Twido programmable controllers

Software Reference Guide

TWD USE 10AE eng Version 2.5

a brand of Schneider Electric

Telemecanique

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.

PLEASE NOTE

Electrical equipment should be serviced only by qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material. This document is not intended as an instruction manual for untrained persons. Assembly and installation instructions are provided in the Twido Hardware Reference Manual, TWD USE 10AE.

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 follow this precaution can result in death, serious 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: Littelfuse 5x20 mm slowblow type 218000 series/Type T. **Failure to follow this precaution can result in death, serious 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, installing the AS-Interface bus interface module 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

User Comments

We welcome your comments about this document. You can reach us by e-mail at TECHCOMM@modicon.com

Description of Twido Software

I

At a Glance

Subject of this Part

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:

Introduction to Twido Software

1

At a Glance

Subject of this Chapter

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.

What's in this Chapter?

This chapter contains the following topics:

Introduction to TwidoSoft

Introduction

TwidoSoft is a graphical development environment for creating, configuring, and maintaining applications for Twido programmable controllers. TwidoSoft allows you to create programs with different types of languages (See *Twido Languages, p. 21*), and then transfer the application 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, Microsoft Windows 2000 Professional or Microsoft Windows XP operating systems.
The main software features of TwidoSoft:
- Standard Windows user interface
- Program and configure Twido controllers
- Controller communication and control

Note: The Controller-PC link uses the TCP/IP protocol. It is essential for this protocol to be installed on the PC.

Minimum configuration

The minimum configuration for using TwidoSoft is:
- Pentium 300MHz,
- 128 Mb of RAM,
- 40 Mb of available space on the hard disk.

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 Language:
  Grafcet language is made up of a series of steps and transitions. 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.

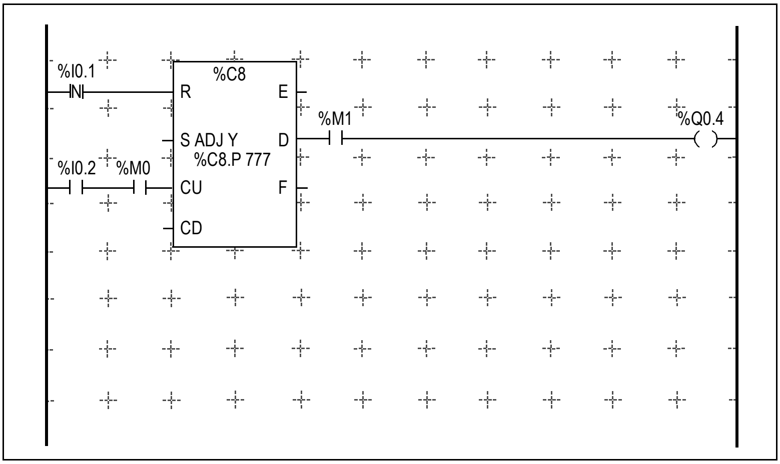
Instruction List Language

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

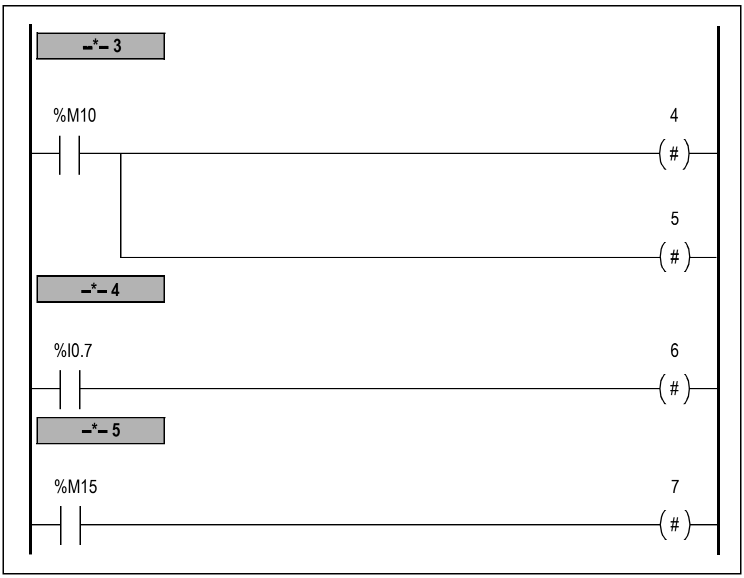
Ladder diagrams are similar to relay logic diagrams that represent relay control circuits. Graphic elements such as coils, contacts, and blocks represent instructions. The following is an example of a Ladder diagram.



Grafcet Language

The Grafcet analytical method divides any sequential control system into a series of steps, with which actions, transitions, and conditions are associated. 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

Subject of this Chapter

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 bit-type software variables 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 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) %Qx.y.z (2)	Note (4)	No Yes
AS-Interface Inputs 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.	%IAx.y.z %QAx.y.z	Note (5)	No Yes
Internal (Memory)	Internal bits are internal memory areas used to store intermediary values while a program is running. **Note:** Unused I/O bits can not be used as internal bits.	%Mi	128 TWDLC•A10 DRF, TWDLC•A16 DRF 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

Type	Description	Address or value	Maximum number	Write access (1)
Function blocks	The function block bits correspond to the outputs of the function blocks. 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.	Variable	Variable	Variable
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 TWDLC•A10 DRF, TWDLC•A16 DRF 96 TWDLC•A24 DRF, TWDLCA•40 DRF and Modular controllers	Yes

Legends:

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.
5. Where, x = address of the expansion module (0..7); y = AS-Interface address (0A..31B); z = channel number (0..3). (See *Addressing I/Os associated with slave devices connected to the AS-Interface V2 bus, p. 223*.)

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%)
- AS-Interface analog I/O words (IWAi, %QWAi)
- 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
±	16384	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 set to 0: the content of the word is a positive value.
- Bit 15 is set to 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 (1579, for example)
- 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 %MW0 to %MW255 are read or written directly by the program.	%MWi	3000	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	256	Yes, only by using TwidoSoft
System	These 16-bit words have several functions: • Provide access to data coming directly from the controller by reading %SWi words.) • 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
Network exchange words	Assigned to controllers connected as Remote Links. These words are used for communication between controllers:			
	Network Input	%INWi.j	4 per remote link	No
	Network Output	%QNWi.j	4 per remote link	Yes

Words	Description	Address or value	Maximum number	Write access (1)
Analog I/O words	Assigned to analog inputs and outputs of AS-Interface slave modules.			
	Analog Inputs	%IWAx.y.z	Note (3)	No
	Analog Outputs	%QWAx.y.z	Note (3)	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
	AS-Interface Slave Input	%IWAx.y.z:Xk	Note (2)	No
	AS-Interface Slave Output	%QWAx.y.z:Xk	Note (2)	Yes
	Network Input	%INWi.j:Xk	Note (2)	No
	Network Output	%QNWi.j:Xk	Note (2)	Yes

Note:
1. Written by the program or by using the Animation Tables Editor.
2. Number is determined by the configuration.
3. Where, x = address of the expansion module (0..7); y = AS-Interface address (0A..31B); z = channel number (0..3). (See *Addressing I/Os associated with slave devices connected to the AS-Interface V2 bus, p. 223*.)

Floating point and double word objects

Introduction

TwidoSoft allows you to perform operations on floating point and double integer word objects.
A floating point is a mathematical argument which has a decimal in its expression (examples: 3.4E+38, 2.3 or 1.0).
A double integer word consists of 4 bytes stored in data memory and containing a value between -2147483648 and +2147483647.

Floating Point Format and Value

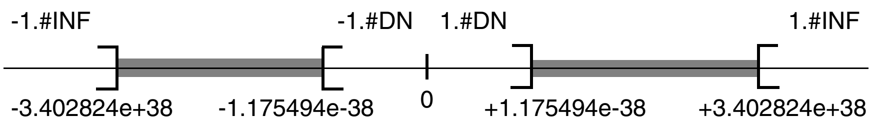
The floating format used is the standard IEEE STD 734-1985 (equivalent IEC 559). The length of the words is 32 bits, which corresponds to the single decimal point floating numbers.
Table showing the format of a floating point value:

Bit 31	Bits {30...23}	Bits {22...0}
S	Exponent	Fractional part

The value as expressed in the above format is determined by the following equation:

32-bit Floating Value = $(-1)^{S}$ * $2^{(\text{Exposant} - 127)}$ * 1.Fractional part

Floating values can be represented with or without an exponent; but they must always have a decimal point (floating point).
Floating values range from -3.402824e+38 and -1.175494e-38 to 1.175494e-38 and 3.402824e+38 (grayed out values on the diagram). They also have the value 0, written 0.0
.



When a calculation result is:
- Less than -3.402824e+38, the symbol -1.#INF (for -infinite) is displayed,
- Greater than +3.402824e+38, the symbol 1.#INF (for +infinite) is displayed,
- Between -1.175494e-38 and 1.175494e-38, it is rounded off to 0.0. A value within these limits cannot be entered as a floating value.
- Indefinite (for example the square root of a negative number) the symbol 1.#NAN or -1.#NAN is displayed.

Representation precision is 2-24. To display floating point numbers, it is unnecessary to display more than 6 digits after the decimal point.

> **Note:**
> - the value "1285" is interpreted as a whole value; in order for it to be recognized as a floating point value, it must be written thus: "1285.0"

Limit range of Arithmetic Functions on Floating Point

The following table describes the limit range of arithmetic functions on floating point objects

Arithmetic Funtion		Limit range and invalid operations	
Type	**Syntax**	**#QNAN (Invalid)**	**#INF (Infinite)**
Square root of an operand	SQRT(x)	x < 0	x > 1.7E38
Power of an integer by a real EXPT(%MF,%MW)	EXPT(y, x) (where: x^y = %MW^%MF)	x < 0	y.ln(x) > 88
Base 10 logarithm	LOG(x)	x <= 0	x > 2.4E38
Natural logarithm	LN(x)	x <= 0	x > 1.65E38
Natural exponential	EXP(x)	x < 0	x > 88.0

Hardware compatibility

Floating point and double word operations are not supported by all Twido controllers.
The following table shows hardware compatibility:

Twido controller	Double words supported	Floating points supported
TWDLMDA40DUK	Yes	Yes
TWDLMDA40DTK	Yes	Yes
TWDLMDA20DUK	Yes	No
TWDLMDA20DTK	Yes	No
TWDLMDA20DRT	Yes	Yes
TWDLCA•40DRF	Yes	Yes
TWDLC•A24DRF	Yes	No
TWDLC•A16DRF	Yes	No
TWDLC•A10DRF	No	No

Validity Check

When the result is not within the valid range, the system bit %S18 is set to 1.
The status word %SW17 bits indicate the cause of an error in a floating operation:
Different bits of the word %SW17:

%SW17:X0	Invalid operation, result is not a number (1.#NAN or -1.#NAN)
%SW17:X1	Reserved
%SW17:X2	Divided by 0, result is infinite (-1.#INF or 1.#INF)
%SW17:X3	Result greater in absolute value than +3.402824e+38, result is infinite (-1.#INF or 1.#INF)
%SW17:X4 to X15	Reserved

This word is reset to 0 by the system on cold start, and also by the program for re-usage purposes.

Description of Floating Point and Double Word Objects

The following table describes floating point and double word objects:

Type of object	Description	Address	Maximum number	Write access	Indexed form
Immediate values	Integers or decimal numbers with identical format to 32 bit objects.	-	[-]	No	-
Internal floating point	Objects used to store values during operation in data memory.	%MFi	1500	Yes	%MFi[index]
Internal double word		%MDi	1500	Yes	%MDi[index]
Floating constant value	Used to store constants.	%KFi	128	Yes, only using TwidoSoft	%KFi[index]
Double constant		%KDi	128	Yes, only using TwidoSoft	%KDi[index]

Possibility of Overlap between Objects

Single, double length and floating words are stored in the data space in one memory zone. Thus, the floating word %MFi and the double word %MDi correspond to the single length words %MWi and %MWi+1 (the word %MWi containing the least significant bits and the word %MWi+1 the most significant bits of the word %MFi).
The following table shows how floating and double internal words overlap:

<table>
<tr><th>Floating and Double</th><th>Odd address</th><th>Internal words</th></tr>
<tr><td rowspan="2">%MF0 / %MD0</td><td></td><td>%MW0</td></tr>
<tr><td rowspan="2">%MF1 / %MD1</td><td>%MW1</td></tr>
<tr><td rowspan="2">%MF2 / %MD2</td><td>%MW2</td></tr>
<tr><td rowspan="2">%MF3 / %MD3</td><td>%MW3</td></tr>
<tr><td rowspan="2">%MF4 / %MD4</td><td>%MW4</td></tr>
<tr><td rowspan="2">...</td><td>%MW5</td></tr>
<tr><td rowspan="2">...</td><td>...</td></tr>
<tr><td rowspan="2">%MFi / %MDi</td><td>%MWi</td></tr>
<tr><td rowspan="2">%MFi+1 / %MDi+1</td><td>%MWi+1</td></tr>
<tr><td colspan="2"></td></tr>
</table>

The following table shows how floating and double constants overlap:

<table>
<tr><th>Floating and Double</th><th>Odd address</th><th>Internal words</th></tr>
<tr><td rowspan="2">%KF0 / %KD0</td><td></td><td>%KW0</td></tr>
<tr><td rowspan="2">%KF1 / %KD1</td><td>%KW1</td></tr>
<tr><td rowspan="2">%KF2 / %KD2</td><td>%KW2</td></tr>
<tr><td rowspan="2">%KF3 / %KD3</td><td>%KW3</td></tr>
<tr><td rowspan="2">%KF4 / %KD4</td><td>%KW4</td></tr>
<tr><td rowspan="2">...</td><td>%KW5</td></tr>
<tr><td rowspan="2">...</td><td>...</td></tr>
<tr><td rowspan="2">%kFi / %kDi</td><td>%KWi</td></tr>
<tr><td rowspan="2">%KFi+1 / %KDi+1</td><td>%KWi+1</td></tr>
<tr><td colspan="2"></td></tr>
</table>

Example:
%MF0 corresponds to %MW0 and %MW1. %KF543 corresponds to %KW543 and %KW544.

Addressing Bit Objects

Syntax

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	Item	Description
Symbol	%	The percent symbol always precedes a software variable.
Type of object	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 addressing:

- %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. 40*) and function blocks (see *Function Block Objects, p. 43*), follows the format described below.

Syntax

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	Item	Description
Symbol	%	The percent symbol always precedes an internal address.
Type of object	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.
Syntax	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 floating objects

Introduction

Addressing floating objects, except for input/output addressing (see *Addressing Inputs/Outputs, p. 40*) and function blocks (see *Function Block Objects, p. 43*), follows the format described below.

Syntax

Use the following format to address internal and constant floating objects:

%	M or K	F	i
Symbol	Type of object	Syntax	Number

Description

The following table describes the elements in the addressing format.

Group	Item	Description
Symbol	%	The percent symbol always precedes an internal address.
Type of object	M	Internal floating objects store intermediary values while a program is running.
	K	Floating constants are used to store constant values. Their content can only be written or modified by using TwidoSoft.
Syntax	F	32 bit object.
Number	i	The maximum number value depends on the number of objects configured.

Examples of floating object addresses:
- %MF15 = internal floating object number 15
- %KF26 = constant floating object number 26

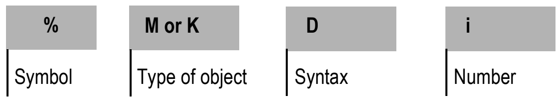
Addressing double word objects

Introduction

Addressing double word objects, except for input/output addressing (see *Addressing Inputs/Outputs, p. 40*) and function blocks (see *Function Block Objects, p. 43*), follows the format described below.

Syntax

Use the following format to address internal and constant double words:



Description

The following table describes the elements in the addressing format.

Group	Item	Description
Symbol	%	The percent symbol always precedes an internal address.
Type of object	M	Internal double words are used to store intermediary values while a program is running.
	K	Constant double words store constant values or alphanumeric messages. Their content can only be written or modified by using TwidoSoft.
Syntax	D	32 bit double word.
Number	i	The maximum number value depends on the number of objects configured.

Examples of double word object addressing:
- %MD15 = internal double word number 15
- %KD26 = constant double word number 26

Addressing Inputs/Outputs

Introduction

Each input/output (I/O) point in a Twido configuration has a unique address: For example, the address "%I0.0.4" is assigned to input 4 of a controller.
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

The TWDNOI10M3 AS-Interface bus interface module has a special address system for the I/Os of its slave devices (See *Addressing I/Os associated with slave devices connected to the AS-Interface V2 bus, p. 223*).

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 only the equation that will give the required status of the output.

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 follow 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	point	I/O type	point	Channel number

Use the following format to address inputs/output exchange words.

%	I, Q	W	x	.	y
Symbol	Object type	Format	Controller position	point	I/O Type

Description

The table below describes the I/O addressing format.

Group	Item	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 1 - 7	Master controller (Remote Link master). Remote controller (Remote Link slave).
I/O Type	y	0 1 - 7	Base I/O (local I/O on controller). Expansion I/O modules.
Channel Number	z	0 - 31	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 the expansion I/O module at address 3 for the controller base (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 address 3 of the remote link.
%I0.3.2	Input point number 2 on the expansion I/O module at address 3 for the controller base.

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. 85* for more details.

Format

Use the following format for network addressing.

%	IN,QN	W	x	.	j
Symbol	Object type	Format	Controller position	point	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 1 - 7	Master controller (Remote Link master). 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.

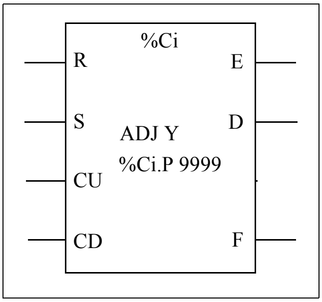
Function Block Objects

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 *Standard function blocks programming principles, p. 319*).
- 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.

Word Objects

Double word objects increase the computational capability of your Twido controller while executing system functions, such as fast counters (%FC), very fast counters (%VFC) and pulse generators (%PLS).
Addressing of 32-bit double word objects used with function blocks simply consists in appending the original syntax of the standard word objects with the "D" character.
The following example, shows how to address the current value of a fast counter in standard format and in double word format:
- %FCi.V is current value of the fast counter in standard format.
- %FCi.VD is the current value of the fast counter in double word format.

Note: Double word objects are not supported by all Twido controllers. Refer to *Hardware compatibility, p. 33* to find out if your Twido controller can accommodate double words.

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. 317*.
- For Advanced Function Blocks, see *Bit and Word Objects Associated with Advanced Function Blocks, p. 370*.

Structured Objects

Introduction

Structured objects are combinations of adjacent objects. Twido supports the following types of structured objects:
- Bit Strings
- Tables of words
- Tables of double words
- Tables of floating words

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

%M8	%M9	%M10	%M11	%M12	%M13

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. 342*).

Available Types of Bits

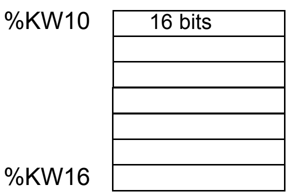
Available types of bits for bit strings:

Type	Address	Maximum size	Write access
Discrete input bits	%I0.0:L or %I1.0:L (1)	0<L<17	No
Discrete output bits	%Q0.0:L or %Q1.0:L (1)	0<L<17	Yes
System bits	%Si:L with i multiple of 8	0<L<17 and i+L≤ 128	Depending on i
Grafcet Step bits	%Xi:L with i multiple of 8	0<L<17 and i+L≤ 95 (2)	Yes (by program)
Internal bits	%Mi:L with i multiple of 8	0<L<17 and i+L≤ 256 (3)	Yes

Key:
1. Only I/O bits 0 to 16 can be read in bit string. For controllers with 24 inputs and 32 I/O modules, bits over 16 cannot be read in bit string.
2. Maximum of i+L for TWWDLCAA10DRF and TWDLCAA16DRF is 62
3. Maximum of i+L for TWWDLCAA10DRF and TWDLCAA16DRF is 128

Tables of words

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. 342*).

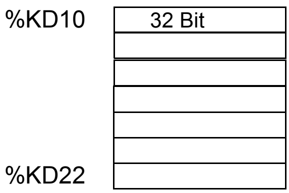
Available Types of Words

Available types of words for word tables:

Type	Address	Maximum size	Write access
Internal words	%MWi:L	0<L<256 and i+L< 3000	Yes
Constant words	%KWi:L	0<L<256 and i+L< 256	No
System Words	%SWi:L	0<L and i+L<128	Depending on i

Tables of double words

Double word tables are a series of adjacent words of the same type and of a defined length (L).
Example: Double word table %KD10:7



Double word tables can be used with the Assignment instruction (see *Assignment Instructions, p. 342*).

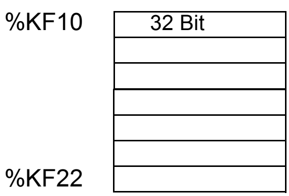
Available Types of Double Words

Available types of words for double word tables:

Type	Address	Maximum size	Write access
Internal words	%MDi:L	0<L<256 and i+L< 3000	Yes
Constant words	%KDi:L	0<L and i+L< 256	No

Tables of floating words

Floating word tables are a series of adjacent words of the same type and of a defined length (L).
Example: Floating point table %KF10:7



Floating point tables can be used with the Assignment instruction (see Advanced instructions).

Types of Floating Words Available

Available types of words for floating word tables:

Type	Address	Maximum size	Write access
Internal words	%MFi:L	0<L<256 and i+L< 3000	Yes
Constant words	%KFi:L	0<L and i+L<256	No

Indexed objects

Introduction

An indexed word is a single or double word or floating point 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).

Objects Available for Indexed Addressing

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

Type	Address	Maximum size	Write access
Internal words	%MWi[MWj]	0≤ i+%MWj<3000	Yes
Constant words	%KWi[%MWj]	0≤ i+%MWj<256	No
Internal double words	%MDi[MWj]	0≤ i+%MWj<2999	Yes
Double constant words	%KDi[%MWj]	0≤ i+%MWj<255	No
Internal floating points	%MFi[MWj]	0≤ i+%MWj<2999	Yes
Constant floating points	%KFi[%MWj]	0≤ i+%MWj<255	No

Indexed objects can be used with the assignment instructions (see *Assignment Instructions, p. 342* for single and double words) and in comparison instructions (see *Comparison Instructions, p. 347* for single and double words). 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 object 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 2999 (for words %MWi) or 255 (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 status = 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.

User Memory

3

At a Glance

Subject of this Chapter

This chapter describes the structure and usage of Twido user memory.

What's in this Chapter?

This chapter contains the following topics:

User Memory Structure

Introduction

The controller memory accessible to your application is divided into two distinct sets:
- Bit values
- Word values (16-bit signed values) and double word values (32-bit signed values)

Bit Memory

The bit memory is located in the controller's built-in RAM. It contains the map of 128 bit objects.

Word Memory

The word memory (16 bits) supports:
- **Dynamic words**: runtime memory (stored in RAM only).
- **Memory words (%MW) and double words (%MD)**: dynamic system data and system data.
- **Program**: descriptors and executable code for tasks.
- **Configuration data**: constant words, initial values, and input/output configuration.

Memory Storage Types

The following are the different types of memory storage for Twido controllers.
- Random Access Memory.
  Internal volatile memory: Contains dynamic words, memory words, program and configuration data.
- EEPROM
  An integrated 32KB EEPROM that provides internal program and data backup. Protects program from corruption due to battery failure or a power outage lasting longer than 30 days. Contains program and configuration data. Holds a maximum of 512 memory words. Program is not backed up here If a 64K extended memory cartridge is being used and Twido has been configured to accept the 64K extended memory cartridge.
- Erase 32K backup cartridge
  An optional external cartridge used to save a program and transfer that program to other Twido controllers. Can be used to update the program in controller RAM. Contains program and constants, but no memory words.
- 64K extended memory cartridge
  An optional external cartridge that stores a program up to 64K. Must remain plugged into the controller as long as that program is being used.

Saving Memory

Your controller's program and memory words can be saved in the following:
- RAM (for up to 30 days with good battery)
- EEPROM (maximum of 32 KB)

Transferring the program from the EEPROM memory to the RAM memory is done automatically when the program is lost in RAM (or if there is no battery).
Manual transfer can also be performed using TwidoSoft.

Memory Configurations

The following tables describe the types of memory configurations possible with Twido compact and modulare controllers.

Memory Type	**Compact Controllers**				
	10DRF	**16DRF**	**24DRF**	**40DRF (32k)**	**40DRF** (64k)**
Internal RAM Mem 1*	10KB	10KB	10KB	10KB	10KB
External RAM Mem 2*		16KB	32KB	32KB	64KB
Internal EEPROM	8KB	16KB	32KB	32KB	32KB***
External EEPROM	32KB	32KB	32KB	32KB	64KB
Maximum program size	8KB	16KB	32KB	32KB	64KB
Maximum external backup	8KB	16KB	32KB	32KB	64KB

Memory Type	**Modular Controllers**		
	20DUK 20DTK	**20DRT 40DUK 40DTK (32k)**	**20DRT 40DUK 40DTK** (64k)**
Internal RAM Mem 1*	10KB	10KB	10KB
External RAM Mem 2*	32KB	32KB	64KB
Internal EEPROM	32KB	32KB	32KB***
External EEPROM	32KB	32KB	64KB
Maximum program size	32KB	32KB	64KB
Maximum external backup	32KB	32KB	64KB

(*) Mem 1 and Mem 2 in memory usage.
(**) in this case the 64KB cartridge must be installed on the Twido and declared in the configuration, if it has not already been declared,
(***) reserved for backup of the first 512 %MW words or the first 256 %MD double words.

Backup and Restore without Backup Cartridge or Extended Memory

Introduction

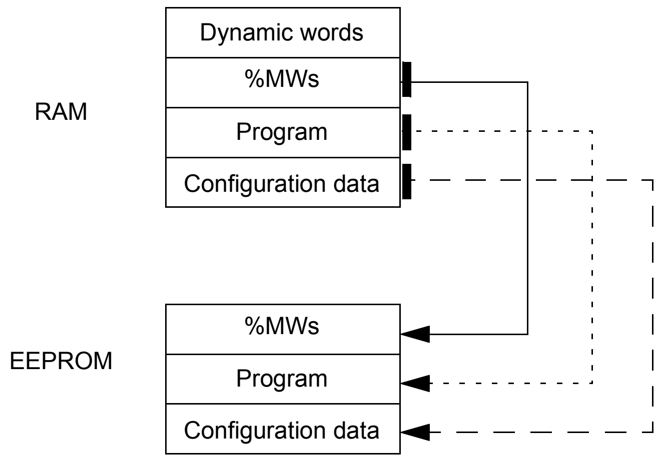
The following information details backup and restore memory functions in modular and compact controllers without a backup cartridge or extended memory plugged in.

At a Glance

Twido programs, memory words and configuration data can be backed up using the controllers internal EEPROM. Because saving a program to the internal EEPROM clears any previously backed up memory words, the program must be backed up first, then the configured memory words. Dynamic data can be stored in memory words then backed up to the EEPROM. If there is no program saved to the internal EEPROM you cannot save memory words to it.

Memory Structure

Here is a diagram of a controller's memory structure. The arrows show what can be backed up to the EEPROM from RAM:



Program Backup

Here are the steps for backing up your program into EEPROM.

Step	Action
1	The following must be true: There is a valid program in RAM.
2	From the Twido software window bring down the menu under 'Controller', scroll down to 'Backup' and click on it.

Program Restore

During power up there is one way the program will be restored to RAM from the EEPROM (assuming there is no cartridge or extended memory in place):
- The RAM program is not valid

To restore a program manually from EEPROM do the following:
- From the Twido software window bring down the menu under 'Controller', scroll down to 'Restore' and click on it.

Data (%MWs) Backup

Here are the steps for backing up data (memory words) into the EEPROM:

Step	Action
1	For this to work the following must be true: A valid program in RAM (%SW96:X6=1). The same valid program already backed up into the EEPROM. Memory words configured in the program.
2	Set %SW97 to the length of the memory words to be saved. **Note:** Length cannot exceed the configured memory word length, and it must be greater than 0 but not greater than 512.
3	Set %SW96:X0 to 1.

Data (%MWs) Restore

Restore %MWs manually by setting system bit %S95 to 1.
For this to work the following must be true:
- A valid backup application is present in the EEPROM
- The application in RAM matches the backup application in EEPROM
- The backup memory words are valid

Backup and Restore with a 32K Backup Cartridge

Introduction

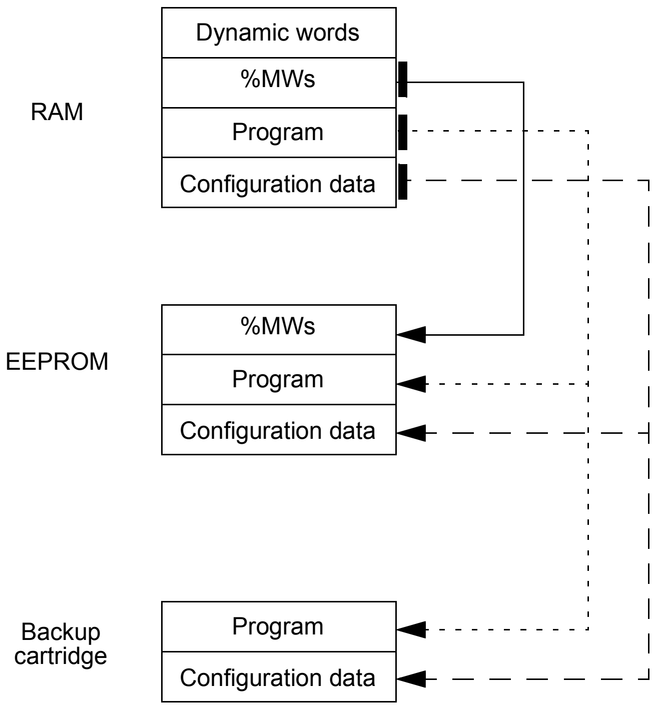
The following information details backup and restore memory functions in modular and compact controllers using a 32K backup cartridge.

At a Glance

The backup cartridge is used to save a program and transfer that program to other Twido controllers. It should be removed from a controller and set aside once the program has been installed or saved. Only program and configuration data can be saved to the cartridge (%MWs cannot be saved to the 32K backup cartridge). Dynamic data can be stored in memory words then backed up to the EEPROM. When program installation is complete any %MWs that were backed up to the internal EEPROM prior to installation will be lost.

Memory Structure

Here is a diagram of a controller's memory structure with the backup cartridge attached. The arrows show what can be backed up to the EEPROM and cartridge from RAM:



Program Backup

Here are the steps for backing up your program into the backup cartridge:

Step	Action
1	Power down the controller.
2	Plug in the backup cartridge.
3	Powerup the controller.
4	From the Twido software window bring down the menu under ‘Controller’, scroll down to ‘Backup’ and click on it.
5	Power down the controller.
6	Remove backup cartridge from controller.

Program Restore

To load a program saved on a backup cartridge into a controller do the following:

Step	Action
1	Power down the controller.
2	Plug in the backup cartridge.
3	Powerup the controller. (If Auto Start is configured you must power cycle again to get to run mode.)
4	Power down the controller.
5	Remove backup cartridge from controller.

Data (%MWs) Backup

Here are the steps for backing up data (memory words) into the EEPROM:

Step	Action
1	For this to work the following must be true: A valid program in RAM. The same valid program already backed up into the EEPROM. Memory words configured in the program.
2	Set %SW97 to the length of the memory words to be saved. **Note** Length cannot exceed the configured memory word length, and it must be greater than 0 but not greater than 512.
3	Set %SW96:X0 to 1.

Data (%MWs) Restore

Restore %MWs manually by setting system bit %S95 to 1.
For this to work the following must be true:
- A valid backup application is present in the EEPROM
- The application in RAM matches the backup application in EEPROM
- The backup memory words are valid

Using the 64K Extended Memory Cartridge

Introduction

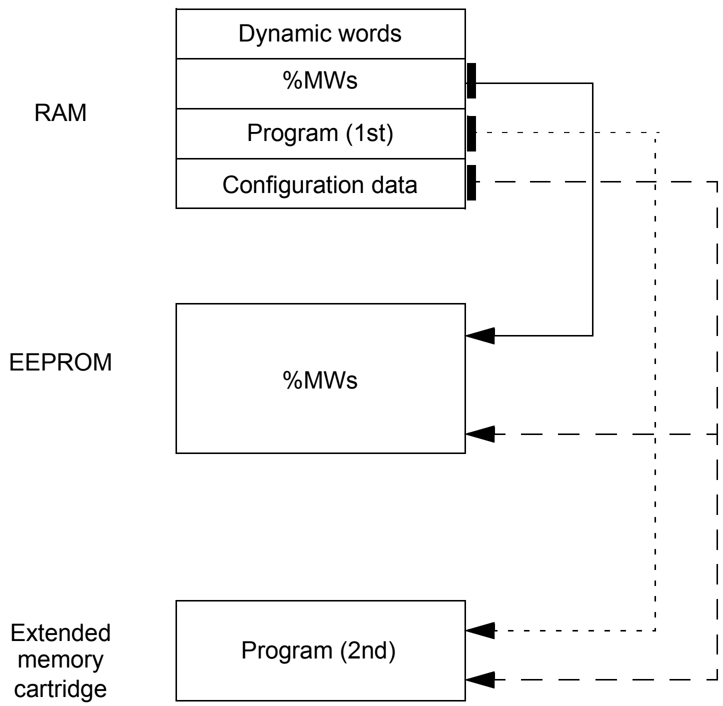
The following information details using the memory functions in modular controllers using a 64K extended memory cartridge.

At a Glance

The 64K extended memory cartridge is used to extend the program memory capability of your Twido controller from 32K to 64K. It must remain plugged into the controller as long as the extended program is being used. If the cartridge is removed the controller will enter the stopped state. Memory words are still backed up into the EEPROM in the controller. Dynamic data can be stored in memory words then backed up to the EEPROM. The 64K extended memory cartridge has the same power up behavior as the 32K backup cartridge.

Memory Structure

Here is a diagram of a controller's memory structure using an extended memory cartridge. The arrows show what is backed up into the EEPROM and the 64K extended memory cartridge from RAM:



Configure Software and Install Extended Memory

Before you begin writing your extended program, you must install the 64K extended memory cartridge into your controller. The following four steps show you how:

Step	Action
1	Under the Hardware option menu on you Twido software window enter 'TWDXCPMFK64'.
2	Power down the controller.
3	Plug in the 64K extended memory cartridge.
4	Powerup the controller.

Save your program.

Once your 64K extended memory cartridge has been installed and your program written:

- From the Twido software window bring down the menu under 'Controller', scroll down to 'Backup' and click on it.

Data (%MWs) Backup

Here are the steps for backing up data (memory words) into the EEPROM:

Step	Action
1	For this to work the following must be true: A valid program is present Memory words are configured in the program.
2	Set %SW97 to the length of the memory words to be saved. **Note:** Length cannot exceed the configured memory word length, and it must be greater than 0 but not greater than 512.
3	Set %SW96:X0 to 1.

Data (%MWs) Restore

Restore %MWs manually by setting system bit %S95 to 1.
For this to work the following must be true:

- A valid program is present
- The backup memory words are valid

Controller Operating Modes

4

At a Glance

Subject of this Chapter

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

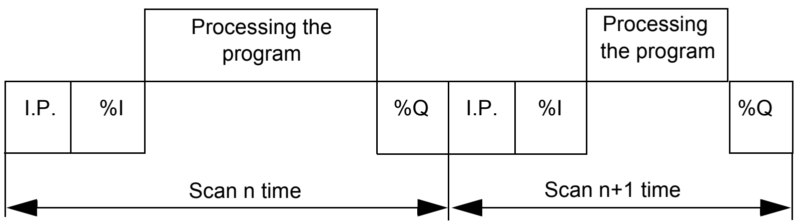
Introduction

Cyclic scanning involves linking controller cycles together one after the other. 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 500 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 the phases of a cycle

The following table describes the phases of a cycle.

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, %IW	Acquisition of input	Writing to the memory the status of discrete and application specific module inputs.
-	Program processing	Running the application program written by the user.
%Q, %QW	Updating of output	Writing output bits or words associated with discrete and application specific modules.

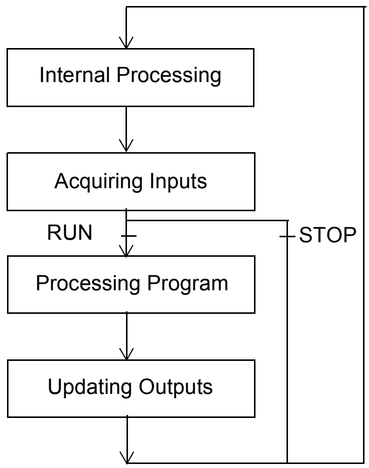
Operating mode

Controller in RUN, the processor carries out:
- Internal processing
- Acquisition of input
- Processing the application program
- Updating of output

Controller in STOP, the processor carries out:
- Internal processing
- Acquisition of input

Illustration

The following illustration shows the operating cycles.



Check Cycle

The check cycle is performed by watchdog.

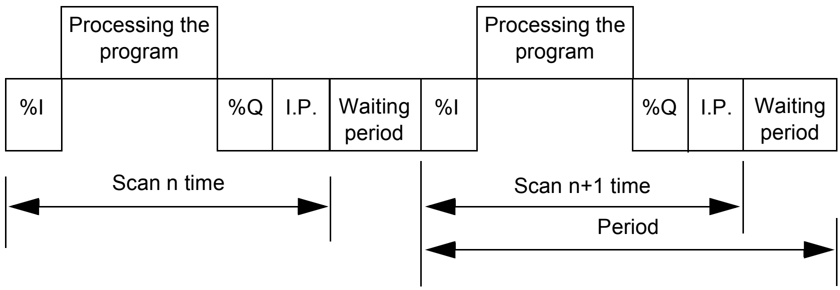
Periodic Scan

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, %IW	Acquisition of input	Writing to the memory the status of discrete and application specific module inputs.
-	Program processing	Running the application program written by the user.
%Q, %QW	Updating of output	Writing output bits or words associated with discrete and application specific modules.

Operating mode

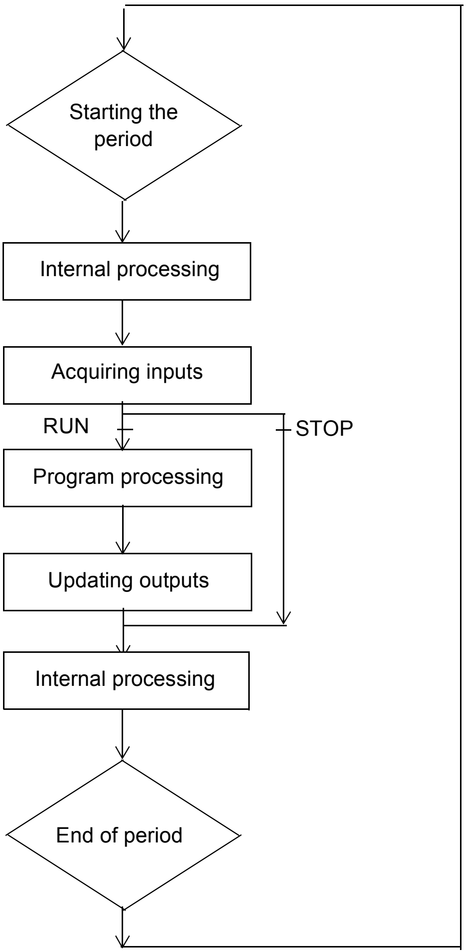
Controller in RUN, the processor carries out:
- Internal processing
- Acquisition of input
- Processing the application program
- Updating of output

If the period has not finished, the processor completes its 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 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 carries out:
- Internal processing
- Acquisition of input

Illustration

The following illustration shows the operating cycles.



Check Cycle

Two checks are carried out:
- Period overflow
- Watchdog

Checking Scan Time

General

The task cycle is monitored by a watchdog timer called Tmax (a maximal duration of the 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 system 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, then reset the program to RUN.

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 program stops on the instruction in progress. Communication with the controller is open.

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 selected on the configuration,
  - Able to 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

Starting through Grafcet

These different operating modes can be obtained either starting from or using the following Grafcet 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.

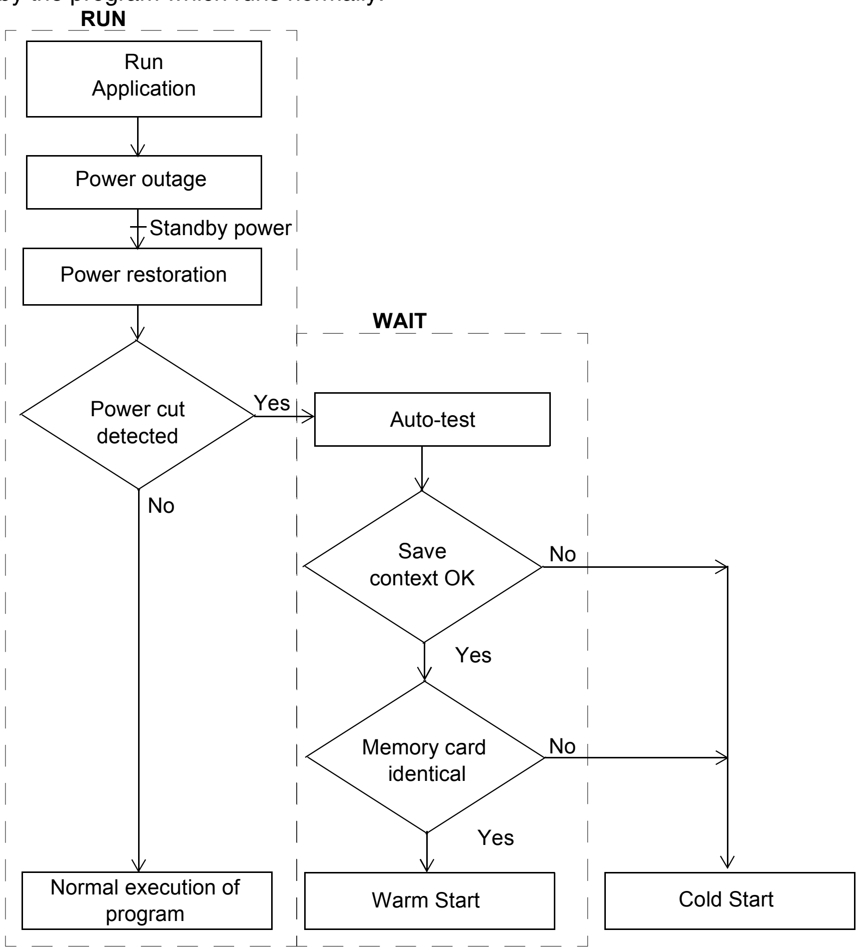
The following table provides Grafcet-related system bits:

Bit	Function	Description
%S21	GRAFCET initialization	Normally set to 0, it is set to 1 by: • a cold-start, **%S0=1**; • The user, in the pre-processing program part only, using a Set Instruction **S %S21** or a set coil **-(S)-%S21**. Consequences: • Deactivation of all active steps. • 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. Consequences: • Deactivation of all active steps. • 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. • Prepositioning by setting %S22 to 1. • Preposition the steps to be activated by a series of S Xi instructions. • Enable prepositioning by setting %S23 to 1. Freezing a situation: • In initial situation: by maintaining %S21 at 1 by program. • In an "empty" situation: by maintaining %S22 at 1 by program. • In a 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. 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	Stop
Zero	One	Stop
Rising edge	No effect	Run
One	No effect	Run
Not configured in software	Zero	Stop
Not configured in software	One	Run

Note: For all Compact type of controllers of software version V1.0, 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. Otherwise will perform a cold restart.

Note: For all Modular and Compact type of controllers of software version V1.11, 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	All outputs are set to fallback status (0).
3	When power is restored, the context saved is compared with the one in progress which defines the type of start to run: ● If the application context has changed (loss of system context or new application), the controller initializes the application: Cold restart (systematic for compact). ● If the application context is the same, the controller restarts without initializing data: warm restart.

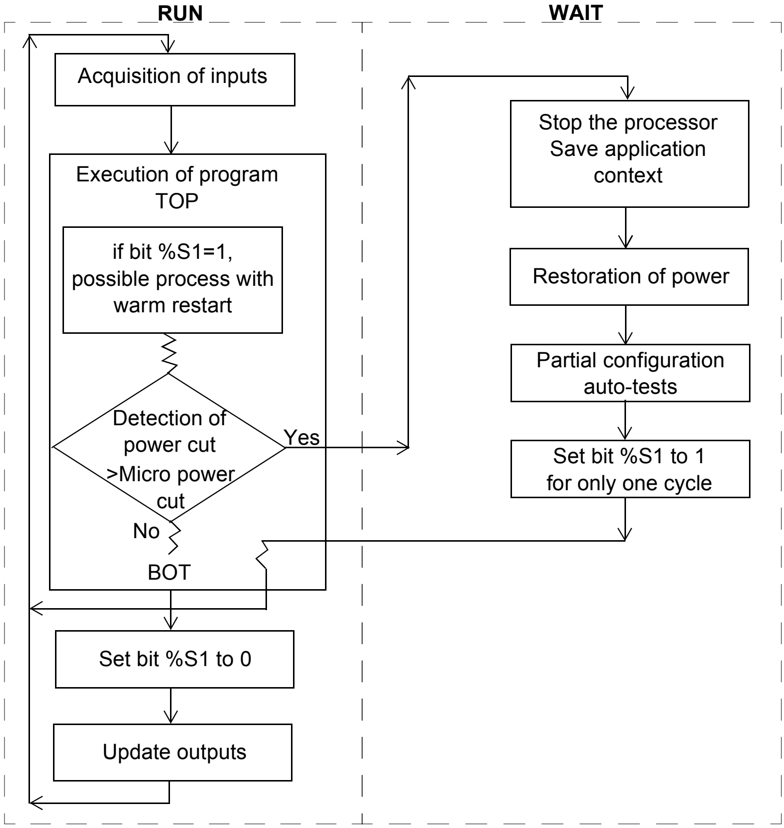
Dealing with a warm restart

Cause of a Warm Restart

A warm restart 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

Illustration

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



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. **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: ● Unreserves the application if it was reserved (and provokes a STOP application in case of debugging) ● Reinitializes the messages
3	The system carries out a restart cycle in which it: ● Relaunches the task with bits **%S1** (warm-start indicator) and **%S13** (first cycle in RUN) set to 1 ● 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

Once a power outage is detected, outputs are set to (default) fallback status (0). When power is restored, outputs are at last state until they are updated again by the task.

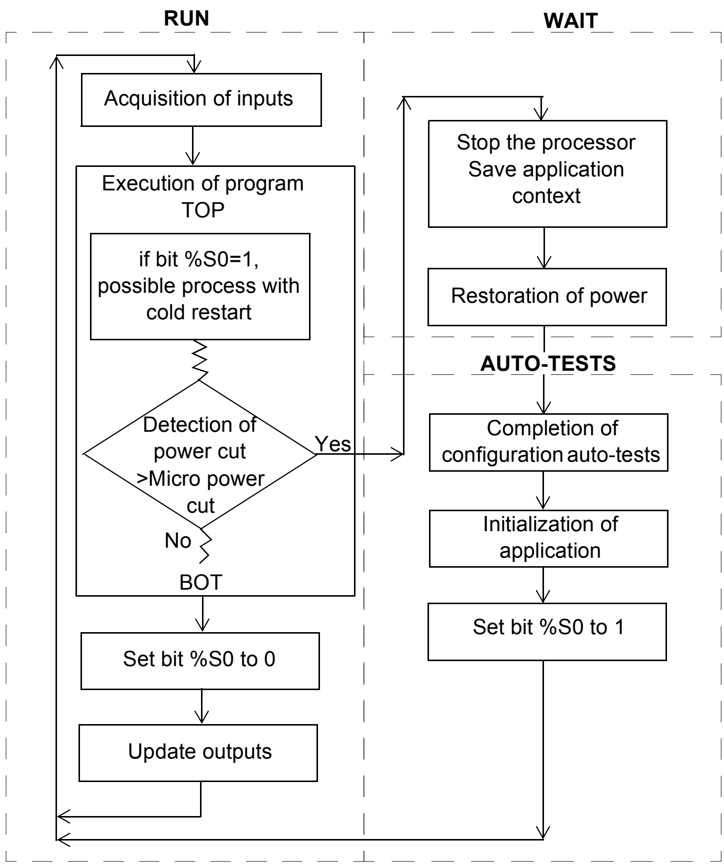
Dealing with a cold start

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 system bit **%S0** is set to state 1 by the program
- From the Operator Display when the controller is in STOP mode

Illustration

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



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. At a cold restart after a stop due to an error, the system forces a cold restart. The program execution restarts at the beginning of the cycle.
2	The system: ● Resets internal bits and words and the I/O images to 0 ● Initializes system bits and words ● Initializes function blocks from configuration data
3	For this first restart cycle, the system: ● Relaunches the task with bits **%S0** (cold-start indicator) and **%S13** (first cycle in RUN) set to 1 ● Resets bits **%S0** and **%S13** to 0 at the end of this first task cycle ● Resets bits **%S31**, **%S38** and **%S39** (event control indicators), and word **%SW48** (number of events executed).

Processing of a Cold-Start

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

Outputs after Power Failure

Once a power outage is detected, outputs are set to (default) fallback status (0). When power is restored, outputs are at zero until they are updated again by the task.

Initialization of objects

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.

Initialization of objects (identical to cold start) on power-up using %S0 and %S1

To initialize objects on power-up, system bit **%S1** and **%S0** must be set to 1.

The following example shows how to program a warm restart object 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.

Event task management

5

In Brief...

At a Glance

This chapter describes event tasks and how they are executed in the controller.

Note: Event tasks are not managed by the Twido Brick 10 controller (TWDLCAA10DRF).

What's in this Chapter?

This chapter contains the following topics:

Overview of event tasks

Introduction

The previous chapter presented periodic (See *Periodic Scan, p. 64*) and cyclic (See *Cyclic Scan, p. 62*) tasks in which objects are updated at the start and end of the task. Event sources may cause a certain task to be stopped while higher priority (event) tasks are executed to allow objects to be updated more quickly.
An event task:
- is a part of a program executed when a given condition is met (event source),
- has a higher priority than the main program,
- guarantees a rapid response time enabling the overall response time of the system to be reduced.

Description of an Event

An event is composed of:
- an event source which can be defined as a software or hardware interrupt condition to interrupt the main program (See *Description of different event sources, p. 79*),
- a section which is a independent programmed entity related to an event,
- an event queue which can be used to store a list of events until they are executed,
- a priority level which specifies the order of event execution.

Description of different event sources

Overview of Different Event Sources

An event source needs to be managed by the software to make the sure the main program is properly interrupted by the event, and to call the programming section linked to the event. The application scan time has no effect on the execution of the events.

The following 9 event sources are allowed:

- 4 conditions linked to the VFC function block thresholds (2 events per %VFC instance),
- 4 conditions linked to the physical inputs of a controller base,
- 1 periodic condition.

An event source can only be attached to a single event, and must be immediately detected by TwidoSoft. Once it is detected, the software executes the programming section attached to the event: each event is attached to a subroutine labeled **SRi:** defined on configuration of the event sources.

Physical Input Events of a Controller Base

Inputs %I0.2, %I0.3, %I0.4 and %I0.5 can be used as event sources, provided they are not locked and that the events are allowed during configuration.

Event processing can be activated by inputs 2 to 5 of a controller base (position 0), on a rising or falling edge.

For further details on configuring this event, refer to the section entitled "Hardware Configuration -> Input Configuration" in the "TwidoSoft Operation Guide" on-line help.

Output Event of a %VFC Function Block

Outputs TH0 and TH1 of the %VFC function block are event sources. Outputs TH0 and TH1 are respectively set:

- to 1 when the value is greater than threshold S0 and threshold S1,
- to 0 when the value is less than threshold S0 and threshold S1.

A rising or falling edge of these outputs can activate an event process.

For further details on configuring this event, refer to the section entitled "Software Configuration -> Very Fast Counters" in the "TwidoSoft Operation Guide" on-line help.

Periodic event

This event periodically executes a single programming section. This task has higher priority than the main task (master).
However, this event source has lower priority than the other event sources.
The period of this task is set on configuration, from 5 to 255 ms. Only one periodic event can be used.
For further details on configuring this event, refer to the section entitled "Configuring Program Parameters -> Scan Mode" in the "TwidoSoft Operation Guide" on-line help.

Event management

Events queue and priority

Events have 2 possible priorities: High and Low. But only **one** type of event (thus only one event source) can have High priority. The other events therefore have Low priority, and their order of execution depends on the order in which they are detected.

To manage the execution order of the event tasks, there are two event queues:
- in one, up to 16 High priority events can be stored (from the same event source),
- in the other, up to 16 Low priority events can be stored (from other event sources).

These queues are managed on a FIFO basis: the first event to be stored is the first to be executed. But they can only hold 16 events, and all additional events are lost. The Low priority queue is only executed once the High priority queue is empty.

Event Queue Management

Each time an interrupt appears (linked to an event source), the following sequence is launched:

Step	Description
1	Interrupt management: ● recognition of the physical interrupt, ● event stored in the suitable event queue, ● verification that no event of the same priority is pending (if so the event stays pending in the queue).
2	Save context.
3	Execution of the programming section (subroutine labeled SRi:) linked to the event.
4	Updating of output
5	Restore context

Before the context is re-established, all the events in the queue must be executed.

Event check

System bits and words are used to check the events (See *System Bits and System Words, p. 509*):
- %S31: used to execute or delay an event,
- %S38: used to decide whether or not to place events in the events queue,
- %S39: used to find out if events are lost,
- %SW48: shows how many events have been executed since the last cold start.

The value of the bits and words is reset to zero on a cold restart or after an application is loaded, but remains unchanged after a warm restart. In all cases, the events queue is reset.

Special Functions

II

At a Glance

Subject of this Part

This part describes communications, built-in analog functions, managing analog I/O modules and installing the AS-Interface V2 bus for Twido controllers.

What's in this Part?

This part contains the following chapters:

Communications

6

At a Glance

Subject of this Chapter

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:

Presentation of the different types of communication

At a Glance

Twido provides one or two serial communications ports used for communications to remote I/O controllers, peer controllers, or general 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).
Moreover, the TWDLCAE40DRF compact controller provides one RJ-45 Ethernet communications port. It supports the Modbus TCP/IP client/server protocol for peer-to-peer communications between controllers over the Ethernet network.

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 send a modbus query to a slave and await its reply. The modbus master mode is supported only 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 other type of 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: 32 devices (without repeaters) can be installed on an RS-485 network (1 master and up to 31 slaves), the addresses of which can be between 1 and 247.

Modbus TCP/IP

Note: Modbus TCP/IP is solely supported by TWDLCAE40DRF series of compact controllers with built-in Ethernet network interface.

The following information describes the Modbus Application Protocol (MBAP).
The Modbus Application Protocol (MBAP) is a layer-7 protocol providing peer-to-peer communication between programmable logic controllers (PLCs) and other nodes on a LAN.
The current Twido controller TWDLCAE40DRF implementation transports Modbus Application Protocol over TCP/IP on the Ethernet network. Modbus protocol transactions are typical request-response message pairs. A PLC can be both client and server depending on whether it is querying or answering messages.

TwidoSoft to Controller communications

At a Glance

Each Twido controller has on its Port 1 a built-in EIA RS-485 terminal port. This has its own internal power supply. Port 1 must be used to communicate with the TwidoSoft programming software.
No optional cartridge or communication module can be used for this port. A modem, however, can use this port.
There are several ways to connect the PC to the Twido controller RS-485 Port 1:

- By TSXPCX cable,
- By telephone line: Modem connection.

Moreover, the TWDLCAE40DRF compact controller has a built-in RJ-45 Ethernet network connection port that can be used to communicate with the Ethernet-capable PC running the TwidoSoft programming software.
There are two ways for the Ethernet-capable PC to communicate with the TWDLCAE40DRF Twido controller RJ-45 port:

- By direct cable connection via a UTP Cat5 RJ45 Ethernet crossover cable (not recommended),
- By connection to the Ethernet network via a SFTP Cat5 RJ45 Ethernet cable available from the Schneider Electric catalog (cable reference: 490NTW000••).

CAUTION

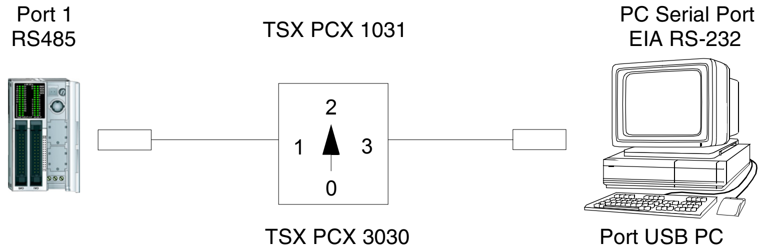
EQUIPMENT DAMAGE

TwidoSoft may not sense the disconnection when physically moving the TSXPCX1031, TSX PCX 3030 or Ethernet 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.

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

TSXPCX Cable Connection

The EIA RS-232C or USB port on your personal computer is connected to the controller's Port 1 using the TSXPCX1031 or TSX PCX 3030 multi-function communication cable. This cable converts signals between EIA RS-232 and EIA RS-485 for the TSX PCX 1031 and between USB and EIA RS-485 for the TSX PCX 3030. 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.



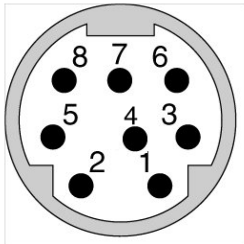
> **Note:** For this cable, the DPT signal on pin 5 is not tied to 0V. This indicates to the controller that the current connection is a TwidoSoft connection. The signal is pulled up internally, informing the firmware executive that this is a TwidoSoft connection.

Pin outs of Male and Female Connectors

The following figure shows the pin outs of a male 8-pin miniDIN connector and of a terminal:

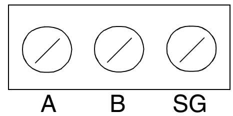
Mini DIN

TWD NAC232D, TWD NAC485D
TWD NOZ485D, TWD NOZ232D



Terminal

TWD NAC485T
TWD NOZ485T

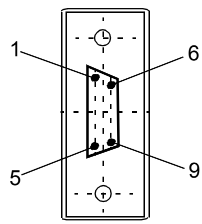


Pin outs	Base RS485	RS485 option	RS232-C
1	A (+)	A (+)	RTS
2	B (-)	B (-)	DTR
3	NC	NC	TXD
4	/DE	NC	RXD
5	/DPT	NC	DSR
6	NC	NC	GND
7	0 V	0 V	GND
8	5 V	5 V	5 V

Pin outs	RS485
A	A(+)
B	B(-)
SG	0V

Note: Maximum total consumption for 5V mode (pin 8): 180mA

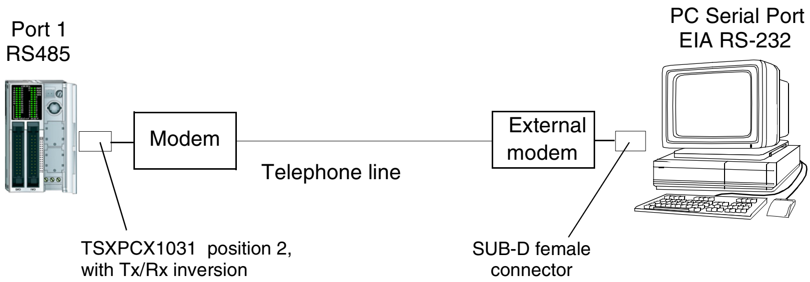
The following figure shows the pin outs of a SubD female 9-pin connector for the TSX PCX 1031.



Pin outs	RS232
1	DCD
2	RX
3	TX
4	DTR
5	SG
6	NC
7	RTS
8	CTS
9	NC

Telephone Line Connection

A modem (See *Communication between TwidoSoft and a Modem, p. 95*) connection enables programming of and communication with the controller using a telephone line.
The modem associated with the controller is a **receiving** modem connected to port 1 of the controller. The modem associated with the PC can be internal, or external and connected to a COM serial port.
This connection is illustrated in the diagram below.



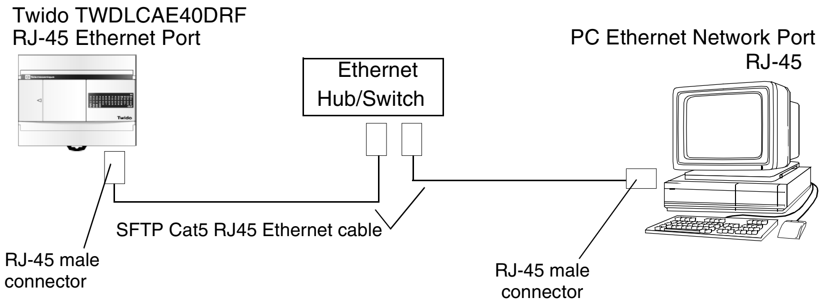
Note: Only one modem can be connected to port 1 of the controller.

Note: Caution. Remember to install the software provided with the modem, as TwidoSoft only takes into account the installed modems.

Ethernet Network Connection

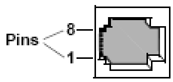
> **Note:** Although direct cable connection (using a Ethernet crossover cable) is supported between the Twido TWDLCAE40DRF and the PC running the TwidoSoft programming software, we do not recommend it. Therefore, you should always favor a connection via a network Ethernet hub/switch.

The following figure shows a PC-to-Twido connection via a network Ethernet hub/ switch:



> **Note:** The PC running the TwidoSoft application must be Ethernet-capable.

The Twido TWDLCAE40DRF features a RJ-45 connector to connect to the 100 BASE-TX network Ethernet with auto negotiation. It can accomodate both 100Mbps and 10 Mbps network speeds.
The following figure shows the RJ-45 connector of the Twido controller:



The eight pins of the RJ-45 connector are arranged vertically and numbered in order from bottom to top. The pinout for the RJ-45 connector is described in the table below:

Pinout	Function	Polarity
8	NC	
7	NC	
6	RxD	(-)
5	NC	
4	NC	
3	RxD	(+)

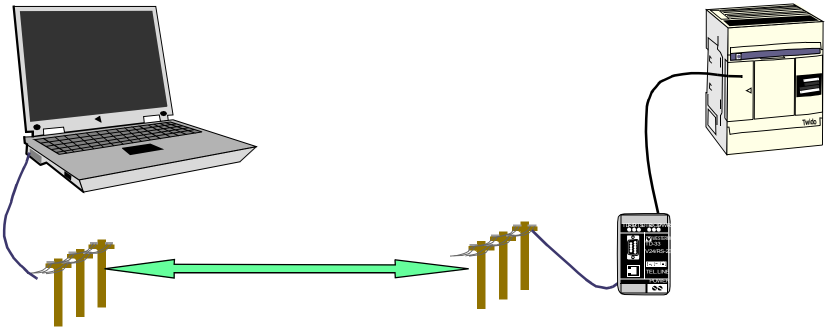
Pinout	Function	Polarity
2	TxD	(-)
1	TxD	(+)

Note:
- The same connector and pinout is used for both 10Base-T and 100Base-TX.
- When connecting the Twido controller to a 100Base-TX network, you should use at least a category 5 Ethernet cable.

