Magelis SCU

SoMachine
Programming Guide

05/2013

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When devices are used for applications with technical safety requirements, the relevant instructions must be followed.

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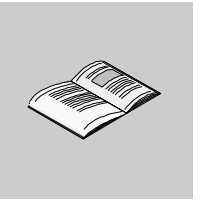

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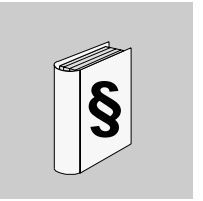
Safety Information



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 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 or serious injury.

⚠ WARNING

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

⚠ CAUTION

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

NOTICE

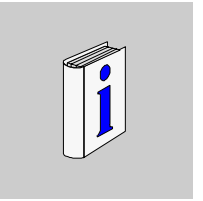
NOTICE is used to address practices not related to physical injury.

PLEASE NOTE

Electrical equipment should be installed, operated, serviced, and maintained only by qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material.

A qualified person is one who has skills and knowledge related to the construction and operation of electrical equipment and its installation, and has received safety training to recognize and avoid the hazards involved.

About the Book



At a Glance

Document Scope

The purpose of this document is to help you to configure and program your HMI SCU. For the programming of the HMI portion, please see the Vijeo-Designer online help which can be found in SoMachine.

NOTE: Read and understand this document and all related documents before installing, operating, or maintaining your HMI SCU.

You should read through the entire document to understand all features.

Validity Note

This document has been updated with the release of SoMachine V3.1 or later.

Related Documents

Title of Documentation	Reference Number
SoMachine Magelis SCU PLCSystem Library Guide	EIO0000001246 (eng), EIO0000001247 (fre), EIO0000001248 (ger), EIO0000001249 (spa), EIO0000001250 (ita), EIO0000001251 (chs)

SoMachine Magelis SCU HSC Library Guide	EIO0000001512 (eng), EIO0000001513 (fre), EIO0000001514 (ger), EIO0000001515 (spa), EIO0000001516 (ita), EIO0000001517 (chs)
SoMachine Magelis SCU PTO/PWM Library Guide	EIO0000001518 (eng), EIO0000001519 (fre), EIO0000001520 (ger), EIO0000001521 (spa), EIO0000001522 (ita), EIO0000001523 (chs)
PLCCommunication Library Guide	EIO0000000361 (eng), EIO0000000742 (fre), EIO0000000743 (ger), EIO0000000744 (spa), EIO0000000745 (ita), EIO0000000746 (chs)

Magelis SCU HMI Controller Hardware Guide	EIO0000001232 (eng), EIO0000001233 (fre), EIO0000001234 (ger), EIO0000001235 (spa), EIO0000001236 (ita), EIO0000001237 (chs), EIO0000001238 (por)

You can download these technical publications and other technical information from our website at www.schneider-electric.com.

Product Related Information

⚠ WARNING

LOSS OF CONTROL

- The designer of any control scheme must consider the potential failure modes of control paths and, for certain critical control functions, provide a means to achieve a safe state during and after a path failure. Examples of critical control functions are emergency stop and overtravel stop, power outage and restart.
- Separate or redundant control paths must be provided for critical control functions.
- System control paths may include communication links. Consideration must be given to the implications of unanticipated transmission delays or failures of the link.
- Observe all accident prevention regulations and local safety guidelines.[1]
- Each implementation of this equipment must be individually and thoroughly tested for proper operation before being placed into service.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

[1] For additional information, refer to NEMA ICS 1.1 (latest edition), "Safety Guidelines for the Application, Installation, and Maintenance of Solid State Control" and to NEMA ICS 7.1 (latest edition), "Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable-Speed Drive Systems" or their equivalent governing your particular location.

⚠ WARNING

UNINTENDED EQUIPMENT OPERATION

- Only use software approved by Schneider Electric for use with this equipment.
- Update your application program every time you change the physical hardware configuration.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

User Comments

We welcome your comments about this document. You can reach us by e-mail at techcomm@schneider-electric.com.

About the Magelis SCU HMI Controller

1

Magelis SCU HMI Controller Devices Overview

Overview

The Schneider Electric Magelis SCU HMI Controller has various powerful features. This controller can service a wide range of applications.

The software configuration and programming is accomplished with the SoMachine software.

Key Features

Programming languages

The Magelis SCU HMI Controller is supported and programmed with the SoMachine software, which supports the following IEC61131-3 programming languages:

- IL: Instruction List
- ST: Structured Text
- FBD: Function Block Diagram
- SFC: Sequential Function Chart
- LD: Ladder Diagram

SoMachine software can also be used to program these controllers using CFC (Continuous Function Chart) language.

Real-Time Clock *(see Magelis SCU, HMI Controller, Hardware Manual)*

The Magelis SCU HMI Controller includes a Real Time Clock (RTC) system

Memory

The table shows the memory specifications:

Area	Element	Size (bytes)
System Area	System area reserved memory	131072
	System and diagnostic variables	
	Physical input addresses (%I)	256
	Physical output addresses (%Q)	256
	Retain variables (1)	16360
	Persistent retain variables	2044
Application Area	Compiled control application	1024000
User Area	Symbols	Dynamic allocation of 1024000
	Variables	
	Libraries	
(1) Not all of the 16360 bytes are available for the customer application because some libraries may use retain variables.		

Embedded Input/Output

The following embedded I/O types are available, depending on the controller model *(see Magelis SCU, HMI Controller, Hardware Manual)*:
- Regular inputs
- Fast inputs (HSC)
- Regular outputs
- Fast outputs (PTO/PWM)
- Analog inputs
- Analog outputs
- Thermocouple inputs
- RTD (Resistance Temperature Detector) inputs

Embedded Communication features

4 types of communication ports are available on the rear panel:
- Ethernet port
- CANopen
- USB programming ports
- Serial link port

For more details, refer to the chapter Integrated Communication Ports *(see Magelis SCU, HMI Controller, Hardware Manual)*.

Magelis SCU HMI Controller Range

Reference	Digital Input	Digital Output	Analog Input	Analog Output	Screen Size
HMISCU6A5	14 regular inputs and 2 fast inputs (HSC)(1)	8 regular outputs and 2 fast outputs (PTO)(2)	No	No	8.9 cm (3.5 in.)
HMISCU8A5					14.48 cm (5.7 in.)
HMISAC					No
HMISCU6B5	6 regular inputs and 2 fast inputs (HSC)(1)	6 regular outputs and 2 fast outputs (PTO)(2)	2 analog inputs (12-bit plus sign SAR ADC) and 2 analog inputs (16-bit), thermocouple and RTD	2 analog outputs (12-bit)	8.9 cm (3.5 in.)
HMISCU8B5					14.48 cm (5.7 in.)
HMISBC					No

(1) The fast inputs can be used either as regular inputs or as fast inputs for counting or event functions.
(2) The fast outputs can be used either as regular outputs or as fast outputs for PTO, PWM functions, or reflex output for HSC.

How to Configure the Controller

2

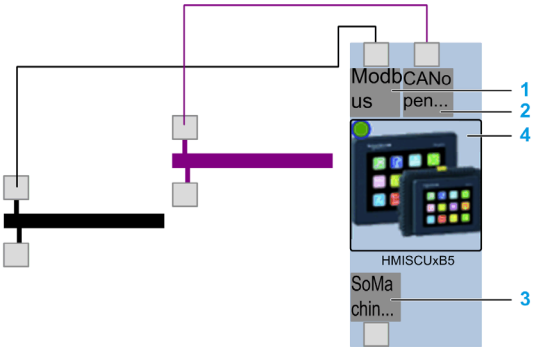
How to Configure the HMI Controller

Introduction

Before configuring the HMI controller, you must first create a new project or open an existing project in the SoMachine software *(see SoMachine, Programming Guide)*.

Graphical Configuration Editor

In the Graphical Configuration Editor *(see SoMachine, Programming Guide)*, the HMI controller is displayed as below:



Click on the element to add (if empty) or replace objects:

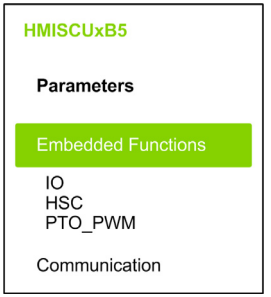
Element	Description
1	COM1 (Serial) port manager (**SoMachine_Network_Manager** by default)
2	CANopen port (CAN)
3	Ethernet port manager
4	Access to the HMI controller configuration screen (double-click the HMI controller)

HMI Controller Configuration Screen

To access the HMI controller configuration screen, proceed as follows:

Step	Action
1	Select the **Configuration** tab.
2	Double-click the HMI controller.

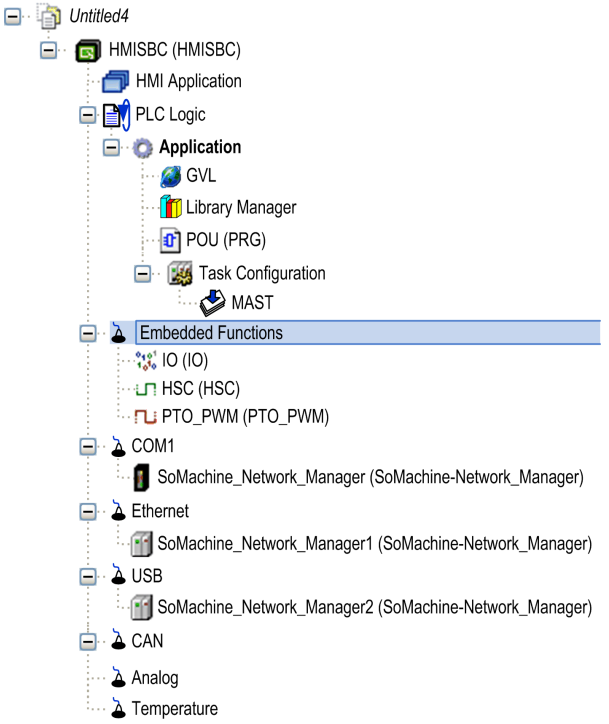
In the task selection pane, entries and sub-entries allow you to access the different configuration windows:



Entry	Sub-entry	Refer to...
Parameters	-	HMI Controller Device Editor *(see page 64)*
Embedded Functions	**IO**	Embedded regular digital I/O configuration *(see page 70)*
	HSC PTO_PWM	I/O Embedded Function configuration *(see page 73)*
	Analog Temperature	Analog I/O embedded function *(see page 79)* and analog temperature embedded function *(see page 83)* **NOTE:** Only available on HMISCU6B5, HMISCU8B5 including HMISBC
Communication	**CAN**	CANopen configuration *(see page 99)*
	COM1	Serial Line configuration *(see page 89)*
	Ethernet	Ethernet configuration *(see page 103)*

Device Tree

The HMI controller functions of the **Configuration** tab are also accessible from the **Program** tab. There, the **Devices** tree describes the hardware configuration (for example, the following **Devices** tree is the default tree when the HMI controller is added):



Item	Description
PLC Logic	This part shows items related to the application: ● Tasks configuration ● Program Organization Units (POUs) ● Library manager ● Global Variable Lists (GVLs) ● etc.
Embedded Functions	This representation shows the embedded functions.
COM1 **Ethernet** **USB** **CAN**	These are the embedded communications.

Content of Device Tree

The device tree represents the objects managed by a specific target (controller or HMI controller). These objects are:

- application objects (Tasks, etc.),
- programming objects (POU, GVL, etc.),
- hardware-related objects (Embedded functions, Embedded I/O, etc.)

By default, the device tree includes the following hardware-related objects:

Reference	Hardware-Related Objects	
HMISCU6A5 HMISCU8A5 HMISCU6B5 HMISCU8B5	**Embedded Functions**	IO HSC PTO_PWM
	Communications	COM1 (SoMachine_Network_Manager) Ethernet (SoMachine_Network_Manager1) USB (SoMachine_Network_Manager2) CAN
HMISCU6B5 HMISCU8B5	**Embedded Analog I/O**	Analog Temperature

Libraries

3

Libraries

Introduction

Libraries provide functions, function blocks, data types and global variables that can be used to develop your project.

The **Library Manager** of SoMachine provides information about the libraries included in your project and allows you to install new ones. For more information on the **Library Manager**, refer to the CoDeSys online help in SoMachine.

Magelis SCU HMI Controller

When you select a Magelis SCU HMI Controller for your application, SoMachine automatically loads the following libraries:

Library name	Description
IoStandard	**CmpIoMgr** configuration types, **ConfigAccess**, Parameters and help functions: manages the I/Os in the application.
Standard	Contains functions and function blocks which are required matching IEC61131-3 as standard POUs for an IEC programming system. The standard POUs must be tied to the project (standard.library).
Util	Analog Monitors, BCD Conversions, Bit/Byte Functions, Controller Datatypes, Function Manipulators, Mathematical Functions, Signals.
HMISCU PLCSystem *(see Magelis SCU, SoMachine PLCSystem, Library Guide)*	Contains functions and variables to get information and send commands to the controller system.

Library name	Description
PLCCommunication *(see SoMachine, Modbus and ASCII Read/Write Functions, PLCCommunication Library Guide)*	**SysMem, Standard, SE_PLCSystem**. These functions facilitate communications between specific devices. Most of them are dedicated to Modbus exchange. Communication functions are processed asynchronously regarding the application task that called the function.
HMISCU HSC *(see Magelis SCU, SoMachine HSC, Library Guide)*	Contains function blocks and variables to get information and send commands to the Fast Inputs/Outputs of the Magelis SCU HMI Controller. These function blocks permit you to implement HSC (High Speed Counting) functions on the Fast Inputs/Outputs of the Magelis SCU HMI Controller.
HMISCU PTOPWM *(see Magelis SCU, SoMachine PTO/PWM, Library Guide)*	Contains function blocks and variables to get information and send commands to the Fast Inputs/Outputs of the Magelis SCU HMI Controller. These function blocks permit you to implement PTO (Pulse Train Output) and PWM (Pulse Width Modulation) functions on the Fast Outputs of the Magelis SCU HMI Controller.
Additional libraries: • _3SCOS: 3S CANopenStack • FDT_CAN: FDT_CANOpenDriver • CIA405: CAA CiA 405 *(see SoMachine, CANopen Management Functions, CAA CiA 405 Library Guide)*	The CAA CiA 405 Library offers a set of function blocks to meet the requirements of the CiA405 for the access to the CANopen network from the application (IEC61131-3 program) of the controller (CANopen master). **NOTE:** These libraries are not loaded automatically when you add the HMI SCU device. They are added when the **CANopen_Optimized** child node under **CAN** is added.

Supported Standard Data Types

4

Supported Standard Data Types

Supported Standard Data Types

The Controller supports the following IEC Data types:

Data type	Lower limit	Upper limit	Information content
BOOL	False	True	1 Bit
BYTE	0	255	8 Bit
WORD	0	65,535	16 Bit
DWORD	0	4,294,967,295	32 Bit
LWORD	0	2^{64}-1	64 Bit
SINT	-128	127	8 Bit
USINT	0	255	8 Bit
INT	-32,768	32,767	16 Bit
UINT	0	65,535	16 Bit
DINT	-2,147,483,648	2,147,483,647	32 Bit
UDINT	0	4,294,967,295	32 Bit
LINT	-2^{63}	2^{63}-1	64 Bit
ULINT	0	2^{64}-1	64 Bit
REAL	1.175494351e-38	3.402823466e+38	32 Bit
LREAL	2.2250738585072014e-308	1.7976931348623158e+308	64 Bit
STRING	1 character	255 characters	1 character = 1 byte
WSTRING	1 character	255 characters	1 character = 1 word
TIME	-	-	32 Bit

For more information on `ARRAY`, `LTIME`, `DATE`, `TIME`, `DATE_AND_TIME`, and `TIME_OF_DAY`, refer to the CoDeSys online help in SoMachine.

Memory Mapping

5

Memory Organization

Introduction

This section describes the RAM (Random Access Memory) size for different areas of the Magelis SCU HMI Controller.

Memory Mapping

The RAM size is 64 Mbytes.

The table shows the memory specifications:

Area	Element	Size (bytes)
System Area	System area reserved memory	131072
	System and diagnostic variables	
	Physical input addresses (%I)	256
	Physical output addresses (%Q)	256
	Retain variables (1)	16360
	Persistent retain variables	2044
Application Area	Compiled control application	1024000
User Area	Symbols	Dynamic allocation of 1024000
	Variables	
	Libraries	
(1) Not all of the 16360 bytes are available for the customer application because some libraries may use retain variables.		

The RAM is composed of 4 areas:

- controller dedicated application memory
- controller OS memory
- HMI application memory
- HMI OS memory

Memory containing Persistent and Retain variables is preserved and protected. The Persistent and Retain variables will be retained during power outages or when the HMI controller is powered off.

System and Diagnostic Variables

Variables	Description
PLC_R	Structure of HMI controller read-only system variables.
PLC_W	Structure of HMI controller read/write system variables.

For more information on System Variables, refer to the *Magelis SCU SoMachine PLCSystem Library Guide (see Magelis SCU, SoMachine PLCSystem, Library Guide)*.

Library Sizes

Library Name	Average Size	Comment
HMISCU HSC *(see Magelis SCU, SoMachine HSC, Library Guide)*	10 kbytes	Depends on the functions used.
HMISCU PLCSystem *(see Magelis SCU, SoMachine PLCSystem, Library Guide)*	25 kbytes	Always embedded in the application. The use of the functions does not consume additional memory.
HMISCU PTO/PWM *(see Magelis SCU, SoMachine PTO/PWM, Library Guide)*	10 kbytes	Depends on the functions used.
PLC Communication	20 kbytes	Depends on the functions used.
CANopen Stack	115 kbytes	Depends on the functions used. Each CANopen Slave consumes approximately an additional 10 kbytes of memory.

Memory Addressing

The table describes the memory addressing for the address sizes D, W, B and X:

DWORDS/WORDS		Bytes	X (bits)		
D0	W0	B0	x0.7	...	x0.0
		B1	x1.7	...	x1.0
	W1	B2			
		B3			
D1	W2	B4			
		B5			
	W3	B6			
		B7			
D2	W4	B8			
		...			
	...	...			
		...			

Overlap of memory ranges, example:

D0 contains B0 - B3, W0 contains B0 and B1, W1 contains B2 and B3.

Tasks

6

Introduction

The Task Configuration node in the SoMachine device tree allows you to define one or several tasks to control the execution of your application program.

The task types available are:
- Cyclic
- Freewheeling
- Event

This chapter begins with an explanation of these task types and provides information regarding the maximum number of tasks, the default task configuration, and task prioritization. In addition, this chapter introduces the task watchdog function and explains its relationship to task execution.

What Is in This Chapter?

This chapter contains the following topics:

Topic	Page
Maximum Number of Tasks	28
Task Configuration Screen	29
Task Types	32
Watchdogs	35
Task Priorities	36
Default Task Configuration	39

Maximum Number of Tasks

Maximum Number of Tasks

The maximum number of tasks you can define for the Magelis SCU HMI Controller are:

- Total number of tasks = 6
- Cyclic tasks = 3
- Freewheeling tasks = 1
- Event tasks = 2

Special Considerations for Freewheeling

A Freewheeling task *(see page 33)* does not have a fixed duration. In Freewheeling mode, each task scan starts when the previous scan has been completed and after a period of system processing (30% of the total duration of the Freewheeling task).

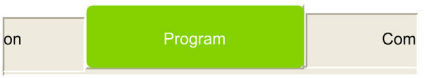
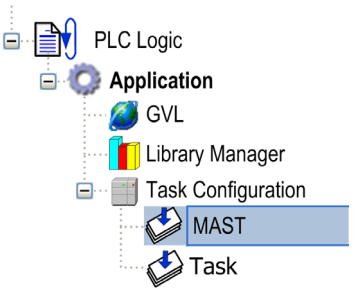
NOTE: You should not use a Freewheeling task in a multi-task application when some high priority and time-consuming tasks are running. Doing so runs the risk of provoking a task Watchdog Timeout. You should not assign CANopen to a freewheeling task. CANopen should be assigned to a cyclic task.

NOTE: This does not include the time required to process the HMI application (which is normally 25% of Controller CPU time).

