SIEMENS



Application Example • 08/2016

Energy Data Acquisition with the Energy Meter of the S7-1200

SIMATIC S7-1200

https://support.industry.siemens.com/cs/ww/en/view/109739414

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1 Task

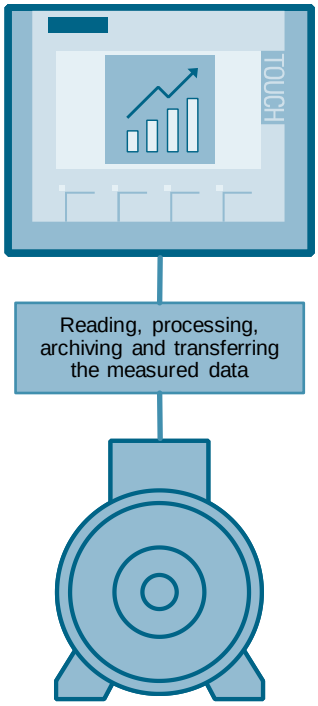
Introduction

In industry, energy efficiency is of increasing significance. Compliance with laws and regulations, increased pressure on return on investment and a growing awareness of climate protection are key factors for the reduction of energy costs and the implementation of an energy management system.

The job is to measure energy data and to visualize it.

Overview of the automation task

Figure 1-1: Automation task



1. With the energy meter the energy data of a consumer is to be measured.
2. The energy data is to be acyclically queried, evaluated and archived with a S7-1200.
3. The energy data is to be displayed graphically on the HMI.
4. An energy value from the S7-1200 is to be written cyclically into a data log (CSV file).
5. This energy value is also to be displayed graphically on the web interface of the S7-1200.

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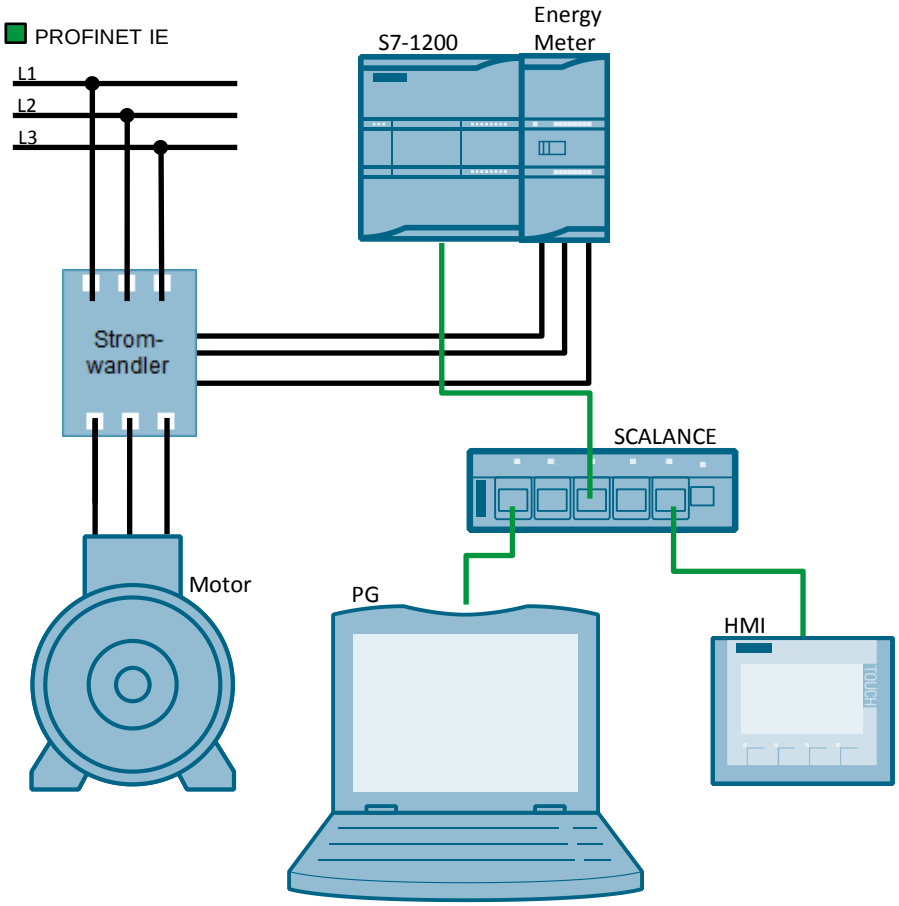
2 Solution

2.1 Overview

Schematic layout

The figure below shows a schematic overview of the most important components of the solution:

Figure 2-1: Schematic representation of the devices



Structure

1. The motor represents the consumer.
2. The current transformer transforms the measured current to a measurable measure for the energy meter.
3. The controller evaluates the measured voltage and current values and saves the energy consumption in a data log.
4. The HMI displays the measured values and shows the power peaks of the last weeks.
5. The controller can load the data log onto the PG/PC via the standard web pages.
6. The data from the data log is shown as a graph via the user-defined web pages.

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Advantages

The solution presented here, offers you the following advantages

- Economical option for energy data acquisition
- Identification of power peaks

Assumed knowledge

Basic knowledge on the following issues is assumed:

- Controllers
- HMI panels and their configuration
- STEP 7 (TIA Portal)

Topics not covered by this application

This application example does not contain a description of the web server of the controller.

