alarm_write*.LEN).
- In *alarm_msg*, the *$14* counts as one character. It is the hex code for the Ctrl-T character.



23. Go to Enter ASCII Characters on page 12-21.

24. Enter the following rung:



25. Enter the input condition (s) that determines when the characters are to be sent:

- You can use any type of input instruction.
- The instruction must change from false to true each time the characters are to be sent.

26. Enter 0.

27. Enter the tag name that stores the ASCII characters. Define the data type as a **string**.

28. Enter a tag name for the AWT instruction and define the data type as SERIAL_PORT_CONTROL.

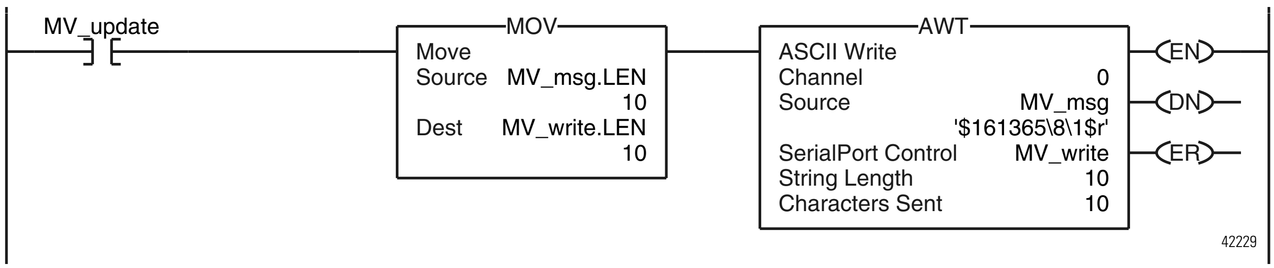
29. Enter the LEN member of the Source tag. (The tag from step 27.)

30. Enter the LEN member of the AWT instruction. (The tag from step 28.)

EXAMPLE

When *MV_update* is on, the AWT instruction sends the characters in *MV_msg*.

- Because the number of characters in *MV_msg* varies, the rung first moves the length of *MV_msg* (*MV_msg*.LEN) to the length of the AWT instruction (*MV_write*.LEN).
- In *MV_msg*, the *$16* counts as one character. It is the hex code for the Ctrl-V character.



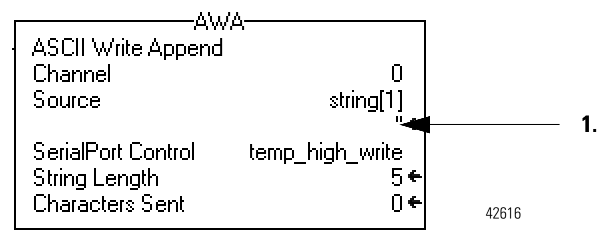
31. Go to Enter ASCII Characters on page 12-21.

Enter ASCII Characters

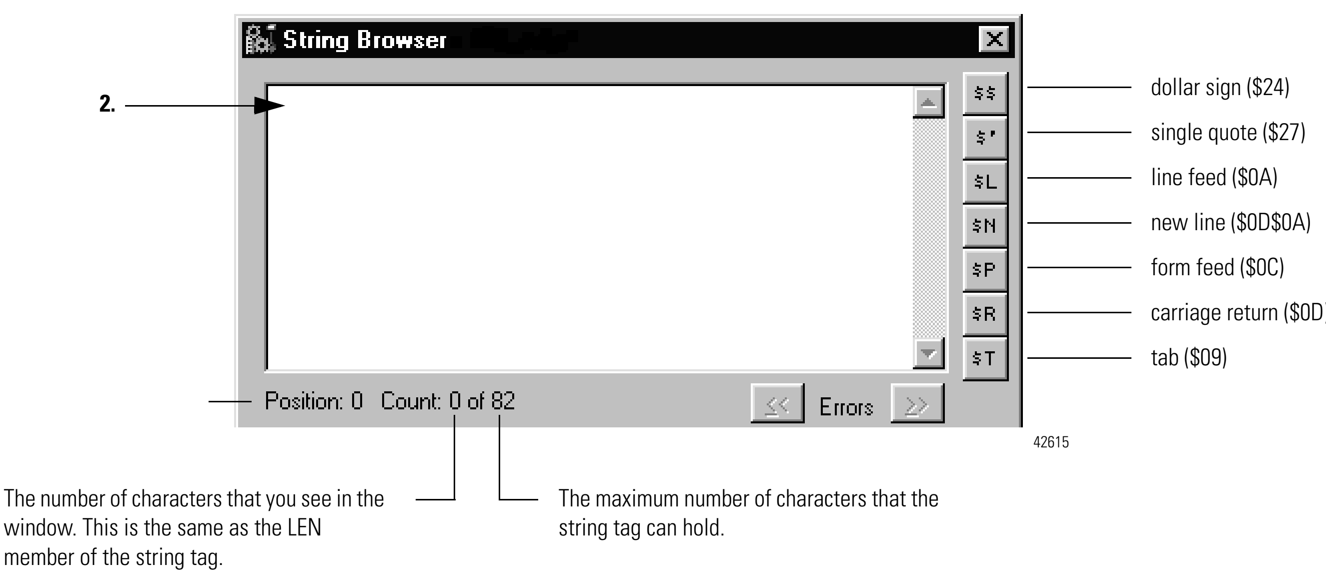
Determine if you must complete this step:

If:	Then:
You want logic to create the string.	Go to “Process ASCII Characters” on page 12-1.
You want to enter the characters.	Go to step 1.

IMPORTANT This String Browser window shows the characters up to the value of the LEN member of the string tag. The string tag may contain additional data, which the String Browser window does not show.



1. Double-click the value area of the Source.



2. Type the characters for the string.

3. Choose *OK*.

Notes:

Process ASCII Characters

When to Use this Procedure

Use this procedure to:

- interpret a bar code and take action based on the bar code
- use a weight from a weigh scale when the weight is sent as ASCII characters
- decode a message from an ASCII triggered device, such as an operator terminal
- build a string for an ASCII triggered device using variables from your application

How to Use this Procedure

IMPORTANT If you are not familiar with how to enter ladder logic in an RSLogix 5000 project, first review "Program Ladder Logic" on page 8-1.

Depending on your application, you may not need to do all the tasks in this procedure. Use the following table to determine where to start:

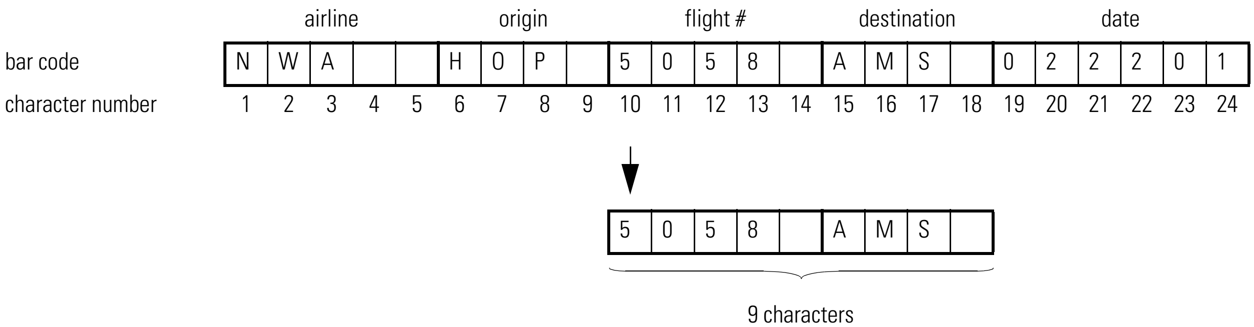
If you want to:	Then go to:	On page:
isolate specific information from a bar code	Extract a Part of a Bar Code	13-2
search an array for a specific string of characters	Look Up a Bar Code	13-4
compare two strings of characters	Check the Bar Code Characters	13-10
use a weight from a weigh scale	Convert a Value	13-12
decode a message from an operator terminal	Decode an ASCII Message	13-14
create a string to send to an operator terminal	Build a String	13-18

For additional information on ASCII-related instructions, refer to *Logix5000 Controllers General Instruction Set Reference Manual*, publication 1756-RM003.

Extract a Part of a Bar Code

Use the following steps to extract a part of a bar code so you can take action based on its value.

For example, a bar code may contain information about a bag on a conveyor at an airport. To check the flight number and destination of the bag, you extract characters 10 - 18.



Steps:

1. Enter the following rung:

2. Enter the EM bit of the ARD instruction that reads the bar code.

3. Enter the string tag that contains the bar code.

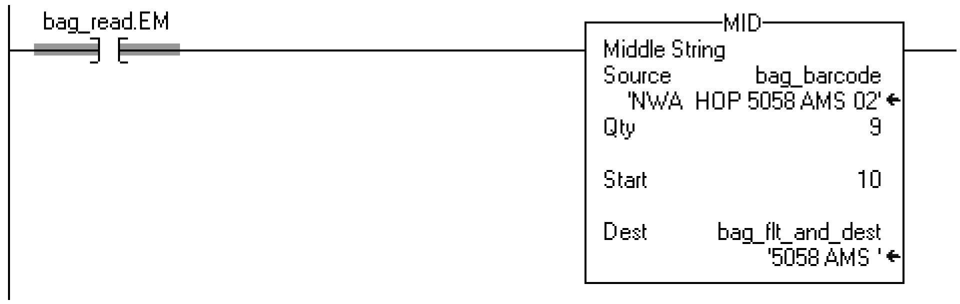
4. Enter the number of characters in the part of the bar code that you want to check.

5. Enter the position of the first character in the part of the bar code that you want to check.

6. Enter a tag name to store the part of the bar code that you want to check. Define the data type as a string.

EXAMPLE

In the baggage handling conveyor of an airport, each bag gets a bar code. Characters 10 - 18 of the bar code are the flight number and destination airport of the bag. After the bar code is read (*bag_read*.EM is on) the MID instruction copies the flight number and destination airport to the *bag_flt_and_dest* tag.



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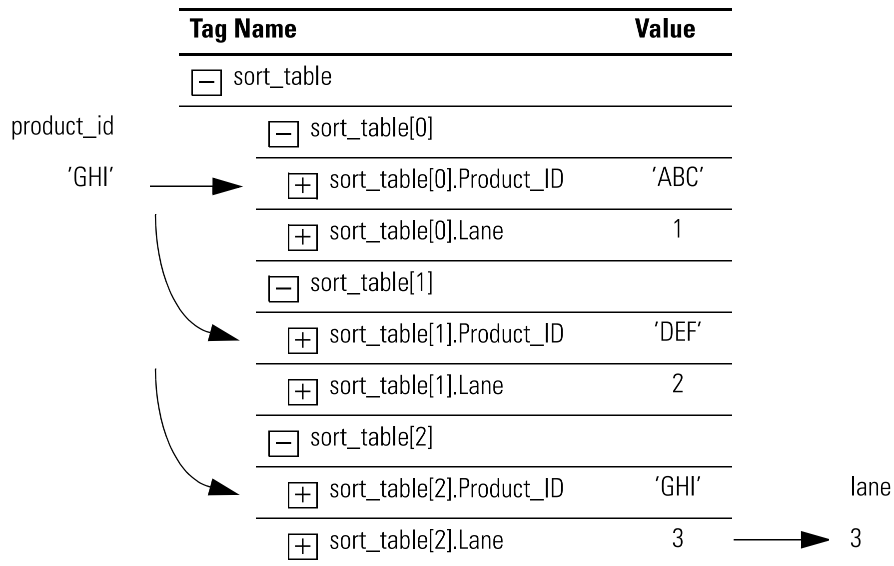
Look Up a Bar Code

Use the following steps to return specific information about an item based on its bar code.

For example, in a sorting operation, an array of a user-defined data type creates a table that shows the lane number for each type of product. To determine which lane to route a product, the controller searches the table for the product ID (characters of the bar code that identify the product).



To look up a bar code:

- Create the PRODUCT_INFO Data Type
- Search for the Characters
- Identify the Lane Number
- Reject Bad Characters
- Enter the Product IDs and Lane Numbers

TIP To copy the above components from a sample project, open the *…\RSLogix 5000\Projects\Samples* folder.

Create the PRODUCT_INFO Data Type

To create a new data type:

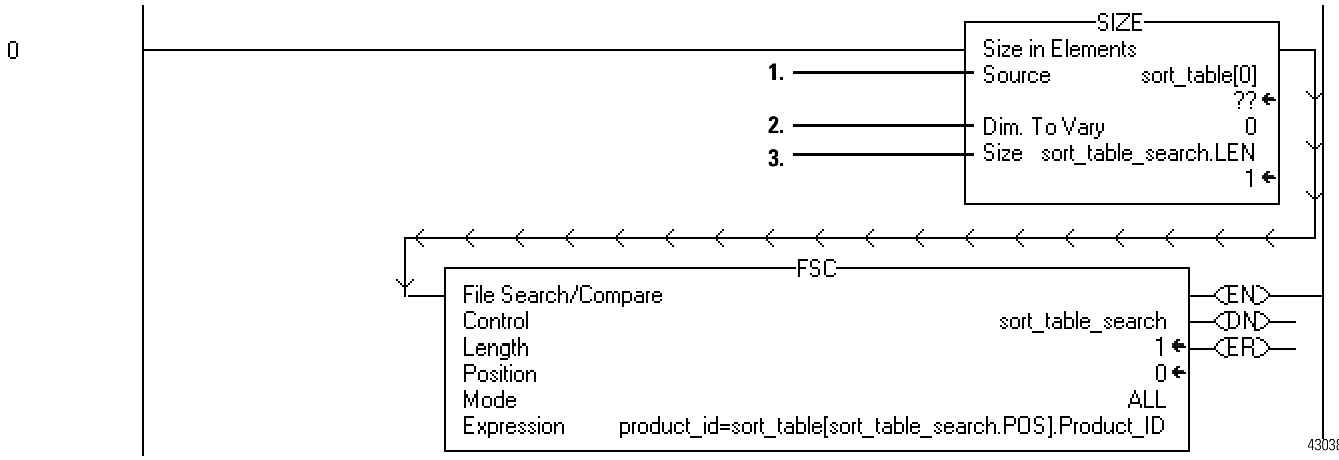
- + Controller Your_Project
- + Tasks
- + Motion Groups
- Trends
- − Data Types
  - User-Defined

Right-click and choose *New Data Type*.

Create the following user-defined data type.

Data Type: PRODUCT_INFO			
Name	PRODUCT_INFO		
Description	Identifies the destination for an item based on an ASCII string of characters that identify the item		
Members			
Name	**Data Type**	**Style**	**Description**
+ Product_ID	STRING		ASCII characters that identify the item
Lane	DINT	Decimal	Destination for the item, based on its ID

Search for the Characters



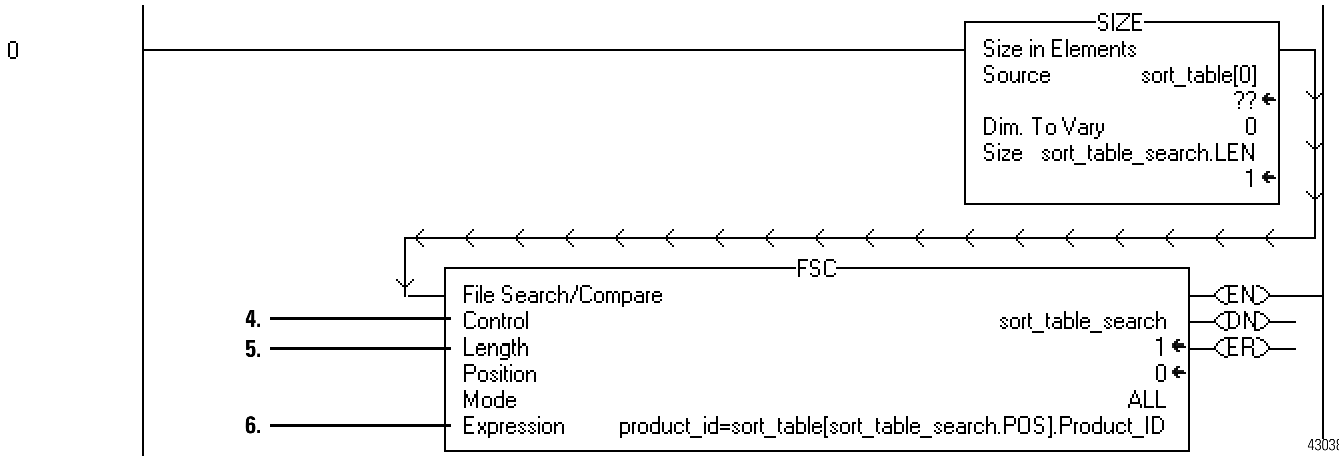
1. The SIZE instruction counts the number of elements in the *sort_table* array. This array contains the product ID for each item and the corresponding lane number for the item.

Tag Name	Type
sort_table	PRODUCT_INFO[*number_of_items*] where: *number_of_items* is the number of items hat you must sort.

2. The SIZE instruction counts the number of elements in Dimension 0 of the array. In this case, that is the only dimension.

3. The SIZE instruction sets the Length of the subsequent FSC instruction equal to the size of the *sort_table* array. This ensures that the FSC instruction searches the exact size of the array.

Tag Name	Type
sort_table_search	CONTROL



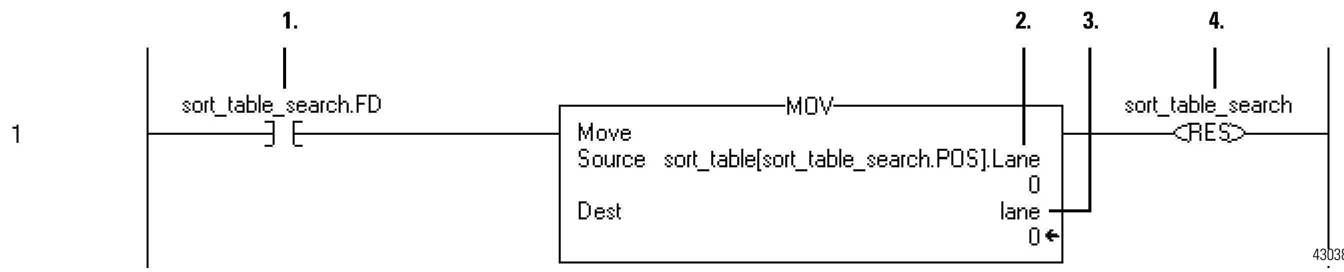
4. The *sort_table_search* tag controls the FSC instruction, which looks through the *sort_table* array for the bar code characters.

5. Although the previous instruction sets the Length of this instruction, the software requires an initial value to verify the project.

6. The *product_id* tag contains the bar code characters that identify the item. The FSC instruction searches each Product_ID member in the *sort_table* array until the instruction finds a match to the *product_id* tag.

Tag Name	Type
product_id	STRING

Identify the Lane Number



1. When the FSC instruction finds the product ID within the *sort_table* array, the instruction sets the FD bit.

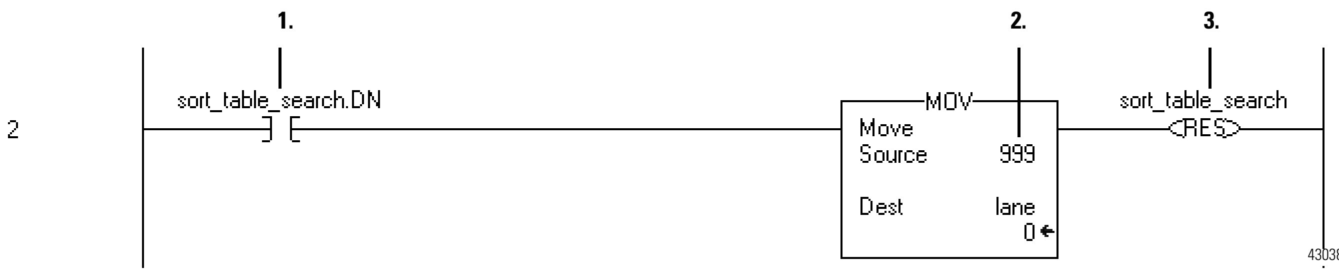
2. When the FSC finds a match. the POS member indicates the element number within the *sort_table* array of the match. The corresponding LANE member indicates the lane number of the match.

3. Based on the POS value, the MOV instruction moves the corresponding lane number into the *lane* tag. The controller uses the value of this tag to route the item.

Tag Name	Type
lane	DINT

4. After the MOV instruction sets the value of the *lane* tag, the RES instruction resets the FSC instruction so it can search for the next product ID.

Reject Bad Characters



1. If the FSC instruction does not find the product ID within the *sort_table* array, the instruction sets the DN bit.

2. When no match is found, the MOV instruction moves 999 into the lane tag. This tells the controller to reject or reroute the item.

3. After the MOV instruction sets the value of the *lane* tag, the RES instruction resets the FSC instruction so it can search for the next product ID.

Enter the Product IDs and Lane Numbers

Into the *sort_table* array, enter the ASCII characters that identify each item and the corresponding lane number for the item.

Tag Name	Value
− sort_table	{…}
− sort_table[0]	{…}
+ sort_table[0].Product_ID	ASCII characters that identify the first item
+ sort_table[0].Lane	lane number for the item
− sort_table[1]	{…}
+ sort_table[1].Product_ID	ASCII characters that identify the next item
+ sort_table[1].Lane	lane number for the item

Check the Bar Code Characters

In this task, you use a compare instruction (EQU, GEQ, GRT, LEQ, LES, NEQ) to check for specific characters.

- The hexadecimal values of the characters determine if one string is less than or greater than another string.
- When the two strings are sorted as in a telephone directory, the order of the strings determines which one is greater.

ASCII Characters	Hex Codes
1ab	$31$61$62
1b	$31$62
A	$41
AB	$41$42
B	$42
a	$61
ab	$61$62

lesser

greater

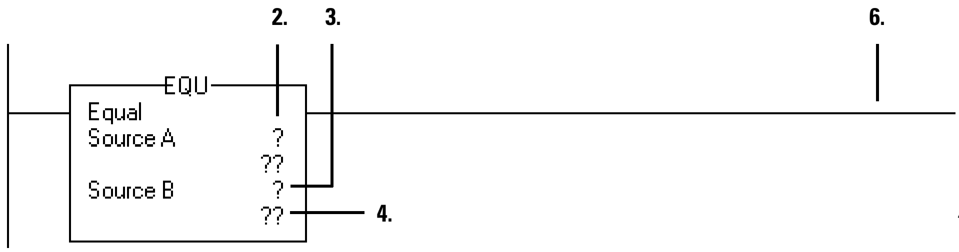
AB < B

a > B

Steps:

1. Enter a rung and a compare instruction:

To see if the string is:	Enter this instruction:
equal to specific characters	EQU
not equal to specific characters	NEQ
greater than specific characters	GRT
equal to or greater than specific characters	GEQ
less than specific characters	LES
equal to or less than specific characters	LEQ

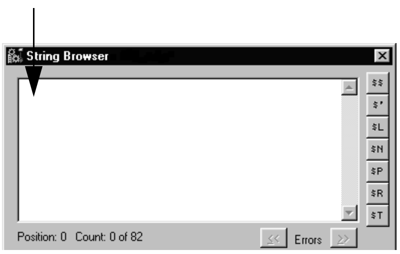


42808

2. Enter the tag that stores the part of the bar code that you want to check. (The Destination from Extract a Part of a Bar Code, step 6.)

3. Enter a tag name to store the characters that you want to test against. Define the data type as a string.

4. Double-click value area of Source B.



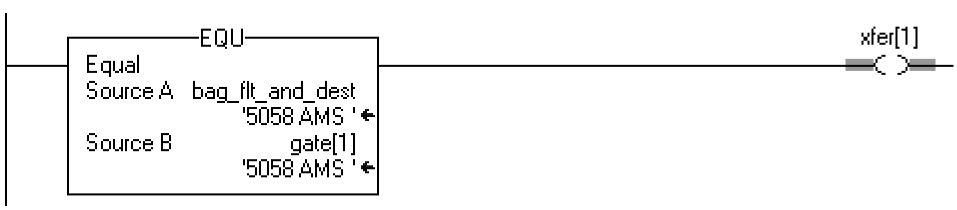
42615

5. Type the ASCII characters to test against and choose *OK*.

6. Enter the required output.

EXAMPLE

When *bag_flt_and_dest* is equal to *gate[1]*, *xfer[1]* turns on. This routes the bag to the required gate.



42808

7. Do you want to check another part of the bar code?

If:	Then:
yes	Go to Extract a Part of a Bar Code on page 13-2.
no	Stop. You are done with this procedure.

Convert a Value

Use the following steps to convert the ASCII representation of a value to an DINT or REAL value that you can use in your application.

- The STOD and STOR instructions skip any initial control or non-numeric characters (except the minus sign in front of a number).
- If the string contains multiple groups of numbers that are separated by delimiters (e.g., /), the STOD and STOR instructions convert only the first group of numbers.

Steps:

1. Which type of number is the value?

If:	Then:
floating-point	Go to step 2.
integer	Go to step 7.

2. Enter the following rung:

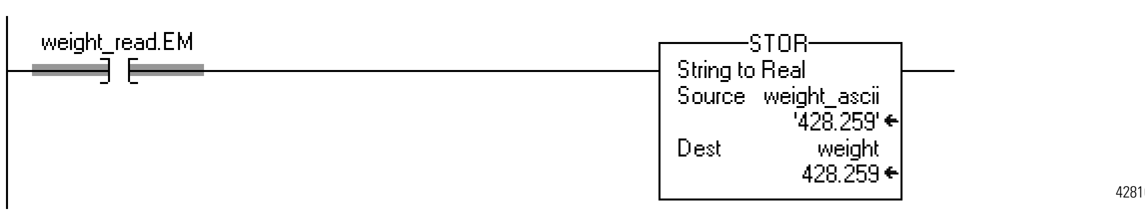
3. Enter the EM bit of the ARD or ARL instruction that read the value.

4. Enter the string tag that contains the value.

5. Enter a tag name to store the value for use in your application. Define the data type as REAL.

EXAMPLE

After reading the weight from the scale (*weight_read*.EM is on) the STOR instruction converts the numeric characters in *weight_ascii* to a REAL value and stores the result in *weight*.



6. Go to step 11.

7. Enter the following rung:

8. Enter the EM bit of the ARD or ARL instruction that read the value.

9. Enter the string tag that contains the value.

10. Enter a tag name to store the value for use in your application. Define the data type as DINT.

EXAMPLE

When *MV_read.EM* is on, the STOD instruction converts the first set of numeric characters in *MV_msg* to an integer value. The instruction skips the initial control character ($06) and stops at the delimiter (\ ).

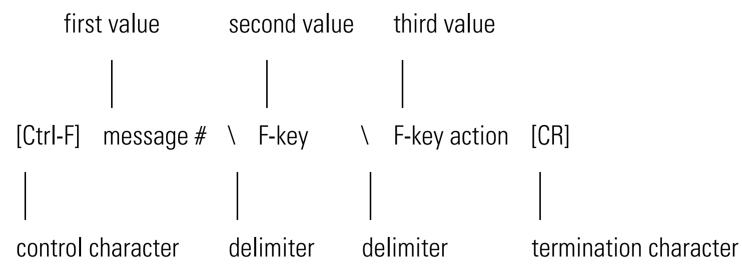
11. Does this string have another value that you want to use?

If:	Then:
yes	Go to Decode an ASCII Message on page 13-14.
no	Stop. You are done with this procedure.

Decode an ASCII Message

Use the following steps to extract and convert a value from an ASCII message that contains multiple values.

For example, a message may look like this:



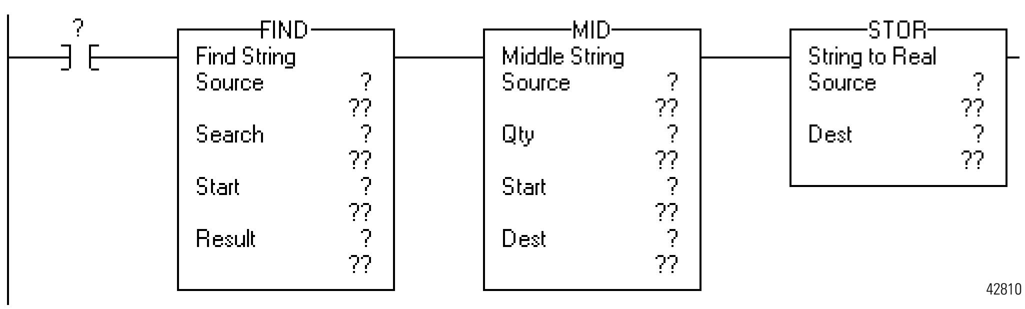
1. Determine where to start:

If the:	And:	Then:
string has more than one value	This is the first value.	Go to Convert a Value on page 13-12.
	This is *not* the value.	Go to step 2.
string has only one value	——————►	Go to Convert a Value on page 13-12.

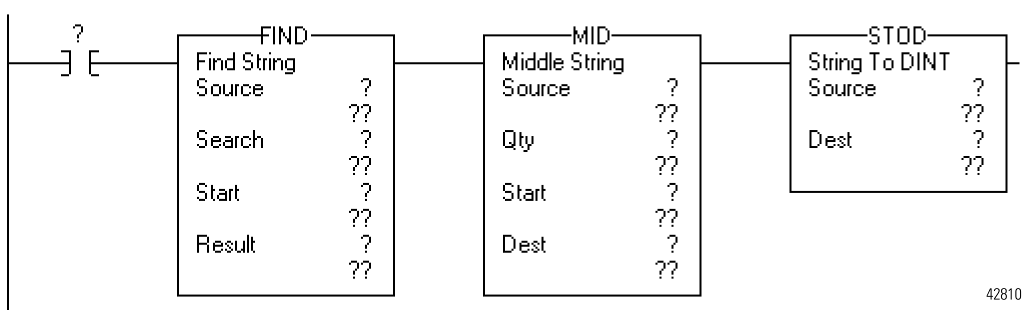
2. Which type of number is the value?

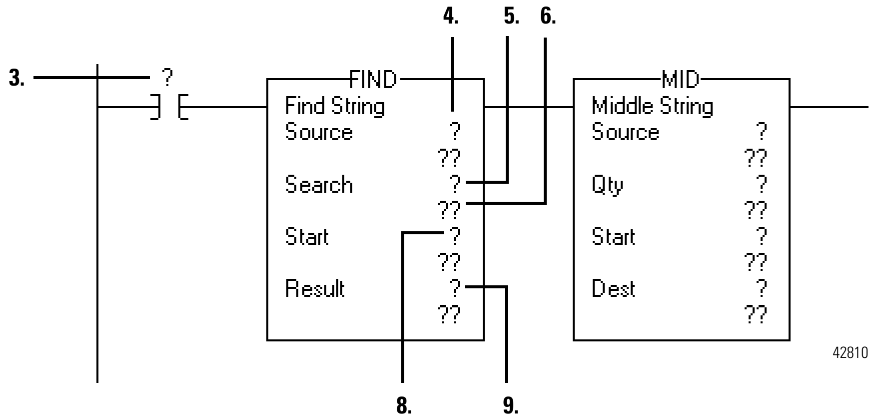
If:	Then:
floating-point	Enter Rung A: Find and Convert a Floating-Point Value
integer	Enter Rung B: Find and Convert an Integer Value

Rung A: Find and Convert a Floating-Point Value



Rung B: Find and Convert an Integer Value



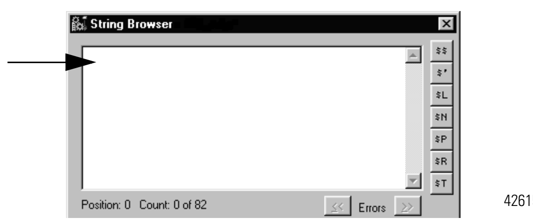


3. Enter the EM bit of the ARL instruction that read the value.

4. Enter the string tag that contains the value.

5. Enter a tag name to store the delimiter that marks the beginning of the value. Define the data type as a string.

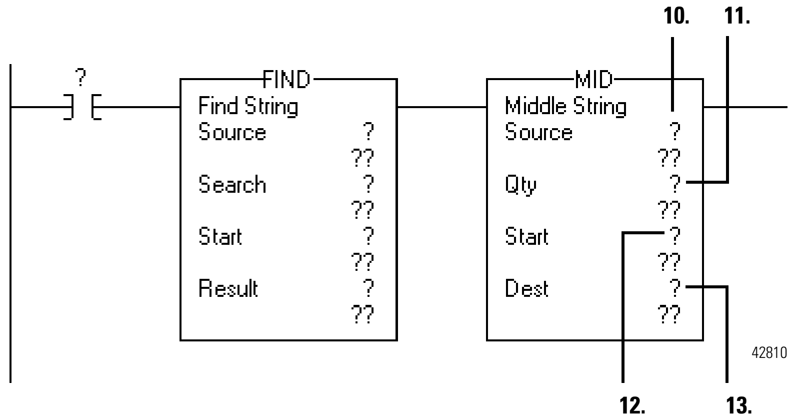
6. Double-click the value area of Search.



7. Type the delimiter and choose *OK*.

8. Enter the position in the string to start the search.
   - Initially, you can use 0 to find the first delimiter.
   - To decode additional data, increase this value to search for the next delimiter.

9. Enter a tag name to store the location of the delimiter. Define the data type as a DINT.



10. Enter the string tag that contains the value.

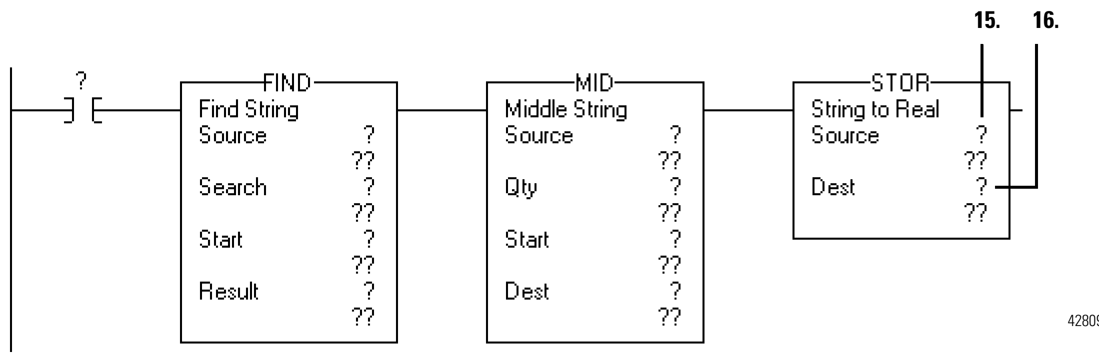
11. Enter the maximum number of characters that this value can contain.

12. Enter the tag that stores the position of the delimiter. (The tag from step 9.)

13. Enter a tag name to store this value. Define the data type as a string.

14. Which type of conversion instruction did you use?

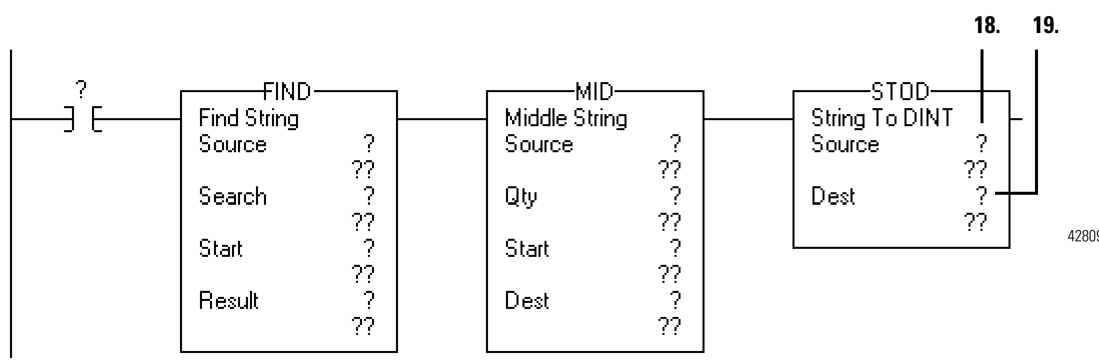
If:	Then:
STOR	Go to step 15.
STOD	Go to step 18.



15. Enter the tag that stores the value. (The tag from step 13.)

16. Enter a tag name to store the value for use in your application. Define the data type as REAL.

17. Go to step 20.



18. Enter the tag that stores the value. (The tag from step 13.)

19. Enter a tag name to store the value for use in your application. Define the data type as DINT.

20. Does the string have another value that you want to use?

If:	Then:
yes	A. Add 1 to the Result of the Find instruction. (The tag from step 9.) B. Repeat steps 2 - 19.
no	Stop. You are done with this procedure.

Build a String

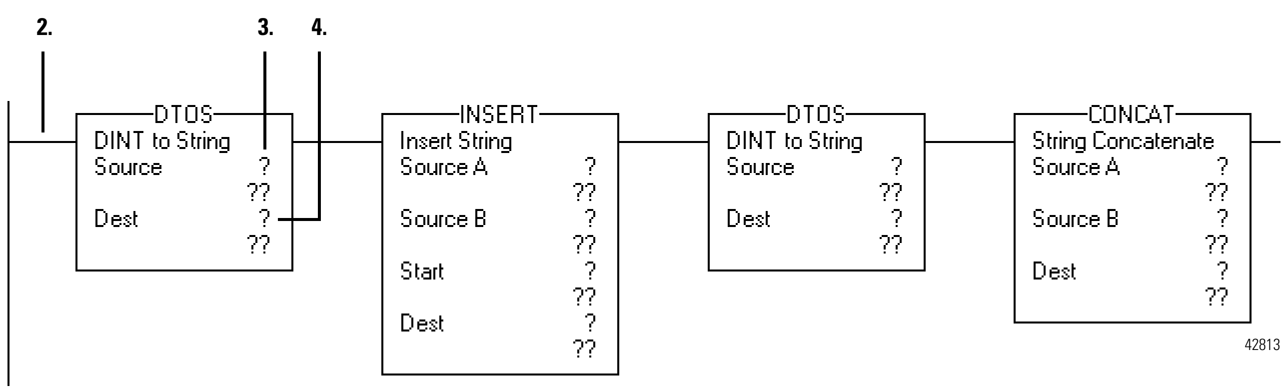
Use the following steps to build a string from variables in your application. You can then send the string to an ASCII triggered device, such as a MessageView terminal.

- In this procedure, you build a string that contains two variables. For example, an operator terminal may require a string that looks like this:

- If you need to include more variables, use additional INSERT or CONCAT instructions.
- If you need to send a floating-point value, use a RTOS instruction in place of the DTOS instruction.
- The final string will not include the termination character. When you send the string, use an AWA instruction to automatically append the termination character.

Steps:

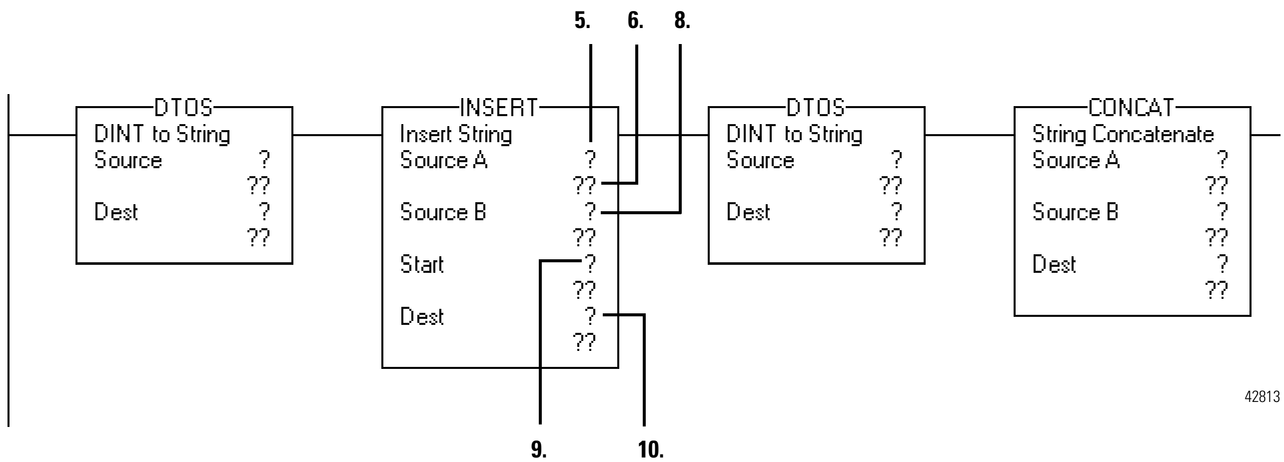
1. Enter the following rung:



2. Enter the input condition (s) that determines when to build the string.

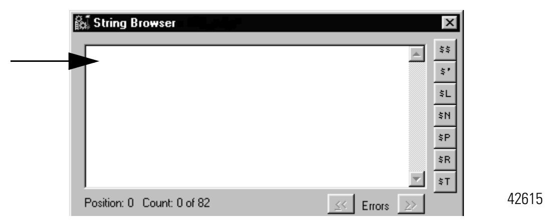
3. Enter the DINT tag that contains the first value for the string.