Task Configuration Screen

Access to Task Configuration

Follow these steps to access the **Task Configuration**:

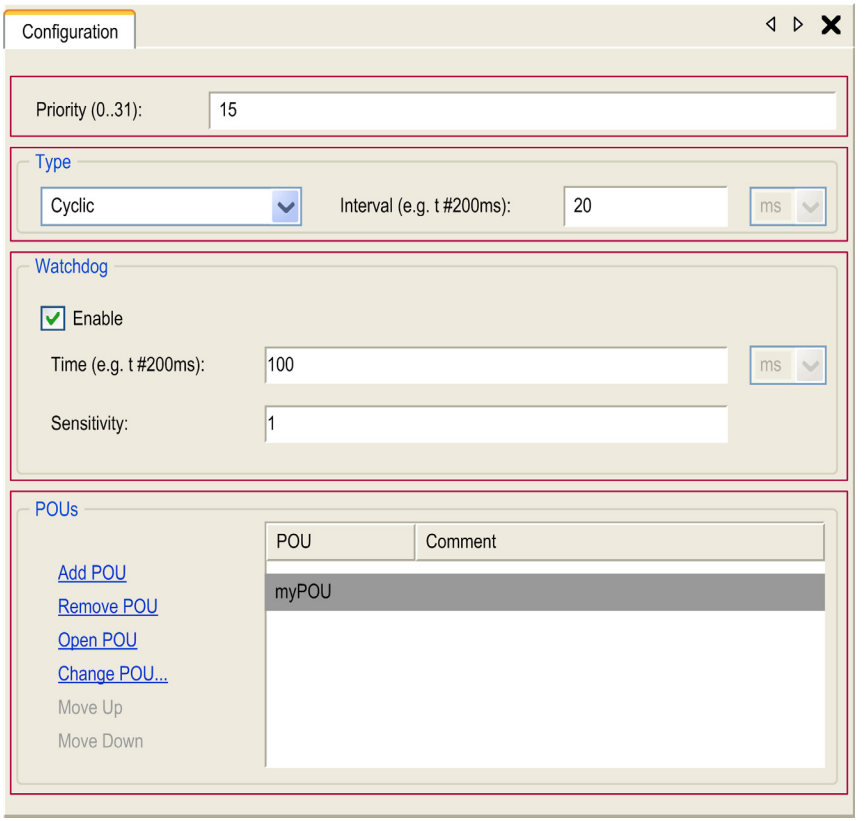
Step	Action
1	Click the **Program** menu: 
2	Double-click the task that you want to configure in the device tree of the **Devices** window: 

NOTE: For more information on adding a task, refer to the SoMachine CoDeSys online help.

Task Configuration Screen

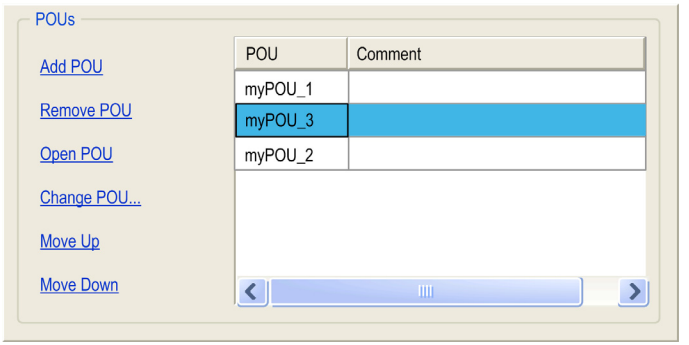
Each task configuration has its own parameters which are independent of the other tasks.

The task **Configuration** window is composed of 4 parts:



The following table describes the fields of the task **Configuration** screen:

Field Name	Definition
Priority	You can configure the priority of each task with a number between 0 and 31 (0 is the highest priority, 31 is the lowest). Only 1 task at a time can be running. The priority determines when the task will run: ● a higher priority task will preempt a lower priority task ● tasks with same priority will run in turn (2 ms time-slice) **NOTE:** Do not assign tasks with the same priority. For important safety information, refer to Task Priorities *(see page 36)*.
Type	3 types of tasks are available: ● Cyclic *(see page 32)* ● Freewheeling *(see page 33)* ● Event *(see page 33)*

Field Name	Definition
Watchdog *(see page 35)*	To configure the watchdog, you must define two parameters: ● Time: enter the timeout before watchdog execution. ● Sensitivity: defines the number of expirations of the watchdog timer before the Controller stops program execution and enters into a HALT state *(see page 48)*.
POUs *(see SoMachine, Programming Guide)*	The list of **POU**s (Programming Organization Unit) controlled by the task is defined in the task **Configuration** window:  ● To add a POU linked to the task, use the command **Add POU**. ● To remove a POU from the list, use the command **Remove POU**. ● The command **Open POU** opens the currently selected POU in the appropriate editor. ● To replace the currently selected POU of the list by another one, use the command **Change POU...** ● POUs are executed in the order they appear in the task **Configuration** window. To rearrange POUs in the list, select a POU and click **Move Up** or **Move Down** Clicking any of the POU commands will open the **Input Assistant** window. **NOTE:** You can create as many POUs as you want. An application with several small POUs, as opposed to one large POU improves the refresh time of the variables in online mode.

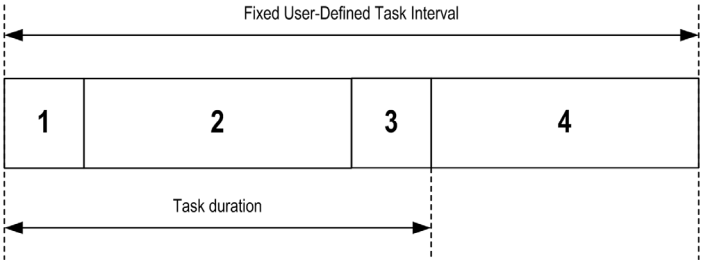
Task Types

Introduction

The following section describes the various task types available for your program, along with a description of the task type characteristics.

Cyclic Task

A Cyclic task is assigned a fixed cycle time using the Interval setting in the Type section of Configuration sub-tab for that task. Each Cyclic task type executes as follows:



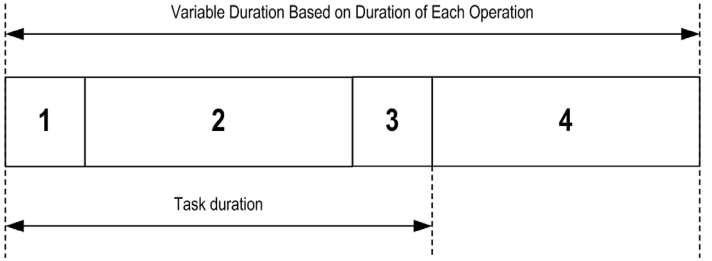
1. **Read Inputs:** The physical input states are written to the %I input memory variables and other system operations are executed.
2. **Task Processing:** The user code (POU, and so on) defined in the task is processed. The %Q output memory variables are updated according to your application program instructions but not yet written to the physical outputs during this operation.
3. **Write Outputs:** The %Q output memory variables are modified with any output forcing that has been defined; however, the writing of the physical outputs depends upon the type of output and instructions used.
   For more information on defining the bus cycle task, refer to the CoDeSys online help in SoMachine and Magelis SCU HMI Controller Settings *(see page 66)*.
   For more information on I/O behavior, refer to Controller States Detailed Description *(see page 41)*.
4. **Remaining Interval time:** The controller firmware carries out system processing and any other lower priority tasks.

NOTE: If you define too short a period for a cyclic task, it will repeat immediately after the write of the outputs and without executing other lower priority tasks or any system processing. This will affect the execution of all tasks and cause the controller to exceed the system watchdog limits, generating a system watchdog exception.

NOTE: You can get and set the interval of a Cyclic Task by application using the **GetCurrentTaskCycle** and **SetCurrentTaskCycle** function. (Refer to Toolbox Advance Library Guide for further details.)

Freewheeling Task

A Freewheeling task does not have a fixed duration. In Freewheeling mode, each task scan begins when the previous scan has been completed and after a short period of system processing. Each Freewheeling task type executes as follows:



1. **Read Inputs:** The physical input states are written to the `%I` input memory variables and other system operations are executed.
2. **Task Processing:** The user code (POU, and so on) defined in the task is processed. The `%Q` output memory variables are updated according to your application program instructions but not yet written to the physical outputs during this operation.
3. **Write Outputs:** The `%Q` output memory variables are modified with any output forcing that has been defined; however, the writing of the physical outputs depends upon the type of output and instructions used.
   For more information on defining the bus cycle task, refer to the CoDeSys online help in SoMachine and Magelis SCU HMI Controller Settings *(see page 66)*.
   For more information on I/O behavior, refer to Controller States Detailed Description *(see page 48)*.
4. **System Processing:** The controller firmware carries out system processing and any other lower priority tasks (for example: http management, Ethernet management, parameters management).

Event Task

This type of task is event-driven and is initiated by a program variable. It starts at the rising edge of the boolean variable associated to the trigger event unless pre-empted by a higher priority task. In that case, the Event task will start as dictated by the task priority assignments.

For example, if you have defined a variable called `my_Var` and would like to assign it to an Event, select the **Event type** on the **Configuration** sub-tab and click on the **Input Assistant** button to the right of the **Event name** field. This will cause the **Input Assistant dialog** box to appear. In the **Input Assistant dialog** box, you navigate the tree to find and assign the `my_Var` variable.

NOTE: The maximum frequency admissible for the event triggering an Event task is governed by the priorities of other tasks and system processes. So you must test your application to ensure reliable event triggering.

Watchdogs

Introduction

One type of watchdog functionality is implemented for the Magelis SCU HMI Controller:

- **Task Watchdogs**: Optional watchdogs that can be defined for each task. These are managed by your application program and are configurable in SoMachine.

NOTE: Infinite loops are not interrupted if a user does not set the Task Watchdog manually.

Task Watchdogs

SoMachine allows you to configure an optional task watchdog for every task defined in your application program. (Task watchdogs are sometimes also referred to as software watchdogs or control timers in the SoMachine online help). When one of your defined task watchdogs reaches its threshold condition, an application error is detected and the controller enters the HALT state.

When defining a task watchdog, the following options are available:

- **Time**: This defines the allowable maximum execution time for a task. When a task takes longer than this the controller will report a task watchdog exception.
- **Sensitivity**: The sensitivity field defines the number of task watchdog exceptions that must occur before the controller detects an application error.

A task watchdog is configured on the Configuration sub-tab of the Task Configuration tab for the individual task. To access this tab, double-click the task in the device tree.

NOTE: For more information on watchdogs, refer to the CoDeSys online help in SoMachine.

Task Priorities

Introduction

You can configure the priority of each task between 0 and 31 (0 is the highest priority, 31 is the lowest). Each task must have a unique priority. If you assign the same priority to more than one task, execution for those tasks is indeterminate and unpredictable, which may lead to unintended consequences.

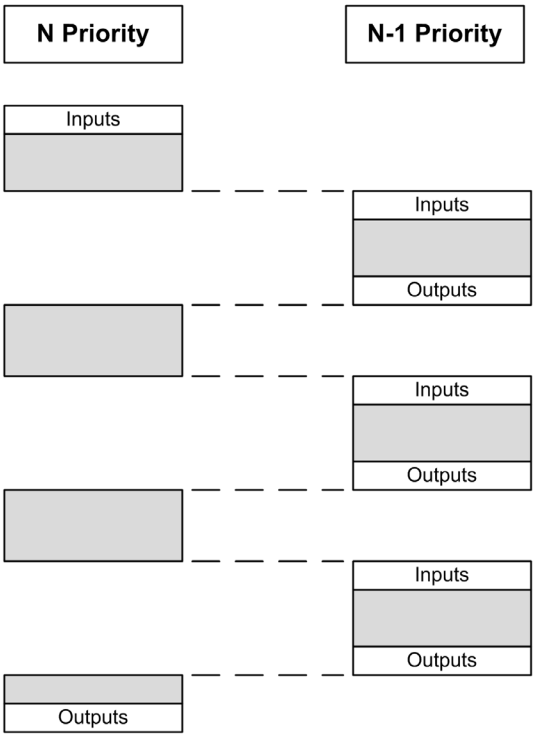
⚠ WARNING
UNINTENDED EQUIPMENT OPERATION Do not assign the same priority to different tasks. **Failure to follow these instructions can result in death, serious injury, or equipment damage.**

Task Priority Recommendations

- Priority 0 to 24: Controller tasks. Assign these priorities to tasks with a high real-time requirement.
- Priority 25 to 31: Background tasks. Assign these priorities to tasks with a low real-time requirement.

Task Preemption Due to Task Priorities

When a task cycle starts, it can interrupt any task with lower priority (task preemption). The interrupted task will resume when the higher priority task cycle is finished.



NOTE: If the same input is used in different tasks the input image may change during the task cycle of the lower priority task.

To improve the likelihood of proper output behavior during multitasking, a warning message will be displayed if outputs in the same byte are used in different tasks.

⚠ WARNING

UNINTENDED EQUIPMENT OPERATION

Map your inputs so that tasks do not alter the input images in an unexpected manner.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

Default Task Configuration

Default Task Configuration

The MAST task can be configured in Freewheeling or Cyclic mode. The MAST task is automatically created by default in Cyclic mode. Its preset priority is medium (15), its preset interval is 20 ms, and its task watchdog service is activated with a time of 100 ms and a sensitivity of 1. Refer to Task Priorities *(see page 36)* for more information on priority settings. Refer to Task Watchdogs *(see page 35)* for more information on watchdogs.

Designing an efficient application program is important in systems approaching the maximum number of tasks. In such an application, it can be difficult to keep the resource utilization below the system watchdog threshold. If priority reassignments alone are not sufficient to remain below the threshold, some lower priority tasks can be made to use fewer system resources if the SysTaskWaitSleep function is added to those tasks. For more information about this function, see the optional SysTask library of the system / SysLibs category of libraries.

NOTE: Do not delete or change the Name of the MAST task. If you do so, SoMachine detects an error when you attempt to build the application, and you will not be able to download it to the controller.

Controller States and Behaviors

7

Introduction

This chapter provides you with information on controller states, state transitions, and behaviors in response to system events. It begins with a detailed controller state diagram and a description of each state. It then defines the relationship of output states to controller states before explaining the commands and events that result in state transitions. It concludes with information about Remanent variables and the effect of SoMachine task programming options on the behavior of your system.

What Is in This Chapter?

This chapter contains the following sections:

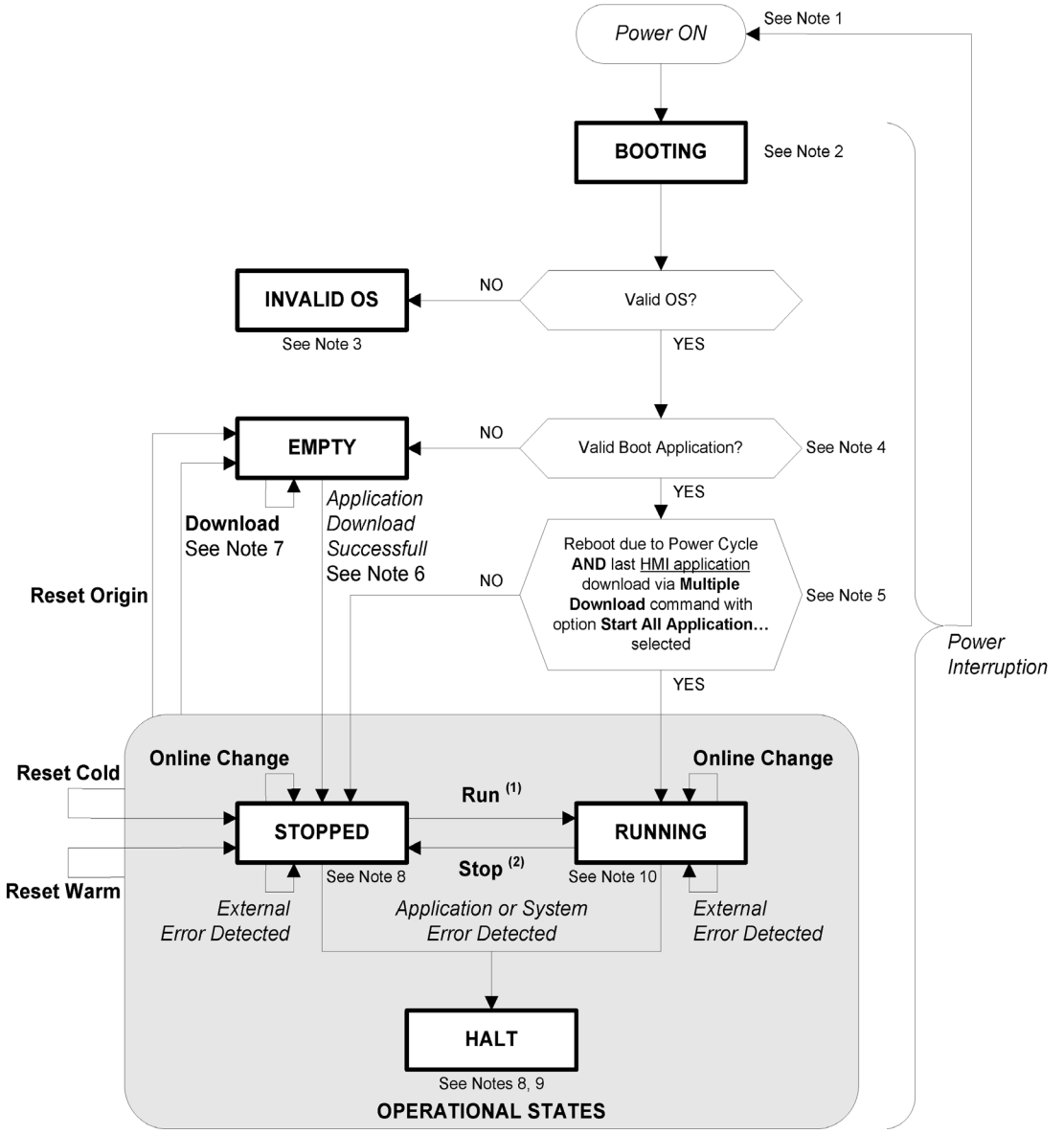
Section	Topic	Page
7.1	HMI Controller State Diagram	42
7.2	HMI Controller States Description	48
7.3	State Transitions and System Events	51

7.1 HMI Controller State Diagram

Controller State Diagram

Controller State Diagram

The following diagram describes the controller operating mode:



Legend:

- Controller states are indicated in **ALL-CAPS BOLD**
- User and application commands are indicated in **Bold**
- System events are indicated in *Italics*
- Decisions, decision results and general information are indicated in normal text

(1) For details on STOPPED to RUNNING state transition, refer to Run Command *(see page 55)*.

(2) For details on RUNNING to STOPPED state transition, refer to Stop Command *(see page 55)*.

Note 1

The Power Cycle (Power Interruption followed by a Power ON) deletes all output forcing settings. Refer to Controller State and Output Behavior for further details.

Note 2

The outputs will assume their initialization states.

Note 3

HMI download screen is displayed prompting the user to download the firmware, HMI and Control application.

Note 4

The application is loaded into RAM after verification of a valid Boot application.

Note 5

The state of the controller will be RUNNING after a reboot if the reboot was provoked by a Power Cycle and the **HMI application** had been downloaded using a **Multiple Download...** command with option **Start all applications after download or online change** selected.

Note 6

During a successful application download the following events occur:
- The application is loaded directly into RAM.
- By default, the Boot application is created and saved into the Flash memory.

Note 7

However, there are two important considerations in this regard:
- **Online Change:** An online change (partial download) initiated while the controller is in the RUNNING state returns the controller to the RUNNING state if successful.
  Before using the **Login with online change** option, test the changes to your application program in a virtual or non-production environment and confirm that the controller and attached equipment assume their expected conditions in the RUNNING state.

⚠ WARNING
UNINTENDED EQUIPMENT OPERATION Always verify that online changes to a RUNNING application program operate as expected before downloading them to controllers. **Failure to follow these instructions can result in death, serious injury, or equipment damage.**

NOTE: Online changes to your program are not automatically written to the Boot application, and will be overwritten by the existing Boot application at the next reboot. If you wish your changes to persist through a reboot, manually update the Boot application by selecting **Create boot application** in the Online menu.