2.2 Hardware and software components

2.2.1 Validity

This application is valid for

- STEP 7 V13 SP1
- WinCC Professional V13 SP1
- S7-1200 Firmware V4.1.2

2.2.2 Components used

The application was created using the following components:

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Hardware components

Table 2-1

Component	Qty.	Article number	Note
CPU 1212C DC/DC/DC	1	6ES7 212-1AE40-0XB0	Alternatively, any other larger CPU from the SIMATIC S7-1200 product family with the firmware V4.1.2 can also be used.
SM 1238 AI	1	6ES7 238-5XA32-0XB0	Energy Meter
Current transformer AC 3x60/5A	1	7KT1200	The current transformer has to be adjusted to the consumer.
FIELD PG M5	1	6ES7717-.....-0...	Alternatively, any other PC on which the TIA Portal is installed can also be used.
SWITCH MODULE CSM 1277	1	6GK7277-1AA10-0AA0	Alternatively, another switch can also be used.

Software components

Table 2-2

Component	Qty.	Article number	Note
STEP 7 BASIC V13 SP1	1	6ES7822-0AA03-0YA5	Alternatively, STEP 7 Professional V13 SP1 can also be used.
WinCC BASIC V13 SP1	1	6AV2100-0AA03-0AA5	Alternatively, WinCC Advanced V13 SP1 can also be used.

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Example files and projects

The following list includes all files and projects that are used in this example.

Table 2-3

Component	Note
109739414_EnergyMeterS71200_CODE_v10.zip	This zip file contains the STEP 7 project.
109739414_EnergyMeterS71200_DOKU_v10_en.pdf	This document

3 Basics on the Energy Meter 480VAC

Introduction

The energy meter provides the measured values and variables by means of the following procedures:

- Cyclic: User data
- Acyclic: Data records (parameter data records, measured value data records)

User data

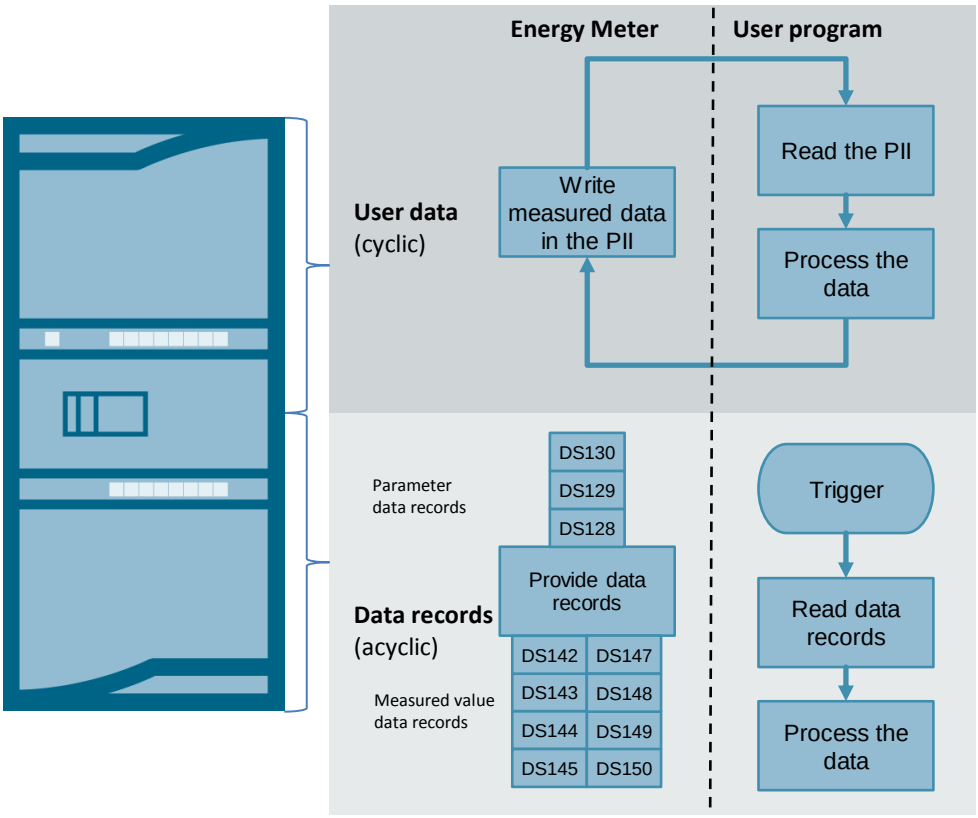
User data provide predefined measured values depending on the configured user data variant. The measured values supplied are cyclically written to the process image of the CPU.

Data records

Each data record provides physical values which can be immediately processed further. The measured value data records are read acyclically by means of the “RDREC” instruction. For each data record to be read, a PLC tag is required whose configuration corresponds to the configuration of the data record.

The figure below schematically shows the data flow in the Energy Meter 480VAC.