Communication between TwidoSoft and a Modem

General

A PC executing Twidosoft can be connected to a Twido controller for transferring applications, animating objects and executing operator mode commands. It is also possible to connect a Twido controller to other devices, such as another Twido controller, for establishing communication with the application process.

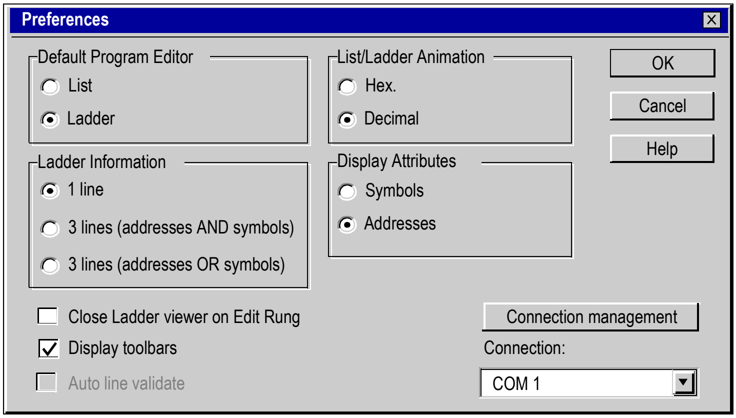


Installing the Modem

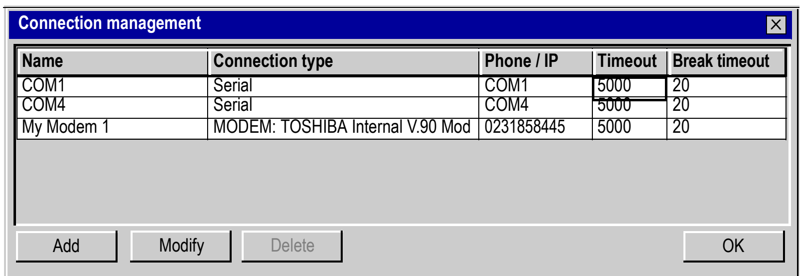
All modems the user wishes to use with Twidosoft must be installed running Windows from your PC.
To install your modems running Windows, follow the Windows documentation.
This installation is independent from Twidosoft.

Establishing Connection

The default communication connection between Twidosoft and the Twido controller is made by a serial communication port, using the TSX PCX 1031 cable and a crossed adaptater (see *Appendix 1, p. 103*).
If a modem is used to connect the PC, this must be indicated in the Twidosoft software.
To select a connection using Twidosoft, click "file", then "preferences".



This screen allows you to select a connection or manage connections (creation, modification, etc.).
To use an existing connection, select it from those displayed in the drop-down menu.
If you have to add, modify or delete a connection, click once on "Manage connections"; a window opens displaying the list of connections and their properties.

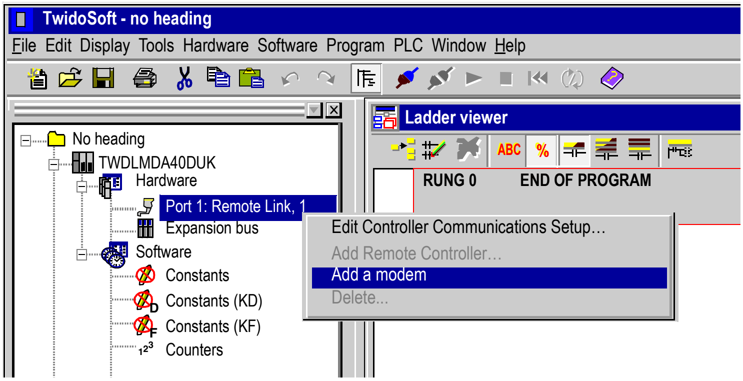


In this case, 2 serial ports are displayed (Com1 and Com4), as well as a modem connection showing a TOSHIBA V.90 model configured to compose the number: 0231858445 (national call).
You can change the name of each connection for application maintenance purposes (COM1 or COM4 cannot be changed).
This is how you define and select the connection you wish to use for connecting your PC to a modem.
However, this is just part of the process for making an overall connection between the computer and the Twido controller.
The next step involves the Twido controller. The remote Twido must be connected to a modem.

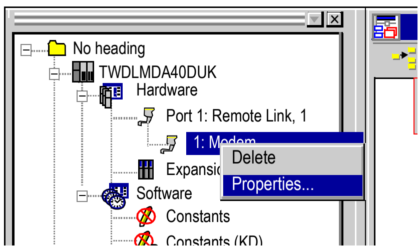
All modems need to be initialized to establish a connection. The Twido controller containing at least version V2.0 firmware is capable, on power-up, of sending an adapted string to the modem, if the modem is configured in the application.

Configuring the Modem

The procedure for configuring a modem in a Twido controller is as follows:



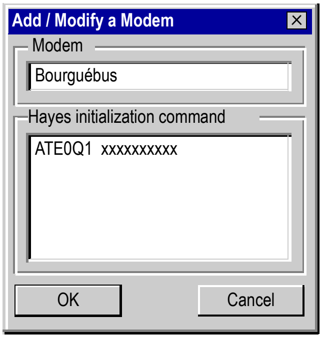
Once the modem is configured on port 1, the properties must be defined. Right-click on the modem to reveal the choice of "delete" or "properties". Clicking "properties" lets you either select a known modem, create a new modem, or modify a modem.



Note: The modem is completely managed by the Twido controller through port 1. This means you can connect a modem to communication port 2, but in this case all of the modem's operating modes and its initialization sequence must be performed manually, and cannot be performed in the same way as with communication port 1.

Next, select "properties", then:

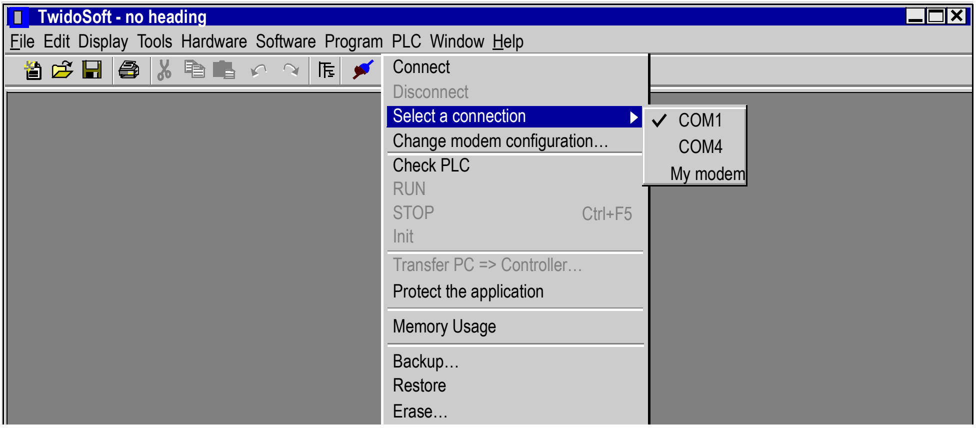
You can select a previously-defined modem, or create a new one by clicking "..." .



Then give the new profile a name and complete the Hayes initialization commands as described in the modem documentation.
In the image, "xxxxxx" represents the initialization sequence you must enter to prepare the modem for suitable communication, i.e. the baud rate, parity, stop bit, and receive mode.
To complete the sequence, please refer to your modem documentation.
The maximum string length is: 127 characters.
When your application is complete, or at least when communication port 1 is fully described, transfer the application using a "point to point connection".
The Twido controller is now ready to be connected to a PC executing Twidosoft via modems.

Connection Sequence

Once Twidosoft and the Twido controller are prepared, establish connection as follows:

Step	Action
1	Power-up the Twido controller and modem.
2	Start your computer and run Twidosoft.
3	Select the "PLC" menu, then "Select a connection", and select "My modem" (or the name you have given to your modem connection – see "creation of a connection":) 
4	Connect TwidoSoft

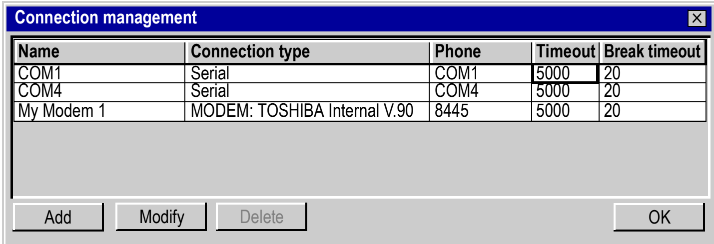
> **Note:** If you want to use your modem connection all the time, click "file", "preferences", and select "my modem" (or the name you have given it). Twidosoft will now memorize this preference.

Operating Modes

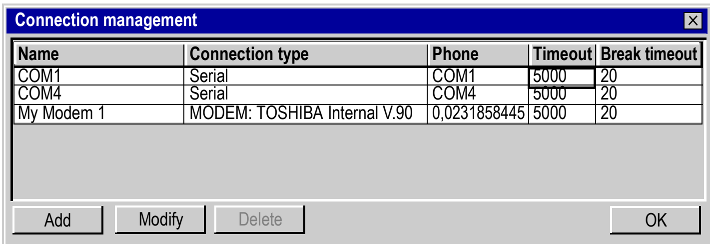
The Twido controller sends the initialization string to the connected, powered-up modem. When a modem is configured in the Twido application, the controller first sends an "FF" command to establish whether the modem is connected. If the controller receives an answer, the initialization string is sent to the modem.

Internal, External and International Calls

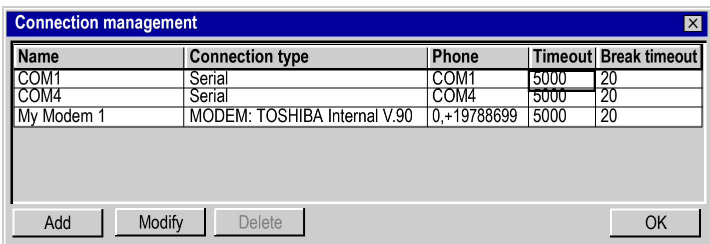
If you are communicating with a Twido controller within your company premises, you can use just the line extension needed to dial, such as: 8445



If you are using an internal switchboard to dial telephone numbers outside your company and you have to first press "0" or "9" before the number, use this syntax: 0,0231858445 or 9,0231858445

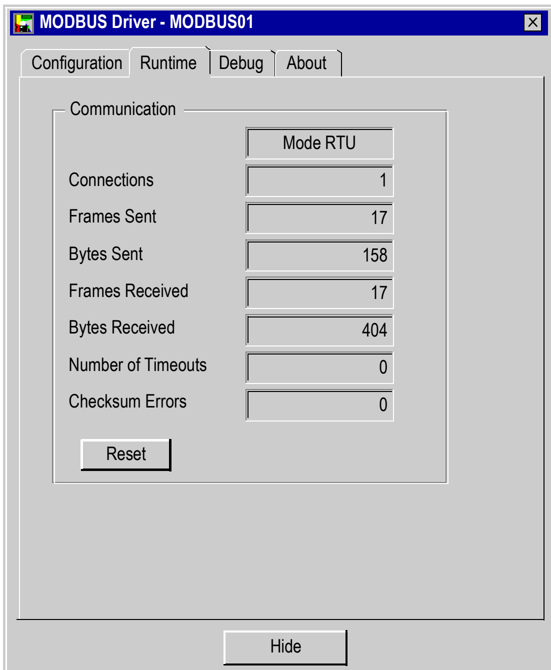


For international calls, the syntax is: +19788699001, for example. And if you are using a switchboard: 0,+ 19788699001



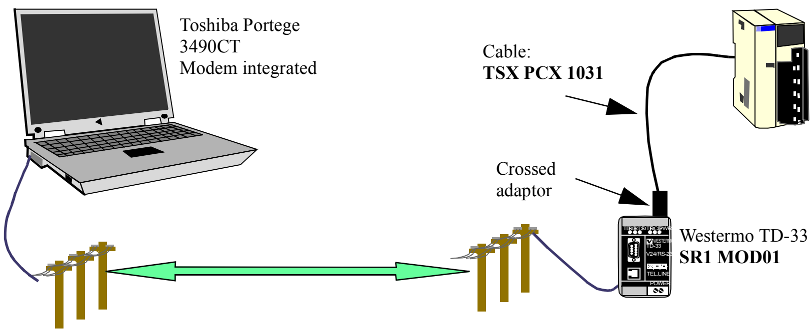
Frequently Asked Questions

When your communication has been established for a few minutes, you can experience some communication errors. In this case, you must adjust the communication parameters.
Twidosoft uses a modbus driver to communicate via serial ports or internal modems. When communication starts, the modbus driver is visible in the toolbar. Double-click on the modbus driver icon to open the window. You now have access to the modbus driver parameters, and the "runtime" tab gives you information on the frames exchanged with the remote controller.
If the "Number of timeouts" increases or is other than 0, change the value using "Connection management", accessible using Twidosoft by clicking "File" then "Preferences" and "Connection management". Click on the "timeout" field, then click the modification button and enter a new, higher value. The default value is "5000", in milliseconds.
Try again with a new connection. Adjust the value until your connection stabilizes.



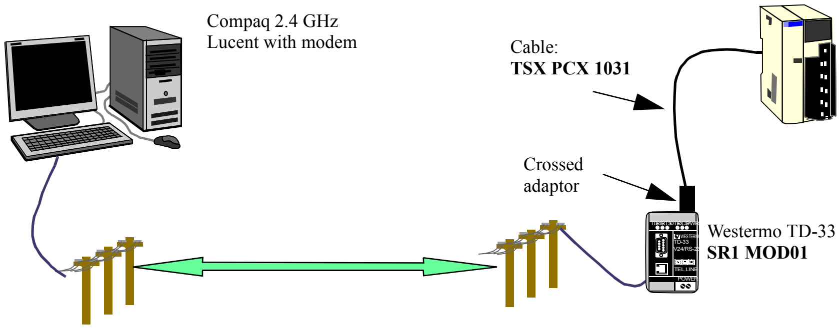
Examples

- **Example 1**: Twidosoft connected to a TWD LMDA 20DRT (Windows 98 SE).
  - PC: Toshiba Portege 3490CT running Windows 98,
  - Modem (internal on PC): Toshiba internal V.90 modem,
  - Twido Controller: TWD LMDA 20DRT version 2.0,
  - Modem (connected to Twido): Type Westermo TD-33 / V.90, reference SR1 MOD01, available from the new Twido catalog (September 03) (see *Appendix 2, p. 104*),
  - Cable: TSX PCX 1031, connected to Twido communication port 1, and an adaptor: 9 pin male / 9 pin male, in order to cross Rx and Tx during connection between the Westermo modem and the Twido controller (see *Appendix 1, p. 103*). You can also use the TSX PCX 1130 cable (RS485/232 conversion and Rx/Tx crossing).



The first test involves using 2 analog telephone lines internal to the company, and not using the entire number – just the extension (hence only 4 digits for the internal Toshiba V.90 modem telephone number).
For this test, the connection parameters (Twidosoft menu "preferences" then "Connection management") were established with their default value, with a timeout of 5000 and break timeout of 20.

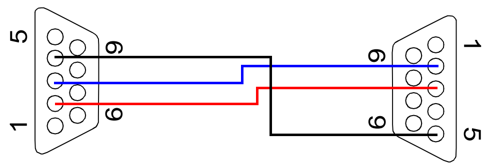
- **Example 2**: Twidosoft connected to TWD LMDA 20DRT (windows XP Pro)
  - PC: Compaq Pentium 4, 2.4GHz,
  - Modem: Lucent Win modem, PCI bus,
  - Twido Controller: TWD LMDA 20DRT version 2.0,
  - Modem (connected to Twido): Type WESTERMO TD-33 / V.90, reference SR1 MOD01, available from the new Twido catalog (September 03) (see *Appendix 2, p. 104*),
  - Cable: TSX PCX 1031, connected to Twido communication port 1, and an adaptor: 9 pin male / 9 pin male, in order to cross Rx and Tx during connection between the Westermo modem and the Twido controller (see *Appendix 1, p. 103*). You can also use the TSX PCX 1130 cable (RS485/232 conversion and Rx/Tx crossing).



The first test involves using two analog telephone lines internal to the company, and not using the entire number – just the extension (hence only 4 digits for the internal Toshiba V.90 modem telephone number).
For this test, the connection parameters (Twidosoft menu "preferences" then "Connection management") were established with their default value, with a timeout of 5000 and break timeout of 20.

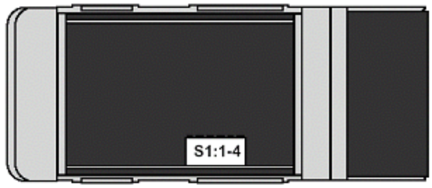
Appendix 1

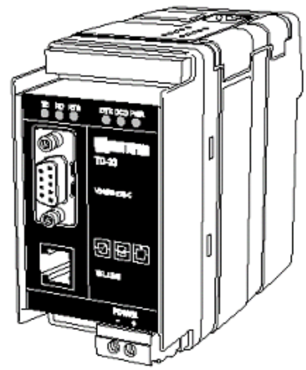
Crossed adaptor for cable TSX PCX 1031 and Westermo TD-33 modem (**SR1 MOD01**):



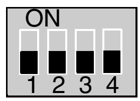
Appendix 2

Modem Westermo TD-33, Schneider reference number **SR1 MOD01**. This modem manages four DIP switches, which must all be set to **OFF**:





Factory Settings



Use stored configuration (speed & format etc)
Disable DTR Hotcall, Auto Band

Appendix 3

Wavecom WMOD2B modem, Schneider reference number **SR1 MOD02** double band (900/1800Hz):

Appendix 4

Reference numbers of the products used in this document:
- Twido product: TWD LMDA 20DRT,
- Twidosoft software: TWD SPU 1002 V10M,
- TSX PCX 1031 cable,
- TSX PCX 1130 cable,
- RTU modem: Westermo TD-33 / V90 **SR1 MOD01**,
- GSM modem: Wavecom WMOD2B **SR1 MOD02**.

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 cannot 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 follow 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

A remote link must use a minimum 3-wire EIA RS-485 port. It can be configured to use either the first or an optional second port if present.

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

The table below lists the devices that can be used:

Remote	Port	Specifications
TWDLC•A10/16/24DRF, TWDLCA•40DRF, TWDLMDA20/40DUK, TWDLMDA20/40DTK, TWDLMDA20DRT	1	Base controller equipped with a 3-wire EIA RS-485 port with a miniDIN connector.
TWDNOZ485D	2	Communication module equipped with a 3-wire EIA RS-485 port with 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 equipped with a 3-wire EIA RS-485 port with a terminal. **Note:** This module is only available for the Modular controllers. When the module is attached, the controller cannot have an Operator Display expansion module.
TWDNAC485D	2	Communication adapter equipped with a 3-wire EIA RS-485 port with a miniDIN connector. **Note:** This adapter is only available for the Compact 16, 24 and 40 I/O controllers and the Operator Display expansion module.
TWDNAC485T	2	Communication adapter equipped with a 3-wire EIA RS-485 port with a terminal. **Note:** This adapter is only available for the Compact 16, 24 and 40 I/O controllers and the Operator Display expansion module.
TWDXCPODM	2	Operator Display expansion module equipped with a 3-wire EIA RS-485 port with a miniDIN connector or a 3-wire EIA RS-485 port with a terminal. **Note:** This module is only available for the Modular controllers. When the module is attached, the controller cannot have a Communication expansion module.

Note: You can only check the presence and configuration (RS232 or RS485) of port 2 at power-up or reset by the firmware executive program.

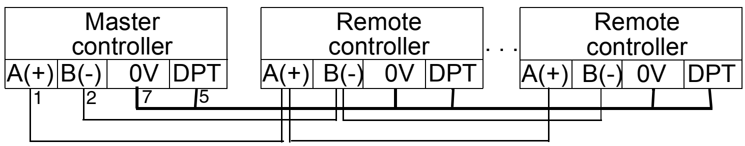
Cable Connection to Each Device

Note: The DPT signal on pin 5 must be tied to 0V 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.

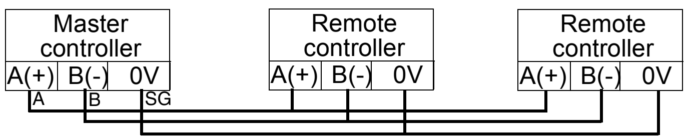
Note: The DPT to 0V connection is only necessary if you are connected to a base controller on Port 1.

The cable connections made to each remote device are shown below.

Mini-DIN connection



Terminal block connection



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 follow 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. These seven remote controllers can be configured either as remote I/Os or as peer controllers. The address of the master configured using TwidoSoft corresponds to address 0.
To configure a controller as a Master Controller, use TwidoSoft to configure port 1 or port 2 as remote links and select the address 0 (Master).
Then, from the "Add remote controller" window, you can specify the slave controllers either as remote I/O, or as peer controllers, as well as their addresses.

Remote Controller Configuration

A remote controller is configured using TwidoSoft, by setting port 1 or 2 as a remote link or by assigning the port an address from 1 to 7.
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 Not even a simple "END" statement RUN mode is coupled to the Master's.	%I and %Q Only the local I/O of the controller is accessible (and not its I/O extension).
Peer controller	Yes Run mode is independent of the Master's.	%INW and %QNW A maximum of 4 input words and 4 output words 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 program execution. 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 bit is set to 1 when a complete update cycle has taken place. The application program is responsible for resetting this to 0.

The master can enable or disable the remote link using system bit %S112.

Controllers can check on the proper configuration and correct operation 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	Status	Indication
%S100	0	master/slave: DPT not active (TwidoSoft cable NOT connected)
	1	master/slave: DPT active (TwidoSoft cable connected)
%S110	0	master/slave: set to 0 by the application
	1	master: all remote link exchanges completed (remote I/O only) slave: exchange with master completed
%S111	0	master: single remote link exchange completed slave: single remote link exchange detected
	1	master: single remote link exchange in progress 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 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.

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 state:
  - The remote I/Os apply a Stop state.
  - A peer controller continues in its current state.

Master Controller Stop

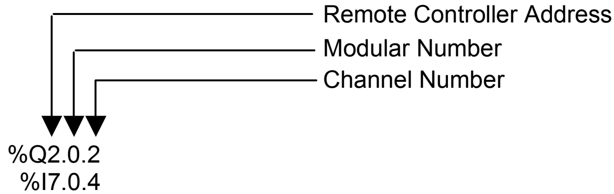
When the master controller enters Stop mode, all slave devices continue communicating with the master. When the master indicates a Stop is requested, then a remote I/O controller will Stop, but peer controllers will continue in their current Run or Stop state.

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.

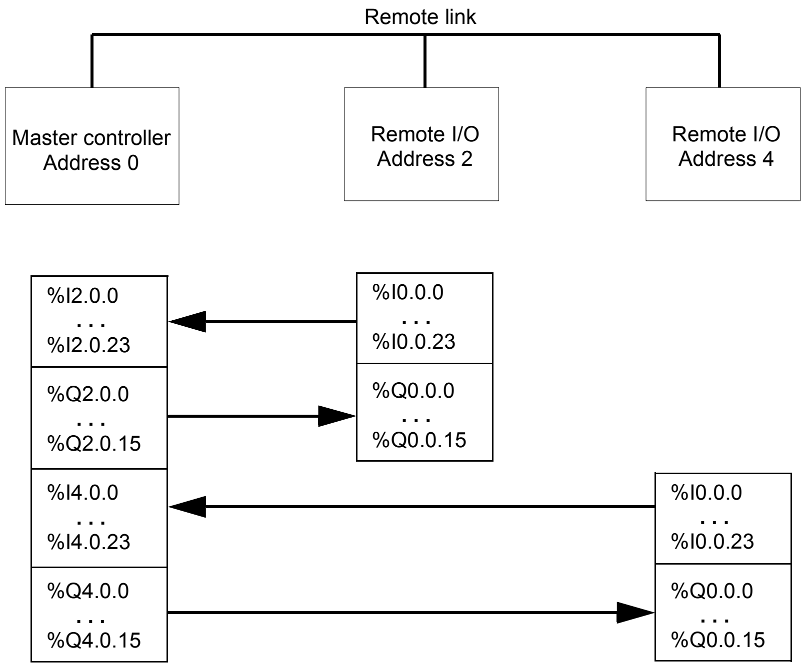
Illustration



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, instruction %Q2.0.2 is used. Similarly, to read the fifth input bit of the remote I/O configured at location 7, instruction %I7.0.4 is used.

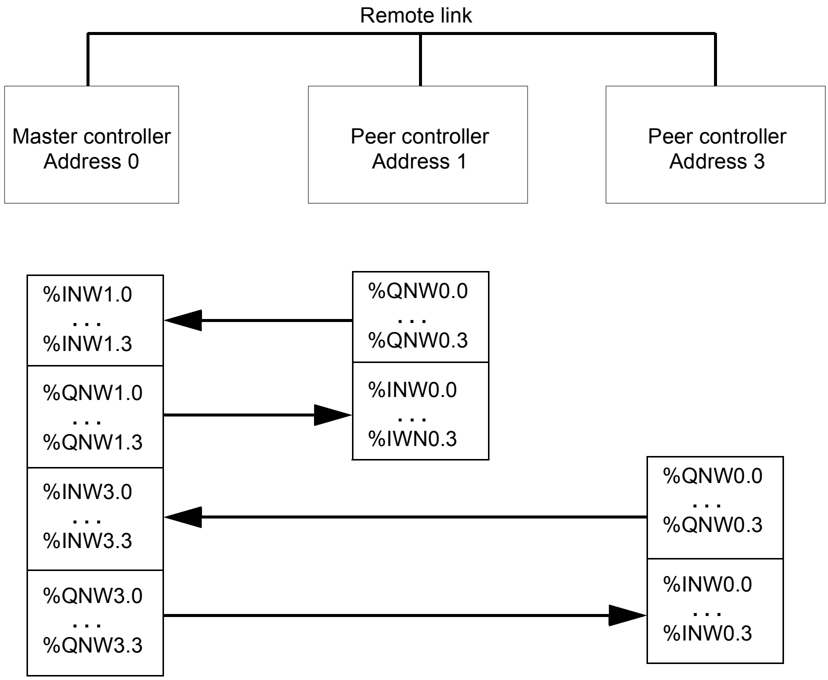
> **Note:** The master is restricted to accessing only the digital I/O that is part of the remote's local I/O. No analog or expansion I/O can be transferred, unless you use peer communications.

Illustration



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 Stop 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. The master application program can be used to manage the network words, in order 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 the presence and configuration status of remote controllers. This action is performed 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.

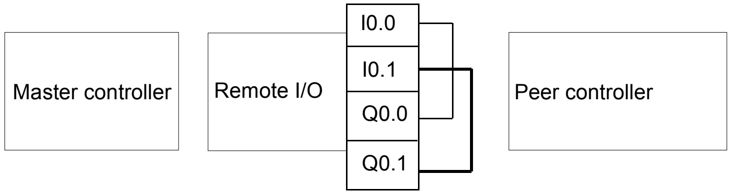
System Words	**Use**	
%SW111	Remote link status: two bits for each remote controller (master only)	
	x0-6	0-Remote controller 1-7 not present
		1-Remote controller 1-7 present
	x8-14	0-Remote I/O detected at Remote controller 1-7
		1-Peer controller detected at Remote controller 1-7
%SW112	Remote Link 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)	
	x0-6	0-Remote controller 1-7 not configured
		1-Remote controller 1-7 configured
	x8-14	0-Remote I/O configured as remote controller 1-7
		1-Peer controller configured as remote controller 1-7

Remote Link Example

To configure a Remote Link, you must:
1. Configure the hardware.
2. Wire the controllers.
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:

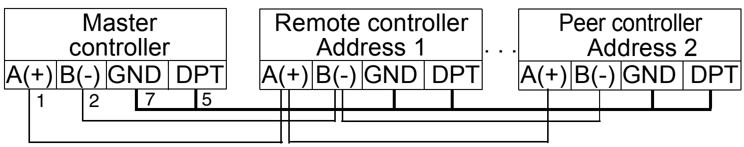


The hardware configuration is three base controllers of any type. Port 1 is used for two communication modes. One mode is to configure and transfer the application program with TwidoSoft. The second mode is for the Remote Link network. If available, an optional Port 2 on any of the controllers can be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

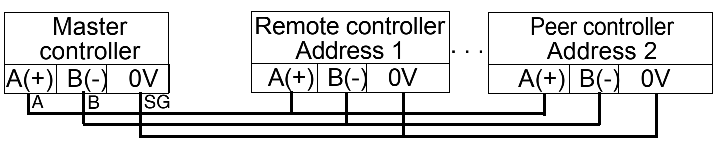
> **Note:** In this example, the two first inputs on the Remote I/O are hard wired to the first two outputs.

Step 2: Wire the controllers

Mini-DIN connection

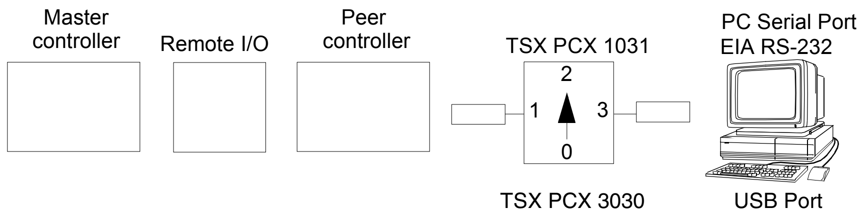


Terminal block connection



Connect the A(+) and B(-) signal wires together. And at each controller, the DPT signal is tied to ground. Although tying the signal to the 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 or TSX PCX 3030 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.

Step 4: Configure the Software:
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)".

Controller comm. settings
Type: Remote link
Address: 0 (Master)

Configure the remote controller on the master by adding a "Remote I/O" at address "1" and a "Peer PLC" at address "2".

Add Remote Controllers

Controller Usage: Remote I/O
Remote Address: 1

Controller Usage: Peer controller
Remote 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".

Controller comm. settings
Type: Remote link
Address: 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".