- **Multiple Download:** SoMachine has a feature that allows you to perform a full application download to multiple targets on your network or fieldbus.
  One of the default options when you select the **Multiple Download...** command is the **Start all applications after download or online change** option, which restarts all download targets in the RUNNING state, irrespective of their last controller state before the multiple download was initiated. Deselect this option if you do not want all targeted controllers to restart in the RUNNING state.
  In addition, before using the **Multiple Download...** option, test the changes to your application program in a virtual or non-production environment and confirm that the targeted controllers and attached equipment assume their expected conditions in the RUNNING state.

⚠ WARNING
UNINTENDED EQUIPMENT OPERATION Always verify that your application program will operate as expected for all targeted controllers and equipment before issuing the "**Multiple Download…**" command with the "**Start all applications after download or online change**" option selected. **Failure to follow these instructions can result in death, serious injury, or equipment damage.**

Note 8

The SoMachine software platform allows many powerful options for managing task execution and output conditions while the controller is in the STOPPED or HALT states. Refer to Controller State and Output Behavior for further details.

Note 9

To exit the HALT state it is necessary to issue one of the Reset commands (Reset Warm, Reset Cold, Reset Origin), download an application or cycle power.

Note 10

The RUNNING state has two exceptional conditions that will be indicated in run state or error messages on HMI screen.

- RUNNING with External Error: You may exit this exceptional condition by clearing the external error. No controller commands are required.
- RUNNING with Breakpoint: Refer to Controller State Description *(see page 48)* for further details on this exceptional condition.

7.2 HMI Controller States Description

Controller States Description

Introduction

This section provides a detailed description of the controller states.

⚠ WARNING

UNINTENDED EQUIPMENT OPERATION

- Never assume that your controller is in a certain controller state before commanding a change of state, configuring your controller options, uploading a program, or modifying the physical configuration of the controller and its connected equipment.
- Before performing any of these operations, consider the effect on all connected equipment.
- Before acting on a controller, always positively confirm the controller state by checking for the presence of output forcing, and reviewing the controller status information via SoMachine (1).

Failure to follow these instructions can result in death, serious injury, or equipment damage.

(1) **Note:** The controller states can be read in the PLC_R.i_wStatus system variable of the PLCSystem library *(see Magelis SCU, SoMachine PLCSystem, Library Guide)*.

Controller States Table

The following table describes the controller states:

Controller State	Description
BOOTING	The controller executes the boot firmware and its own internal self-tests. It then checks the checksum of the firmware and user applications. It does not execute the application nor does it communicate.
INVALID_OS	There is not a valid firmware file present In the Flash memory. The controller does not execute the application. Communication is only possible through the USB host port, and then only for uploading a valid OS.
EMPTY	There is no or an invalid application.
RUNNING	The controller is executing a valid application.

Controller State	Description
RUNNING with Breakpoint	This state is the same as the RUNNING state with the following exceptions: • The task-processing portion of the program does not resume until the breakpoint is cleared. See online CoDeSys help in SoMachine for details on breakpoints management.
RUNNING with detection of an *External Error*	This state is the same as the normal RUNNING state.
STOPPED	The controller has a valid application that is stopped. See Details of the STOPPED State *(see page 49)* for an explanation of the behavior of outputs and field buses in this state.
STOPPED with detection of an *External Error*	This state is the same as the normal STOPPED state.
HALT	The controller stops executing the application because it has detected an Application or a System Error. This description is the same as for the STOPPED state with the following exceptions: • The task responsible for the Application Error always behaves as if the **Update I/O while in stop** option was not selected. All other tasks follow the actual setting.

Details of the STOPPED State

The following statements are always true for the STOPPED state:

- Ethernet, Serial (Modbus, ASCII, etc.), and USB communication services remain operational and commands written by these services can continue to affect the application, the controller state, and the memory variables.
- All outputs initially assume their configured state (**Keep current values** or **Set all outputs to default**) or the state dictated by output forcing if used. The subsequent state of the outputs depends on the value of the **Update I/O while in stop** setting and on commands received from remote devices.

Task and I/O Behavior When Update I/O While In Stop Is Selected

When the **Update I/O while in stop** setting is selected:

- The Read Inputs operation continues normally. The physical inputs are read and then written to the %I input memory variable.
- The Task Processing operation is not executed.
- The Write Outputs operation continues. The %Q output memory variable is updated to reflect either the **Keep current values** configuration or the **Set all outputs to default** configuration, adjusted for any output forcing, and then written to the physical outputs.

NOTE: Expert functions continue to operate. For example, a counter will continue to count. However, these Expert functions do not affect the state of the outputs. The outputs of Expert I/O conform to the behavior stated here.

NOTE: Commands received by Ethernet, Serial, USB, and CAN communications can continue to write to the memory variables. Changes to the %Q output memory variables are written to the physical outputs.

CAN Behavior When Update I/O While In Stop Is Selected

The following is true for the CAN buses when the Update I/O while in stop setting is selected:

- The CAN bus remains fully operational. Devices on the CAN bus continue to perceive the presence of a functional CAN Master.
- TPDO and RPDO continue to be exchanged.
- The optional SDO, if configured, continue to be exchanged.
- The Heartbeat and Node Guarding functions, if configured, continue to operate.
- If the **Behavior for outputs in Stop** field is set to **Keep current values**, the TPDOs continue to be issued with the last actual values.
- If the **Behavior for outputs in Stop** field is **Set all outputs to default** the last actual values are updated to the default values and subsequent TPDOs are issued with these default values.

Task and I/O Behavior When Update I/O While In Stop Is Not Selected

When the **Update I/O while in stop** setting is not selected, the controller sets the I/O to either the **Keep current values** or **Set all outputs to default** condition (as adjusted for output forcing if used). After this, the following becomes true:

- The Read Inputs operation ceases. The %I input memory variable is frozen at its last values.
- The Task Processing operation is not executed.
- The Write Outputs operation ceases. The %Q output memory variables can be updated via the Ethernet, Serial, and USB connections. However, the physical outputs are unaffected and retain the state specified by the configuration options.

NOTE: Expert functions cease operating. For example, a counter will be stopped.

CAN Behavior When Update I/O While In Stop Is Not Selected

The following is true for the CAN buses when the **Update I/O while in stop** setting is not selected:

- The CAN Master ceases communications. Devices on the CAN bus assume their configured fallback states.
- TPDO and RPDO exchanges cease.
- Optional SDO, if configured, exchanges cease.
- The Heartbeat and Node Guarding functions, if configured, stop.
- The current or default values, as appropriate, are written to the TPDOs and sent once before stopping the CAN Master.

7.3 State Transitions and System Events

Overview

This section begins with an explanation of the output states possible for the controller. It then presents the system commands used to transition between controller states and the system events that can also affect these states. It concludes with an explanation of the Remanent variables, and the circumstances under which different variables and data types are retained through state transitions.

What Is in This Section?

This section contains the following topics:

Topic	Page
Controller States and Output Behavior	52
Commanding State Transitions	55
Error Detection, Types, and Management	60
Remanent Variables	62

Controller States and Output Behavior

Introduction

The Magelis SCU HMI Controller defines output behavior in response to commands and system events in a way that allows for greater flexibility. An understanding of this behavior is necessary before discussing the commands and events that affect controller states. For example, typical controllers define only two options for output behavior in stop: fallback to default value or keep current value.

The possible output behaviors and the controller states to which they apply are:

- Managed by Application Program
- Keep Current Values
- Set All Outputs to Default
- Initialization Values
- Output Forcing

ControllerLockout Feature

The **ControllerLockout** feature locks or unlocks the controller stop mode. A locked controller cannot be restarted until the controller is unlocked.

Attempts to restart a locked controller are ignored and a message appears.You can only initiate lockout once the controller is in STOPPED state. If the controller is in RUNNING state and you attempt to lockout, the attempt is ignored and a message appears.

The **ControllerLockout** is not managed through SoMachine, it is an internal boolean variable (_ControllerLockout) of the HMI in Vijeo-Designer.

For more information on managing this variable, refer to the Vijeo-Designer Online Help.

Managed by Application Program

Your application program manages outputs normally. This applies in the RUNNING and RUNNING with External Error states.

Keep Current Values

You can select this option by choosing **Keep current values** in the **Behavior for outputs in Stop** drop-down menu of the **PLC settings** sub-tab of the **Controller Editor**. To access the Controller Editor, right-click on the controller in the device tree and select **Edit Object**.

You can also double-click on the name representing the HMISCU device in the **Devices** windows to access the **Controller Editor**.

This output behavior applies in the STOPPED controller state. It also applies to CAN bus in the HALT controller state. Outputs are set to and maintained in their current state, although the details of the output behavior varies greatly depending on the setting of the **Update I/O while in stop** option and the actions commanded via configured fieldbuses. Refer to Controller States Description *(see page 48)* for more details on these variations.D-SE-0004939.1

Set All Outputs to Default

You can select this option by choosing **Set all outputs to default** in the **Behavior for outputs in Stop** drop-down menu of the **PLC settings** sub-tab of the **Controller Editor**. To access the **Controller Editor**, right-click on the controller in the device tree and select **Edit Object**.

This output behavior applies in the STOPPED controller state. It also applies to CAN bus in the HALT controller state. Outputs are set to and maintained in their current state, although the details of the output behavior varies greatly depending on the setting of the **Update I/O while in stop** option and the actions commanded via configured fieldbuses. Refer to Controller States Description *(see page 48)*D-SE-0008934.1 for more details on these variations.

Initialization Values

This output state applies in the BOOTING, EMPTY (following power cycle with no boot application or after the detection of a system error), and INVALID_OS states.

In the initialization state, analog, transistor and relay outputs assume the following values:

- For an analog output: Z (High Impedance)
- For a fast transistor output: Z (High Impedance)
- For a regular transistor output: 0 Vdc
- For a relay output: Open

Output Forcing

The controller allows you to force the state of selected outputs to a defined value for the purposes of system testing, commissioning and maintenance.

You are only able to force the value of an output while your controller is connected to SoMachine.

To do so you use the Force Values command in the Debug/Watch menu.

Output forcing overrides all other commands to an output irrespective of the task programming that is being executed (this does not apply to an output currently used by a controller's embedded functions, such as HSC/PTO/PWM).

When you logout of SoMachine when output forcing has been defined, you are presented with the option to retain output forcing settings. If you select this option, the output forcing continues to control the state of the selected outputs until you download an application or use one of the Reset commands.

When the option **Update I/O while in stop** is checked (default state), the forced outputs keep the forcing value even when the logic controller is in STOP.

Output Forcing Considerations

The output you wish to force must be contained in a task that is currently being executed by the controller. Forcing outputs in unexecuted tasks, or in tasks whose execution is delayed either by priorities or events will have no effect on the output. However, once the task that had been delayed is executed, the forcing will take effect at that time.

Depending on task execution, the forcing could impact your application in ways that may not be obvious to you. For example, an event task could turn on an output. Later, you may attempt to turn off that output but the event is not being triggered at the time. This would have the effect of the forcing apparently being ignored. Further, at a later time, the event could trigger the task at which point the forcing would take effect.

⚠ WARNING

UNINTENDED EQUIPMENT OPERATION

- You must have a thorough understanding of how forcing will affect the outputs relative to the tasks being executed.
- Do not attempt to force I/O that is containted in tasks that you are not certain will be executed in a timely manner, unless your intent is for the forcing to take affect at the next execution of the task whenever that may be.
- If you force an output and there is no apparent affect on the physical output, do not exit SoMachine without removing the forcing.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

Commanding State Transitions

Run Command

Effect: Commands a transition to the RUNNING controller state.

Starting Conditions: BOOTING or STOPPED state.

Methods for Issuing a Run Command:

- SoMachine Online Menu: Select the **Start** command.
- By an HMI command using the PLC_W. q_wPLCControl and PLC_W. q_uiOpenPLCControl system variables of the PLCSystem library *(see Magelis SCU, SoMachine PLCSystem, Library Guide)*.
- **Login with online change** option: An online change (partial download) initiated while the controller is in the RUNNING state returns the controller to the RUNNING state if successful.
- **Multiple Download** Command: sets the controllers into the RUNNING state if the **Start all applications after download or online change** option is selected, irrespective of whether the targeted controllers were initially in the RUNNING, STOPPED, HALT or EMPTY state.
- The controller is restarted into the RUNNING state automatically under certain conditions.

Refer to Controller State Diagram *(see page 43)* for further details.

Stop Command

Effect: Commands a transition to the STOPPED controller state.

Starting Conditions: BOOTING, EMPTY or RUNNING state.

Methods for Issuing a Run Command:

- SoMachine Online Menu: Select the **Stop** command.
- By an internal call by the application or an HMI command using the PLC_W. q_wPLCControl and PLC_W. q_uiOpenPLCControl system variables of the PLCSystem library *(see Magelis SCU, SoMachine PLCSystem, Library Guide)*.
- **Login with online change** option: An online change (partial download) initiated while the controller is in the STOPPED state returns the controller to the STOPPED state if successful.
- **Download** Command: implicitly sets the controller into the STOPPED state.
- **Multiple Download** Command: sets the controllers into the STOPPED state if the **Start all applications after download or online change** option is not selected, irrespective of whether the targeted controllers were initially in the RUNNING, STOPPED, HALT or EMPTY state.

- REBOOT by USB file system download:: The application download from on a USB memory key will issue a REBOOT as its final command. The controller will be rebooted into the STOPPED state provided the other conditions of the boot sequence allow this to occur. Refer to Saving your Application and Firmware on a USB Memory Key *(see page 106)* and Reboot *(see page 105)* for further details.
- The controller is restarted into the STOPPED state automatically under certain conditions.

Refer to Controller State Diagram *(see page 43)* for further details.

Reset Warm

Effect: Resets all variables, except for the remanent variables, to their default values. Places the controller into the STOPPED state.

Starting Conditions:
- RUNNING, STOPPED, or HALT states.
- ControllerLockout = 0.

Methods for Issuing a Reset Warm Command:
- SoMachine Online Menu: Select the **Reset warm** command.
- By an internal call by the application or an HMI command using the PLC_W. q_wPLCControl and PLC_W. q_uiOpenPLCControl system variables of the PLCSystem library *(see Magelis SCU, SoMachine PLCSystem, Library Guide)*.

Effects of the Reset Warm Command:
1. The application stops.
2. Forcing is erased.
3. Diagnostic indications for detected errors are reset.
4. The values of the retain variables are maintained.
5. The values of the retain-persistent variables are maintained.
6. All non-located and non-remanent variables are reset to their initialization values.
7. All fieldbus communications are stopped and then restarted after the reset is complete.
8. All I/O are briefly reset to their initialization values and then to their user-configured default values.

For details on variables, refer to Remanent Variables *(see page 62)*.

Reset Cold

Effect: Resets all variables, except for the retain-persistent type of remanent variables, to their initialization values. Places the controller into the STOPPED state.

Starting Conditions:
- RUNNING, STOPPED, or HALT states.
- ControllerLockout = 0.

Methods for Issuing a Reset Cold Command:

- SoMachine Online Menu: Select the **Reset cold** command.
- By an internal call by the application or an HMI command using the PLC_W. q_wPLCControl and PLC_W. q_uiOpenPLCControl system variables of the PLCSystem library *(see Magelis SCU, SoMachine PLCSystem, Library Guide)*.

Effects of the Reset Cold Command:

1. The application stops.
2. Forcing is erased.
3. Diagnostic indications for detected errors are reset.
4. The values of the retain variables are reset to their initialization value.
5. The values of the retain-persistent variables are maintained.
6. All non-located and non-remanent variables are reset to their initialization values.
7. All fieldbus communications are stopped and then restarted after the reset is complete.
8. All I/O are briefly reset to their initialization values and then to their user-configured default values.

For details on variables, refer to Remanent Variables *(see page 62)*.

Reset Origin

Effect: Resets all variables, including the remanent variables, to their initialization values. Erases all user files on the controller. Places the controller into the EMPTY state.

Starting Conditions:

- RUNNING, STOPPED, or HALT states.
- ControllerLockout = 0.

Methods for Issuing a Reset Origin Command:

- SoMachine Online Menu: Select the **Reset origin** command.

Effects of the Reset Origin Command:

1. The application stops.
2. Forcing is erased.
3. All user files (Boot application, data logging) are erased.
4. Diagnostic indications for detected errors are reset.
5. The values of the retain variables are reset.
6. The values of the retain-persistent variables are reset.
7. All non-located and non-remanent variables are reset.
8. All fieldbus communications are stopped.
9. Embedded Expert I/O are reset to their previous user-configured default values.
10. All other I/O are reset to their initialization values.

For details on variables, refer to Remanent Variables *(see page 62)*.

Reboot

Effect: Commands a reboot of the controller.

Starting Conditions:

- ControllerLockout = 0.

Methods for Issuing the Reboot Command:

- Power cycle.
- REBOOT by USB file system download: The file application download from on a USB memory key will issue a REBOOT as its final command. The controller will be rebooted into the STOPPED state provided the other conditions of the boot sequence allow this to occur. Refer to Saving your Application and Firmware on a USB Memory Key *(see page 106)* for further details.

Effects of the Reboot:

1. The state of the controller depends on a number of conditions:
   - **a.** The controller state will be RUNNING if:
     - The Reboot was provoked by a power cycle, and
     - Controller state was RUNNING prior to the power cycle.
   - **b.** The controller state will be STOPPED if:
     - The Reboot was provoked by a Reboot by script, or
     - The boot application is different than the application loaded prior to the reboot, or
     - Controller state was STOPPED prior to a power cycle, or
     - The previously saved context is invalid.
   - **c.** The controller state will be EMPTY if:
     - There is no boot application or the boot application is invalid, or
   - **d.** The controller state will be INVALID_OS if there is no valid OS.
2. Forcing is maintained if the boot application is loaded successfully. If not, forcing is erased.
3. Diagnostic indications for detected errors are reset.
4. The values of the retain variables are restored if saved context is valid.
5. The values of the retain-persistent variables are restored if saved context is valid.
6. All non-located and non-remanent variables are reset to their initialization values.
7. All fieldbus communications are stopped and restarted after the boot application is loaded successfully.
8. All I/O are reset to their initialization values and then to their user-configured default values if the controller assumes a STOPPED state after the reboot.

For details on variables, refer to Remanent Variables *(see page 62)*.

NOTE: The Check context test concludes that the context is valid when the application and the remanent variables are the same as defined in the Boot application.

NOTE: If you make an online change to your application program while your controller is in the RUNNING or STOPPED state but do not manually update your Boot application, the controller will detect a difference in context at the next reboot, the remanent variables will be reset as per a Reset cold command, and the controller will enter the STOPPED state.

Download Application

Effect: Loads your application executable into the RAM memory. Optionally, creates a Boot application in the Flash memory.

Starting Conditions:
- RUNNING, STOPPED, HALT, and EMPTY states.
- ControllerLockout = 0.

Methods for Issuing the Download Application Command:
- SoMachine:
  Two options exist for downloading a full application:
  - Download command.
  - Multiple Download command.

  For important information on the application download commands, refer to Controller State Diagram *(see page 43)*.
- USB memory key: Load Boot application file using a USB memory key connected to the controller USB host port. The updated file is applied at the next reboot. Refer to Saving your Application and Firmware on a USB Memory Key *(see page 106)* for further details.

Effects of the SoMachine Download Command:
1. The existing application stops and then is erased.
2. If valid, the new application is loaded and the controller assumes a STOPPED state.
3. Forcing is erased.
4. Diagnostic indications for detected errors are reset.
5. The values of the retain variables are reset to their initialization values.
6. The values of any existing retain-persistent variables are maintained.
7. All non-located and non-remanent variables are reset to their initialization values.
8. All fieldbus communications are stopped and then any configured fieldbus of the new application is started after the download is complete.
9. Embedded Expert I/O are reset to their previous user-configured default values and then set to the new user-configured default values after the download is complete.
10. All other I/O are reset to their initialization values and then set to the new user-configured default values after the download is complete.

For details on variables, refer to Remanent Variables *(see page 62)*.

Effects of USB memory key Download Command:

There are no effect until the next reboot. At the next reboot, the effects are the same as a reboot with an invalid context. Refer to Reboot *(see page 105)*.

