# Twido
Programmable Controllers
Software Reference Guide

TWD USE 10AE Version 1.0

Schneider Electric

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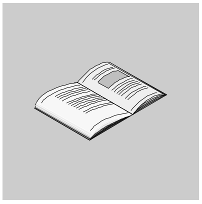
# Table of Contents



# Safety Information

## Important Information

**NOTICE**

Read these instructions carefully, and look at the equipment to become familiar with the device before trying to install, operate, or maintain it. The following special messages may appear throughout this documentation or on the equipment to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure.

The addition of this symbol to a Danger or Warning safety label indicates that an electrical hazard exists, which will result in personal injury if the instructions are not followed.

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

**DANGER**

DANGER indicates an imminently hazardous situation, which, if not avoided, **will result** in death, serious injury, or equipment damage.

**WARNING**

WARNING indicates a potentially hazardous situation, which, if not avoided, **can result** in death, serious injury, or equipment damage.

**CAUTION**

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

ADDITIONAL SAFETY INFORMATION

Those responsible for the application, implementation or use of this product must ensure that the necessary design considerations have been incorporated into each application, completely adhering to applicable laws, performance and safety requirements, regulations, codes and standards.

## GENERAL WARNINGS AND CAUTIONS

**WARNING**

**EXPLOSION HAZARD**

- Substitution of components may impair suitability for Class I, Div 2 compliance.
- Do not disconnect equipment unless power has been switched off or the area is known to be non-hazardous.

**Failure to observe this precaution can result in severe injury or equipment damage.**

**WARNING**

**UNINTENDED EQUIPMENT OPERATION**

- Turn power off before installing, removing, wiring, or maintaining.
- This product is not intended for use in safety critical machine functions. Where personnel and or equipment hazards exist, use appropriate hard-wired safety interlocks.
- Do not disassemble, repair, or modify the modules.
- This controller is designed for use within an enclosure.
- Install the modules in the operating environment conditions described.
- Use the sensor power supply only for supplying power to sensors connected to the module.
- Use an IEC60127-approved fuse on the power line and output circuit to meet voltage and current requirements. Recommended fuse: Liitlefuse 5x20 mm slowblow type 218000 series/Type T.

**Failure to observe this precaution can result in severe injury or equipment damage.**

# About the Book

## At a Glance

**Document Scope**

This is the Software Reference manual for Twido programmable controllers and consists of the following major parts:
- Description of the Twido programming software and an introduction to the fundamentals needed to program Twido controllers.
- Description of communications, managing analog I/O, and other special functions.
- Description of the software languages used to create Twido programs.
- Description of instructions and functions of Twido controllers.

**Validity Note**

The information in this manual is applicable **only** for Twido programmable controllers.

**Product Related Warnings**

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# Description of Twido Software

I

## At a Glance

**Overview**

This part provides an introduction to the software languages and the basic information required to create control programs for Twido programmable controllers.

**What's in this Part?**

This part contains the following chapters:

| Chapter | Chapter Name | Page |
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| 1 | Introduction to Twido Software | 17 |
| 2 | Twido Language Objects | 23 |
| 3 | User Memory | 41 |
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# Introduction to Twido Software

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## At a Glance

**Overview**

This chapter provides a brief introduction to TwidoSoft, the programming and configuration software for Twido controllers, and to the List, Ladder, and Grafcet programming languages used to create control programs.

**What's in this Chapter?**

This chapter contains the following topics:

| Topic | Page |
|---|---|
| Introduction to TwidoSoft | 18 |
| Introduction to Twido Languages | 19 |

## Introduction to TwidoSoft

**Introduction**

TwidoSoft is a graphical development environment for creating, configuring, and maintaining applications for Twido programmable controllers. TwidoSoft allows you to enter control programs using the TwidoSoft Ladder or List program editors and then transfer the program to run on a controller.

**TwidoSoft**

TwidoSoft is a 32-bit Windows-based program for a personal computer (PC) running Microsoft Windows 98 Second Edition or Microsoft Windows 2000 Professional operating systems.
The main software features of TwidoSoft:
- Standard Windows user interface
- Program and configure Twido controllers
- Controller communication and control

For more details, see the TwidoSoft Operation Guide.

## Introduction to Twido Languages

**Introduction**

A programmable controller reads inputs, writes to outputs, and solves logic based on a control program. Creating a control program for a Twido controller consists of writing a series of instructions in one of the Twido programming languages.

**Twido Languages**

The following languages can be used to create Twido control programs:

- Instruction List language
  An Instruction List program is a series of logical expressions written as a sequence of Boolean instructions.
- Ladder diagrams
  A Ladder diagram is a graphical means of displaying a logical expression.
- Grafcet
  Twido supports the use of Grafcet list instructions, but not graphical Grafcet.

You can use a personal computer (PC) to create and edit Twido control programs using these programming languages.
A List/Ladder reversibility feature allows you to conveniently reverse a program from Ladder to List and from List to Ladder.

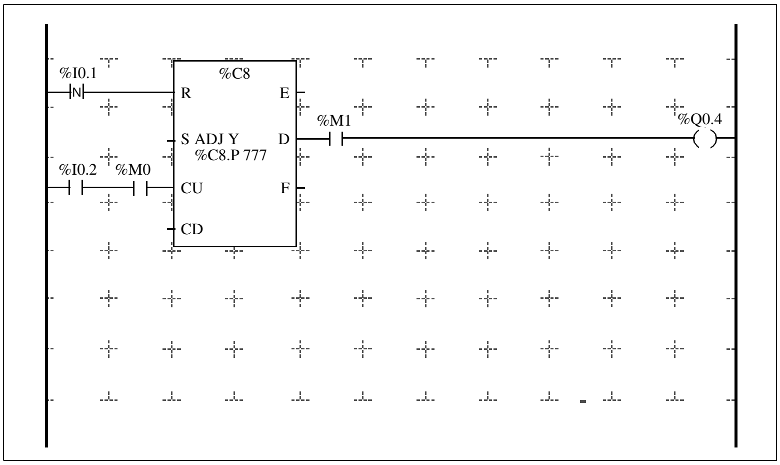
**Instruction List Language**

A program written in Instruction List language consists of a series of instructions executed sequentially by the controller. The following is an example of a List program.

```
0    BLK     %C8
1    LDF     %I0.1
2    R
3    LD      %I0.2
4    AND     %M0
5    CU
6    OUT_BLK
7    LD      D
8    AND     %M1
9    ST      %Q0.4
10   END_BLK
```

## Ladder Diagrams

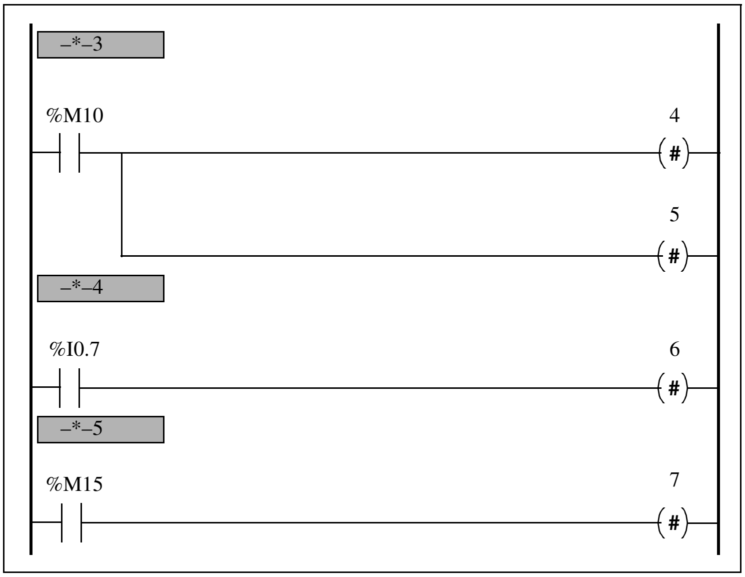
Ladder diagrams are similar to relay logic diagrams that are used to represent relay control circuits. Graphic elements such as coils, contacts, and blocks represent instructions. The following is an example of a Ladder diagram.



## Grafcet Language

Grafcet is an analytical method which divides any sequential control system into a series of steps which have associated actions, transitions, and conditions. The following illustration shows examples of Grafcet instructions in List and Ladder programs respectively.

```
0    -*-    3
1    LD     %M10
2    #      4
3    #      5
4    -*-    4
5    LD     %I0.7
6    #      6
7    -*-    5
8    LD     %M15
9    #      7
10   ...
```



# Twido Language Objects

2

## At a Glance

**Overview**

This chapter provides details about the language objects used for programming Twido controllers.

**What's in this Chapter?**

This chapter contains the following topics:

## Language Object Validation

**Introduction**

Word and bit objects are valid if they have been allocated memory space in the controller. To do this, they must be used in the application before downloaded to the controller.

**Example**

The range of valid objects is from zero to the maximum reference for that object type. For example, if your application's maximum references for memory words is %MW9, then %MW0 through %MW9 are allocated space. %MW10 in this example is not valid and can not be accessed either internally or externally.

## Bit Objects

**Introduction**

Bit objects are software variable bits that are single bits of data that can be used as operands and tested by Boolean instructions. The following is a list of bit objects:

- I/O bits
- Internal bits (memory bits)
- System bits
- Step bits
- Bits extracted from words

**List of Operand Bits**

The following table lists and describes all of the main bit objects that are used as operands in Boolean instructions.

| Type | Description | Address or Value | Maximum number | Write access[1] |
|---|---|---|---|---|
| Immediate values | 0 or 1 (False or True) | 0 or 1 | - | - |
| Inputs<br>Outputs | These bits are the "logical images" of the electrical states of the I/O. They are stored in data memory and updated during each scan of the program logic. | %Ix.y.z[2]<br>%Qx.y.z[2] | Note[4] | No<br>Yes |
| Internal (Memory) | Internal bits are internal memory areas used to store intermediary values while a program is running.<br>**Note:** Unused I/O bits can not be used as internal bits. | %Mi | 128 TWDLCAA10DRF, TWDLCAA16DRF<br>256 All other controllers | Yes |
| System | System bits %S0 to %S127 monitor the correct operation of the controller and the correct running of the application program. | %Si | 128 | According to i |
| Function blocks | The function block bits correspond to the outputs of the function blocks.<br>These outputs may be either directly connected or used as an object. | %TMi.Q, %Ci.P, and so on. | Note[4] | No[3] |
| Reversible function blocks | Function blocks programmed using reversible programming instructions BLK, OUT_BLK, and END_BLK. | E, D, F, Q, TH0, TH1 | Note[4] | No |
| Word extracts | One of the 16 bits in some words can be extracted as operand bits. | Varies | Varies | Varies |
| Grafcet steps | Bits %X1 to %Xi are associated with Grafcet steps. Step bit Xi is set to 1 when the corresponding step is active, and set to 0 when the step is deactivated. | %X21 | 62 TWDLCAA10DRF, TWDLCAA16DRF<br>94 TWDLCAA24DRF, Modular Controllers | Yes |

**Notes:**
1. Written by the program or by using the Animation Tables Editor.
2. See I/O Addressing.
3. Except for %SBRi.j and %SCi.j, these bits can be read and written.
4. Number is determined by controller model.

## Word Objects

**Introduction**

Word objects that are addressed in the form of 16-bit words that are stored in data memory and can contain an integer value between -32768 and 32767 (except for the fast counter function block which is between 0 and 65535).

Examples of word objects:
- Immediate values
- Internal words (%MWi) (memory words)
- Constant words (%KWi)
- I/O exchange words (%IWi, %QWi)
- System words (%SWi)
- Function blocks (configuration and/or runtime data)

**Word Formats**

The contents of the words or values are stored in user memory in 16-bit binary code (two's complement) using the following convention:

| F | E | D | C | B | A | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | Bit position |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | Bit state |
| ± | 16348 | 8192 | 4096 | 2048 | 1024 | 512 | 256 | 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 | Bit value |

In signed binary notation, bit 15 is allocated by convention to the sign of the coded value:
- Bit 15 is 0: the content of the word is a positive value.
- Bit 15 is 1: the content of the word is a negative value (negative values are expressed in two's complement logic).

Words and immediate values can be entered or retrieved in the following format:
- Decimal
  Min: -32768, Max: 32767 (for example, 1579)
- Hexadecimal
  Min: 16#0000, Max: 16#FFFF (for example, 16#A536)
  Alternate syntax: #A536

## Descriptions of Word Objects

The following table describes the word objects.

| Words | Description | Address or value | Maximum number | Write access[1] |
|---|---|---|---|---|
| Immediate values | These are integer values that are in the same format as the 16-bit words, which enables values to be assigned to these words. | | - | No |
| | Base 10 | -32768 to 32767 | | |
| | Base 16 | 16#0000 to 16#FFFF | | |
| Internal (Memory) | Used as "working" words to store values during operation in data memory. Words %MWO to %MW255 are read or written directly by the program. | %MWi | 1500 | Yes |
| Constants | Store constants or alphanumeric messages. Their content can only be written or modified by using TwidoSoft during configuration. Constant words %KW0 through %KW63 are read-only by the program. | %KWi | 64 | Yes, only by using TwidoSoft |
| System | These 16-bit words have several functions:<br>● Provide access to data coming directly from the controller by reading %SWi words (for example, potentiometers.)<br>● Perform operations on the application (for example, adjusting schedule blocks). | %SWi | 128 | According to i |
| Function blocks | These words correspond to current parameters or values of function blocks. | %TM2.P, %Ci.P, etc. | | Yes |
| I/O Exchange words | Assigned to controllers connected as Remote Links. These words are used for communication between controllers. | | | |
| | Inputs | %IWi.j | Note[2] | No |
| | Outputs | %QWi.j | Note[2] | Yes |
| Extracted bits | It is possible to extract one of the 16 bits from the following words: | | | |
| | Internal | %MWi:Xk | 1500 | Yes |
| | System | %SWi:Xk | 128 | Depends on i |
| | Constants | %KWi:Xk | 64 | No |
| | Input | %IWi.j:Xk | Note[2] | No |
| | Output | %QWi.j:Xk | Note[2] | Yes |

**Note:**
**1.** Written by the program or by using the Animation Tables Editor.
**2.** Number is determined by controller model.

## Addressing Bit Objects

**Format**

Use the following format to address internal, system, and step bit objects:

| | | |
|---|---|---|
| % | M, S, or X | i |
| Symbol | Object type | Number |

**Description**

The following table describes the elements in the addressing format.

| Group | Element | Description |
|---|---|---|
| Symbol | % | The percent symbol always precedes a software variable. |
| Object type | M | Internal bits store intermediary values while a program is running. |
| | S | System bits provide status and control information for the controller. |
| | X | Step bits provide status of step activities. |
| Number | i | The maximum number value depends on the number of objects configured. |

**Examples of bit object addresses:**

- %M25 = internal bit number 25
- %S20 = system bit number 20
- %X6 = step bit number 6

**Bit Objects Extracted from Words**

TwidoSoft is used to extract one of the 16 bits from words. The address of the word is then completed by the bit row extracted according to the following syntax:

| | | |
|---|---|---|
| WORD | : X | k |
| Word address | | Position k = 0 - 15 bit rank in the word address. |

**Examples:**

- %MW5:X6 = bit number 6 of internal word %MW5
- %QW5.1:X10 = bit number 10 of output word %QW5.1

## Addressing Word Objects

**Introduction**

Addressing word objects, except for input/output addressing (see *Addressing Inputs/Outputs, p. 31*) and function blocks (see *Function Block Objects, p. 34*), follows the format described below.

**Format**

Use the following format to address internal, constant and system words.

| | | | |
|---|---|---|---|
| % | M, K or S | W | i |
| Symbol | Object type | Format | Number |

**Description**

The following table describes the elements in the addressing format.

| Group | Element | Description |
|---|---|---|
| Symbol | % | The percent symbol always precedes an internal address. |
| Object type | M | Internal words store intermediary values while a program is running. |
| | K | Constant words store constant values or alphanumeric messages. Their content can only be written or modified by using TwidoSoft. |
| | S | System words provide status and control information for the controller. |
| Format | W | 16-bit word. |
| Number | i | The maximum number value depends on the number of objects configured. |

**Examples of word object addressing:**

- %MW15 = internal word number 15
- %KW26 = constant word number 26
- %SW30 = system word number 30

## Addressing Inputs/Outputs

**Introduction**

Each input/output (I/O) point in a Twido configuration has a unique address: for example, a specific input on a controller is assigned the address of "%I0.0.4".
I/O addresses can be assigned for the following hardware:

- Controller configured as Remote Link Master
- Controller configured as Remote I/O
- Expansion I/O modules

**Multiple References to an Output or Coil**

In a program, you can have multiple references to a single output or coil. Only the result of the last one solved is updated on the hardware outputs. For example, %Q0.0.0 can be used more than once in a program, and there will not be a warning for multiple occurrences. So it is important to confirm which output will result in the desired operation.

**CAUTION**

**Unintended Operation**

No duplicate output checking or warnings are provided. Review the use of the outputs or coils before making changes to them in your application.

**Failure to observe this precaution can result in injury or equipment damage.**

**Format**

Use the following format to address inputs/outputs.

| % | I, Q | x | y | z |
|---|---|---|---|---|
| **Symbol** | **Object type** | **Controller position** | **I/O type** | **Channel number** |

## Description

The table below describes the I/O addressing format.

| Group | Element | Value | Description |
|---|---|---|---|
| Symbol | % | - | The percent symbol always precedes an internal address. |
| Object type | I | - | Input. The "logical image" of the electrical state of a controller or expansion I/O module input. |
|  | Q | - | Output. The "logical image" of the electrical state of a controller or expansion I/O module output. |
| Controller position | x | 0<br>1 - 7 | Master controller (Remote Link master).<br>Remote controller (Remote Link slave). |
| I/O type | y | 0<br>1 - 7 | Base I/O (local I/O on controller).<br>Expansion I/O modules. |
| Channel number | z |  | I/O channel number on controller or expansion I/O module. Number of available I/O points depends on controller model or type of expansion I/O module. |

## Examples

The table below shows some examples of I/O addressing.

| I/O object | Description |
|---|---|
| %I0.0.5 | Input point number 5 on the base controller (local I/O). |
| %Q0.3.4 | Output point number 4 on expansion I/O module at expansion address number 3 for the base controller (expansion I/O). |
| %I0.0.3 | Input point number 3 on base controller. |
| %I3.0.1 | Input point number 1 on remote I/O controller at remote link address number 3. |
| %I0.3.2 | Input point number 2 on expansion I/O module at address number 3 for the base controller. |

## Network Addressing

**Introduction**

Application data is exchanged between peer controllers and the master controller on a Twido Remote Link network by using the network words %INW and %QNW. See *Communications , p. 63* for more details.

**Format**

Use the following format for network addressing.

| % | IN, QN | W | x | j |
|---|---|---|---|---|
| **Symbol** | **Object type** | **Format** | **Controller position** | **Word** |

**Description of Format**

The table below describes the network addressing format.

| Group | Element | Value | Description |
|---|---|---|---|
| Symbol | % | - | The percent symbol always precedes an internal address. |
| Object type | IN | - | Network input word. Data transfer from master to peer. |
|  | QN | - | Network output word. Data transfer from peer to master. |
| Format | W | - | A16-bit word. |
| Controller position | x | 0<br>1 - 7 | Master controller (Remote Link master).<br>Remote controller (Remote Link slave). |
| Word | j | 0 - 3 | Each peer controller uses from one to four words to exchange data with the master controller. |

**Examples**

The table below shows some examples of networking addressing.

| Network object | Description |
|---|---|
| %INW3.1 | Network word number 1 of remote controller number 3. |
| %QNW0.3 | Network word number 3 of the base controller. |

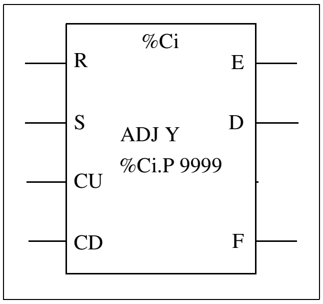
## Function Block Objects

**Introduction**

Function blocks provide bit objects and specific words that can be accessed by the program.

**Example of a Function Block**

The following illustration shows a counter function block.



Up/down counter block

**Bit Objects**

Bit objects correspond to the block outputs. These bits can be accessed by Boolean test instructions using either of the following methods:

- Directly (for example, LD E) if they are wired to the block in reversible programming (see *Principles for Programming Basic Function Blocks, p. 208*).
- By specifying the block type (for example, LD %Ci.E).

Inputs can be accessed in the form of instructions.

**Word Objects**

Word objects correspond to specified parameters and values as follows:

- Block configuration parameters: some parameters are accessible by the program (for example, pre-selection parameters), and some are inaccessible by the program (for example, time base).
- Current values: for example, %Ci.V, the current count value.

**Objects Accessible by the Program**

See the following appropriate sections for a list of objects that are accessible by the program.

- For Basic Function Blocks, see *Basic Function Blocks, p. 206*.
- For Advanced Function Blocks, see *Bit and Word Objects Associated with Advanced Function Blocks, p. 257*.

## Structured Objects

### Introduction

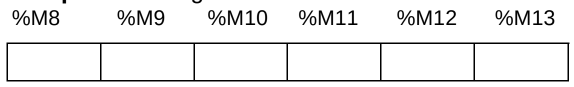
Structured objects are combinations of simple objects. Twido supports the following types of structured objects:

- Bit Strings
- Word Tables

### Bit Strings

Bit strings are a series of adjacent object bits of the same type and of a defined length (L).

**Example:** Bit string %M8:6



**Note:** %M8:6 is acceptable (8 is a multiple of 8), while %M10:16 is unacceptable (10 is not a multiple of 8).

Bit strings can be used with the Assignment instruction (see *Assignment Instructions, p. 232*).

### Available Types of Bits

Available types of bits for bit strings:

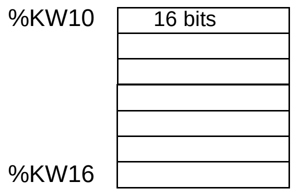
| Type | Address | Maximum size | Write access |
|---|---|---|---|
| Discrete input bits | %I0.0:L or %I1.0:L1 | 0<L<17 | No |
| Discrete output bits | %Q0.0:L or %Q1.0:L1 | 0<L<17 | Yes |
| System bits | %Si:L<br>with i multiple of 8 | 0<L<17 and i+L-128 | Depending on i |
| Grafcet Step bits | %Xi:L<br>with i multiple of 8 | 0<L<17 and i+L-95 | Yes (by program) |
| Internal bits | %Mi:L<br>with i multiple of 8 | 0<L<17 and i+L-256 | Yes |

**Note:** (1) Only bits 0...L-1 can be addressed. Not all I/O can be addressed in bit strings.

## Word Tables

Word tables are a series of adjacent words of the same type and of a defined length (L).

**Example:** Word table %KW10:7



Word tables can be used with the Assignment instruction (see *Assignment Instructions, p. 232*).

## Available Types of Words

Available types of words for word tables:

| **Type** | **Address** | **Maximum size** | **Write access** |
|---|---|---|---|
| Internal words | %MWi:L | 0<L<256 and i+L< or = 1500 | Yes |
| Constant words | %KWi:L | 0<L and i+L-64 | No |
| System words | %SWi:L | 0<L and i+L-128 | Depending on i |

## Indexed Words

**Introduction**

An indexed word is an internal or constant word with an indexed object address. There are two types of object addressing:
- Direct addressing
- Indexed addressing

**Direct Addressing**

A direct address of an object is set and defined when a program is written.
**Example:** %M26 is an internal bit with the direct address 26.

**Indexed Addressing**

An indexed address of an object provides a method of modifying the address of an object by adding an index to the direct address of an object. The content of the index is added to the object's direct address. The index is defined by an internal word %MWi. The number of "index words" is unlimited.
**Example:** %MW108[%MW2] is a word with an address consisting of the direct address 108 plus the contents of word %MW2.
If word %MW2 has a value of 12, writing to %MW108[%MW2] is equivalent to writing to %MW120 (108 plus 12).

**Words Available for Indexed Addressing**

The following are the available types of words for indexed addressing.

| Type | Address | Maximum size | Write access |
|---|---|---|---|
| Internal words | %MWi[MWi] | 0-i< or = %MWj<1500 | Yes |
| Constant words | %KWi[%MWj] | 0-i<%MWj<64 | No |

Indexed words can be used with the Assignment instruction (see *Assignment Instructions, p. 232*) and in Comparison instructions (see *Comparison Instructions, p. 236*). This type of addressing enables series of objects of the same type (such as internal words and constants) to be scanned in succession, by modifying the content of the index word via the program.

## Index Overflow System Bit %S20

An overflow of the index occurs when the address of an indexed object exceeds the limits of the memory zone containing the same type of object. In summary:

- The object address plus the content of the index is less than 0.
- The object address plus the content of the index is greater than the largest word directly referenced in the application. The maximum number is 1499 (for words %MWi) or 63 (for words %KWi).

In the event of an index overflow, the system sets system bit %S20 to 1 and the object is assigned an index value of 0.

**Note:** The user is responsible for monitoring any overflow. Bit %S20 must be read by the user program for possible processing. The user must confirm that it is reset to 0.
%S20 (initial state = 0):

- On index overflow: set to 1 by the system.
- Acknowledgment of overflow: set to 0 by the user, after modifying the index.

## Symbolizing Objects

**Introduction**

You can use Symbols to address Twido software language objects by name or customized mnemonics. Using symbols allows for quick examination and analysis of program logic, and greatly simplifies the development and testing of an application.

**Example**

For example, WASH_END is a symbol that could be used to identify a timer function block that represents the end of a wash cycle. Recalling the purpose of this name should be easier than trying to remember the role of a program address such as %TM3.

**Guidelines for Defining Symbols**

The following are guidelines for defining symbols:

- A maximum of 32 characters.
- Letters (A-Z), numbers (0 -9), or underscores (_).
- First character must be an alphabetical or accented character. You can not use the percentile sign (%).
- Do not use spaces or special characters.
- Not case-sensitive. For example, Pump1 and PUMP1 are the same symbol and can only be used once in an application.

**Editing Symbols**

Symbols are defined and associated with language objects in the Symbol Editor. Symbols and their comments are stored with the application on the PC hard drive, but are not stored on the controller. Therefore, they can not be transferred with the application to the controller.
See the TwidoSoft Operation Guide for more details for using symbols.

# User Memory

3

## User Memory Structure

**Introduction**

The controller memory accessible by an user application is divided into two distinct sets:
- Bit values
- Word values (16-bit signed values)

**Bit Memory**

The bit memory is stored in the internal RAM memory that is integrated into the controller. It contains the map of 1280 bit objects.

**Role of the Words Memory**

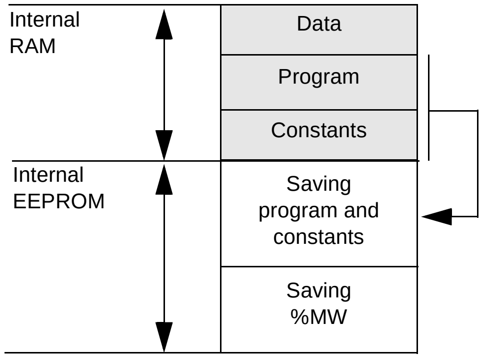
The words memory (16 bits) supports:
- **Data**: dynamic application data and system data.
- **Program**: descriptors and executable code for tasks.
- **Constants**: constant words, initial values, and input/output configuration.

**Memory Types**

The following are the different types of memory for Twido controllers.
- Internal RAM (integrated)
  This is integrated controller RAM memory. The first 10KB of internal RAM memory is fast RAM while the next 32 KB is standard RAM. Internal RAM contains program, constants, and data.
- Internal EEPROM
  An integrated 32KB EEPROM that provides internal backup in the controller of an application. Protects application from corruption due to battery failure or a power outage lasting longer than 30 days. Contains program and constants.
- External memory backup cartridge
  An optional external EEPROM cartridge for backing up an application or allowing for a larger application. Can be used to update the application in controller RAM. Contains program and constants, but no data.

## Structure without External Memory Cartridge

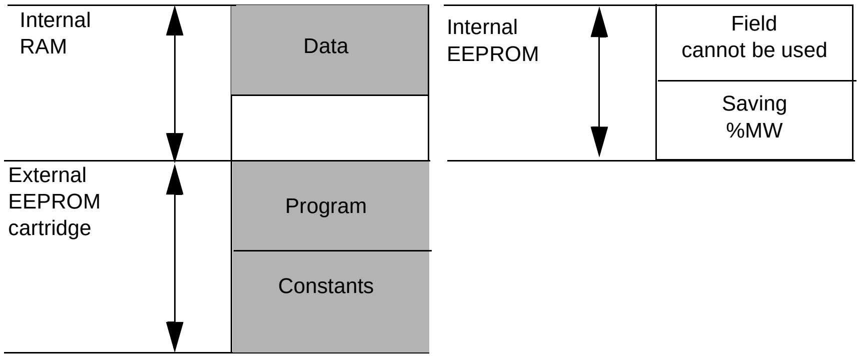
The following diagram describes the memory structure without an external memory cartridge.



The internal EEPROM is integrated into the controller and provides 32 KB of memory for the following:
- The application program (32 KB)
- 512 internal words (%MWi)

## Structure with External Memory Cartridge

The optional external memory cartridge provides back up for programs and constants, and also offers expanded memory for larger applications.
The following diagram describes the memory structure with the external memory cartridge.



The internal 32 KB EEPROM can save 512 internal words (%MWi).

**Saving Memory**

The controller internal RAM memory can be saved by one of the following:
- Internal battery (for up to 30 days)
- Internal EEPROM (maximum of 32 KB)
- Optional external memory cartridge (maximum of 64KB)

Transferring the application from the internal EEPROM memory to the RAM memory is done automatically when the application is lost in RAM (if it has not been saved or if there is no battery).
Manual transfer can also be performed using TwidoSoft.

**Memory Configurations**

The following table describes the types of memory configurations possible with Twido controllers.

| Memory type | Compact Controllers | | | Modular Controllers | | |
|---|---|---|---|---|---|---|
| | **10DRF** | **16DRF** | **24DRF** | **20DUK 20DTK** | **20DRT** | **40DUK 40DTK** |
| Internal RAM | 10KB | 32KB | 32KB | 32KB | 32KB | 32KB |
| Available extended memory* | | | | | 64KB | 64KB |
| Maximum application size | 10KB | 32KB | 32KB | 32KB | 32KB or 64KB* | 32KB or 64KB* |
| Maximum external backup | 32KB | 32KB | 32KB | 64KB | 32KB or 64KB | 32KB or 64KB |

**Note:** *Memory can be expanded to 64KB for the TWDLMDA20DRT, TWDLMDA40DUK, and TWDLMDA40DTK controllers by installing the optional 64KB external memory cartridge. The cartridge must remain installed for running and backing up the application.

# Controller Operating Modes

# 4

## At a Glance

**Overview**

This chapter describes controller operating modes and cyclic and periodic program execution. Included are details about power outages and restoration.

**What's in this Chapter?**

This chapter contains the following topics:

## Cyclic Scan

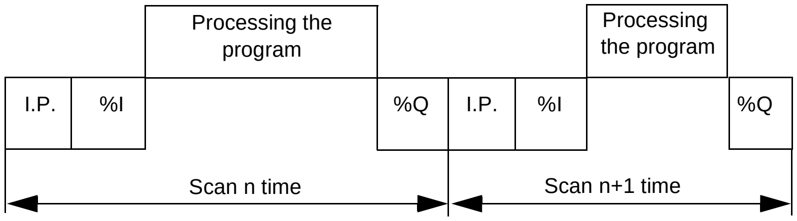
### Introduction

The cyclic scan binds the master task cycles one after the other without waiting for anything except the inevitable system processing. After having effected the output update (third phase of the task cycle), the system executes a certain number of its own tasks and immediately triggers another task cycle.

**Note:** The scan time of the user program is monitored by the controller watchdog timer and must not exceed 150 ms. Otherwise a fault appears causing the controller to stop immediately in Halt mode. Outputs in this mode are forced to their default fallback state.

### Operation

The following drawing shows the running phases of the cyclical scan time.



### Description of Operating Phases

The table below describes the operating phases.

| Address | Phase | Description |
|---|---|---|
| I.P. | Internal processing | The system implicitly monitors the controller (managing system bits and words, updating current timer values, updating status lights, detecting RUN/STOP switches, etc.) and processes requests from TwidoSoft (modifications and animation). |
| %I | Acquisition of inputs | Writing to the memory the status of information on discrete and application specific module inputs associated with the task. |
| - | Program processing | Running the application program written by the user. |
| %Q | Updating outputs | Writing output bits or words associated with discrete and application specific modules associated with the task according to the status defined by the application program. |

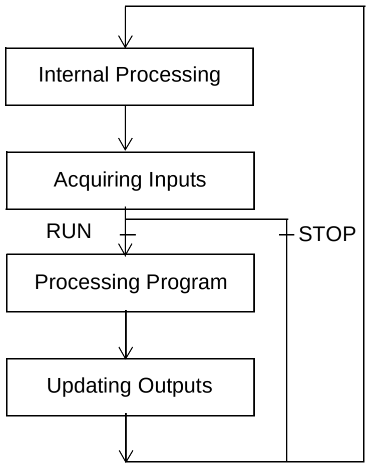
**Operating Mode**

**Controller in RUN,** the processor performs:
- Internal processing
- Acquiring inputs
- Processing the application program
- Updating outputs

**Controller in STOP**, the processor performs:
- Internal processing
- Acquiring inputs

**Illustration**

The following illustration shows the operating cycles.



**Check Cycle**

The check cycle is performed by watchdog.

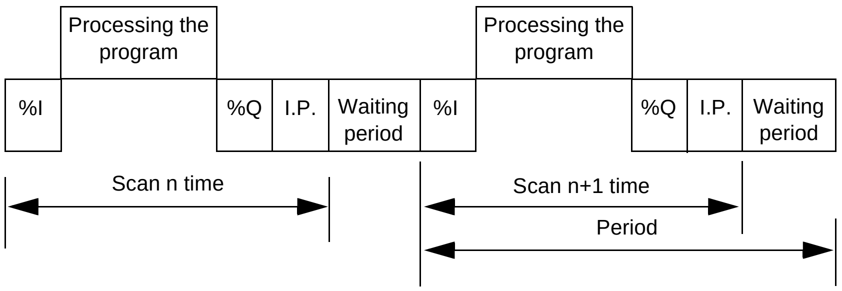
## Periodic Scan

**Introduction**

In this operating mode, acquiring inputs, processing the application program, and updating outputs are done periodically according to the time defined at configuration (from 2-150 ms).
At the beginning of the controller scan, a timer, the value of which is initialized at the period defined at configuration, starts to count down.The controller scan must end before the timer has finished and relaunches a new scan.

**Operation**

The following drawing shows the running phases of the periodic scan time.



**Description of Operating Phases**

The table below describes the operating phases.

| **Address** | **Phase** | **Description** |
|---|---|---|
| I.P. | Internal processing | The system implicitly monitors the controller (managing system bits and words, updating current timer values, updating status lights, detecting RUN/STOP switches, etc.) and processes requests from TwidoSoft (modifications and animation). |
| %I | Acquiring inputs | Writing to the memory the status of information on discrete and application specific module inputs associated with the task. |
| - | Program processing | Running the application program written by the user. |
| %Q | Updating outputs | Writing output bits or words associated with discrete and application specific modules associated with the task according to the status defined by the application program. |

## Operating Mode

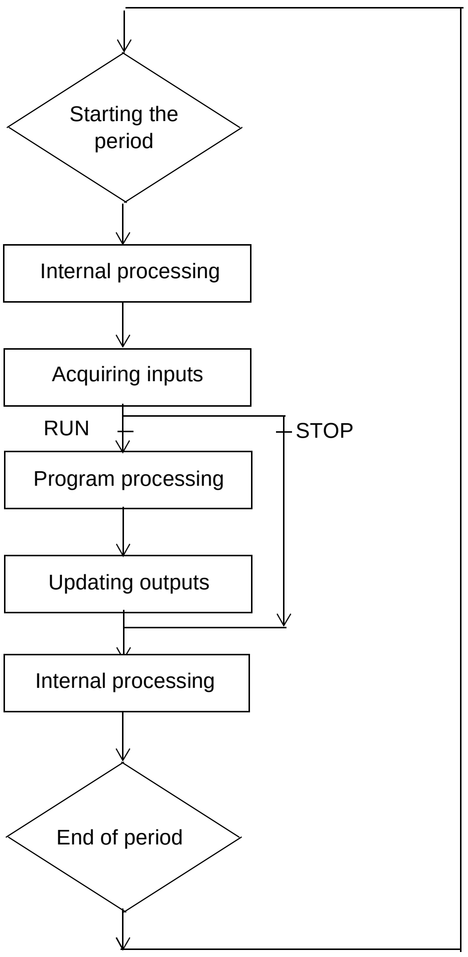
**Controller in RUN**, the processor performs:
- Internal processing order
- Acquiring inputs
- Processing the application program
- Updating outputs

If the period has not finished, the processor completes it operating cycle until the end of the internal processing period. If the operating time is longer than that allocated to the period, the controller indicates that the period has been exceeded by setting the task system bit %S19 to 1. The process continues and is run completely (however, it must not exceed the watchdog time limit). The following scan is linked in after writing the outputs of the scan in progress implicitly.

**Controller in STOP**, the processor performs:
- Internal processing
- Acquiring inputs

**Illustration**

The following illustration shows the operating cycles.



**Check Cycle**

Two checks are carried out:
- Period overflow
- Watchdog

## Checking Scan Time

**General Points**

The master task cycle is monitored by a watchdog timer called Tmax (a maximal duration of master task cycle). It permits the showing of application errors (infinite loops, and so on.) and assures a maximal duration for output refreshing.

**Software WatchDog (Periodic or Cyclic Operation)**

In periodic or cyclic operation, the triggering of the watchdog causes a software error. The application passes into a HALT state and sets bit %S11 to 1. The relaunching of the task necessitates a connection to Twido Soft in order to analyze the cause of the error, modification of the application to correct the error, and relaunching the INIT and RUN requests.

**Note:** The HALT state is when the application is stopped immediately because of an application software error such as a scan overrun. The data retains the current values, which allows for an analysis of the cause of the error. The tasks are all stopped on the current instruction. Communication with the controller is available.

**Check on Periodic Operation**

In periodic operation an additional check is used to detect the period being exceeded:

- **%S19** indicates that the period has been exceeded. It is set to:
  - 1 by the system when the scan time is greater that the task period.
  - 0 by the user.
- **%SW0** contains the period value (0-150 ms). It is:
  - Initialized when starting from a cold start by the value set in the configuration.
  - It can be modified by the user.

**Using Master Task Running Time**

The following system words are used for information on the controller scan cycle time:

- **%SW11** initializes to the maximum watchdog time (10 to 500 ms).
- **%SW30** contains the execution time for the last controller scan cycle.
- **%SW31** contains the execution time for the longest controller scan cycle since the last cold start.
- **%SW32** contains the execution time for the shortest controller scan cycle since the last cold start.

**Note:** This different information can also be accessed from the configuration editor.

## Operating Modes

**Introduction**

Twido Soft is used to take into account the three main operating mode groups:
- Checking
- Running or production
- Stopping

**Note:** These operating modes are defined in the "Design Guide for Operating and Stopping Modes" produced by the Applied Industrial Automation Development Agency.

**Starting through Grafcet**

These different operating modes can be obtained around or starting from Grafcet using the following methods:
- Grafcet initialization
- Presetting of steps
- Maintaining a situation
- Freezing charts

Preliminary processing and use of system bits ensure effective operating mode management without complicating and overburdening the user program.

## Grafcet System Bits

Use of bits %S21, %S22 and %S23 is reserved for preliminary processing only. These bits are automatically reset by the system. They must be written by Set Instruction **S** only.

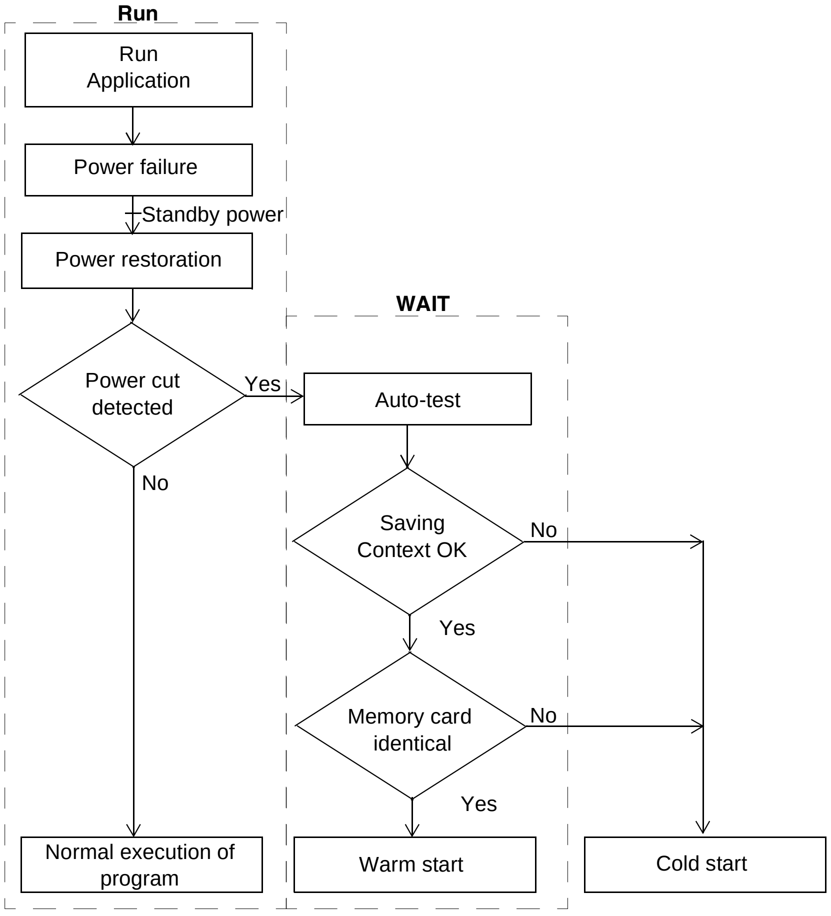
The following table provides Grafcet-related system bits:

| Bit | Function | Description |
|---|---|---|
| %S21 | GRAFCET initialization | Normally set to 0, it is set to 1 by:<br>● A cold restart, **%S0=1**.<br>● The user, in the pre-processing program part only, using a Set Instruction **S %S21** or a set coil **-(S)-%S21**.<br>Consequences:<br>● Deactivation of all active steps.<br>● Activation of all initial steps. |
| %S22 | GRAFCET RESET | Normally set to 0, it can only be set to 1 by the program in pre-processing.<br>Consequences:<br>● Deactivation of all active steps.<br>● Scanning of sequential processing stopped. |
| %S23 | Preset and freeze GRAFCET | Normally set to 0, it can only be set to 1 by the program in pre-processing.<br>● Reset Grafcet by setting %S22 to 1.<br>● Preposition the steps to be activated by a series of S Xi instructions.<br>● Enable prepositioning by setting %S23 to 1.<br>Freezing a situation:<br>● In initial situation: by maintaining %S21 at 1 by program.<br>● In "empty" situation: by maintaining %S22 at 1 by program.<br>● In situation determined by maintaining %S23 at 1. |

## Dealing with Power Cuts and Power Restoration

**Illustration**

The following illustration shows the various power restarts detected by the system. If the duration of the cut is less than the power supply filtering time (about 10 ms for an alternating current supply or 1 ms for a direct current supply), this is not noticed by the program which runs normally.



**Note:** The context is saved in a battery backed-up RAM. At power up, the system checks the state of the battery and the saved context to decide if a warm start can occur.

## Run/Stop Input Bit Versus Auto Run

The Run/Stop input bit has priority over the Automatic Start in Run option that is available from the Scan Mode dialog box (see the TwidoSoft Operation Guide). If the Run/Stop bit is set, then the controller will restart in the Run Mode when power is restored.
The mode of the controller is determined as follows:

| Run/Stop Input Bit | Auto Start in Run | Resulting State |
|---|---|---|
| Zero | Zero | Stopped |
| Zero | One | Stopped |
| Rising edge | Don't care | Running |
| One | Don't care | Running |
| Not configured in software | Zero | Stopped |
| Not configured in software | One | Running |

**Note:** For all Compact type of controllers, if the controller was in Run mode when power was interrupted, and the "Automatic Start in Run" flag was not set from the Scan Mode dialog box, the controller will restart in Stop mode when power is restored.

**Note:** For all Modular type of controllers, if the battery in the controller is operating normally when power was interrupted, the controller will startup in the mode that was in effect at the time the power was interrupted. The "Automatic Start in Run" flag, that was selected from the Scan Mode dialog, will have no effect on the mode when the power is restored.

## Operation

The table below describes the processing phases for power cuts.

| Phase | Description |
|---|---|
| 1 | In the event of a power cut the system stores the application context and the time of the cut. |
| 2 | It sets all outputs in a fallback state as a function of the security parameters (%S9). |
| 3 | When power is restored, the context saved is compared with the one in progress which defines the type of start to run:<br>● If the application context has changed (loss of system context or new application), the controller initializes the application: start up from cold,<br>● If the application context is the same, the controller restarts without initializing data: warm restart. |

## Dealing with a Warm Restart

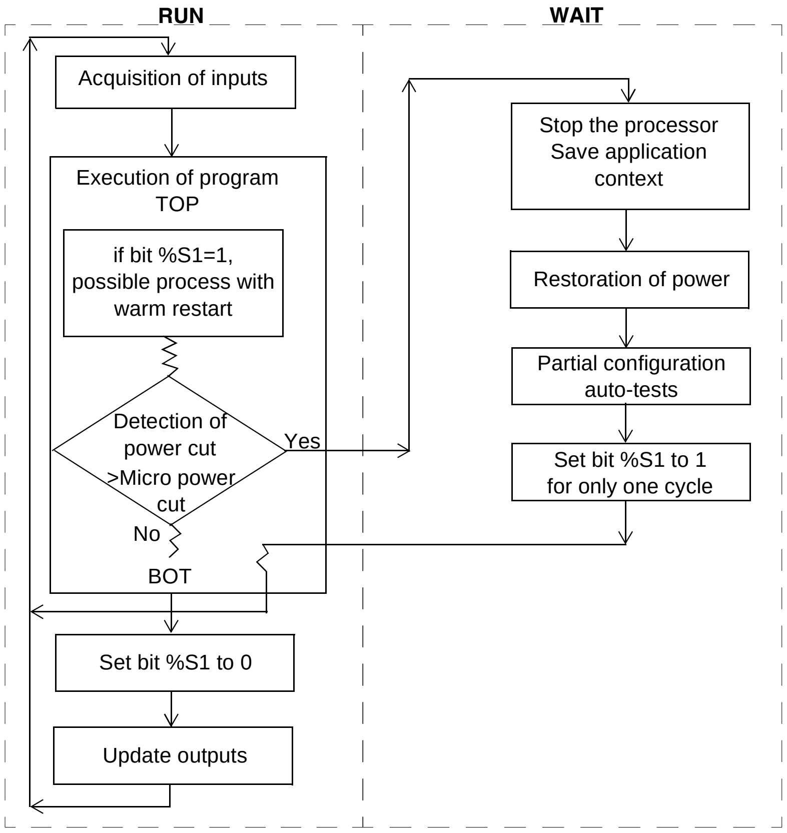
### Cause of a Warm Restart

A warm-start can occur:
- When power is restored without loss of application context,
- When bit **%S1** is set to state 1 by the program,
- From the Operator Display when the controller is in STOP mode.

**Note:** Compact controllers always power-up in cold-start. Modular controllers always restart in warm restart.

### Illustration

The drawing below describes a warm restart operation in RUN mode.


RUN
WAIT
Acquisition of inputs
Execution of program
TOP
if bit %S1=1, possible process with warm restart
Detection of power cut >Micro power cut
Yes
No
BOT
Set bit %S1 to 0
Update outputs
Stop the processor Save application context
Restoration of power
Partial configuration auto-tests
Set bit %S1 to 1 for only one cycle

## Restart of the Program Execution

The table below describes the restart phases for running a program after a warm restart.

| Phase | Description |
|---|---|
| 1 | The program execution resumes from the same element where it was prior to the power cut, without updating the outputs.<br>**Note:** Only the same element from the user code is restarted. The system code (for example, the updating of outputs) is not restarted. |
| 2 | At the end of the restart cycle, the system:<br>● Unreserves the application if it was reserved (and provokes a STOP application in case of debugging)<br>● Reinitializes the messages |
| 3 | The system carries out a restart cycle in which it:<br>● Relaunches the task with bits **%S1** (warm-start flag) and **%S13** (first cycle in RUN) set to 1<br>● Resets bits **%S1** and **%S13** to 0 at the end of the first task cycle |

## Processing of a Warm-Start

In the event of a warm-start, if a particular application process is required, bit **%S1** must be tested at the start of the task cycle, and the corresponding program called up.

## Outputs after Power Failure

As soon as a power failure is detected, the outputs are set to a fall-back (default) state of 0.
When power is restored, outputs are at last state until they are updated again by the task.

## Dealing with a Cold Start

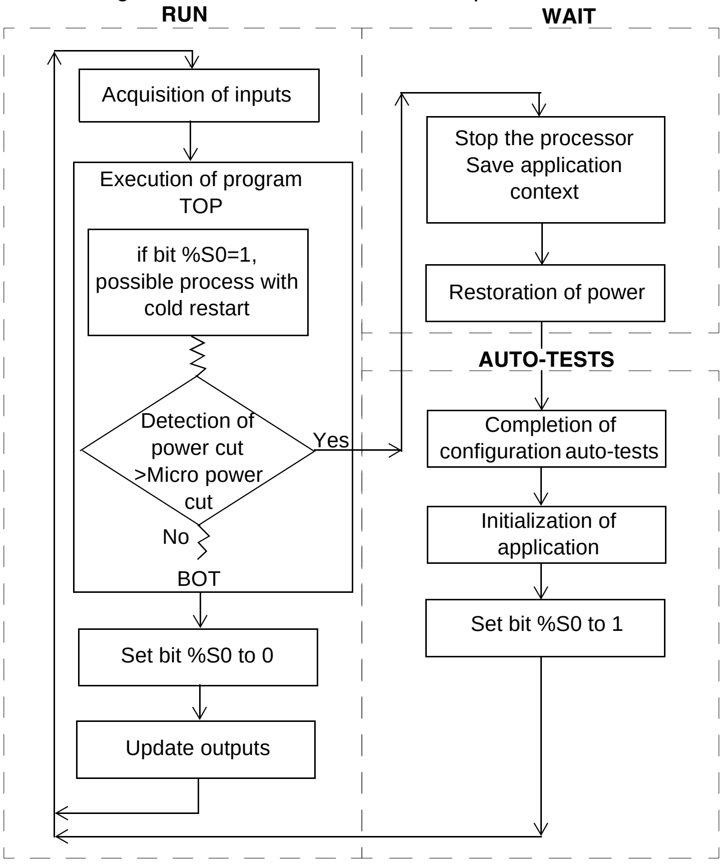
**Cause of a Cold Start**

A cold-start can occur:
- When loading a new application into RAM
- when power is restored with loss of application context
- When bit **%S0** is set to state 1 by the program
- From the Operator Display when the controller is in STOP mode

**Note:** Compact controllers always power-up in cold-start. Modular controllers always restart in warm restart.

**Illustration**

The drawing below describes a cold restart operation in RUN mode.


