

MV electrical network management

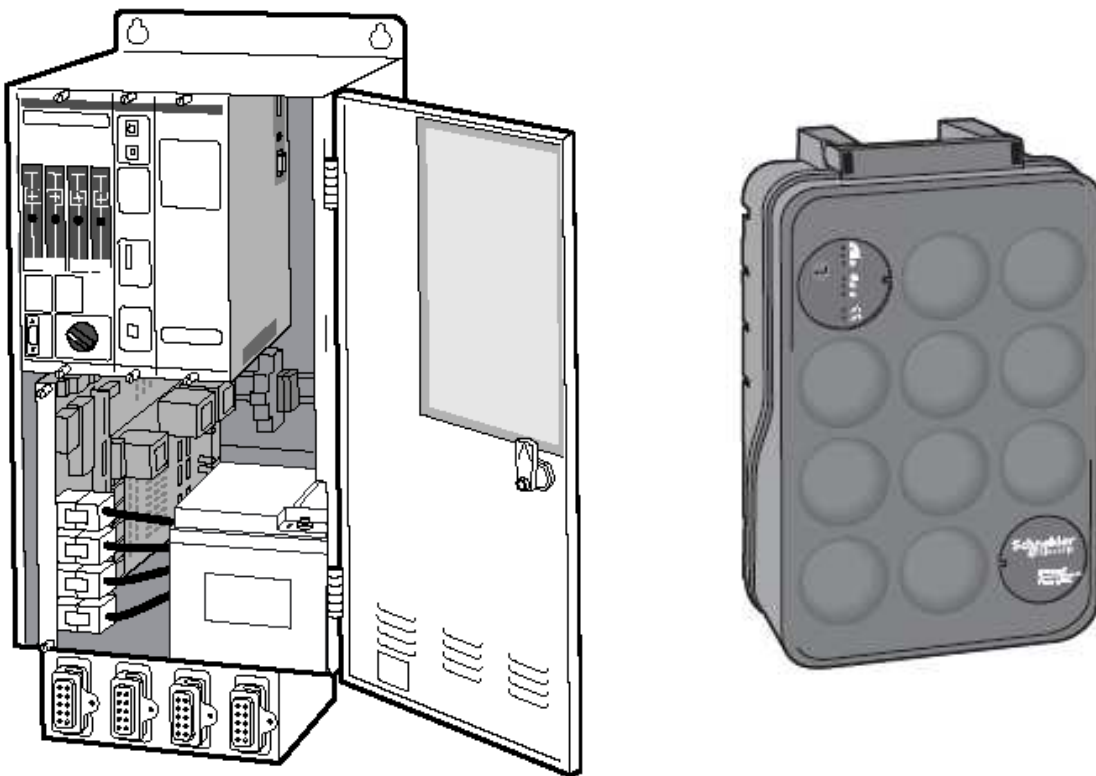
Easergy range

Flair 200C and T200

MV substation remote monitoring and control unit

RTU Control and Formulas

Addendum to the user's manual



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1 Virtual PLC

1.1 Description

As an option, the T200 and the Flair 200C can provide an IEC 61131-3 programmable automation functions through an embedded virtual machine (PLC).

The typical applications that can be created with a PLC program :

- Automatic MV loop reconfiguration (Self Healing Grid).
- Automatism similar to the one embedded in T200 (ATS, BTA): ATS between 2 T200 or involving more than two channels for example.
- Application of load-shedding.
- Any other automatism specific to a customer.

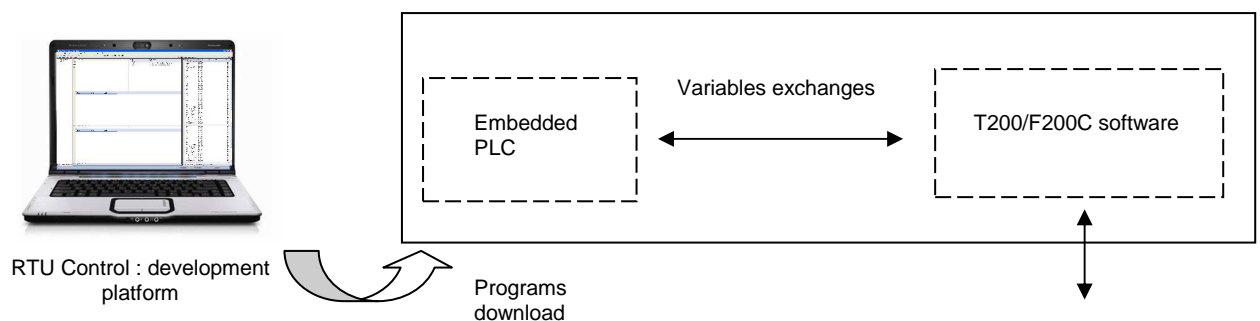
Warning: it is not possible to have simultaneously in the product the option IEC 61131-3 PLC and the predefined automation (ATS, Sectionalizer, ...).

A development platform allows creating, simulating and testing programs using one of the following languages:

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

This development platform is the software RTU Control supplied with the product.

This platform can generate a program that will be executed by a virtual PLC. This virtual PLC, embedded in the T200I, exchange data in Read/Write mode with the T200I software, allowing the exploitation of internal variables.



The details of programming with IEC61131-3 languages, and the use of the platform will not be explained in this document. The specific documentation can be accessed through the RTU Control software.

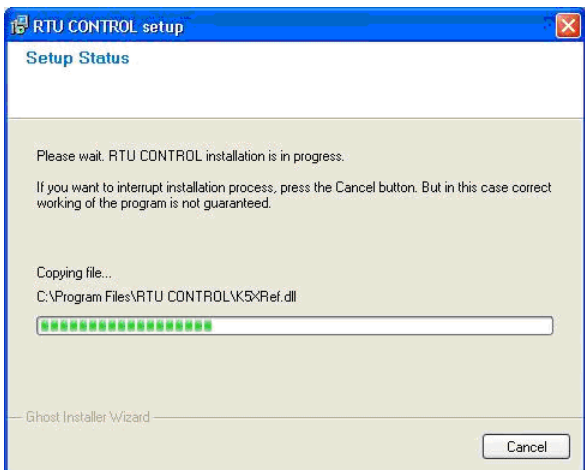
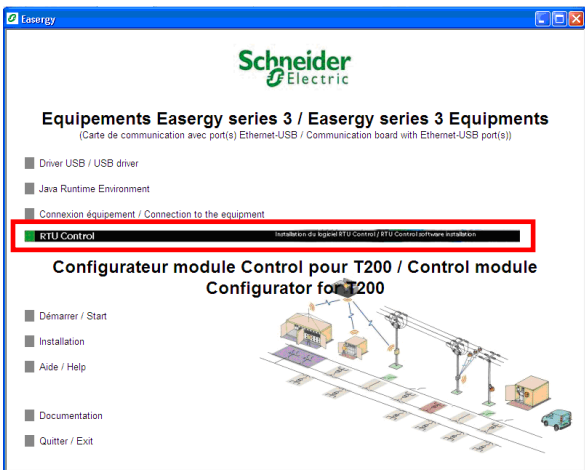
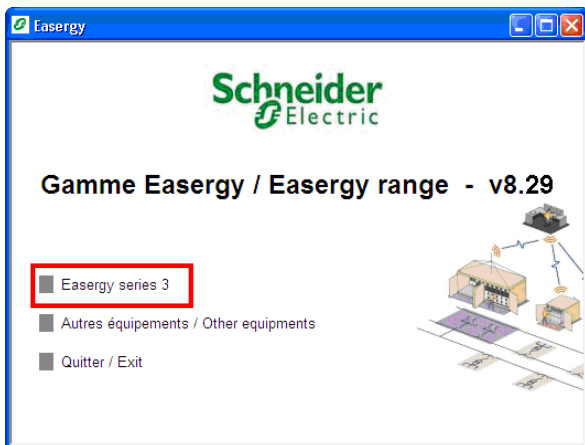
However, we shall explain in this document how to download and use a PLC program established in the Web server of the T200/F200C and provide brief initial instructions regarding the platform and management of the parameters and associated variables.

1.2 Installation of RTU Control software

The "RTU Control" software is supplied with the unit. It is included in the Easergy CD-Rom.

To install the software from the CD follow these instructions:

- Insert the CD-Rom supplied.
- The software on CD must start automatically and a window "Easergy range - V8.xx" appears on screen.
- Click on "Easergy series 3" link.
- In the next window that appears, click on the link "RTU CONTROL".
- Software installation begins.
- Then follow the various steps for installation without changing the options proposed.
- Wait for the end of the installation and then exit the program.



Now that the RTU Control software is installed, download a program established in the PLC.