Error Detection, Types, and Management

Detected Error Management

The controller manages 3 types of detected errors:

- external detected errors
- application detected errors
- system detected errors

The following table describes the types of errors that may be detected:

Type of Error Detected	Description	Resulting Controller State
External Error Detected	External errors are detected by the system while RUNNING or STOPPED but do not affect the ongoing controller state. An external error is detected in the following cases: • A connected device reports an error to the controller • The controller detects an error with an external device whether or not it reports an error, for example when the external device is communicating but not properly configured for use with the controller • The controller detects an error with the state of an output • The controller detects a loss of communication with a device • The boot application in Flash memory is not the same as the one in RAM. Examples: • output short circuit • missing expansion module • communication lost • etc.	RUNNING with External Error Detected Or STOPPED with External Error Detected
Application Error Detected	An application error is detected when improper programming is encountered or when a task watchdog threshold is exceeded. Examples: • task (software) watchdog exception • execution of an unknown function • division by zero • etc.	HALT

Type of Error Detected	Description	Resulting Controller State
System Error Detected	A system error is detected when the controller enters a condition that cannot be managed during runtime. Most such conditions result from firmware or hardware exceptions, but there are some cases when incorrect programming can result in the detection of a system error, for example, when attempting to write to memory that was reserved during runtime. Examples: • System (hardware) watchdog overflow • exceeding the defined size of an array • etc. **NOTE:** There are some system errors that can be managed by runtime and are therefore treated like application errors.	BOOTING → EMPTY

NOTE: refer to the HMI SCU PLCSystem Library Guide *(see Magelis SCU, SoMachine PLCSystem, Library Guide)* for more detailed information on diagnostics.

Remanent Variables

Remanent Variables

Remanent variables can retain their values in the event of power outages, reboots, resets, and application program downloads. There are two types of remanent variables, declared individually as **Retain** or **Persistent retain**. **Retain** variables can be declared within a **POU** or as **Global**. **Persistent retain** variables, however, are only declarable as **Global**.

Remanent variables are retained only if the battery charge is sufficient.

The following table describes the behavior of remanent variables in each case:

Action	**VAR**	**VAR RETAIN**	**VAR GLOBAL PERSISTENT RETAIN**
Online change to application program	X	X	X
Stop	X	X	X
Power cycle	-	X	X
Reset warm	-	X	X
Reset cold	-	-	X
Reset origin	-	-	-
Download of application program	-	-	X
X The value is maintained **-** The value is re initialized			

NOTE: VAR **PERSISTENT RETAIN** symbols must be declared in the **Persistent Variables**... node. To add the node, right-click the **Application** in the **Devices** window, then select **Persistent Variables**... from the **Add Object** menu. One cannot simply declare them in a **POU** or **GVL**.

Controller Configuration

8

Introduction

This chapter describes how to configure the Magelis SCU HMI Controller.

What Is in This Chapter?

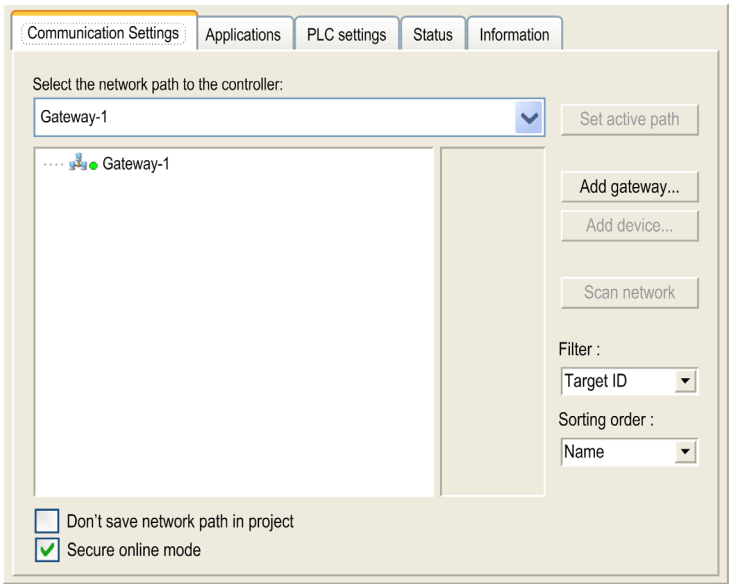
This chapter contains the following topics:

Topic	Page
Controller Configuration	64
Applications	65
HMI SCU Controller Settings	66

Controller Configuration

Controller Configuration Window

Double-click the controller name representing the HMI SCU device in the **Devices** window to access the **Controller Configuration** window:



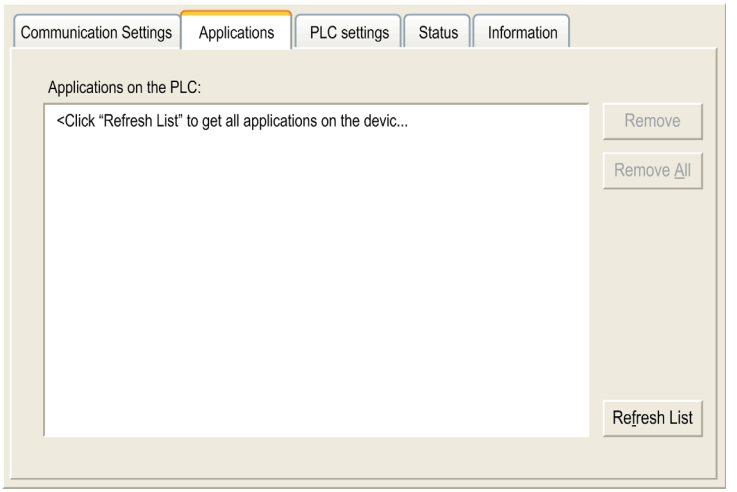
The table describes the tabs of the **Controller Configuration Editor** screen:

Tab Name	Description
Communication Settings	Allows you to configure the connection between SoMachine and the controller. For more information, refer to the CoDeSys online help in SoMachine.
Applications *(see page 65)*	Shows the applications currently running in the controller and allows you to remove applications from the controller.
PLC Settings *(see page 66)*	Configuration of: ● Application for I/O handing ● I/O behavior in stop ● Bus cycle options
Status	Displays device-specific status and diagnostic messages.
Information	Displays general information on the device (name, description, provider, version, image).

Applications

Overview

The figure shows the **Applications** tab:



This dialog box allows scanning and removing applications on the Controller.

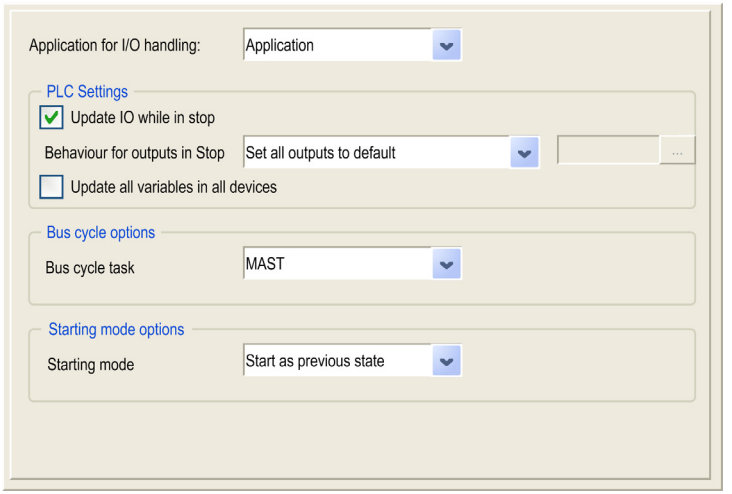
Element		Description
Applications on the Controller		List of the names of applications which have been found on the Controller during the last scan. **NOTE:** SoMachine controllers currently support only one application in a device at a time.
Buttons	Refresh List	The Controller will be scanned for applications, the list will be updated.
	Remove	The application currently selected in the list will be removed from the Controller.
	Remove all	All applications will be removed from the Controller.

For more information, refer to the CoDeSys online help in SoMachine.

HMI SCU Controller Settings

Overview

The figure shows the **PLC Settings** tab:



The table describes the elements of the **PLC Settings Tab**:

Element		Description
Application for I/O handling		By default, set to **Application** because there is only one application in the controller.
PLC settings	Update I/O while in stop	If this option is activated (default), the values of the input channels will be updated when the Controller is stopped.
	Behavior for outputs in Stop	From the selection list choose one of the following options to configure how the values at the output channels should be handled in case of Controller stop: ● **Keep current values**: The current values will not be modified. ● **Set all outputs to default**: The default (fallback) values resulting from the mapping will be assigned. **NOTE:** This option is not taken into account for the outputs used by the HSC, PTO or PWM.
	Update all variables in all devices	If this option is activated, then for all devices of the current Controller configuration all I/O variables will get updated in each cycle of the bus cycle task. This corresponds to the option Always update variables, which can be set separately for each device in the **I/O Mapping** dialog.

Element		Description
Bus cycle options	Bus cycle task	This configuration setting is the parent for all Bus cycle task parameters used in the application device tree. Some devices with cyclic calls, such as a CANopen manager, can be attached to a specific task. In the device, when this setting is set to **Use parent bus cycle setting**, the setting set for the Controller is used. The selection list offers all tasks currently defined in the Task Configuration of the active application. The default setting is the MAST task. **NOTE:** The selection **<unspecified>** signifies that the slowest cyclic task possible is used.

Embedded Functions

9

Overview

This chapter describes how to configure the embedded functions of the Magelis SCU HMI Controller.

The number of inputs and outputs dedicated to the embedded function depends on the HMI controller reference *(see page 13)*.

What Is in This Chapter?

This chapter contains the following topics:

Topic	Page
I/O Embedded Function	70
HSC Embedded Function	73
PTO_PWM Embedded Function	76
Analog I/O Embedded Function	79
Analog Temperature Embedded Function	83

I/O Embedded Function

Overview

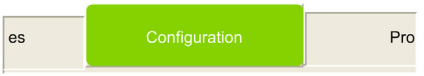
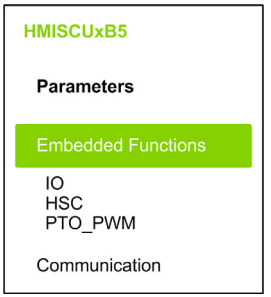
The embedded I/O function allows configuring of the controller inputs.

The table describes the digital inputs of the controllers:

Reference	Total Number of Digital Inputs	Number of Fast Inputs
HMISCU6A5	16	2 fast inputs (FI0, FI1)
HMISCU8A5		
HMISAC		
HMISCU6B5	10	2 fast inputs (FI0, FI1)
HMISCU8B5		
HMISBC		

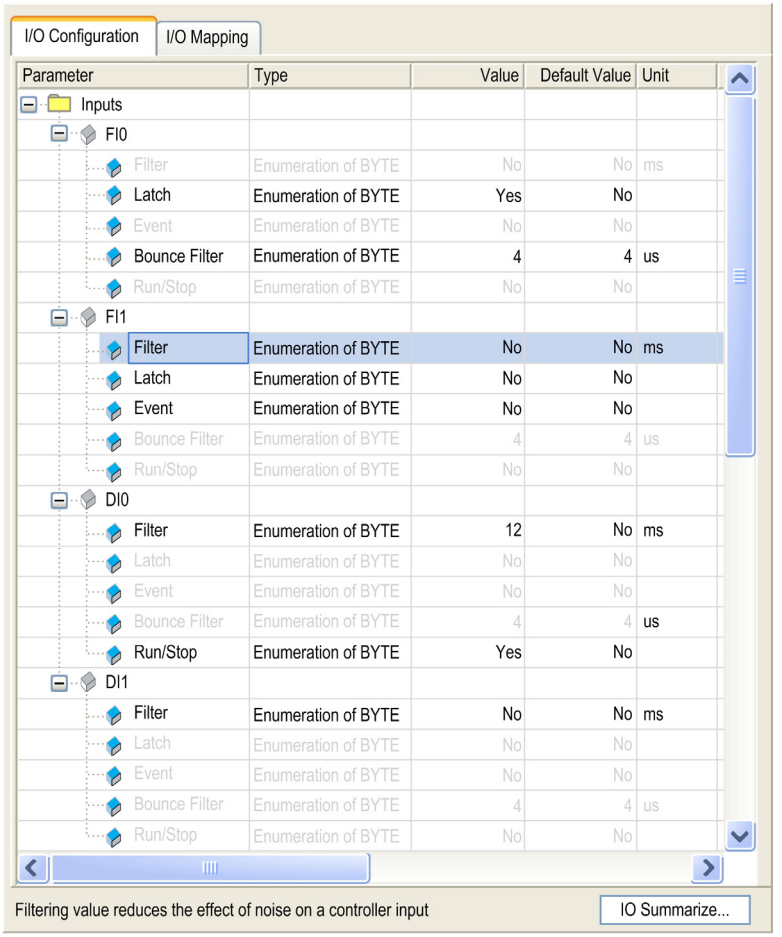
Accessing the I/O Configuration Window

Follow these steps to access the embedded I/O configuration window:

Step	Description
1	Select the **Configuration** tab: 
2	Double-click the controller. **NOTE:** You can also right-click the controller and select **Edit device parameters**.
3	In the Task Pane, click **Embedded Functions** → **IO**: 

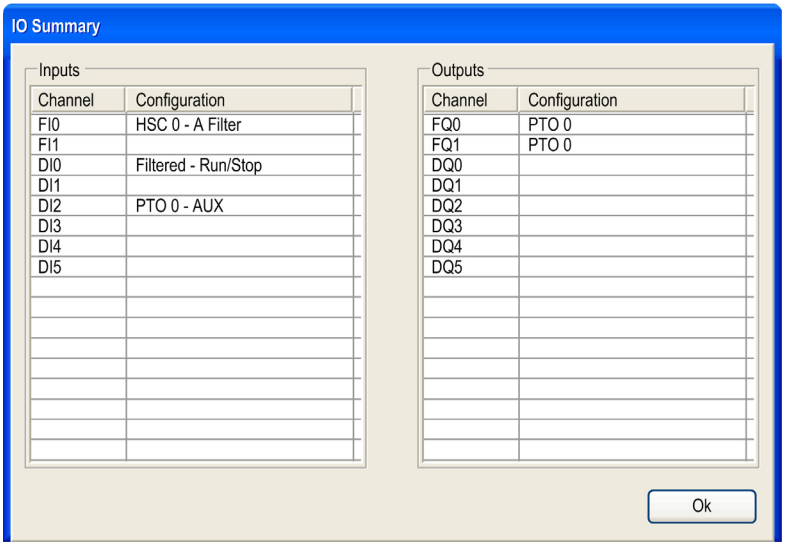
I/O Configuration Window

The window allows you to configure the embedded digital inputs:



NOTE: For more information on the I/O Mapping tab, refer to the CoDeSys online help in SoMachine.

When you click the **IO Summarize** button, the **IO Summary** window appears. It allows you to check your configured I/O mapping:



Configuration Parameters

For each digital input, you can configure the parameters:

Parameter	Value	Description	Constraint
Filter	No* 3 ms 12 ms	Reduce the effect of noise on a controller input.	Available if **Latch** and **Event** are disabled. In the other cases, this parameter is disabled and its value is No.
Latch	No* Yes	Allows incoming pulses with amplitude widths shorter than the controller scan time to be captured and recorded.	This parameter is only available for the fast inputs FI0 and FI1. Available if **Run/Stop** is disabled.
Bounce Filter	4 µs* 40 µs	Reduces the effect of bounce on a controller input.	Available if **Latch** is enabled. In the other cases, this parameter is disabled.
Run/Stop	No* Yes	The Run/Stop input can be used to run or stop a program in the controller	Any of the inputs can be configured as Run/Stop, but only one input can be configured for this purpose.
* parameter default value			

NOTE: The parameter is unavailable if the selection displays as gray in color.

HSC Embedded Function

Overview

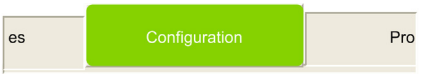
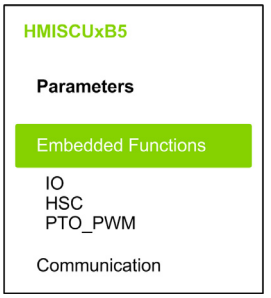
The HSC function can execute fast counts of pulses from sensors, encoders, switches, and so on, that are connected to the dedicated fast inputs.

There are 2 types of HSC:

- **Simple** type: a single input counter *(see Magelis SCU, SoMachine HSC, Library Guide)*.
- **Main** type: a counter that uses up to 4 inputs (2 fast inputs and 2 standard inputs) and 2 reflex outputs *(see Magelis SCU, SoMachine HSC, Library Guide)*.

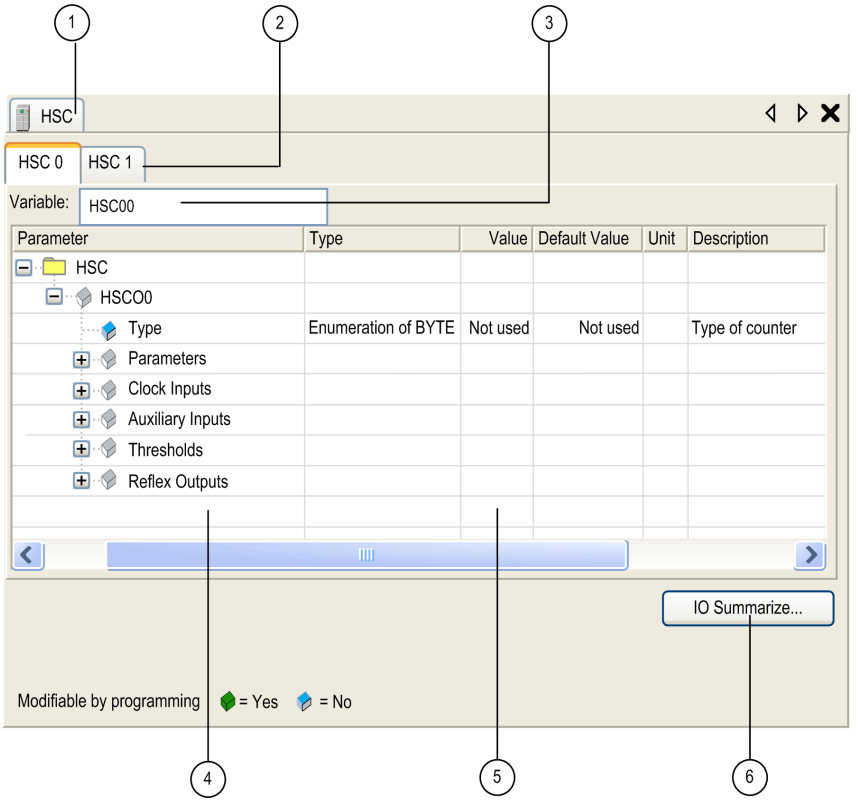
Accessing the HSC Configuration Window

Follow these steps to access the embedded HSC configuration window:

Step	Description
1	Select the **Configuration** tab: 
2	Double-click the controller. **NOTE:** You can also right-click the controller and select **Edit device parameters**.
3	In the Task pane, click **Embedded Functions** → **HSC**: 

HSC Configuration Window

The figure shows a sample HSC configuration window used to configure the HSC:



The table describes the areas of the HSC configuration window:

Number	Action
1	Select the **HSC** tab to access each one of the HSC configuration Windows.
2	Select a specific HSC tab to access the HSC channel you need to configure.
3	Choose the type of HSC (**Simple** or **Main**) you want. The global variable name representing the channel instance can be defined here. Default for HSC 0 is **HSC00**, and for HSC 1 is **HSC01**.
4	You can expand each parameter by clicking the plus sign next to it to access its settings.
5	Configuration window where the HSC parameters are set depending on the mode used.
6	When you click the **IO Summarize** button, the **IO Summary** window appears. It allows you to check your configured physical I/O mapping.

For detailed information on configuration parameters, refer to HMI SCU HSC choice matrix *(see Magelis SCU, SoMachine HSC, Library Guide)*.

PTO_PWM Embedded Function

Overview

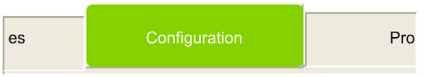
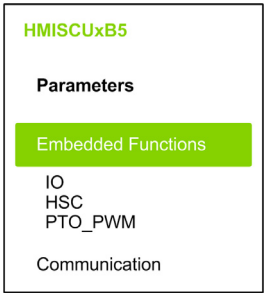
The PTO embedded function can provide 2 different functions:

PTO The PTO (Pulse Train Output) implements digital technology *(see Magelis SCU, SoMachine PTO/PWM, Library Guide)* that provides precise positioning for open loop control of motor drives.