Controller comm. settings
Type: Remote link
Address: 2

Step 5: Write the applications:
For the Master controller, write the following application program:

```
LD 1

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

LD %I0.0
ST %Q1.00.0
LD %I1.0.0
ST %Q0.0

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

For the controller configured as a remote I/O, do not write any application program.
For the controller configured as peer, write the following application:

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

In this example, the 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.

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 256 bytes.

Hardware Configuration

An ASCII link (see system bits %S103 and %S104 (See *System Bits (%S), p. 510*)) 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:

Remote	Port	Specifications
TWDLC•A10/16/24DRF, TWDLCA•40DRF, TWDLMDA20/40DTK, TWDLMDA20DRT	1	Base controller equipped with a 3-wire EIA RS-485 port with a miniDIN connector.
TWDNOZ232D	2	Communication module equipped with a 3-wire EIA RS-232 port with 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 equipped with a 3-wire EIA RS-485 port with 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 equipped with a 3-wire EIA RS-485 port with a terminal. **Note:** This module is only available for the Modular controllers. When the module is attached, the controller cannot have an Operator Display expansion module.

Remote	Port	Specifications
TWDNAC232D	2	Communication adapter equipped with a 3-wire EIA RS-232 port with a miniDIN connector. **Note:** This adapter is only available for the Compact 16, 24 and 40 I/O controllers and the Operator Display expansion module.
TWDNAC485D	2	Communication adapter equipped with a 3-wire EIA RS-485 port with a miniDIN connector. **Note:** This adapter is only available for the Compact 16, 24 and 40 I/O controllers and the Operator Display expansion module.
TWDNAC485T	2	Communication adapter equipped with a 3-wire EIA RS-485 port with a terminal. **Note:** This adapter is only available for the Compact 16, 24 and 40 I/O controllers and the Operator Display expansion module.
TWDXCPODM	2	Operator Display expansion module equipped with a 3-wire EIA RS-232 port with a miniDIN connector, a 3-wire EIA RS-485 port with a miniDIN connector and a 3-wire EIA RS-485 port with a terminal. **Note:** This module is only available for the Modular controllers. When the module is attached, the controller cannot have a Communication expansion module.

Note: You can only check the presence and configuration (RS232 or RS485) of port 2 at power-up or reset by the firmware executive program.

Nominal Cabling

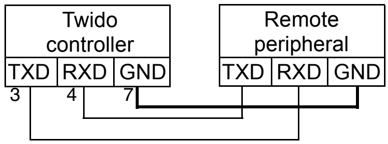
Nominal cable connections are illustrated below for both the EIA RS-232 and the EIA RS-485 types.

Note: If port 1 is used on the Twido controller, the DPT signal on pin 5 must be tied to 0V on pin 7. 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.

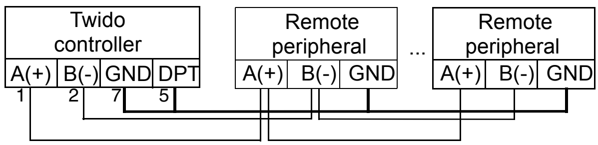
Cable connections to each device are illustrated below.

Mini-DIN connection

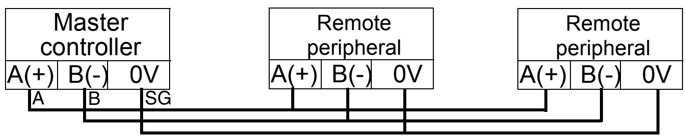
RS-232 EIA cable



RS-485 EIA cable



Terminal block connection



Software Configuration

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

Step	Description
1	Configure the serial port for ASCII using TwidoSoft.
2	Create in your application a transmission/reception table that will be used by 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 communication adapters or modules 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 Transmission/ Reception table for ASCII mode

The maximum size of the transmitted and/or received frames is 256 bytes. The word table associated with the EXCHx instruction is composed of the transmission and reception control tables.

	Most significant byte	Least significant byte
Control table	Command	Length (transmission/reception)
	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 table

The **Length** byte contains the length of the transmission table in bytes (250 max.), 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: Send/receive
- 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, %MSGx.D is set to 1, and a new EXCHx instruction can be executed.

When in Transmit/Receive 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 256 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 256 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. In this case an error (receive table overflowed) appears in the word %SW63 and %SW64. 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.

Message Exchange

The language offers two services for the communication:
- **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 256 bytes 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]
where: x = port number (1 or 2)
L = number of words in the control words and transmission and reception tables

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 parameter L (length of the 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 transmission of a previous message is complete.
- **Transmission of priority messages**
  The %MSGx function block allows current message transmissions 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. 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. 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 (see %SW7) 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
- Processing of EXCHx instructions is not re-tried in the event of an error
- Reset input (R) 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: 0 - operation was successful 1 – number of bytes to be transmitted is too great (> 250) 2 - transmission table too small 3 - word table too small 4 - receive table overflowed 5 - time-out elapsed 6 - transmission error 7 - bad command within table 8 - selected port not configured/available 9 - reception error 10 - cannot use %KW if receiving 11 - transmission offset larger than transmission table 12 - reception offset larger than reception table 13 - controller stopped EXCH processing
%SW64	EXCH2 error code: See %SW63.

Consequence of Controller Restart on the Communication

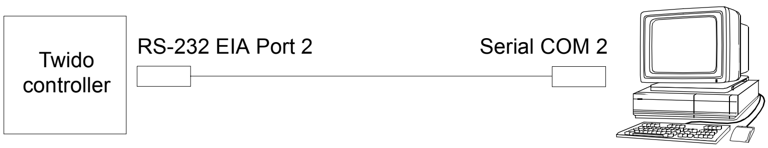
If a controller restarts, one of the following events happens:
- A cold start (%S0 = 1) forces a re-initialization of the communications.
- A warm start (%S1 = 1) forces a re-initialization of the communications.
- In Stop, the controller stops all ASCII communications.

ASCII Link Example

To configure an 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.

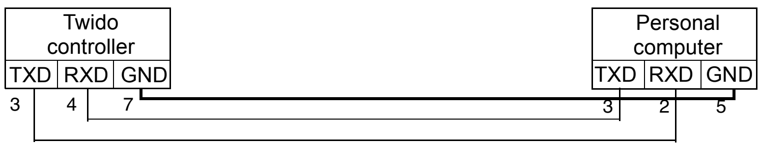
The diagram below illustrates the use of the ASCII communications with a Terminal Emulator on a PC.

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 or a TWDNAC232D in the TWDXCPODM. 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 of 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. The wiring schematic is provided in the next step.

Step 2: ASCII Communications Cable (EIA RS-232) Wiring Schematic:



The minimum number of wires used in an ASCII communications cable is 3. 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: Port Configuration:

Hardware -> Add Option	
TWDNOZ232D	

Hardware => Adjust Controller Comm. Setting	
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 the COM2 port 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, in order to terminate character reception. 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 the 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 Transmission tables 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 status bit associated with %MSG2 and issue the EXCH2 instruction only if the port is ready. For the EXCH2 instruction, a value of 8 words 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 accurate.

Step 5: Initialize the Animation Table Editor:

Address	Current	Retained	Format
1 %MW10	0104		Hexadecimal
2 %MW11	0000		Hexadecimal
3 %MW12	4F4B		Hexadecimal
4 %MW13	0A0D		Hexadecimal
5 %MW14	TW		ASCII
6 %MW15	ID		ASCII
7 %MW16	O		ASCII
8 %MW17	A		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. The characters "O"-"K"-CR-LF can be displayed as many times as the EXCH block response timeout has elapsed and the new EXCH block has been started. 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. Each of these ports can be assigned its own Modbus address, using system bit %S101 and system words %SW101 and %SW102 (See *System Bits (%S), p. 510*). (See also *System Words (%SW), p. 517*).

The table below lists the devices that can be used:

Remote	Port	Specifications
TWDLC•A10/16/24DRF, TWDLCA•40DRF, TWDLMDA20/40DTK, TWDLMDA20DRT	1	Base controller supporting a 3-wire EIA RS-485 port with a miniDIN connector.
TWDNOZ232D	2	Communication module equipped with a 3-wire EIA RS-232 port with 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 equipped with a 3-wire EIA RS-485 port with 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 equipped with a 3-wire EIA RS-485 port with a terminal. **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 equipped with a 3-wire EIA RS-232 port with a miniDIN connector. **Note:** This adapter is only available for the Compact 16, 24 and 40 I/O controllers and the Operator Display expansion module.

Remote	Port	Specifications
TWDNAC485D	2	Communication adapter equipped with a 3-wire EIA RS-485 port with a miniDIN connector. **Note:** This adapter is only available for the Compact 16, 24 and 40 I/O controllers and the Operator Display expansion module.
TWDNAC485T	2	Communication adapter equipped with a 3-wire EIA RS-485 port with a terminal connector. **Note:** This adapter is only available for the Compact 16, 24 and 40 I/O controllers and the Operator Display expansion module.
TWDXCPODM	2	Operator Display expansion module equipped with a 3-wire EIA RS-232 port with a miniDIN connector, a 3-wire EIA RS-485 port with a miniDIN connector and a 3-wire EIA RS-485 port with a terminal. **Note:** This module is only available for the Modular controllers. When the module is attached, the controller cannot have a Communication expansion module.

Note: The presence and configuration (RS232 or RS485) of Port 2 is checked at power-up or at reset by the firmware executive program.

Nominal Cabling

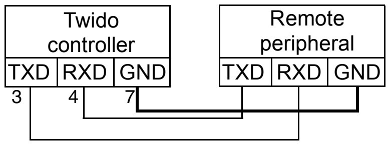
Nominal cable connections are illustrated below for both the EIA RS-232 and the EIA RS-485 types.

Note: If port 1 is used on the Twido controller, the DPT signal on pin 5 must be tied to 0V on pin 7. 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.

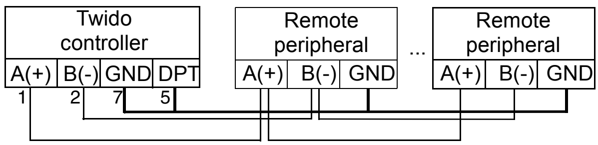
The cable connections made to each remote device are shown below.

Mini-DIN connection

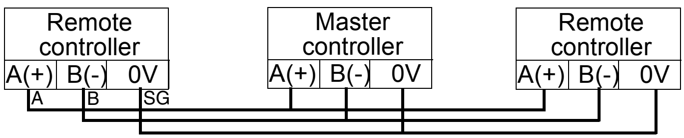
RS-232 EIA cable



RS-485 EIA cable



Terminal block connection



Software Configuration

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

Step	Description
1	Configure the serial port for Modbus using TwidoSoft.
2	Create in your application a transmission/reception table that will be used by 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 communication adapters or modules 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 send a Modbus query to a slave, and to wait for the response. 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 transmitted and/or received frames is 250 bytes. Moreover, the word table associated with the EXCHx instruction is composed of the control, transmission and reception tables.

	Most significant byte	**Least significant byte**
Control table	Command	Length (Transmission/ Reception)
	Reception offset	Transmission 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	

Note: In addition to queries to invidual slaves, the Modbus master controller can initiate a **broadcast** query to all slaves. The **command** byte in case of a boradcast query must be set to 00, while the **slave address** must be set to 0.

Control table

The **Length** byte contains the length of the transmission table (maximum 250 bytes), 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 length of the transmission frame. If the Tx Offset parameter is not equal to 0, one byte of the transmission table (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 rank (1 for the first byte, 2 for the second byte, and so on) within the Transmission Table of the byte to ignore when transmitting the bytes. 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 rank (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:

- time out on a character or frame has been detected,
- end-of-frame character received in ASCII mode,
- 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 Bytes X** 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

The Modbus slave mode allows the controller to respond to standard Modbus queries from a Modbus master.
When the TSXPCX1031 cable is attached to the controller, TwidoSoft communications are 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 can end 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
- Words: 125 words of 16 bits on request

Message Exchange

The language offers two services for communication:

- **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) containing control information and the data to be sent and/or received (up to 250 bytes 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]

where: x = port number (1 or 2)

L = number of words in the control words, transmission and reception tables

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 parameter L (length of the 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 transmission of a previous message is complete.
- **Transmission of priority messages**
  The %MSGx function block allows current message transmissions 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. 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. 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 presence and configuration (RS232 or RS485) is checked 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
- Processing of EXCHx instructions is not re-tried in the event of an error

- Reset input (R) 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: 0 - operation was successful 1 – number of bytes to be transmitted is too great (> 250) 2 - transmission table too small 3 - word table too small 4 - receive table overflowed 5 - time-out elapsed 6 - transmission 7 - bad command within table 8 - selected port not configured/available 9 - reception error 10 - can not use %KW if receiving 11 - transmission offset larger than transmission table 12 - reception offset larger than reception table 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.

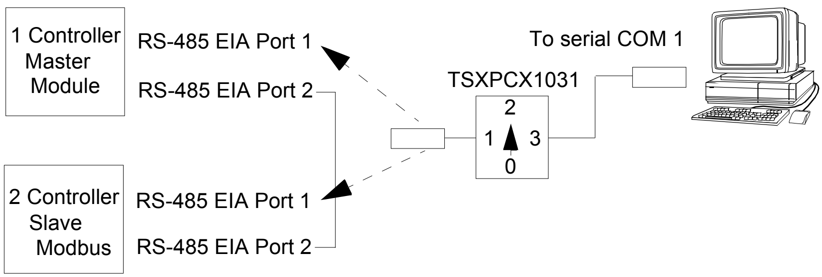
Modbus Link Example 1

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 request 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, or if you use TWDXCPODM, it can be either a TWDNAC485D or a TWDNAC485T. On a Compact controller, the optional Port 2 can be either a TWDNAC485D or a TWDNAC485T.

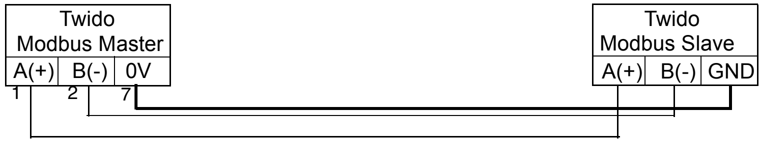
To configure each controller, connect the TSXPCX1031 cable to Port 1 of the controller.

Note: The TSXPCX1031 can only be connected to one controller at a time, on RS-485 EIA port 1 only.

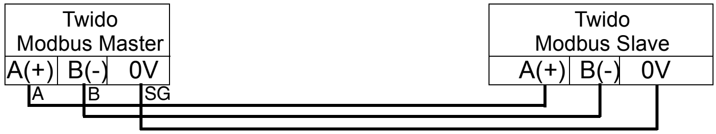
Next, connect the cable to the COM 1 port of the PC. Be sure that the cable is in switch position 2. Download and monitor the application. Repeat procedure for second controller.

Step 2: Connect the Modbus Communications Cable:

Mini-DIN connection



Terminal block connection



The wiring in this example demonstrates a simple point to point connection. The three signals A(+), B(-), and 0V are wired according to the diagram.
If using Port 1 of the Twido controller, the DPT signal (pin 5) must be tied to 0V (pin 7). This conditioning of DPT determines if TwidoSoft is connected. When tied to the ground, the controller will use the port configuration set in the application to determine the type of communication.

Step 3: Port Configuration:

Hardware -> Add Option TWDNOZ485-	Hardware -> Add Option TWDNOZ485-
Hardware => Controller Comm. Setting 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 => Controller Comm. Setting 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. Ensure that the controller's communication parameters are modified in Modbus protocol and at 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 the 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 simply write some memory words to a set of known values. In the master, the word table of the EXCHx instruction 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 executing the EXCH2 instruction, the application checks the communication 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 accurate.

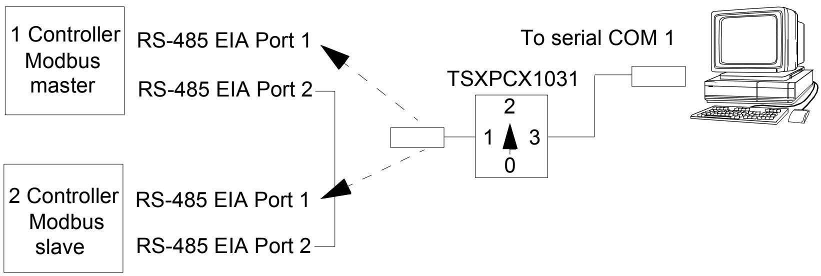
Step 5: Initialize the animation table editor in the master:

	Address	Current	Retained	Format
1	%MW5	0203	0000	Hexadecimal
2	%MW6	0008	0000	Hexadecimal
3	%MW7	6566	0000	Hexadecimal
4	%MW8	6768	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

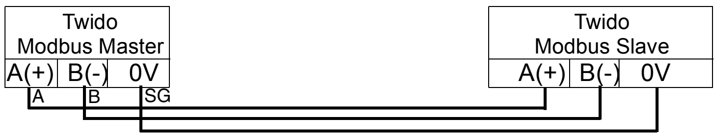
The diagram below illustrates the use of Modbus request 16 to write output words to a slave. This example uses two Twido Controllers.
Step 1: Configure the Hardware:



The hardware configuration is identical to the previous example.
Step 2: Connect the Modbus Communications Cable (RS-485):

Mini-DIN connection

Terminal block connection



The Modbus communications cabling is identical to the previous example.

Step 3: Port Configuration:

Master	Slave
Hardware -> Add Option TWDNOZ485-	Hardware -> Add Option TWDNOZ485-
Hardware => Controller Comm. Setting 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 => Controller Comm. Setting 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

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

Step 4: Write the 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, write 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 Modbus request would be trying to write to locations that did not exist on the slave.

In the master, the word table of the EXCH2 instruction is initialized to read 4 bytes to the slave at Modbus address 2 at the address %MW16 (10 hexadecimal).

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

Before executing the EXCH2 instruction, the application checks the communication 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 accurate.

Step 5: Initialize the Animation Table Editor:

Create the following animation table on the master:

	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

Create the following animation table on the slave:

	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 on the slave controller. 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

These requests are used to exchange memory words or bits between remote devices. The table format is the same for both RTU and ASCII modes.

Format	Reference number
Bit	%Mi
Word	%MWi

Modbus Master: Read N Bits

The following table represents requests 01 and 02.

	Table Index	Most significant byte	Least significant byte
Control table	0	01 (Transmission/ reception)	06 (Transmission length) (*)
	1	00 (Reception offset)	00 (Transmission offset)
Transmission table	2	Slave@(1..247)	01 or 02 (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 (if N>1)	
	...		
	(N/2)+6	Byte N read (if N>1)	

(*) This byte also receives the length of the string transmitted after response

Modbus Master: Read N Words

The following table represents requests 03 and 04.

	Table Index	Most significant byte	Least significant byte
Control table	0	01 (Transmission/ reception)	06 (Transmission length) (*)
	1	03 (Reception Offset)	00 (Transmission offset)
Transmission table	2	Slave@(1..247)	03 or 04 (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)	

(*) This byte also receives the length of the string transmitted after response

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

Modbus Master: Write Bit

This table represents Request 05.

	Table Index	Most significant byte	Least significant byte
Control table	0	01 (Transmission/ reception)	06 (Transmission length) (*)
	1	00 (Reception offset)	00 (Transmission 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	

(*) This byte also receives the length of the string transmitted after response

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, and 0 for the bit to write 0.

Modbus Master: Write Word

This table represents Request 06.

	Table Index	Most significant byte	Least significant byte
Control table	0	01 (Transmission/ reception)	06 (Transmission length) (*)
	1	00 (Reception offset)	00 (Transmission 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	

(*) This byte also receives the length of the string transmitted after response

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 of N Bits

This table represents Request 15.

	Table Index	Most significant byte	Least significant byte
Control table	0	01 (Transmission/ reception)	8 + number of bytes (transmission)
	1	00 (Reception Offset)	07 (Transmission 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 second byte	Value of the second byte
Control table	7	Value of the third byte	Value of the fourth byte
	...		
Transmission table	6+(N_2/2)	Value of the N_2nd 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. This also allows a good correspondence of words' values in the transmission table.

Modbus Master: Write of N Words

This table represents Request 16.

	Table Index	Most significant byte	Least significant byte
Control table	0	01 (Transmission/ reception)	8 + (2*N) (Transmission length)
	1	00 (Reception offset)	07 (Transmission 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 = Number of bytes to write
	6	First word value to write	
	7	Second value to write	
	...		
	N+5	N values 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 words written (= N)	

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

Ethernet TCP/IP Communications Overview

Ethernet Features

The following information describes the Ethernet-capable features of the Twido TWDLCAE40DRF base controller.
The TWDLCAE40DRF base controller is an Ethernet-capable device that implements the Modbus Application Protocol (MBAP) over TCP/IP. Modbus TCP/IP provides peer-to-peer communications over the network in a client/server topology.

Frame Format

The Twido TWDLCAE40DRF compact controller supports the Ethernet II frame format only. It does not accommodate IEEE802.3 framing. Note that other PLCs available from Schneider Electric, such as the Premium and Quantum series support both Ethernet II and IEEE802.3 frame formats and are frame format selectable. Therefore, if you are planning to team up your Twido controller with Premium or Quantum PLCs, you should configure them as using Ethernet II frame format to allow for optimum compatibility.

TCP Connections

The TWDLCAE40DRF compact controller is a 4-simultaneous-channel device capable of communicating over a 100Base-TX Ethernet network. It implements 100Base-TX auto-negotiation and can work on a 10Base-T network as well. Moreover, it allows one marked IP connection, as configured in the TwidoSoft application program (see *Marked IP Tab, p. 166* for more details about Marked IP).

IP Address

Each TWDLCAE40DRF base controller is assigned a unique static IP address as default. The device default IP address is derived from the unique MAC physical address (IEEE Global Address) permanently stored in the compact controller.
For increased flexibility on your network, other than using the default IP address, the TwidoSoft application program allows you to configure a different static IP address for this device, along with defining the subnetwork and gateway IP addresses.

Modbus TCP Client/Server

A TWDLCAE40DRF controller can be both Modbus TCP/IP Client and Server depending on whether it is querying or answering a remote device, respectively. TCP messaging service is implemented via TCP port 502.
Modbus Client is implemented via the %EXCH3 instruction and %MSG3 function. You may program several %EXCH3 instructions, however one %EXCH3 only can be active at a time. The TCP connection is automatically negotiated by the compact controller as soon as the %EXCH3 instruction is active.

Quick TCP/IP Setup Guide for PC-to-Controller Ethernet Communication

Scope

This Quick TCP/IP Setup Guide is intended to provide Ethernet connectivity information and TCP/IP configuration information to rapidly setup communication between your PC running the TwidoSoft application and the Twido Controller over a stand-alone Ethernet network.

Checking the Current IP Settings of your PC

The following procedure describes how to check the current IP settings of your PC Also, this procedure is valid for all versions of the Windows operating system:

Step	Action
1	Select **Run** from the Windows **Start** menu.
2	Type **"command"** in the **Open** textbox of the Run dialog box. **Result:** The **C:\WINDOWS\system32\command.com** prompt appears.
3	Type **"ipconfig"** at the command prompt.
4	The Windows **IP Configuration** appears, and displays the following parameters: IP Address..................: Subnet Mask..............: Default Gateway........: **Note:** The above IP settings cannot be changed directly at the command prompt. They are available for consultation only. If you plan to change the IP configuration of your PC, please refer to the following section.

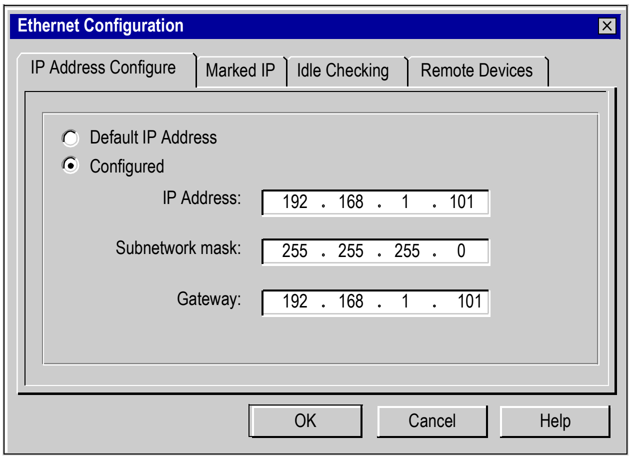
Configuring the TCP/IP Settings of your PC

The following information will help configure the TCP/IP settings of your PC running the TwidoSoft application for programming and control of the Twido controller over the network. The procedure outlined below is workable on a PC equipped with a Windows XP operating system, and is intended as an example only. (Otherwise, for other operating systems, please refer to TCP/IP setup instructions outlined in the user's guide of the particular operating system installed on your PC.)

Step	Action
Note: If your PC is already installed and the Ethernet card is configured over the existing stand-alone network, you will not need to change the IP address settings (skip steps 1-6 and continue to the following section). Follow steps 1-6 of this procedure only if you intend to change the PC's TCP/IP settings.	
1	Select **Control Panel > Network Connections** from the Windows **Start** menu.
2	Right click on the **Local Area Connection** (the stand-alone network) on which you are planning to install the Twido controller, and select **Properties**.
3	Select **TCP/IP** from the list of network components installed, and click **Properties**. **Note:** If TCP/IP protocol is not among the list of installed components, please refer to the user's manual of your operating system to find out how to install the TCP/IP network component.
4	The **TCP/IP Properties** dialog box appears and displays the current TCP/IP settings of your PC, including **IP Address** and **Subnet Mask**. **Note:** On a stand-alone network, do not use the **Obtain an IP address automatically** option. The **Specify an IP address** radio-button must be selected, and the IP Address and Subnet Mask fields must contain valid IP settings.
5	Enter a valid **static IP Address** in dotted decimal notation. Over a stand-alone network, we suggest you to specify a Class-C network IP address (see *IP Addressing, p. 156.*). For example, `192.168.1.198` is a Class-C IP address. **Note:** The IP address you specify must be compatible with the network ID of the existing network. For example, if the existing network supports `192.168.1.xxx` IP addresses (where `192.168.1` is the network ID, and `xxx = 0-255` is the host ID), than you may specify `191.168.1.198` as a valid IP address for your PC. (Make sure the host ID `198` is unique over the network).
6	Enter a valid **Subnet Mask** in dotted decimal notation. If subnetting is not used on your Class-C network, we suggest you to specify a Class-C network default subnet mask such as `255.255.255.0`.

Configuring the TCP/IP Settings of your Twido Controller

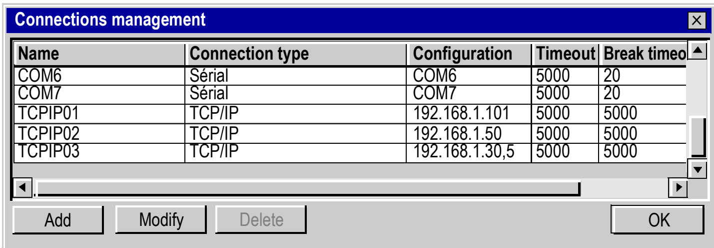
Once you have configured the TCP/IP settings of your PC hosting the TwidoSoft application, you will need to configure the TCP/P settings of the Twido controller you wish TwidoSoft to communicate with over the network, as described below:

Step	Action
1	Connect a serial cable (TSXPCX1031) from the PC running TwidoSoft to the Twido controller's RS-485 console port.
2	Launch the **TwidoSoft** application program on your PC.
3	Select a new **Hardware** from the TwisoSoft Application Brower and choose the **TWDLCAE40DRF** controller.
4	Select **PLC > Select a connection** from the TwidoSoft menu bar, and choose the **COM1** port.
5	Double-click on the **Ethernet Port** icon in the TwisoSoft Application Browser (or select **Hardware > Ethernet** from the menu bar) to call up the **Ethernet Configuration** dialog box, as shown below: 
6	From the **IP Address Configure** tab, select the **Configured** radio-button, and start configuring the IP Address, Subnetwork mask and Gateway address fields as explained in steps 7-9. **Note:** At this stage, we are only dealing with the basic configuration of PC-to-controller communication over the Ethernet network. Therefore, you will not need to configure the Marked IP, Idle Checking and Remote Devices tabs yet.

Step	Action
7	Enter a valid static **IP Address** for the Twido controller in dotted decimal notation. This IP address must be compatible with that of the PC's IP address that you have configured in the previous section. **Note:** The IP addresses of the Twido controller and the PC must share the same network ID. However, the Twido controller's host ID must be different from the PC's host ID, and unique over the network. For example, if the PC's Class-C IP address is `192.168.1.198`, then a valid address for the Twido controller is `192.168.1.xxx` (where `192.168.1` is the network ID, and `xxx = 0-197, 199-255` is the host ID).
8	Enter a valid **Subnetwork mask** in dotted decimal notation. The Twido controller and the PC running TwidoSoft must be on the same network segment. Therefore, you must enter a subnet mask that is identical to that specified for the PC. **Note:** If subnetting is not used on your Class-C network, we suggest you to specify a Class-C network default subnet mask, such as `255.255.255.0` .
9	Enter a valid **Gateway** address in dotted decimal notation. **Note:** If there is no gateway device on your stand-alone network, enter the Twido controller's own IP Address that you have just configured in step 6 in this field.
10	Click on **OK** to save the Ethernet configuration settings of your Twido controller.

Setting Up a New TCP/IP Connection in TwidoSoft

You will now set up a new TCP/IP connection in the TwidoSoft application. The new dedicated TCP/IP connection will allow the PC running TwidoSoft and the Twido controller to communicate over the Ethernet network.

Step	Action
1	Select **File > Preferences > Connections Management** from the TwidoSoft menu bar to call up the **Connections Management** dialogbox, as shown below: 
2	Click the **Add** button in the **Connections Management** dialogbox. **Result:** A new connection line is added. The new line displays suggested default connection settings. You will need to change these settings. **Note:** To set a new value in a field, you have two options: ● Click once to select the desired field, then click the **Modify** button. ● Double-click the desired field.
3	In the **Name** field, enter a descriptive name for the new connection. A valid name may contain up to 32 alphnumeric characters.
4	In the **Connection Type** field, click to unfold the dropdown list and select **TCP/IP** as you are setting up a new Ethernet connection between your PC and a Ethernet-capable Twido controller.
5	In the **Configuration** field, enter a valid **IP address** and **Unit ID** (if any) which is the IP information of the Twido TWDLCAE40DRF controller you wish to connect to. The IP address and the Unit ID must be seperated by a comma. **IP Address:** Enter the static IP address that you have specified for your Twido controller in a previous section. **Unit ID:** Leave this part of the field blank unless you are specifically connecting to a Twido controller located across a Bridge on a Modbus serial link.
6	Use the default settings in **Timeout** and **Break Timeout** fields, unless you have specific timeout needs. (For more details, please refer to *Ethernet Connections Management, p. 173*.)
7	Click the **OK** button to save the new connection settings and close the Connections management dialog box. **Result:** The names of all the newly-added connections are added to the dropdown list of connections in the **File > Preferences** dialog box and in the **PLC > Select a connection**.

Connecting your Controller to the Network

Overview

The following information describes how to install your TDWLCAE40DRF compact controller on your Ethernet network.

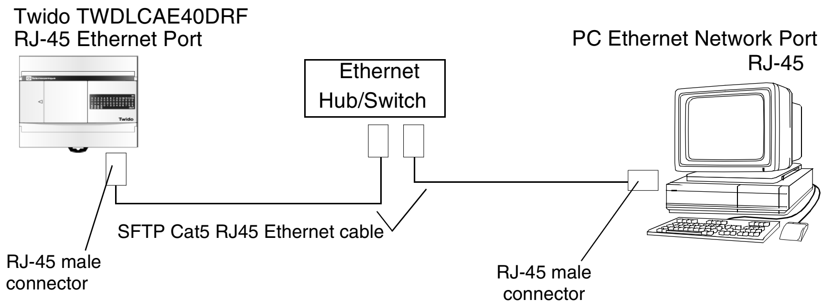
Determining the Appropriate IP Address Set

Consult your network administrator to determine if you must configure a new set of device IP, gateway and subnet mask addresses. If the administrator assigns new IP address parameters, you will need to enter this information manually in the TwidoSoft application. Follow the directions in the *TCP/IP Setup, p. 162* section hereafter.

Ethernet Network Connection

> **Note:** Although direct cable connection (using a Ethernet crossover cable) is supported between the Twido TWDLCAE40DRF and the PC running the TwidoSoft programming software, we do not recommend it. Therefore, you should always favor a connection via a network Ethernet hub/switch.

The following figure shows a Twido network connection via an Ethernet hub/switch:



The Twido TWDLCAE40DRF features a RJ-45 connector to connect to the 100BASE-TX network Ethernet with auto negotiation. It can accommodate both 100Mbps and 10 Mbps network speeds.

> **Note:** When connecting the Twido controller to a 100BASE-TX network, you should use at least a category 5 Ethernet cable.

IP Addressing

Overview

This section provides you with information on IP Address notation, subnet and gateway concepts as well.

IP Address

An IP address is a 32-bit quantity expressed in dotted decimal notation. It consists of four groups of numbers ranging in value from 0 to 255 and separated from one another by a dot. For example, 192.168.2.168 is an IP address in dotted decimal notation (note that this is a reserved IP address provided as an example only).
On usual networks, IP addresses fall into three categories named Class A, B, and C networks. Classes can be differentiated according to the value of their first number which ranges as described in the following table:

First decimal group	IP class
0-127	Class A
128-191	Class B
192-223	Class C

IP Subnet Mask

An IP address consists of two parts, the network ID and the host ID. The subnet mask is used to split the network portion of the IP address to artificially create subnetworks with a larger number of host IDs. Thus, subnetting is used as a means of connecting multiple physical networks to logical networks. All devices on the same subnetwork share the same network ID.
All devices on the same subnetwork share the same network ID.

Note: If you are part of a large organization, then there is a good chance that subnetting is being implemented on your company's networks. Check with your network administrator to obtain adequate subnetting information when you are installing your new Twido controller on the existing network.

Gateway Address

The Gateway is the networking device also called router that provides to your network segment access to other network segments on your company's global network, access to the Internet or to a remote Intranet.
The gateway address uses the same dotted decimal notation format as the IP address described above.

Note: Check with your network administrator to obtain adequate gateway information when you are installing your new Twido controller on the existing network.

Assigning IP Addresses

Overview

This section provides you with information on how to determine which type of IP address you can assign to the Twido TWDLCAE40DRF controller that you wish to install on your network.

Installation on a Stand-alone Network

Your Twido TWDLCAE40DRF controller is intended for installation on a stand-alone Ethernet network.

Note: A network is called stand-alone when it is not linked to the Internet or a company's Intranet.

MAC Address and Default IP Address of the Controller

MAC Address: Each Twido TWDLCAE40DRF controller has its own factory-set MAC address that is a worldwide-unique 48-bit address assigned to each Ethernet device.
Default IP Address: The default Ethernet interface IP address of the Twido controller is derived from its unique MAC address.
The default IP address expressed in dotted decimal notation is defined as follows: `085.016.xxx.yyy`, where:

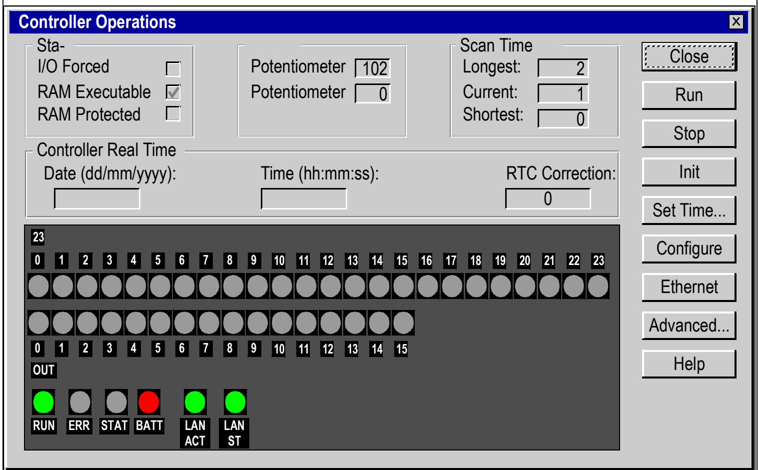
- `085.016.` is a set header shared by all IP addresses derived from MAC address,
- `xxx` and `yyy` are last two numbers of the device MAC address.

For example, the IP address derived from MAC address `00.80.F4.81.01.11` is `085.016.001.11`.

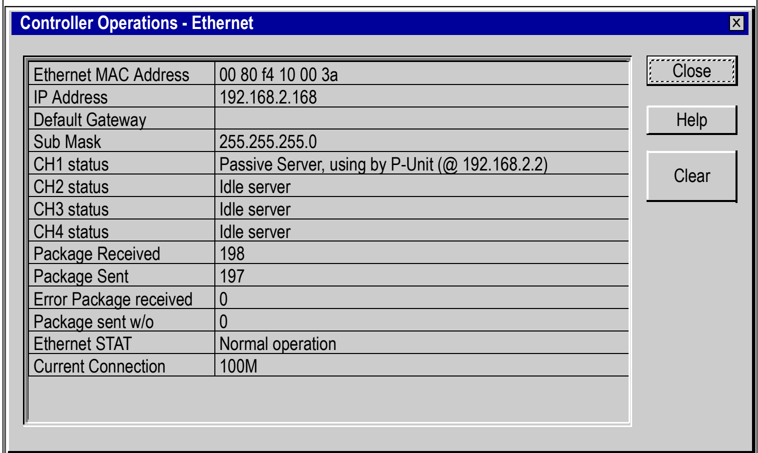
Checking the MAC Address and Current IP Address of the Controller

To check out the MAC address and the current IP address of your Twido controller, along with IP configuration settings (subnetwork mask and gateway addresses) and Ethernet connection status, follows these instructions:

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>1</td><td>In TwidoSoft application program, select PLC from the menu bar.</td></tr>
<tr><td>2</td><td>Select Check PLC from the menu items list.
Result: The Controller Operations dialogbox appears, displaying the Twido LEDs on a soft front-panel, as shown in the figure below:



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

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>3</td><td>Click the Ethernet button located in the right portion of the screen to access the connection parameters.
Result: The Control Operations - Ethernet table appears, displaying MAC, current IP ,Subnet and Gateway information, as well as Ethernet connection information, as shown in the following figure:

</td></tr>
<tr><td>4</td><td>Note that the unique MAC address of the Twido controller is showing on the first row of the Ethernet table.</td></tr>
<tr><td>5</td><td>The IP information displayed in this table varies depending on the user-settings in the IP Configure tab of the Ethernet Configuration dialogbox (see IP Address Configure Tab, p. 164):
● if you selected Default IP Address from the IP Configure tab, the above table displays the default IP address (derived from MAC address) of the Twido controller, the default subnet and gateway as well.
● if you selected Configured from the IP Configure tab, the above table displays the current IP address, subnet and gateway settings that you have previouly entered in the IP Configure tab.
Note: The remaining fields provide information about the current status of the Ethernet connection. To find out more information, please refer to (See TwdoSOFT).</td></tr>
</table>

Private IP Addresses

If your network is stand-alone (isolated from the Internet), you may therefore assign to your network node (Twido controller) any arbitrary IP address (as long as the IP address conforms to the IANA notation rule and it doesn't conflict with the IP address of another device already connected to the network).
Privates IP addresses meet the need for arbitrary IP addressing over a stand-alone network. Note that addresses within this private address space will only be unique within the enterprise.
The following table outlines the private IP address space:

Network	Valid range for private IP addresses
Class A	10.0.0.0 -> 10.255.255.255
Class B	172.16.0.0 -> 172.31.255.255
Class C	192.168.0.0 -> 192.168.255.255

Assigning an IP Address to your Controller

Today’s networks are rarely either totally isolated from the Internet or from the rest of the company's Ethernet network. Therefore, if you are installing and connecting your Twido base controller to an existing network, do not assign an arbitrary IP address without prior consulting with your network administrator. you should follow the directions outlined below when assigning an IP address to your controller.

Note: It is good practice to use Class-C IP addresses on stand-alone networks.

TCP/IP Setup

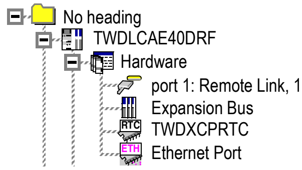
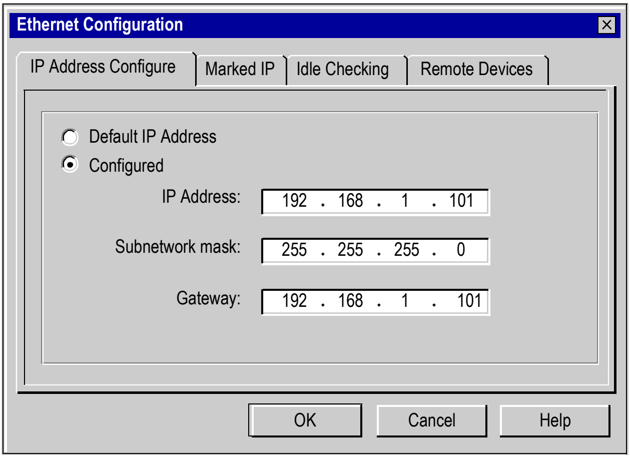
Overview

The following are detailed instructions on how to set up the Ethernet TCPI/IP configuration for your Twido TWDLCAE40DRF compact controller.

Note: TCP/IP setup can be performed when the TwidoSoft application program is in offline mode only

Calling up the Ethernet Configuration Dialogbox

The following steps detail how to call up the **Ethernet Configuration** dialogbox:

Step	Action
1	Open the **Application Browser**, as shown in the figure below. **Result:**  **Note:** Make sure an Ethernet-capable device such as TWDLCAE40DRF is selected as the current hardware, or otherwise the Ethernet Port hardware option will not appear.
2	Double-click on the **Ethernet Port** icon to bring up the **Ethernet Configuration** dialogbox, as shown below. **Result:**  **Note:** There are two alternate ways to call up the Ethernet Configuration screen: **1.** Right-click on the **Ethernet Port** icon and select **Edit** from the popup list. **2.** Select **Hardware > Ethernet** from the TwidoSoft menu bar.

TCP/IP Setup

The following sections detail how to configure the Twido TWDLCAE40DRF TCP/IP parameters by using the **IP Address Configure, Marked IP, Idle Checking** and **Remote Devices** tabs.

IP Address Configure Tab

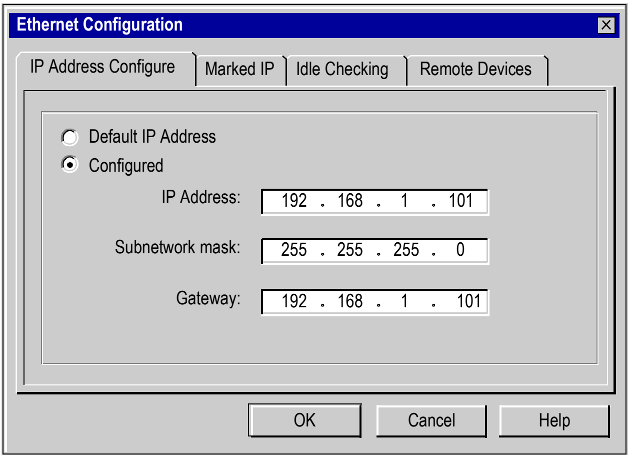
Overview

The following information describes how to configure the IP Address Configure tab of the Ethernet Configuration dialogbox.

> **Note:** The IP address of the Twido controller can be configured when the TwidoSoft application program is in offline mode only

IP Address Configure tab

The following figure presents a sample screen of the IP Address Configure tab showing examples of IP, Subnet and Gateway addresses configured manually by the user:



Configuring the IP Address tab

The following information describes how to configure the various fields in the IP Address Configure tab:

Field	Configuring
Default IP Address	Check this radio button if you do not wish to set the IP address of the Twido controller manually (the IP Address, Subnetwork mask and Gateway textboxes are grayed out). The Twido controller will then use the default Ethernet interface IP address derived from its MAC address. **Note:** To find out more information about the MAC address, please refer to *Assigning IP Addresses, p. 158*.
Configured	Check this radio button to configure the IP, subnetwork and gateway addresses manually. **Note:** Consult with your network or system administrator to obtain valid IP parameters for your network.

Field	Configuring
IP Address	Enter the static IP address of your Twido in dotted decimal notation. **Caution:** For good device communication, the IP addresses of the PC running the TwidoSoft application and the Twido controller must share the same network ID. **Note:** To allow good communication over the network, each connected device must have a unique IP address. When connected to the network, the Twido controller runs a check for duplicate IP address. If a duplicate IP address is located over the network, the LAN ST LED of the Twido controller will emit 4 flashes periodically. You must then enter a new duplicate-free IP address in this field.
Subnetwork mask	Enter the valid subnet mask assigned to your controller by your network administrator. Please note that you cannot leave this field blank; you must enter a value. As default, the TwidoSoft application automatically computes and displays a default subnet mask based on the class IP that you have provided in the IP Address field above. Default subnet mask values, according to the category of the Twido network IP address, follow this rule: Class A network -> Default subnet mask: 255.0.0.0 Class B network -> Default subnet mask: 255.255.0.0 Class C network -> Default subnet mask: 255.255.255.0 **Caution:** For good device communication, the subnet mask configured on the PC running the TwidoSoft application and the Twido controller's subnet mask must match. **Note:** Unless your Twido controller has special need for subnetting, use the default subnet mask.
Gateway	Enter the IP address of the gateway. On the LAN, the gateway must be on the same segment as your Twido controller. This information typically is provided to you by your network administrator. Please note that no default value is provided by the application, and that you must enter a valid gateway address in this field. **Note:** If there is no gateway device on your network, simply enter your Twido controller's IP address in the Gateway field.

Marked IP Tab

Overview

The following information describes how to configure the Marked IP tab of the Ethernet Configuration dialogbox.

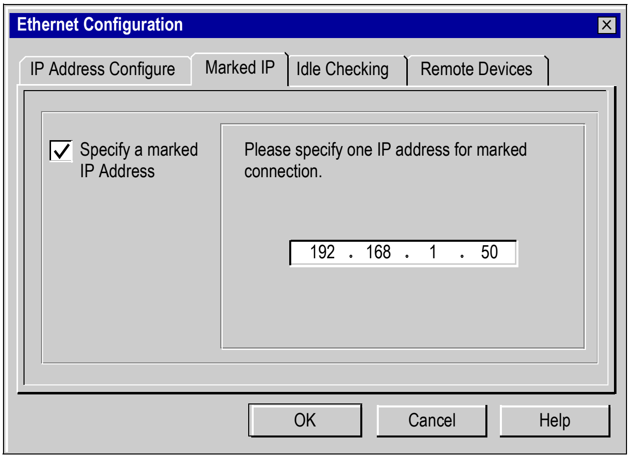
Note:
- The Marked IP can be configured when the TwidoSoft application program is in offline mode only.
- You may use a Marked IP only if you configured the Twido controller's IP address manually in the IP Address Configure tab. Marked IP does not function with the Default IP Address.

Definition of the Marked IP Function

This function allows you to reserve one of the four Ethernet TCP connection channels supported by your Twido controller for a particular client host designated as Marked IP.
Marked IP can ensure that one TCP channel is reserved and always available for communication with the specified remote device, even if the idle timeout is disabled (idle timeout is set to "0".)

Marked IP tab

The following figure presents a sample screen of the Marked IP tab showing an example of marked IP address entered by the user:



Configuring the Marked IP tab

To configure the Marked IP tab, follow these steps:

Step	Action
1	Check the box labeled **Specify a marked IP address** to enable the Marked IP function. Note that Marked IP is disabled, as default. **Result:** The IP address box becomes active in the right portion of the frame, as shown in the previous figure.
2	Enter the IP address of the client host you wish to mark the IP in the provided IP address box. **Note:** There is no default value in this field. You must provide the IP address of the marked device, or otherwise uncheck the Specify a marked IP address box to disable this function.

Idle Checking Tab

Overview

The following information describes how to configure the Idle Checking tab of the Ethernet Configuration dialogbox.

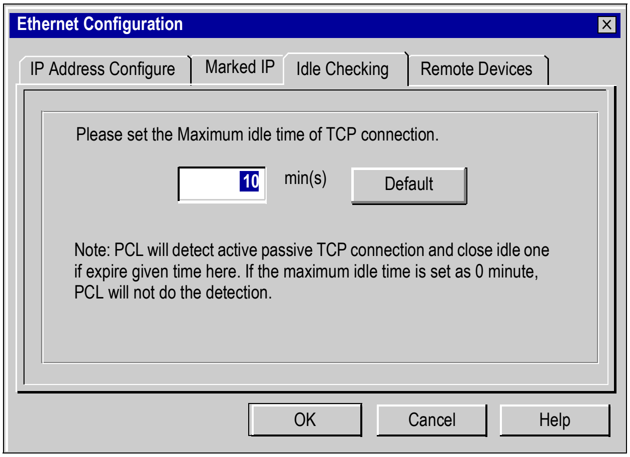
Note: The Idle Checking of the Twido controller can be configured when the TwidoSoft application program is in offline mode only.

Definition of Idle Checking

Idle Checking applies an idle timeout to all current Ethernet TCP connections of the Twido controller. The idle timeout is the amount of time that any of the four Ethernet TCP connection channels may remain idle before the remote client host connection to this channel is dropped.
Note: The idle timer is reset whenever there is data traffic on the monitored connection channel.

Idle Checking tab

The following figure presents a sample screen of the Idle Checking tab showing the 10 min default value of the idle timer:



Configuring the Idle Checking tab

To set the Idle timer, enter directly the elapsed time in minutes in the **min(s)** textbox, as shown in the previous figure.

Note:

1. The default elapsed time is 10 minutes. After you entering a value, to **reset** the configured elapsed time to 10 minutes, click on the **Default** button.
2. To **disable** the Idle Checking function, set the elapsed time to **0.** The Twido controller no longer performs idle checks. As a result, the TCP connections stay up indefinitely.
3. The maximum idle time allowed to set is 255 minutes.

Remote Devices Tab

Overview

The following information describes how to configure the Remote Devices tab of the Ethernet Configuration dialogbox when you intend to use use the EXCH3 instruction for the Twido controller to act as Modbus TCP/IP client.

Note: The Remote Devices tab of the Twido controller can be configured when the TwidoSoft application program is in offline mode only.

What You Should Know at First

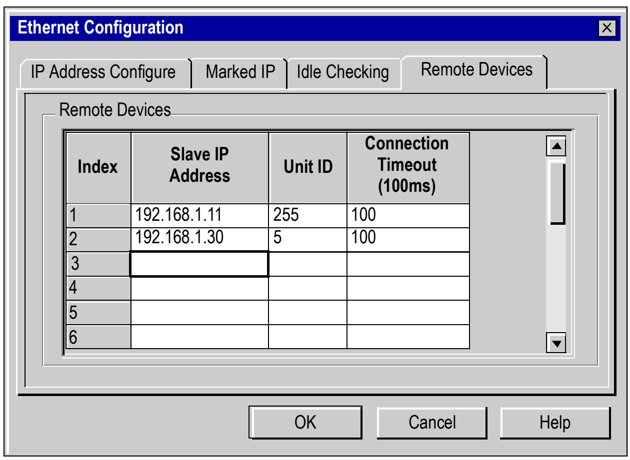
You do not need to configure the Remote Devices on any controller other than the controller that you want to use the Modbus TCP/IP client (legacy Modbus master) instruction (EXCH3).

Remote Devices Table

The Remote Devices table stores information about remote controllers (acting as Modbus TCP/IP servers) over the Ethernet network that can be queried by the Modbus TCP/IP client using the EXCH3 instruction. Therefore, you must configure the Remote Devices table properly so that the Modbus TCP/IP client controller can poll Modbus TCP/IP server controllers over the network.

Remote Devices tab

The following figure presents a sample screen of the Remote Devices tab configured on the Twido controller acting as Modbus TCP/IP client:



Configuring the Remote Devices tab

The following information describes how to configure the various fields in the Remote Devices tab:

Field	Configuring
Index	This is a read-only field that contains the MBAP Index associated with the Ethernet network IP address of the remote device (Modbus TPC/IP server specified in the Slave IP Address field). The MBAP Index is called by the EXCH3 instruction as one of the function's arguments to identify which remote controller specified in the table is being queried by the Modbus TCP/IP client. **Note:** You may specify up to 16 different remote devices indexed from 1 to 16 in this table.
Slave IP Address	Enter the IP address of the remote device (Modbus TCP/IP server) controller in this field. **Note:** You must configure the slave IP addresses starting at Index 1 and in growing index number, in a consecutive manner. For example, configuring slave IPs of index 1 than 3 is not allowed, for you must first configure the entry indexed 2 prior to index 3.
Unit ID	Enter the Modbus Unit ID (or Protocol Address) in this field. A valid Unit ID can range from 0 to 255. The default setting is 255. A Unit ID (other than 255) makes communications with a remote device across a Modbus bridge or gateway possible. If the target device is another Twido controller or a legacy Modbus device installed on another bus - serial link address via a gateway, than you may set the Unit ID of that remote device, accordingly. In the field, you should set the Slave IP as the gateway or bridge IP address, and the Unit ID as the Modbus serial link address of your target device.
Connection Timeout (100 ms)	Specify the elapsed time in units of 100 ms that the Twido controller will keep trying to establish a TCP connection with the remote device. If the connection is still not established after Timeout, the Twido controller will give up trying, until the next connection request by an EXCH3 instruction. A valid timeout setting can range from 0 to 65535 (which translates to 0 to 6553.5 s). The default setting is 100.

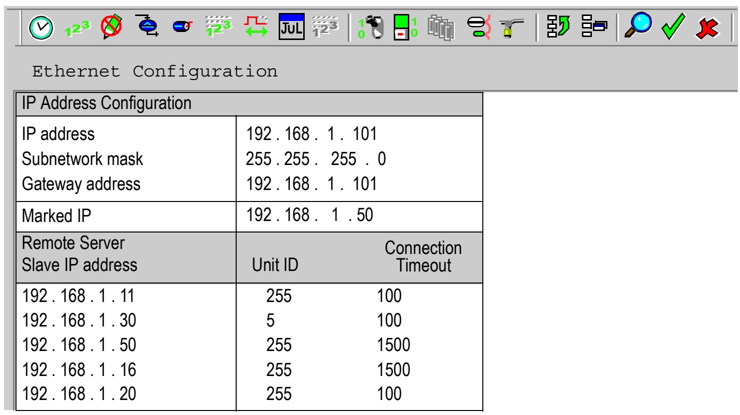
Viewing the Ethernet Configuration

Overview

You may use the TwidoSoft **Configuration Editor** to view the current Ethernet configuration of the Twido controller.

Viewing the Ethernet Configuration

To view the current Ethernet configuration settings using the Configuration Editor, follow these instructions:

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>1</td><td>Select Program > Configuration Editor from the TwidoSoft menu bar.</td></tr>
<tr><td>2</td><td>Click on the shortcut labeled ETH in the Configuration Editor taskbar or double click on the Ethernet Port shortcut in the Application Browser.</td></tr>
<tr><td>3</td><td>The Ethernet TCP/IP Configuration parameters appear in a table as shown in the figure below:

</td></tr>
<tr><td>4</td><td>At this stage, if you have just made changes to your Twido's Ethernet TCP/IP configuration settings, you may still decide to keep the changes or to discard them and restore the previous configuration, as explained below:
● Select Tools > Accept Changes from the TwidoSoft menu bar, to keep the changes you have made to the TCP/IP Ethernet configuration.
● Select Tools > Cancel Changes to discard the changes and restore the previous TCP/IP Ethernet configuration settings.
● Select Tools > Edit... to return to the Ethernet Configuration dialogbox and modify the TCP/IP configuration settings.
● Select Tools > Update PLC Program to upload the complete PLC configuration file into the Twido controller.</td></tr>
</table>

Ethernet Connections Management

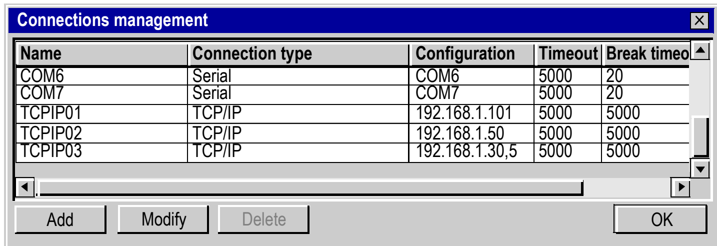
Overview

The following information describes how to configure/add/delete/select a PC-to-controller Ethernet TPC/IP connection.

Setting up a New TCP/IP Connection

To set up an Ethernet TCP/IP connection between your PC running the TwidoSoft application and a TWDLCAE40DRF controller installed on your network, follow these instructions:

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>1</td><td>Select File > Preferences > Connections Management from the TwidoSoft menu bar to call up the Connections Management dialogbox, as shown below:



</td></tr>
<tr><td>2</td><td>Click the Add button in the Connections Management dialogbox.
Result: A new connection line is added. The new line displays suggested default connection settings. You will need to change these settings.
Note: To set a new value in a field, you have two options:
● Click once to select the desired field, then click the Modify button.
● Double-click the desired field.</td></tr>
<tr><td>3</td><td>In the Name field, enter a descriptive name for the new connection. A valid name may contain up to 32 alphanumeric characters.</td></tr>
<tr><td>4</td><td>In the Connection Type field, click to unfold the dropdown list and select TCP/IP as you are setting up a new Ethernet connection between your PC and a Ethernet-capable Twido controller.</td></tr>
</table>

Step	Action
5	In the **Configuration** field, enter a valid IP address and Unit ID (if any) which is the IP information of the Twido TWDLCAE40DRF controller you wish to connect to. The IP address and the Unit ID must be seperated by a comma. **IP address:** Depending on how you chose to configure the Twido controller, enter either the Default IP Address or the user-specified Static IP Address assigned to the controller. **Unit ID:** Enter an integer between 0 and 255: ● If the target Twido controller is located past a gateway or bridge on a Modbus serial link, the Unit ID is the device serial ● If the target Twido controller is located on the same Ethernet network layer as your PC, you may leave this field blank. The default Unit ID (255) will be assigned automatically.
6	In the **Timeout** field, enter a timeout value in milliseconds (ms) for establishing a connection with the Twido controller. After timeout has elapsed and the PC has failed to connect to the controller, the TwidoSoft application will give up trying to establish a connection. To resume a new attempt for connection, select **PLC > Select a connection** from the TwidoSoft menu bar. **Note:** The maximum timeout value is 65535 ms (65.5 s).
7	The **Break timeout** is the maximum elapsed time allowed between a Modbus TCP/IP query and the reception of the response frame. If Break timeout is exceeded without receiving the requested response frame, the TwidoSoft application breaks the connection between the PC and the controller. Note: The maximum timeout value is 65535 ms (65.5 s). The default value is 5000 ms. Note that zero is not a valid entry; you must set a non-zero value in this field. **Note:** The maximum timeout value is 65535 ms (65.5 s).
8	Click the **OK** button to save the new connection settings and close the Connections management dialog box. **Result:** The names of all the newly-added connections are added to the dropdown list of connections in the **File > Preferences** dialog box and in the **PLC > Select a connection**.

Modifying and Deleting a TCP/IP Connection

Existing Ethernet TCP/IP connections can be deleted or have their parameters modified, as follows:

- To delete a connection from the Ethernet management dialogbox, click once on the Name of the desired connection, and click the **Delete** button. Note that after deletion, all the connection parameters are permanently lost.
- To modify the parameters of an existing connection, click once to select the desired field, and click the **Modify** button. Then, you may start entering the new value in the selected field.

Ethernet LED Indicators

Overview

Two Ethernet communications LED indicators are located on the LED panel, at the front panel of the TWDLCAE40DRF controller and on the soft front-panel accessible via the **PLC > Check PLC** path in the TwidoSoft application as well. They are label as follows:·

- LAN ACT
- LAN ST

The Ethernet LEDs provide continuous monitoring of the Ethernet port connections status and diagnostics.

LED Status

The following table describes the status of both **LAN ACT** and **LAN ST** Ethernet LED indicators.

LED	State	Color	Description
LAN ACT	Off	-	No Ethernet signal on RJ-45 port.
	Steady	Green	10BASE-TX link beat signal to indicate a 10 Mbps connection.
	Blinking		Data packets sent or received over the 10BASE-TX connection.
	Steady	Amber	100BASE-TX link beat signal to indicate a 100 Mbps connection.
	Blinking		Data packets sent or received over the 100BASE-TX connection.
LAN ST	Steady	Green	Base controller is powered on. Ethernet port is ready to communicate over the network.
	Flashing twice		Ethernet initialization at power-up.
	2 Flashes, long off		No valid MAC address.
	3 Flashes, long off		Any of three possible causes: ● No link beat detected. ● Ethernet network cable is not plugged correctly or faulty cable. ● Network device (hub/switch) is faulty or not properly configured.
	4 Flashes, long off		Duplicate IP address detected over the network. (To remedy this situation, try assigning a different IP address to your Twido controller.)
	6 Flashes, long off		Using a valid converted default IP address; FDR safe-mode.
	9 Flashes, long off		Ethernet hardware failure.

TCP Modbus Messaging

Overview

You may use TCP Modbus messaging to allow the Modbus TCP Client (Master controller) to send and receive Ethernet messages to and from the Modbus TCP Server (Slave controller). As TCP Modbus is a peer-to-peer communications protocol, a Twido Ethernet-capable controller can be both Client and Server depending on whether it is querying or answering requests, respectively.

Message Exchange over the Ethernet Network

Ethernet messaging is handled by the EXCH3 instruction and the %MSG3 function block: Routing to an Ethernet host or via a gateway is supported by EXCH3, as well.
- **EXCH3 instruction:** to transmit/receive messages
- **%MSG3 Function Block:** to control the message exchanges.

EXCH3 Instruction

The EXCH3 instruction allows the Twido controller to send and/or receive information to/from Ethernet network nodes. The user defines a table of words (%MWi:L) containing control information and the data to be sent and/or received (up to 128 bytes in transmission and/or reception). The format for the word table is described in the following section.
A message exchange is performed using the EXCH3 instruction:

Syntax: [EXCH3 %MWi:L]
where: L = number of words in the control words, transmission and reception tables

The Twido controller must finish the exchange from the first EXCH3 instruction before a second can be launched. The %MSG3 function block must be used when sending several messages.
The processing of the EXCH3 list instruction occurs immediately, with any transmissions started under interrupt control (reception of data is also under interrupt control), which is considered background processing.

Note: Usage of the EXCH3 instruction is the same as EXCHx (where x = 1 or 2) used with legacy Modbus. Instruction syntaxes are also identical. However, there is one major difference in the information carried by Byte1 of the transmission and reception tables. While Byte1 of the legacy Modbus conveys the serial link address of the slave controller, Byte1 of the TCP Modbus carries the **Index** number of the Modbus TCP client controller. The Index number is specified and stored in the Remote Devices table of the TwidoSoft Ethernet Configuration (for more details see*Remote Devices Tab, p. 170*).

EXCH3 Word Table

The maximum size of the transmitted and/or received frames is 128 bytes (note that this limitation applies to the TCP Modbus client only, while the TCP Modbus server supports the standard Modbus PDU length of 256 bytes). Moreover, the word table associated with the EXCH3 instruction is composed of the control, transmission and reception tables, as described below:

	Most significant byte	**Least significant byte**
Control table	Command	Length (Transmission/ Reception)
	Reception Offset	Transmission Offset
Transmission table	Transmitted Byte 1 (**Index** as specified in the Remote Device Table of the TwidoSoft Ethernet Configuration dialogbox.)	Transmitted Byte 2 as Modbus serial
	...	...
	...	Transmitted Byte n
	Transmitted Byte n+1	
Reception table	Received Byte 1 (**Index** as specified in the Remote Device Table of the TwidoSoft Ethernet Configuration dialogbox.)	Received Byte 2 as Modbus serial
	...	...
	...	Received Byte p
	Received Byte p+1	

%MSG3 Function Block

The use of the %MSG3 function is identical to that of %MSGx used with legacy Modbus. %MSG3 is used to manage data exchanges by providing:

- Communications error checking
- Coordination of multiple messages
- Transmission of priority messages

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. 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. 1: if bad command, table incorrectly configured, incorrect character received (speed, parity, and so on.), or reception table full.

EXCH3 Error Code

When an error occurs with the EXCH3 instruction:
- bits **%MSG3.D** and **%MSG3.E** are set to **1**, and
- the Ethernet communication **error code** is recorded into system word **%SW65**.

The following table presents the EXCH3 error code:

EXCH3 Error Code (recorded into System Word %SW65)
Standard error codes common to all EXCHx (x = 1, 2, 3): 0 - operation was successful 1 – number of bytes to be transmitted is too great (> 128) 2 - transmission table too small 3 - word table too small 4 - receive table overflowed 5 - time-out elapsed (Note that eror code 5 is void with the EXCH3 instruction and replaced by the Ethernet-specific error codes 109 and 122 described below.) 6 - transmission 7 - bad command within table 8 - selected port not configured/available 9 - reception error 10 - can not use %KW if receiving 11 - transmission offset larger than transmission table 12 - reception offset larger than reception table 13 - controller stopped EXCH processing
Error codes dedicated to Modbus response: 81 - slave (server) PLC returns ILLEGAL FUNCTION response 82 - slave (server) PLC returns ILLEGAL DATA ADDRESS response 83 - slave (server) PLC returns ILLEGAL DATA VALUE response 84 - slave (server) PLC returns SLAVE DEVICE FAILURE response 85 - slave (server) PLC returns ACKNOWLEDGE response 86 - slave (server) PLC returns SLAVE DEVICE BUSY response 87 - slave (server) PLC returns NEGATIVE ACKNOWLEDGE response 88 - slave (server) PLC returns MEMORY PARITY ERROR response

EXCH3 Error Code (recorded into System Word %SW65)
Ethernet-specific error codes for EXCH3: 101 - no such IP address 102 - the TCP connection is broken 103 - no socket available (all connection channels are busy) 104 - network is down 105 - network cannot be reached 106 - network dropped connection on reset 107 - connection aborted by peer device 108 - connection reset by peer device 109 - connection time-out elapsed 110 - rejection on connection attempt 111 - host is down 120 - unknown index (remote device is not indexed in configuration table) 121 - fatal (MAC, Chip, Duplicated IP)122 - receiving timed-out elapsed after data was sent 123 - Ethernet initialization in progress

Built-In Analog Functions

7

At a Glance

Subject of this Chapter

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

What's in this Chapter?

This chapter contains the following topics:

Analog potentiometer

Introduction

Twido controllers have:
- An analog potentiometer on TWDLC•A10DRF, TWDLC•A16DRF controllers and on all modular controllers (TWDLMDA20DTK, TWDLMDA20DUK, TWDLMDA20DRT, TWDLMDA40DTK and TWDLMDA40DUK,
- Two potentiometers on the TWDLC•A24DRF and TWDLCA•40DRFcontrollers.

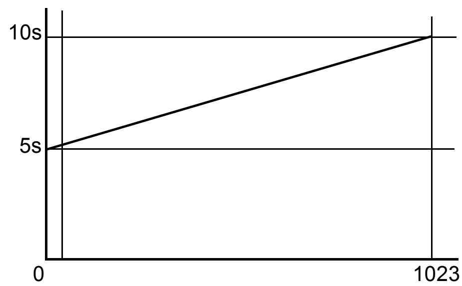
Programming

The numerical values, from 0 to 1023 for analog potentiometer 1, and from 0 to 511 for analog potentiometer 2, corresponding to the analog values provided by these potentiometers are contained in the following two input words:
- %IW0.0.0 for analog potentiometer 1 (on left)
- %IW0.0.1 for analog potentiometer 2 (on right)

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

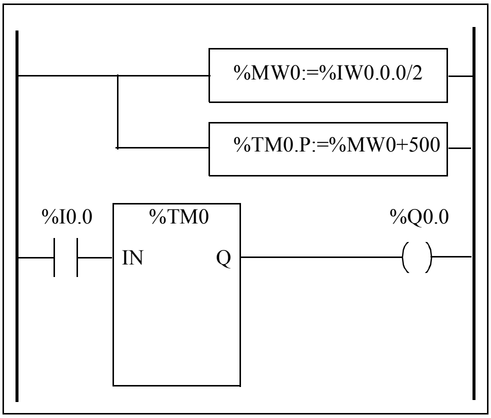
Adjusting the duration of a time-delay from 5 to 10 s using analog potentiometer 1:

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

The following parameters are selected at configuration for the time-delay block %TM0:
- Type TON
- Timebase: 10 ms

The preset value of the time-delay is calculated from the adjustment value of the potentiometer using the following equation %TM0.P := (%IW0.0.0/2)+500.

Code for the above example:




```
LD       1
[%MW0:=%IW0.0.0/2]
[%TM0.P:=%MW0+500]
BLK      %TM0
LD       %I0.0
IN
OUT_BLK
LD       Q
ST       %Q0.0
END_BLK
..................
```

Analog Channel

Introduction

All Modular controllers (TWDLMDA20DTK, TWDLMDA20DUK, TWDLMDA20DRT, TWDLMDA40DTK, and TWDLMDA40DUK) 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

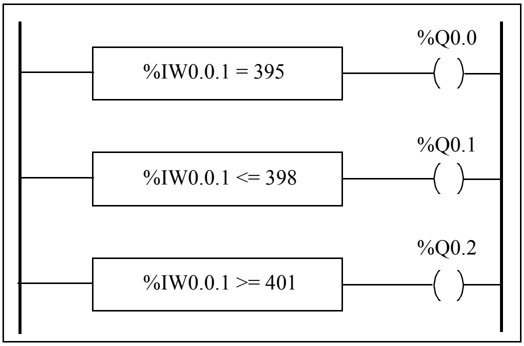
An analog to digital converter samples an input voltage from 0 to 10 V to a digital value from 0 to 511. This value is stored in system word %IW0.0.1. The value is linear through the entire range, so that each increment is approximately 20 mV (10 V/512). Once the system detects value 511, the channel is considered saturated.

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 %Q0.0 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

8

At a Glance

Subject of this Chapter

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	Points	Signal Range	Encoding
TWDAMI2HT	2 In	0 - 10 Volts or 4 - 20 mA	12 Bit
TWDAM01HT	1 output	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 PT100, 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 start-up of devices

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 follow this precaution can result in injury or equipment damage.

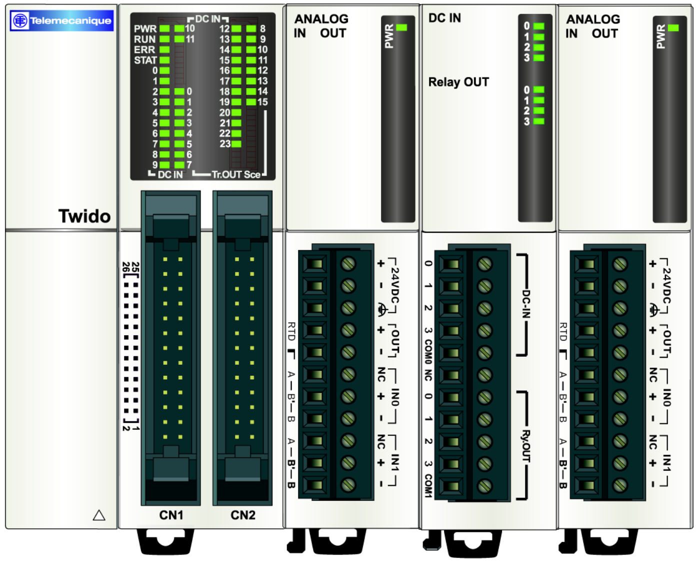
Addressing Analog Inputs and Outputs

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 a built-in analog-adjusted 10-bit potentiometer, a 9-bit built-in analog channel. On the expansion bus are the following: 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	%IW0.0.1			
Analog in channel 1		%IW0.1.0		%IW0.3.0
Analog in channel 2		%IW0.1.1		%IW0.3.1
Analog output 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

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 follow 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.

Analog Module Status Information

Status Table

The following table has the information you need to monitor the status of Analog I/O modules.

System Word	Function	Description
%SW80	Base I/O Status	Bit [0] Channels in normal operation (for all its channels) Bit [1] Module under initialization (or of initializing information of all channels) Bit [2] Hardware failure (external power supply failure, common to all channels) Bit [3] Module configuration fault Bit [4] Converting data input channel 0 in progress Bit [5] Converting data input channel 1 in progress Bit [6] Input thermocouple channel 0 not configured Bit [7] Input thermocouple channel 1 not configured Bit [8] Not used Bit [9] Unused Bit [10] Analog input data channel 0 over range Bit [11] Analog input data channel 1 over range Bit [12] Incorrect wiring (analog input data channel 0 below current range, current loop open) Bit [13] Incorrect wiring (analog input data channel 1 below current range, current loop open) Bit [14] Unused Bit [15] Output channel not available
%SW81	Expansion I/O Module 1 Status: Same definitions as %SW80	
%SW82	Expansion I/O Module 2 Status: Same definitions as %SW80	
%SW83	Expansion I/O Module 3 Status: Same definitions as %SW80	
%SW84	Expansion I/O Module 4 Status: Same definitions as %SW80	
%SW85	Expansion I/O Module 5 Status: Same definitions as %SW80	
%SW86	Expansion I/O Module 6 Status: Same definitions as %SW80	
%SW87	Expansion I/O Module 7 Status: Same definitions as %SW80	

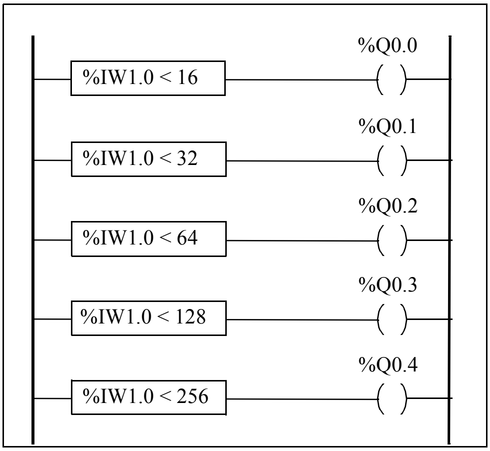
Example of Using Analog Modules

Introduction

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

Example: analog input

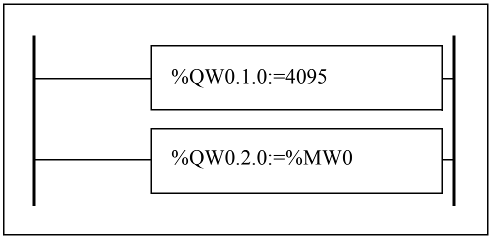
This example compares the analog input signal with five separate threshold values. A comparison of the analog input is made and a bit is set on the base controller if it is less than or equal to the threshold.




```
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
```

Example: analog output

The following program uses an analog card in slot 1 and 2. The card used in slot 1 has a 10-volt output with a "normal" range:




```
LD    1
[%QW0.1.0:=4095
LD    1
[%QW0.2.0:=%MW0
```

- Example of output values for %QW1.0=4095 (normal case):

The following table shows the output voltage value according to the maximum value assigned to %QW1.0:

	numerical value	**analog value (volt)**
Minimum	0	0
Maximum	4095	10
Value 1	100	0.244
Value 2	2460	6

- Example of output values for a customized range (minimum = 0, maximum = 1000):

The following table shows the output voltage value according to the maximum value assigned to %QW1.0:

	numerical value	**analog value (volt)**
Minimum	0	0
Maximum	1000	10
Value 1	100	1
Value 2	600	6

Installing the AS-Interface V2 bus

9

At a Glance

Subject of this Chapter

This chapter provides information on the software installation of the AS-Interface Master module TWDNOI10M3 and its slaves.

What's in this Chapter?

This chapter contains the following topics:

Presentation of the AS-Interface V2 bus

Introduction

The AS-Interface Bus (Actuator Sensor-Interface) allows the interconnection on a single cable of sensor devices/actuators at the lowest level of automation.
These sensors/actuators will be defined in the documentation as **slave devices**.

To implement the AS-Interface application you need to define the physical context of the application into which it will integrated (expansion bus, supply, processor, modules, AS-Interface slave devices connected to the bus) then ensure its software implementation.

This second aspect will be carried out from the different TwidoSoft editors:
- either in local mode,
- or in online mode.

AS-Interface V2 Bus

The AS-interface Master module **TWDNOI10M3** includes the following functionalities:
- M3 profile: This profile includes all the functionalities defined by the AS-Interface V2 standard, but does not support the S7-4 analog profiles
- One AS-Interface channel per module
- Automatic addressing for the slave with the address 0
- Management of profiles and parameters
- Protection from polarity reversion on the bus inputs

The AS-Interface bus then allows:
- Up to 31 standard address and 62 extended address slaves
- Up to 248 inputs and 186 outputs
- Up to 7 analog slaves (Max of four I/0 per slave)
- A cycle time of 10 ms maximum

A maximum of 2 AS-Interface Master modules can be connected to a Twido modular controller, a TWDLC•A24DRF or a TWDLCA•40DRFcompact controller.

General functional description

General Introduction

For the AS-Interface configuration, TwidoSoft software allows the user to:

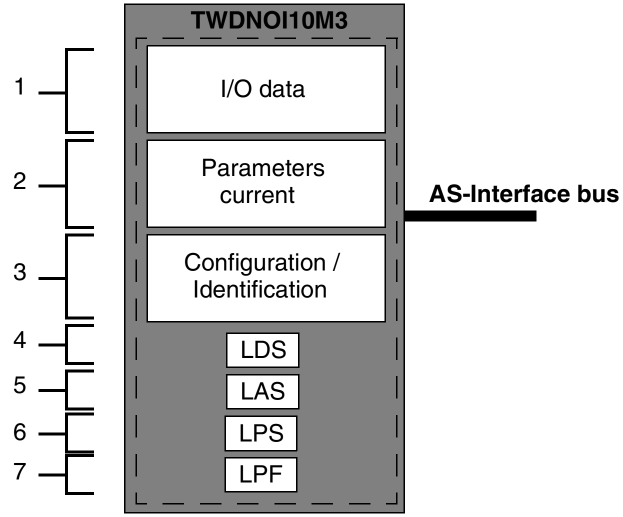
- Manually configure the bus (declaration of slaves and assignment of addresses on the bus)
- Adapt the configuration according to what is present on the bus
- Acknowledge the slave parameters
- Control bus status

For this reason, all data coming from or going to the AS-Interface Master are stored in specific objects (words and bits).

AS-Interface Master Structure

The AS-Interface module includes data fields that allow you to manage the lists of slaves and the images of input / output data. This information is stored in volatile memory.

The figure below shows **TWDNOI10M3** module architecture.



Key:

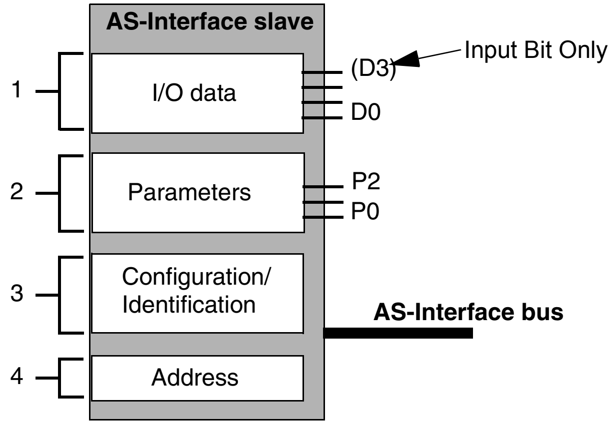
Address	Item	Description
1	I/O data (IDI, ODI)	Images of 248 inputs and 186 outputs of AS-Interface V2 bus.
2	Current parameters (PI, PP)	Image of the parameters of all the slaves.
3	Configuration/ Identification (CDI, PCD)	This field contains all the I/O codes and the identification codes for all the slaves detected.
4	LDS	List of all slaves detected on the bus.
5	LAS	List of slaves activated on the bus.
6	LPS	List of slaves provided on the bus and configured via TwidoSoft.
7	LPF	List of slaves having a device fault.

Structure of Slave Devices

The standard address slaves each have:
- 4 input/output bits
- 4 parametering bits

The slaves with extended addresses each have:
- 4 input/output bits (the last bit is reserved for entry only)
- 3 parametering bits

Each slave has its own address, profile and sub-profile (defines variables exchange).
The figure below shows the structure of an extended address slave:



Key:

Address	Item	Description
1	Input/output data	Input data is stored by the slave and made available for the AS-Interface master. Output data is updated by the master module.
2	Parameters	The parameters are used to control and switch internal operating modes to the sensor or the actuator.
3	Configuration/ Identification	This field contains: ● the code which corresponds to I/O configuration, ● the slave identification (ID) code, ● the slave identification codes (ID1 and ID2).
4	Address	Physical address of slave.

Note: The operating parameters, address, configuration and identification data are saved in a non-volatile memory.

Software set up principles

At a Glance

To respect the philosophy adopted in TwidoSoft, the user should adopt a step-by-step approach when creating an AS-Interface application.

Set up principle

The user must know how to functionally configure his AS-Interface bus (See *How to insert a slave device into an existing AS-Interface V2 configuration, p. 221*).
The following table shows the different software implementation phases of the AS-Interface bus.

Mode	Phase	Description
Local	Declaration of module	Choice of the slot for the AS-Interface Master module TWDNOI10M3 on the expansion bus.
	Configuration of the module channel	Choice of "master" modes.
	Declaration of slave devices	Selection for each device: ● of its slot number on the bus, ● of the type of standard or extended address slave.
	Confirmation of configuration parameters	Confirmation at slave level.
	Global confirmation of the application	Confirmation of application level.
Local or connected	Symbolization (optional)	Symbolization of the variables associated with the slave devices.
	Programming	Programming the AS-Interface V2 function.
Connected	Transfer	Transfer of the application to the PLC.
	Debugging	Debugging the application with the help of: ● the debug screen, used on the one hand to display slaves (address, parameters), and on the other, to assign them the desired addresses, ● diagnostic screens allowing identification of errors.

Note: The declaration and deletion of the AS-Interface Master module on the expansion bus is the same as for another expansion module. However, once two AS-Interface Master modules have been declared on the expansion bus, TwidoSoft will not permit another one to be declared.

Precautions Prior to Connection

Before connecting (via the software) the PC to the controller and to avoid any detection problem:

- Ensure that no slave is physically present on the bus with address 0
- Ensure that 2 slaves are not physically present with the same address.

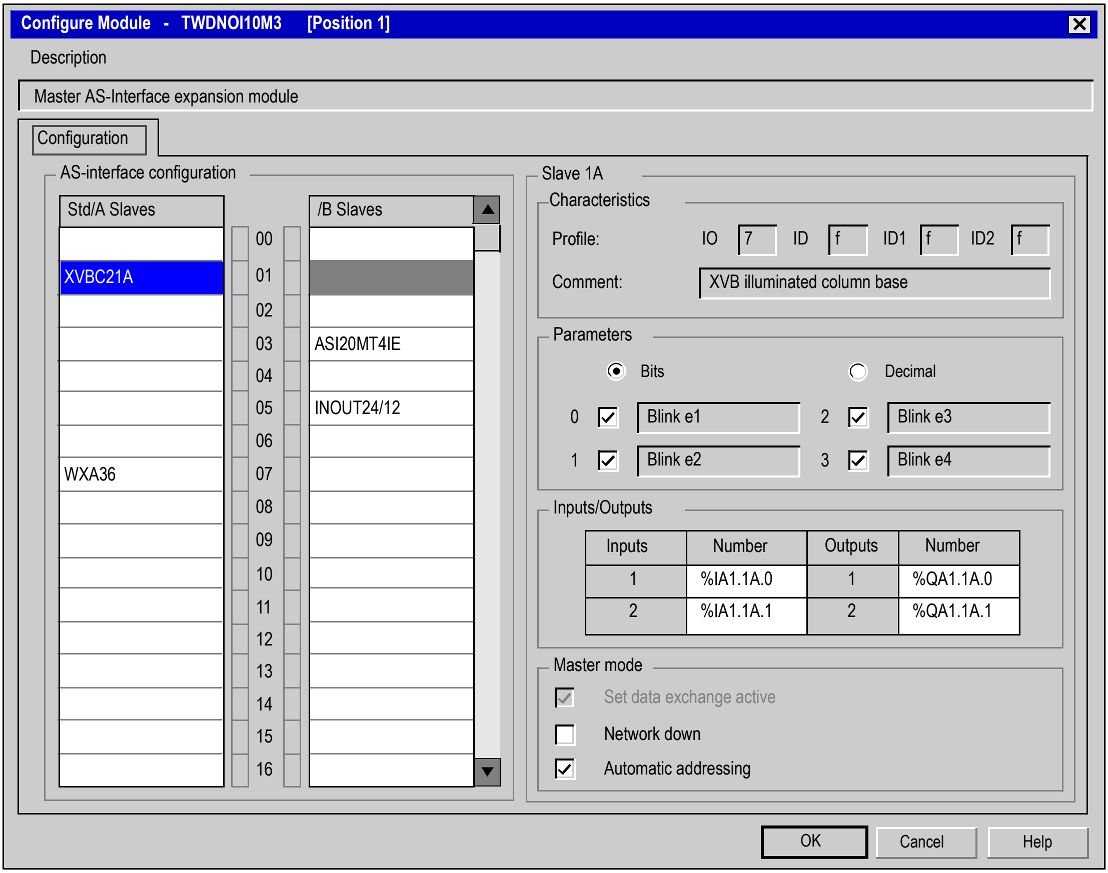
Description of the configuration screen for the AS-Interface bus

At a Glance

The configuration screen of the AS-Interface master module gives access to the parameters associated with the module and the slave devices.
It can be used to display and modify parameters in offline mode.

Illustration of Offline Mode

Illustration of the configuration screen in offline mode:



Description of the Screen in Offline Mode

This screen groups all data making up the bus in three blocks of information:

Blocks	Description
AS-interface configuration	Bus image desired by the user: view of standard and extended address setting slaves expected on the bus. Move the cursor down the vertical bar to access the following addresses. Grayed out addresses correspond to addresses not available here for slave configuration. If, for example, a new standard address setting slave is declared with the address 1A, the address 1B is automatically grayed out.
Slave xxA/B	Configuration of the selected slave: ● Characteristics: IO code, ID code, ID1 and ID2 codes (profiles), and comments on the slave, ● Parameters: list of parameters (modifiable), in binary (4 check boxes) or decimal (1 check box) form, at the discretion of the user, ● Inputs/Outputs: list of available I/Os and their respective addresses.
Master mode	Activation or deactivation is possible for the two functionalities available for this AS-Interface module (for example, automatic addressing). "Network down" allows you to force the AS-Interface bus to enter the offline mode. "Automatic addressing" mode is checked by default. Note: The "Data exchange activation" function is not yet available.

The screen also includes 3 buttons:

Buttons	Description
OK	Used to save the AS-Interface Bus configuration visible on the configuration screen Then return to the main screen. The configuration can then be transferred to the Twido controller.
Cancel	Returns to the main screen without acknowledging the changes in progress.
Help	Opens a Help window on-screen.

Note: Changes in the configuration screen can only be made in offline mode.

Configuration of the AS-Interface bus

Introduction

AS-Interface bus configuration takes place in the configuration screen in local mode. Once the AS-Interface Master and the master modes have been selected, configuration of the AS-Interface bus consists of configuring the slave devices.

Procedure for Declaring and Configuring a Slave

Procedure for creating or modifying a slave on the AS-Interface V2 bus:

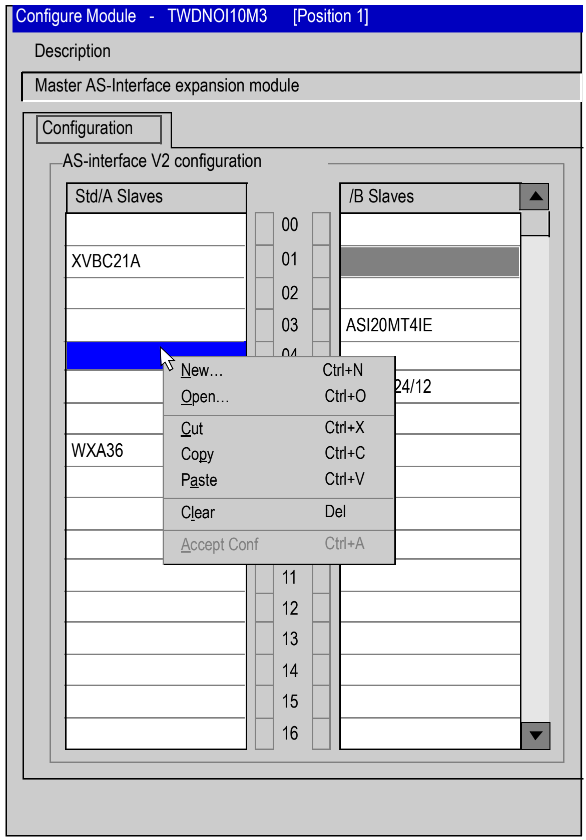
<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>1</td><td>
On the desired address cell (not grayed out) in the bus image:

- Double click: access to step 3

OR

- Right click:

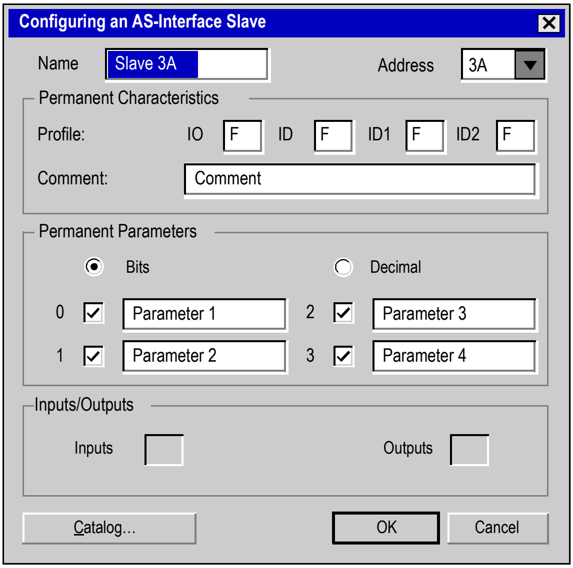
Result:



Note:

A shortcut menu appears. This is used to:

- Configure a new slave on the bus
- Modify the configuration of the desired slave
- Copy (or Ctrl+C), cut (or Ctrl+X), paste a slave (or Ctrl+V)
- Delete a slave (or Del)
</td></tr>
</table>

Step	Action
2	In the shortcut menu, select: ● "New" to create a new slave: A slave configuration screen is displayed; the "Address" field shows the selected address, the "Profile" fields are set to F by default and all other fields in the screen are blank. ● "Open" to create a new slave or to modify the configuration of the selected slave. For a new slave, a new screen for configuring the slave is displayed, the "Address" field shows the selected address, the "Profile" fields are set to F by default and all other fields in the screen are blank. For a modification, the slave configuration screen is displayed with fields containing the values previously defined for the selected slave. Illustration of a Configuration Screen for a New Slave: 
3	In the slave configuration screen that is then displayed, enter or modify: ● the name of the new profile (limited to 13 characters), ● a comment (optional). Or click "Catalog..." and select a slave from the pre-configured AS-Interface profile family.
4	Enter: ● the IO code (corresponds to the input/output configuration), ● the ID code (identifier), (plus ID1 and for an extended type). Note: The "Inputs" and "Outputs" fields show the number of input and output channels. They are automatically implemented when the IO code is entered.

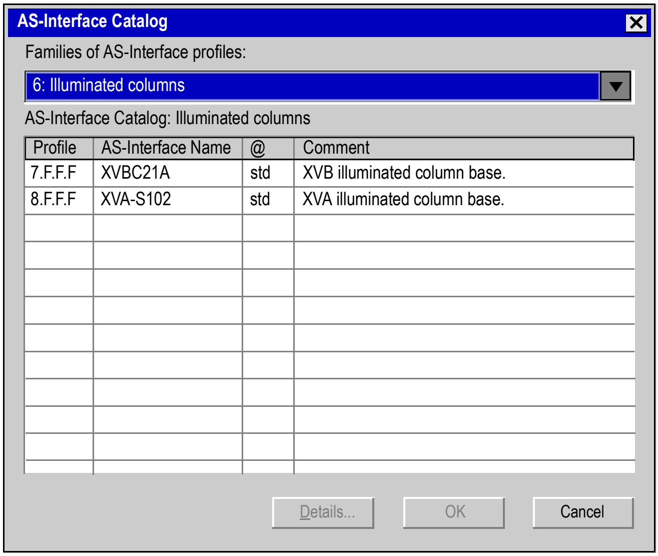
Step	Action
5	For each parameter define: ● the system's acknowledgement (box checked in "Bits" view, or decimal value between 0 and 15 in "Decimal" view), ● a name that is more meaningful than "Parameter X" (optional). Note: The selected parameters are the image of permanent parameters to be provided to the AS-Interface Master.
6	If needed, modify "Address" (within the limit of available addresses on the bus), by clicking the up/down arrows to the left of the address (access is then given to authorized addresses) or by entering the address using the keyboard.
7	Confirm the slave configuration by clicking on the "OK" button. The result is the check that: ● the IO and ID are authorized, ● the slave address is authorized (if keyboard entry is used) according to the ID code ("bank" /B slaves are only available if the ID code is equal to A). If an error occurs, an error message warns the user (for example: "The slave cannot have this address") and the screen is displayed again with the initial values (in the profile or address, depending on the error).

Note: The software limits the number of analog slave declarations to 7.

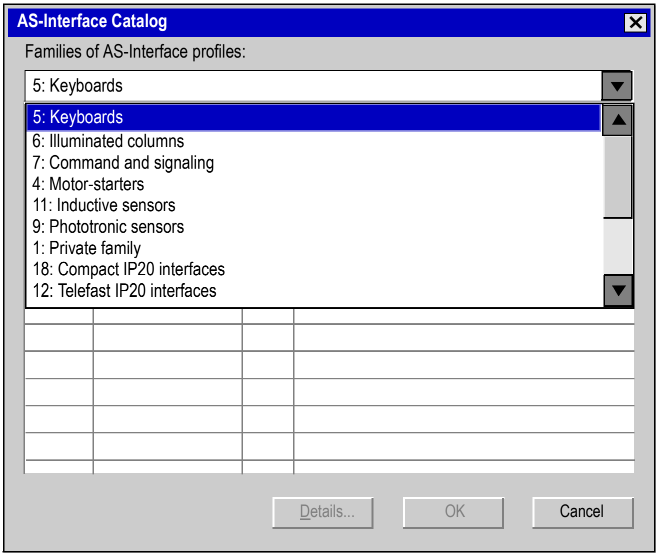
Note: About the Schneider AS-Interface catalog: when you click Catalog, you can create and configure slaves in "Private family" (other than those in the Schneider AS-Interface catalog.

AS-Interface Catalog

The Catalog button can be used to facilitate configuration of slaves on the bus. When you use a slave from the Schneider family, use this button to simplify and speed up configuration.
Clicking on "Catalog" in the window "Configure an AS-Interface slave" opens the following window:



The drop-down menu gives you access to all the families of the Schneider AS-Interface catalog:



When you have chosen your family, the list of corresponding slaves appears. Click on the required slave and validate by clicking "OK"

Note: You can display the characteristics of a slave by clicking "Details".

Note: You can add and configure slaves that are not part of the Schneider catalog. Simply select the private family and configure the new slave.

Description of the debug screen

At a Glance

When the PC is **connected** to the controller (after uploading the application to the controller), the "Debug" tab appears to the right of that of "Configuration"; it allows the debug screen to be accessed.
The debug screen dynamically provides an image of the physical bus that includes the:

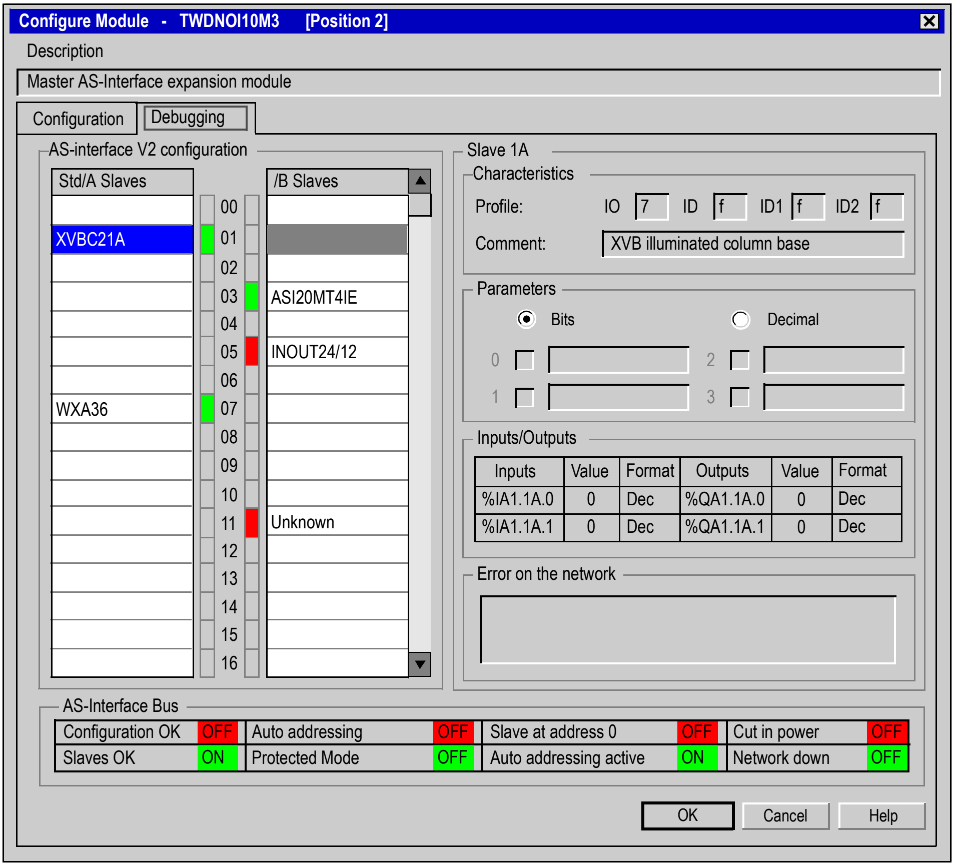
- List of expected slaves (entered) during configuration with their name, and the list of detected slaves (with unknown names, but otherwise expected),
- Status of the AS-Interface module and the slave devices,
- Image of the profile, parameters and input/output values of the selected slaves.

It also enables the user:

- To obtain diagnostics of the slaves on which an error has occurred (See *Displaying Slave Status, p. 212*),
- To modify the address of a slave in online mode (See *Modification of Slave Address, p. 213*),
- To transmit the image of the slaves to the configuration screen (See *Updating the AS-Interface bus configuration in online mode, p. 215*),
- To address all the slaves with the desired addresses (during the first debugging).

Illustration of the "Debug" Screen

The illustration of the debug screen (in online mode only) looks like this:



Description of the Debug Screen

The "Debug" screen provides the same information as theconfiguration screen (See *Description of the Screen in Offline Mode, p. 203*).
The differences are listed in the following table:

Schedule	Description
AS-interface V2 configuration	Image of the physical bus. Includes slave status: ● Green indicator lamp: the slave with this address is active. ● Red indicator lamp: an error has occurred on the slave at this address, and the message informs you of the error type in the "Error on the network" window.
Slave xxA/B	Image of the configuration of the selected slave: ● Characteristics: image of the profile detected (grayed out, non-modifiable), ● Parameters: image of the parameters detected. The user can select only the parameter display format, ● Inputs/Outputs: the input/output values detected are displayed, non-modifiable.
Error on the network	Informs you of the error type, if an error has occurred on the selected slave.
AS-Interface Bus	Information resulting from an implicit "Read Status" command. ● Shows bus status: for example, "Configuration OK = OFF" indicates that the configuration specified by the user does not correspond to the physical configuration of the bus, ● Shows the authorized functionalities for the AS-Interface Master module: for example, "Automatic addressing active = ON" indicates that the automatic addressing Master mode is authorized.

Displaying Slave Status

When the indicator lamp associated with an address is red, there is an error on the slave associated with this address. The "Error on the network" window then provides the diagnostics of the selected slave.
Description of errors:
- The profile specified by the user by the configuration of a given address does not correspond to the actual profile detected for this address on the bus (diagnostics: "Profile error"),
- A new slave, not specified at configuration, is detected on the bus: a red indicator lamp is then displayed for this address and the slave name displayed is "Unknown" (diagnostics: "Slave not projected"),
- Peripheral fault, if the slave detected supports it (diagnostics: "Peripheral fault"),
- A configured profile is specified but no slave is detected for this address on the bus (diagnostics: "Slave not detected").

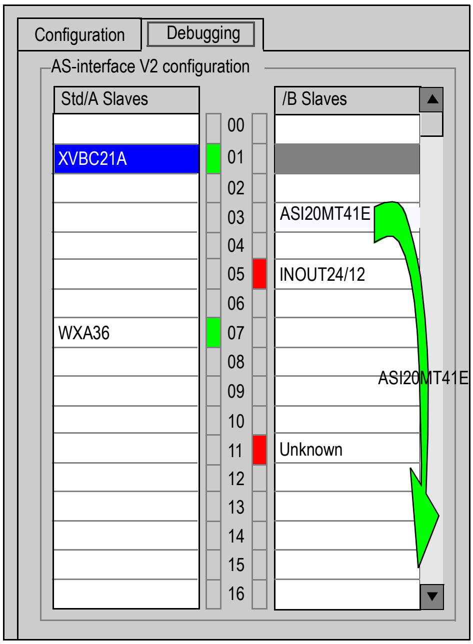
Modification of Slave Address

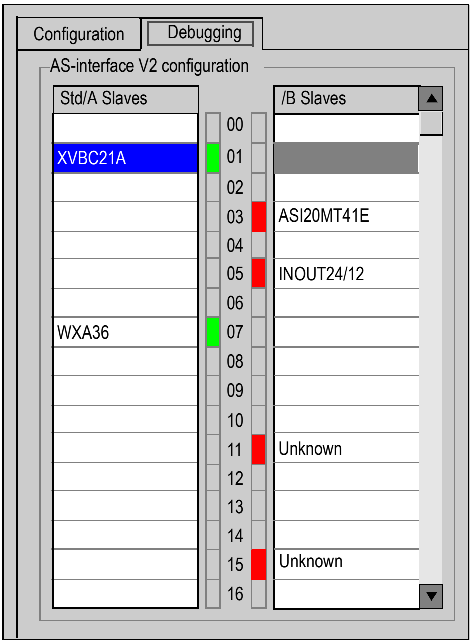
At a Glance

From the debug screen, the user can modify the address of a slave in online mode.

Modification of Slave Address

The following table shows the procedure for modifying a slave address:

Step	Description
1	Access the "Debug" screen.
2	Select a slave in the "AS-interface V2 Configuration" zone.
3	Drag and drop the slave to the cell corresponding to the desired address. Illustration: Dragging and dropping slave 3B to address 15B 

Step	Description
	Result: All the slave parameters are automatically checked to see if the operation is possible. Illustration of result:  After performing this operation, the diagnostics for the slave at address 3B indicate "slave not detected" meaning that the slave expected at this address is no longer there. By selecting the address 15B, the profile and the parameters of the moved slave can be re-located, but the name of the slave remains unknown as it was not expected at this address.

Note: The profile and parameters of a slave are not associated with a name. Several slaves with different names can have the same profiles and parameters.

Updating the AS-Interface bus configuration in online mode

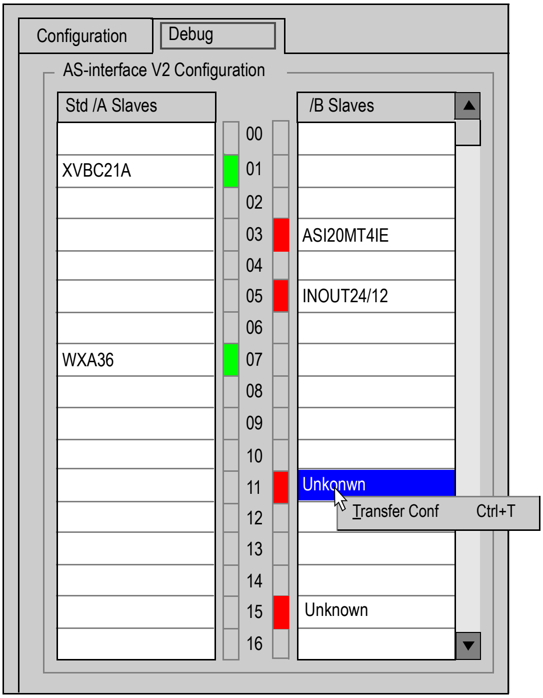
At a Glance

In online mode, no modification of the configuration screen is authorized and the physical configuration and software configuration can be different. Any difference in profile or parameters for a configured or non-configured slave can be taken into account in the configuration screen; in fact, it is possible to transmit any modification to the configuration screen before transferring the new application to the controller. The procedure to follow in order to take the physical configuration into account is the following:

Step	Description
1	Transfer of the desired slave configuration to the configuration screen.
2	Acceptance of the configuration in the configuration screen.
3	Confirmation of the new configuration.
4	Transfer of the application to the module.

Transfer of a Slave Image to the Configuration Screen.

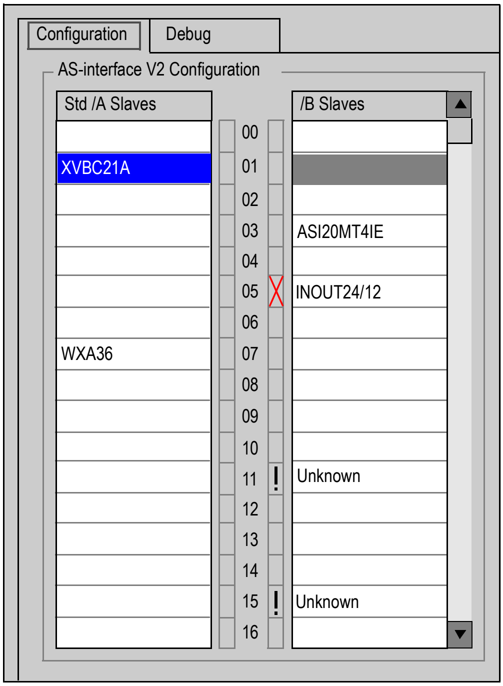
In the case when a slave that is not specified in the configuration is detected on the bus, an "Unknown" slave appears in the "AS-interface V2 Configuration zone" of the debug screen for the detected address.
The following table describes the procedure for transferring the image of the "Unknown" slave to the configuration screen:

Step	Description
1	Access the "Debug" screen.
2	Select the desired slave in the "AS-interface V2 Configuration" zone.
3	Right click on the mouse to select "Transfer Conf". Illustration:  Result: The image of the selected slave (image of the profile and parameters) is then transferred to the configuration screen.
4	Repeat the operation for each of the slaves whose image you would like to transfer to the configuration screen.

Return to the Configuration Screen

When the user returns to the configuration screen, all the new slaves (unexpected) which have been transferred are visible.

Illustration of the configuration screen following the transfer of all slaves:



Key:

- The cross signifies that there are differences between the image of the profile of the transferred slave, and the profile initially desired in the configuration screen.
- The exclamation mark signifies that a new profile was added to the configuration screen.

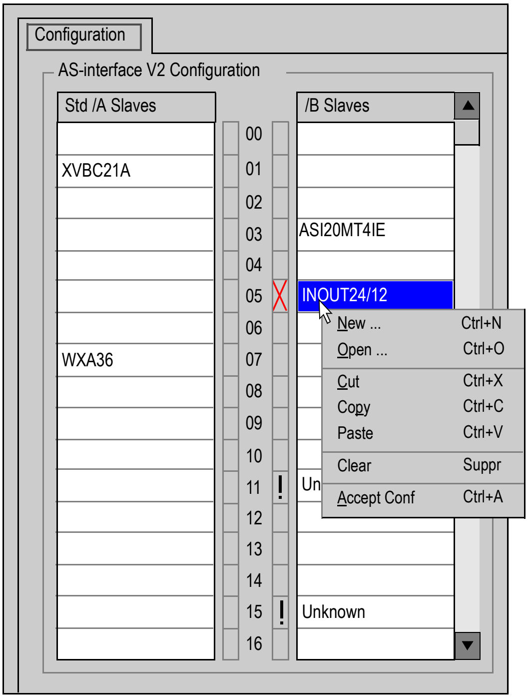
Explanation:

The configuration screen always shows the permanent image of the desired configuration (this is why the slave is still present as 3B in spite of the change of address (See *Modification of Slave Address, p. 213*)), completed by the current image of the bus.

The profiles and parameters of the expected slaves displayed correspond to those which were expected. The profiles and parameters of the unknown slaves displayed correspond to the images of those detected.

Procedure for Transferring the Definitive Application to the Module

Before transferring a new application to the module, the user can, for each slave, accept the detected profile and parameters (transferred to the configuration screen) or modify the configuration "manually" (See *Procedure for Declaring and Configuring a Slave, p. 205*).
The following table describes the steps to follow to confirm and transfer the definitive configuration to the module:

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>1</td><td>Via the software, disconnect the PC from the module.
Note:
No modification can be carried out in the configuration screen if the PC is connected to the module.</td></tr>
<tr><td>2</td><td>Right click on the desired slave.</td></tr>
<tr><td>3</td><td>2 choices:
● Select "Accept Conf" to accept the detected profile of the selected slave.
Illustration:


For each of the slaves marked with a cross, a message will warn the user that this operation will overwrite the initial profile (displayed on-screen) of the slave.
● Select the other choices in the right click menu to configure the selected slave manually.</td></tr>
</table>

Step	Action
4	Repeat the operation for each of the desired slaves in the configuration.
5	Press the "OK" button to confirm and create the new application. Result: Automatic return to the main screen.
6	Transfer the application to the module.

Automatic addressing of an AS-Interface V2 slave

At a Glance

Each slave on the AS-Interface bus must be assigned (via configuration) a unique physical address. This must be the same as the one declared in TwidoSoft.

TwidoSoft software offers an automatic slave addressing utility so that an AS-Interface console does not have to be used.
The automatic addressing utility is used for:
- replacing a faulty slave,
- inserting a new slave.

Procedure

The table below shows the procedure for setting the **Automatic addressing** parameter.

Step	Action
1	Access the AS-Interface V2 master module's configuration screen.
2	Click on the **Automatic addressing** check box found in the **Master mode** zone. **Result**: The **Automatic addressing** utility will be activated (box checked) or disabled (box not checked. **Note**: By default, the **Automatic addressing** parameter has been selected in the configuration screen.

How to insert a slave device into an existing AS-Interface V2 configuration

At a Glance

It is possible to insert a device into an existing AS-Interface V2 configuration without having to use the pocket programmer.
This operation is possible once:

- the **Automatic addressing** utility of configuration mode is active (See *Automatic addressing of an AS-Interface V2 slave, p. 220*),
- a single slave is absent in the physical configuration,
- the slave which is to be inserted is specified in the configuration screen,
- the slave has the profile expected by the configuration,
- the slave has the address 0 (A).

The AS-Interface V2 module will therefore automatically assign to the slave the value predefined in the configuration.

Procedure

The following table shows the procedure for making the automatic insertion of a new slave effective.

Step	Action
1	Add the new slave in the configuration screen in local mode.
2	Carry out a configuration transfer to the PLC in connected mode.
3	Physically link the new slave with address 0 (A) to the AS-Interface V2 bus.

Note: An application can be modified by carrying out the above manipulation as many times as necessary.

Automatic replacement of a faulty AS-Interface V2 slave

Principle

When a slave has been declared faulty, it can be automatically replaced with a slave of the same type.
This happens without the AS-Interface V2 bus having to stop, and without requiring any manipulation since the configuration mode's **Automatic addressing** utility is active (See *Automatic addressing of an AS-Interface V2 slave, p. 220*).

Two options are available:
- The replacement slave is programmed with the same address using the pocket programmer, and has the same profile and sub-profile as the faulty slave. It is thus automatically inserted into the list of detected slaves (LDS) and into the list of active slaves (LAS),
- The replacement slave is blank (address 0 (A), new slave) and has the same profile as the faulty slave. It will automatically assume the address of the replaced slave, and will then be inserted into the list of detected slaves (LDS) and the list of active slaves (LAS).

Addressing I/Os associated with slave devices connected to the AS-Interface V2 bus

At a Glance

This page presents the details relating to the addressing of digital or analog I/Os of slave devices.
To avoid confusion with Remote I/Os, new symbols are available with an AS-Interface syntax: %I**A** for example.

Illustration

Reminder of the principles of addressing:

%	IA, QA, IWA, QWA	x	.	n	.	i
Symbol	Type of object	Expansion module address		slave address		Channel no.

Specific Values

The table below gives specific values to AS-Interface V2 slave objects:

Part	Values	Comment
IA	-	Image of the physical digital input of the slave.
QA	-	Image of the physical digital output of the slave.
IWA	-	Image of the physical analog input of the slave.
QWA	-	Image of the physical analog output of the slave.
x	1 to 7	Address of AS-Interface module on the expansion bus.
n	0A to 31B	Slot 0 cannot be configured.
i	0 to 3	-

Examples

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

I/O object	Description
%IWA4.1A.0	Analog input 0 of slave 1A of the AS-Interface module situated in position 4 on the expansion bus.
%QA2.5B.1	Digital output 1 of slave 5B of the AS-Interface module situated in position 2 on the expansion bus.
%IA1.12A.2	Digital input 2 of slave 12A of the AS-Interface module situated in position 1 on the expansion bus.

Implicit Exchanges

The objects described below are exchanged implicitly, in other words they are exchanged automatically on each PLC cycle.

Programming and diagnostics for the AS-Interface V2 bus

Explicit Exchanges

Objects (words and bits) associated with the AS-Interface bus contribute data (for example: bus operation, slave status, etc.) and additional commands to carry out advanced programming of the AS-Interface function.
These objects are exchanged explicitly between the Twido controller and the AS-Interface Master by the expansion bus:

- At the request of the program user by way of the instruction: ASI_CMD (see "Presentation of the ASI_CMD" instruction below)
- Via the debug screen or the animation table.

Reserved Specific System Words

System words reserved in the Twido controller for the AS-Interface Master modules enable you to determine the status of the network: %SW73 is reserved for the first AS-Interface expansion module, and %SW74 for the second. Only the first 5 bits of these words are used; they are read-only.
The following table shows the bits used:

System Words	Bit	Description
%SW73 and %SW74	0	system status (= 1 if configuration OK, otherwise 0)
	1	data exchange (= 1 data exchange is enabled, 0 if in mode Data Exchange Off (See *AS-Interface V2 bus interface module operating mode:, p. 230*))
	2	system stopped (= 1 if the Offline (See *Offline Mode, p. 230*) mode is enabled, otherwise 0)
	3	ASI_CMD instruction terminated (= 1 if terminated, 0 if in progress)
	4	ASI_CMD error instruction (= 1 if there is an error in the instruction, otherwise 0)

Example of use (for the first AS-Interface expansion module):
Before using an ASI_CMD instruction, the %SW73:X3 bit must be checked to see whether an instruction is not in progress: check that %SW73:X3 = 1.
To ascertain whether the instruction has then correctly executed, check that the %SW73:X4 bit equals 0.

Presentation of the ASI_CMD Instruction

For each user program, the ASI_CMD instruction allows the user to program his network and obtain the slave diagnostics. The instruction parameters are passed by internal words (memory words) **%MW**x.
The syntax of the instruction is as follows:
ASI_CMD`n` **%MW**`x`**:**`l`
Legend:

Symbol	Description
n	Address of AS-Interface expansion module (1 to 7).
x	Number of the first internal word (memory word) passed in parameter (0 to 254).
l	Length of the instruction in number of words (2).

Using the ASI_CMD Instruction

The following table describes the action of the ASI_CMD instruction according to the value of the parameters %MW(x), and %MW(x+1) when necessary. For slave diagnostics requests, the result is returned in %MW(x+1).

%MWx	%MWx+1	Action
1	0	Exits Offline mode.
1	1	Switches to Offline mode.
2	0	Prohibits the exchange of data between the Master and its slaves (enters Data Exchange Off mode).
2	1	Authorizes the exchange of data between the Master and its slaves (exits Data Exchange Off mode).
3	Reserved	-
4	Result	Reads the list of active slaves (LAS table) with addresses from 0A to 15A (1 bit per slave).
5	Result	Reads the list of active slaves (LAS table) with addresses from 16A to 31A (1 bit per slave).
6	Result	Reads the list of active slaves (LAS table) with addresses from 0B to 15B (1 bit per slave).
7	Result	Reads the list of active slaves (LAS table) with addresses from 16B to 31B (1 bit per slave).
8	Result	Reads the list of detected slaves (LDS table) with addresses from 0A to 15A (1 bit per slave).
9	Result	Reads the list of detected slaves (LDS table) with addresses from 16A to 31A (1 bit per slave).
10	Result	Reads the list of detected slaves (LDS table) with addresses from 0B to 15B (1 bit per slave).

%MWx	%MWx+1	Action
11	Result	Reads the list of detected slaves (LDS table) with addresses from 16B to 31B (1 bit per slave).
12	Result	Reads the list of peripheral faults on slaves (LPF table) with addresses 0A to 15A (1 bit per slave).
13	Result	Reads the list of peripheral faults on slaves (LPF table) with addresses 16A to 31A (1 bit per slave).
14	Result	Reads the list of peripheral faults on slaves (LPF table) with addresses 0B to 15B (1 bit per slave).
15	Result	Reads the list of peripheral faults on slaves (LPF table) with addresses 16B to 31B (1 bit per slave).
16	Result	Reads bus status. See the results details in the next paragraph.

Note: Bus status is updated on each PLC scan.. But the result of the ASI_CMD bus reading instruction is available only at the end if the following PLC scan.

Details of the results of the ASI_CMD instruction to read bus status

In the case when bus status is read by the ASI_CMD instruction (value of the %MWx parameter is equal to 16), the format of the result in the %MWx+1 word is as follows:

%MWx+1		**Designation (1=OK, 0=NOK)**
least significant	bit 0	Configuration OK
	bit 1	LDS.0 (slave present with address 0)
	bit 2	Auto addressing active
	bit 3	Auto addressing available
	bit 4	Configuration Mode active
	bit 5	Normal operation active
	bit 6	APF (power supply problem)
	bit 7	Offline ready
most significant	bit 0	Peripheral fault
	bit 1	Data exchange active
	bit 2	Offline Mode
	bit 3	Normal mode (1)
	bit 4	Communication fault with the AS-Interface Master
	bit 5	ASI_CMD instruction in progress
	bit 6	ASI_CMD instruction error

Details of the results of the ASI_CMD instruction to read slave status

In the case of slave diagnostics by ASI_CMD instruction (%MWx value between 4 and 15), the slaves' status is returned in the bits (1=OK) of the %MWx+1 word. The following table gives the detail of the results according to the value of the %MWx word:

%MWx	**%MWx+1**															
value	most significant byte								least significant byte							
	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
4, 8, 12	15A	14A	13A	12A	11A	10A	9A	8A	7A	6A	5A	4A	3A	2A	1A	0A
5, 9, 13	31A	30A	29A	28A	27A	26A	25A	24A	23A	22A	21A	20A	19A	18A	17A	16A
6, 10, 14	15B	14B	13B	12B	11B	10B	9B	8B	7B	6B	5B	4B	3B	2B	1B	0B
7, 11, 15	31B	30B	29B	28B	27B	26B	25B	24B	23B	22B	21B	20B	19B	18B	17B	16B

To read whether slave 20B is active, the ASI_CMD instruction must be executed with the %MWx internal word having a value of 7. The result is returned in the %MWx+1 internal word; the status of slave 20B is given by the value of bit 4 of the least significant byte: If bit 4 is equal to 1, then slave 20B is active.

Programming Examples for the ASI_CMD Instruction

To force the AS-Interface Master (positioned at 1 on the expansion bus) to switch to Offline mode:

```
LD 1
[%MW0 := 16#0001 ]
[%MW1 := 16#0001 ]
LD %SW73:X3          //If no ASI_CMD instruction is in progress, then continue
[ASI_CMD1 %MW0:2]    //to force the switch to Offline mode
```

To read the table of slaves active for addresses 0A to 15A:

```
LD 1
[%MW0 := 16#0004 ]
[%MW1 := 16#0000          //optional]
LD %SW73:X3   //If no ASI_CMD instruction is in progress, then continue
[ASI_CMD1 %MW0:2]    //to read the LAS table for addresses 0A to 15A
```

AS-Interface V2 bus interface module operating mode:

At a Glance

The AS-Interface bus interface module TWDNOI10M3 has three operating modes, each of which responds to particular needs. These modes are:
- Protected mode,
- Offline mode,
- Data Exchange Off mode.

Using the ASI_CMD (See *Presentation of the ASI_CMD Instruction, p. 226*) instruction in a user program allows you to enter or exit these modes.

Protected Mode

The protected operating mode is the mode generally used for an application which is running. It assumes that the AS-Interface V2 module is configured in TwidoSoft. This:
- continually checks that the list of detected slaves is the same as the list of expected slaves,
- monitors the power supply.

In this mode, a slave will only be activated if it has been declared in the configuration and been detected.
At power up or during the configuration phase, the Twido controller forces the AS-Interface module into protected mode.

Offline Mode

When the module is put into Offline mode, it first resets all the slaves present to zero and stops exchanges on the bus. When in Offline mode, the outputs are forced to zero.
In addition to using the PB2 button on the TWDNOI10M3 AS-Interface module, Offline mode can also be accessed via the software by using the ASI_CMD (See *Programming Examples for the ASI_CMD Instruction, p. 229*) instruction, which also allows you to exit the mode and return to protected mode.

Data Exchange Off Mode

When the Data Exchange Off mode is engaged, exchanges on the bus continue to function, but data is no longer refreshed.
This mode can only be accessed by using the ASI_CMD (See *Using the ASI_CMD Instruction, p. 226*) instruction.

Operator Display Operation

10

At a Glance

Subject of this Chapter

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 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.

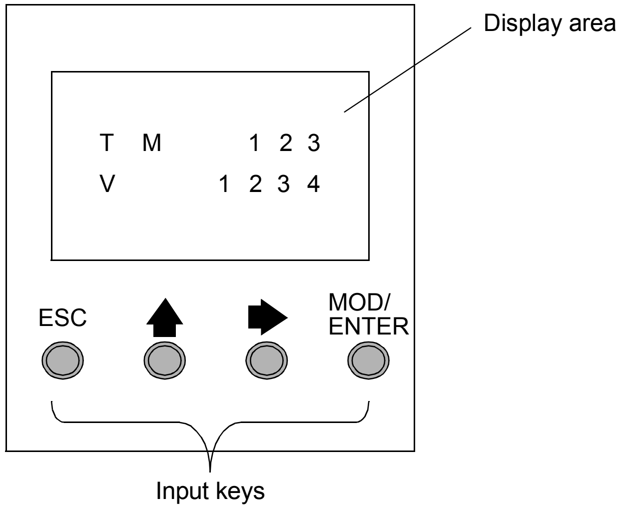
Displays and Functions

The Operator Display provides the following separate displays with the associated functions you can perform for each display.
- Controller Identification and State Information: Operations Display
  Display firmware revision and the controller state. Change the controller state with the Run, Initial, and Stop commands.
- System Objects and Variables: Data Display
  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: Communication Display
  Display and modify communication port settings.
- Time of Day Clock: Time/Date Display
  Display and configure the current date and time (if the RTC is installed).
- Real Time Correction: RTC Factor
  Display and modify the RTC Correction value for the optional RTC.

Note:
1. The TWDLCA•40DRF series of compact controllers have RTC onboard.
2. On all other controllers, 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 illustration shows a view 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.
⬆		Go to the next value of an object being edited.
➡	Advance to next display.	Go to the next object type to edit.
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, pressing the ESC key will return to the Controller Identification and State Information screen. Only when editing System Objects and Variables that are 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 key again.

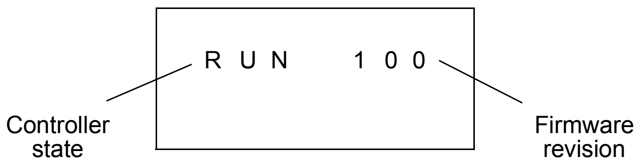
Controller Identification and State Information

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. 510*).
- **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. Inputs are updated and data values are held at their last value. 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 (not executable)**
  An online modification was made to user logic. Consequences: The application is no longer executable. It will not go back into this state until all causes for the Non-Executable 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 state 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	%Ix.y.z	Value	Read/Force
Output	%Qx.y.z	Value	Read/Write/Force
Timer	%TMX.V %TMX.P %TMX.Q	Current Value Preset value Done	Read/Write Read/Write Read
Counter	%Cx.V %Cx.P %Cx.D %Cx.E %Cx.F	Current Value Preset value Done Empty Full	Read/Write Read/Write Read Read Read
Memory Bit	%Mx	Value	Read/Write
Word Memory	%MWx	Value	Read/Write
Constant Word	%KWx	Value	Read
System Bit	%Sx	Value	Read/Write
System Word	%SWx	Value	Read/Write
Analog Input	%IWx.y.z	Value	Read
Analog output	%QWx.y.z	Value	Read/Write
Fast Counter	%FCx.V %FCx.VD* %FCx.P %FCx.PD* %FCx.D	Current Value Current Value Preset value Preset value Done	Read Read Read/Write Read/Write Read

Object	Variable/Attribute	Description	Access
Very Fast Counter	%VFCx.V %VFCx.VD* %VFCx.P %VFCx.PD* %VFCx.U %VFCx.C %VFCx.CD* %VFCx.S0 %VFCx.S0D* %VFCx.S1 %VFCx.S1D* %VFCx.F %VFCx.T %VFCx.R %VFCx.S	Current Value Current Value Preset value Preset value Count Direction Catch Value Catch Value Threshold 0 Value Threshold 0 Value Threshold Value1 Threshold Value1 Overflow Timebase Reflex Output Enable Reflex Input Enable	Read Read Read/Write Read/Write Read Read Read Read/Write Read/Write Read/Write Read/Write Read Read/Write Read/Write Read/Write
Input Network Word	%INWx.z	Value	Read
Output Network Word	%QNWx.z	Value	Read/Write
Grafcet	%Xx	Step Bit	Read
Pulse Generator	%PLS.N %PLS.ND* %PLS.P %PLS.D %PLS.Q	Number of Pulses Number of Pulses Preset value Done Current Output	Read/Write Read/Write Read/Write Read Read
Pulse Width Modulator	%PWM.R %PWM.P	Ratio Preset value	Read/Write Read/Write
Drum Controller	%DRx.S %DRx.F	Current Step Number Full	Read Read
Step counter	%SCx.n	Step Counter bit	Read/Write
Register	%Rx.I %Rx.O %Rx.E %Rx.F	Input Output Empty Full	Read/Write Read/Write Read Read
Shift bit register	%SBR.x.yy	Register Bit	Read/Write
Message	%MSGx.D %MSGx.E	Done Error	Read Read
AS-Interface slave input	%IAx.y.z	Value	Read/Force

Object	Variable/Attribute	Description	Access
AS-Interface analog slave input	%IWAx.y.z	Value	Read
AS-Interface slave output	%QAx.y.z	Value	Read/Write/Force
AS-Interface analog slave output	%QWAx.y.z	Value	Read/Write

Notes:

1. (*) means a 32-bit double word variable. The double word option is available on all controllers with the exception of the Twido TWDLC•A10DRF controllers.
2. Variables will not be displayed if they are not used in an application since Twido uses dynamic memory allocation.
3. If the value of %MW is greater than +32767 or less than -32768, the operator display will continue to blink.
4. 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.
5. If a value is entered for %PLS.P that is more than the limit, the value written is the saturation value.

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. The Input object ("I") will be displayed in the upper left corner of the display area. The letter " I " (or the name of the object previously viewed as data) is not blinking.
2	Press the MOD/ENTER key to enter edit mode. The Input Object "I" character (or previous object name viewed as data) 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. 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. 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 seven formats:
- I/O format
- AS-Interface slaves 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 (e.g.: %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

AS-Interface slaves I/O format

AS-Interface slave I/O objects (%IA, %QA, %IWA and %QWA) have four-part addresses (e.g.: %IAx.y.z) and are displayed as follows:

- The object type in the upper-left
- AS-Interface master address on the expansion bus in the upper-left center
- Address of the slave on the AS-Interface bus in the upper-right center
- Slave I/O channel in the upper-right.

In the case of a simple input (%IA) and output (%QA), 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 %QA1.3A.2 appears in the display area as follows:

QA	1	3A	2
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. They 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, %MD, %KD, %MF, %KF, %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:
- Object type 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 network word of the remote controller configured at remote address #2 is set to a value -4.

```
I  N  W  2     0
     -         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
- Step counter bit in the upper right
- The value of the step counter bit 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) appears in the display area as follows:
- Object name and number in the upper-left
- Register bit number in the upper-right
- Register bit value in the lower-right

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

S B R 4	9
	1

Serial Port Settings

Introduction

The operator display allows you to display the protocol settings and change the addresses of all serial ports configured using TwidoSoft. 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 4.

```
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 to increment the value of that field.
5	Continue steps 3 and 4 until the address 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.
7	

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
```

Note:
1. The TWDLCA•40DRF series of compact controllers have RTC onboard.
2. On all other controllers, time of day clock and real-time correction are only available if the Real-Time Clock (RTC) option cartridge (TWDXCPRTC) is installed.

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 edit mode.
3	Press the ➡ key until you are in the field that you wish to modify.
4	Press the ⬆ key to 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

Subject of this Part

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 chapters:

11 Ladder Language

At a Glance

Subject of this Chapter

This chapter describes programming using Ladder Language.

What's in this Chapter?

This chapter contains the following topics:

Introduction to Ladder Diagrams

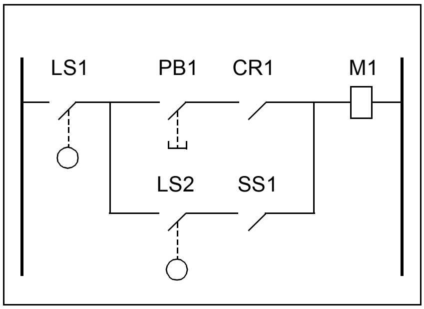
Introduction

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:

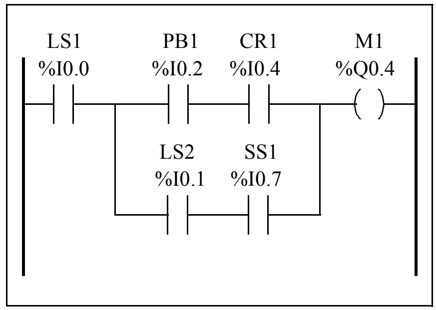
- All inputs are represented by contact symbols (⊣⊢).
- All outputs are represented by coil symbols (⊣( )⊢).
- Numerical operations are included in the graphical Ladder instruction set.

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, etc.)
- Functions of the controller (timers, counters, etc.)
- Math and logic operations (addition, division, AND, XOR, etc.)
- Comparison operators and other numerical operations (A<B, A=B, shift, rotate, etc.)
- Internal variables in the controller (bits, words, etc.)

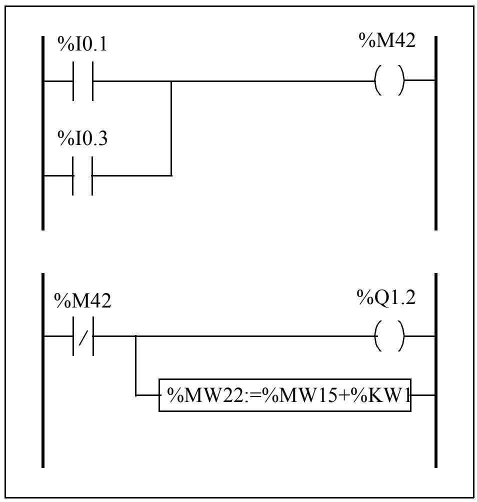
These graphical instructions are arranged with vertical and horizontal connections leading eventually to one or several outputs and/or actions. A rung cannot support more than one group of linked instructions.

Example of Ladder Rungs

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

Example Rung 1

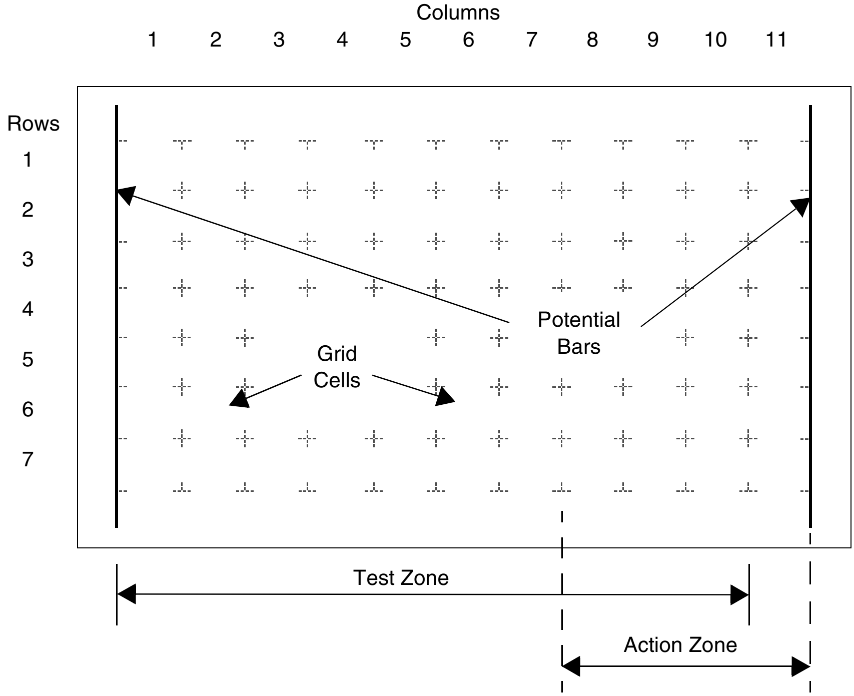
Example Rung 2



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. 268*.

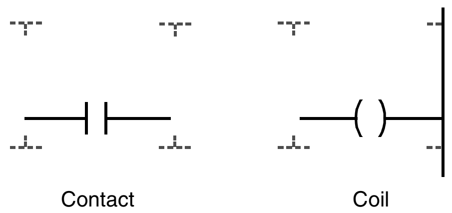
Ladder Diagram Blocks

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.

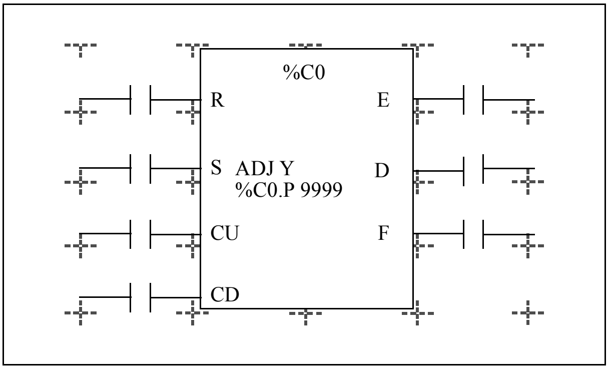


Function Blocks

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.

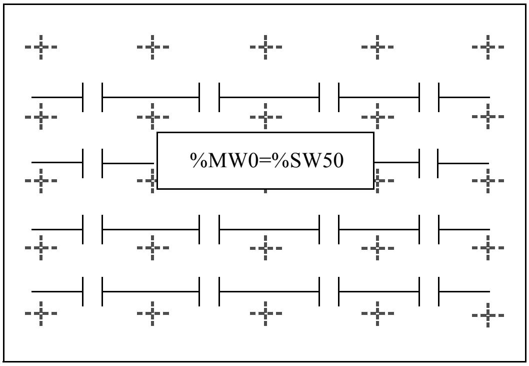
Function blocks are vertically oriented and occupy two columns by four rows of the programming grid.

The following is an example of a counter function block.



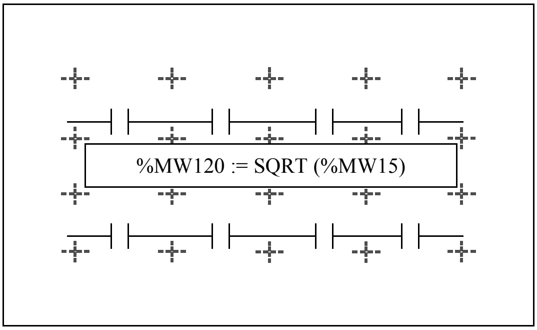
Comparison Blocks

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.



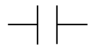
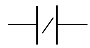
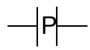
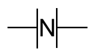
Ladder Language Graphic Elements

Introduction

Instructions in Ladder diagrams consist of graphic elements.

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	Function
Horizontal connection		Links in series the test and action graphic elements between the two potential bars.
Vertical connection		Links the test and action graphic elements in parallel.

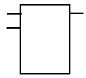
Coils

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**	**Function**
Direct coil	—( )—	ST	The associated bit object takes the value of the test zone result.
Inverse 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 ->>%SRi	JMP SR	Connect to a labeled instruction, upstream or downstream.
Transition condition coil	—(#)—		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.

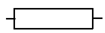
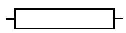
Function blocks

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**	**Function**
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 to 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**	**Function**
Comparison block		Compares two operands, the output changes to 1 when the result is checked. Size: one row by two columns
Operation block		Performs arithmetic and logic operations. Size: one row by four columns

Special Ladder Instructions OPEN and SHORT

Introduction

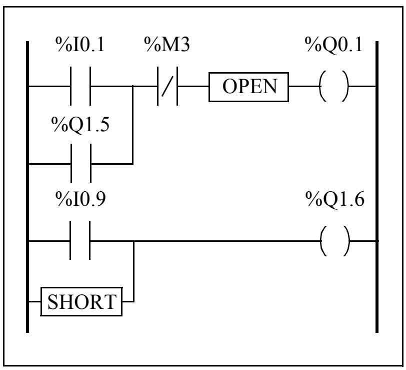
The OPEN and SHORT instructions provide a convenient method for debugging and troubleshooting Ladder programs. These special instructions alter the logic of a rung by either shorting or opening the continuity of a rung as explained in the following table.

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. A downstream instruction line appears after a jump in a program.).

Programming of Outputs

Output bits, like internal bits, should only be modified 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. An automatic restart of the installation could cause unexpected operation of equipment (use system bits %S0, %S1 and %S9).

Time and Schedule Block Management

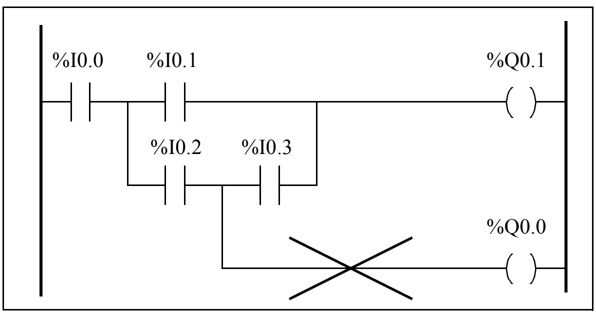
The state of system bit %S51, which indicates any RTC faults, should be checked.

Syntax and Error Checking

When a program is entered, TwidoSoft checks the syntax of the instructions, the operands, and their association.

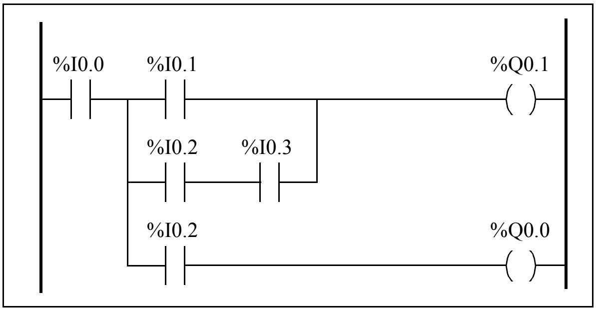
Additional Notes on Using Parentheses

Assignment operations should not be placed within parentheses:



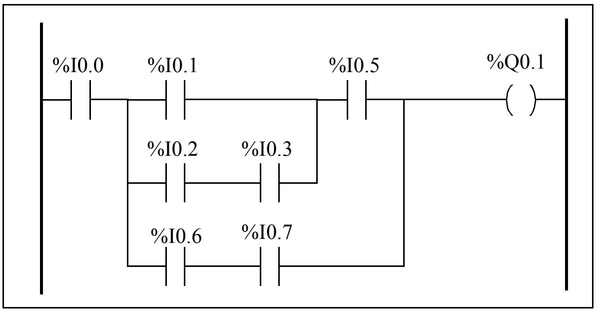

```
LD      %I0.0
AND     %I0.1
OR(     %I0.2
ST      %Q0.0
AND     %I0.3
)
ST      %Q0.1
```

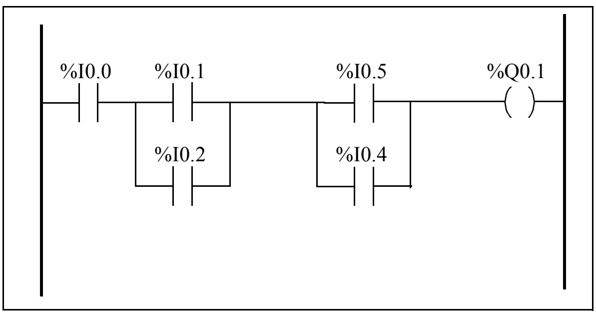
In order to perform the same function, the following equations must be programmed:



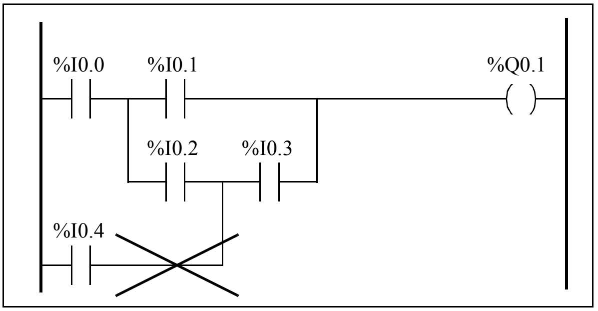

```
LD      %I0.0
MPS
AND(    %I0.1
OR(     %I0.2
AND     %I0.3
)
)
ST      %Q0.1
MPP
AND     %I0.2
ST      %Q0.0
```

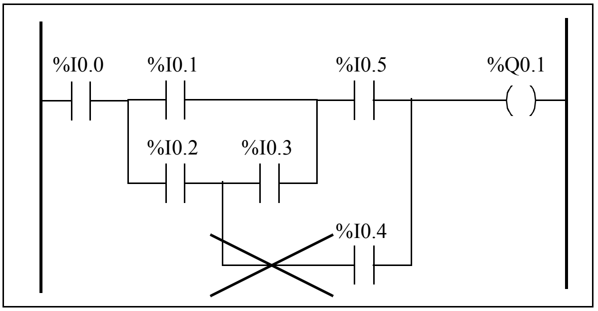
If several contacts are parellelized, they must be nested within each other or completely separate:



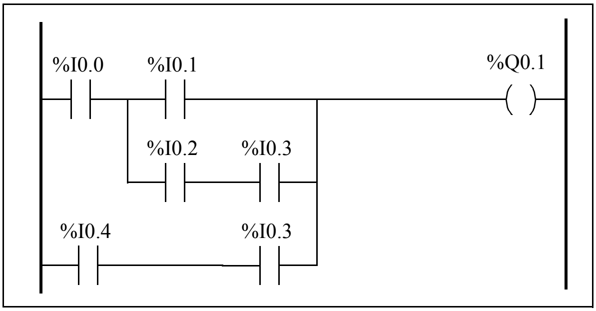


The following schematics cannot be programmed:

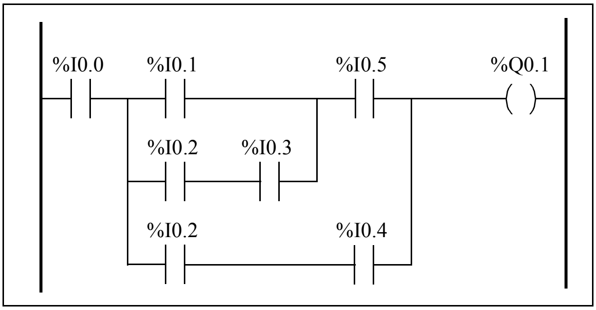




In order to execute schematics equivalent to those, they must be modified as follows:




```
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

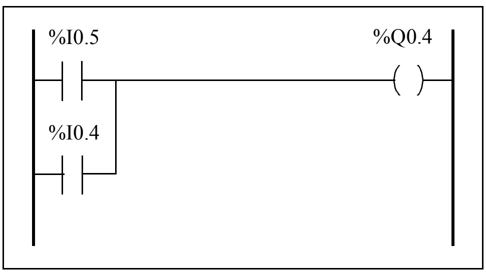
Program reversibility is a feature of the TwidoSoft programming software that provides conversion of application programs from Ladder to List and from List back to Ladder.
Use TwidoSoft to set the default display of programs: either List or Ladder format (by setting user preferences). TwidoSoft can also be used to toggle List and Ladder views.

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. However, 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. 266*.

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 *Standard function blocks programming principles, p. 319*.

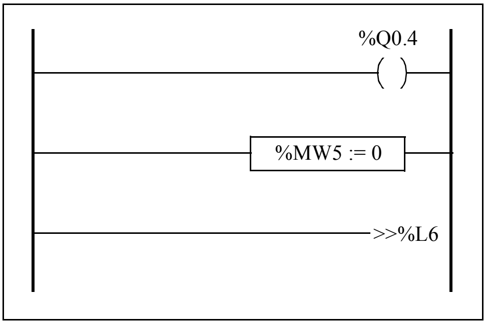
Non-Equivalent Instructions to Avoid

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:

- 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. These are 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. For this, 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
```

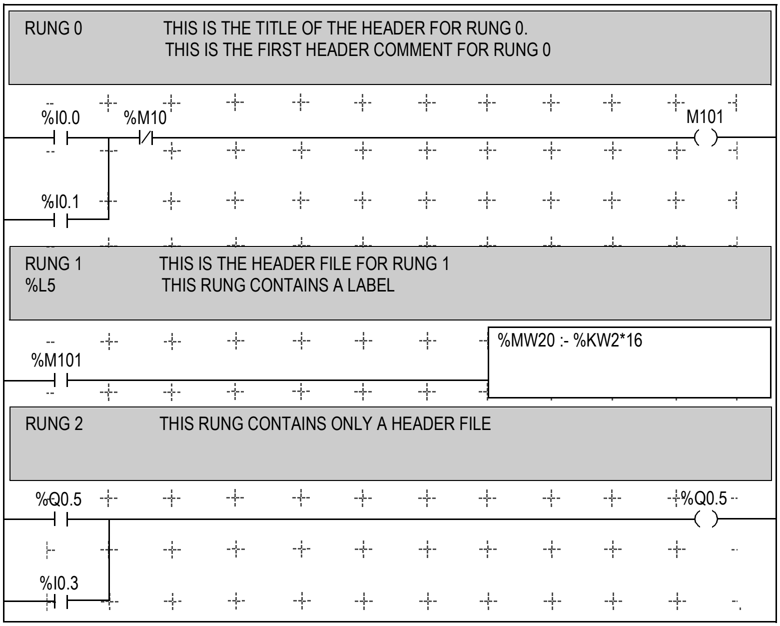
Reversing List Comments to Ladder

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.



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 List sequence.
- If the List was reversed to Ladder, any comments that were ignored will reappear in the List Editor.

Instruction List Language

12

At a Glance

Subject of this Chapter

This chapter describes programming using Instruction List Language.

What's in this Chapter?

This chapter contains the following topics:

Overview of List Programs

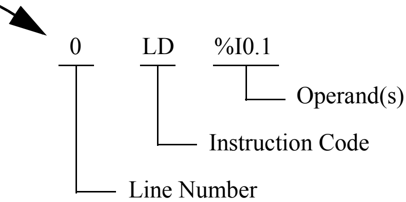
Introduction

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 produces 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 shows a selection of instructions in List Instruction language:

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

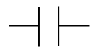
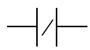
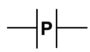
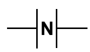
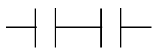
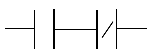
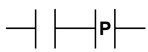
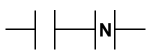
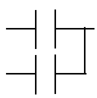
Introduction

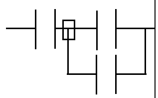
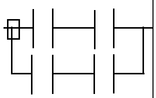
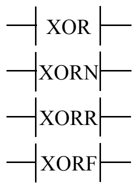
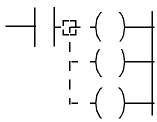
List language consists of the following types of instructions:
- Test Instructions
- Action instructions
- Function block instructions

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 MRD MPP		Switching to the coils.
N	-	Negation (NOT)

Action instructions

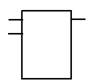
The following table describes action instructions in List language.

Name	Equivalent graphic element	Function
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.

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

Using Parentheses

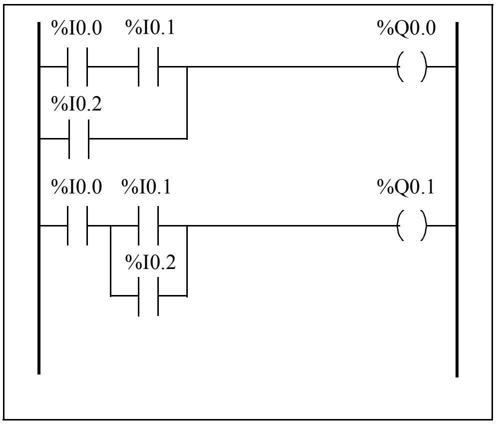
Introduction

In AND and OR logical instructions, parentheses are use to specify divergences in Ladder Editors. 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

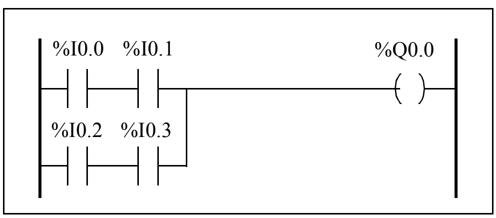
The following diagrams are examples of using a parentheses with an AND instruction: AND(...).




```
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 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. 347*

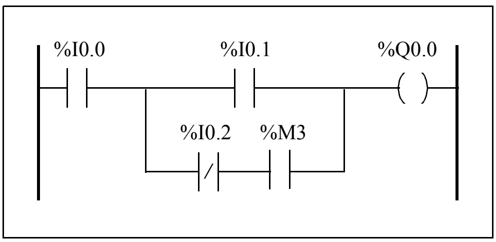
Nesting Parenthesis

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

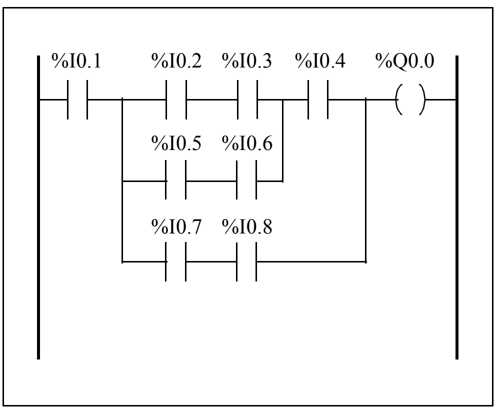
- Each open parentheses must have a corresponding closed parentheses.
- Labels (%Li:), subroutines (SRi:), jump instructions (JMP), and function block instructions must not be placed in expressions between parentheses.
- Store instructions ST, STN, S, and R must not be programmed between parentheses.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

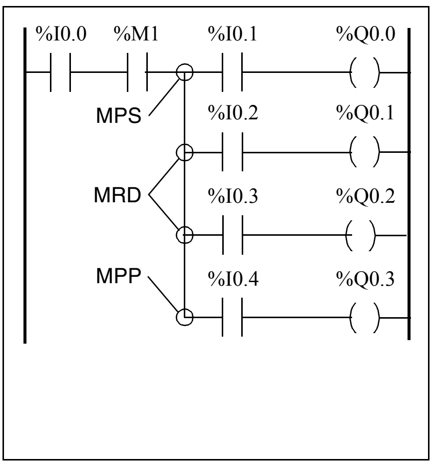
Operation of Stack Instructions

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

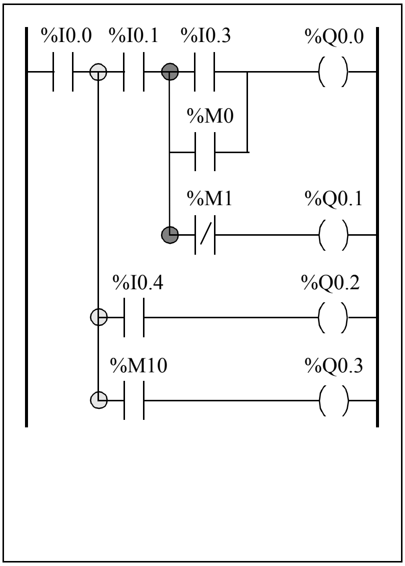
The following diagrams are examples of using stack instructions.



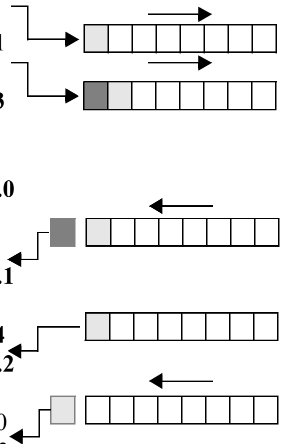

```
LD      %I0.0
AND     %M1
MPS
AND     %I0.1
ST      %Q0.0
MRD
AND     %I0.2
ST      %Q0.1
MRD
AND     %I0.3
ST      %Q0.2
MPP
AND     %I0.4
ST      %Q0.3
```

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

13

At a Glance

Subject of this Chapter

This chapter describes programming using Grafcet Language.

What's in this Chapter?

This chapter contains the following topics:

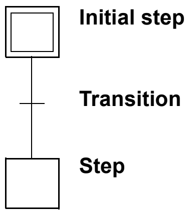
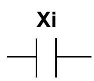
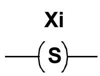
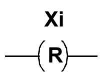
Description of Grafcet Instructions

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

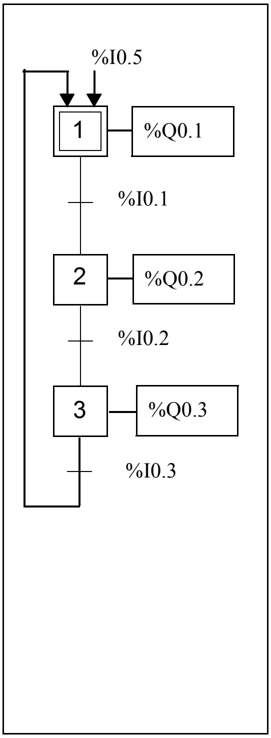
The following table lists all instructions and objects required to program a Grafcet chart:

Graphic representation (1)	Transcription in TwidoSoft language	Function
Illustration: 	=*= 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 AND %Xi, ANDN %Xi, OR %Xi, ORN %Xi XOR %Xi, XORN %Xi	Test the activity of step i
	S %Xi	Activate step i
	R %Xi	Deactivate step i

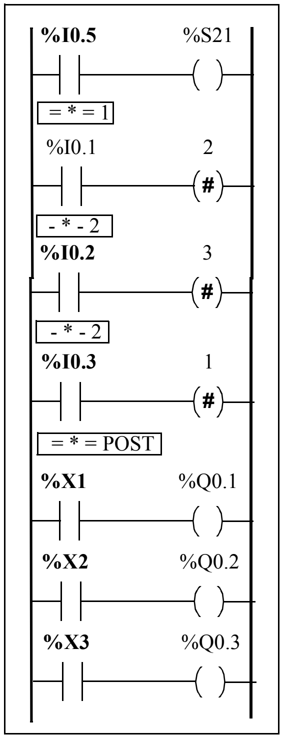
(1) The graphic representation is not taken into account.
(2) The first step =*=i or -*-i written indicates the start of sequential processing and thus the end of preprocessing.

Grafcet Examples

Linear sequence:



Not supported

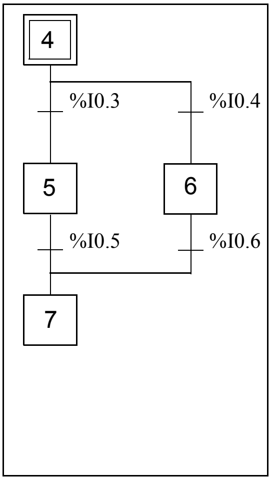


Twido Ladder Language programme

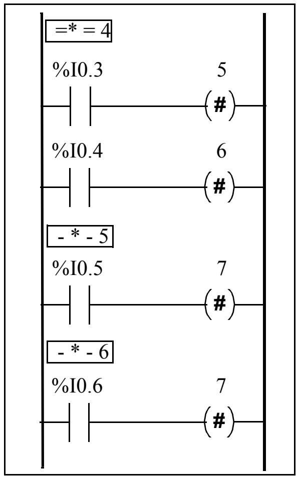
```
LD      %I0.5
ST      %S21
=*=     1
LD      %I0.1
#       2
-*-     2
LD      %I0.2
#       3
-*-     3
LD      %I0.3
#       1
=*=     POST
LD      %X1
ST      %Q0.1
LD      %X2
ST      %Q0.2
LD      %X3
ST      %Q0.3
```

Twido Instruction List programme

Alternative sequence:



Not supported

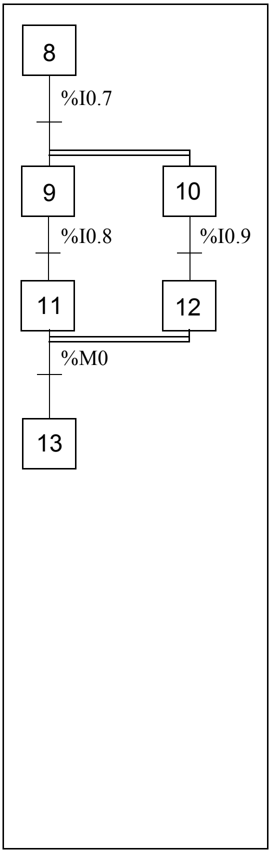


Twido Ladder Language programme

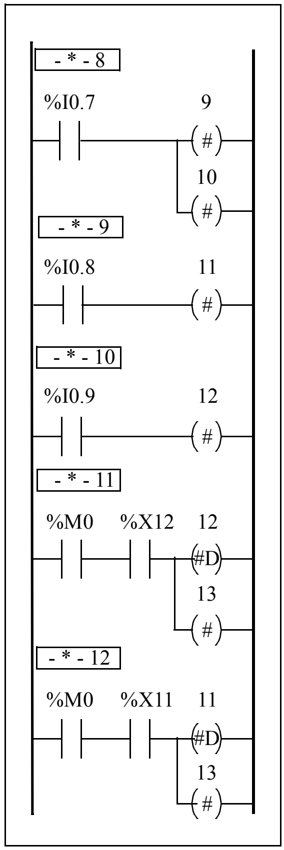
```
=*=     4
LD      %I0.3
#       5
LD      %I0.4
#       6

-*-     5
LD      %I0.5
#       7

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

Twido Instruction List programme

Simultaneous sequences:



Not supported



Twido Ladder Language programme

```
-*-     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 Instruction List programme

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

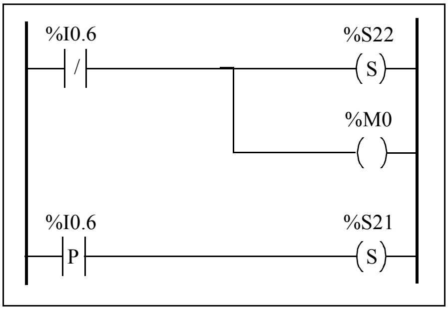
Introduction

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

The rising edge of input %I0.6 sets bit %S21 to 1. This disables the active steps and enables the inactive steps.




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

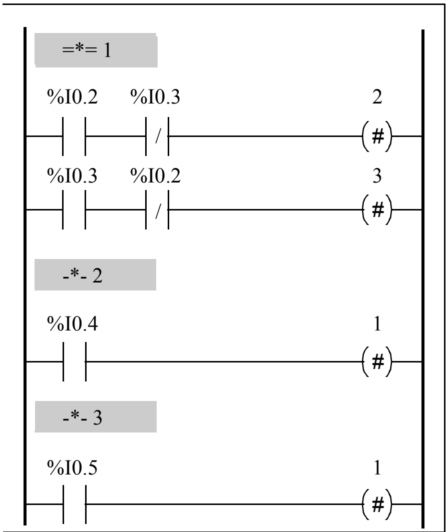
Preprocessing begins with the first line of the program and ends with the first occurrence of a "= * =" or "- * -" instruction.
Three system bits are dedicated to Grafcet control: %S21, %S22 and %S23. Each of these system bits are set to 1 (if needed) by the application, normally in preprocessing. The 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	Grafcet re-initialization	All steps are deactivated.
%S23	Grafcet pre-positioning	This bit must be set to 1 if %Xi objects 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:



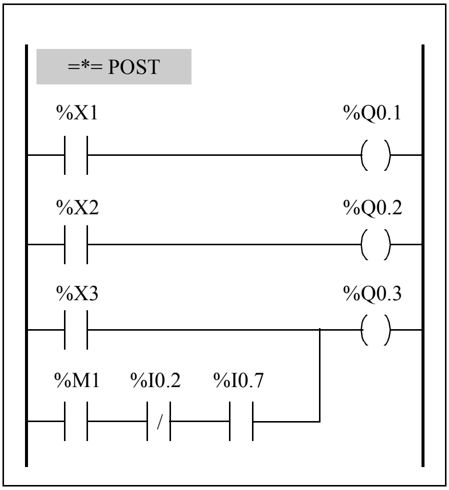

```
005    =*=    1
006    LD     %I0.2
007    ANDN   %I0.3
008    #      2
009    LD     %I0.3
010    ANDN   %I0.2
011    #      3
012    -*-    2
013    LD     %I0.4
014    #      1
015    -*-    3
016    LD     %I0.5
017    #      1
```

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:




```
=*=    POST
LD     %X1
ST     %Q0.1
LD     %X2
ST     %Q0.2
LD     %X3
OR(    %M1
ANDN   %I0.2
AND    %I0.7
)
ST     %Q0.3
```

Actions Associated with Grafcet Steps

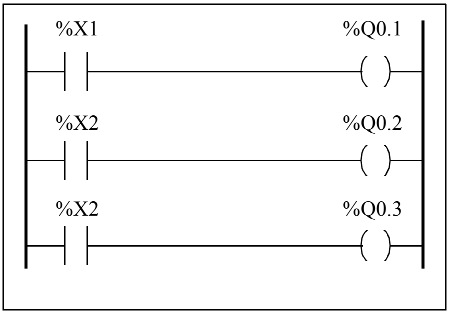
Introduction

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:

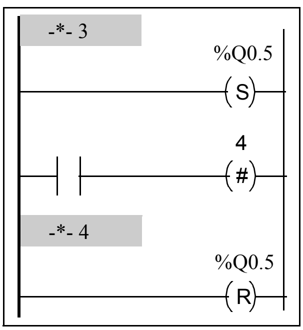



```
018   =*=   POST
019   LD    %X1
020   ST    %Q0.1
021   LD    %X2
022   ST    %Q0.2
023   LD    %X3
024   ST    %Q0.3
```

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

Subject of this Part

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:

Basic Instructions

14

At a Glance

Subject of this Chapter

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 chapter contains the following sections:

14.1 Boolean Processing

At a Glance

Aim of this Section

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. These instructions are summarized in the following table.

Item	Instruction	Example	Description
Test elements	The Load (LD) instruction is equivalent to an open contact.	LD %I0.0	Contact is closed when bit %I0.0 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
```

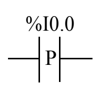
Testing Controller Inputs

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". This edge 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 input value 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

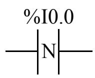


P: Positive transition sensing contact

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.