There are two methods for downloading a PLC program into the T200/F200C equipment:

- **Via the RTU Control platform**, provided that the RTU Control program is installed on the PC connected to the T200/F200C and that the equipment is powered up with the PLC function started
- **Via the embedded Web server of the T200/F200C**, provided that the PLC program is available in the form of a file with a *.cod extension

1.3 Downloading a program via RTU Control software

This chapter shows the first method for downloading a program from the PLC software "RTU control". This assumes that the RTU Control software is installed on the PC that is connected to the web server of T200/F200C, and that the corresponding project is available.

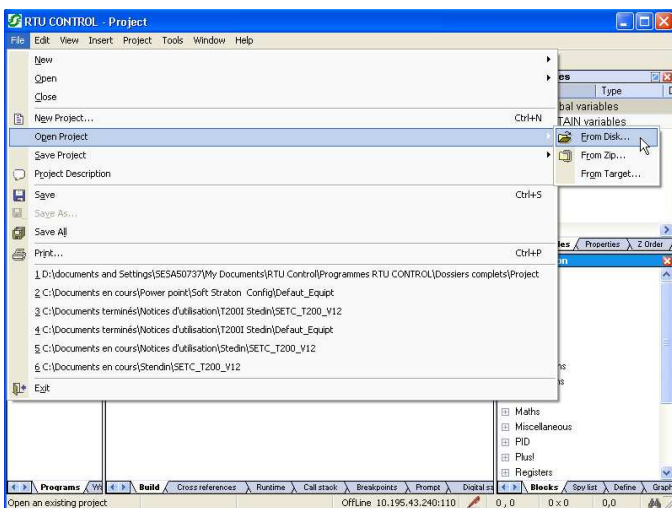
1.3.1 Opening a project

The opening of the project is carried out from the program interface RTU Control:

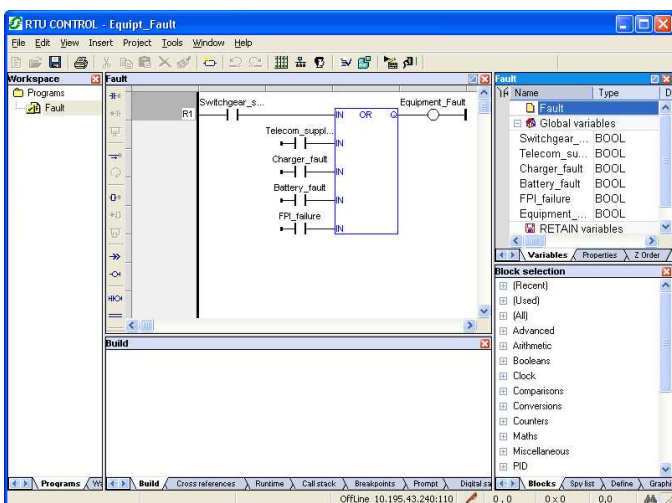
Menu File → Open project → From Disk

Then choose the project to be downloaded

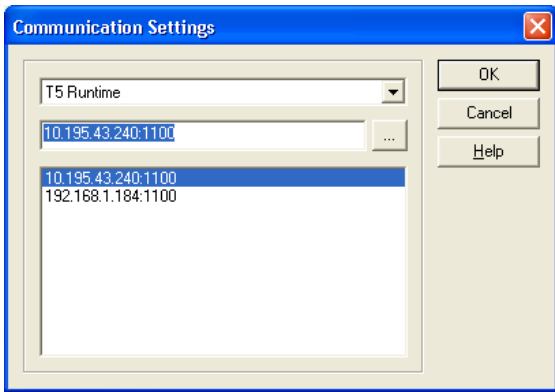
The project opens in the workbench.



Selecting a program to be open in RTU Control



Program open in the workbench



1.3.2 Connection to the PLC and download of a program

Once the project is open, configure the connection to the virtual PLC.

From the RTU Control workbench, open the following link :

Menu Tools → Communication parameters:

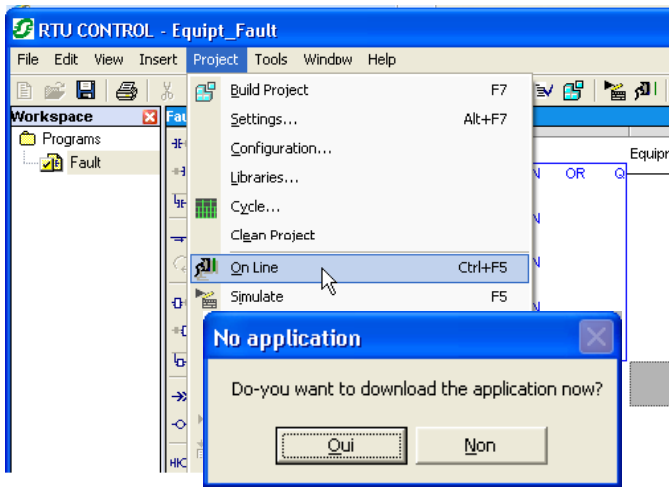
- Select "T5 Runtime"
- Enter the IP address of the device, followed by the IP port number used by the Virtual Machine (configured previously on the unit). The two fields must be separated by the character ':' (if IP port is omitted, 1100 will be used)
- The example shows a configuration for a T200 with the IP address 10.199.45.103 and the IP Port number 1100
- Click on "Ok"

To connect the workbench to the T200/F200C and download the application to the target, click on:

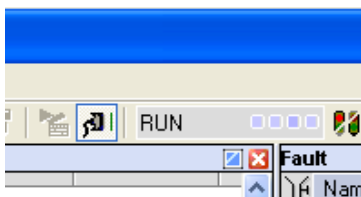
Menu Project / On line / Download application

To stop the application, click on the same button.

Note: this command can be done directly using the task bar.



Button for downloading application

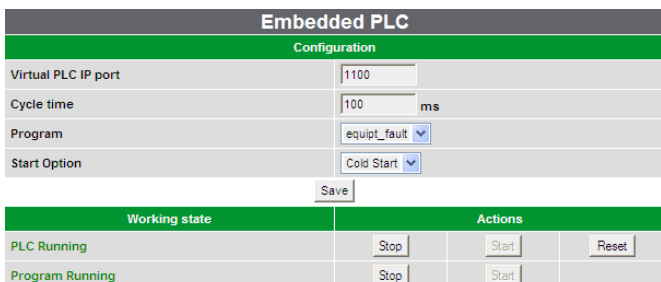


"Run" status in the RTU Control workbench

The program is now ready to be used in the unit. It appears now with the "running" status:

- In the **RTU Control software**
- In the **Embedded PLC** page of the T200/F200C's Web server

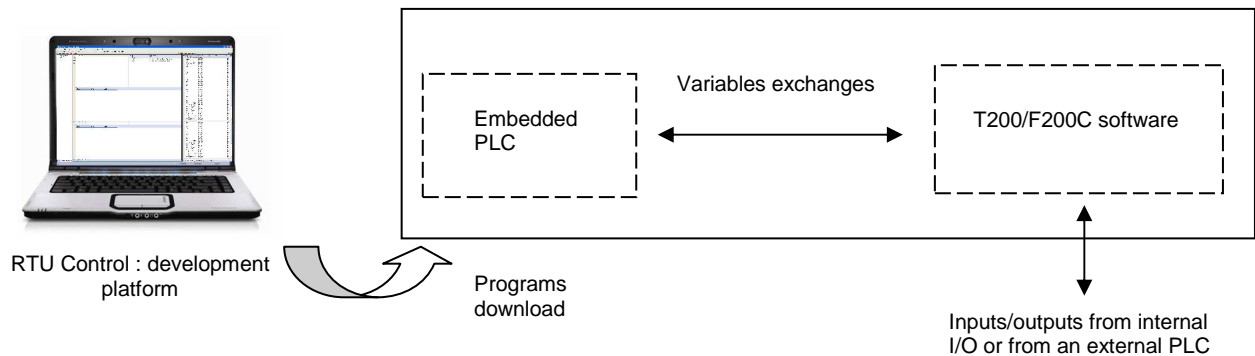
Note: We shall learn later the details regarding this Embedded PLC page and how to access it.