PWM The PWM (Pulse Width Modulation) function generates a programmable square wave signal on a dedicated output *(see Magelis SCU, SoMachine PTO/PWM, Library Guide)* with adjustable duty cycle and frequency.

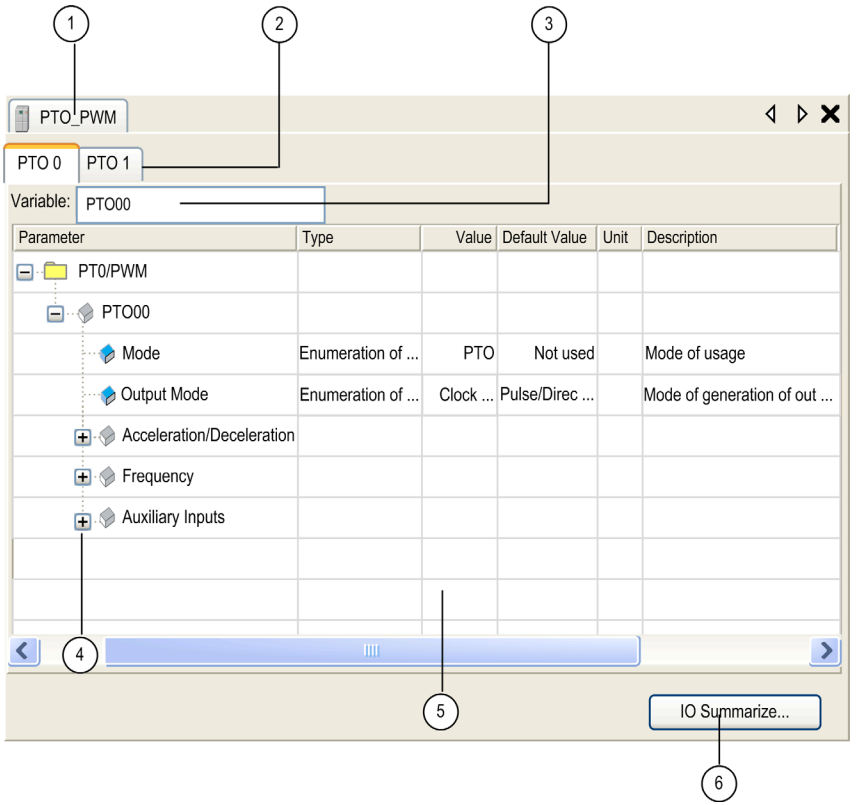
Accessing the PTO_PWM Configuration Window

Follow these steps to access the PTO_PWM embedded function configuration window:

Step	Description
1	Select the **Configuration** tab: 
2	Double-click the controller. **NOTE:** You can also right-click the controller and select **Edit device parameters**.
3	In the Task Pane click **Embedded Functions** → **PTO_PWM**: 

PTO_PWM Configuration Window

The figure shows a sample PTO_PWM configuration window used to configure a PTO or PWM:



The table describes the areas of the PTO_PWM configuration window:

Number	Action
1	Select the **PTO_PWM** tab to access each one of the PTO_PWM configuration Windows.
2	Select a specific PTO tab to access the PTO_PWM channel you need to configure.
3	Choose the type of PTO_PWM (**PTO**, **PWM**) you want, use the field **Variable** to change the **Global Variable** name representing the instance of the channel. Default variable name for PTO 0 channel is **PTO00**. For PTO 1 channel, it is **PTO01**.
4	You can expand each parameter by clicking the plus sign next to it to access its settings.

Number	Action
5	Configuration window where the embedded function is used for: ● PTO ● PWM
6	When you click the **IO Summarize** button, the **IO Summary** window appears. It shows the configured I/O mapping.

For detailed information on configuration parameters, refer to:

- PTO configuration *(see Magelis SCU, SoMachine PTO/PWM, Library Guide)*.
- PWM configuration *(see Magelis SCU, SoMachine PTO/PWM, Library Guide)*.

Analog I/O Embedded Function

Overview

The HMISCU6B5, HMISCU8B5 and HMISBC HMI controllers have embedded analog I/O:

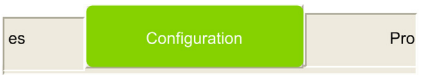
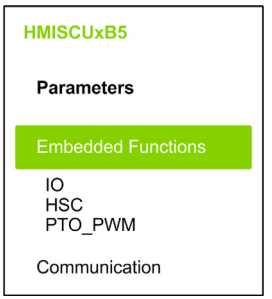
- 2 analog inputs
- 2 analog outputs

NOTICE
INOPERABLE EQUIPMENT Be sure that the physical wiring of the analog circuit is compatible with the software configuration for the analog channel. **Failure to follow these instructions can result in equipment damage.**

For information about the technical characteristics of the analog I/O, refer to the Hardware Guide *(see Magelis SCU, HMI Controller, Hardware Manual)*.

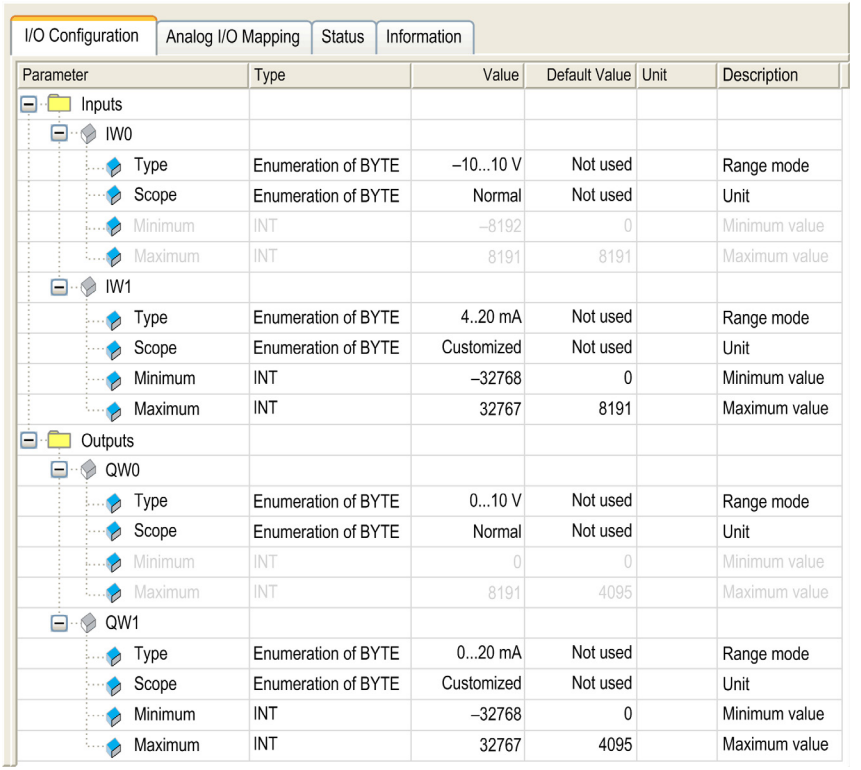
Accessing the Analog I/O Configuration Window

Follow these steps to access the analog I/O embedded function configuration window:

Step	Description
1	Select the **Configuration** tab: 
2	Double-click the controller. **NOTE:** You can also right-click the controller and select **Edit device parameters**.
3	In the Task Pane, click **Embedded Functions** → **Analog IO**: 

Analog I/O Configuration Window

This window allows you to configure the analog I/O:



I/O Configuration | Analog I/O Mapping | Status | Information

Parameter	Type	Value	Default Value	Unit	Description
Inputs					
IW0					
Type	Enumeration of BYTE	–10...10 V	Not used		Range mode
Scope	Enumeration of BYTE	Normal	Not used		Unit
Minimum	INT	–8192	0		Minimum value
Maximum	INT	8191	8191		Maximum value
IW1					
Type	Enumeration of BYTE	4..20 mA	Not used		Range mode
Scope	Enumeration of BYTE	Customized	Not used		Unit
Minimum	INT	–32768	0		Minimum value
Maximum	INT	32767	8191		Maximum value
Outputs					
QW0					
Type	Enumeration of BYTE	0...10 V	Not used		Range mode
Scope	Enumeration of BYTE	Normal	Not used		Unit
Minimum	INT	0	0		Minimum value
Maximum	INT	8191	4095		Maximum value
QW1					
Type	Enumeration of BYTE	0...20 mA	Not used		Range mode
Scope	Enumeration of BYTE	Customized	Not used		Unit
Minimum	INT	–32768	0		Minimum value
Maximum	INT	32767	4095		Maximum value

NOTE: Embedded analog I/Os are always physically updated by the MAST task.

For more information on the **Analog I/O Mapping** tab, refer to the CoDeSys online help in SoMachine.

I/O Configuration Tab

To configure the HMI SCU, select the **I/O Configuration** tab.

The table describes the analog parameters configuration:

Parameter	Value	Description	Constraint
Type	Not used * – 10...10 V 0...10 V 0...20 mA 4...20 mA	Range mode	–

Parameter		Value	Description	Constraint
Scope		Normal * Customized	Unit	Available if **Type** value is defined.
Minimum	Normal Analog input	– 10...10 V: – 8192 0...10 V: 0 0...20 mA: 0 4...20 mA: 0	Minimum value	Not configurable.
	Normal Analog output	– 10...10 V: – 2048 0...10 V: 0 0...20 mA: 0 4...20 mA: 0		Not configurable.
	Customized Analog I/O	– 10...10 V: – 32768 0...10 V: – 32768 0...20 mA: – 32768 4...20 mA: – 32768		Inferior that the configured maximum. Configured minimum must be less than the configured maximum.
Maximum	Normal Analog input	– 10...10 V: 8191 0...10 V: 16383 0...20 mA: 16383 4...20 mA: 16383	Maximum value	Not configurable.
	Normal Analog output	– 10...10 V: 2047 0...10 V: 4095 0...20 mA: 4095 4...20 mA: 4095		Not configurable.
	Customized Analog I/O	– 10...10 V: 32767 0...10 V: 32767 0...20 mA: 32767 4...20 mA: 32767		Superior that the configured minimum. Configured maximum must be more than the configured minimum.
* parameter default value				

NOTE: The parameter is unavailable if the selection displays as gray in color.

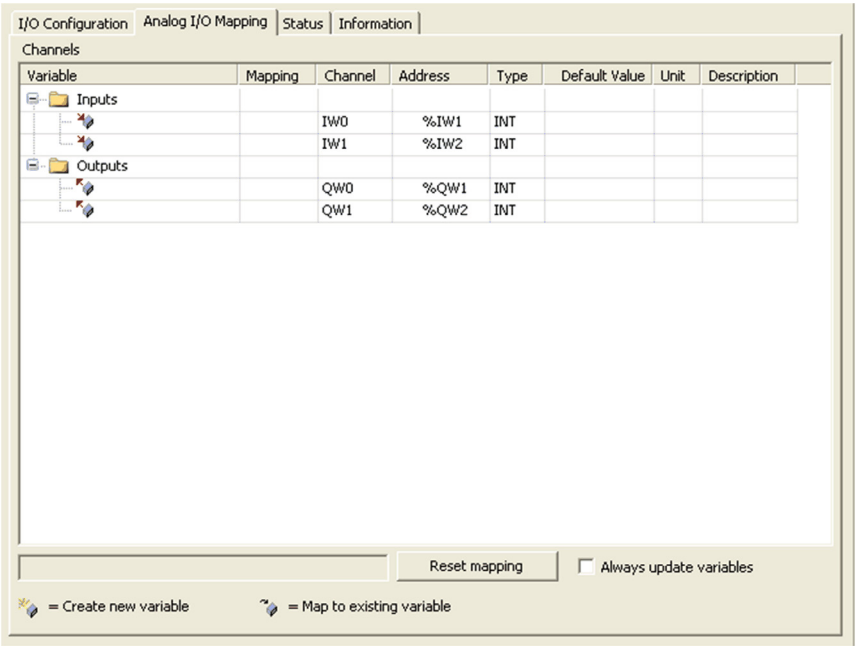
Analog to Digital Conversion Rate

Analog-to-digital conversion rate for data acquisition is made using the converter hardware. All analog I/O that are configured are converted every 2 ms.

I/O Mapping Tab

Variables can be defined and named in the **Analog I/O Mapping** tab. Additional information such as topological addressing is also provided in this tab.

This window shows the **Analog I/O Mapping** tab:



The table describes the I/O mapping configuration:

Variable	Channel	Type	Default value	Description
Inputs	IW0	INT	–	Current value of the input 0
	IW1			Current value of the input 1
Outputs	QW0	INT	–	Current value of the output 0
	QW1			Current value of the output 1

Analog Temperature Embedded Function

Overview

The HMISCU6B5, HMISCU8B5 and HMISBC HMI controllers have embedded analog temperature with 2 Inputs. The HMI SCU is designed for various sensor types. The sensor type must be specified because of the different adjustment values.

NOTICE
INOPERABLE EQUIPMENT Be sure that the physical wiring of the analog circuit is compatible with the software configuration for the analog channel. **Failure to follow these instructions can result in equipment damage.**

For information about the technical characteristics of the analog temperature inputs, refer to the Hardware Guide *(see Magelis SCU, HMI Controller, Hardware Manual)*.

Analog Temperature Input Configuration Window

This window allows you to configure the analog temperature inputs:

I/O Configuration | Temperature I/O Mapping | Status | Information

Parameter	Type	Value	Default Value	Unit	Description
Inputs					
IW0					
Type	Enumeration of BYTE	Thermocouple J	Not used		Range mode
Scope	Enumeration of BYTE	Celsius (0.1 °C)	Not used		Unit
Minimum	INT (–2000...7600)	–2000	–32768		Minimum value
Maximum	INT (–2000...7600)	7600	32767		Maximum value
IW1					
Type	Enumeration of BYTE	PT100(3 Wire)	Not used		Range mode
Scope	Enumeration of BYTE	Customized	Not used		Unit
Minimum	INT (–32768...32767)	–32768	–32768		Minimum value
Maximum	INT (–32768...32767)	32767	32767		Maximum value

NOTE: Embedded analog I/Os are always physically updated by the MAST task.

For more information on the **Analog I/O Mapping** tab, refer to the CoDeSys online help in SoMachine.

I/O Configuration Tab

To configure the HMI SCU, select the **I/O Configuration** tab.

The table describes the analog input parameter configuration:

Parameter	Value	Description	Constraint
Type	Not used * Thermocouple J Thermocouple K Thermocouple R Thermocouple B Thermocouple S Thermocouple T Thermocouple E Thermocouple N PT100 (2/4 Wire) PT1000 (2/4 Wire) NI100 (2/4 Wire) NI1000 (2/4 Wire) PT100 (3 Wire) PT1000 (3 Wire) NI100 (3 Wire) NI1000 (3 Wire)	Range mode	–
Scope	Not used * Normal Customized Celsius (0.1 °C) Fahrenheit (0.1 °F)	Unit	Available if **Type** value is defined.

Parameter		Value	Description	Constraint
Minimum	Normal	0	Minimum value	Not configurable.
	Customized	– 32768	Minimum value	Lowest configurable value.
	Celsius	Thermocouple J: –2000 Thermocouple K: –2400 Thermocouple R: 0 Thermocouple B: 2000 Thermocouple S: 0 Thermocouple T: –2000 Thermocouple E: –2000 Thermocouple N: –2000 PT100: –2000 PT1000: –2000 NI100: –500 NI1000: –500	Minimum value	Not configurable.
	Fahrenheit	Thermocouple J: –3280 Thermocouple K: –4000 Thermocouple R: 32 Thermocouple B: –3920 Thermocouple S: 32 Thermocouple T: –3280 Thermocouple E: –3280 Thermocouple N: –3280 PT100: –3280 PT1000: –3280 NI100: -580 NI1000: -580	Minimum value	Not configurable.

Parameter		Value	Description	Constraint
Maximum	Normal	65535	Maximum value	Not configurable.
	Customized	32767	Maximum value	Highest configurable value.
	Celsius	Thermocouple J: 7600 Thermocouple K: 13700 Thermocouple R: 16000 Thermocouple B: 18000 Thermocouple S: 16000 Thermocouple T: 4000 Thermocouple E: 9000 Thermocouple N: 13000 PT100: 6000 PT1000: 6000 NI100: 2000 NI1000: 2000	Maximum value	Not configurable.
	Fahrenheit	Thermocouple J: 14000 Thermocouple K: 24980 Thermocouple R: 29120 Thermocouple B: 32720 Thermocouple S: 29120 Thermocouple T: 7520 Thermocouple E: 16520 Thermocouple N: 23720 PT100: 11120 PT1000: 11120 NI100: 3920 NI1000: 3920	Maximum value	Not configurable.
* parameter default value				

NOTE:

- To reduce cycle time, do not activate a channel when there is no sensor connected.
- The data type is always INT which is a 16 bit integer value. The minimum and maximum values are shown according to the entries in the table above. (for example, for thermocouple J in Celsius the Type would read: **INT**(– 2000...7600))
- The parameter is unavailable if the selection displays as gray in color.

Analog to Digital Conversion Rate

Analog-to-digital conversion rate for data acquisition is made using the converter hardware. All temperature analog I/Os that are configured are converted every 2 ms.

Terminal Temperature (Cold Junction) Compensation

Terminal Temperature (Cold Junction) Compensation is measured and calculated internally. No extra temperature measurement of the terminal is required.

I/O Mapping Tab

Variables can be defined and named in the **I/O Mapping** tab. Additional information such as topological addressing is also provided in this tab.

The table describes the I/O mapping configuration:

Variable	Channel	Type	Default Value	Description
Inputs	IW0	INT	–	Current value of the input 0
	IW1			Current value of the input 1

Serial Line Configuration

10

Introduction

This chapter describes how to configue the serial line communication of the Magelis SCU HMI Controller.

What Is in This Chapter?

This chapter contains the following topics:

Topic	Page
Serial Line Configuration	90
Serial Line Protocol Manager	92
SoMachine Network Manager	94
Modbus Manager	95

Serial Line Configuration

Introduction

The serial line **Configuration** window allows configuring the physical parameters of the serial line (baud rate, parity, and so on).

The Serial Line port(s) of your controller are configured for the SoMachine protocol by default when new or when you update the controller firmware. The SoMachine protocol is incompatible with other protocols such as that of Modbus Serial Line.

In an active Modbus configured serial line, if a new controller is connected or if controller firmware is updated, this can cause the other devices available on the serial line to stop communicating.

Check that the controller is not connected to an active Modbus serial line network before downloading a valid application having the concerned port or ports properly configured for the intended protocol.

⚠ WARNING

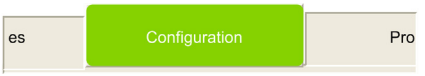
UNINTENDED EQUIPMENT OPERATION

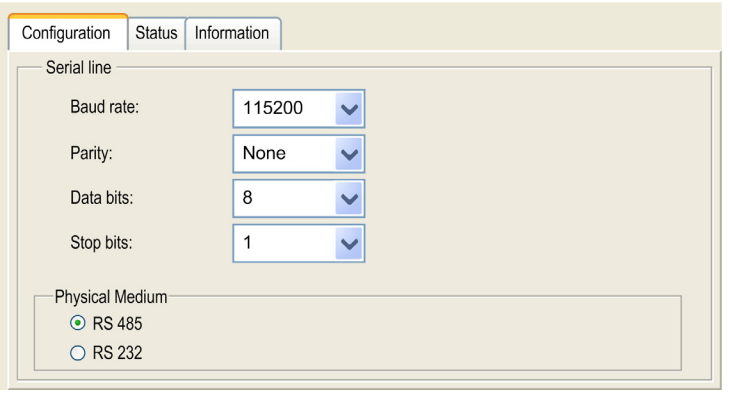
Verify that your application has the Serial Line port(s) properly configured for Modbus before physically connecting the controller to an operational Modbus serial line network.

Failure to follow these instructions can result in death, serious injury, or equipment damage.