4. Enter a tag name to stores the ASCII representation of the value. Define the data type as a string.



5. Enter a tag name to store the control and delimiter characters for the string. Define the data type as a string.

6. Double-click the value area of the Source A.



7. Type the control character and delimiter and choose *OK*.

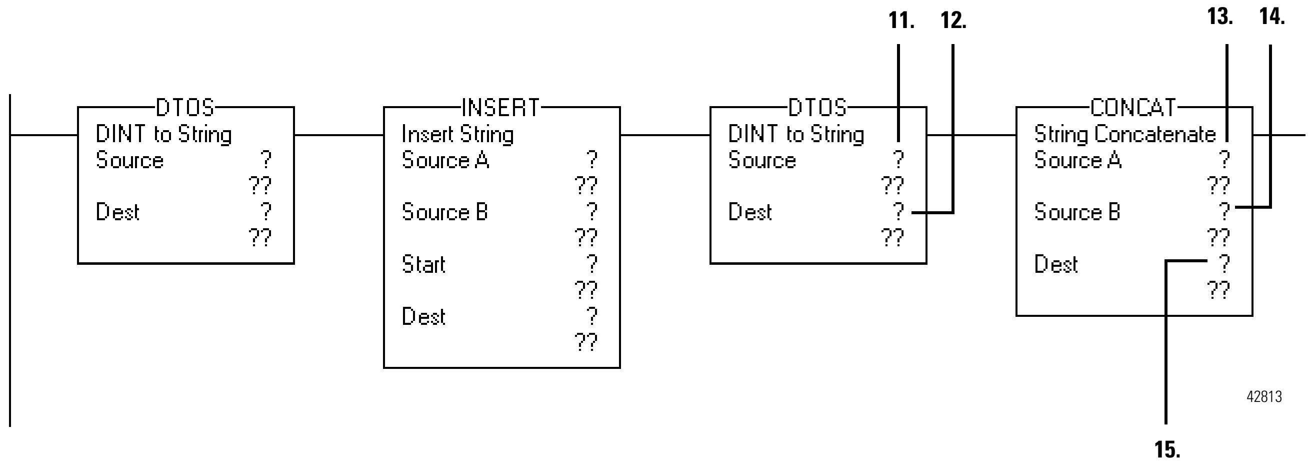
   For a control character, type the hex code of the character. For a list of hex codes, see the back cover of this manual.

8. Enter the tag that stores the ASCII representation of the first value. (The tag from step 4.)

9. Enter 2.

   This puts the value after the first character (control character) in Source A.

10. Enter a tag name to store the partially completed string. Define the data type as a string.



11. Enter the DINT tag that contains the second value for the string.

12. Enter a tag name to store the ASCII representation of the value. Define the data type as a string.

13. Enter the tag that stores the partially completed string. (The tag from step 10.)

14. Enter the tag that stores the ASCII representation of the second value. (The tag from step 12.)

15. Enter a tag name to store the completed string. Define the data type as a string.

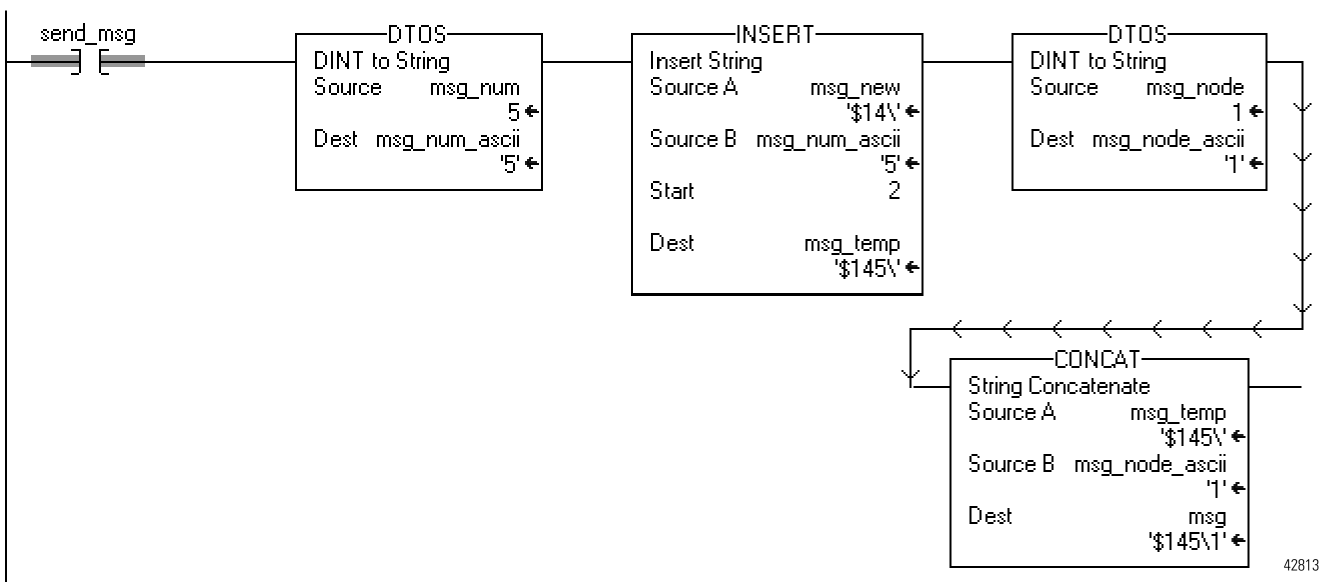
EXAMPLE

To trigger a message in a MessageView terminal, the controller sends the terminal a message in the following format: [Ctrl-T] message # \ address [CR]

When *send_msg* is on, the rung does the following:

- The first DTOS instruction converts the message number to ASCII characters.
- The INSERT instruction inserts the message number (in ASCII) after the control character [Ctrl-T]. (The hex code for Ctrl-T is $14.)
- The second DTOS instruction converts the node number of the terminal to ASCII characters.
- The CONCAT instruction puts the node number (in ASCII) after the backslash [\ ] and stores the final string in *msg*.

To send the message, an AWA instruction sends the *msg* tag and appends the carriage return [CR].



Notes:

Force Logic Elements

When to Use This Procedure

Use a force to override data that your logic either uses or produces. For example, use forces in the following situations:

- test and debug your logic
- check wiring to an output device
- temporarily keep your process functioning when an input device has failed

Use forces only as a temporary measure. They are *not* intended to be a permanent part of your application.

How to Use This Procedure

If you want to:	See:
review the precautions that you should take whenever you add, change, remove, or disable forces	"Precautions" on page 14-2
determine current state of forces in your project	"Check Force Status" on page 14-4
determine which type of element to force in your project	"What to Force" on page 14-6
review general information about I/O forces, including which elements you are permitted to force and how an I/O force effects your project	"When to Use an I/O Force" on page 14-6
force an I/O value	"Add an I/O Force" on page 14-8
review general information about stepping through a transition or a simultaneous path	"When to Use Step Through" on page 14-9
step through an active transition	"Step Through a Transition or a Force of a Path" on page 14-9
step through a simultaneous path that is forced false	
review general information about SFC forces, including which elements you are permitted to force and how the forces effect the execution of your SFC	"When to Use an SFC Force" on page 14-9
force a transition or simultaneous path within an SFC	"Add an SFC Force" on page 14-12
stop the effects of a force	"Remove or Disable Forces" on page 14-13

Precautions

When you use forces, take the following precautions:

ATTENTION

Forcing can cause unexpected machine motion that could injure personnel. Before you use a force, determine how the force will effect your machine or process and keep personnel away from the machine area.

- Enabling I/O forces causes input, output, produced, or consumed values to change.
- Enabling SFC forces causes your machine or process to go to a different state or phase.
- Removing forces may still leave forces in the enabled state.
- If forces are enabled and you install a force, the new force immediately takes effect.

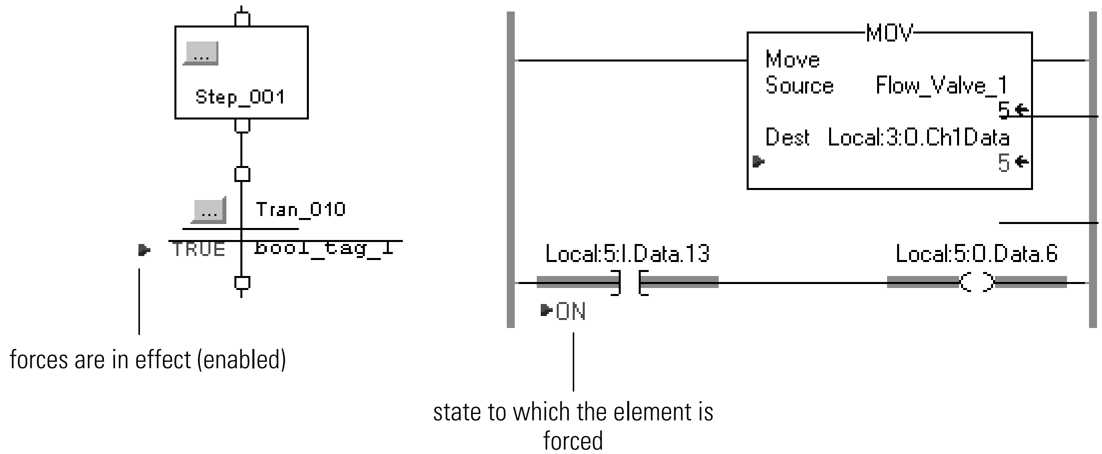
Enable Forces

For a force to take effect, you enable forces. You can only enable and disable forces at the controller level.

- You can enable I/O forces and SFC forces separately or at the same time.
- You cannot enable or disable forces for a specific module, tag collection, or tag element.

IMPORTANT If you download a project that has forces enabled, the programming software prompts you to enable or disable forces after the download completes.

When forces are in effect (enabled), a ▶ appears next to the forced element.



Disable or Remove a Force

To stop the effect of a force and let your project execute as programmed, disable or remove the force.

- You can disable or remove I/O and SFC forces at the same time or separately.
- Removing a force on an alias tag also removes the force on the base tag.

ATTENTION

Changes to forces can cause unexpected machine motion that could injure personnel. Before you disable or remove forces, determine how the change will effect your machine or process and keep personnel away from the machine area.

Check Force Status

Before you use a force, determine the status of forces for the controller. You can check force status in the following ways:

To determine the status of:	Use any of the following:
I/O forces	• Online Toolbar • FORCE LED • GSV Instruction
SFC forces	Online Toolbar

Online Toolbar

The Online toolbar shows the status of forces. It shows the status of I/O forces and SFC forces separately.

This:	Means:
Enabled	• If the project contains any forces of this type, they *are* overriding your logic. • If you add a force of this type, the new force immediately takes effect
Disabled	Forces of this type are inactive. If the project contains any forces of this type, they *are not* overriding your logic.
Installed	At least one force of this type exists in the project.
None Installed	No forces of this type exist in the project.

FORCE LED

If your controller has a FORCE LED, use the LED to determine the status of any I/O forces.

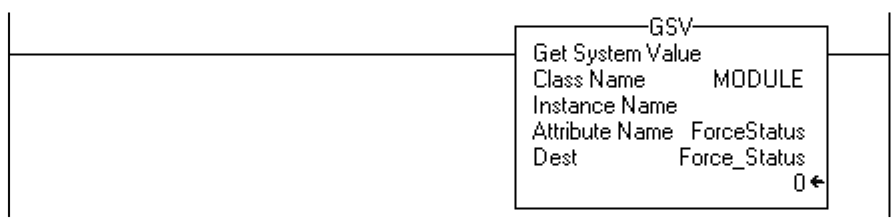
IMPORTANT The FORCE LED shows only the status of I/O forces. It *does not* show that status of SFC forces.

If the FORCE LED is:	Then:
off	• No tags contain force values. • I/O forces are inactive (disabled).
flashing	• At least one tag contains a force value. • I/O forces are inactive (disabled).
solid	• I/O forces are active (enabled). • Force values may or may not exist.

GSV Instruction

IMPORTANT The ForceStatus attribute shows only the status of I/O forces. It *does not* show the status of SFC forces.

The following example shows how to use a GSV instruction to get the status of forces.



where:

Force_Status is a DINT tag.

To determine if:	Examine this bit:	For this value:
forces are installed	0	1
no forces are installed	0	0
forces are enabled	1	1
forces are disabled	1	0

What to Force

You can force the following elements of your project:

If you want to:	Then:
override an input value, output value, produced tag, or consumed tag	Add an I/O Force
override the conditions of a transition one time to go from an active step to the next step	Step Through a Transition or a Force of a Path
override one time the force of a simultaneous path and execute the steps of the path	
override the conditions of a transition in a sequential function chart	Add an SFC Force
execute some but not all the paths of a simultaneous branch of a sequential function chart	

When to Use an I/O Force

Use an I/O force to accomplish the following:

- override an input value from another controller (i.e., a consumed tag)
- override an input value from an input device
- override your logic and specify an output value for another controller (i.e., a produced tag)
- override your logic and specify the state of an output device

IMPORTANT Forcing increases logic execution time. The more values you force, the longer it takes to execute the logic.

IMPORTANT I/O forces are held by the controller and not by the programming workstation. Forces remain even if the programming workstation is disconnected.

When you force an I/O value:

- You can force all I/O data, except for configuration data.
- If the tag is an array or structure, such as an I/O tag, force a BOOL, SINT, INT, DINT, or REAL element or member.
- If the data value is a SINT, INT, or DINT, you can force the entire value or you can force individual bits within the value. Individual bits can have a force status of:
  - no force
  - force on
  - force off

- You can also force an alias to an I/O structure member, produced tag, or consumed tag.
  - An alias tag shares the same data value as its base tag, so forcing an alias tag also forces the associated base tag.
  - Removing a force from an alias tag removes the force from the associated base tag.

Force an Input Value

Forcing an input or consumed tag:

- overrides the value regardless of the value of the physical device or produced tag
- does not affect the value received by other controllers monitoring that input or produced tag

Force an Output Value

Forcing an output or produced tag overrides the logic for the physical device or other controller (s). Other controllers monitoring that output module in a listen-only capacity will also see the forced value.

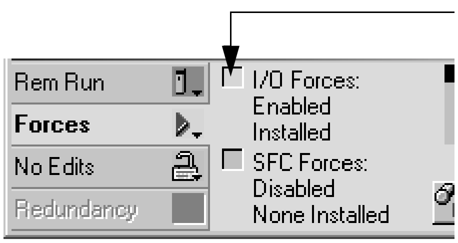
Add an I/O Force

To override an input value, output value, produced tag, or consumed tag, use an I/O force:

ATTENTION

Forcing can cause unexpected machine motion that could injure personnel. Before you use a force, determine how the force will effect your machine or process and keep personnel away from the machine area.

- Enabling I/O forces causes input, output, produced, or consumed values to change.
- If forces are enabled and you install a force, the new force immediately takes effect.



1. What is the state of the I/O Forces indicator?

If:	Then note the following:
off	No I/O forces currently exist.
flashing	No I/O forces are active. But at least one force already exists in your project. When you enable I/O forces, *all* existing I/O forces will also take effect.
solid	I/O forces are enabled (active). When you install (add) a force, it immediately takes effect.

2. Open the routine that contains the tag that you want to force.

3. Right-click the tag and choose *Monitor…* If necessary, expand the tag to show the value that you want to force (e.g., BOOL value of a DINT tag).

4. Install the force value:

To force a:	Do this:
BOOL value	Right-click the tag and choose *Force ON* or *Force OFF*.
non-BOOL value	In the *Force Mask* column for the tag, type the value to which you want to force the tag. Then press the *Enter* key.

5. Are I/O forces enabled? (See step 1.)

If:	Then:
no	From the *Logic* menu, choose *I/O Forcing* ⇒ *Enable All I/O Forces*. Then choose *Yes* to confirm.
yes	Stop.

When to Use Step Through

To override a false transition one time and go from an active step to the next step, use the *Step Through* option. With the *Step Through* option:

- You *do not* have to add, enable, disable, or remove forces.
- The next time the SFC reaches the transition, it executes according to the conditions of the transition.

This option also lets you override one time the false force of a simultaneous path. When you step through the force, the SFC executes the steps of the path.

Step Through a Transition or a Force of a Path

To step through the transition of an active step or a force of a simultaneous path:

1. Open the SFC routine.

2. Right-click the transition or the path that is forced and choose *Step Through*.

When to Use an SFC Force

To override the logic of an SFC, you have the following options:

If you want to:	Then:
override the conditions of a transition each time the SFC reaches the transition	Force a Transition
prevent the execution of one or more paths of a simultaneous branch	Force a Simultaneous Path

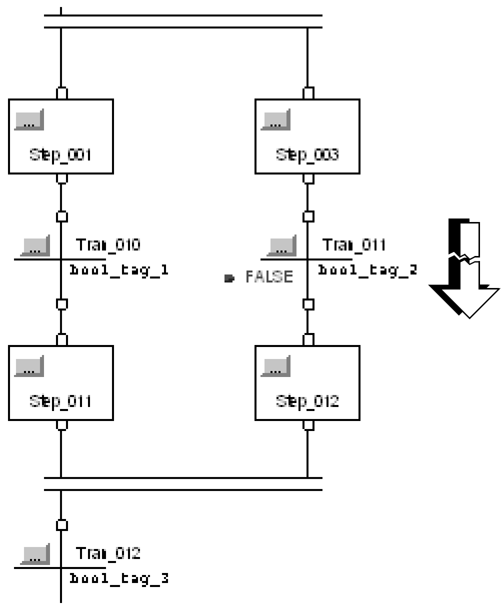
Force a Transition

To override the conditions of a transition through repeated executions of an SFC, force the transition. The force remains until you remove it or disable forces

If you want to:	Then:
prevent the SFC from going to the next step	force the transition false
cause the SFC go to the next step regardless of transition conditions	force the transition true

If you force a transition within a simultaneous branch to be false, the SFC stays in the simultaneous branch as long as the force is active (installed and enabled).

- To leave a simultaneous branch, the last step of each path must execute at least one time and the transition below the branch must be true.
- Forcing a transition false prevents the SFC from reaching the last step of a path.
- When you remove or disable the force, the SFC can execute the rest of the steps in the path.



For example, to exit this branch, the SFC must be able to:

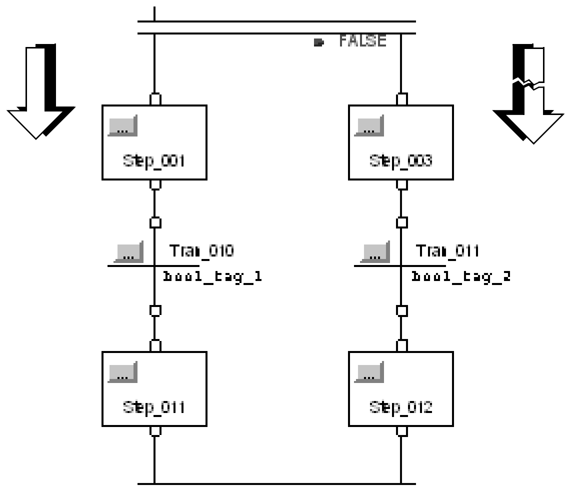
- execute *Step_011* at least once
- get past *Tran_011* and execute *Step_012* at least once
- determine that *Tran_012* is

Force a Simultaneous Path

To prevent the execution of a path of a simultaneous branch, force the path false. When the SFC reaches the branch, it executes only the un-forced paths.

This path executes.

This path *does not* execute.



If you force a path of a simultaneous branch to be false, the SFC stays in the simultaneous branch as long as the force is active (installed and enabled).

- To leave a simultaneous branch, the last step of each path must execute at least one time and the transition below the branch must be true.
- Forcing a path false prevents the SFC from entering a path and executing its steps.
- When you remove or disable the force, the SFC can execute the steps in the path.

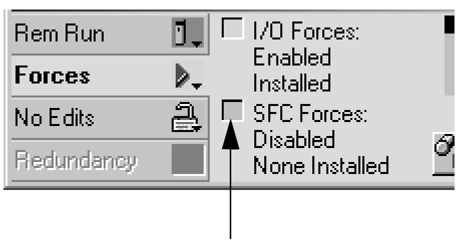
Add an SFC Force

To override the logic of an SFC, use an SFC force:

ATTENTION

Forcing can cause unexpected machine motion that could injure personnel. Before you use a force, determine how the force will effect your machine or process and keep personnel away from the machine area.

- Enabling SFC forces causes your machine or process to go to a different state or phase.
- If forces are enabled and you install a force, the new force immediately takes effect.



1. What is the state of the SFC Forces indicator?

If:	Then note the following:
off	No SFC forces currently exist.
flashing	No SFC forces are active. But at least one force already exists in your project. When you enable SFC forces, *all* existing SFC forces will also take effect.
solid	SFC forces are enabled (active). When you install (add) a force, it immediately takes effect.

2. Open the SFC routine.

3. Right-click the transition or start of a simultaneous path that you want to force, and choose either *Force TRUE* (only for a transition) or *Force FALSE*.

4. Are SFC forces enabled? (See step 1.)

If:	Then:
no	From the *Logic* menu, choose *SFC Forcing* ⇒ *Enable All SFC Forces*. Then choose *Yes* to confirm.
yes	Stop.

Remove or Disable Forces

ATTENTION

Changes to forces can cause unexpected machine motion that could injure personnel. Before you disable or remove forces, determine how the change will effect your machine or process and keep personnel away from the machine area.

If you want to:	And:	Then:
stop an individual force	leave other forces enabled and in effect	Remove an Individual Force
stop all I/O forces but leave all SFC forces active	leave the I/O forces in the project	Disable All I/O Forces
	remove the I/O forces from the project	Remove All I/O Forces
stop all SFC forces but leave all I/O forces active	leave the SFC forces in the project	Disable All SFC Forces
	remove the SFC forces from the project	Remove All SFC Forces

Remove an Individual Force

ATTENTION

If you remove an individual force, forces remain in the enabled state and any new force immediately takes effect.

Before you remove a force, determine how the change will effect your machine or process and keep personnel away from the machine area.

1. Open the routine that contains the force that you want to remove.

2. What is the language of the routine?

If:	Then:
SFC	Go to step 4.
ladder logic	Go to step 4.
function block	Go to step 3.
structured text	Go to step 3.

3. Right-click the tag that has the force and choose *Monitor…* If necessary, expand the tag to show the value that is forced (e.g., BOOL value of a DINT tag).

4. Right-click the tag or element that has the force and choose *Remove Force*.

Disable All I/O Forces

From the *Logic* menu, choose *I/O Forcing* ⇒ *Disable All I/O Forces*. Then choose *Yes* to confirm.

Remove All I/O Forces

From the *Logic* menu, choose *I/O Forcing* ⇒ *Remove All I/O Forces*. Then choose *Yes* to confirm.

Disable All SFC Forces

From the *Logic* menu, choose *SFC Forcing* ⇒ *Disable All SFC Forces*. Then choose *Yes* to confirm.

Remove All SFC Forces

From the *Logic* menu, choose *SFC Forcing* ⇒ *Remove All SFC Forces*. Then choose *Yes* to confirm.

Handle a Major Fault

Using this Chapter

Use this chapter to develop logic that handles specific fault conditions.

Develop a Fault Routine

If a fault condition occurs that is severe enough for the controller to shut down, the controller generates a **major fault** and stops the execution of logic.

- Depending on your application, you may not want all major faults to shut down your entire system.
- In those situations, you can use a fault routine to clear a specific fault and let at least some of your system continue to operate.

EXAMPLE

Use a fault routine

In a system that uses recipe numbers as indirect addresses, a miss-typed number could produce a major fault, such as type 4, code 20.

To keep the entire system from shutting down, a fault routine clears any type 4, code 20, major faults.

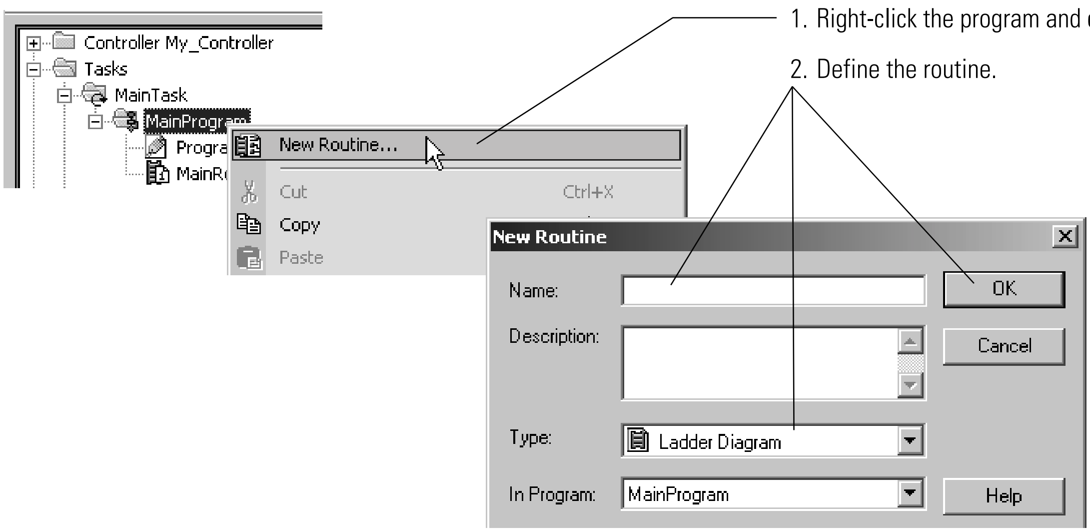
Choose Where to Place the Fault Routine

A fault routine lets you program logic to take specific action after a fault, such as clear the fault and resume execution. Where you place the routine depends on the type of fault that you want to handle:

If you want take specific action/clear the fault when:		Do this:	See page:
Condition:	**Fault type:**		
The execution of an instruction faults	4	Create a Fault Routine for a Program	15-2
Communication with an I/O module fails	3	Create a Routine for the Controller Fault Handler	15-3
Watchdog time for a task expires	6		
While a project is downloading to the controller, the keyswitch is placed in RUN	8		
A motion axis faults	11		
The controller powers up in run/remote run mode	1	Create a Routine for the Power-Up Handler	15-4

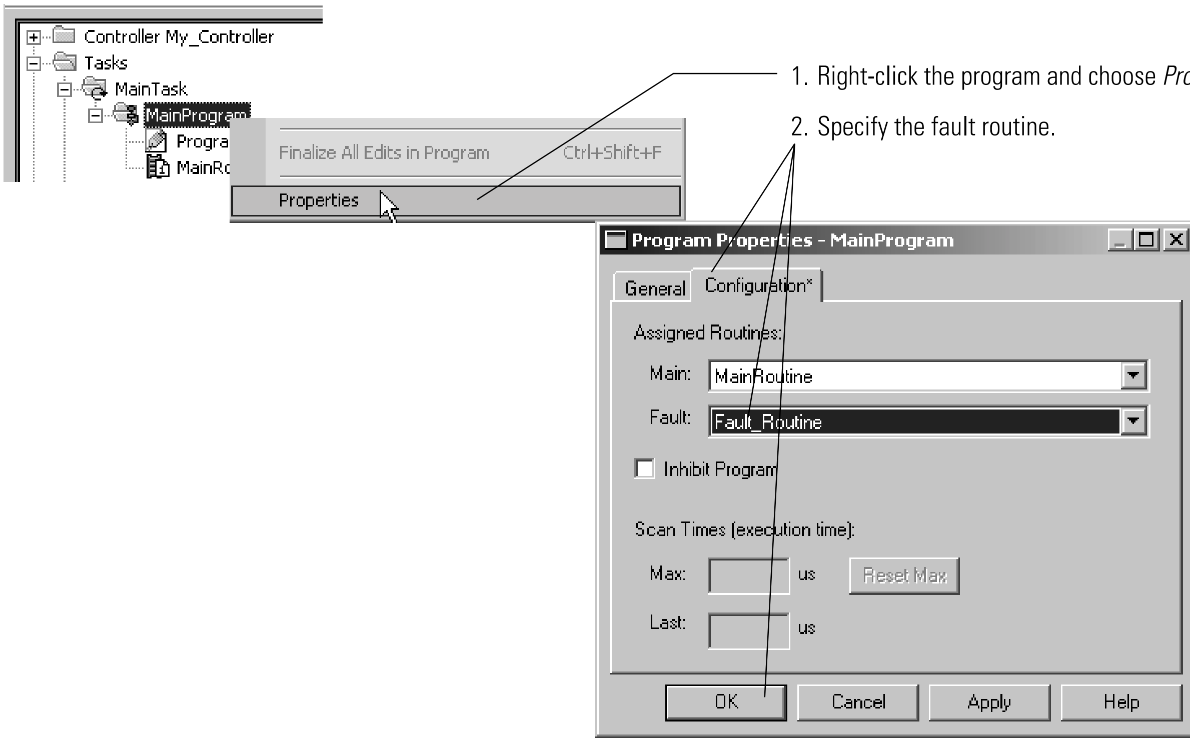
Create a Fault Routine for a Program

Create the Routine



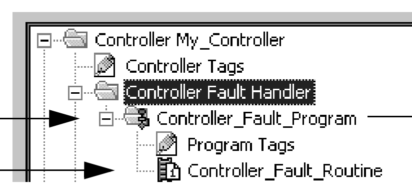
1. Right-click the program and choose *New Routine*.
2. Define the routine.

Assign the Routine as the Fault Routine

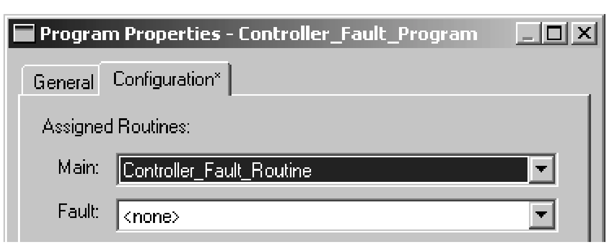


1. Right-click the program and choose *Properties*.
2. Specify the fault routine.

Create a Routine for the Controller Fault Handler



1. Create a program for the Controller Fault Handler.
2. Create a routine for the program.

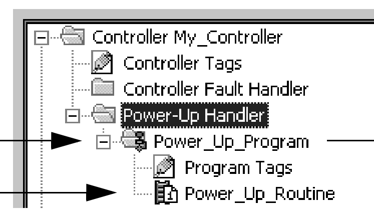


3. Configure the routine as the main routine for the program.

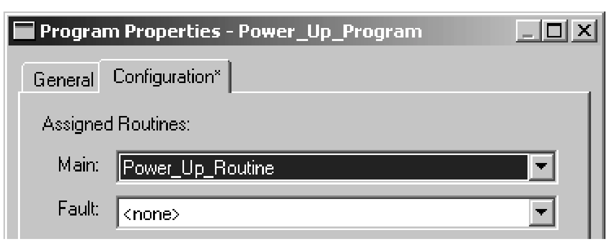
Create a Routine for the Power-Up Handler

The **power-up handler** is an optional task that executes when the controller powers up in run/remote run mode. Use the power-up handler when you want to accomplish either of the following after power is lost and then restored:

To:	Do this:
Prevent the controller from returning to run/remote mode	Leave the routine for the Power-Up Handler empty. When power is restored, a major fault (type 1, code 1) occurs and the controller enters the Faulted mode.
When power is restored, take specific actions and then resume normal operation	In the routine for the Power-Up Handler: 1. Clear the major fault (type 1, code 1). 2. Enter the logic for the actions.



1. Create a program for the Power-Up Handler.
2. Create a routine for the program.



3. Configure the routine as the main routine for the program.

Programmatically Clear a Major Fault

To clear a major fault that occurs during the execution of your project, complete the following actions in the appropriate routine. (See *Choose Where to Place the Fault Routine* on page 15-2.)

Create a Data Type to Store Fault Information

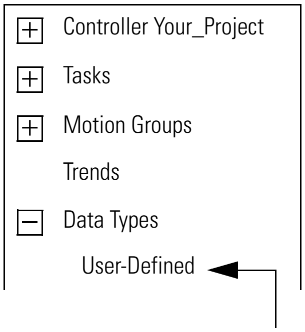
Logix5000 controllers store system information in objects. Unlike PLC-5 or SLC 500 controllers, there is no status file.

- To access system information, you use a Get System Value (GSV) or Set System Value (SSV) instruction.
- For status information about a program, you access the PROGRAM object.
- For fault information, you access the following attribute of the PROGRAM object.

Attribute:	Data Type:	Instruction:	Description:
MajorFaultRecord	DINT[11]	GSV SSV	Records major faults for this program Specify the program name to determine which PROGRAM object you want. (Or specify THIS to access the PROGRAM object for the program that contains the GSV or SSV instruction.)

To simplify access to the MajorFaultRecord attribute, create the following user-defined data type:

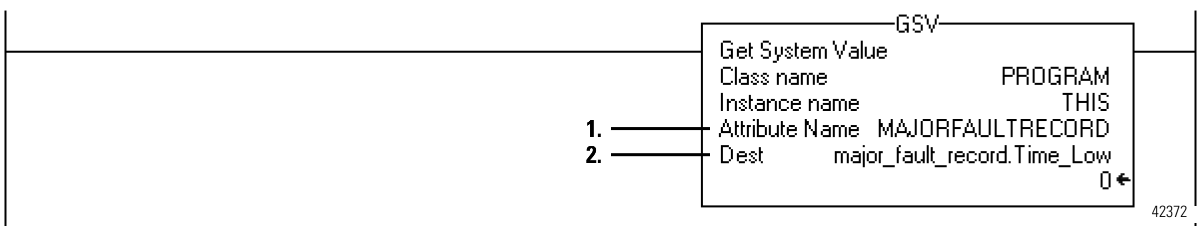
To create a new data type:



Right-click and choose *New Data Type*.

Data Type: FAULTRECORD				
Name	FAULTRECORD			
Description	Stores the MajorFaultRecord attribute or MinorFaultRecord attribute of the PROGRAM object.			
Members				
	Name	**Data Type**	**Style**	**Description**
	Time_Low	DINT	Decimal	lower 32 bits of the fault timestamp value
	Time_High	DINT	Decimal	upper 32 bits of the fault timestamp value
	Type	INT	Decimal	fault type (program, I/O, etc)
	Code	INT	Decimal	unique code for the fault
	Info	DINT[8]	Hex	fault specific information

Get the Fault Type and Code

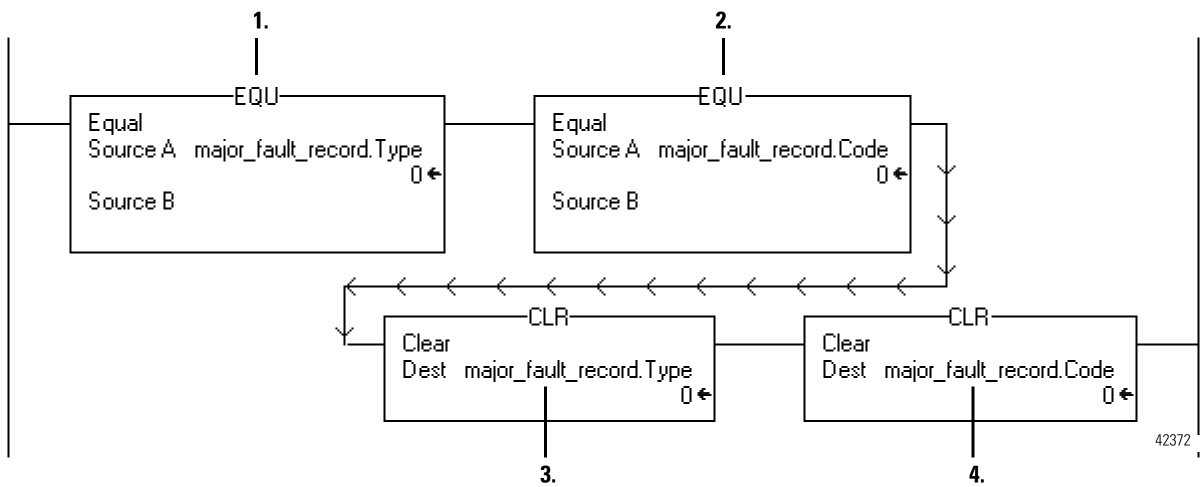


1. The GSV instruction accesses the MAJORFAULTRECORD attribute of this program. This attribute stores information about the fault.

2. The GSV instruction stores the fault information in the *major_fault_record* tag. When you enter a tag that is based on a structure, enter the first member of the tag.

Tag Name	Type
major_fault_record	FAULTRECORD

Check for a Specific Fault



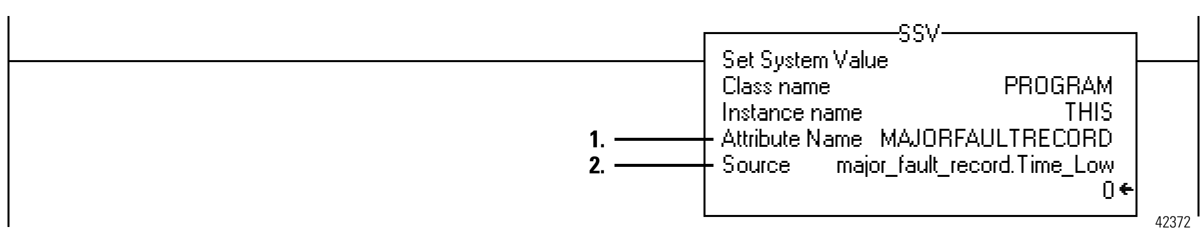
1. This EQU instruction checks for a specific type of fault, such as program, I/O. In Source B, enter the value for the type of fault that you want to clear.

2. This EQU instruction checks for a specific fault code. In Source B, enter the value for the code that you want to clear.

3. This CLR instruction sets to zero the value of the fault type in the *major_fault_record* tag.

4. This CLR instruction sets to zero the value of the fault code in the *major_fault_record* tag.

Clear the Fault



1. The SSV instruction writes new values to the MAJORFAULTRECORD attribute of this program.

2. The SSV instruction writes the values contained in the *major_fault_record* tag. Since the *Type* and *Code* member are set to zero, the fault clears and the controller resumes execution.

Clear a Major Fault During Prescan

If the controller faults immediately after you switch it to the Run mode, then examine the **prescan** operation for the fault. Depending on the revision of your controller, an array subscript that is beyond the range of the array (out of range) during prescan may or may not produce a fault:

If your controller is revision:	Then:
11.x or earlier	During prescan, an array subscript that is beyond the range of the array (out of range) produces a major fault.
12.x	See the release notes for the firmware of your controller.
13.0 or later	During prescan, the controller automatically clears any faults due to an array subscript that is beyond the range of the array (out of range).