"PLC Running" status in the "Embedded PLC" page of web server

1.4 Shared variables

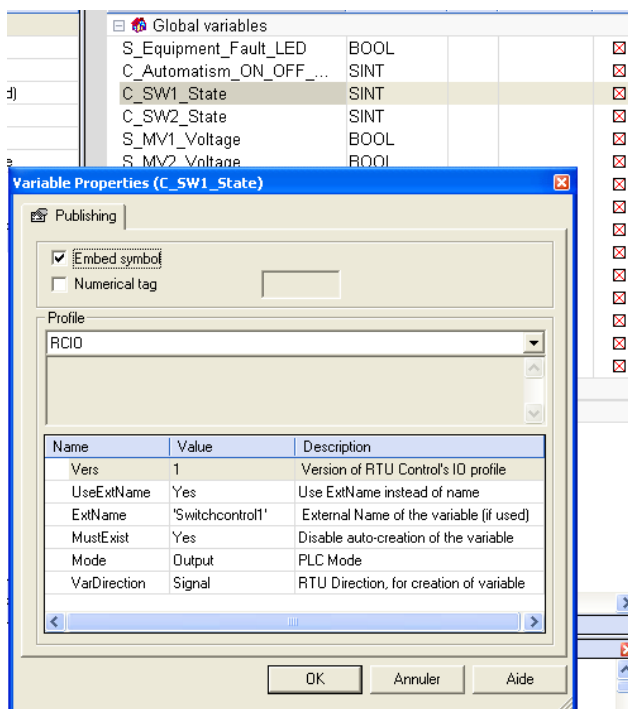
The embedded PLC handles internal variables and can also share variables with the T200/F200C software. A variable shared on the platform will be automatically linked to a T200/F200C variable at start-up of the application.



The variables that can be shared are **Global** variables. These variables can be used anywhere in the program;

The link between PLC variables and T200/F200C variables can be done in different manners:

- strict equality of the name or using different names
- automatic creation of variables in the T200/F200C or use of existing variables
- in case of creation, choice of exchange mode (T200/F200C point of view)

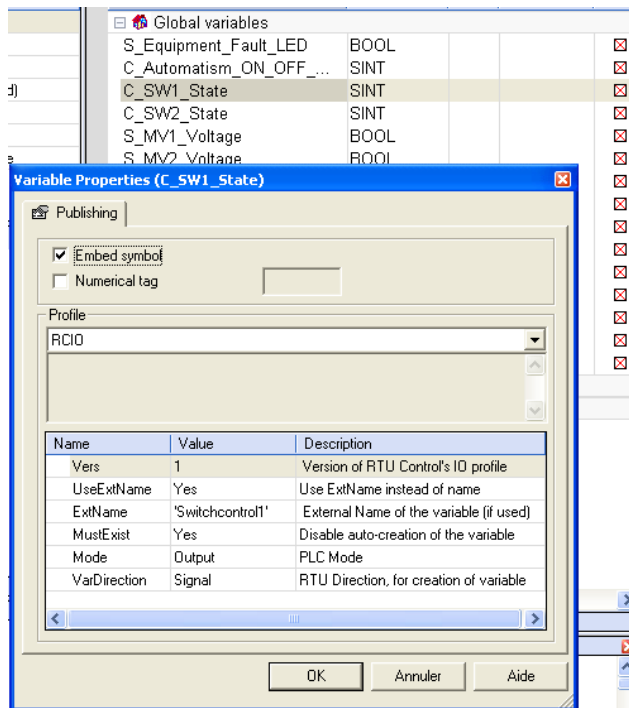


1.4.1 Share a variable

From the workbench (disconnected from the device or program stopped), right-click on a variable and select "properties".

To share the selected variable with the T200/F200C software :

- Check the box "Embed symbol"
- Select the profile "RCIO" in the profile list
- Complete following parameters depending on the desired link mode.



UseExtName: Choice to use the name of the variable declared in the workbench, if this one is different from the one defined in the T200/F200C ("Yes"), or to force to use the same name as the variable defined in the T200/F200C ("No", default value).

ExtName: Name of the T200/F200C variable associated to the workbench variable. This parameter allows you to make the relation between the variable of the T200/F200C and the corresponding variable in the workbench, if they have different name (used only if "UseExtName" = "Yes"). The field length is limited to 15 characters.

MustExist: Choice to authorize creation of variable (No, default value), or to impose using already existing variables.

At start of the program, the T200/F200C checks all shared variables. If the associated variable exists, the link is done. If the variable does not exist, the T200/F200C can be authorized or forbidden to create it.

This parameter allows a better control when the goal is to link to an existing variable.

Mode : [Input/Output] Data exchange mode.

the Mode is used to determine whether from the PLC application perspective, variables are read-only or read-write. Variables defined as Inputs in the PLC application will be read-only, i.e. changed only by the RTU firmware. Variables defined as Outputs will be read-write. For both Inputs and Outputs, the current value will be read at the beginning of each PLC cycle. Only Output variables will be updated at the end of the PLC cycle.

Note that concrete variables (such as TSS) are automatically read only.

VarDirection: [Signal/Command] Type of variable, from the T200/F200C point of view. Used when a variable is created by the T200/F200C (MustExist = no and corresponding variable does not exist).

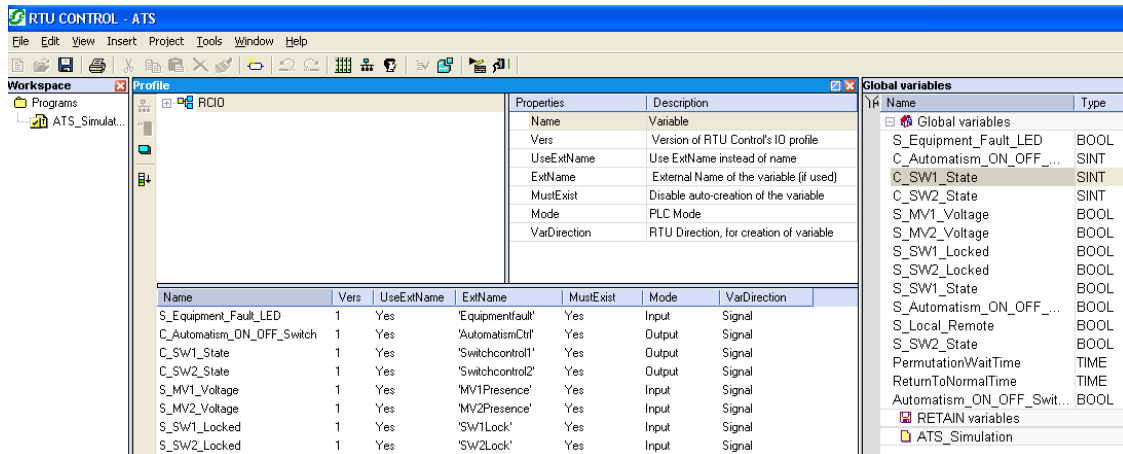
Variable defined as "Signal" will be created as an Input (DI or AI). Variable defined as "Command" will be created as an Output (DO or AO).

The commands can be controlled by the user via the web interface or via the protocol (example: parameter, set point, option).

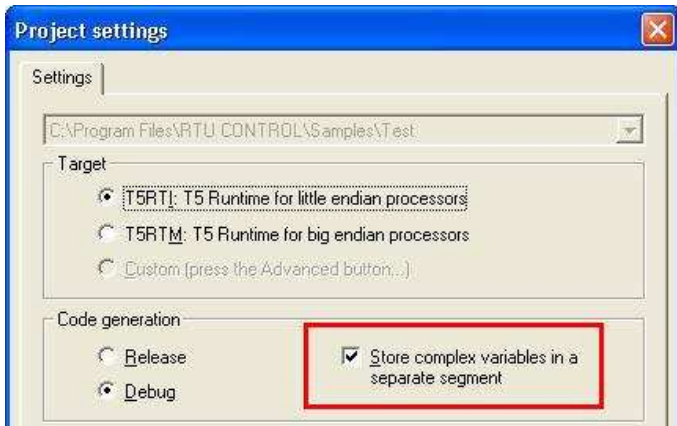
Warning: the input/output notion from the T200/F200C point of view is different from the PLC notion, where a parameter is an 'input' of a function block for example.

After changes have been done to the variables configuration, the program must be re-build and reloaded into the device so that the modification is taken into account.

Settings management for the shared variables can be done via the browser profiles (icon "Open Profiles"):



This explorer allows to have a global view on the variables associated to the RCIO profile, and to modify them. "drag and drop" function allows to link easily a variable to a profile.

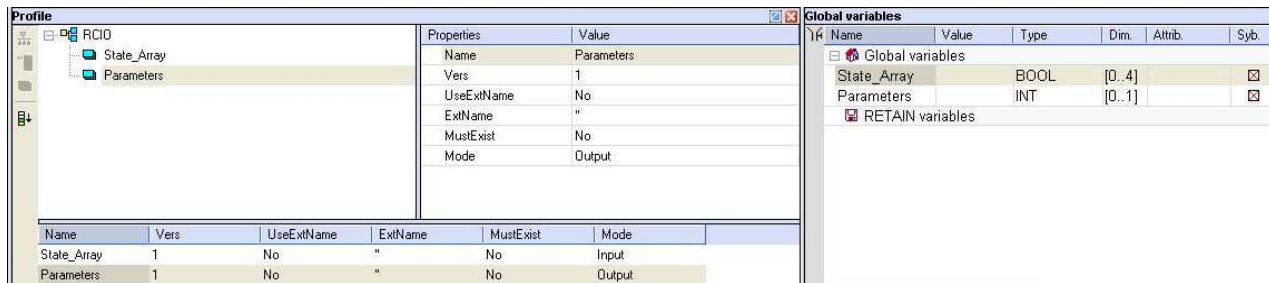


1.4.2 Use of Arrays

Complex arrays of variables or structures can be used internally by the PLC program. In case of shared variables, the use of arrays is limited to arrays of simple types, one dimension. In that case, it is necessary to activate the option "Store complex variables in a separate segment" in the options of the project (Project\Settings...)