Serial Line Configuration

To configure the serial line, proceed as follows:

Step	Action
1	Select the **Configuration** tab and double-click the controller. 

Step	Action
2	Click the **Communication** → **COM1** entry on the task selection pane.
3	Click the **Physical Settings** entry. The **Configuration** window is displayed: 

NOTE: You can also select the **Program** tab and double-click the **COM1** in the device tree to access the **Configuration** window.

The following parameters must be identical for each serial device connected to the port:

Element	Description
Baud rate	Transmission speed
Parity	Used for error detection
Data bits	Number of bits for transmitting data
Stop bits	Number of stop bits
Physical medium	Specify to use RS-232 or RS-485

Serial Line Protocol Manager

Overview

The Magelis SCU HMI Controller is equipped with 1 serial line:

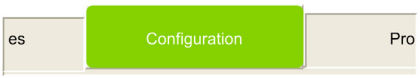
Serial Line	Supported protocol
COM1	Modbus Manager SoMachine Network Manager *
Legend. *: Default setting for COM1	

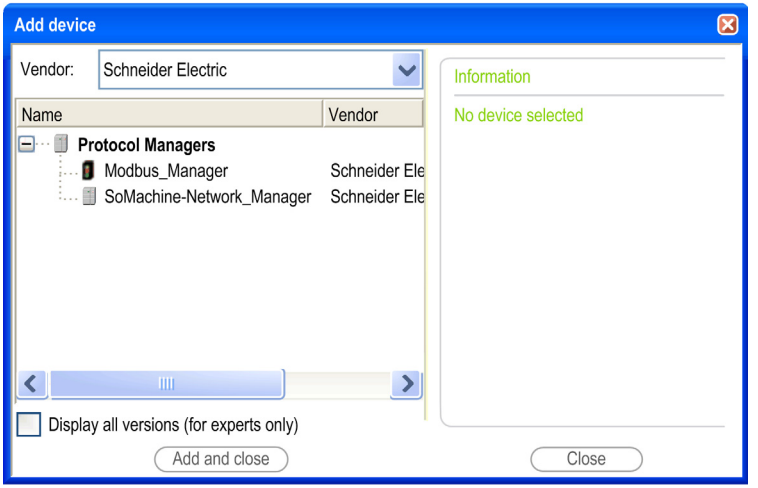
The following table indicates the Manager baud rate characteristic:

Manager	Maximum Baud Rate (bits/s)	Supported Baud Rate (bits/s)
SoMachine Network Manager	115200	115200, 57600, 38400, 19200, 9600
Modbus Manager	115200	115200, 57600, 38400, 19200, 9600

Adding the Serial Line Protocol Manager

Follow these steps to add a protocol manager on the serial line:

Step	Action
1	Select **Configuration** tab and double-click the controller. 
2	Click **Communication** → **COM 1**.
3	Click the **Protocol Settings** entry.

Step	Action
4	Click the **Remove/Change Protocol**, and the **Add device** window is displayed.  **NOTE:** You also can access this window by selecting the **Configuration** tab and clicking the serial line port of the controller from the graphical configuration editor.
5	Select the manager and click **Add and close**.

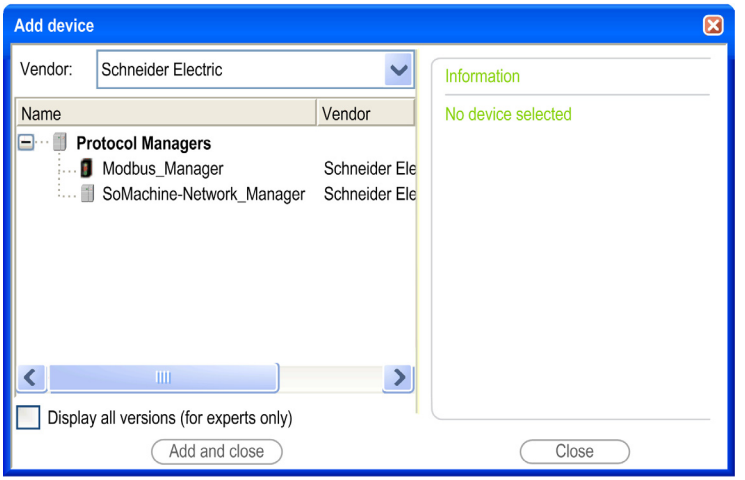
SoMachine Network Manager

Introduction

The SoMachine Network Manager must be used if you want to exchange variables with a controller such as M238 or M258, or a SoMachine compatible HMI such as the Magelis GTO using SoMachine software protocol.

Adding the Manager

To add a Manager on Serial Line, proceed as follows:

Step	Action
1	Select the **Configuration** tab and double-click on the controller.
2	Click the **Communication** → **COM1** entry on the left hand side.
3	Click the **Protocol Settings** entry.
4	Click the **Remove/Change Protocol** button. Select the **SoMachine-Network_Manager** object and click **Add and close**: 

Configuring the Manager

There is no configuration for the SoMachine Network Manager.

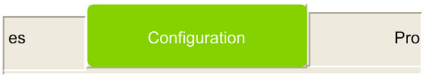
Modbus Manager

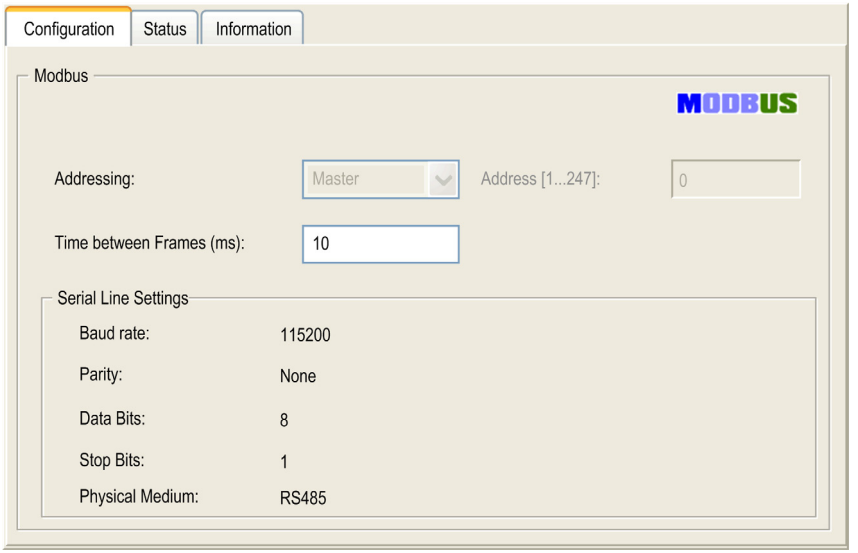
Introduction

The Modbus Manager is used for Modbus RTU protocol in master mode.

Configuring the Manager

To configure the **Modbus_Manager** of your controller, proceed as follows:

Step	Action
1	Select the **Configuration** tab and double-click the controller. 
2	Click the **Communication** → **COM1** entry on the task selection pane.

Step	Action
3	Click the **Protocol Settings** entry. **Result:** The **Modbus_Manager** configuration window is displayed if **Modbus_Manager** is already configured on this serial line port. 

Set the parameters as described in the following table:

Element	Description
Addressing	The HMI SCU is configured as a master. No other options are available.
Address [1...247]	Modbus address of the device. For Modbus master, this is set to 0.
Time between Frames (ms)	Time to avoid bus-collision. This parameter must be identical for each Modbus device on the link.
Serial Line Settings	Displays the parameters specified in **[Physical Settings]** of the Serial Line configuration menu *(see page 90)*.

Modbus Master

When the controller is configured as a Modbus Master, the following Function Blocks are supported from the PLCCommunication Library:

- ADDM
- READ_VAR
- SINGLE_WRITE
- WRITE_READ_VAR
- WRITE_VAR

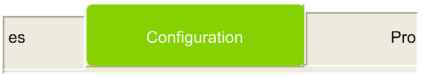
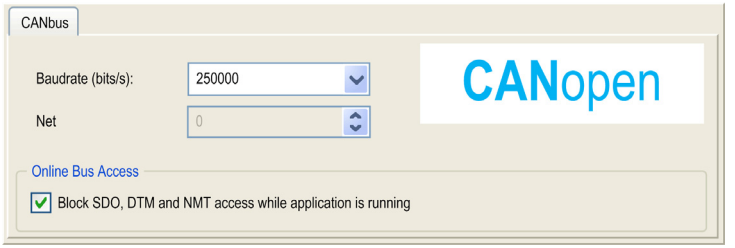
For further information, see Function Block Descriptions *(see SoMachine, Modbus and ASCII Read/Write Functions, PLCCommunication Library Guide)* of the PLCCommunication Library *(see SoMachine, Modbus and ASCII Read/Write Functions, PLCCommunication Library Guide)*.

CANopen Configuration

11

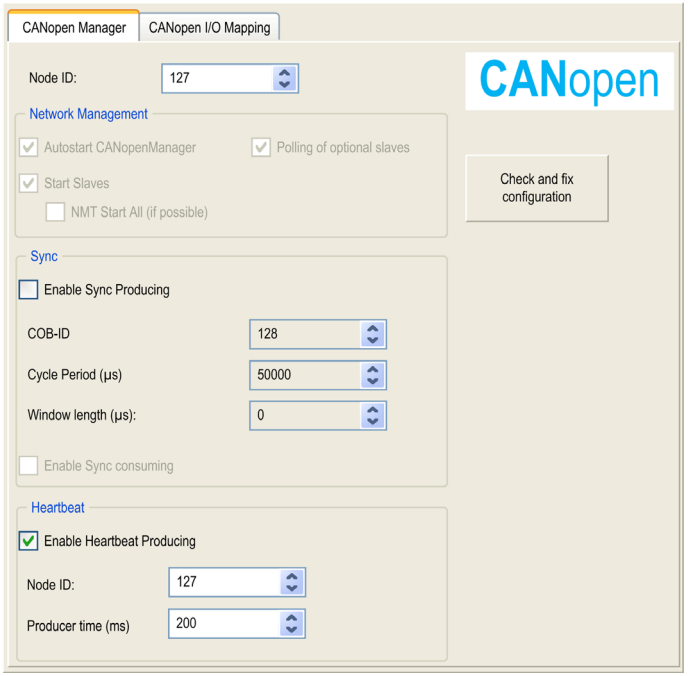
CANopen Interface Configuration

To configure the CAN bus of your controller, proceed as follows:

Step	Action
1	Select the **Configuration** tab and double-click the controller: 
2	Click the **Communication** entry on the left-hand side of the screen.
3	Click the **CAN** entry.
4	Click the **Physical Settings** entry. **Result:** The tabbed configuration dialog box for CANopen networks is displayed on the right-hand side of the screen.
5	Configure the baudrate (by default: 250000 bits/s):  **NOTE:** The **Online Bus Access** option allows you to block SDO, DTM and NMT sending through the status screen.

CANopen Manager Creation and Configuration

To create and configure the **CANopen Manager**, proceed as follows:

Step	Action
1	Click the **Protocol Settings** entry and select **CANopen Optimized** in the **Devices** window.
2	Click the **Add and close** button. **Result:** The **CANopen Manager** configuration window appears: 

For more information, refer to the CoDeSys online help in SoMachine.

Adding a CANopen Device

For more information on adding a CANopen slave device, refer to the CoDeSys online help in SoMachine and Adding Slave Devices to a Communication Manager *(see SoMachine, Programming Guide)*.

CANopen Operating Limits

The Magelis SCU HMI Controller CANopen master has the following recommended operating limits:

Maximum number of slave devices	16
Maximum number of Received PDO (RPDO)	32
Maximum number of Transmitted PDO (TPDO)	32

⚠ WARNING

UNINTENDED EQUIPMENT OPERATION

- Do not connect more than 16 CANopen slave devices to the controller
- Program your application to use 32 or fewer Transmit PDO (TPDO)
- Program your application to use 32 or fewer Receive PDO (RPDO)

Failure to follow these instructions can result in death, serious injury, or equipment damage.

Ethernet Configuration

12

IP Address Configuration

Introduction

Setting up an Ethernet connection and IP address configuration with the HMI controllers is accomplished with Vijeo-Designer.

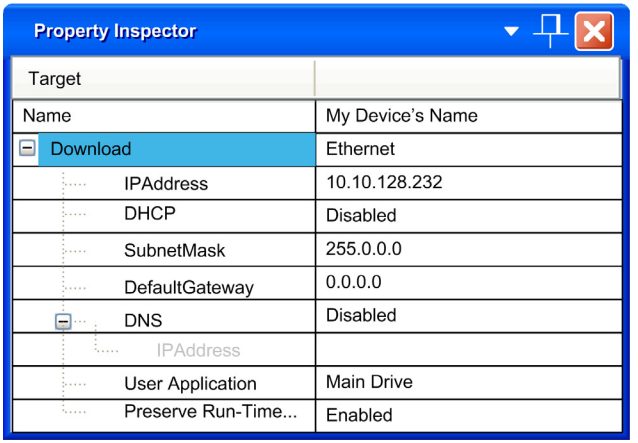
There are two ways to assign the IP address of the controller with Vijeo-Designer:

- DHCP server
- Fixed IP address

NOTE: If the above addressing modes are not operational, the PLC starts with a *default IP address (see page 104)* derived from its MAC address.

Ethernet Configuration

For the HMI controller, the Ethernet configuration is done via the Vijeo-Designer **Property Inspector** window:



NOTE: The Ethernet configuration parameters are applied after a download of the HMI application.

The following table briefly explains the different parameters needed for setting up an Ethernet configuration:

Element	Description
Download	Choose the project download method you want in the drop down menu list. When configuring ethernet connection, select **Ethernet**. The project download methods are: ● Ethernet ● File System ● USB ● SoMachine
IP Address	IP address of the controller.
DHCP	When DHCP is: ● **Enable**: The controller automatically retrieves an IP address from a DHCP server. ● **Disabled**: The controller uses a static IP address.
SubnetMask	When using a static IP setting, provide the subnet mask of your network.
DefaultGateway	When using a static IP setting, provide the default gateway of your network.
DNS	**Enable** DNS to use domain names instead of IP addresses.
DNS IP Address	When using DNS, provide the IP address for the DNS server.

NOTE: For more information on how to configure the Ethernet connection between your computer and the HMI controller, refer to Vijeo-Designer online help.

Default IP Address

The default IP address is based on MAC address of the device. The first two bytes are 10 and 10. The last two bytes are the last two bytes of the device's MAC address.

The default subnet mask is 255.0.0.0.

NOTE: A MAC address has an hexadecimal format and an IP address has a decimal format. Convert the MAC address into decimal format.

Example: If the MAC address is 00.80.F4.01.80.F2, the default IP address is 10.10.128.242.

Connecting the Magelis SCU HMI Controller to a PC

13

Connecting the Controller to a PC

Application Transfer

To transfer and run applications, connect your HMISCU to a PC that has SoMachine installed. To transfer an application, use Ethernet, serial link or a USB memory key.

NOTICE
POSSIBLE ELECTRICAL DAMAGE TO CONTROLLER COMPONENTS
Connect the communication cable to the PC before connecting it to the controller.
Failure to follow these instructions can result in equipment damage.

NOTE: Only one HMISCU can be connected to a computer at a time, except when using Ethernet.

Automatic Reboot after Application Transfer

The HMISCU automatically reboots after a download of the application, this includes the control part (SoMachine) and the HMI part (Vijeo-Designer).

Firmware Update

When transferring an application (via Ethernet or a USB memory key), the firmware update is done automatically. As a matter of good practice, you should always have a backup of your application/firmware combination on a USB memory key *(see page 106)*. At the very least, be sure to properly archive your application with the versions of SoMachine it was created and maintained under.

Application Download with Firmware Downgrade

The HMISCU can download an application and downgrade the firmware from a USB memory key. You must first save the application and the appropriate firmware version on a USB memory key.

To download an application and downgrade the firmware of your controller follow the steps in the table below:

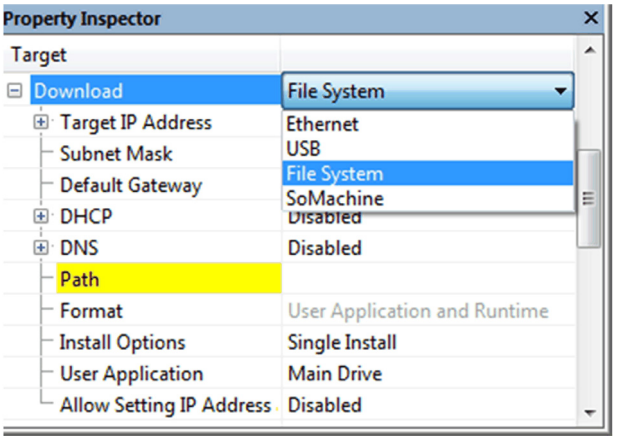
Step	Action
1	Turn off the power supply of your controller, prior to connecting the USB memory key.
2	Connect the USB memory key containing the application and firmware into the USB port of your controller.
3	Turn on your controller. **Result:** The application and the firmware version from the USB memory key are downloaded.

NOTE: If you plug a USB memory key containing the application and firmware while the controller is on, a screen is displayed asking you whether you want to install the application from the USB memory key.

Saving your Application and Firmware on a USB memory key

You can save your application and firmware on a FAT 32 USB memory key. To save, follow the steps in the table below:

Step	Action
1	Insert a USB memory key into the USB port of your computer.
2	Double-click on **HMI Application** in the **Devices** window of your project. **Result:** The project switches for the HMI and the main Vijeo Designer window appears.
3	Right click on the controller node in the **Navigator** window, and select **Properties**. **Result:** The **Property Inspector** window appears.

Step	Action
4	Select **File System** from the **Download** menu as shown in the following figure: 
5	Set the directory from the **Path** menu to the USB memory key. **NOTE:** Select the root level of your USB memory key.
6	Click the **OK** button. **Result:** The directory is now set to the USB memory key.
7	Click **Build** → **Download All** from the Vijeo Designer main menu bar. **Result:** The application is saved onto the USB memory key.

NOTE: Use a FAT32 USB memory key to save your application and firmware.

Firmware Update

14

Upgrading Magelis SCU HMI Controller Firmware/Runtime

Introduction

There are three methods of updating the Firmware/Runtime on an HMISCU:

- Use the **Runtime Installer Tool**. From the **Start Bar** in Windows, it is located in: **All ProgramsSchneider Electric Vijeo Designer ToolsRuntime Installer**.
- Download an HMI project from a newer version of **Vijeo Designer Editor** to the HMISCU. This can be done via **Vijeo Designer Editor** or **SoMachine Editor** with any connection method. A prompt will appear if the Runtime version on the HMI is older than that of the **Vijeo Designer Editor** software.
- Download an HMI project from a newer version of **Vijeo Designer Editor** to a USB memory stick. Then insert the memory stick into the HMISCU. A prompt will appear on the screen of the HMISCU to install the new project.

For more information, refer to the **Vijeo Designer Online Help**, section Installing Vijeo Designer Runtime.

NOTICE
LOSS OF APPLICATION DATA • Perform a backup of the application program to the hard disk of the PC before attempting a firmware update. • Restore the application program to the device after a successful firmware update. **Failure to follow these instructions can result in equipment damage.**

If there is a power outage or communication interruption during the transfer of the application program or a firmware update, your device may become inoperative. If a communication interruption or a power outage occurs, reattempt the transfer.

NOTICE

INOPERABLE EQUIPMENT

- Do not interrupt the transfer of the application program or a firmware update once the transfer has begun.
- Do not place the device into service until the transfer has completed successfully.

Failure to follow these instructions can result in equipment damage.

Magelis SCU HMI Controller - Troubleshooting and FAQ

15

What Is in This Chapter?

This chapter contains the following topics:

Topic	Page
Troubleshooting	112
Frequently Asked Questions	116

Troubleshooting

Introduction

This section lists the possible troubleshooting solutions with the HMISCU, and procedures for troubleshooting them.

Transferring the Application is not Possible

Possible causes:

- PC cannot communicate with the controller.
- SoMachine not configured for the current connection.
- Is your application valid?
- Is the CoDeSys gateway running?
- Is the CoDeSys SP win running?