Figure 3-1: Data flow in the Energy Meter



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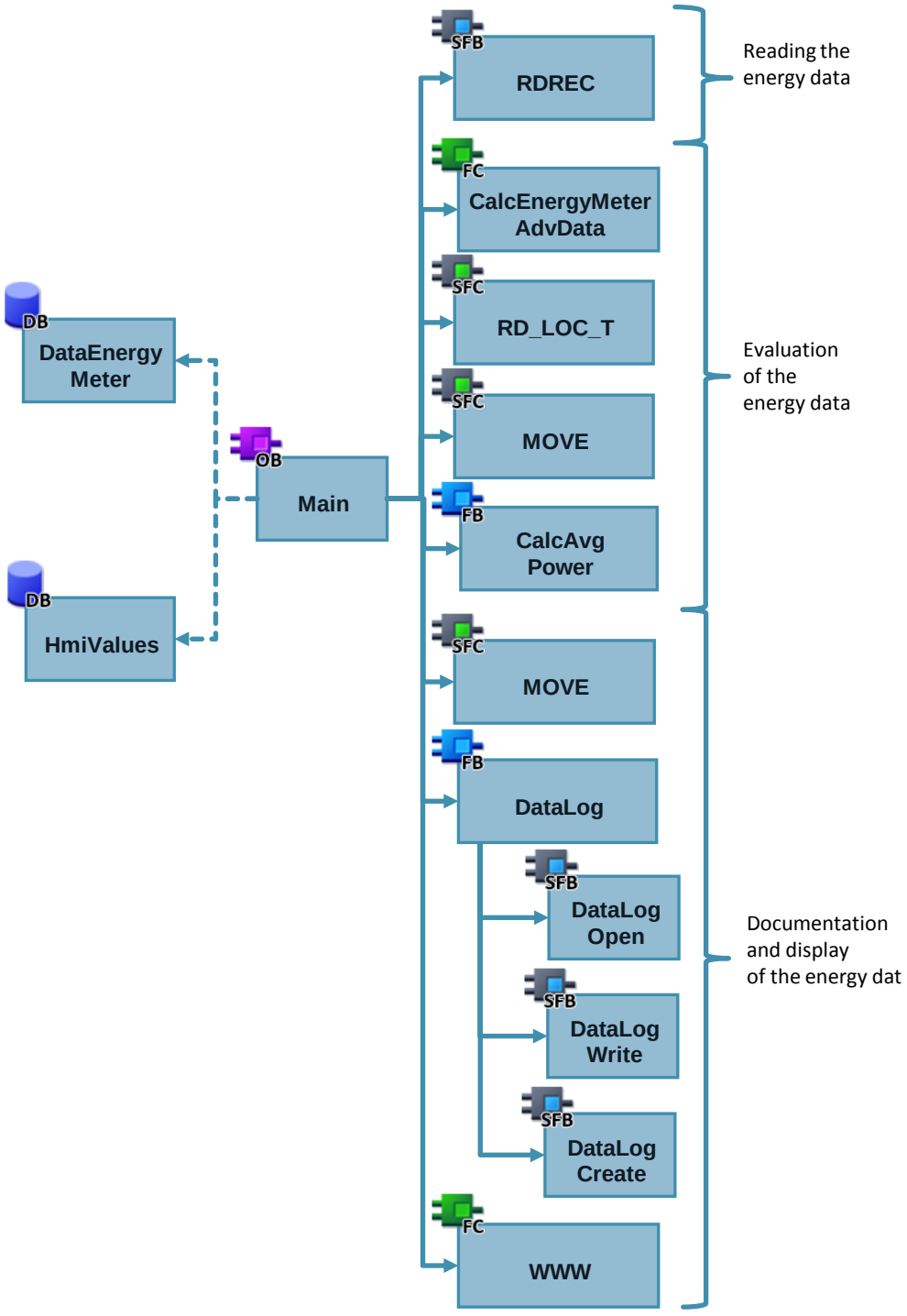
4 Mode of Operation

4.1 General overview

Figure 4-1: Program structure



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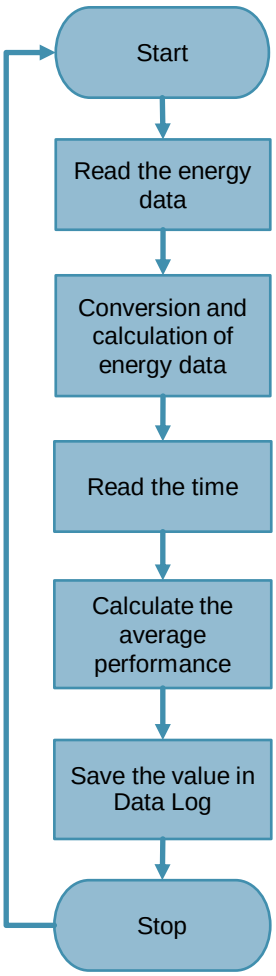
4.2 Functioning of OB1 “Main”

Figure 4-2: Flow chart “Main” OB



In the “Main” OB all called blocks are processed cyclically.

With the “RDREC” system function the energy data is read out and stored in the “DataEnergyMeter” data block.

Note Information on switching the “RDREC” system function can be found in chapter 5 Configuration and Settings

The measured energy data is converted into a different unit and other averages are calculated with the function “CalcEnergyMeterAdvData”. (See 0

Converting and calculating energy data)

The time for checking the time is determined with the “RD_LOC_T” instruction.