An array of N variables will be linked to N variables in the T200/F200C software. The name of those variables will be NameArray_@x with x from 1 to N.

Example: creation of arrays "State_Array" of 5 booleans (BOOL), and "Parameters" of 2 integers (INT)



Variables created in the T200/F200C software are State_Array_@1 to State_Array_@5 and Parameters_@1 to Parameters_@2

STATE ARRAY @1		DI18	-
STATE ARRAY @2		DI19	-
STATE ARRAY @3		DI20	-
STATE ARRAY @4		DI21	-
STATE ARRAY @5		DI22	-
PARAMETERS @1		AO13	-

1.4.3 Miscellaneous

Advices concerning the names of the variables:

- Use only capital letters
- Do not give the same name to two different variables
- Do not use an integer as a name (for example "5")

Variable Types:

The T200/F200C supports the following types: BOOL, SINT, INT, DINT, BYTE, WORD, REAL.

Warning: type must be compatible.

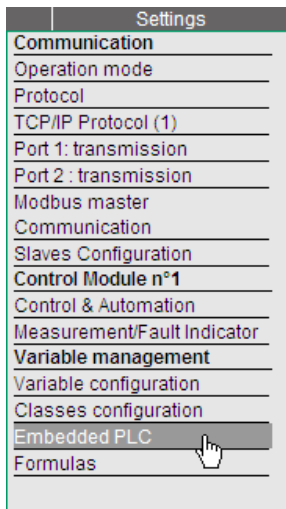
BOOL <--> TSS, TSL, DI or DO

SINT, INT, DINT, WORD, DWORD, REAL <--> TM, AI or AO

DINT <--> Counters

Important : the TSD/TCD are not binary but numeric variables (BYTE), with three possible status :

TSD/TCD value	Status
0	Undefined
1	Off
2	On



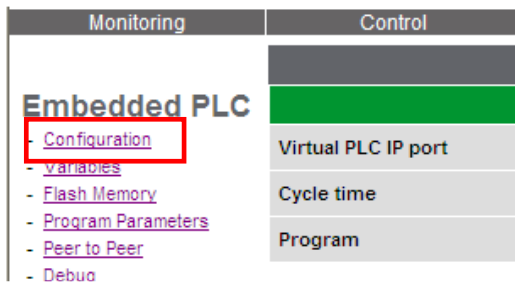
1.5 PLC setting

In the same section "PLC" of the web server, other pages are also linked to the PLC, notably those concerning the configuration parameters.

1.5.1 PLC Configuration

Click on the "Parameters" link to access the PLC parameters configuration page.

This page contains informations about the operating status of the virtual machine and the associated program, and possible presence or error messages.



1.5.1.1 Virtual PLC IP port:

Number of the IP port that will be used by the PLC program (RTU CONTROL).
Default value: 1100

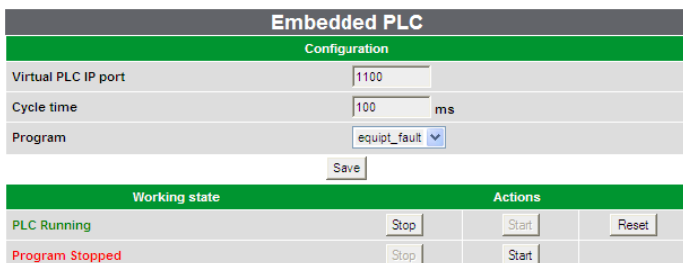
1.5.1.2 Cycle time:

This value is in milliseconds is a period which correspond to the cycle of the virtual machine. This value in ms must be defined between 100 and 10000ms (10 seconds).

1.5.1.3 Program:

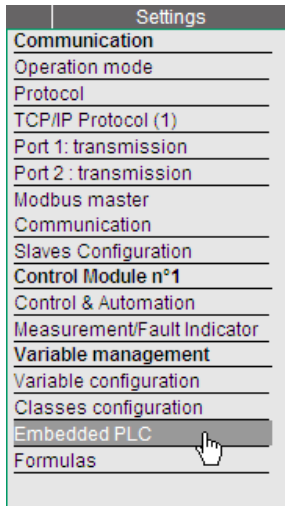
Name of the program loaded and executed by the virtual machine, including all such programs in the flash memory. The T200/F200C help maintain multiple programs in memory, but only one can be executed.

(See chapter "Downloading a program via the embedded Web server" for more information.)



Embedded PLC configuration page

Note: the option to start the PLC is not configurable. This start-up is always performed as a "Cold start". Consequently, all the internal variables of the PLC will be reset to their initial values during start-up period. The values of "Retain" variables are not used.



1.5.2 Downloading a program via the embedded Web server

This chapter explains the second method to download a PLC program from the embedded Web server of T200/F200C.

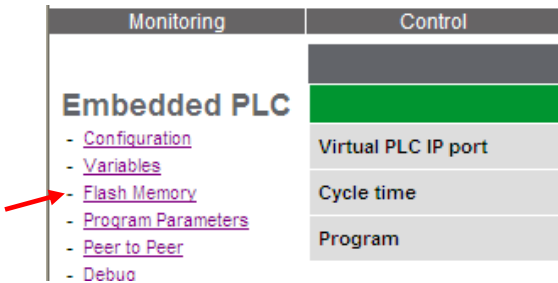
To be able to download the program, you need first to get the *.cod file.

To access the Embedded PLC page of the embedded Web server, click on the corresponding link ("*Embedded PLC*").

If RTU Control software has never been activated in equipment, enter the activation code (provided by Schneider Telecontrol).



Page for RTU Control software activation

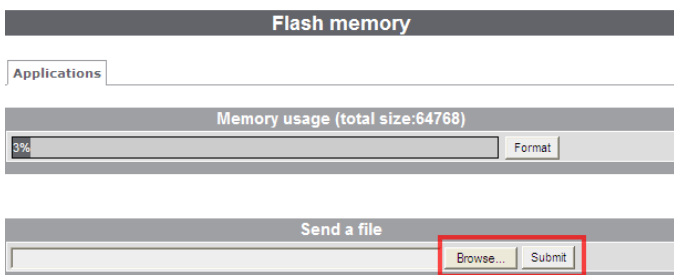


Then click on the "*Flash Memory*" link to access the PLC file and memory management page

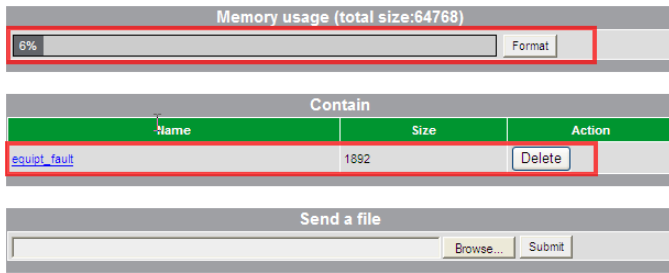
This page manages the programs of the application to be uploaded or already uploaded in Flash memory of the device.

Click on the "*Browse*" button to define the location of the PLC program file (extension "*.cod") to be downloaded.

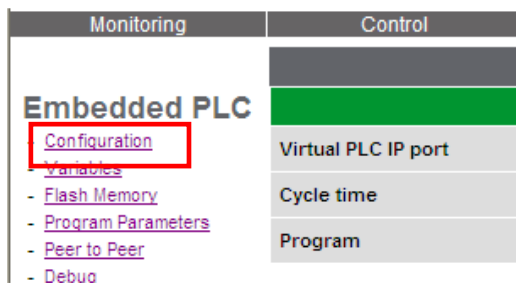
Then click on the "*Submit*" button to recognize the program in the virtual PLC.



"Flash memory" page



"Flash memory" page



Working state	Actions		
PLC Stopped	Stop	Start	Reset

PLC stopped

Working state	Actions		
PLC Running	Stop	Start	Reset
Program Stopped	Stop	Start	

PLC running, program stopped

Working state	Actions		
PLC Running	Stop	Start	Reset
Program Running	Stop	Start	

PLC and program running

Errors
Error Loading Program
Error Saving Program
Error Saving code change

Different error messages

The program is ready to be used.

The name of the program is then displayed in the "Contain" part with an indication of the file size.

It is possible to erase this program in the PLC via the "Delete" button.

It is possible to download this file to the PC's hard disk in the form of a *.cod extension, by clicking on the name of the program.