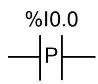
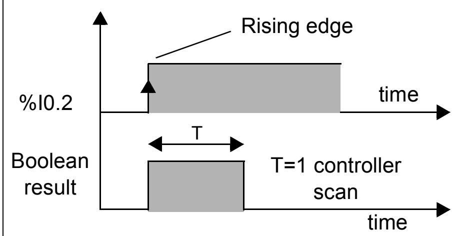
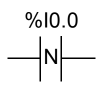
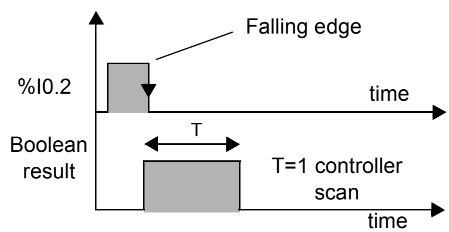
LDF %I0.0



N: Negative transition sensing contact

Edge Detection

The following table summarizes the instructions and timing for detecting edges:

Edge	**Test Instruction**	**Ladder diagram**	**Timing diagram**
Rising edge	LDR %I0.0		
Falling edge	LDF %I0.0		

Note: It is now possible to apply edge instructions to the %Mi internal bits.

Understanding the Format for Describing Boolean Instructions

Introduction

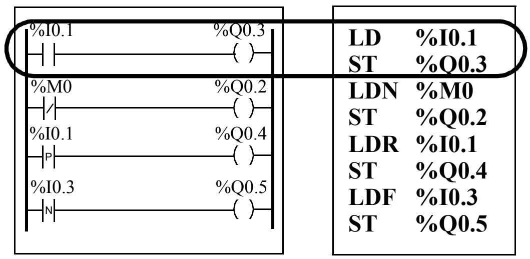
Each Boolean instruction in this section is described using the following information:

- 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.



Ladder diagram equivalents List instructions

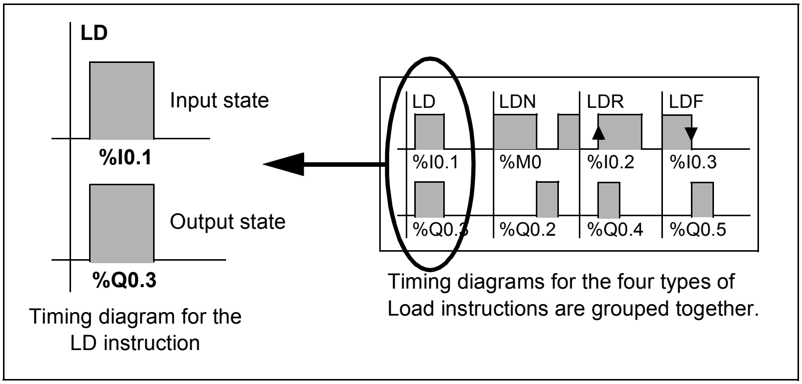
Permitted Operands

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.



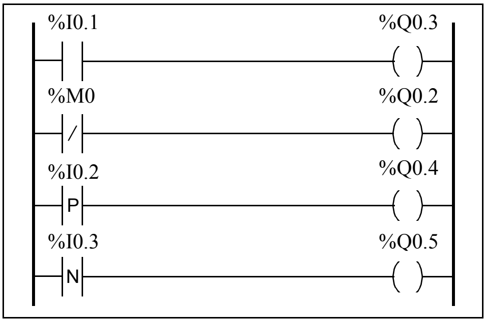
Load Instructions (LD, LDN, LDR, LDF)

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 and internal words, and for AS-Interface slave inputs).

Examples

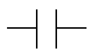
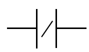
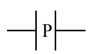
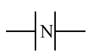
The following diagrams are examples of Load instructions.



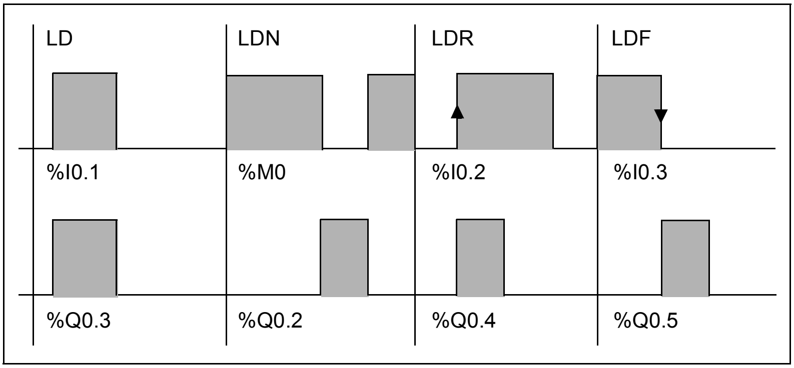

```
LD    %I0.1
ST    %Q0.3
LDN   %M0
ST    %Q0.2
LDR   %I0.2
ST    %Q0.4
LDF   %I0.3
ST    %Q0.5
```

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, %IA, %Q, %QA, %M, %S, %X, %BLK.x, %•:Xk,[
LDN		0/1, %I, %IA, %Q, %QA, %M, %S, %X, %BLK.x, %•:Xk,[
LDR		%I, %IA, %M
LDF		%I, %IA, %M

Timing diagram The following diagram displays the timing for Load instructions.



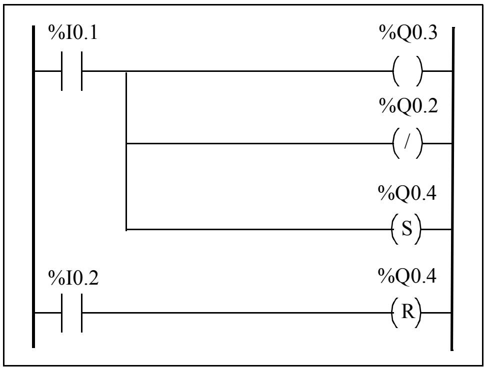
Assignment instructions (ST, STN, R, S)

Introduction

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

Examples

The following diagrams are examples of assignment instructions.



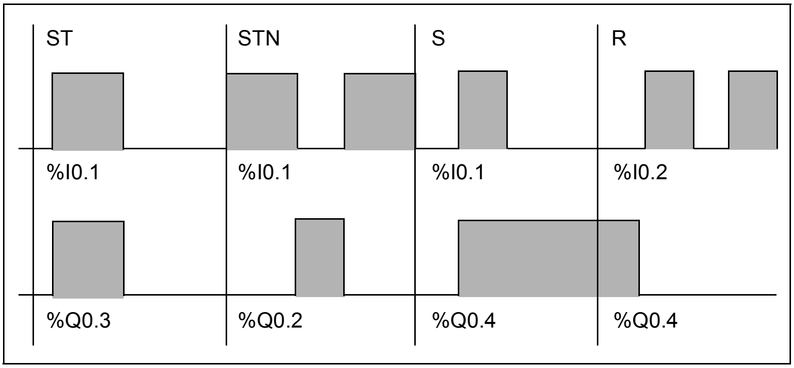

```
LD    %I0.1
ST    %Q0.3

STN   %Q0.2
S     %Q0.4

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

Permitted Operands

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

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

Timing diagram The following diagram displays the timing for assignment instructions.



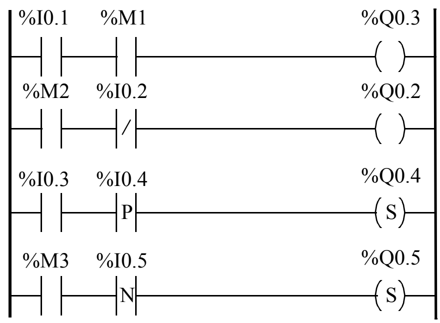
Logical AND Instructions (AND, ANDN, ANDR, ANDF)

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

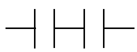
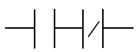
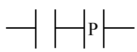
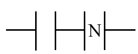
The following diagrams are examples of logic AND instructions.



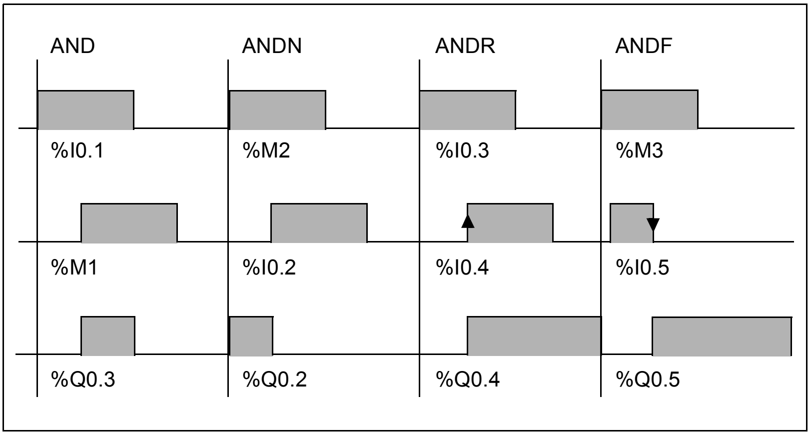

```
LD      %I0.1
AND     %M1
ST      %Q0.3
LD      %M2
ANDN    %I0.2
ST      %Q0.2
LD      %I0.3
ANDR    %I0.4
S       %Q0.4
LD      %M3
ANDF    %I0.5
S       %Q0.5
```

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, %IA, %Q, %QA, %M, %S, %X, %BLK.x, %•:Xk, [
ANDN		0/1, %I, %IA, %Q, %QA, %M, %S, %X, %BLK.x, %•:Xk, [
ANDR		%I, %IA, %M
ANDF		%I, %IA, %M

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



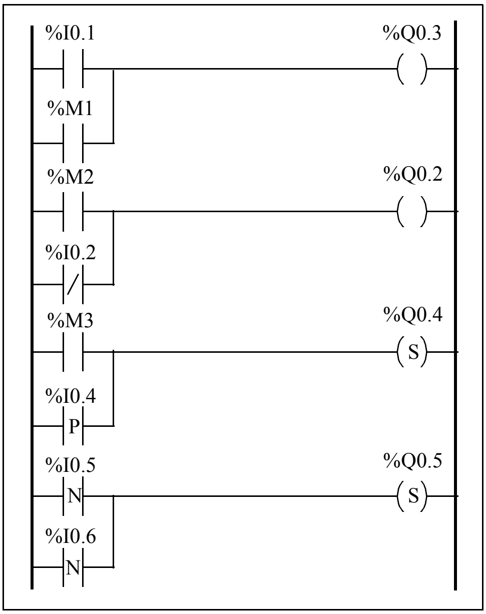
Logical OR Instructions (OR, ORN, ORR, ORF)

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

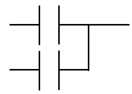
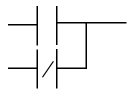
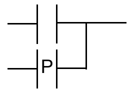
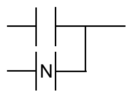
The following diagrams are examples of logic OR instructions.




```
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
```

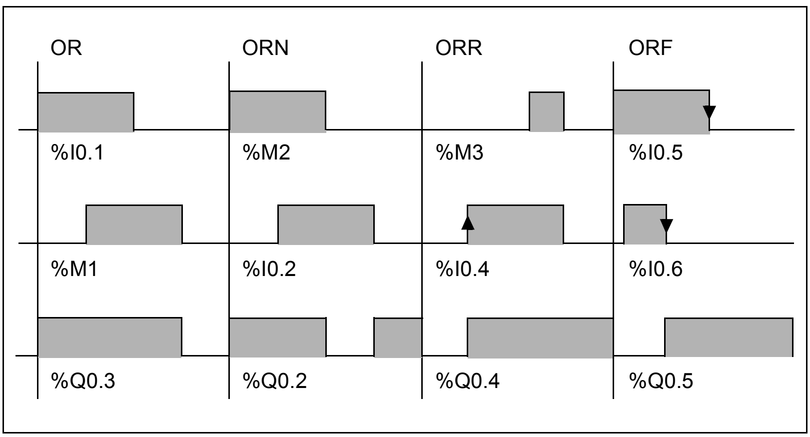
Permitted Operands

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,%IA, %Q, %QA, %M, %S, %X, %BLK.x, %•:Xk
ORN		0/1, %I,%IA, %Q, %QA, %M, %S, %X, %BLK.x, %•:Xk
ORR		%I, %IA, %M
ORF		%I, %IA, %M

Timing diagram

The following diagram displays the timing for the OR instructions.



Exclusive OR, instructions (XOR, XORN, XORR, XORF)

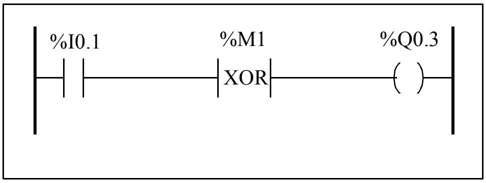
Introduction

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

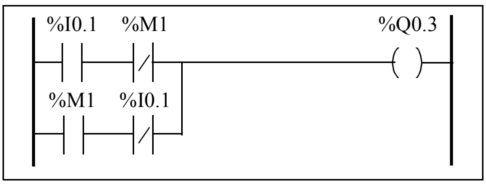
The following example shows the use of XOR instructions.

Schematic using XOR instruction:




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

Schematic NOT using XOR instruction :




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

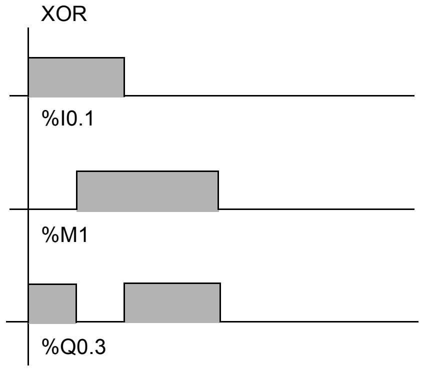
Permitted Operands

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

List instruction	Permitted Operands
XOR	%I, %IA, %Q, %QA, %M, %S, %X, %BLK.x, %•:Xk
XORN	%I, %IA, %Q, %QA, %M, %S, %X, %BLK.x, %•:Xk
XORR	%I, %IA, %M
XORF	%I, %IA, %M

Timing Diagram

The following diagram displays the timing for the XOR instructions.

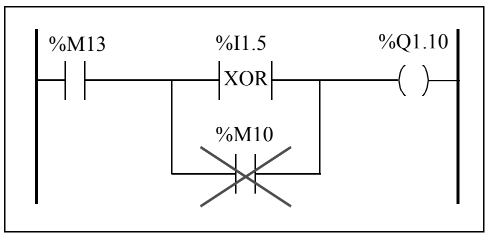


Special Cases

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
```

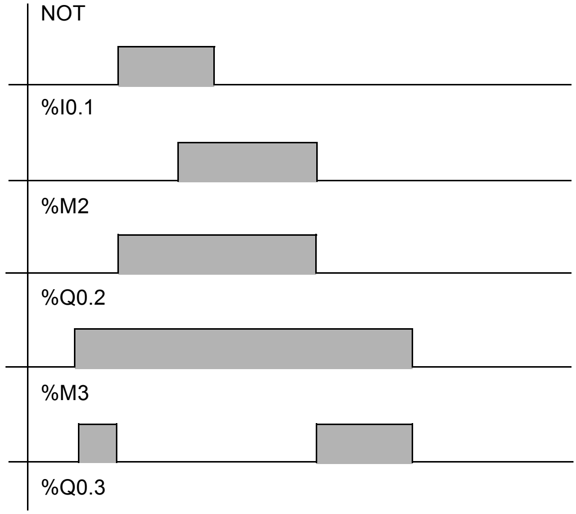
Note: The NOT instruction is not reversible.

Permitted Operands

Not applicable.

Timing Diagram

The following diagram displays the timing for the NOT instruction.



14.2 Basic Function Blocks

At a Glance

Aim of this Section

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

What's in this Section?

This section contains the following topics:

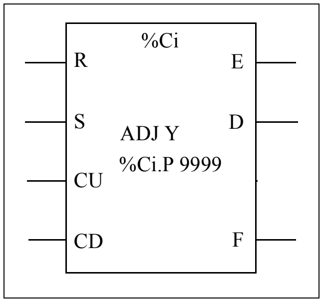
Basic Function Blocks

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 *Standard function blocks programming principles, p. 319*).
- 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 - 127	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

Standard function blocks programming principles

Introduction

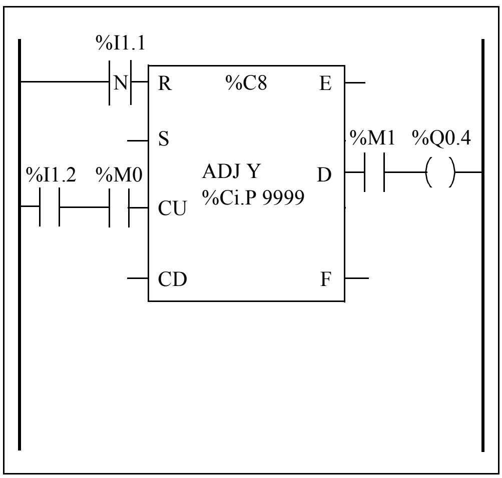
Use one of the following methods to program standard function blocks:
- Function block instructions (for example, `BLK` %TM2): This reversible method of programming ladder language enables operations to be performed on the block in a single place in the program.
- Specific instructions (for example, `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 Output Wiring

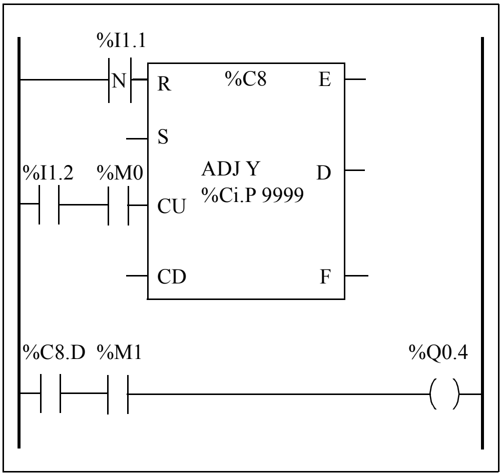
The following example shows reversible programming of a counter function block with wired outputs.




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

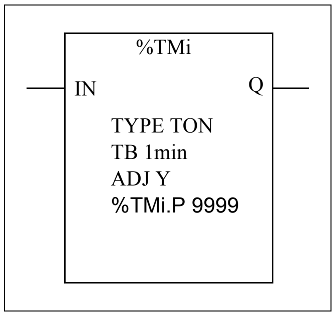
Introduction

There are three types of Timer function blocks:
- TON (Timer On-Delay): this type of timer is used to control on-delay actions.
- TOF (Timer Off-Delay): this type of timer is used to control off-delay actions.
- TP (Timer - Pulse): this type of timer is used 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: TWDLCAA10DRF and TWDLCAA16DRF 0 to 127 for all other controllers.
Type	TON	• Timer On-Delay (default)
	TOF	• Timer Off-Delay
	TP	• pulse (monostable)
Time base	TB	1 min (default), 1 s, 100 ms, 10 ms, 1 ms
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 Animation Tables 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 %TMi.P x TB.
Animation Tables Editor	Y/N	Y: Yes, the preset %TMi.P value can be modified using the Animation Tables Editor. N: No, the preset %TMi.P value cannot be modified.
Enable (or instruction) input	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

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

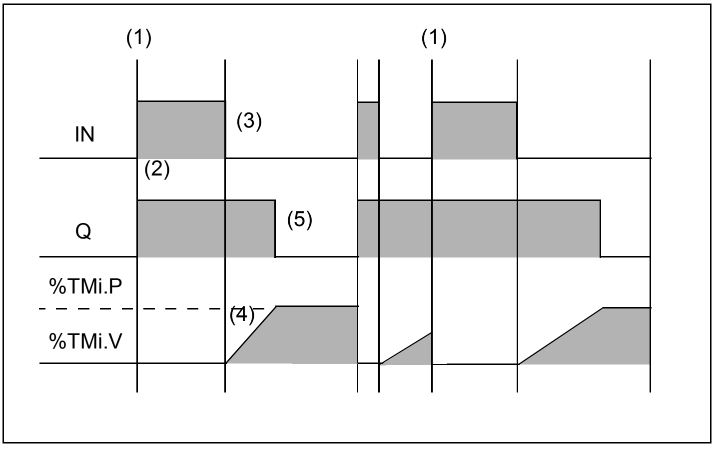
TOF Type of Timer

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.

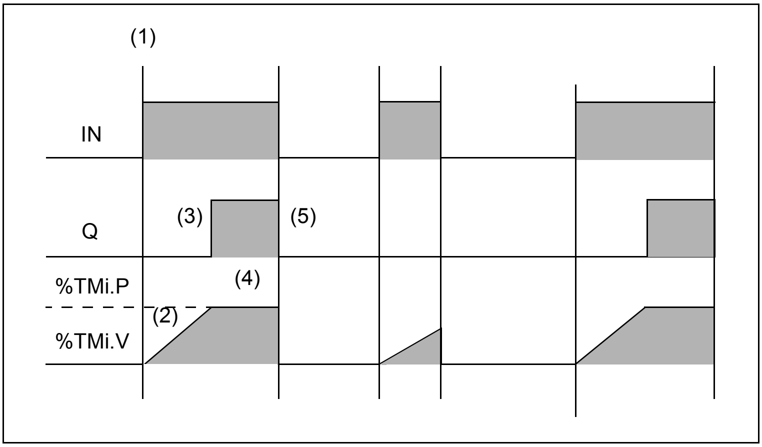
TON Type of Timer

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.

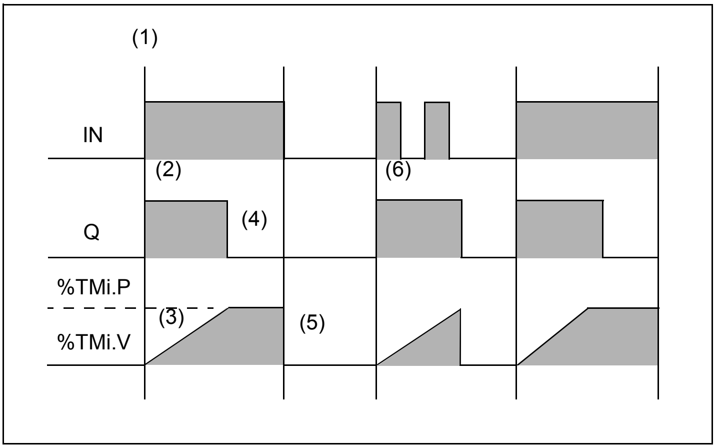
TP Type of Timer

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 pulse of the time base TB.
4	The %TMi.Q output bit is set to 0 when the current value has reached %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.

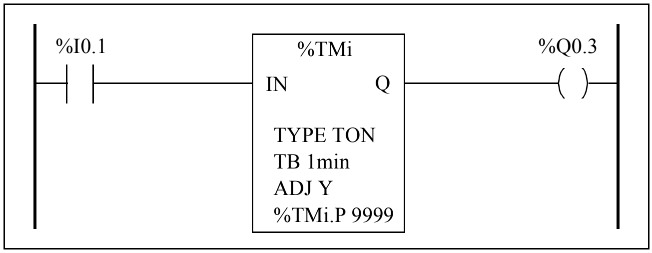
Programming and Configuring Timers

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
- Timebase: 1 min, 1 s, 100 ms, 10 ms or 1 ms
- Preset value (%TMi.P): 0 to 9999
- Adjust: Checked or Not Checked

Special Cases

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

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.

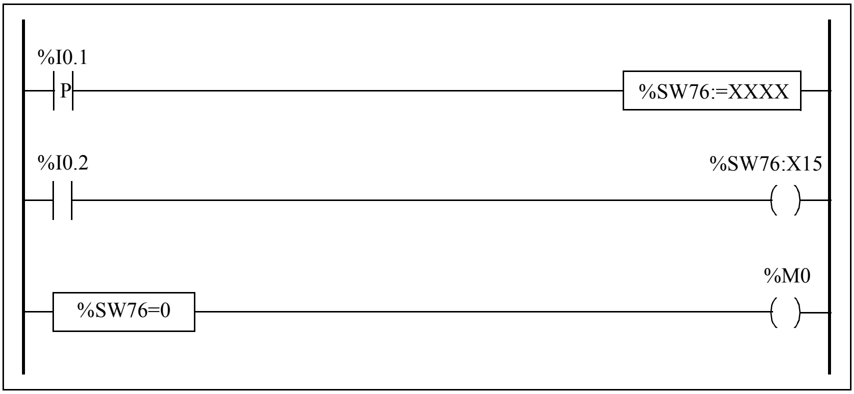
Timers with a 1 ms Time Base

The 1 ms time base is only available with the first five 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 test)
ST      %M0
..............
```



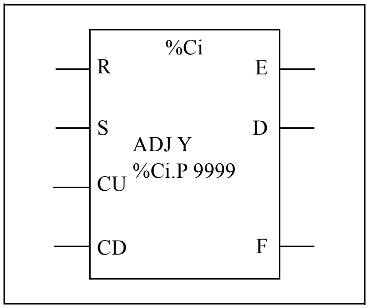
Up/Down Counter Function Block (%Ci)

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 127
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 Animation Tables Editor	ADJ	• Y: Yes, the preset value can be modified by using the Animation Tables Editor. • N: No, the preset value cannot be modified by using the Animation Tables Editor.
Reset input (or instruction)	R	At state 1: %Ci.V = 0.
Reset input (or instruction)	S	At state 1: %Ci.V = %Ci.P.
Upcount input (or instruction)	CU	Increments %Ci.V on a rising edge.

Parameter	Label	Value
Downcount input (or instruction)	CD	Decrements %Ci.V on a rising edge.
Downcount overflow 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.
Upcount 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
Counting	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 switches to 1.
	The %Ci.V current value changes from 9999 to 0.	The output bit %Ci.F (upcounting overflow) switches to 1.
	If the counter continues to count up.	The output bit %Ci.F (upcounting overflow) is reset to zero.
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 (downcounting overflow) switches to 1.
	If the counter continues to count down.	The output bit %Ci.F (downcounting overflow) is reset to zero.
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 simultaneously. These two inputs are then scanned in succession. If they are both at 1, the current value remains unchanged.	

Operation	Action	Result
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.
Preset	If input S is set to 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 shows a list of special operating/configuration cases for counters.

Special case	Description
Effect of a cold restart (%S0=1)	• The current value %Ci.V is set to 0. • Output bits %Ci.E, %Ci.D, and %Ci.F are set to 0. • 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).

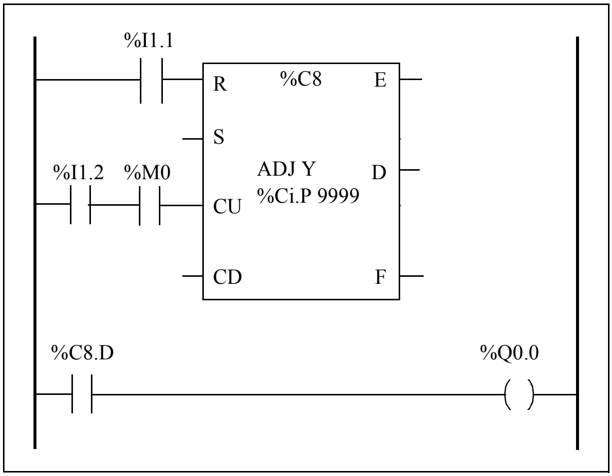
Programming and Configuring Counters

Introduction

The following example is a counter that provides a count of up to 5000 items. Each pulse on input %I1.2 (when internal bit %M0 is set to 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
```

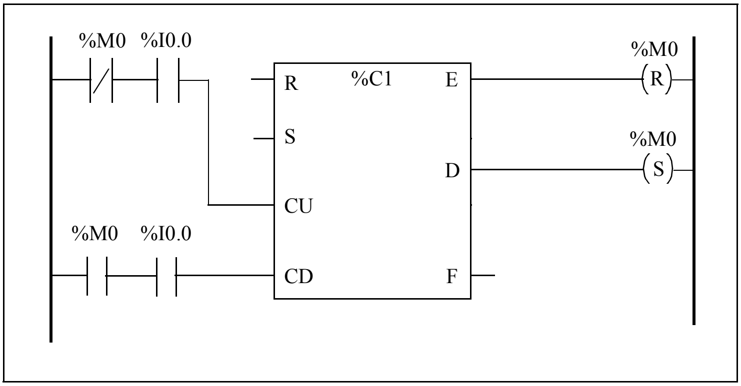
Non-Reversible programming

Configuration

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

Example of an Up/Down Counter

The following illustration is an example of an Up/Down Counter function block.



Ladder diagram

In this example, if we take %C1.P 4, the current value of the %C1.V counter will be incremented from 0 to 3, then decremented from 3 to 0. Whereas %I0.0=1 %C1.V oscillates between 0 and 3.

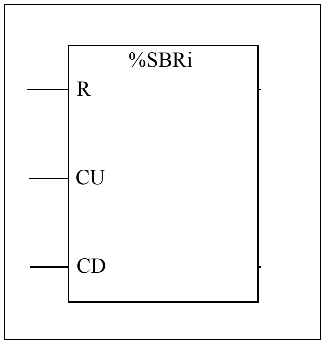
Shift Bit Register Function Block (%SBRi)

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.



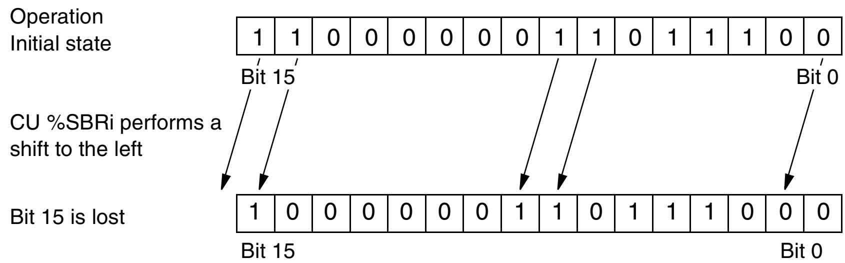
Parameters

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	When function parameter R is 1, this 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

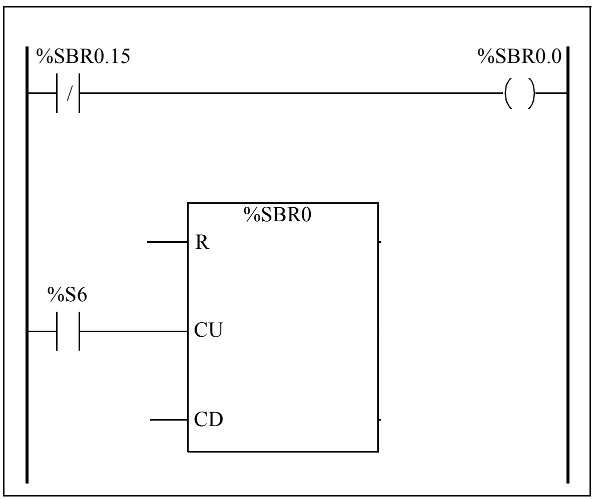
The following illustration shows a bit pattern before and after a shift operation.



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.

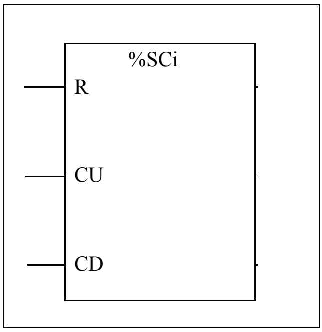
Step Counter Function Block (%SCi)

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.



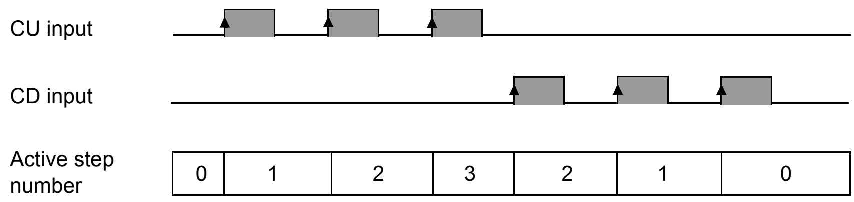
Parameters

The step function block has the following parameters:

Parameter	Label	Value
Step counter number	%SCi	0 - 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	When function parameter R is 1, this 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 timing diagram illustrates the operation of the step function block.

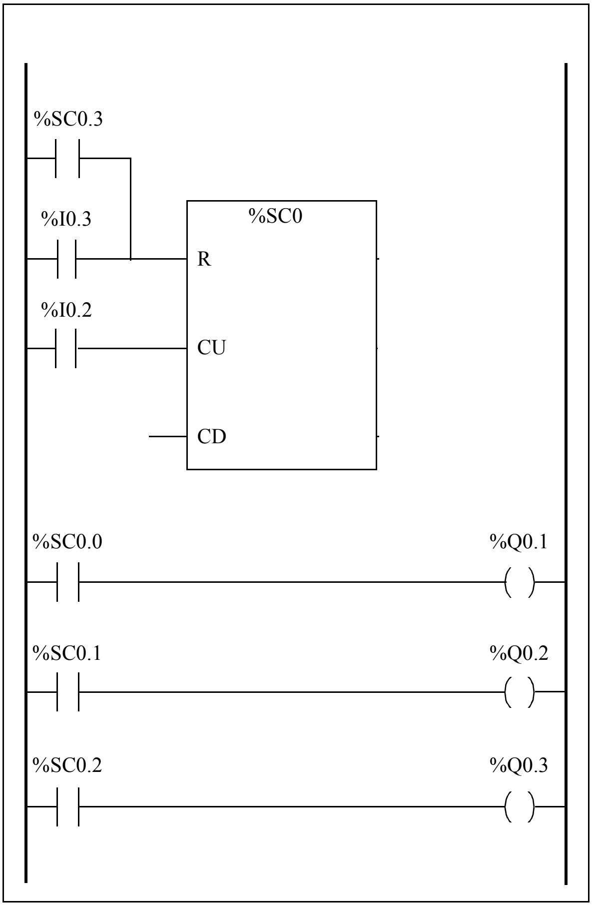


Programming

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 case

The following table contains a list of special cases for operating 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.

14.3 Numerical Processing

At a Glance

Aim of this Section

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

At a Glance

Numerical instructions generally apply to 16-bit words (see *Word Objects, p. 29*) and to 32-bit double words (See *Floating point and double word objects, p. 32*). 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.

[Op1:=Op2] <=> Op2 -> Op1

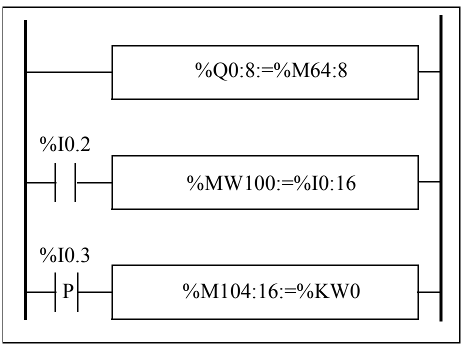
Assignment operations can be performed on:
- Bit strings
- Words
- Double words
- Floating word
- Word tables
- Double word tables
- Floating word tables

Assignment of Bit Strings

Operations can be performed on the following bit strings (see *Structured Objects, p. 45*):
- Bit string -> bit string (Example 1)
- Bit string -> word (Example 2) or double word (indexed)
- Word or double word (indexed) -> 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] Operand 1 (Op1) assumes the value of operand 2 (Op2)	%MWi,%QWi, %QWAi,%SWi %MWi[%MWi], %MDi, %MDi[%MWi] **%Mi:L, %Qi:L, %Si:L, %Xi:L**	Immediate value, %MWi, %KWi, %IW,%IWAi, %INWi, %QWi, %QWAi %QNWi, %SWi, %BLK.x, %MWi[%MWi], %KWi[%MWi], %MDi[%MWi], %KDi[%MWi], **%Mi:L,%Qi:L, %Si:L, %Xi:L, %Ii:L**

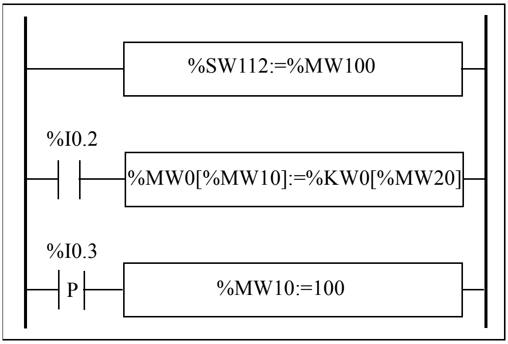
Note: The abbreviation %BLK.x (for example, %C0.P) is used to describe any function block word.

Assignment of Words

Assignment operations can be performed on the following words and double words:
- Word (indexed) -> word (2, for example) (indexed or not)
- Double word (indexed) -> double word (indexed or not)
- Immediate whole value -> word (Example 3) or double word (indexed or not)
- Bit string -> word or double word
- Floating point (indexed or not)-> floating point (indexed or not)
- Word or double word -> bit string
- Immediate floating point value -> floating point (indexed or not)

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
:=	[Op1: = Op2] Operand 1 (Op1) assumes the value of operand 2 (Op2)

The following table gives details operands:

Type	Operand 1 (Op1)	Operand 2 (Op2)
word, double word, bit string	**%BLK.x, %MWi, %QWi, %QWAi, %SWi %MWi[MWi**, %MDi, %MDi[%MWj]], %Mi:L, %Qi:L, %Si:L, %Xi:L	**Immediate value, %MWi, %KWi, %IW, %IWAi, %QWi, %QWAi, %SWi, %MWi[MWi], %KWi[MWi], %MDi, %MDi[%MWj], %KDi, %KDi[MWj]** , %INW, %Mi:L, %Qi:L, %QNW, %Si:L, %Xi:L, %Ii:L
Floating point	**%MFi, %MFi[%MWj]**	**Immediate floating point value, %MFi, %MFi[%MWj], %KFi, %KFi[%MWj]**

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, ...).

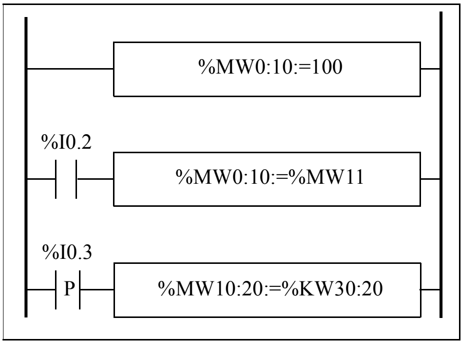
Assignment of Word, Double Word and Floating Point Tables

Assignment operations can be performed on the following object tables (see *Tables of words, p. 46*):

- Immediate whole value -> word table (Example 1) or double word table
- Word -> word table (Example 2)
- Word table -> word table (Example 3)
  Table length (L) should be the same for both tables.
- Double word -> double word table
- Double word table -> double word table
  Table length (L) should be the same for both tables.
- Immediate floating point value -> floating point table
- Floating point -> floating point table
- Floating point table-> floating point table
  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, double word and floating point table assignments

Operator	Syntax
:=	[Op1: = Op2] Operand 1 (Op1) assumes the value of operand 2 (Op2)

The following table gives details operands:

Type	Operand 1 (Op1)	Operand 2 (Op2)
word table	**%MWi:L, %SWi:L**	**%MWi:L, %SWi:L**, Immediate whole value, %MWi, %KWi, %IW, %QW, %IWA, %QWA, %SWi, %BLK.x
Double word tables	**%MDi:L**	**Immediate whole value, %MDi, %KDi,%MDi:L, %KDi:L**
Floating word tables	**%MFi:L]**	**Immediate floating point value, %MFi, %KFi, %MFi:L, %KFi:L**

Note: The abbreviation %BLK.x (for example, R3.I) is used to describe any function block word.

Comparison Instructions

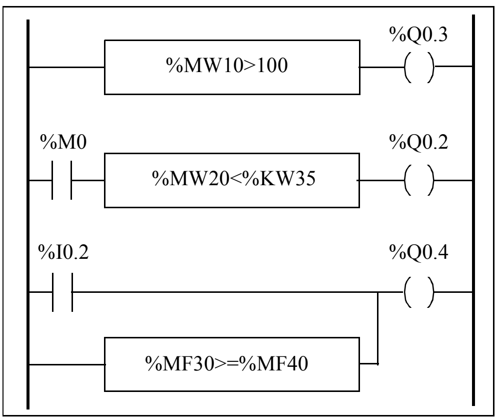
Introduction

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 operand 2
=	Test if operand 1 is equal than operand 2
<>	Test if operand 1 is different from 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   [%MF30>=%MF40]
ST   %Q0.4
```

Syntax

Syntax for Comparison instructions:

Operator	Syntax
>, >=, <, <=, =, <>	LD [Op1 Operator Op2] AND [Op1 Operator Op2] OR [Op1 Operator Op2]

Operands:

Type	Operand 1 (Op1)	Operand 2 (Op2)
Words	%MWi, %KWi, %INWi, %IW, %IWAi, %QNWi, %QWi, %QWAi, %QNWi, %SWi, %BLK.x	Immediate value, %MWi, %KWi, %INWi, %IW, %IWAi, %QNWi, %QW, %QWAi, %SWi, %BLK.x, %MWi [%MWi], %KWi [%MWi]
Double words	%MDi, %KDi	Immediate value, %MDi, %KDi, %MDi [%MWi], %KD [%MWi]
Floating word	%MFi, %KFi	Immediate floating point value, %MFi, %KFi, %MFi [%MWi], %KFi [%MWi]

Note: Comparison instructions can be used within parentheses.

An example of using Comparison instruction within parentheses:

```
LD      %M0
AND(    [%MF20 > 10.0]
OR      %I0.0
)
ST      %Q0.1
```

Arithmetic Instructions on Integers

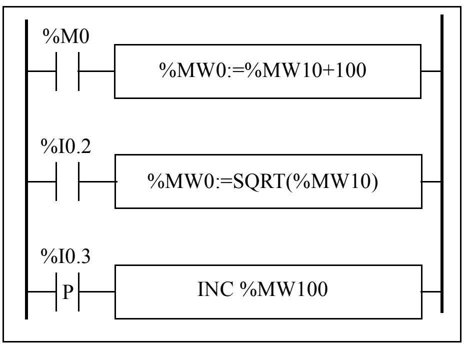
Introduction

Arithmetic instructions are used to perform arithmetic operations between two integer operands or on one integer 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
ABS	Absolute value of 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
+,-,*,/,REM	[Op1: = Op 2 Operator Op3]
INC, DEC	[Operator Op1]
SQRT (1)	[Op1: = SQRT(Op2)]
ABS (1)	[Op1: = ABS(Op2)]

Operands:

Type	Operand 1 (Op1)	Operands 2 and 3 (Op2 & 3) (1)
Words	%MWi, %QWi, %QWAi, %SWi	Immediate value, %MWi, %KWi, %INW, %IW, %IWAi, %QNW, %QW, %QWAi, %SWi, %BLK.x
Double words	%MDi	Immediate value, %MDi, %KDi

Note: (1) With this operator, Op2 cannot be an immediate value.
The ABS function can only be used with double words (%MD and %KD) and floating points (%MF and %KF). Consequently, OP1 and OP2 must be double words or floating points.

Overflow and Error Conditions

Addition

- Overflow during word operation
  If the result exceeds the capacity of the result word, bit %S18 (overflow) is set to 1 and the result is not significant (see Example 1, next page). The user program manages bit %S18.

Note:
For double words, the limits are -2147483648 and 21474836487.

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.

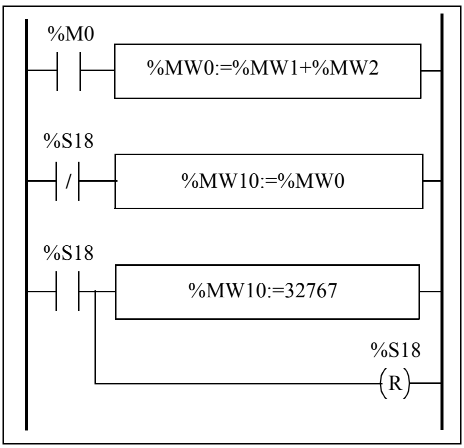
Square root extraction

- 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.

Logic Instructions

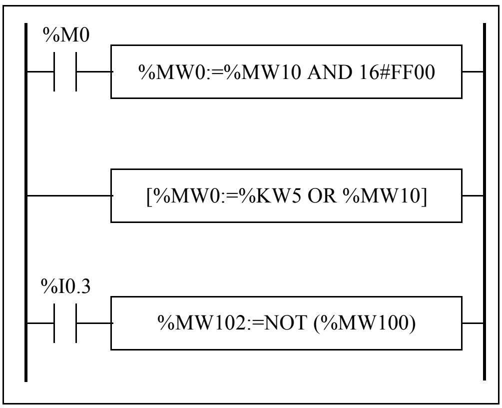
Introduction

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: = Op2 Operator Op3]	%MWi, %QWi, %QWAi, %SWi	Immediate value (1), %MWi, %KWi, %IW, %IWAi, %QW, %QWAi, %SWi, %BLK.x
NOT	[Op1:=NOT(Op2)]		

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

Example

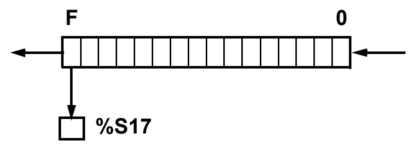
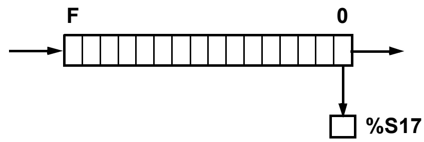
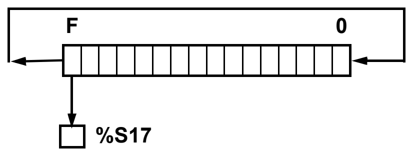
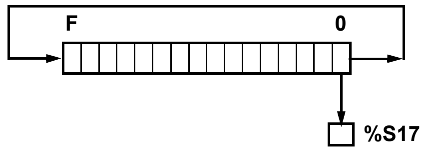
The following is an example of a logical AND instruction:

```
[%MW15:=%MW32 AND %MW12]
```

Shift Instructions

Introduction

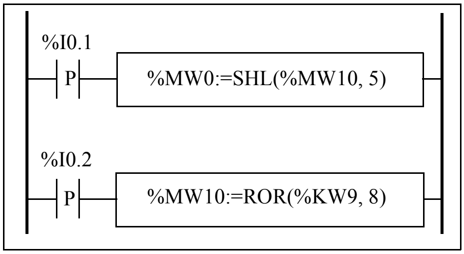
Shift instructions move bits of an operand a certain number of positions to the right or to the left.
The following table lists the types of Shift instructions.

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		
ROR(op2,i)	Rotate shift of i positions to the left.	
ROL(op2,i)	Rotate shift of i positions to the right.	

Note: System bit %S17 (See *System Bits (%S), p. 510*) is used for capacity overrun.

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
SHL, SHR	[Op1: = Operator (Op2,i)]
ROL, ROR	

Operands:

Types	Operand 1 (Op1)	Operand 2 (Op2)
Words	%MWi, %QWi, %QWAi, %SWi	%MWi, %KWi, %IW, %IWAi, %QW, %QWAi, %SWi, %BLK.x
Double word	%MDi	%MDi, %KDi

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), and a 32 bit double word object can therefore contain an eight-figure number.
During conversion, system bit %S18 is set to 1 if the value is not BCD. This bit must be tested and reset to 0 by the program.
BCD representation of decimal numbers:

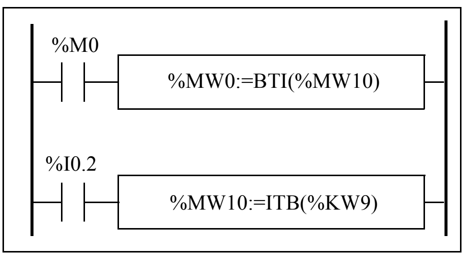
Decimal	0	1	2	3	4	5	6	7	8	9
BCD	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001

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
BTI, ITB	[Op1: = Operator (Op2)]

Operands:

Type	Operand 1 (Op1)	Operand 2 (Op2)
Words	%MWi, %QWi, %QWAi, %SWi	%MWi, %KWi, %IW, %IWAi, %QW, %QWAi, %SWi, %BLK.x
Double word	%MDi	%MDi, %KDi

Application Example:

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.

Single/double word conversion instructions

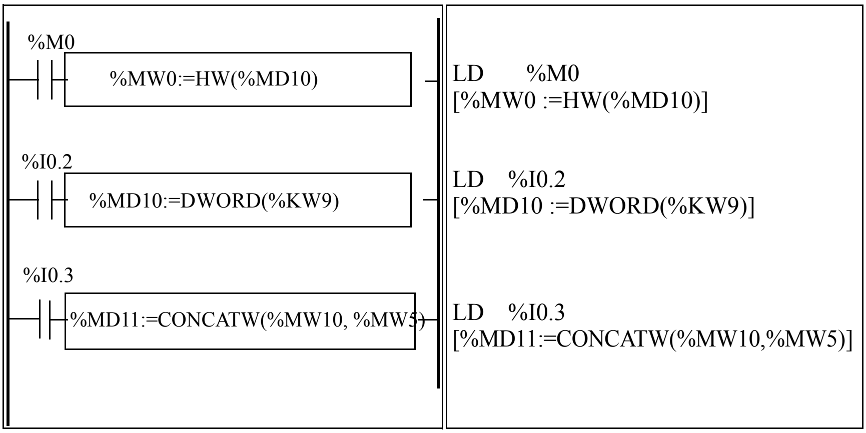
Introduction

The following table describes instructions used to perform conversions between single and double words:

Instruction	Function
LW	LSB of double word extracted to a word.
HW	MSB of double word extracted to a word.
CONCATW	Concatenates two words into a double word.
DWORD	Converts a 16 bit word into a 32 bit double word.

Structure

Conversion operations are performed as follows:



Syntax

The syntax depends on the operators used as shown in the following table: l

Operator	Syntax	Operand 1 (Op1)	Operand 2 (Op2)	Operand 3 (Op3)
LW, HW	Op1 = Operator (Op2)	%MWi	%MDi, %KDi	[-]
CONCATW	Op1 = Operator (Op2, Op3))	%MDi	%MWi, %KWi, immediate value	%MWi, %KWi, immediate value
DWORD	Op1 = Operator (Op2)	%MDi	%MWi, %KWi	[-]

14.4 Program Instructions

At a Glance

Aim of this Section

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.

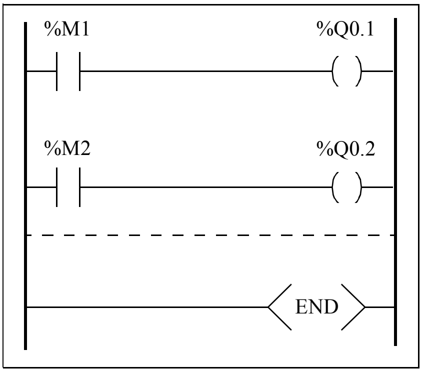
END, ENDC, and ENDCN

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.

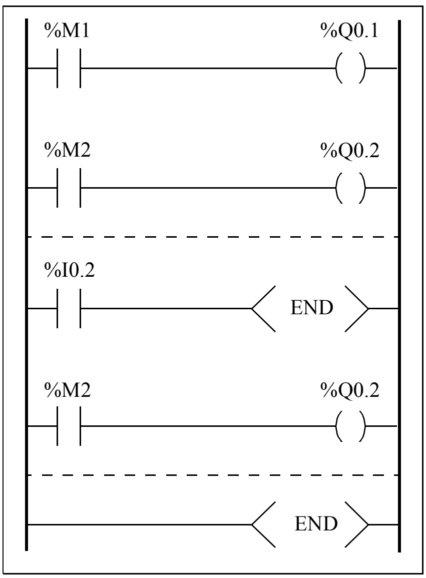
Examples

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
```

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 = 1 to 16 for a compact and 1 to 63 for the others).