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Note For the time to be right, the controller has to regularly check the time and if required adjust it. Alternatively, the time can also be synchronized via an NTP server. More information on time synchronization via NTP server can be found in the manual of the S7-1200 in: https://support.industry.siemens.com/cs/ww/en/view/109478121/60802457867

The average power is calculated with the “CalcAvgPower” function block and saved in a ring buffer. (See 4.4 Calculating the average power)

The data log is opened, created and written with the “DataLog” function block.

(See 4.5 Saving the value in the data log)

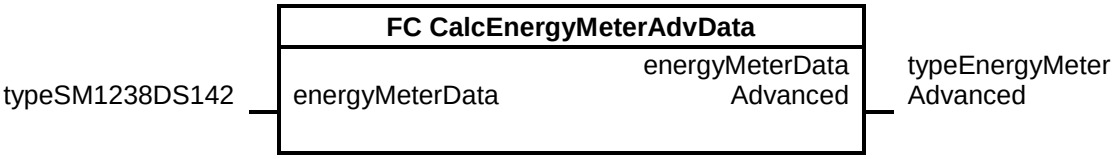
4.3 Converting and calculating energy data

Short description

In the “CalcEnergyMeterAdvData” function the units of energy values are converted (for example: “W” in “kW”). Furthermore, the averages of voltage and current values are calculated via three phases, for example uLNAvg:= (uL1N + uL2N + uL3N) / 3

Block

Figure 4-3: FC CalcEnergyMeterAdvData



Input parameter

Table 4-1: Input parameter

Parameter	Data type	Description
energyMeterData	typeSM1238DS142	Read energy data of the “RDREC” instruction

Output parameter

Table 4-2: Output parameter

Parameter	Data type	Description
energyMeterDataAdvanced	typeEnergyMeterAdvanced	Converted and newly calculated energy data.

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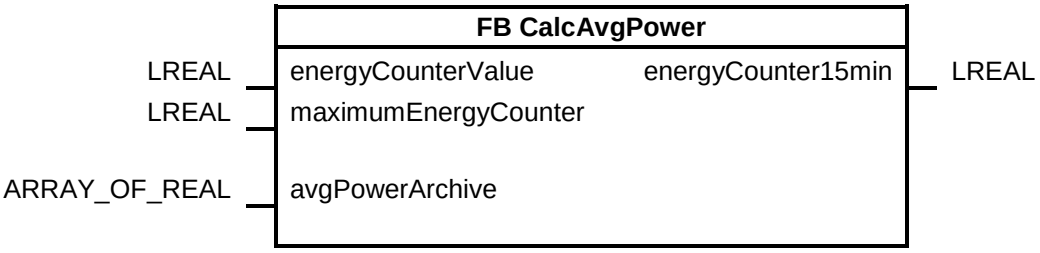
4.4 Calculating the average power

Short description

In this block the average power of a quarter hour is calculated.

Block

Figure 4-4: FB CalcAvgPower



Input parameter

Table 4-3: Input parameter

Parameter	Data type	Description
energyCounterValue	LREAL	Current value of the energy counter.
maximumEnergyCounter	LREAL	Configured maximum value of the energy counter from the hardware settings of the energy meter.

Output parameter

Table 4-4: Output parameter

Parameter	Data type	Description
energyCounter15min	typeEnergyMeterAdvanced	Value of the energy counter at defined times (a quarter past, half past, a quarter to, or at the full hour).

Input/Output parameters (InOut)

Table 4-5: Input/Output parameters (InOut)

Parameter	Data type	Description
avgPowerArchive	ARRAY_OF_REAL	Ring buffer in which the average power is saved every quarter hour.

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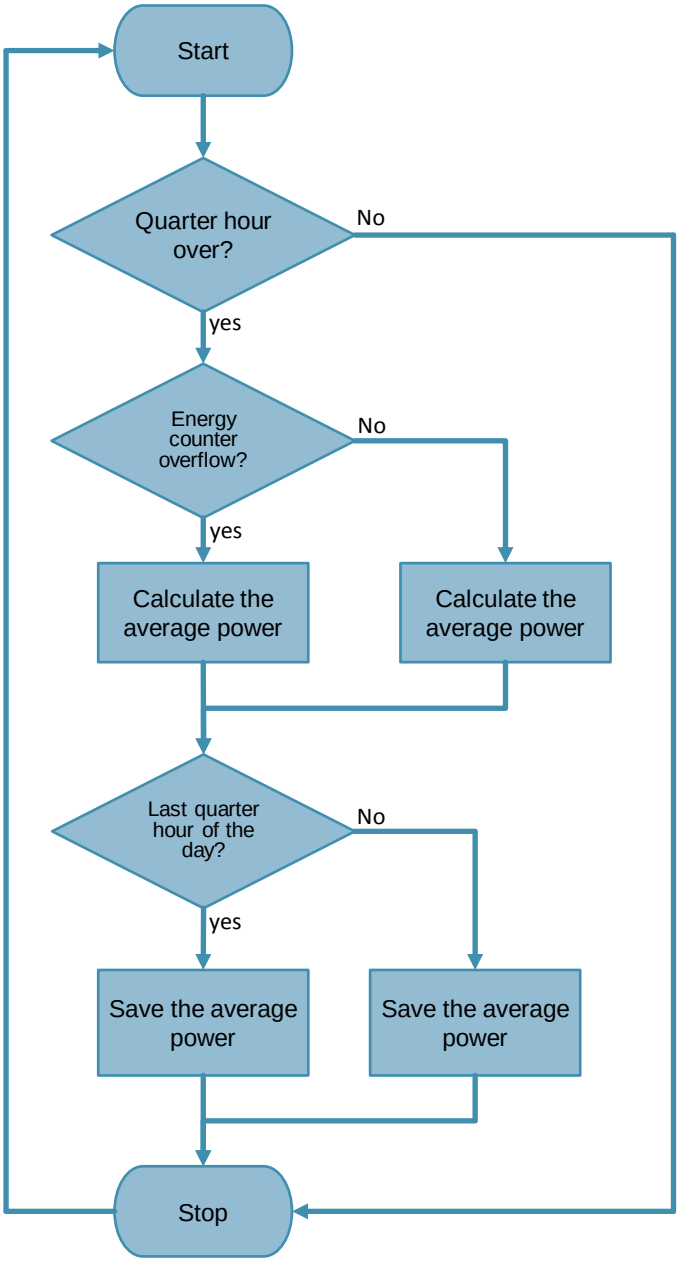
Mode of operation