To clear a major fault that occurs during prescan:

☐ Identify When the Controller is in Prescan

☐ Get the Fault Type and Code

☐ Check for a Specific Fault

☐ Clear the Fault

Identify When the Controller is in Prescan

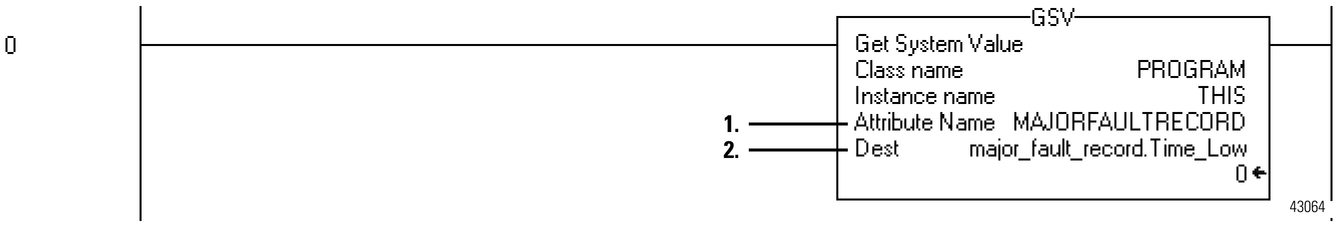
In the main routine of your program, enter the following rung:

1. Enter this rung as the first rung in the main routine of the program.
2. The fault routine of this program uses the status of this bit to determine if the fault occurred during prescan or normal scan of the logic:
   - During prescan, this bit is off. (During prescan, the controller resets all bits that are referenced by OTE instructions.)
   - Once the controller begins to execute the logic, this bit will always be on.

Tag Name	Type
CPU_scanning	BOOL

Get the Fault Type and Code

Enter this rung in the fault routine for the program:

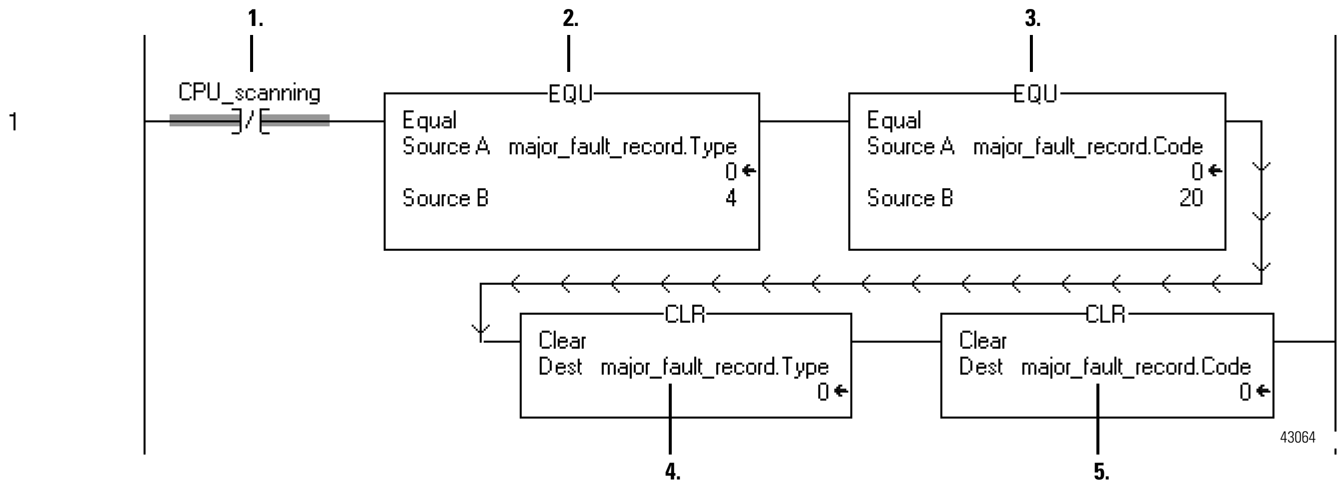


1. The GSV instruction accesses the MAJORFAULTRECORD attribute of this program. This attribute stores information about the fault.
2. The GSV instruction stores the fault information in the *major_fault_record* tag. When you enter a tag that is based on a structure, enter the first member of the tag.

Tag Name	Type
major_fault_record	FAULTRECORD

Check for a Specific Fault

Enter this rung in the fault routine for the program:



1. During prescan the bits of all OTE instructions are off and this instruction is true. Once the controller begins to execute the logic, this instruction is always false.

2. This EQU instruction checks for a fault of type 4, which means that an instruction in this program caused the fault.

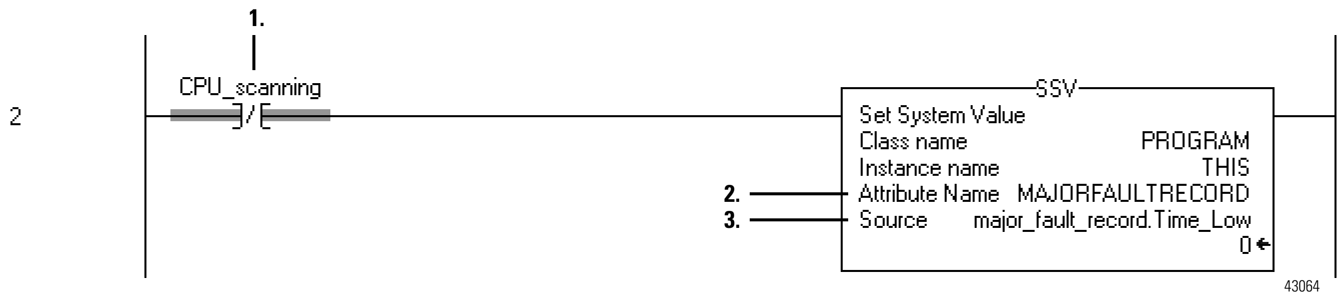
3. This EQU instruction checks for a fault of code 20, which means that either an array subscript is too large, or a POS or LEN value of a CONTROL structure is invalid.

4. This CLR instruction sets to zero the value of the fault type in the *major_fault_record* tag.

5. This CLR instruction sets to zero the value of the fault code in the *major_fault_record* tag.

Clear the Fault

Enter this rung in the fault routine for the program:



1. During prescan the bits of all OTE instructions are off and this instruction is true. Once the controller begins to execute the logic, this instruction is always false.

2. The SSV instruction writes new values to the MAJORFAULTRECORD attribute of this program.

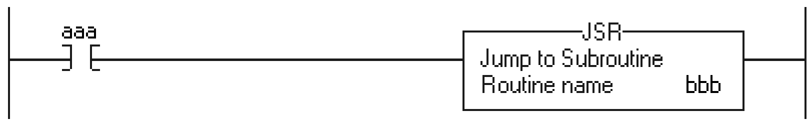
3. The SSV instruction writes the values contained in the *major_fault_record* tag. Since the *Type* and *Code* member are set to zero, the fault clears and the controller resumes execution.

Test a Fault Routine

You can use a JSR instruction to test the fault routine of a program without creating an error (i.e., simulate a fault):

1. Create a BOOL tag that you will use to initiate the fault.

2. In the main routine or a subroutine of the program, enter the following rung:

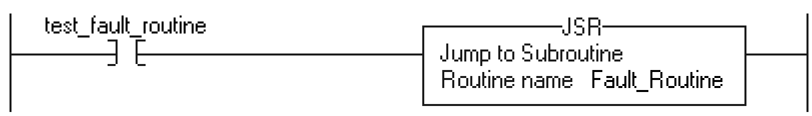


where:	is the:
aaa	tag that you will use to initiate the fault (Step 1.)
bbb	fault routine of the program

3. To simulate a fault, set the input condition.

EXAMPLE Test a fault routine

When *test_fault_routine* is on, a major fault occurs and the controller executes *Fault_Routine.*



Create a User-Defined Major Fault

If you want to suspend (shut down) the controller based on conditions in your application, create a user-defined major fault. With a user-defined major fault:

- The fault type = 4.
- You define a value for the fault code. Choose a value between 990 to 999. These codes are reserved for user-defined faults.
- The controller handles the fault the same as other major faults:
  - The controller changes to the **faulted mode** (major fault) and stops executing the logic.
  - Outputs are set to their configured state or value for faulted mode.

EXAMPLE

User-defined major fault

When *Tag_1.0* = 1, produce a major fault and generate a fault code of 999.

To create a user-defined major fault:

- ☐ Create a Fault Routine for the Program
- ☐ Configure the Program to Use the Fault Routine
- ☐ Jump to the Fault Routine

Create a Fault Routine for the Program

Does a fault routine already exist for the program?

If:	Then:
Yes	Go to "Jump to the Fault Routine" on page 15-14
No	Create a fault routine for the program:

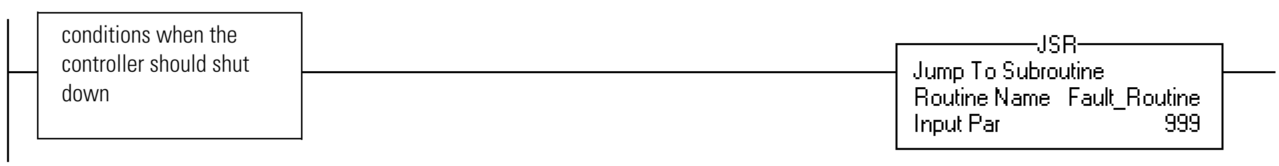
1. In the controller organizer, right-click the program and choose *New Routine*.
2. In the name box, type a name for the fault routine (`name_of_fault_routine`).
3. From the *Type* drop-down list, choose *Ladder*.
4. Choose *OK*.

Configure the Program to Use the Fault Routine

1. In the controller organizer, right-click the program and choose *New Routine*.
2. Click the *Configuration* tab.
3. From the *Fault* drop-down list, choose the fault routine.
4. Choose *OK*.

Jump to the Fault Routine

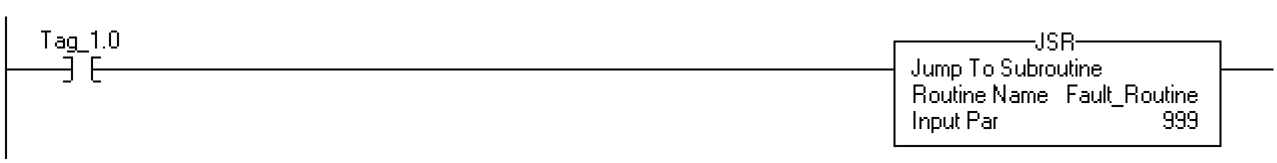
In the main routine of the program, enter the following rung:



where:	is:
`Fault_Routine`	name of the fault routine for the program
`x`	value for the fault code

EXAMPLE Create a User-Defined Major Fault

When *Tag_1.0* = 1, execution jumps to *name_of_fault_routine*. A major fault occurs and the controller enters the faulted mode. Outputs go to the faulted state. The Controller Properties dialog box, Major Faults tab, displays the code *999*.



Major Fault Codes

Use the following table to determine the cause and corrective action for a major fault. The type and code correspond to the type and code displayed in these locations:

- Controller Properties dialog box, Major Faults tab
- PROGRAM object, MAJORFAULTRECORD attribute

Table 15.1 Major Fault Types and Codes

Type:	Code:	Cause:	Recovery Method:
1	1	The controller powered on in Run mode.	Execute the power-loss handler.
1	60	For a controller with *no* CompactFlash card installed, the controller: • detected a non-recoverable fault • cleared the project from memory	1. Clear the fault. 2. Download the project. 3. Change to remote run/run mode. If the problem persists: 1. Before you cycle power to the controller, record the state of the OK and RS232 LEDs. 2. Contact Rockwell Automation support. See the back of this publication.
1	61	For a controller with a CompactFlash card installed, the controller: • detected a non-recoverable fault • wrote diagnostic information to the CompactFlash card • cleared the project from memory	1. Clear the fault. 2. Download the project. 3. Change to remote run/run mode. If the problem persists, contact Rockwell Automation support. See the back of this publication.
3	16	A required I/O module connection failed.	Check that the I/O module is in the chassis. Check electronic keying requirements. View the controller properties Major Fault tab and the module properties Connection tab for more information about the fault.
3	20	Possible problem with the ControlBus chassis.	Not recoverable - replace the chassis.
3	23	At least one required connection was not established before going to Run mode.	Wait for the controller I/O light to turn green before changing to Run mode.
4	16	Unknown instruction encountered.	Remove the unknown instruction. This probably happened due to a program conversion process.
4	20	Array subscript too big, control structure .POS or .LEN is invalid.	Adjust the value to be within the valid range. Don't exceed the array size or go beyond dimensions defined.
4	21	Control structure .LEN or .POS < 0.	Adjust the value so it is > 0.
4	31	The parameters of the JSR instruction do not match those of the associated SBR or RET instruction.	Pass the appropriate number of parameters. If too many parameters are passed, the extra ones are ignored without any error.
4	34	A timer instruction has a negative preset or accumulated value.	Fix the program to not load a negative value into timer preset or accumulated value.
4	42	JMP to a label that did not exist or was deleted.	Correct the JMP target or add the missing label.

Table 15.1 Major Fault Types and Codes (Continued)

Type:	Code:	Cause:	Recovery Method:
4	82	A sequential function chart (SFC) called a subroutine and the subroutine tried to jump back to the calling SFC. Occurs when the SFC uses either a JSR or FOR instruction to call the subroutine.	Remove the jump back to the calling SFC.
4	83	The data tested was not inside the required limits.	Modify value to be within limits.
4	84	Stack overflow.	Reduce the subroutine nesting levels or the number of parameters passed.
4	89	In a SFR instruction, the target routine does not contain the target step.	Correct the SFR target or add the missing step.
6	1	Task watchdog expired. User task has not completed in specified period of time. A program error caused an infinite loop, or the program is too complex to execute as quickly as specified, or a higher priority task is keeping this task from finishing.	Increase the task watchdog, shorten the execution time, make the priority of this task “higher,” simplify higher priority tasks, or move some code to another controller.
7	40	Store to nonvolatile memory failed.	1. Try again to store the project to nonvolatile memory. 2. If the project fails to store to nonvolatile memory, replace the memory board.
7	42	Load from nonvolatile memory failed because the firmware revision of the project in nonvolatile memory does not match the firmware revision of the controller.	Update the controller firmware to the same revision level as the project that is in nonvolatile memory.
8	1	Attempted to place controller in Run mode with keyswitch during download.	Wait for the download to complete and clear fault.
11	1	Actual position has exceeded positive overtravel limit.	Move axis in negative direction until position is within overtravel limit and then execute Motion Axis Fault Reset.
11	2	Actual position has exceeded negative overtravel limit.	Move axis in positive direction until position is within overtravel limit and then execute Motion Axis Fault Reset.
11	3	Actual position has exceeded position error tolerance.	Move the position within tolerance and then execute Motion Axis Fault Reset.
11	4	Encoder channel A, B, or Z connection is broken.	Reconnect the encoder channel then execute Motion Axis Fault Reset.
11	5	Encoder noise event detected or the encoder signals are not in quadrature.	Fix encoder cabling then execute Motion Axis Fault Reset.
11	6	Drive Fault input was activated.	Clear Drive Fault then execute Motion Axis Fault Reset.
11	7	Synchronous connection incurred a failure.	First execute Motion Axis Fault Reset. If that doesn’t work, pull servo module out and plug back in. If all else fails replace servo module.

Table 15.1 Major Fault Types and Codes (Continued)

Type:	Code:	Cause:	Recovery Method:
11	8	Servo module has detected a serious hardware fault.	Replace the module.
11	9	Asynchronous Connection has incurred a failure.	First execute Motion Axis Fault Reset. If that doesn't work, pull servo module out and plug back in. If all else fails replace servo module.
11	32	The motion task has experienced an overlap.	The group's course update rate is too high to maintain correct operation. Clear the group fault tag, raise the group's update rate, and then clear the major fault.

Notes:

Monitor Minor Faults

When to Use This Procedure

If a fault condition occurs that is *not* severe enough for the controller to shut down, the controller generates a **minor fault**.

- The controller continues to execute.
- You do not need to clear a minor fault.
- To optimize execution time and ensure program accuracy, you should monitor and correct minor faults.

Monitor Minor Faults

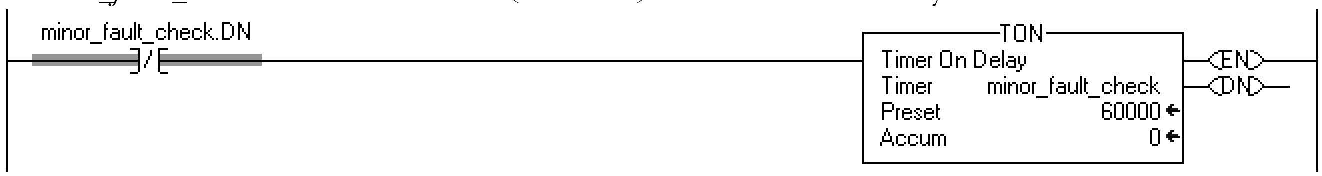
To use ladder logic to capture information about a minor fault:

<table>
<tr><th>To check for a:</th><th>Do this:</th></tr>
<tr><td>periodic task overlap</td><td>1. Enter a GSV instructions that gets the FAULTLOG object, MinorFaultBits attribute.
2. Monitor bit 6.</td></tr>
<tr><td>load from nonvolatile memory</td><td>1. Enter a GSV instructions that gets the FAULTLOG object, MinorFaultBits attribute.
2. Monitor bit 7.</td></tr>
<tr><td>problem with the serial port</td><td>1. Enter a GSV instructions that gets the FAULTLOG object, MinorFaultBits attribute.
2. Monitor bit 9.</td></tr>
<tr><td>low battery</td><td>1. Enter a GSV instructions that gets the FAULTLOG object, MinorFaultBits attribute.
2. Monitor bit 10.</td></tr>
<tr><td>problem with an instruction</td><td>1. Create a user-defined data type that stores the fault information. Name the data type FaultRecord and assign the following members:
<table>
<tr><th>Name:</th><th>Data Type:</th><th>Style:</th></tr>
<tr><td>TimeLow</td><td>DINT</td><td>Decimal</td></tr>
<tr><td>TimeHigh</td><td>DINT</td><td>Decimal</td></tr>
<tr><td>Type</td><td>INT</td><td>Decimal</td></tr>
<tr><td>Code</td><td>INT</td><td>Decimal</td></tr>
<tr><td>Info</td><td>DINT[8]</td><td>Hex</td></tr>
</table>
2. Create a tag that will store the values of the MinorFaultRecord attribute. Select the data type from step 1.
3. Monitor S:MINOR.
4. If S:MINOR is on, use a GSV instruction to get the values of the MinorFaultRecord attribute.
5. If you want to detect a minor fault that is caused by another instruction, reset S:MINOR. (S:MINOR remains set until the end of the scan.)</td></tr>
</table>

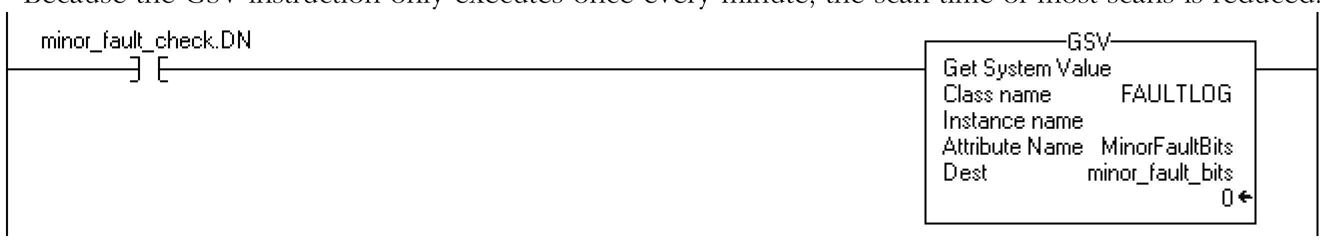
The following example checks for a low battery warning.

EXAMPLE Check for a minor fault

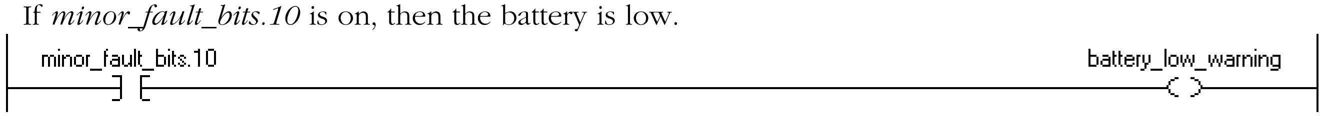
Minor_fault_check times for 1 minute (60000 ms) and then automatically restarts itself.



Every minute, *minor_fault_check.DN* turns on for one scan. When this occurs, the GSV instruction gets the value of the *FAULTLOG* object, *MinorFaultBits* attribute, and stores it in the *minor_fault_bits* tag. Because the GSV instruction only executes once every minute, the scan time of most scans is reduced.



If *minor_fault_bits.10* is on, then the battery is low.



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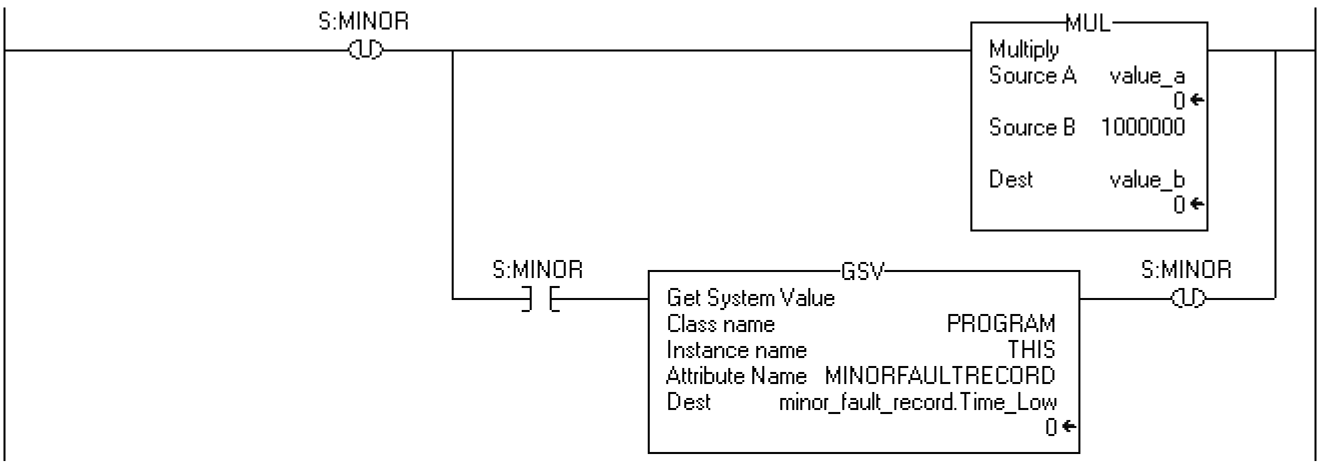
The following example checks for a minor fault that is caused by a specific instruction.

EXAMPLE Check for a minor fault that is caused by an instruction

Multiplies *value_a* by 1000000 and checks for a minor fault, such as a math overflow:

- To make sure that a previous instruction did not produce the fault, the rung first clears S:MINOR.
- The rung then executes the multiply instruction.
- If the instruction produces a minor fault, the controller sets S:MINOR.
- If S:MINOR is set, the GSV instruction gets information about the fault and resets S:MINOR.



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Minor Fault Codes

Use the following table to determine the cause and corrective action for a minor fault. The type and code correspond to the type and code displayed in these locations:

- Controller Properties dialog box, Minor Faults tab
- PROGRAM object, MINORFAULTRECORD attribute

Table 16.1 Minor Fault Types and Codes

Type:	Code:	Cause:	Recovery Method:
4	4	An arithmetic overflow occurred in an instruction.	Fix program by examining arithmetic operations (order) or adjusting values.
4	5	In a GSV/SSV instruction, the specified instance was not found.	Check the instance name.
4	6	In a GSV/SSV instruction, either: • specified Class name is *not* supported • specified Attribute name is *not* valid	Check the Class name and Attribute name.
4	7	The GSV/SSV destination tag was too small to hold all of the data.	Fix the destination so it has enough space.
4	35	PID delta time ≤ 0.	Adjust the PID delta time so that it is > 0.
4	36	PID setpoint out of range	Adjust the setpoint so that it is within range.
4	51	The LEN value of the string tag is greater than the DATA size of the string tag.	1. Check that no instruction is writing to the LEN member of the string tag. 2. In the LEN value, enter the number of characters that the string contains.
4	52	The output string is larger than the destination.	Create a new string data type that is large enough for the output string. Use the new string data type as the data type for the destination.
4	53	The output number is beyond the limits of the destination data type.	Either: • Reduce the size of the ASCII value. • Use a larger data type for the destination.
4	56	The Start or Quantity value is invalid.	1. Check that the Start value is between 1 and the DATA size of the Source. 2. Check that the Start value plus the Quantity value is less than or equal to the DATA size of the Source.
4	57	The AHL instruction failed to execute because the serial port is set to no handshaking.	Either: • Change the Control Line setting of the serial port. • Delete the AHL instruction.
6	2	Periodic task overlap. Periodic task has not completed before it is time to execute again.	Simplify program(s), or lengthen period, or raise relative priority, etc.
7	49	Project loaded from nonvolatile memory.	

Table 16.1 Minor Fault Types and Codes (Continued)

Type:	Code:	Cause:	Recovery Method:
9	0	Unknown error while servicing the serial port.	Contact GTS personnel.
9	1	The CTS line is not correct for the current configuration.	Disconnect and reconnect the serial port cable to the controller. Make sure the cable is wired correctly
9	2	Poll list error. A problem was detected with the DF1 master's poll list, such as specifying more stations than the size of the file, specifying more then 255 stations, trying to index past the end of the list, or polling the broadcast address (STN #255).	Check for the following errors in the poll list: • total number of stations is greater than the space in the poll list tag • total number of stations is greater than 255 • current station pointer is greater than the end of the poll list tag • a station number greater than 254 was encountered
9	5	DF1 slave poll timeout. The poll watchdog has timed out for slave. The master has not polled this controller in the specified amount of time.	Determine and correct delay for polling.
9	9	Modem contact was lost. DCD and/or DSR control lines are not being received in proper sequence and/or state.	Correct modem connection to the controller.
10	10	Battery not detected or needs to be replaced.	Install new battery.

Notes:

Store and Load a Project Using Nonvolatile Memory

When to Use This Procedure

IMPORTANT Nonvolatile memory stores the contents of the user memory at the time that you store the project.

- Changes that you make after you store the project are *not* reflected in nonvolatile memory.
- If you make changes to the project but do not store those changes, you overwrite them when you load the project from nonvolatile memory. If this occurs, you have to upload or download the project to go online.
- If you want to store changes such as online edits, tag values, or a ControlNet network schedule, store the project again after you make the changes.

Use this procedure to **store** or **load** a project using the **nonvolatile memory** of a controller.

- If the controller loses power and does not have enough battery capacity, it loses the project in user memory.
- Nonvolatile memory lets you keep a copy of your project on the controller. The controller does not need power to keep this copy.
- You can load the copy from nonvolatile memory to the user memory of the controller:
  - on every power-up
  - whenever there is no project in the controller and it powers-up
  - anytime through RSLogix 5000 software

How to Use This Procedure

If you want to:	See:
review preliminary information on how to use nonvolatile memory	"Before You Use Nonvolatile Memory" on page 17-2
store a project in the nonvolatile memory of the controller	"Store a Project" on page 17-9
overwrite the current project in the controller with the project that is stored in the nonvolatile memory of the controller	"Load a Project" on page 17-12
load the project after a power loss cleared the memory because there was no battery	
use ladder logic to flag that your project loaded from nonvolatile memory	"Check for a Load" on page 17-14
remove a project from the nonvolatile memory of the controller	"Clear Nonvolatile Memory" on page 17-15
• assign a different project to load from a CompactFlash card • change the load parameters for a project on a CompactFlash card	"Use a CompactFlash Reader" on page 17-18

Before You Use Nonvolatile Memory

A store or load has the following parameters:

Parameter:	Store:	Load:
How much time does a store or load take?	If the controller does *not* use a 1784-CF64 Industrial CompactFlash card, a store may take up to 3 minutes. If the controller uses a CompactFlash card, the store is considerably faster (less than a minute).	several seconds
In what controller mode (s) can I store or load a project?	program mode	
Can I go online with the controller during a store or load?	no	
What is the state of the I/O during a store or load?	I/O remains in its configured state for program mode.	

Choose a Controller That Has Nonvolatile Memory

The following Logix5000 controllers have nonvolatile memory for project storage.

Controller Type:	Catalog #:	Firmware Revision:	Requires a 1784-CF64 Industrial CompactFlash memory card:
CompactLogix5320	1769-L20	10.x or later	no
CompactLogix5330	1769-L30	10.x or later	no
CompactLogix5331	1769-L31	13.x or later	yes
CompactLogix5332E	1769-L32E	13.x or later	yes
CompactLogix5335CR	1769-L35CR	13.x or later	yes
CompactLogix5335E	1769-L35E	12.x or later	yes
ControlLogix5555	1756-L55M22	10.x or later	no
	1756-L55M23	8.x or later	no
	1756-L55M24	8.x or later	no
ControlLogix5560M03SE	1756-L60M03SE	13.x or later	yes
ControlLogix5561	1756-L61	12.x or later	yes
ControlLogix5562	1756-L62	12.x or later	yes
ControlLogix5563	1756-L63	11.x or later	yes
DriveLogix5720	various	10.x or later	no
DriveLogix5730	various	13.x or later	yes
FlexLogix5433	1794-L33	10.x or later	no
FlexLogix5434 Series B	1794-L34/B	11.x or later	no

Prevent a Major Fault During a Load

If the major and minor revision of the project in nonvolatile memory does not match the major and minor revision of the controller, a major fault *may* occur during a load.

If the controller:	Then:
does not use a CompactFlash card	Make sure that the major and minor revision of the project in nonvolatile memory matches the major and minor revision of the controller. The nonvolatile memory of the controller stores only the project. It does not store the firmware for the controller.
uses a CompactFlash card	The CompactFlash card stores the firmware for projects ≥ 12.0. Depending on the current revision of the controller, you may be able to use the CompactFlash card to update the firmware of the controller and load the project. See "Determine How to Handle Firmware Updates" on page 17-6.

Format a CompactFlash Card

When you store a project to a 1784-CF64 Industrial CompactFlash memory card, the controller formats the card, if required.

<table>
<tr><th>If the revision of your project is:</th><th>Then:</th></tr>
<tr><td>11.x</td><td>The CompactFlash card uses a special format.
• Use only a Logix5000 controller to store a project on a CompactFlash card. Do not use a CompactFlash reader to read from or write to the card with a computer.
• Store only a single Logix5000 project and no other data on a CompactFlash card.
• When you store a project on a CompactFlash card, you overwrite the entire contents of the card. In other words, you lose everything that is currently on the card.</td></tr>
<tr><td>≥ 12.0</td><td>The CompactFlash card uses the FAT16 file system.
<table>
<tr><th>If the card:</th><th>Then the controller:</th></tr>
<tr><td>is already formatted for the FAT16 file system</td><td>• Leaves existing data.
• Creates folders and files for the project and firmware.</td></tr>
<tr><td>is not formatted for the FAT16 file system</td><td>• Deletes existing data.
• Formats the card for the FAT16 file system.
• Creates folders and files for the project and firmware.</td></tr>
</table>
Once the CompactFlash card is formatted for the FAT16 file system:
• The CompactFlash card stores multiple projects and associated firmware.
• If the CompactFlash card already contains a project with same name, a store overwrites the project on the CompactFlash card.
• The CompactFlash card loads the most recently stored project.
With a revision ≥ 12.0, you can also use a CompactFlash reader to read and manipulate the files on a CompactFlash card. See “Use a CompactFlash Reader” on page 17-18.</td></tr>
</table>

Determine How to Handle Firmware Updates

The following table outlines the options and precautions for updating the firmware of a controller that has nonvolatile memory.

<table>
<tr><th>If:</th><th>Then:</th></tr>
<tr><td>You meet all of the following conditions:
❑ The controller uses a 1784-CF64 Industrial CompactFlash card.
❑ The project on the CompactFlash card has a revision ≥ 12.0.
❑ The project on the CompactFlash card has a Load Image option = On Power Up or On Corrupt Memory.
❑ If the controller is a 1756-L63 controller, its firmware revision is either:
❑ For a controller just out of its box, revision ≥ 1.4. (Look for the F/W REV. on the side of the controller or its box.)
❑ For a controller already in service, revision ≥ 12.0.</td>
<td>Update the firmware using either:
• CompactFlash card
• RSLogix 5000 software
• ControlFlash software
To update the firmware and load the project using the CompactFlash card:
1. Install the card in the controller.
2. If the Load Image option = On Corrupt Memory and the controller contains a project, disconnect the battery from the controller.
3. Turn on or cycle power to the controller.
If you use RSLogix 5000 software or ControlFlash software to update the firmware:
1. During the update, the controller sets the Load Image option of the CompactFlash card to User Initiated. To prevent this, remove the card from the controller.
2. After you update the firmware, store the project again to nonvolatile memory. This ensures that the revision of the project in nonvolatile memory matches the revision of the controller.</td></tr>
<tr><td>You do not meet all of the conditions listed above:</td>
<td>Update the firmware using either:
• RSLogix 5000 software
• ControlFlash software
Take these precautions:
1. Before you update the firmware:
<table>
<tr><th>If the controller:</th><th>Then:</th></tr>
<tr><td>does not use a CompactFlash card</td><td>Save the project to an offline file. When you update the firmware of the controller, you erase the contents of the nonvolatile memory (revision 10.x or later).</td></tr>
<tr><td>uses a CompactFlash card</td><td>Either:
• Remove the CompactFlash card from the controller.
• Check the Load Image option of the CompactFlash card. If it is set to On Power Up or On Corrupt Memory, first store the project with the Load Image option set to User Initiated.
Otherwise, you may get a major fault when you update the firmware of the controller. This occurs because the On Power Up or On Corrupt Memory options cause the controller to load the project from nonvolatile memory. The firmware mismatch after the load then causes a major fault.</td></tr>
</table>
2. After you update the firmware, store the project again to nonvolatile memory. This ensures that the revision of the project in nonvolatile memory matches the revision of the controller.</td></tr>
</table>

Choose When to Load an Image

You have several options for when (under what conditions) to load the project back into the user memory (RAM) of the controller:

If you want to load it:	Then select:	Notes:

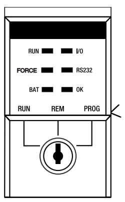
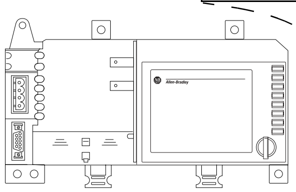
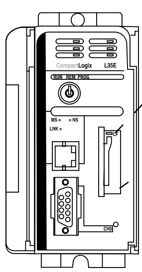
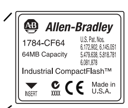
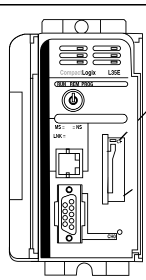
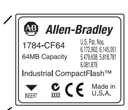
whenever you turn on or cycle the chassis power	*On Power Up*	• During a power cycle, you will lose any online changes, tag values, and network schedule that you have not stored in the nonvolatile memory.
		• A 1784-CF64 Industrial CompactFlash card may also change the firmware of the controller.
		  • This occurs if both the revision of the project on the CompactFlash card and the revision of the controller firmware are ≥ 12.0.
		  • For more information, see “Determine How to Handle Firmware Updates” on page 17-6.
		• You can always use RSLogix 5000 software to load the project.

whenever there is no project in the controller and you turn on or cycle the chassis power	*On Corrupt Memory*	• For example, if the battery becomes discharged and the controller loses power, the project is cleared from memory. When power is restored, this load option loads the project back into the controller.
		• A 1784-CF64 Industrial CompactFlash card may also change the firmware of the controller.
		  • This occurs if both the revision of the project on the CompactFlash card and the revision of the controller firmware are ≥ 12.0.
		  • For more information, see “Determine How to Handle Firmware Updates” on page 17-6.
		• You can always use RSLogix 5000 software to load the project.

only through RSLogix 5000 software	*User Initiated*	

Examples

Here are some example uses for the different load options:

Example:	Description:
1.  Nonvolatile memory Load Image = On Power Up Load Mode = Program	1. You update the firmware of the controller to the desired revision. 2. You store the project for the controller in nonvolatile memory. 3. When you turn on power to the controller after installation, the project loads into the controller. 4. The controller remains in program mode.
2. Nonvolatile memory Load Image = On Corrupt Memory Load Mode = Run 	1. You store the project for the controller in nonvolatile memory. (The major and minor revision of firmware in the controller match the major and minor revision of the project in nonvolatile memory.) 2. If the battery of the controller becomes completely discharged and power to the controller is interrupted, the project is cleared from controller memory. 3. When power is restored, the project automatically loads into the controller and the controller returns to the run mode.
3.   Load Image = On Power Up Load Mode = Program Revision ≥ 12.0	1. The controller fails. 2. You remove the CompactFlash card. 3. You replace the failed controller with a new controller. 4. You replace the CompactFlash card. 5. When you turn on the power, both the firmware and project load into the controller. The controller remains in program mode.
4.   Load Image = User Initiated Load Mode = n/a	1. You want to load a different project into your controller. 2. A CompactFlash card contains the desired project. 3. With the CompactFlash card installed in the controller, you use RSLogix 5000 software to load the project into the controller.

Store a Project

In this task, you store a project in the nonvolatile memory of the controller.

ATTENTION

During a store, all active servo axes are turned off. Before you store a project, make sure that this *will not* cause any unexpected movement of an axis.

Before you store the project:

- make all the required edits to the logic
- download the project to the controller
- schedule your ControlNet networks

To store a project:

- ☐ Configure the Store Operation
- ☐ Store the Project
- ☐ Save the Online Project

Configure the Store Operation

1. Go online with the controller.

2. Put the controller in Program mode (Rem Program or Program).

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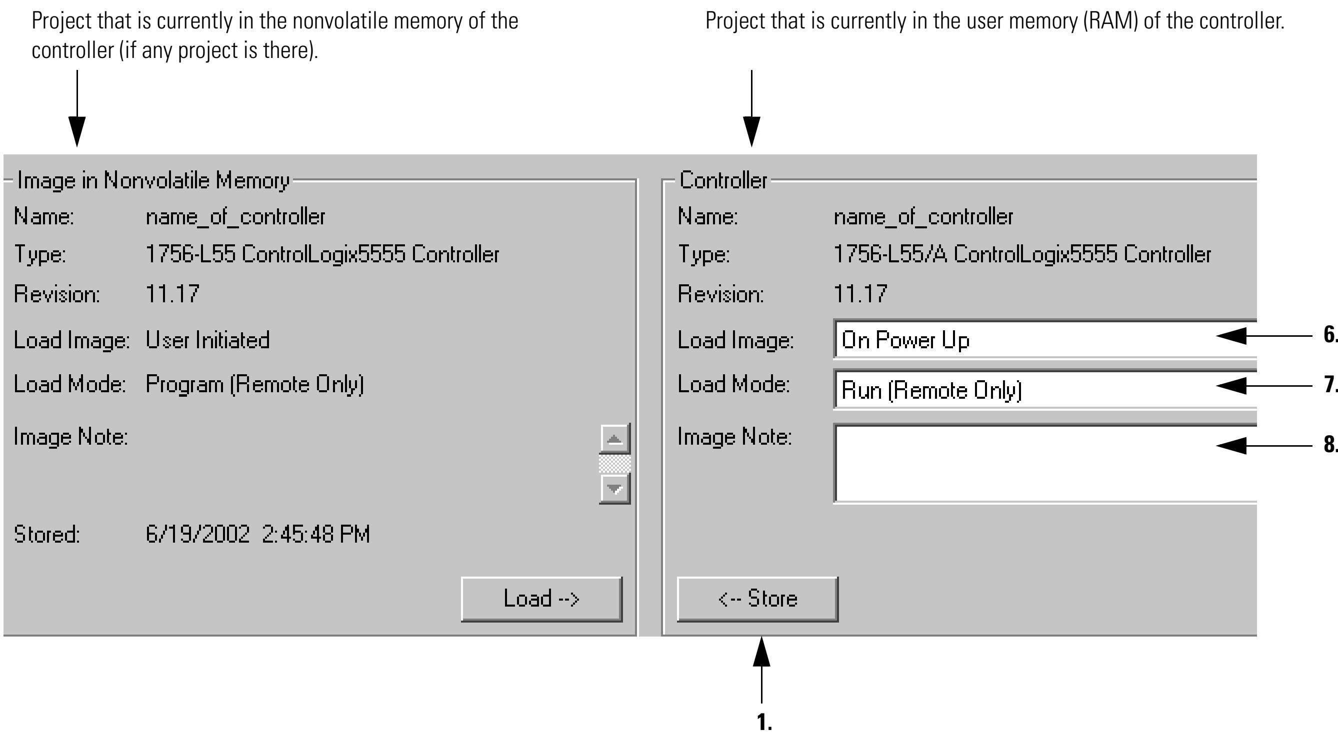
3. On the Online toolbar, click the controller properties button.