RUN
WAIT
Acquisition of inputs
Execution of program
TOP
if bit %S0=1, possible process with cold restart
Detection of power cut >Micro power cut
Yes
No
BOT
Set bit %S0 to 0
Update outputs
Stop the processor Save application context
Restoration of power
AUTO-TESTS
Completion of configuration auto-tests
Initialization of application
Set bit %S0 to 1

**Operation**

The table below describes the restart phases for running a program after a cold restart.

| Phase | Description |
|---|---|
| 1 | At start up, the controller is in RUN.<br>At a cold restart after a stop due to an ERROR, the system forces a cold restart.<br>The program execution restarts at the beginning of the cycle. |
| 2 | The system:<br>● Resets internal bits and words and the I/O images to 0<br>● Initializes system bits and words<br>● Initializes function blocks from configuration data |
| 3 | For this first restart cycle, the system:<br>● Relaunches the task with bits **%S0** (cold restart flag) and **%S13** (first cycle in RUN) set to 1<br>● Resets bits **%S0** and **%S13** to 0 at the end of this first task cycle |

**Processing of a Cold-Start**

In the event of a cold-start, if a particular application process is required, bit **%S0** (which stays at 1) must be tested during the first cycle of the task.

**Outputs after Power Failure**

As soon as a power failure is detected, the outputs are set to a fall-back (default) state of 0.
When power is restored, outputs are at 0 until they are updated again by the task.

## Initializing the Controller

**Introduction**

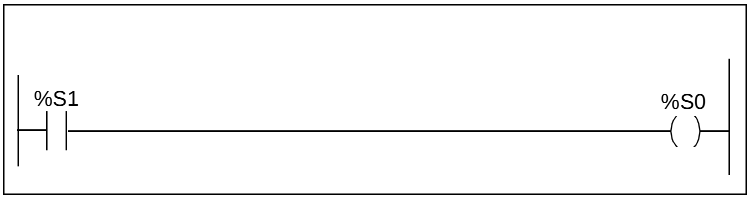
The controllers can be initialized by Twido Soft by setting system bits **%S0** (a cold restart) and **%S1** (a warm restart).

**Cold Start Initialization**

For a cold start initialization, system bit **%S0** must be set to 1.

**Warm Start Initialization Using %S0 and %S1**

For a warm start initialization, system bit **%S1** and **%S0** must be set to 1.
The following example shows how to program a warm restart initialization using system bits.



```
LD  %S1    If %S1 = 1 (warm restart), set %S0 to 1 initialize the controller.
ST  %S0    These two bits are reset to 0 by the system at the end of the
           following scan.
```

**Note:** Do not set %S0 to 1 for more than one controller scan.

**Warm Start Initialization Using INIT Command**

A warm start initialization can also be requested using an INIT command. The INIT command sends the controller into the IDLE state, and reinitialization of the application data and task state in STOPPED state.

# Special Functions

II

## At a Glance

**Overview**

This part describes communications, built-in analog functions, and managing analog I/O modules for Twido controllers.

**What's in this Part?**

This part contains the following chapters:

# Communications

5

## At a Glance

**Overview**

This chapter provides an overview of configuring, programming, and managing communications available with Twido controllers.

**What's in this Chapter?**

This chapter contains the following topics:

## Communications Overview

**Overview**

Twido provides one or two serial communications ports used for communications to remote controllers, peer controllers, or general external devices. Either port, if available, can be used for any of the services, with the exception of communicating with Twido Soft, which can only be performed using the first port. Three different base protocols are supported on each Twido controller: Remote Link, ASCII, or Modbus (modbus master or modbus slave).

**Remote Link**

The remote link is a high-speed master/slave bus designed to communicate a small amount of data between the master controller and up to seven remote (slave) controllers. Application or I/O data is transferred, depending on the configuration of the remote controllers. A mixture of remote controller types is possible, where some can be remote I/O and some can be peers.

**ASCII**

The ASCII protocol is a simple half-duplex character mode protocol used to transmit and/or receive a character string to/from a simple device (printer or terminal). This protocol is supported only via the "EXCH" instruction.

**Modbus**

The Modbus protocol is a master/slave protocol that allows for one, and only one, master to request responses from slaves, or to act based on the request. The master can address individual slaves, or can initiate a broadcast message to all slaves. Slaves return a message (response) to queries that are addressed to them individually. Responses are not returned to broadcast queries from the master.
**Modbus Master** - The modbus master mode allows the Twido controller to initiate transmission of a modbus query, with a response expected from a modbus slave. The modbus master mode is only supported via the "EXCH" instruction. Both Modbus ASCII and RTU are supported in modbus master mode.
**Modbus Slave** - The modbus slave mode allows the Twido controller to respond to modbus queries from a modbus master, and is the default communications mode if no communication is configured. The Twido controller supports the standard modbus data and control functions and service extensions for object access. Both Modbus ASCII and RTU are supported in modbus slave mode.

**Note:** There can be up to 32 nodes on an RS-485 network (1 master and up to 31 slaves), whose addresses can be in the range of 1-247.

## TwidoSoft to Controller Communications

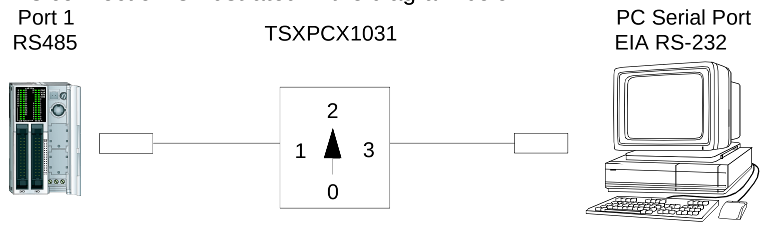
### Overview

Each Twido controller has on its Port 1 a built-in EIA RS-485 terminal port with internal power supply. You must use Port 1 to communicate to the TwidoSoft programming package. No optional cartridge or communication module can be used for this connection.

| | **CAUTION** |
|---|---|
| ⚠ | **UNEXPECTED EQUIPMENT DAMAGE**<br>TwidoSoft may not sense a disconnect when physically moving the TSXPCX1031 communication cable from a first controller and quickly inserting it in a second controller. To avoid this condition, use TwidoSoft to disconnect before moving the cable.<br>**Failure to observe this precaution can result in injury or equipment damage.** |

### Cable Connection

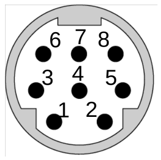
The EIA RS-232C Port on your personal computer is connected to the controller's Port 1 using the TSXPCX1031 multi-function communication cable. This cable converts signals between EIA RS-232 and EIA RS-485. This cable is equipped with a 4-position rotary switch to select different modes of operation. The switch designates the four positions as "0-3", and the appropriate setting for TwidoSoft to Twido controller is location 2.
This connection is illustrated in the diagram below.



**Note:** The DPT signal is not tied to ground. The signal is internally pulled up indicating to the firmware executive that this is a TwidoSoft connection.

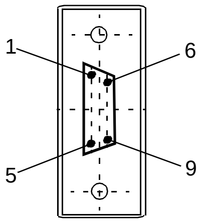
## Pin outs of Male and Female Connectors

The following figure shows the pin outs of a male 8-pin miniDIN connector.



| Pin outs | RS-485 |
|---|---|
| 1 | A (+) |
| 2 | B (-) |
| 3 | NC |
| 4 | /DE |
| 5 | DPT |
| 6 | NC |
| 7 | 0 V |
| 8 | 5 V |

The following figure shows the pin outs of a female 9-pin subD connector.



| Pin outs | RS-232 |
|---|---|
| 1 | DCD |
| 2 | RX |
| 3 | TX |
| 4 | DTR |
| 5 | SG |
| 6 | NC |
| 7 | RTS |
| 8 | CTS |
| 9 | NC |

## Remote Link Communications

### Introduction

The remote link is a high-speed master/slave bus designed to communicate a small amount of data between the master controller and up to seven remote (slave) controllers. Application or I/O data is transferred, depending on the configuration of the remote controllers. A mixture of remote controller types is possible, where some can be remote I/O and some can be peers.

**Note:** The master controller contains information regarding the address of a remote I/O. It does not know which specific controller is at the address. Therefore, the master can not validate that all the remote inputs and outputs used in the user application actually exist. Take care that these remote inputs or outputs actually exist.

**Note:** The remote I/O bus and the protocol used is proprietary and no third party devices are allowed on the network.

**CAUTION**

**UNEXPECTED EQUIPMENT OPERATION**

- Be sure that there is only one master controller on a remote link and that each slave has a unique address. Failure to observe this precaution may lead to corrupted data or unexpected and ambiguous results.
- Be sure that all slaves have unique addresses. No two slaves should have the same address. Failure to observe this precaution may lead to corrupted data or unexpected and ambiguous results.

**Failure to observe this precaution can result in injury or equipment damage.**

**Note:** The remote link requires an EIA RS-485 connection and can only run on one communications port at a time.

## Hardware Configuration

Remote link must use a minimum 3-wire EIA RS-485 port. This means that it can be configured to use either the first or an optional second port if present.

**Note:** Only one communication port can be configured as a remote link.

The table below lists the devices that can be used:

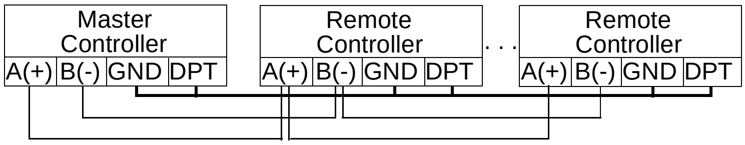
| Device | Port | Characteristics |
|---|---|---|
| TWDCAA10/16/24DRF, TWDLMDA20/40DUK, TWDLMDA20/40DTK, TWDLMDA20DRT | 1 | Base controller supporting a 3-wire EIA RS-485 using a miniDin connector. |
| TWDNOZ232D | 2 | Communication module supporting a 3-wire EIA RS-232 using a miniDin connector. **Note:** This module is only available for the Modular controllers. When the module is attached, the controller cannot have an Operator Display expansion module. |
| TWDNOZ485D | 2 | Communication module supporting a 3-wire EIA RS-485 using a miniDin connector. **Note:** This module is only available for the Modular controllers. When the module is attached, the controller cannot have an Operator Display expansion module. |
| TWDNOZ485T | 2 | Communication module supporting a 3-wire EIA RS-485 using a terminal connector. **Note:** This module is only available for the Modular controllers. When the module is attached, the controller cannot have an Operator Display expansion module. |
| TWDNAC232D | 2 | Communication adapter supporting a 3-wire EIA RS-232 using a miniDin connector. **Note:** This adapter is only available for the Compact 16 and 24 I/O controllers and the Operator Display expansion module. |
| TWDNAC485D | 2 | Communication adapter supporting a 3-wire EIA RS-485 using a miniDin connector. **Note:** This adapter is only available for the Compact 16 and 24 I/O controllers and the Operator Display expansion module. |
| TWDNAC485T | 2 | Communication adapter supporting a 3-wire EIA RS-485 using a terminal connector. **Note:** This adapter is only available for the Compact 16 and 24 I/O controllers and the Operator Display expansion module. |
| TWDXCPODM | 2 | Operator Display expansion module supporting either a 3-wire EIA RS-232 using a miniDIN connector, EIA RS-485 using a miniDIN connector, or EIA RS-485 using a terminal connector. **Note:** This module is only available for the Modular controllers. When the module is attached, the controller cannot have an Communication expansion module. |

**Note:** Port 2 configuration (availability and type) is checked only at power-up or reset.

## Cable Connection to Each Device

**Note:** The DPT signal on pin 5 must be tied to ground on pin 7 in order to signify the use of remote link communications. When this signal is not tied to ground, the Twido controller as either the master or slave will default to a mode of attempting to establish communications with TwidoSoft.

Cable connections to each device are illustrated below.



**Note:** The DPT to GND connection is only necessary if you are connected to a base controller on Port 1.

## Software Configuration

There must be only one master controller defined on the remote link. In addition, each remote controller must maintain a unique slave address. Multiple masters or slaves using identical addresses can either corrupt transmissions or create ambiguity.

**CAUTION**

**Unexpected Equipment Operation**

Be sure that there is only one master controller on a remote link and that each slave has a unique address. Failure to observe this precaution may lead to corrupted data or unexpected and ambiguous results.

**Failure to observe this precaution can result in injury or equipment damage.**

## Master Controller Configuration

The master controller is configured using TwidoSoft to manage a remote link network of up to seven remote controllers. The master supports a heterogeneous mixture of both remote controllers (either as remote I/O and peer controllers) on the remote link. The address of the master is configured using TwidoSoft to be at address 0.

## Remote Controller Configuration

Each of the remote controllers can be used as either a remote I/O or a peer controller. These are configured using TwidoSoft to be assigned address from 1 and 7 (Note that 0 is reserved for the remote link master).
The table below summarizes the differences and constraints of each of these types of remote controller configurations:

| **Type** | **Application Program** | **Data Access** |
|---|---|---|
| Remote I/O | No<br><br>Not even a simple "END" statement | %I and %Q<br><br>Only local I/O on the remote controller is accessible. (Not its expansion I/O) |
| Peer controller | Yes<br><br>Run mode is not coupled to Master's | %INW and %QNW<br><br>A maximum of 4 words of input and 4 words of output can be transmitted to and from each peer |

## Remote Controller Scan Synchronization

The update cycle of the remote link is not synchronized with the master controller's scan. The communications with the remote controllers is interrupt driven and happens as a background task in parallel with the running of the master controller's scan. At the end of the scan cycle, the most up to date values are read into the application data to be used for the next solve. This processing is the same for remote I/O and peer controllers.
Any controller can check for general link activity using system bit %S111. But to achieve synchronization, a master or peer will have to use system bit %S110. This is set to 1 when a complete update cycle has taken place. The application program is responsible to reset this to 0.
The master can enable or disable the remote link using system bit %S112.
Controllers can check on the proper configuration and health of the remote link using %S113. The DPT signal on Port 1 (used to determine if TwidoSoft is connected) is sensed and reported on %S100.
All these are summarized in the following table:

| System Bit | State | Indication |
|---|---|---|
| %S100 | 0 | master/slave: DPT not active (TwidoSoft cable NOT connected) |
| | 1 | master/slave: DPT active (TwidoSoft cable connected) |
| %S110 | 0 | master/slave: reset by application |
| | 1 | master: all remote link exchanges completed (remote I/O only)<br>slave: exchange with master completed |
| %S111 | 0 | master: single remote link exchange completed<br>slave: single remote link exchange detected |
| | 1 | master: single remote link exchange active<br>slave: single remote link exchange detected |
| %S112 | 0 | master: remote link disabled |
| | 1 | master: remote link enabled |
| %S113 | 0 | master/slave: remote link configuration/operation OK |
| | 1 | master: remote link configuration/operation error<br>slave: remote link operation error |

## Master Controller Restart

If a master controller restarts, one of the following events happens:
- A cold start (%S0 = 1) forces a re-initialization of the communications.
- A warm start (%S1 = 1) forces a re-initialization of the communications.
- In Stop mode, the master continues communicating with the slaves, with the Run/Stop bit set to indicate stop.

**Slave Controller Restart**

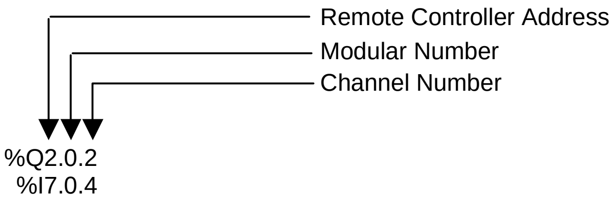
If a slave controller restarts, one of the following events happens:

- A cold start (%S0 = 1) forces a re-initialization of the communications.
- A warm start (%S1 = 1) forces a re-initialization of the communications.
- In Stop mode, the slave continues communicating with the master. If the master indicates a Stop is requested:
  - The remote I/O affects a Stop,
  - A peer controller continues in it’s current state.

**Remote I/O Data Access**

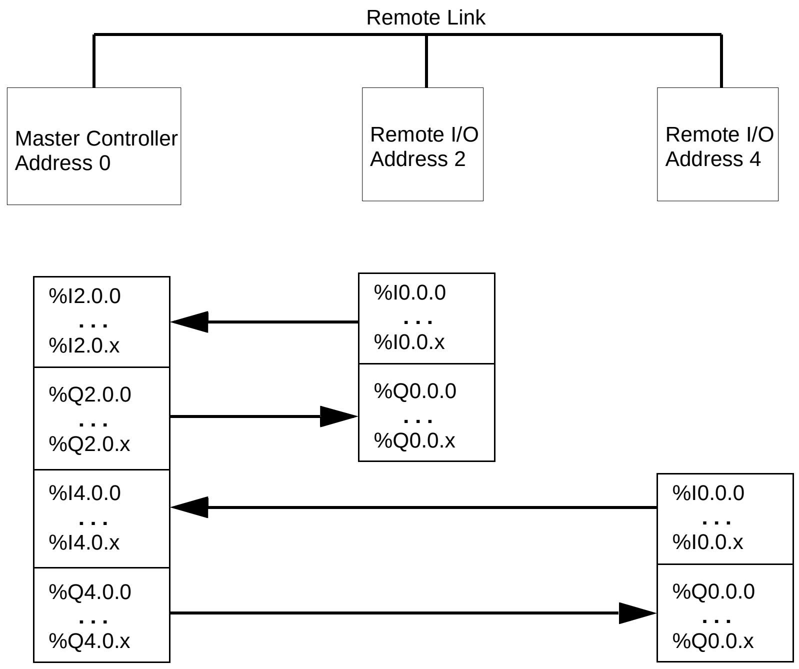
The remote controller configured to be a remote I/O does not have or execute its own application program. The remote controller's base digital inputs and outputs are a simple extension of the master controller's. The application must only use the full three digit addressing mechanism provided.

**Note:** The module number is always zero for remote I/O.



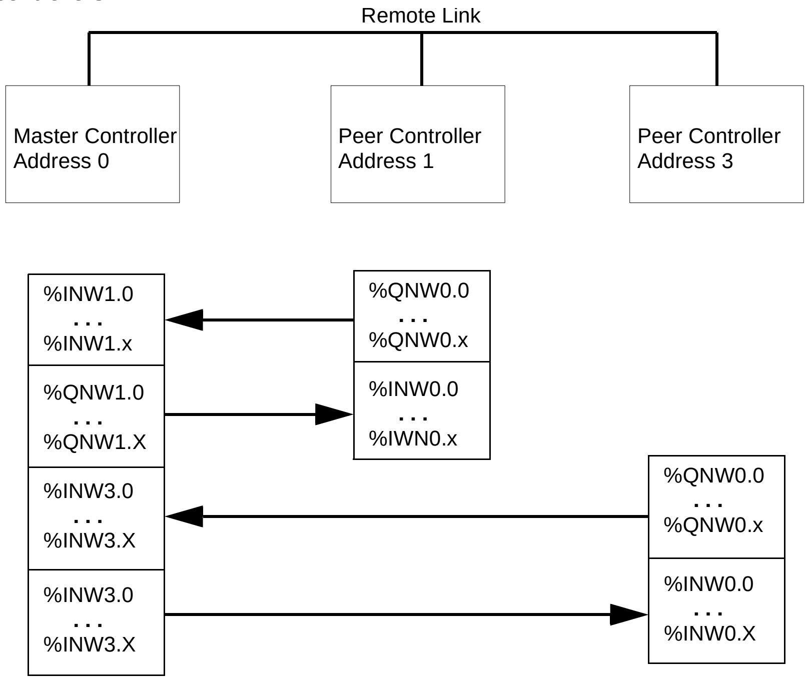
To communicate with remote I/O, the master controller uses the standard input and output notation of %I and %Q. To access the third output bit of the remote I/O configured at address 2, the master would set %Q2.0.2. Similarly, to read the fifth input bit of the remote I/O configured at location 7, the master would load %I7.0.4.

**Note:** The master is restricted to accessing only the digital I/O that is part of the remote’s local I/O. No analog or expansion I/O can be transferred, unless you use peer communications.


Remote Link
Master Controller Address 0
Remote I/O Address 2
Remote I/O Address 4
%I2.0.0 ... %I2.0.x
%Q2.0.0 ... %Q2.0.x
%I4.0.0 ... %I4.0.x
%Q4.0.0 ... %Q4.0.x
%I0.0.0 ... %I0.0.x
%Q0.0.0 ... %Q0.0.x
%I0.0.0 ... %I0.0.x
%Q0.0.0 ... %Q0.0.x

## Peer Controller Data Access

To communicate with peer controllers, the master uses network words %INW and %QNW to exchange data. Each peer on the network is accessed by its remote address "j" using words %INWj.k and %QNWj.k. Each peer controller on the network uses %INW0.0 to %INW0.3 and %QNW0.0 to %QNW0.3 to access data on the master. Network words are updated automatically when the controllers are in RUN or STOPPED mode.
The example below illustrates the exchange of a master with two configured peer controllers.



There is no peer-to-peer messaging within the remote link. Application programs can be used in conjunction with the network words, to transfer information between the remote controllers, in effect using the master as a bridge.

## Status Information

In addition to the system bits explained earlier, the master maintains status on the presence and configuration of remote controllers. This is done in system words %SW111 and %SW113. Either the remote or the master can acquire the value of the last error that occurred while communicating on the remote link in system word %SW112.
Each of these is detailed in the following table:

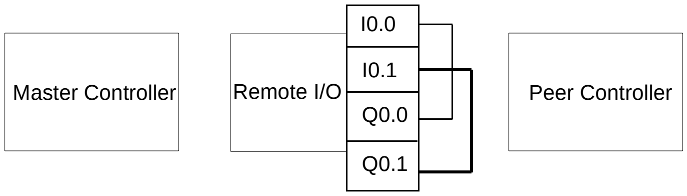
| System Words | Use | |
|---|---|---|
| %SW111 | | Remote Link status: two bits for each remote controller (master only) |
| | x0-5 | 0 - Remote controller 1-6 not present |
| | | 1 - Remote controller 1-6 present |
| | x6 | 0 - Remote controller 7 not present |
| | | 1 - Remote controller 7 present |
| | x8-13 | 0 - Remote I/O detected at remote controller 1-6 |
| | | 1 - Peer controller detected at remote controller 1-6 |
| | x14 | 0 - Remote I/O detected at remote controller 7 |
| | | 1 - Peer controller detected at remote controller 7 |
| %SW112 | | Remote Link configuration/operation error code: |
| | | 0 - operations are successful |
| | | 1 - timeout detected (slave) |
| | | 2 - checksum error detected (slave) |
| | | 3 - configuration mismatch (slave) |
| %SW113 | | Remote Link configuration: two bits for each remote controller (master only) |
| | x0-5 | 0 - Remote controller 1-6 not configured |
| | | 1 - Remote controller 1-6 configured |
| | x6 | 0 - Remote controller 7 not configured |
| | | 1 - Remote controller 7 configured |
| | x8-13 | 0 - Remote I/O configured as remote controller 1-6 |
| | | 1 - Peer controller configured as remote controller 1-6 |
| | x14 | 0 - Remote I/O configured as remote controller 7 |
| | | 1 - Peer controller configured as remote controller 7 |

## Remote Link Example

To configure a Remote Link, you must:
1. Configure the hardware.
2. Connect the controller cabling.
3. Connect the communications cable between the PC to the controllers.
4. Configure the software.
5. Write an application.

The diagrams below illustrate the use of the remote link with remote I/O and a peer controller.

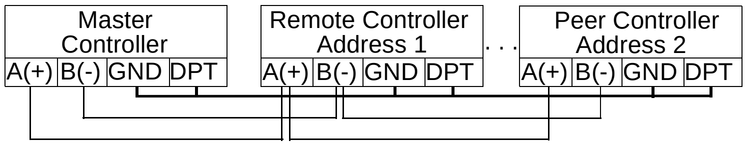
Step 1: Configure the Hardware:



The hardware configuration is three base controllers of any type. Port 1 is used in a dual mode. One mode is to configure and transfer the application program with TwidoSoft. The second mode is for the Remote Link network. If available, an optional Port 2 on any of the controllers can be used, but a controller only supports a single Remote Link.

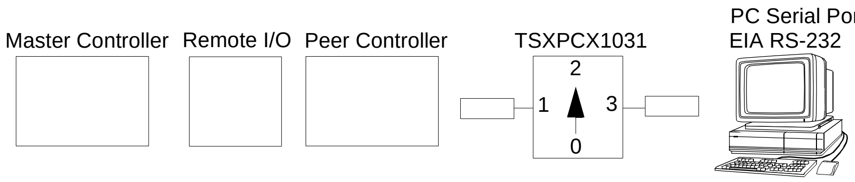
**Note:** In this example the first two inputs on the Remote I/O are hard wired to its outputs.

Step 2: Connect the Controller Cabling:



Connect the D(+) and D(-) signal wires together. And at each controller, the DPT signal is tied to ground. Although tying the signal to ground is not required for use with a remote link on Port 2 (optional cartridge or communication module), it is good practice.

Step 3: Connect the Communications Cable between the PC and Controllers:



The TSXPCX1031 multi-function programming cable is used to communicate with each of the three base controllers. Be sure that the cable is on switch position 2. In order to program each of the controllers, a point-to-point communication with each controller will need to be to established. To establish this communication: connect to Port 1 of the first controller, transfer the configuration and application data, and set the controller to the run state. Repeat this procedure for each controller.

**Note:** The cable needs to be moved after each controller configuration and application transfer.

Once all three controllers are programmed, connect the controllers on the Remote Link network as described in Step 2.
Step 4: Configure the Software:

**Controller Comm Setup**
Type: Remote Link
Address: 0 (Master)

**Controller Comm Setup**
Type: Remote Link
Address: 1

**Controller Comm Setup**
Type: Remote Link
Address: 2

**Add Remote Controllers**
Controller Usage: Remote I/O
Remote Address: 1

Controller Usage: Peer
Remote Address: 2

Each of the three controllers uses TwidoSoft to create a configuration, and if appropriate, the application program. For the master controller, edit the controller communication setup to set the protocol to "Remote Link" and the Address to "0 (Master)".

**Note:** Only one controller can be configured as the master on a Remote Link.

In TwidoSoft, add a "Remote I/O" at address "1" and a "Peer controller" at address "2".
For the controller configured as a remote I/O, verify that the controller communication setup is set to "Remote Link" and the address is set to "1". For the controller configured as peer, verify that the controller communication setup is set to "Remote Link" and the address is set to "2".

Step 5: Write an Application:

```
LD 1

[%MW0 := %MW0 +1]
[%QNW2.0 := %MW0]
[%MW1 := %INW2.0]

LD %I0.0
ST %Q1.0.0
LD %I1.0.0
ST %Q0.0

LD %I0.1
ST %Q1.0.1
LD %I1.0.1
ST %Q0.1
```

```
LD 1
[%QNW0.0 := %INW0.0]
```

In this example, master application increments an internal memory word and communicates this to the peer controller using a single network word. The peer controller takes the word received from the master and echoes it back. In the master, a different memory word receives and stores this transmission.
For communication with the remote I/O controller, the master sends its local inputs to the remote I/O's outputs. With the external I/O hard wiring of the remote I/O, the signals are returned and retrieved by the master.

**Note:** This communication takes place under the master's application. There is no application in the remote I/O controller.

## ASCII Communications

**Introduction**

ASCII protocol provides Twido controllers a simple half-duplex character mode protocol to transmit and/or receive data with a simple device. This protocol is supported using the EXCHx instruction and controlled using the %MSGx function block.

Three types of communications are possible with the ASCII Protocol:

- Transmission Only
- Transmission/Reception
- Reception Only

The maximum size of frames transmitted and/or received using the EXCHx instruction is 128 bytes.

## Hardware Configuration

An ASCII link can be established on either the EIA RS-232 or EIA RS-485 port and can run on as many as two communications ports at a time.
The table below lists the devices that can be used:

| Device | Port | Characteristics |
|---|---|---|
| TWDCAA10/16/24DRF, TWDLMDA20/40DUK, TWDLMDA20/40DTK, TWDLMDA20DRT | 1 | Base controller supporting a 3-wire EIA RS-485 using a miniDin connector. |
| TWDNOZ232D | 2 | Communication module supporting a 3-wire EIA RS-232 using a miniDin connector. **Note:** This module is only available for the Modular controllers. When the module is attached, the controller cannot have an Operator Display expansion module. |
| TWDNOZ485D | 2 | Communication module supporting a 3-wire EIA RS-485 using a miniDin connector. **Note:** This module is only available for the Modular controllers. When the module is attached, the controller cannot have an Operator Display expansion module. |
| TWDNOZ485T | 2 | Communication module supporting a 3-wire EIA RS-485 using a terminal connector. **Note:** This module is only available for the Modular controllers. When the module is attached, the controller cannot have an Operator Display expansion module. |
| TWDNAC232D | 2 | Communication adapter supporting a 3-wire EIA RS-232 using a miniDin connector. **Note:** This adapter is only available for the Compact 16 and 24 I/O controllers and the Operator Display expansion module. |
| TWDNAC485D | 2 | Communication adapter supporting a 3-wire EIA RS-485 using a miniDin connector. **Note:** This adapter is only available for the Compact 16 and 24 I/O controllers and the Operator Display expansion module. |
| TWDNAC485T | 2 | Communication adapter supporting a 3-wire EIA RS-485 using a terminal connector. **Note:** This adapter is only available for the Compact 16 and 24 I/O controllers and the Operator Display expansion module. |
| TWDXCPODM | 2 | Operator Display expansion module supporting a 3-wire EIA RS-232 using a miniDIN connector, EIA RS-485 using a miniDIN connector, or EIA RS-485 using a terminal connector. **Note:** This module is only available for the Modular controllers. When the module is attached, the controller cannot have an Communication expansion module. |

**Note:** Port 2 configuration (availability and type) is checked only at power-up or reset by the firmware executive.

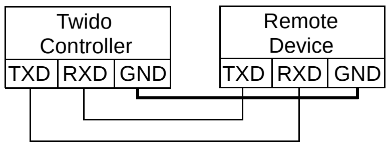
## Nominal Cabling

Nominal cable connections are illustrated below for both the EIA RS-232 and the EIA RS-485 types.

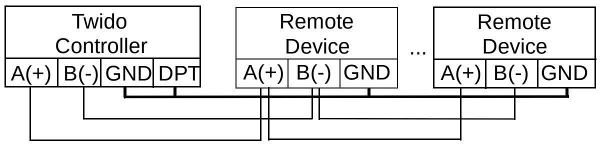
**Note:** If port 1 is used on the Twido controller, the DPT signal must be tied to GND. This signifies to the Twido controller that the communications through port 1 is ASCII and is not the protocol used to communicate with the TwidoSoft software. The specific remote device might require the use of additional signals (DTR, DSR, and so on).

Cable connections to each device are illustrated below.

EIA RS-232 Cable



EIA RS-485 Cable



**Note:** The DPT to GND connection is only necessary if you are connected to a base controller on Port 1.

## Software Configuration

To configure the controller to use a serial connection to send and receive characters using the ASCII protocol, you must:

| Stage | Description |
|---|---|
| 1 | Configure the serial port for ASCII using TwidoSoft. |
| 2 | Create in your application a transmit/receive buffer for ASCII to use the EXCHx instruction. |

**Configuring the Port**

A Twido controller can use its primary port 1 or an optionally configured port 2 to use the ASCII protocol. To configure a serial port for ASCII:

| Step | Action |
|---|---|
| 1 | Define any additional option cartridges or modules physically configured to the base. |
| 2 | Right-click on the port and click Edit Controller Comm Setup... and change serial port type to "ASCII". |
| 3 | Set the associated communication parameters. |

**Configuring the Transmit/ Receive Buffer for ASCII**

The maximum size of the frames transmitted and/or received is 128 bytes, and the word table associated with the EXCHx instruction is composed of both the transmission and reception tables.

| | Most Significant Byte | Least Significant Byte |
|---|---|---|
| **Control words** | Command | Length (Tx/Rx) |
| | Reserved (0) | Reserved (0) |
| **Transmission table** | Transmitted Byte 1 | Transmitted Byte 2 |
| | ... | ... |
| | ... | Transmitted Byte n |
| | Transmitted Byte n+1 | |
| **Reception table** | Received Byte 1 | Received Byte 2 |
| | ... | ... |
| | ... | Received Byte p |
| | Received Byte p+1 | |

**Control Parameters**

The **Length** byte contains the length to be transmitted, which is overwritten by the number of characters received at the end of the reception, if reception is requested.
The **Command** byte must contain one of the following:
- 0: Transmission Only
- 1: Transmission/Reception
- 2: Reception Only

**Transmission/ Reception Tables**

When in Transmit Only mode, the Control and Transmission tables are filled in prior to executing the EXCHx instruction, and can be of type %KW or %MW. No space is required for the reception of characters in Transmission Only mode. Once all bytes are transmitted, the state of %MSGx.D is set to 1, and a new EXCHx instruction can be executed.
When in Transmission/Reception mode, the Control and Transmission tables are filled in prior to executing the EXCHx instruction, and must be of type %MW. Space for up to 128 reception bytes is required at the end of the Transmission table. Once all bytes are transmitted, the Twido controller switches to reception mode and waits to receive any bytes.
When in Reception Only mode, the Control table is filled in prior to executing the EXCHx instruction, and must be of type %MW. Space for up to 128 reception bytes is required at the end of the Control table. The Twido controller immediately enters the reception mode and waits to receive any bytes.
Reception ends when the end-of-frame byte is received, or the Reception table is full. If a non-zero time out is configured, reception ends when the time out is completed. If a zero time out value is selected, there is no reception time out; therefore to stop reception, the %MSGx.R input must be activated.
There is no inherent addressing associated with the ASCII protocol, unless the simple device has it built into the protocol, but the Twido controller does not support it.

**Message Exchange**

The Twido controller can be configured to send and/or receive messages in character mode. The language offers two services for this:
- **EXCHx instruction:** to transmit/receive messages
- **%MSGx function block:** to control the message exchanges.

The Twido controller uses the protocol configured for that port when processing an EXCHx instruction.

**Note:** Each communications port can be configured for different protocols or the same. The EXCHx instruction or %MSGx function block for each communications port is accessed by appending the port number (1 or 2).

## EXCHx Instruction

The EXCHx instruction allows the Twido controller to send and/or receive information to/from ASCII devices. The user defines a table of words (%MWi:L or %KWi:L) containing control information and the data to be sent and/or received (up to 64 data words in transmission and/or reception). The format for the word table is described earlier.

A message exchange is performed using the EXCHx instruction:

Syntax: [EXCHx %MWi:L] or [EXCHx %KWi:L]

where: x = port number (1 or 2)
L = number of words in the word table

The Twido controller must finish the exchange from the first EXCHx instruction before a second can be launched. The %MSGx function block must be used when sending several messages.

The processing of the EXCHx list instruction occurs immediately, with any transmissions started under interrupt control (reception of data is also under interrupt control), which is considered background processing.

## %MSGx Function Block

The use of the %MSGx function block is optional; it can be used to manage data exchanges. The %MSGx function block has three purposes:

- **Communications error checking**
  The error checking verifies that the block length (word table) programmed with the EXCHx instruction is large enough to contain the length of the message to be sent. This is compared with the length programmed in the least significant byte of the first word of the word table).
- **Coordination of multiple messages**
  To ensure the coordination when sending multiple messages, the %MSGx function block provides the information required to determine when a previous message is complete.
- **Transmission of priority messages**
  The %MSGx function block allows the current message transmission to be stopped, in order to allow the immediate sending of an urgent message.

The %MSGx function block has one input and two outputs associated with it:

| Input/Output | Definition | Description |
|---|---|---|
| R | Reset input | Set to 1: re-initializes communication or resets block (%MSGx.E = 0 and %MSGx.D = 1). |
| %MSGx.D | Communication complete | 0: Request in progress.<br>1: communication done if end of transmission, end character received, error, or reset of block. |
| %MSGx.E | Error | 0: Message length OK and link OK.<br>1: if bad command, table incorrectly configured, incorrect character received (speed, parity, and so on.), or reception table full. |

## Limitations

It is important to note the following limitations:

- Port 2 availability and type is checked only at power-up or reset
- Any message processing on Port 1 is aborted when the TwidoSoft is connected
- EXCHx or %MSG can not be processed on a port configured as Remote Link
- EXCHx aborts active Modbus Slave processing (except for TwidoSoft processing)
- Processing of EXCHx instructions is not re-tried in the event of an error
- R %MSGx can be used to abort EXCHx instruction reception processing
- EXCHx instructions can be configured with a time out to abort reception
- Multiple messages are controlled via %MSGx.D

## Error and Operating Mode Conditions

If an error occurs when using the EXCHx instruction, bits %MSGx.D and %MSGx.E are set to 1 and system word %SW63 contains the error code for Port 1, and %SW64 contains the error code for Port 2.

| System Words | Use |
|---|---|
| %SW63 | EXCH1 error code:<br>0 - operation was successful<br>1 - transmission buffer too large (> 128)<br>2 - transmission buffer too small<br>3 - word table too small<br>4 - receive table overflowed<br>5 - time-out elapsed<br>6 - transmission error (received error in response)<br>7 - bad command within table<br>8 - selected port not configured/available<br>9 - reception error<br>10 - can not use %KW if receiving<br>11 - transmission offset larger than transmission table<br>12 - reception offset larger than reception table<br>13 - controller stopped EXCH processing |
| %SW64 | EXCH2 error code. See %SW63. |

## Master/Slave Controller Restart

If a master/slave controller restarts, one of the following events happens:
- A cold start (%S0 = 1) forces a re-initialization of the communications.
- A warm start (%S1 = 1) forces a re-initialization of the communications.
- In Stop mode, the controller stops all ASCII communications.

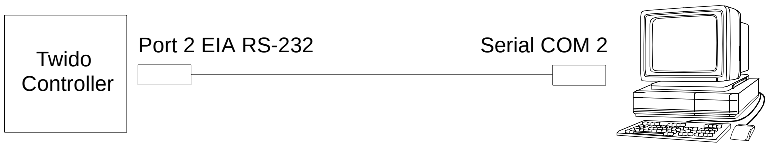
## ASCII Link Example

To configure a ASCII Link, you must:

**1.** Configure the hardware.
**2.** Connect the ASCII communications cable.
**3.** Configure the port.
**4.** Write an application.
**5.** Initialize the Animation Table Editor.

The diagram below illustrates the use of the ASCII communications with a Terminal Emulator on a PC.

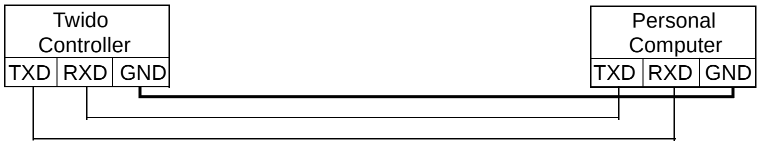
Step 1: Configure the Hardware:



The hardware configuration is two serial connections from the PC to a Twido controller with an optional EIA RS-232 Port 2. On a Modular controller, the optional Port 2 is a TWDNOZ232D. On the Compact controller, the optional Port 2 is a TWDNAC232D.

To configure the controller, connect the TSXPCX1031 cable (not shown) to Port 1 of the Twido controller. Next, connect the cable to the COM 1 port on the PC. Be sure that the switch is in position 2. Finally, connect the COM 2 port of the PC to the optional EIA RS-232 Port 2 on the Twido controller. Pin connections and wiring are provided in the next step.

Step 2: Connect the ASCII Communications Cable (EIA RS-232):



The minimum requirement for the wiring of the ASCII communications cable is a basic 3-wire connection. Cross the transmit and receive signals.

**Note:** On the PC side of the cable, additional connections (such as Data Terminal Ready and Data Set Ready) may be needed to satisfy the handshaking. No additional connections are required to satisfy the Twido controller.

Step 3: Configure the Port:

Hardware -> Add Option
TWDNOZ232D

Hardware => Controller Comm. Setup

| | |
|---|---|
| Port: | 2 |
| Type: | ASCII |
| Baud rate: | 19200 |
| Data: | 8 Bit |
| Parity: | None |
| Stop: | 1 Bit |
| End of Frame: | 65 |
| Response Timeout: | 100 x 100 ms |

Terminal Emulator on a PC

| | |
|---|---|
| Port: | COM2 |
| Baud rate: | 19200 |
| Data: | 8 Bit |
| Parity: | None |
| Stop: | 1 Bit |
| Flow Control: | None |

Use a simple Terminal Emulator application on the PC to configure a basic port configuration and to ensure that there is no flow control.

Use TwidoSoft to configure the controller’s port. First, the hardware option is configured. In this example, the TWDNOZ232D is added to the Modular base controller.

Second, the Controller Communication Setup is initialized with all of the same parameter settings as the Terminal Emulator on the PC. In this example, capital letter "A" is chosen for the "End of Frame" character, to terminate the input receive buffer. A 10 second time out for the "Response Timeout" parameter is chosen. Only one of these two parameters will be invoked, depending on whichever one happens first.

Step 4: Write an Application:

```
LD 1
[%MW10 := 16#0104 ]
[%MW11 := 16#0000 ]
[%MW12 := 16#4F4B ]
[%MW13 := 16#0A0D ]
LD 1
AND %MSG2.D
[EXCH2 %MW10:8]
LD %MSG2.E
ST %Q0.0
END
```

Use TwidoSoft to create an application program with three primary parts. First, initialize the control and transfer buffer to use for the EXCH instruction. In this example, a command is set up to both send and receive data. The amount of data to send is set to 4 bytes and is initialized to the characters: "O", "K", CR, LF.

Next, check the Done bit associated with %MSG2 and issue the EXCH2 instruction only if the port is ready. For the EXCH2 instruction, a value of 8 characters is specified. There are 2 control words (%MW10 and %MW11), 2 words to be used for transmit information (%MW12 and %MW13), and 4 words to receive data (%MW14 through %MW17).

Finally, the error status of the %MSG2 is sensed and stored on the first output bit on the local base controller I/O. Additional error checking using %SW64 could also be added to make this more robust.
Step 5: Initialize the Animation Table Editor:

| | Address | Current | Retained | Format |
|---|---|---|---|---|
| 1 | %MW10 | 0104 | 0000 | Hexadecimal |
| 2 | %MW11 | 0000 | 0000 | Hexadecimal |
| 3 | %MW12 | 4F4B | 0000 | Hexadecimal |
| 4 | %MW13 | 0A0D | 0000 | Hexadecimal |
| 5 | %MW14 | TW | 0000 | ASCII |
| 6 | %MW15 | ID | 0000 | ASCII |
| 7 | %MW16 | O | 0000 | ASCII |
| 8 | %MW17 | A | 0000 | ASCII |

The final step is to download this application controller and run it. Initialize an Animation Table Editor to animate and display the %MW10 through %MW17 words. On the Terminal Emulator, the characters "O"-"K"-CR-LF are displayed. There may be many of these depending on the number of times the EXCH block times out and a new one is issued. On the Terminal Emulator, type "T"-"W"-"I"-"D"-"O"-" "-"A". This is exchanged with the Twido controller and displayed in the Animation Table Editor.

## Modbus Communications

**Introduction**

The Modbus protocol is a master-slave protocol that allows for one, and only one, master to request responses from slaves, or to act based on the request. The master can address individual slaves, or can initiate a broadcast message to all slaves. Slaves return a message (response) to queries that are addressed to them individually. Responses are not returned to broadcast queries from the master.

## Hardware Configuration

A Modbus link can be established on either the EIA RS-232 or EIA RS-485 port and can run on as many as two communications ports at a time.
The table below lists the devices that can be used:

| Device | Port | Characteristics |
|---|---|---|
| TWDCAA10/16/24DRF, TWDLMDA20/40DUK, TWDLMDA20/40DTK, TWDLMDA20DRT | 1 | Base controller supporting a 3-wire EIA RS-485 using a miniDin connector. |
| TWDNOZ232D | 2 | Communication module supporting a 3-wire EIA RS-232 using a miniDin connector. **Note:** This module is only available for the Modular controllers. When the module is attached, the controller cannot have an Operator Display expansion module. |
| TWDNOZ485D | 2 | Communication module supporting a 3-wire EIA RS-485 using a miniDin connector. **Note:** This module is only available for the Modular controllers. When the module is attached, the controller cannot have an Operator Display expansion module. |
| TWDNOZ485T | 2 | Communication module supporting a 3-wire EIA RS-485 using a terminal connector. **Note:** This module is only available for the Modular controllers. When the module is attached, the controller cannot have an Operator Display expansion module. |
| TWDNAC232D | 2 | Communication adapter supporting a 3-wire EIA RS-232 using a miniDin connector. **Note:** This adapter is only available for the Compact 16 and 24 I/O controllers and the Operator Display expansion module. |
| TWDNAC485D | 2 | Communication adapter supporting a 3-wire EIA RS-485 using a miniDin connector. **Note:** This adapter is only available for the Compact 16 and 24 I/O controllers and the Operator Display expansion module. |
| TWDNAC485T | 2 | Communication adapter supporting a 3-wire EIA RS-485 using a terminal connector. **Note:** This adapter is only available for the Compact 16 and 24 I/O controllers and the Operator Display expansion module. |
| TWDXCPODM | 2 | Operator Display expansion module supporting a 3-wire EIA RS-232 using a miniDIN connector, EIA RS-485 using a miniDIN connector, or EIA RS-485 using a terminal connector. **Note:** This module is only available for the Modular controllers. When the module is attached, the controller cannot have an Communication expansion module. |

**Note:** Port 2 configuration (availability and type) is checked only at power-up or reset by the firmware executive.

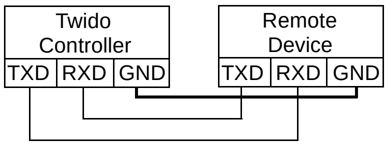
## Nominal Cabling

Nominal cable connections are illustrated below for both the EIA RS-232 and the EIA RS-485 types.

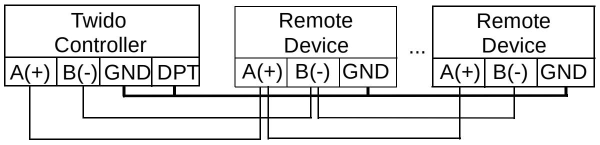
**Note:** If port 1 is used on the Twido controller, the DPT signal must be tied to GND. This signifies to the Twido controller that the communications through port 1 is Modbus and is not the protocol used to communicate with the TwidoSoft software. The specific remote device might require the use of additional signals (DTR, DSR, and so on).

Cable connections to each device are illustrated below.

EIA RS-232 Cable



EIA RS-485 Cable



**Note:** The DPT to GND connection is only necessary if you are connected to a base controller on Port 1.

## Software Configuration

To configure the controller to use a serial connection to send and receive characters using the Modbus protocol, you must:

| Stage | Description |
|---|---|
| 1 | Configure the serial port for Modbus using TwidoSoft. |
| 2 | Create in your application a transmit/receive buffer for Modbus to use the EXCHx instruction. |

## Configuring the Port

A Twido controller can use its primary port 1 or an optionally configured port 2 to use the Modbus protocol. To configure a serial port for Modbus:

| Step | Action |
|---|---|
| 1 | Define any additional option cartridges or modules physically configured to the base. |
| 2 | Right-click on the port and click Edit Controller Comm Setup... and change serial port type to "Modbus". |
| 3 | Set the associated communication parameters. |

## Modbus Master

Modbus master mode allows the controller to initiate transmission of a Modbus query, with a response expected from a Modbus slave. The Modbus Master mode is only supported via the EXCHx instruction. Both Modbus ASCII and RTU are supported in Modbus Master mode.
The maximum size of the frames transmitted and/or received is 128 bytes, and the word table associated with the EXCHx instruction is composed of transmission and reception tables.

| | **Most Significant Byte** | **Least Significant Byte** |
|---|---|---|
| **Control words** | Command | Length (Tx/Rx) |
| | Rx Offset | Tx Offset |
| **Transmission table** | Transmitted Byte 1 | Transmitted Byte 2 |
| | ... | ... |
| | ... | Transmitted Byte n |
| | Transmitted Byte n+1 | |
| **Reception table** | Received Byte 1 | Received Byte 2 |
| | ... | ... |
| | ... | Received Byte p |
| | Received Byte p+1 | |

## Control Parameters

The **Length** byte contains the length to transmit, which is overwritten by the number of characters received at the end of the reception, if reception is requested.
This parameter is the length in bytes of the transmission table. If the Tx Offset parameter is equal to 0, this parameter will be equal to the frame length itself minus the 2 CRC bytes. If the Tx Offset parameter is not equal to 0, one byte of the buffer (indicated by the offset value) will not be transmitted and this parameter is equal to the frame length itself plus 1.
The **Command** byte in case of Modbus RTU request (except for broadcast) must always equal to 1 (Tx and Rx).
The **Tx Offset** byte contains the offset (1 for the first byte, 2 for the second byte, and so on.) within the Transmission Table to ignore when transmitting the packet. This is used to handle the issues associated with byte/word values within the Modbus protocol. For example, if this byte contains 3, the third byte would be ignored, making the fourth byte in the table the third byte to be transmitted.
The **Rx Offset** byte contains the offset (1 for the first byte, 2 for the second byte, and so on.) within the Reception Table to add when transmitting the packet. This is used to handle the issues associated with byte/word values within the Modbus protocol. For example, if this byte contains 3, the third byte within the table would be filled with a ZERO, and the third byte was actually received would be entered into the fourth location in the table.

## Transmission/ Reception Tables

When using either mode (Modbus ASCII or Modbus RTU), the Transmission table is filled with the request prior to executing the EXCHx instruction. At execution time, the controller determines what the Data Link Layer is, and performs all conversions necessary to process the transmission and response. Start, end, and check characters are not stored in the Transmission/Reception tables.

Once all bytes are transmitted, the controller switches to reception mode and waits to receive any bytes. Reception is completed in one of several ways: end-of-frame character received in ASCII mode; time out on a character or frame has been detected; the Reception table is full.

The **Transmitted Byte X** entries contain Modbus protocol (RTU encoding) data that is to be transmitted. If the communications port is configured for Modbus ASCII, the correct framing characters are appended to the transmission. The first byte contains the device address (specific or broadcast), the second byte contains the function code, and the rest contain the information associated with that function code.

**Note:** This is a typical application, but does not define all the possibilities. No validation of the data being transmitted will be performed.

The **Received Byte X** entries contain Modbus protocol (RTU encoding) data that is to be received. If the communications port is configured for Modbus ASCII, the correct framing characters are removed from the response. The first byte contains the device address, the second byte contains the function code (or response code), and the rest contain the information associated with that function code.

**Note:** This is a typical application, but does not define all the possibilities. No validation of the data being received will be performed, except for checksum verification.

## Modbus Slave

Modbus slave mode allows the controller to respond to Modbus queries from a Modbus master. The controller supports the standard Modbus Data and Control functions, and UMAS extensions for configuration and object access.
When the TSXPCX1031 cable is attached to the controller, Modbus Slave mode communications is started at the port, temporarily disabling the communications mode that was running prior to the cable being connected.
The Modbus protocol supports two Data Link Layer formats: ASCII and RTU. Each is defined by the Physical Layer implementation, with ASCII using 7 data bits, and RTU using 8 data bits.
When using Modbus ASCII mode, each byte in the message is sent as two ASCII characters. The Modbus ASCII frame begins with a start character (':'), and ends with two end characters (CR and LF). The end-of-frame character defaults to 0x0A (line feed), and the user can modify the value of this byte during configuration. The check value for the Modbus ASCII frame is a simple two's complement of the frame, excluding the start and end characters.
Modbus RTU mode does not reformat the message prior to transmitting; however, it uses a different checksum calculation mode, specified as a CRC.
The Modbus Data Link Layer has the following limitations:

- Address 1-247
- Bits: 128 bits on request using Modbus open requests
- Words: 64 words of 16 bits on request using Modbus open requests

## Message Exchange

The Twido controller can be configured to send and/or receive messages in character mode. The language offers two services for this:

- **EXCHx instruction:** to transmit/receive messages
- **%MSGx function block:** to control the message exchanges.