The program is configured as shown in the following figure.

Figure 4-5: Flow chart “CalcAvgPower” FB



The average power is calculated every quarter hour (a quarter past, half past, a quarter to and at the full hour).
It is calculated from the difference between the value of the energy counter at the beginning and at the end of the last quarter hour. A possible overflow of the energy counter is to be noted. The calculated power is then stored in a ring buffer.

Note The energy meter measures the current and the voltage. From this, the power is calculated and the energy counter is integrated.

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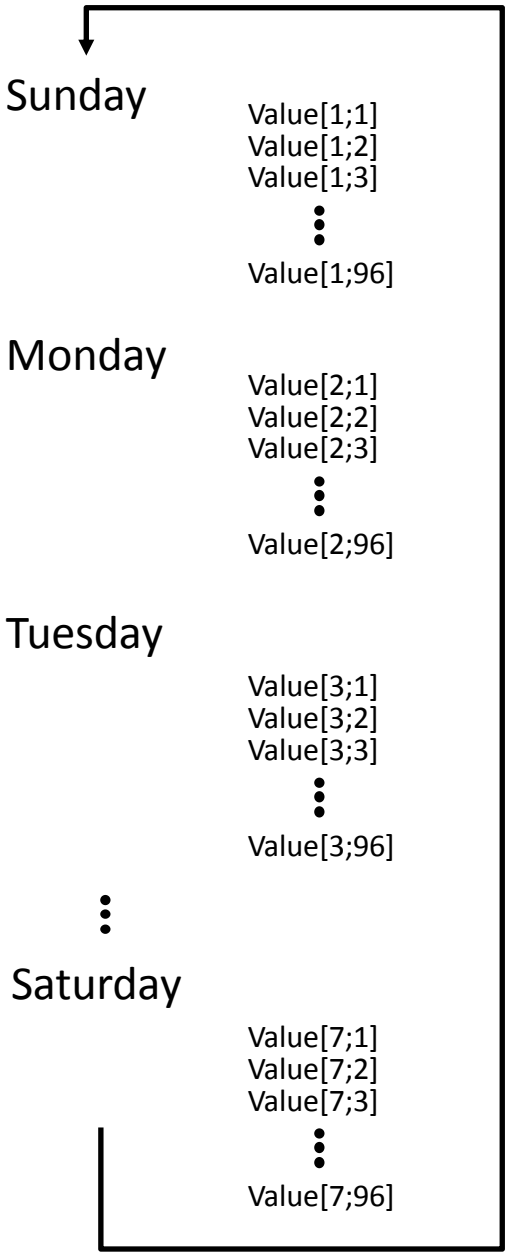
4.4.1 Structure of the ring buffer

Figure 4-6: Ring buffer



The ring buffer consists of a two dimensional array. The first array index determines the weekday. The second array index determines the quarter hour of the day. If a new day is written, all previous values of the day are reset to “0”.

Note The numbering of the weekdays (Sunday = “1”, Saturday = “7”) correspond to the numbering of the weekdays in data type “DTL”.

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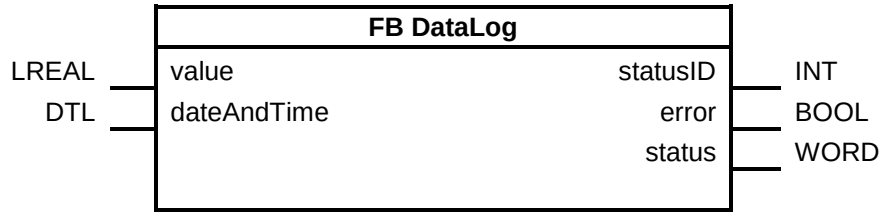
4.5 Saving the value in the data log

Short description

In this block a value is written into a data log every quarter hour.

Block

Figure 4-7: FB DataLog



Input parameter

Table 4-6: Input parameter

Parameter	Data type	Description
value	LREAL	Value that is to be saved in the data log.
dateAndTime	DTL	Current time stamp.

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Input/Output parameters (InOut)

Table 4-7: Input/Output parameters (InOut)

Parameter	Data type	Description
statusID	INT	“statusID” returns the ID of the block reporting the status. See table below.
error	BOOL	0: no errors 1: Block error, “statusID” returns error source, “status” returns error code.
status	WORD	“status” returns the status/error code. See table below.