4. Click the *Nonvolatile Memory* tab.

5. Choose *Load/Store*.



6. Choose when (under what conditions) to load the project back into the user memory (RAM) of the controller.

7. In step 6, which load image option did you select?

If:	Then:
On Power Up On Corrupt Memory	Select the mode that you want the controller to go to after a load: • remote program • remote run To go to this mode after a load, turn the keyswitch of the controller to the REM position.
User Initiated	Go to step 8.

8. Type a note that describes the project that you are storing, if desired.

Store the Project

1. Choose <– *Store*.

A dialog box asks you to confirm the store.

2. To store the project, choose *Yes*.

During the store, the following events occur:

- On the front of the controller, the OK LED displays the following sequence:
  flashing green ⇒ solid red ⇒ solid green
- RSLogix 5000 software goes offline.
- A dialog box tells you that the store is in progress.

3. Choose *OK*.

When the store is finished, you remain offline.

Save the Online Project

1. Go online with the controller.

2. Save the project.

Load a Project

In this task, you use RSLogix 5000 software to load the project from nonvolatile memory.

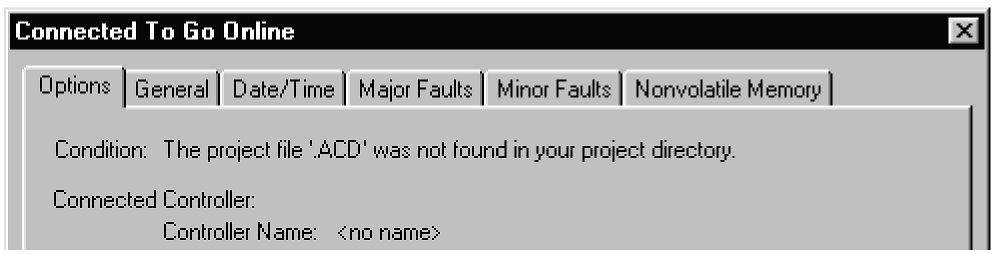
ATTENTION

During a load, all active servo axes are turned off. Before you load a project, make sure that this *will not* cause any unexpected movement of an axis.

Steps:

1. Go online with the controller.

2. Did the following dialog box open?



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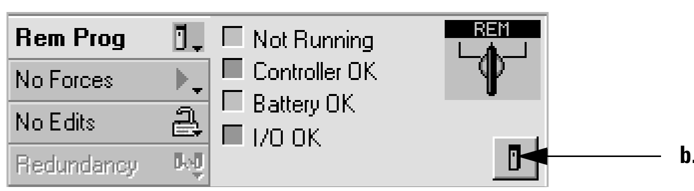
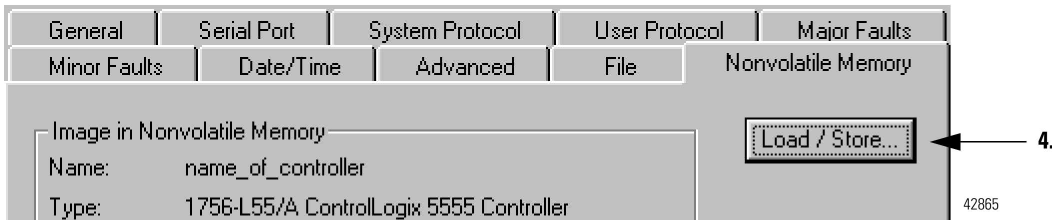
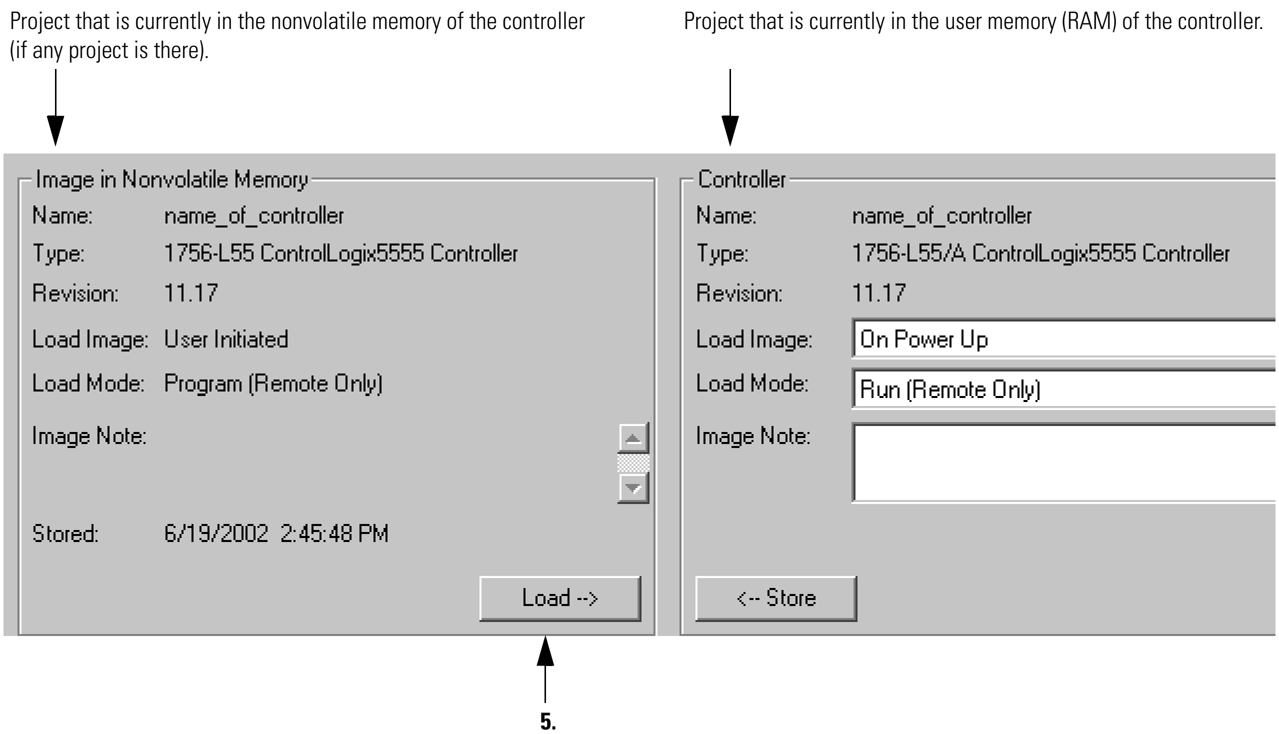
If:	Then:
No	a. Put the controller in Program mode (Rem Program or Program).  b. On the Online toolbar, click the controller properties button.
Yes	Put the controller in Program mode (Rem Program or Program). Use either the: • *General* tab of the *Connected To Go Online* dialog box. • keyswitch on the front of the controller

3. Click the *Nonvolatile Memory* tab.



4. Choose *Load/Store*.



5. Choose *Load* –>.

A dialog box asks you to confirm the load.

6. To load the project from the nonvolatile memory, choose *Yes*.

During the load, the following events occur:

- On the front of the controller, the OK LED displays the following sequence:

If the load:	Then the OK LED displays:
does not include firmware	solid red ⇒ solid green
includes firmware	flashing red ⇒ solid red ⇒ solid green

- RSLogix 5000 software goes offline.

When the load is finished, you remain offline. If you want to be online, you must manually go online.

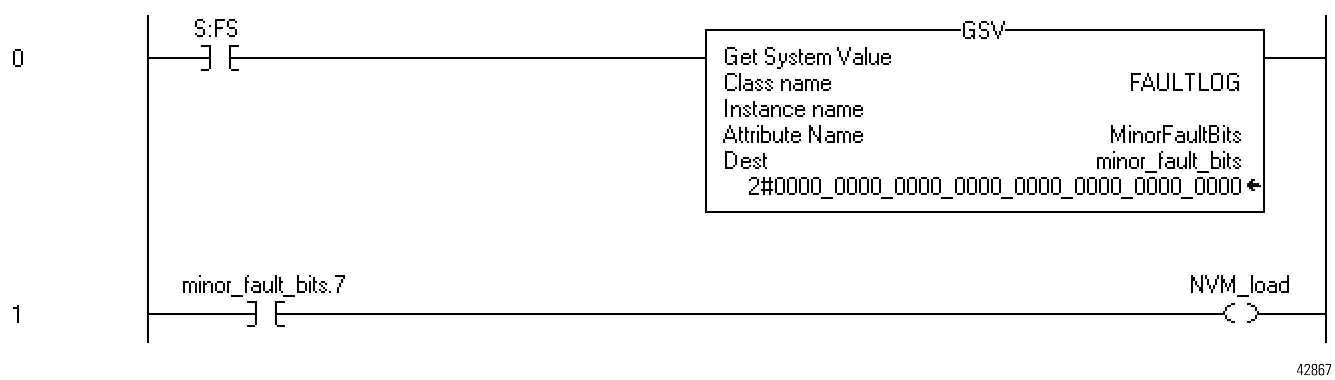
Check for a Load

When the controller loads a project from nonvolatile memory, it provides the following information:

- logs a minor fault (type 7, code 49)
- sets the FAULTLOG object, MinorFaultBits attribute, bit 7

If you want your project to flag that it loaded from nonvolatile memory, use the following ladder logic:

On the first scan of the project (*S:FS* is on), the GSV instruction gets the FAULTLOG object, MinorFaultBits attribute, and stores the value in *minor_fault_bits*. If bit 7 is on, the controller loaded the project from its nonvolatile memory.



Where:	Is:
`minor_fault_bits`	Tag that stores the FAULTLOG object, MinorFaultBits attribute. Data type is DINT.
`NVM_load`	Tag that indicates that the controller loaded the project from its nonvolatile memory.

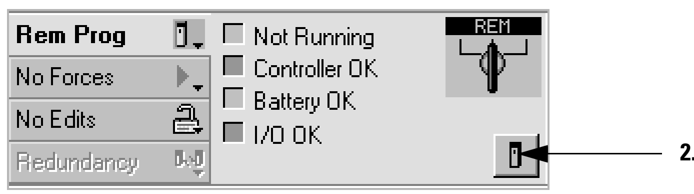
Clear Nonvolatile Memory

To remove a project from nonvolatile memory, complete the following actions:

- ☐ Check the Current Load Image Option
- ☐ Change the Load Image Option
- ☐ Clear the Project from the Controller
- ☐ Store the Empty Image

Check the Current Load Image Option

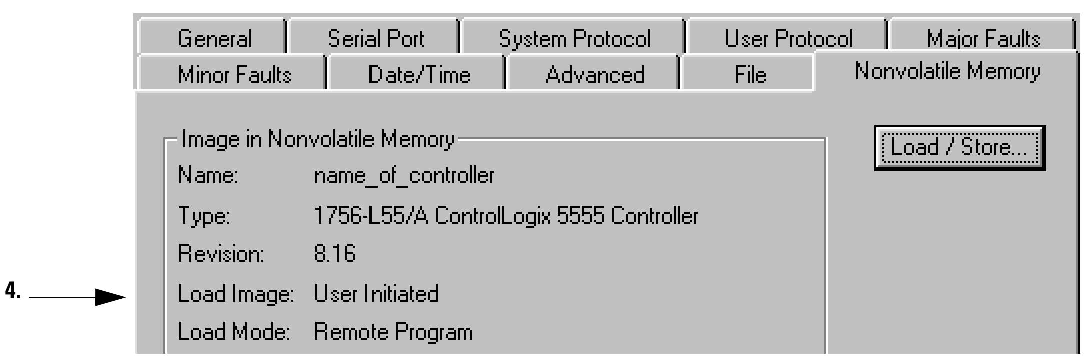
1. Go online with the controller.



42627

2. On the Online toolbar, click the controller properties button.

3. Click the *Nonvolatile Memory* tab.



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4. Is the *Load Image* option set to *User Initiated*?

If:	Then:
No	Go to “Change the Load Image Option” on page 17-16.
Yes	Go to “Clear the Project from the Controller” on page 17-16.

Change the Load Image Option

1. Choose *Load/Store*.
2. In the *Load Image* drop-down list, select *User Initiated*.
3. Choose <- *Store*.

   A dialog box asks you to confirm the store.
4. To store the project, choose *Yes*.

   A dialog box tells you that the store is in progress.
5. Choose *OK*.
6. Wait until the OK LED on the front of the controller is steady green. This indicates that the store is finished.

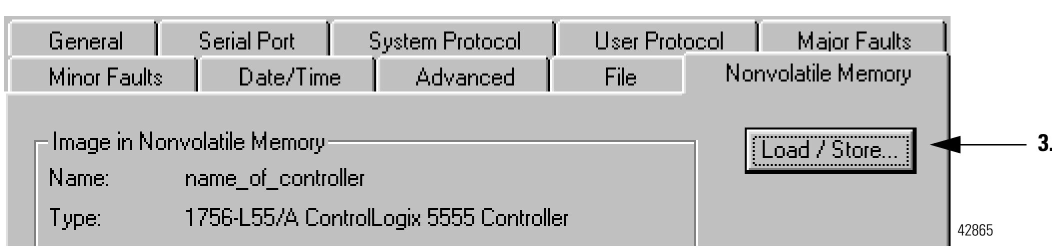
Clear the Project from the Controller

1. Disconnect the battery from the controller.
2. Cycle the power to the chassis.
3. Re-connect the battery to the controller.

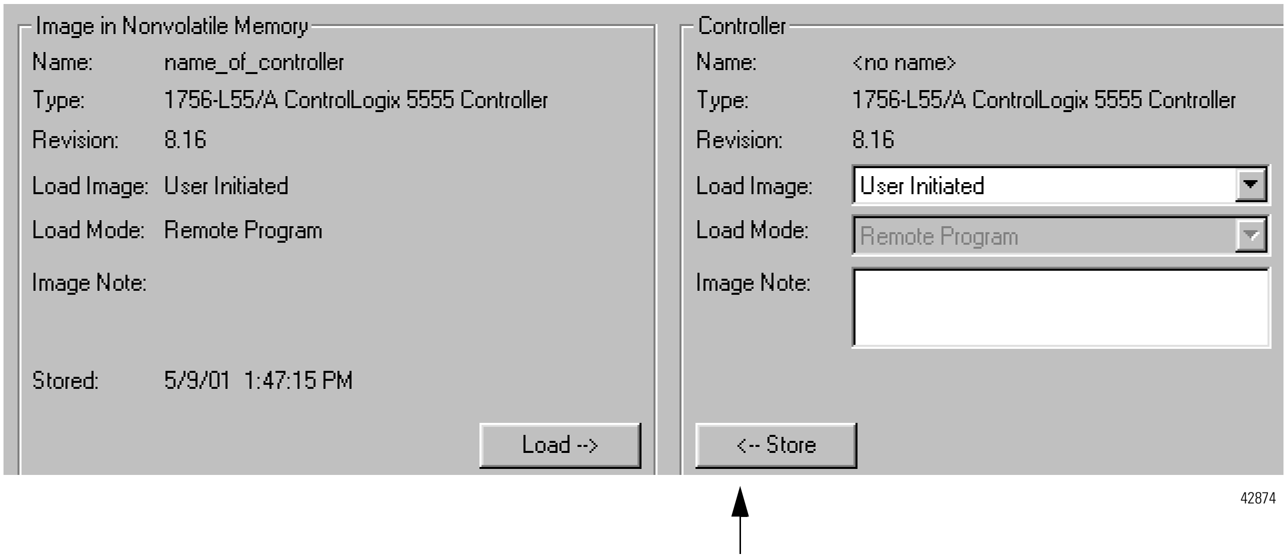
Store the Empty Image

1. Go online with the controller.

   The Connected To Go Online dialog box opens.
2. Click the *Nonvolatile Memory* tab.



3. Choose *Load/Store*.



4. Choose <– *Store*.

   A dialog box asks you to confirm the store.

5. To store the project, choose *Yes*.

   During the store, the following events occur:

   - On the front of the controller, the OK LED displays the following sequence:
     flashing green ⇒ red ⇒ green
   - RSLogix 5000 software goes offline.
   - A dialog box tells you that the store is in progress.

6. Choose *OK*.

When the store is finished, you remain offline. If you want to be online, you must manually go online.

Use a CompactFlash Reader

If the revision of the project or projects on your CompactFlash card are ≥ 12.0, then the card is formatted using the FAT16 file system.

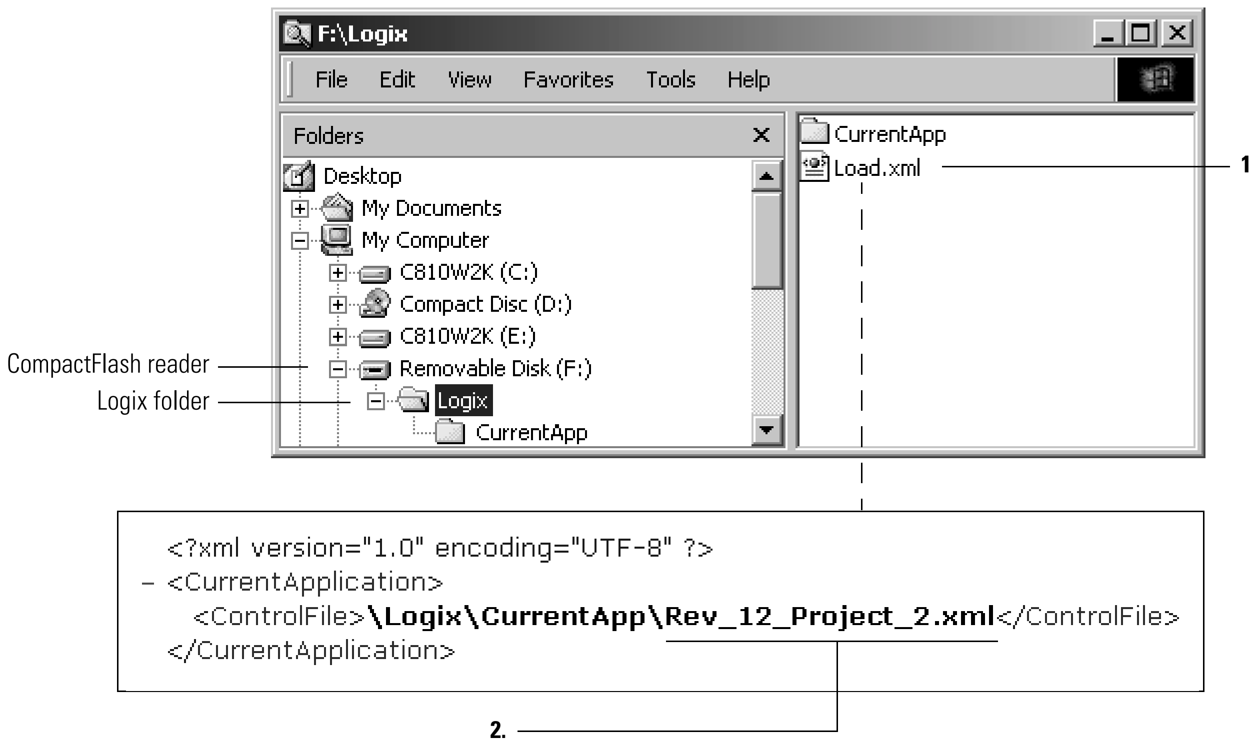
- Typically, you do *not* have to manage the files on a CompactFlash card. The card automatically loads the project that you most recently stored.
- For additional flexibility, the file system also lets you:

  - [ ] Manually Change Which Project Loads from the CompactFlash Card
  - [ ] Manually Change the Load Parameters for a Project

Manually Change Which Project Loads from the CompactFlash Card

A CompactFlash card stores multiple projects. By default, the controller loads the project that you most recently stored, according to the load options of that project.

To assign a different project to load from the CompactFlash card, edit the *Load.xml* file on the card.



1. To change which project loads from the card, open *Load.xml*. Use a text editor to open the file.

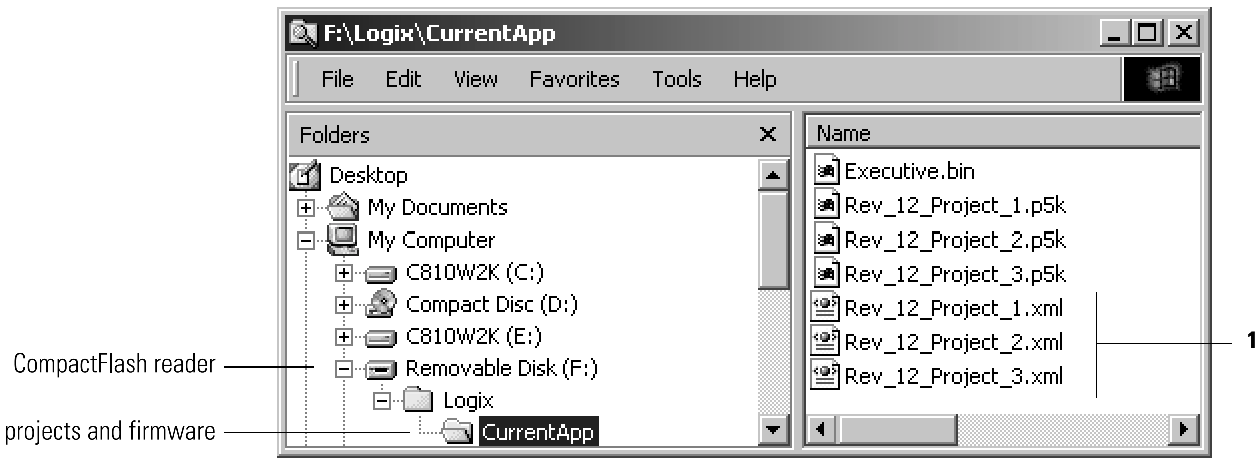
2. Edit the name of the project that you want to load.
   - Use the name of an XML file that is in the *CurrentApp* folder.
   - In the *CurrentApp* folder, a project is comprised of an XML file and a P5K file.

Manually Change the Load Parameters for a Project

When you store a project to nonvolatile memory, you define:

- when the project is to load (*On Power Up*, *On Corrupt Memory, User Initiated*)
- mode to which to set the controller (if the keyswitch is in REM and the load mode is not *User Initiated*)

To assign a different project to load from the CompactFlash card, edit the *Load.xml* file on the card.



1. To change the load parameters for a project, open the XML file with the same name as the project. Use a text editor to open the file.

```
     <?xml version="1.0" encoding="UTF-8" ?>
   - <Controller>
     - <ExecutiveLoadOption>
         <ExecFile>\Logix\CurrentApp\Executive.bin</ExecFile>
       </ExecutiveLoadOption>
     - <ProgramLoadOption>
2.       <ProgramLoadMode>CORRUPT_RAM</ProgramLoadMode>
         <LoadFile>\Logix\CurrentApp\Rev_12_Project_2.p5k</LoadFile>
       </ProgramLoadOption>
     - <ControllerModeOption>
3.       <ControllerMode>RUN</ControllerMode>
       </ControllerModeOption>
     </Controller>
```

2. Edit the Load Image option of the project.

If you want to set the Load Image option to:	Then enter:
On Power Up	ALWAYS
On Corrupt Memory	CORRUPT_RAM
User Initiated	USER_INITIATED

3. Edit the Load Mode option of the project (doesn't apply if the Load Image option is *User Initiated*).

If you want to set the Load Mode option to:	Then enter:
Program (Remote Only)	PROGRAM
Run (Remote Only)	RUN

Secure a Project

When to Use This Procedure

Use this procedure to control who has access to your project. To secure a project, these options are available:

If you want to:	Then:	See page:
Prevent others from seeing the logic within one or more routines of a project	Use Routine Source Protection	18-1
Assign varying levels of access to a project, such as let: • engineers have full access • maintenance personal make limited changes • operators only view logic and data	Use RSI Security Server to Protect a Project	18-13

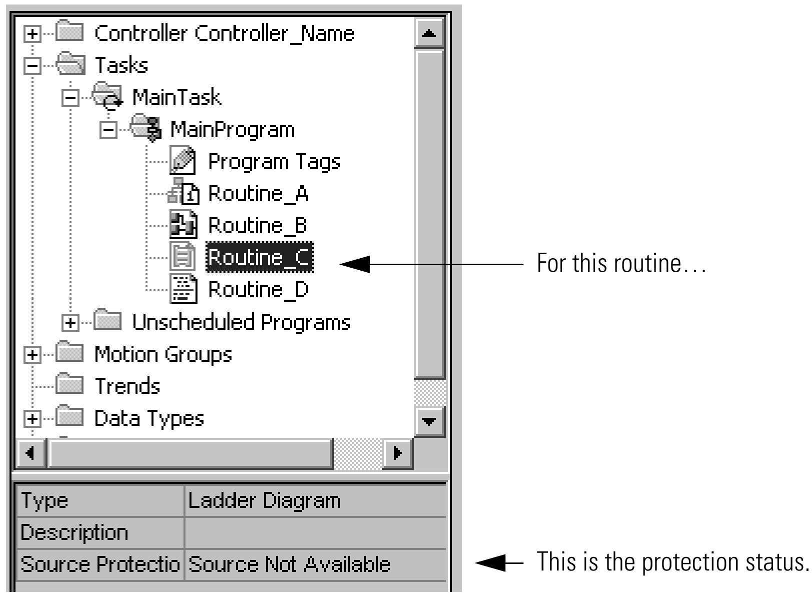
You may use both options at the same time.

Use Routine Source Protection

To limit who has access to a routine, use RSLogix 5000 software to assign a **source key** to the routine (protect the routine).

- To protect a routine, you have to first activate the feature for RSLogix 5000 software.
- Once you protect a routine, a computer requires the source key to edit, copy, or export the routine.
- You have the option of making a routine either viewable or not viewable without the source key.
- Regardless of whether or not the source key is available, you can always download the project and execute all the routines.
- You can regain access to a protected routine from a specific computer using either of the following methods:
  - Add the source key file and point RSLogix 5000 software to the location of the file.
  - Create the source key file and manually enter the name for the source key.

The controller organizer shows the protection status of a routine:

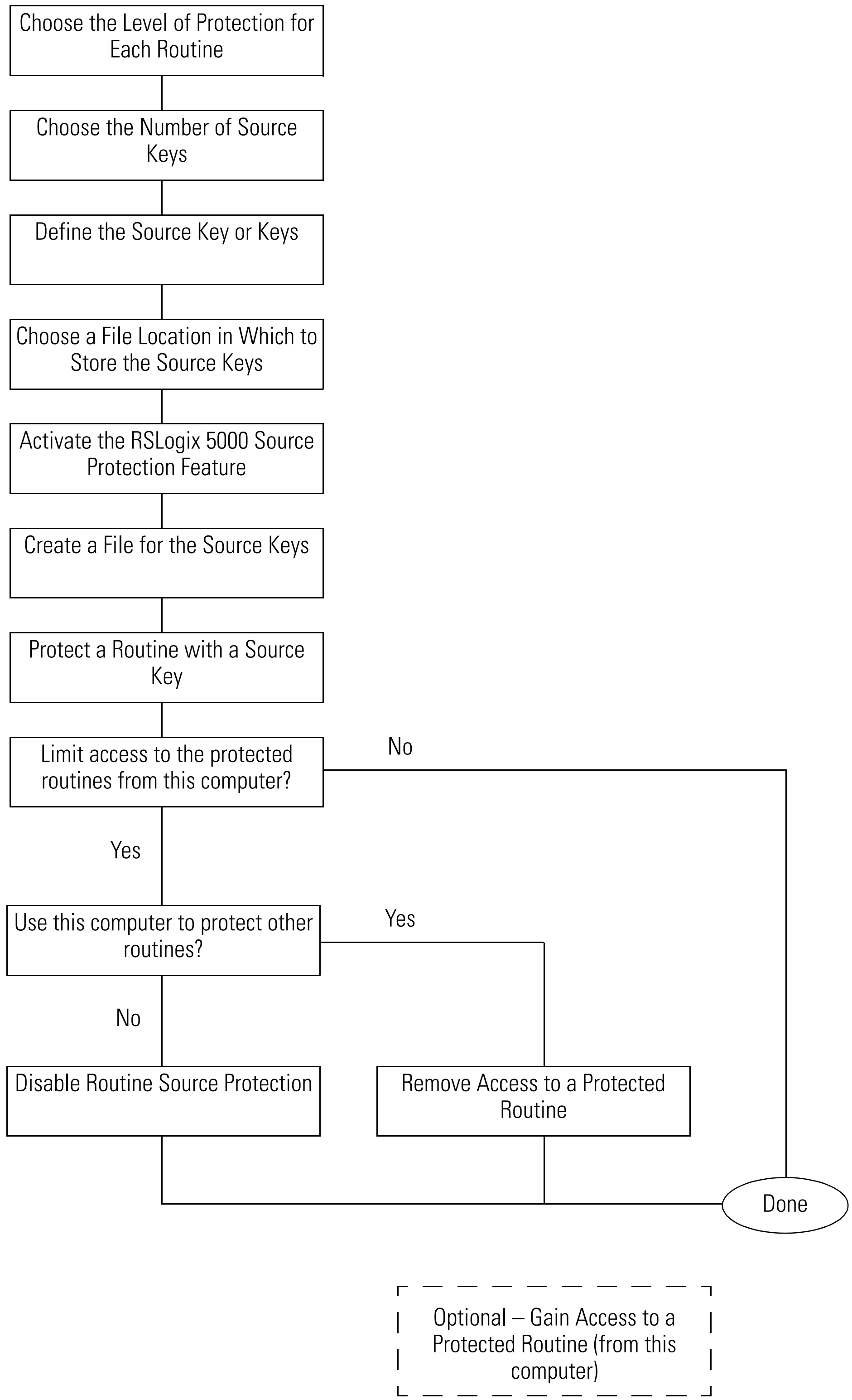


If the controller organizer displays:	Then:
Source Not Available	• A source key is assigned to the routine. • To open the routine, your computer requires the source key for the routine.
Source Not Available (Viewable)	• A source key is assigned to the routine. • You can only open and view the routine. • You cannot make any changes or copy any of contents of the routine.
Source Available	• A source key is assigned to the routine. • You have full access to the routine.
Source Available (Viewable)	• A source key is assigned to the routine. • You have full access to the routine. • Those who do not have the source key can still view the routine.
none of the above	• No source key is assigned to the routine. • You have full access to the routine.

IMPORTANT If the source of a routine is unavailable, *do not* export the project.

- An export file (.L5K) contains only routines where the source code is available.
- If you export a project where the source code is *not* available for all routines, you will *not* be able to restore the entire project.

To assign and manage source keys, perform the following actions:



Choose the Level of Protection for Each Routine

Source protection protects your project at the routine level. You can protect some routines of a project while leaving other routines unprotected (accessible to anyone). You also have the option of protecting a routine but letting anyone view it.

Table 18.1 Routine Protection Options

If you want to:	And:	Then:	
		Protect the routine?	**Allow viewing?**
prevent someone from doing this: • edit the routine • change the properties of the routine • export the routine	also prevent someone from doing this: • open (display) the routine • search the routine • go to cross references within the routine • print the routine	yes	no
	no other limitations	yes	yes
let anyone have full access to the routine	→	no	

Choose the Number of Source Keys

To protect a routine, you assign a **source key** to the routine. You can reuse a source key as often as you like, as shown below.

This:	Gives you:
one source key for all projects	fewest number of source keys (easier to manage but less protection)
unique source key for each project	
unique source key for each routine in each project	greatest number of source keys (more difficult to manage but more protection)

Choose the number of source keys that balances your need for protection verses the level of source key management that you want to undertake.

Define the Source Key or Keys

Source keys follow the same rules for names as other RSLogix 5000 components, such as routines, tags, and modules. Follow these rules to define the name of a source key:

- must begin with an alphabetic character (A-Z or a-z) or an underscore (_)
- can contain only alphabetic characters, numeric characters, and underscores
- can have as many as 40 characters
- must not have consecutive or trailing underscore characters (_)
- are *not* case sensitive

Choose a File Location in Which to Store the Source Keys

A source key file (sk.dat) stores the source keys. The source key file is separate from the RSLogix 5000 project files (.acd). You can store the source key file in any folder that you choose.

Activate the RSLogix 5000 Source Protection Feature

To use the routine source protection feature of RSLogix 5000 software, you have to make the following registry entry, which activates the feature:

Key:	**Value Entry:**		
	Name:	**Type:**	**Data:**
HKEY_CURRENT_USER\Software\Rockwell Software\RSLogix 5000\ProtectedRoutine	PTCRoutine	DWORD	1

To make the registry entry:

1. Get your RSLogix 5000 software CD.
2. From the CD, execute the following file:

   `language` \Tools\Source Protection Tool\Enable Protected Routine Config.reg

   where:

   `language` is the language of your software. For example, for software that is in English, open the ENU folder.

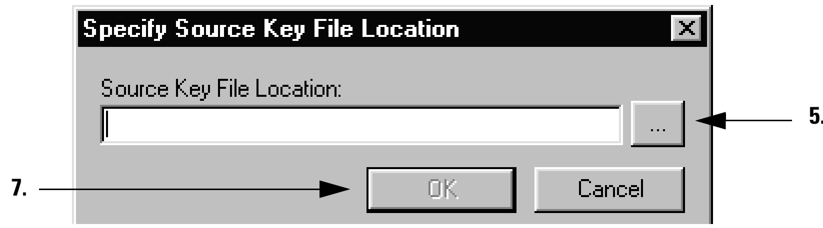
   The Enable Protected Routine Config.reg file makes the required registry entry.

Create a File for the Source Keys

1. Open the RSLogix 5000 project that you want to protect.
2. From the *Tools* menu, choose *Security* ⇒ *Configure Source Protection*.
3. Does RSLogix 5000 software prompt you to specify the location for the source key file?

If:	**Then:**
No	Your computer already has the source key file. Go to "Protect a Routine with a Source Key"on page 18-7.
Yes	Go to step 4.

4. Choose *Yes*.



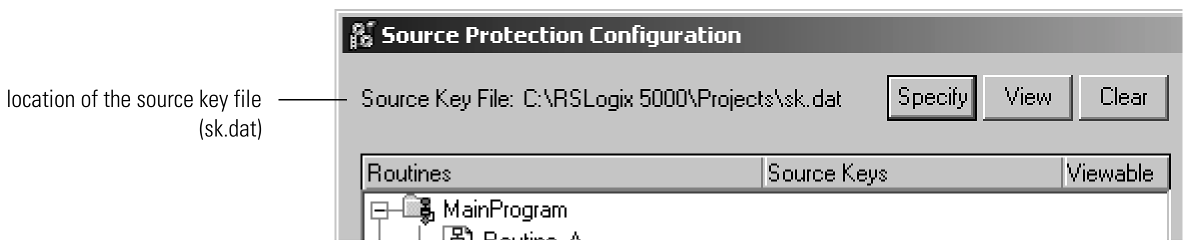
5. Click ...

6. Select a folder in which to store the file and choose *OK*.

7. Choose *OK*.

   A dialog box asks if you want to create the source key file (sk.dat).

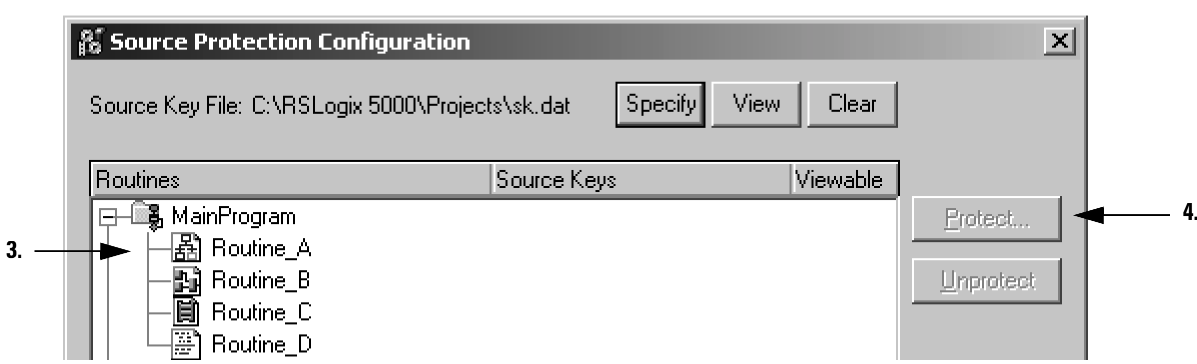
8. Choose *Yes*.



Protect a Routine with a Source Key

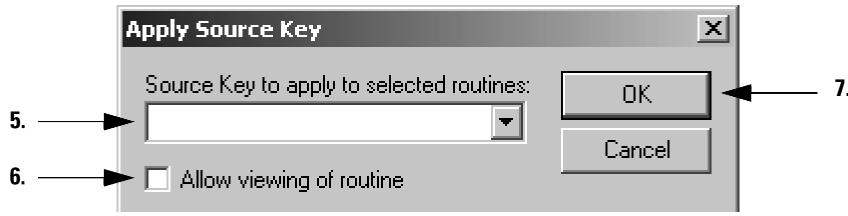
1. Open the RSLogix 5000 project that you want to protect.

2. From the *Tools* menu, choose *Security* ⇒ *Configure Source Protection*.



3. Select the routine or routines that you want to protect.

4. Click *Protect*.



5. Type a **name** that you want to use as the source key. Or select an existing source key from the drop-down list.

6. If someone does not have the source key, do you want to let them open and view the routine?

If:	Then:
No	Clear (uncheck) the *Allow viewing of routine* check box (default).
Yes	Check the *Allow viewing of routine* check box.

7. Choose *OK*.

8. When you have assigned the required source keys to the project, click *Close*.

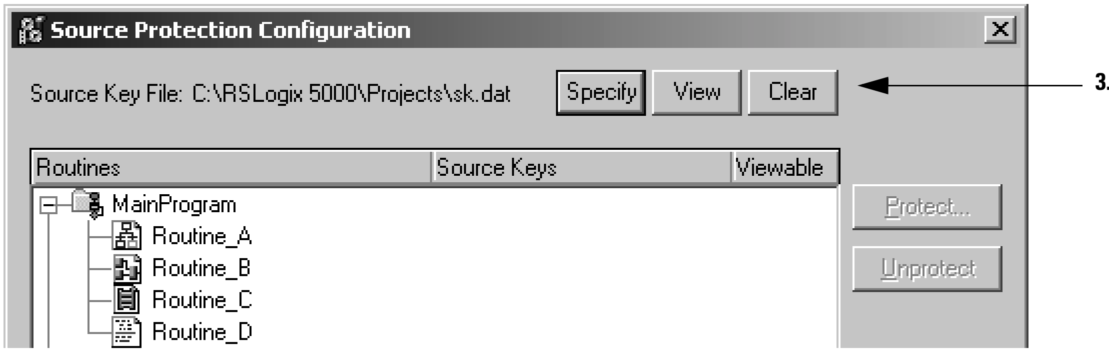
9. From the *File* menu, choose *Save*.

Remove Access to a Protected Routine

IMPORTANT Before you remove the source key file (sk.dat) from a computer either write down the source keys or make a copy of the file and store it in a secure location.

1. Open the RSLogix 5000 project that is protected.

2. From the *Tools* menu, choose *Security* ⇒ *Configure Source Protection*.



3. Click *Clear*.

   A dialog box asks if you want to delete the source key file (sk.dat).

4. Do you want to remove the source key file from the computer (prevent future access to the file)?

If:	Then:
Yes	Choose *Yes*.
No	Choose *No*.