The Twido controller uses the protocol configured for that port when processing an EXCHx instruction.

**Note:** Each communications port can be configured for different protocols or the same. The EXCHx instruction or %MSGx function block for each communications port is accessed by appending the port number (1 or 2).

## EXCHx Instruction

The EXCHx instruction allows the Twido controller to send and/or receive information to/from Modbus devices. The user defines a table of words (%MWi:L or %KWi:L) containing control information and the data to be sent and/or received (up to 64 data words in transmission and/or reception). The format for the word table is described earlier.

A message exchange is performed using the EXCHx instruction:

Syntax: [EXCHx %MWi:L] or [EXCHx %KWi:L]

where: x = port number (1 or 2)
L = number of words in the word table

The Twido controller must finish the exchange from the first EXCHx instruction before a second can be launched. The %MSGx function block must be used when sending several messages.

The processing of the EXCHx list instruction occurs immediately, with any transmissions started under interrupt control (reception of data is also under interrupt control), which is considered background processing.

## %MSGx Function Block

The use of the %MSGx function block is optional; it can be used to manage data exchanges. The %MSGx function block has three purposes:

- **Communications error checking**
  The error checking verifies that the block length (word table) programmed with the EXCHx instruction is large enough to contain the length of the message to be sent. This is compared with the length programmed in the least significant byte of the first word of the word table).
- **Coordination of multiple messages**
  To ensure the coordination when sending multiple messages, the %MSGx function block provides the information required to determine when a previous message is complete.
- **Transmission of priority messages**
  The %MSGx function block allows the current message transmission to be stopped, in order to allow the immediate sending of an urgent message.

The %MSGx function block has one input and two outputs associated with it:

| Input/Output | Definition | Description |
|---|---|---|
| R | Reset input | Set to 1: re-initializes communication or resets block (%MSGx.E = 0 and %MSGx.D = 1). |
| %MSGx.D | Communication complete | 0: Request in progress.<br>1: communication done if end of transmission, end character received, error, or reset of block. |
| %MSGx.E | Error | 0: Message length OK and link OK.<br>1: if bad command, table incorrectly configured, incorrect character received (speed, parity, and so on.), or reception table full. |

## Limitations

It is important to note the following limitations:

- Port 2 availability and type is checked only at power-up or reset
- Any message processing on Port 1 is aborted when the TwidoSoft is connected
- EXCHx or %MSG can not be processed on a port configured as Remote Link
- EXCHx aborts active Modbus Slave processing (except for TwidoSoft processing)
- Processing of EXCHx instructions is not re-tried in the event of an error
- R %MSGx can be used to abort EXCHx instruction reception processing
- EXCHx instructions can be configured with a time out to abort reception
- Multiple messages are controlled via %MSGx.D

## Error and Operating Mode Conditions

If an error occurs when using the EXCHx instruction, bits %MSGx.D and %MSGx.E are set to 1 and system word %SW63 contains the error code for Port 1, and %SW64 contains the error code for Port 2.

| System Words | Use |
|---|---|
| %SW63 | EXCH1 error code:<br>0 - operation was successful<br>1 - transmission buffer too large (> 128)<br>2 - transmission buffer too small<br>3 - word table too small<br>4 - receive table overflowed<br>5 - time-out elapsed<br>6 - transmission error (received error in response)<br>7 - bad command within table<br>8 - selected port not configured/available<br>9 - reception error<br>10 - can not use %KW if receiving<br>11 - transmission offset larger than transmission table<br>12 - reception offset larger than reception table<br>13 - controller stopped EXCH processing |
| %SW64 | EXCH2 error code. See %SW63. |

## Master Controller Restart

If a master/slave controller restarts, one of the following events happens:
- A cold start (%S0 = 1) forces a re-initialization of the communications.
- A warm start (%S1 = 1) forces a re-initialization of the communications.
- In Stop mode, the controller stops all Modbus communications.

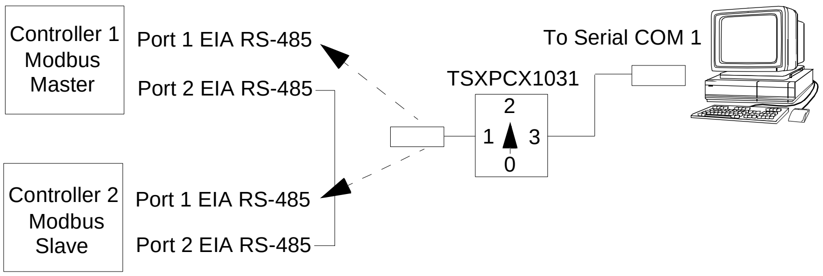
## Modbus Link Example 1

To configure a Modbus Link, you must:

**1.** Configure the hardware.
**2.** Connect the Modbus communications cable.
**3.** Configure the port.
**4.** Write an application.
**5.** Initialize the Animation Table Editor.

The diagrams below illustrate the use of Modbus function code 3 to read a slave's output words. This example uses two Twido controllers.

Step 1: Configure the Hardware:



The hardware configuration is two Twido controllers. One will be configured as the Modbus Master and the other as the Modbus Slave.

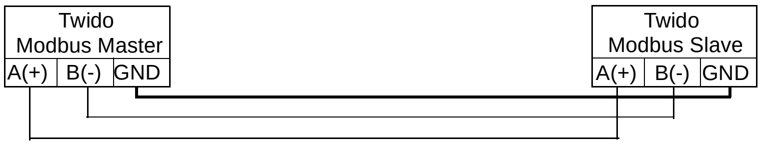
> **Note:** In this example, each controller is configured to use EIA RS-485 on Port 1 and an optional EIA RS-485 Port 2. On a Modular controller, the optional Port 2 can be either a TWDNOZ485D or a TWDNOZ485T. On a Compact controller, the optional Port 2 can be either a TWDNAC485D or a TWDNAC485T.

To configure each controller, connect the TSXPCX1031 cable to Port 1 of the first controller.

> **Note:** The TSXPCX1031 cable can only be connected to one controller at a time, on the EIA RS-485 Port 1 only.

Next, connect the cable to the COM 1 port of the PC. Be sure that the switch is in position 2. Download and monitor each application. Repeat procedure for second controller.

Step 2: Connect the Modbus Communications Cable:



The wiring in this example demonstrates a simple point to point connection. The three signals A(+), B(-), and GND signals are wired according to the diagram.
If using Port 1 of the Twido controller, the DPT signal must be tied to ground This conditioning of DPT determines if TwidoSoft is connected. When tied to ground, the controller will use the port configuration set in the application to determine the type of communication.
Step 3: Configure the Port:

Hardware -> Add Option
TWDNOZ485-

| Hardware => Controller Comm. Setup | |
|---|---|
| Port: | 2 |
| Type: | Modbus |
| Address: | 1 |
| Baud rate: | 19200 |
| Data: | 8 Bit |
| Parity: | None |
| Stop: | 1 Bit |
| End of Frame: 65 | |
| Response Timeout: 10 x 100 ms | |
| Frame Timeout: 10 ms | |

Hardware -> Add Option
TWDNOZ485-

| Hardware => Controller Comm. Setup | |
|---|---|
| Port: | 2 |
| Type: | Modbus |
| Address: | 2 |
| Baud rate: | 19200 |
| Data: | 8 Bit |
| Parity: | None |
| Stop: | 1 Bit |
| End of Frame: 65 | |
| Response Timeout: 100 x 100 ms | |
| Frame Timeout: 10 ms | |

In both the master and slave applications, the optional EIA RS-485 ports are configured. Be sure to change the controller communications to initialize the Modbus addresses or Port 2 to two different addresses. In this example, the master is set to an address of 1 and the slave to 2. The number of bits is set to 8, indicating that we will be using Modbus RTU mode. If this had been set to 7, then we would be using Modbus-ASCII mode. The only other default modified was to increase the response timeout to 1 second.

**Note:** Since Modbus RTU mode was selected, the "End of Frame" parameter was ignored.

Step 4: Write an Application:

```
LD 1
[%MW0 := 16#0106 ]
[%MW1 := 16#0300 ]
[%MW2 := 16#0203 ]
[%MW3 := 16#0000 ]
[%MW4 := 16#0004 ]
LD 1
AND %MSG2.D
[EXCH2 %MW0:11]
LD %MSG2.E
ST  %Q0.0
END
```

```
LD 1
[%MW0 := 16#6566 ]
[%MW1 := 16#6768 ]
[%MW2 := 16#6970 ]
[%MW3 := 16#7172 ]
END
```

Using TwidoSoft, an application program is written for both the master and the slave. For the slave, we simple initialize some memory words to a set of known values. In the master, the exchange block is initialized to read 4 words from the slave at Modbus address 2 starting at location %MW0.

**Note:** Notice the use of the RX offset set in %MW1 of the Modbus master. The offset of three will add a byte (value = 0) at the third position in the reception area of the table. This aligns the words in the master so that they fall correctly on word boundaries. Without this offset, each word of data would be split between two words in the exchange block. This offset is used for convenience.

Before issuing the EXHC2 instruction, the application checks the Done bit associated with %MSG2. Finally, the error status of the %MSG2 is sensed and stored on the first output bit on the local base controller I/O. Additional error checking using %SW64 could also be added to make this more robust.

Step 5: Initialize the Animation Table Editor:

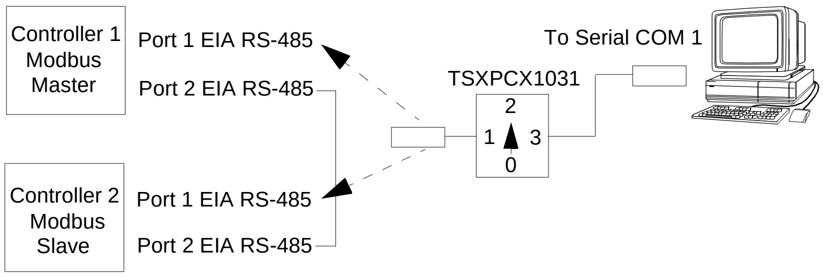
```
Address  Current Retained Format
1 %MW5   0203     0000     Hexadecimal
2 %MW6   0008     0000     Hexadecimal
3 %MW7   6566     0000     Hexadecimal
4 %MW8   6868     0000     Hexadecimal
5 %MW9   6970     0000     Hexadecimal
6 %MW10 7172     0000     Hexadecimal
```

After downloading and setting each controller to run, open an animation table on the master. Examine the response section of the table to check that the response code is 3 and that the correct number of bytes was read. Also in this example, note that the words read from the slave (beginning at %MW7) are aligned correctly with the word boundaries in the master.

**Modbus Link Example 2**

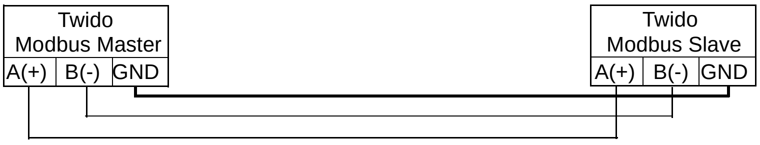
The diagram below illustrates the use of Modbus function code 16 to write output words to a slave. This example uses two Twido Controllers.

Step 1: Configure the Hardware:



The hardware configuration is identical to the previous example.

Step 2: Connect the Modbus Communications Cable:



The Modbus communications cabling is identical to the previous example.

Step 3: Configure the Port:

| Master | Slave |
|---|---|
| Hardware -> Add Option TWDNOZ485- | Hardware -> Add Option TWDNOZ485- |
| Hardware => Controller Comm. Setup | Hardware => Controller Comm. Setup |
| Port: 2 | Port: 2 |
| Type: Modbus | Type: Modbus |
| Address: 1 | Address: 2 |
| Baud rate: 19200 | Baud rate: 19200 |
| Data: 8 Bit | Data: 8 Bit |
| Parity: None | Parity: None |
| Stop: 1 Bit | Stop: 1 Bit |
| End of Frame: 65 | End of Frame: 65 |
| Response Timeout: 10 x 100 ms | Response Timeout: 100 x 100 ms |
| Frame Timeout: 10 ms | Frame Timeout: 10 ms |

The port configurations are identical to those in the previous example.

Step 4: Write an Application:

```
LD 1
[%MW0 := 16#010C ]
[%MW1 := 16#0007 ]
[%MW2 := 16#0210 ]
[%MW3 := 16#0010 ]
[%MW4 := 16#0002 ]
[%MW5 := 16#0004 ]
[%MW6 := 16#6566 ]
[%MW7 := 16#6768 ]
LD 1
AND %MSG2.D
[EXCH2 %MW0:11]
LD %MSG2.E
ST  %Q0.0
END
```

```
LD 1
[%MW18 := 16#FFFF ]
END
```

Using TwidoSoft, an application program is created for both the master and the slave. For the slave, initialize a single memory word %MW18. This will allocate space on the slave for the memory addresses from %MW0 through %MW18. Without allocating the space, the exchange block would be trying to write to locations that did not exist on the slave.
In the master, the exchange block is initialized to write 12 (0C hexadecimal) words to the slave at Modbus address 2 starting at location %MW16 (10 hexadecimal).

**Note:** Notice the use of the TX offset set in %MW1 of the Modbus master's application. The offset of seven will suppress the upper most byte in the sixth word (the value 00 hexadecimal in %MW5). This works to align the data values in the transmission table of the exchange block so that they fall correctly on word boundaries.

Before issuing the EXHC2 instruction, the application checks the Done bit associated with %MSG2. Finally, the error status of the %MSG2 is sensed and stored on the first output bit on the local base controller I/O. Additional error checking using %SW64 could also be added to make this more robust.

Step 5: Initialize the Animation Table Editor:

| Address | Current | Retained | Format |
|---|---|---|---|
| 1 %MW0 | 010C | 0000 | Hexadecimal |
| 2 %MW1 | 0007 | 0000 | Hexadecimal |
| 3 %MW2 | 0210 | 0000 | Hexadecimal |
| 4 %MW3 | 0010 | 0000 | Hexadecimal |
| 5 %MW4 | 0002 | 0000 | Hexadecimal |
| 6 %MW5 | 0004 | 0000 | Hexadecimal |
| 7 %MW6 | 6566 | 0000 | Hexadecimal |
| 8 %MW7 | 6768 | 0000 | Hexadecimal |
| 9 %MW8 | 0210 | 0000 | Hexadecimal |
| 10 %MW9 | 0010 | 0000 | Hexadecimal |
| 11 %MW10 | 0004 | 0000 | Hexadecimal |

| Address | Current | Retained | Format |
|---|---|---|---|
| 1 %MW16 | 6566 | 0000 | Hexadecimal |
| 2 %MW17 | 6768 | 0000 | Hexadecimal |

After downloading and setting each controller to run, open an animation table. The two values in %MW16 and %MW17 are written to the slave. In the master, the animation table can be used to examine the reception table portion of the exchange data. This data displays the slave address, the response code, the first word written, and the number of words written starting at %MW8 in the example above.

## Standard Modbus Requests

### Introduction

You can use these requests to exchange data between devices to access bit and word information. The same table format is used for both RTU and ASCII modes.

| Format | Reference |
|---|---|
| Bit | %Mi, 0x or 1x registers |
| Word | %MWi, 3x or 4x registers |

### Modbus Master: Read N Output and Input Bits

This table represents Request 01 and Request 02.

| | Table Index | Most Significant Byte | Least Significant Byte |
|---|---|---|---|
| **Control** | 0 | 01 (Tx/Rx) | 06 (Length Tx) |
| | 1 | 00 (Rx Offset) | 00 (Tx Offset) |
| **Transmission table** | 2 | Slave@(1..247) | 01 (Request code) |
| | 3 | Number of the first bit to read | |
| | 4 | N = Number of bits to read | |
| **Reception table (after response)** | 5 | Slave@(1..247) | 01 (Response code) |
| | 6 | Number of data bytes transmitted (1 byte by bit) | |
| | 7 | First byte read (value = 00 or 01) | Second byte read (if N>1) |
| | 8 | Third byte read | |
| | ... | | |
| | (N/2)+6 | Byte N read (if N>1) | |

## Modbus Master: Read N Output and Input Words

This table represents Request 03 and Request 04.

| | **Table Index** | **Most Significant Byte** | **Least Significant Byte** |
|---|---|---|---|
| **Control** | 0 | 01 (Tx/Rx) | 06 (Length Tx) |
| | 1 | 03 (Rx Offset) | 00 (Tx Offset) |
| **Transmission table** | 2 | Slave@(1..247) | 03 (Request code) |
| | 3 | Number of the first word to read | |
| | 4 | N = Number of words to read | |
| **Reception table (after response)** | 5 | Slave@(1..247) | 03 (Response code) |
| | 6 | 00 (byte added by Rx Offset action) | 2*N (number of bytes read) |
| | 7 | First word read | |
| | 8 | Second word read (if N>1) | |
| | ... | | |
| | N+6 | word N read (if N>2) | |

**Note:** The Rx Offset=3 will add a byte (value=0) at the third position in the reception table. Allow a good positioning of the number of bytes read and of the read words' values in this table.

## Modbus Master: Write 1 Output Bit

This table represents Request 05.

| | Table Index | Most Significant Byte | Least Significant Byte |
|---|---|---|---|
| **Control** | 0 | 01 (Tx/Rx) | 06 (Length Tx) |
| | 1 | 00 (Rx Offset) | 00 (Tx Offset) |
| **Transmission table** | 2 | Slave@(1..247) | 05 (Request code) |
| | 3 | Number of the bit to write | |
| | 4 | Bit value to write | |
| **Reception table (after response)** | 5 | Slave@(1..247) | 05 (Response code) |
| | 6 | Number of the bit written | |
| | 7 | Value written | |

**Note:**
- This request does not need the use of offset.
- The response frame is the same as the request frame here (in a normal case).
- For a bit to write 1, the associated word in the transmission table must contain the value FF00H. 0 for a bit value is 0.

## Modbus Master: Write 1 Output Word

This table represents Request 06.

| | Table Index | Most Significant Byte | Least Significant Byte |
|---|---|---|---|
| **Control** | 0 | 01 (Tx/Rx) | 06 (Length Tx) |
| | 1 | 00 (Rx Offset) | 00 (Tx Offset) |
| **Transmission table** | 2 | Slave@(1..247) | 06 (Request code) |
| | 3 | Number of the word to write | |
| | 4 | Word value to write | |
| **Reception table (after response)** | 5 | Slave@(1..247) | 06 (Response code) |
| | 6 | Number of the word written | |
| | 7 | Value written | |

**Note:**
- This request does not need the use of offset.
- The response frame is the same as the request frame here (in a normal case).

## Modbus Master: Write N Output Bits

This table represents Request 15.

| | Table Index | Most Significant Byte | Least Significant Byte |
|---|---|---|---|
| **Control** | 0 | 01 (Tx/Rx) | 8 + number of bytes (Tx) |
| | 1 | 00 (Rx Offset) | 07 (Tx Offset) |
| **Transmission table** | 2 | Slave@(1..247) | 15 (Request code) |
| | 3 | Number of the first bit to write | |
| | 4 | $N_1$ = Number of bits to write | |
| | 5 | 00 (byte not sent, offset effect) | $N_2$ = Number of data bytes to write |
| | 6 | Value of the first byte | Value of the second byte |
| | 7 | Value of the third byte | |
| | ... | | |
| | 6+($N_2$/2) | Value of the $N_2$th byte | |
| **Reception table (after response)** | | Slave@(1..247) | 15 (Response code) |
| | | Number of the first bit written | |
| | | Number of bits written (= $N_1$) | |

**Note:**
- The Tx Offset=7 will suppress the 7th byte in the sent frame. Allow a good correspondence of words' values in the transmission table.

## Modbus Master: Write N Output Words

This table represents Request 16.

| | Table Index | Most Significant Byte | Least Significant Byte |
|---|---|---|---|
| **Control** | 0 | 01 (Tx/Rx) | 8 + (2*N) (Length Tx) |
| | 1 | 00 (Rx Offset) | 07 (Tx Offset) |
| **Transmission table** | 2 | Slave@(1..247) | 16 (Request code) |
| | 3 | Number of the first word to write | |
| | 4 | N = Number of words to write | |
| | 5 | 00 (byte not sent, offset effect) | 2*N=NR of bytes to write |
| | 6 | First word value to write | |
| | 7 | Second value to write | |
| | ... | | |
| | N+5 | N value to write | |
| **Reception table (after response)** | N+6 | Slave@(1..247) | 16 (Response code) |
| | N+7 | Number of the first word written | |
| | N+8 | Number of word written (= N) | |

**Note:** The Tx Offset=7 will suppress the 5th MMSB byte in the sent frame. Allow a good correspondence of words' values in the transmission table.

# Built-In Analog Functions

6

## At a Glance

**Overview**

This chapter describes how to manage the built-in analog channel and potentiometers.

**What's in this Chapter?**

This chapter contains the following topics:

## Potentiometers

**Introduction**

Twido controllers have:

- One potentiometer on the TWDLCAA10DRF and TWDLCAA16DRF controllers
- Two potentiometers on the TWDLCAA24DRF controller

**Programming**

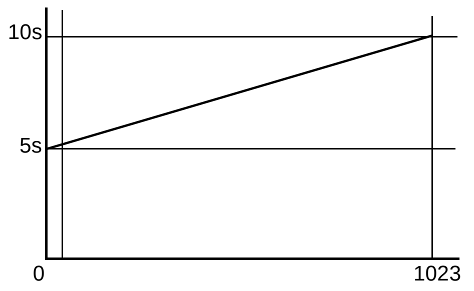
The numerical values, from 0 to 1023 for potentiometer 1 and 0 to 511 for potentiometer 2, corresponding to the analog values provided by these potentiometers are contained in the following two system words:

- %IW0.0.0 for potentiometer 1 (leftmost)
- %IW0.0.1 for potentiometer 2 (rightmost)

These words can be used in arithmetic operations. They can be used for any type of adjustment, for example, presetting a time-delay or a counter, adjusting the frequency of the pulse generator or machine preheating time.

**Example**

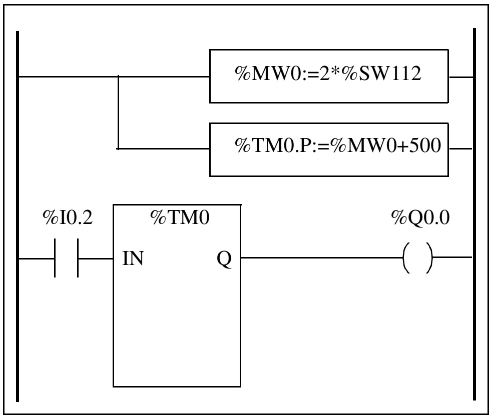
Adjusting the duration of a time-delay from 5 to 10 s using potentiometer 1:

| | |
|---|---|
| For this adjustment practically the entire adjustment range of the potentiometer 1 from 0 to 1023 is used. |  |

The following parameters are selected at configuration for the time-delay block %TM0:

- Type TON
- Time base TB : 10 ms

The preset value of the time-delay is calculated from the adjustment value of the potentiometer using the following equation %TM0.P := 2*%SW112+500.
Code for the above example:



```
LD      1
[%MW0:=2*%SW112]
[%TM0.P:=%MW0+500]
BLK     %TM0
LD      %I0.0
IN
OUT_BLK
LD      Q
ST      %Q0.0
END_BLK
..................


END
```

## Analog Channel

### Introduction

All Modular controllers (TWDLMDA20DTK, TWDLMDA20DUK, TWDLMDA20DRT, TWDLMD40DTK, and TWDLMD40DUK) have a built-in analog channel. The voltage input ranges from 0 to 10 V and the digitized signal from 0 to 511. The analog channel takes advantage of a simple averaging scheme that takes place over eight samples.

### Principle

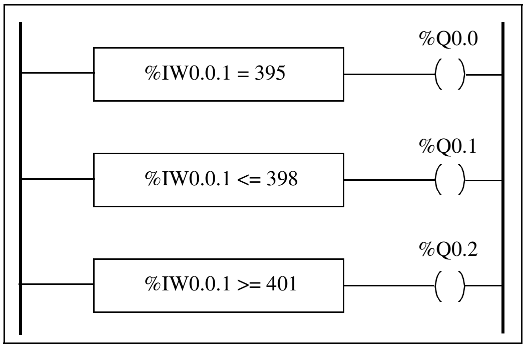
An analog to digital converter samples an input voltage from 0 to 10 V to a digital value from 0 to 511. This value is stored in system word %IW0.0.1. The value is linear through the entire range, so that each count is approximately 20 mV (10 V/ 512). A reading of 511 is used to detect whether the maximum value of the input signal has been exceeded.

### Programming Example

**Controlling the temperature of an oven**: The cooking temperature is set to 350°C. A variation of +/- 2.5°C results in tripping of output %Q0.1 and %Q0.2, respectively. Practically all of the possible setting ranges of the analog channel from 0 to 511 is used in this example. Analog setting for the temperature set points are:

| **Temperature (°C)** | **Voltage** | **System Word %IW0.0.1** |
|---|---|---|
| 0 | 0 | 0 |
| 347.5 | 7.72 | 395 |
| 350 | 7.77 | 398 |
| 352.5 | 7.83 | 401 |
| 450 | 10 | 511 |

Code for the above example:



```
LD      [%IW0.0.1 = 395]
ST      %Q0.0

LD      [%IW0.0.1 <= 398]
ST      %Q0.1

LD      [%IW0.0.1 >= 401]
ST      %Q0.2
```

# Managing Analog Modules

7

## At a Glance

**Overview**

This chapter provides an overview of managing analog modules for Twido controllers.

**What's in this Chapter?**

This chapter contains the following topics:

## Analog Module Overview

**Introduction**

In addition to the built-in 10-bit potentiometer and 9-bit analog channel, all the Twido controllers that support expansion I/O are also able to configure and communicate analog I/O modules.
These analog modules are:

| Name | Channels | Signal Range | Encoding |
|---|---|---|---|
| TWDAMI2HT | 2 In | 0 - 10 Volts or 4 - 20 mA | 12 Bit |
| TWDAM01HT | 1 Out | 0 - 10 Volts or 4 - 20 mA | 12 Bit |
| TWDAMM3HT | 2 In, 1 Out | 0 - 10 Volts or 4 - 20 mA | 12 Bit |
| TWDALM3LT | 2 In, 1 Out | 0 - 10 Volts, Inputs Th or RTD, Outputs 4 - 20 mA | 12 Bit |

**Operating Analog Modules**

Input and output words (%IW and %QW) are used to exchange data between the user application and any of the analog channels. The updating of these words is done synchronously with the controller scan during RUN mode.

**CAUTION**

**Unexpected Equipment Operation**

When the controller is set to STOP, the analog output is set to its fall-back position. As is the case with digital output, the fall-back position is zero.

**Failure to observe this precaution can result in injury or equipment damage.**

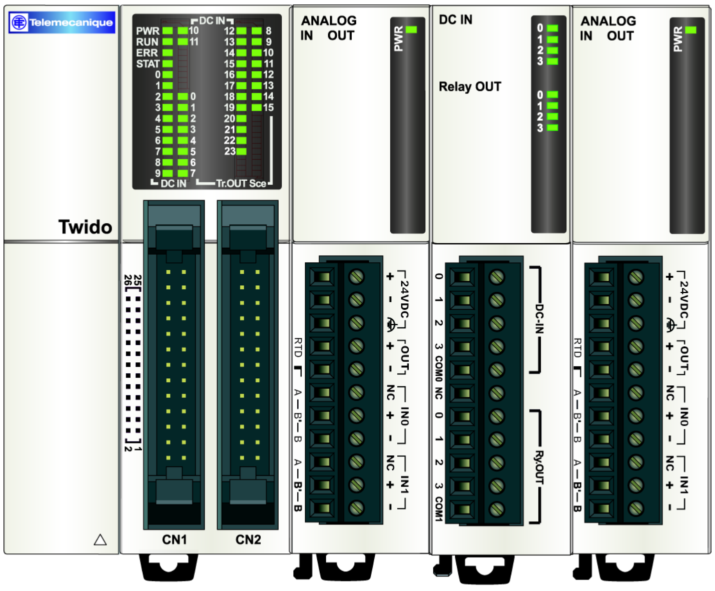
## Addressing Analog Inputs and Outputs

**Introduction**

Addresses are assigned to the analog channels depending on their location on the expansion bus.

## Example of Addressing Analog I/O

In this example, a TWDLMDA40DUK has its built-in 10-bit potentiometer, a 9-bit built-in analog channel. On the expansion bus, a TWDAMM3HT analog module, a TWDDMM8DRT input/output digital relay module, and a second TWDAMM3HT analog module are configured.



Base Module 1 Module 2 Module 3

The table below details the addressing for each output.

| Description | Base | Module 1 | Module 2 | Module 3 |
|---|---|---|---|---|
| Potentiometer 1 | %IW0.0.0 | | | |
| Built-in analog channel or Potentiometer 2 | %IW0.0.1 | | | |
| Analog in channel 1 | | %IW0.1.0 | | %IW0.3.0 |
| Analog in channel 2 | | %IW0.1.1 | | %IW0.3.1 |
| Analog out channel 1 | | %QW0.1.0 | | %QW0.3.0 |
| Digital in channels | | | %I0.2.0 - %I0.2.3 | |
| Digital out channels | | | %Q0.2.0 -%Q0.2.3 | |

## Configuring Analog Inputs and Outputs

### Introduction

This section provides information on configuring analog module's inputs and outputs.

### Configuring Analog I/O

The Configure Module dialog box is used to manage the parameters of the analog modules.

**Note:** You can only modify the parameters offline, when you are not connected to a controller.

Addresses are assigned to the analog channels depending on their location on the expansion bus. As a programming aid, you can also assign previously defined symbols to manipulate the data in your user application.
You can configure channel types for the TWDAM01HT, TWDAMM3HT, and TWDALM3LT's single output channel to be:

- Not used
- 0 - 10 V
- 4 - 20 mA

You can configure channel types for the TWDAMI2HT and TWDAMM3HT's two input channels to be:

- Not used
- 0 - 10 V
- 4 - 20 mA

**CAUTION**

**Unexpected Equipment Damage**

If you have wired your input for a voltage measurement, and you configure TwidoSoft for a current type of configuration, you may permanently damage the analog module. Ensure that the wiring is in agreement with the TwidoSoft configuration.

**Failure to observe this precaution can result in injury or equipment damage.**

The TWDALM3LT’s two input channels can be configured of type:
- Not used
- Thermocouple K
- Thermocouple J
- Thermocouple T
- PT 100

When a channel is configured, you can choose to assign units and map the range of inputs according to the following table:

| **Range** | **Units** | **Description** |
|---|---|---|
| Normal | None | Fixed range from a minimum of 0 to a maximum of 4095. |
| Custom | None | User defined with a minimum of no less than -32768 and a maximum no higher than 32767 |
| Celsius | 0.1°C | International thermometric scale. This is only available for the TWDALM3LT input channels. |
| Fahrenheit | 0.1°F | Thermometric scale where the boiling point of water is 212°F (100°C) and the freezing point is 32°F (0°C). This is only available for the TWDALM3LT input channels. |

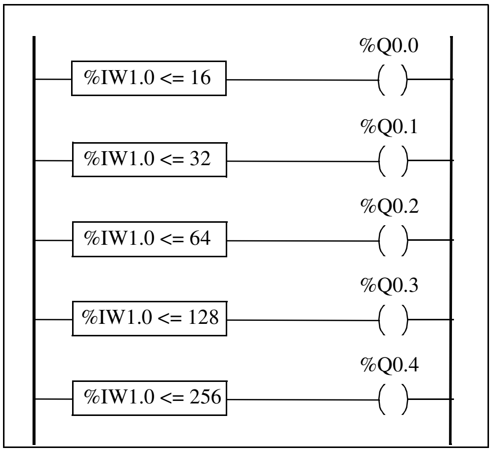
## Example of Using Analog Modules

**Introduction**

This section provides an example of using Analog modules available with Twido.

**Example**

This example compares the analog input signal with five separate threshold values. A comparison of the analog input is made and a bit is set on the base controller if it is less than the threshold.



```
LD [%IW1.0 <= 16]
ST %Q0.0

LD [%IW1.0 <= 32]
ST %Q0.1

LD [%IW1.0 <= 64]
ST %Q0.2

LD [%IW1.0 <= 128]
ST %Q0.3

LD [%IW1.0 <= 256]
ST %Q0.4
```

# Operator Display Operation

# 8

## At a Glance

**Overview**

This chapter provides details for using the optional Twido Operator Display.

**What's in this Chapter?**

This chapter contains the following topics:

## Operator Display

**Introduction**

The Operator Display is a Twido option that provides an interface for displaying and controlling application data and some controller functions such as operating state and the Real-Time Clock (RTC). This option is available as a cartridge (TWDXCPODC) for the Compact controllers or as an expansion module (TWDXCPODM) for the Modular controllers.
The Operator Display has two operating modes:

- Display mode: only displays data.
- Edit mode: allows you to change data.

**Note:** The operator display is updated at a specific interval of the controller scan cycle. This can cause confusion in interpreting the display of dedicated outputs for %PLS or %PWM pulses. At the time these outputs are sampled, their value will always be zero, and this value will be displayed. Ensure that the actual dedicated output is manipulated by the configuration of the controlling function block.

**Displays and Functions**

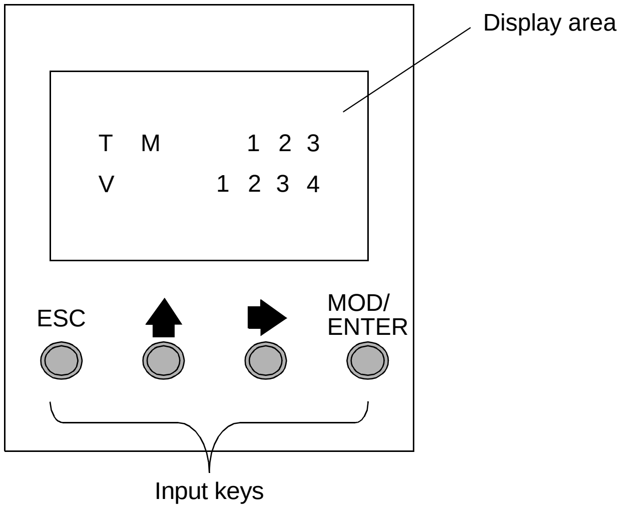
The Operator Display provides the following separate displays with the associated functions you can perform for each display.

- Controller identification and state information
  Display firmware revision and the controller state.Change the controller state with the Run, Initial, and Stop commands. Display error codes in the Halted state.
- System objects and variables
  Select application data by the address: %I, %Q, and all other software objects on the base controller. Monitor and change the value of a selected software data object.
- Serial port settings
  Display and configure communication port settings.
- Time of day clock
  Display and configure the current date and time (if the RTC is installed).
- Real-Time correction factor
  Display and modify the RTC Correction value for the optional RTC.

**Note:** Time of day clock and real-time correction are only available if the Real-Time Clock (RTC) option cartridge (TWDXCPRTC) is installed.

**Illustration**

The following is a simplified diagram of the Operator Display, which consists of a display area and four push-button input keys.



**Display Area**

The Operator Display provides an LCD display capable of displaying two lines of characters:

- The first line of the display has three 13-segment characters and four 7-segment characters.
- The second line has one 13-segment character, one 3-segment character (for a plus/minus sign), and five 7-segment characters.

**Input Keys**

The functions of the four input push-buttons depend on the Operator Display mode:

| **Key** | **In Display Mode** | **In Edit Mode** |
|---|---|---|
| ESC | | Discard changes and return to previous display. |
| ⬆ | | Change current edit element to successor value. |
| ➡ | Advance to next display. | Advance to next editing element. |
| MOD/ ENTER | Go to edit mode. | Accept changes and return to previous display. |

## Selecting and Navigating the Displays

The initial display or screen of the Operator Display shows the controller identification and state information. Press the ➡ push-button to sequence through each of the displays. The screens for the Time of Day Clock or the Real-Time Correction Factor are not displayed If the optional RTC cartridge (TWDXCPRTC) is not detected on the controller.

As a shortcut, press the ESC key to return to the initial display screen. For most screens, depressing ESC will return to the Controller Identification and State Information screen. Only when editing a System Objects and Variable that is not the initial entry (%I0.0.0), will pressing ESC take you to the first or initial system object entry.

To modify an object value, instead of pressing the ➡ push-button to go to the first value digit, press the MOD/ENTER again.

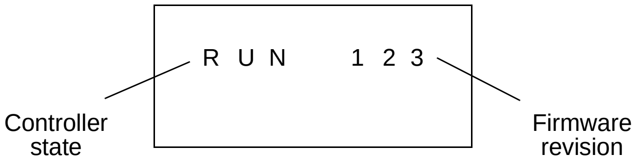
## Controller Identification and State Information

**Introduction**

The initial display or screen of the Twido optional Operator Display shows the Controller Identification and State Information.

**Example**

The firmware revision is displayed in the upper-right corner of the display area, and the controller state is displayed in the upper-left corner of the display area, as seen in the following:



## Controller States

Controller states include any of the following:

- **NCF: Not Configured**
  The controller is in the NCF state until an application is loaded. No other state is allowed until an application program is loaded. You can test the I/O by modifying system bit S8 (see *System Bits (%S), p. 318*).
- **STP: Stopped**
  Once an application is present in the controller, the state changes to the STP or Stopped state. In this state, the application is not running. The inputs are updated and internal data is held at its last values. Outputs are not updated in this state.
- **INI: Initial**
  You can choose to change the controller to the INI or initial state only from the STP state. The application is not running. The controller's inputs are updated and data values are set to their initial state. No outputs are updated from this state.
- **RUN: Running**
  When in the RUN or running state the application is running. The controller's inputs are updated and data values are set according to the application. This is the only state where the outputs are updated.
- **HLT: Halted (User Application Error)**
  If the controller has entered an ERR or error state, the application is halted. Inputs are updated and data values are held at their last value. From this state, outputs are not updated. In this mode, the error code is displayed in the lower-right portion of the Operator Display as an unsigned decimal value.
- **NEX: Not Executable**
  An online change was made to the user logic that caused the application to be no longer executable. The application in the PLC will not go back into the executable state until all causes for the non Exec State have been resolved.

## Displaying and Changing Controller States

Using the Operator Display, you can change to the INI state from the STP state, or from STP to RUN, or from RUN to STP.  Do the following to change the state of the controller:

| Step | Action |
|---|---|
| 1 | Press the ➡ key until the Operations Display is shown (or press ESC).  The current controller states is displayed in the upper-left corner of  the display area. |
| 2 | Press the MOD/ENTER key to enter edit mode. |
| 3 | Press the ⬆ key to select a controller state. |
| 4 | Press the MOD/ENTER key to accept the modified value. Or press the ESC key to discard any modifications made while in edit mode. |

## System Objects and Variables

**Introduction**

The optional Operator Display provides these features for monitoring and adjusting application data:
- Select application data by address (such as %I or %Q).
- Monitor the value of a selected software object/variable.
- Change the value of the currently displayed data object (including forcing inputs and outputs).

**System Objects and Variables**

The following table lists the system objects and variables, in the order accessed, that can be displayed and modified by the Operator Display.

| Object | Variable/Attribute | Description | Access |
|---|---|---|---|
| Input | %I.x.y.z | Value | Read/Force |
| Output | %Q.x.y.z | Value | Read/Write/Force |
| Timer | %TMX.V<br>%TMX.P<br>%TMX.Q | Current Value<br>Preset Value<br>Done | Read/Write<br>Read/Write<br>Read |
| Counter | %Cx.V<br>%Cx.P<br>%Cx.D<br>%Cx.E<br>%Cx.F | Current Value<br>Preset Value<br>Done<br>Empty<br>Full | Read/Write<br>Read/Write<br>Read<br>Read<br>Read |
| Memory Bit | %Mx | Value | Read/Write |
| Memory Word | %MWx | Value | Read/Write |
| Constant Word | %KWx | Value | Read |
| System Bit | %Sx | Value | Read/Write |
| System Word | %SWx | Value | Read/Write |
| Analog Input | %IW.x.y.z | Value | Read |
| Analog Output | %QW.x.y.z | Value | Read/Write |
| Fast Counter | %FCx.V<br>%FCx.P<br>%FCx.D | Current Value<br>Preset value<br>Done | Read/Write<br>Read/Write<br>Read |

| **Object** | **Variable/Attribute** | **Description** | **Access** |
|---|---|---|---|
| Very Fast Counter | %VFCx.V<br>%VFCx.P<br>%VFCx.U<br>%VFCx.C<br>%VFCx.S0<br>%VFCx.S1<br>%VFCx.F<br>%VFCx.M<br>%VFC.T<br>%VFC.R<br>%VFC.S | Current Value<br>Preset Value<br>Count Direction<br>Catch Value<br>Threshold Value 0<br>Threshold Value1<br>Overflow<br>Frequency Done<br>Timebase<br>Reflex Output Enable<br>Reflex Input Enable | Read/Write<br>Read/Write<br>Read<br>Read<br>Read/Write<br>Read/Write<br>Read<br>Read/Write<br>Read/Write<br>Read/Write<br>Read/Write |
| Input Network Word | %INWx.z | Value | Read/Write |
| Output Network Word | %QNWx.z | Value | Read/Write |
| Grafcet | %Xx | Step Bit | Read |
| Pulse Generator | %PLS.N<br>%PLS.P<br>%PLS.D<br>%PLS.Q | Number of Pulses<br>Preset value<br>Done<br>Current Output | Read/Write<br>Read/Write<br>Read<br>Read |
| Pulse Width Modulator | %PMW.R<br>%PMW.P | Ratio<br>Preset value | Read/Write<br>Read/Write |
| Drum Controller | %DRx.S<br>%DRx.F | Current Step Number<br>Full | Read<br>Read |
| Step Counter | %SCx.n | Step Counter bit | Read/Write |
| Register | %Rx.I<br>%Rx.O<br>%Rx.E<br>%Rx.F | Input<br>Output<br>Empty<br>Full | Read/Write<br>Read<br>Read<br>Read |
| Shift Bit Register | %SBR.x.yy | Register Bit | Read/Write |
| Message | %MSGx.D<br>%MSGx.E | Done<br>Error | Read<br>Read |

Notes:

1. Variables will not be displayed if they are not used in an application since Twido uses dynamic memory allocation.
2. If the value of %MW is greater than +32767 or less than -32787, the operator display will continue to blink.
3. If the value of %SW is greater than 65535, the operator display continues to blink, except for %SW0 and %SW11. If a value is entered that is more than the limit, the value will return to the configured value.
4. If a value is entered for %PLS.P that is more than the limit, the value will be set to saturation.

## Displaying and Modifying Objects and Variables

Each type of system object is accessed by starting with the Input Object (%I), sequencing through to the Message object (%MSG), and finally looping back to the Input Object (%I).
To display a system object:

| Step | Action |
|---|---|
| 1 | Press the ➡ key until the Data Display screen is shown.<br>The Input object ("I") will be displayed in the upper left corner of the display area. The "I" character (or previous object name) is not blinking. |
| 2 | Press the MOD/ENTER key to enter edit mode.<br>The Input Object "I" character (or previous object name) begins blinking. |
| 3 | Press the ⬆ key to step sequentially through the list of objects. |
| 4 | Press the ➡ key to step sequentially through the field of an object type and press the ⬆ key to increment through the value of that field. You can use the ➡ key and ⬆ key to navigate and modify all fields of the displayed object. |
| 5 | Repeat Steps 3 and 4 until editing is complete. |
| 6 | Press the MOD/ENTER key to accept the modified values.<br>Note: The object's name and address have to be validated before accepting any modifications. That is, they must exist in the configuration of the controller prior to using the operator display.<br>Press ESC to discard any changes made in edit mode. |

## Data Values and Display Formats

In general, the data value for an object or variable is shown as a signed or unsigned integer in the lower-right of the display area. In addition, all fields suppress leading zeros for displayed values. The address of each object is displayed on the Operator Display in one of the following six formats:

- I/O format
- Function block format
- Simple format
- Network I/O format
- Step counter format
- Shift bit register format

## Input/Output Format

The input/output objects (%I, %Q, %IW, and %QW) have three-part addresses such as %IX.Y.Z and are displayed as follows:

- Object type and controller address in the upper-left
- Expansion address in the upper-center
- I/O channel in the upper-right

In the case of a simple input (%I) and output (%Q), the lower-left portion of the display will contain a character that is either "U" for unforced or "F" for a forced bit. The force value is displayed in the lower-right of the screen.
The output object %Q0.3.11 appears in the display area as follows:

```
Q   0   3     1 1
F               1
```

## Function Block Format

The function blocks (%TM, %C, %FC, %VFC, %PLS, %PWM, %DR, %R, and %MSGj) have two-part addresses containing an object number and a variable or attribute name and are displayed as follows:

- Function block name in the upper-left
- Function block number (or instance) in the upper-right
- The variable or attribute in the lower-left
- Value for the attribute in the lower-right

In the following example, the current value for timer number 123 is set to 1,234.

```
T  M        1 2 3
V         1 2 3 4
```

## Simple Format

A simple format is used for objects %M, %MW, %KW, %S, %SW, and %X as follows:

- Object number in the upper-right
- Signed value for the objects in the lower portion

In the following example, memory word number 67 contains the value +123.

```
M  W          6 7
     +      1 2 3
```

## Network Input/ Output Format

The network input/output objects (%INW and %QNW) appear in the display area as follows:
- The object name in the upper-left
- Controller address in the upper-center
- Object number in the upper-right
- Signed value for the object in the lower portion

In the following example, the first input or network word of the remote controller configured at remote address #2 is set to the value -4.

```
M N W   2      1
      -        4
```

## Step Counter Format

The step counter (%SC) format displays the object number and the step counter bit as follows:
- Object name and number in the upper left
- The step counter bit  in the upper right
- The value of the object in the lower portion of the display

In the following example, bit number 129 of step counter number 3 is set to -1.

```
S C 3      1 2 9
      -        1
```

## Shift Bit Register Format

The shift bit register (%SBR)  format displays an object number and the register bit as follows:
- Object name and number in the upper left
- The register bit in the upper right

The following example shows the display of shift bit register number 4.

```
S B R  4       9
               1
```

## Serial Port Settings

### Introduction

You can display and modify protocol settings using the Operator Display. The maximum number of serial ports is two. In the example below, the first port is configured as Modbus protocol with an address 123. The second serial port is configured as a Remote Link with an address of 5.

```
M          1 2 3
R              4
```

### Displaying and Modifying Serial Port Settings

Twido controllers can support up to two serial ports.  To display the serial port settings using the operator display:

| Step | Action |
|---|---|
| 1 | Press the ➡ key until the Communication Display is shown. The single letter of the protocol setting of the first serial port ("M", "R", or "A") will be displayed in the upper left corner of the operator display. |
| 2 | Press the MOD/ENTER key to enter the edit mode. |
| 3 | Press the ➡ key until you are in the field that you wish to modify. |
| 4 | Press the ⬆ key increment the value of that field. |
| 5 | Continue steps 3 and 4 until the Serial Port Settings are complete. |
| 6 | Press the MOD/ENTER key to accept the modified values or ESC to discard any modifications made while in edit mode. |

## Time of Day Clock

### Introduction

You can modify the date and time using the operator display if the RTC option cartridge (TWDXCPRTC) is installed on your Twido controller. The Month is displayed in the upper-left side of the HMI Display. Until a valid time has been entered, the month field will contain the value "RTC". The day of the month is displayed in the upper-right corner of the display. The time of day is in military format. The hours and minutes are shown in the lower-right corner of the display and are separated by the letter "h". The example below shows that the RTC is set to March 28, at 2:22 PM.

```
M A R     2 8
        1 4 h 2 2
```

## Displaying and Modifying Time of Day Clock

To display and modify the Time of Day Clock:

| Step | Action |
|---|---|
| 1 | Press the ➡ key until the Time/Date Display is shown. The month value ("JAN", "FEB") will be displayed in the upper-left corner of the display area. The value "RTC" will be displayed in the upper-left corner if no month has been initialized. |
| 2 | Press the MOD/ENTER key to enter the edit mode. |
| 3 | Press the ➡ key until you are in the field that you wish to modify. |
| 4 | Press the ⬆ key increment the value of that field. |
| 5 | Continue steps 3 and 4 until the Time of Day value is complete. |
| 6 | Press the MOD/ENTER key to accept the modified values or ESC to discard any modifications made while in edit mode. |

## Real-Time Correction Factor

**Introduction**

You can display and modify the Real-Time Correction Factor using the operator display. Each Real-Time Clock (RTC) Option module has a RTC Correction Factor value that is used to correct for inaccuracies in the RTC module’s crystal. The correction factor is an unsigned 3-digit integer from 0 to 127 and is displayed in the lower-right corner of the display.
The example below shows a correction factor of 127.

```
R T C     C o r r
              1 2 7
```

**Displaying and Modifying RTC Correction**

To display and modify the Real-Time Correction Factor:

| Step | Action |
|---|---|
| 1 | Press the ➡ key until the RTC Factor Display is shown. "RTC Corr" will be displayed in the upper line of the operator display. |
| 2 | Press the MOD/ENTER key to enter the edit mode. |
| 3 | Press the ➡ key until you are in the field that you wish to modify. |
| 4 | Press the ⬆ key increment the value of that field. |
| 5 | Continue Steps 3 and 4 until the RTC correction value is complete. |
| 6 | Press the MOD/ENTER key to accept the modified values or ESC to discard any modifications made while in edit mode. |

# Description of Twido Languages

III

## At a Glance

**Overview**

This part provides instructions for using the Ladder, List, and Grafcet programming languages to create control programs for Twido programmable controllers.

**What's in this Part?**

This part contains the following topics:

# Ladder Language

9

## At a Glance

**Overview**

This chapter describes programming with Ladder language.

**What's in this Chapter?**

This chapter contains the following topics:

## Introduction to Ladder Diagrams

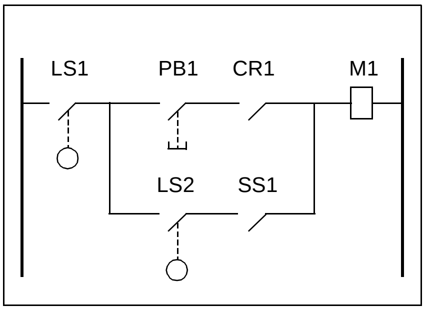
**Introduction**

Ladder diagrams are similar to relay logic diagrams that represent relay control circuits. The main differences between the two are the following features of Ladder programming that are not found in relay logic diagrams:

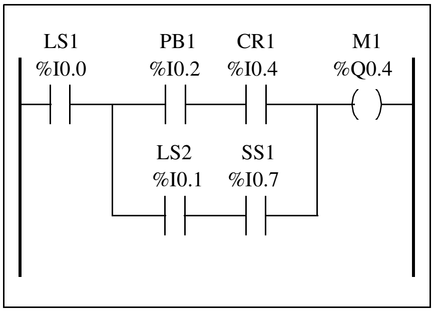
- All inputs are represented by contact symbols (⊣⊢).
- All outputs are represented by coil symbols (⊣( )⊢).
- Numerical operations are included in the graphical Ladder instruction set.