Status and error displays

Table 4-8: Status/error codes

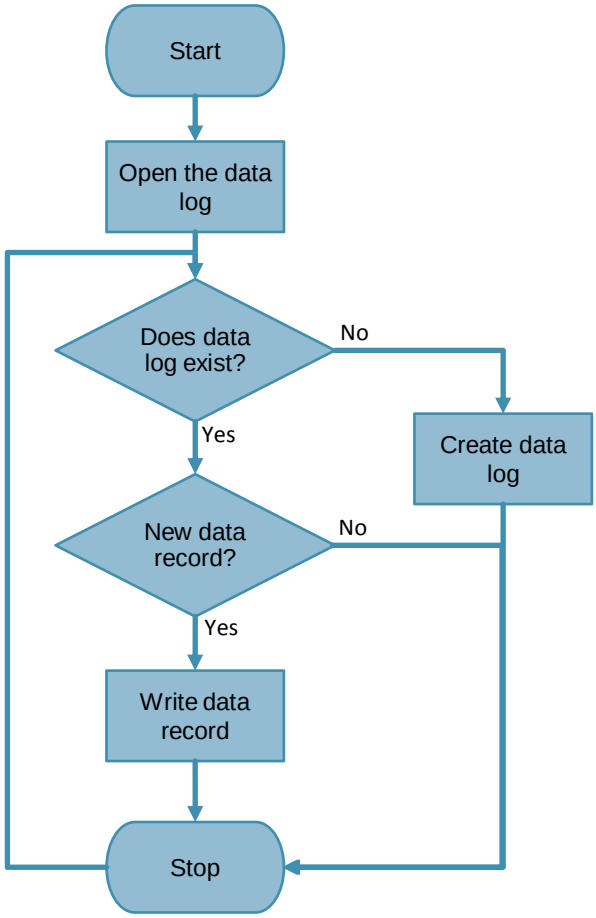
statusID	status	Meaning	Remedy/notes
1	-	Error of subordinate “DataLogOpen” block	-
2	-	Error of subordinate “DataLogOpen” block	-
3	-	Error of subordinate “DataLogOpen” block	-

Note All values with the “status” output come directly from the called instructions. All information on the status information of these instructions can be found in the TIA Portal online help.

Mode of operation

The program is configured as shown in the following figure.

Figure 4-8: “DataLog” FB flow chart



The data log is opened in this function block. If the data log was deleted or not yet created, a new one is automatically created. Every 15 minutes (at a quarter past, half past, a quarter to, or at the full hour) a new value is written into the data log.

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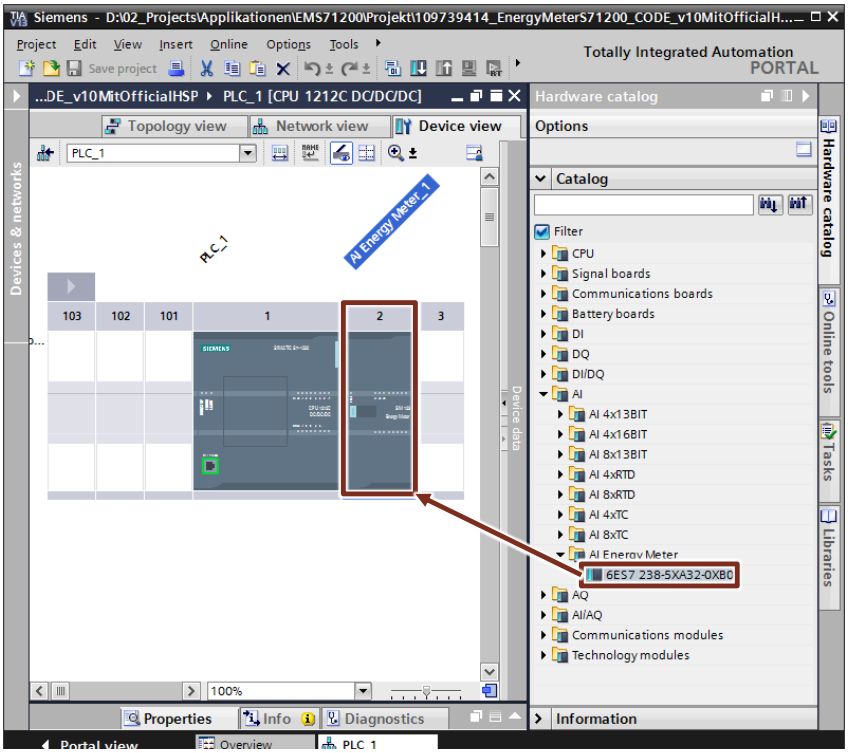
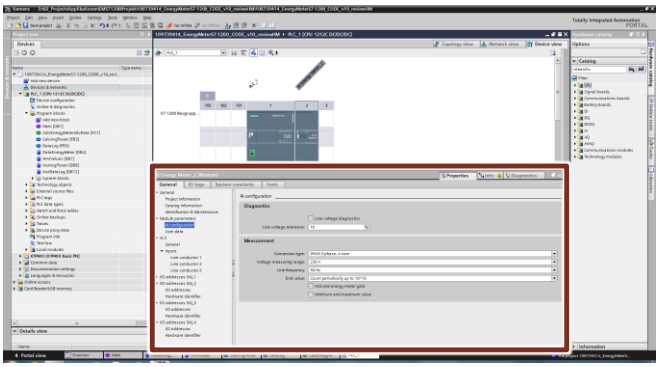
5 Configuration and Settings

5.1 Configuring the energy meter.

Table 5-1

No.	
1.	Add the energy meter to your hardware configuration. 
2.	Open the hardware properties of the energy meter. 