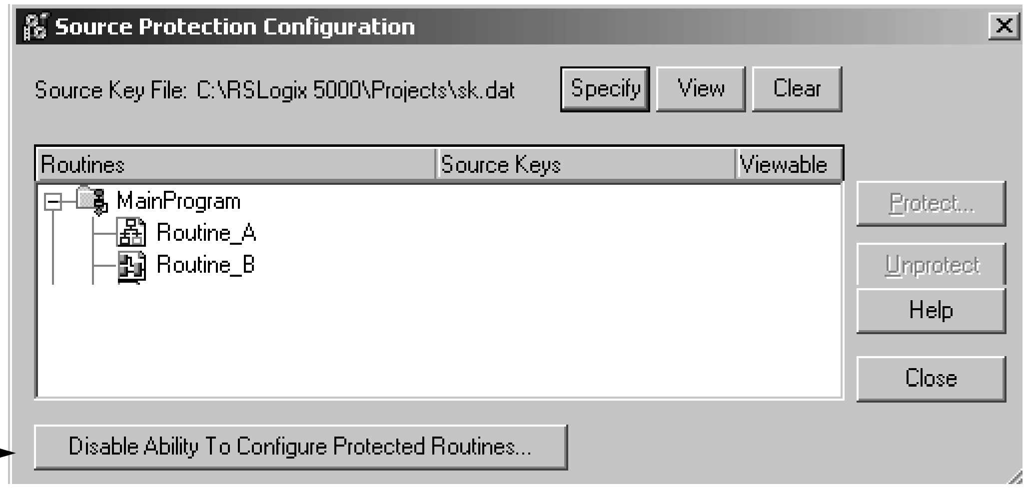
Disable Routine Source Protection

IMPORTANT Before you remove the source key file (sk.dat) from a computer either write down the source keys or make a copy of the file and store it in a secure location.

1. Open the RSLogix 5000 project that is protected.

2. From the *Tools* menu, choose *Security* ⇒ *Configure Source Protection*.

4.



3. Click *Disable Ability To Configure Protected Routines*.

   A dialog box prompts you to confirm the action.

4. Choose *Yes*.

   A dialog box asks if you want to delete the source key file (sk.dat).

5. Do you want to remove the source key file from the computer (prevent future access to the file)?

If:	Then:
Yes	Choose *Yes*.
No	Choose *No*.

Gain Access to a Protected Routine

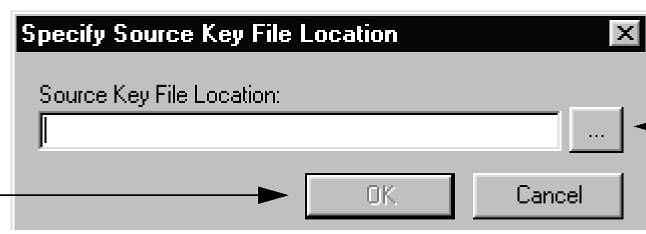
1. Open the RSLogix 5000 project that contains the protected routines.

2. From the *Tools* menu, choose *Security* ⇒ *Configure Source Protection*.

3. Does RSLogix 5000 software prompt you to specify the location for the source key file?

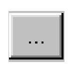
If:	Then:
No	Go to step 7.
Yes	Go to step 4.

4. Choose *Yes*.



5.

7.

5. Click 

6. Does this computer already have a source key file (sk.dat)?

If:	Then:
Yes	A. Select the folder that contains the file and choose *OK*. B. Choose *OK*.
No	A. Select the folder in which to store the new file and choose *OK*. A dialog box asks if you want to create the source key file (sk.dat). B. Choose *Yes*.

7. Click *View*.
    - If you are prompted to select a program with which to open the file, select a word processing program, such as Notepad.
    - The sk.dat file opens.

8. Type the name of the source key. To enter multiple keys, type each key on a separate line.

sk.dat - Notepad
key1
key2
key3

9. Save and close the sk.dat file.

Use RSI Security Server to Protect a Project

RSI Security Server software lets you control the access that individuals have to RSLogix 5000 projects. With this software, you customize access to projects based on the:

- user that is currently logged into the workstation
- RSLogix 5000 project that the user is accessing
- workstation from which the user is accessing the RSLogix 5000 project

Before you use Security Server software for RSLogix 5000 projects, set up the software:

- Install RSI Security Server Software
- Set Up DCOM
- Enable Security Server for RSLogix 5000 Software
- Import the RSLogix5000Security.bak File
- Define the Global Actions for Your Users
- Define the Project Actions for Your Users
- Add Users
- Add User Groups
- Assign Global Access to RSLogix 5000 Software
- Assign Project Actions for New RSLogix 5000 Projects

Once Security Server software is set up for RSLogix 5000 projects, complete the following actions to protect a project:

- Secure an RSLogix 5000 Project
- Assign Access to an RSLogix 5000 Project
- Refresh RSLogix 5000 Software, If Needed

Install RSI Security Server Software

IMPORTANT If RSLogix 5000 software is already on your computer when you install Security Server software, enable security for RSLogix 5000 software when you are prompted.

See *Getting Results with Rockwell Software's Security Server (Standalone Edition)*, which ships with the RSI Security Server software.

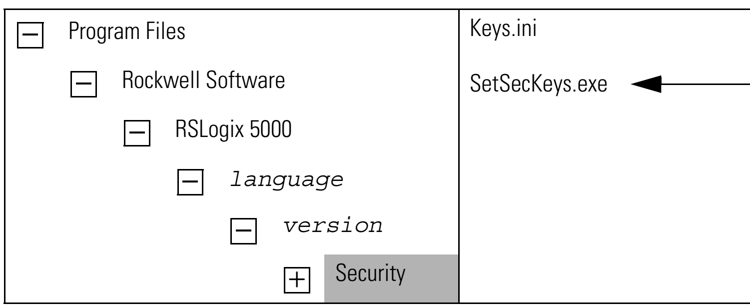
Set Up DCOM

See *Getting Results with Rockwell Software's Security Server (Standalone Edition)*, which ships with the RSI Security Server software.

Enable Security Server for RSLogix 5000 Software

Did you install Security Server *before* you installed RSLogix 5000 software?

If:	Then:
Yes	Go to step 1.
No	Go to "Import the RSLogix5000Security.bak File"on page 18-15.



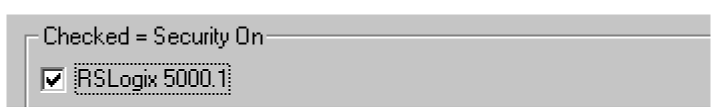
1. Run this file.

Where:	Is the:
`language`	language of your software. For example, for software that is in English, open the ENU folder.
`version`	version of your software, such as v10

The Locate Project File dialog box opens. By default, the *Keys.ini* file should already be selected.

2. Choose *Open*.

3. Select the RSLogix 5000 check box and choose *OK*.



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Import the RSLogix5000Security.bak File

The RSLogix5000Security.bak file provides the configuration that Security Server requires to operate with RSLogix 5000 software.

1. Start the Security Configuration explorer.

2. From the *File* menu, choose *Import Database*.

3. Which revision of Security Server software are you using:

<table>
<tr><th>If:</th><th>Then:</th></tr>
<tr><td>2.00</td><td>Look in this folder:

Program Files
  Rockwell Software
    RSLogix 5000
      language
        version
          Security

<table>
<tr><th>Where:</th><th>Is the:</th></tr>
<tr><td>language</td><td>language of your software. For example, for software that is in English, open the ENU folder.</td></tr>
<tr><td>version</td><td>version of your software, such as v10</td></tr>
</table></td></tr>
<tr><td>2.01</td><td>Look in this folder:

Program Files
  Rockwell Software
    Security Server
      System</td></tr>
</table>

4. Select the *RSLogix5000Security.bak* file and then choose *Open*.

Define the Global Actions for Your Users

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Global actions are tasks that are not tied to a particular project, such as create a new project or update the firmware of a controller. The following global actions apply to RSLogix 5000 software.

Table 18.2 Global Actions

To let a user:	Then grant access to the following actions:
secure any unsecured controller	Secure Controller
create a new RSLogix 5000 project	New Project
open an .L5K file in RSLogix 5000 software, which creates a project	
translate a PLC or SLC project to an .L5K file	
use RSLogix 5000 software to start ControlFLASH software and update the firmware of a controller	Update Firmware

Use the following worksheet to record the global actions that you will permit each group of users to perform.

Table 18.3 Global actions for each group of users

This group of users:	Requires this access:		
	Secure Controller	New Project	Update Firmware

Define the Project Actions for Your Users

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Project actions let you perform specific tasks on a specific project or group of projects.

- When you enable security for an RSLogix 5000 project or create a new project with security turned on, it becomes a member of the *New RSLogix 5000 Resources* group.
  - Users who work with projects in this group require the appropriate access.
  - We recommend that you grant *Full Access* to anyone who has access to create a project.
- To customize the access of a project, move it out of the *New RSLogix 5000 Resources* group and assign privileges that are specific to that project.

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The following actions apply to a secured RSLogix 5000 project or group of projects.

Table 18.4 Project Actions

To let a user:	And:	And:	Grant this action:
• open a project offline • copy components from a project • export the tags of a project	→	→	View Project
	go online and monitor a project	→	Go Online
		• save a project • save a project as a different .ACD file • open an older revision of a project • compact a project • export a project • download or upload a project • change the mode of the controller • change the path to the controller • print a report • clear faults • change the wall clock time • create, delete, edit, and run a trend • change the configuration of an I/O module • change the configuration of a MSG instruction • enter, enable, disable, and remove forces • change tag values • update firmware	Maintain Project
perform all actions available through RSLogix 5000 software *except* unsecure a secured controller	→	→	Full Access
unsecure a secured controller	→	→	Full Access *and* Unsecure Controller
update the firmware of a controller	→	→	Update Firmware

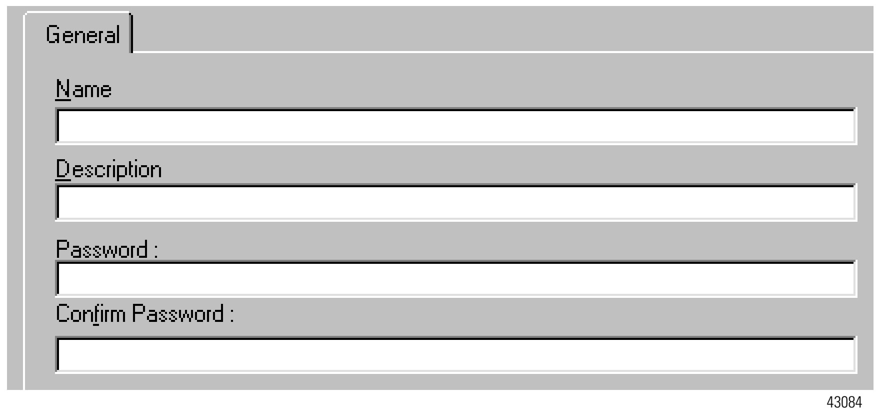
Use the worksheet on page 18-19 to record the project actions that you will permit each user or group of users to perform.

Table 18.5 Project actions for projects that are in the New RSLogix 5000 Resources group and for individual projects

For this project or group of projects:	This user or group of users:	Requires this access:					
		View Project	Go Online	Maintain Project	Full Access	Unsecure Controller	Update Firmware
New RSLogix 5000 Resources							
New RSLogix 5000 Resources							
New RSLogix 5000 Resources							
New RSLogix 5000 Resources							

Add Users

1. Right-click and choose *New*.

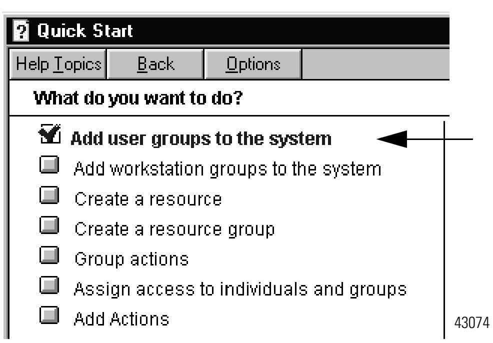


2. Type the information for the user and then choose *OK*.

Add User Groups

A group lets you manage multiple users who require similar privileges.

1. From the *Help* menu, choose *Quick Start*.



2. Follow the steps for this task.

Assign Global Access to RSLogix 5000 Software

To permit users to perform global actions:

1. In the Configuration explorer, select the *RSLOGIX 5000* group.

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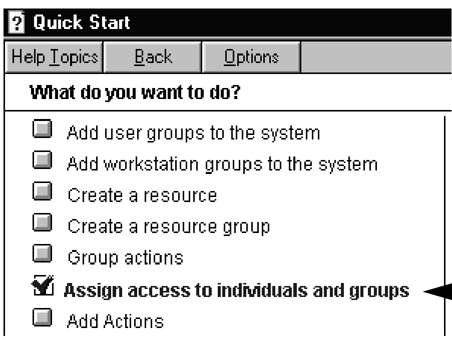
2. From the *Help* menu, choose *Quick Start*.



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3. Follow the steps for this task. Assign the actions that you recorded on Table 18.3 on page 18-16.

Assign Project Actions for New RSLogix 5000 Projects

To let users perform actions on projects that are in the New RSLogix 5000 Resources group:

1. In the Configuration explorer, select the *New RSLogix 5000 Resources* group.

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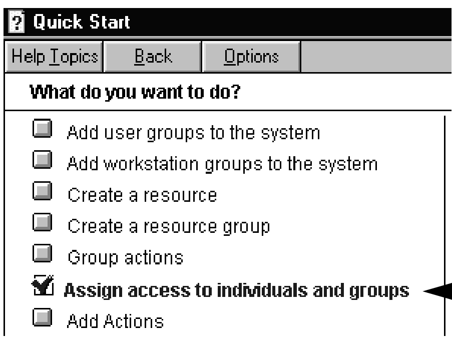
2. From the *Help* menu, choose *Quick Start*.



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3. Follow the steps for this task. Assign the actions that you recorded on Table 18.5 on page 18-19.

Secure an RSLogix 5000 Project

For new projects, the security option is available when you create the project. To let Security Server software protect an existing project, enable security for the project.

1. Open the RSLogix 5000 Project.

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2. Click the controller properties button.

3. Click the *Advanced* tab.

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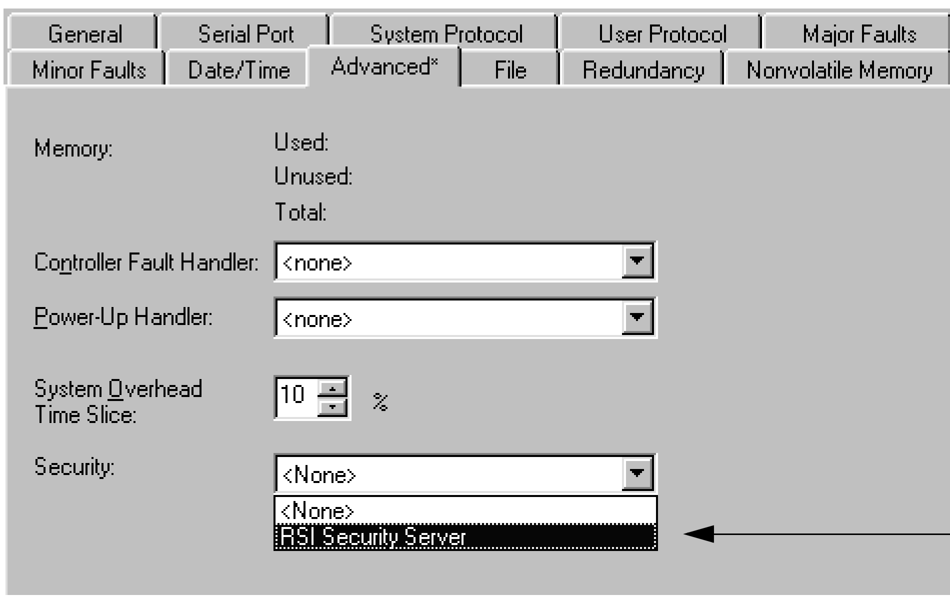


4. Select *RSI Security Server.*

5. Choose *OK* and then *Yes*.

In the Security Server software, the project appears as a member of the *New RSLogix 5000 Resources* group. If Security Server software is already open, then from its *View* menu, choose *Refresh*.

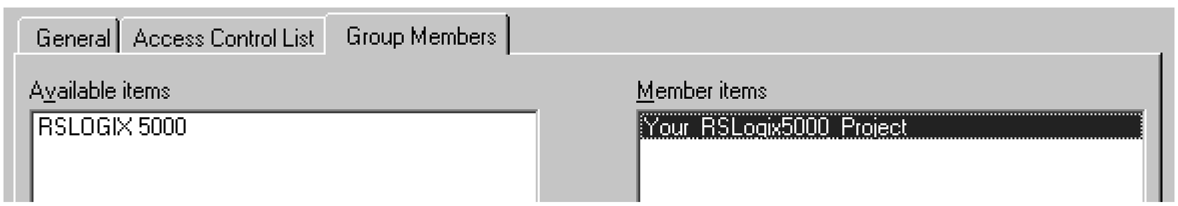
Assign Access to an RSLogix 5000 Project

While a project is in the New RSLogix 5000 Resources group, the access control list of that group determines the actions that a user can perform on a project. To customize the access of a project, move it out of the group and assign specific actions:

1. In the Configuration explorer, select the *New RSLogix 5000 Resources* group.

43075

2. Click the *Group Members* tab.



3.

43079

3. In the *Member items* list, select the project and click the << button.

4. Choose *Apply*.

5. In the Configuration explorer, select the project.

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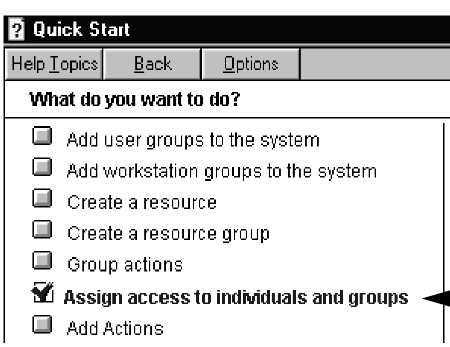
6. From the *Help* menu, choose *Quick Start*.



43076

7. Follow the steps for this task. Assign the actions that you recorded on Table 18.5 on page 18-19.

Refresh RSLogix 5000 Software, If Needed

If an RSLogix 5000 project is open and changes are made in RSI Security Server software that effect the project, refresh RSLogix 5000 software:

From the *Tools* menu, choose *Security* ⇒ *Refresh Privileges*.

Notes:

Determine Controller Memory Information

When to Use This Chapter

Use this chapter to get information about the memory of your Logix5000 controller.

Determine What Memory Information You Want

Depending on your type of controller, the memory of the controller may be divided into several areas:

If you have this controller:	Then it stores this:	In this memory:
ControlLogix	I/O tags	I/O memory
	produced tags	
	consumed tags	
	communication via Message (MSG) instructions	
	communication with workstations	
	communication with polled (OPC/DDE) tags that use RSLinx software[1]	
	tags other than I/O, produced, or consumed tags	data and logic memory[2]
	logic routines	
	communication with polled (OPC/DDE) tags that use RSLinx software[1]	
• CompactLogix • FlexLogix • DriveLogix • SoftLogix5800	These controllers *do not* divide their memory. They store all elements in one common memory area.	

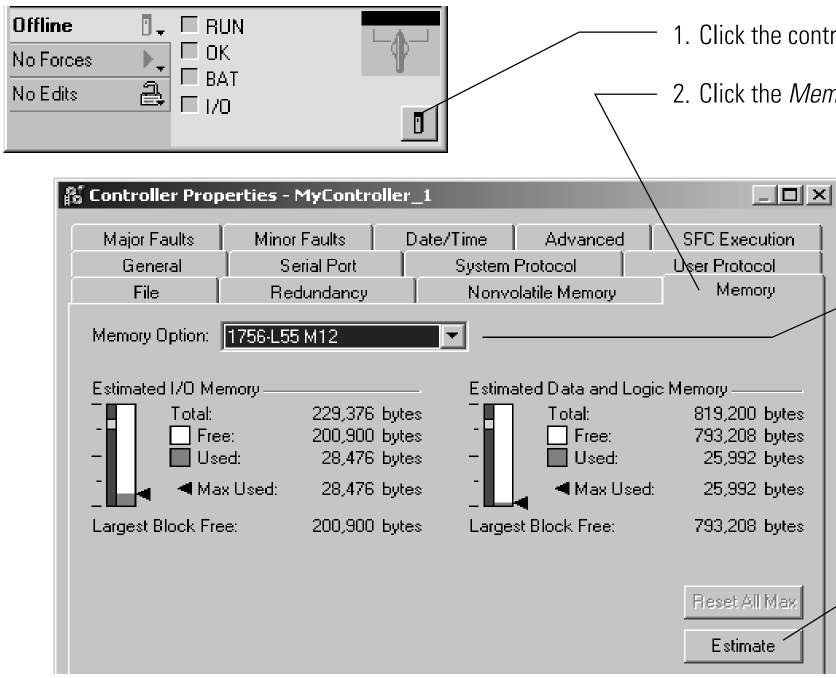
(1) To communicate with polled tags, the controller uses both I/O and data and logic memory.

(2) 1756-L55M16 controllers have an additional memory section for logic.

Estimate Memory Information Offline

To estimate how much controller memory your project requires, use the *Memory* tab of the controller properties dialog box. For each of the memory areas of your controller, it lets you estimate number of bytes of:

- free (unused) memory
- used memory
- largest free contiguous block of memory

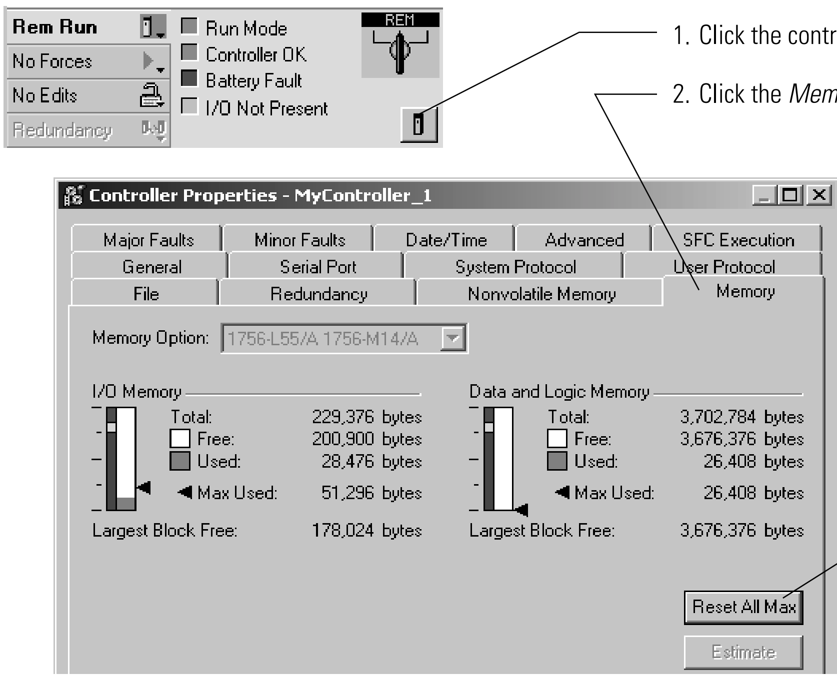


1. Click the controller properties button.
2. Click the *Memory* tab.
3. For controllers with different memory options, choose the memory size (e.g., M12).
4. View the memory information since the last estimate.
5. Estimate the amount of controller memory.

View Run Time Memory Information

When online with a controller, the *Memory* tab shows the actual memory usage of the controller. While the controller is running, it uses additional memory for communication. The amount it needs varies depending on the state of the communication.

The *Memory* tab of the controller includes a *Max Used* entry for each type of memory. The *Max Used* values show the peak of memory usage as communications occur.



1. Click the controller properties button.
2. Click the *Memory* tab.
3. View the memory information.
4. To reset the *Max Used* values, click here.

Write Logic to Get Memory Information

To use logic to get memory information for the controller:

- ☐ Get Memory Information from the Controller
- ☐ Choose the Memory Information That You Want
- ☐ Convert INTs to a DINT

Get Memory Information from the Controller

To get memory information from the controller, execute a Message (MSG) instruction that is configured as follows:

On this tab:	For this item:	Type or select:	Which means:	
Configuration	Message Type	CIP Generic	Execute a Control and Information Protocol command.	
	Service Type	Custom	Create a CIP Generic message that is not available in the drop-down list.	
	Service Code	3	Read specific information about the controller (GetAttributeList service).	
	Class	72	Get information from the user memory object.	
	Instance	1	This object contains only 1 instance.	
	Attribute	0	Null value	
	Source Element	*source_array* of type SINT[12]		
		In this element:	**Enter:**	**Which means:**
		source_array[0]	5	Get 5 attributes
		source_array[1]	0	Null value
		source_array[2]	1	Get free memory
		source_array[3]	0	Null value
		source_array[4]	2	Get total memory
		source_array[5]	0	Null value
		source_array[6]	5	Get largest contiguous block of additional free logic memory
		source_array[7]	0	Null value
		source_array[8]	6	Get largest contiguous block of free I/O memory
		source_array[9]	0	Null value
		source_array[10]	7	Get largest contiguous block of free data and logic memory
		source_array[11]	0	Null value
	Source Length	12	Write 12 bytes (12 SINTs).	
	Destination	*INT_array* of type INT[29]		
Communication	Path	1, *slot_number_of_controller*		

Choose the Memory Information That You Want

The MSG instruction returns the following information to *INT_array* (destination tag of the MSG):

IMPORTANT

- The controller returns the values in number of 32-bit words. To see a value in bytes, multiple it by 4.
- If your controller does not divide its memory, then the values show up as I/O memory.
- For a 1756-L55M16 controller, the MSG instruction returns two values for each logic memory category. To determine the free or total logic memory of a 1756-L55M16 controller, add both values for the category.

If you want the:	Then copy these array elements:	Description:
amount of free I/O memory (32-bit words)	*INT_array*[3]	lower 16 bits of the 32 bit value
	INT_array[4]	upper 16 bits of the 32 bit value
amount of free data and logic memory (32-bit words)	*INT_array*[5]	lower 16 bits of the 32 bit value
	INT_array[6]	upper 16 bits of the 32 bit value
1756-L55M16 controllers only—amount of additional free logic memory (32-bit words)	*INT_array*[7]	lower 16 bits of the 32 bit value
	INT_array[8]	upper 16 bits of the 32 bit value
total size of I/O memory (32-bit words)	*INT_array*[11]	lower 16 bits of the 32 bit value
	INT_array[12]	upper 16 bits of the 32 bit value
total size of data and logic memory (32-bit words)	*INT_array*[13]	lower 16 bits of the 32 bit value
	INT_array[14]	upper 16 bits of the 32 bit value
1756-L55M16 controllers only—additional logic memory (32-bit words)	*INT_array*[15]	lower 16 bits of the 32 bit value
	INT_array[16]	upper 16 bits of the 32 bit value
1756-L55M16 controllers only—largest contiguous block of additional free logic memory (32-bit words)	*INT_array*[19]	lower 16 bits of the 32 bit value
	INT_array[20]	upper 16 bits of the 32 bit value
largest contiguous block of free I/O memory (32-bit words)	*INT_array*[23]	lower 16 bits of the 32 bit value
	INT_array[24]	upper 16 bits of the 32 bit value
largest contiguous block of free data and logic memory (32-bit words)	*INT_array*[27]	lower 16 bits of the 32 bit value
	INT_array[28]	upper 16 bits of the 32 bit value

Convert INTs to a DINT

The MSG instruction returns each memory value as two separate INTs.

- The first INT represents the lower 16 bits of the value.
- The second INT represents the upper 16 bits of the value.

To convert the separate INTs into one usable value, use a Copy (COP) instruction, where:

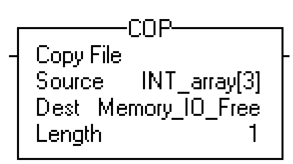
In this operand:	Specify:	Which means:
Source	first INT of the 2 element pair (lower 16 bits)	Start with the lower 16 bits
Destination	DINT tag in which to store the 32-bit value	Copy the value to the DINT tag.
Length	1	Copy 1 times the number of bytes in the Destination data type. In this case, the instruction copies 4 bytes (32 bits), which combines the lower and upper 16 bits into one 32-bit value.

In the following example, the COP instruction produces the 32-bit value that represents the amount of free I/O memory, in 32-bit words.

EXAMPLE

Convert INTs to a DINT

- Elements 3 of *INT_array* is the lower 16 bits of the amount of free I/O memory. Element 4 is the upper 16 bits.
- *Memory_IO_Free* is a DINT tag (32 bits) in which to store the value for the amount of free I/O memory.
- To copy all 32 bits, specify a Length of 1. This tells the instruction to copy 1 times the size of the Destination (32 bits). This copies both element 3 (16 bits) and element 4 (16 bits) and places the 32-bit result in *Memory_IO_Free*.



Manage Multiple Messages

Purpose

This appendix describes how to use ladder logic to send groups of Message (MSG) instructions in sequence. This lets them enter and exit the message queue in an ordered fashion.

When to Use this Appendix

Use this appendix if you need to control the execution of a large number of MSGs.

- To be processed, each MSG instruction must enter the message queue.
- The queue holds 16 MSGs.
- If more than 16 MSGs are enabled at one time, there may not be room on the queue when a MSG is enabled.
- If this occurs, the MSG has to wait until there is room on the queue before the controller can process the MSG. On each subsequent scan of the MSG, it checks the queue to see if there is room.

The message manager logic in this appendix lets you control the number of MSGs that are enabled at one time and enable subsequent MSGs in sequence. In this way, MSGs enter and exit the queue in an ordered fashion and do not have to wait for room on the queue to become available.

How to Use this Appendix

In this appendix, the message manager logic sends three groups of MSGs.

- To make the example easier to follow, each groups contains only 2 MSGs.
- In your project, use more MSGs in each group, such as 5.
- Use as many groups as needed to include all your MSGs.

The *Msg_Group* tag controls the enabling of each MSG.

- The tag uses the DINT data type.
- Each bit of the tag corresponds to a group of MSGs.
- For example, *Msg_Group.0* enables and disables the first group of MSGs (group 0).

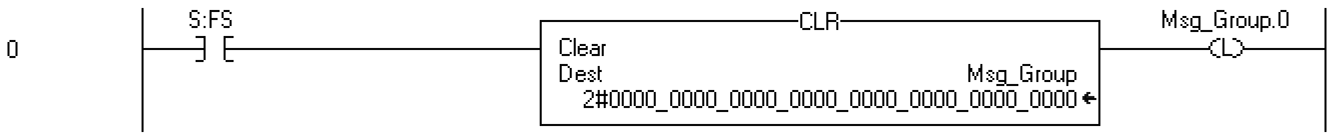
Message Manager Logic

Initialize the Logic

If S:FS = 1 (first scan), then initialize the MSGs:

Msg_Group = 0, which disables all the MSGs.

Msg_Group.0 =1, which enables the first group of MSGs.



Restart the Sequence, If Required

If the MSGs in group 2 (last group) are currently enabled (*Msg_Group.2* = 1)

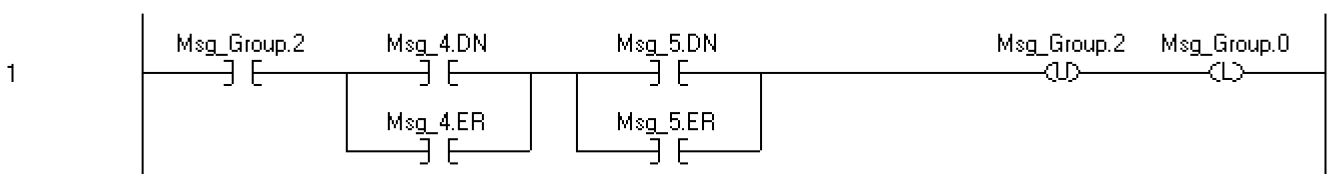
And *Msg_4* is done or errored

And *Msg_5* is done or errored

Then restart the sequence of MSGs with the first group:

Msg_Group.2 = 0. This disables the last group of MSGs.

Msg_Group.0 = 1. This enables the first group of MSGs.



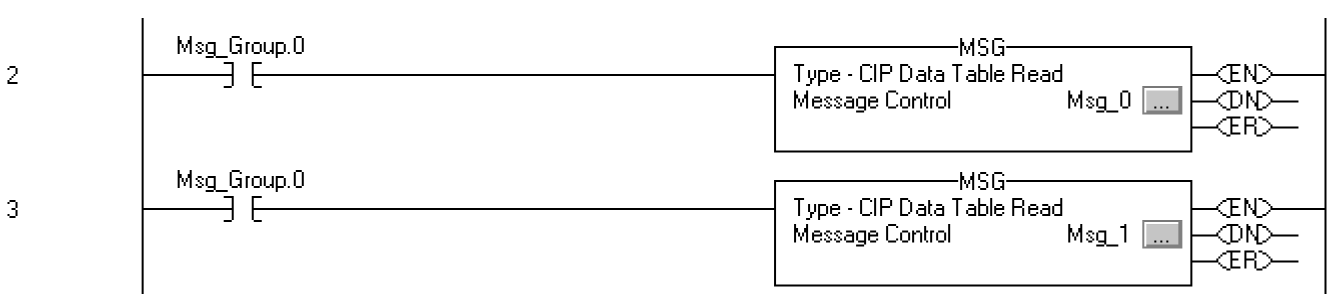
Send the First Group of MSGs

If *Msg_Group.0* changes from 0 -> 1 then

Send *Msg_0*.

Send *Msg_1*.

Because a MSG instruction is a transitional instruction, it executes only when its rung-condition-in changes from false to true.



Enable the Next Group of MSGs

If the MSGs in group 0 are currently enabled (*Msg_Group.0* = 1)

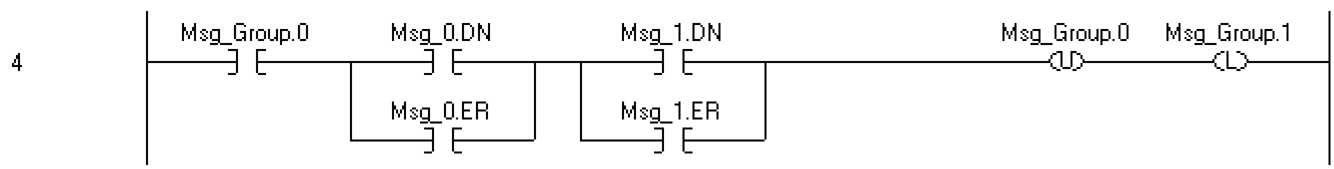
And *Msg_0* is done or errored

And *Msg_1* is done or errored

Then

Msg_Group.0 = 0. This disables the current group of MSGs.

Msg_Group.1 = 1. This enables the next group of MSGs.

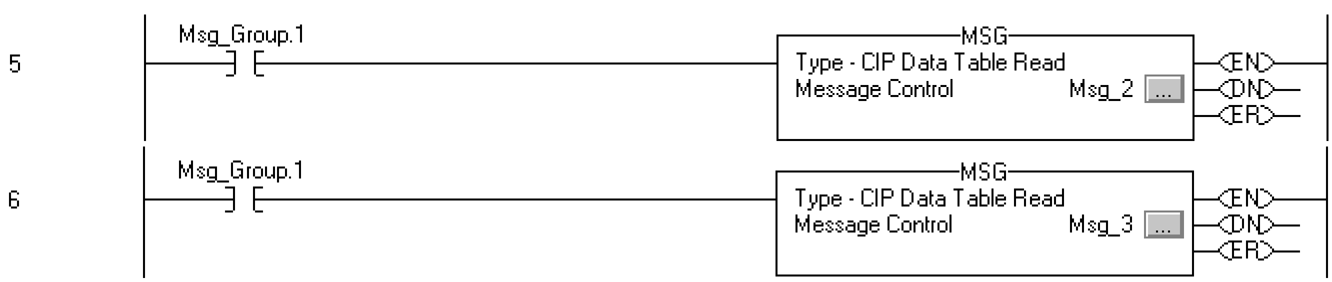


Send the Next Group of MSGs

If *Msg_Group.1* changes from 0 -> 1 then

Send *Msg_2*.

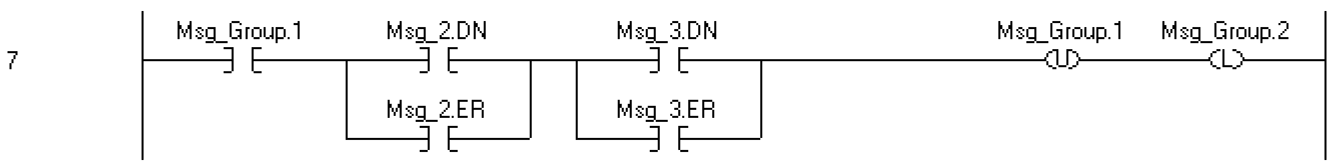
Send *Msg_3*.



Enable the Next Group of MSGs

If the MSGs in group 1 are currently enabled (*Msg_Group.1* = 1)
And *Msg_2* is done or errored
And *Msg_3* is done or errored
Then

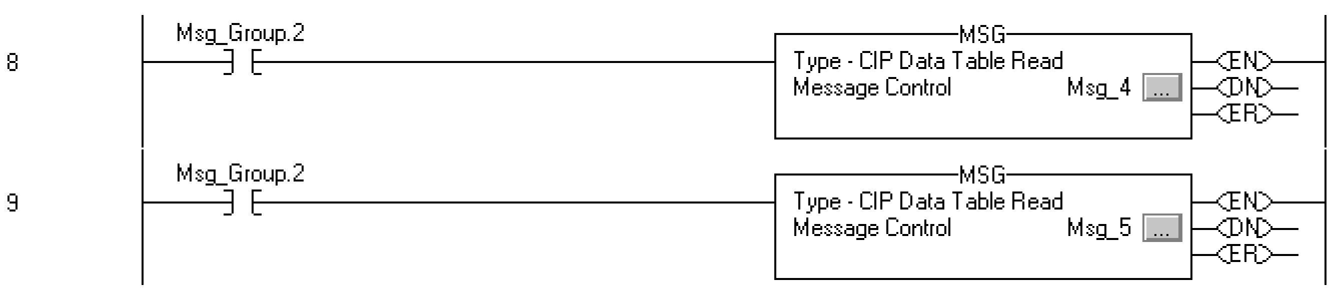
Msg_Group.1 = 0. This disables the current group of MSGs.
Msg_Group.2 = 1. This enables the next group of MSGs.



Send the Next Group of MSGs

If *Msg_Group.1* changes from 0 -> 1 then

Send *Msg_2*.
Send *Msg_3*.

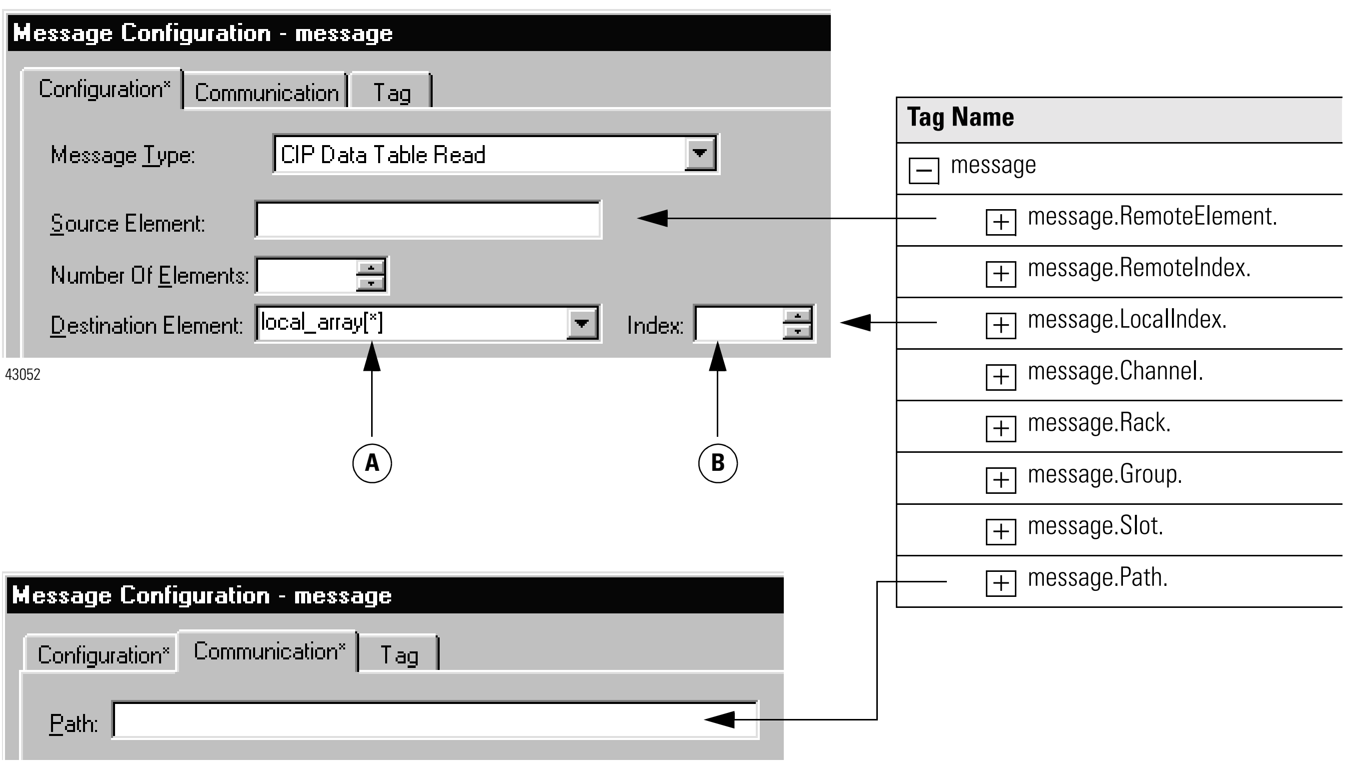


Send a Message to Multiple Controllers

Use the following procedure to program a single message instruction to communicate with multiple controllers. To reconfigure a MSG instruction during runtime, write new values to the members of the MESSAGE data type.