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              Jump to label %L8 if %M15 is at 1
002 LD      [%MW24>%MW12]
003 ST      %M15
004 JMP     %L12             Unconditional jump to label %L12:
005 %L8:
006 LD      %M12
007 AND     %M13
008 ST      %M12
009 JMPCN   %L12             Jump to label %L12 if %M12 is at 0
010 OR      %M11
011 S       %Q0.0
012 %L12:
013 LD      %I0.0

. . . . . . . . . . . . . . .
```

Guidelines

- Jump 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, 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 triggering of the watchdog.

Subroutine Instructions

Introduction

The Subroutine instructions cause a program to perform a subroutine and then return to the main program.

SRn, SRn: and RET.

The 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 for 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

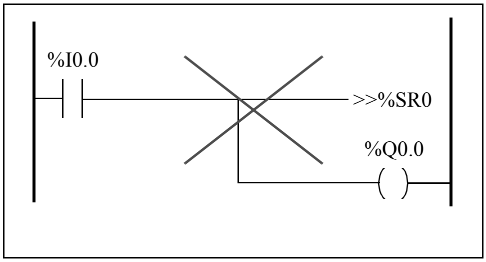
Examples of subroutine instructions.

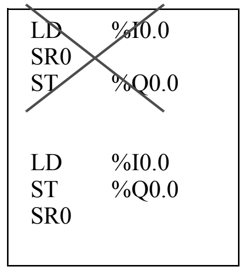
```
000  LD     %M15
001  AND    %M5
002  ST     %Q0.0
003  LD     [%MW24>%MW12]
004  SR8                          Jump to subroutine SR8
005  LD     %I0.4
006  AND    M13
007  _
008  _
009  _
010  END

011  SR8:
012  LD     1
013  IN     %TM0
014  LD     %TM0.Q
015  ST     %M15
010  RET                          Return to main subroutine

 . . . . . . . . . . . . . . . . . . . . .
```

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.





Advanced Instructions

15

At a Glance

Subject of this Chapter

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:

15.1 Advanced Function Blocks

At a Glance

Aim of this Section

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 standard 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)
- Step counter (%SC)
- Message control block (%MSG)

Objects Accessible by the Program

The table below contains an overview of the words and bits accessible by the program that are 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	Register input	%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	No
%FC	Word	Current Value	%FCi.V	Yes
	Word	Preset value	%FCi.P	Yes
	Bit	Done	%FCi.D	No

Advanced Function Block	Associated Words and Bits		Address	Write Access
%VFC	Word	Current Value	%VFCi.V	No
	Word	Preset value	%VFCi.P	Yes
	Bit	Counting direction	%VFCi.U	No
	Word	Capture Value	%VFCi.C	No
	Word	Threshold 0 Value	%VFCi.S0	Yes
	Word	Threshold Value1	%VFCi.S1	Yes
	Bit	Overflow	%VFCi.F	No
	Bit	Reflex Output 0 Enable	%VFCi.R	Yes
	Bit	Reflex Output 1 Enable	%VFCi.S	Yes
	Bit	Threshold Output 0	%VFCi.TH0	No
	Bit	Threshold Output 1	%VFCi.TH1	No
	Bit	Frequency 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
%MSG	Bit	Done	%MSGi.D	No
	Bit	Error	%MSGi.E	No

Programming Principles for Advanced Function Blocks

At a Glance

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 "reversibility" 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.
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.

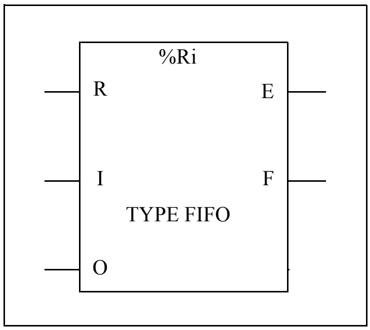
LIFO/FIFO Register Function Block (%Ri)

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 Counter function block has the following parameters:

Parameter	Label	Value
Register number	%Ri	0 to 3.
Type	FIFO or LIFO	Queue or 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 of the register 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.

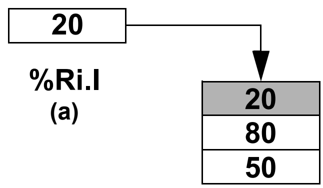
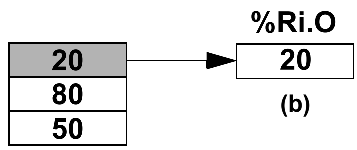
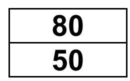
LIFO Operation

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. Output word %Ri.O does not change and retains its value.	Retrieval of the data word highest in the stack. 
3	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.	

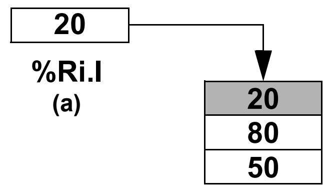
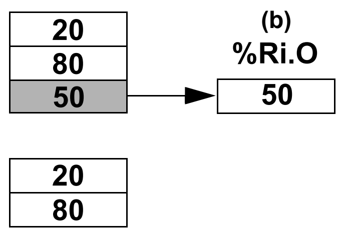
FIFO,operation

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. Output word %Ri.O does not change and retains its value.	Retrieval of the first data item which is then loaded into %Ri.O. 
3	The queue can be reset at any time (state 1 at input R or activation of instruction R).	

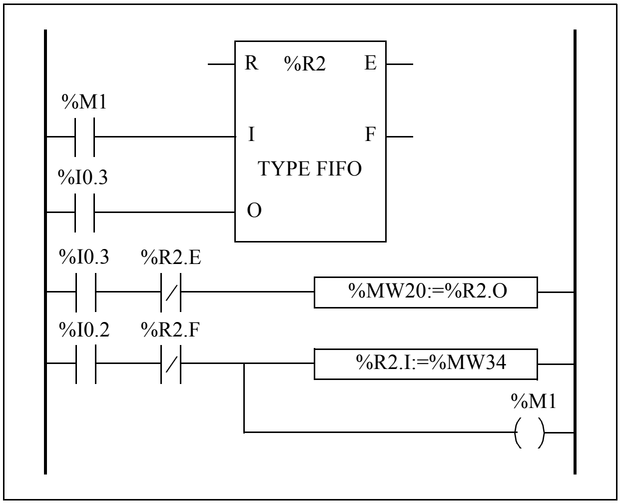
Programming and Configuring Registers

Introduction

The following programming example shows the content of a memory word (%MW34) being loaded into a register (%R2.I) on reception of a 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).

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.O]
LD             %I0.2
ANDN           %R2.F
[%R2.I:=%MW34]
ST             %M1
```

Reversible program

```
LD             %M1
I              %R2
LD             %I0.3
O              %R2
ANDN           %R2.E
[%MW20:=%R2.O]
LD             %I0.2
ANDN           %R2.F
[%R2.I:=%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 for programming the Shift Bit Register function block:

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.

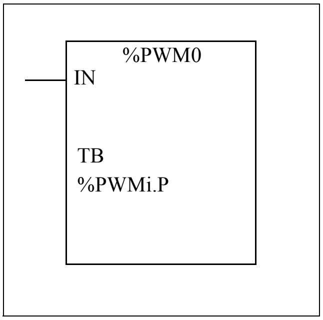
Pulse Width Modulation Function Block (%PWM)

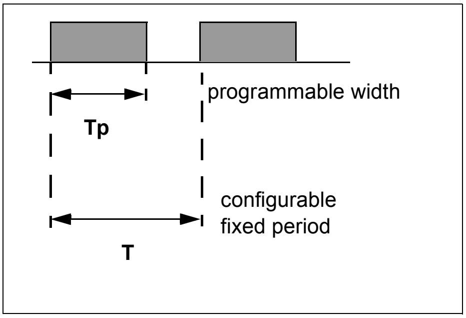
Introduction

The Pulse Width Modulation (%PWM) function block generates a square wave signal on dedicated output channels %Q0.0.0 or %Q0.0.1, with variable width and, consequently, 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.

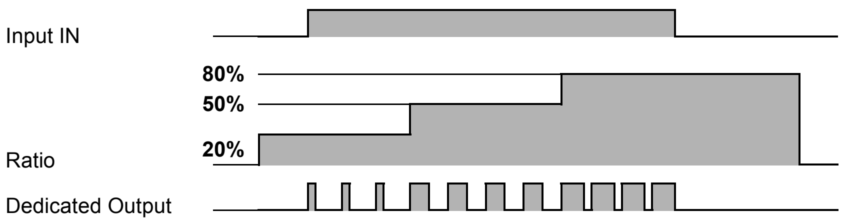
Parameter	Label	Description
Timebase	TB	0.142 ms, 0.57 ms, 10 ms, 1 s (default value)
Preselection of the period	%PWMi.P	0 < %PWMi.P <= 32767 with time base 10 ms or 1 s 0 < %PWMi.P <= 255 with time base 0.57 ms or 0.142 s 0 = Function not in use
Duty cycle	%PWMi.R	This value gives the percentage of the signal in state 1 in a period. The width Tp is thus equal to: Tp = T * (%PWMi.R/100). The user application writes the value for %PWMi.R. It is this word which controls the duty cycle of the period. 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.

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./84 Hz to 1.75 kHz)
- 10 ms to 5.45 mins in steps of 10 ms
- 1 sec to 9.1 hours in steps of 1 sec

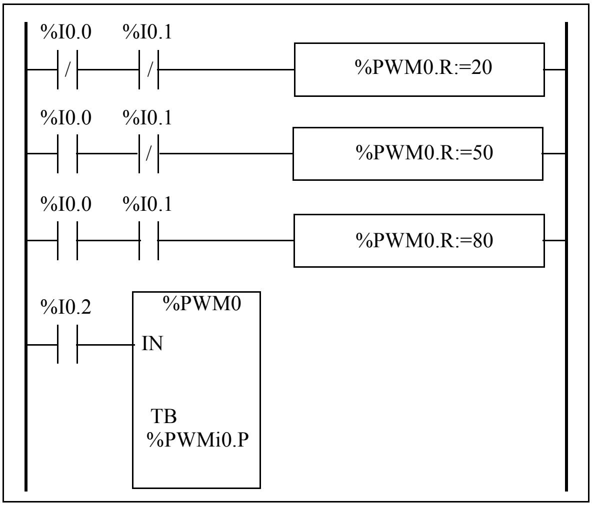
Operation

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 duty cycle 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.



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 shows a list of special operating of 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.
Effect due to the fact that outputs are dedicated to the %PWM block	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)

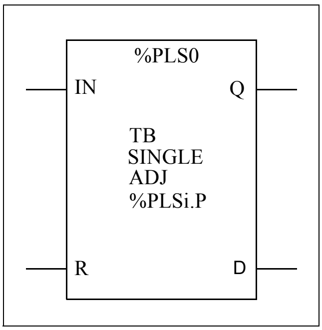
Introduction

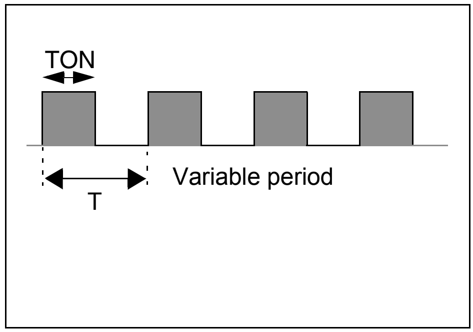
The %PLS function block is used to generate square wave signals. There are two %PLS functions available on the dedicated output channels %Q0.0.0 or %Q0.0.1. The %PLS function block allows only a single signal width, or duty cycle, of 50%. You can choose to limit the number of pulses or the period when the pulse train is executed. These can be determined at the time of configuration and/or updated by the user application.

Note: Controllers with relay outputs for these two channels do not support %PLS function.

Representation

An example of the pulse generator function block in single-word mode:





- TON=T/2 for the 0.142ms and 0.57ms time bases
  = (%PLSi.P*TB)/2
- TON=[whole part(%PLSi.P)/2]*TB for the 10ms to 1s time bases.

Specifications

The table below contains the characteristics of the PLS function block:

Function	Object	Description
Timebase	TB	0.142 ms, 0.57 ms, 10 ms, 1 sec
Preset period	%PLSi.P	Pulses on output %PLS1 are not stopped when %PLS1.N or %PLS1.ND* is reached for time bases 0.142 ms and 0.57 ms. ● 1 < %PLSi.P <= 32767 for time base 10 ms or 1 s ● 0 < %PLSi.P <= 255 for time base 0.57 ms or 0.142 ms ● 0 = Function not in use. To obtain a good level of precision from the duty cycle with time bases of 10ms and 1s, you are recommended to have a %PLSi >= 100 if P is odd.
Number of pulses	%PLSi.N %PLSi.ND *	The number of pulses to be generated in period T can be limited to the range 0 <= %PLSi.N <= 32767 in standard mode or 0 <= %PLSi.ND <= 4294967295 in double word mode . The default value is set to 0. To produce an unlimited number of pulses, set %PLSi.N or %PLSi.ND 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, outputs %PLSi.Q and %PLSi.D are set to 0.The number of pulses generated in period T is set to 0.
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.

Note:

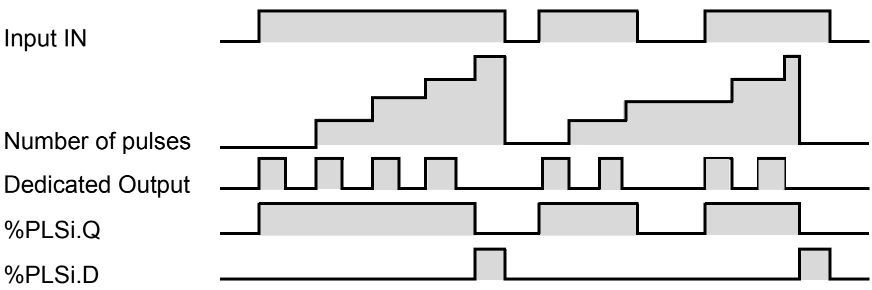
Note: (*) Means a double word variable.

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 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 (6.84 Hz to 1.75 kHz)
- 20 ms to 5.45 mins in steps of 10 ms
- 2 sec to 9.1 hours in steps of 1 sec

Operation

The following is an illustration 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 modifying the preset (%PLSi.P)	Takes effect immediately
Effect due to the fact that outputs are dedicated to the %PLS block	Forcing output %Q0.0.0 or %Q0.0.1 using a programming device does not stop the signal generation.

Note: %PLSx.D is set when the number of desired pulses has been reached. It is reset by either setting the IN or the R inputs to 1.

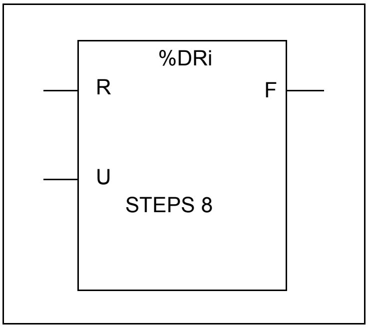
Drum Controller Function Block (%DR)

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 controller. 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)
Input to return to step 0(or instruction)	R (Reset)	At state 1, sets the drum controller to step 0.
Advance input (or instruction)	U (Upper)	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 %DRi Operation

Introduction

The drum controller consists of:

- 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 is associated with a configured output (%Qi.j.k) or memory word (%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.

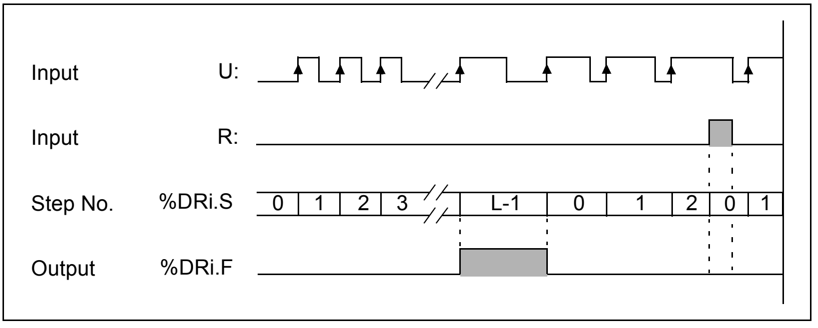
Column	**0**	**1**	**2**		**D**	**O**	**F**
Control bits	%Q0.1	%Q0.3	%Q1.5		%Q0.6	%Q0.5	%Q1.0
0 steps	0	0	1		1	1	0
1 steps	1	0	1		1	0	0
5 steps	1	1	1		0	0	0
6 steps	0	1	1		0	1	0
7 steps	1	1	1		1	0	0

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 illustrates the operation of the drum controller.



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 (update of control bits).
Effect of a warm restart (%S1=1)	Updates the control bits after the current step.
Effect of a program jump	The fact that the drum controller is no longer scanned means the control bits are not reset.
Updating the control bits	Only occurs when there is a change of step or in the case of a warm or cold restart.

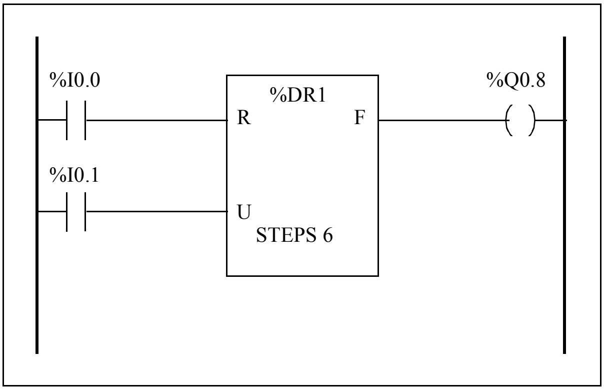
Programming and Configuring Drum Controllers

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
```

Configuration

The following information is defined during configuration:
- 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)

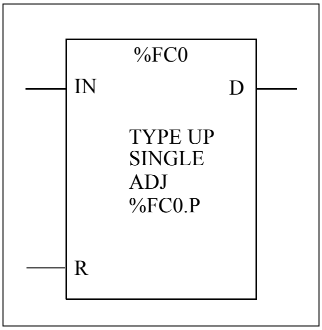
Introduction

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 in single word or double word computational mode. 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.

The TWDLCA•40DRF Compact controllers can accomodate up to four fast counters, while all other series of Compact controllers can be configured to use a maximum of three fast counters. Modular controllers can only use a maximum of two. The Fast Counter function blocks %FC0, %FC1, %FC2, and %FC3 use dedicated inputs %I0.0.2, %I0.0.3, %I0.0.4 and %I0.0.5 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 an example of a Fast Counter function block in single-word mode.



Parameters

The following table lists parameters for the Fast Counter function block.

Parameter	Label	Description
Function	TYPE	Set at configuration, this can be set to either up-count or down-count.
Preset value	%FCi.P %FCi.PD	Initial value may be set: ->between 1 and 65635 in standard mode, ->between 1 and 4294967295 in double word mode,
Adjustable	Y/N	If set to Y, it is possible to modify the preset value %FCi.P or %FCi.PD and the current value %FCi.V or %FCi.VD with the Operator Display or Animation Tables Editor. If set to N, there is no access to the preset.
Current Value	%FCi.V %FCi.VD	The current value increments or decrements according the up or down counting function selected. For up-counting, the current counting value is updated and can reach 65535 in standard mode (%FCi.V) and 4294967295 in double word mode (%FCi.VD). For down-counting, the current value is the preset value %FCi.P or %FCi.PD and can count down to zero.
Enter to enable	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 or %FCi.PD 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 or %FCi.VD reaches the %FCi.P or %FCi.PD configured as an up-counter, or when %FCi.V or %FCi.VD reaches zero when configured as a down-counter. This read-only bit is reset only by the setting %FCi.R to 1.

Special Note

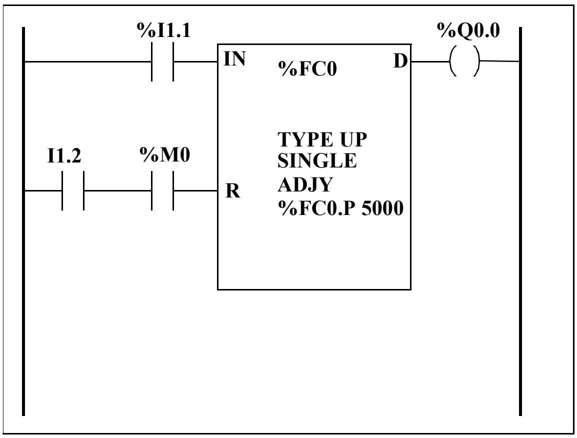
If configured to be adjustable, then the application can change the preset value %FCi.P or %FCi.PD and current value %FCi.V or %FCi.VD at any time. But, a new value is taken into account only if the input reset is active or at the rising edge of output %FCi.D. This allows for successive different counts 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 incremented by one. When the preset value %FCi.P or %FCi.PD is reached, the Done output bit %FCi.D is set to 1 and zero is loaded into the current value %FCi.V or %FCi.VD.
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.V or %FCi.VD.

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 to 1 and retains the same value until %FC0.R is commanded by the result of "AND" on %I1.2 and %M0.




```
BLK      %FC0
LD       %I1.1
IN
LD       %I1.2
AND      %M0
R
OUT_BLK
LD D
ST %Q0.0
END_BLK
```

Special Cases

The following table contains a list of special operating cases for 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 parameter settings enabled at the time the controller was stopped.

Very Fast Counter Function Block (%VFC)

Introduction

The Very Fast Counter function block (%VFC) can be configured by TwidoSoft to perform any one of the following functions:
- Up/down counter
- Up/down 2-phase counter
- Single Up Counter
- Single Down Counter
- Frequency Meter

The %VFC supports counting of digital input up to frequencies of 20kHz in single word or double word computational mode. The TWDLCA•40DRF Compact controllers can accomodate up to two very fast counters, while all other series of Compact controllers can configure one very fast counter (%VFC). Modular controllers can configure up to two very fast counters (%VFC).

Dedicated I/O Assignments

The Very Fast Counter function blocks (%VFC) 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 array summarizes these assignments:

		Main inputs		**Auxiliary inputs**		**Reflex outputs**	
%VFC0	Selected Use	IA input	IB input	IPres	Ica	Output 0	Output 1
	Up/down counter	%I0.0.1	%I0.0.0 (UP=0/DO=1)	%I0.0.2 (1)	%I0.0.3 (1)	%Q0.0.2 (1)	%Q0.0.3 (1)
	Up/Down 2-Phase Counter	%I0.0.1	%I0.0.0 (Pulse)	%I0.0.2 (1)	%I0.0.3 (1)	%Q0.0.2 (1)	%Q0.0.3 (1)
	Single Up Counter	%I0.0.1	(2)	%I0.0.2 (1)	%I0.0.3 (1)	%Q0.0.2 (1)	%Q0.0.3 (1)
	Single Down Counter	%I0.0.1	(2)	%I0.0.2 (1)	%I0.0.3 (1)	%Q0.0.2 (1)	%Q0.0.3 (1)
	Frequency Meter	%I0.0.1	(2)	(2)	(2)	(2)	(2)
%VFC1	Selected Use	IA input	Input IB)	IPres	Ica	Output 0	Output 1
	Up/down counter	%I0.0.7	%I0.0.6 (UP = 0/DO = 1)	%I0.0.5 (1)	%I0.0.4 (1)	%Q0.0.4 (1)	%Q0.0.5 (1)
	Up/Down 2-Phase Counter	%I0.0.7	%I0.0.6 (Pulse)	%I0.0.5 (1)	%I0.0.4 (1)	%Q0.0.4 (1)	%Q0.0.5 (1)
	Single Up Counter	%I0.0.7	(2)	%I0.0.5 (1)	%I0.0.4 (1)	%Q0.0.4 (1)	%Q0.0.5 (1)
	Single Down Counter	%I0.0.7	(2)	%I0.0.5 (1)	%I0.0.4 (1)	%Q0.0.4 (1)	%Q0.0.5 (1)
	Frequency Meter	%I0.0.7	(2)	(2)	(2)	(2)	(2)

Comments:

(1) = optional
(2) = not used
Ipres = preset input
Ica= Catch input

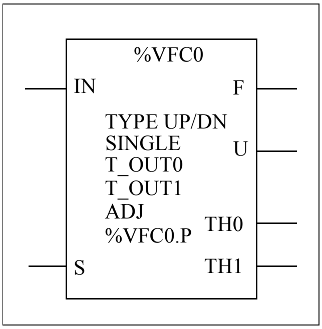
Input IA = pulse input
Input IB = pulses or UP/DO
UP/DO = Up / Down counting

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 (%VFC) in single-word mode:



Specifications

The following table lists characteristics for the very fast counter (%VFC) function block.

Function	Description	Values	%VFC Use	Run-time Access
Current Value (%VFCi.V) (%VFCi.VD*)	Current value that is increased or decreased according to the physical inputs and the function selected. This value can be preset or reset using the preset input (%VFCi.S).	%VFCi.V: 0 -> 65535 %VFCi.VD: 0 -> 4294967295	CM	Read
Preset value (%VFCi.P) (%VFCi.PD*)	Only used by the up/down counting function and single up or down counting.	%VFCi.P: 0 -> 65535 %VFCi.PD: 0 -> 4294967295	CM or FM	Read and Write (1)
Capture Value (%VFCi.C) (%VFCi.CD*)	Only used by the up/down counting function and single up or down counting.	%VFCi.C: 0 -> 65535 %VFCi.CD: 0 -> 4294967295	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: As a single phase up or down counter, %I0.0.0 decides the direction for %VFC0 and %I0.0.6 for %VFC1. 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 to IB and %I0.1 to IA. For %VFC1, %I0.6 is dedicated to IB and %I0.7 to IA.	0 (Down counting) 1 (Up counting)	CM	Read

Function	Description	Values	%VFC Use	Run-time Access
Enable Reflex Output 0 (%VFCi.R)	Validate Reflex Output 0	0 (Disable) 1 (Enable)	CM	Read and Write (2)
Enable Reflex Output 1 (%VFCi.S)	Validate Reflex Output 1	0 (Disable) 1 (Enable)	CM	Read and Write (2)
Threshold Value S0 (%VFCi.S0) (%VFCi.S0D*)	This word contains the value of threshold 0. The meaning is defined during configuration of the function block. Note: This value must be less than %VFCi.S1.	%VFCi.S0: 0 -> 65535 %VFCi.S0D: 0 -> 4294967295	CM	Read and Write (1)
Threshold Value S1 (%VFCi.S1) (%VFCi.S1D*)	This word contains the value of threshold 0. The meaning is defined during configuration of the function block. Note: This value must be greater than %VFCi.S0.	%VFCi.S1: 0 -> 65535 %VFCi.S1D: 0 -> 4294967295	CM	Read and Write (1)
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.	N (No) Y (Yes)	CM or FM	No
Enter to enable (IN)	Used to validate or inhibit the current function.	0 (No)	CM or FM	Read and Write (3)
Preset input (S)	Depending on the configuration, at state 1: • Up/Down or Down Counting: initializes the current value with the preset value. • Single Up Counting: resets the current value to zero. 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)	0 to 65535 or from 65535 to 0 in standard mode 0 to 4294967295 or from 4294967295 to 0 in double word mode	0 or 1	CM	Read

Function	Description	Values	%VFC Use	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

(*)Means a 32-bit double word variable. The double word option is available on all controllers with the exception of the Twido TWDLC•A10DRF controllers.
(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.
CM = Counting Mode
FM = Frequency Meter Mode

Counting Function Description

The very fast counting function (%VFC) works at a maximum frequency of 20 kHz, with a range of 0 to 65535 in standard mode and 0 to 4294967295. The pulses to be counted are applied in the following way:
Table:

Function	Description	%VFC0		%VFC1	
		IA	IB	IA	IB
Up/Down Counter	The pulses are applied to the physical input, the current operation (upcount/downcount) 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	ND	%I0.0.7	ND
Single Down Counter	The pulses are applied to the physical input IA. IB is not used.	%I0.0.1	ND	%I0.0.7	ND

Notes on Function Blocks

Upcount or downcount operations are made on the rising edge of pulses, and only if the counting block is enabled.
There are two optional inputs used in counting mode: ICa and IPres. ICa is used to capture the current value (%VFCi.V or %VFCi.VD) and stored it in %VFCi.C or %VFCi.CD. 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 affected in the following ways:

- For up counting, %VFCi.V or %VFCi.VD is reset to 0
- For downcounting, %VFCi.V or %VFCi.VD is written with the content of %VFCi.P or %VFCi.PD, respectively.
- For frequency counting, %VFCi.V or %VFCi.PD is set to 0

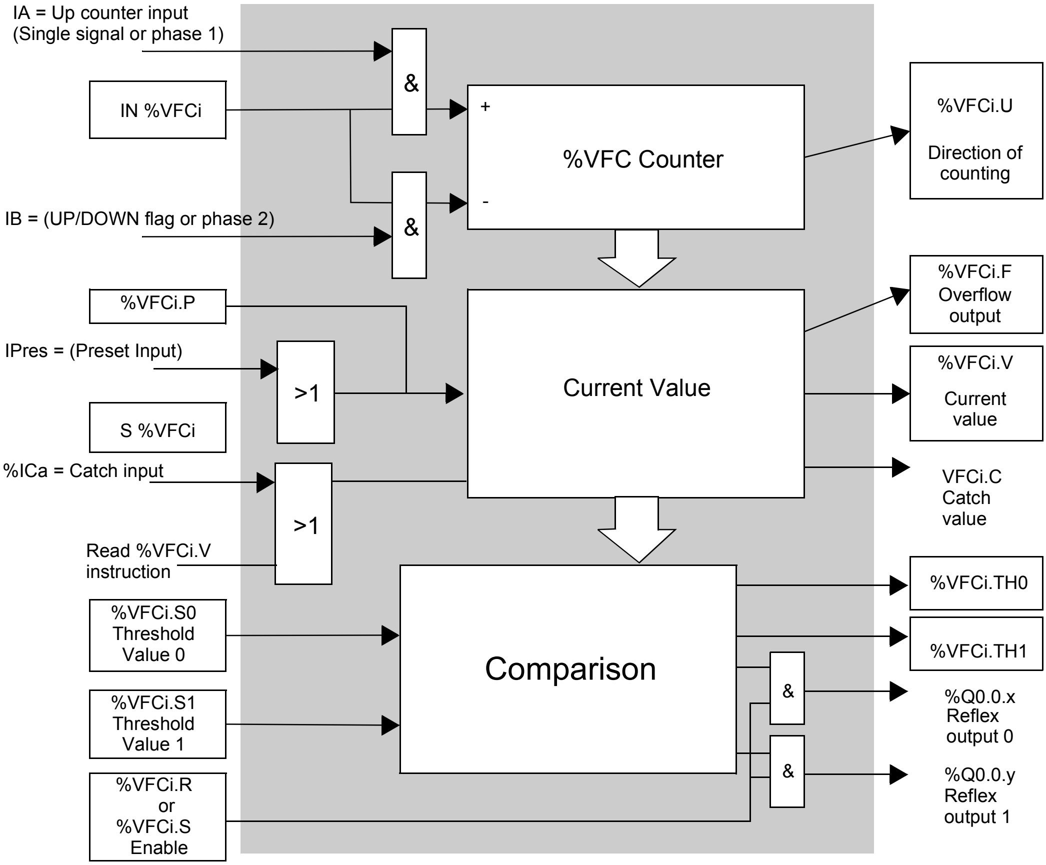
Warning: %VFCi.F is also set to 0. The IPres inputs are specified as %I0.0.2 for %VFC0 and %I0.0.5 for %VFC1 if available.

Notes on Function Block Outputs

For all functions, the current value is compared to two thresholds (%VFCi.S0 or %VFCi.S0D and % VFCi.S1 or %VFCi.S1D). 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 to 1 in accordance with these comparisons. Note: 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

The following is a counting function diagram in standard mode (in double word mode, you will use the double word function variables, accordingly):



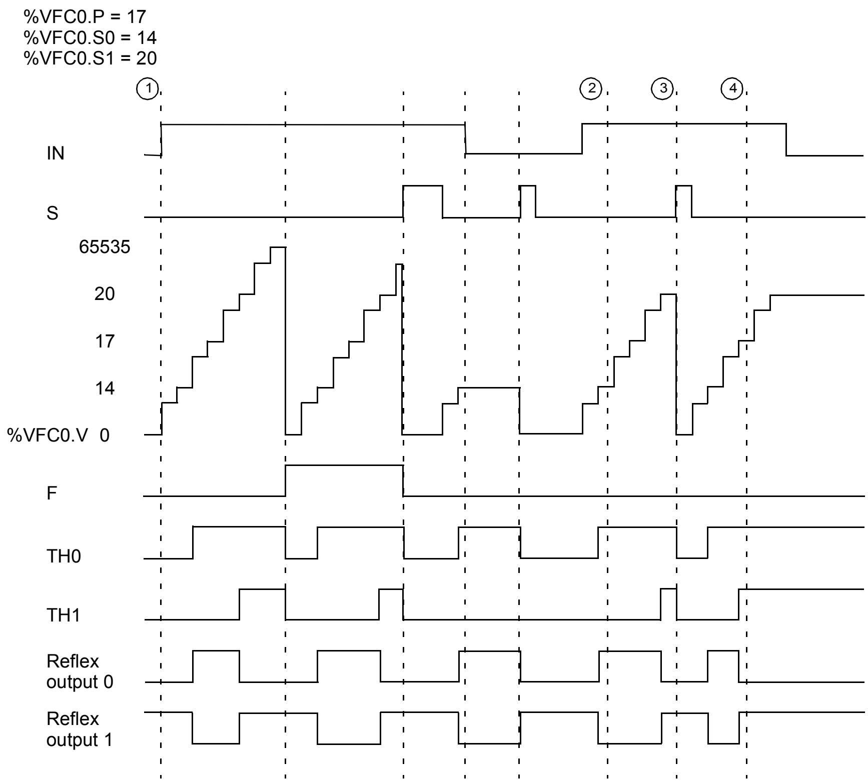
Note: Outputs are managed independently from the controller cycle time. The response time is between 0 and 1ms.

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, while the %VFC0.S0 lower threshold value is 14, and the %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

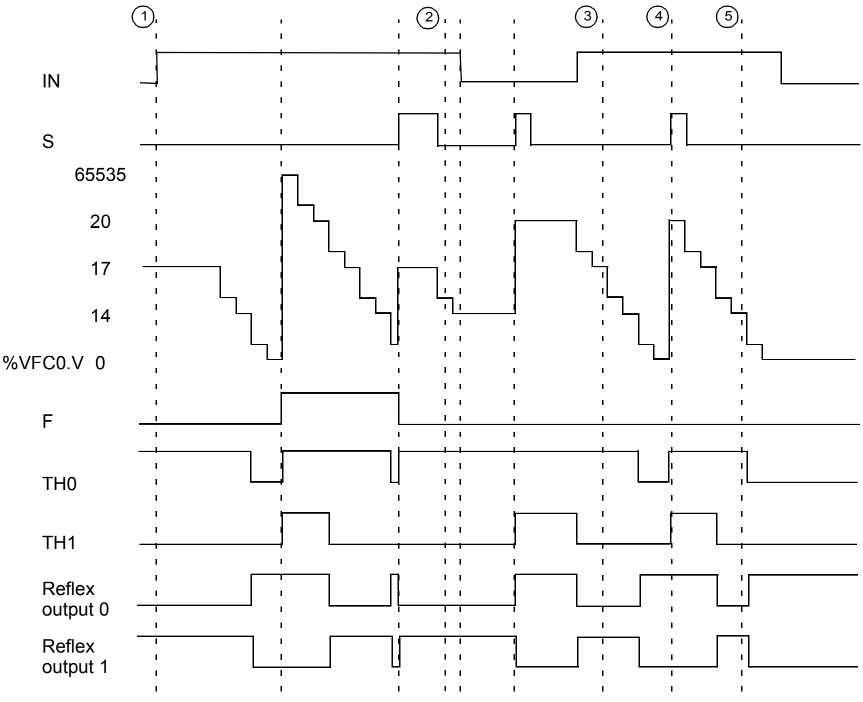
Single Down Counter Operation

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, while the %VFC0.S0 lower threshold value is 14, and the %VFC0.S1 upper threshold is 20.

Reflex Output	**<%VFC.S0**	**%VFC0.S0 <=< %VFC0.S1**	**>= %VFC0.S1**
%Q0.0.2	X		X
%Q0.0.3		X	

Example:

%VFC0.P = 17
%VFC0.S0 = 14
%VFC0.S1 = 20



(1) : %VFC0.U = 0 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

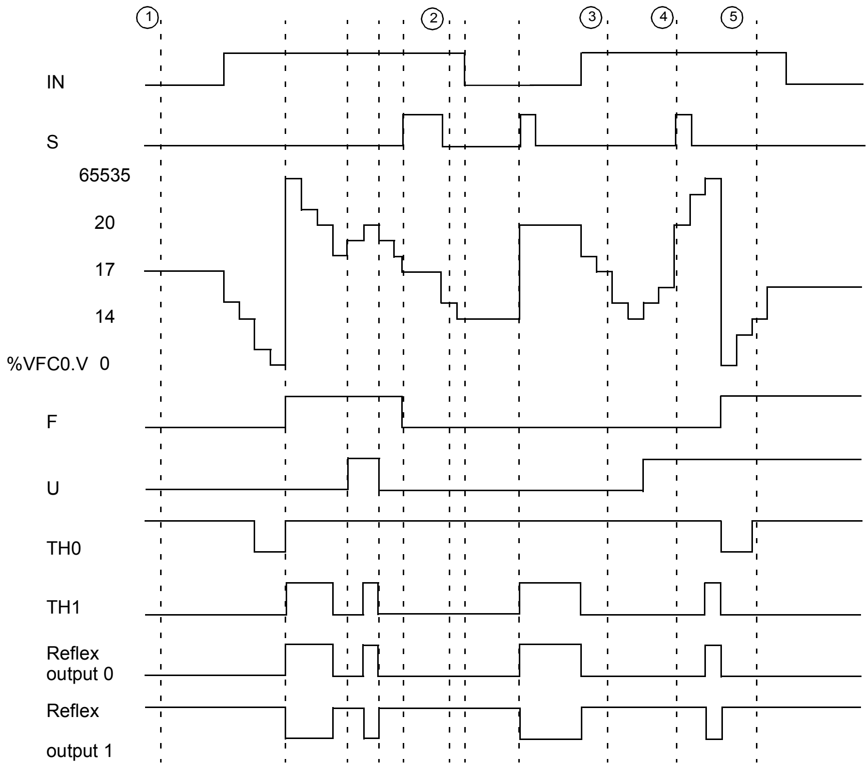
Up-Down Counter Operation

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, while the %VFC0.S0 lower threshold value is 14, and the %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	

Example:

%VFC0.P = 17
%VFC0.S0 = 14
%VFC0.S1 = 20



(1) : Input IN is set to 1 and input S set to 1
(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

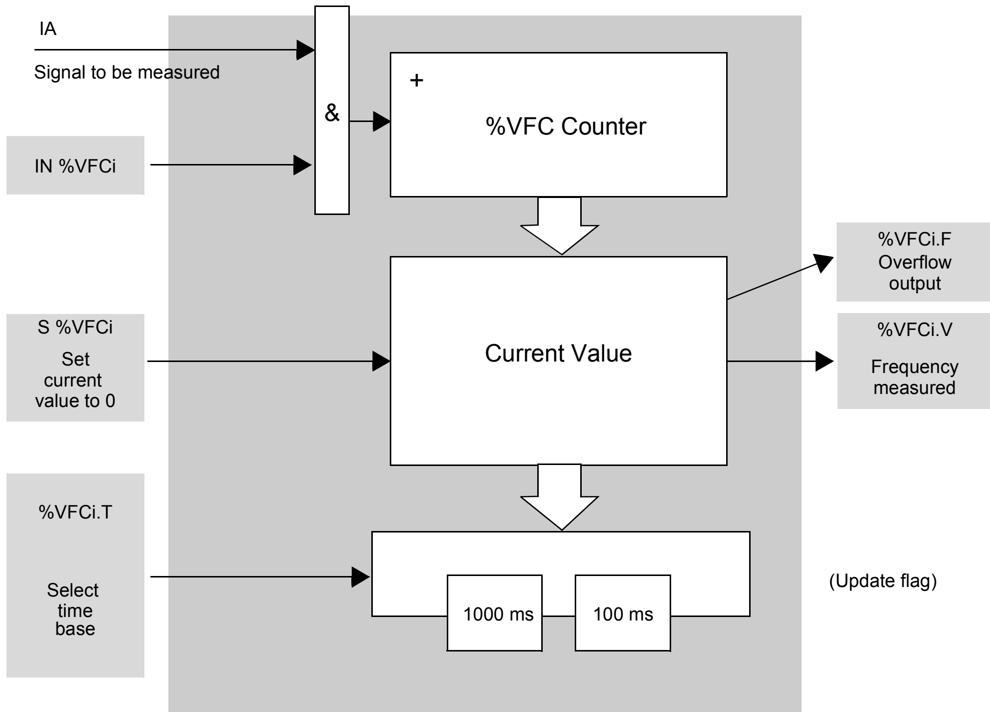
Frequency Meter Function Description

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 10 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	Accuracy	Update
100 ms	100 Hz to 20 kHz	0.05 % for 20 kHz, 10 % for 100 Hz	10 times per second
1 s	10 Hz to 20 kHz	0.005 % for 20 kHz, 10 % for 10 Hz	Once per second

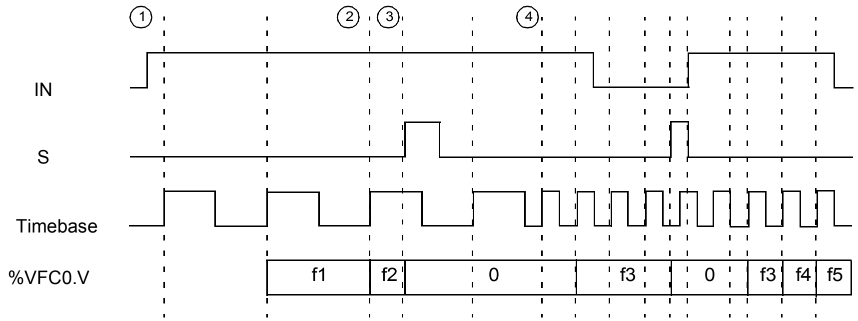
Frequency Meter Function Diagram

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 : Input IN is 1 and input S is 1

4 : Change %VFC0.T to 100 ms: this change cancels the current measurement and starts another one.

Special Cases

The following table shows a list of special operating of 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 communication port can be assigned a different protocol. The communication ports are accessed by appending the port number to the EXCH or %MSG function (EXCH1, EXCH2, %MSG1, %MSG2).
In addition, TWDLCAE40DRF series controllers implement Modbus TCP messaging over the Ethernet network by using the EXCH3 intruction and %MSG3 function.

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) containing the data to be sent and/or received (up to 250 data bytes 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]
Where: x = serial port number (1 or 2); x = Ethernet port (3); L = total number of words of the word table (maximum 121). 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.

Note: To find out more information about the Modbus TCP messaging instruction EXCH3, please refer to *TCP Modbus Messaging, p. 177*.

Exchange Control Function Block (%MSGx)

Introduction

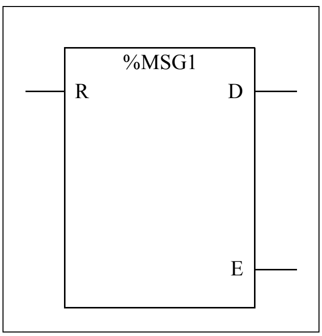
Note: The "x" in %MSGx signifies the controller port: "x = 1 or 2"
- x = 1 or 2, signifies the serial port 1 or 2 of the controller, respectively;
- x = 3, signifies the Ethernet network port of the controller (on TWDLCAE40DRF controllers only). For more information about the %MSG3 function, please refer to *TCP Modbus Messaging, p. 177*.

The %MSGx 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 %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 programming of the %MSGx function block is optional.

Illustration

The following is an example of the %MSGx function block.



Parameters

The following table lists parameters for the %MSGx function block.

Parameter	Label	Value
Reset input (or instruction)	R	At state 1, reinitializes communication: %MSGx.E = 0 and %MSGx.D = 1.
Comm. done output	%MSGx.D	State 1, comm. done, if: ● End of transmission (if transmission) ● End of reception (end character received) ● Error ● Reset the block State 0, request in progress.
Fault (Error) output	%MSGx.E	State 1, comm. done, if: ● Bad command ● Table incorrectly configured ● Incorrect character received (speed, parity, etc.) ● Reception table full (not updated) State 0, message length OK, link OK.

If an error occurs when using an EXCH 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. See *System Words (%SW), p. 517*.

Reset Input (R)

When Reset Input 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 (%MSGx.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 by FA).
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.

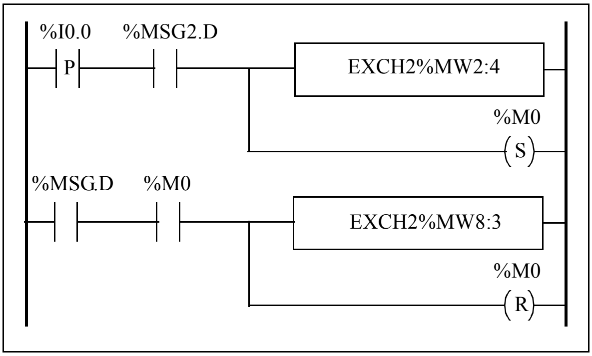
Communications Done output (%MSGx.D)

When the Done output is set to 1, the Twido controller is ready to send another message. Use of the %MSGx.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 (%MSGx.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 on port 2:

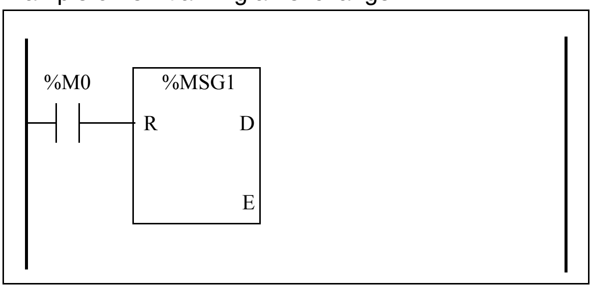



```
LDR      %I0.0
AND      %MSG2.D
[EXCH2 %MW2:4]
S        %M0
LD       %MSG2.D
AND      %M0
[EXCH2 %MW8:3]
R        %M0
```

Reinitializing Exchanges

An exchange is cancelled by activating the input (or instruction) R. This input initializes communication and resets output %MSGx.E to 0 and output %MSGx.D to 1. It is possible to reinitialize an exchange if a fault is detected.

Example of reinitializing an exchange:




```
BLK     %MSG1
LD      %M0
R
END_BLK
```

Special Cases

The following table the special operating cases for the %MSGx 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 %MSGx.D and %MSGx.E.

15.2 Clock Functions

At a Glance

Aim of this Section

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 and system word %SW118 to confirm that the Real-Time Clock (RTC) option is installed see *System Bits (%S), p. 510*. The RTC option is required for using schedule blocks.

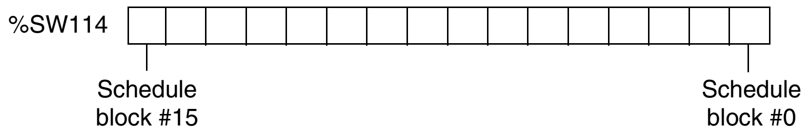
Parameters

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. 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

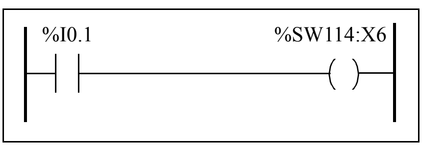
If the same output (%Mi or %Qj.k) is assigned by several blocks, it is the OR of the results of each of the blocks which is finally assigned to this object (it is possible to have several "operating ranges" for the same output).

Example

The following table shows the parameters for a summer month spray program example:

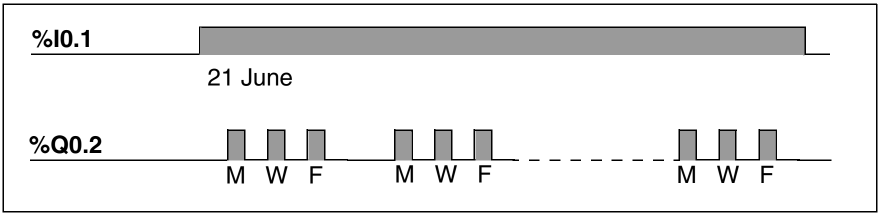
Parameter	**Value**	**Description**
Schedule block	6	Schedule block number 6
Output bit	%Q0.2	Activate output %Q0.2
Start month	June	Start activity in June
End month	September	Stop activity in September
Start date	21	Start activity on the 21st day of June
End date	21	Stop activity on the 21st day of 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. 517*). 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 %SW49 to %SW53 contain the current date and time in BCD format (see *Review of BCD Code, p. 356*, 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. 517*.

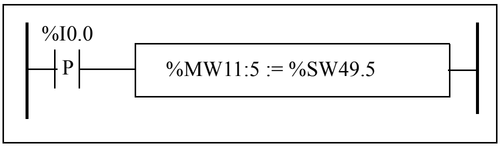
Note: Date and time and also be set by using the optional Operator Display (see *Time of Day Clock, p. 245*).

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
[%MW11:5 := %SW49:5]
```

Once an event is detected, the word table contains:

Encoding	Most significant byte	Least significant byte
%MW11		Day of the week[1]
%MW12	00	Second
%MW13	Hour	Minute
%MW14	Month	Day
%MW15	Century	Year

Note: (1) 1 = Monday, 2 = Tuesday, 3 = Wednesday, 4 = Thursday, 5 = Friday, 6 = Saturday, 7 = Sunday.

Example of Word Table

Example data for 13:40:30 on Monday, 19 April, 2002:

Word	Value (hex)	Meaning
%MW11	0001	Monday
%MW12	0030	30 seconds
%MW13	1340	13 hours, 40 minutes
%MW14	0419	04 = April, 19th
%MW15	2002	2002

Date and time of the 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. 517*).

Setting the Date and Time

Introduction

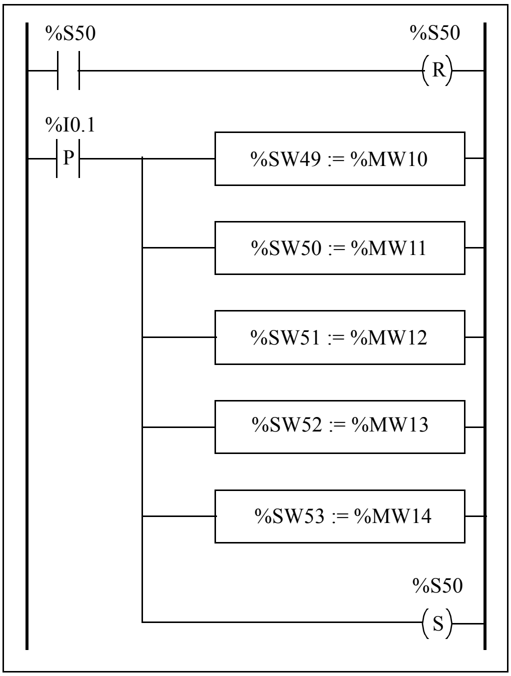
You can update the date and time settings by using one of the following methods:
- TwidoSoft
  Use the **Set Time** dialog box. This dialog box is available from the **Controller Operations** dialog box. This is displayed by selecting **Controller Operations** from the **Controller** menu.
- System Words
  Use system words %SW49 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. Note that the TWDLCA•40DRF series of compact controllers have RTC onboard.

Using %SW49 to %SW53

To use system words %SW49 to %SW53 to set the date and time, bit %S50 must be set to 1. This results in the following:
- Cancels the update of words %SW49 to %SW53 via the internal clock.
- Transmits the values written in words %SW49 to %SW53 to the internal clock.

Programming Example:




```
LD      %S50
R       %S50

LDR     %I0.1
[%SW49 := %MW10]
[%SW50 := %MW11]
[%SW51 := %MW12]
[%SW52 := %MW13]
[%SW53 := %MW14]
S       %S50
```

Words %MW10 to %MW14 will contain the new date and time in BCD format (see *Review of BCD Code, p. 356*) and will correspond to the coding of words %SW49 to %SW53.
The word table must contain the new date and time:

Encoding	Most significant byte	Least significant byte
%MW10		Day of the week[1]
%MW11		Second
%MW12	Hour	Minute
%MW13	Month	Day
%MW14	Century	Year

Note: (1) 1 = Monday, 2 = Tuesday, 3 = Wednesday, 4 = Thursday, 5 = Friday, 6 = Saturday, 7 = Sunday.

Example data for Monday, 19 April, 2002:

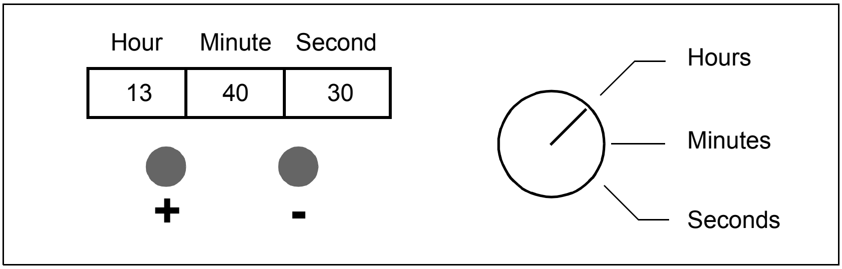
Word	Value (hex)	Meaning
%MW10	0001	Monday
%MW11	0030	30 seconds
%MW12	1340	13 hours, 40 minutes
%MW13	0419	04 = April, 19th
%MW14	2002	2002

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 1 enables adjustment of the current date and time by word %SW59 (see *System Words (%SW), p. 517*). %SW59 increments or decrements each of the date and time components on a rising edge.

Application Example

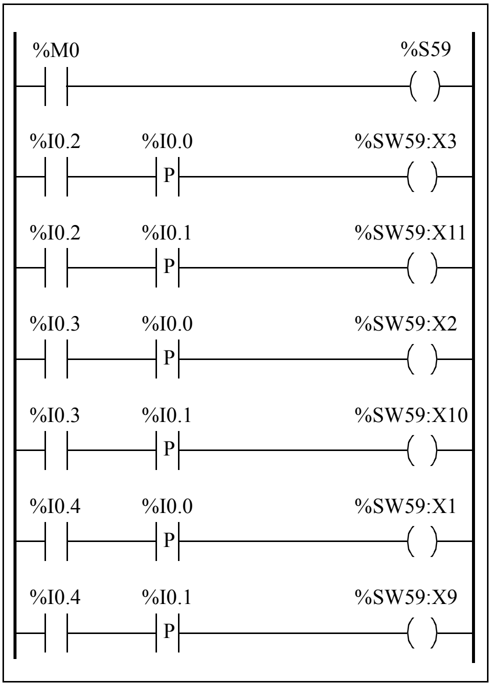
The following front panel is created to modify the hour, minutes, and seconds of the internal clock.



Description of the Commands:

- 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
```

15.3 PID Function

At a Glance

Aim of this Section

This section describes the behavior, functionalities and implementation of the PID function.

Note: To find out quick setup information about your PID controller as well as the PID autotuning, please refer to the **Twido PID Quick Start Guide** available in electronic form on your TwidoSoft installation and documentation CD.

What's in this Section?

This section contains the following topics:

Overview

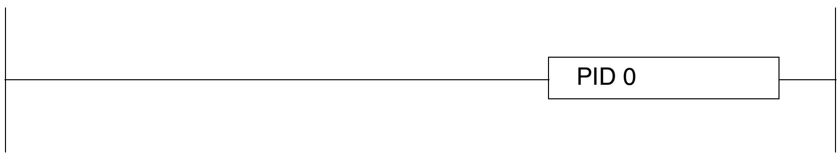
General

The PID regulation function is a TwidoSoft programming language function.
It allows programming of PID regulation loops on Twido version 1.2 or higher controllers.

This function is particularly adapted to:
- Answering the needs of the sequential process which need the auxiliary adjustment functions (examples: plastic film packaging machine, finishing treatment machine, presses, etc.)
- Responding to the needs of the simple adjustment process (examples: metal furnaces, ceramic furnaces, small refrigerating groups, etc.)

It is very easy to install as it is carried out in the:
- Configuration
- and Debug

screens associated with a program line (operation block in Ladder Language or by simply calling the PID in Instruction List) indicating the number of the PID used.
Example of a program line in Ladder Language:



Note: In any given Twido automation application, the maximum number of configurable PID functions is 14.

Key Features

The key features are as follows:
- Analog input,
- Linear conversion of the configurable measurement,
- High or low configurable input alarm,
- Analog or PWM output,
- Cut off for the configurable output,
- Configurable direct or inverse action.

Principal of the Regulation Loop

At a Glance

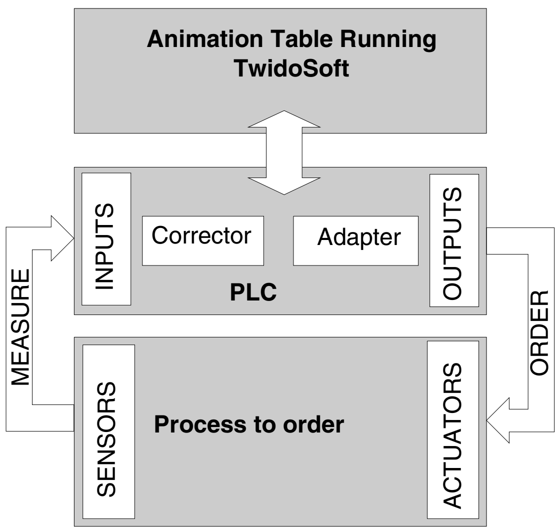
The working of a regulation loop has three distinct phases:
- The acquisition of data:
  - Measurements from the process' sensors (analog, encoders)
  - Setpoint(s) generally from the controller's internal variables or from data from a TwidoSoft animation table
- Execution of the PID regulation algorithm
- The sending of orders adapted to the characteristics of the actuators to be driven via the discrete (PWM) or analog outputs

The PID algorithm generates the command signal from:
- The measurement sampled by the input module
- The setpoint value fixed by either the operator or the program
- The values of the different corrector parameters

The signal from the corrector is either directly handled by a controller analog output card linked to the actuator, or handled via a PWM adjustment on a discrete output of the controller.

Illustration

The following diagram schematizes the principal of a regulation loop.

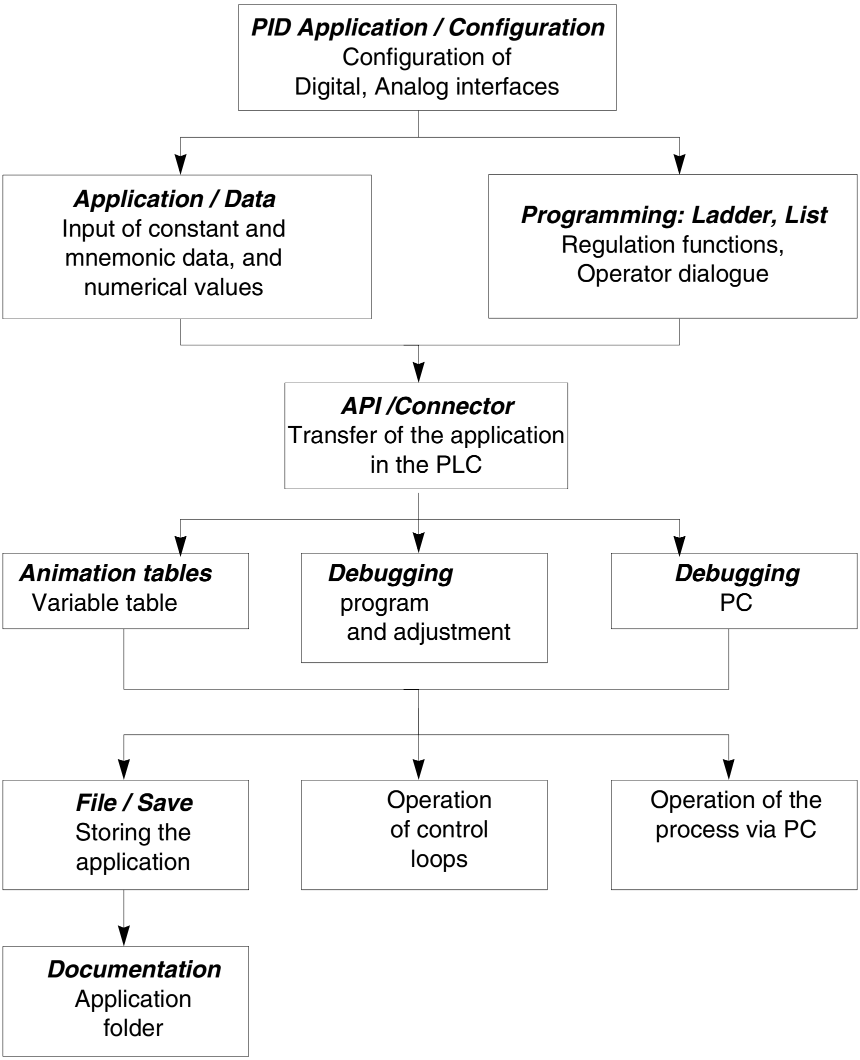


Development Methodology of a Regulation Application

Diagram of the Principal

The following diagram describes all of the tasks to be carried out during the creation and debugging of a regulation application.

Note: The order defined depends upon your own work methods, and is provided as an example.



Compatibilities and Performances

At a Glance

The Twido PID function is a function that is available for Twido version 1.2 and higher, which is why its installation is subject to a number of hardware and software compatibilities described in the following paragraphs.
In addition, this function requires the resources presented in the **Performances** paragraph.

Compatibility

The Twido PID function is available on Twidos with version 1.2 or higher software. If you have Twidos with an earlier version of the software, you can update your firmware in order to use this PID function.

Note: The version 1.0 analog input/output modules can be used as PID input/output modules without needing to be updated.

In order to configure and program a PID on these different hardware versions, you must have version **1.2 of the TwidoSoft software**.

Performance

The PID regulation loops have the following performances:

Description	Time
Loop execution time	0.4 ms

Detailed characteristics of the PID function

General

The PID function completes a PID correction via an analog measurement and setpoint in the default [0-10000] format and provides an analog command in the same format or a Pulse Width Modulation (PWM) on a digital output.
All the PID parameters are explained in the windows used to configure them. Here, we will simply summarize the functions available, indicate measurement values and describe how they integrate into PID in a functional flow diagram.

Note: For use at full scale (optimum resolution), you can configure your analog input connected to the PID's measurement branch in 0-10000 format. However, if you use the default configuration (0-4095), the controller will function correctly.

Note: In order for regulation to operate correctly, it is essential that the Twido PLC **is in periodic mode**. The PID function is then executed periodically on each cycle, and the PID input data sampling complies with the period set in configuration (see table below).

Details of Available Functions

The following table indicates the different functions available and their scale:

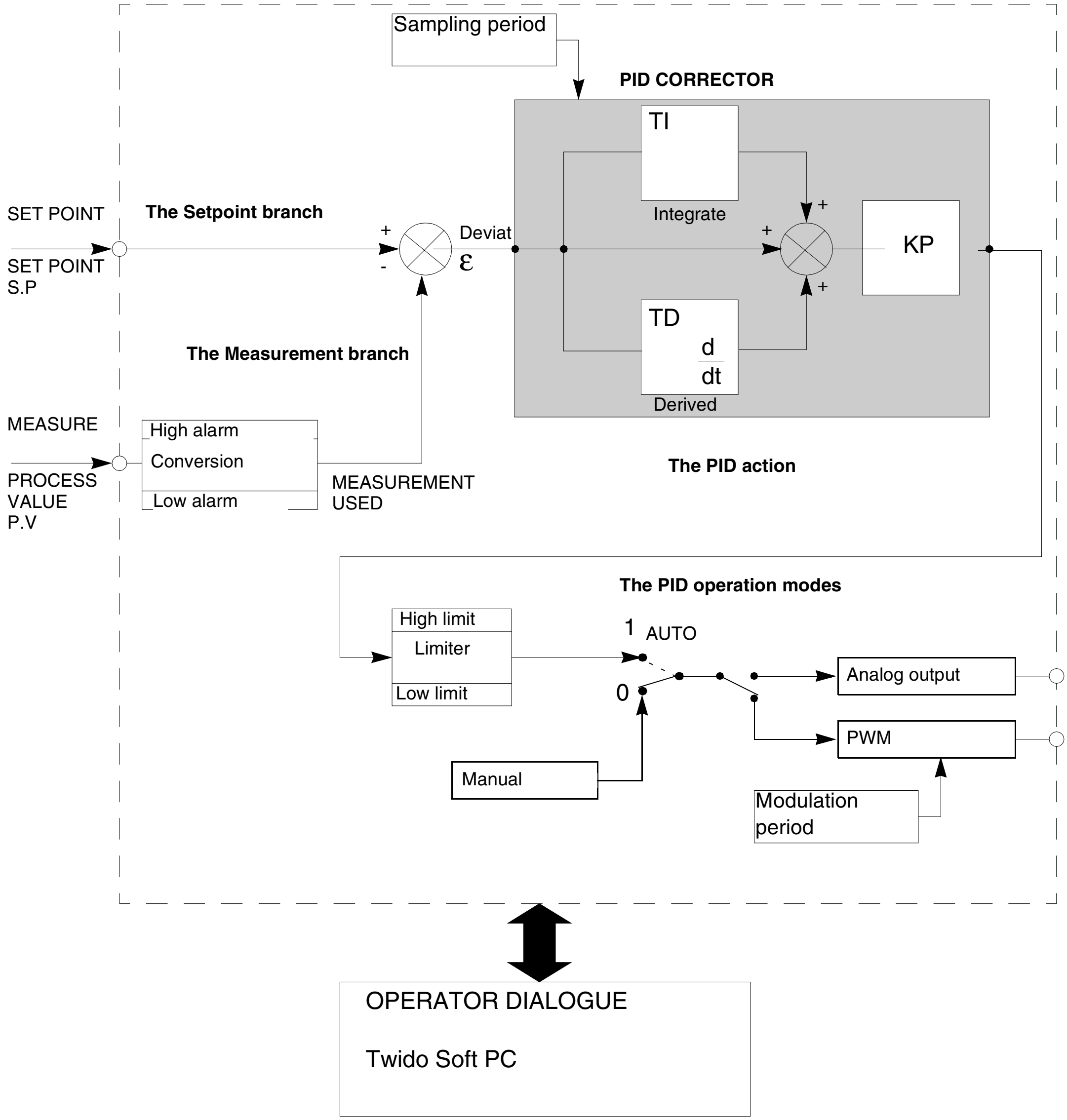
Function	Scale and comment
Linear conversion of input	Allows you to convert a value in 0 to 10000 format (analog input module resolution) to a value between -32768 and 32767
Proportional gain	Using a factor of 100, its value is between 1 and 10000. This corresponds to a gain value varying between 0.01 and 100. **Note:** If you enter an invalid value of gain (negative or null gain), TwidoSoft ignores this user-setting and automatically assigns the default value of 100 to this factor.
Integral time	Using a timebase of 0.1 seconds, its value is between 0 and 20000. This corresponds to an integral time of between 0 and 2000.0 seconds.
Derivative time	Using a timebase of 0.1 seconds, its value is between 0 and 10000. This corresponds to a derivative time of between 0 and 1000.0 seconds.

Function	Scale and comment
Sampling period	Using a timebase of 0.01 seconds, its value is between 1 and 10000. This corresponds to a sampling period of between 0.01 and 100 seconds.
PWM output	Using a timebase of 0.1 seconds, its value is between 1 and 500. This corresponds to a modulation period of between 0.1 and 50 seconds.
Analog output	Value between 0 and +10000
High level alarm on process variable	This alarm is set after conversion. It is set to a value between -32768 and 32767 if conversion is activated and to 0 and 10000 if it is not.
Low level alarm on process variable	This alarm is set after conversion. It is set to a value between -32768 and 32767 if conversion is activated and to 0 and 10000 if it is not.
High limit value on output	This limit value is between 0 and 10000 for an analog output value. When PWM is active, the limit corresponds to a percentage of the modulated period. 0% for 0 and 100% for 10000.
Low limit value on output	This limit value is between 0 and 10000 for an analog output value. When PWM is active, the limit corresponds to a percentage of the modulated period. 0% for 0 and 100% for 10000.
Manual mode	When manual mode is active the output is assigned a fixed value set by the user. This output value is between 0 and 10000 (0 to 100% for PWM output).
Direct or inverse action	Direct or inverse is available and acts directly on the output.
Auto-Tuning (AT)	This function provides automatic tuning of the Kp, Ti, Td and Direct/Reverse Action parameters to achieve optimum convergence of the control process.

Note: For a more in-depth explanation of how each of the functions described in the above table works, refer to the diagram below.

Operating Principles

The following diagram presents the operating principle of the PID function.



Note: The parameters used are described in the table on the page above and in the configuration screens.

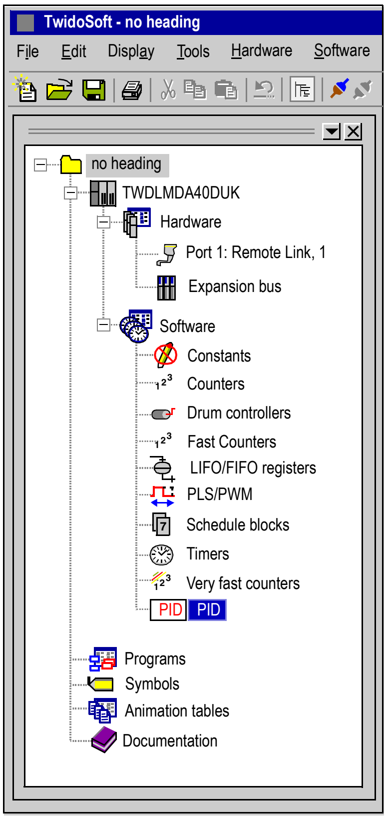
How to access the PID configuration

At a Glance

The following paragraphs describe how to access the PID configuration screens on TWIDO controllers.