The memory size used by the program is also displayed as a percentage.

It is recommended to format the memory before first use, via the "Format" button.

1.5.3 Working state of the PLC

1.5.3.1 PLC status

In the "Embedded PLC/Configuration" page, the first line of the "Working state" section indicates if the module is running or stopped.

The module can be started or stopped using the corresponding buttons.

This parameter is saved (if the RTU re-start, the module will be in the last state)

Note: to allow the connection with the virtual machine, the module must be running.

1.5.3.2 Virtual machine state

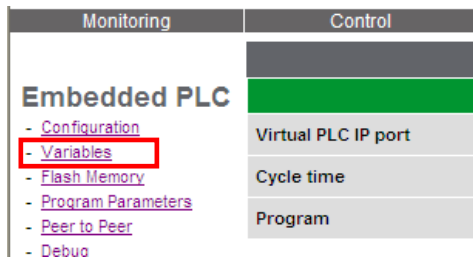
If the module is running, a second line shows the state of the virtual machine, executing the program.

The program can be started or stopped from the interface using the buttons.

Note: depending on the number of variables in the program, the start-up delay can be shorter or longer.

1.5.4 Error messages

If the start of the module or the program has failed, one or more error messages can be shown.



1.5.5 PLC variables page

The page "Variables" of the "Embedded PLC" menu permits to manage the internal variables that are used for the internal exchange between PLC and the T200/F200C unit.

Variables that can be shared are:

- **Existing** variables of the T200/F200C defined to be shared with RTU Control, because used in the PLC program.
- **Virtual** variables created specifically for the RTU Control program.

The value of a virtual variable can, if necessary, be modified in this page via the "Change Value" button.

Clicking on the name of the variable provides access to the configuration page for that variable. Virtual variables are differentiated from the other variables by a topic value = "Virtual".

Except for the Topic value, the configuration of these variables is identical to the other types of T200/F200C variables. See section 2.4.1 Creating variables.

Variables					Refresh
Name	Type	Internal Address	Value	Action	
Switchgear_supply_OFF	Boolean	TSS19	FALSE		
Telecom_supply_OFF	Boolean	TSS20	FALSE		
Charger_fault	Boolean	TSS21	FALSE		
Battery_fault	Boolean	TSS22	FALSE		
FPI_failure	Boolean	TSS47	FALSE		
Equipment_Fault	Boolean	DI2	FALSE	Change Value	

"Variables" page

Digital input configuration

General parameters

Variable name: Equipment_Fault Type:

Logical address: DI2 Class: T200 Internal fault

Internal address: 0,0 External

Active/Inactive status definition: Active (1): Yes Inactive

Communication parameters

Topic: Virtual Type: single bit

Log configuration

On status change: On active On inactive

Page of configuration for a virtual variable

The screenshot shows the 'Embedded PLC' menu with 'Program Parameters' highlighted in a red box. Below the menu is a table titled 'PLC Program Parameters'.

Name	Value	Associated Ao Logic Address
SHG_TOVloss_s	120	AO1 - SHG_TOVloss
SHG_TOCommand_s	17	AO2 - SHG_TOCommand
SHG_TOAutoComms_s	900	AO3 - SHG_TOAutoComms
SHG_Comm_NodeType	2 - 2: Middle Node	AO4 - SHG_Comm_NodeType
SHG_Comm_Path	1 - Path B	AO5 - SHG_Comm_Path
SHG_Master_Node	0 - No	AO6 - SHG_Master_Node
SHG_CheckVoltage	1 - Yes	AO7 - SHG_CheckVoltage
Corresp_Switch_A	1	AO8 - Corresp_Switch_A
Corresp_Switch_B	2	AO9 - Corresp_Switch_B
Corresp_Switch_C	3	AO10 - Corresp_Switch_C
SHGClosingPriority	1 - B,A,C	AO11 - SHGClosingPriority
SHG_StartDelay	0	AO12 - SHG_StartDelay
FeederLimit	630	AO13 - FeederLimit

Example of PLC parameters

1.5.6 Program parameters

A set of parameters which are applicable for the PLC Application can be created and modified using this page. The parameters values are saved together with the Easergy configuration without having to change the PLC Application. These parameters can be numeric, within a defined range, or part of a list which associates a text to a numeric value.

To transfer the parameter values to the PLC application, it is necessary to define virtual Analog Output variables. Each parameter is linked to one Analog Output which must be defined as a shared I/O variable in the PLC program.

- The PLC parameter value is written to the AOs:
- when the RTU starts up (technically when the PLC virtual machine thread starts up)
 - after new values are entered on the PLC parameter web page
 - after the system detects a change in the configuration for MODBUS master and/or virtual variables.

PLC Program Parameters

General parameters

Parameter name: SHG_TOAutoComms

Value: 900

Associated AO: A03 - SHG_TOAutoComms

Type: Numeric List

Min value: 0 Max value: 85535

PLC Program Parameters

General parameters

Parameter name: SHG_Comm_NodeType

Value: 2 - 2: Middle Node

Associated AO: A04 - SHG_Comm_NodeType

Type: Numeric List

Min value: 0 Max value: 3

List configuration

Name	Value
0: Not configured	0
1: End Node	1
2: Middle Node	2
3: Test Node	3

Add a new item...

Save Cancel Delete

Up to 20 parameters can be defined. For each, the following parameters can be defined:

- the name
- the value
- the Associated AO (the AO must be previously defined)
- the type "Numeric" or "List"
- the possible range of value (Min/Max)
- for a parameter of type "List", add and edit the possible items of the list

Monitoring	Control
Embedded PLC	
- Configuration	
- Variables	Virtual PLC IP port
- Flash Memory	Cycle time
- Program Parameters	Program
- Peer to Peer	
- Debug	

1.5.7 Peer to Peer configuration page

The Peer-to-peer feature allows direct "side-ways" communication between two or more RTUs independently of the "upwards" communication to a SCADA system. The RTUs must be installed on the same TCP/IP network (Ethernet or GPRS/UMTS).

This page shows the configuration of the transfer tables that are used to send messages between two neighbouring equipments.

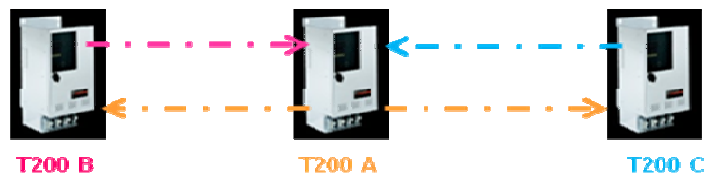
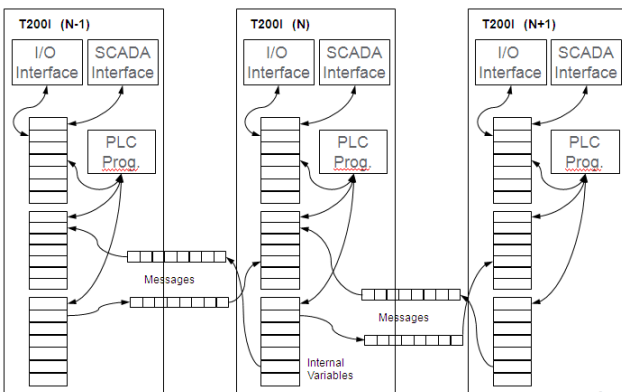
Peer to Peer principle:

The peer to peer communication can copy the values of a set of variables from one RTU to another using the MODBUS TCP protocol and the "write multiple registers" command. This is similar to the concept of a "dataset" in other protocols".

Each dataset is defined as an exchange table within both peer devices. On the sending device, the table is defined as type "Write" and on the receiver it is defined as type "Read". Each exchange table defines a range of MODBUS addresses. Variable are part of the dataset if they have a "peer-to-peer" address within the range.

For "Write" tables, the variables may have any type. For "Read" tables the variables must be either DO or AO types.

The PLC program can launch the sending of the "Write" tables, and is warned when the "Read" tables are updated. The process uses additional variable to indicate the success or failure of each message. These can be used by the PLC program to retry messages if needed.



Transfer Table Configuration					
Transfer Table 1					
Name	A_In	Start Address	310	Length	6
Transfer Type	02: Read	Slave Number	0	Distant Address	0
		SendDataActive Index	-	ReceiveDataValid Index	D027
		SendDataInProgress Index	-		
		SendDataResult Index	-		
Save					
Transfer Table 2					
Name	A_Out	Start Address	410	Length	6
Transfer Type	01: Write	Slave Number	21	Distant Address	320
		SendDataActive Index	DO52	ReceiveDataValid Index	-
		SendDataInProgress Index	DO53		
		SendDataResult Index	AO22		
Save					

Configuration:

Up to 6 tables can be defined.