**Ladder Equivalents to Relay Circuits**

The following illustration shows a simplified wiring diagram of a relay logic circuit and the equivalent Ladder diagram.



Relay logic circuit



Ladder diagram

Notice that in the above illustration, all inputs associated with a switching device in the relay logic diagram are shown as contacts in the Ladder diagram. The M1 output coil in the relay logic diagram is represented with an output coil symbol in the Ladder diagram. The address numbers appearing above each contact/coil symbol in the Ladder diagram are references to the locations of the external input/output connections to the controller.

## Ladder Rungs

A program written in Ladder language is composed of rungs which are sets of graphical instructions drawn between two vertical potential bars. The rungs are executed sequentially by the controller.
The set of graphical instructions represent the following functions:
- Inputs/outputs of the controller (push buttons, sensors, relays, pilot lights, ...)
- Functions of the controller (timers, counters, ...)
- Math and logic operations (addition, division, AND, XOR, ...)
- Comparison operators and other numerical operations (A<B, A=B, shift, rotate, ...)
- Internal variables in the controller (bits, words, ...)

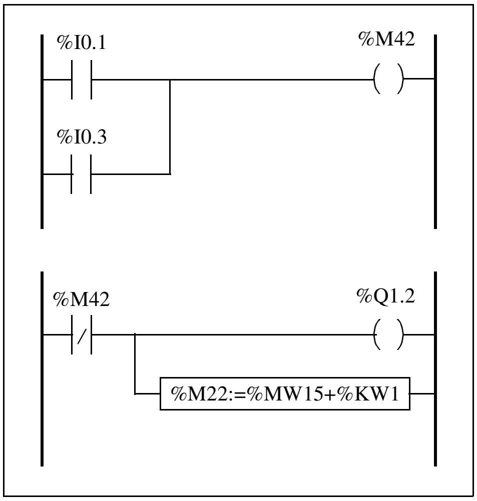
These graphical instructions are arranged with vertical and horizontal connections leading eventually to one or several outputs and/or actions. A rung cannot support more than one group of linked instructions.

## Example of Ladder Rungs

The following diagram is an example of a Ladder program composed of two rungs.

Example Rung 1

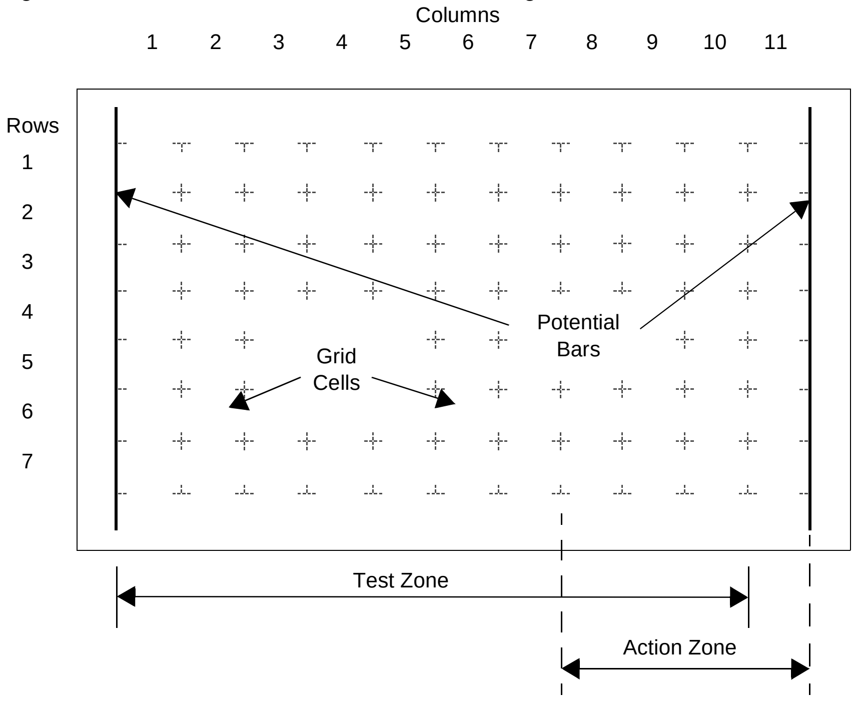
Example Rung 2



## Programming Principles for Ladder Diagrams

### Programming Grid

Each Ladder rung consists of a grid of seven rows by eleven columns that are organized into two zones as shown in the following illustration.



### Grid Zones

The Ladder diagram programming grid is divided into two zones:

- Test Zone
  Contains the conditions that are tested in order to perform actions. Consists of columns 1 - 10, and contains contacts, function blocks, and comparison blocks.
- Action Zone
  Contains the output or operation that will be performed according to the results of the tests of the conditions in the Test Zone. Consists of columns 8 - 11, and contains coils and operation blocks.

## Entering Instructions in the Grid

A Ladder rung provides a seven by eleven programming grid that starts in the first cell in the upper left-hand corner of the grid. Programming consists of entering instructions into the cells of the grid. Test instructions, comparisons, and functions are entered in cells in the test zone and are left-justified. The test logic provides continuity to the action zone where coils, numerical operations, and program flow control instructions are entered and are right-justified.
The rung is solved or executed (tests made and outputs assigned) within the grid from top to bottom and from left to right.

## Rung Headers

In addition to the rung, a rung header appears directly above the rung. Use the rung header to document the logical purpose of the rung. The rung header can contain the following information:
- Rung number
- Labels (%Li)
- Subroutine declarations (SRi:)
- Rung title
- Rung comments

For more details about using the rung header to document your programs, see *Program Documentation, p. 159*.

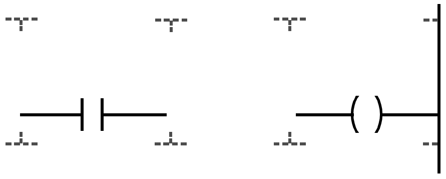
## Ladder Diagram Blocks

**Introduction**

Ladder diagrams consist of blocks representing program flow and functions such as the following:
- Contacts
- Coils
- Program flow instructions
- Function blocks
- Comparison blocks
- Operate blocks

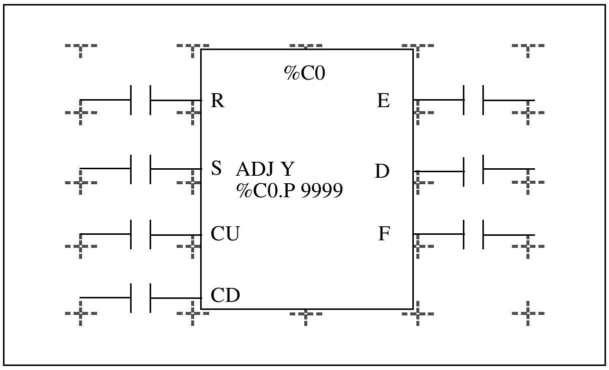
**Contacts, Coils, and Program Flow**

Contacts, coils, and program flow (jump and call) instructions occupy a single cell of the ladder programming grid. Function blocks, comparison blocks, and operate blocks occupy multiple cells.
The following are examples of a contact and a coil.



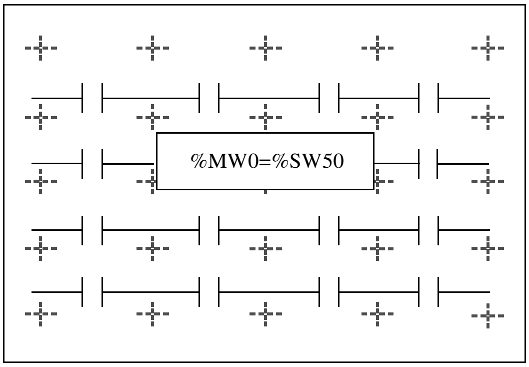
## Function Blocks

Function blocks are placed in the test zone of the programming grid. The block must appear in the first row; no ladder instructions or lines of continuity may appear above or below the function block. Ladder test instructions lead to the function block's input side, and test instructions and/or action instructions lead from the block's output side.
Function blocks are vertically oriented and occupy two columns by four rows of the programming grid.
The following is an example of a counter function block.



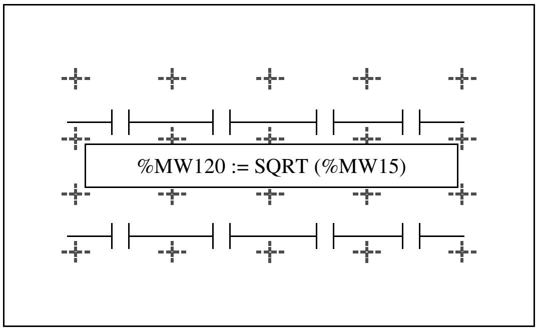
**Comparison Blocks**

Comparison blocks are placed in the test zone of the programming grid. The block may appear in any row or column in the test zone as long as the entire length of the instruction resides in the test zone.
Comparison blocks are horizontally oriented and occupy two columns by one row of the programming grid.
See the following example of a comparison block.



**Operate Blocks**

Operate blocks are placed in the action zone of the programming grid. The block may appear in any row in the action zone. The instruction is right-justified; it appears on the right and ends in the last column.
Operate blocks are horizontally oriented and occupy four columns by one row of the programming grid.
The following is an example of an operate block.



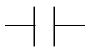
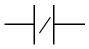
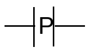
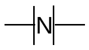
## Ladder Language Graphic Elements

**Introduction**

Instructions in Ladder diagrams consist of graphic elements. This section lists and describes graphic elements used in Twido Ladder instructions. See the TwidoSoft Operation Guide for details on using these graphic elements in Twido Ladder programs.

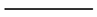
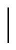
**Contacts**

The contacts graphic elements are programmed in the test zone and take up one cell (one row high by one column wide).

| Name | Graphic element | Instruction | Function |
|---|---|---|---|
| Normally open contact |  | LD | Passing contact when the controlling bit object is at state 1. |
| Normally closed contact |  | LDN | Passing contact when the controlling bit object is at state 0. |
| Contact for detecting a rising edge |  | LDR | Rising edge: detecting the change from 0 to 1 of the controlling bit object. |
| Contact for detecting a falling edge |  | LDF | Falling edge: detecting the change from 1 to 0 of the controlling bit object. |

**Link Elements**

The graphic link elements are used to connect the test and action graphic elements.

| Name | Graphic element | Functions |
|---|---|---|
| Horizontal connector |  | Links in series the test and action graphic elements between the two potential bars. |
| Down connector |  | Links the test and action graphic elements in parallel (a vertical connection). |

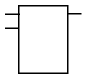
## Coils

The coil graphic elements are programmed in the action zone and take up one cell (one row high and one column wide).

| Name | Graphic element | Instruction | Functions |
|---|---|---|---|
| Direct coil | —( )— | ST | The associated bit object takes the value of the test zone result. |
| Negated coil | —(/)— | STN | The associated bit object takes the negated value of the test zone result. |
| Set coil | —(S)— | S | The associated bit object is set to 1 when the result of the test zone is 1. |
| Reset coil | —(R)— | R | The associated bit object is set to 0 when the result of the test zone is 1. |
| Jump or Subroutine call | ->>%Li<br>->>%SRi | JMP<br>SR | Connect to a labeled instruction, upstream or downstream. |
| Transition condition coil | —(#)— |  | Provided in Grafcet language, used when the programming of the transition conditions associated with the transitions causes a changeover to the next step. |
| Return from a subroutine | <RET> | RET | Placed at the end of subroutines to return to the main program. |
| Stop program | <END> | END | Defines the end of the program. |

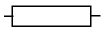
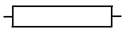
**Function Blocks**

The graphic elements of function blocks are programmed in the test zone and require four rows by two columns of cells (except for very fast counters which require five rows by two columns).

| **Name** | **Graphic element** | **Functions** |
|---|---|---|
| Timers, counters, registers, and so on. |  | Each of the function blocks uses inputs and outputs that enable links to the other graphic elements.. Note: Outputs of function blocks can not be connected o each other (vertical shorts). |

**Operate and Comparison Blocks**

Comparison blocks are programmed in the test zone, and operate blocks are programmed in the action zone.

| **Name** | **Graphic element** | **Functions** |
|---|---|---|
| Comparison block |  | Compares two operands, the output changes to 1 when the result is checked.<br>Size: one row by two columns |
| Operation block |  | Performs arithmetic and logic operations.<br>Size: one row by four columns |

## Special Ladder Instructions OPEN and SHORT

**Introduction**

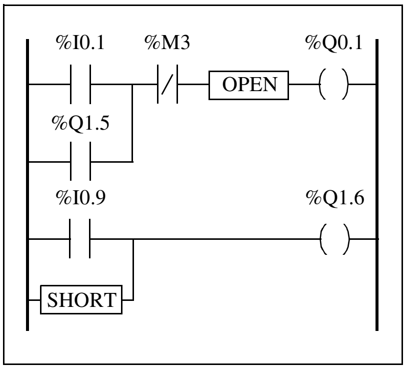
The OPEN and SHORT instructions provide a convenient method for debugging and troubleshooting Ladder programs. These special instructions alter the logic of a rung by either shorting or opening the continuity of a rung as explained in the following table.

| Instruction | Description | List Instruction |
|---|---|---|
| OPEN | Creates a break in the continuity of a ladder rung regardless of the results of the last logical operation. | `AND 0` |
| SHORT | Allows the continuity to pass through the rung regardless of the results of the last logical operation. | `OR 1` |

In List programming, the OR and AND instructions are used to create the OPEN and SHORT instructions using immediate values of 0 and 1 respectively.

**Examples**

The following are examples of using the OPEN and SHORT instructions.



```
LD      %I0.1
OR      %Q1.5
ANDN    %M3
AND     0
ST      %Q0.1
LD      %I0.9
OR      1
ST      %Q1.6
```

## Programming Advice

**Handling Program Jumps**

Use program jumps with caution to avoid long loops that can increase scan time. Avoid jumps to instructions that are located upstream. (An upstream instruction line appears before a jump in a program, while a downstream instruction line appears after a jump in a program.)

**Programming of Outputs**

An output bit or internal bit can only be controlled once in the program. In the case of output bits, only the last value scanned is taken into account when the outputs are updated.

**Using Directly-Wired Emergency Stop Sensors**

Sensors used directly for emergency stops must not be processed by the controller. They must be connected directly to the corresponding outputs.

**Handling Power Returns**

Make power returns conditional on a manual operation, as an automatic restart of the installation could cause unexpected operation of equipment (use system bits %S0, %S1 and %S9).

**Time and Schedule Block Management**

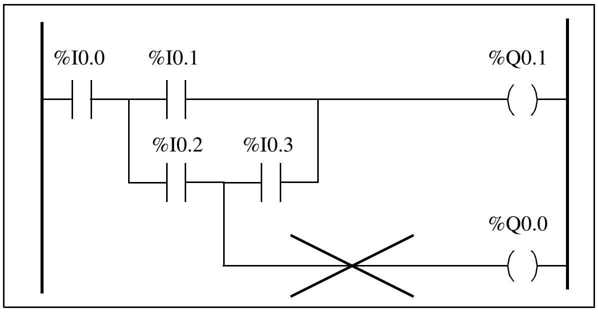
The state of system bit %S51, which indicates any schedule block faults, should be checked.

**Syntax and Error Checking**

When a program is entered, TwidoSoft checks the syntax of the instructions, the operands, and their association. See the TwidoSoft Operation Guide for more details.

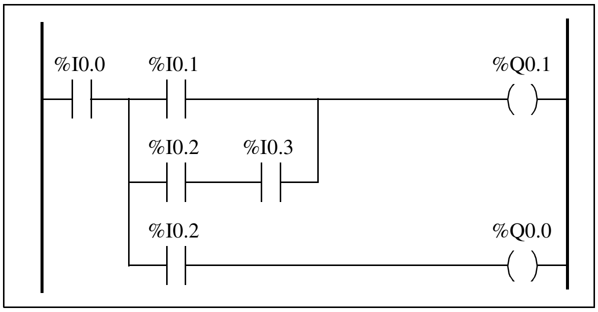
## Additional Notes on Using Parentheses

Assignment operations should not be placed within parentheses:



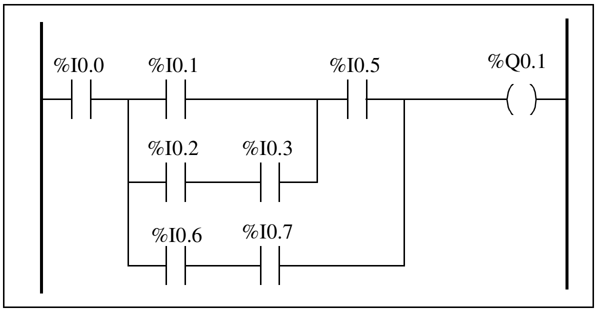
```
LD      %I0.0
AND     %I0.1
OR(     %I0.2
~~ST      %Q0.0~~
~~AND     %I0.3~~
)
ST      %Q0.1
```

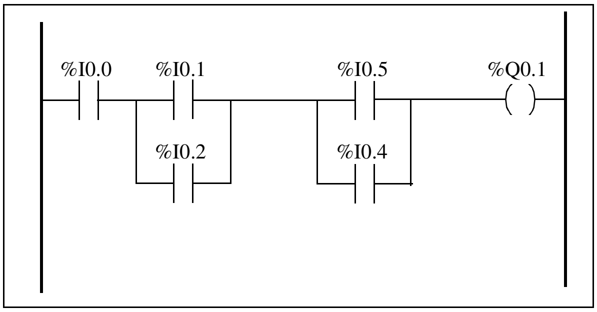
In order to perform the same function, the following equations must be programmed:



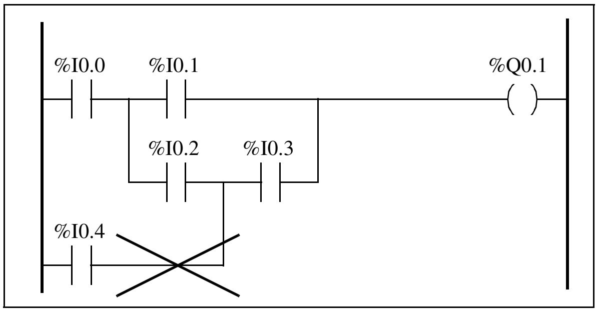
```
LD      %I0.0
MPS
AND(    %I0.1
OR(     %I0.2
AND     %I0.3
)
)
ST      %Q0.1
MPP
AND     %I0.2
ST      %Q0.0
```

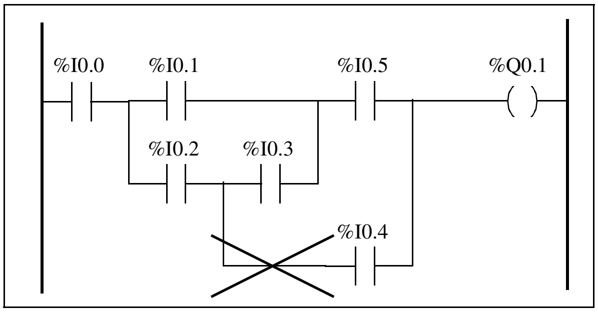
If several contacts are placed in parallel, they should either be nested within one another or totally dissociated from each other:



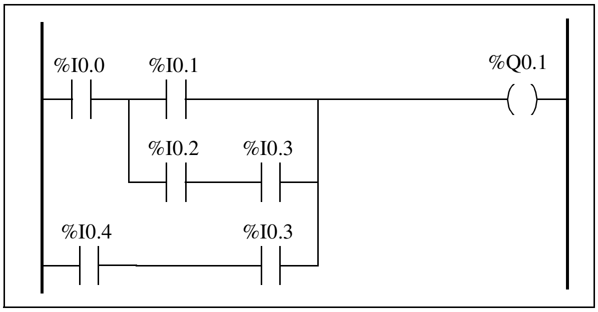


The following schematics cannot be programmed:

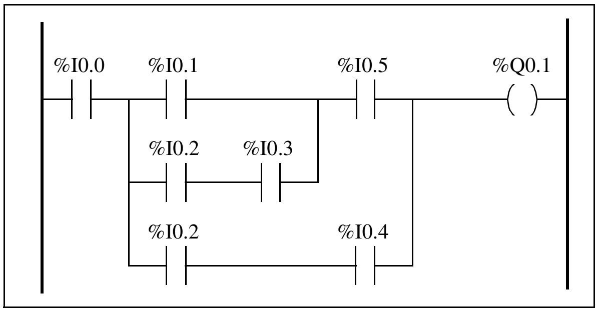




In order to execute schematics equivalent to those, they must be modified as follows:



```
LD      %I0.0
AND(    %I0.1
OR(     %I0.2
AND     %I0.3
)
)
OR(     %I0.4
AND     %I0.3
)
ST      %Q0.1
```



```
LD      %I0.0
AND(    %I0.1
OR(     %I0.2
AND     %I0.3
)
AND     %I0.5
OR(     %I0.2
AND     %I0.4
)
)
ST      %Q0.1
```

## Ladder/List Reversibility

**Introduction**

Program reversibility is a feature of the TwidoSoft programming software that provides conversion of application programs from Ladder to List and from List back to Ladder.

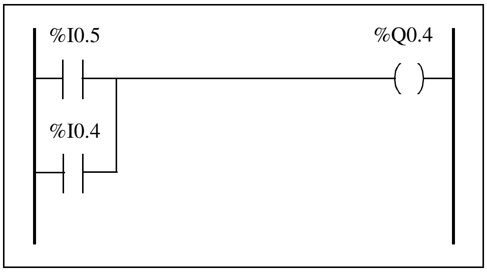
Use TwidoSoft to set the default display of programs for either List or Ladder format (by setting user preferences), and to toggle List and Ladder views (see the TwidoSoft Operation Guide for more details).

**Understanding Reversibility**

A key to understanding the program reversibility feature is examining the relationship of a Ladder rung and the associated instruction List sequence:

- **Ladder rung**: A collection of Ladder instructions that constitute a logical expression.
- **List sequence**: A collection of List programming instructions that correspond to the Ladder instructions and represents the same logical expression.

The following illustration displays a common Ladder rung and its equivalent program logic expressed as a sequence of List instructions.



```
LD      %I0.5
OR      %I0.4
ST      %Q0.4
```

An application program is stored internally as List instructions, regardless if the program is written in Ladder language or List language. TwidoSoft takes advantage of the program structure similarities between the two languages and uses this internal List image of the program to display it in the List and Ladder viewers and editors as either a List program (its basic form), or graphically as a Ladder diagram, depending upon the selected user preference.

**Ensuring Reversibility**

Programs created in Ladder can always be reversed to List, but some List logic may not reverse to Ladder. To ensure reversibility from List to Ladder, it is important to follow the set of List programming guidelines in *Guidelines for Ladder/List Reversibility, p. 157* .

## Guidelines for Ladder/List Reversibility

### Instructions Required for Reversibility

The structure of a reversible function block in List language requires the use of the following instructions:

- **BLK** marks the block start, and defines the beginning of the rung and the start of the input portion to the block.
- **OUT_BLK** marks the beginning of the output portion of the block.
- **END_BLK** marks the end of the block and the rung.

The use of the reversible function block instructions are not mandatory for a properly functioning List program. For some instructions it is possible to program in List which is not reversible. For a description of non-reversible List programming of standard function blocks, see *Principles for Programming Basic Function Blocks, p. 208*.

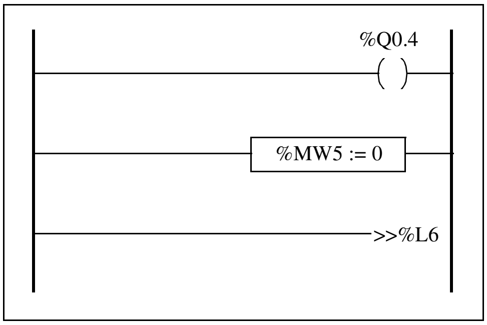
### Non-Equivalent Instructions to Avoid

Avoid the use of certain List instructions, or certain combinations of instructions and operands, which have no equivalents in Ladder diagrams. For example, the N instruction (inverses the value in the Boolean accumulator) has no equivalent Ladder instruction.
The following table identifies all List programming instructions that will not reverse to Ladder.

| List Instruction | Operand | Description |
|---|---|---|
| JMPCN | %Li | Jump Conditional Not |
| N | none | Negation (Not) |
| ENDCN | none | End Conditional Not |

**Unconditional Rungs**

Programming unconditional rungs also requires following List programming guidelines to ensure List-to-Ladder reversibility. Unconditional rungs do not have tests or conditions, the outputs or action instructions are always energized or executed.
The following diagram provides examples of unconditional rungs and the equivalent List sequence.



```
LD      1
ST      %Q0.4
LD      1
[%MW5 := 0]
JMP     %L6
```

Notice that each of the above unconditional List sequences begin with a load instruction followed by a one, except for the JMP instruction. This combination sets the Boolean accumulator value to one, and therefore sets the coil (store instruction) to one and sets%MW5 to zero on every scan of the program. The exception is the unconditional jump List instruction (JMP %L6) which is executed regardless of the value of the accumulator and does not need the accumulator set to one.

**Ladder List Rungs**

If a List program is reversed that is not completely reversible, the reversible portions are displayed in the Ladder view and the irreversible portions are displayed in Ladder List Rungs.
A Ladder List Rung functions just like a small List editor, allowing the user to view and modify the irreversible parts of a Ladder program.

## Program Documentation

### Documenting Your Program

You can document your program by entering comments using the List and Ladder editors (see the TwidoSoft Operation Guide for details on using these program editors):

- Use the List Editor to document your program with List Line Comments. These comments may appear on the same line as programming instructions, or they may appear on lines of their own.
- Use the Ladder Editor to document your program using rung headers found directly above the rung.

The TwidoSoft programming software uses these comments for reversibility, When reversing a program from List to Ladder, TwidoSoft uses some of the List comments to construct a rung header, and the  comments inserted between List sequences are used for rung headers.

### Example of List Line Comments

The following is an example of a List program with List Line Comments.

```
---- ( * THIS IS THE TITLE OF THE HEADER FOR RUNG 0 * )
---- ( * THIS IS THE FIRST HEADER COMMENT FOR RUNG 0 * )
---- ( * THIS IS THE SECOND HEADER COMMENT FOR RUNG 0 * )
     0   LD  % I0. 0  ( * THIS IS A LINE COMMENT *)
     1   OR  %I0. 1  ( * A LINE COMMENT IS IGNORED WHEN REVERSING TO LADDER * )
     2   ANDM  %M10
     3   ST        M101
---- ( * THIS IS THE HEADER FOR RUNG 1 * )
---- ( * THIS RUNG CONTAINS A LABEL * )
---- ( * THIS IS THE SECOND HEADER COMMENT FOR RUNG 1 * )
---- ( * THIS IS THE THIRD HEADER COMMENT FOR RUNG 1 * )
---- ( * THIS IS THE FOURTH HEADER COMMENT FOR RUNG 1 * )
     4   % L5:
     5   LD  %M101
     6   [ %MW20 := %KW2 * 16 ]
---- ( * THIS RUNG ONLY CONTAINS A HEADER TITLE * )
     7   LD  %Q0. 5
     8   OR  %I0.  3
     9   ORR  I0.  13
    10   ST  %Q0.5
```

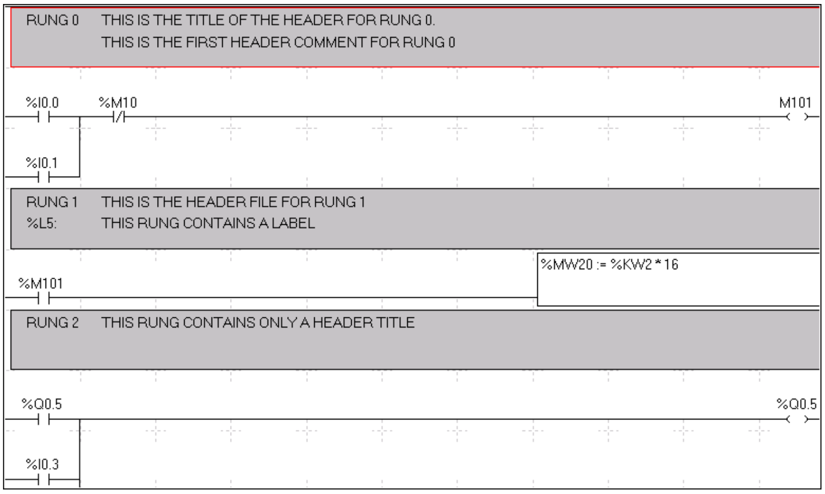
**Reversing List Comments to Ladder**

When List instructions are reversed to a Ladder diagram, List Line Comments are displayed in the Ladder Editor according to the following rules:

- The first comment that is on a line by itself is assigned as the rung header.
- Any comments found after the first become the body of the rung.
- Once the body lines of the header are occupied, then the rest of the line comments between List sequences are ignored, as are any comments that are found on list lines that also contain list instructions.

**Example of Rung Header Comments**

The following is an example of a Ladder program with rung header comments.



RUNG 0 THIS IS THE TITLE OF THE HEADER FOR RUNG 0.
THIS IS THE FIRST HEADER COMMENT FOR RUNG 0

RUNG 1 THIS IS THE HEADER FILE FOR RUNG 1
%L5: THIS RUNG CONTAINS A LABEL

%MW20 := %KW2 * 16

RUNG 2 THIS RUNG CONTAINS ONLY A HEADER TITLE

**Reversing Ladder Comments to List**

When a Ladder diagram is reversed to List instructions, rung header comments are displayed in the List Editor according to the following rules:

- Any rung header comments are inserted between the associated List sequences.
- Any labels (%Li:) or subroutine declarations (SRi:) are placed on the next line following the header and immediately prior to the beginning of the List sequence.
- If the List was reversed to Ladder, any comments that were ignored will reappear in the List Editor.

# Instruction List Language

10

## At a Glance

**Overview**

This chapter describes programming in the Instruction List language.

**What's in this Chapter?**

This chapter contains the following topics:

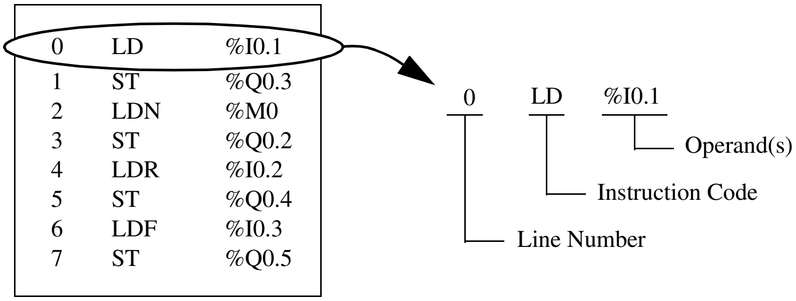
## Overview of List Programs

**Introduction**

A program written in List language consists of a series of instructions executed sequentially by the controller. Each List instruction is represented by a single program line and consists of three components:
- Line number
- Instruction code
- Operand(s)

**Example of a List Program**

The following is an example of a List program.



```
0   LD    %I0.1
1   ST    %Q0.3
2   LDN   %M0
3   ST    %Q0.2
4   LDR   %I0.2
5   ST    %Q0.4
6   LDF   %I0.3
7   ST    %Q0.5
```

**Line Number**

Line numbers are generated automatically when you enter an instruction. Blank lines and Comment lines do not have line numbers.

**Instruction Code**

The instruction code is a symbol for an operator that identifies the operation to be performed using the operand(s). Typical operators specify Boolean and numerical operations.
For example, in the sample program above, LD is the abbreviation for the instruction code for a LOAD instruction. The LOAD instruction places (loads) the value of the operand %I0.1 into an internal register called the accumulator.
There are basically two types of instructions:
- Test instructions
  These setup or test for the necessary conditions to perform an action. For example, LOAD (LD) and AND.
- Action instructions
  These perform actions as a result of setup conditions. For example, assignment instructions such as STORE (ST) and RESET (R).

**Operand**

An operand is a number, address, or symbol representing a value that a program can manipulate in an instruction. For example, in the sample program above, the operand %I0.1 is an address assigned the value of an input to the controller. An instruction can have from zero to three operands depending on the type of instruction code.

Operands can represent the following:

- Controller inputs and outputs such as sensors, push buttons, and relays.
- Predefined system functions such as timers and counters.
- Arithmetic, logical, comparison, and numerical operations.
- Controller internal variables such as bits and words.

## Operation of List Instructions

**Introduction**

List instructions have only one explicit operand, the other operand is implied. The implied operand is the value in the Boolean accumulator. For example, in the instruction LD %I0.1, %I0.1 is the explicit operand. An implicit operand is stored in the accumulator and will be written over by value of %I0.1.

**Operation**

A List instruction performs a specified operation on the contents of the accumulator and the explicit operand, and replaces the contents of the accumulator with the result. For example, the operation AND %I1.2 performs a logical AND between the contents of the accumulator and the Input 1.2 and will replace the contents of the accumulator with this result.
All Boolean instructions, except for Load, Store, and Not, operate on two operands. The value of the two operands can be either True or False, and program execution of the instructions produce a single value, either True or False. Load instructions place the value of the operand in the accumulator, while Store instructions transfer the value in the accumulator to the operand. The Not instruction has no explicit operands and simply inverts the state of the accumulator.

**Supported List Instructions**

The following table is a summary of the types of supported List instructions.

| Type of Instruction | Example | Function |
|---|---|---|
| Bit instruction | LD %M10 | Reads internal bit %M10 |
| Block instruction | IN %TM0 | Starts the timer %TM0 |
| Word instruction | [%MW10 := %MW50+100] | Addition operation |
| Program instruction | SR5 | Calls subroutine #5 |
| Grafcet instruction | -*-8 | Step #8 |

## List Language Instructions

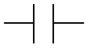
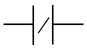
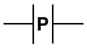
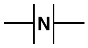
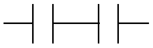
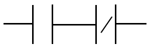
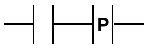
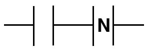
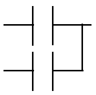
**Introduction**

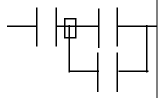
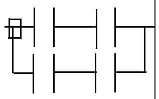
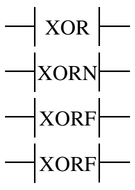
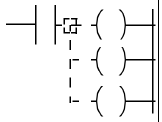
List language consists of the following types of instructions:
- Test instructions
- Action instructions
- Function block instructions

This section identifies and describes the Twido instructions for List programming.

**Test Instructions**

The following table describes test instructions in List language.

| Name | Equivalent graphic element | Function |
|---|---|---|
| LD |  | The Boolean result is the same as the status of the operand. |
| LDN |  | The Boolean result is the same as the reverse status of the operand. |
| LDR |  | The Boolean result changes to 1 on detection of the operand (rising edge) changing from 0 to 1. |
| LDF |  | The Boolean result changes to 1 on detection of the operand (falling edge) changing from 1 to 0. |
| AND |  | The Boolean result is equal to the AND logic between the Boolean result of the previous instruction and the status of the operand. |
| ANDN |  | The Boolean result is equal to the AND logic between the Boolean result of the previous instruction and the reverse status of the operand. |
| ANDR |  | The Boolean result is equal to the AND logic between the Boolean result of the previous instruction and the detection of the operand's rising edge (1 = rising edge). |
| ANDF |  | The Boolean result is equal to the AND logic between the Boolean result of the previous instruction and the detection of the operand's falling edge (1 = falling edge). |
| OR |  | The Boolean result is equal to the OR logic between the Boolean result of the previous instruction and the status of the operand. |

| **Name** | **Equivalent graphic element** | **Function** |
|---|---|---|
| AND( |  | Logic AND (8 parenthesis levels) |
| OR( |  | Logic OR (8 parenthesis levels) |
| XOR, XORN, XORR, XORF |  | Exclusive OR |
| MPS<br>MRD<br>MPP |  | Switching to the coils. |
| N | - | Negation (NOT) |

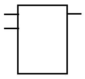
## Action instructions

The following table describes action instructions in List language.

| Name | Equivalent graphic element | Functions |
|---|---|---|
| ST | —( )— | The associated operand takes the value of the test zone result. |
| STN | —(/)— | The associated operand takes the reverse value of the test zone result. |
| S | —(S)— | The associated operand is set to 1 when the result of the test zone is 1. |
| R | —(R)— | The associated operand is set to 0 when the result of the test zone is 1. |
| JMP | ->>%Li | Connect unconditionally to a labeled sequence, upstream or downstream. |
| SRn | ->>%SRi | Connection at the beginning of a subroutine. |
| RET | <RET> | Return from a subroutine. |
| END | <END> | End of program. |
| ENDC | <ENDC> | End of the conditioned program at a Boolean result of 1. |
| ENDCN | <ENDCN> | End of the conditioned program at a Boolean result of 0. |

## Function Block Instructions

The following table describes function blocks in List language.

| Name | Equivalent graphic element | Functions |
|---|---|---|
| Timers, counters, registers, and so on. |  | For each of the function blocks, there are instructions for controlling the block.<br>A structured form is used to hardwire the block inputs and outputs directly.<br>**Note:** Outputs of function blocks can not be connected to each other (vertical shorts). |

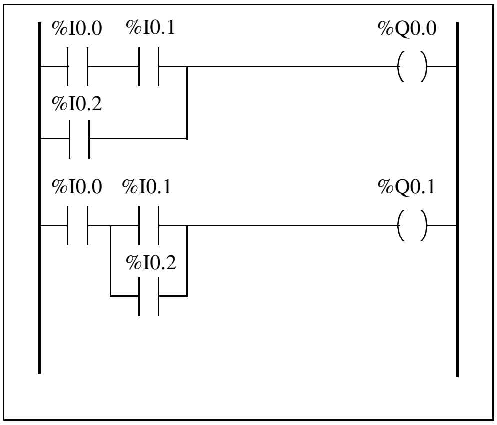
## Using Parentheses

**Introduction**

Use parentheses in AND and OR logic instructions to indicate parallel branches in Ladder diagrams. The open and closed parentheses are associated with instructions as follows:
- Opening the parentheses is associated with the AND or OR instruction.
- Closing the parentheses is an instruction which is required for each open parentheses.

**Example Using an AND Instruction**

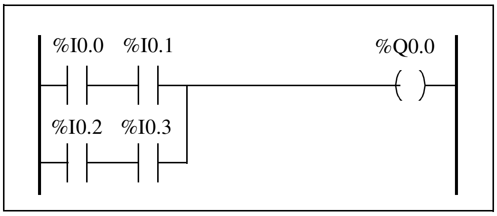
The following diagrams are examples of using a parentheses with an AND instruction: AND(...).



```
LD      %I0.0
AND     %I0.1
OR      %I0.2
ST      %Q0.0

LD      %I0.0
AND(    %I0.1
OR      %I0.2
)
ST      %Q0.1
```

**Example Using an OR Instruction**

The following diagrams are examples of using a parentheses with an OR instruction: OR(...).



```
LD      %I0.0
AND     %I0.1
OR(     %I0.2
AND     %I0.3
)
ST      %Q0.0
```

## Modifiers

The following table lists modifiers that can be assigned to parentheses.

| Modifier | Function | Example |
|---|---|---|
| N | Negation | AND(N or OR(N |
| F | Falling edge | AND(F or OR(F |
| R | Rising edge | AND(R or OR(R |
| [ | Comparison | See *Comparison Instructions, p. 236* |

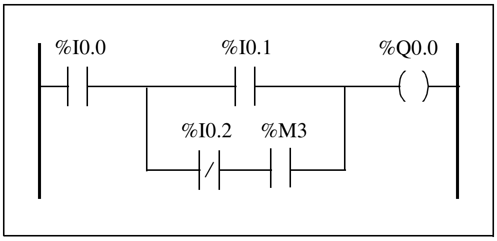
## Nesting Parenthesis

It is possible to nest up to eight levels of parentheses.
Observe the following rules when nesting parentheses:

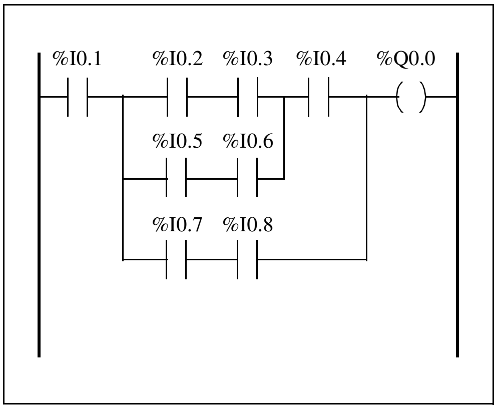
- Each open parentheses must have a corresponding closed parentheses.
- Labels (%Li:), subroutines (SRi:), jump instructions (JMP), and function block instructions must not be placed in expressions between parentheses.
- Store instructions ST, STN, S, and R must not be programmed between parentheses.
- Stack instructions MPS, MRD, and MPP cannot be used between parentheses.

**Examples of Nesting Parentheses**

The following diagrams provide examples of nesting parentheses.



```
LD      %I0.0
AND(    %I0.1
OR(N    %I0.2
AND     %M3
)
)
ST      %Q0.0
```



```
LD      %I0.1
AND(    %I0.2
AND     %I0.3
OR(     %I0.5
AND     %I0.6
)
AND     %I0.4
OR(     %I0.7
AND     %I0.8
)
)
ST      %Q0.0
```

## Stack Instructions (MPS, MRD, MPP)

**Introduction**

The Stack instructions process routing to coils.The MPS, MRD, and MPP instructions use a temporary storage area called the stack which can store up to eight Boolean expressions.

**Note:** These instructions can not be used within an expression between parentheses.

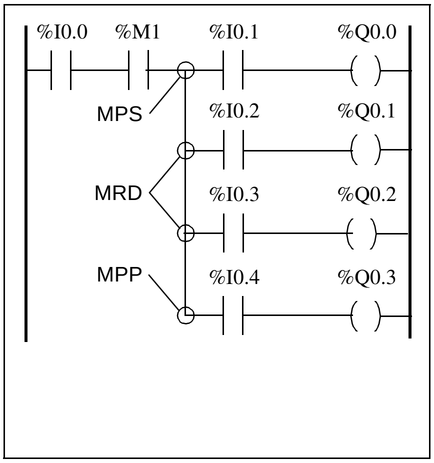
**Operation of Stack Instructions**

The following table describes the operation of the three stack instructions.

| Instruction | Description | Function |
|---|---|---|
| MPS | Memory Push onto stack | Stores the result of the last logical instruction (contents of the accumulator) onto the top of stack (a push) and shifts the other values to the bottom of the stack. |
| MRD | Memory Read from stack | Reads the top of stack into the accumulator. |
| MPP | Memory Pop from stack | Copies the value at the top of stack into the accumulator (a pop) and shifts the other values towards the top of the stack. |

## Examples of Stack Instructions

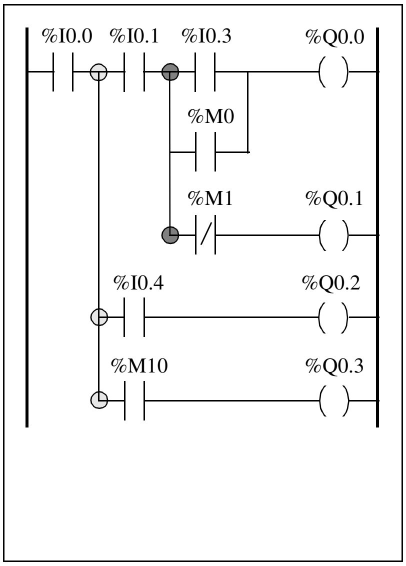
The following diagrams are examples of using stack instructions.



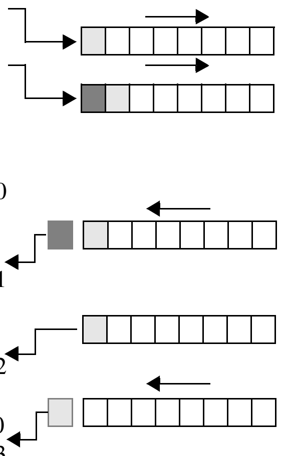
```
LD      %I0.0
AND     %M1
MPS
AND     %I0.1
ST      %Q0.0
MRD
AND     %I0.2
ST      %Q0.1
MRD
AND     %I0.3
ST      %Q0.2
MPP
AND     %I0.4
ST      %Q0.3
```

## Examples of Stack Operation

The following diagrams display how stack instructions operate.



```
LD    %I0.0
MPS
AND   %I0.1
MPS
AND(  %I0.3
OR    %M0
)
ST    %Q0.0
MPP
ANDN  %M1
ST    %Q0.1
MRD
AND   %I0.4
ST    %Q0.2
MPP
AND   %M10
ST    %Q0.3
```



# Grafcet

11

## At a Glance

**Overview**

This chapter describes programming with Grafcet language.

**What's in this Chapter?**

This chapter contains the following topics:

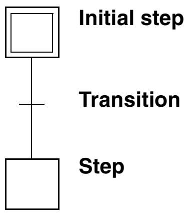
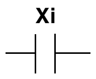
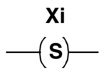
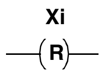
## Description of Grafcet Instructions

**Introduction**

Grafcet instructions in TwidoSoft offer a simple method of translating a control sequence (Grafcet chart).
The maximum number of Grafcet steps depend on the type of Twido controller. The number of steps active at any one time is limited only by the total number of steps. For the TWDLCAA10DRF and the TWDLCAA16DRF, steps 1 through 62 are available. Steps 0 and 63 are reserved for pre- and post-processing. For all other controllers, steps 1 through 95 are available.

## Grafcet Instructions

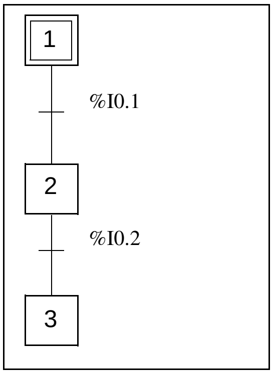
The following table lists all instructions and objects required to program a Grafcet chart:

| Graphic representation (1) | Transcription in TwidoSoft Language | Role |
|---|---|---|
|  | =*= i | Start the initial step (2) |
| | # i | Activate step i after deactivating the current step |
| | -*- i | Start step i and validate the associated transition (2) |
| | # | Deactivate the current step without activating any other steps |
| | #Di | Deactivate step i and the current step |
| | =*= POST | Start post-processing and end sequential processing |
| | %Xi | Bit associated with step i, can be tested and written (maximum number of steps depends on controller) |
|  | LD %Xi, LDN %Xi<br>AND %Xi, ANDN %Xi,<br>OR %Xi, ORN %Xi<br>XOR %Xi, XORN %Xi | Test the activity of step i |
|  | S %Xi | Activate step i |
|  | R %Xi | Deactivate step i |

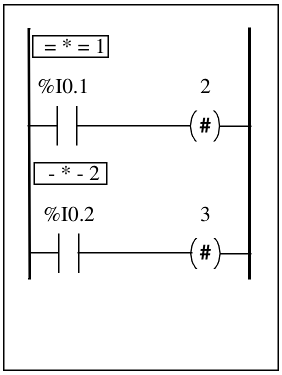
(1) Graphical Grafcet is not supported.
(2) The first step =*=i or -*-i written indicates the start of sequential processing and thus the end of preprocessing.

**Grafcet Examples**

Linear sequence:



Not supported

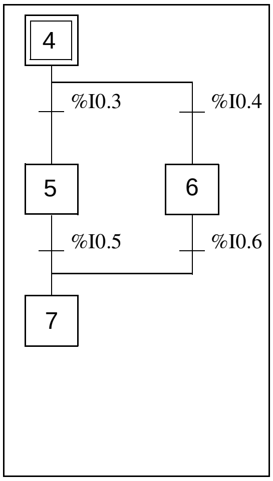


Twido Ladder program

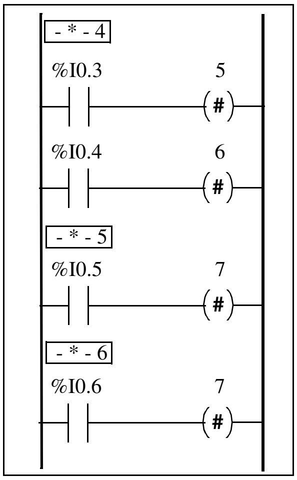
```
=*=     1
LD      %I0.1
 #      2

-*-     2
LD      %I0.2
 #      3
```

Twido List program

Alternative sequence:



Not supported

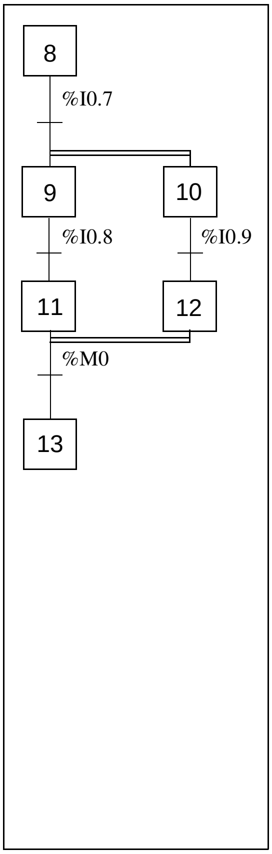


Twido Ladder program

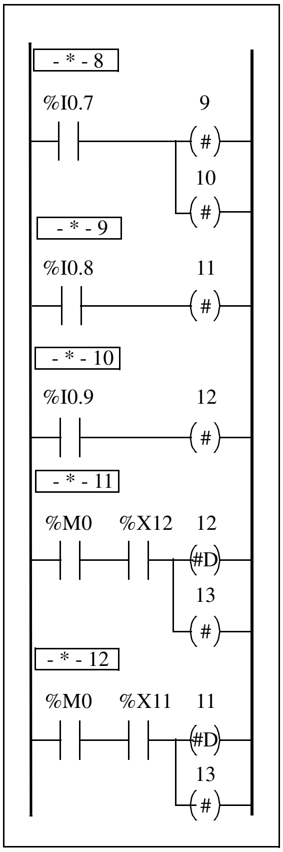
```
-*-     4
LD      %I0.3
#       5
LD      %I0.4
#       6

-*-     5
LD      %I0.5
#       7

-*-     6
LD      %I0.6
#       7
```

Twido List program

Simultaneous sequences:



Not supported



Twido Ladder program

```
 -*-      8
LD        %I0.7
#         9
#         10

-*-       9
LD        %I0.8
#         11

-*-       10
LD        %I0.9
#         12

-*-       11
LD        %M0
AND       %X12
#D        12
#         13

-*-       12
LD        %M0
AND       %X11
#D        11
#         13
```

Twido List program

**Note:** For a Grafcet Chart to be operational, at least one active step must be declared using the =*=i instruction (initial step) or the chart should be pre-positioned during preprocessing using system bit %S23 and the instruction S %Xi.