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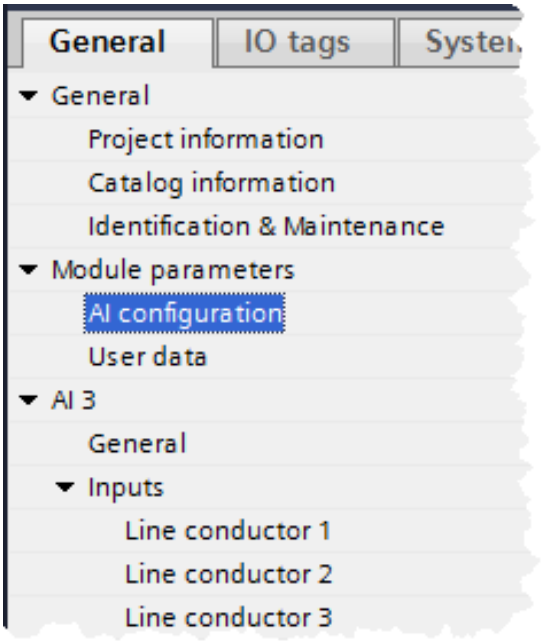
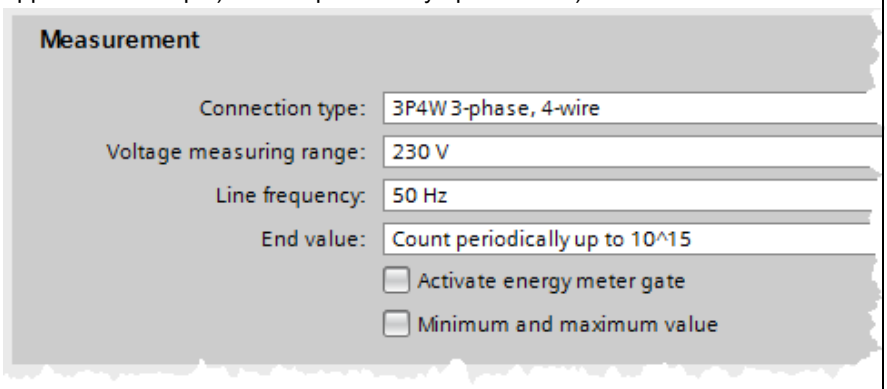
No.	
3.	Click on “Module parameters” -> “AI configuration”. 
4.	Select the data depending on the configuration of your structure to be measured. Note: The application example is meant for a 3-phase system. Enter the maximum value for the energy counter in “End value”. (In the application example): “Count periodically up to 10^15”) 

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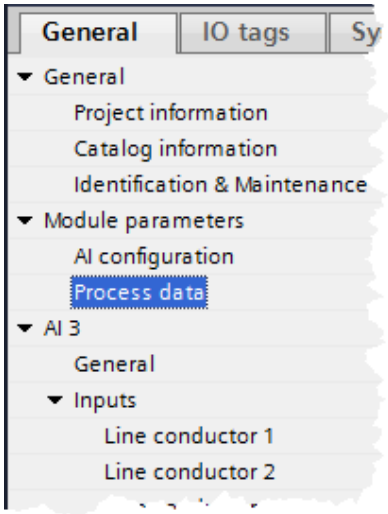
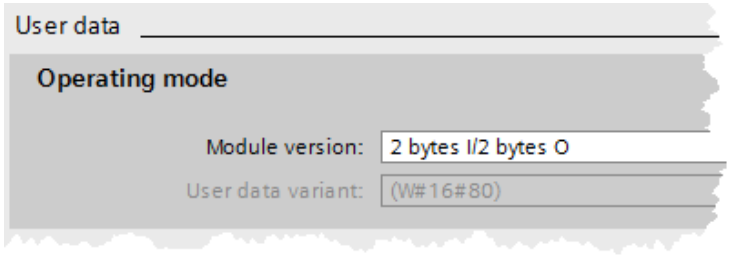
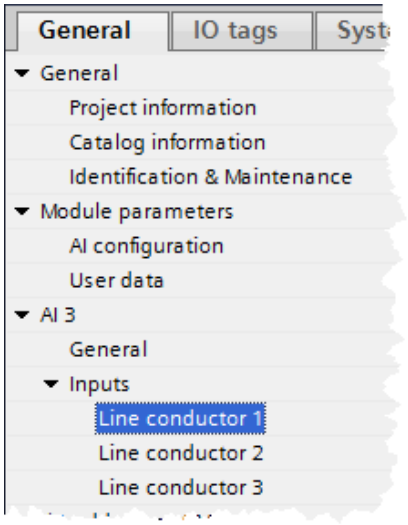
No.	
5.	Click on “Process data”. 
6.	Select “2byte I/2 bytes O” for “Module version”. This module version is used, so that the I/O image is not unnecessarily stressed. The data of the module is read via the acyclic communication of the user program. 
7.	Click on AI3 -> “Inputs” -> “Line conductor1”. 