For each table,

- Name
- Transfer Type: Inactiv, Write or Read
- Start address: local MODBUS address that correspond to the first variable of the table
- Length: Number of 16 bit MODBUS registers. Maximum 6. Digital variables are mapped to a single bit. Analog variables use one 16 bit register. The "length" value must be the same in the "Write" table and in the "Read" table.

For type "Write":

- Slave number: correspond to the slave index on the Slaves configuration page (where its IP address will be defined)
- Distant address: MODBUS address on the slave where the table will be written
- SendDataActive Index: DO index (control variable). This is the index of the DO variable to be activated by the PLC application to request the firmware to write the content of the table into the distant device. This is reset automatically by the firmware when the transfer is in progress.
- SendDataInProgress DO index (control variable). This is the index of the DO variable that indicates the write process is in progress for this table. It is reset automatically when the transfer is complete or times out. Useful for commissioning
- SendDataResult Index: index of an AO (control variable) that shows the status of the transfer. Possible values of the AO are:
 0: Operation successful
 1: Invalid MODBUS function
 2: Invalid address
 3: Invalid data
 15: Communication Error – problem creating a TCP connection
 16: Communication error – request or reply timed out
 20: Set when a message is in progress

Codes 1,2,3 indicate that the message was successfully delivered but that the receiving device rejected it. This usually means some sort of configuration error.

For type "Read":

- ReceiveDataValid Index: DO index (control variable). This is the index of a DO variable that is set when new data has been written by a distant device. It should be reset by the PLC application.

Settings	
Communication	
Operation mode	
Protocol	
TCP/IP Protocol - IEC104 (1)	
TCP/IP Protocol - ModBus (2)	
Port 1: transmission	
Port 2: transmission	
Modbus master	
Communication	
Slaves Configuration	
Variable management	
Variable configuration	
Classes configuration	
Embedded PLC	
Formulas	

Protocols and Variable Addresses

As the peer-to-peer feature is using the MODBUS TCP protocol, both the MODBUS master, and the MODBUS TCP slave protocol is always enabled on the equipment in addition to the main "slave" protocol (IEC101/104 or DNP3/DNP3 IP).

Each of these protocols have their own web pages for configuration.

Variable name	Type	address	Peer to Peer address
Switch state 1			
SW1_command	TC01	4	48,0
SW1_Status_int	TS01	32	52,0
SW1_locked	TSS49	68	56,8
SW1_voltage	TSS54	78	57,2
SW1_earth_fault	TSS71	81	56,1

Type:	Double	Single
Access	DISPLAY	
External Address	68	
Peer to Peer address :	56,8	
Inactive (0)	No	

For each variable, the "External address" is used by the main protocol, and the "Peer-to-peer address" is used in MODBUS TCP for the peer-to-peer feature.

If the main protocol is MODBUS/MODBUS TCP, the same addresses (external address) are used for both Scada communication and peer-to-peer communication.

Monitoring	Control
Embedded PLC	
<ul style="list-style-type: none"> - Configuration - Variables - Flash Memory - Program Parameters - Peer to Peer - Debug 	
Virtual PLC IP port	
Cycle time	
Program	

1.5.8 PLC debug page

The PLC trace can be used to check that the RTU Control program is running correctly and that the variables have been downloaded into the equipment without errors.

In normal operation, it is not necessary to control program execution. It's only in case of abnormal behaviour of the PLC that the control of its operation can be useful.

```

Traces
-----
T5 runtime - SE Telecontrol
V1.0 - 2007 - (c) COPALP/ SE Telecontrol
Flash:
  Code: 0x103d0000 (65536 bytes)
  VMDB: 0x103e0000 (65536 bytes)
  Key : 0x103f0000 (65536 bytes)
Starting Program (Cold/Warm)
Can Not open File In memory, code error #0F00112
Starting Program default_equipt (Cold/Warm)
Name : PANNE_DET_DEFAULTS Type Input
Name : MANQUE ALIM EQUIPT Type Input
Name : MANQUE ALIM MOTOR Type Input
Name : DEFAULT_EQUIPEMENT Type Output
Name : DEFAULT_CHARGEUR Type Input
Name : DEFAULT_BATTERIE Type Input
    
```

1.6 Examples

Some demonstration projects are provided as examples. They are part of RTU Control installation and are included in the in the folder "RTU CONTROL\Samples\Easergy".

These projects allow for example to show the link between RTU Control and the T200 variables and also the management of TSD/TCD. They include corresponding T200 or F200C configurations in a dedicated folder

These projects are dedicated to the demonstration and are not supported by the technical support.

No responsibility is assumed by Schneider Electric for any consequences arising out of the use of these programs.

2 Calculation formulas

2.1 Presentation

Contrary to the PLC which is an option for the T200 and Flair 200C, the calculation formulas are provided as standard with the basic T200.

The calculation formulas allow arithmetic and combinational operations between variables.

The formulas make it possible to:

- Perform mathematical calculations based on physical measurements (consumption, conversions, etc.).
- Create personalized indications (combinations of variables, grouped faults, etc.).
- Define new type of automation for controlling or monitoring (change over, etc...).

A formula is associated with a variable. Following its execution, the formula will assign the value obtained to the associated variable. Its value is updated at each execution of the formula, according to a configurable cycle time (minimum cycle time = 100 ms).

2.2 Syntaxes and rules

The formulas use a natural and intuitive syntax that combines references with measurement values (variables, historians, etc), literal expressions (constants, operators, etc) and function calls (min, max, delta, etc).

The user does not need to worry about data formats; the interpreter takes care of the conversions. This makes it possible to combine logical and mathematical operations: $(B > 3) * C$, $(B > 3)$ is a logical expression (true (1) or false (0)).

The formulas only make sense if at the end of their execution the value obtained is allocated to a variable (or to a database cell). It should be understood that **a formula is not a script language**; there is no concept of loops (for, while) or instruction jumps (goto, if..then). However, there is a conditional operator that allows the allocating of such and such a value according to a logical expression.

The formulas take into account the case (lowercase or uppercase) of the operands and functions. The maximum length of a formula is 200 characters. A formula can accept up to 50 elements (operands, operators...).

A formula may be split into several "sub-formulas" separated by a **semi-colon (the comma is reserved for separating a function's parameters)**.

Each "sub-formula" is executed successively in their order of writing during the same processing cycle.

2.2.1 Operands

2.2.1.1 Numerical constants (integers, decimal numbers):

The numbers may be positive or negative, whole or decimal and/or exponent: 123, -45.1, 12.5E3, etc.

To enter a hexadecimal number, its value must be prefixed with the symbol \$ (or the letter H), for example \$10 (or H10).

For "decimal" values, the decimal separator is the point.

The type of value (integer, word, IEEE) is automatically determined by analysis of the formula.

2.2.1.2 Character strings:

A character string must be entered between single ' quote marks, for example 'my string'. Character strings are used to reference certain function parameters or names of tables or database columns.

2.2.1.3 Variables:

By entering the name of a **variable** (without quote marks), the operand will be interpreted as **the value of the variable** at the time of execution. The type of value is that of the variable.

Warning, **the name** of a variable used with a formula **must not contain spaces**.

2.2.2 Operators

2.2.2.1 Mathematical:

+	Addition
-	Subtraction
*	Multiplication
/	Division (dividing by zero causes an execution error)
%	Modulo: Remainder of the whole division (whole numbers)
**	Power: $A**B = A^{\text{exponent}} B = A^B$

2.2.2.2 Logical:

&&	Logical AND	$A \&\& B = \text{true}$ if $A = \text{true}$ AND $B = \text{true}$, otherwise <i>false</i>
## 	Logical OR	$A \#\# B = \text{true}$ if $A = \text{true}$ OR $B = \text{true}$, otherwise <i>false</i>
^^	Logical EXCLUSIVE OR	$A \wedge\wedge B = \text{true}$ if $(A = \text{true}$ AND $B = \text{false})$ OR $(A = \text{false}$ AND $B = \text{true})$
!	Logical NOT	$!A = \text{true}$ if $A = \text{false}$

Remark : the symbol « | » is obtained by pressing simultaneously the keys [AltGr] and [6] from the keyboard.

2.2.2.3 Binary:

&	Bitwise AND	$\$AA \& \$55 = \$00$
 #	Bitwise OR	$\$AA \$55 = \$FF$
^	Bitwise EXCLUSIVE OR	$\$AA \wedge \$A5 = \$0F$
~	Bitwise NOT (Complement to 1)	$\sim A$, inverts all the A bits, those at 1 change to 0 and vice versa
<<	Shift left	$A \ll B$, shifts the A bits by B bits to the left
>>	Shift right	$A \gg B$, shifts the A bits by B bits to the right

2.2.2.4 Comparisons:

=	Equal
==	
!=	Different
<>	
>	Greater than
<	Less than
>=	Greater than or equal to
<=	Less than or equal to

2.2.2.5 Allocation operator

The operator := is used to allocate a value to a variable:

Example: "mavar := 2".