IMPORTANT In the MESSAGE data type, the RemoteElement member stores the tag name or address of the data in the controller that receives the message.

If the message:	Then the RemoteElement is the:
reads data	Source Element
writes data	Destination Element



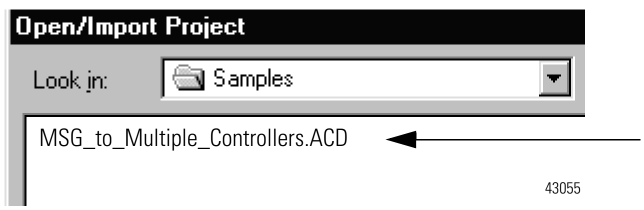
A. If you use an asterisk [*] to designate the element number of the array, the value in B provides the element number.

B. The *Index* box is only available when you use an asterisk [*] in the *Source Element* or *Destination Element*. The instruction subustitutes the value of *Index* for the asterisk [*].

To send a message to multiple controllers:

- Set Up the I/O Configuration
- Define Your Source and Destination Elements
- Create the MESSAGE_CONFIGURATION Data Type
- Create the Configuration Array
- Get the Size of the Local Array
- Load the Message Properties for a Controller
- Configure the Message
- Step to the Next Controller
- Restart the Sequence

TIP To copy the above components from a sample project, open the *…\RSLogix 5000\Projects\Samples* folder.

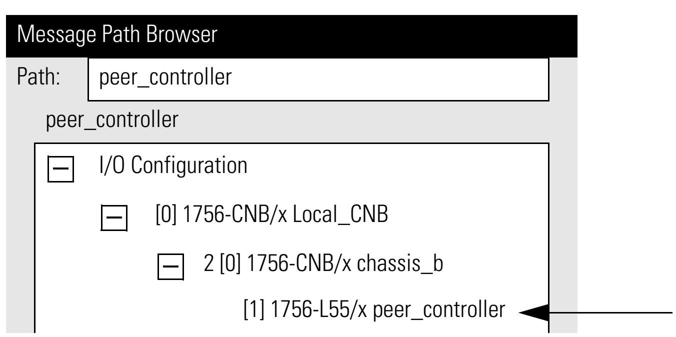


Open this project.

Set Up the I/O Configuration

Although not required, we recommend that you add the communication modules and remote controllers to the I/O configuration of the controller. This makes it easier to define the path to each remote controller.

For example, once you add the local communication module, the remote communication module, and the destination controller, the *Browse* button lets you select the destination.



Define Your Source and Destination Elements

In this procedure, an array stores the data that is read from or written to each remote controller. Each element in the array corresponds to a different remote controller.

1. Use the following worksheet to organize the tag names in the local and remote controllers:

Name of the remote controller:	Tag or address of the data in the remote controller:	Tag in this controller:
		local_array[0]
		local_array[1]
		local_array[2]
		local_array[3]

2. Create the *local_array* tag, which stores the data in this controller.

Tag Name	Type
local_array	`data_type [length ]` where: `data_type` is the data type of the data that the message sends or receives, such as DINT, REAL, or STRING. `length` is the number of elements in the local array.

Create the MESSAGE_CONFIGURATION Data Type

In this procedure, you create a user-defined data type to store the configuration variables for the message to each controller.

- Some of the required members of the data type use a string data type.
- The default STRING data type stores 82 characters.
- If your paths or remote tag names or addresses use less than 82 characters, you have the option of creating a new string type that stores fewer characters. This lets you conserve memory.
- To create a new string type, choose *File ⇒ New Component ⇒ String Type…*
- If you create a new string type, use it in place of the STRING data type in this procedure.

To create a new data type:

- ⊞ Controller Your_Project
- ⊞ Tasks
- ⊞ Motion Groups
- Trends
- ⊟ Data Types
  - User-Defined

Right-click and choose *New Data Type*.

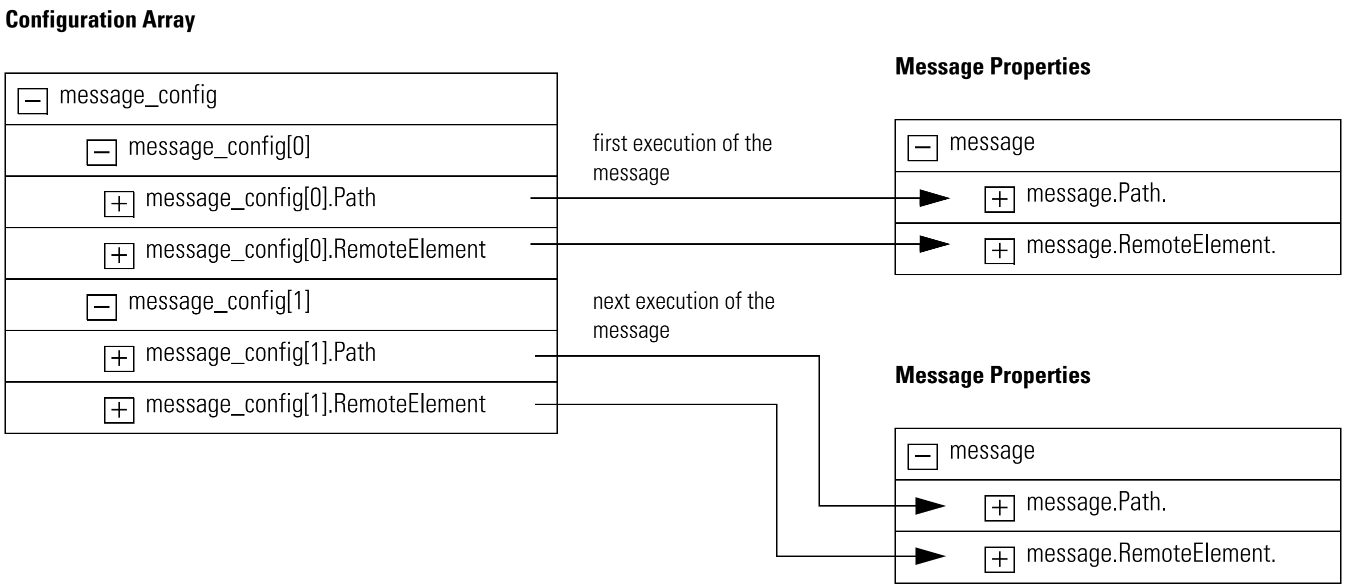
To store the configuration variables for the message to each controller, create the following user-defined data type.

Data Type: MESSAGE_CONFIGURATION				
Name	MESSAGE_CONFIGURATION			
Description	Configuration properties for a message to another controller			
Members				
	Name	**Data Type**	**Style**	**Description**
	⊞ Path	STRING		
	⊞ RemoteElement	STRING		

Create the Configuration Array

In this procedure, you store the configuration properties for each controller in an array. Before each execution of the MSG instruction, your logic loads new properties into the instruction. This sends the message to a different controller.

Figure B.1 Load New Configuration Properties Into a MSG Instruction



Steps:

1. To store the configuration properties for the message, create the following array:

Tag Name	Type	Scope
message_config	MESSAGE_CONFIGURATION[*number*]	any

where:

number is the number of controllers to which to send the message.

2. Into the *message_config* array, enter the **path** to the first controller that receives the message.

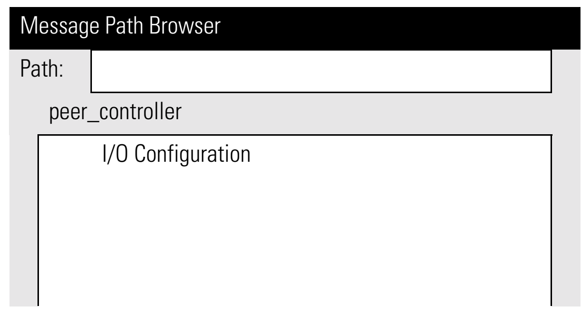
Tag Name	Value
⊟ message_config	{…}
⊟ message_config[0]	{…}
⊞ message_config[0].Path	
⊞ message_config[0].RemoteElement	

Right-click and choose *Go to Message Path Editor.*

Type the **path** to the remote controller.

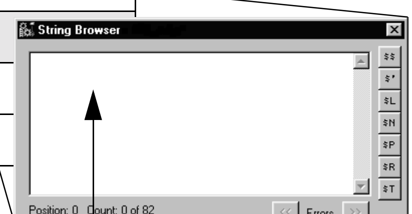
or

Browse to the remote controller.



3. Into the *message_config* array, enter the tag name or address of the data in the first controller to receive the message.

Tag Name	Value
⊟ message_config	{…}
⊟ message_config[0]	{…}
⊞ message_config[0].Path	
⊞ message_config[0].RemoteElement	...
⊟ message_config[1]	
⊞ message_config[1].Path	
⊞ message_config[1].RemoteElement	

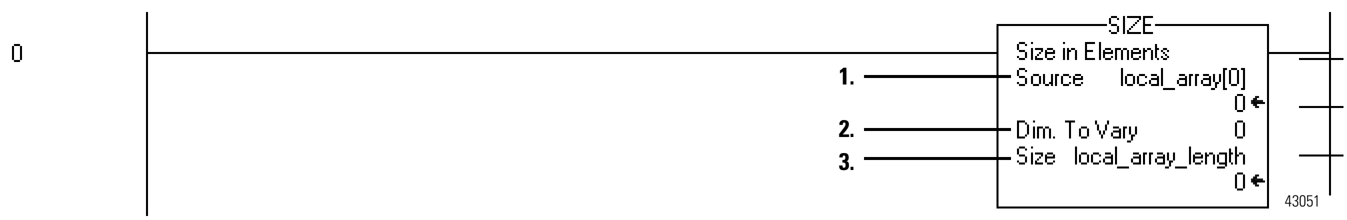


Type the tag name or address of the data in the other controller.

4. Enter the path and remote element for each additional controller:

Tag Name	Value
message_config	{...}
message_config[0]	{...}
message_config[0].Path	
message_config[0].RemoteElement	
message_config[1]	{...}
message_config[1].Path	
message_config[1].RemoteElement	

Get the Size of the Local Array



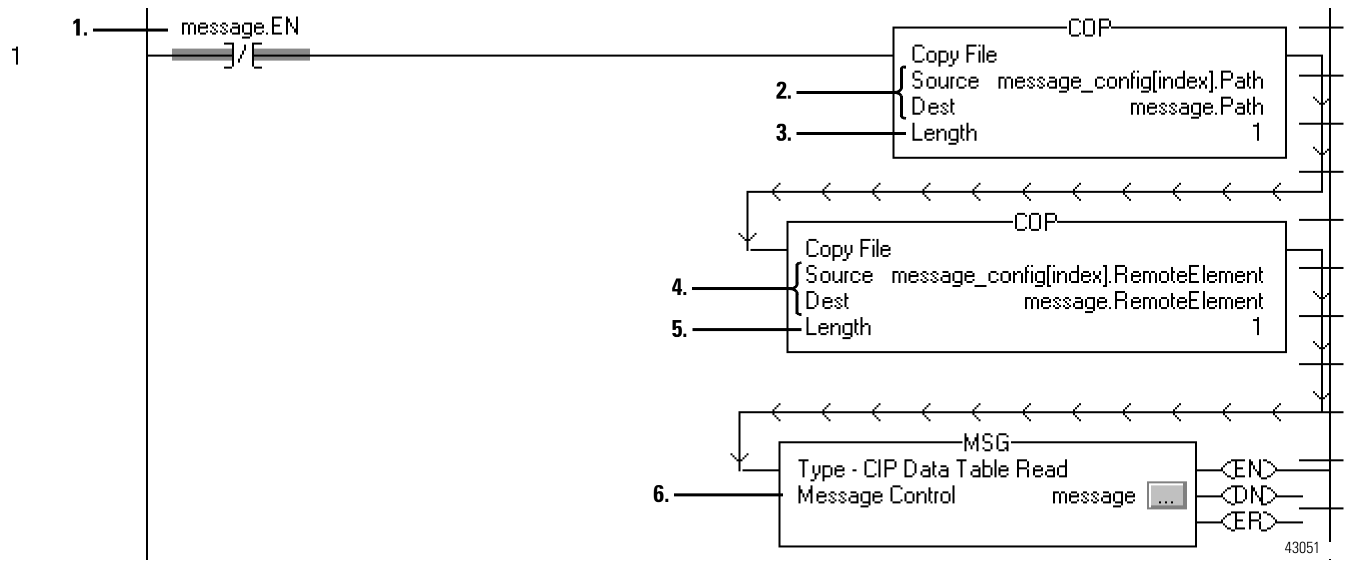
1. The SIZE instruction counts the number of elements in *local_array*.

2. The SIZE instruction counts the number of elements in Dimension 0 of the array. In this case, that is the only dimension.

3. *Local_array_length* stores the size (number of elements) of *local_array*. This value tells a subsequent rung when the message has been sent to all the controllers and to start with the first controller again.

Tag Name	Type
local_array_length	DINT

Load the Message Properties for a Controller



1. This XIO instruction conditions the rung to continuously send the message.

Tag Name	Type	Scope
message	MESSAGE	controller

2. The COP instruction loads the path for the message. The value of *index* determines which element the instruction loads from *message_config*. See Figure B.1 on page B-6.

Tag Name	Type	Scope
index	DINT	any

3. The instruction loads 1 element from *message_config.*

4. The COP instruction loads the tag name or address of the data in the controller that receives the message. The value of *index* determines which element the instruction loads from *message_config*. See Figure B.1 on page B-6.

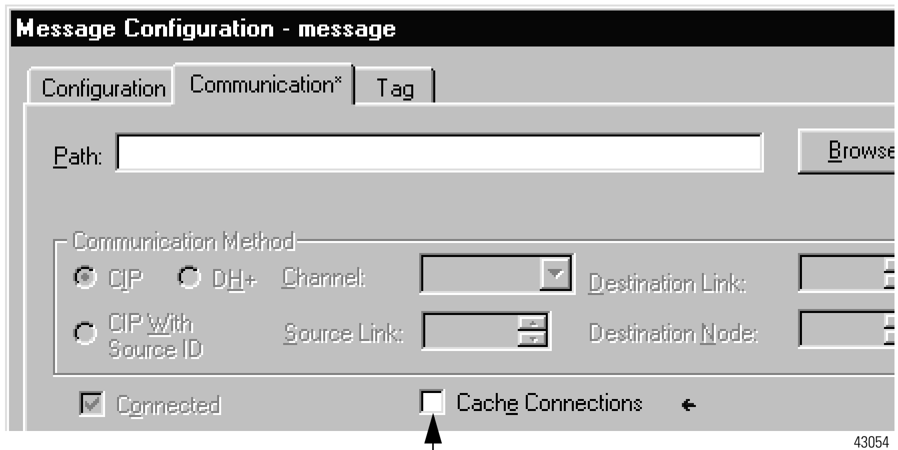
5. The instruction loads 1 element from *message_config.*

6. MSG instruction

Configure the Message

Although your logic controls the remote element and path for the message, the Message Properties dialog box requires an initial configuration.

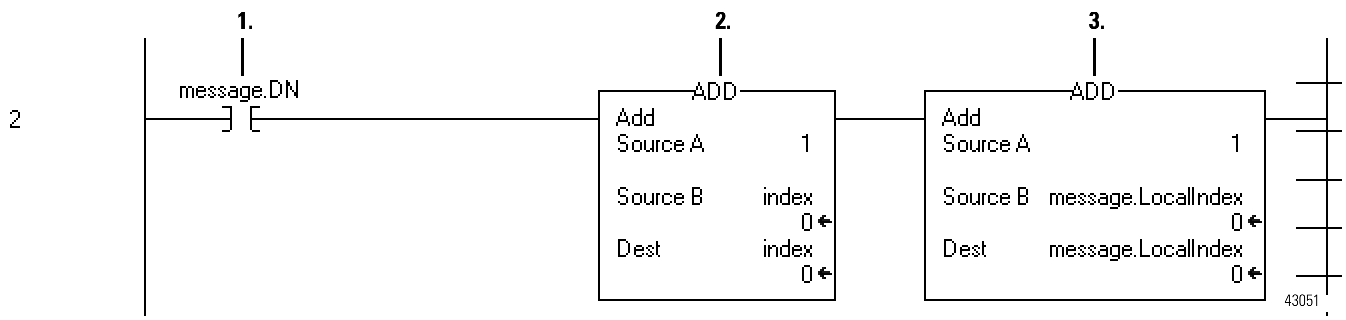
IMPORTANT



Clear the *Cache Connection* check box.

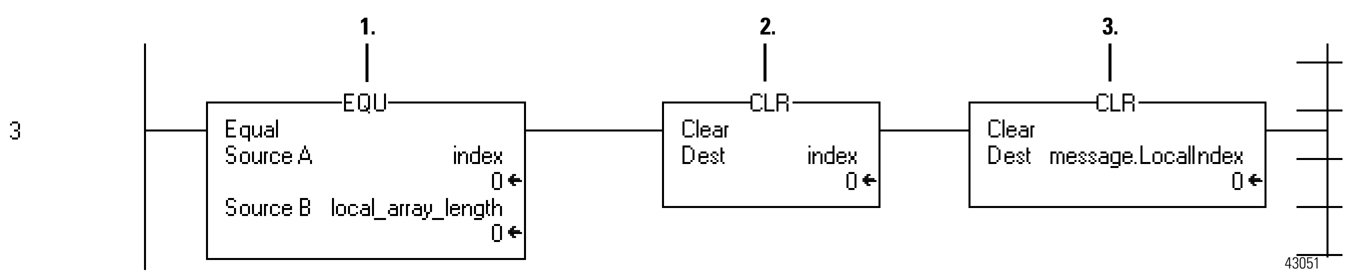
On this tab:	If you want to:	For this item:	Type or select:
Configuration	read (receive) data from the other controllers	Message Type	the read-type that corresponds to the other controllers
		Source Element	tag or address that contains the data in the first controller
		Number Of Elements	1
		Destination Tag	local_array[*]
		Index	0
	write (send) data to the other controllers	Message Type	the write-type that corresponds to other controllers
		Source Tag	local_array[*]
		Index	0
		Number Of Elements	1
		Destination Element	tag or address that contains the data in the first controller
Communication	→	Path	path to the first controller
		Cache Connections	Clear the *Cache Connection* check box. Since this procedure continuously changes the path of the message, it is more efficient to clear this check box.

Step to the Next Controller



1. After the MSG instruction sends the message…
2. This ADD instruction increments *index*. This lets the logic load the configuration properties for the next controller into the MSG instruction.
3. This ADD instruction increments the *LocalIndex* member of the MSG instruction. This lets the logic load the value from the next controller into the next element of *local_array*..

Restart the Sequence



1. When index equal local_array_length, the controller has sent the message to all the other controllers.
2. This CLR instruction sets *index* equal to 0. This lets the logic load the configuration properties for the first controller into the MSG instruction and start the sequence of messages again.
3. This CLR instruction sets the *LocalIndex* member of the MSG instruction equal to 0. This lets the logic load the value from the first controller into the first element of *local_array*..

IEC61131-3 Compliance

Using This Appendix

For information about:	See page:
Operating System	C-2
Data Definitions	C-2
Programming Languages	C-3
Instruction Set	C-4
IEC61131-3 Program Portability	C-4
IEC Compliance Tables	C-5

Introduction

The International Electrotechnical Commission (IEC) has developed a series of specifications for programmable controllers. These specifications are intended to promote international unification of equipment and programming languages for use in the controls industry. These standards provide the foundation for Logix5000 controllers and RSLogix 5000 programming software.

The IEC programmable controller specification is broken down into five separate parts each focusing on a different aspect of the control system:

- Part 1: General Information
- Part 2: Equipment and Requirements Test
- Part 3: Programming Languages
- Part 4: User Guidelines
- Part 5: Messaging Service Specification

The controls industry as a whole has focused on part 3 (IEC61131-3), Programming Languages, because it provides the cornerstone for implementing the other standards and provides the most significant end user benefit by reducing training cost. Because of this, only IEC61131-3 is addressed here.

The IEC61131-3 programming language specification addresses numerous aspects of programmable controller including the operating system execution, data definitions, programming languages, and instruction set. Components of the IEC61131-3 specification are categorized as required by the specification, optional or extensions. By so doing, the IEC61131-3 specification provides a minimum set of functionality that can be extended to meet end user application needs. The downside of this approach is that each programmable control system vendor may implement different components of the specification or provide different extensions.

Operating System

The preemptive, multitasking operating system (OS) of Logix5000 controllers complies with the IEC61131-3 definition. In IEC61131-3, the programmable controllers OS can contain zero or more tasks, that can execute one or more programs each containing one or more functions or routines. According to IEC61131-3, the number of each of these components is implementation dependent. Logix5000 controllers provide multiple tasks, each containing multiple programs and an unlimited number of functions or routines.

IEC61131-3 provides an option for creating different task execution classifications. Tasks may be configured as continuous, periodic, or event based. A continuous task does not need to be scheduled in that it will utilize any left over processing time when other tasks are dormant. Periodic tasks are scheduled to operate based on a reoccurring time period. The IEC61131-3 specification does not specify a time base for periodic task configuration. An IEC61131-3 event based task is triggered upon detection of the rising edge of a configured input. Logix5000 controllers support both continuous and periodic tasks. Additionally, the period for a periodic task is configurable starting as low as 1 millisecond (ms).

Data Definitions

The IEC61131-3 specification provides access to memory through the creation of named variables. IEC61131-3 names for variables consist of a minimum of six characters (RSLogix5000 programming software supports a minimum of 1 character) starting with an underscore "_" or an alpha character (A-Z), followed by one or more characters consisting of an underscore "_", alpha character (A-Z) or a number (0-9). Optionally, lower case alpha characters (a-z) can be supported as long as they are case insensitive (A = a, B = b, C = c …). Logix5000 controllers provide full compliance with this definition, support the lower case option, and extend the name to support up to 40 character names.

Data variables in IEC61131-3 may be defined such that they are accessible to all programs within a resource or controller, or limited access is provided only to the functions or routines within a single program. To pass data between multiple resources or controllers, access paths may be configured to define the location of the data within a system. Logix5000 controllers provide compliance by providing program scoped, controller scoped data and permits the configuration of access paths using produced/consumed data.

The memory interpretation of a variable within IEC61131-3 is defined through the use of either an elementary data type or an optional derived data type that is created from a group of multiple data types. Logix5000 controllers support the use of the BOOL (1 bit), SINT (8 bit integer), INT (16 bit integer), DINT (32 bit integer) and REAL (IEEE floating point number) elementary data types. Additionally, the optional derived data types are supported through the creation of user defined structures and arrays.

Programming Languages

The IEC61131-3 specification defines five (5) different programming languages and a set of common elements. All languages are defined as optional but at least one must be supported in order to claim compliance with the specification. The IEC61131-3 programming language components are defined as follows:

- Common Language Elements
- Common Graphical Elements
- Instruction List (IL) Language Elements
- Structured Text Language (ST) Elements
- Ladder Diagram (LD) Language Elements
- Sequential Function Chart (SFC) Language Elements
- Function Block Diagram (FBD) Language Elements

Logix5000 controllers and RSLogix5000 provide support for the common language elements and the Structured Text, Ladder Diagram, Sequential Function Chart, and Function Block Diagram language options. Additionally, the environment utilizes an ASCII import/export format based on the Structured Text language. The instruction set and program file exchange features are discussed in detail in the sections that follow.

Instruction Set

The instruction set specified by IEC61131-3 is entirely optional. The specification lists a limited set of instructions that if implemented must conform to the stated execution and visual representation. IEC61131-3 however, does not limit the instructions set to those listed within the specification. Each PLC vendor is free to implement additional functionality in the form of instructions over and above those listed by the specification. Examples of such extended instructions are those needed to perform diagnostics, PID loop control, motion control and data file manipulation. Because extended instructions are not defined by the IEC61131-3 specification, there is no guarantee that the implementation between different PLC vendors will be compatible. Thus utilization of these instructions may preclude the movement of logic between vendors.

Logix5000 controllers and RSLogix5000 provide a suite of instructions that execute as defined by the IEC61131-3 specification. The physical representation of these instructions maintain their look and feel with existing systems so as to reduce the training cost associated with working with the environment. In addition to the IEC61131-3 compliant instructions, a full range of instructions from existing products have been brought forward into the environment so that no functionality is lost.

IEC61131-3 Program Portability

One of the goals of end-users creating programs in an IEC61131-3 compliant environment is the movement or portability of programs between controllers developed by different vendors. This area is a weakness of IEC61131-3 because no file exchange format is defined by the specification. This means that if any program created in one vendor's environment will require manipulation to move it to another vendor's system.

In order to minimize the effort involved in performing cross-vendor portability, the RSLogix 5000 programming software for the controllers includes a full ASCII export and import utility. Additionally, the file format that is utilized by this tool is based on a hybrid of the IEC61131-3 Structured Text language definition. Controller operating system and data definitions follow the appropriate IEC61131-3 formats. Extensions were implemented in order to convert Ladder Diagram logic into ASCII text since this is not defined by IEC61131-3.

For more information on the ASCII export and import utility of RSLogix 5000 programming software, see the *Logix5000 Controllers Import/Export Reference Manual*, publication 1756-RM084.

IEC Compliance Tables

Logix5000 controllers and RSLogix5000 comply with the requirements of IEC61131-3 for the following language features:

Table Number:(1)	Feature Number:	Feature Description:	Extensions and Implementation Notes:
1	2	Lower case letters	none
1	3a	Number sign (#)	Used for immediate value data type designation
1	4a	Dollar sign ($)	Used for description and string control character
1	6a	Subscript delimiters ([ ])	Array subscripts
2	1	Identifiers using upper case and numbers	Task, program, routine, structure and tag names
2	2	Identifiers using upper case, numbers, and embedded underlines	Task, program, routine, structure and tag names
2	3	Identifiers using upper and lower case, numbers and embedded underlines	Task, program, routine, structure and tag names
3	1	Comments	ST Comments, also support /* Comment */, and // End of line comments.
4	1	Integer literal	12, 0, -12
4	2	Real literal	12.5, -12.5
4	3	Real literal with exponents	-1.34E-12, 1.234E6
4	4	Base 2 literal	2#0101_0101
4	5	Base 8 literal	8#377
4	6	Base 16 literal	16#FFE0
4	7	Boolean zero and one	0, 1
5	1A	Empty String ''	Descriptions, and String Editor
5	1B	String of length one containing a character 'A'	Descriptions, and String Editor
5	1C	String of length one containing a space ' '	Descriptions, and String Editor
5	1D	String of length one containing a single quote character '$''	Descriptions, and String Editor
5	1E	String of length one containing a double quote character '"'	Descriptions, and String Editor
5	1F	String of length two containing CR and LF characters	Descriptions, and String Editor
5	1G	String of length one containing the LF character '$0A'	Descriptions, and String Editor
5	1H	String of length 5 which would print as "$1.00" using '$$1.00'	Descriptions, and String Editor
5	1I	Equivalent strings of length two 'AE', and '$C4$CB'	Descriptions, and String Editor
6	2	String dollar sign '$$'	Descriptions, and String Editor
6	3	String single quote '$''	Descriptions, and String Editor
6	4	String Line Feed '$L' or '$l'	Descriptions, and String Editor

Table Number:[1]	Feature Number:	Feature Description:	Extensions and Implementation Notes:
6	5	String New-line '$N' or '$n'	Descriptions, and String Editor
6	6	String From Feed (page) '$P' or '$p'	Descriptions, and String Editor
6	7	String Carriage return '$R' or '$r'	Descriptions, and String Editor
6	8	String Tab '$T' or '$t'	Descriptions, and String Editor
6	9	String double quote $"	Descriptions, and String Editor
10	1	BOOL Data Type	Tag variable definition
10	2	SINT Data Type	Tag variable definition
10	3	INT Data Type	Tag variable definition
10	4	DINT Data Type	Tag variable definition
10	10	REAL Data Type	Tag variable definition
10	12	Time	Tag variable definition, TIMER Structure
10	16	STRING data type	8 Bits
11	1	Data type Hierarchy	none
12	1	Direct Derivation from elementary types	User Defined data type structures
12	4	Array data types	Tag variable definition
12	5	Structured Data types	User defined data type structures
13	1	BOOL, SINT, INT, DINT initial value of 0	Tag variable definition
13	4	REAL, LREAL initial value of 0.0	Tag variable definition
13	5	Time initial value of T#0s	Tag variable definition, reset (RES) instruction
13	9	Empty String ''	Descriptions and Strings
14	1	Initialization of directly derived types	Import/export
14	4	Initialization of array data types	Import/export
14	5	Initialization of structured type elements	Import/export
14	6	Initialization of derived structured data types	Import/export
19a	2a	Textual invocation, non-formal	Available in ST
20	1	Use of EN and ENO	Function present in LD but not labeled. Available in FBD.
20	2	Usage without EN and ENO	Available in FBD
20	3	Usage with EN and without ENO	Available in FBD
20	4	Usage without EN and with ENO	Available in FBD
21	1	Overloaded functions ADD(INT, DINT) or ADD(DINT, REAL)	All overloaded types that are supported are documented with each instruction
22	1	_TO_ conversion function	RAD, DEG instructions Radians to/from Decimal. String numeric conversion STOD, STOR, RTOS, DTOS. Others not needed because of instruction overloading
22	2	Truncate conversion function	TRN instruction in LD and TRUNC function in ST
22	3	BCD to INT Convert	FRD instruction in LD

Table Number:(1)	Feature Number:	Feature Description:	Extensions and Implementation Notes:
22	4	INT to BCD Convert	TOD instruction in LD
23	1	Absolute value	ABS instruction
23	2	Square root	SQR instruction in LD and FBD and SQRT function in ST.
23	3	Natural log	LN instruction
23	4	Log base 10	LOG instruction
23	6	Sine in radians	SIN instruction / function
23	7	Cosine in radians	COS instruction / function
23	8	Tangent in radians	TAN instruction / function
23	9	Principal arc sine	ASN instruction in LD and FBD, and ASIN function in ST
23	10	Principal arc cosine	ACS instruction in LD and FBD, and ACOS function in ST
23	11	Principal arc tangent	ATN instruction in LD and FBD, and ATAN function in ST
24	12	Arithmetic add	ADD instruction in LD and FBD, and + in ST.
24	13	Arithmetic multiplication	MUL instruction in LD and FBD, and * in ST.
24	14	Arithmetic subtraction	SUB instruction in LD and FBD, and - in ST.
24	15	Arithmetic divide	DIV instruction in LD and FBD, and / in ST.
24	16	Modulo	MOD instruction LD and ST
24	17	Exponentiation	XPY instruction in LD and FBD, and ** in ST.
24	18	Value move	MOV instruction in LD, and := in ST.
25	1	Bit shift left	Functionality contained in BSL instruction in LD for shift of 1
25	2	Bit shift right	Functionality contained in BSR instruction in LD for shift of 1
25	3	Bit rotate left	Functionality contained in BSL instruction in LD for shift of 1
25	4	Bit rotate right	Functionality contained in BSR instruction in LD for shift of 1
26	5	AND	BAND instruction in FBD, and "&" operator in ST
26	6	OR	BOR instruction in FBD
26	7	XOR	BXOR instruction in FBD
26	8	NOT	BNOT instruction in FBD
27	1	SELECT	SEL instruction in FBD
27	2a	Maximum select MAX	Functionality contained in ESEL instruction in FBD and ST
27	2b	Minimum select MIN	Functionality contained in ESEL instruction in FBD and ST

Table Number:(1)	Feature Number:	Feature Description:	Extensions and Implementation Notes:
27	3	High/Low limit LIMIT	HLL instruction in FBD and ST
27	4	Multiplexer MUX	MUX instruction in FBD
28	5	Comparison greater-than	GRT instruction in LD and FBD, and > in ST.
28	6	Comparison greater-than or equal	GRE instruction in LD and FBD, and >= in ST.
28	7	Comparison equal	EQU instruction in LD and FBD, and = in ST.
28	8	Comparison less-than	LES instruction in LD and FBD, and < in ST.
28	9	Comparison less-than or equal	LEQ instruction in LD and FBD, and <= in ST.
28	10	Comparison not equal	NEQ instruction in LD and FBD, and <> in ST.
29	1	String length LEN	Contained as parameter of STRING data type
29	4	Middle string MID	MID instruction in LD and ST
29	5	String concatenation CONCAT	CONCAT instruction in LD and ST
29	6	String insert INSERT	INSERT instruction in LD and ST
29	7	String delete DELETE	DELETE instruction in LD and ST
29	9	Find string FIND	FIND instruction in LD and ST
32	1	Input read	FBD and ST
32	2	Input write	FBD and ST
32	3	Output read	FBD and ST
32	4	Output write	FBD and ST
34	1	Bistable set dominant	SETD instruction in FBD and ST
34	2	Bistable reset dominant	RESD instruction in FBD and ST
35	1	Rising edge detector	OSR instruction in LD and OSRI instruction in FBD and ST
35	2	Falling edge detector	OSF instruction in LD and OSFI instruction in FBD and ST
36	1b	Up-counter	Functionality contained in CTU and RES instructions in LD and in CTUD instruction in FBD and ST
37	2a	On-delay timer	Functionality contained in TON instruction in LD and TONR instruction in FBD and ST
37	3a	Off-delay timer	Functionality contained in TOF instruction in LD and TOFR instruction in FBD and ST
38	2	On-delay timing	Functionality contained in TON instruction in LD and TONR instruction in FBD and ST
38	3	Off-delay timing	Functionality contained in TOF instruction in LD and TOFR instruction in FBD and ST
40	1a	SFC Step	
40	1b	SFC initial Step	
40	2a	SFC Step Textual	Import/export, step name is specified using the format "Operand := step_name"

Table Number:(1)	Feature Number:	Feature Description:	Extensions and Implementation Notes:
40	2b	SFC initial Step textual	Import/export, uses "InitialStep" parameter and step name is specified using the format "Operand := step_name"
40	3a	SFC Step Flag general form	Step backing tag
40	4	Step elapsed time general form	Step backing tag
41	1	Transition using ST	
41	5	Transition textual form	Import/export with different formatting
41	7	Transition Name	Transition Backing Tag
41	7a	Transition Set by LD	Transition Backing Tag
41	7b	Transition Set by FBD	Transition Backing Tag
41	7d	Transition Set by ST	Transition Backing Tag
42	1	Action Boolean	Action Backing tag
42	3s	Action textual representation	Import/export
43	1	Step Action association	
43	2	Step with Concatenated Actions	
43	3	Textual Step body	Import/export with different formatting
43	4	Action Body Field	Embedded ST
44	1	Action Block Qualifier	
44	2	Action Block Name	
44	3	Action Indicator Tag	Extended this to support DINT, INT, SINT, or REAL in addition to BOOL
44	5	Action using ST	Supports both embedded ST and JSR to ST routine
44	6	Action using LD	Using JSR to LD routine
44	7	Action using FBD	Using JSR to FBD Routine
45	1	Action Qualifier None	Default is N when none is explicitly entered
45	2	Action Qualifier N - Non-stored	
45	3	Action Qualifier R - Reset	
45	4	Action Qualifier S - Set / Stored	
45	5	Action Qualifier L - Time Limited	
45	6	Action Qualifier D - Time Delayed	
45	7	Action Qualifier P - Pulse	
45	8	Action Qualifier SD - Stored and Time Delayed	
45	9	Action Qualifier DS - Delayed and Stored	
45	10	Action Qualifier SL - Stored and time limited	
45	11	Action Qualifier P1 - Pulse Rising Edge	
45	12	Action Qualifier P0 - Pulse Falling Edge	

Table Number:(1)	Feature Number:	Feature Description:	Extensions and Implementation Notes:
45a	1	Action Control	
45a	2	Action Control	
46	1	SFC Single Sequence	
46	2a	SFC Divergence of sequence selection	Use of line connections vs. asterisk
46	2b	SFC Divergence of sequence selection with execution order.	
46	3	SFC Convergence of sequence selection	
46	4a	SFC Simultaneous sequence divergence	
46	4b	SFC Simultaneous sequence convergence	
46	5a, b, c	SFC Sequence Skip	
46	6a, b, c	SFC Sequence Loop	
46	7	SFC Loop directional arrows	When wire is hidden
47	1	SFC Graphical representation	
47	4	SFC Graphical representation	
48	1	SFC Minimal Step Compliance Requirements	Refer to notes on individual tables above.
48	2	SFC Minimal Transition Compliance Requirements	Refer to notes on individual tables above.
48	3	SFC Minimal Action Compliance Requirements	Refer to notes on individual tables above.
48	4	SFC Minimal Action Body Compliance Requirements	Refer to notes on individual tables above.
48	5	SFC Minimal Action Qualifier Compliance Requirements	Refer to notes on individual tables above.
48	6	SFC Minimal Branch Compliance Requirements	Refer to notes on individual tables above.
48	7	SFC Minimal Block Connection Compliance Requirements	Refer to notes on individual tables above.
55	1	ST Parenthesization (expression)	
55	2	ST Function Evaluation	Using non-formal form of invocation for built in functions. JSR used within ST language to call user developed code.
55	3	ST Exponentiation **	
55	4	ST Negation -	
55	5	ST Negation NOT	
55	6	ST Multiply *	
55	7	ST Divide /	
55	8	ST Modulo MOD	
55	9	ST Add +	
55	10	ST Subtract -	
55	11	ST Comparison <, >, <=, >=	

<table>
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<tr><td>55</td><td>13</td><td>ST Inequality <></td><td></td></tr>
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<tr><td>56</td><td>6</td><td>ST FOR / END_FOR</td><td></td></tr>
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<tr><td>56</td><td>9</td><td>ST EXIT</td><td></td></tr>
<tr><td>56</td><td>10</td><td>ST Empty Statement ;</td><td></td></tr>
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<tr><td>57</td><td>5, 6</td><td>Horizontal / Vertical connection</td><td>LD editor, FBD editor</td></tr>
<tr><td>57</td><td>7, 8</td><td>Line crossings without connection</td><td>FBD editor</td></tr>
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<tr><td>58</td><td>2</td><td>Unconditional jump</td><td>JMP instruction in LD</td></tr>
<tr><td>58</td><td>3</td><td>Jump target</td><td>LBL instruction in LD</td></tr>
<tr><td>58</td><td>4</td><td>Conditional jump</td><td>JMP instruction in LD</td></tr>
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<tr><td>59</td><td>2</td><td>Right hand power rail</td><td>LD editor</td></tr>
<tr><td>60</td><td>1</td><td>Horizontal link</td><td>LD editor</td></tr>
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<tr><td>62</td><td>1</td><td>Coil --( )--</td><td>OTE instruction in LD</td></tr>
</table>

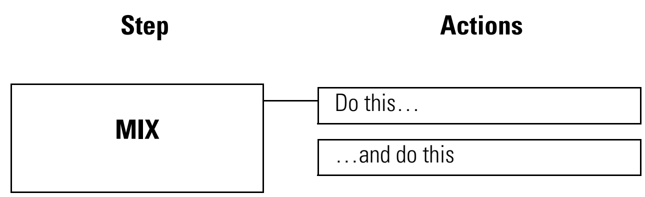
Table Number:[1]	Feature Number:	Feature Description:	Extensions and Implementation Notes:
62	3	Set (latch) coil	Functionality contained in OTL instruction in LD
62	4	Reset (unlatch) coil	Functionality contained in OTU instruction in LD
62	8	Positive transition sensing coil	OSR instruction in LD
62	9	Negative transition sensing coil	OSF instruction in LD

(1) Table associated with languages other than structured text, sequential function chart, ladder diagram and function block diagram have been skipped.