## Description of Grafcet Program Structure

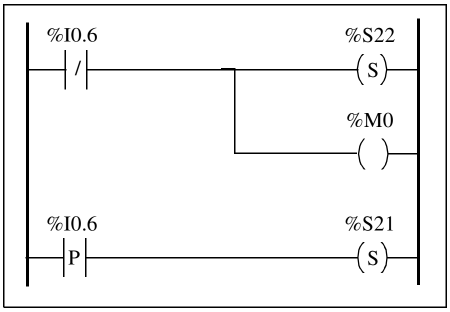
**Introduction**

A TwidoSoft Grafcet program has three parts:
- Preprocessing
- Sequential processing
- Post-processing

**Preprocessing**

Preprocessing consists of the following:
- Power returns
- Faults
- Changes of operating mode
- Pre-positioning Grafcet steps
- Input logic

In the preprocessing example below (the area prior to the first Grafcet step), state 0 of input %I0.6 prompts a reset of the Grafcet chart by setting system bit %S22 to 1. This deactivates the active steps. The rising edge of input %I0.6 pre-positions the chart to step X1. Finally, the use of system bit %S21 forces the initialization of Grafcet.



```
000     LDN     %I0.6
001     S       %S22
002     ST      %M0
003     LDR     %I0.6
004     S       %S21
```

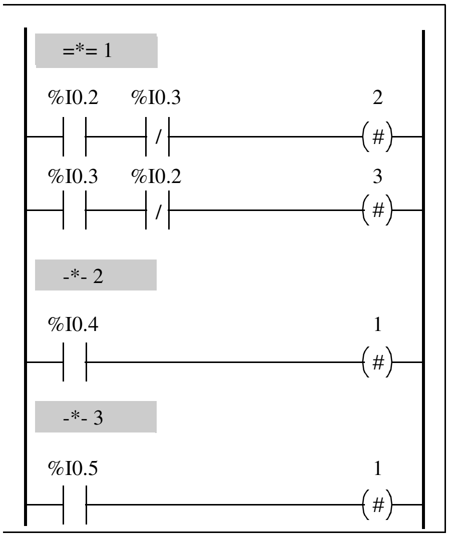
Preprocessing begins with the first line of the program and ends with the first occurrence of a "= * =" or "- * -" instruction.
Three system bits are dedicated to Grafcet control: %S21, %S22, and %S23. Each of these system bits are set to 1 (if needed) by the application, normally in preprocessing. The associated function is performed by the system at the end of preprocessing and the system bit is then reset to 0 by the system.

| System Bit | Name | Description |
|---|---|---|
| %S21 | Grafcet Initialization | All active steps are deactivated and the initial steps are activated. |
| %S22 | Reset Grafcet | All steps are deactivated. |
| %S23 | Grafcet Pre-positioning | This bit must be set to 1 if %Xi are explicitly written by the application in preprocessing. If this bit is maintained to 1 by the preprocessing without any explicit change of the %Xi objects, Grafcet is frozen (no updates are taken into account). |

**Sequential Processing**

Sequential processing takes place in the chart (instructions representing the chart):
- Steps
- Actions associated with steps
- Transitions
- Transition conditions

Example:



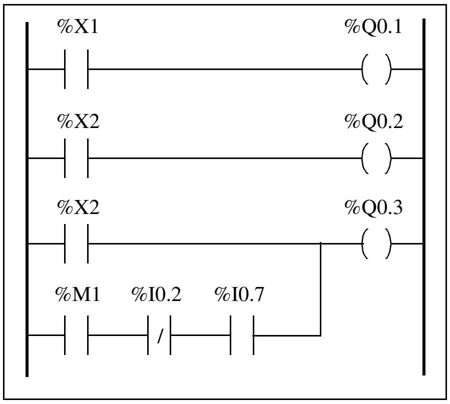
```
005    =*=    1
006    LD     %I0.2
007    ANDN   %I0.3
008    #      2
009    LD     %I0.3
010    ANDN   %I0.2
011    #      3
012    -*-    2
013    LD     %I0.4
014    #      1
015    -*-    3
016    LD     %I0.5
017    #      1
```

Sequential processing ends with the execution of the "= * = POST" instruction or with the end of the program.

## Post-Processing

Post-processing consists of the following:
- Commands from the sequential processing for controlling the outputs
- Safety interlocks specific to the outputs

Example:



```
018     =*=     POST
019     LD      %X1
020     ST      %Q0.1
021     LD      %X2
022     ST      %Q0.2
023     LD      %X3
024     OR(     %M1
025     ANDN    %I0.2
026     AND     %I0.7
027     )
028     ST      %Q0.3
```

## Actions Associated with Grafcet Steps

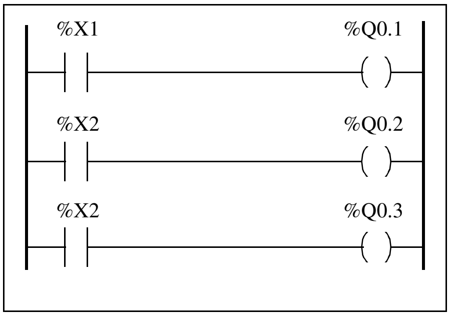
**Introduction**

A TwidoSoft Grafcet program offers two ways to program the actions associated with steps:
- In the post-processing section
- Within List instructions or Ladder rungs of the steps themselves

**Associating Actions in Post-Processing**

If there are security or running mode constraints, it is preferable to program actions in the post-processing section of a Grafcet application. You can use Set and Reset List instructions or energize coils in a Ladder program to activate Grafcet steps (%Xi).

**Example:**

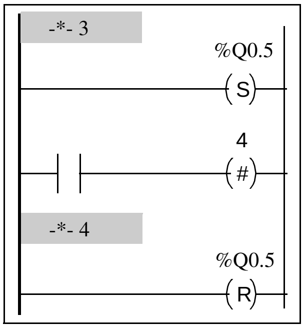


```
018    =*=    POST
019    LD     %X1
020    ST     %Q0.1
021    LD     %X2
022    ST     %Q0.2
023    LD     %X3
024    ST     %Q0.3
```

**Associating Actions from an Application**

You can program the actions associated with steps within List instructions or Ladder rungs. In this case, the List instruction or Ladder rung is not scanned unless the step is active. This is the most efficient, readable, and maintainable way to use Grafcet.

**Example:**



```
020    -*-    3
021    LD     1
022    S      %Q0.5
023    LD     %M10
024    #      4
025    -*-    4
026    LD     1
027    R      %Q0.5
028    ...
029    ...
```

# Description of Instructions and Functions

IV

## At a Glance

### Overview

This part provides detailed descriptions about basic and advanced instructions and system bits and words for Twido languages.

### What's in this Part?

This part contains the following chapters:

| Chapter | Chapter Name | Page |
|---|---|---|
| 12 | Basic Instructions | 187 |
| 13 | Advanced Instructions | 255 |
| 14 | System Bits and System Words | 317 |

# Basic Instructions

# 12

## At a Glance

**Overview**

This chapter provides details about instructions and function blocks that are used to create basic control programs for Twido controllers.

**What's in this Chapter?**

This capter contains the following sections:

## 12.1 Boolean Processing

### Introduction to Boolean Processing

**Overview**

This section provides an introduction to Boolean processing including descriptions and programming guidelines for Boolean instructions.

**What's in this Section?**

This section contains the following topics:

## Boolean Instructions

**Introduction**

Boolean instructions can be compared to Ladder language elements as summarized in the following table.

| Element | Instruction | Example | Description |
|---|---|---|---|
| Test elements | The Load (LD) instruction is equivalent to an open contact. | LD %I0.0 | Contact is closed when the controlling bit is at state 1. |
| Action elements | The Store (ST) instruction is equivalent to a coil. | ST %Q0.0 | The associated bit object takes a logical value of the bit accumulator (result of previous logic). |

The Boolean result of the test elements is applied to the action elements as shown by the following instructions.

```
LD    %I0.0
AND   %I0.1
ST    %Q0.0
```

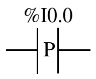
**Testing Controller Inputs**

Boolean test instructions can be used to detect rising or falling edges on the controller inputs. An edge is detected when the state of an input has changed between "scan n-1" and the current "scan n", and it remains detected during the current scan.

**Rising Edge Detection**

The LDR instruction (Load Rising Edge) is equivalent to a rising edge detection contact. The rising edge detects a change of the controlling inputs from 0 to 1.
A positive transition sensing contact is used to detect a rising edge as seen in the following diagram.

LDR %I0.0

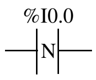


P: Positive transition sensing contact

## Falling Edge Detection

The LDF instruction (Load Falling Edge) is equivalent to a falling edge detection contact. The falling edge detects a change of the controlling input from 1 to 0.
A negative transition sensing contact is used to detect a falling edge as seen in the following diagram.

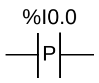
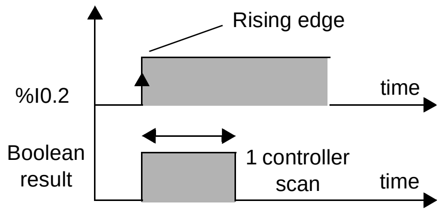
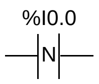
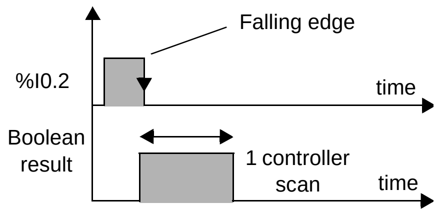
LDF %I0.0



N: Negative transition sensing contact

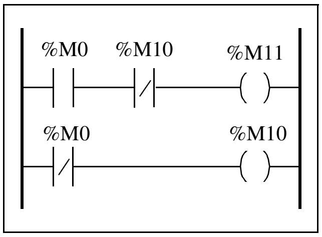
## Edge Detection Timing

The following table summarizes the instructions and timing for the Boolean instructions used to test for rising and falling edges.

| **Edge** | **Test Instruction** | **Ladder Diagram** | **Timing** |
|---|---|---|---|
| Rising edge | LDR %I0.0 |  |  |
| Falling edge | LDF %I0.0 |  |  |

**Using Internal Bits for Edge Detection**

Instructions on a rising or falling edge apply to inputs %I, but it is possible to detect edges on any other bit (or Boolean result) using two internal bits.
In the following example, bit %M11 records the rising edge of bit %M0.



```
LD      %M0
ANDN    %M10
ST      %M11
LDN     %M0
ST      %M10
```

**Note:** On a cold or warm restart, the application detects a rising edge even if the input has remained at 1. This can be masked by starting the program on LD %S1 and ENDC instructions.

**Note:** Directly detecting rising and falling edges can only be done using input bits (%Ii).

## Understanding the Format for Describing Boolean Instructions

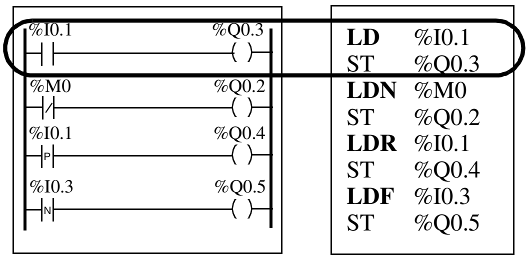
**Introduction**

Each Boolean instruction in this section is described using the following information:
- Brief description
- Example of the instruction and the corresponding ladder diagram
- List of permitted operands
- Timing diagram

The following explanations provide more detail on how Boolean instructions are described in this section.

**Examples**

The following illustration shows how examples are given for each instruction.



```
LD   %I0.1
ST   %Q0.3
LDN  %M0
ST   %Q0.2
LDR  %I0.1
ST   %Q0.4
LDF  %I0.3
ST   %Q0.5
```

Ladder diagram equivalents     List instructions

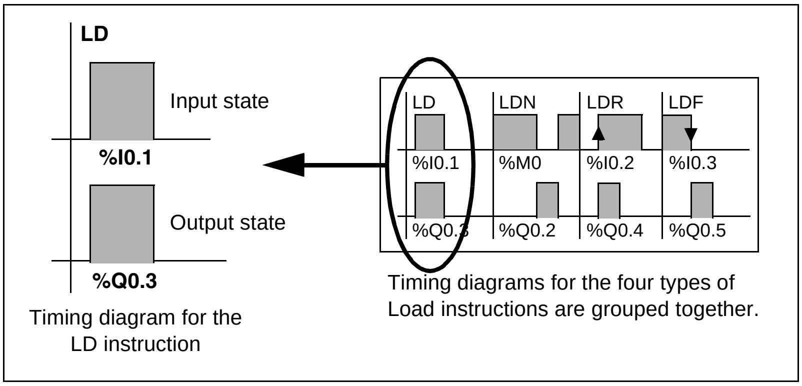
**Permitted Operands**

The following table defines the types of permitted operands used for Boolean instructions.

| Operand | Description |
|---|---|
| 0/1 | Immediate value of 0 or 1 |
| %I | Controller input %Ii.j |
| %Q | Controller output %Qi.j |
| %M | Internal bit %Mi |
| %S | System bit %Si |
| %X | Step bit %Xi |
| %BLK.x | Function block bit (for example, %TMi.Q) |
| %•:Xk | Word bit (for example, %MWi:Xk) |
| [ | Comparison expression (for example, [%MWi<1000]) |

## Timing Diagrams

The following illustration shows how timing diagrams are displayed for each instruction.


LD
Input state
%I0.1
Output state
%Q0.3
Timing diagram for the LD instruction
LD
LDN
LDR
LDF
%I0.1
%M0
%I0.2
%I0.3
%Q0.3
%Q0.2
%Q0.4
%Q0.5
Timing diagrams for the four types of Load instructions are grouped together.

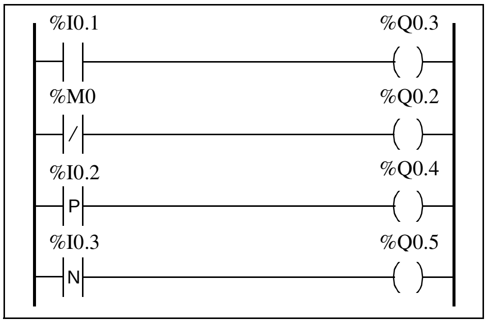
## Load Instructions (LD, LDN, LDR, LDF)

**Introduction**

Load instructions LD, LDN, LDR, and LDF correspond respectively to the opened, closed, rising edge, and falling edge contacts (LDR and LDF are used only with controller inputs).

**Examples**

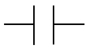
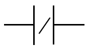
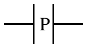
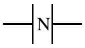
The following diagrams are examples of Load instructions.



```
LD    %I0.1
ST    %Q0.3
LDN   %M0
ST    %Q0.2
LDR   %I0.2
ST    %Q0.4
LDF   %I0.3
ST    %Q0.5
```

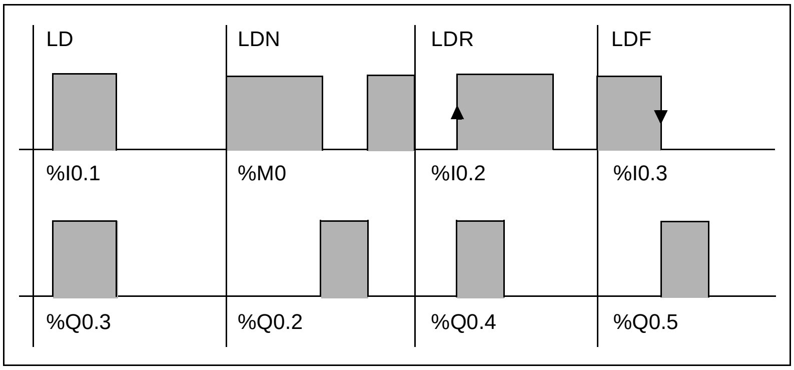
**Permitted Operands**

The following table lists the types of load instructions with Ladder equivalents and permitted operands.

| List Instruction | Ladder Equivalent | Permitted Operands |
|---|---|---|
| LD |  | 0/1,%I,%Q,%M,%S,%X,%BLK.x,%•:Xk,[ |
| LDN |  | %I,%Q,%M,%S,%X,%BLK.x,%•:Xk,[ |
| LDR |  | %I |
| LDF |  | %I |

**Timing Diagram**

The following diagram displays the timing for the Load instructions.



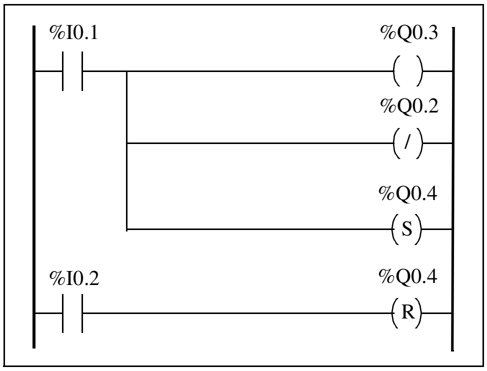
## Store Instructions (ST, STN, R, S)

**Introduction**

The Store instructions ST, STN, S, and R correspond respectively to the direct, inverse, set, and reset coils.

**Examples**

The following diagrams are examples of Store instructions.



```
LD      %I0.1
ST      %Q0.3

STN     %Q0.2
S       %Q0.4


LD      %I0.2
R       %Q0.4
```

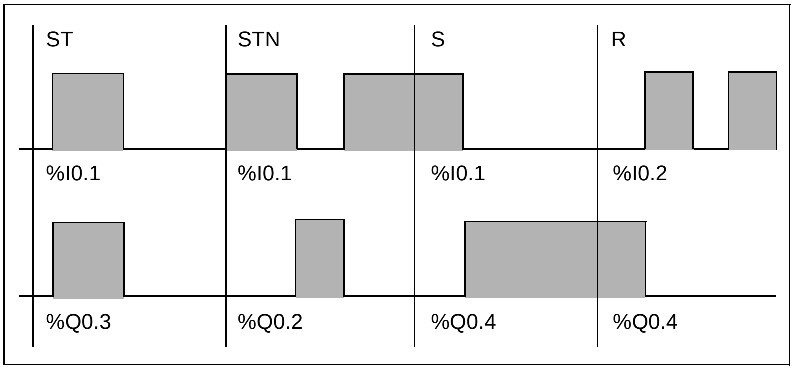
**Permitted Operands**

The following table lists the types of Store instructions with Ladder equivalents and permitted operands.

| List Instruction | Ladder Equivalent | Permitted Operands |
|---|---|---|
| ST | ( ) | %Q,%M,%S,%BLK.x,%•:Xk |
| STN | (/) | %Q,%M,%S,%BLK.x,%•:Xk |
| S | (S) | %Q,%M,%S,%X,%BLK.x,%•:Xk |
| R | (R) | %Q,%M,%S,%X,%BLK.x,%•:Xk |

## Timing Diagram

The following diagram displays the timing for the Store instructions.



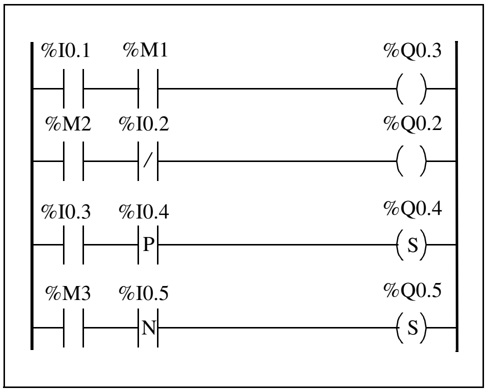
## Logical AND Instructions (AND, ANDN, ANDR, ANDF)

**Introduction**

The AND instructions perform a logical AND operation between the operand (or its inverse, or its rising or falling edge) and the Boolean result of the preceding instruction.

**Examples**

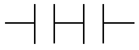
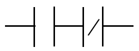
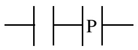
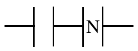
The following diagrams are examples of logic AND instructions.



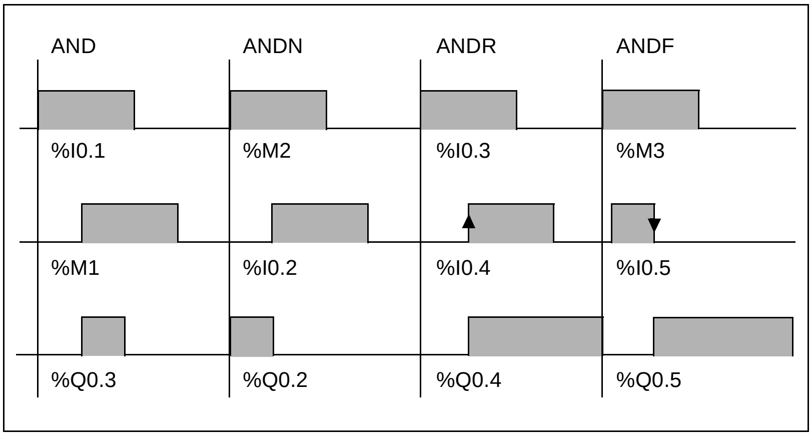
```
LD      %I0.1
AND     %M1
ST      %Q0.3
LD      %M2
ANDN    %I0.2
ST      %Q0.2
LD      %I0.3
ANDR    %I0.4
S       %Q0.4
LD      %M3
ANDF    %I0.5
S       %Q0.5
```

**Permitted Operands**

The following table lists the types of AND instructions with ladder equivalents and permitted operands.

| List Instruction | Ladder Equivalent | Permitted Operands |
|---|---|---|
| AND |  | 0/1,%I,%Q,%M,%S,%X,%BLK.x,%•:Xk, [ |
| ANDN |  | %I,%Q,%M,%S,%X,%BLK.x,%•:Xk, [ |
| ANDR |  | %I |
| ANDF |  | %I |

**Timing Diagram** The following diagram displays the timing for the AND instructions.



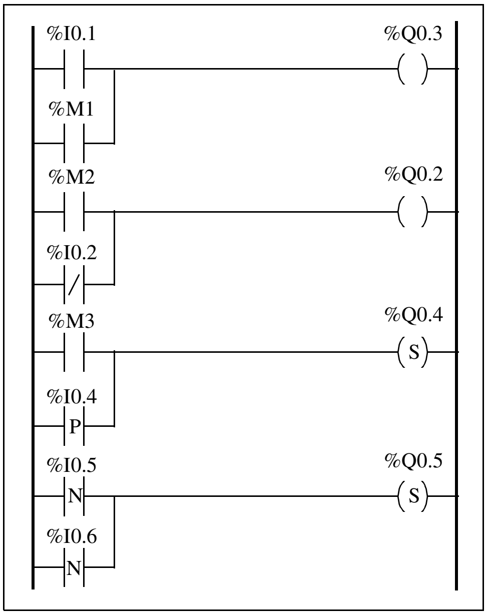
## Logical OR Instructions (OR, ORN, ORR, ORF)

**Introduction**

The OR instructions perform a logical OR operation between the operand (or its inverse, or its rising or falling edge) and the Boolean result of the preceding instruction.

**Examples**

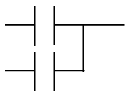
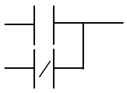
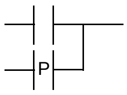
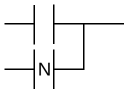
The following diagrams are examples of logic OR instructions.



```
LD      %I0.1
OR      %M1
ST      %Q0.3

LD      %M2
ORN     %I0.2
ST      %Q0.2

LD      %M3
ORR     %I0.4
S       %Q0.4

LDF     %I0.5
ORF     %I0.6
S       %Q0.5
```

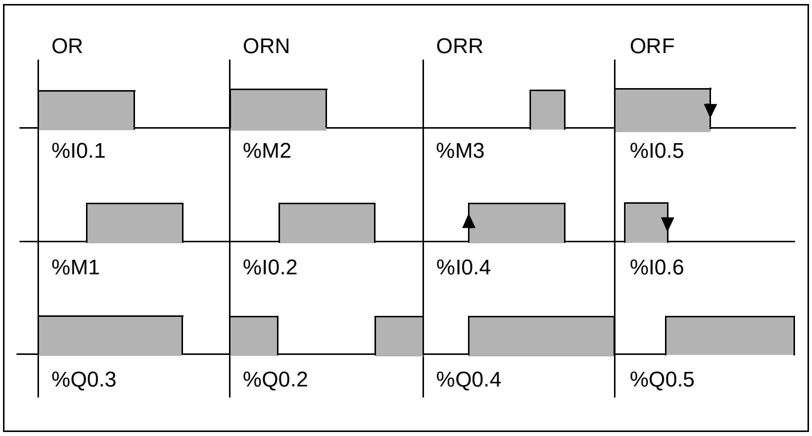
**Permitted Operands**

The following table lists the types of OR instructions with Ladder equivalents and permitted operands.

| List Instruction | Ladder Equivalent | Permitted Operands |
|---|---|---|
| OR |  | 0/1,%I,%Q,%M,%S,%X,%BLK.x,%•:Xk |
| ORN |  | %I,%Q,%M,%S,%X,%BLK.x,%•:Xk |
| ORR |  | %I |
| ORF |  | %I |

**Timing Diagram**

The following diagram displays the timing for the OR instructions.



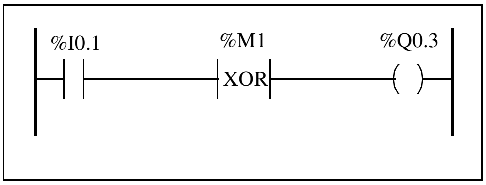
## Exclusive OR Instructions (XOR, XORN, XORR, XORF)

**Introduction**

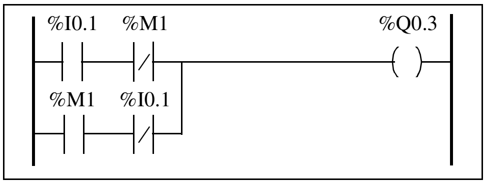
The XOR instructions perform an exclusive OR operation between the operand (or its inverse, or its rising or falling edge) and the Boolean result of the preceding instruction.

**Examples**

The XOR instructions can be used as shown in the following examples.



```
LD      %I0.1
XOR     %M1
ST      %Q0.3
```



```
LD      %I0.1
ANDN    %M1
OR(     %M1
ANDN    %I0.1
)
ST      %Q0.3
```

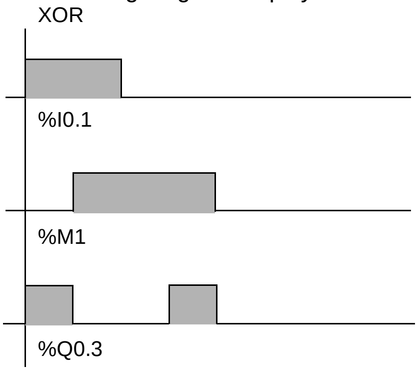
**Permitted Operands**

The following table lists the types of XOR instructions and permitted operands.

| Instruction list | Permitted Operands |
|---|---|
| XOR | %I,%Q,%M,%S,%X,%BLK.x,%•:Xk |
| XORN | %I,%Q,%M,%S,%X,%BLK.x,%•:Xk |
| XORR | %I |
| XORF | %I |

**Timing Diagram**

The following diagram displays the timing for the XOR instructions.

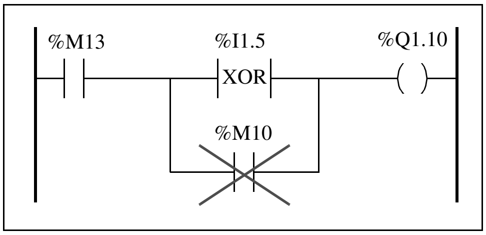


**Special Cases**

The following are special precautions for using XOR instructions in Ladder programs:

- Do not insert XOR contacts in the first position of a rung.
- Do not insert XOR contacts in parallel with other ladder elements (see the following example.)

As shown in the following example, inserting an element in parallel with the XOR contact will generate a validation error.



## NOT Instruction (N)

**Introduction**

The NOT (N) instruction negates the Boolean result of the preceding instruction.

**Example**

The following is an example of using the NOT instruction.

```
LD      %I0.1
OR      %M2
ST      %Q0.2
N
AND     %M3
ST      %Q0.3
```

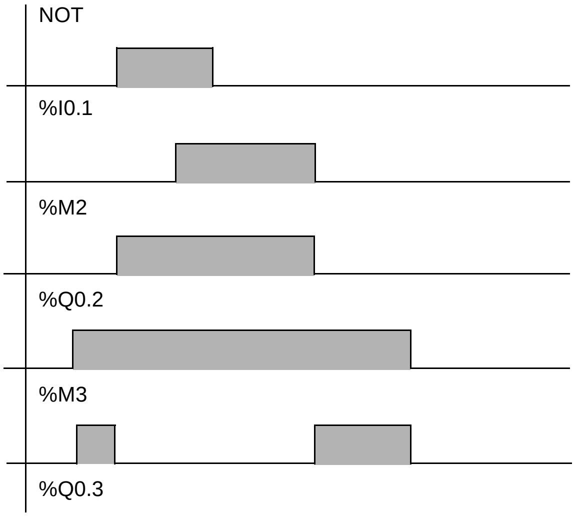
**Note:** The NOT instruction is not reversible.

**Permitted Operands**

Not applicable.

**Timing Diagram**

The following diagram displays the timing for the NOT instruction.



## 12.2 Basic Function Blocks

### At a Glance

**Overview**

This section provides descriptions and programming guidelines for using basic function blocks.

**What's in this Section?**

This section contains the following topics:

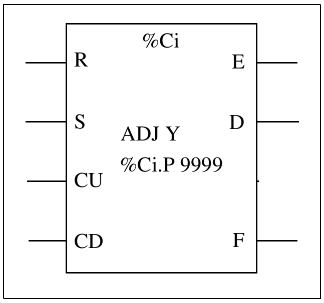
## Basic Function Blocks

**Introduction**

Function blocks are the sources for bit objects and specific words that are used by programs. Basic function blocks provide simple functions such as timers or up/down counting.

**Example of a Function Block**

The following illustration is an example of an up/down Counter function block.



Up/down counter block

**Bit Objects**

Bit objects correspond to the block outputs. These bits can be accessed by Boolean test instructions using either of the following methods:
- Directly (for example, LD E) if they are wired to the block in reversible programming (see *Principles for Programming Basic Function Blocks, p. 208*).
- By specifying the block type (for example, LD %Ci.E).

Inputs can be accessed in the form of instructions.

**Word Objects**

Word objects correspond to specified parameters and values as follows:
- **Block configuration parameters:** Some parameters are accessible by the program (for example, pre-selection parameters) and some are inaccessible by the program (for example, time base).
- **Current values:** For example, %Ci.V, the current count value.

## Accessible Bit and Word Objects

The following table describes the Basic function blocks bit and word objects that can be accessed by the program.

| Basic Function Block | Symbol | Range (i) | Types of Objects | Description | Address | Write Access |
|---|---|---|---|---|---|---|
| Timer | %TMi | 0 - 127 | Word | Current value | %TMi.V | no |
| | | | | Preset value | %TMi.P | yes |
| | | | Bit | Timer output | %TMi.Q | no |
| Up/Down counter | %Ci | 0 - 31 | Word | Current value | %Ci.V | no |
| | | | | Preset value | %Ci.P | yes |
| | | | Bit | Underflow output (empty) | %Ci.E | no |
| | | | | Preset output reached | %Ci.D | no |
| | | | | Overflow output (full) | %Ci.F | no |

## Principles for Programming Basic Function Blocks

**Introduction**

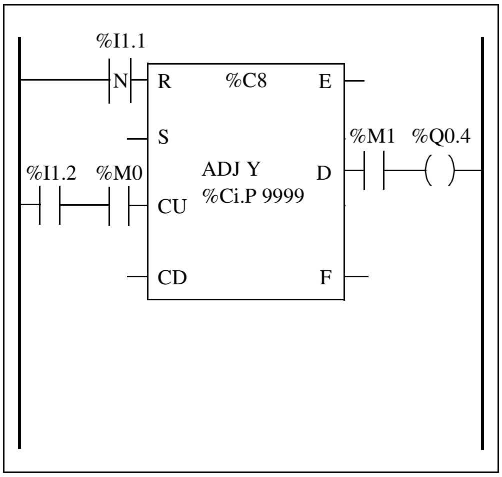
Use one of the following methods to program basic function blocks:
- Function block instructions (for example, `BLK` %TM2): This reversible method of programming ladder language enables operations to be performed on the block in a single place in the program.
- Specific instructions (for example, `CU %Ci`): This non-reversible method enables operations to be performed on the block's inputs in several places in the program (for example, `line 100 CU %C1`, `line 174 CD %C1`, `line 209 LD %C1.D`).

**Reversible Programming**

Use instructions BLK, OUT_BLK, and END_BLK for reversible programming:
- **BLK:** Indicates the beginning of the block.
- **OUT_BLK:** Is used to directly wire the block outputs.
- **END_BLK:** Indicates the end of the block.

**Example with Wired Outputs**

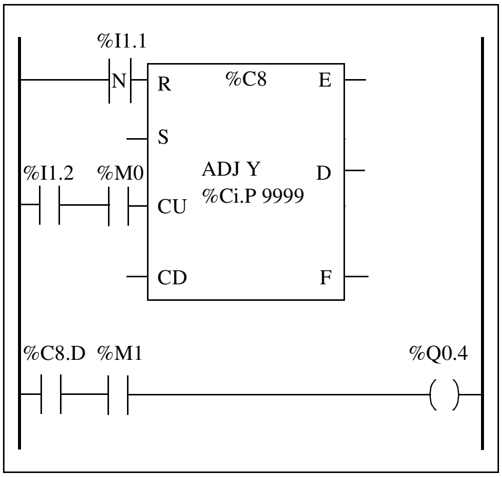
The following example shows reversible programming of a counter function block with wired outputs.



```
BLK      %C8    ┐
LDF      %I1.1  │
R               │  Input
LD       %I1.2  │  Processing
AND      %M0    │
CU              ┘
OUT_BLK         ┐
LD       D      │  Output
AND      %M1    │  Processing
ST       %Q0.4  ┘
END_BLK
```

**Example without Output Wiring**

This example shows reversible programming of a counter function block without wired outputs.



```
BLK      %C8     ┐
LDF      %I1.1   │
R                │  Input
LD       %I1.2   │  Processing
AND      %M0     │
CU               ┘
END_BLK
LD       %C8.D   ┐
AND      %M1     │  Output
ST       %Q0.4   ┘  Processing
```

**Note:** Only test and input instructions on the relevant block can be placed between the BLK and OUT_BLK instructions (or between BLK and END_BLK when OUT_BLK is not programmed).

## Timer Function Block (%TMi)

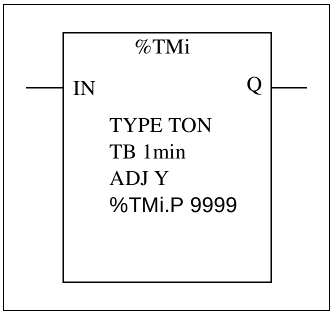
**Introduction**

There are three types of Timer function blocks:
- TON (Timer On-Delay): Use this type of timer to control on-delay actions.
- TOF (Timer Off-Delay): Use this type of timer to control off-delay actions.
- TP (Timer - Pulse): Use this type of timer to create a pulse of a precise duration.

The delays or pulse periods are programmable and may be modified using the TwidoSoft.

**Illustration**

The following is an illustration of the Timer function block.



Timer function block

## Parameters

The Timer function block has the following parameters:

| Parameter | Label | Value |
|---|---|---|
| Timer number | %TMi | 0 to 63 Compact Controller<br>0 to 127 Modular Controllers |
| Type | TON | • on-delay (by default) |
| | TOF | • off-delay |
| | TP | • pulse (monostable) |
| Time base | TB | 1 min (default), 1s, 100ms, 10ms, 1ms (for TM0 and TM1). |
| Current value | %TMi.V | Word which increments from 0 to %TMi.P when the timer is running. May be read and tested, but not written by the program. %TMi.V can be modified using the Data Editor. |
| Preset value | %TMi.P | 0 - 9999. Word which may be read, tested, and written by the program. Default value is 9999. The period or delay generated is equal to %TMi.P x TB. |
| Data Editor | Y/N | Y: Yes, the preset %TMi.P value can be modified using the Data Editor.<br>N: No, the preset %TMi.P value cannot be modified. |
| Setting Input (or instruction) | IN | Starts the timer on rising edge (TON or TP types) or falling edge (TOF type). |
| Timer output | Q | Associated bit %TMi.Q is set to 1 depending on the function performed: TON, TOF, or TP.1. |

**Note:** The larger the preset value, the greater the timer accuracy.

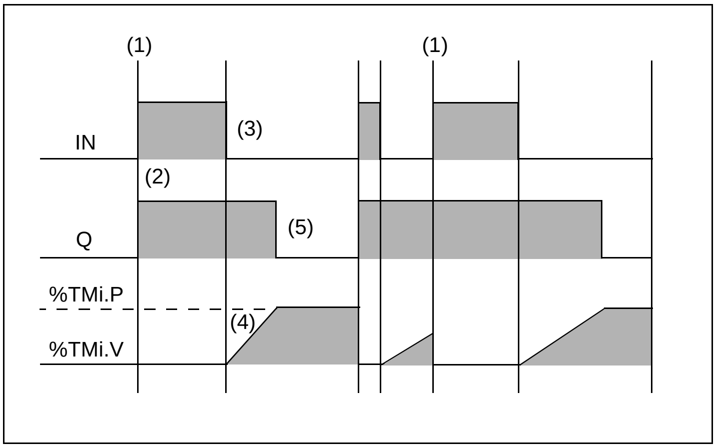
## TOF Type of Timer

**Introduction**

Use the TOF (Timer Off-Delay) type of timer to control off-delay actions. This delay is programmable using TwidoSoft.

**Timing Diagram**

The following timing diagram illustrates the operation of the TOF type timer.



**Operation**

The following table describes the operation of the TOF type timer.

| Phase | Description |
|---|---|
| 1 | The current value %TMi.V is set to 0 on a rising edge at input IN, even if the timer is running. |
| 2 | The %TMi.Q output bit is set to 1 when a rising edge is detected at input N. |
| 3 | The timer starts on the falling edge of input IN. |
| 4 | The current value %TMi.V increases to %TMi.P in increments of one unit for each pulse of the time base TB. |
| 5 | The %TMi.Q output bit is reset to 0 when the current value reaches %TMi.P. |

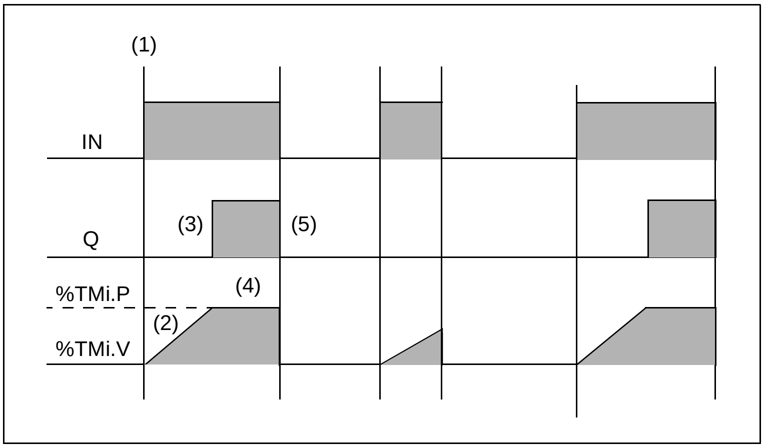
## TON Type of Timer

**Introduction**

The TON (Timer On-Delay) type of timer is used to control on-delay actions. This delay is programmable using the TwidoSoft.

**Timing Diagram**

The following timing diagram illustrates the operation of the TON type timer.



**Operation**

The following table describes the operation of the TON type timer.

| Phase | Description |
|---|---|
| 1 | The timer starts on the rising edge of the IN input. |
| 2 | The current value %TMi.V increases from 0 to %TMi.P in increments of one unit for each pulse of the time base TB. |
| 3 | The %TMi.Q output bit is set to 1 when the current value has reached %TMi.P. |
| 4 | The %TMi.Q output bit remains at 1 while the IN input is at 1. |
| 5 | When a falling edge is detected at the IN input, the timer is stopped, even if the timer has not reached %TMi.P, and %TMi.V is set to 0. |

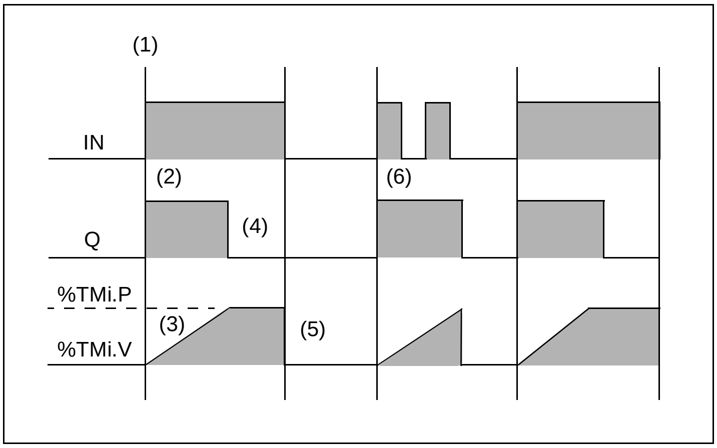
## TP Type of Timer

**Introduction**

The TP (Timer - Pulse) type of timer is used to create pulses of a precise duration. This delay is programmable using the TwidoSoft.

**Timing Diagram**

The following timing diagram illustrates the operation of the TP type timer.



**Operation**

The following table describes the operation of the TP type timer.

| Phase | Description |
|---|---|
| 1 | The timer starts on the rising edge of the IN input. The current value %TMi.V is set to 0 if the timer has not already started. |
| 2 | The %TMi.Q output bit is set to 1 when the timer starts. |
| 3 | The current value %TMi.V of the timer increases from 0 to %TMi.P in increments of one unit per each pulse of the time base TB. |
| 4 | The %TMi.Q output bit is set to 0 when the current value reaches %TMi.P. |
| 5 | The current value %TMi.V is set to 0 when %TMi.V equals %TMi.P and input IN returns to 0. |
| 6 | This timer cannot be reset. Once %TMi.V equals %TMi.P, and input IN is 0, then %TMi.V is set to 0. |

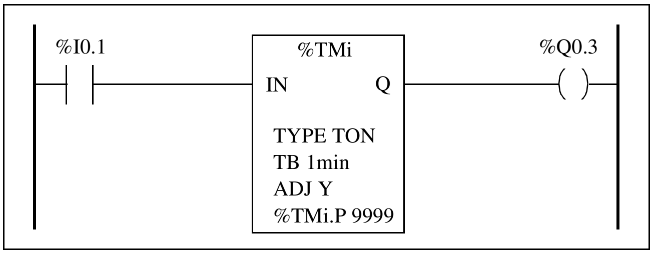
## Programming and Configuring Timers

**Introduction**

Timer function blocks (%TMi) are programmed in the same way regardless of how they are to be used. The timer function (TON, TOF, or TP) is selected during configuration.

**Examples**

The following illustration is a timer function block with examples of reversible and non-reversible programming.



Reversible programming

```
BLK      %TM1
LD       %I0.1
IN
OUT_BLK
LD       Q
ST       %Q0.3
END_BLK
```

Non-Reversible programming

```
LD       %I0.1
IN       %TM1
LD       %TM1.Q
ST       %Q0.3
```

**Configuration**

The following parameters must be entered during configuration:

- Timer type: TON, TOF, or TP
- Time base (TB): 1 min, 1s, 100 ms, 10 ms, or 1 ms
- Preset value (%TMi.P): 0 to 9999
- Adjust: Yes or No (Y or N)

## Special Cases

The following table contains a list of special cases of programming and configuring timers.

| Special Case | Description |
|---|---|
| Effect of a cold restart (%S0=1) | Forces the current value to 0. Sets output %TMi.Q to 0. The preset value is reset to the value defined during configuration. |
| Effect of a warm restart (%S1=1) | Has no effect on the current and preset values of the timer. The current value does not change during a power outage. |
| Effect of a controller stop | Stopping the controller does not freeze the current value. |
| Effect of a program jump | Jumping over the timer block does not freeze the timer. The timer will continue to increment until it reaches the preset value (%TMi.P). At that point, the Done bit (%TMi.Q) assigned to output Q of the timer block changes state; however, the associated output wired directly to the block output is not activated and not scanned by the controller. |
| Testing by bit %TMi.Q (done bit) | It is advisable to test bit %TMi.Q only once in the program. |
| Effect of modifying the preset %TMi.P | Modifying the present value by using an instruction or by adjusting the value only takes effect on the next activation of the timer. |

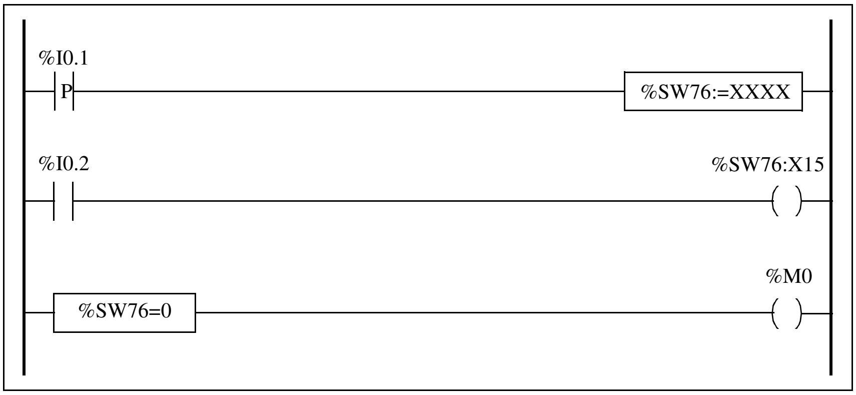
## Timers with a 1ms Time Base

The 1 ms time base is only available on %TM0 and %TM1 timers. The four system words %SW76, %SW77, %SW78, and SW79, can be used as "hourglasses." These four words are decremented individually by the system every millisecond **if they have a positive value.**
Multiple timing can be achieved by successive loading of one of these words or by testing the intermediate values. If the value of one of these four words is less than 0, it will not be modified. A timer can be "frozen" by setting the corresponding bit 15 to 1, and then "unfrozen" by resetting it to 0.

## Programming Example

The following is an example of programming a timer function block.

```
LDR     %I0.1          (Launching the timer on the rising edge of %I0.1)
[%SW76:=XXXX]          (XXXX = required value)
LD      %I0.2          (optional management of freeze, input I0.2 freezes)
ST      %SW76:X15
LD      [%SW76=0]      (timer end reset)
ST      %M0
..............
```



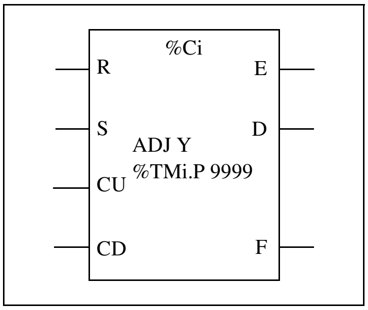
## Up/Down Counter Function Block (%Ci)

**Introduction**

The Counter function block (%Ci) provides up and down counting of events. These two operations can be done simultaneously.

**Illustration**

The following is an illustration of the up/down Counter function block.



Up/down counter function block

## Parameters

The Counter function block has the following parameters:

| Parameter | Label | Value |
|---|---|---|
| Counter number | %Ci | 0 to 31 |
| Current value | %Ci.V | Word is incremented or decremented according to inputs (or instructions) CU and CD. Can be read and tested but not written by the program. Use the Data Editor to modify %Ci.V. |
| Preset value | %Ci.P | 0 - %Ci.P-9999. Word can be read, tested, and written (default value: 9999). |
| Edit using the Data Editor | Y/N | ● Y: Yes, the preset value can be modified by using the Data Editor.<br>● N: No, the preset value cannot be modified by using the Data Editor. |
| Reset input (or instruction) | R | At state 1: %Ci.V = 0. |
| Set input (or instruction) | S | At state 1: %Ci.V = %Ci.P. |
| Upcount input (or instruction) | CU | Increments %Ci.V on a rising edge. |
| Downcount input (or instruction) | CD | Decrements %Ci.V on a rising edge. |
| Underflow output | E (Empty) | The associated bit %Ci.E=1, when down counter %Ci.V changes from 0 to 9999 (set to 1 when %Ci.V reaches 9999, and reset to 0 if the counter continues to count down). |
| Preset output reached | D (Done) | The associated bit %Ci.D=1, when %Ci.V=%Ci.P. |
| Overflow output | F (Full) | The associated bit %Ci.F=1, when %Ci.V changes from 9999 to 0 (set to 1 when %Ci.V reaches 0, and reset to 0 if the counter continues to count up). |

## Operation

The following table describes the main stages of up/down counter operation.

| Operation | Action | Result |
|---|---|---|
| Upcount | A rising edge appears at the upcounting input CU (or instruction CU is activated). | The %Ci.V current value is incremented by one unit. |
| | The %Ci.V current value is equal to the %Ci.P preset value. | The "preset reached" output bit %Ci.D assigned to output D changes to state 1. |
| | The %Ci.V current value changes from 9999 to 0. | The output bit %Ci.F (Upcount overflow) changes to state 1. |
| | If the counter continues to count up. | The output bit %Ci.F (Upcount overflow) is reset to 0. |
| Downcount | A rising edge appears at the downcounting input CD (or instruction CD is activated). | The current value %Ci.V is decremented by one unit. |
| | The current value %Ci.V changes from 0 to 9999. | The output bit %Ci.E (underflow) changes to state 1. |
| | If the counter continues to count down. | The output bit %Ci.E (underflow) is reset to 0. |
| Up/down count | To use both the upcount and downcount functions simultaneously (or to activate both instructions CD and CU), the two corresponding inputs CU and CD must be controlled. These two inputs are then scanned in succession, If they are both at 1, the current value remains unchanged. | |
| Reset | Input R is set to state 1(or the R instruction is activated). | The current value%Ci.V is forced to 0. Outputs %Ci.E, %Ci.D and %Ci.F are at 0. The reset input has priority. |
| Set | If input S is at state 1 (or the S instruction is activated) and the reset input is at 0 (or the R instruction is inactive). | The current value %Ci.V takes the %Ci.P value and the %Ci.D output is set to 1. |

## Special Cases

The following table contains a list of special cases of programming and configuring counters.

| Special Case | Description |
|---|---|
| Effect of a cold restart (%S0=1) | • The current value %Ci is set to 0.<br>• Output bits %Ci.E, %Ci.D, and %Ci.F are set to 0.<br>• The preset value is initialized with the value defined during configuration. |
| Effect of a warm restart (%S1=1) of a controller stop | Has no effect on the current value of the counter (%Ci.V). |
| Effect of modifying the preset %Ci.P | Modifying the preset value via an instruction or by adjusting it takes effect when the block is processed by the application (activation of one of the inputs). |

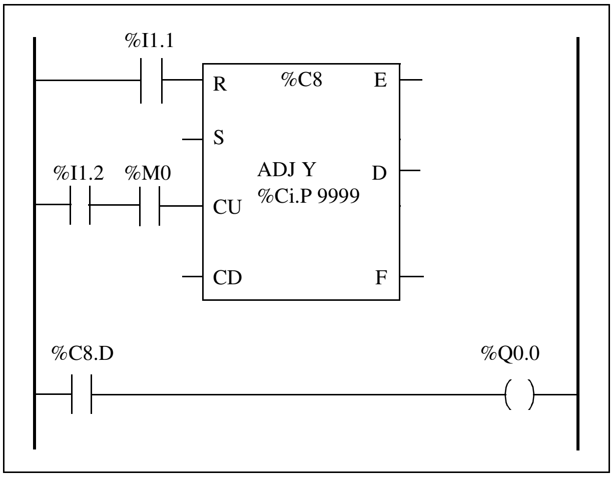
## Programming and Configuring Counters

**Introduction**

The following example is a counter that provides a count of items up to 5000. Each pulse on input %I1.2 (when internal bit %M0 is at 1) increments the counter %C8 up to its final preset value (bit %C8.D=1). The counter is reset by input %I1.1.

**Programming Example**

The following illustration is a counter function block with examples of reversible and non-reversible programming.