The user does not need to worry about the destination data format as the conversions are automatic.

In the case of an input/output peripheral variable, allocation will cause the sending of an order of writing to the peripheral when the formula is executed.

2.2.2.6 Conditional operator

The operator (expr) ? A : B returns A if expr is true, otherwise B.

expr must be a boolean expression.

For example:

A := (B>C) ? D : E; will allocate D to A if B is greater than C, otherwise it will allocate E to A.

It is of course possible to use brackets to create more complex expressions.

The same principle applies to operations:

A + ((B>C) ? D : E) is worth A + D if B > C, otherwise it is worth A + E.

The conditional operator can also be used for allocation:

((B > C) ? D : E) := A;

in this case, if B > C, D is allocated with the value A, otherwise it is E that is allocated with the value A.

2.2.2.7 Order of importance of operators and use of brackets

The decreasing order of importance in the execution of an expression's operations is the following:

Function	Fcn ()	P0 = max priority
Positive sign	+ (Var)	P1
Negative sign	- (Var)	
Logical NOT	!	
Complement to 1 *	~	
Power	**	P2
Multiplication	*	P3
Division	/	
Remainder *	%	
Addition	+	
Subtraction	-	P4
Shift left *	<<	
Shift right *	>>	
Bitwise AND *	&	
Bitwise OR *	/#	P5
Bitwise EXCLUSIVE	^	
Logical AND	&&	
Logical OR	/##	
Logical EXCLUSIVE	^^	P6
Test equal to	=	
Test less or equal to	<=	
Test great or equal to	>=	
Test less than	<	
Test greater than	>	
Test different from	!</>	
Allocation	:=	
		P7 = min priority

"*" : Operation on integer only (manipulation on bits)

2.3 Functions

The functions' arguments may be any kind of operand, but also mathematical or logical expressions or function results. This makes it possible to link together several function and operation calls.

", ...)": the three small dots indicate functions with a varying number of arguments.

"[x]": the square brackets refer to one (or several) operational argument(s).

3.1 Mathematical functions

Excluding indications to the contrary, the data format of the values returned by these functions is IEEE (floating simple precision)..

2.3.1.1 abs(x)

Returns the absolute value of its argument x

The type of data returned by the function is the same as that of x.

Example: Abs(VAR1*3)

2.3.1.2 sqrt(x)

Returns the square root of x.

If x is less than zero, the operation causes an execution error.

2.3.1.3 log(x)

Returns the Napierian logarithm of x.

If x is less than or equal to 0, the operation causes an execution error.

2.3.1.4 log10(x)

Returns the logarithm in base 10 of x.

If x is less than or equal to 0, the operation causes an execution error.

2.3.1.5 exp(x)

Returns the exponential of x. $\exp(\log(x)) = x$.

2.3.1.6 pow(x, y)

Returns x to the power of y. $\text{pow}(x, y) = x^{**} y = xy$.

2.3.1.7 intg(x)

Returns the whole part of x. For example, $\text{intg}(12.46) = 12$.

The value returned is an integer (INT32).

2.3.1.8 rand(x)

Returns a random whole number greater than or equal to 0 and less than x.

The value returned is a double word (DWORD).

2.3.2 Statistical functions:

2.3.2.1 mini(A, B, ...)

Returns the argument whose value is the smallest.
This function must include **at least two** arguments.

Note that this function returns not only the value of the argument but also its reference. This means it is possible to combine it with an allocation operation:

mini(VAR1, VAR2, VAR3) := 4; with VAR1, VAR2, VAR3 of the variable references, if VAR3 has the minimum value, this variable will then be allocated with the value 4.

2.3.2.2 maxi(A, B, ...)

Returns the argument whose value is the largest.
This function must include **at least two** arguments.

As with **mini**, this function returns the argument reference.

2.3.2.3 pmini(A, B, ...)

Returns the position (from 0) of the argument whose value is the smallest.
This function must include **at least two** arguments.

2.3.2.4 pmaxi(A, B, ...)

Returns the position (from 0) of the argument whose value is the largest.
This function must include **at least two** arguments.

2.3.2.5 sum(A, B, ...)

Returns the value of the sum of the arguments.
This function must include **at least two** arguments.

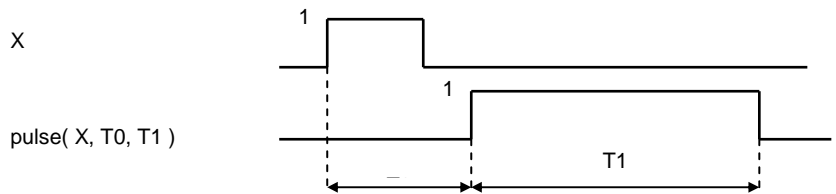
2.3.2.6 avg(A, B, ...)

Returns the value of the argument's average.
This function must include **at least two** arguments.

2.3.3 Logical functions:

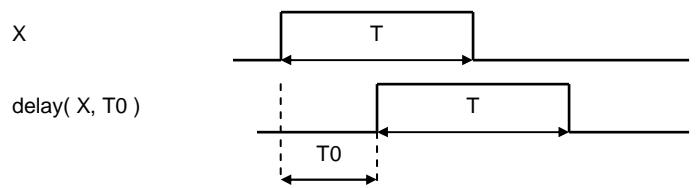
2.3.3.1 pulse(X, T0, T1)

X is a boolean value. T0 and T1 are numbers of seconds. On front edge of X (transition from 0 to 1), after T0 seconds, the function returns true (1) for T1 seconds. The rest of the time it returns false (0).



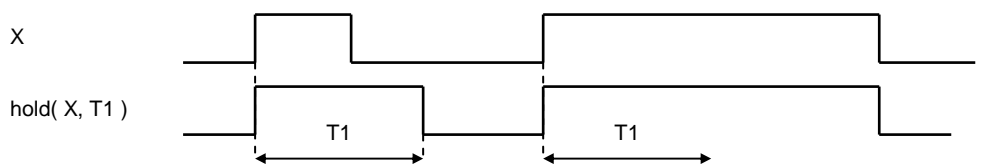
2.3.3.2 delay(X, T0)

X is a boolean value. T0 is a number of seconds. The function copies the value of X is shifted in time by T0 seconds.



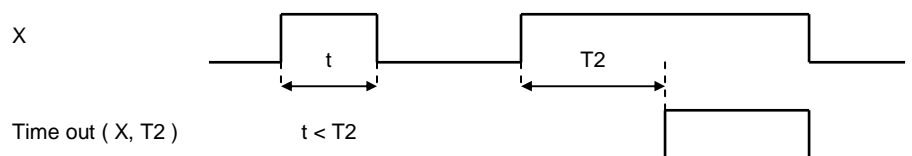
2.3.3.3 hold(X, T1)

X is a boolean value. T1 is a number of seconds. The function returns true for at least T1 seconds on a front edge (transition from 0 to 1) of X. If X stays at 1 (true) for more than T1 seconds, the hold function returns true during this time.



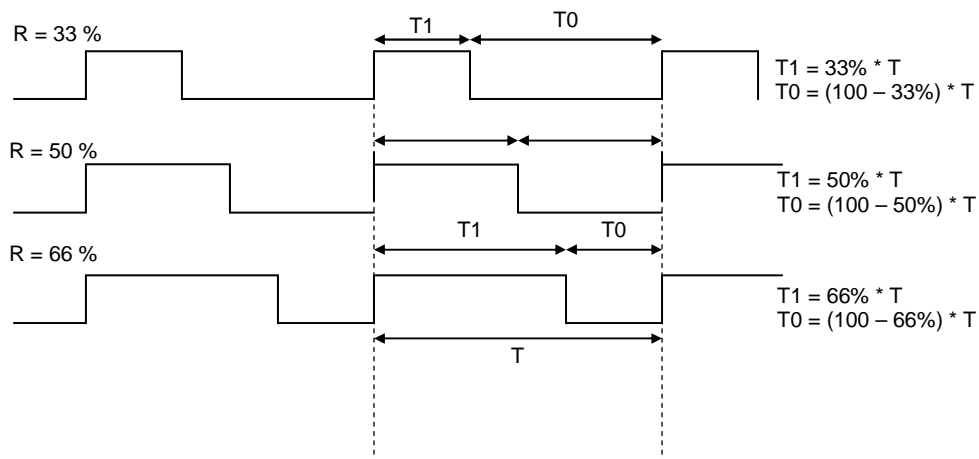
2.3.3.4 tempo(X, T2)

X is a boolean value. T2 is a number of seconds. The function returns true if X moves to 1 for at least T2 seconds. After this time, the function returns true as long as X is at true.



2.3.3.5 `pwm(T, R)`

The function returns a boolean value at the rhythm of a PWM signal of period T and cyclical ratio R as a percentage. R must be between 0 and 100%.