Resolution:

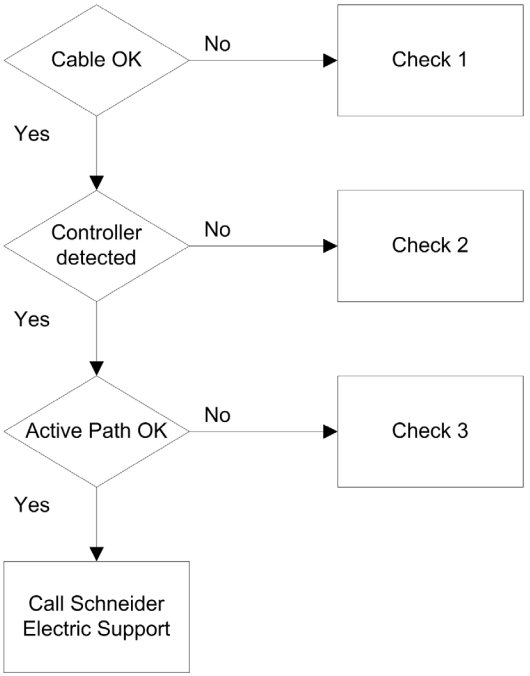
- Refer to Communication between SoMachine and the HMISCU *(see page 112)*.
- Your application program must be valid. Refer to the debugging section in the CoDeSys Online-Help.
- The CoDeSys gateway must be running:
  a. click the CoDeSys Gateway icon in the task bar,
  b. select **Start Gateway**.

Communication Between SoMachine and the HMISCU is not Possible.

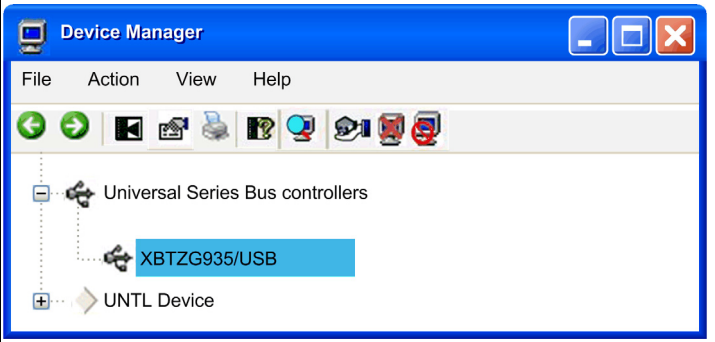
Possible causes:

- SoMachine not configured for the current connection.
- Incorrect cable usage.
- Controller not detected by the PC.
- Communication settings are not correct.
- The controller has detected an error or its firmware is invalid.

Resolution: Follow the flowchart below for troubleshooting purposes and then refer to the next table:



Check	Action
1	Check that: ● The cable is correctly linked to the controller and to the PC, and is not damaged, ● You used the specific cable or adapter, depending on the connection type: ● Ethernet and Serial link connection. ● XBTZG935 cable for a USB connection. ● XBTZG935 and XBTZGUSB or TCSXCNAMUM3P and XBTZGUSBB connection when the controller is mounted on a front panel.

Check	Action
2	Check that the HMISCU has been detected by your PC: **1.** Click **Start** → **Control Panel** → **System**, then select the **Hardware** tab and click **Device Manager**, **2.** Check that the HMISCU node appears in the list, as shown below:  **3.** If the HMISCU node does not appear, or if there is an icon in front of the node, disconnect and reconnect the cable on the controller side.
3	Check that the active path is correct: **1.** Double-click the controller node in the device view. **2.** Check that the HMISCU node appears in bold, not in italic. If not: **a.** Stop the CoDeSys Gateway: right click the icon in the task bar and select **Stop Gateway**. **b.** Disconnect and reconnect the cable on the controller side. **c.** Start the CoDeSys Gateway: right click the icon in the task bar and select **Start Gateway**. **d.** Select the gateway in the controller window of SoMachine and click **Scan network**. Select the HMISCU node and click **Set active path**. **NOTE:** If your PC is connected to an Ethernet network, its address might have changed. In this case, the currently set active path is no longer correct and the HMISCU node appears in italics. Select the HMISCU node and click **Resolve Name**. If the node no longer appears in italics, click **Set Active Path** to correct this.

Application Does Not Go To RUN State

Possible causes:

- No POU declared in the task.
- ControllerLockout activated.

Resolution:

As POUs are managed by tasks, add a POU to a task:

1. Double-click a task in the device view.
2. Click **Add POU** in the task window.
3. Select the POU you want to execute in the **Input Assistant** window and click **OK**.
4. Unlock ControllerLockout in Vijeo Designer.

Creating the Boot Application is not Possible

Possible cause:

Operation not possible while the controller is in RUN state.

Resolution:

- Select **Stop Application**.
- Select **Create Boot Project**.

Changing Device Name does not work

Possible cause:

Application is running.

Resolution:

- Select **Stop Application**,
- Change device name.

CANopen Heartbeat is not sent on a regular basis

Possible cause:

Heartbeat value is not correct.

Resolution:

The Heartbeat of the CANopen master must be reset:

- Calculate the Heartbeat consumer time:
  Heartbeat Consumer Time = Producer Time * 1.5
- Update the Heartbeat value

Monitoring of the POU is slow

Possible cause:

- Task interval is too small or POU is too big.
- Connection speed low between controller and device (over serial connection).

Resolution:

- Increase the configured task interval.
- Split the application into smaller POUs.

Out of Memory appears on the HMI screen

Possible cause:

- The number of variables and symbols shared between the controller and the HMI is too high.

Resolution:

- Decrease the number of variables and symbols shared between the controller and the HMI.
- Power cycle the HMI.

Frequently Asked Questions

What Programming Languages are supported by a HMISCU?

The following languages are supported:
- Continuous Function Chart (CFC)
- Function Block Diagram (FBD)
- Instruction List (IL)
- Ladder Logic Diagram (LD)
- Sequential Function Chart (SFC)
- Structured Text (ST)

What Variable Types are supported by an HMISCU Controller?

Refer to the *Supported Variables section*.

Can I Use the SoMachine Network to Communicate with Equipment Connected to the Serial Line of my HMISCU?

Communication is possible with an HMISCU only if the serial line is configured with the *Network Protocol*.

Limitations:
- Slow access to the remote equipment.
- You cannot cascade other equipment.

For more information, refer to SoMachine - Network/Combo: HMISCU part, available in the appendix of the Vijeo-Designer online help.

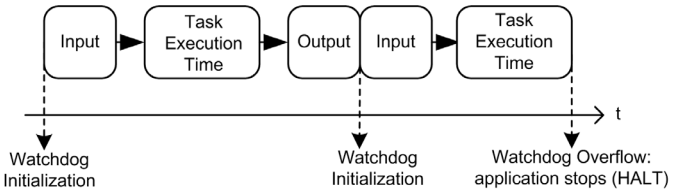
When Should I Use Freewheeling or Cyclic Mode?

Freewheeling or cyclic mode usage:
- Freewheeling: use this mode if you want a variable cycle time. The next cycle starts after a waiting period equal to 30% of the last cycle execution time.
- Cyclic: use this mode if you want to control the frequency cycle.

How Do I Configure the Watchdog?

You can configure the watchdog (control timer per task) using SoMachine by defining the following parameters:
- **Time**: Set the maximum period of a given task. If the task execution time exceeds the maximum period, the watchdog is triggered.
- **Sensitivity**: Set the number of allowed consecutive and cumulate watchdog overruns before a watchdog trigger is generated.

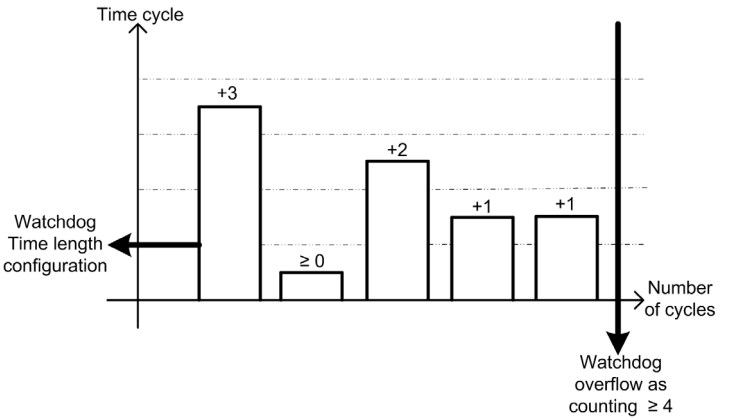
Depending on the **Time** and **Sensitivity** parameters, if the watchdog is triggered, the controller is stopped and goes into HALT mode. The associated task remains uncompleted, as shown in the following diagram:



During a task execution, the firmware:

- Resets the overtime timer if the watchdog is not triggered.
- Increments the overtime timer if the watchdog is triggered.

In the following example the **Sensitivity** is set to 5:



What does the Start all application after download or online change checkbox do?

- Case 1: Standalone HMI application download or HMI and Control applications download
  - The BOOT state of the Control application is updated based on the checkbox setting
- Case 2: Control application download only
  - The setting of the checkbox takes effect after the download/online change
  - The RUN of the control application at BOOT time is not affected

Can I connect several HMISCU through several USB ports on my PC?

No, this is not supported.

When I use a new any controller within SoMachine with a previous HMI application, why can't I communicate anymore?

This is because the new controller name in the HMI application (Vijeo-Designer) is not updated. The HMI application is configured with the previous controller name.

To update the controller name you can:

- Update manually *(see page 118)* the controller name in the HMI application to be consistent with the controller name used in SoMachine, or,
- Update manually *(see page 122)* the controller name in SoMachine to be consistent with the controller name used in the HMI application (Vijeo-Designer), or,
- Create a generic application *(see page 124)* that can be easily used without modifying the HMI application.

How do I select the HMISCU boot up behavior (RUN or STOP) after a power cycle?

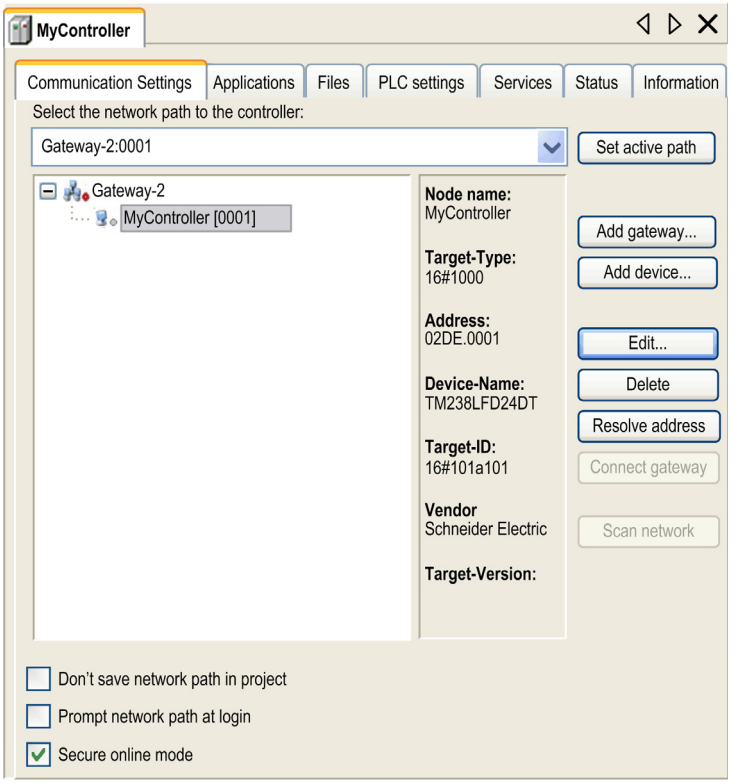
The RUN/STOP state of the HMISCU depends on the status of the "Start all applications after download or online change" checkbox which appears when you use "Multiple download".

If it is checked, the HMISCU will boot in RUN. If not, it will boot in STOP.

How do I manually update the any controller within SoMachine name in my HMI application using Vijeo-Designer?

Copy the controller device name from SoMachine as explained in the procedure:

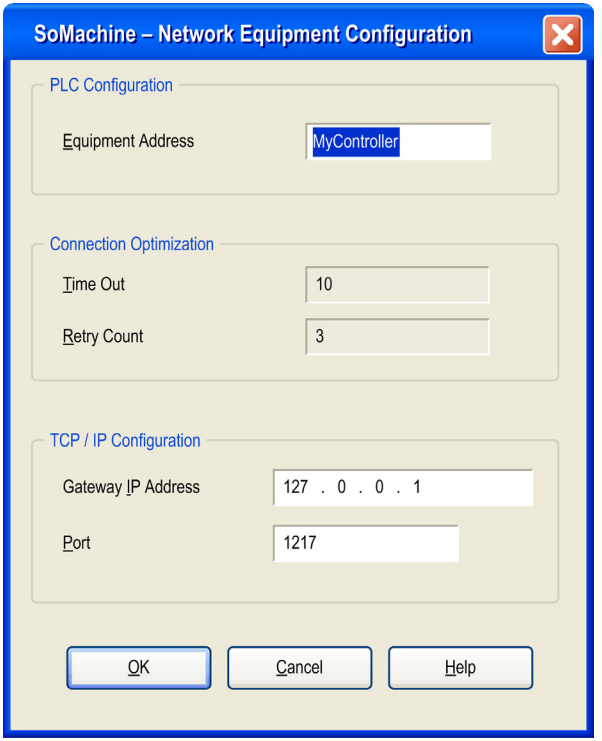
Step	Action
1	Double-click the controller in the **Devices tree** **Result:** The **Device Editor** window opens
2	Select the **Controller selection** tab

Step	Action
3	Select your controller available in the gateway, as shown in the next figure 

Step	Action
4	Click **Edit...**, the **Device** window opens:
5	Copy the controller name available in the **Address** → **Device Name** field

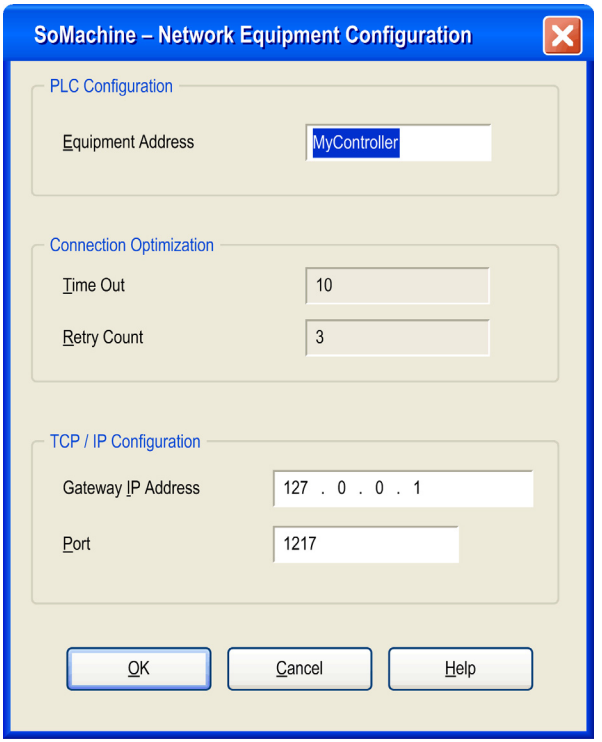
Paste the controller device name into Vijeo-Designer **Network Equipment Configuration** window, as explained in the procedure:

Step	Action
1	Double-click **IO Manager** → **SoMachineNetwork** → **Your controller** from the Vijeo-Designer **Navigator** **Result:** The **Network Equipment Configuration** window opens

Step	Action
2	Paste the controller device name in **PLC Configuration** → **Equipment Address** field 
3	Click the **OK** button
4	Double-click **IO Manager** → **SoMachineNetwork** → **Your HMI** from the Vijeo-Designer **Navigator** **Result:** The **Network Equipment Configuration** window opens
5	Paste the controller device name in **PLC Configuration** → **Equipment Address** field
6	Click the **OK** button
7	Download the application into your HMI device **Result:** Your HMI device name is now updated

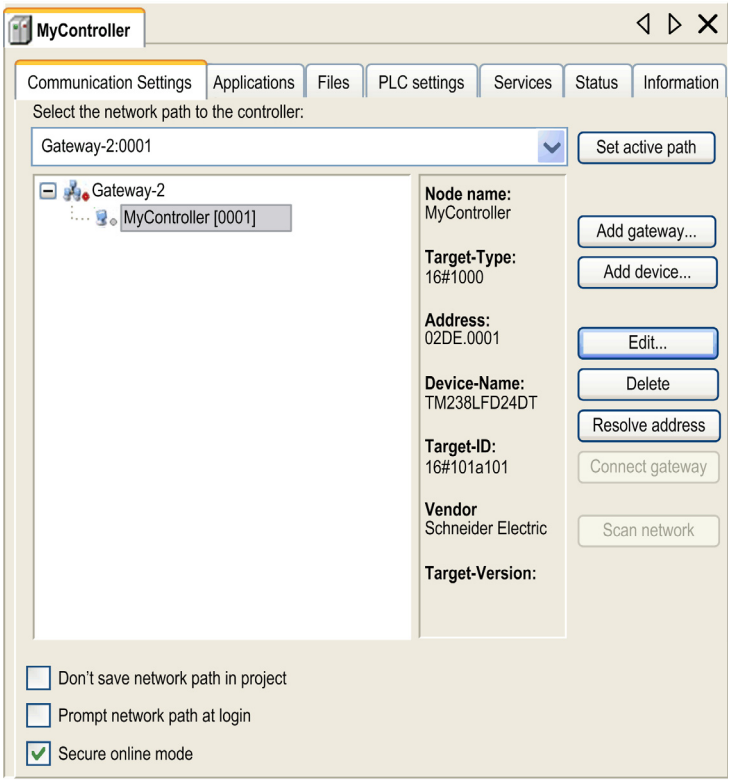
How do I manually update the any controller within SoMachine name in my SoMachine application using Vijeo-Designer?

Paste the controller device name from Vijeo-Designer as explained in the procedure:

Step	Action
1	Double-click **IO Manager** → **SoMachineNetwork** → **Your controller** from the Vijeo-Designer **Navigator** **Result:** The **Network Equipment Configuration** window opens
2	Copy the controller device name in **PLC Configuration** → **Equipment Address** field 
3	Click the **OK** button

Copy the controller device name into the SoMachine **Device Editor** as explained in the procedure:

Step	Action
1	Double-click the controller in the **Devices tree** **Result:** The **Device Editor** window opens

Step	Action
2	Select the **Controller selection** tab
3	Select your controller available in the gateway, as shown in the next figure 

Step	Action
4	Click **Edit...**, the **Device** window opens:
5	Paste the controller name available in the **Address** → **Device Name** field
6	Click the **OK** button **Result:** Your controller device name is now updated

How do I create a generic application?

The following procedure shows the main steps for creating and using generic application. Note that all these steps are explained in the next paragraphs:

Step	Action
1	Create a project *(see page 125)* archive file
2	Save the controller device name used by the HMI device
3	Extract the project archive file
4	Copy the controller device name saved in step 2
5	Use the application with the new controller and the existing HMI application

Create a Project Archive File

Create a project archive file by selecting **File** → **Project Archive** → **Save/Send Archive** from the SoMachine menu.

Why does the Task Monitor always show zero ms for the Average and Minimum Task Times?

The HMISCU only supports reporting back of cycle times to a 1 ms resolution, and requires a minimum of 2 ms for one HMI with a Control Process cycle (since the CPU is scheduled to give HMI and Control each 1 ms per 2 ms).

If a task requires less than 2 ms (2000 µs) to run, the Task Monitor will show 0 µs.

Appendices

Overview

This appendix lists the documents necessary for technical understanding of the HMI SCU Programming Guide.

What Is in This Appendix?

The appendix contains the following chapters:

Chapter	Chapter Name	Page
A	Function and Function Block Representation	129
B	Controller Performance	137

Function and Function Block Representation

A

Overview

Each function can be represented in the following languages:

- IL: Instruction List
- ST: Structured Text
- LD: Ladder Diagram
- FBD: Function Block Diagram
- CFC: Continuous Function Chart

This chapter provides functions and function blocks representation examples and explains how to use them for IL and ST languages.

What Is in This Chapter?