Ladder diagram

```
BLK     %C8
LD      %I1.1
R
LD      %I1.2
AND     %M0
CU
END_BLK
LD      %C8.D
ST      %Q0.0
```

Reversible programming

```
LD      %I1.1
R       %C8
LD      %I1.2
AND     %M0
CU      %C8
LD      %C8.D
ST      %Q0.0
```

Non-reversible programming

**Configuration**

The following parameters must be entered during configuration:
- Preset value (%Ci.P): set to 5000 in this example
- Adjust: Yes

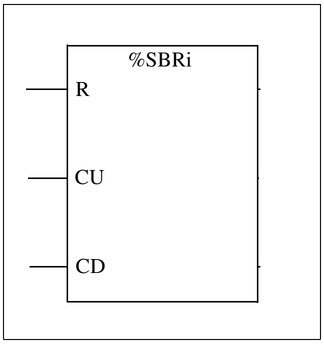
## Shift Bit Register Function Block (%SBRi)

**Introduction**

The Shift Bit Register function block (%SBRi) provides a left or right shift of binary data bits (0 or 1).

**Illustration**

The following is an example of a Shift Register function block.



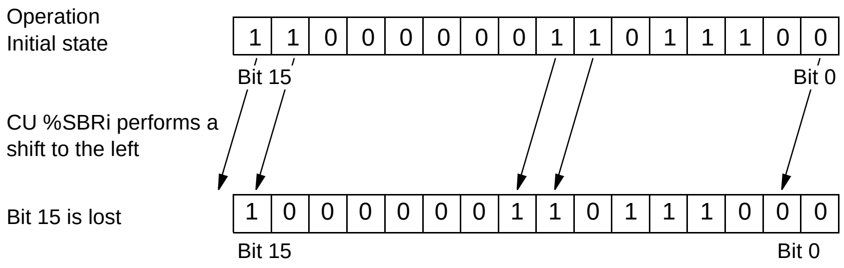
**Parameters**

The Shift Bit Register function block has the following parameters.

| **Parameter** | **Label** | **Value** |
|---|---|---|
| Register number | %SBRi | 0 to 7 |
| Register bit | %SBRi.j | Bits 0 to 15 (j = 0 to 15) of the shift register can be tested by a Test instruction and written using an Assignment instruction. |
| Reset input (or instruction) | R | On a rising edge, sets register bits 0 to 15 %SBRi.j to 0. |
| Shift to left input (or instruction) | CU | On a rising edge, shifts a register bit to the left. |
| Shift to right input (or instruction) | CD | On a rising edge, shifts a register bit to the right. |

## Operation

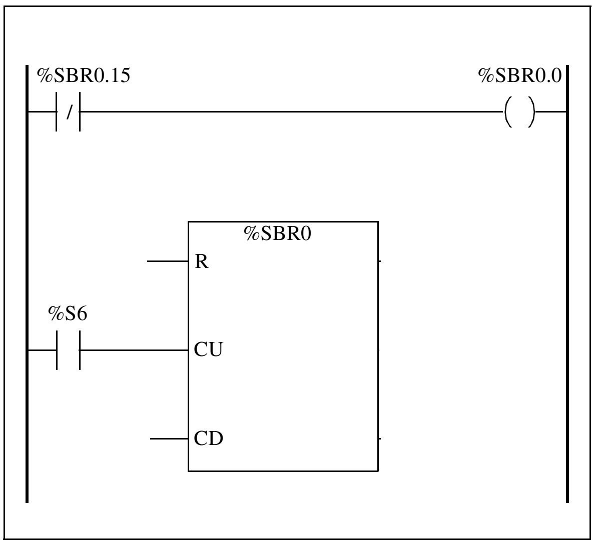
The following illustration shows a bit pattern before and after a shift operation.



This is also true of a request to shift a bit to the right (Bit 15 to Bit 0) using the CD instruction. Bit 0 is lost.
If a 16-bit register is not adequate, it is possible to use the program to cascade several registers.

## Programming

In the following example, a bit is shifted to the left every second while Bit 0 assumes the opposite state to Bit 15.



Reversible programming

```
LDN     %SBR0.15
ST      %SBR0.0
BLK     %SBR0
LD      %S6
CU
END_BLK
```

Non-Reversible programming

```
LDN     %SBR0.15
ST      %SBR0.0
LD      %S6
CU      %SBR0
```

## Special Cases

The following table contains a list of special cases for programming the Shift Bit Register function block.

| Special Case | Description |
|---|---|
| Effect of a cold restart (%S0=1) | Sets all the bits of the register word to 0. |
| Effect of a warm restart (%S1=1) | Has no effect on the bits of the register word. |

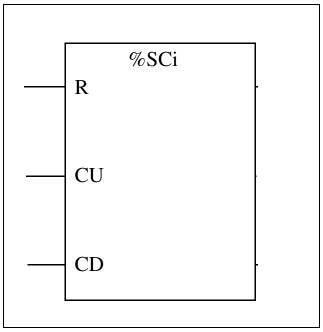
## Step Counter Function Block (%SCi)

**Introduction**

A Step Counter function block (%SCi) provides a series of steps to which actions can be assigned. Moving from one step to another depends on external or internal events. Each time a step is active, the associated bit is set to 1. Only one step of a step counter can be active at a time.

**Illustration**

The following is an example of a Step Counter function block.



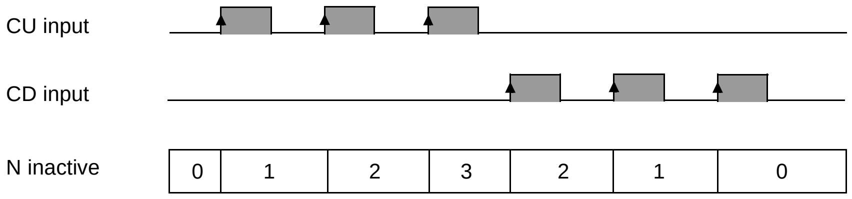
**Parameters**

The Step Counter function block has the following parameters.

| Parameter | Label | Value |
|---|---|---|
| Step counter number | %SCi | 0 to 7 |
| Step counter bit | %SCi.j | Step counter bits 0 to 255 (j = 0 to 255) can be tested by a Load logical operation and written by an Assignment instruction. |
| Reset input (or instruction) | R | On a rising edge, resets the step counter. |
| Increment input (or instruction) | CU | On a rising edge, increments the step counter by one step. |
| Decrement input (or instruction) | CD | On a rising edge, decrements the step counter by one step. |

## Timing Diagram

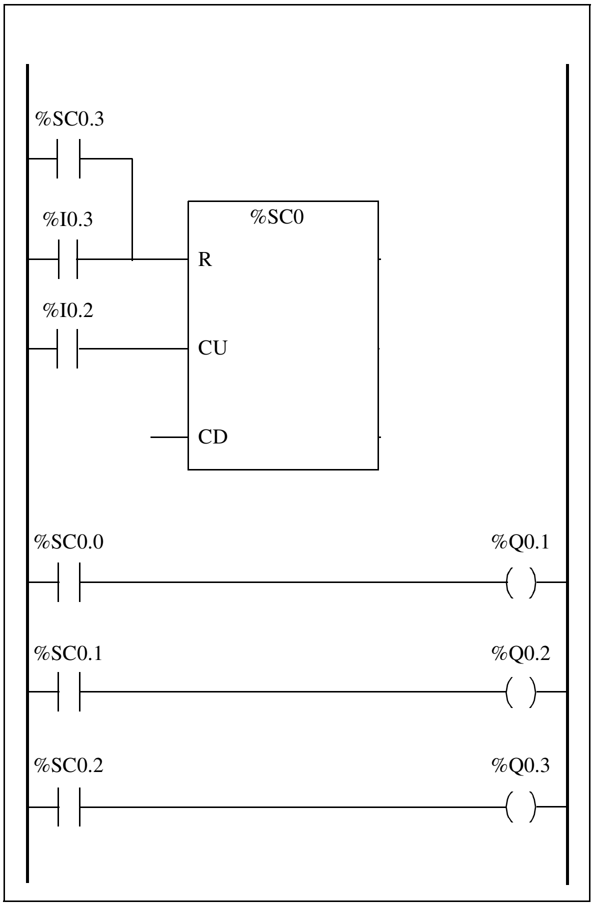
The following diagram illustrates the operation of the Step Counter function block.



**Programming**

The following is an example of a Step Counter function block.
- Step Counter 0 is incremented by input %I0.2.
- Step Counter 0 is reset to 0 by input %I0.3 or when it arrives at step 3.
- Step 0 controls output %Q0.1, step 1 controls output %Q0.2, and step 2 controls output %Q0.3.

The following illustration shows both reversible and non-reversible programming for this example.



Reversible programming

```
BLK     %SC0
LD      %SC0.3
OR      %I0.3
R
LD      %I0.2
CU
END_BLK
LD      %SC0.0
ST      %Q0.1
LD      %SC0.1
ST      %Q0.2
LD      %SC0.2
ST      %Q0.3
```

Non-Reversible programming

```
LD      %SC0.3
OR      %I0.3
R       %SC0
LD      %I0.2
CU      %SC0
LD      %SC0.0
ST      %Q0.1
LD      %SC0.1
ST      %Q0.2
LD      %SC0.2
ST      %Q0.3
```

## Special Cases

The following table contains a list of special cases for programming the Step Counter function block.

| Special Case | Description |
|---|---|
| Effect of a cold restart (%S0=1) | Initializes the step counter. |
| Effect of a warm restart (%S1=1) | Has no effect on the step counter. |

## 12.3 Numerical Processing

### Introduction to Numerical Processing

**Overview**

This section provides an introduction to Numerical Processing including descriptions and programming guidelines.

**What's in this Section?**

This section contains the following topics:

## Introduction to Numerical Instructions

**Overview**

Numerical instructions generally apply to 16-bit words (see *Word Objects, p. 27*). They are written between square brackets. If the result of the preceding logical operation was true (Boolean accumulator = 1), the numerical instruction is executed. If the result of the preceding logical operation was false (Boolean accumulator = 0), the numerical instruction is not executed and the operand remains unchanged.

## Assignment Instructions

**Introduction**

Assignment instructions are used to load operand Op2 into operand Op1.

**Assignment**

Syntax for Assignment instructions.

$\boxed{[Op1:=Op2]} \iff \boxed{Op2 \text{ -> } Op1}$

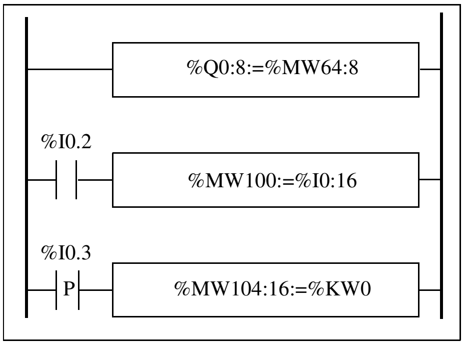
Assignment operations can be performed on:
- Bit strings
- Words
- Word tables

**Assignment of Bit Strings**

Operations can be performed on the following bit strings (see *Structured Objects, p. 35*):
- Bit string -> bit string (Example 1)
- Bit string -> word (Example 2)
- Word -> bit string (Example 3)
- Immediate value -> bit string

**Examples**

Examples of bit string assignments.



```
LD      1
[%Q0:8:=%M64:8]              (Ex. 1)

LD      %I0.2
[%MW100:=%I0:16]             (Ex. 2)

LDR     %I0.3
[%M104:16:=%KW0]             (Ex. 3)
```

Usage rules:
- For bit string -> word assignment: The bits in the string are transferred to the word starting on the right (first bit in the string to bit 0 in the word), and the word bits which are not involved in the transfer (length<16) are set to 0.
- For word -> bit string assignment: The word bits are transferred from the right (word bit 0 to the first bit in the string).

## Bit String Assignments

Syntax for bit string assignments.

| Operator | Syntax | Operand 1 (Op1) | Operand 2 (Op2) |
|---|---|---|---|
| := | [Op1: = Op2 ]<br><br>Operand 1 (Op1) assumes the value of operand 2 (Op2) | %MWi,%QWi, %SWi %MWi[MWi], **%Mi:L, %Qi:L, %Si:L, %Xi:L** | Immediate value, %MWi, %KWi, %IW, %INWi, %QW, %QNWi, %SWi, %BLK.x, %MWi[MWi], %KWi[MWi], **%Mi:L,%Qi:L, %Si:L, %Xi:L, %Ii:L** |

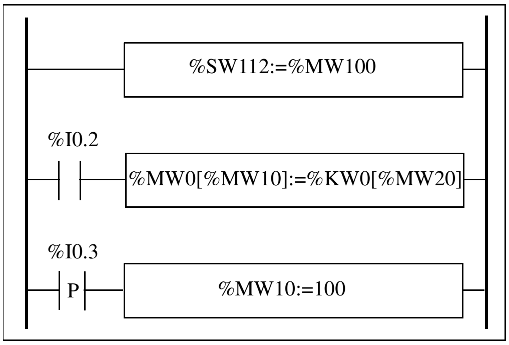
**Note:** The abbreviation %BLK.x (for example, %C0.P) is used to describe any function block word.

## Assignment of Words

Assignment operations can be performed on the following words:
- Word -> word (Example 1)
- Indexed word -> word
- Immediate value -> word (Example 3)
- Bit string -> word
- Word -> indexed word
- Indexed word -> indexed word (Example 2)
- Immediate value -> indexed word
- Word -> bit string

## Examples

Examples of word assignments.



```
LD      1
[%SW112:=%MW100]      (Ex. 1)

LD      %I0.2
[%MW0[%MW10]:=]       (Ex. 2)
%KW0[%MW20]

LDR     %I0.3         (Ex. 3)
[%MW10:=100]
```

## Syntax

Syntax for word assignments.

| Operator | Syntax | Operand 1 (Op1) | Operand 2 (Op2 ) |
|---|---|---|---|
| := | [Op1: = Op2 ]<br><br>Operand 1 (Op1) assumes the value of operand 2 (Op2) | **%BLK.x, %MWi, %QWi, %SWi %MWi[MWi]**, %Mi:L, %Qi:L, %Si:L, %Xi:L | **Immediate value, %MWi, %KWi, %IW, %QW, %SWi, %MWi[MWi], %KWi[MWi]**, %INW, %Mi:L, %Qi:L, %QNW, %Si:L, %Xi:L, %Ii:L |

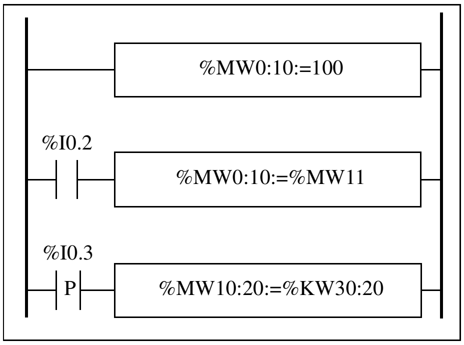
**Note:** The abbreviation %BLK.x (for example, R3.I) is used to describe any function block word. For bit strings %Mi:L, %Si:L, and %Xi:L, the base address of the first of the bit string must be a multiple of 8 (0, 8, 16, ..., 96, ...).

## Assignment of Word Tables

Assignment operations can be performed on the following word tables (see *Word Tables, p. 36*):
- Immediate value -> word table (Example 1)
- Word -> word table (Example 2)
- Word table -> word table (Example 3)
  Table length (L) should be the same for both tables.

## Examples

Examples of word table assignments:



```
LD      1
[%MW0:10:=100]              (Ex. 1)

LD      %I0.2
[%MW0:10:=%MW11]            (Ex. 2)

LDR     %I0.3
[%MW10:20:=%KW30:20]        (Ex. 3)
```

## Syntax

Syntax for word table assignments:

| Operator | Syntax | Operand 1 (Op1) | Operand 2 (Op2 ) |
|---|---|---|---|
| := | [Op1: = Op2 ] Operand 1 (Op1) assumes the value of operand 2 (Op2) | **%MWi:L, %SWi:L** | **%MWi:L, %SWi:L**, Immediate value, %MWi, %KWi, %IW, %QW, %SWi, %BLK.x |

**Note:** The abbreviation %BLK.x (for example, R3.I) is used to describe any function block word. For bit strings %Mi:L, %Si:L and %Xi:L, the base address of the first of the bit string must be a multiple of 8 (0, 8, 16, ..., 96, ...).

## Comparison Instructions

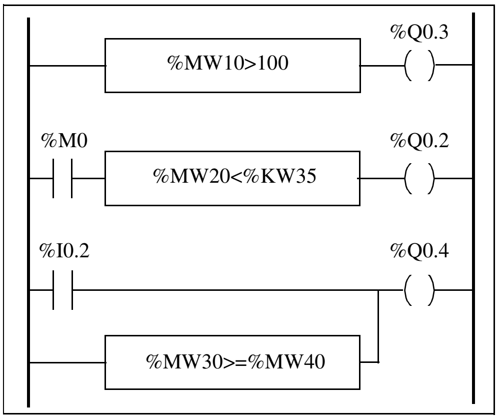
### Introduction

Comparison instructions are used to compare two operands.
The following table lists the types of Comparison instructions.

| Instruction | Function |
|---|---|
| > | Test if operand 1 is greater than operand 2 |
| >= | Test if operand 1 is greater than or equal to operand 2 |
| < | Test if operand 1 is less than operand 2 |
| <= | Test if operand 1 is less than or equal to than operand 2 |
| = | Test if operand 1 is equal than operand 2 |
| <> | Test if operand 1 is different than operand 2 |

### Structure

The comparison is executed inside square brackets following instructions LD, AND, and OR. The result is 1 when the comparison requested is true.
Examples of Comparison instructions.



```
LD    [%MW10 > 100]
ST    %Q0.3

LD    %M0
AND   [%MW20 < %KW35]
ST    %Q0.2

LD    %I0.2
OR    [%MW30>=%MW40]
ST    %Q0.4
```

## Syntax

Syntax for Comparison instructions.

| Operator | Syntax | Operand 1 (Op1) | Operand 2 (Op2) |
|---|---|---|---|
| >, >=, <, <=, =, <> | LD [Op1 Operator Op2]<br>AND [Op1 Operator Op2]<br>OR [Op1 Operator Op2] | %MWi, %KWi, %INWi, %IW, %QNWi, %QWi, %QNWi, %SWi, %BLK.x | Immediate value, %MWi, %KWi, %INWi, %IW, %QNWi, %QW, %SWi, %BLK.x, %MWi [%MWi], %KWi [%MWi] |

**Note:** Comparison instructions can be used within parentheses.

An example of using Comparison instruction within parentheses:

```
LD      %M0
AND(    [%MW20 > 10]
OR      %I0.0
)
ST      %Q0.1
```

## Arithmetic Instructions

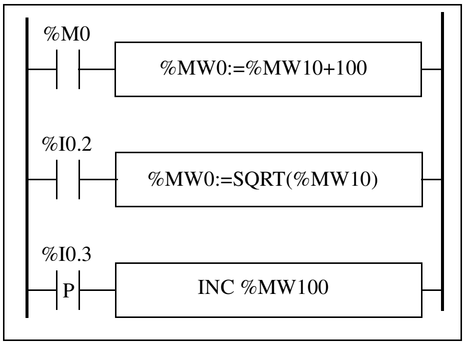
**Introduction**

Arithmetic instructions are used to perform arithmetic operations between two operands or on one operand.
The following table lists the types of Arithmetic instructions.

| Instruction | Function |
|---|---|
| + | Add two operands |
| - | Subtract two operands |
| * | Multiply two operands |
| / | Divide two operands |
| REM | Remainder of division of the two operands |
| SQRT | Square root of an operand |
| INC | Increment an operand |
| DEC | Decrement an operand |

**Structure**

Arithmetic operations are performed as follows:



```
LD      %M0
[%MW0:=%MW10 + 100]

LD      %I0.2
[%MW0:=SQRT(%MW10)]

LDR     %I0.3
[INC %MW100]
```

**Syntax**

The syntax depends on the operators used as shown in the table below.

| Operator | Syntax | Operand 1 (Op1) | Operands 2 and 3 (Op2 & 3) |
|---|---|---|---|
| +,-,*,/,REM | [Op1: = Op 2 Operator Op3] | %MWi, %QWi, %SWi | Immed.value (2), %MWi, %KWi, %INW, %IW, %QNW, %QW, %SWi, %BLK.x |
| SQRT (1) | [Op1: = SQRT(Op2)] | | |
| INC, DEC | [Operator Op1] | | |

**Note:** (1) With SQRT, Op2 cannot be an immediate value.

## Overflow and Error Conditions

**Addition**

- Overflow during operation
  If the result exceeds the limits of -32768 or +32767, bit %S18 (overflow) is set to 1. The result is then, in itself, not correct (see Example 1 on next page). The user program manages bit %S18.
- Absolute overflow of the result (unsigned arithmetic)
  During certain calculations, it may be necessary to interpret an operand in unsigned arithmetic (bit 15 then represents the value 32768). The maximum value for an operand is 65535. Adding two absolute values (unsigned) whose result is greater than 65535 causes an overflow. This is signaled by system bit %S17 (carry) changing to 1, which represents the value 65536.

**Subtraction**

- Negative result
  If the result of a subtraction is less than 0, system bit %S17 is set to 1.

**Multiplication**

- Overflow during operation
  If the result exceeds the capacity of the result word, bit %S18 (overflow) is set to 1 and the result is not significant.

**Division/Remainder**

- Division by 0
  If the divider is 0, the division is impossible and system bit %S18 is set to 1. The result is then incorrect.
- Overflow during operation
  If the division quotient exceeds the capacity of the result word, bit %S18 is set to 1.

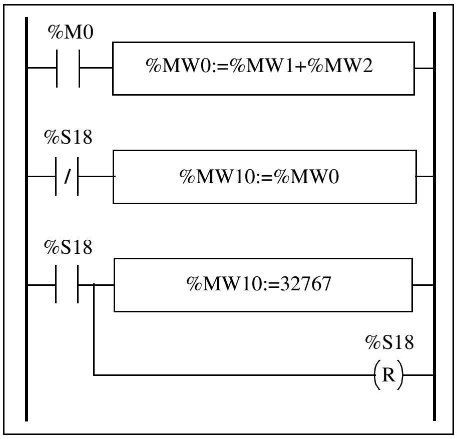
**Square root extraction**

- Overflow during operation
  Square root extraction is only performed on positive values. Thus, the result is always positive. If the square root operand is negative, system bit %S18 is set to 1 and the result is incorrect.

**Note:** The user program is responsible for managing system bits %S17 and %S18. These are set to 1 by the controller and must be reset by the program so that they can be reused (see previous page for example).

**Examples**

Example 1: overflow during addition.



```
LD      %M0
[%MW0:=%MW1 + %MW2]

LDN     %S18
[%MW10:=%MW0]

LD      %S18
[%MW10:=32767]
R       %S18
```

If %MW1 =23241 and %MW2=21853, the real result (45094) cannot be expressed in one 16-bit word, bit %S18 is set to 1 and the result obtained (-20442) is incorrect. In this example when the result is greater than 32767, its value is fixed at 32767.

Example 2: [%MW2:=%MW0 + %MW1] where %MW0 =65086, %MW1=65333 Word %MW2 contains the number 64883. Bit %S17 is set to 1 and represents the value 65536. The unsigned arithmetic result is then equal to: 65536 + 64883 = 130419.

Example 3: [%MW2:=%MW0 + %MW1] where %MW0 =45736 (that is, a signed value of -19800), %MW1=38336 (that is, a signed value of 27200). The two system bits %S17 and %S18 are set to 1. The signed arithmetic result (+18536) is incorrect. In unsigned arithmetic, the result (18536 + the value of %S17, which is 84072) is correct.

## Logic Instructions

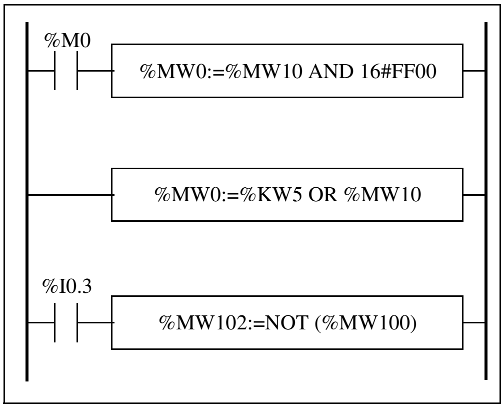
### Introduction

The Logic instructions are used to perform a logical operation between two word operands or on one word operand.
The following table lists the types of Logic instructions.

| Instruction | Function |
|---|---|
| AND | AND (bit-wise) between two operands |
| OR | Logic OR (bit-wise) between two operands |
| XOR | Exclusive OR (bit-wise) between two operands |
| NOT | Logic complement (bit-wise) of an operand |

### Structure

Logic operations are performed as follows:



```
LD      %M0
[%MW0:=%MW10 AND 16#FF00]

LD      1
[%MW0:=%KW5 OR %MW10]

LD      %I0.3
[%MW102:=NOT(%MW100)]
```

**Syntax**

The syntax depends on the operators used:

| **Operator** | **Syntax** | **Operand 1 (Op1)** | **Operands 2 and 3 (Op2 & 3)** |
|---|---|---|---|
| AND, OR, XOR | [Op1: = Op 2 Operator Op3] | %MWi, %QWi, %SWi | Immed.value (1), %MWi, %KWi, %IW, %QW, %SWi, %BLK.x |
| NOT | [NOT(Op2)] | | |

**Note:** (1) With NOT, Op2 cannot be an immediate value.

**Example**

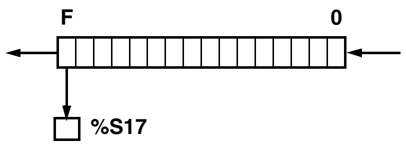
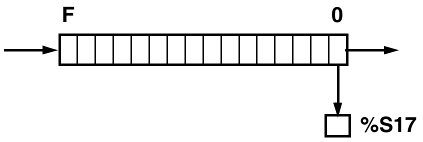
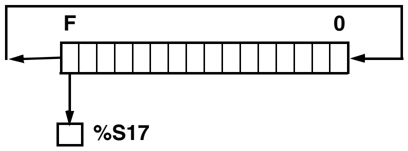
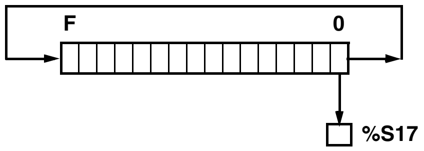
The following is an example of a logical AND instruction:

```
[%MW15:=%MW32 AND %MW12]
```

## Shift Instructions

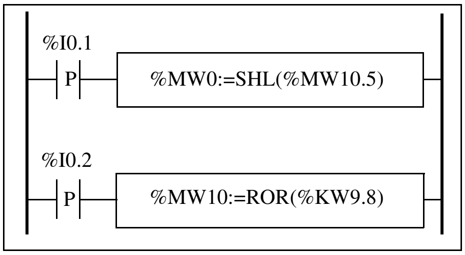
### Introduction

Shift instructions move bits of an operand a certain number of positions to the right or to the left.
The following table lists the types of Shift instructions.

| Instruction | Function | |
|---|---|---|
| Logic shift | | |
| SHL(op2,i) | logic shift of i positions to the left. |  |
| SHR(op2,i) | logic shift of i positions to the right. |  |
| Rotate shift | | |
| ROL(op2,i) | rotate shift of i positions to the left. |  |
| ROR(op2,i) | rotate shift of i positions to the right. |  |

**Structure**

Shift operations are performed as follows:



```
LDR     %I0.1
[%MW0 :=SHL(%MW10.5)]

LDR     %I0.2
[%MW10 :=ROR(%KW9.8)]
```

**Syntax**

The syntax depends on the operators used as shown in the table below.

| Operator | Syntax | Operand 1 (Op1) | Operand 2 (Op2) |
|---|---|---|---|
| SHL, SHR<br>ROL, ROR | [Op1: = Operator (Op2,i)] | %MWi, %QWi, %SWi | %MWi, %KWi, %IW, %QW, %SWi, %BLK.x |

## Conversion Instructions

**Introduction**

Conversion instructions perform conversion between different representations of numbers.
The following table lists the types of Conversion instructions.

| Instruction | Function |
|---|---|
| BTI | BCD --> Binary conversion |
| ITB | Binary --> BCD conversion |

**Review of BCD Code**

Binary Coded Decimal (BCD) represents a decimal digit (0 to 9) by coding four binary bits. A 16-bit word object can thus contain a number expressed in four digits (0000 - 9999).
During a conversion, if the value is not BCD, the system bit %S18 is set to 1. This bit must be tested and reset to 0 by the program.
BCD representation of decimal numbers:

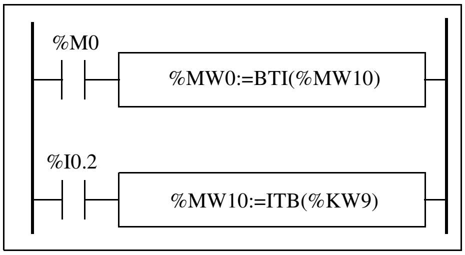
| Decimal | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| BCD | 0000 | 0001 | 0010 | 0011 | 0100 | 0101 | 0110 | 0111 | 1000 | 1001 |

Examples:
- Word %MW5 expresses the BCD value "2450" which corresponds to the binary value: 0010 0100 0101 0000
- Word %MW12 expresses the decimal value "2450" which corresponds to the binary value: 0000 1001 1001 0010

Word %MW5 is converted to word %MW12 by using instruction BTI.
Word %MW12 is converted to word %MW5 by using instruction ITB.

**Structure**

Conversion operations are performed as follows:



```
LD      %M0
[%MW0 :=BTI(%MW10)]

LD    %I0.2
[%MW10 :=ITB(%KW9)]
```

**Syntax**

The syntax depends on the operators used as shown in the table below.

| Operator | Syntax | Operand 1 (Op1) | Operand 2 (Op2) |
|---|---|---|---|
| BTI, ITB | [Op1: = Operator (Op2,i)] | %MWi, %QWi, %SWi | %MWi, %KWi, %IW, %QW, %SWi, %BLK.x |

**Application Examples**

The BTI instruction is used to process a setpoint value at controller inputs via BCD encoded thumb wheels.
The ITB instruction is used to display numerical values (for example, the result of a calculation, the current value of a function block) on BCD coded displays.

## 12.4 Program Instructions

### Introduction to Program Instructions

**Overview**

This section provides an introduction to Program Instructions.

**What's in this Section?**

This section contains the following topics:

## END Instructions

**Introduction**

The End instructions define the end of the execution of a program scan.

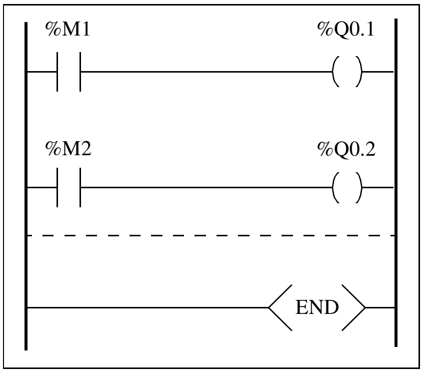
**END, ENDC, and ENDCN**

Three different end instructions are available:
- END: unconditional end of program
- ENDC: end of program if Boolean result of preceding test instruction is 1
- ENDCN: end of program if Boolean result of preceding test instruction is 0

By default (normal mode) when the end of program is activated, the outputs are updated and the next scan is started.
If scanning is periodic, when the end of period is reached the outputs are updated and the next scan is started.

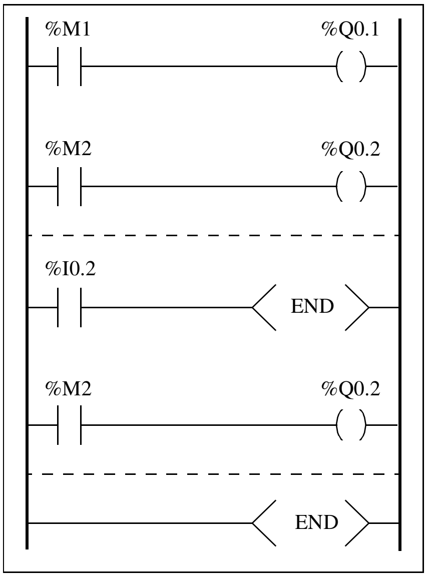
## Examples

Example of an unconditional END instruction.



```
LD      %M1
ST      %Q0.1
LD      %M2
ST      %Q0.2


..................


END
```

Example of a conditional END instruction.



```
LD      %M1
ST      %Q0.1
LD      %M2
ST      %Q0.2


..................


LD      %I0.2
ENDC
LD      %M2
ST      %Q0.2


..................

END
```

$\rightarrow$ If %I0.2 = 1, end of program scanning

If %I0.2 = 0, continues program scanning until new END instruction

## NOP Instruction

**NOP**

The NOP instruction does not perform any operation. Use it to "reserve" lines in a program so that you can insert instructions later without modifying the line numbers.

## Jump Instructions

**Introduction**

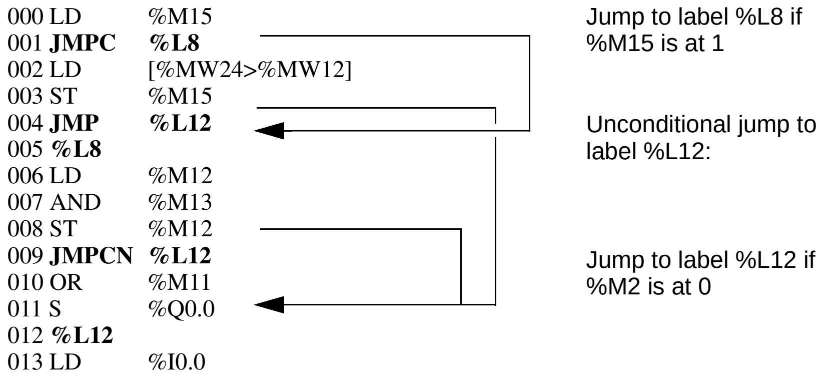
Jump instructions cause the execution of a program to be interrupted immediately and to be continued from the line after the program line containing label %Li (i = 0 to 15).

**JMP, JMPC and JMPCN**

Three different Jump instructions are available:
- JMP: unconditional program jump
- JMPC: program jump if Boolean result of preceding logic is 1
- JMPCN: program jump if Boolean result of preceding logic is 0

**Examples**

Examples of jump instructions.



```
000 LD      %M15
001 JMPC    %L8
002 LD      [%MW24>%MW12]
003 ST      %M15
004 JMP     %L12
005 %L8
006 LD      %M12
007 AND     %M13
008 ST      %M12
009 JMPCN   %L12
010 OR      %M11
011 S       %Q0.0
012 %L12
013 LD      %I0.0
```

Jump to label %L8 if %M15 is at 1
Unconditional jump to label %L12:
Jump to label %L12 if %M2 is at 0

**Guidelines**

- Jump instructions are not permitted between parentheses, and they must not be placed between the instructions AND(, OR(, and a close parenthesis instruction ")".
- The label can only be placed before a LD, LDN, LDR, LDF or BLK instruction.
- The label number of label %Li must be defined only once in a program.
- The program jump is performed to a line of programming which is downstream or upstream. When the jump is upstream, attention must be paid to the program scan time. Extended scan time can cause the watchdog timer to expire.

## Subroutine Instructions

**Introduction**

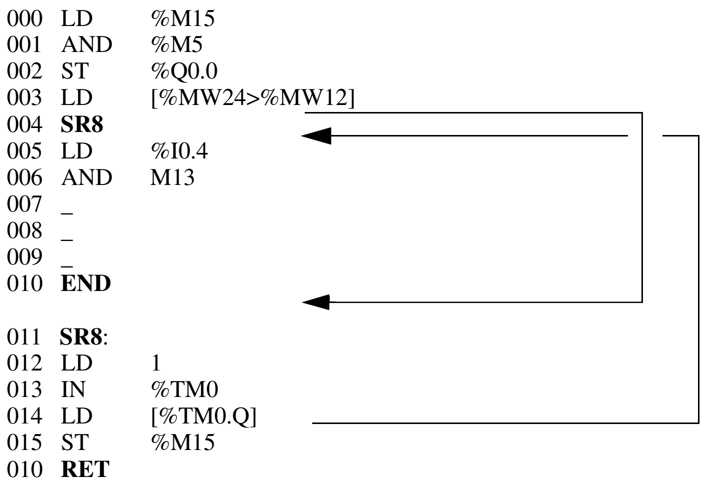
The Subroutine instructions cause a program to perform a subroutine and then return to the main program.

**SRn, SRn: and RET**

Subroutines consist of three steps:
- The **SRn** instruction calls the subroutine referenced by label SRn, if the result of the preceding Boolean instruction is 1.
- The subroutine is referenced by a label **SRn:** with n= 0 to 15 TWDLCAA10DRF, TWDLCAA16DRF and 0 to 63 for all other Controllers.
- The **RET** instruction placed at the end of the subroutine returns program flow to the main program.

**Example**

Examples of subroutine instructions.

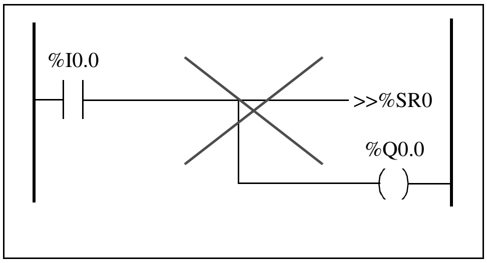


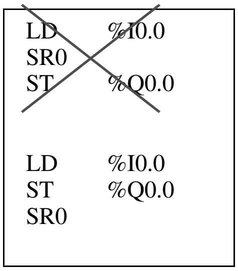
```
000  LD    %M15
001  AND   %M5
002  ST    %Q0.0
003  LD    [%MW24>%MW12]
004  SR8
005  LD    %I0.4
006  AND   M13
007  _
008  _
009  _
010  END

011  SR8:
012  LD    1
013  IN    %TM0
014  LD    [%TM0.Q]
015  ST    %M15
010  RET
```

**Guidelines**

- A subroutine should not call up another subroutine.
- Subroutine instructions are not permitted between parentheses, and must not be placed between the instructions AND(, OR(, and a close parenthesis instruction ")".
- The label can only be placed before a LD or BLK instruction marking the start of a Boolean equation (or rung).
- Calling the subroutine should not be followed by an assignment instruction. This is because the subroutine may change the content of the boolean accumulator. Therefore upon return, it could have a different value than before the call. See the following example.

Example of programming a subroutine.





~~LD %I0.0~~
~~SR0~~
~~ST %Q0.0~~

LD %I0.0
ST %Q0.0
SR0

# Advanced Instructions

# 13

## At a Glance

**Overview**

This chapter provides details about instructions and function blocks that are used to create advanced control programs for Twido programmable controllers.

**What's in this Chapter?**

This chapter contains the following sections:

## 13.1 Advanced Function Blocks

### At a Glance

**Overview**

This section provides an introduction to advanced function blocks including programming examples.

**What's in this Section?**

This section contains the following topics:

## Bit and Word Objects Associated with Advanced Function Blocks

**Introduction**

Advanced function blocks use similar types of dedicated words and bits as the basic function blocks, but require more programming experience than basic function blocks. Advanced function blocks include:
- LIFO/FIFO Registers (%R)
- Drum controllers (%DR)
- Fast counters (%FC
- Very fast counters (%VFC)
- Pulse width modulation output (%PWM)
- Pulse generator output (%PLS)
- Shift bit register (%SBR)
- Shift counter (%SC)
- Message control block (%MSG)

## Objects Accessible by the Program

The table below contains an overview of the words and bits associated with the various advanced function blocks. Please note that write access in the table below depends on the "Adjustable" setting selected during configuration. Setting this allows or denies access to the words or bits by TwidoSoft or the operator interface.

| **Advanced Function Block** | **Associated Words and Bits** | | **Address** | **Write Access** |
|---|---|---|---|---|
| %R | Word | Access to register | %Ri.I | Yes |
| | Word | Register output | %Ri.O | Yes |
| | Bit | Register output full | %Ri.F | No |
| | Bit | Register output empty | %Ri.E | No |
| %DR | Word | Current step number | %DRi.S | Yes |
| | Bit | Last step equals current step | %DRi.F | Yes |
| %FC | Word | Current Value | %FCi.V | No |
| | Word | Preset Value | %FCi.P | Yes |
| | Bit | Done | %FCi.D | No |
| %VFC | Word | Current Value | %VFCi.V | No |
| | Word | Preset Value | %VFCi.P | Yes |
| | Bit | Count Direction | %VFCi.U | NO |
| | Word | Catch Value | %VFCi.C | No |
| | Word | Threshold 0 Value | %VFCi.SO | Yes |
| | Word | Threshold 0 Value | %VFCi.S1 | Yes |
| | Bit | Overflow | %VFCi.F | No |
| | Bit | Frequency done | %VFCi.M | Yes |
| | Bit | Reflex Output 0 Enable | %VFCi.R | Yes |
| | Bit | Reflex Output 1 Enable | %VFCi.S | Yes |
| | Bit | Threshold Output 0 | %VFCi.TH0 | No |
| | Bit | Freq. Measure Time Base | %VFCi.T | Yes |
| %PWM | Word | Percentage of pulse at 1 in relationship to the total period. | %PWMi.R | Yes |
| | Word | Preset period | %PWMi.P | Yes |
| %PLS | Word | Number of Pulses | %PLSi.N | Yes |
| | Word | Preset value | %PLSi.P | Yes |
| | Bit | Current output enabled | %PLSi.Q | No |
| | Bit | Generation done | %PLSi.D | No |
| %SBR | Bit | Register Bit | %SBRi.J | No |
| %SC | Bit | Step counter Bit | %SCi.J | Yes |

| Advanced Function Block | Associated Words and Bits | | Address | Write Access |
|---|---|---|---|---|
| %MSG | Bit | Done | %MSGi.D | No |
| | Bit | Error | %MSGi.E | No |

## Programming Principles for Advanced Function Blocks

**Overview**

All Twido applications are stored in the form of List programs, even if written in the Ladder Editor, and therefore, Twido controllers can be called List "machines." The term "irreversibility" refers to the ability of TwidoSoft to represent a List application as Ladder and then back again. By default, all Ladder programs are reversible.
As with basic function blocks, advanced function blocks must also take into consideration reversibility rules. The structure of reversible function blocks in List language requires the use of the following instructions:

- **BLK**: Marks the block start and the input portion of the function block
- **OUT_BLK**: Marks the beginning of the output portion of the function block
- **END_BLK**: Marks the end of the function block

**Note:** The use of these reversible function block instructions is not mandatory for a properly functioning List program. For some instructions it is possible to program in List language without being reversible.

## Dedicated Inputs and Outputs

The Fast Counter, Very Fast Counter, PLS, and PWM advanced functions use dedicated inputs and outputs, but these bits are not reserved for exclusive use by any single block. Rather, the use of these dedicated resources must be managed. When using these advanced functions, you must manage how the dedicated inputs and outputs are allocated. TwidoSoft assists in configuring these resources by displaying input/output configuration details and warning if a dedicated input or output is already used by a configured function block (see the TwidoSoft Operation Guide).

The following tables summarizes the dependencies of dedicated inputs and outputs and specific functions.

When used with counting functions:

| **Inputs** | **Use** |
|---|---|
| %I0.0.0 | %VFC0: Up/Down management or Phase B |
| %I0.0.1 | %VFC0: Pulse input or Phase A |
| %I0.0.2 | %FC0: Pulse input or %VFC0 pre-set input |
| %I0.0.3 | %FC1: Pulse input or %VFC0 capture input |
| %I0.0.4 | %FC2: Pulse input or %VFC1 capture input |
| %I0.0.5 | %VFC1 pre-set input |
| %I0.0.6 | %VFC1: Up/Down management or Phase B |
| %I0.0.7 | %VFC1: Pulse input or Phase A |

When used with counting or special functions:

| **Outputs** | **Use** |
|---|---|
| %Q0.0.0 | %PLS0 or PWM0 output |
| %Q0.0.1 | %PLS1 or PWM1 output |
| %Q0.0.2 | Reflex outputs for %VFC0 |
| %Q0.0.3 | |
| %Q0.0.4 | Reflex outputs for %VFC1 |
| %Q0.0.5 | |

## Using Dedicated Inputs and Outputs

TwidoSoft enforces the following rules for using dedicated inputs and outputs.

- Each function block that uses dedicated I/O must be configured and then referenced in the application. The dedicated I/O is only allocated when a function block is configured and not when it is referenced in a program.
- After a function block is configured, its dedicated input and output cannot be used by the application or by another function block.
  For example, if you configure %PLS0, you can not use %Q0.0.0 in %DR0 (drum controller) or in the application logic (that is, ST %Q0.0.0).
- If a dedicated input or output is needed by a function block that is already in use by the application or another function block, this function block cannot be configured.
  For example, if you configure %FC0 as an up counter, you can not configure %VFC0 to use %I0.0.2 as capture input.

**Note:** To change the use of dedicated I/O, unconfigure the function block by setting the type of the object to "not used," and then remove references to the function block in your application.

## LIFO/FIFO Register Function Block (%Ri)

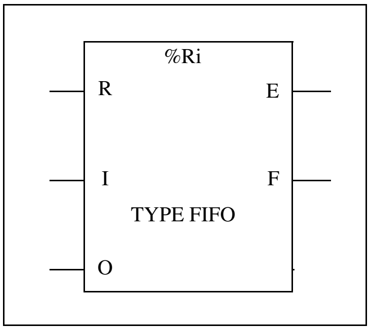
**Introduction**

A register is a memory block which can store up to 16 words of 16 bits each in two different ways:

- Queue (First In, First Out) known as FIFO
- Stack (Last In, First Out) know as LIFO

**Illustration**

The following is an illustration of the register function block.



Register function block

## Parameters

The register function block has the following parameters:

| Parameter | Label | Value |
|---|---|---|
| Register number | %Ri | 0 to 3 |
| Type | FIFO LIFO | Queue (default selection)<br>Stack |
| Input word | %Ri.I | Register input word. Can be read, tested, and written. |
| Output word | %Ri.O | Register output word. Can be read, tested, and written. |
| Storage Input (or instruction) | I (In) | On a rising edge, stores the contents of word %Ri.I in the register. |
| Retrieval Input (or instruction) | O (Out) | On a rising edge, loads a data word into word %Ri.O. |
| Reset Input (or instruction) | R (Reset) | At state 1, initializes the register. |
| Empty Output | E (Empty) | The associated bit %Ri.E indicates that the register is empty. Can be tested. |
| Full Output | F (Full) | The associated bit %Ri.F indicates that the register is full. Can be tested. |

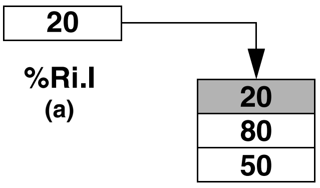
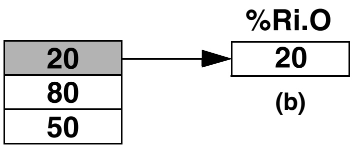
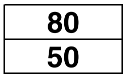
## LIFO Operation

**Introduction**

In LIFO operation (Last In, First Out), the last data item entered is the first to be retrieved.

**Operation**

The following table describes LIFO operation.

| Step | Description | Example |
|---|---|---|
| 1 | When a storage request is received (rising edge at input I or activation of instruction I), the contents of input word %Ri.I (which has already been loaded) are stored at the top of the stack (Fig. a). When the stack is full (output F=1), no further storage is possible. | Storage of the contents of %Ri.I at the top of the stack.  |
| 2 | When a retrieval request is received (rising edge at input O or activation of instruction O), the highest data word (last word to be entered) is loaded into word %Ri.0 (Fig. b). When the register is empty (output E=1) no further retrieval is possible. | Retrieval of the data word highest in the stack.  |
| 3 | Output word %Ri.O does not change and retains its last value. The stack can be reset at any time (state 1 at input R or activation of instruction R). The element indicated by the pointer is then the highest in the stack. |  |

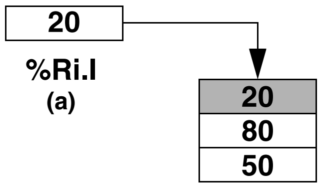
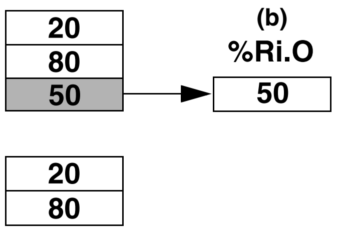
## FIFO Operation

**Introduction**

In FIFO operation (First In, First Out), the first data item entered is the first to be retrieved.

**Operation**

The following table describes FIFO operation.

| Step | Description | Example |
|---|---|---|
| 1 | When a storage request is received (rising edge at input I or activation of instruction I), the contents of input word %Ri.I (which has already been loaded) are stored at the top of the queue (Fig. a). When the queue is full (output F=1), no further storage is possible. | Storage of the contents of %Ri.I at the top of the queue.  |
| 2 | When a retrieval request is received (rising edge at input O or activation of instruction O), the data word lowest in the queue is loaded into output word %Ri.O and the contents of the register are moved down one place in the queue (Fig. b). When the register is empty (output E=1) no further retrieval is possible. | Retrieval of the first data item which is then loaded into %Ri.O.  |
| 3 | Output word %Ri.O does not change and retains its value. The queue can be reset at any time (state 1 at input R or activation of instruction R). | |

## Programming and Configuring Registers

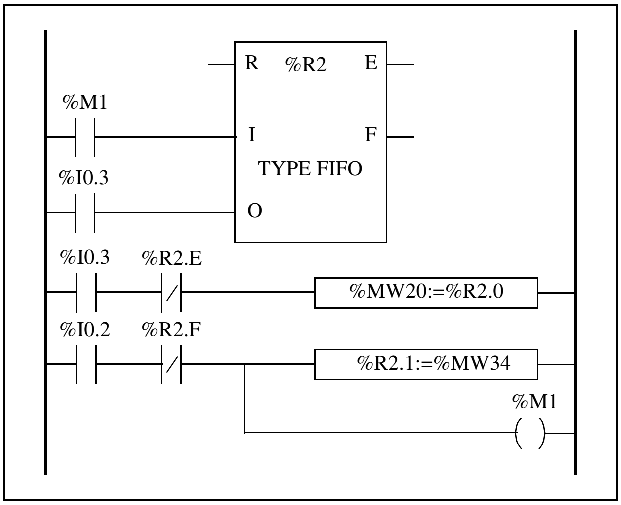
**Introduction**

The following programming example shows a memory word (%MW34) being loaded into a register (%R2.I) at the storage request %I0.2, if register %R2 is not full (%R2.F = 0). The storage request in the register is made by %M1. The retrieval request is made by input %I0.3, and %R2.O is loaded into %MW20, if the register is not empty (%R2.E = 0).

1. A storage request in the register is made by %M1.
2. A memory word (%MW34) is loaded into a register (%R2.I) A storage request at %I0.2, if register %R2 is not full (%R2.F = 0).
3. A storage request at %I0.2, if register %R2 is not full (%R2.F = 0).

**Programming Example**

The following illustration is a register function block with examples of reversible and non-reversible programming.