Procedure

The following table describes the procedure for accessing the PID configuration screens:

Step	Action
1	Check that you are in **offline** mode.
2	Open the browser. **Result:** 

Step	Action
3	Double-click on **PID**. **Result:** The PID configuration window opens and displays the **General** (See *General tab of PID function, p. 434*) tab by default. **Note**: You can also right-click on **PID** and select the **Edit** option or select **Software** → **PID** from the menu or use the **Program** → **Configuration Editor** → **PID Icon** menu or, if using the latter method, select the PID and click on the **Magnifying glass** icon to select a specific PID.

General tab of PID function

At a Glance

When you open PID from the browser, you open the PID configuration window. This window allows you to:
- configure each TWIDO PID,
- debug each TWIDO PID,

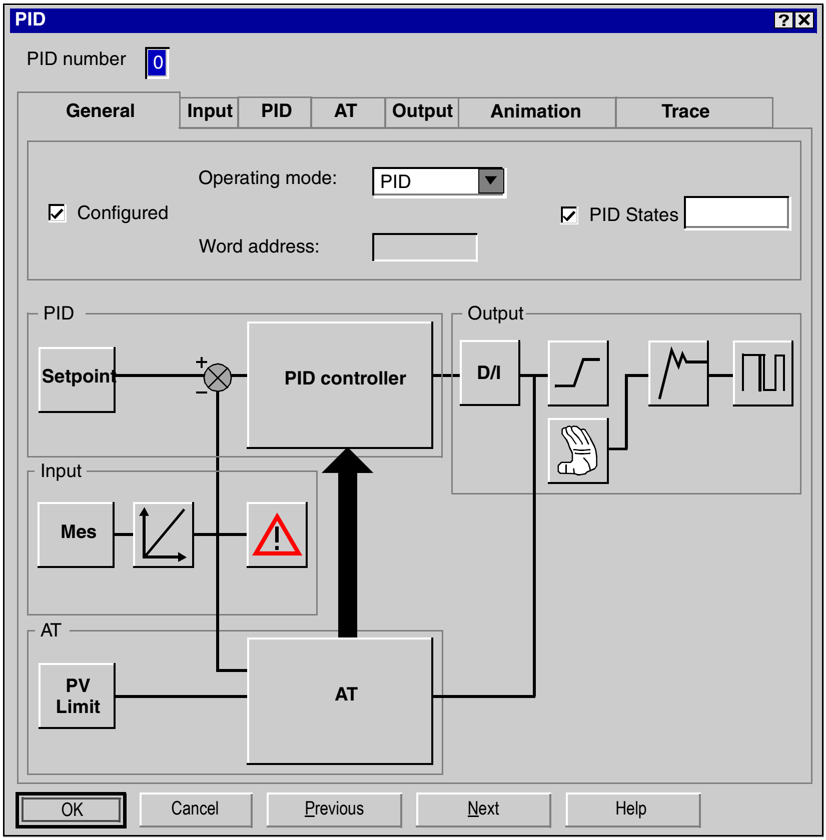
When you open this screen, if you are:
- in offline mode: you will go to the **General** tab by default and will have access to the configuration parameters,
- in online mode: you will go to the **Animation** tab and will have access to the debugging and adjustment parameters.

Note: In some cases, the grayed-out tabs and fields may not be accessible for any of the two reasons listed below: The "PID only" operating mode is selected, which prevents access to the AT tab parameters that are no longer needed.
- The operating mode (offline or online) which is currently active does not allow you to access these parameters.
- The "PID only" operating mode is selected, which prevents access to the AT tab parameters that are no longer needed.

The following paragraphs describe the **General** tab.

General Tab of the PID Function

The screen below is used to enter the general PID parameters.



Description

The table below describes the settings that you may define.

Field	Description
PID number	Specify the PID number that you wish to configure here. The value is between 0 and 13, 14 PID maximum per application.
Configured	To configure the PID, this box must be checked. Otherwise no action can be performed in these screens and the PID, though it exists in the application, cannot be used.
Operating mode	Specify the desired operating mode here. You may choose from three operating modes and a word address, as follows: ● PID ● AT ● AT+PID ● Word address
Word address	You may provide an internal word in this text box (%MW0 to %MW2999) that is used to programmatically set the operating mode. The internal word can take three possible values depending on the operating mode you wish to set: ● %MWx = 1 (to set PID only) ● %MWx = 2 (to set AT + PID) ● %MWx = 3 (to set AT only)
PID States	If you check to enable this option, you may provide a memory word in this text box (%MW0 to %MW2999) that is used by the PID controller to store the current PID state while running the PID controller and/or the autotuning function (for more details, please refer to *PID States and Errors Codes, p. 456*.)
Diagram	The diagram allows you to view the different possibilities available for configuring your PID.

Input tab of the PID

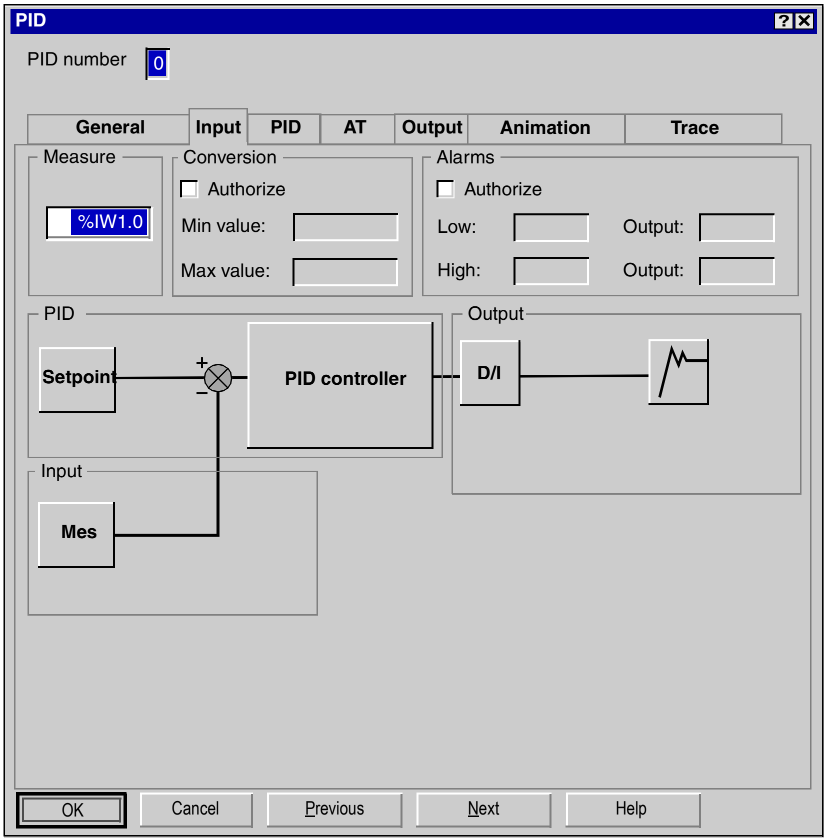
At a Glance

The tab is used to enter the PID input parameters.

Note: It is accessible in offline mode.

Input tab of the PID Function

The screen below is used to enter the PID input parameters.



Description

The table below describes the settings that you may define.

Field	Description
PID number	Specify the PID number that you wish to configure here. The value is between 0 and 13, 14 PID maximum per application.
Measurement	Specify the variable that will contain the process value to be controlled here. The default scale is 0 to 10000. You can enter either an internal word (%MW0 to %MW2999) or an analog input (%IWx.0 to %IWx.1).
Conversion	Check this box if you wish to convert the process variable specified as a PID input. If this box is checked, both the **Min value** and **Max value** fields are accessible. The conversion is linear and converts a value between 0 and 10,000 into a value for which the minimum and maximum are between -32768 and +32767.
Min value **Max value**	Specify the minimum and maximum of the conversion scale. The process variable is then automatically rescaled within the **[Min value to Max value]** interval. **Note**: The **Min value** must always be less than the **Max value**. **Min value** or **Max value** can be internal words (%MW0 to %MW2999), internal constants (%KW0 to %KW255) or a value between -32768 and +32767.
Alarms	Check this box if you wish to activate alarms on input variables. **Note**: The alarm values should be determined relative to the process variable obtained after the conversion phase. They must therefore be between **Min value** and **Max value** when conversion is active. Otherwise they will be between **0 and 10000.**
Low **Output**	Specify the high alarm value in the **Low** field. This value can be an internal word (%MW0 to %MW2999), an internal constant (%KW0 to %KW255) or a direct value. **Output** must contain the address of the bit which will be set to 1 when the lower limit is reached. **Output** can be either an internal bit (%M0 to %M255) or an output (%Qx.0 to %Qx.32).
High **Output**	Specify the low alarm value in the **High** field. This value can be an internal word (%MW0 to %MW2999), an internal constant (%KW0 to %KW255) or a direct value. **Output** must contain the address of the bit which will be set to 1 when the upper limit is reached. **Output** can be either an internal bit (%M0 to %M255) or an output (%Qx.0 to %Qx.32).
Diagram	The diagram allows you to view the different possibilities available for configuring your PID.

PID tab of PID function

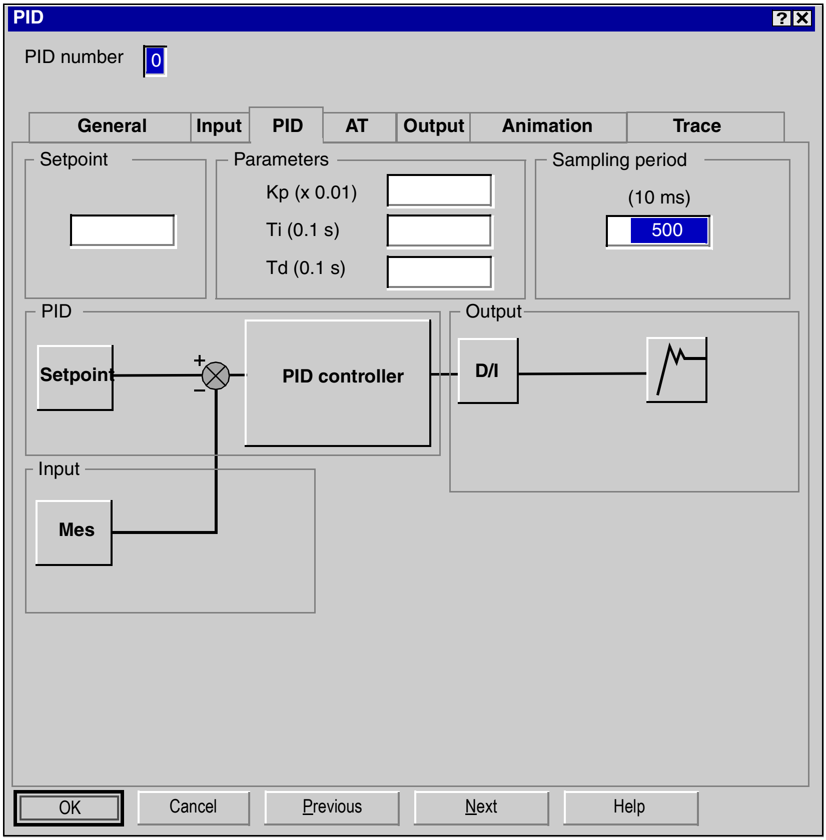
At a Glance

The tab is used to enter the internal PID parameters.

Note: It is accessible in offline mode.

PID tab of the PID Function

The screen below is used to enter the internal PID parameters.



Description

The table below describes the settings that you may define.

Field	Description
PID number	Specify the PID number that you wish to configure here. The value is between 0 and 13, 14 PID maximum per application.
Setpoint	Specify the PID setpoint value here. This value can be an internal word (%MW0 to %MW2999), an internal constant (%KW0 to %KW255) or a direct value. This value must therefore be between 0 and 10000 when conversion is inhibited. Otherwise it must be between the **Min value** and the **Max value** for the conversion.
Kp * 100	Specify the PID proportional coefficient multiplied by 100 here. This value can be an internal word (%MW0 to %MW2999), an internal constant (%KW0 to %KW255) or a direct value. The valid range for the Kp parameter is: $0 < Kp < 10000$. **Note:** If Kp is mistakenly set to 0 ($Kp \le 0$ is invalid), the default value Kp=100 is automatically assigned by the PID function.
TI (0.1 sec)	Specify the integral action coefficient here for a timebase of 0.1 seconds. This value can be an internal word (%MW0 to %MW2999), an internal constant (%KW0 to %KW255) or a direct value. It must be between 0 and 20000. **Note:** To disable the integral action of the PID, set this coefficient to 0.
Td (0.1 sec)	Specify the derivative action coefficient here for a timebase of 0.1 seconds. This value can be an internal word (%MW0 to %MW2999), an internal constant (%KW0 to %KW255) or a direct value. It must be between 0 and 10000. **Note:** To disable the derivative action of the PID, set this coefficient to 0.
Sampling period	Specify the PID sampling period here for a timebase of 10^{-2} seconds (10 ms). This value can be an internal word (%MW0 to %MW2999), an internal constant (%KW0 to %KW255) or a direct value. It must be between 1 (0.01 s) and 10000 (100 s).
Diagram	The diagram allows you to view the different possibilities available for configuring your PID.

Note: When AT is enabled, Kp, Ti and Td parameters are no longer set by the user for they are automatically and programmatically set by the AT algorithm. In this case, you must enter in these fields an **internal word** only (%MW0 to %MW2999). Caution: Do not enter an internal constant or a direct value when AT is enable, for this will trigger an error when running your PID application.

AT tab of PID function

At a Glance

The setting of correct PID parameters may be tedious, time-consuming and error-prone. All these make process control difficult to setup for the yet experienced, but not necessarily process control professional user. Thus, optimum tuning may sometimes be difficult to achieve.
The PID Auto-Tuning algorithm is designed to determine autmatically and adequately the following four PID terms:

- Gain factor,
- Integral value,
- Derivative value, and
- Direct or Reverse action.

Thus, the AT function can provide rapid and optimum tuning for the process loop.

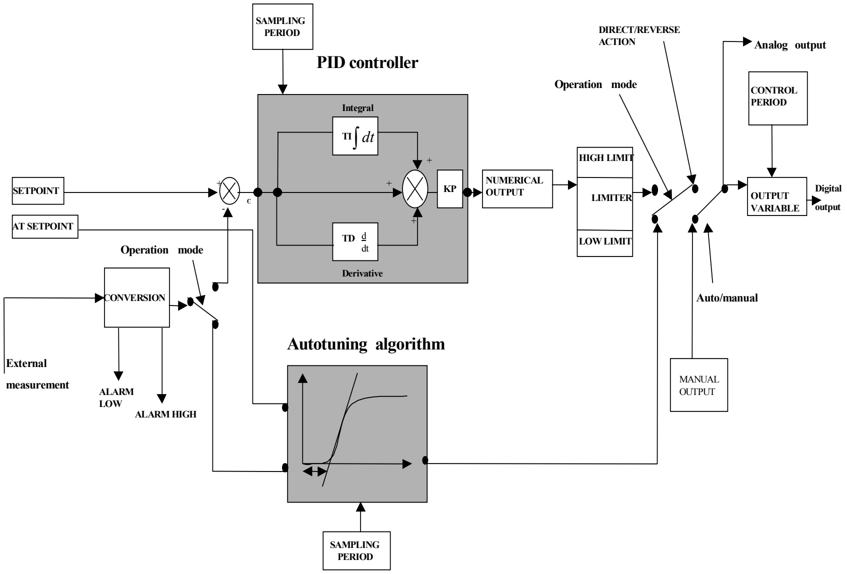
AT Requirements

PID Auto-tuning is particularly suited for temperature control processes.
In a general manner, the processes that the AT function can be used to control must meet the following requirements:

- the process is mostly linear over the entire operating range,
- the process response to a level change of the analog output follows a transient asymptotic pattern, and
- there is little disturbance in process variables. (In the case of a temperature control process, this implies there is no abnormally high rate of heat exchange between the process and its environment.)

AT Operating Principle

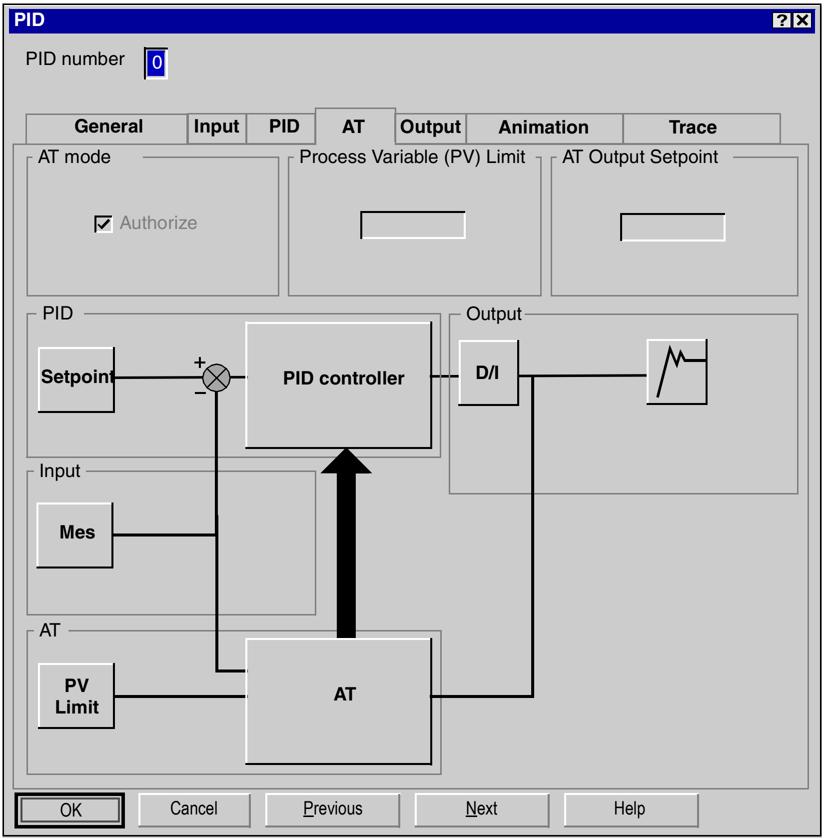
The following diagram describes the operating principle of the AT function and how it interacts with the PID loops:



AT Tab of the PID function

The screen below is used to enable/disable the AT function and enter the AT parameters.

Note: It is accessible in offline mode only.



Description

WARNING

The Process Variable (PV) Limit and the Output Setpoint values must be set carefully.

PID Auto-Tuning is an open-loop process that is acting directly on the control process without regulation or any limitation other than provided by the Process Variable (PV) Limit and the Output Setpoint. Therefore, both values must be carefully selected within the allowable range as specified by the process to prevent potential process overload.

Failure to follow this precaution can result in death, serious injury, or equipment damage.

The table below describes the settings that you may define.

Field	Description
Authorize	Check this box if you wish to enable the AT mode. There are two ways to use this checkbox, depending on whether you set the operating mode manually or via a word address in the General tab of the PID function: ● If you set the **Operating mode** to **PID+AT** or **AT** from the **General tab** (see *General tab of PID function, p. 434*), then the Authorize option is automatically checked and grayed out (it cannot be unchecked). ● If you set the operating mode via a word address %MWx (%MWx = 2: PID+AT; %MWx = 3: AT), then you must check the Authorize option manually to allow configuring the AT parameters. **Result:** In either of the above cases, all the fields in this AT tab configuration screen become active and you must fill in the Setpoint and Output fields with the appropriate values.
Process Variable (PV) Limit	Specify the limit that the measured process variable shall not exceed during the AT process. This parameter provides safety to the control system, as AT is an open loop process. This value can be an internal word (%MW0 to a maximum of %MW2999, depending on amount of system memory available), an internal constant (%KW0 to %KW255) or a direct value. This value must therefore be between 0 and 10000 when conversion is inhibited. Otherwise it must be between the Min value and the Max value for the conversion.

Field	Description
AT Output setpoint	Specify the AT output value here. This is the value of the step-change that is applied to the process. This value can be an internal word (%MW0 to %MW2999), an internal constant (%KW0 to %KW255) or a direct value. This value must therefore be between 0 and 10000. **Note:** The AT Output Setpoint must always be larger than the output last applied to the process.

Note: When the AT function is enabled, constants (%KWx) or direct values are no longer allowed, only memory words are allowed in the following set of PID fields:
- **Kp, Ti** and **Td** parameters must be set as **memory words** (%MWx) in the PID tab;
- **Action** field is automatically set to **"Address bit"** in the OUT tab;
- **Bit** box must be filled in with an adequate **memory bit** (%Mx) in the OUT tab.

Calculated Kp, Ti, Td Coefficients

Once tha AT process is complete, the calculated Kp, Ti and Td PID coefficients:
- are stored in their respective memory words (%MWx), and
- can be viewed in the **Animation** tab, in TwidoSoft online mode only.

Output tab of the PID

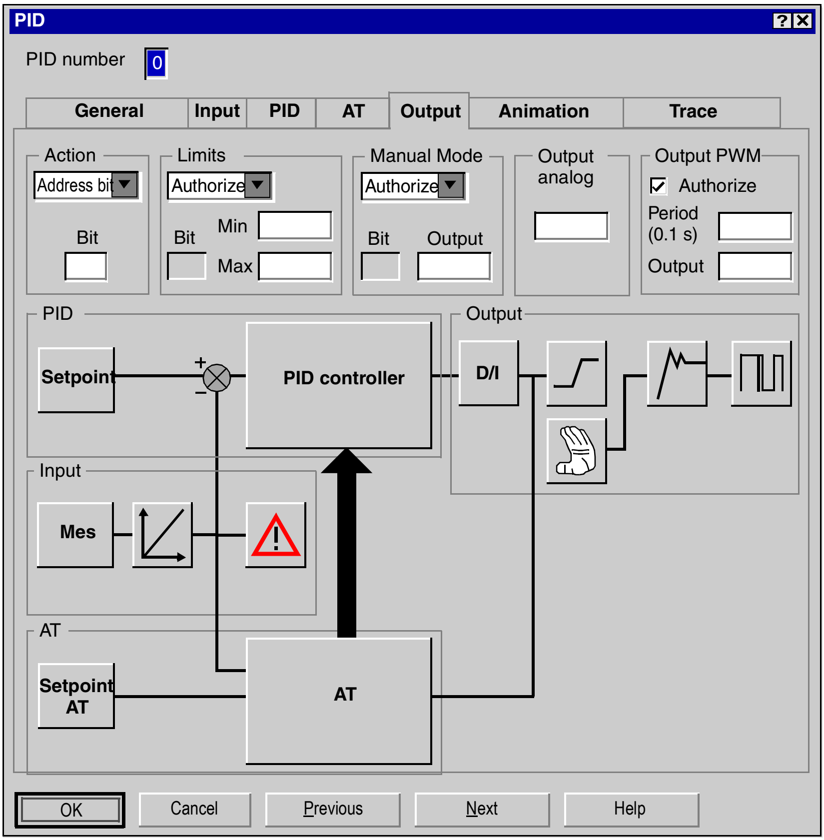
At a Glance

The tab is used to enter the PID output parameters.

Note: It is accessible in offline mode.

Ouput Tab of the PID Function

The screen below is used to enter the internal PID parameters.



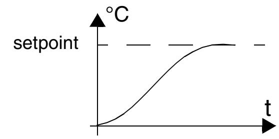
Description

The table below describes the settings that you may define.

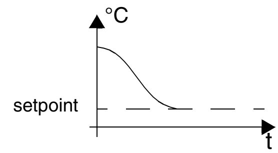
Field	Description
PID number	Specify the PID number that you wish to configure here. The value is between 0 and 13, 14 PID maximum per application.
Action	Specify the type of PID action on the process here. Three options are available: **Reverse**, **Direct** or **bit address**. If you have selected **bit address,** you can modify this type via the program, by modifying the associated bit which is either an internal bit (%M0 to %M255) or an input (%Ix.0 to %Ix.32). Action is direct if the bit is set to 1 and reverse if it is not. **Note:** When AT is enabled, the Auto-Tuning algorithm automatically determines the correct type of action direct or reverse for the control process. In this case, only one option is available from the Action dropdown list: **Address bit.** You must then enter in the associated **Bit** textbox an **internal word** (%MW0 to %MW2999). Do not attempt to enter an internal constant or a direct value in the **Bit** textbox, for this will trigger an execution error.
Limits **Bit**	Specify here whether you want to place limits on the PID output. Three options are available: **Enable**, **Disable** or **bit address**. If you have selected **bit address,** you can enable (bit to 1) or disable (bit to 0) limit management by the program, by modifying the associated bit which is either an internal bit (%M0 to %M255) or an input (%Ix.0 to %Ix.32).
Min. **Max.**	Set the high and low limits for the PID output here. **Note**: The **Min.** must always be less than the **Max.**. **Min.** or **Max.** can be internal words (%MW0 to %MW2999), internal constants (%KW0 to %KW255) or a value between 1 and 10000.
Manual mode **Bit** **Output**	Specify here whether you want to change the PID to manual mode. Three options are available: **Enable**, **Disable** or **bit address**. If you have selected **bit address,** you can switch to manual mode (bit to 1) or switch to automatic mode (bit to 0) using the program, by modifying the associated bit which is either an internal bit (%M0 to %M255) or an input (%Ix.0 to %Ix.32). The **Output** of manual mode must contain the value that you wish to assign to the analog output when the PID is in manual mode. This **Output** can be either a word (%MW0 to %MW2999) or a direct value in the [0-10000] format.
Analog output	Specify the PID output in auto mode here. This **Analog output** can be %MW-type (%MW0 to %MW2999) or %QW-type (%QWx.0).

Field	Description
PWM output enabled **Period (0.1s)** **Output**	Check this box if you want to use the PWM function of PID. Specify the modulation period in **Period (0.1s)**. This period must be between 1 and 500 and can be an internal word (%MW0 to %MW2999) or an internal constant (%KW0 to %KW255). Specify the PWM output bit as the value in **Output**. This can be either an internal bit (%M0 to %M255) or an output (%Qx.0 to %Qx.32).
Diagram	The diagram allows you to view the different possibilities available for configuring your PID.

Note: The term Reverse in the action field is used to reach a high setpoint (e.g.: for heating)



The term Direct in the action field is used to reach a low setpoint (e.g.: for cooling)



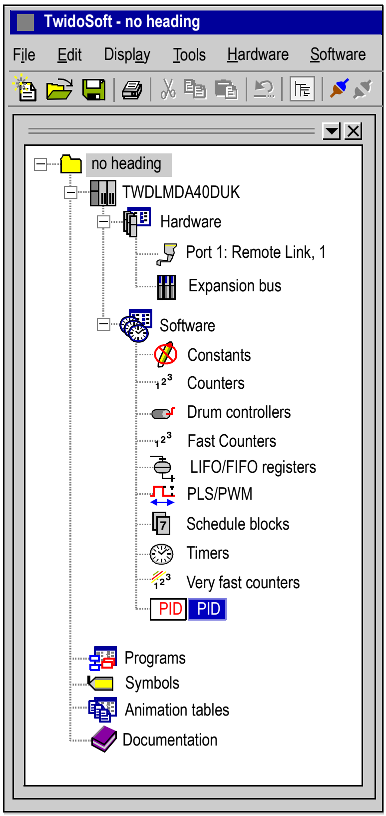
How to access PID debugging

At a Glance

The following paragraphs describe how to access the PID debugging screens on TWIDO controllers.

Procedure

The following table describes the procedure for accessing the PID debugging screens:

Step	Action
1	Check that you are in **online** mode.
2	Open the browser. **Result:** 

Step	Action
3	Double-click on **PID**. **Result:** The PID configuration window opens and displays the **Animation** (See *Animation tab of PID function, p. 452*) tab by default. **Note**: You can also right-click on **PID** and select the **Edit** option or select **Software** → **PID** from the menu or use the **Program** → **Configuration Editor** → **PID Icon** menu or, if using the latter method, select the PID and click on the **Magnifying glass** icon to select a specific PID.

Animation tab of PID function

At a Glance

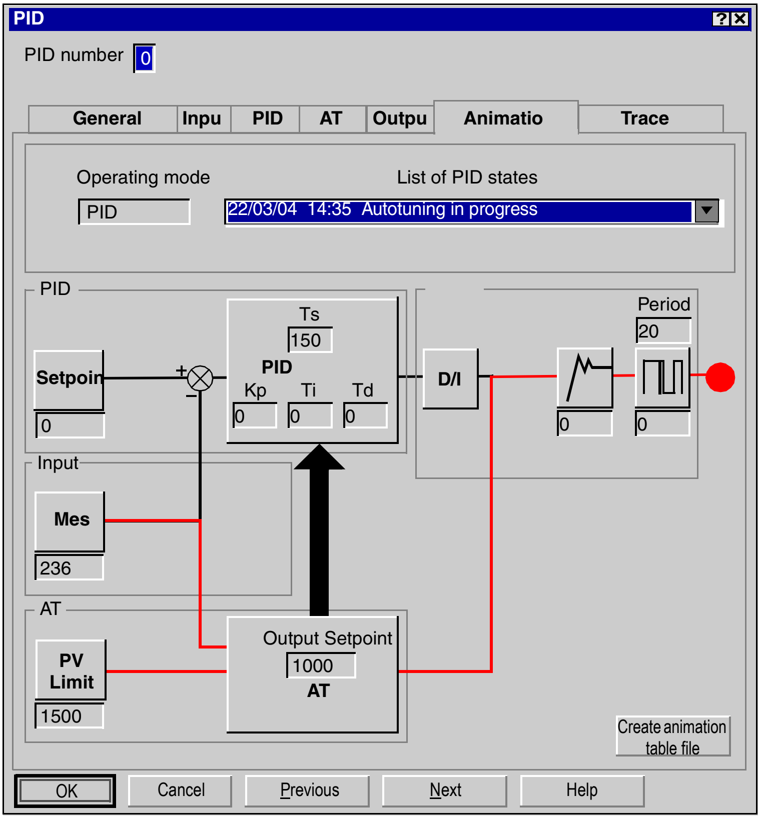
The tab is used to debug the PID.
The diagram depends on the type of PID control that you have created. Only configured elements are shown.

The display is dynamic. Active links are shown in red and inactive links are shown in black.

Note: It is accessible in online mode.

Animation Tab of PID Function

The screen below is used to view and debug the PID.



Description

The following table describes the different zones of the window.

Field	Description
PID number	Specify the PID number that you wish to debug here. The value is between 0 and 13, 14 PID maximum per application.
Operating mode	This field shows the current PID operating mode.
List of PID states	This dropdown list allows you to view the last 15 PID states in real time. This list is updated with each change of state indicating the date and time of the change as well as the current state.
Create an Animation Table	Click on **Create an Animation Table**, to create a file containing all the variables shown in the diagram to enable you modify them online and debug your PID.

Trace tab of PID function

At a Glance

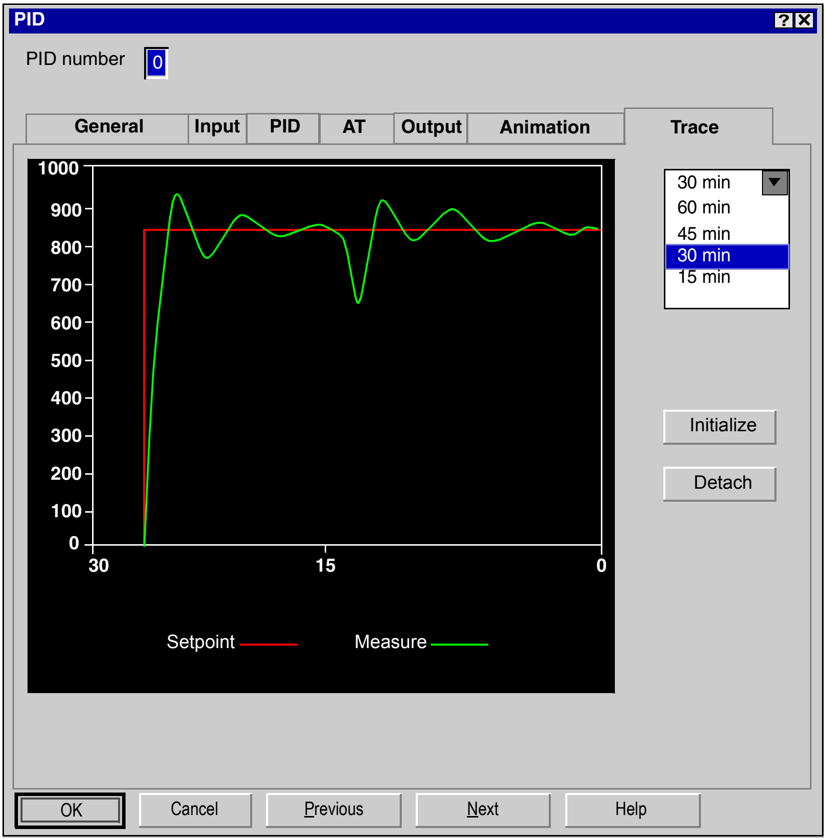
This tab allows you to view PID operation and to make adjustments to the way it behaves.

The graphs begin to be traced as soon as the debug window is displayed.

Note: It is accessible in online mode.

Animation Tab of PID Function

The screen below is used to view the PID control.



Description

The following table describes the different zones of the window.

Field	Description
PID number	Specify the PID number that you wish to view here. The value is between 0 and 13, 14 PID maximum per application.
Chart	This zone displays the **setpoint** and **process value** graphs. The scale on the horizontal axis (X) is determined using the menu to the top right of the window. The scale on the vertical axis is determined using the PID input configuration values (with or without conversion). It is automatically optimized so as to obtain the best view of the graphs.
Horizontal axis scale menu	This menu allows you to modify the scale of the horizontal axis. You can choose from 4 values: 15, 30, 45 or 60 minutes.
Initialize	This button clears the chart and restarts tracing the graphs.

PID States and Errors Codes

At a Glance

In addition to the **List of PID States** available from the **Animation** dialog box (see *Animation tab of PID function, p. 452*) that allows to view and switch back to one of the 15 latest PID states, the Twido PID controller also has the ability to record the current state of both the PID controller and the AT process to a user-defined memory word.
To find out how to enable and configure the **PID state memory word** (%MWi) see *General tab of PID function, p. 434*.

PID State Memory Word

The PID state memory word can record any of three types of PID information, as follows:
- Current state of the PID controller (PID State)
- Current state of the autotuning process (AT State)
- PID and AT error codes

Note: The PID state memory word is read-only.

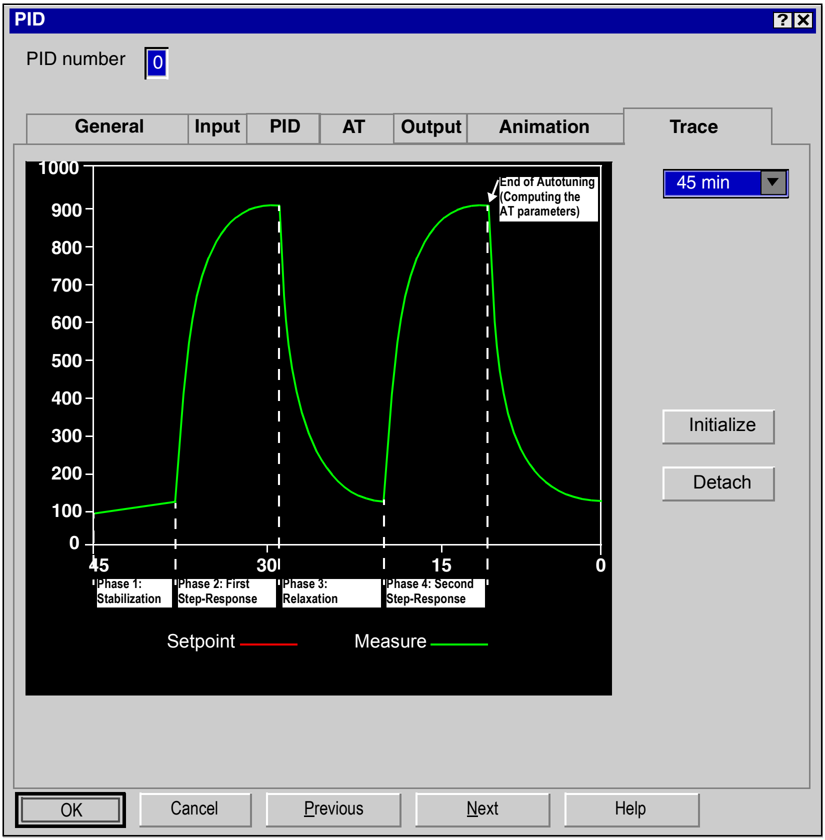
PID State Memory Word

The following is the PID controller state versus memory word hexadecimal coding concordance table:

PID State hexadecimal notation	Description
0000h	PID control is not active
2000h	PID control in progress
4000h	PID setpoint has been reached

Description of AT State

The autotuning process is divided into 4 consecutive phases. Each phase of the process must be fulfilled in order to bring the autotuning to a successful completion. The following process response curve and table describe the 4 phases of the Twido PID autotuning:



The autotuning phases are described in the following table:

AT Phase	Description
1	**Phase 1** is the stabilization phase. It starts at the time the user launches the AT process. During this phase, the Twido autotuning performs checks to ensure that the process variable is in steady state. **Note:** The output last applied to the process before start of the autotuning is used as both the starting point and the relaxation point for the autotuning process.
2	**Phase 2** applies the fist step-change to the process. It produces a process step-response similar to the one shown in the above figure.

AT Phase	Description
3	**Phase 3** is the relaxation phase that starts when the first step-response has stabilized. **Note:** Relaxation occurs toward equilibrium that is determined as the output last applied to the process before start of the autotuning.
4	**Phase 4** applies the second step-change to the process in the same amount and manner as in Phase 2 described above. The autotuning process ends and the AT parameters are computed and stored in their respective memory words upon completion of Phase 4. **Note:** After this phase is complete, the process variable is restored to the output level last applied to the process before start of the autotuning.

AT State Memory Word

The following is the PID controller state versus memory word hexadecimal coding concordance table:

AT State hexadecimal notation	Description
0100h	Autotuning phase 1 in progress
0200h	Autotuning phase 2 in progress
0400h	Autotuning phase 3 in progress
0800h	Autotuning phase 4 in progress
1000h	Autotuning process complete

PID and AT Error Codes

The following table describes the potential execution errors that may be encountered during both PID control and autotuning processes:

PID/AT Processes	Error code (hexadecimal)	Description
PID Error	8001h	Operating mode value out of range
	8002h	Linear conversion min and max equal
	8003h	Upper limit for digital output lower than lower limit
	8004h	Process variable limit out of linear conversion range
	8005h	Process variable limit less than 0 or greater than 10000
	8006h	Setpoint out of linear conversion range
	8007h	Setpoint less than 0 or greater than 10000
	8008h	Control action different from action determined at AT start
Autotuning Error	8009h	Autotuning error: the process variable (PV) limit has been reached
	800Ah	Autotuning error : due to either oversampling or output setpoint too low
	800Bh	Autotuning error: Kp is zero
	800Ch	Autotuning error: the time constant is negative
	800Dh	Autotuning error: delay is negative
	800Eh	Autotuning error: error calculating Kp
	800Fh	Autotuning error: time constant over delay ratio > 20
	8010h	Autotuning error: time constant over delay ratio < 2
	8011h	Autotuning error: the limit for Kp has been exceeded
	8012h	Autotuning error: the limit for Ti has been exceeded
	8013h	Autotuning error: the limit for Td has been exceeded

PID Tuning With Auto-Tuning (AT)

Overview of PID Tuning

The PID control function relies on the following three user-defined parameters: Kp, Ti and Td. PID tuning aims at determining these process parameters accurately to provide optimum control of the process.

Scope of the Auto-Tuning

TheAT function of the Twido PLC is especially suited for automatic tuning of thermal processes. As values of the PID parameters may vary greatly from one control process to another, the auto-tuning function provided by the Twido PLC can help you determine more accurate values than simply provided by best guesses, with less effort.

Auto-Tuning Requirements

When using the auto-tuning function, make sure the control process and the Twido PLC meet all of the following four requirements:

- The control process must be an open-loop, stable system.
- At the start of the auto-tuning run, the control process must be in steady state with a null process input (e.g.: an oven or a furnace shall be at ambient temperature.)
- During operation of the auto-tuning, make sure that no disturbances enter through the process for either computed parameters will be erroneous or the auto-tuning process will simply fail (e.g.: the door of the oven shall not be opened, not even momentarily.)
- Configure the Twido PLC to scan in **Periodic mode.** Once you have determined the correct sampling period (Ts) for the auto-tuning, the scan period must be configured so that the sampling period (Ts) is an exact multiple of the Twido PLC scan period.

Note: To ensure a correct run of the PID control and of the auto-tuning process, it is essential that the Twido PLC be configured to execute scans in Periodic mode (not Cyclic). In Periodic mode, each scan of the PLC starts at regular time intervals. This way, the sampling rate is constant throughout the measurement duration (unlike cyclic mode where a scan starts as soon as the previous one ends, which makes the sampling period unbalanced from scan to scan.)

AT Operating Modes

The auto-tuning can be used either independently (AT mode) or in conjunction with the PID control (AT + PID):

- **AT mode:** After convergence of the AT process and successful completion with the determination of the PID control parameters Kp, Ti and Td (or after detection of an error in the AT algorithm), the AT numerical output is set to 0 and the following message appears in the **List of PID States** drop-down list: "Auto-tuning complete."
- **AT + PID mode:** The AT is launched first. After successful completion of the AT, the PID control loop starts (based on the Kp, TI and Td parameters computed by the AT)."
  Note on AT+PID: If the AT algorithm encounters an error:
  - no PID parameter is computed;
  - the AT numerical output is set to output last applied to the process before start of the autotuning;
  - an error message appears in the List of PID States drop-down list
  - the PID control is cancelled.

> **Note: Bumpless transition**
> While in **AT+PID mode**, the transition from AT to PID is bumpless.

Methods for Determining the Sampling Period (Ts)

As will be explained in the two following sections (see *Appendix 1: PID Theory Fundamentals, p. 476* and *Appendix 2: First-Order With Time Delay Model*, p. *478*), the **sampling period (Ts)** is a key parameter of the PID control. The sampling period can be deduced from the AT **time constant (τ).**
There are two methods for evaluating the correct sampling period (Ts) by using the auto-tuning:· They are described in the following sections.

- The process response curve method
- The trial-and-error method

Both methods are described in the two following subsections.

Introducing the Process Response Curve Method

This method consists in setting a step change at the control process input and recording the process output curve with time.
The process response curve method makes the following assumption:

- The control process can be adequately described as a first-order with time delay model by the following transfer function:

$$\frac{S}{U} = \frac{k}{1 + \tau p} \cdot e^{-\theta p}$$

(For more details, see Appendix 2: First-Order With Time Delay Model)

Using the Process Response Curve Method

To determine the sampling period (Ts) using the process response curve method, follow these steps:

Step	Action
1	It is assumed that you have already configured the various settings in the General, Input, PID, AT and Output tabs of the PID.
2	Select the **PID > Output** tab from the Application Browser.
3	Select **Authorize** or **Address bit** from the **Manual mode** dropdown list to allow manual output and set the **Output** field to a high level (in the [5000-10000] range).
4	Select **PLC > Transfer PC => PLC...** from menu bar to download the application program to the Twido PLC.
5	Within the PID configuration window, switch to **Trace** mode.
6	Run the PID and check the response curve rise.
7	When the response curve has reached a steady state, stop the PID measurement. **Note:** Keep the PID Trace window active.
8	Use the following graphical method to determine time constant (τ) of the control process: **1.** Compute the process variable output at 63% rise ($S_{[63\%]}$) by using the following formula: $S_{[63\%]} = S_{[initial]} + (S_{[ending]}-S_{[initial]})x63\%$ **2.** Find out graphically the time abscissa ($t_{[63\%]}$) that corresponds to S(63%). **3.** Find out graphically the initial time ($t_{[initial]}$) that corresponds the start of the process response rise. **4.** Compute the time constant (τ) of the control process by using the following relationship: $\tau = t_{[63\%]}-t_{[initial]}$
9	Compute the sampling period (Ts) based the value of (τ) that you have just determined in the previous step, using the following rule: Ts = τ/75 **Note:** The base unit for the sampling period is 10ms. Therefore, you should round up/down the value of Ts to the nearest 10ms.
10	Select **Program > Scan mode edit** and proceed as follows: **1.** Set the **Scan mode** of the Twido PLC to **Periodic**. **2.** Set the **Scan Period** so that the sampling period (Ts) is an **exact multiple** of the scan period, using the following rule: Scan Period = Ts / n, where "n" is a positive integer. **Note:** You must choose "n" so that the resulting Scan Period is a positive integer in the range [2 - 150 ms].

Example of Process Response Curve

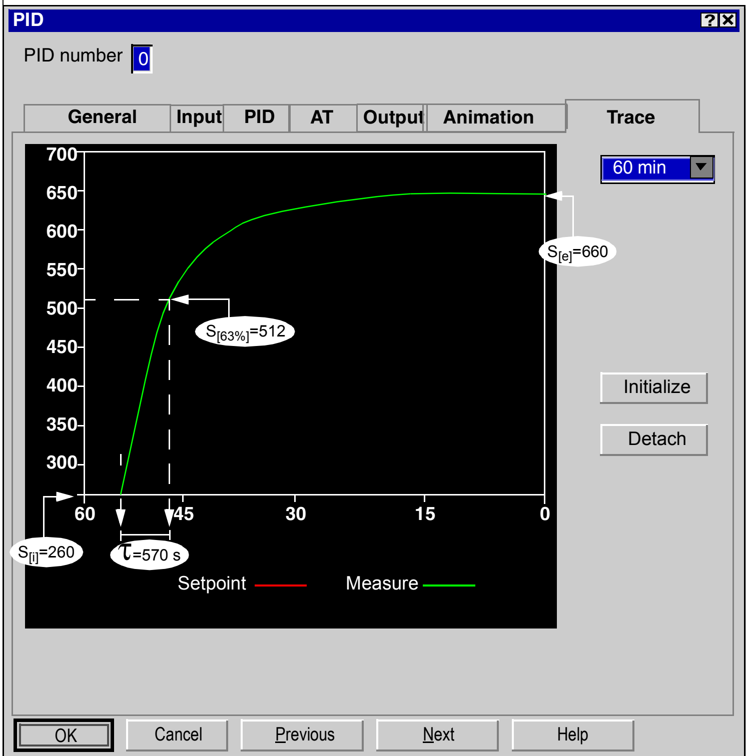
This example shows you how to measure the time constant (τ) of a simple thermal process by using the process response curve method described in the previous subsection.

The experimental setup for the time constant measurement is as follows:

- The control process consists in a forced air oven equipped with a heating lamp.
- Temperature measurements are gathered by the Twido PLC via a Pt100 probe, and temperature data are recorded in °C.
- The Twido PLC drives a heating lamp via the PWM discrete output of the PID.

The experiment is carried out as follows:

Step	Action
1	The PID **Output tab** is selected from the PID configuration screen.
2	**Manual mode** is selected from the Output tab.
3	The manual mode **Output** is set to 10000.
4	The PID run is launched from the PID **Trace tab.**
5	The PID run is stopped when the oven's temperature has reached a steady state.

Step	Action
6	The following information is obtained directly from the graphical analysis of the response curve, as shown in the figure below:  where ● $S_{[i]}$ = initial value of process variable = 260 ● $S_{[e]}$ = ending value of process variable = 660 ● $S_{[63\%]}$ = process variable at 63% rise = $S_{[i]}$ + ($S_{[i]}$ - $S_{[e]}$) x 63% = 260+(660-260)x63% = 512 ● τ = time constant = time elapsed from the start of the rise till $S_{[63\%]}$ is reached = 9 min 30 s = 570 s
7	The sampling period (Ts) is determined using the following relationship: Ts = τ/75 = 570/75 = 7.6 s (7600 ms)

Step	Action
8	In the **Program > Scan mode edit** dialog box, the **Scan Period** must be set so that the sampling period (Ts) is an exact multiple of the scan period, as in the following example: Scan Period = Ts/76 = 7600/76 = 100 ms (which satisfies the condition: 2 ms ≤ Scan Period ≤ 150 ms.)

Trial-and-Error Method

The trial-and-error method consists in providing successive guesses of the sampling period to the auto-tuning function until the auto-tuning algorithm converges successfully towards Kp, Ti and Td that are deemed satisfactory by the user.

Note: Unlike the process response curve method, the trial-and-error method is not based on any approximation law of the process response. However, it has the advantage of converging towards a value of the sampling period that is in the same order of magnitude as the actual value.

Top perform a trial-and-error estimation of the auto-tuning parameters, follow these steps:

Step	Action
1	Select the **AT tab** from the PID configuration window.
2	Set the **Output limitation** of AT to **10000.**
3	Select the **PID tab** from the PID configuration window.
4	Provide the first or n^{th} guess in the **Sampling Period** field. **Note:** If you do not have any first indication of the possible range for the sampling period, set this value to the minimum possible: 1 (1 unit of 10 ms).
5	Select **PLC > Transfer PC => PLC...** from menu bar to download the application program to the Twido PLC.
6	Launch **Auto-Tuning.**
7	Select the **Animation** tab from the PID configuration screen.
8	Wait till the auto-tuning process ends.

9	Two cases may occur:
	● **Auto-tuning completes successfully:** You may continue to Step 9.
	● **Auto-tuning fails:** This means the current guess for the sampling period (Ts) is not correct. Try a new Ts guess and repeat steps 3 through 8, as many times as required until the auto-tuning process eventually converges. Follow these guidelines to provide a new Ts guess:
	  ● AT ends with the error message **"The computed time constant is negative!":** This means the sampling period **Ts is too large.** You should decrease the value of Ts to provide as new guess.
	  ● AT ends with the error message **"Sampling error!":** This means the sampling period **Ts is too small.** You should increase the value of Ts to provide as new guess.

10	You may now view the PID control parameters (Kp, Ti and Td) in Animation tab, and adjust them in the PID tab of the PID configuration screen, as needed. **Note:** If the PID regulation provided by this set of control parameters does not provide results that are totally satisfactory, you may still refine the trial-and-error evaluation of the sampling period until you obtain the right set of Kp, Ti and Td control parameters.

Adjusting PID Parameters

To refine the process regulation provided by the PID parameters (Kp, Ti, Td) obtained from auto-tuning, you also have the ability to adjust those parameter values manually, directly from the PID tab of the PID configuration screen or via the corresponding memory words (%MW).

Limitations on Using the Auto-tuning and the PID Control

The **auto-tuning** is best suited for processes whose time constant (τ) and delay-time (θ) meet the following requirement: $(\tau + \theta) < 2700$ s (i.e.: 45 min)
The **PID control** is best suited for the regulation of processes that satisfy the following condition: $2 < (\tau/\theta) < 20$, where (τ) is the time constant of the process and (θ) is the delay-time.

Note: Depending on the ratio (τ/θ):
- $(\tau/\theta) < 2$: The PID regulation has reached its limitations; more advanced regulation techniques are needed in this case.
- $(\tau/\theta) > 20$: In this case, a simple on/off (or two-step) controller can be used in place of the PID controller.

Troubleshooting Errors of the Auto-tuning Function

The following table records the auto-tuning error messages and describes possible causes as well as troubleshooting actions:

Error Message	Possible Cause	Explanation / Possible Solution
Autotuning error: the process variable (PV) limit has been reached	The process variable is reaching the maximum value allowed.	This is a system safety. As the AT is an open-loop process, the Process Variable (PV) Limit works as an upper limit.
Autotuning error : due to either oversampling or output setpoint too low	Any of two possible causes: • Sampling period is too small. • AT Output is set too low.	Increase either the sampling period or the AT Output Setpoint value.
Autotuning error: the time constant is negative	The sampling period may be too large.	For more details, please check out *PID Tuning With Auto-Tuning (AT), p. 460*.
Autotuning error: error calculating Kp	The AT algorithm has failed (no convergence).	Check the PID and AT parameters and make adjustments that can improve convergence. Check also that there is no disturbance that could affect the process variable.
Autotuning error: time constant over delay ratio > 20	$\tau/\theta > 20$	PID regulation is no longer guaranteed. For more details, please check out *PID Tuning With Auto-Tuning (AT), p. 460*.
Autotuning error: time constant over delay ratio < 2	$\tau/\theta < 2$	PID regulation is no longer guaranteed. For more details, please check out *PID Tuning With Auto-Tuning (AT), p. 460*.
Autotuning error: the limit for Kp has been exceeded	Computed value of static gain (Kp) is greater than 10000.	Measurement sensitivity of some application variables may be too low. The application's measurement range must be rescaled within the [0-10000] interval.
Autotuning error: the limit for Ti has been exceeded	Computed value of integral time constant (Ti) is greater than 20000.	Computational limit is reached.
Autotuning error: the limit for Td has been exceeded	Computed value of derivative time constant (Td) is greater than 10000.	Computational limit is reached.

PID parameter adjustment method

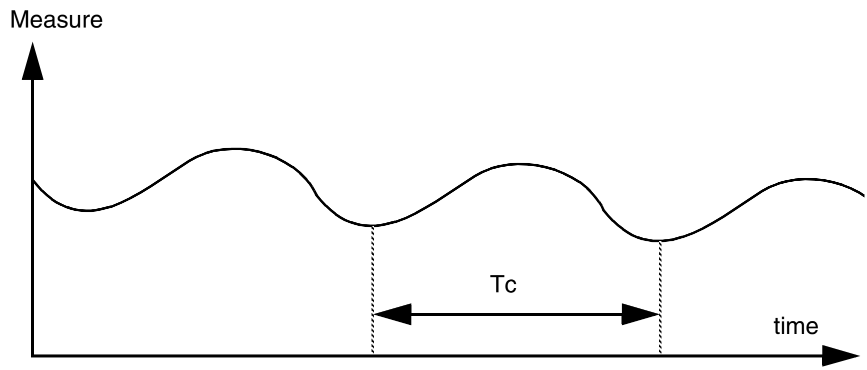
Introduction

Numerous methods to adjust the PID parameters exist, we suggest Ziegler and Nichols which have two variants:
- closed loop adjustment,
- open loop adjustment.

Before implementing one of these methods, you must set the PID action direction:
- if an increase in the OUT output causes an increase in the PV measurement, make the PID inverted (KP > 0),
- on the other hand, if this causes a PV reduction, make the PID direct (KP < 0).

Closed loop adjustment

This principal consists of using a proportional command (Ti = 0, Td = 0) to start the process by increasing production until it starts to oscillate again after having applied a level to the PID corrector setpoint. All that is required is to raise the critical production level (Kpc) which has caused the non damped oscillation and the oscillation period (Tc) to reduce the values giving an optimal regulation of the regulator.



According to the kind of (PID or PI) regulator, the adjustment of the coefficients is executed with the following values:

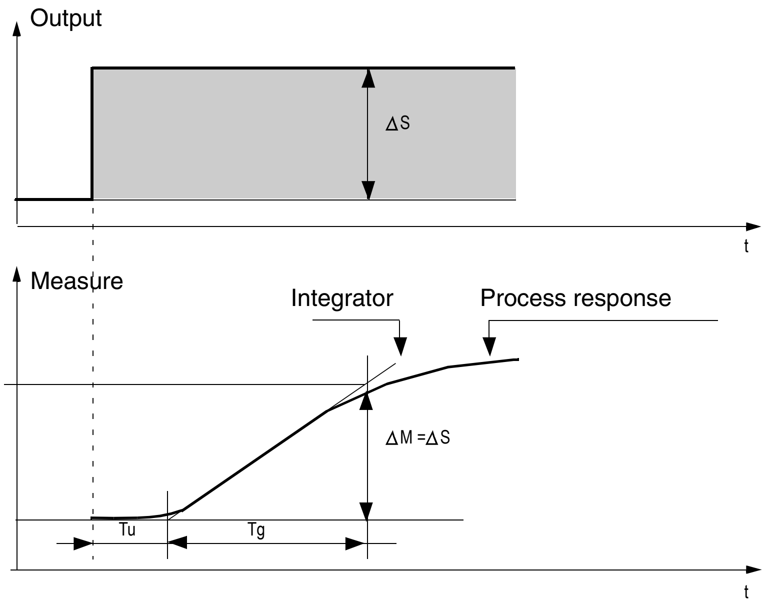
-	Kp	Ti	Td
PID	Kpc/1,7	Tc/2	Tc/8
PI	Kpc/2,22	0,83 x Tc	-

where Kp = proportional production, Ti = integration time and TD = diversion time.

Note: This adjustment method provides a very dynamic command which can express itself through unwanted overshootsduring the change of setpoint pulses. In this case, lower the production value until you get the required behaviour.

Open loop adjustment

As the regulator is in manual mode, you apply a level to the output and make the procedure response start the same as an integrator with pure delay time. .



The intersection point on the right hand side which is representative of the integrator with the time axes, determines the time Tu. Next, Tg time is defined as the time necessary for the controlled variable (measurement) to have the same variation size (% of the scale) as the regulator output.
According to the kind of (PID or PI) regulator, the adjustment of the coefficients is executed with the following values:

-	Kp	Ti	Td
PID	-1,2 Tg/Tu	2 x Tu	0,5 x Tu
PI	-0,9 Tg/Tu	3,3 x Tu	-

where Kp = proportional production, Ti = integration time and TD = diversion time.

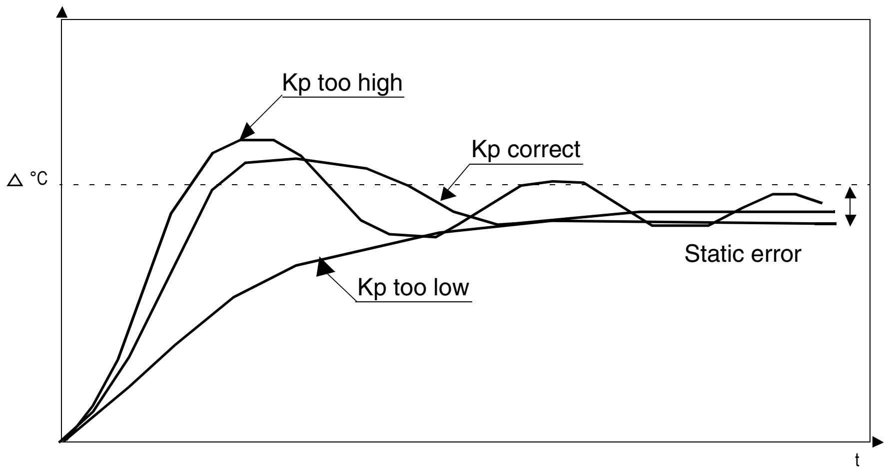
Note: Attention to the units. If the adjustment is carried out in PL7, multiply the value obtained for KP by 100.

This adjustment method also provides a very dynamic command, which can express itself through unwanted overshoots during the change of setpoints' pulses. In this case, lower the production value until you get the required behavior. The method is interesting because it does not require any assumptions about the nature and the order of the procedure. You can apply it just as well to the stable procedures as to real integrating procedures. It is really interesting in the case of slow procedures (glass industry,…) because the user only requires the beginning of the response to regulate the coefficients Kp, Ti and Td.

Role and influence of PID parameters

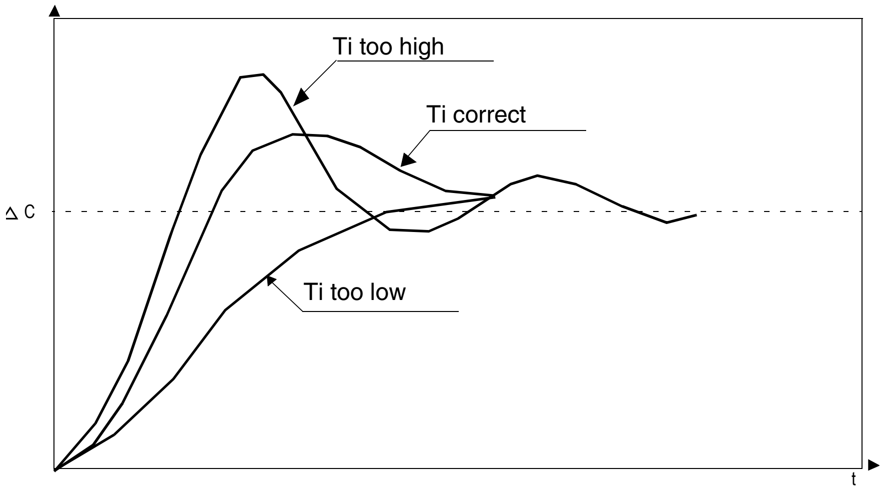
Influence of proportional action

Proportional action is used to influence the process response speed. The higher the gain, the faster the response, and the lower the static error (in direct proportion), though the more stability deteriorates. A suitable compromise between speed and stability must be found. The influence of integral action on process response to a scale division is as follows:



Influence of integral action

Integral action is used to cancel out static error (deviation between the process value and the setpoint). The higher the level of integral action (low Ti), the faster the response and the more stability deteriorates. It is also necessary to find a suitable compromise between speed and stability. The influence of integral action on process response to a scale division is as follows:

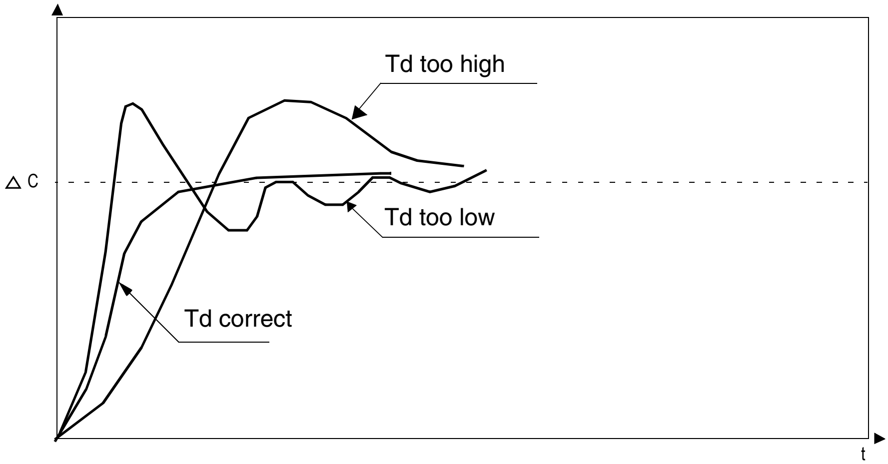


Note: A low Ti means a high level of integral action.

where Kp = proportional gain, Ti = integration time and Td = derivative time.