This chapter contains the following topics:

Topic	Page
Differences Between a Function and a Function Block	130
How to Use a Function or a Function Block in IL Language	131
How to Use a Function or a Function Block in ST Language	134

Differences Between a Function and a Function Block

Function

A function:
- is a **POU** (Program Organization Unit) that returns one immediate result
- is directly called with its name (not through an **Instance**)
- has no persistent state from one call to the other
- can be used as an operand in other expressions

Examples: boolean operators (`AND`), calculations, conversion (`BYTE_TO_INT`)

Function Block

A function block:
- is a **POU** (Program Organization Unit) that returns one or more outputs
- is always called through an **Instance** (function block copy with dedicated name and variables)
- each **Instance** has a persistent state (outputs and internal variables) from one call to the other

Examples: timers, counters

In the example, `Timer_ON` is an instance of the Function Block `TON`:

```
PROGRAM MyProgram_ST
VAR
    Timer_ON: TON;  // Function Block Instance
    Timer_RunCd: BOOL;
    Timer_PresetValue: TIME := T#5S;
    Timer_Output: BOOL;
    Timer_ElapsedTime: TIME;
END_VAR
```

```
Timer_ON(
    IN:=Timer_RunCd,
    PT:=Timer_PresetValue,
    Q=>Timer_Output,
    ET=>Timer_ElapsedTime);
```

How to Use a Function or a Function Block in IL Language

General Information

This part explains how to implement a Function and a Function Block in IL language.

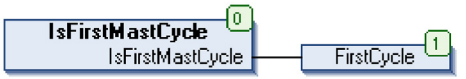
Functions `IsFirstMastCycle` and `SetRTCDrift` and Function Block `TON` are used as examples to show implementations.

Using a Function in IL Language

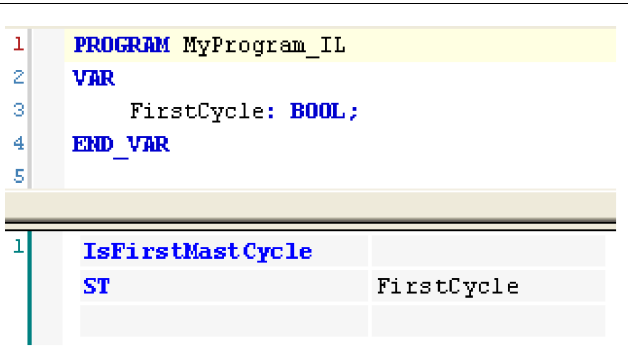
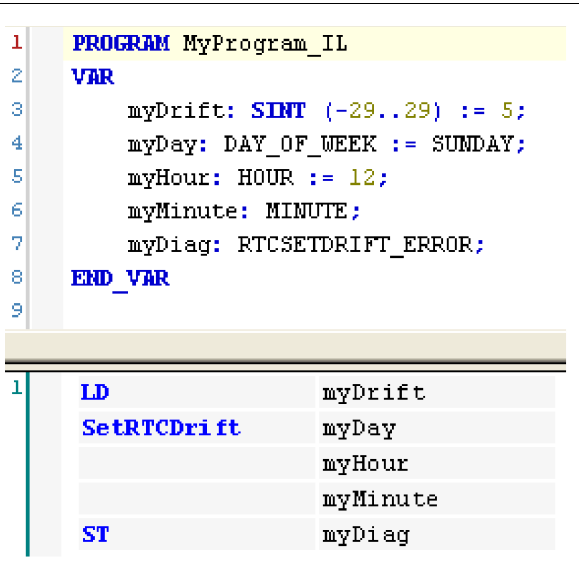
This procedure describes how to insert a function in IL language:

Step	Action
1	Open or create a new POU in **Instruction List** language. **NOTE:** The procedure to create a POU is not detailed here. For more information, refer to the SoMachine global help.
2	Create the variables that the function requires.
3	If the function has 1 or more inputs, start loading the first input using LD instruction.
4	Insert a new line below and: ● type the name of the function in the operator column (left field), or ● use the **Input Assistant** to select the function (select **Insert Box** in context menu).
5	If the function has more than 1 input and when **Input Assistant** is used, the necessary number of lines is automatically created with `???` in the fields on the right. Replace the `???` with the appropriate value or variable that corresponds to the order of inputs.
6	Insert a new line to store the result of the function into the appropriate variable: type ST instruction in the operator column (left field) and the variable name in the field on the right.

To illustrate the procedure, consider the Functions `IsFirstMastCycle` (without input parameter) and `SetRTCDrift` (with input parameters) graphically presented below:

Function	Graphical Representation
without input parameter: `IsFirstMastCycle`	
with input parameters: `SetRTCDrift`	

In IL language, the function name is used directly in the **Operator Column**:

Function	Representation in SoMachine POU IL Editor
IL example of a function without input parameter: `IsFirstMastCycle`	
IL example of a function with input parameters: `SetRTCDrift`	

Using a Function Block in IL language

This procedure describes how to insert a function block in IL language:

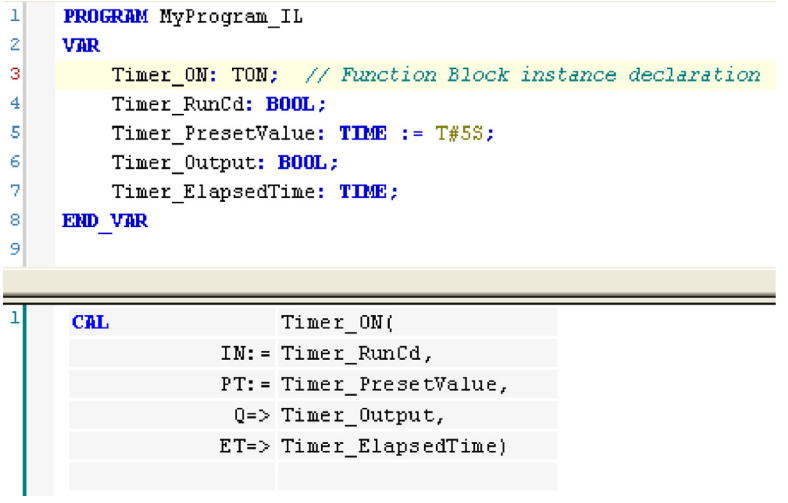
Step	Action
1	Open or create a new POU in **Instruction List** language. **NOTE:** The procedure to create a POU is not detailed here. For more information, refer to the SoMachine global help.
2	Create the variables that the function block requires, including the instance name.

Step	Action
3	Function Blocks are called using a CAL instruction: ● Use the **Input Assistant** to select the FB (right-click and select **Insert Box** in context menu). ● Automatically, the CAL instruction and the necessary I/O are created. Each parameter (I/O) is an instruction: ● Value to inputs are set by ":=". ● Values to outputs are set by "=>".
4	In the CAL right-side field, replace ??? with the instance name.
5	Replace other ??? with an appropriate variable or immediate value.

To illustrate the procedure, consider this example with the TON Function Block graphically presented below:

Function Block	Graphical Representation
TON	

In IL language, the function block name is used directly in the **Operator Column**:

Function Block	Representation in SoMachine POU IL Editor
TON	

How to Use a Function or a Function Block in ST Language

General Information

This part explains how to implement a Function and a Function Block in ST language.

Function `SetRTCDrift` and Function Block `TON` are used as examples to show implementations.

Using a Function in ST Language

This procedure describes how to insert a function in ST language:

Step	Action
1	Open or create a new POU in **Structured Text** language. **NOTE:** The procedure to create a POU is not detailed here. For more information, refer to the SoMachine global help.
2	Create the variables that the function requires.
3	Use the general syntax in the **POU ST Editor** for the ST language of a function. The general syntax is: `FunctionResult:= FunctionName(VarInput1, VarInput2,.. VarInputx);`

To illustrate the procedure, consider the function `SetRTCDrift` graphically presented below:

Function	Graphical Representation
`SetRTCDrift`	

The ST language of this function is the following:

Function	Representation in SoMachine POU ST Editor

`SetRTCDrift`	`PROGRAM MyProgram_ST`
	`VAR myDrift: SINT(-29..29) := 5;`
	`myDay: DAY_OF_WEEK := SUNDAY;`
	`myHour: HOUR := 12;`
	`myMinute: MINUTE;`
	`myRTCAdjust: RTCDRIFT_ERROR;`
	`END_VAR`
	`myRTCAdjust:= SetRTCDrift(myDrift, myDay, myHour, myMinute);`

Using a Function Block in ST Language

This procedure describes how to insert a function block in ST language:

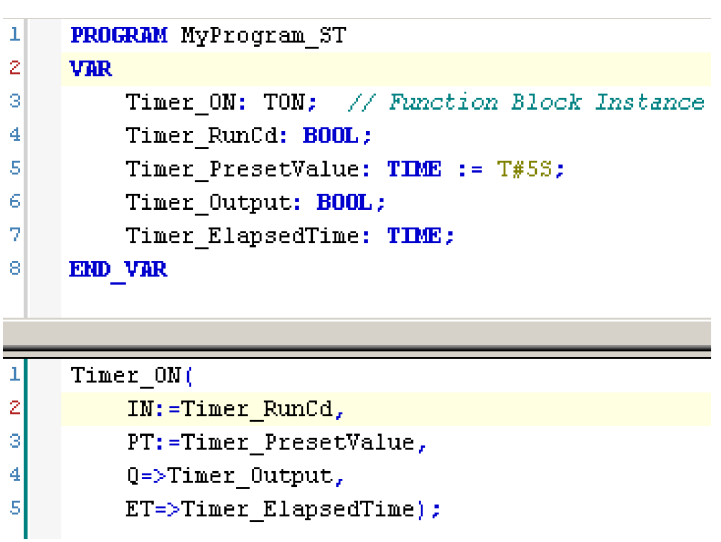
Step	Action
1	Open or create a new POU in **Structured Text** language. **NOTE:** The procedure to create a POU is not detailed here. For more information, refer to the SoMachine global help.
2	Create the input and output variables and the instance required for the function block: ● Input variables are the input parameters required by the function block ● Output variables receive the value returned by the function block

3	Use the general syntax in the **POU ST Editor** for the ST language of a Function Block. The general syntax is:
	`FunctionBlock_InstanceName(Input1:=VarInput1, Input2:=VarInput2,...`
	`Ouput1=>VarOutput1, Ouput2=>VarOutput2,...);`

To illustrate the procedure, consider this example with the `TON` function block graphically presented below:

Function Block	Graphical Representation
`TON`	

This table shows examples of a function block call in ST language:

Function Block	Representation in SoMachine POU ST Editor
TON	

```
PROGRAM MyProgram_ST
VAR
    Timer_ON: TON;  // Function Block Instance
    Timer_RunCd: BOOL;
    Timer_PresetValue: TIME := T#5S;
    Timer_Output: BOOL;
    Timer_ElapsedTime: TIME;
END_VAR
```

```
Timer_ON(
    IN:=Timer_RunCd,
    PT:=Timer_PresetValue,
    Q=>Timer_Output,
    ET=>Timer_ElapsedTime);
```

Controller Performance

B

Processing Performance

Introduction

This chapter provides information about the HMI SCU controller processing performance.

Logic Processing

The table shows logic processing performance for various logical instructions:

IL Instruction Type	Duration for 1000 Instructions
Addition/subtraction/multiplication of INT	380 µs
Addition/subtraction/multiplication of DINT	401 µs
Addition/subtraction/multiplication of REAL	7608 µs
Division of REAL	15,978 µs
Operation on BOOLEAN, for example, Status:= Status and value	572 µs
LD INT + ST INT	386 µs
LD DINT + ST DINT	430 µs
LD REAL + ST REAL	750 µs

Basic System Time

The table shows the basic overhead performance for each MAST cycle:

I/O Type	Overhead for each MAST cycle
Embedded Inputs & Internal processing	1500 µs
Embedded outputs	450 µs

HSC, PWM, and PTO Processing

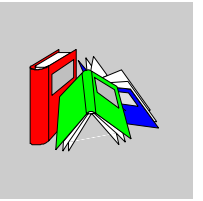
The table shows the processing performance for complex functions for each MAST cycle:

Complex Function Type	Overhead for each MAST cycle
HSC Simple	150 µs
HSC Main	350 µs
PWM	150 µs
PTO Simple	200 µs

Communication and System Processing Time

The communication processing time varies, depending on the number of sent/received requests.

Glossary



A

analog input

Converts received voltage or current levels into numerical values. You can store and process these values within the controller.

analog output

Converts numerical values within the controller and sends out proportional voltage or current levels.

ARRAY

The systematic arrangement of data objects of a single type in the form of a table defined in controller memory. The syntax is as follows: `ARRAY [<dimension>] OF <Type>`

Example 1: `ARRAY [1..2] OF BOOL` is a 1-dimensional table with 2 elements of type `BOOL`.

Example 2: `ARRAY [1..10, 1..20] OF INT` is a 2-dimensional table with 10 x 20 elements of type `INT`.

ASCII

(*American standard code for Information Interchange*) A protocol for representing alphanumeric characters (letters, numbers, certain graphics, and control characters).

B

BCD

(*binary coded decimal*) The format that represents decimal numbers between 0 and 9 with a set of 4 bits (a nybble/nibble, also titled as half byte). In this format, the 4 bits used to encode decimal numbers have an unused range of combinations.

For example, the number 2,450 is encoded as `0010 0100 0101 0000`.

BOOL

(*boolean*) A basic data type in computing. A `BOOL` variable can have one of these values: 0 (`FALSE`), 1 (`TRUE`). A bit that is extracted from a word is of type `BOOL`; for example, `%MW10.4` is a fifth bit of memory word number 10.

Boot application

(*boot application*) The binary file that contains the application. Usually, it is stored in the PLC and allows PLC to boot on the application that the user has generated.

byte

A type that is encoded in an 8-bit format, ranging from `16#00` to `16#FF` in hexadecimal representation.

C

CAN

(*controller area network*) A protocol (ISO 11898) for serial bus networks, designed for the interconnection of smart devices (from multiple manufacturers) in smart systems and for real-time industrial applications. Originally developed for use in automobiles, CAN is now used in a variety of industrial automation control environments.

CFC

(*continuous function chart*) A graphical programming language (an extension of the IEC 61131-3 standard) based on the function block diagram language that works like a flowchart. However, no networks are used and free positioning of graphic elements is possible, which allows feedback loops. For each block, the inputs are on the left and the outputs on the right. You can link the block outputs to the inputs of other blocks to create complex expressions.

controller

Automates industrial processes (also known as programmable logic controller or programmable controller).

D

DHCP

(*dynamic host configuration protocol*) An advanced extension of BOOTP. DHCP is more advanced, but both DHCP and BOOTP are common. (DHCP can handle BOOTP client requests.)

DINT

(*double integer type*) Encoded in 32-bit format.

DNS

(*domain name system*) The naming system for computers and devices connected to a LAN or the Internet.

DWORD

(*double word*) Encoded in 32-bit format.

E

equipment

A part of a machine including sub-assemblies such as conveyors, turntables, and so on.

Ethernet

A physical and data link layer technology for LANs, also known as IEE 802.3.

F

FB

(*function block*) A convenient programming mechanism that consolidates a group of programming instructions to perform a specific and normalized action, such as speed control, interval control, or counting. A function block may comprise configuration data, a set of internal or external operating parameters and usually 1 or more data inputs and outputs.

FBD

(*function block diagram*) One of 5 languages for logic or control supported by the standard IEC 61131-3 for control systems. Function block diagram is a graphically oriented programming language. It works with a list of networks, where each network contains a graphical structure of boxes and connection lines, which represents either a logical or arithmetic expression, the call of a function block, a jump, or a return instruction.

FBD

(*function block diagram*) One of the 5 languages for logic or control supported by the standard IEC 61131-3 for control systems. Function block diagram is a graphically oriented programming language. It works with a list of networks where each network contains a graphical structure of boxes and connection lines representing either a logical or arithmetic expression, the call of a function block, a jump, or a return instruction.

firmware

Represents the BIOS, data parameters, and programming instructions that constitute the operating system on a controller. The firmware is stored in non-volatile memory within the controller.

freewheeling

When a logic controller is in freewheeling scan mode, a new task scan starts as soon as the previous scan has been completed. Contrast with *periodic scan mode*.

H

HSC

(*high-speed counter*)

I

IEC

(*international electrotechnical commission*) A non-profit and non-governmental international standards organization that prepares and publishes international standards for electrical, electronic, and related technologies.

IEC 61131-3

Part 3 of a 3-part IEC standard for industrial automation equipment. IEC 61131-3 is concerned with controller programming languages and defines 2 graphical and 2 textual programming language standards. The graphical programming languages are ladder diagram and function block diagram. The textual programming languages include structured text and instruction list.

IL

(*instruction list*) A program written in the language that is composed of a series of text-based instructions executed sequentially by the controller. Each instruction includes a line number, an instruction code, and an operand (refer to IEC 61131-3).

INT

(*integer*) A whole number encoded in 16 bits.

IP

(*Internet protocol* Part of the TCP/IP protocol family that tracks the Internet addresses of devices, routes outgoing messages, and recognizes incoming messages.

L

LD

(*ladder diagram*) A graphical representation of the instructions of a controller program with symbols for contacts, coils, and blocks in a series of rungs executed sequentially by a controller (refer to IEC 61131-3).

LINT

(*long integer*) A whole number encoded in a 64-bit format (4 times `INT` or 2 times `DINT`).

LREAL

(*long real*) A floating-point number encoded in a 64-bit format.

LWORD

(*long word*) A data type encoded in a 64-bit format.

M

MAC address

(*media access control address*) A unique 48-bit number associated with a specific piece of hardware. The MAC address is programmed into each network card or device when it is manufactured.

MAST

A processor task that is run through its programming software. The MAST task has 2 sections:

- **IN:** Inputs are copied to the IN section before execution of the MAST task.
- **OUT:** Outputs are copied to the OUT section after execution of the MAST task.

Modbus

The protocol that allows communications between many devices connected to the same network.

ms

(*millisecond*)

N

network

A system of interconnected devices that share a common data path and protocol for communications.

P

POU

(*program organization unit*) A variable declaration in source code and a corresponding instruction set. POUs facilitate the modular re-use of software programs, functions, and function blocks. Once declared, POUs are available to one another.

PTO

(*pulse train outputs*) a fast output that oscillates between off and on in a fixed 50-50 duty cycle, producing a square wave form. The PTO is especially well suited for applications such as stepper motors, frequency converters, and servo motor control, among others.

PWM

(*pulse width modulation*) A fast output that oscillates between off and on in an adjustable duty cycle, producing a rectangular wave form (though you can adjust it to produce a square wave). The PTO is well adapted to simulate or approximate an analog output in that it regulates the voltage of the output over its period making it useful in light dimming or speed control applications, among others.

R

REAL

A data type that is defined as a floating-point number encoded in a 32-bit format.

RPDO

(*receive process data object* An unconfirmed broadcast message or sent from a producer device to a consumer device in a CAN-based network. The transmit PDO from the producer device has a specific identifier that corresponds to the receive PDO of the consumer devices.

S

SDO

(*service data object*) A message used by the field bus master to access (read/write) the object directories of network nodes in CAN-based networks. SDO types include service SDOs (SSDOs) and client SDOs (CSDOs).

SFC

(*sequential function chart*) A language that is composed of steps with associated actions, transitions with associated logic condition, and directed links between steps and transitions. (The SFC standard is defined in IEC 848. It is IEC 61131-3 compliant.)

SINT

(*signed integer*) A 15-bit value plus sign.

SL

(*serial line*)

ST

(*structured text*) A language that includes complex statements and nested instructions (such as iteration loops, conditional executions, or functions). ST is compliant with IEC 61131-3.

STOP

A command that causes the controller to stop running an application program.

string

A variable that is a series of ASCII characters.

T

task

A group of sections and subroutines, executed cyclically or periodically for the MAST task or periodically for the FAST task.

A task possesses a level of priority and is linked to inputs and outputs of the controller. These I/O are refreshed in relation to the task.

A controller can have several tasks.

TPDO

(*transmit process data object*) An unconfirmed broadcast message or sent from a producer device to a consumer device in a CAN-based network. The transmit PDO from the producer device has a specific identifier that corresponds to the receive PDO of the consumer devices.

U

UDINT

(*unsigned double integer*) Encoded in 32 bits.

UINT

(*unsigned integer*) Encoded in 16 bits.

V

variable

A memory unit that is addressed and modified by a program.

W

WORD

A type encoded in a 16-bit format.

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