2.3.3.6 `iswithin(X, min, max)`

returns a boolean value that is worth true if $(X \geq \text{min})$ **AND** $(x \leq \text{max})$, and otherwise false.

2.3.4 Time / Date and time functions:

The TIME_T format is a data format that allows the recording of a date/time couple in numbers of seconds since a single reference (1st January 1970 at 00:00:00).

The days of the week are associated with the following values:
1 = Sunday, 2 = Monday, 4 = Tuesday, 8 = Wednesday, 16 = Thursday, 32 = Friday, 64 = Saturday.

2.3.4.1 dt([[T], X]) or now([[T], X])

Without an argument, the function returns the current date and time as TIME_T.

With T as TIME_T and X, T serves as a reference for the argument X

With X only, the current date and time functions serve as references for the argument X

if X = 1 or 'Y', returns the year in 4 figures

if X = 2 or 'M', returns the month (from 1 to 12)

if X = 3 or 'D', returns the day of the month (from 1 to 31)

if X = 4 or 'H', returns the time according to the 24Hr clock (from 0 to 23)

if X = 5 or 'm', returns the minute (from 0 to 59)

if X = 6 or 's', returns the second (from 0 to 59)

if X = 7 or 'd', returns the day of the week (1, 2, 4, 8, 16, 32, 64)

if X = 8 or 'p', returns 0 if the time is before midday (AM), 1 for the afternoon (PM)

if X = 9 or 'h', returns the time according to the 12Hr clock

if X = 10 or 'y', returns the year in 2 figures

2.3.4.2 time(X [, F])

With X only, if X is a character string, the function converts into TIME_T format the date and time corresponding to X according to the default date and time format. If X is numerical the function converts this number into TIME_T.

With X and F, X must be a character string, F is also a character string that defines the read format for the date and time. The function therefore returns date X as TIME_T according to format F.

F is in the form '**d/m/y H:M:S**' with:

d = the day of the month (from 1 to 31)

m = the month of the year (from 1 to 12)

y = the year in 2 figures

Y = the year in 4 figures

H = the time according to the 24hr clock

h = the time according to the 12hr clock

M = the minute (from 0 to 59)

S = the second (from 0 to 59)

2.3.4.3 isweek([X])

If **X (optional) is absent**, the function returns the boolean value true if the current date is a working day (from Monday to Friday inclusive).

If **X is of type TIME_T**, the function returns true if the date X is a working day. **Otherwise** X refers to a number for the day of the week and the function returns true if day X is a working day.

2.3.4.4 deltats()

Returns the time in SECONDS between two executions of the formula.

This function is very powerful as it allows the creation of integrations, differential coefficients, etc.

It is based on the system's real time clock.

2.3.4.5 deltatms()

Returns the time in MILLISECONDS between two executions of the formula.

This function is very powerful as it allows the creation of integrations, differential coefficients, etc.

It is based on the CPU's quartz clock. This means that it is relatively inaccurate over the long term

2.3.5 Other functions:

2.3.5.1 bounds(X, min, max)

Returns the value of X limited by *min* and *max*.

If X is less than *min*, returns *min*; if X is greater than *max*, returns *max*; otherwise returns X.

2.3.5.2 delta(X) or deltav(X)

Returns the difference between the value of X on the previous execution of the formula and the current value of X. The period for calculating the difference in X is therefore the execution period of the formula. See also deltats() and deltatms().

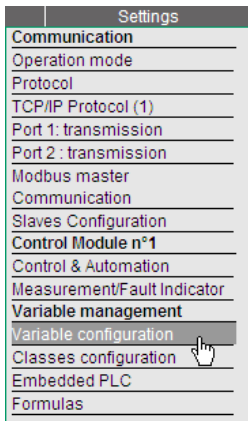
2.3.5.3 switch(X, A0, A1 [, A2, ...]) or cond(X, A0, A1 [, A2, ...])

X must be a positive whole value.

This function must include **at least three** arguments.

If X = 0, the function returns the argument A0, if X = 1, returns A1, if X = 2, returns A2, etc.

If X < 0, the function returns the argument A0, if X is greater than the number of arguments, the most recent is returned.



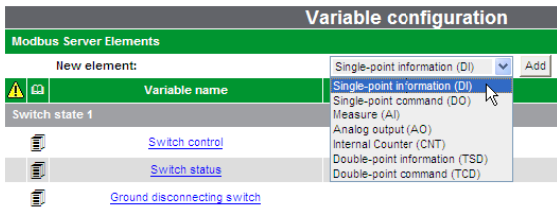
2.4 Settings

2.4.1 Creating variables

The user must declare variables that are specifically associated to the "Formulas". They will be updated only by the "Formulas" function but will be managed like any other variables regarding protocol and display of status.

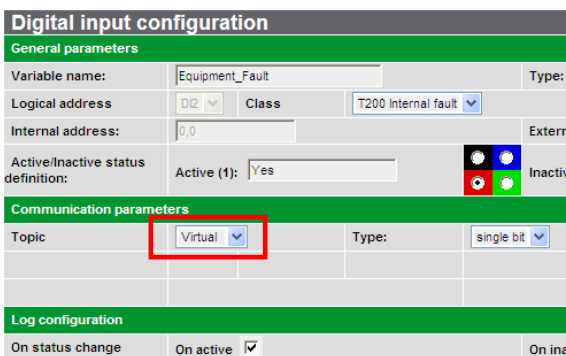
Creation is performed from the "Variable Configuration" page of the Web server, in the same way as for the other types of variables.

The types of variables that can be created for the functions are:



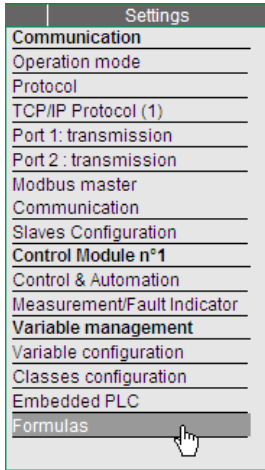
"Variable configuration" page

Variable type	Use	Description
DI	Single remote signal	Single bit indication
DO	Single remote command	Single bit command
AI	Analogue measurements	Analogue measurements performed by the T200/F200C (currents, voltages, etc.)
AO	Analogue command	Analogue writing
CNT	Counter	Change of state counter on single bit
TCD	Double remote command	Double command on switch/circuit breaker
TSD	Double remote signal	Indication of switch/circuit breaker position



The name of the variables associated with the calculation formulas should not contain any space

A variable associated with a formula should be configured with a "Virtual" topic.



2.4.2 Entering the formula

Once the variable has been created, the associated formula must be entered in the "Formulas" page of the Web server

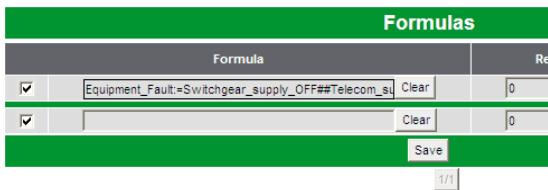
This page can include at most 100 formulas. 20 formulas can be displayed simultaneously.

Rules for entering the formula:

- Each formula should start with "name_of_the_variable:="
- No space is accepted in the name of the variables.
- The content of the formula with the operands and operators is defined after the sign "...:="
- The case must be complied with for names of variables and operands.

Each formula can be activated/deactivated via a check box.

A formula refresh period should be defined. A period defined as "Auto." = the shortest possible period (100 ms).



Example of formula defined

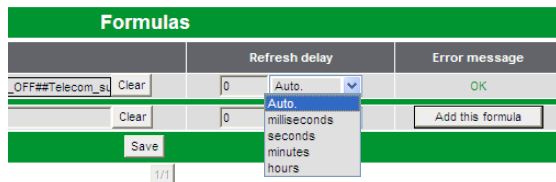
Rules for entering the formula:

- Each formula should start with "name_of_the_variable:="
- No space is accepted in the name of the variables.
- The content of the formula with the operands and operators is defined after the sign "...:="
- The case must be complied with for names of variables and operands.

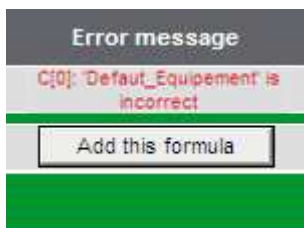
An error message is displayed if the syntax of the formula is not correct.

The result of the formula can be viewed in the "Monitoring" page

It corresponds to the state of the variable associated with the formula which corresponds to its result.



Refresh delay of a formula



Example of error message in case of incorrect input in formula

T200 Internal fault	
Switchgear_supply_OFF	No
Telecom_supply_OFF	No
Charger_fault	No
Battery_fault	Yes
FPI_failure	No
Equipment_Fault	Yes

Formula result in "Monitoring" page.

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