A

action

In a sequential function chart (SFC), an action represents a functional division of a step. Several actions make up a step. Each action performs a specific function, such as controlling a motor, opening a valve, or placing a group of devices in a specific mode.



Each action includes a qualifer. When a step is active (executing) the qualifier determines when the action starts and stops.

See *sequential function chart*, *step, qualifier*.

alias tag

A tag that references another tag. An alias tag can refer to another alias tag or a base tag. An alias tag can also refer to a component of another tag by referencing a member of a structure, an array element, or a bit within a tag or member. See *base tag*.

ASCII

A 7-bit code (with an optional parity bit) that is used to represent alphanumerical characters, punctuation marks, and control-code characters. For a list of ASCII codes, see the back cover of this manual.

asynchronous

Actions that occur independent of each other and lack a regular pattern. In Logix5000 controllers, I/O values update asynchronous to the execution of logic.:

- Programs within a task access input and output data directly from controller-scoped memory.
- Logic within any task can modify controller-scoped data.
- Data and I/O values are asynchronous and can change during the course of a task's execution.
- An input value referenced at the beginning of a task's execution can be different when referenced later.

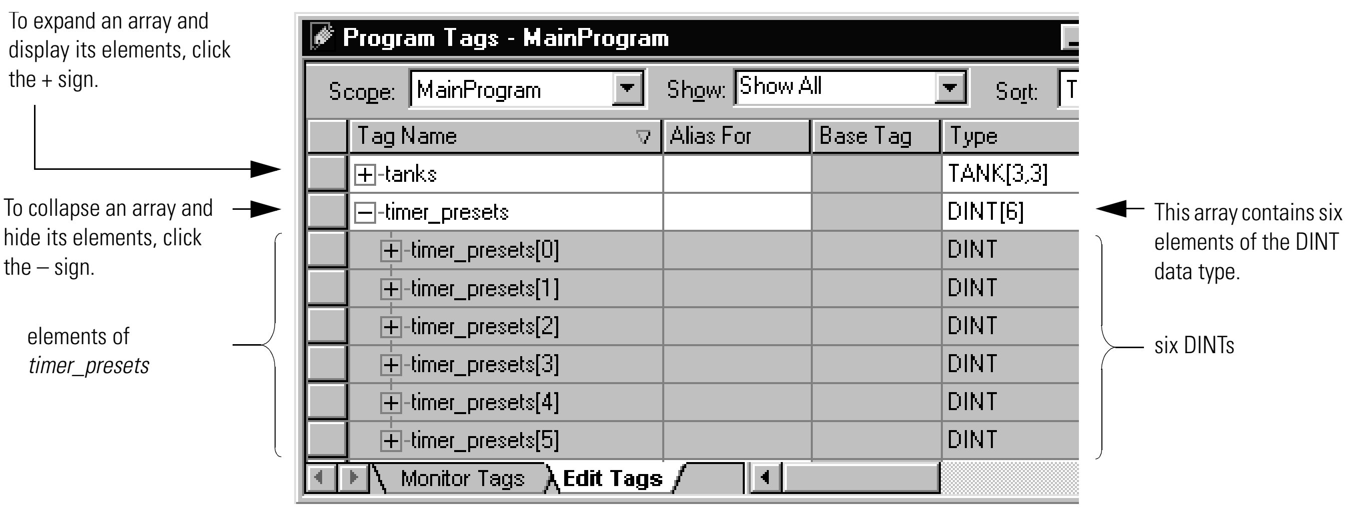
ATTENTION

Take care to ensure that data memory contains the appropriate values throughout a task's execution. You can duplicate or buffer data at the beginning of the scan to provide reference values for your logic.

array

An array lets you group data (of the same data type) under a common name.

- An array is similar to a file.
- A subscript (s) identifies each individual **element** within the array.
- A subscript starts at 0 and extends to the number of elements minus 1 (zero based).



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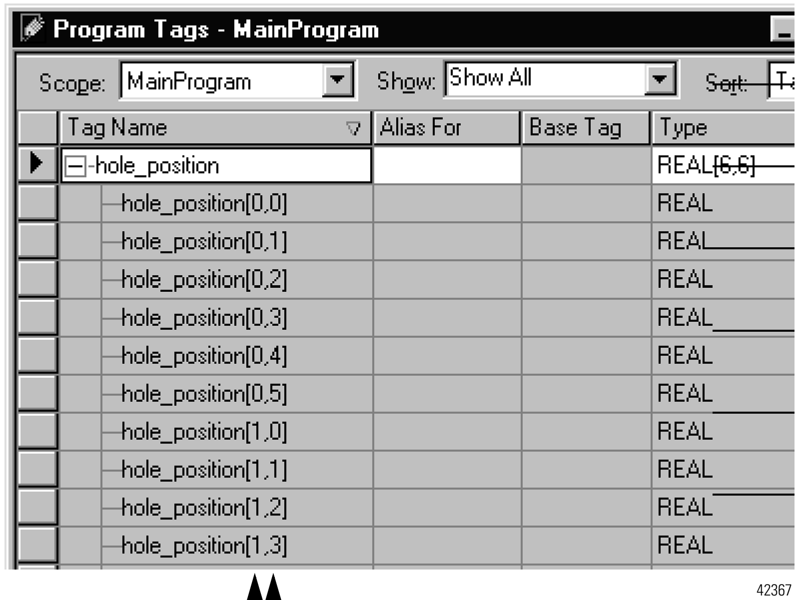
- An array tag occupies a contiguous block of memory in the controller, each element in sequence.
- You can use array and sequencer instructions to manipulate or index through the elements of an array
- An array can have as many as three dimensions. This gives you the flexibility to identify an element using one, two, or three subscripts (coordinates).

- In an array with two or three dimensions, the right-most dimension increments first in memory.

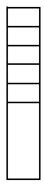
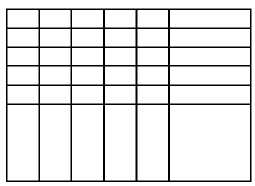
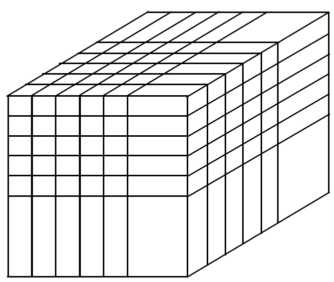


This array contains a two-dimensional grid of elements, six elements by six elements.

The right-most dimension increments to its maximum value then starts over.

When the right-most dimension starts over, the dimension to the left increments by one.

- The total number of elements in an array is the product of each dimension's size, as depicted in the following examples:

This array:	Stores data like:	For example:				
one dimension		Tag name:	Type	Dimension 0	Dimension 1	Dimension 2
		one_d_array	DINT[7]	7	--	--
		total number of elements = 7				
		valid subscript range DINT[x] where x=0–6				
two dimension		Tag name:	Type	Dimension 0	Dimension 1	Dimension 2
		two_d_array	DINT[4,5]	4	5	--
		total number of elements = 4 ∗ 5 = 20				
		valid subscript range DINT[x,y] where x=0–3; y=0–4				
three dimension		Tag name:	Type	Dimension 0	Dimension 1	Dimension 2
		three_d_array	DINT[2,3,4]	2	3	4
		total number of elements = 2 ∗ 3 ∗ 4 = 24				
		valid subscript range DINT[x,y,z] where x=0–1; y=0–2, z=0–3				

- You can modify array dimensions when programming offline without loss of tag data. You cannot modify array dimensions when programming online.

application

The combination of routines, programs, tasks, and I/O configuration used to define the operation of a single controller. See *project*.

B

base tag

A tag that actually defines the memory where a data element is stored. See *alias tag*.

bidirectional connection

A connection in which data flows in both directions: from the originator to the receiver and from the receiver to the originator. See *connection, unidirectional connection*.

binary

Integer values displayed and entered in base 2 (each digit represents a single bit). Prefixed with 2#. Padded out to the length of the boolean or integer (1, 8, 16, or 32 bits). When displayed, every group of four digits is separated by an underscore for legibility. See *decimal*, *hexadecimal*, *octal*.

bit

Binary digit. The smallest unit of memory. Represented by the digits 0 (cleared) and 1 (set).

BOOL

An data type that stores the state of a single bit, where:

- *0* equals *off*
- *1* equals *on*

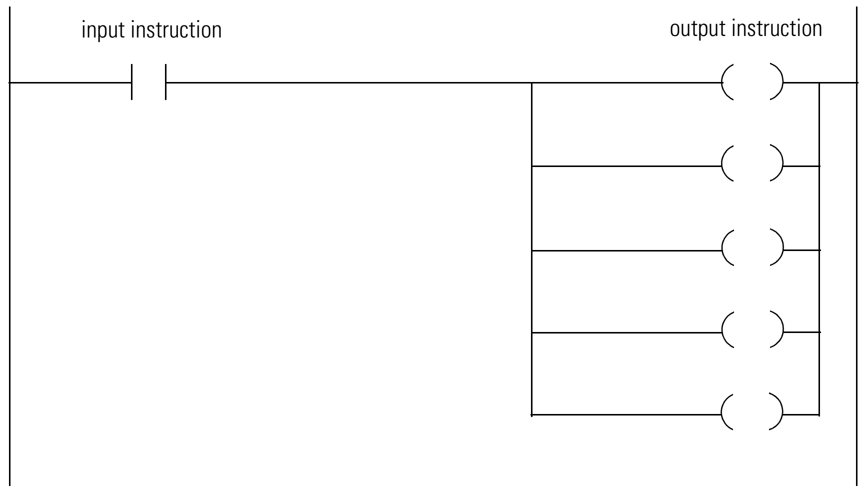
BOOL expression

In structured text, an expression that produces either the BOOL value of 1 (true) or 0 (false).

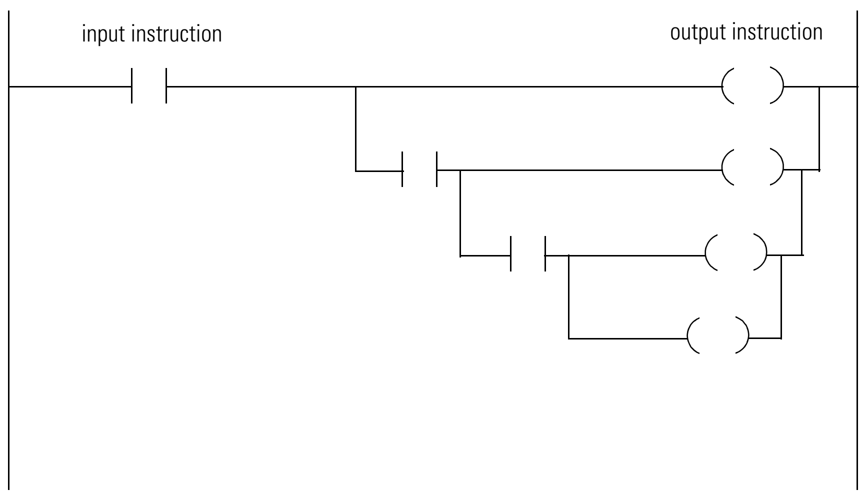
- A bool expression uses bool tags, relational operators, and logical operators to compare values or check if conditions are true or false. For example, `tag1>65`.
- A simple bool expression can be a single BOOL tag.
- Typically, you use bool expressions to condition the execution of other logic.

branch

There is no limit to the number of parallel branch levels that you can enter. The following figure shows a parallel branch with five levels. The main rung is the first branch level, followed by four additional branches.



You can nest branches to as many as 6 levels. The following figure shows a nested branch. The bottom output instruction is on a nested branch that is three levels deep.



byte

A unit of memory consisting of 8 bits.

C

cache

Depending on how you configure a MSG instruction, it may use a connection to send or receive data.

This type of message:	And this communication method:	Uses a connection:
CIP data table read or write	→	✓
PLC2, PLC3, PLC5, or SLC (all types)	CIP	
	CIP with Source ID	
	DH+	✓
CIP generic	→	your option (1)
block-transfer read or write	→	✓

(1) You can connect CIP generic messages. But for most applications we recommend you leave CIP generic messages unconnected.

If a MSG instruction uses a connection, you have the option to leave the connection open (cache) or close the connection when the message is done transmitting.

If you:	Then:
Cache the connection	The connection stays open after the MSG instruction is done. This optimizes execution time. Opening a connection each time the message executes increases execution time.
Do not cache the connection	The connection closes after the MSG instruction is done. This frees up that connection for other uses.

The controller has the following limits on the number of connections that you can cache:

If you have this software and firmware revision:	Then you can cache:
11.x or earlier	• block transfer messages for up to 16 connections • other types of messages for up to 16 connections
12.x or later	up to 32 connections

If several messages go to the same device, the messages may be able to share a connection.

If the MSG instructions are to:	And they are:	Then:
different devices	⟶	Each MSG instruction uses 1 connection.
same device	enabled at the same time	Each MSG instruction uses 1 connection.
	NOT enabled at the same time	The MSG instructions share the connection. (I.e., Together they count as 1 connection.)

EXAMPLE

Share a Connection

If the controller alternates between sending a block-transfer read message and a block-transfer write message to the same module, then together both messages count as 1 connection. Caching both messages counts as 1 on the cache list.

See *connection, uncached connection*.

change of state (COS)

Any change in the status of a point or group of points on an I/O module.

CIP

See Control and Information Protocol.

communication format

Defines how an I/O module communicates with the controller. Choosing a communication format defines:

- what configuration tabs are available through the programming software
- the tag structure and configuration method

compatible module

An electronic keying protection mode that requires that the vendor, catalog number, and major revision attributes of the physical module and the module configured in the software match in order to establish a connection to the module. See *disable keying*, *exact match*.

connection

A communication link between two devices, such as between a controller and an I/O module, PanelView terminal, or another controller.

- Connections are allocations of resources that provide more reliable communications between devices than unconnected messages.
- The number of connections that a single controller can have is limited.
- You indirectly determine the number of connections the controller uses by configuring the controller to communicate with other devices in the system.

consumed tag

A tag that receives the data that is broadcast by a produced tag over a ControlNet network or ControlLogix backplane. A consumed tag must be:

- controller scope
- same data type (including any array dimensions) as the remote tag (produced tag)

See *produced tag*.

continuous task

The task that runs continuously.

- The continuous task runs in the background. Any CPU time not allocated to other operations (such as motion, communications, and periodic tasks) is used to execute the programs within the continuous task.
- The continuous task restarts itself after the last of its programs finishes.
- A project does not require a continuous task.
- If used, there can be only one continuous task.
- All periodic tasks interrupt the continuous task.
- When you create a project, the default *MainTask* is the continuous task. You can leave this task as it is, or you can change its properties (name, type, etc.).

See *periodic task*.

Control and Information Protocol

Messaging protocol used by Allen-Bradley's Logix5000 line of control equipment. Native communications protocol used on the ControlNet network.

controller fault handler

The controller fault handler is an optional task that executes when the:

- major fault is not an instruction-execution fault
- program fault routine:
  - could not clear the major fault
  - faulted
  - does not exist

You can create only one program for the controller fault handler. After you create that program, you must configure one routine as the main routine.

- The controller fault program does *not* execute a fault routine.
- If you specify a fault routine for the controller fault program, the controller never executes that routine.
- You can create additional routines and call them from the main routine.

controller scope

Data accessible anywhere in the controller. The controller contains a collection of tags that can be referenced by the routines and alias tags in any program, as well as other aliases in the controller scope.
See *program scope*.

Coordinated System Time (CST)

A 64-bit value that represents the number of microseconds since the CST master controller started counting.

- The CST value is stored as a DINT[2] array, where:
  - first element stores the lower 32 bits
  - second element stores the upper 32 bits
- You can use the CST timestamp to compare the relative time between data samples.

COUNTER

Structure data type that contains status and control information for counter instructions

D

data type

A definition of the memory size and layout that will be allocated when you create a tag of that data type.

decimal

Integer values displayed and entered in base 10. No prefix. Not padded to the length of the integer. See *binary*, *hexadecimal*, *octal*.

description

Optional text that you can use to further document your application.

- You can use any printable character, including carriage return, tab, and space.
- Descriptions do not download to the controller. They remain in the offline project file.
- Descriptions have these length limitations:
  - For tags, you can use up to 120 characters.
  - For other objects (tasks, programs, modules, etc.), you can use up to 128 characters.

dimension

Specification of the size of an array. Arrays can have as many as three dimensions. See *array*.

DINT

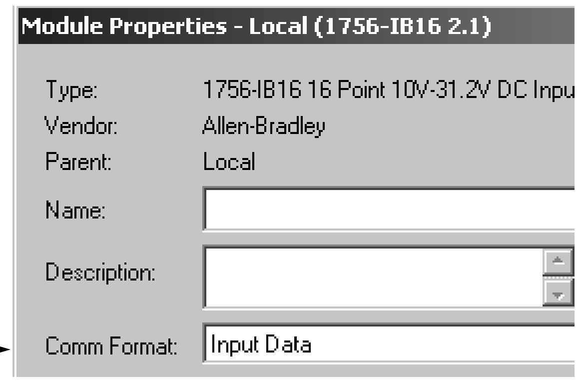
A data type that stores a 32-bit (4-byte) signed integer value (-2,147,483,648 to +2,147,483,647). In Logix5000 controllers, use DINTs for integers:

- Logix5000 controllers execute more efficiently and use less memory when working with 32-bit integers (DINTs) instead of 16-bit integers (INTs) or 8-bit integers (SINTs).
- Typically, instructions convert SINT or INT values to an **optimal data type** (usually a DINT or REAL value) during execution. Because this requires additional time and memory, minimize the use of the SINT and INT data types.

direct connection

A direct connection is a real-time, data transfer link between the controller and an I/O module. The controller maintains and monitors the connection with the I/O module. Any break in the connection, such as a module fault or the removal of a module while under power, sets fault bits in the data area associated with the module.

A direct connection is any connection that *does not* use the Rack Optimization Comm Format.



See *rack-optimized connection*.

disable keying

An electronic keying protection mode that requires no attributes of the physical module and the module configured in the software to match and still establishes a connection to the module. See *compatible module*, *exact match*.

download

The process of transferring the contents of a project on the workstation into the controller. See *upload*.

E

elapsed time

The total time required for the execution of all operations configured within a single task.

- If the controller is configured to run multiple tasks, elapsed time includes any time used/shared by other tasks performing other operations.
- While online, you can use the *Task Properties* dialog box to view the maximum scan time and the last scan time in ms for the current task. These values are elapsed time, which includes any time spent waiting for higher-priority tasks.

See *execution time*.

electronic keying

A feature of the 1756 I/O line where modules can be requested to perform an electronic check to insure that the physical module is consistent with what was configured by the software. Enables the user via the software to prevent incorrect modules or incorrect revisions of modules from being inadvertently used. See *compatible module*, *disable keying*, *exact match*.

element

An addressable unit of data that is a sub-unit of a larger unit of data. A single unit of an array.

- You specify an element in an array by its subscript(s):

For this array:	Specify:
one dimension	*array_name[subscript_0]*
two dimension	*array_name[subscript_0, subscript_1]*
three dimension	*array_name[subscript_0, subscript_1, subscript_2]*

See *array*.

exact match

An electronic keying protection mode that requires that all attributes (vendor, catalog number, major revision, and minor revision) of the physical module and the module configured in the software match in order to establish a connection to the module.

execution time

The total time required for the execution of a single program.

- Execution time includes only the time used by that single program, and excludes any time shared/used by programs in other tasks performing other operations.
- When online, use the *Program Properties* dialog box to view the maximum scan time and the last scan time (in µs) for the current program. These values are execution times for the program and do not include any time spent waiting for other programs or higher-priority tasks.

See *elapsed time*.

exponential

Real values displayed and entered in scientific or exponential format. The number is always displayed with one digit to the left of the decimal point, followed by the decimal portion, and then by an exponent. See *style*.

F

faulted mode

The controller generated a major fault, could not clear the fault, and has shut down.

See *major fault*.

float

Real values displayed and entered in floating point format. The number of digits to the left of the decimal point varies according to the magnitude of the number. See *style*.

H

hexadecimal

Integer values displayed and entered in base 16 (each digit represents four bits). Prefixed with 16#. Padded out to length of the boolean or integer (1, 8, 16, or 32 bits). When displayed, every group of four digits is separated by an underscore for legibility. See *binary*, *decimal*, *octal*.

I

immediate value

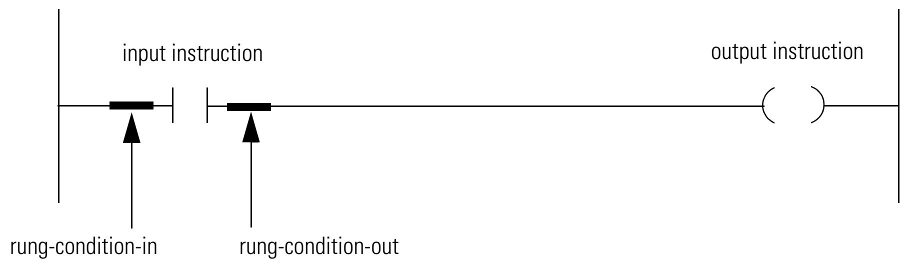
An actual 32-bit signed real or integer value. Not a tag that stores a value.

index

A reference used to specify an element within an array.

instruction

The controller evaluates ladder instructions based on the rung condition preceding the instruction (rung-condition-in).



Only input instructions affect the rung-condition-in of subsequent instructions on the rung:

- If the rung-condition-in to an input instruction is true, the controller evaluates the instruction and sets the rung-condition-out to match the results of the evaluation.
  - If the instruction evaluates to true, the rung-condition-out is true.
  - If the instruction evaluates to false, the rung-condition-out is false.
- An output instruction does not change the rung-condition-out.
  - If the rung-condition-in to an output instruction is true, the rung-condition-out is set to true.
  - If the rung-condition-in to an output instruction is false, the rung-condition-out is set to false.

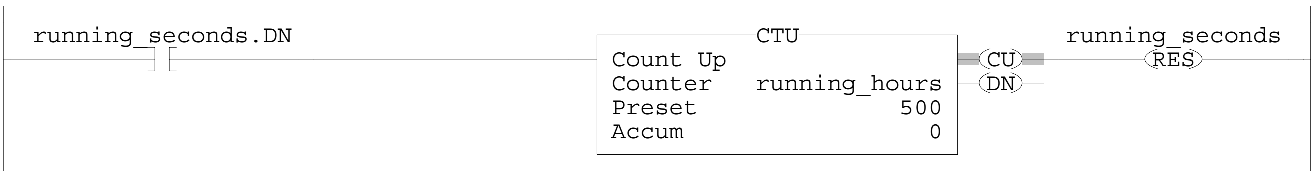
In Logix5000 controllers, you can enter multiple output instructions per rung of logic. You can enter the output instructions:

- in sequence on the rung (serial)
- between input instructions, as long as the last instruction on the rung is an output instruction

The following example uses more than one output on a rung.

EXAMPLE Place multiple outputs on a rung

When *running_seconds.DN* turns on, *running_hours* counts up by one and *running_seconds* resets.



When *machine_on* turns on, turns on *drill_1_on*. When both *machine_on* and *drill[1].part_advance* are on, turns on *conveyor_on*.

42362

INT

A data type that stores a 16-bit (2-byte) integer value (-32,768 to +32,767). Minimize your use of this data type:

- Typically, instructions convert SINT or INT values to an **optimal data type** (usually a DINT or REAL value) during execution. Because this requires additional time and memory, minimize the use of the SINT and INT data types.

interface module (IFM)

A pre-wired I/O field wiring arm.

L

listen-only connection

An I/O connection where another controller owns/provides the configuration data for the I/O module. A controller using a listen-only connection does not write configuration data and can only maintain a connection to the I/O module when the owner controller is actively controlling the I/O module. See *owner controller.*

load

To copy a project from nonvolatile memory to the user memory (RAM) of the controller. This overwrites any project that is currently in the controller. See *nonvolatile memory, store*.

M

main routine

The first routine to execute when a program executes. Use the main routine to call (execute) other routines (subroutines).

major fault

A fault condition that is severe enough for the controller to shut down, unless the condition is cleared. When a major fault occurs, the controller:

1. Sets a major fault bit

2. Runs user-supplied fault logic, if it exists

3. If the user-supplied fault logic cannot clear the fault, the controller goes to faulted mode

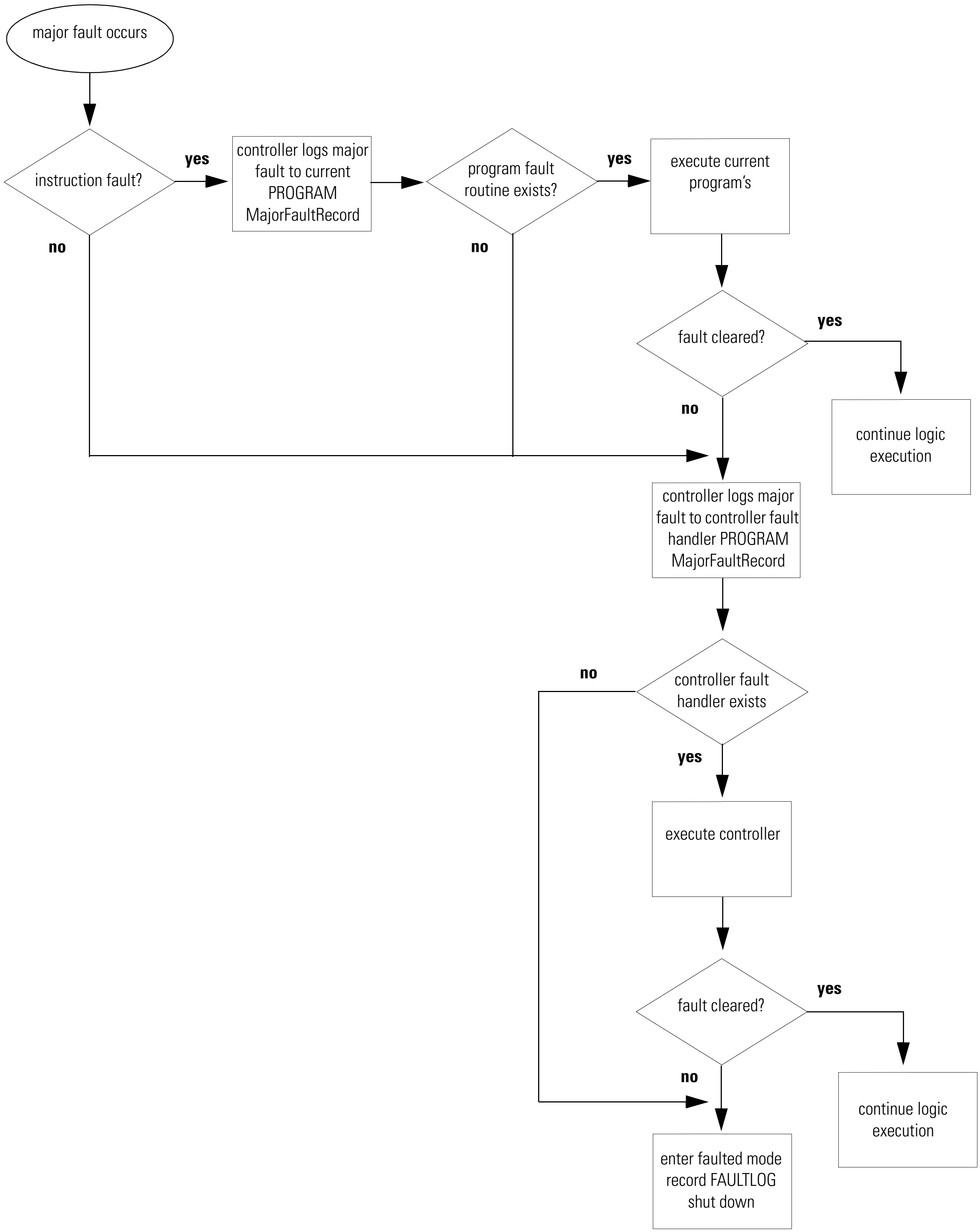
4. Sets outputs according to their output state during program mode

5. OK LED flashes red

The controller supports two levels for handling major faults:

- program fault routine:
  - Each program can have its own fault routine.
  - The controller executes the program's fault routine when an instruction fault occurs.
  - If the program's fault routine does not clear the fault or a program fault routine does not exist, the controller proceeds to execute the controller fault handler (if defined).
- controller fault handler:
  - If the controller fault handler does not exist or cannot clear the major fault, the controller enters faulted mode and shuts down. At this point, the FAULTLOG is updated. (See the next page.)
  - All non-instruction faults (I/O, task watchdog, etc.) execute the controller fault handler directly. (No program fault routine is called.)

The fault that was not cleared, and up to two additional faults that have not been cleared, are logged in the controller fault log.


major fault occurs
instruction fault?
yes
no
controller logs major fault to current PROGRAM MajorFaultRecord
program fault routine exists?
yes
no
execute current program's
fault cleared?
yes
no
continue logic execution
controller logs major fault to controller fault handler PROGRAM MajorFaultRecord
controller fault handler exists
no
yes
execute controller
fault cleared?
yes
no
continue logic execution
enter faulted mode record FAULTLOG shut down

See faulted state, minor fault.

major revision

The 1756 line of modules have major and minor revision indicators. The major revision is updated any time there is a functional change to the module. See *electronic keying*, *minor revision*.

master (CST)

Within a single chassis, one and only one, controller must be designated as the Coordinated System Time (CST) master. All other modules in the chassis synchronize their CST values to the CST master.

member

An element of a structure that has its own data type and name.

- Members can be structures as well, creating nested structure data types.
- Each member within a structure can be a different data type.
- To reference a member in a structure, use this format:

  `tag_name.member_name`

  For example:

This address:	References the:
timer_1.pre	PRE value of the *timer_1* structure.
input_load as data type *load_info* *input_load.height*	*height* member of the user-defined *input_load* structure

- If the structure is embedded in another structure, use the tag name of the structure at the highest level followed by a substructure tag name and member name:

  `tag_name.substructure_name.member_name`

  For example:

This address:	References the:
input_location as data type *location* *input_location.load_info.height*	*height* member of the *load_info* structure in the *input_location* structure.

- If the structure defines an array, use the array tag, followed by the position in the array and any substructure and member names.

  array_tag[position].member

  or

  array_tag[position].substructure_name.member_name

  For example:

This address:	References the:
conveyor[10].source	*source* member of the 11th element in the *conveyor* array (array elements are zero based).
conveyor[10].info.height	*height* member of the *info* structure in the 11th element of the *conveyor* array (array elements are zero based).

See *structure*.

memory

Electronic storage media built into a controller, used to hold programs and data.

minor fault

A fault condition that is *not* severe enough for the controller to shut down:

If this occurs:	The controller:
problem with an instruction	1. sets S:MINOR 2. logs information about the fault to the PROGRAM object, MinorFaultRecord attribute 3. sets bit 4 of the FAULTLOG object, MinorFaultBits attribute
periodic task overlap	sets bit 6 of the FAULTLOG object, MinorFaultBits attribute
problem with the serial port	sets bit 9 of the FAULTLOG object, MinorFaultBits attribute
low battery	sets bit 10 of the FAULTLOG object, MinorFaultBits attribute

To clear minor faults:

1. In the controller organizer, right-click the *Controller* `name_of_controller` folder and select *Properties*.

2. Click the *Minor Fault*s tab.

3. Use the information in the *Recent Faults* list to correct the cause of the fault. Refer to "Minor Fault Codes" on page 16-4.

4. Click the *Clear Minors* button.

See *major fault*.

minor revision

The 1756 line of modules have major and minor revision indicators. The minor revision is updated any time there is a change to a module that does not affect its function or interface. See *electronic keying*, *major revision*.

multicast

A mechanism where a module can send data on a network that is simultaneously received by more that one listener. Describes the feature of the ControlLogix I/O line which supports multiple controllers receiving input data from the same I/O module at the same time.

multiple owners

A configuration setup where more than one controller has exactly the same configuration information to simultaneously own the same input module.

N

name

Names identify controllers, tasks, programs, tags, modules, etc. Names follow IEC-1131-3 identifier rules and:

- must begin with an alphabetic character (A-Z or a-z) or an underscore (_)
- can contain only alphabetic characters, numeric characters, and underscores
- can have as many as 40 characters
- must not have consecutive or trailing underscore characters (_)
- are *not* case sensitive
- download to the controller

network update time (NUT)

The repetitive time interval in which data can be sent on a ControlNet network. The network update time ranges from 2ms-100ms.

nonvolatile memory

Memory of the controller that retains its contents while the controller is without power or a battery. See *load*, *store.*

numeric expression

In structured text, an expression that calculates an integer or floating-point value.

- A numeric expression uses arithmetic operators, arithmetic functions, and bitwise operators. For example, `tag1+5`.
- Often, you nest a numeric expression within a bool expression. For example, `(tag1+5)>65`.

O

object

A structure of data that stores status information. When you enter a GSV/SSV instruction, you specify the object and its attribute that you want to access. In some cases, there are more than one instance of the same type of object, so you might also have to specify the object name. For example, there can be several tasks in your application. Each task has its own TASK object that you access by the task name.

octal

Integer values displayed and entered in base 8 (each digit represents three bits). Prefixed with 8#. Padded out to the length of the boolean or integer (1, 8, 16, or 32 bits). When displayed, every group of three digits is separated by an underscore for legibility. See *binary*, *decimal*, *hexadecimal*.

offline

Viewing and editing a project that is on the hard disk of a workstation. See *online*.

online

Viewing and editing the project in a controller. See *offline*.

optimal data type

A data type that a Logix5000 instruction actually uses (typically the DINT and REAL data types).

- In the instruction set reference manuals, a **bold** data type indicates an optimal data type.

  - Instructions execute faster and require less memory if all the operands of the instruction use:
    - the same data type
    - an optimal data type

- If you mix data types and use tags that are not the optimal data type, the controller converts the data according to these rules

    - Are *any* of the operands a REAL value?

If:	Then input operands (e.g., source, tag in an expression, limit) convert to:
Yes	REALs
No	DINTs

    - After instruction execution, the result (a DINT or REAL value) converts to the destination data type, if necessary.

- Because the conversion of data takes additional time and memory, you can increase the efficiency of your programs by:
  - – using the same data type throughout the instruction
  - – minimizing the use of the SINT or INT data types

  In other words, use all DINT tags or all REAL tags, along with immediate values, in your instructions.

- The following table summarizes how the controller converts data between data types:

<table>
<tr><th>Conversion:</th><th>Result:</th></tr>
<tr><td>larger integer to smaller integer</td><td>The controller truncates the upper portion of the larger integer and generates an overflow.

For example:<table><tr><th></th><th>Decimal</th><th>Binary</th></tr><tr><td>DINT</td><td>65,665</td><td>0000_0000_0000_0001_0000_0000_1000_0001</td></tr><tr><td>INT</td><td>129</td><td>0000_0000_1000_0001</td></tr><tr><td>SINT</td><td>-127</td><td>1000_0001</td></tr></table></td></tr>
<tr><td>SINT or INT to REAL</td><td>No data precision is lost</td></tr>
<tr><td>DINT to REAL</td><td>Data precision could be lost. Both data types store data in 32 bits, but the REAL type uses some of its 32 bits to store the exponent value. If precision is lost, the controller takes it from the least-significant portion of the DINT.</td></tr>
<tr><td>REAL to integer</td><td>The controller rounds the fractional part and truncates the upper portion of the non-fractional part. If data is lost, the controller sets the overflow status flag.

Numbers round as follows:
• Numbers other than x.5 round to the nearest number.
• X.5 rounds to the nearest even number.

For example:<table><tr><th>REAL (source)</th><th>DINT (result)</th></tr><tr><td>-2.5</td><td>-2</td></tr><tr><td>-1.6</td><td>-2</td></tr><tr><td>-1.5</td><td>-2</td></tr><tr><td>-1.4</td><td>-1</td></tr><tr><td>1.4</td><td>1</td></tr><tr><td>1.5</td><td>2</td></tr><tr><td>1.6</td><td>2</td></tr><tr><td>2.5</td><td>2</td></tr></table></td></tr>
</table>

overlap

A condition where a task (perioidic or event) is triggered while the task is still executing from the preivious trigger.

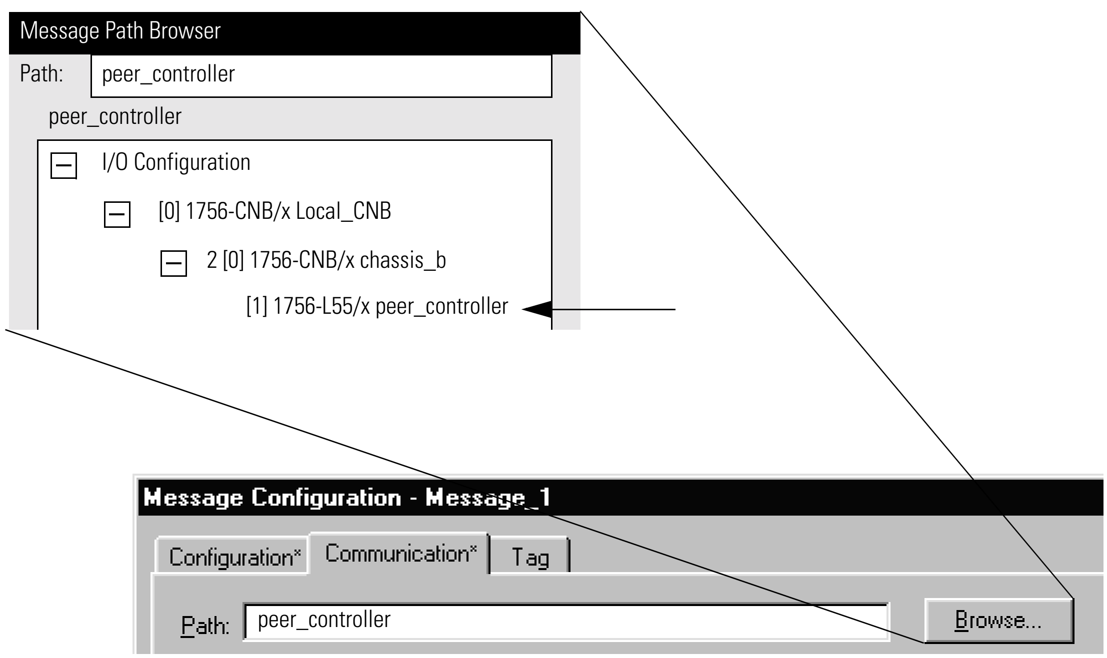
owner controller

The controller that creates the primary configuration and communication connection to a module. The owner controller writes configuration data and can establish a connection to the module. See *listen-only connection*.

P

path

The path describes the route that a message takes to get to the destination. If the I/O configuration of the controller contains the destination device, use the *Browse* button to select the device. This automatically defines the path.



If the I/O configuration *does not* contain the destination device, then type the path to the destination using the following format:

port,address,port,address

Where:	For this:	Is:
port	backplane from any 1756 controller or module	1
	DF1 port from a Logix5000 controller	2
	ControlNet port from a 1756-CNB module	
	Ethernet port from a 1756-ENBx or -ENET module	
	DH+ port over channel A from a 1756-DHRIO module	
	DH+ port over channel B from a 1756-DHRIO module	3
address	ControlLogix backplane	slot number
	DF1 network	station address (0-254)
	ControlNet network	node number (1-99 decimal)
	DH+ network	8# followed by the node number (1-77 octal) For example, to specify the octal node address of 37, type 8#37.
	EtherNet/IP network	You can specify a module on an EtherNet/IP network using any of these formats: IP address (e.g., 130.130.130.5) IP address:Port (e.g., 130.130.130.5:24) DNS name (e.g., tanks) DNS name:Port (e.g., tanks:24)

See *connection*.

periodic task

A task that is triggered by the operating system at a repetitive period of time.