Influence of derivative action

Derivative action is anticipatory. In practice, it adds a term which takes account of the speed of variation in the deviation, which makes it possible to anticipate changes by accelerating process response times when the deviation increases and by slowing them down when the deviation decreases. The higher the level of derivative action (high Td), the faster the response. A suitable compromise between speed and stability must be found. The influence of derivative action on process response to a scale division is as follows:



Limits of the PID control loop

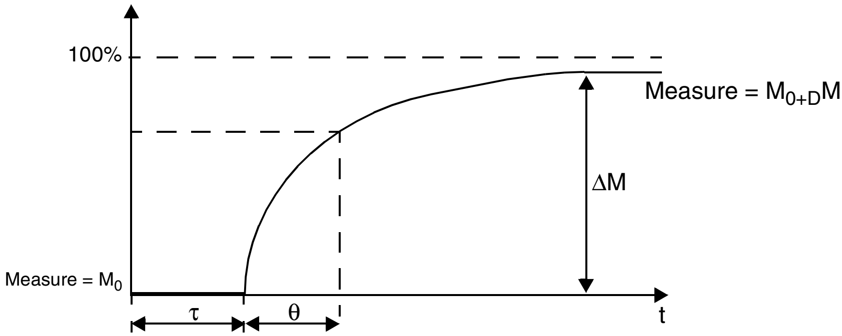
If the process is assimilated to a pure delay first order with a transfer function:

$$(H(p)) = K\frac{(e^{(-\tau)p})}{(1+\theta p)}$$

where:

τ =model delay,

θ = model time constant,



The process control performance depends on the ratio $\frac{\tau}{\theta}$

The suitable PID process control is attained in the following domain: 2- $\frac{\tau}{\theta}$ -20

For $\frac{\tau}{\theta}$ <2, in other words for fast control loops (low θ) or for processes with a large delay (high t) the PID process control is no longer suitable. In such cases more complex algorithms should be used.

For $\frac{\tau}{\theta}$ >20, a process control using a threshold plus hysterisis is sufficient.

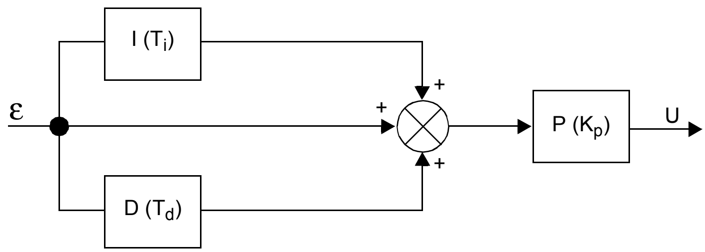
Appendix 1: PID Theory Fundamentals

Introduction

The PID control function onboard all Twido controllers provides an efficient control to simple industrial processes that consist of one system stimulus (referred to as Setpoint in this document) and one measurable property of the system (referred to as Measure or Process Variable).

The PID Controller Model

The Twido PID controller implements a mixed (serial - parallel) PID correction (see PID Model Diagram below) via an analog measurement and setpoint in the [0-10000] format and provides an analog command to the controlled process in the same format.
The mixed form of the PID controller model is described in the following diagram:



where
where:
- I = the **integral** action (acting independently and parallel to the derivative action),
- D = the **derivative** action (acting independently and parallel to the integral action),
- P = the **proportional** action (acting serially on the combined output of the integral and derivative actions,
- U = the PID controller output (later fed as input into the controlled process.)

The PID Control Law

The PID controller is comprised of the mixed combination (serial - parallel) of the controller gain (Kp), and the integral (Ti) and derivative (Td) time constants. Thus, the PID control law that is used by the Twido controller is of the following form *(Eq.1):*

$$u(i) = K_P \cdot \left\{ \varepsilon(i) + \frac{T_s}{T_i} \sum_{j=1}^{i} \varepsilon(j) + \frac{T_d}{T_s}[\varepsilon(i) - \varepsilon(i-1)] \right\}$$

where

- Kp = the controller proportional gain,
- Ti = the integral time constant,
- Td = the derivative time constant,
- Ts = the sampling period,
- ε(i) = the deviation (ε(i) = setpoint - process variable.)

Note: Two different computational algorithms are used, depending on the value of the integral time constant (Ti):

- Ti ≠ 0: In this case, an incremental algortihm is used.
- Ti = 0: This is the case for non-integrating processes. In this case, a positional algotrithm is used, along with a +5000 offset that is applied to the PID output variable.

For a detailed description of Kp, Ti and Td please refer to *PID tab of PID function, p. 439*.

As can be inferred from *(equ.1)* and *(equ.1')*, the key parameter for the PID regulation is the **sampling period (Ts)**. The sampling period depends closely on the **time constant (τ)**, a parameter intrinsic to the process the PID aims to control. (See *Appendix 2: First-Order With Time Delay Model, p. 478*.)

Appendix 2: First-Order With Time Delay Model

Introduction

This section presents the first-order with time delay model used to describe a variety of simple but nonetheless important industrial processes, including thermal processes.

First-Order With Time Delay Model

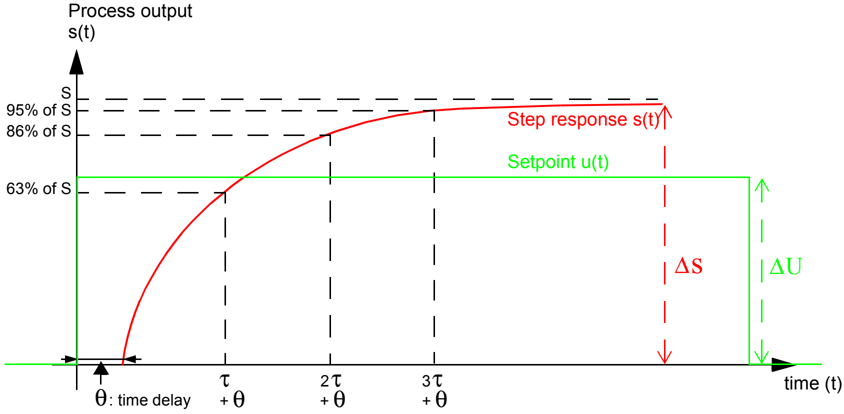
It is widely assumed that simple (one-stimulus) thermal processes can be adequately approximated by a first-order with time delay model.
The transfer function of such first-order, open-loop process has the following form in the Laplace domain *(equ.2):*

$$\frac{S}{U} = \frac{k}{1 + \tau p} \cdot e^{-\theta p}$$

where
- k = the static gain,
- τ = the time constant,
- θ = the delay-time,
- U = the process input (this is the output of the PID controller),
- S = the process output.

The Process Time Constant τ

The key parameter of the process response law *(equ.2)* is the **time constant** τ**.** It is a parameter intrinsic to the process to control.
The time constant (τ) of a first-order system is defined as the time (in sec) it takes the system output variable to reach 63% of the final output from the time the system started reacting to the step stimulus u(t).
The following figure shows a typical first-order process response to a step stimulus:



where
- k = the static gain computed as the ratio ΔS/ΔU,
- τ = the time at 63% rise = the time constant,
- 2τ = the time at 86% rise,
- 3τ = the time at 95% rise.

Note: When auto-tuning is implemented, the sampling period (Ts) must be chosen in the following range: [τ/125 <Ts < τ/25]. Ideally, you should use [Ts= τ/75]. (See *PID Tuning With Auto-Tuning (AT), p. 460.*)

15.4 Floating point instructions

At a Glance

Aim of this Section

This section describes advanced floating point (See *Floating point and double word objects, p. 32*) instructions in TwidoSoft language.
The Comparison and Assignment instructions are described in the *Numerical Processing, p. 340*

What's in this Section?

This section contains the following topics:

Arithmetic instructions on floating point

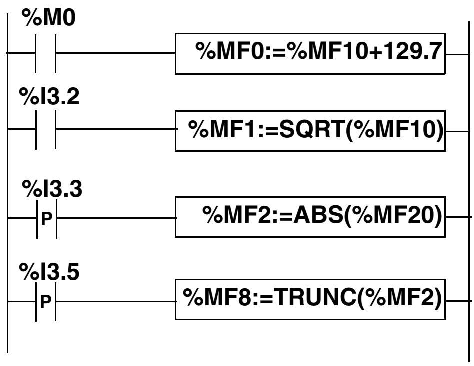
General

These instructions are used to perform an arithmetic operation between two operands or on one operand.

+	addition of two operands	**SQRT**	square root of an operand
-	subtraction of two operands	**ABS**	absolute value of an operand
*****	multiplication of two operands	**TRUNC**	whole part of a floating point value
/	division of two operands	**EXP**	natural exponential
LOG	base 10 logarithm	**EXPT**	power of an integer by a real
LN	natural logarithm		

Structure

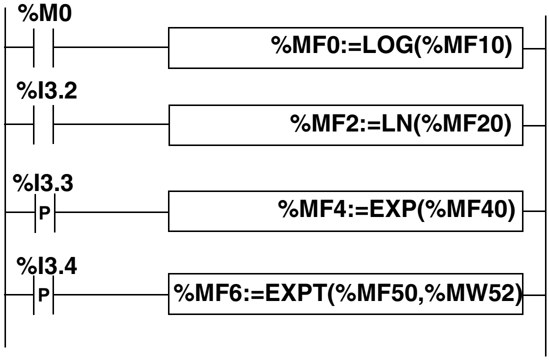
Ladder Language



Instruction List Language

```
LD %M0
[%MF0:=%MF10+129.7]

LD %I3.2
[%MF1:=SQRT(%MF10)]

LDR %I3.3
[%MF2:=ABS(%MF20)]

LDR %I3.5
[%MF8:=TRUNC(%MF2)]
```

Ladder Language



Instruction List Language

```
LD %M0
[%MF0:=LOG(%MF10]

LD %I3.2
[%MF2:=LN(%MF20)]

LDR %I3.3
[%MF4:=EXP(%MF40)]

LDR %I3.4
[%MF6:=EXPT(%MF50,%MW52)]
```

Syntax

Operators and syntax of arithmetic instructions on floating point

Operators	Syntax
+, - *, /	Op1:=Op2 Operator Op3
SQRT, ABS, TRUNC, LOG, EXP, LN	Op1:=Operator(Op2)
EXPT	Op1:=Operator (Op2,Op3)

Note: When you perform an addition or subtraction between 2 floating point numbers, the two operands must comply with the condition: $\mathrm{Op1} > \mathrm{Op2} \times 2^{-24}$, where Op1>Op2. If this condition is not respected, the result is equal to operand 1 (Op1). This phenomenon is of little consequence in the case of an isolated operation, as the resulting error is very low (2^{-24}), but it can have unforeseen consequences where the calculation is repeated.
E.g. in the case where the instruction **%MF2:= %MF2 + %MF0** is repeated indefinitely. If the initial conditions are %MF0 = 1.0 and %MF2 = 0, the value %MF2 becomes blocked at 16777216.
We therefore recommend you take great care when programming repeated calculations. If, however, you wish to program this type of calculation, it is up to the client application to manage truncation errors.

Operands of arithmetic instructions on floating point:

Operators	Operand 1 (Op1)	Operand 2 (Op2)	Operand 3 (Op3)
+, - *, /	%MFi	%MFi, %KFi, immediate value	%MFi, %KFi, immediate value
SQRT, ABS, LOG, EXP, LN	%MFi	%MFi, %KFi	[-]
TRUNC	%MFi	%MFi, %KFi	[-]
EXPT	%MFi	%MFi, %KFi	%MWi, %KWi, immediate value

Rules of use

- Operations on floating point and integer values can not be directly mixed. Conversion operations (See *Integer Conversion Instructions <-> Floating, p. 488*) convert into one or other of these formats.)
- The system bit %S18 is managed in the same way as integer operations (See *Arithmetic Instructions on Integers, p. 349*), the word %SW17 (See *System Words (%SW), p. 517*) indicates the cause of the fault.
- When the operand of the function is an invalid number (e.g.: logarithm of a negative number), it produces an indeterminate or infinite result and changes bit %S18 to 1, the word %SW17 indicates the cause of the error.

Trigonometric Instructions

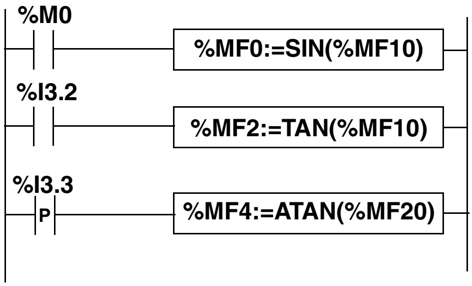
General

These instructions enable the user to perform trigonometric operations.

SIN	sine of an angle expressed as a radian,	**ASIN**	arc sine (result within $-\frac{\pi}{2}$ and $\frac{\pi}{2}$)
COS	cosine of an angle expressed as a radian,	**ACOS**	arc cosine (result within 0 and π)
TAN	tangent of an angle expressed as a radian,	**ATAN**	arc tangent (result within $-\frac{\pi}{2}$ and $\frac{\pi}{2}$)

Structure

Ladder language



Instruction List Language

```
LD %M0
[%MF0:=SIN(%MF10)]

LD %I3.2
[%MF2:=TAN(%MF10)]

LDR %I3.3
[%MF4:=ATAN(%MF20)]
```

Structured text language

```
IF %M0 THEN
 %MF0:=SIN(%MF10);
END_IF;
IF %I3.2 THEN
 %MF2:=TAN(%MF10);
END_IF;
IF %I3.3 THEN
 %MF4:=ATAN(%MF20);
END_IF;
```

Syntax

Operators, operands and syntax of instructions for trigonometric operations

Operators	Syntax	Operand 1 (Op1)	Operand 2 (Op2)
SIN, COS, TAN, ASIN, ACOS, ATAN	Op1:=Operator(Op2)	%MFi	%MFi, %KFi

Rules of use

- when the operand of the function is an invalid number (e.g.: arc cosine of a number greater than 1), it produces an indeterminate or infinite result and changes bit %S18 to 1, the word %SW17 (See *System Words (%SW), p. 517*) indicates the cause of the error.
- the functions SIN/COS/TAN allow as a parameter an angle between -4096π and 4096π but their precision decreases progressively for the angles outside the period -2π and $+2\pi$ because of the imprecision brought by the modulo 2π carried out on the parameter before any operation.

Conversion instructions

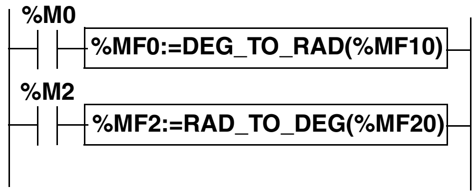
General

These instructions are used to carry out conversion operations.

DEG_TO_RAD	conversion of degrees into radian, the result is the value of the angle between 0 and 2π
RAD_TO_DEG	cosine of an angle expressed in radian, the result is the value of the angle between 0 and 360 degrees

Structure

Ladder language



Instruction List Language

```
LD %M0
[%MF0:=DEG_TO_RAD(%MF10)]

LD %M2
[%MF2:=RAD_TO_DEG(%MF20)]
```

Structured Text language

```
IF %M0 THEN
 %MF0:=DEG_TO_RAD(%MF10);
END_IF;
IF %M2 THEN
 %MF2:=RAD_TO_DEG(%MF20);
END_IF;
```

Syntax

Operators, operands and syntax of conversion instructions

Operators	Syntax	Operand 1 (Op1)	Operand 2 (Op2)
DEG_TO_RAD **RAD_TO_DEG**	Op1:=Operator(Op2)	%MFi	%MFi, %KFi

Rules of use

The angle to be converted must be between -737280.0 and +737280.0 (for DEG_TO_RAD conversions) or between -4096π and 4096π (for RAD_TO_DEG conversions).
For values outside these ranges, the displayed result will be + 1.#NAN, the %S18 and %SW17:X0 bits being set at 1.

Integer Conversion Instructions <-> Floating

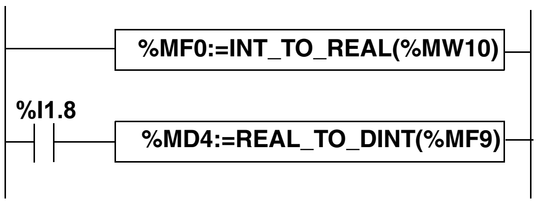
General

Four conversion instructions are offered.
Integer conversion instructions list<-> floating:

INT_TO_REAL	conversion of an integer word --> floating
DINT_TO_REAL	double conversion of integer word --> floating
REAL_TO_INT	floating conversion --> integer word (the result is the nearest algebraic value)
REAL_TO_DINT	floating conversion --> double integer word (the result is the nearest algebraic value)

Structure

Ladder language



Instruction List Language

```
LD TRUE
[%MF0:=INT_TO_REAL(%MW10)]

LD I1.8
[%MD4:=REAL_TO_DINT(%MF9)]
```

Structured Text language

```
%MF0:=INT_TO_REAL(%MW10);
IF %I1.8 THEN
 %MD4:=REAL_TO_DINT(%MF9);
END_IF;
```

Syntax

Operators and syntax (conversion of an integer word --> floating):

Operators	Syntax
INT_TO_REAL	Op1=INT_TO_REAL(Op2)

Operands (conversion of an integer word --> floating):

Operand 1 (Op1)	Operand 2 (Op2)
%MFi	%MWi,%KWi

Example: integer word conversion --> floating: 147 --> 1.47e+02

Operators and syntax (double conversion of integer word --> floating):

Operators	Syntax
DINT_TO_REAL	Op1=DINT_TO_REAL(Op2)

Operands (double conversion of integer word --> floating):

Operand 1 (Op1)	Operand 2 (Op2)
%MFi	%MDi,%KDi

Example:integer double word conversion --> floating: 68905000 --> 6.8905e+07

Operators and syntax (floating conversion --> integer word or integer double word):

Operators	Syntax
REAL_TO_INT	Op1=Operator(Op2)
REAL_TO_DINT	

Operators (floating conversion --> integer word or integer double word):

Type	Operand 1 (Op1)	Operand 2 (Op2)
Words	%MWi	%MFi, %KFi
Double words	%MDi	%MFi, %KFi

Example:
floating conversion --> integer word: 5978.6 --> 5979
floating conversion --> integer double word: -1235978.6 --> -1235979

Note: If during a real to integer (or real to integer double word) conversion the floating value is outside the limits of the word (or double word),bit %S18 is set to 1.

Precision of Rounding

Standard IEEE 754 defines 4 rounding modes for floating operations.
The mode employed by the instructions above is the "rounded to the nearest" mode: "if the nearest representable values are at an equal distance from the theoretical result, the value given will be the value whose low significance bit is equal to 0".
In certain cases, the result of the rounding can thus take a default value or an excess value.

For example:
Rounding of the value 10.5 -> 10
Rounding of the value 11.5 -> 12

15.5 Instructions on Object Tables

At a Glance

Aim of this Section

This section describes instructions specific to tables:

- of double words,
- of floating point objects.

Assignment instructions for tables are described in the chapter on "basic instructions" (See *Assignment of Word, Double Word and Floating Point Tables, p. 345*).

What's in this Section?

This section contains the following topics:

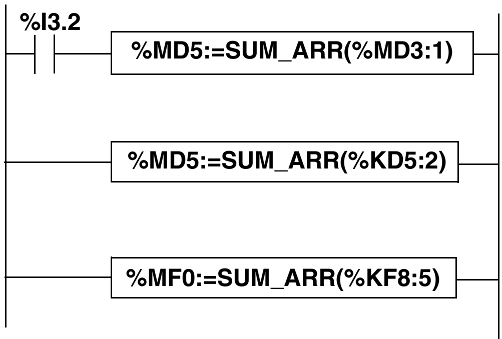
Table summing functions

General

The SUM_ARR function adds together all the elements of an object table:
- if the table is made up of double words, the result is given in the form of a double word
- if the table is made up of floating words, the result is given in the form of a floating word

Structure

Ladder language



Instruction List Language

```
LD %I3.2
[%MD5:=SUM_ARR(%MD3:1)]
%MD5:=SUM_ARR(%KD5:2)
%MF0:=SUM_ARR(%KF8:5)
```

Syntax

Syntax of table summing instruction:

```
Res:=SUM_ARR(Tab)
```

Parameters of table summing instruction

Type	Result (res)	Table (Tab)
Double word tables	%MDi	%MDi:L,%KDi:L
Floating word tables	%MFi	%MFi:L,%KFi:L

Note: When the result is not within the valid double word format range according to the table operand, the system bit %S18 is set to 1.

Example

```
%MD5:=SUM(%MD30:4)
```

where %MD30=10, %MD31=20, %MD32=30, %MD33=40
%MD5=10+20+30+40=100

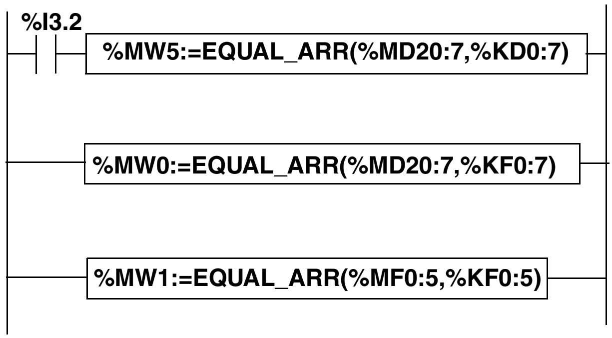
Table comparison functions

General

The EQUAL _ARR function carries out a comparison of two tables, element by element.
If a difference is shown, the rank of the first dissimilar elements is returned in the form of a word, otherwise the returned value is equal to -1.
The comparison is carried out on the whole table.

Structure

Ladder language



Instruction List Language

```
LD %I3.2
[%MW5:=EQUAL_ARR(%MD20:7,KD0:7)]
```

Structured Text language

```
%MW0:=EQUAL_ARR(%MD20:7,%KF0:7)

%MW1:=EQUAL_ARR(%MF0:5,%KF0:5)
```

Syntax

Syntax of table comparison instruction:

```
Res:=EQUAL_ARR(Tab1,Tab2)
```

Parameters of table comparison instructions:

Type	Result (Res)	Tables (Tab1 and Tab2)
Double word tables	%MWi	%MDi:L,%KDi:L
Floating word tables	%MWi	%MFi:L,%KFi:L

Note:
- it is mandatory that the tables are of the same length and same type.

Example

```
%MW5:=EQUAL_ARR(%MD30:4,%KD0:4)
```

Comparison of 2 tables:

Rank	Word Table	Constant word tables	Difference
0	%MD30=10	%KD0=10	=
1	%MD31=20	%KD1=20	=
2	%MD32=30	%KD2=60	Different
3	%MD33=40	%KD3=40	=

The value of the word %MW5 is 2 (different first rank)

Table search functions

General

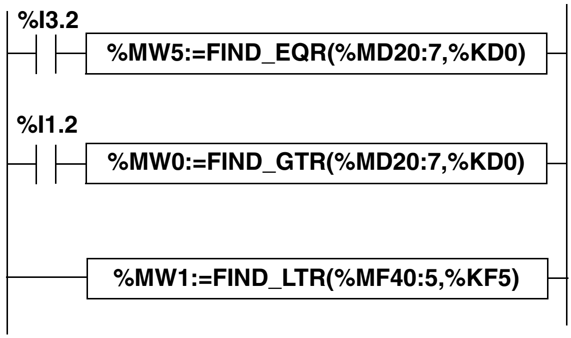
There are 3 search functions:

- **FIND_EQR**: searches for the position in a double or floating word table of the first element which is equal to a given value
- **FIND_GTR**: searches for the position in a double or floating word table of the first element which is greater than a given value
- **FIND_LTR**: searches for the position in a double or floating word table of the first element which is less than a given value

The result of these instructions is equal to the rank of the first element which is found or at -1 if the search is unsuccessful.

Structure

Ladder language



Instruction List Language

```
LD %I3.2
[%MW5:=FIND_EQR(%MD20:7,KD0)]
LD %I1.2
[%MW0:=FIND_GTR(%MD20:7,%KD0)]
%MW1:=FIND_LTR(%MF40:5,%KF5)
```

Syntax

Syntax of table search instructions:

Function	Syntax
FIND_EQR	Res:=Function(Tab,Val)
FIND_GTR	
FIND_LTR	

Parameters of floating word and double word table search instructions:

Type	Result (Res)	Table (Tab)	Value (val)
Floating word tables	%MWi	%MFi:L,%KFi:L	%MFi,%KFi
Double word tables	%MWi	%MDi:L,%KDi:L	%MDi,%KDi

Example

`%MW5:=FIND_EQR(%MD30:4,%KD0)`

Search for the position of the first double word =%KD0=30 in the table:

Rank	Word Table	Result
0	%MD30=10	-
1	%MD31=20	-
2	%MD32=30	Value (val), rank
3	%MD33=40	-

Table search functions for maxi and mini values

General

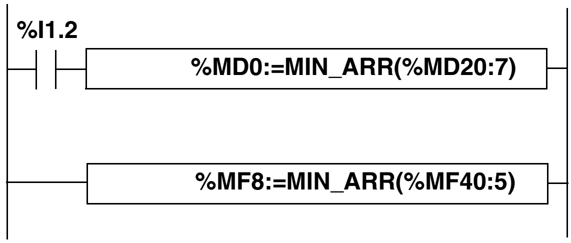
There are 2 search functions:

- **MAX_ARR**: search for the maximum value in a double word and floating word table
- **MIN_ARR**: search for the minimum value in a double word and floating word table

The result of these instructions is equal to the maximum value (or minimum) found in the table.

Structure

Ladder language



Instruction List Language

```
LD %I1.2
[%MD0:=MIN_ARR(%MD20:7)]
%MF8:=MIN_ARR(%MF40:5)
```

Syntax

Syntax of table search instructions for max and min values:

Function	Syntax
MAX_ARR	Res:=Function(Tab)
MIN_ARR	

Parameters of table search instructions for max and min values:

Type	Result (Res)	Table (Tab)
Double word tables	%MDi	%MDi:L,%KDi:L
Floating word tables	%MFi	%MFi:L,%KFi:L

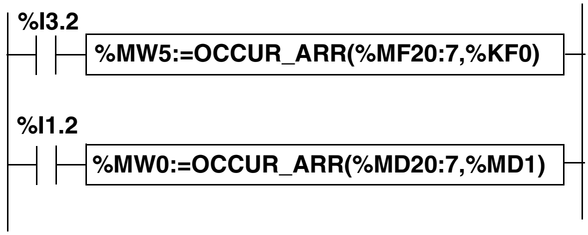
Number of occurrences of a value in a table

General

This search function:
- **OCCUR_ARR**: searches in a double word or floating word table for a number of elements equal to a given value

Structure

Ladder language



Instruction List Language

```
LD %I3.2
[%MW5:=OCCUR_ARR(%MF20:7,%KF0)]
LD %I1.2
[%MW0:=OCCUR_ARR(%MD20:7,%MD1)
```

Syntax

Syntax of table search instructions for max and min values:

Function	Syntax
OCCUR_ARR	Res:=Function(Tab,Val)

Parameters of table search instructions for max and min values:

Type	Result (Res)	Table (Tab)	Value (Val)
Double word tables	%MWi	%MDi:L,%KDi:L	%MDi,%KDi
Floating word tables	%MFi	%MFi:L,%KFi:L	%MFi,%KFi

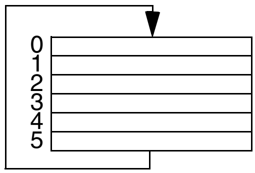
Table rotate shift function

General

There are 2 shift functions:

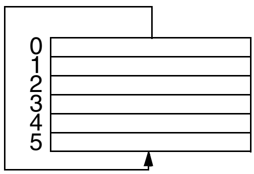
- **ROL_ARR**: performs a rotate shift of n positions from top to bottom of the elements in a floating word table

Illustration of the ROL_ARR functions



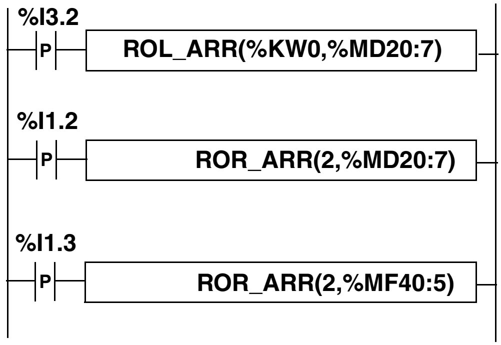
- **ROR_ARR**: performs a rotate shift of n positions from bottom to top of the elements in a floating word table

Illustration of the ROR_ARR functions



Structure

Ladder language



Instruction List Language

```
LDR %I3.2
[ROL_ARR(%KW0,%MD20:7)]
LDR %I1.2
 [ROR_ARR(2,%MD20:7)]
LDR %I1.3
[ROR_ARR(2,%MF40:5)]
```

Syntax

Syntax of rotate shift instructions in floating word or double word tables **ROL_ARR** and **ROR_ARR**

Function	Syntax
ROL_ARR	Function(n,Tab)
ROR_ARR	

Parameters of rotate shift instructions for floating word tables: **ROL_ARR** and **ROR_ARR**:

Type	Number of positions (n)	Table (Tab)
Floating word tables	%MWi, immediate value	%MFi:L
Double word tables	%MWi, immediate value	%MDi:L

Note: if the value of n is negative or null, no shift is performed.

Table sort function

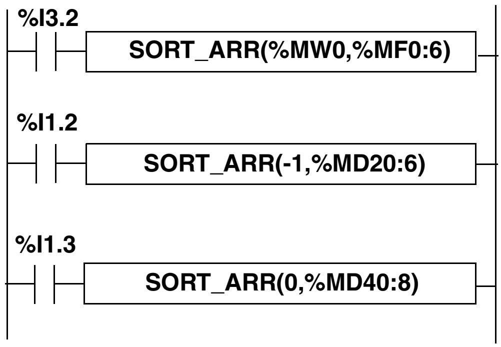
General

The sort function available is as follows:

- **SORT_ARR**: performs sorts in ascending or descending order of the elements of a double word or floating word table and stores the result in the same table.

Structure

Ladder language



Instruction List Language

```
LD %I3.2
[SORT_ARR(%MW20,%MF0:6)]
LD %I1.2
[SORT_ARR(-1,%MD20:6)]
LD %I1.3
[SORT_ARR(0,%MF40:8)
```

Syntax

Syntax of table sort functions:

Function	Syntax
SORT_ARR	Function(direction,Tab)

- the "direction" parameter gives the order of the sort: direction > 0 the sort is done in ascending order; direction < 0, the sort is done in descending order, direction = 0 no sort is performed.
- the result (sorted table) is returned in the Tab parameter (table to sort).

Parameters of table sort functions:

Type	Sort direction	Table (Tab)
Double word tables	%MWi, immediate value	%MDi:L
Floating word tables	%MWi, immediate value	%MFi:L

Floating point table interpolation function

Overview

The **LKUP** function is used to interpolate a set of X versus Y floating point data for a given X value.

Interpolation Rule

The LKUP function makes use the linear interpolation rule, as defined in the following equation:

(equation 1:) $$Y = Y_i + \left[\frac{(Y_{i+1} - Y_i)}{(X_{i+1} - X_i)} \cdot (X - X_i)\right]$$

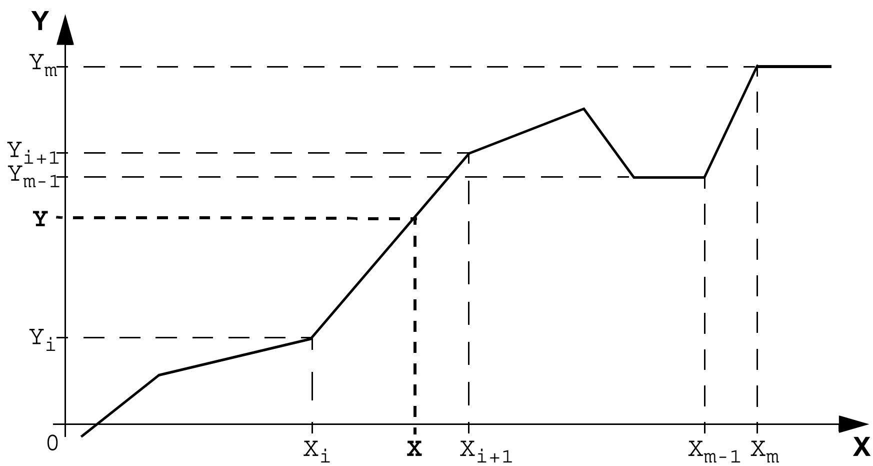
for $X_i \le X \le X_{i+1}$, where $i = 1\ldots(m-1)$;

assuming X_i values are ranked in ascending order: $X_1 \le X_2 \le \ldots X \ldots \le X_{m-1} \le X_m$.

> **Note:** If any of two consecutive Xi values are equal (X_i=X_{i+1}=X), equation (1) yields an invalid exception. In this case, to cope with this exception the following algorithm is used in place of equation (1):
>
> *(equation 2:)* $$Y = \left[\frac{(Y_{i+1} - Y_i)}{2}\right]$$
>
> for $X_i = X_{i+1} = X$, where $i = 1\ldots(m-1)$.

Graphical Representation of the Linear Interpolation Rule

The following graph illustrates the linear interpolation rule described above:



Syntax of the LKUP Function

The LKUP function uses three operands, two of which are function attributes, as described in the following table:

Syntax	Operand 1 (Op1) Output variable	Operand 2 (Op2) User-defined (X) value	Operands 3 (Op3) User-defined (X_i,Y_i) variable array
[Op1: = LKUP(Op2,Op3)]	%MWi	%MF0	Integer value, %MWi or %KWi

Definition of Op1

Op1 is the memory word that contains the output variable of the interpolation function.
Depending on the value of Op1, the user can know whether the interpolation was successful or failed, and what caused for the failure, as outlined in the following table:

Op1 (%Mwi)	Description
0	Successful interpolation
1	Interpolation error: Bad array, $X_m < X_{m-1}$
2	Interpolation error: Op2 out of range, $X < X_1$
4	Interpolation error: Op2 out of range, $X > X_m$
8	Invalid size of data array: ● Op3 is set as odd number, or ● Op3 < 6.

Note: Op1 **does not** contain the computed interpolation value (Y). For a given (X) value, the result of the interpolation (Y) is contained in %MF2 of the Op3 array (See *Definition of Op3* below).

Definition of Op2

Op2 is the floating point variable (%MF0 of the Op3 floating point array) that contains the user-defined (X) value for which to compute the interpolated (Y) value:

- Valid range for Op2 is as follows: $X_1 \leq Op2 \leq X_m$.

Definition of Op3

Op3 sets the size (Op3 / 2) of the floating-point array where the (X_i,Y_i) data pairs are stored.
X_i and Y_i data are stored in floating point objects with even indexes, starting at %MF4 (note that %MF0 and %MF2 floating point objects are reserved for the user set-point X and the interpolated value Y, respectively).

Given an array of (m) data pairs (X_i,Y_i), the upper index (u) of the floating point array (%MFu) is set by using the following relationships:

- *(equation 3:)* $Op3 = 2 \cdot m$;
- *(equation 4:)* $u = 2 \cdot (Op3 - 1)$.

The floating point array Op3 (%MFi) has a structure similar to that of the following example (where Op3=8):

(X)		(X_1)		(X_2)		(X_3)	
%MF0		**%MF4**		**%MF8**		**%MF12**	
	%MF2		**%MF6**		**%MF10**		**%MF14**
	(Y)		(Y_1)		(Y_2)		(Y_3)
							(Op3=8)

Note: As a result of the above floating-point array's structure, Op3 must meet both of the following requirements, or otherwise this will trigger an error of the LKUP function:
- Op3 is an even number, and
- Op3 ≥ 6 (for there must be at least 2 data points to allow linear interpolation).

Structure

Interpolation operations are performed as follows:


```
LD      %I3.2
[%MF20:=LKUP(%MF0,%KW1)]

LD      %I1.2
[%MF22:=LKUP(%MF0,10)]
```

Example

The following is an example use of a LKUP interpolation function:

`[%MW20:=LKUP(%MF0,10)]`

In this example:

- %MW20 is Op1 (the output variable).
- %MF0 is the user-defined (X) value which corresponding (Y) value must be computed by linear interpolation.
- %MF2 stores the computed value (Y) resulting from the linear interpolation.
- 10 is Op3 (as given by *equation 3* above). It sets the size of the floating point array. The highest ranking item %MFu, where u=18 is given by *equation 4,* above.

There are 4 pairs of data points stored in Op3 array [%MF4..%MF18]:

- %MF4 contains X_1,%MF6 contains Y_1.
- %MF8 contains X_2,%MF10 contains Y_2.
- %MF12 contains X_3,%MF14 contains Y_3.
- %MF16 contains X_4,%MF18 contains Y_4.

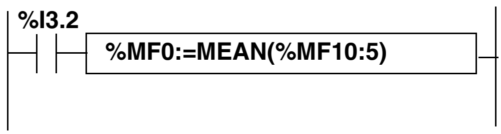
Mean function of the values of a floating point table

General

The **MEAN** function is used to calculate the mean average from a given number of values in a floating point table.

Structure

Ladder Language



Instruction List Language

```
LD %I3.2
[%MF0:=MEAN(%MF10:5)]
```

Syntax

Syntax of the floating point table mean calculation function:

Function	Syntax
MEAN	Result=Function(Op1)

Parameters of the calculation function for a given number L of values from a floating point table:

Operand (Op1)	Result (Res)
%MFi:L, %KFi:L	%MFi

System Bits and System Words

16

At a Glance

Subject of this Chapter

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:

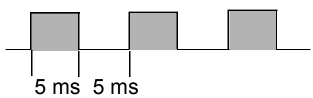
System Bits (%S)

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 of the system bits and how they are controlled:

System Bit	Function	Description	Init state	Control
%S0	Cold Start	Normally set to 0, it is set to 1 by: ● A power return with loss of data (battery fault), ● The user program or Animation Table Editor, ● Operations Display. 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 set to 0, it is set to 1 by: ● A power return with data backup, ● The user program or Animation Table Editor, ● Operations Display. It is reset to 0 by the system at the end of the complete scan.	0	S or U->S
%S4 %S5 %S6 %S7	Time base: 10 ms Time base: 100 ms Time base: 1 s Time base: 1 min	The rate of status changes is measured by an internal clock. They are not synchronized with the controller scan. Example: %S4 	-	S
%S8	Wiring test	Initially set to 1, this bit is used to test the wiring when the controller is in "non-configured" state. To modify the value of this bit, use the operations display keys to make the required output status changes: ● Set to 1, output reset, ● Set to 0, wiring test authorized.	1	U
%S9	Reset outputs	Normally set to 0. It can be set to 1 by the program or by the terminal (in the Animation Table Editor): ● At state 1, outputs are forced to 0 when the controller is in RUN mode, ● At state 0, outputs are updated normally.	0	U

System Bit	Function	Description	Init state	Control
%S10	I/O fault	Normally set to 1. This bit can be set to 0 by the system when an I/O fault is detected.	1	S
%S11	Watchdog overflow	Normally set to 0. This bit can be set to 1 by the system when the program execution time (scan time) exceeds the maximum scan time (software watchdog). Watchdog overflow causes the controller to change to HALT.	0	S
%S12	PLC in RUN mode	This bit reflects the running state of the controller. The systems sets the bit to 1 when the controller is running. Or to 0 for stop, init, or any other state.	0	S
%S13	First cycle in RUN	Normally at 0, this bit is set to 1 by the system during the first scan after the controller has been changed to RUN.	1	S
%S17	Capacity exceeded	Normally set to 0, it is set to 1 by the system: ● During a rotate or shift operation. The system switches the bit output to 1. 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
%S18	Arithmetic overflow or error	Normally set to 0. It is set to 1 in the case of an overflow when a 16 bit operation is performed, that is: ● A result greater than + 32 767 or less than - 32 768, in single length, ● A result greater than + 2 147 483 647 or less than - 2 147 483 648, in double length, ● A result greater than + 3.402824E+38 or less than - 3.402824E+38, in floating point, ● Division by 0, ● The square root of a negative number, ● BTI or ITB conversion not significant: BCD value out of limits. 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). This bit is reset to 0 by the user.	0	S->U

System Bit	Function	Description	Init state	Control
%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. 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 set to 0, it is set to 1 by: ● A cold restart, %S0=1, ● The user program, in the preprocessing program part only, using a Set Instruction (S %S21) or a set coil -(S)- %S21, ● The terminal. At state 1, it causes GRAFCET initialization. Active steps are deactivated and initial steps are activated. It is reset to 0 by the system after GRAFCET initialization.	0	U->S
%S22	GRAFCET reset	Normally set to 0, it can only be set to 1 by the program in pre-processing. 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 set to 0, it can only be set to 1 by the program in the pre-processing program module. Set to 1, it validates the pre-positioning of GRAFCET. 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	Operations Display	Normally at 0, this bit can be set to 1 by the user. ● At state 0, the Operator Display is operating normally, ● At state 1, the Operator Display is frozen, stays on current display, blinking disabled, and input key processing stopped.	0	U->S

System Bit	Function	Description	Init state	Control
%S31	Event mask	Normally at 1. • Set to 0, events cannot be executed and are queued. • Set to 1, events can be executed, This bit can be set to 0 by the user and the system (on cold re-start).	1	U->S
%S38	Permission for events to be placed in the events queue	Normally at 1. • Set to 0, events cannot be placed in the events queue. • Set to 1, events are placed in the events queue as soon as they are detected, This bit can be set to 0 by the user and the system (on cold re-start).	1	U->S
%S39	Saturation of the events queue	Normally at 0. • Set to 0, all events are reported, • Set to 1, at least one event is lost. This bit can be set to 0 by the user and the system (on cold re-start).	0	U->S
%S50	Updating the date and time using words %SW49 to %SW53	Normally on 0, this bit can be set to 1 or 0 by the program or the Operator Display. • Set to 0, the date and time can be read, • Set to 1, the date and time can be updated. The controller's internal RTC is updated on a falling edge of %S50.	0	U->S
%S51	Time-of-day clock status	Normally on 0, this bit can be set to 1 or 0 by the program or the Operator Display. • Set to 0, the date and time are consistent, • Set to 1, the date and time must be initialized by the user. 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 (never configured, difference between the corrected clock value and the saved value, or value out of range). State 1 transitioning to state 0 forces a write of the correction constant to the RTC.	0	U->S

System Bit	Function	Description	Init state	Control
%S52	RTC = error	This bit managed by the system indicates that the RTC correction has not been entered, and the date and time are false. ● Set to 0, the date and time are consistent, ● At state 1, the date and time must be initialized.	0	S
%S59	Updating the date and time using word %SW59	Normally on 0, this bit can be set to 1 or 0 by the program or the Operator Display. ● Set to 0, the system word %SW59 is not managed, ● Set to 1, the date and time are incremented or decremented according to the rising edges on the control bits set in %SW59.	0	U
%S66	BAT LED display enable/disable (only on controllers that support an external battery: TWDLCA•40DRF controllers.)	This system bit can be set by the user. It allows the user to turn on/off the BAT LED: ● Set to 0, BAT LED is enabled (it is reset to 0 by the system at power-up), ● Set to 1, BAT LED is disabled (LED remains off even if there is a low external battery power or there is no external battery in the compartment).	0	S or U->S
%S69	User STAT LED display	Set to 0, STAT LED is off. Set to 1, STAT LED is on.	0	U
%S75	External battery status (only on controllers that support an external battery: TWDLCA•40DRF controllers.)	This system bit is set by the system. It indicates the external battery status and is readble by the user: ● Set to 0, external battery is operating normally, ● Set to 1, external battery power is low, or external battery is absent from compartment.	0	S
%S95	Restore memory words	This bit can be set when memory words were previously saved to the internal EEPROM. Upon completion the system sets this bit back to 0 and the number of memory words restored is set in %SW97	0	U
%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. ● Set to 0, the backup program is invalid. ● Set to 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. ● Set to 0, save %MW is not OK. ● Set to 1, save %MW is OK.	0	S

System Bit	Function	Description	Init state	Control
%S100	TwidoSoft communications cable connection	Shows whether the TwidoSoft communication cable is connected. ● Set to 1, TwidoSoft communications cable is either not attached or TwidoSoft is connected. ● Set to 0, TwidoSoft Remote Link cable is connected.	-	S
%S101	Changing a port address (Modbus protocol)	Used to change a port address using system words %SW101 (port 1) and %SW102 (port 2). To do this, %S101 must be set to 1. ● Set to 0, the address cannot be changed. The value of %SW101 and %SW102 matches the current port address, ● Set to 1, the address can be changed by changing the values of %SW101 (port 1) and %SW102 (port 2). Having modified the values of the system words, %S101 must be set back to 0.	0	U
%S103 %S104	Using the ASCII protocol	Enables the use of the ASCII protocol on Comm 1 (%S103) or Comm 2 (%S104). The ASCII protocol is configured using system words %SW103 and %SW105 for Comm 1, and %SW104 and %SW106 for Comm 2. ● Set to 0, the protocol used is the one configured in Twido Soft, ● Set to 1, the ASCII protocol is used on Comm 1 (%S103) or Comm 2 (%S104). In this case, the system words %SW103 and %SW105 must be previously configured for Comm 1, and %SW104 and %SW106 for Comm 2.	0	U
%S110	Remote link exchanges	This bit is reset to 0 by the program or by the terminal. ● Set to 1 for a master, all remote link exchanges (remote I/O only) are completed. ● Set to 1 for a slave, exchange with master is completed.	0	S->U
%S111	Single remote link exchange	● Set to 0 for a master, a single remote link exchange is completed. ● Set to 1 for a master, a single remote link exchange is active.	0	S
%S112	Remote link connection	● Set to 0 for a master, the remote link is activated. ● Set to 1 for a master, the remote link is deactivated.	0	U

System Bit	Function	Description	Init state	Control
%S113	Remote link configuration/operation	• Set to 0 for a master or slave, the remote link configuration/operation is OK. • Set to 1 for a master, the remote link configuration/ operation has an error. • Set to 1 for a slave, the remote link configuration/ operation has an error.	0	S->U
%S118	Remote I/O error	Normally set to 1. This bit can be set to 0 when an I/O fault is detected on the remote link.	1	S
%S119	Local I/O error	Normally set to 1. This bit can be set to 0 when an I/O fault is detected on the remote link. %SW118 determines the nature of the fault. Resets to 1 when the fault disappears.	1	S

Table Abbreviations Described

Abbreviation table:

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 Words	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 Status	Controller Status: 0 = NO CONFIG 2 = STOP 3 = RUN 4 = HALT	S

System Words	Function	Description	Control

%SW7	Controller state	• Bit [0]: Backup/restore in progress:
		  • Set to 1 if backup/restore in progress,
		  • Set to 0 if backup/restore complete or disabled.
		• Bit [1]: Controller's configuration OK:
		  • Set to 1 if configuration ok.
		• Bit [3..2] EEPROM status bits:
		  • 00 = No cartridge
		  • 01 = 32 Kb EEPROM cartridge
		  • 10 = 64 Kb EEPROM cartridge
		  • 11 = Reserved for future use
		• Bit [4]: Application in RAM different than EEPROM:
		  • Set to 1 if RAM application different to EEPROM.
		• Bit [5]: RAM application different to cartridge:
		  • Set to 1 if RAM application different to cartridge.
		• Bit [6] not used (status 0)
		• Bit [7]: Controller reserved:
		  • Set to 1 if reserved.
		• Bit [8]: Application in Write mode:
		  • Set to 1 if application is protected.
		• Bit [9] not used (status 0)
		• Bit [10]: Second serial port installed:
		  • Set to 1 if installed.
		• Bit [11]: Second serial port type: (0 = EIA RS-232, 1 = EIA RS-485):
		  • Set to 0 = EIA RS-232
		  • Set to 1 = EIA RS-485
		• Bit [12]: application valid in internal memory:
		  • Set to 1 if application valid.
		• Bit [13] Valid application in cartridge:
		  • Set to 1 if application valid.
		• Bit [14] Valid application in RAM:
		  • Set to 1 if application valid.
		• Bit [15]: ready for execution:
		  • Set to 1 if ready for execution.
			S

%SW11	Software watchdog value	Contains the maximum value of the watchdog. The value (10 to 500 ms) is defined by the configuration.	U

System Words	Function	Description	Control
%SW17	Default status for floating operation	When a fault is detected in a floating arithmetic operation, bit %S18 is set to 1 and the default status of %SW17 is updated according to the following coding: ● Bit [0]: Invalid operation, result is not a number (1.#NAN or -1.#NAN), ● Bit 1: Reserved, ● Bit 2: Divided by 0, result is infinite (-1.#INF or 1.#INF), ● Bit 3: Result greater in absolute value than +3.402824e+38, result is infinite (-1.#INF or 1.#INF).	S and U
%SW18-%SW19	100 ms absolute timer counter	The counter works using two words: ● **%SW18** represents the least significant word, ● **%SW19** represents the most significant word.	S and U
%SW30	Last scan time	Shows execution time of the last controller scan cycle (in ms). **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). **Notes:** ● This time corresponds to the time elapsed between the start (acquisition of inputs) and the end (update of outputs) of a scan cycle. ● To allow proper detection when a pulse signal is provided on input, the pulse period (T_{pulse}) of that signal must be longer than twice the maximum scan time recorded in system word %SW31, as specified by the following condition: [$T_{pulse} \geq 2$ x %SW31].	S
%SW32	Min. scan time	Shows execution time of shortest controller scan cycle since the last cold start (in ms). **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
%SW48	Number of events	Shows how many events have been executed since the last cold start. **Note:** Set to 0 (after application loading and cold start), increments on each event execution.	S

System Words	Function	Description		Control
%SW49 %SW50 %SW51 %SW52 %SW53	Real-Time Clock (RTC)	RTC Functions: words containing current date and time values (in BCD):		S and U
		%SW49	xN Day of the week (N=1 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. On a falling edge of **%S50** the controller's internal RTC is updated from the values written in these words.		
%SW54 %SW55 %SW56 %SW57	Date and time of the last stop	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. Contains two sets of 8 bits to adjust current date. 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 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	Month	
		bit 6	bit 14	Years	
		bit 7	bit 15	Centuries	
%SW60	RTC correction	RTC correction value			U
%SW63	EXCH1 block error code	EXCH1 error code: 0 - operation was successful 1 – number of bytes to be transmitted is too great (> 250) 2 - transmission table too small 3 - word table too small 4 - receive table overflowed 5 - time-out elapsed 6 - transmission 7 - bad command within table 8 - selected port not configured/available 9 - reception error 10 - can not use %KW if receiving 11 - transmission offset larger than transmission table 12 - reception offset larger than reception table 13 - controller stopped EXCH processing			S
%SW64	EXCH2 block error code	EXCH2 error code: See %SW63.			S

System Word	Function	Description	Control
%SW65	EXCH3 block error code	EXCH3 error code is implemented on Ethernet-capable TWDLCAE40DRF Twido controllers only 1-4, 6-13: See %SW63. (Note that eror code 5 is invalid and replaced by the Ethernet-specific error codes 109 and 122 described below.) The following are dedicated to Modbus response: 81 - slave (server) PLC returns ILLEGAL FUNCTION response 82 - slave (server) PLC returns ILLEGAL DATA ADDRESS response 83 - slave (server) PLC returns ILLEGAL DATA VALUE response 84 - slave (server) PLC returns SLAVE DEVICE FAILURE response 85 - slave (server) PLC returns ACKNOWLEDGE response 86 - slave (server) PLC returns SLAVE DEVICE BUSY response 87 - slave (server) PLC returns NEGATIVE ACKNOWLEDGE response 88 - slave (server) PLC returns MEMORY PARITY ERROR response The following are Ethernet-specific error codes: 101 - no such IP address 102 - the TCP connection is broken 103 - no socket available (all connection channels are busy) 104 - network is down 105 - network cannot be reached 106 - network dropped connection on reset 107 - connection aborted by peer device 108 - connection reset by peer device 109 - connection time-out elapsed 110 - rejection on connection attempt 111 - host is down 120 - unknown index (remote device is not indexed in configuration table) 121 - fatal (MAC, Chip, Duplicated IP)122 - receiving timed-out elapsed after data was sent 123 - Ethernet initialization in progress	S
%SW67	Function and type of controller	Contains the following information: ● Controller type bits [0 -11] ● 8B0 = TWDLC•A10DRF ● 8B1 = TWDLC•A16DRF ● 8B2 = TWDLMDA20DUK/DTK ● 8B3 = TWDLC•A24DRF ● 8B4 = TWDLMDA40DUK/DTK ● 8B6 = TWDLMDA20DRT ● 8B8 = TWDLCAA40DRF ● 8B9 = TWDLCAE40DRF ● Bit 12,13,14,15 not used = 0	S

System Words	Function	Description	Control
%SW73 and %SW74	AS-Interface System State	• Bit [0]: Set to 1 if configuration OK. • Bit [1]: Set to 1 if data exchange enabled. • Bit [2]: Set to 1 if module in Offline mode. • Bit [3]: Set to 1 if ASI_CMD instruction terminated. • Bit [4]: Set to 1 error in ASI_CMD instruction in progress.	S and U
%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 decrementation.	S and U
%SW80	Base I/O Status	Bit [0] Channels in normal operation (for all its channels) Bit [1] Module under initialization (or of initializing information of all channels) Bit [2] Hardware failure (external power supply failure, common to all channels) Bit [3] Module configuration fault Bit [4] Converting data input channel 0 in progress Bit [5] Converting data input channel 1 in progress Bit [6] Input thermocouple channel 0 not configured Bit [7] Input thermocouple channel 1 not configured Bit [8] Not used Bit [9] Unused Bit [10] Analog input data channel 0 over range Bit [11] Analog input data channel 1 over range Bit [12] Incorrect wiring (analog input data channel 0 below current range, current loop open) Bit [13] Incorrect wiring (analog input data channel 1 below current range, current loop open) Bit [14] Unused Bit [15] Output channel not available	
%SW81	Expansion I/O Module 1 Status: Same definitions as %SW80		
%SW82	Expansion I/O Module 2 Status: Same definitions as %SW80		
%SW83	Expansion I/O Module 3 Status: Same definitions as %SW80		
%SW84	Expansion I/O Module 4 Status: Same definitions as %SW80		
%SW85	Expansion I/O Module 5 Status: Same definitions as %SW80		
%SW86	Expansion I/O Module 6 Status: Same definitions as %SW80		
%SW87	Expansion I/O Module 7 Status: Same definitions as %SW80		
%SW81 to %SW87	Expansion module status		

System Words	Function	Description	Control

%SW96	Command and/or diagnostics for save/restore function of application program and %MW.	• Bit [0]: Indicates that the %MW memory words must be saved to EEPROM:
		  • Set to 1 if a backup is required,
		  • Set to 0 if the backup in progress is not complete.
		• Bit [1]: This bit is set by the firmware to indicate when the save is complete:
		  • Set to 1 if the backup is complete,
		  • Set to 0 if a new backup request is asked for.
		• Bit [2]: Backup error, refer to bits 8, 9, 10 and 14 for further information:
		  • Set to 1 if an error appeared,
		  • Set to 0 if a new backup request is asked for.
		• Bit [6]: Set to 1 if the controller contains an empty application.
		• Bit [8]: Indicates that the number of %MWs specified in %SW97 is greater than the number of %MWs configured in the application:
		  • Set to 1 if an error is detected,
		• Bit [9]: Indicates that the number of %MWs specified in %SW97 is greater than the maximum number of %MWs that can be defined by any application in TwidoSoft.
		  • Set to 1 if an error is detected,
		• Bit [10]: Difference between internal RAM and internal EEPROM (1 = yes).
		  • Set to 1 if there is a difference.
		• Bit [14]: Indicates if an EEPROM write fault has occurred:
		  • Set to 1 if an error is detected,
			S and U

%SW97	Command or diagnostics for save/restore function	When saving memory words, this value represents the physical number %MW to be saved to internal EEPROM. When restoring memory words, this value is updated with the number of memory words restored to RAM. For the save operation, when this number is set to 0, memory words will not be stored. The user must define the user logic program. Otherwise, this program is set to 0 in the controller application, except in the following case: On cold start, this word is set to -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** list, the value of the number of saved memory words in the file must be set in this system word **%SW97**.	S and U

System Words	Function	Description	Control
%SW101 %SW102	Value of the port's Modbus address	When bit %S101 is set to 1, you can change the Modbus address of port 1 or port 2. The address of port 1 is %SW101, and that of port 2 is %SW102.	S

<table>
<tr><th>System Words</th><th>Function</th><th>Description</th><th>Control</th></tr>
<tr><td>%SW103
%SW104</td><td>Configuration for use of the ASCII protocol</td><td>When bit %S103 (Comm 1) or %S104 (Comm 2) is set to 1, the ASCII protocol is used. System word %SW103 (Comm 1) or %SW104 (Comm 2) must be set according to the elements below:
<table>
<tr><td>15</td><td>14</td><td>13</td><td>12</td><td>11</td><td>10</td><td>9</td><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td colspan="8">End of the character string</td><td>Data bit</td><td>Stop bit</td><td colspan="2">Parity</td><td>RTS / CTS</td><td colspan="3">Baud rate</td></tr>
</table>

Baud rate:
0: 1200 bauds,
1: 2400 bauds,
2: 4800 bauds,
3: 9600 bauds,
4: 19200 bauds,
5: 38400 bauds.
RTS/CTS:
0: disabled,
1: enabled.
Parity:
00: none,
10: odd,
11: even.
Stop bit:
0: 1 stop bit,
1: 2 stop bits.
Data bits:
0: 7 data bits,
1: 8 data bits.
</td><td>S</td></tr>
<tr><td>%SW105
%SW106</td><td>Configuration for use of the ASCII protocol</td><td>When bit %S103 (Comm 1) or %S104 (Comm 2) is set to 1, the ASCII protocol is used. System word %SW105 (Comm 1) or %SW106 (Comm 2) must be set according to the elements below:
<table>
<tr><td>15</td><td>14</td><td>13</td><td>12</td><td>11</td><td>10</td><td>9</td><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td colspan="8">Timeout frame in ms</td><td colspan="8">Timeout response
in multiple of 100 ms</td></tr>
</table></td><td>S</td></tr>
<tr><td>%SW111</td><td>Remote link status</td><td>Indication: Bit 0 corresponds to remote controller 1, bit 1 to remote controller 2, etc.
Bit [0] to [6]:
Set to 0 = remote controller 1-7 absent
Set to 1 = remote controller 1-7 present
Bit [8] to bit [14]:
Set to 0 = remote I/O detected on remote controller 1-7
Set to 1 = extension controller detected on remote controller 1-7</td><td>S</td></tr>
</table>

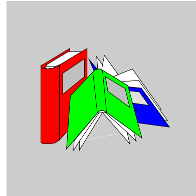
System Words	Function	Description	Control
%SW112	Remote Link configuration/ operation error code	00: successful operations 01: timeout detected (slave) 02: checksum error detected (slave) 03: configuration mismatch (slave) This is set to 1 by the system and must be reset by the user.	S
%SW113	Remote link configuration	Indication: Bit 0 corresponds to remote controller 1, bit 1 to remote controller 2, etc. Bit [0] to [6]: ● Set to 0 = remote controller 1-7 not configured ● Set to 1 = remote controller 1-7 configured Bit [8] to bit [14]: ● Set to 0 = remote I/O configured as remote controller 1-7 ● Set to 1 = peer controller configured as remote controller 1-7	S
%SW114	Enable schedule blocks	Enables or disables operation of schedule blocks by the user program or operator display. Bit 0: 1 = enables schedule block #0 ... Bit 15: 1 = enables schedule block #15 Initially all schedule blocks are enabled. If schedule blocks are configured the default value is FFFF If no schedule blocks are configured the default value is 0.	S and U
%SW118	Base controller status word	Shows faults detected on master controller. Bit 9: 0 = External fault or comm. Fault Bit 12: 0 = RTC not installed Bit 13: 0 = Configuration fault (I/O extension configured but absent or faulty). 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. Address 0 = Bit 0 1 = Unhealthy 0 = OK	S

Table Abbreviations Described

Abbreviation table:

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

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 converted 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 a 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) Communication protocol for representing alphanumeric characters, notably letters, figures and certain graphic 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

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

Client A computer process requesting service from other computer processes.

Coil A ladder diagram element representing an output from the controller.

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 by loading a new application into controller RAM. Any controller without battery backup always powers 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 texts 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 configured value that cannot be modified by the program being executed.

Contact A ladder diagram element representing an input to the controller.

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

Data variable See Variable.

Date/Clock functions Allow control of events by month, day of month, and time of day. See Schedule Blocks.

Default gateway The IP address of the network or host to which all packets addressed to an unknown network or host are sent. The default gateway is typically a router or other device.

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 the application in the controller, and has two options:
- To delete the contents of the controller RAM, the controller internal EEPROM, and the installed optional backup cartridge.
- To delete the contents of the installed optional backup cartridge only.

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.

Frame A group of bits which form a discrete block of information. Frames contain network control information or data. The size and composition of a frame is determined by the network technology being used.

Framing types Two common framing types are Ethernet II and IEEE 802.3.

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

Gateway A device which connects networks with dissimilar network architectures and which operates at the Application Layer. This term may refer to a router.

Grafcet Grafcet is used to represent the functioning of a sequential operation in a structured and graphic form.
This is an analytical method that divides any sequential control system into a series of steps, with which actions, transitions, and conditions are associated.

H

Host A node on a network.

Hub A device which connects a series of flexible and centralized modules to create a network.

I

Init state The operating state of TwidoSoft that is displayed on the Status Bar when TwidoSoft is started or does not have an open application.

Initialize A command that sets all data values to initial states. The controller must be in Stop or Error mode.

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.

Internet The global interconnection of TCP/IP based computer communication networks.

IP Internet Protocol. A common network layer protocol. IP is most often used with TCP.

IP Address Internet Protocol Address. A 32-bit address assigned to hosts using TCP/IP.

L

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

MAC Address Media Access Control address. The hardware address of a device. A MAC address is assigned to an Ethernet TCP/IP module in the factory.

Master controller A Twido controller configured to be the Master on a Remote Link network.

MBAP Modbus Application Protocol

Memory cartridge Optional Backup Memory Cartridges that can be used to backup and restore an application (program and configuration data). There are two sizes available: 32 and 64 Kb.

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.

N

Network Interconnected devices sharing a common data path and protocol for communication.

Node An addressable device on a communications network.

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. Online operation can be used to debug an application.

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 Indicates the TwidoSoft state. Displayed in 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

Packet The unit of data sent across a network.

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).

PLC Twido programmable controller. There are two types of controllers: Compact and Modular.

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 all reads and writes of the application program.

Protocol Describes message formats and a set of rules used by two or more devices to communicate using those formats.

PWM Pulse Width Modulation. A function block that generates a rectangular 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.

Router A device that connects two or more sections of a network and allows information to flow between them. A router examines every packet it receives and decides whether to block the packet from the rest of the network or transmit it. The router will attempt to send the packet through the network by the most efficient path.

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 located between two potential bars in a grid and is composed of a group of graphical elements joined to each other by horizontal and 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.

Server A computer process that provides services to clients. This term may also refer to the computer process on which the service is based.

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.

Subnet A physical or logical network within an IP network, which shares a network address with other portions of the network.

Subnet mask A bit mask used to identify or determine which bits in an IP address correspond to the network address and which bits correspond to the subnet portions of the address. The subnet mask is the network address plus the bits reserved for identifying the subnetwork.

Switch A network device which connects two or more separate network segments and allows traffic to be passed between them. A switch determines whether a frame should be blocked or transmitted based on its destination address.

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

TCP Transmission Control Protocol.

TCP/IP A protocol suite consisting of the Transmission Control Protocol and the Internet Protocol; the suite of communications protocols on which the Internet is based.

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 counter: 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.

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