Ladder diagram

```
BLK           %R2
LD            %M1
I
LD            %I0.3
O
END_BLK
LD            %I0.3
ANDN          %R2.E
[%MW20:=%R2.0]
LD            %I0.2
ANDN          %R2.F
[%R2.1:=%MW34]
ST            %M1
```

Reversible program

```
LD            %M1
I             %R2
LD            %I0.3
O             %R2
ANDN          %R2.E
[%MW20:=%R2.0]
LD            %I0.2
ANDN          %R2.F
[%R2.1:=%MW34]
ST            %M1
```

Non-reversible program

## Configuration

The only parameter that must be entered during configuration is the type of register:

- FIFO (default), or
- LIFO

## Special Cases

The following table contains a list of special cases of programming and configuring registers.

| Special Case | Description |
|---|---|
| Effect of a cold restart (%S0=1) | Initializes the contents of the register. The output bit %Ri.E associated with the output E is set to 1. |
| Effect of a warm restart (%S1=1) of a controller stop | Has no effect on the current value of the register, nor on the state of its output bits. |

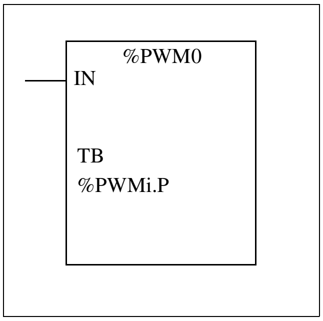
## Pulse Width Modulation Function Block (%PWM)

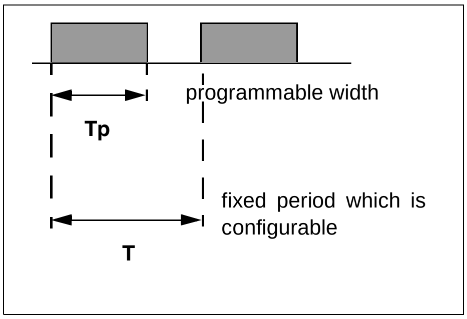
**Introduction**

The Pulse Width Modulation (%PWM) function block generates a square wave signal on dedicated output channels %Q0.0.0 or %Q0.0.1. The %PWM allows you to vary the signal width, or duty cycle. Controllers with relay outputs for these two channels do not support this function due to a frequency limitation.
There are two %PWM blocks available. %PWM0 uses dedicated output %Q0.0.0 and %PMW1 uses dedicated output %Q0.0.1. The %PLS function blocks contend to use these same dedicated outputs so you must choose between the two functions.

**Illustration**

PWM block and timing diagram:





## Parameters

The following table lists parameters for the PWM function block.

| Parameter | Label | Description |
|---|---|---|
| Time base | TB | 0.1ms[1], 10ms, 1s (default value) |
| Preset period | %PWMi.P | 0 < %PWMi.P <= 32767 with time base 10ms or 1sec<br>0 < %PWMi.P <= 255 with time base 0.57 ms or 0.142 ms<br>0 = Function not in use |
| Pulse ratio (Duty cycle) | %PWMi.R | This value gives the percentage of the signal in state 1 in a period. The width Tp is thus equal to:<br>Tp = T * (%PWMi.R/100). The user application writes the value for %PWMi.R. It is this word which controls the width modulation. For T definition, see "range of periods" below. The default value is 0 and values greater than 100 are considered to be equal to 100. |
| Pulse generation input | IN | At state 1, the pulse width modulation signal is generated at the output channel. At state 0, the output channel is set to 0. |

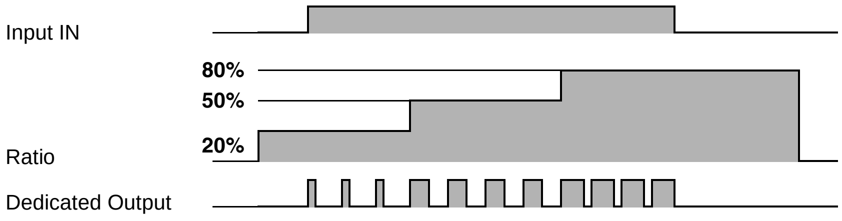
**Note:**
**1.** This time base is not advisable for Twido controllers with relay outputs.

## Range of Periods

The preset value and the time base can be modified during configuration. They are used to fix the signal period T=%PWMi.P * TB. The lower the ratios to be obtained, the greater the selected %PWMi.P must be. The range of periods available:
- 0.142 ms to 36.5 ms in steps of 0.142 ms (27.4Hz to 7kHz)
- 0.57 ms to 146 ms in steps of 0.57 ms (6.84Hz to 1.75kHz)
- 20 ms to 5.45 min in steps of 10 ms
- 2 sec to 9.1 hours in steps of 1 sec

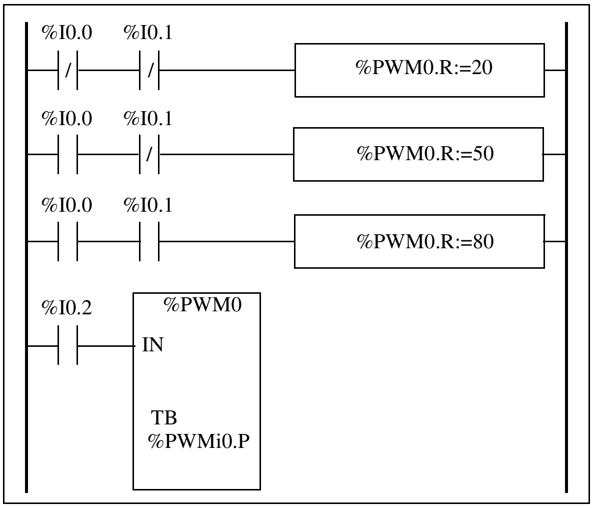
**Operation**

The frequency of the output signal is set during configuration by selecting the time base TB and the preset %PWMi.P. Modifying the % PWMi.R ratio in the program modulates the width of the signal. Below is an illustration of a pulse diagram for the PWM function block with varying duty cycles.
Pulse diagram for the PWM function block:



**Programming and Configuration**

In this example, the signal width is modified by the program according to the state of controller inputs %I0.0.0 and %I0.0.1.
If %I0.0.1 and %I0.0.2 are set to 0, the %PWM0.R ratio is set at 20%, the duration of the signal at state 1 is then: 20% x 500 ms = 100 ms.
If %I0.0.0 is set to 0 and %I0.0.1 is set to 1, the %PWM0.R ratio is set at 50% (duration 250 ms).
If %I0.0.0 and %I0.0.1 are set to 1, the %PWM0.R ratio is set at 80% (duration 400 ms).
Programming example:



```
LDN        %I0.0
ANDN       %I0.1
[%PWM0.R:=20]
LD         %I0.0
ANDN       %I0.1
[%PWM0.R:=50]
LD         %I0.0
AND        %I0.1
[%PWM0.R:=80]
BLK        %PWM0
LD         %I0.2
IN
END_BLK
```

## Special Cases

The following table contains a list of special cases for programming the PWM function block:

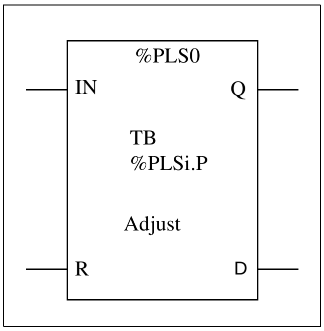
| Special Case | Description |
|---|---|
| Effect of a cold restart (%S0=1) | Sets the %PWMi.R ratio to 0. In addition, the value for %PWMi.P is reset to the configured value, and this will supersede any changes made with the Animations Table Editor or the optional Operator Display. |
| Effect of a warm restart (%S1=1) | Has no effect. |
| Using 0.142ms or 0.57ms time base | Forcing output %Q0.0.0 or %Q0.0.1 using a programming device does not stop the signal generation. |

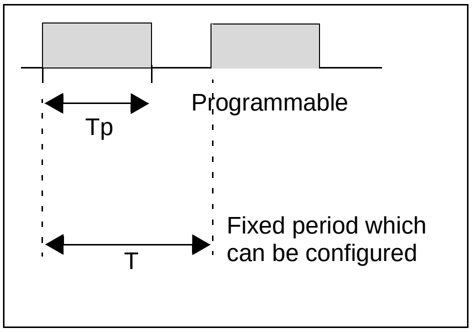
## Pulse Generator Output Function Block (%PLS)

**Introduction**

The %PWM function block is used to generate a square wave signal on a dedicated output channels %Q0.0.0 or %Q0.0.1. The %PWM allows you to vary the signal width, or duty cycle. Controller's with relay outputs for these two channels do not support this function due to a frequency limitation.
There are two %PWM blocks available. %PWM0 uses dedicated output %Q0.0.0 and %PMW1 uses dedicated output %Q0.0.1. The %PLS function blocks contend to use these same dedicated outputs so you must choose between the two.

**Representation**





## Characteristics

The table below contains the characteristics of the PLS function block:

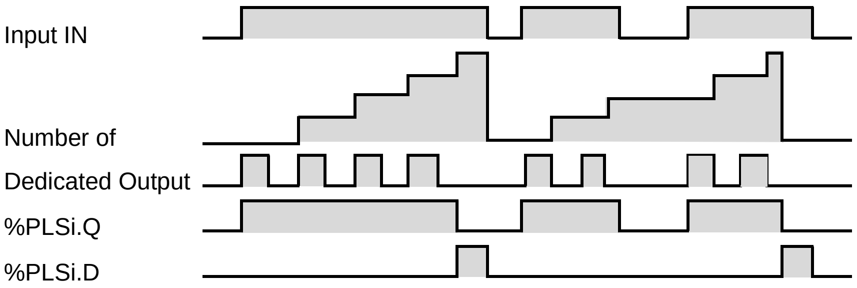
| Function | Object | Description |
|---|---|---|
| Time base | TB | 0.142 ms, 0.57 ms, 10ms, 1sec |
| Preset period | %PLSi.P | %PLS1 output does not stop pulsing when %PLS1.N is reached. This is only valid for %PLS0.<br>0 < %PLSi.P <= 32767 with time base 10ms or 1sec0 < %PLSi.P <= 255 with time base 0.57 ms or 0.142 ms0 = Function not in use |
| Number of pulses | %PLSi.N | The number of pulses to be generated in period T can be limited 0 < %PLSi.N < 32767. The default value is set to 0.<br>To produce an unlimited number of pulses, set %PLSi.N to zero. The number of pulses can always be changed irrespective of the Adjustable setting. |
| Adjustable | Y/N | If set to Y, it is possible to modify the preset value %PLSi.P via the HMI or Animation Tables Editor. Set to N means that there is no access to the preset. |
| Pulse generation input | IN | At state 1, the pulse generation is produced at the dedicated output channel. At state 0, the output channel is set to 0. |
| Reset input | R | At state 1, resets the number of pulses of outputs %PLSi.Q and %PLSi.D to zero. |
| Current pulse output generation | %PLSi.Q | At state 1, indicates that the pulse signal is generated at the dedicated output channel configured. |
| Pulse generation done output | %PLSi.D | At state 1, signal generation is complete. The number of desired pulses has been reached. |

## Range of Periods

The preset value and the time base can be modified during configuration. They are used to fix the signal period T=%PLSi.P * TB. The lower the ratios to be obtained, the greater the selected %PLSi.P must be. The range of periods available:
- 0.142 ms to 36.5 ms in steps of 0.142 ms (27.4Hz to 7kHz)
- 0.57 ms to 146 ms in steps of 0.57 ms (6.84Hz to 1.75kHz)
- 20 ms to 5.45 min in steps of 10 ms
- 2 sec to 9.1 hours in steps of 1 sec

## Operation

The following is an illustration of the pulse diagram of the %PLS function block.



## Special Cases

| Special case | Description |
|---|---|
| Effect of cold restart (%S0=1) | Sets the %PLSi.P to that defined during configuration |
| Effect of warm restart (%S1=1) | Has no effect |
| Effect of a controller stop | The output %Q0.0.0 or %Q0.0.1 is set to 0 regardless of the state of system bit %S8. |
| Effect of modifying the preset (%PLSi.P) | Takes effect immediately |
| Using 0.142ms or 0.57ms Time base | Forcing output %Q0.0.0 or %Q0.0.1 using a programming device does not stop the signal generation. |

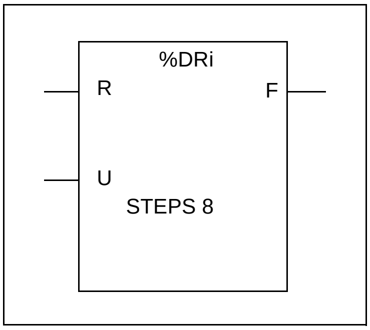
## Drum Controller Function Block (%DR)

**Introduction**

The drum controller operates on a principle similar to an electromechanical drum controller which changes step according to external events. On each step, the high point of a cam gives a command which is executed by the control system. In the case of a drum controller, these high points are symbolized by state 1 for each step and are assigned to output bits %Qi.j or internal bits %Mi, known as control bits.

**Illustration**

The following is an illustration of the drum controller function block.



Drum controller function block

## Parameters

The drum controller function block has the following parameters:

| Parameter | Label | Value |
|---|---|---|
| Number | %DRi | 0 to 3 Compact Controller0 to 7 Modular Controllers |
| Current step number | %DRi.S | 0-%DRi.S-7. Word which can be read and written. Written value must be a decimal immediate value. When written, the effect takes place on the next execution of the function block. |
| Number of steps | | 1 to 8 (default) |
| Return to step 0 input (or instruction) | R (Reset) | At state 1, sets the drum controller to step 0. |
| Advance input (or instruction) | U (Up) | On a rising edge, causes the drum controller to advance by one step and updates the control bits. |
| Output | F (Full) | Indicates that the current step equals the last step defined. The associated bit %DRi.F can be tested (for example, %DRi.F=1, if %DRi.S= number of steps configured - 1). |
| Control bits | | Outputs or internal bits associated with the step (16 control bits) and defined in the Configuration Editor. |

## Drum Controller Function Block Operation

**Introduction**

The drum controller consists of the following:

- A matrix of constant data (the cams) organized in eight steps (0 to 7) and 16 data bits (state of the step) arranged in columns numbered 0 to F.
- A list of control bits (one per column) corresponding either to outputs %Q0.i or %Q1.i, or to internal bits %Mi. During the current step, the control bits take on the binary states defined for this step.

The example in the following table summarizes the main characteristics of the drum controller.

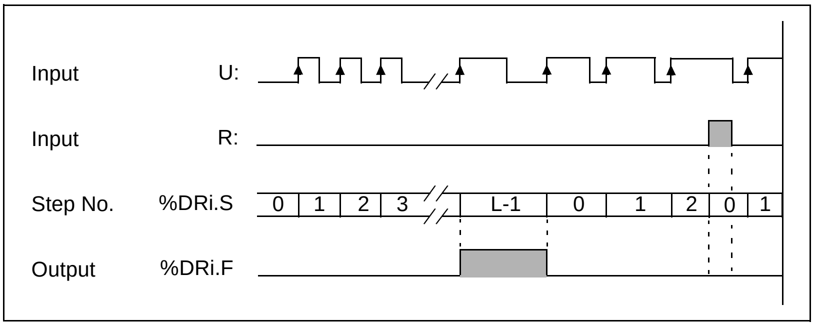
| **Column** | **0** | **1** | **2** | | **D** | **E** | **F** |
|---|---|---|---|---|---|---|---|
| Control Bits | %Q0.1 | %Q0.3 | %Q1.5 | | %Q0.6 | %Q0.5 | %Q1.0 |
| Step 0 | 0 | 0 | 1 | | 1 | 1 | 0 |
| Step 1 | 1 | 0 | 1 | | 1 | 0 | 0 |
| | | | | | | | |
| Step 5 | 1 | 1 | 1 | | 0 | 0 | 0 |
| Step 6 | 0 | 1 | 1 | | 0 | 1 | 0 |
| Step 7 | 1 | 1 | 1 | | 1 | 0 | 0 |

**Operation**

In the above example, step 5 is the current step, control bits %Q0.1, %Q0.3, and %Q1.5 are set to state 1; control bits %Q0.6, %Q0.5, and %Q1.0 are set to state 0. The current step number is incremented on each rising edge at input U (or on activation of instruction U). The current step can be modified by the program.

**Timing Diagram**

The following diagram shows the timing of the drum controller operation.



## Special Cases

The following table contains a list of special cases for drum controller operation.

| **Special Case** | **Description** |
|---|---|
| Effects of a cold restart (%S0=1) | Resets the drum controller to step 0 (updating the control bits). |
| Effect of a warm restart (%S1=1) | Updates the control bits after the current step. |
| Effect of a program jump | If the drum controller is not scanned, the control bits are not reset to 0. |
| Updating the control bits | Only occurs when there is a change of step or in the case of a warm or cold restart. |

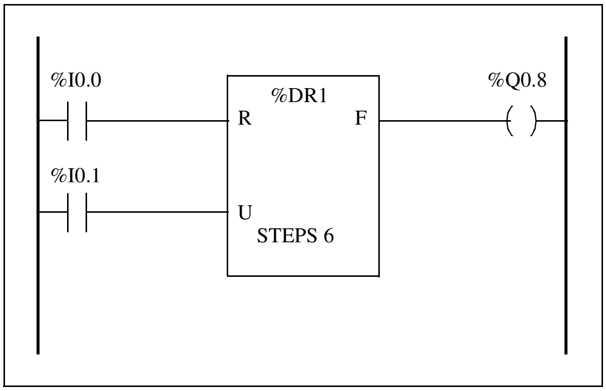
## Programming and Configuring Drum Controllers

**Introduction**

The following is an example of programming and configuring a drum controller. the first six outputs %Q0.0 to %Q0.5 are activated in succession each time input %I0.1 is set to 1. Input I0.0 resets the outputs to 0.

**Programming Example**

The following illustration is a drum controller function block with examples of reversible and non-reversible programming.



Ladder diagram

```
BLK       %DR1
LD        %I0.0
R
LD        %I0.1
U
OUT_BLK
LD        F
ST        %Q0.8
END_BLK
```

Reversible program

```
LD        %I0.0
R         %DR1
LD        %I0.1
U         %DR1
LD        %DR1.F
ST        %Q0.8
```

Non-Reversible program

**Configuration**

The following information is defined during configuration:
- The number of steps: 6
- The output states (control bits) for each drum controller step.

| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Step 1 : | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Step 2 : | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Step 3 : | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Step 4 : | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Step 5 : | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Step 6 : | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

- Assignment of the control bits.

| | | | |
|---|---|---|---|
| 1 : | %Q0.0 | 4 : | %Q0.1 |
| 2 : | %Q0.2 | 5 : | %Q0.3 |
| 3 : | %Q0.4 | 6 : | %Q0.5 |

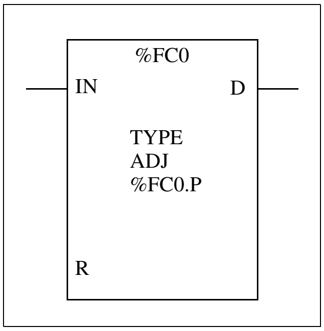
## Fast Counter Function Block (%FC)

**Introduction**

The Fast Counter function block (%FC) serves as either an up-counter or a down-counter. It can count the rising edge of digital inputs up to frequencies of 5kHz. Because the Fast Counters are managed by specific hardware interrupts, maintaining maximum frequency sampling rates may vary depending on your specific application and hardware configuration.
Compact controllers can be configured to use a maximum of three fast counters, while Modular controllers can only use a maximum of two. The Fast Counter function blocks %FC0, %FC1, and %FC2 use dedicated inputs %I0.0.2, %I0.0.3, and %I0.0.4 respectively. These bits are not reserved for their exclusive use. Their allocation must be considered with the use of other function blocks for these dedicated resources.

**Illustration**

The following is example of a Fast Counter function block.



**Parameters**

The following table lists parameters for the Fast Counter function block.

| **Parameter** | **Label** | **Description** |
|---|---|---|
| Direction | TYPE | Set at configuration, this can be set to either up-count or down-count. |
| Preset Value | %FCi.P | Initial value set between 1 and 65535. |
| Adjustable | Y/N | If set to Y, it is possible to modify the preset value %FCi.P and %FCi.V with the Operator Display or Animatio Tables Editor. If set to N, there is no access to the preset. |
| Current Value | %FCi.V | The current value counts increment or decrement according the up or down counting function selected. For up counting, the current value resets to zero and counts up to 65536. For down counting, the current value resets to the preset value %FCi.P, and counts down to zero. |
| Enable Input | IN | At state 1, the current value is updated according to the pulses applied to the physical input. At state 0, the current value is held at its last value. |
| Reset | %FCi.R | Used to initialize the block. At state 1, the current value is reset to 0 if configured as an up-counter, or set to %FCi.P if configured as a down-counter.The done bit %FCi.D is set back to its default value. |
| Done | %FCi.D | This bit is set to 1 when:%FCi.V reaches the %FCi.P configured as an up-counter%FCi.V reaches zero when configured as a down-counter.<br>This read-only bit is reset only by the setting %FCi.R to 1. |

**Special Note**

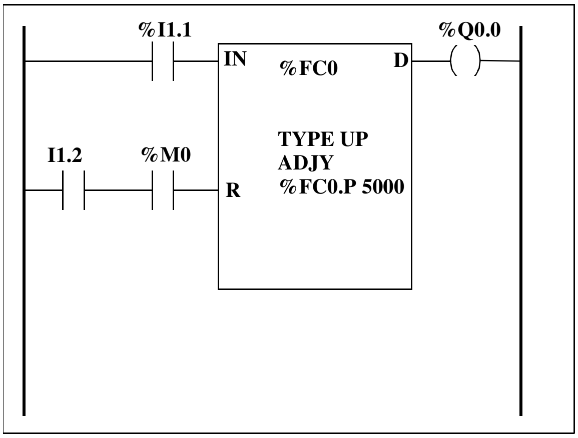
If configured to be adjustable, then the application can change the preset value %FCi.P and current value %FCi.V at any time. But, a new value is taken into account only if the input reset is active or at the rising edge of output %FCi.D. This allows for successive different counts without the loss of a single pulse.

**Operation**

If configured to up-count, when a rising edge appears at the dedicated input, the current value is incriminated by one. When the value is equal to the preset value %FCi.P, the Done output bit %FCi.D is set to 1 and zero is loaded into the current value %FCi.V.
If configured to down-count, when a rising edge appears at the dedicated input, the current value is decreased by one. When the value is zero, the Done output bit %FCi.D is set to 1 and the preset value is loaded into the current value %FCi.P.

**Configuration and Programming**

In this example, the application counts a number of items up to 5000 while %I1.1 is set to 1. The input for %FC0 is the dedicated input %I0.0.2. When the preset value is reached, %FC0.D is set on and remains there until %FC0.R is reset by the result of "ANDing" %I1.2 and %M0.



```
BLK        %FC0
LD         %I1.1
IN
LD         %I1.2
AND        %MO
R
OUT_BLK
LD D
ST %Q0.0
END_BLK
```

**Special Cases**

The following table contains a list of special cases for programming the %FC function block:

| Special Case | Description |
|---|---|
| Effect of cold restart (%S0=1) | Resets all the %FC attributes with the values configured by the user or user application. |
| Effect of warm restart (%S1=1) | Has no effect. |
| Effect of controller stop | The %FC continues to count with the attribute settings in effect at the time the controller was stopped. |

## Very Fast Counter Function Block (%VFC)

**Introduction**

The Very Fast Counter function block (%VFC) is configurable using TwidoSoft and performs any one of the following functions:
- Up/Down Counter
- Up/Down Two-Phase Counter
- Single Up Counter
- Single Down Counter
- Frequency Meter

The %VFC provides counting of digital inputs up to frequencies of 20 kHz. The Compact controllers can configure one very fast counter, while the Modular controllers can configure up to two very fast counters.

**Dedicated I/O Assignments**

The Very Fast Counter function blocks use dedicated inputs and auxiliary inputs and outputs. These inputs and outputs are not reserved for their exclusive use. Their allocation must be considered with the use of other function blocks for these dedicated resources. The following table summarizes these assignments:

| | | **Main inputs** | | **Auxiliary inputs** | | **Reflex outputs** | |
|---|---|---|---|---|---|---|---|
| **%VFC** | **Selected Use** | **First input (pulses) IA** | **Second Input (pulses or UP/DO) IB** | **Preset Input Ipres** | **Catch Input Ica** | **First Reflex Output** | **Second Reflex Output** |
| | UP/DOWN counter | %I0.0.1 (Pulses) | %I0.0.0 (Indicates UP=1/ DO=0) | %I0.0.2 Optional | %I0.0.3 Optional | %Q0.0.2 Optional | %Q0.0.3 Optional |
| | UP/DOWN Two-Phase counter | %I0.0.1 (Pulses) | %I0.0.0 (pulse phase B) | %I0.0.2 Optional | %I0.0.3 Optional | %Q0.0.2 Optional | %Q0.0.3 Optional |
| | Single UP counter | %I0.0.1 (Pulses) | Not Used | %I0.0.2 Optional | %I0.0.3 Optional | %Q0.0.2 Optional | %Q0.0.3 Optional |
| | Single DOWN counter | %I0.0.1 (Pulses) | Not Used | %I0.0.2 Optional | %I0.0.3 Optional | %Q0.0.2 Optional | %Q0.0.3 Optional |
| | Frequency counter | %I0.0.1 (Pulses) | Not Used | Not Used | Not Used | Not Used | Not Used |
| | UP/DOWN counter | %I0.0.7 (Pulses) | %I0.0.6 (Indicates UP=1/ DO=0) | %I0.0.5 Optional | %I0.0.4 Optional | %Q0.0.4 Optional | %Q0.0.5 Optional |
| | UP/DOWN Two-Phase counter | %I0.0.7 (Pulses) | %I0.0.6 (pulses phase B) | %I0.0.5 Optional | %I0.0.4 Optional | %Q0.0.4 Optional | %Q0.0.5 Optional |
| | Single UP counter | %I0.0.7 (Pulses) | Not Used | %I0.0.5 Optional | %I0.0.4 Optional | %Q0.0.4 Optional | %Q0.0.5 Optional |
| | Single DOWN counter | %I0.0.7 (Pulses) | Not Used | %I0.0.5 Optional | %I0.0.4 Optional | %Q0.0.4 Optional | %Q0.0.5 Optional |
| | Frequency meter | %I0.0.7 (Pulses) | Not Used | Not Used | Not Used | Not Used | Not Used |

Comments:

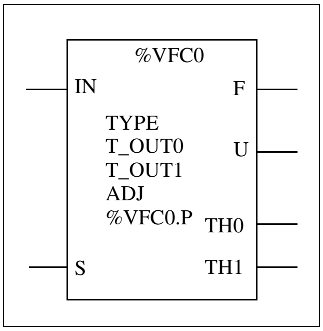
UP/DO = UP/DOWN
Opt. Use = Optional use

When not used, the input or output remains a normal digital I/O available to be managed by the application in the main cycle.

If %I0.0.2 is used %FC0 is not available.
If %I0.0.3 is used %FC2 is not available.
If %I0.0.4 is used %FC3 is not available.

## Illustration

Here is a block representation of the Very Fast Counter:



**Parameters**

The following table lists characteristics for the very fast counter function block.

| **Function** | **Description** | **Values** | **VFC Use**[4] | **Run-time Access** |
|---|---|---|---|---|
| Current Value (%VFCi.V) | Current value that is increased or decreased according to the physical inputs and the function selected. This value can be set or reset using Set Input (%VFCi.S). | 0 -> 65535 | CM | Read |
| Preset Value (%VFCi.P) | Only used by the up/down counting function and single up or down counting. | 0 -> 65535 | CM or FM | Read and Write[1] |
| Capture Value | Only used by the up/down counting function and single up or down counting. | 0 -> 65535 | CM | Read |
| Counting direction (%VFCi.U) | Set by the system, this bit is used by the up/down counting function to indicate to you the direction of counting. When set to 1, the counting is up and when set to 0 the counting is down.<br>As a single phase up or down counter, %I0.0.0 decides the direction for %VFC0 and %I0.0.6 for %VFC1.<br>For a two-phase up/down counter, it is the phase difference between the two signals that determines the direction. For %VFC0, %I0.0 is dedicated for IB and %I0.1 for IA. For %VFC1, %I0.6 is dedicated for IB and %I0.7 for IA. | 0 (Down)<br>1 (Up) | CM | Read |
| Enable Reflex Output 0 (%VFCi.R) | Enable Reflex Ouput 0 | 0 (Disable)<br>1 (Enable) | CM | Read and Write[2] |
| Enable Reflex Output 1 (%VFCi.S) | Enable Reflex Output 1 | 0 (Disable)<br>1 (Enable) | CM | Read and Write[2] |
| Threshold Value S0 (%VFCi.S0) | This word contains the value of threshold 0. The meaning is defined during configuration of the function block. Note that this value must be less than %VFCi.S1. | 0 -> 65535 | CM | Read and Write[2] |

| **Function** | **Description** | **Values** | **VFC Use**[4] | **Run-time Access** |
|---|---|---|---|---|
| Threshold Value S1 (%VFCi.S1) | This word contains the value of threshold 0. The meaning is defined during configuration of the function block. Note that this value must be greater than %VFCi.S0. | 0 -> 65535 | CM | Read and Write[1] |
| Frequency Measure Valid (%VFCi.M) | Bit used to determine if the controller has finished a frequency measurement. | 0 (Invalid)<br>1 (Valid) | FM | Read and Write |
| Frequency Measure Time Base (%VFCi.T) | Configuration item for 100 or 1000 millisecond time base. | 1000 or 100 | FM | Read and Write[1] |
| Adjustable (Y/N) | Configurable item that when selected, allows the user to modify the preset, threshold, and frequency measure time base values while running. | 0 (No)<br>1 (Yes) | CM or FM | No |
| Enable Input (IN) | Used to validate or inhibit the current function. | 0 (No) | CM or FM | Read and Write[3] |
| Set Input (S) | Depending on the configuration, at state 1:<br>● Up/Down or Down Counting: Set the current value to the preset value<br>● Single Up Counting: Resets the current value to zero<br>In addition, this also initializes the operation of the threshold outputs and takes into account any user modifications to the threshold values set by the Operator Display or user program. | 0 or 1 | CM or FM | Read and Write |
| Overflow Output (F) | Set to 1 if %VFCi.V passes from 0 to 65535 or 0 to 65535. This value is cleared by a setting the preset value using a digital input or the S instruction or a cold restart. | 0 or 1 | CM | Read |

| Function | Description | Values | VFC Use[4] | Run-time Access |
|---|---|---|---|---|
| Threshold Bit 0 (%VFCi.TH0) | Set to 1 when the current value is greater than or equal to the threshold value %VFCi.S0. It is advisable to test this bit only once in the program because it is updated in real time. The user application is responsible for the validity of the value at its time of use. | 0 or 1 | CM | Read |
| Threshold Bit 1 (%VFCi.TH1) | Set to 1 when the current value is greater than or equal to the threshold value %VFCi.S1. It is advisable to test this bit only once in the program because it is updated in real time. The user application is responsible for the validity of the value at its time of use. | 0 or 1 | CM | Read |

**Note:**
1. Writable only if Adjust is set to one.
2. Access available only if configured.
3. Read and write access only through the application, not the Operator Display or Animation Tables Editor.
4. CM = Counting Mode and FM = Frequency Meter Mode.

**Counting Function Description**

The very fast counting function works at a maximum frequency of 20 kHz, with a range of 0 to 65535. The pulses to be counted are applied in the following way:

| Function | Description | %VFC0 IA ... IB | | IA ... IB IA ... IB | |
|---|---|---|---|---|---|
| UP/Down Counter | The pulses are applied to the physical input, the current operation (increase/decrease) is given by the state of the physical input IB. | %I0.0.1 | %I0.0.0 | %I0.0.7 | %I0.0.6 |
| UP/Down 2-Phase Counter | The two phases of the encoder are applied to physical inputs IA and IB. | %I0.0.1 | %I0.0.0 | %I0.0.7 | %I0.0.6 |
| Single Up Counter | The pulses are applied to the physical input IA. (IB is not used). | %I0.0.1 | NA | %I0.0.7 | NA |
| Single Down Counter | The pulses are applied to the physical input IA. (IB is not used) | %I0.0.1 | NA | %I0.0.7 | NA |

**Notes on Function Blocks**

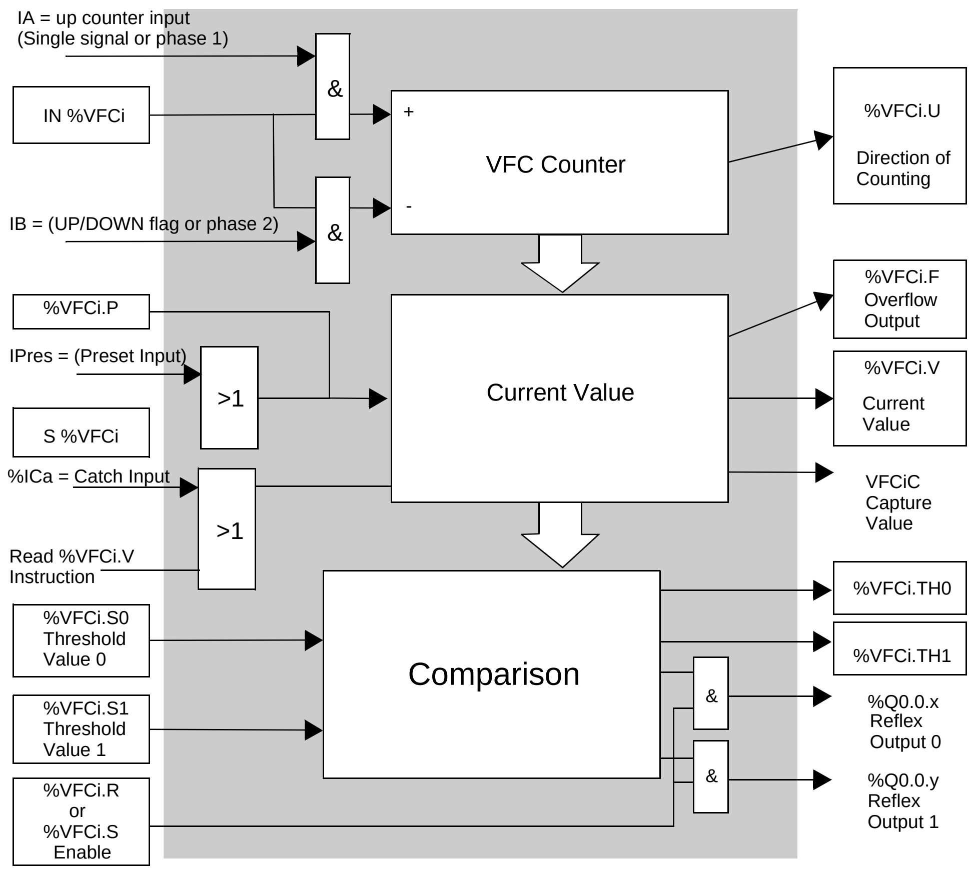
Increase or decrease operations are made on the rising edge of pulses, and only if the counting function is enabled.
There are two optional inputs used in counting mode: ICa and IPres. ICa is used to capture the current value (%VFCi.V) and stored it in %VFCi.C. The Ica inputs are specified as %I0.0.3 for %VFC0 and %I0.0.4 for %VFC1 if available.
When IPres input is active, the current value is effected in the following ways:
- For up counting, %VFCi.V is reset to 0
- For down-counting, %VFCi.V is set to %VFCi.P
- For frequency counting, %VFCi.V and VFCi.M are set to 0

Also note that %VFCi.F will be reset to zero. The IPres inputs are specified as %I0.0.2 for %VFC0 and %I0.0.5 for %VFC1 if available.

**Notes on Function Block Outputs**

For all functions, the current value is compared to two thresholds (%VFCi.S0 and % VFCi.S1). According to the result of this comparison two bit objects (%VFCi.TH0 and %VFCi.TH1) are set to 1 if the current value is greater or equal to the corresponding threshold, or reset to 0 in the opposite case. Reflex outputs (if configured) are set in accordance with these comparisons. Note that none, 1 or 2 outputs can be configured.
%VFC.U is an output of the FB, it gives the direction of the associated counter variation (1 for UP, 0 for DOWN).

## Counting Function Diagram

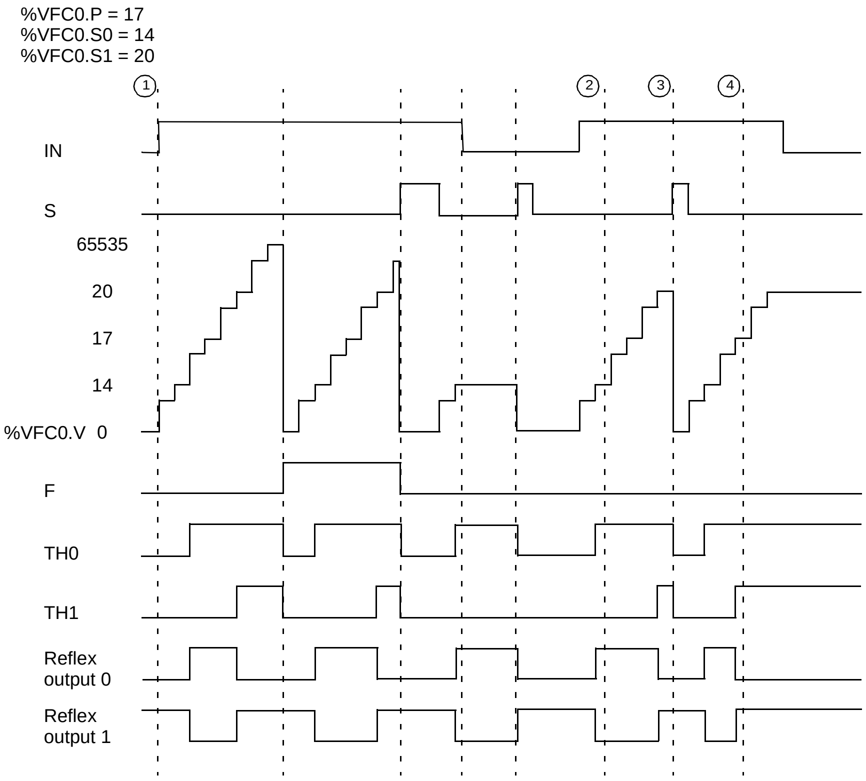


**Single Up Counter Operation**

The following is an example of using %VFC in a single up counter mode. The following configuration elements have been set for this example:
%VFC0.P preset value is 17%VFC0.S0, lower threshold value is 14, and %VFC0.S1 upper threshold is 20.

| **Reflex Output** | **<%VFC.S0** | **%VFC0.S0 <= < %VFC0.S1** | **>= %VFC0.S1** |
|---|---|---|---|
| %Q0.0.2 | | X | |
| %Q0.0.3 | X | | X |

A timing chart follows:



1 : %VFC0.U = 1 because VFC is an up-counter

2 : change %VFC0.S1 to 17

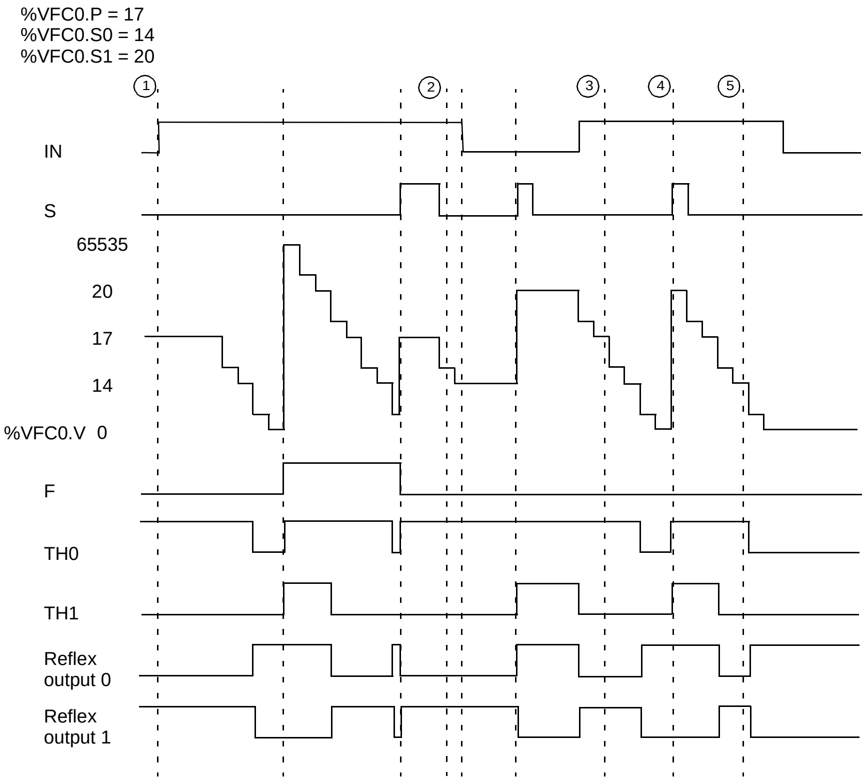
3 : S input active makes threshold S1 new value to be granted in next count

4 : a catch of the current value is made, so %VFC0.C = 17

**Single Down Counter Operation**

The following is an example of using %VFC in a single down counter mode. The following configuration elements have been set for this example:
%VFC0.P preset value is 17%VFC0.S0, lower threshold value is 14 %VFC0.S1, upper threshold is 20.

| **Reflex Output** | **<%VFC.S0** | **%VFC0.S0 <=  < %VFC0.S1** | **>= %VFC0.S1** |
|---|---|---|---|
| %Q0.0.2 | | X | |
| %Q0.0.3 | X | | X |



1 : %VFC0.U = 1 because VFC is a down-counter

2 : change %VFC0.P to 20

3 : change %VFC0.S1 to 17

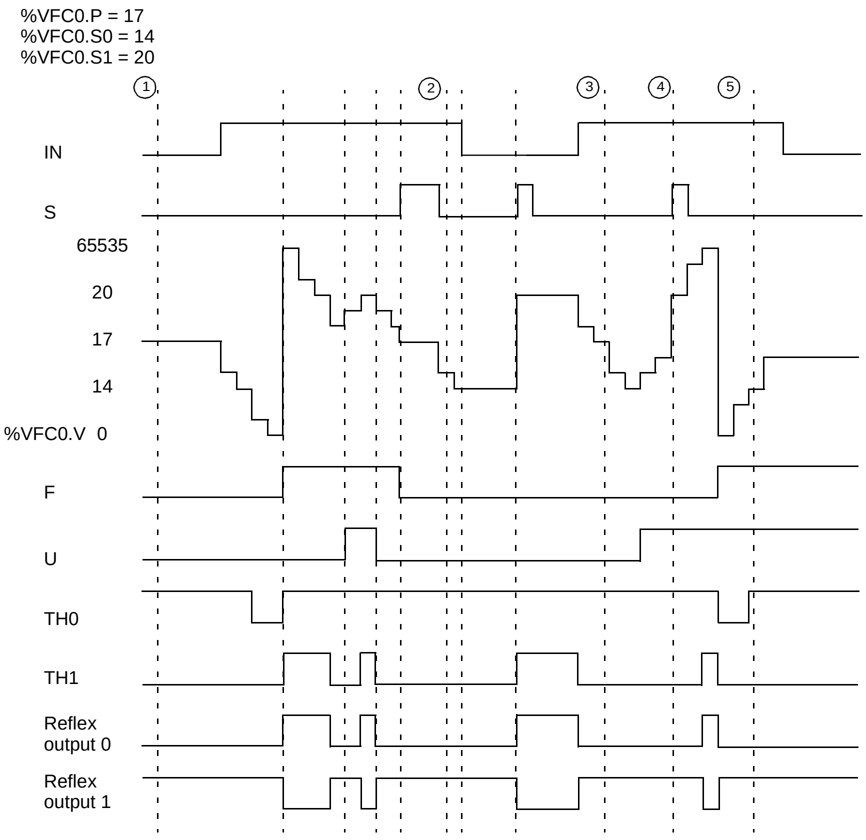
4 : S input active makes threshold S1 new value to be granted in next count

5 : a catch of the current value is made, so %VFC0.C = 17

**Up-Down Counter Operation**

The following is an example of using %VFC in an up-down counter mode. The following configuration elements have been set for this example:
%VFC0.P preset value is 17%VFC0.S0, lower threshold value is 14 %VFC0.S1, upper threshold is 20.

| **Reflex Output** | **<%VFC.S0** | **%VFC0.S0 <=< %VFC0.S1** | **%VFC0.S1** |
|---|---|---|---|
| %Q0.0.2 | | X | |
| %Q0.0.3 | X | | X |



(1) : %VFC0.U = 1 because VFC is a down-counter

(2) : change %VFC0.P to 20

(3) : change %VFC0.S1 to 17

(4) : S input active makes threshold S1 new value to be granted in next count

(5) : a catch of the current value is made, so %VFC0.C = 17

**Frequency Meter Function Description**

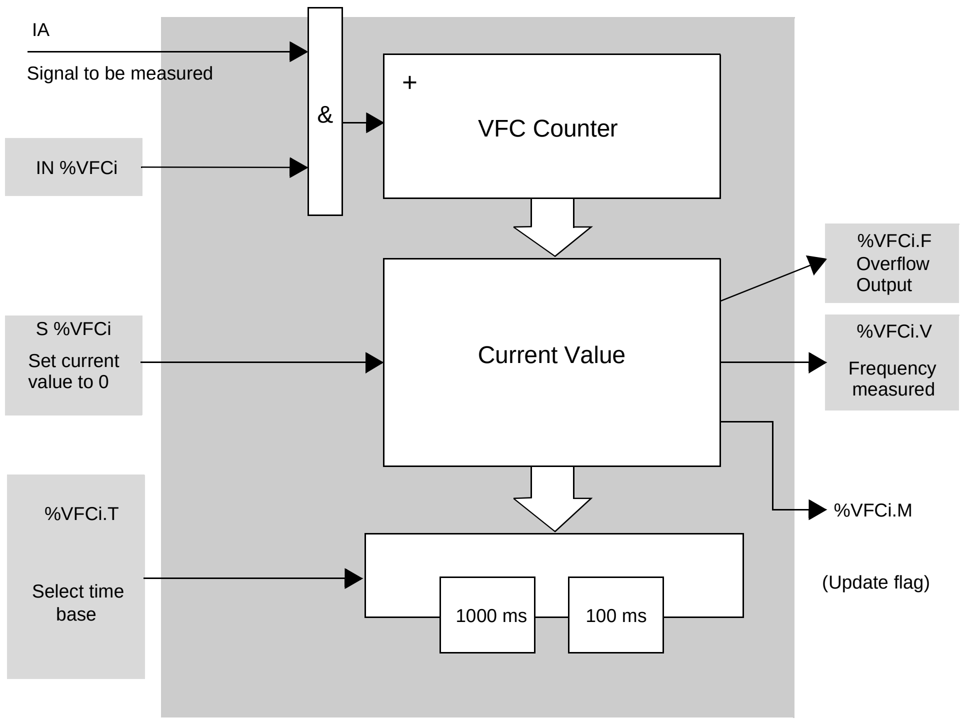
The frequency meter function of a %VFC is used to measure the frequency of a periodic signal in Hz on input IA . The frequency range which can be measured is from 10Hz to 20kHz. The user can choose between 2 time bases, the choice being made by a new object %VFC.T (Time base). A value of 100 = time base of 100 ms and a value of 1000 = time base of 1 second.

| Time Base | Measurement range | Precision | Update |
|---|---|---|---|
| 100 ms | 100 Hz to 20 Khz | 0.05% for 20kHz 10% for 100Hz | 10 times per second |
| 1 s | 10 Hz to 20 Khz | 0.005% for 20kHz 10% for 10Hz | Once per second |

The object %VFC.M (Frequency Measure Valid) is set to 1 to indicate that the measurement is complete.

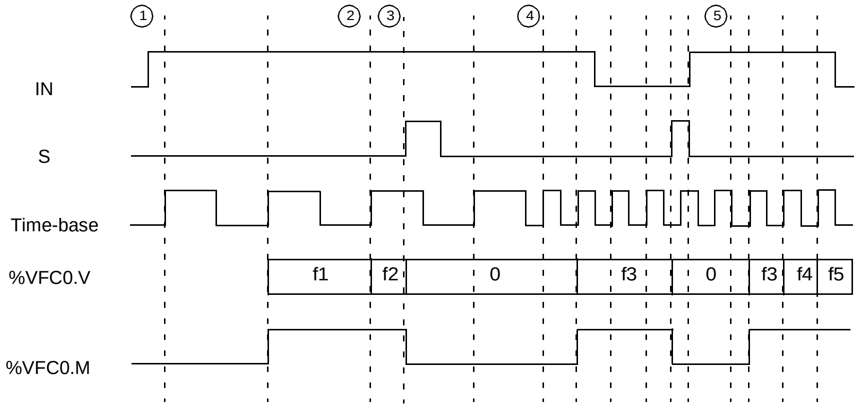
**Frequency Meter Function Diagram**

The following is a frequency meter function diagram:



## Frequency Meter Operation

The following is a timing diagram example of using %VFC in a frequency meter mode.



1 : The first frequency measurement starts here.

2 : The current frequency value is updated.

3 : S input active sets %VFC0.V to 0.

4 : Change %VFC0.T to 100 ms: this change cancels the current measurement and starts another one.

5 : %VFC0.M is set to 0 by the user.

## Special Cases

The following table contains a list of special cases for programming the %VFC function block:

| Special case | Description |
|---|---|
| Effect of cold restart (%S0=1) | Resets all the %VFC attributes with the values configured by the user or user application. |
| Effect of warm restart (%S1=1) | Has no effect |
| Effect of Controller stop | The %VFC stops its function and the outputs stay in their current state. |

## Transmitting/Receiving Messages - the Exchange Instruction (EXCH)

**Introduction**

A Twido controller can be configured to communicate with Modbus slave devices or can send and/or receive messages in character mode (ASCII).
TwidoSoft provides the following functions for these communications:

- EXCH instruction to transmit/receive messages
- Exchange control function block (%MSG) to control the data exchanges

The Twido controller uses the protocol configured for the specified port when processing an EXCH instruction. Each communications port can be configured for different protocols or the same, and the EXCH instruction or %MSG function block for each communications port is accessed by appending the port number (1 or 2).

**EXCH Instruction**

The EXCH instruction allows a Twido controller to send and/or receive information to/from ASCII devices. The user defines a table of words (%MWi:L or %KWi:L) containing the data to be sent and/or received (up to 64 data words in transmission and/or reception). The format for the word table is described in the paragraphs about each protocol. A message exchange is performed using the EXCH instruction.

**Syntax**

The following is the format for the EXCH instruction:
[EXCHx %MWi:L] or [EXCHx %KWi:L
Where: x = port number (1 or 2); L = Number of words in the word table. Values of the internal word table %MWi:L are such as i+L - 255.]
The Twido controller must finish the exchange from the first EXCHx instruction before a second exchange instruction can be started. The %MSG function block must be used when sending several messages.

## Exchange Control Function Block (%MSG)

**Introduction**

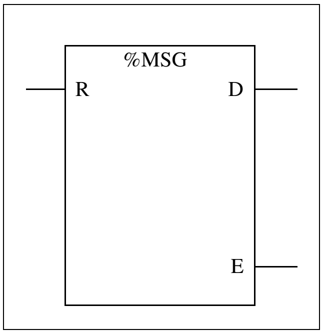
The %MSG function block manages data exchanges and has three functions:

- Communications error checking
  Error checking verifies that the block length (word table) programmed with the EXCH instruction is large enough to contain the length of the message to be sent (compare with length programmed in the least significant byte of the first word of the word table).
- Coordination of multiple messages
  To ensure coordination when sending multiple messages, the %MSG function block provides the information required to determine when a previous message is complete.
- Transmission of priority messages
  The %MSG function block allows current message transmissions to be stopped in order to allow the immediate sending of an urgent message.