- Use a periodic task for functions that require accurate or deterministic execution.
- Whenever the time expires, the task is triggered and its programs are executed.
- Data and outputs established by the programs in the task retain their values until the next execution of the task or they are manipulated by another task.
- You can configure the time period from 1 ms to 2000 s. The default is 10 ms.

ATTENTION

Ensure that the time period is longer than the sum of the execution times of all the programs assigned to the task. If the controller detects that a periodic task trigger occurs for a task that is already operating, a minor fault occurs.

- Periodic tasks always interrupt the continuous task.
- Depending on the priority level, a periodic task may interrupt other periodic tasks in the controller.

See *continuous task*.

periodic task overlap

A condition that occurs when a task is executing and the same task is triggered again. The execution time of the task is greater than the periodic rate configured for the task. See *periodic task*.

predefined structure

A structure data type that stores related information for a specific instruction, such as the TIMER structure for timer instructions. Predefined structures are always available, regardless of the system hardware configuration. See *product defined structure*.

prescan

Prescan is an intermediate scan during the transition to Run mode.

- The controller performs prescan when you change from Program mode to Run mode.
- The prescan examines all programs and instructions and initializes data based on the results.
- Some instructions execute differently during prescan than they do during the normal scan.

priority

Specifies which task to execute first if two tasks are triggered at the same time.

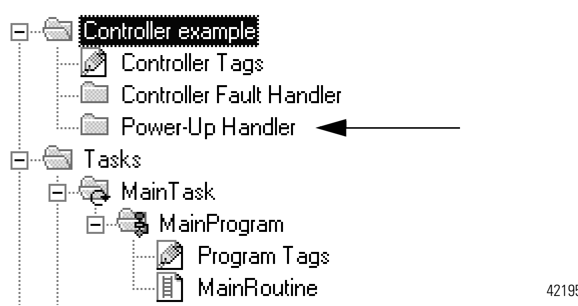
- The task with the higher priority executes first.
- Priorities range from 1-15, with 1 being the highest priority.
- A higher priority task will interrupt any lower priority task.
- If two tasks with the same priority are triggered at the same time, the controller switches between the tasks every millisecond.

postscan

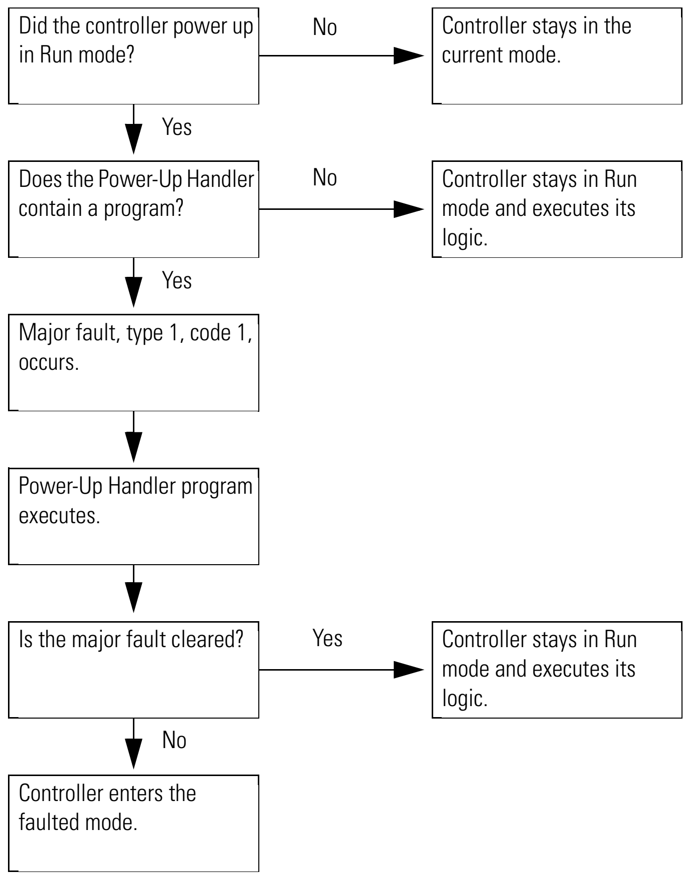
A function of the controller where the logic within a program is examined before disabling the program in order to reset instructions and data.

power-up handler

An optional task that executes when the controller powers up in the Run mode. To use the Power-Up Handler, you must create a power-up program and associated main routine.



The Power-Up Handler executes as follows:



produced tag

A tag that a controller is making available for use by other controllers. Produced tags are always at controller scope. See *consumed tag*.

product defined structure

A structure data type that is automatically defined by the software and controller. By configuring an I/O module you add the product defined structure for that module.

program

A set of related routines and tags.

- Each program contains program tags, a main executable routine, other routines, and an optional fault routine.
- To execute the routines in a program, you assign (schedule) the program to a task:
  - When a task is triggered, the scheduled programs within the task execute to completion from first to last.
  - When a task executes a program, the main routine of the program executes first.
  - The main routine can, in turn, execute subroutines using the JSR instruction.
- The *Unscheduled Program*s folder contains programs that aren't assigned to a task.
- If the logic in the program produces a major fault, execution jumps to a configured fault routine for the program.
- The routines within a program can access the following tags:
  - program tags of the program
  - controller tags
- Routines cannot access the program tags of other programs.

See *routine*, *task*.

program scope

Data accessible only within the current program. Each program contains a collection of tags that can only be referenced by the routines and alias tags in that program. See *controller scope*.

project

The file on your workstation (or server) that stores the logic, configuration, data, and documentation for a controller.

- The project file has an .ACD extension.
- When you create a project file, the file name is the name of the controller.
- The controller name is independent of the project file name. If you save a current project file as another name, the controller name is unchanged.
- If the name of the controller is different than the name of the project file, the title bar of the RSLogix 5000 software displays both names.

See *application*.

Q

qualifier
In the action of a sequential function chart (SFC), a qualifier defines when an action starts and stops.

See *action*, *sequential function chart*, *step*.

R

rack-optimized connection

For digital I/O modules, you can select rack-optimized communication. A rack-optimized connection consolidates connection usage between the controller and all the digital I/O modules in the chassis (or DIN rail). Rather than having individual, direct connections for each I/O module, there is one connection for the entire chassis (or DIN rail).

See *direct connection*.

rate

For a periodic task, the rate at which the controller executes the task, from 1 ms to 2,000,000 ms (2000 seconds). The default is 10 ms.

REAL

A data type that stores a 32-bit (4-byte) IEEE floating-point value, with the following range:

- $-3.40282347E^{38}$ to $-1.17549435E^{-38}$ (negative values)
- 0
- $1.17549435E^{-38}$ to $3.40282347E^{38}$ (positive values)

The REAL data type also stores ±infinity, ±NAN, and -IND, but the software display differs based on the display format.

Display Format:	Equivalent:	
Real	+infinite - infinite +NAN -NAN -indefinite	1.$ -1.$ 1.#QNAN -1.#QNAN -1.#IND
Exponential	+infinite - infinite +NAN -NAN -indefinite	1.#INF000e+000 -1.#INF000e+000 1.#QNAN00e+000 -1.#QNAN00e+000 -1.#IND0000e+000

The software also stores and displays the IEEE subnormal range:

- $-1.17549421E^{-38}$ to $-1.40129846E^{-45}$ (negative values)
- $1.40129846E^{-45}$ to $1.17549421E^{-38}$ (positive values)

removal and insertion under power (RIUP)

A ControlLogix feature that allows a user to install or remove a module while chassis power is applied.

requested packet interval (RPI)

When communicating over a the network, this is the maximum amount of time between subsequent production of input data.

- Typically, this interval is configured in microseconds.
- The actual production of data is constrained to the largest multiple of the network update time that is smaller than the selected RPI.
- Use a power of two times the ControlNet network update time (NUT).

  For example, if the NUT is 5 ms, type a rate of 5, 10, 20, 40 ms, etc.

See *network update time (NUT).*

routine

A set of logic instructions in a single programming language, such as a ladder diagram.

- Routines provide the executable code for the project in a controller (similar to a program file in a PLC or SLC controller).
- Each program has a main routine:
  - When the controller triggers the associated task and executes the associated program, the main routine is the first routine to execute.
  - To call another routine within the program, enter a JSR instruction in the main routine.
- You can also specify an optional program fault routine.
  - If any of the routines in the associated program produce a major fault, the controller executes program fault routine

See *program*, *task.*

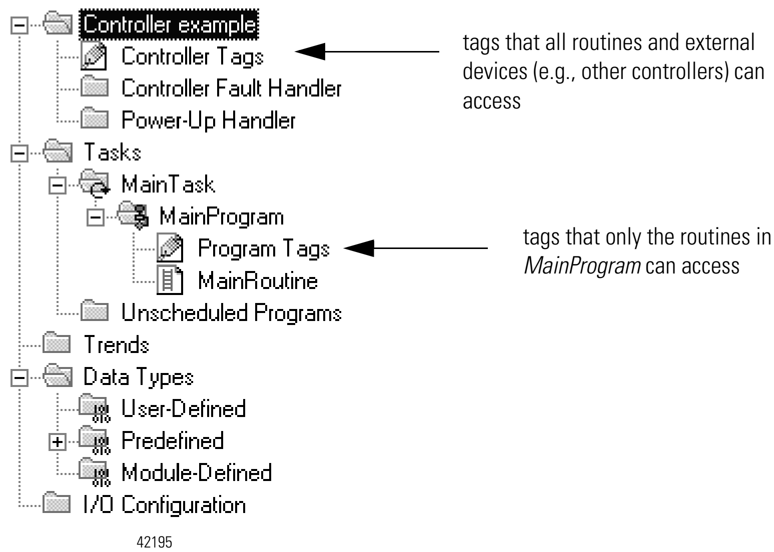
S

scan time

See *elapsed time*, *execution time*.

scope

Defines where you can access a particular set of tags. When you create a tag, you assign (scope) it as either a controller tag or a program tag for a specific program, as depicted below.



You can have multiple tags with the same name:

- Each tag must have a different scope. For example, one of the tags can be a controller tag and the other tags can be program tags for different programs. Or, each tag can be a program tag for a different program.
- Within a program, you cannot reference a controller tag if a tag of the same name exists as a program tag for that program.

See *controller scope*, *program scope*.

sequential function chart

A sequential function chart (SFC) is similar to a flowchart. It uses steps and transitions to control a machine or process.

See *action, step, transition*.

SINT

A data type that stores an 8-bit (1-byte) signed integer value (-128 to +127). Minimize your use of this data type:

- Typically, instructions convert SINT or INT values to an **optimal data type** (usually a DINT or REAL value) during execution. Because this requires additional time and memory, minimize the use of the SINT and INT data types.

source key

A mechanism that limits who can view a routine.

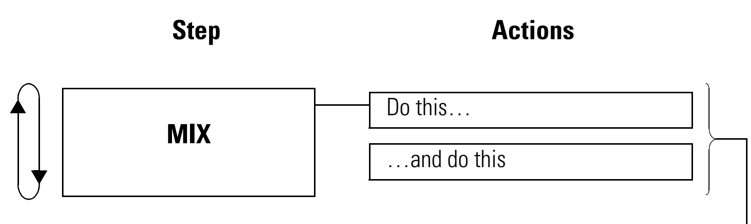
- You assign a source key to one or more routines.
- Source keys follow the same rules for names as other RSLogix 5000 components, such as routines, tags, and modules.
- To assign a source key to a routine (protect the routine), use RSLogix 5000 software. (You have to first activate the tool.).
- A source key file (sk.dat) stores the source keys. The source key file is separate from the RSLogix 5000 project files (.acd).
- To view a routine that is protected by a source key, you must have the source key.
- Without the source key, you cannot open a routine. RSLogix 5000 software displays “Source Not Available.”
- Regardless of whether or not the source key is available, you can always download the project and execute all the routines.

See *name.*

step

In a sequential function chart (SFC), a step represents a major function of a process. It contains the events that occur at a particular time, phase, or station.

A step executes continuously until a logic condition tells the controller to go to the next step.



A step is organized into one or more actions. Each action performs a specific function, such as controlling a motor, opening a valve, or placing a group of devices in a specific mode.

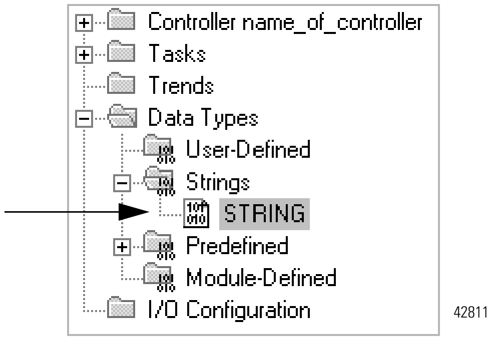
See *action, sequential function chart*, *transition*.

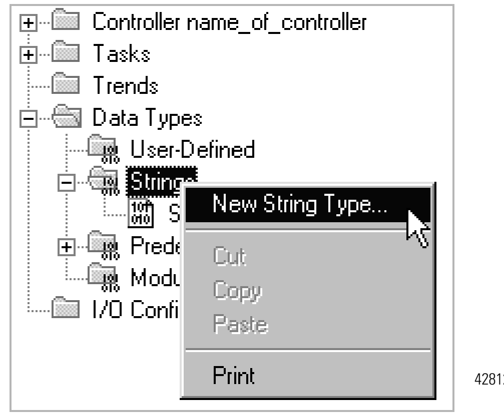
store

To copy a project to the nonvolatile memory of the controller. This overwrites any project that is currently in the nonvolatile memory. See *load, nonvolatile memory.*

string

A group of data types that store ASCII characters.





You can use the default STRING data type. It stores up to 82 characters.

or

You can create a new string data type to store the number of characters that you define.

Each string data type contains the following members:

Name:	Data Type:	Description:	Notes:
LEN	DINT	number of characters in the string	The LEN automatically updates to the new count of characters whenever you: • use the String Browser dialog box to enter characters • use instructions that read, convert, or manipulate a string The LEN shows the length of the current string. The DATA member may contain additional, old characters, which are not included in the LEN count.
DATA	SINT array	ASCII characters of the string	• To access the characters of the string, address the name of the tag. For example, to access the characters of the *string_1* tag, enter *string_1*. • Each element of the DATA array contains one character. • You can create new string data types that store less or more characters.

New string data types are useful in the following situations:

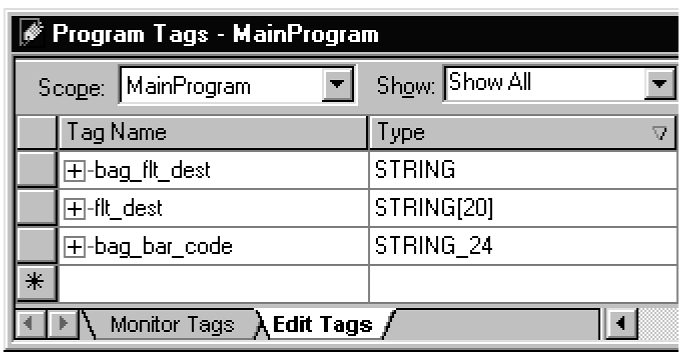
- If you have a large number of strings with a fixed size that is less than 82 characters, you can conserve memory by creating a new string data type.
- If you must handle strings that have more than 82 characters, you can create a new string data type to fit the required number of characters.

IMPORTANT

Use caution when you create a new string data type. If you later decide to change the size of the string data type, you may lose data in any tags that currently use that data type.

If you:	Then:
make a string data type smaller	• The data is truncated. • The LEN is unchanged.
make a string data type larger	The data and LEN is reset to zero.

The following example shows the STRING data type and a new string data type.



42234

This tag uses the default STRING data type.

This tag is an 20 element array of the default STRING data type.

This tag uses a new string data type.

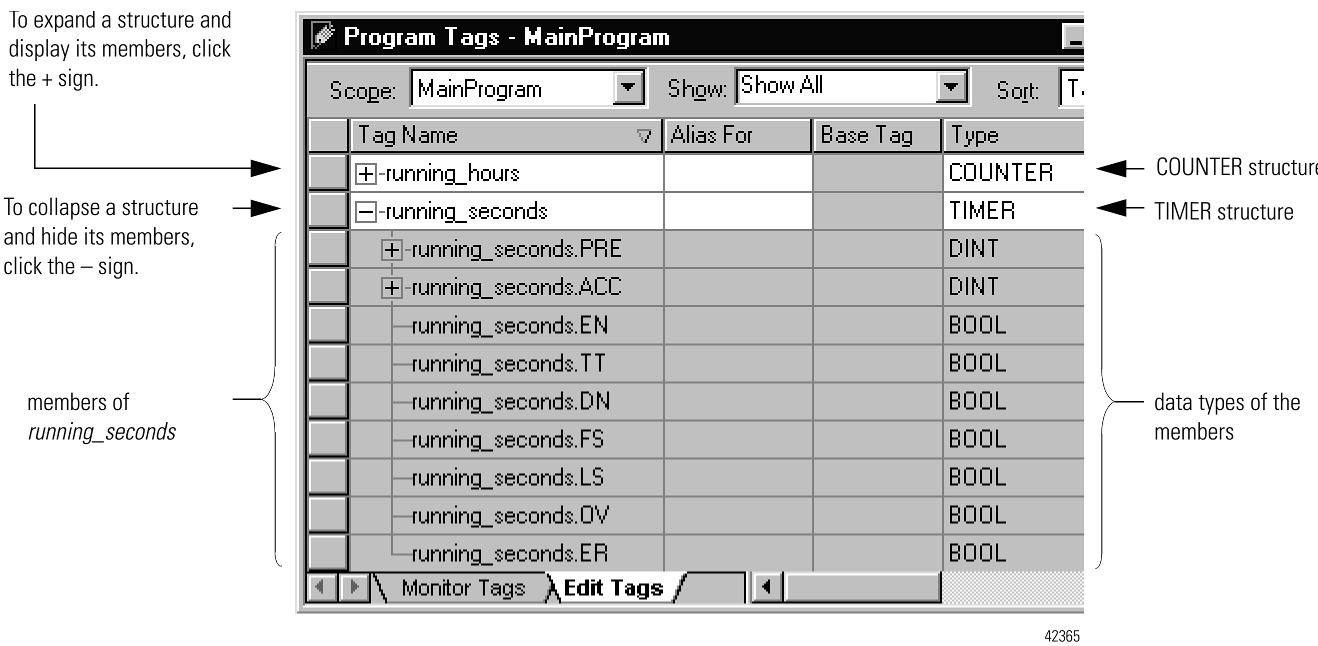
- The user named the string data type *STRING_24*.
- The new string data type stores

structure

Some data types are a structure.

- A structure stores a group of data, each of which can be a different data type.
- Within a structure, each individual data type is called a **member**.
- Like tags, members have a name and data type.
- You create your own structures, called a **user-defined data type**, using any combination of individual tags and most other structures.
- To copy data to a structure, use the COP instruction. See the *Logix5000 Controllers General Instruction Set Reference Manual*, publication 1756-RM003.

The COUNTER and TIMER data types are examples of commonly used structures.



See *member*, *user-defined data type.*

style

The format that numeric values are displayed in. See *ASCII*, *binary, decimal, exponential, float, hexadecimal, octal.*

system overhead time slice

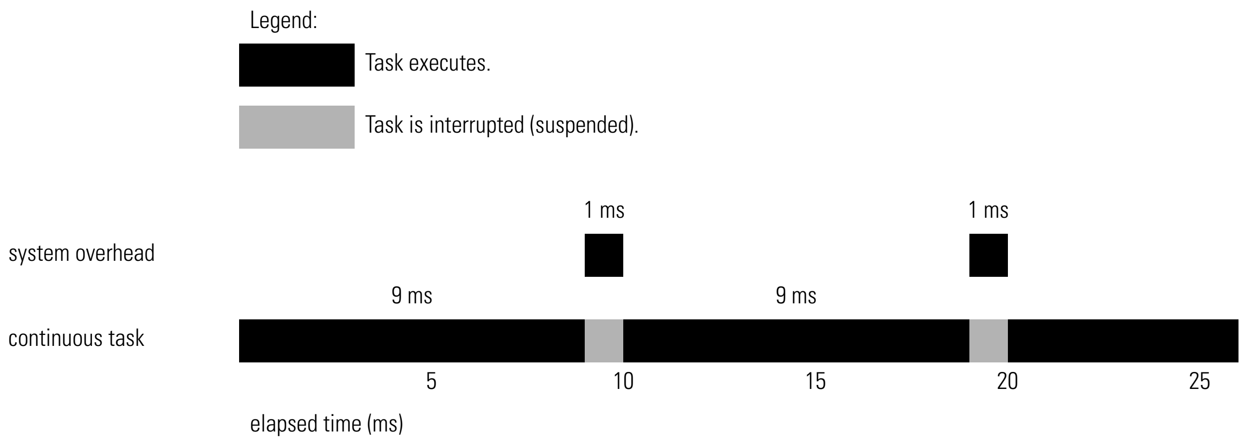
Specifies the percentage of controller time (excluding the time for periodic tasks) that is devoted to communication and background functions (system overhead):

- The controller performs system overhead functions for up to 1 ms at a time.
- If the controller completes the overhead functions in less than 1 ms, it resumes the continuous task.
- Communication and background functions include the following:
  - communicate with programming and HMI devices (such as RSLogix 5000 software)
  - respond to messages
  - send messages, including block-transfers
  - re-establish and monitor I/O connections (such as RIUP conditions); this *does not* include normal I/O communications that occur during program execution
  - bridge communications from the serial port of the controller to other ControlLogix devices via the ControlLogix backplane
- If communications are not completing fast enough, increase the system overhead timeslice.

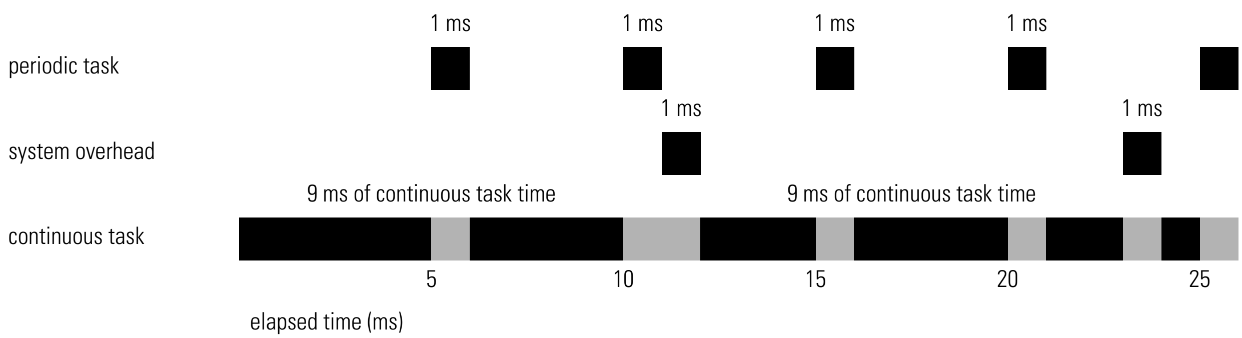
The following table shows the ratio between the continuos task and the system overhead functions:

At this time slice:	The continuous tasks runs for:	And then overhead occurs for up to:
10%	9 ms	1 ms
20%	4 ms	1 ms
33%	2 ms	1 ms
50%	1 ms	1 ms

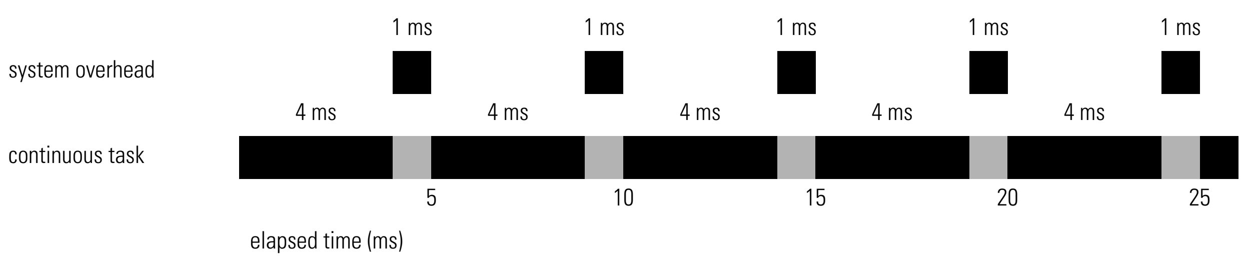
At the default time slice of 10 %, system overhead interrupts the continuous task every 9 ms (of continuous task time).



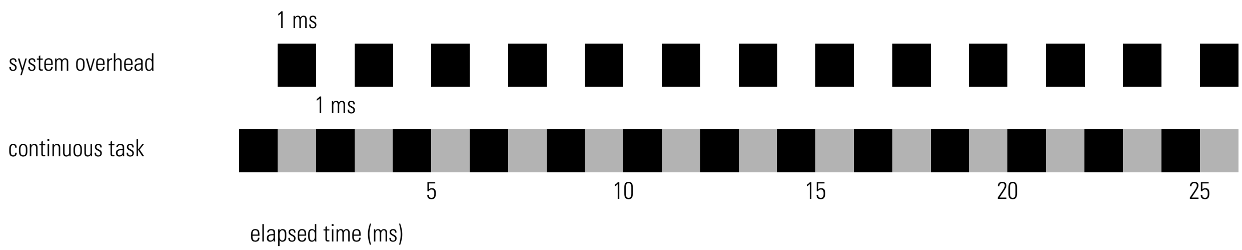
The interruption of a periodic task increases the elapsed time (clock time) between the execution of system overhead.



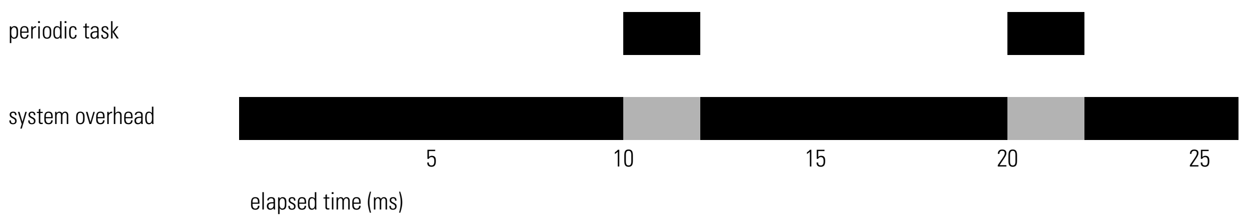
If you increase the time slice to 20 %, the system overhead interrupts the continuous task every 4 ms (of continuous task time).



If you increase the time slice to 50 %, the system overhead interrupts the continuous task every 1 ms (of continuous task time).



If the controller only contains a periodic task (s), the system overhead timeslice value has no effect. System overhead runs whenever a periodic task is not running.



To change the system overhead time slice:

1. Open the RSLogix 5000 project.
2. In the controller organizer, right-click the *Controller* `name_of_controller` folder and select *Properties*.
3. Click the *Advanced* tab.
4. In the *System Overhead Time Slice* text box, type or select the percentage of overhead time (10 -90%).
5. Click *OK*.

T

tag

A named area of the controller's memory where data is stored.

- Tags are the basic mechanism for allocating memory, referencing data from logic, and monitoring data.
- The minimum memory allocation for a tag is four bytes.
  - When you create a tag that stores a BOOL, SINT, or INT (which are smaller than four bytes), the controller allocates four bytes, but the data only fills the part it needs.
  - User-defined data types and arrays store data in contiguous memory and pack smaller data types into 32-bit words.

The following examples show memory allocation for various tags:

– *start*, which uses the BOOL data type:

Memory allocation	**Bits**			
	31	**1**	**0**	
allocation	not used		*start*	

– *station_status*, which uses the DINT data type:

Memory allocation:	**Bits**	
	31	**0**
allocation	*station_status*	

– *mixer*, which uses a user-defined data type:

Memory allocation	**Bits**			
	31 24	**23 16**	**15 8**	**7 0**
allocation 1	*mixer.pressure*			
allocation 2	*mixer.temp*			
allocation 3	*mixer.agitate_time*			
allocation 4	unused	unused	unused	bit 0 *mixer.inlet* bit 1 *mixer.drain* bit 2 *mixer.agitate*

– *temp_buffer*, which is an array of four INTS (INT[4]):

Memory allocation:	Bits	
	31 16	0
allocation 1	*temp_buffer*[1]	*temp_buffer*[0]
allocation 2	*temp_buffer*[3]	*temp_buffer*[2]

See *alias tag*, *base tag*, *consumed tag*.

task

A scheduling mechanism for executing a program.

- By default, each new project file contains a pre-configured continuous task.
- You configure additional, periodic tasks, as needed.
- A task provides scheduling and priority information for a set of one or more programs that execute based on specific criteria.
- Once a task is triggered (activated), all the programs assigned (scheduled) to the task execute in the order in which they are displayed in the controller organizer.
- You can only assign a program to one task at a time.

See *continuous task*, *periodic task*.

timestamp

A ControlLogix process that records a change in input data with a relative time reference of when that change occurred.

transition

In a sequential function chart (SFC), a transition is the true or false condition or conditions that determine when to go to the next step.

U

uncached connection

With the MSG instruction, an uncached connection instructs the controller to close the connection upon completion of the mSG instruction. Clearing the connection leaves it available for other controller uses. See *connection, cached connection*.

unidirectional connection

A connection in which data flows in only one direction: from the originator to the receiver. See *connection, bidirectional connection*.

upload

The process of transferring the contents of the controller into a project file on the workstation.

If you do not have the project file for a controller, you can upload from the controller and create a project file. However, not everything that is stored in a project file is available from the controller. If you upload from a controller, the new project file will not contain:

- rung comments
- descriptions for tags, tasks, programs, routines, modules, or user-defined structures
- chains of aliases (aliases pointing to other aliases)

  Alias chains are not completely reconstructed from the controller. If there are several possible names for a data item, the firmware and software choose a best-fit alias that may not reflect how the alias was specified in the original project.

See *download*.

user-defined data type

You can also create your own **structures**, called a user-defined data type (also commonly referred to as a user-defined structure). A user-defined data type groups different types of data into a single named entity.

- Within a user-defined data type, you define the **members**.
- Like tags, members have a name and data type.
- You can include arrays and structures.
- Once you create a user-defined data type, you can create one or more tags using that data type.
- Minimize your use of the following data type because they typically increase the memory requirements and execution time of your logic:
  - **INT**
  - **SINT**

For example, some system values use the SINT or INT data type. If you create a user-defined data type to store those values, then use the corresponding SINT or INT data type.

- If you include members that represent I/O devices, you must use ladder logic to copy the data between the members in the structure and the corresponding I/O tags. See "Buffer I/O" on page 2-8.
- When you use the BOOL, SINT, or INT data types, place members that use the same data type in sequence:

more efficient	less efficient
BOOL	BOOL
BOOL	DINT
BOOL	BOOL
DINT	DINT
DINT	BOOL

- You can use single dimension arrays.
- You can create, edit, and delete user-defined data types only when programming offline.
- If you modify a user-defined data type and change its size, the existing values of any tags that use the data type are set to zero (0).
- To copy data to a structure, use the COP instruction. See the *Logix5000 Controllers General Instruction Set Reference Manual*, publication 1756-RM003.

See *structure.*

W

watchdog

Specifies how long a task can run before triggering a major fault.

- Each task has a watchdog timer that monitors the execution of the task.
- A watchdog time can range from 1 ms to 2,000,000 ms (2000 seconds). The default is 500 ms.
- The watchdog timer begins to time when the task is initiated and stops when all the programs within the task have executed.
- If the task takes longer than the watchdog time, a major fault occurs: (The time includes interruptions by other tasks.)
- A watchdog time-out fault (major fault) also occurs if a task triggered again while it is executing (periodic task overlap). This can happen if a lower-priority task is interrupted by a higher-priority task, delaying completion of the lower-priority task.
- You can use the controller fault handler to clear a watchdog fault. If the same watchdog fault occurs a second time during the same logic scan, the controller enters faulted mode, regardless of whether the controller fault handler clears the watchdog fault.

ATTENTION

If the watchdog timer reaches a configurable preset, a major fault occurs. Depending on the controller fault handler, the controller might shut down.

To change the watchdog time of a task:

1. Open the RSLogix 5000 project.
2. In the controller organizer, right-click `name_of_task` and select *Properties*.
3. Click the *Configuration* tab.
4. In the *Watchdog* text box, type a watchdog time.
5. Click *OK*.

Numerics

U

V

W

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Pub. No. 1756-PM001G-EN-P Pub. Date March 2004 Part No. 957867-41

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ASCII Character Codes

Character	Dec	Hex
[ctrl-@] NUL	0	$00
[ctrl-A] SOH	1	$01
[ctrl-B] STX	2	$02
[ctrl-C] ETX	3	$03
[ctrl-D] EOT	4	$04
[ctrl-E] ENQ	5	$05
[ctrl-F] ACK	6	$06
[ctrl-G] BEL	7	$07
[ctrl-H] BS	8	$08
[ctrl-I] HT	9	$09
[ctrl-J] LF	10	$l ($0A)
[ctrl-K] VT	11	$0B
[ctrl-L] FF	12	$0C
[ctrl-M] CR	13	$r ($0D)
[ctrl-N] SO	14	$0E
[ctrl-O] SI	15	$0F
[ctrl-P] DLE	16	$10
[ctrl-Q] DC1	17	$11
[ctrl-R] DC2	18	$12
[ctrl-S] DC3	19	$13
[ctrl-T] DC4	20	$14
[ctrl-U] NAK	21	$15
[ctrl-V] SYN	22	$16
[ctrl-W] ETB	23	$17
[ctrl-X] CAN	24	$18
[ctrl-Y] EM	25	$19
[ctrl-Z] SUB	26	$1A
ctrl-[ESC	27	$1B
[ctrl-\] FS	28	$1C
ctrl-] GS	29	$1D
[ctrl-^] RS	30	$1E
[ctrl-_] US	31	$1F

Character	Dec	Hex
SPACE	32	$20
!	33	$21
“	34	$22
#	35	$23
$	36	$24
%	37	$25
&	38	$26
’	39	$27
(	40	$28
)	41	$29
*	42	$2A
+	43	$2B
,	44	$2C
-	45	$2D
.	46	$2E
/	47	$2F
0	48	$30
1	49	$31
2	50	$32
3	51	$33
4	52	$34
5	53	$35
6	54	$36
7	55	$37
8	56	$38
9	57	$39
:	58	$3A
;	59	$3B
<	60	$3C
=	61	$3D
>	62	$3E
?	63	$3F

Character	Dec	Hex
@	64	$40
A	65	$41
B	66	$42
C	67	$43
D	68	$44
E	69	$45
F	70	$46
G	71	$47
H	72	$48
I	73	$49
J	74	$4A
K	75	$4B
L	76	$4C
M	77	$4D
N	78	$4E
O	79	$4F
P	80	$50
Q	81	$51
R	82	$52
S	83	$53
T	84	$54
U	85	$55
V	86	$56
W	87	$57
X	88	$58
Y	89	$59
Z	90	$5A
[	91	$5B
\	92	$5C
]	93	$5D
^	94	$5E
_	95	$5F

<table>
<tr><th>Character</th><th>Dec</th><th>Hex</th></tr>
<tr><td>‘</td><td>96</td><td>$60</td></tr>
<tr><td>a</td><td>97</td><td>$61</td></tr>
<tr><td>b</td><td>98</td><td>$62</td></tr>
<tr><td>c</td><td>99</td><td>$63</td></tr>
<tr><td>d</td><td>100</td><td>$64</td></tr>
<tr><td>e</td><td>101</td><td>$65</td></tr>
<tr><td>f</td><td>102</td><td>$66</td></tr>
<tr><td>g</td><td>103</td><td>$67</td></tr>
<tr><td>h</td><td>104</td><td>$68</td></tr>
<tr><td>i</td><td>105</td><td>$69</td></tr>
<tr><td>j</td><td>106</td><td>$6A</td></tr>
<tr><td>k</td><td>107</td><td>$6B</td></tr>
<tr><td>l</td><td>108</td><td>$6C</td></tr>
<tr><td>m</td><td>109</td><td>$6D</td></tr>
<tr><td>n</td><td>110</td><td>$6E</td></tr>
<tr><td>o</td><td>111</td><td>$6F</td></tr>
<tr><td>p</td><td>112</td><td>$70</td></tr>
<tr><td>q</td><td>113</td><td>$71</td></tr>
<tr><td>r</td><td>114</td><td>$72</td></tr>
<tr><td>s</td><td>115</td><td>$73</td></tr>
<tr><td>t</td><td>116</td><td>$74</td></tr>
<tr><td>u</td><td>117</td><td>$75</td></tr>
<tr><td>v</td><td>118</td><td>$76</td></tr>
<tr><td>w</td><td>119</td><td>$77</td></tr>
<tr><td>x</td><td>120</td><td>$78</td></tr>
<tr><td>y</td><td>121</td><td>$79</td></tr>
<tr><td>z</td><td>122</td><td>$7A</td></tr>
<tr><td>{</td><td>123</td><td>$7B</td></tr>
<tr><td>|</td><td>124</td><td>$7C</td></tr>
<tr><td>}</td><td>125</td><td>$7D</td></tr>
<tr><td>~</td><td>126</td><td>$7E</td></tr>
<tr><td>DEL</td><td>127</td><td>$7F</td></tr>
</table>

Rockwell Automation Support

Rockwell Automation provides technical information on the web to assist you in using our products. At http://support.rockwellautomation.com, you can find technical manuals, a knowledge base of FAQs, technical and application notes, sample code and links to software service packs, and a MySupport feature that you can customize to make the best use of these tools.

For an additional level of technical phone support for installation, configuration and troubleshooting, we offer TechConnect Support programs. For more information, contact your local distributor or Rockwell Automation representative, or visit http://support.rockwellautomation.com.

Installation Assistance

If you experience a problem with a hardware module within the first 24 hours of installation, please review the information that's contained in this manual. You can also contact a special Customer Support number for initial help in getting your module up and running:

United States	1.440.646.3223 Monday – Friday, 8am – 5pm EST
Outside United States	Please contact your local Rockwell Automation representative for any technical support issues.

New Product Satisfaction Return

Rockwell tests all of our products to ensure that they are fully operational when shipped from the manufacturing facility. However, if your product is not functioning and needs to be returned:

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Outside United States	Please contact your local Rockwell Automation representative for return procedure.

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www.rockwellautomation.com

Corporate Headquarters
Rockwell Automation, 777 East Wisconsin Avenue, Suite 1400, Milwaukee, WI, 53202-5302 USA, Tel: (1) 414.212.5200, Fax: (1) 414.212.5201

Headquarters for Allen-Bradley Products, Rockwell Software Products and Global Manufacturing Solutions
Americas: Rockwell Automation, 1201 South Second Street, Milwaukee, WI 53204-2496 USA, Tel: (1) 414.382.2000, Fax: (1) 414.382.4444
Europe: Rockwell Automation SA/NV, Vorstlaan/Boulevard du Souverain 36-BP 3A/B, 1170 Brussels, Belgium, Tel: (32) 2 663 0600, Fax: (32) 2 663 0640
Asia Pacific: Rockwell Automation, 27/F Citicorp Centre, 18 Whitfield Road, Causeway Bay, Hong Kong, Tel: (852) 2887 4788, Fax: (852) 2508 1846

Headquarters for Dodge and Reliance Electric Products
Americas: Rockwell Automation, 6040 Ponders Court, Greenville, SC 29615-4617 USA, Tel: (1) 864.297.4800, Fax: (1) 864.281.2433
Europe: Rockwell Automation, Brühlstraße 22, D-74834 Elztal-Dallau, Germany, Tel: (49) 6261 9410, Fax: (49) 6261 17741
Asia Pacific: Rockwell Automation, 55 Newton Road, #11-01/02 Revenue House, Singapore 307987, Tel: (65) 351 6723, Fax: (65) 355 1733

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Allen-Bradley

Logix5000™ Controllers Common Procedures

Programming Manual