The programming of the %MSG function block is optional.

**Illustration**

The following is an example of the %MSG function block.



**Parameters**

The following table lists parameters for the %MSG function block.

| Parameter | Label | Value |
|---|---|---|
| Reset input (or instruction) | R | At state 1, reinitializes communication: %MSG.E = 0, and %MSG.D = 1. |
| Comm. done output | %MSG.D | State 1, comm. done, if:<br>● End of transmission (if transmission)<br>● End of reception (end character received)<br>● Error<br>● Reset the block<br>State 0, request in progress. |
| Fault (Error) output | %MSG.E | State 1, comm. done, if:<br>● Bad command<br>● Table incorrectly configured<br>● Incorrect character received (speed, parity, etc.)<br>● Reception table full (not updated)<br>State 0, message length OK, link OK. |

If an error occurs when using an EXCH instruction, bits %MSG.D and %MSG.E are set to 1, and system word %SW63 contains the error code for Port 1, and %SW64 contains the error code for Port 2. See *System Words (%SW), p. 325*.

**Reset Input (R)**

When the Reset input is set to 1:
- Any messages that are being transmitted are stopped.
- The Fault (Error) output is reset to 0.
- The Done bit is set to 1.

A new message can now be sent.

**Fault (Error) Output (%MSG.E)**

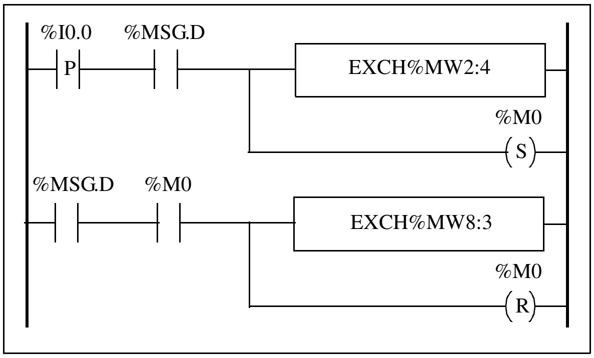
The error output is set to 1 either because of a communications programming error or a message transmission error. The error output is set to 1 if the number of bytes defined in the data block associated with the EXCH instruction (word 1, least significant byte) is greater than 128 (80 in hexadecimal).
The error output is also set to 1if a problem exists in sending a Modbus message to a Modbus device. In this case, the user should check wiring, and that the destination device supports Modbus communication.

**Communications Done output (%MSG.D)**

When the Done output is set to 1, the Twido controller is ready to send another message. Use of the %MSG.D bit is recommended when multiple messages are sent. If it is not used, messages may be lost.

## Transmission of Several Successive Messages

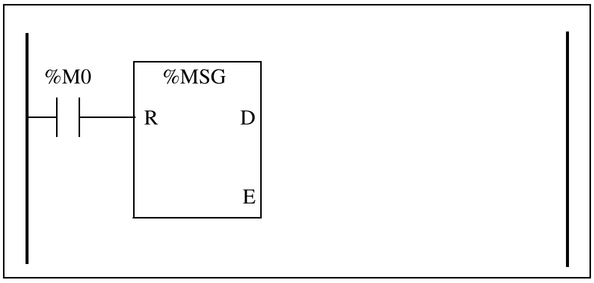
Execution of the EXCH instruction activates a message block in the application program. The message is transmitted if the message block is not already active (%MSG.D = 1). If several messages are sent in the same cycle, only the first message is transmitted. The user is responsible for managing the transmission of several messages using the program.
Example of a transmission of two messages in succession:



```
LDR     %I0.0
AND     %MSG.D
[EXCH %MW2:4]
S       %M0
LD      %MSG.D
AND     %M0
[EXCH %MW8:3]
R       %M0
```

## Reinitializing Exchanges

An exchange is cancelled by activating the input (or instruction) R. This input initializes communication and resets output %MSG.E to 0 and output %MSG.D to 1. It is possible to reinitialize an exchange if a fault is detected.
Example of reinitializing an exchange:



```
BLK     %MSG
LD      %M0
R
END_BLK
```

## Special Cases

The following table lists special cases for programming the %MSG function block.

| Special Case | Description |
|---|---|
| Effect of a cold restart (%S0=1) | Forces a reinitialization of the communication. |
| Effect of a warm restart (%S1=1) | Has no effect. |
| Effect of a controller stop | If a message transmission is in progress, the controller stops its transfer and reinitializes the outputs %MSG.D and %MSG.E. |

## 13.2 Clock Functions

### At a Glance

**Overview**

This section describes the time management functions for Twido controllers.

**What's in this Section?**

This section contains the following topics:

## Clock Functions

**Introduction**

Twido controllers have a time-of-day clock function, which requires the Real-Time Clock option (RTC) and provides the following:
- **Schedule blocks** are used to control actions at predefined or calculated times.
- **Time/date stamping** is used to assign time and dates to events and measure event duration.

The Twido time-of-day clock can be accessed by selecting **Schedule Blocks** from from the TwidoSoft **Software** menu. Additionally, the time-of-day clock can be set by a program. Clock settings continue to operate for up to 30 days when the controller is switched off, if the battery has been charged for at least six consecutive hours before the controller is switched off.
The time-of-day clock has a 24-hour format and takes leap years into account.

**RTC Correction Value**

The RTC Correction value is necessary for the correct operation of the RTC. Each RTC unit has its own correction value written on the unit. This value is configurable in TwidoSoft by using the **Configure RTC** option from the **Controller Operations** dialog box.

## Schedule Blocks

**Introduction**

Schedule Blocks are used to control actions at a predefined month, day, and time. A maximum of 16 schedule blocks can be used and do not require any program entry.

**Note:** Check system bit %S51 to confirm that the Real-Time Clock (RTC) option is installed see *System Bits (%S), p. 318*. The RTC option is required for using schedule blocks.

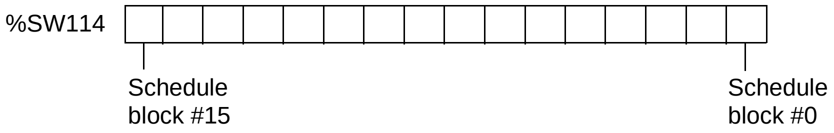
**Parameters**

The following table lists parameters for a schedule block:

| Parameter | Format | Function/Range |
|---|---|---|
| Schedule block number | n | n = 0 to 15 |
| Configured | Check box | Check this box to configure the selected schedule block number. |
| Output bit | %Qx.y.z | Output assignment is activated by schedule block: %Mi or %Qj.k.<br>This output is set to 1 when the current date and time are between the setting of the start of the active period and the setting of the end of the active period. |
| Start month | January to December | The month to start the schedule block. |
| End month | January to December | The month to end the schedule block. |
| Start date | 1 - 31 | The day in the month to start the schedule block. |
| End date | 1 - 31 | The day in the month to end the schedule block. |
| Start time | hh:mm | The time-of-day, hours (0 to 23) and minutes (0 to 59), to start the schedule block. |
| Stop time | hh:mm | The time-of-day, hours (0 to 23) and minutes (0 to 59), to end the schedule block. |
| Day of week | Monday - Sunday | Check boxes that identify the day of the week for activation of the schedule block. |

**Enabling Schedule Blocks**

The bits of system word %SW114 enable (bit set to 1) or disable (bit set to 0) the operation of each of the 16 schedule blocks.
Assignment of schedule blocks in %SW114:



By default (or after a cold restart) all bits of this system word are set to 1. Use of these bits by the program is optional.

**Output of Schedule Blocks**

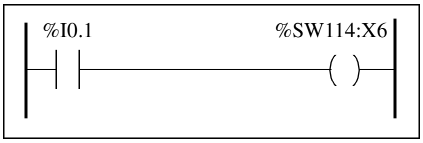
If the same output (%Mi or %Qj.k) is assigned by several blocks, it is the OR of the results of each of the blocks which is finally assigned to this object (it is possible to have several "operating ranges" for the same output).

## Example

The following table shows the parameters for a summer month spray program example:

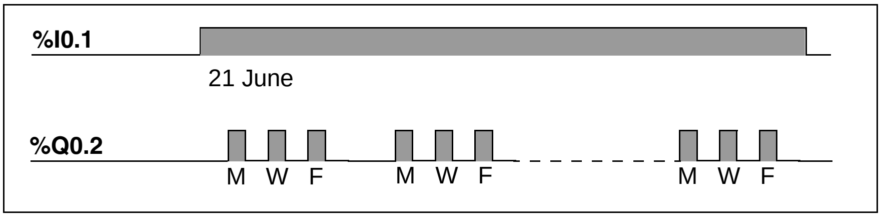
| Parameter | Value | Description |
|---|---|---|
| Schedule block | 6 | Schedule block number 6 |
| Output bit | %Qx.y.z | Activate output %Qx.y.z |
| Start month | June | Start activity in June |
| End month | September | Stop activity in September |
| Start date | 21 | Start activity on the 21st day of June |
| End date | 21 | Stop activity on the 21st day of September |
| Day of week | Monday, Wednesday, Friday | Run activity on Monday, Wednesday and Friday |
| Start time | 21:00 | Start activity at 21:00 |
| Stop time | 22:00 | Stop activity at 22:00 |

Using the following program, the schedule block can be disabled through a switch or a humidity detector wired to input %I0.1.



```
LD      %I0.1
ST      %SW114:X6
```

The following timing diagram shows the activation of output %Q0.2.



## Time Dating by Program

Date and time are both available in system words %SW50 to %SW53 (see *System Words (%SW), p. 325*). It is therefore possible to perform time and date stamping in the controller program by making arithmetic comparisons between the current date and time and the immediate values or words %MWi (or %KWi), which can contain setpoints.

## Time/Date Stamping

**Introduction**

System words %SW50 to %SW53 contain the current date and time in BCD format (see *Review of BCD Code, p. 246*, which is useful for display on or transmission to a peripheral device. These system words can be used to store the time and date of an event (see *System Words (%SW), p. 325*.

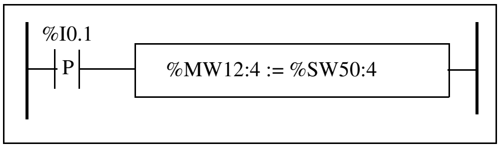
**Note:** Date and time and also be set by using the optional Operator Display (see *Time of Day Clock, p. 134*).

**Dating an Event**

To date an event it is sufficient to use assignment operations, to transfer the contents of system words to internal words, and then process these internal words (for example, transmission to display unit by EXCH instruction).

**Programming Example**

The following example shows how to date a rising edge on input %I0.1.



```
LDR      %I0.0
[%MW12:4 := %SW50:4]
```

Once an event is detected, the word table contains:

| Coding | Most significant byte | Least significant byte |
|---|---|---|
| %MW12 | Second | Day of the week (1) |
| %MW13 | Hour | Minute |
| %MW14 | Month | Day |
| %MW15 | Century | Year |

**Note:** (1)  0 = Monday, 1 = Tuesday, 2 = Wednesday, 3 = Thursday, 4 = Friday, 5 = Saturday, 6 = Sunday.

**Example of Word Table**

Example data for 13:40:30 on Monday, 19 April, 2002:

| Word | Value (hex) | Meaning |
|---|---|---|
| %MW12 | 3000 | 30 seconds, 00 = Monday |
| %MW13 | 1340 | 13 hours, 40 minutes |
| %MW14 | 0419 | 04 = April, 19th |
| %MW15 | 2002 | 2002 |

**Date and Time of Last Stop**

System words %SW54 to %SW57 contain the date and time of the last stop, and word %SW58 contains the code showing the cause of the last stop, in BCD format (see *System Words (%SW), p. 325*).

## Setting the Date and Time

**Introduction**

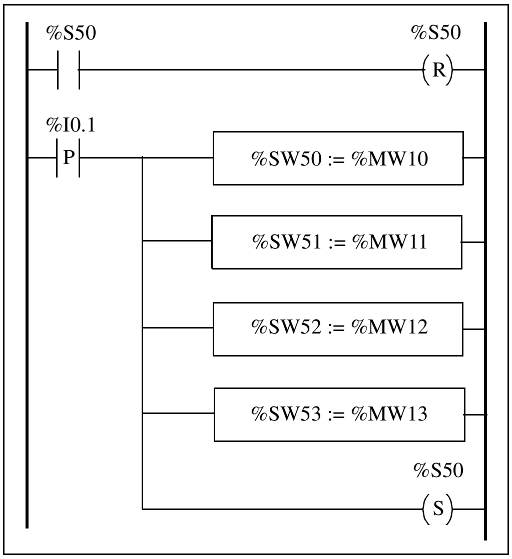
You can update the date and time settings by using one of the following methods:
- TwidoSoft
  Use the **Set Time** dialog box. This dialog is available from the **Controller Operations** dialog box which is displayed by selecting **Controller Operations** from the **Controller** menu (see the TwidoSoft Operation Guide).
- System words
  Use system words %SW50 to %SW53 or system word %SW59.

The date and time settings can only be updated when the RTC option cartridge (TWDXCPRTC) is installed on the controller.

**Using %SW 50 to %SW53**

To use system words %SW50 to %SW53 to set the date and time, bit %S50 must be set to 1, which results in the following:
- Cancels the update of words %SW50 to %SW53 via the internal clock.
- Transmits the values written in words %SW50 to %SW53 to the internal clock.

Programming example:



```
LD        %S50
R         %S50


LDR       %I0.1
[%SW50 := %MW10]
[%SW51 := %MW11]
[%SW52 := %MW12]
[%SW53 := %MW13]
S         %S50
```

Words %MW10 to %MW13 will contain the new date and time in BCD format (see *Review of BCD Code, p. 246*) and will correspond to the coding of words %SW50 to 53.
The word table must contain the new date and time:

| Coding | Most significant byte | Least significant byte |
|---|---|---|
| %MW10 | Second | Day of the week (1) |
| %MW11 | Hour | Minute |
| %MW12 | Month | Day |
| %MW13 | Century | Year |

**Note:** (1)  0 = Monday, 1 = Tuesday, 2 = Wednesday, 3 = Thursday, 4 = Friday, 5 = Saturday, 6 = Sunday.

Example data for Monday, 19 April, 2002:

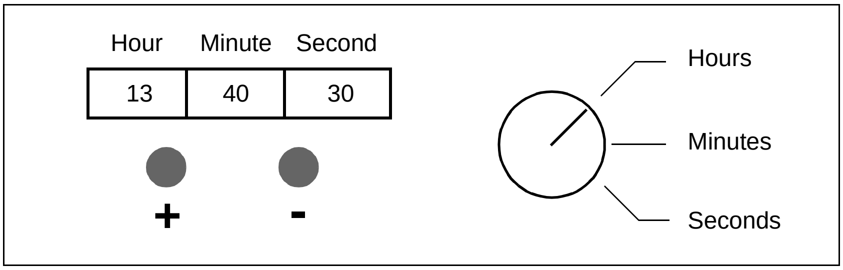
| Word | Value (hex) | Meaning |
|---|---|---|
| %MW10 | 3000 | 30 seconds, 00 = Monday |
| %MW11 | 1340 | 13 hours, 40 minutes |
| %MW12 | 0419 | 04 = April, 19th |
| %MW13 | 2002 | 2002 |

## Using %SW59

Another method of updating the date and time is to use system bit %S59 and date adjustment system word %SW59.
Setting bit %S59 to 1enables adjustment of the current date and time by word %SW59 (see *System Words (%SW), p. 325*). %SW59 increments or decrements each of the date and time components on a rising edge.

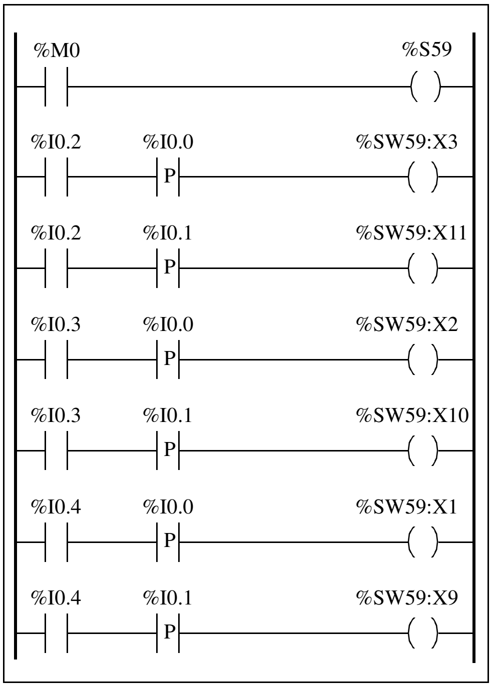
**Application Example**

The following front panel is created to modify the hour, minutes, and seconds of the internal clock.



Description of the controls:
- The Hours/Minutes/Seconds switch selects the time display to change using inputs %I0.2, %I0.3, and %I0.4 respectively.
- Push button "+" increments the selected time display using input %I0.0.
- Push button "-" decrements the selected time display using input %I0.1.

The following program reads the inputs from the panel and sets the internal clock.



```
LD      %M0
ST      %S59
LD      %I0.2           (Hour)
ANDR    %I0.0
ST      %SW59:X3
LD      %I0.2
ANDR    %I0.1
ST      %SW59:X11
LD      %I0.3           (Minute)
ANDR    %I0.0
ST      %SW59:X2
LD      %I0.3
ANDR    %I0.1
ST      %SW59:X10
LD      %I0.4           (Second)
ANDR    %I0.0
ST      %SW59:X1
LD      %I0.4
ANDR    %I0.1
ST      %SW59:X9
```

# System Bits and System Words

# 14

## At a Glance

**Overview**

This chapter provides an overview of the system bits and system words that can be used to create control programs for Twido controllers.

**What's in this Chapter?**

This chapter contains the following topics:

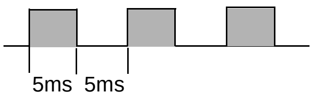
## System Bits (%S)

**Introduction**

The following section provides detailed information about the function of system bits and how they are controlled.

**Detailed Description**

The following table provides an overview over the system bits and how they are controlled:

| System Bit | Function | Description | Init State | Control |
|---|---|---|---|---|
| %S0 | Cold Start | Normally at 0. It is set to 1 by:<br>● A power return with loss of data (battery fault)<br>● The user program or Animation Table Editor<br>● Operator Display<br>This bit is set to 1 during the first complete scan. It is reset to 0 by the system before the next scan. | 0 | S or U->S |
| %S1 | Warm Start | Normally at 0. It is reset to 1 by:<br>● A power return with saving of data<br>● The user program or Animation Table Editor<br>● Operator Display<br>It is reset to 0 by the system at the end of the complete scan. | 0 | S or U->S |
| %S4<br>%S5<br>%S6<br>%S7 | Time base: 10 ms<br>Time base 100 ms<br>Time base 1 s<br>Time base 1 min | Changes in the status of these bits are controlled by an internal clock. They are not synchronized with the controller scan.<br>Example: %S4<br> | - | S |
| %S8 | Output freeze | Initially at 1, it can be set to 0 by the program or by the terminal (in the Animation Table Editor):<br>● At state 1, clears outputs during NO CONFIG state.<br>● At state 0, allows wiring tests during NO CONFIG state. | 1 | U |

| System Bit | Function | Description | Init State | Control |
|---|---|---|---|---|
| %S9 | Reset outputs | Normally not set. It can be set to 1 by the program or by the terminal (in the Animation Table Editor):<br>● At state 1, outputs are forced to 0 when the controller is in RUN mode.<br>● At state 0, outputs are updated normally. | 0 | U |
| %S10 | I/O fault | Normally at 1. It is set to 0 by the system when a I/O fault is detected. | 1 | S |
| %S11 | Watchdog overflow | Normally at 0, it is set to 1 by the system when the program execution time (scan time) exceeds the maximum scan time (software watchdog).<br>Watchdog overflow causes the controller to change to HALT. | 0 | S |
| %S12 | Controller running | This bit reflects the running state of the controller. The systems sets the bit to 1 when the controller is running, else 0 for stop, init, or any other state. | 0 | S |
| %S13 | First scan | Normally at 0, it is set to 1 by the system during the first scan after the controller has been changed to RUN. | 1 | S |
| %S17 | Carry overflow | Normally at 0, it is set to 1 by the system:<br>● In the case of carry overflow during a non-signed arithmetic operation (remainder)<br>● During a rotate or shift operation it indicates the output of a bit at 1. It must be tested by the user program after each operation where there is a risk of overflow, then reset to 0 by the user if an overflow occurs. | 0 | S->U |

| System Bit | Function | Description | Init State | Control |
|---|---|---|---|---|
| %S18 | Arithmetic overflow or error | Normally at 0. It is set to 1 in the case of an overflow when a 16 bit operation is performed, that is:<br>● A result greater than + 32767 or less than - 32768<br>● Division by 0<br>● The square root of a negative number<br>● BTI or ITB conversion not significant: BCD value out of limits<br>It must be tested by the user program, after each operation where there is a risk of an overflow, then reset to 0 by the user if an overflow occurs. | 0 | S->U |
| %S19 | Scan period overrun (periodic scan) | Normally at 0, this bit is set to 1 by the system in the event of a scan period overrun (scan time greater than the period defined by the user at configuration or programmed in %SW0).<br>This bit is reset to 0 by the user. | 0 | S->U |
| %S20 | Index overflow | Normally at 0, it is set to 1 when the address of the indexed object becomes less than 0 or more than the maximum size of an object.<br>It must be tested by the user program, after each operation where there is a risk of overflow, then reset to 0 if an overflow occurs. | 0 | S->U |
| %S21 | GRAFCET initialization | Normally at 0. It is set to 1 by:<br>● A cold restart, %S0=1<br>● The user program, in the preprocessing program part only, using a Set Instruction (S %S21) or a set coil -(S)- %S21.<br>● The terminal.<br>At state 1, it causes GRAFCET initialization. Active steps are deactivated and initial steps are activated.<br>It is reset to 0 by the system after GRAFCET initialization. | 0 | U->S |

| System Bit | Function | Description | Init State | Control |
|---|---|---|---|---|
| %S22 | GRAFCET RESET | Normally at 0, it can only be set to 1 by the program in pre-processing.<br>At state 1 it causes the active steps of the entire GRAFCET to be deactivated. It is reset to 0 by the system at the start of the execution of the sequential processing. | 0 | U->S |
| %S23 | Preset and freeze GRAFCET | Normally at 0, it can only be set to 1 by the user program in the pre-processing program module.<br>At state 1, it validates the presetting of the GRAFCET chart. Maintaining this bit at 1 freezes the GRAFCET (freezes the chart). It is reset to 0 by the system at the start of the execution of the sequential processing to ensure that the GRAFCET chart moves on from the frozen situation. | 0 | U->S |
| %S24 | Operator Display | Normally at 0, this bit can be set to 1 by the user.<br>● At state 0, the Operator Display is operating normally.<br>● At state 1, the Operator Display is frozen, stays on current display, blinking disabled, and input key processing stopped. | 0 | U->S |
| %S50 | Updating the date and time using words %SW50 to 53 | Normally at 0, this bit can be set to 1 or to 0 by the program or the Operator Display.<br>● At state 0, the date and time can be read.<br>● At state 1, the date and time can be updated. | 0 | U->S |

| System Bit | Function | Description | Init State | Control |
|---|---|---|---|---|
| %S51 | Time-of-day clock status | Normally at 0, this bit can be set to 1 or to 0 by the program or the Operator Display.<br>● At state 0, the date and time are set.<br>● At state 1, the date and time must be set by the user.<br>When this bit is set to 1, the time of day clock data is not valid. The date and time may never have been configured, the battery may be low, or the controller correction constant may be invalid.<br>State 1 transitioning to state 0 forces a write of the correction constant to the RTC. | 0 | U->S |
| %S59 | Updating  the date and time using word %SW59 | Normally at 0, this bit can be set to 1 or to 0 by the program or the Operator Display.<br>● At state 0, the date and time remain unchanged.<br>● At state 1, the date and time are incremented or decremented according to the control bits set in %SW59. | 0 | U |
| %S69 | User STAT LED display | At state 0, STAT LED is off<br>At state 1, STAT LED is on | 0 | U |
| %S70 | Refreshing data on AS-i bus | This bit is set on 1 by the system at the end of each controller cycle or at the end of AS-i bus scanning cycle.<br>On power-up, it indicates that all data has been refreshed at least once and it is thus significant.<br>This bit is to be reset on 0 by the user. | 0 | S->U |
| %S73 | Switching to protect mode on AS-i bus | Normally on 0, this bit is set on 1 by the user to switch to protected mode on the AS-i bus. Before this, the bit must have already been on 1.<br>This bit will only be used in a wiring system test, and has no application within the controller. | 0 | S |

| System Bit | Function | Description | Init State | Control |
|---|---|---|---|---|
| %S74 | Saving configuration in AS-i bus | Normally on 0, this bit is set on 1 by the user to save the current configuration in the AS-i bus.<br>This bit will only be used in a wiring system test, and has no application within the controller. | 0 | S |
| %S96 | Backup program OK | This bit can be read at any time (either by the program or while adjusting), in particular after a cold start or a warm restart.<br>● At state 0, the backup program is invalid.<br>● At state 1, the backup program is valid. | 0 | S |
| %S97 | Save %MW OK | This bit can be read at any time (either by the program or while adjusting), in particular after a cold start or a warm restart.<br>● At state 0, save %MW is not OK.<br>● At state 1, save %MW is OK. | 0 | S |
| %S100 | TwidoSoft communications cable connection | Shows whether the TwidoSoft communication cable is connected.<br>● At state 1, TwidoSoft communications cable is either not attached or TwidoSoft is connected.<br>● At state 0, TwidoSoft Remote Link cable is connected. | - | S |
| %S110 | Remote link exchanges | This bit is reset to 0 by the program or by the terminal.<br>● At state 1 for a master, all remote link exchanges (remote I/O only) are completed.<br>● At state 1 for a slave, exchange with master is completed. | 0 | S->U |

| System Bit | Function | Description | Init State | Control |
|---|---|---|---|---|
| %S111 | Single remote link exchange | • At state 0 for a master, a single remote link exchange is completed.<br>• At state 0 for a slave, single remote link exchange is detected.<br>• At state 1 for a master, single remote link exchange is active.<br>• At state 1 for a slave, single remote link exchange is detected. | 0 | S |
| %S112 | Remote link connection | • At state 0 for a master, the remote link is disabled.<br>• At state 1 for a master, the remote link is enabled. | 0 | U |
| %S113 | Remote link configuration/ operation | • At state  0 for a master or slave, the remote link configuration/operation is OK.<br>• At state 1 for a master, the remote link configuration/operation has an error.<br>• At state 1 for a slave, the remote link configuration/operation has an error. | 0 | S->U |
| %S118 | Remote I/O error | Normally at 1, it is set to 0 when an I/O fault is detected on the remote link. | 1 | S |
| %S119 | Local I/O error | Normally at 1, it is set to 0 when an I/O fault is detected on the local I/O (base or expansion). %SW118 determines the nature of the fault. Resets to 1 when the fault disappears. | 1 | S |

## Table Abbreviations Described

| Abbreviation | Description |
|---|---|
| S | Controlled by the system |
| U | Controlled by the user |
| U->S | Set to 1 by the user, reset to 0 by the system |
| S->U | Set to 1 by the system, reset to 0 by the user |

## System Words (%SW)

**Introduction**

The following section provides detailed information about the function of the system words and how they are controlled.

**Detailed Description**

The following table provides detailed information about the function of the system words and how they are controlled:

| System Word | Function | Description | Control |
|---|---|---|---|
| %SW0 | Controller scan period (periodic task) | Modifies controller scan period defined at configuration through the user program in the Animation Table Editor. | U |
| %SW6 | Controller state | Controller state:<br>0 = NO CONFIG<br>2 = STOPPED<br>3 = RUN<br>4 = HALT | S |
| %SW7 | Controller status | Bit [0] Backup/restore in progress<br>Bit [1] Controller configuration OK<br>Bit [3..2] EEPROM status bits:<br>● 00 = No cartridge<br>● 01 = 32 KB EEPROM cartridge<br>● 10 = 64 KB EEPROM cartridge<br>● 11 = Reserved for future use<br>Bit [4] Application in RAM different than EEPROM (1 = yes)<br>Bit [5] Application in RAM different than cartridge (1 = yes)<br>Bit [6] Some device tasks are in STOP mode<br>Bit [7] Controller reserved<br>Bit [8] Application in write protect mode<br>Bit [9] Unused<br>Bit [10] Second serial port installed<br>Bit [11] Second serial port type (0 = EIA RS-232, 1 = EIA RS-485)<br>Bit [12] Valid application in internal memory (1 = yes)<br>Bit [13] Valid application in cartridge (1 = yes)<br>Bit [14] Valid application in RAM (1 = yes)<br>Bit [15] Ready to run | S |
| %SW11 | Software watchdog time | Initializes to maximum watchdog time. The value (10 to 500 ms) is defined by the configuration. | U |

| System Word | Function | Description | Control |
|---|---|---|---|
| %SW18-<br>%SW19 | 100 ms absolute timer counter | 100 ms absolute timer counter.<br>**%SW18** represents the least significant bytes and **%SW19** represents the most significant bytes. | S and U |
| %SW30 | Last scan time | Shows execution time of the last controller scan cycle (in ms).<br>**Note:** This time corresponds to the time elapsed between the start (acquisition of inputs) and the end (update of outputs) of a scan cycle. | S |
| %SW31 | Max scan time | Shows execution time of the longest controller scan cycle since the last cold start (in ms).<br>**Note:** This time corresponds to the time elapsed between the start (acquisition of inputs) and the end (update of outputs) of a scan cycle. | S |
| %SW32 | Min scan time | Shows execution time of shortest controller scan cycle since the last cold start (in ms).<br>**Note:** This time corresponds to the time elapsed between the start (acquisition of inputs) and the end (update of outputs) of a scan cycle. | S |

| System Word | Function | Description | | Control |
|---|---|---|---|---|
| %SW49<br>%SW50<br>%SW51<br>%SW52<br>%SW53 | Schedule block function | Schedule block (RTC) function: words containing current date and time values (in BCD): | | S and U |
| | | %SW49 | xN Day of the week (N=0 for Monday) | |
| | | %SW50 | 00SS Seconds | |
| | | %SW51 | HHMM Hour and Minute | |
| | | %SW52 | MMDD Month and Day | |
| | | %SW53 | CCYY Century and Year | |
| | | These words are controlled by the system when bit **%S50** is at 0. These words can be written by the user program or by the terminal when bit **%S50** is set to 1. | | |

| System Word | Function | Description | | Control |
|---|---|---|---|---|
| %SW54<br>%SW55<br>%SW56<br>%SW57 | Schedule block function | Schedule block (RTC) function.<br>System words containing the date and time of the last power failure or controller stop (in BCD): | | S |
| | | %SW54 | SS Seconds | |
| | | %SW55 | HHMM Hour and minute | |
| | | %SW56 | MMDD Month and day | |
| | | %SW57 | CCYY Century and year | |
| %SW58 | Code of last stop | Displays code giving cause of last stop: | | S |
| | | 1 = | Run/Stop input edge | |
| | | 2 = | Stop at software fault (controller scan overshoot) | |
| | | 3 = | Stop command | |
| | | 4 = | Power outage | |
| | | 5 = | Stop at hardware fault | |

| System Word | Function | Description | | | Control |
|---|---|---|---|---|---|
| %SW59 | Adjust current date | Adjusts the current date.<br>Contains two sets of 8 bits to adjust current date.<br>The operation is always performed on rising edge of the bit. This word is enabled by bit **%S59**. | | | U |
| | | **Increment** | **Decrement** | **Parameter** | |
| | | bit 0 | bit 8 | Day of the week | |
| | | bit 1 | bit 9 | Seconds | |
| | | bit 2 | bit 10 | Minutes | |
| | | bit 3 | bit 11 | Hours | |
| | | bit 4 | bit 12 | Days | |
| | | bit 5 | bit 13 | Months | |
| | | bit 6 | bit 14 | Years | |
| | | bit 7 | bit 15 | Centuries | |
| %SW60 | RTC correction value | Real-Time Clock (RTC) correction value | | | U |

| System Word | Function | Description | Control |
|---|---|---|---|
| %SW63 | EXCH1 block error code | If an error occurs when using the EXCH block, output bits %MSG.D and %MSG.E change to 1. This system word contains the error code. The possible values are as follows:<br>● 0: No error, exchange correct<br>● 1: Transmission buffer too large<br>● 2: Transmission buffer too small<br>● 3: Table too small<br>● 4: Receive table overflow<br>● 5: Time - out elapsed<br>● 6: Transmission error<br>● 7: Bad ASCII command (ASCII mode only)<br>● 8: Selected port not configurable/available<br>● 9: Reception error (ASCII mode only)<br>● 10: Table %KWi prohibited<br>● 11: Transmission offset larger than transmission table<br>● 12: Reception offset larger than reception table<br>● 13: Controller stopped EXCH processing<br>This word is set to 0 every time the EXCH block is used. | S |
| %SW64 | EXCH2 block error code | Same as %SW63 | S |
| %SW67 | Function and type of controller | Contains the following information:<br>● Controller type bits [0 -11]<br>● 8B0 = TWDLCAA10DRF<br>● 8B1 = TWDLCAA16DRF<br>● 8B2 = TWDLMDA20DUK/DTK<br>● 8B3 = TWDLCAA24DRF<br>● 8B4 = TWDLMDA40DUK/DTK<br>● 8B6 = TWDLMDA20DRT<br>● Bit 12 not used = 0<br>● Remote link address bits [13-15]<br>● 000 = master controller<br>● 001 - 111 = remote controller 1-7<br>● 001 = address 1<br>● 111 = address 7 | S |

| System Word | Function | Description | Control |
|---|---|---|---|
| %SW76 to %SW79 | Down counters 1-4 | These 4 words serve as 1 ms timers. They are decremented individually by the system every ms if they have a positive value. This gives 4 down counters down counting in ms which is equal to an operating range of 1 ms to 32767 ms. Setting bit 15 to 1 can stop decrementing. | S and U |
| %SW96 | Command and/ or diagnostics for save/restore function of application program and %MW. | Bit [0] This bit is set by the User Logic to indicate that memory words, %MWi, need to be stored to EEPROM. The executive sets this bit back to 0 when the %MW store process has begun, not when it is finished.<br>Bit [1] This bit is set by the firmware to indicate when the save is complete. This means that when the bit is 1, any save request to EEPROM has completed. This bit is set to zero upon the next save to EEPROM request.<br>Bit [2] When set to 1, this indicates that an error has occurred during the last save or restore request. See bits 8, 9, 10, and 14 for additional information.<br>Bit [6] Controller contains a valid application (1 = yes).<br>Bit [8] Number of %MWs specified in %SW97 greater than the maximum number of memory words allowed by TwidoSoft (1 = yes).<br>Bit [9] Number of %MWs specified in %SW97 is greater than the maximum number of memory words allowed by TwidoSoft (1 = yes)<br>Bit [10] Difference between internal RAM and internal EEPROM (1 = yes).<br>Bit [14] EEPROM write fault has occurred (1 = yes). | |

| System Word | Function | Description | Control |
|---|---|---|---|
| %SW97 | Command or diagnostics for save/restore function | This value represents the physical number of memory words **%MW** to be saved to internal EEPROM only. It is not used in a restore of memory words.<br>When this number is 0, memory words will not be stored. The user must set the user logic program, otherwise it will be set to 0 in the controller application except for in the following case:<br>On cold start, this word is set on -1 if the internal Flash EEPROM has no saved memory word **%MW** file. In the case of a cold start where the internal Flash EEPROM contains a memory word **%MW** file, the value of the number of saved memory words in the file must be set in this system word **%SW97**. | U |

| System Word | Function | Description | Control |
|---|---|---|---|
| %SW111 | Remote link status | Two bits for each remote controller (master only):<br>x0-5:0 - remote controller 1-6 not present<br>1- remote controller 1-6 present<br>x6:0 - remote controller 7 not present<br>1 - remote controller 7 present<br>x8-13:0 - remote I/O detected at remote controller 1-6<br>1 - peer controller detected at remote controller 1-6x14:0 - remote I/O detected at remote controller 7<br>1 - peer controller detected at remote controller 7 | S |
| %SW112 | Remote link configuration/ operation error code | 0 - operations are successful<br>1 - timeout detected (slave)<br>2 - checksum error detected (slave)<br>3 - configuration mismatch (slave)<br>This is set by the system, and must be reset by the user. | S |

| System Word | Function | Description | Control |
|---|---|---|---|
| %SW113 | Remote link configuration | Two bits for each remote controller (master only):<br>x0-5:0 - remote controller 1-6 not configured<br>1 - remote controller 1-6 configured<br>x6:0 - remote controller 7 not configured<br>1 - remote controller 7 configured<br>x8-13:0 - remote I/O configured as remote controller 1-6<br>1 - peer controller configured as remote controller 1-6<br>x14:0 - remote I/O configured as remote controller 7<br>1 - peer controller configured as remote controller 7 | S |
| %SW114 | Enable schedule blocks (RTC) | Enables or disables operation of schedule blocks (RTC) by the user program or Operator Display.<br>Bit 0: 1 = enables schedule block #0<br>Bit 15: 1 = enables schedule block #15<br>Initially all schedule blocks are enabled, initial state is 0. If no schedule blocks are configured then the default value is FFFF. | S and U |
| %SW118 | Base controller status word | Shows faults detected on master controller.<br>Bit 9: 0= external fault or comm. Fault<br>Bit 12: 0= RTC not installed<br>Bit 13: 0= configuration fault (I/O extension configured but absent or faulty).<br>All the other bits of this word are set to 1 and are reserved. For a controller which has no fault, the value of this word is FFFFh. | S |
| %SW120 | Expansion I/O module health | One bit per module.<br>Address 0 = Bit 0<br>1 = Unhealthy<br>0 = OK | S |

## Table Abbreviations Described

| Abbreviation | Description |
|---|---|
| S | Controlled by the system |
| U | Controlled by the user |

# Glossary

## !

| | |
|---|---|
| **%** | Prefix that identifies internal memory addresses in the controller that are used to store the value of program variables, constants, I/O, and so on. |

## A

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|---|---|
| **Addresses** | Internal registers in the controller used to store values for program variables, constants, I/O, and so on. Addresses are identified with a percentage symbol (%) prefix. For example, %I0.1 specifies an address within the controller RAM memory containing the value for input channel 1. |
| **Analog Potentiometer** | An applied voltage that can be adjusted and converter into a digital value for use by an application. |
| **Analyze Program** | A command that compiles a program and checks for program errors: syntax and structure errors, symbols without corresponding addresses, resources used by the program that are not available, and if the program does not fit in available controller memory. Errors are displayed in the Program Errors Viewer. |
| **Animation Table** | Table created within an language editor or an operating screen. When a PC is connected to the controller, provides a view of controller variables and allows values to be forced when debugging. Can be saved as a separate file with an extension of .tat. |

| | |
|---|---|
| **Animation Tables Editor** | A specialized window in the TwidoSoft application for viewing and creating Animation Tables. |
| **Application** | A TwidoSoft application consists of a program, configuration data, symbols, and documentation. |
| **Application Browser** | A specialized window in the TwidoSoft that displays a graphical tree-like view of an application. Provides for convenient configuration and viewing of an application. |
| **Application file** | Twido applications are stored as file type .twd. |
| **ASCII** | American Standard Code for Information Interchange. A communication protocol that uses seven bits to represent alphanumeric characters including letters, numbers, and some graphical and control characters. |
| **Auto Line Validate** | When inserting or modifying List instructions, this optional setting allows for program lines to be validated as each is entered for errors and unresolved symbols. Each element must be corrected before you can exit the line. Selected using the Preferences dialog box. |
| **Auto Load** | A feature that is always enabled and provides for the automatic transfer of an application from a backup cartridge to the controller RAM in case of a lost or corrupted application. At power up, the controller compares the application that is presently in the controller RAM to the application in the optional backup memory cartridge (if installed). If there is a difference, then the copy in the backup cartridge is copied to the controller and the internal EEPROM. If the backup cartridge is not installed, then the application in the internal EEPROM is copied to the controller. |

## B

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|---|---|
| **Backup** | A command that copies the application in controller RAM into both the controller internal EEPROM and the optional backup memory cartridge (if installed). |

## C

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|---|---|
| **Coil** | A ladder diagram element representing an output from the controller. |

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|---|---|
| **Cold Start or Restart** | A start up by the controller with all data initialized to default values, and the program started from the beginning with all variables cleared. All software and hardware settings are initialized. A Cold Restart can be caused automatically by a power failure (Compact controllers only), or by loading a new application into controller RAM. All Compact controllers or any controller without battery backup always power up in Cold Start. |
| **Comment Lines** | In List programs, comments can be entered on separate lines from instructions. Comments lines do not have line numbers, and must be inserted within parenthesis and asterisks such as: (*COMMENTS GO HERE*). |
| **Comments** | Comments are text you enter to document the purpose of a program. For Ladder programs, enter up to three lines of text in the Rung Header to describe the purpose of the rung. Each line can consist of 1 to 64 characters. For List programs, enter text on n unnumbered program line. Comments must be inserted within parenthesis and asterisks such as: (*COMMENTS GO HERE*). |
| **Compact Controller** | Type of Twido controller that provides a simple, all-in-one configuration with limited expansion. Modular is the other type of Twido controller. |
| **Configuration Editor** | Specialized TwidoSoft window used to manage hardware and software configuration. |
| **Constants** | A memory unit such as a bit or word whose contents cannot be modified by the program being executed. |
| **Contact** | A ladder diagram element representing an input to the controller. |
| **Controller** | Twido programmable controller. There are two types of controllers: Compact and Modular. |
| **Counter** | A function block used to count events (up or down counting). |
| **Cross References** | Generation of a list of operands, symbols, line/rung numbers, and operators used in an application to simplify creating and managing applications. |
| **Cross References Viewer** | A specialized window in the TwidoSoft application for viewing cross references. |

## D

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|---|---|
| **Data Variable** | See Variable. |
| **Date/Clock Functions** | Allow control of events by month, day of month, and time of day. See Schedule Blocks. |
| **Drum Controller** | A function block that operates similar to an electromechanical drum controller with step changes associated with external events. |

## E

| | |
|---|---|
| **EEPROM** | Electrically Erasable Programmable Read-Only Memory. Twido has an internal EEPROM and an optional external EEPROM memory cartridge. |
| **Erase** | This command deletes application storage and has two options: delete the contents of the controller RAM, the controller internal EEPROM, and an installed optional backup cartridge; or, only delete the content of an installed optional backup cartridge. |
| **Executive Loader** | A 32-Bit Windows application used for downloading a new Firmware Executive program to a Twido controller. |
| **Expansion Bus** | Expansion I/O Modules connect to the base controller using this bus. |
| **Expansion I/O Modules** | Optional Expansion I/O Modules are available to add I/O points to a Twido controller. (Not all controller models allow expansion). |

## F

| | |
|---|---|
| **Fast Counters** | A function block that provides for faster up/down counting than available with the Counters function block. A Fast Counter can count up to a rate of 5 KHz. |
| **FIFO** | First In, First Out. A function block used for queue operations. |

| | |
|---|---|
| **Firmware Executive** | The Firmware Executive is the operating system that executes your applications and manages controller operation. |
| **Forcing** | Intentionally setting controller inputs and outputs to 0 or 1 values even if the actual values are different. Used for debugging while animating a program. |
| **Function Block** | A program unit of inputs and variables organized to calculate values for outputs based on a defined function such as a timer or a counter. |

## G

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|---|---|
| **Grafcet** | A program written in Grafcet language consists of steps containing a graphical and structured description of the operation of sequential automation. Simple graphic symbols are used to describe the sequence of steps. |

## I

| | |
|---|---|
| **Init** | A command that sets all data values to initial states. The controller must be in Stop or Error mode. |
| **Initial State** | The operating state of TwidoSoft that is displayed on the Status Bar when TwidoSoft is started or does not have an open application. |
| **Instance** | A unique object in a program that belongs to a specific type of function block. For example, in the timer format %TMi, i is a number representing the instance. |
| **Instruction List Language** | A program written in instruction list language (IL) is composed of a series of instructions executed sequentially by the controller. Each instruction is composed of a line number, an instruction code, and an operand. |

## L

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|---|---|
| **Ladder Editor** | Specialized TwidoSoft window used to edit a Ladder program. |

|  |  |
|---|---|
| **Ladder language** | A program written in Ladder language is composed of graphical representation of instructions of a controller program with symbols for contacts, coils, and blocks in a series of rungs executed sequentially by a controller. |
| **Ladder List Rung** | Displays parts of a List program that are not reversible to Ladder language. |
| **Latching input** | Incoming pulses are captured and recorded for later examination by the application. |
| **LIFO** | Last In, First Out. A function block used for stack operations. |
| **List Editor** | Simple program editor used to create and edit a List program. |

## M

|  |  |
|---|---|
| **Master Controller** | A Twido controller configured to be the Master on a Remote Link network. |
| **Memory Cartridge** | Optional Backup Memory Cartridges that can be used to backup and restore an application (program and configuration data). Two sizes are available: 32K bytes and 64K bytes. |
| **Memory Usage Indicator** | A portion of the Status Bar in the TwidoSoft main window that displays a percentage of total controller memory used by an application. Provides a warning when memory is low. |
| **Modbus** | A master-slave communications protocol that allows one single master to request responses from slaves. |
| **Modular Controller** | Type of Twido controller that offers flexible configuration with expansion capabilities. Compact is the other type of Twido controller. |
| **Monitor State** | The operating state of TwidoSoft that is displayed on the Status Bar when a PC is connected to a controller in a non-write mode. |

## O

|  |  |
|---|---|
| **Offline Operation** | An operation mode of TwidoSoft when a PC is not connected to the controller and the application in PC memory is not the same as the application in controller memory. You create and develop an application in Offline operation. |

| | |
|---|---|
| **Offline State** | The operating state of TwidoSoft that is displayed on the Status Bar when a PC is not connected to a controller. |
| **Online Operation** | An operation mode of TwidoSoft when a PC is connected to the controller and the application in PC memory is the same as the application in controller memory. You debug and adjust an application in Online operation. |
| **Online State** | The operating state of TwidoSoft that is displayed on the Status Bar when a PC is connected to the controller. |
| **Operand** | A number, address, or symbol representing a value that a program can manipulate in an instruction. |
| **Operating States** | Indicate the status of TwidoSoft and is displayed on the Status Bar. There are four operating states: Initial, Offline, Online, and Monitor. |
| **Operator** | A symbol or code specifying the operation to be performed by an instruction. |

## P

| | |
|---|---|
| **PC** | Personal Computer. |
| **Peer Controller** | A Twido controller configured as a slave on a Remote Link network. An application can be executed in the Peer Controller memory and the program can access both local and expansion I/O data, but I/O data can not be passed to the Master Controller. The program running in the Peer Controller passes information to the Master Controller by using network words (%INW and QNW). |
| **PLS** | Pulse Generation. A function block that generates a square wave with a 50% on and 50% off duty cycle. |
| **Preferences** | A dialog box with selectable options for setting up the List and Ladder program editors. |
| **Program Errors Viewer** | Specialized TwidoSoft window used to view program errors and warnings. |
| **Programmable Controller** | A Twido controller. There are two types of controllers: Compact and Modular. |

| | |
|---|---|
| **Protection** | Refers to two different types of application protection: password protection which provides access control, and controller application protection which prevents unauthorized viewing and copying of an application. |
| **PWM** | Pulse Width Modulation. A function block that generates a square wave with a variable duty cycle that can be set by a program. |

## R

| | |
|---|---|
| **RAM** | Random Access Memory. Twido applications are downloaded into internal volatile RAM to be executed. |
| **Real-Time Clock** | An option that will keep the time even when the controller is not powered for a limited amount of time. |
| **Reflex Output** | In a counting mode, the very fast counter's current value (%VFC.V) is measured against its configured thresholds to determine the state of these dedicated outputs. |
| **Registers** | Special registers internal to the controller dedicated to LIFO/FIFO function blocks. |
| **Remote Controller** | A Twido controller configured to communicate with a Master Controller on a Remote Link network. |
| **Remote Link** | High-speed master/slave bus designed to communicate a small amount of data between a Master Controller and up to seven Remote Controllers (slaves). There are two types of Remote Controllers that can be configured to transfer data to a Master Controller: a Peer Controller that can transfer application data, or a Remote I/O Controller that can transfer I/O data. A Remote link network can consist of a mixture of both types. |
| **Resource Manager** | A component of TwidoSoft that monitors the memory requirements of an application during programming and configuring by tracking references to software objects made by an application. An object is considered to be referenced by the application if it is used as an operand in a list instruction or ladder rung. Displays status information about the percentage of total memory used, and provides a warning if memory is getting low. See Memory Usage Indicator. |
| **Reversible Instructions** | A method of programming that allows instructions to be viewed alternately as List instructions or Ladder rungs. |
| **RTC** | See Real-Time Clock. |

| | |
|---|---|
| **RTU** | Remote Terminal Unit. A protocol using eight bits that is used for communicating between a controller and a PC. |
| **Run** | A command that causes the controller to run an application program. |
| **Rung** | A rung is entered between two potential bars in a grid and is composed of a group of graphical elements joined to each other by horizontal or vertical links.The maximum dimensions of a rung are seven rows and eleven columns. |
| **Rung Header** | A panel that appears directly over a Ladder rung and can be used to document the purpose of the rung. |

## S

| | |
|---|---|
| **Scan** | A controller scans a program and essentially performs three basic functions. First, it reads inputs and places these values in memory. Next, it executes the application program one instruction at a time and stores results in memory. Finally, it uses the results to update outputs. |
| **Scan Mode** | Specifies how the controller scans a program. There are two types of scan modes: Normal (Cyclic), the controller scans continuously, or Periodic, the controller scans for a selected duration (range of 2 - 150 msec) before starting another scan. |
| **Schedule Blocks** | A function block used to program Date and Time functions to control events. Requires Real-Time Clock option. |
| **Step** | A Grafcet step designates a state of sequential operation of automation. |
| **Stop** | A command that causes the controller to stop running an application program. |
| **Symbol** | A symbol is a string of a maximum of 32 alphanumeric characters, of which the first character is alphabetic. It allows you to personalize a controller object to facilitate the maintainability of the application. |
| **Symbol Table** | A table of the symbols used in an application. Displayed in the Symbol Editor. |

## T

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|---|---|
| **Threshold Outputs** | Coils that are controlled directly by the very fast counter (%VFC) according to the settings established during configuration. |
| **Timer** | A function block used to select a time duration for controlling an event. |
| **Twido** | A line of Schneider Electric controllers consisting of two types of controllers (Compact and Modular), Expansion Modules to add I/O points, and options such as Real-Time Clock, communications, operator display, and backup memory cartridges. |
| **TwidoSoft** | A 32-Bit Windows, graphical development software for configuring and programming Twido controllers. |

## U

| | |
|---|---|
| **Unresolved Symbol** | A symbol without a variable address. |

## V

| | |
|---|---|
| **Variable** | Memory unit that can be addressed and modified by a program. |
| **Very Fast Counters** | A function block that provides for faster counting than available with Counters and Fast Counters function blocks. A Very Fast Counter can count up to a rate of 20 KHz. |

## W

| | |
|---|---|
| **Warm Restart** | A power-up by the controller after a power loss without changing the application. Controller returns to the state which existed before the power loss and completes the scan which was in progress. All of the application data is preserved. This feature is only available on modular controllers. |

# Index