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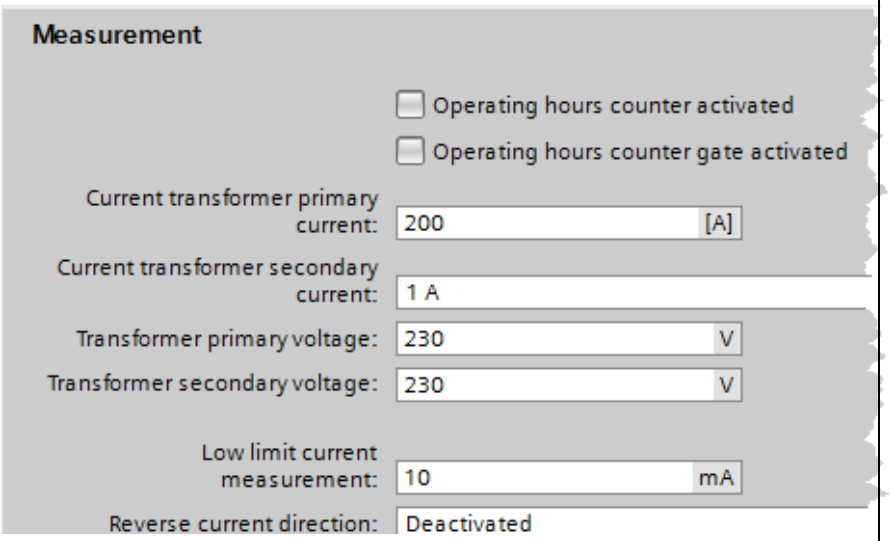
No.	
8.	In “Measurement” in “Current transformer primary current” enter the primary current of your current transformer. Enter the secondary current of your current transformer in “Current transformer secondary current”. Specify from what milliampere onward the current measurement is to be set to “0” in “Low limit current measurement”. 
9.	Repeat point 7 for “Line conductor 2” and “Line conductor 3”.

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5.2 Configuring the “RDREC” function.

To be able to read out the energy data of an energy meter acyclically, the “RDREC” instruction has to be configured as follows.

Figure 5-1: Call “RDREC”

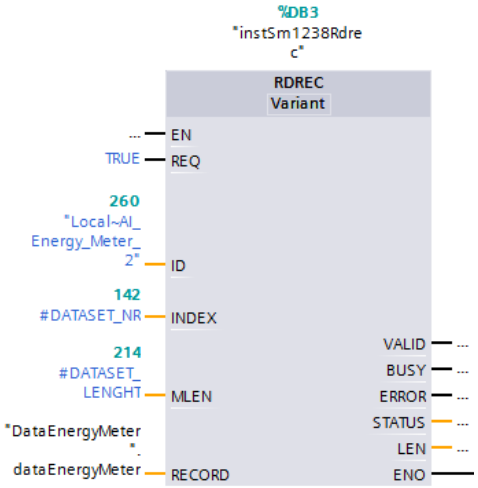
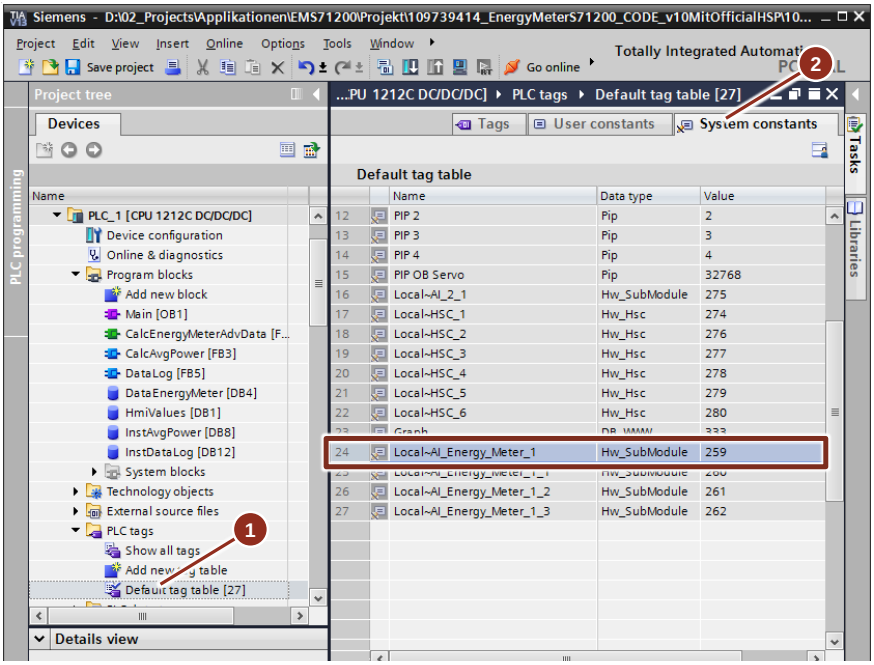


Table 5-2

No.	
1.	Assign the system constant with hardware ID of the signal module to the “ID” input. The system constants can be found in “PLC tags” > “Default tag table” in the “System constants” tab. The hardware ID of the signal module is also shown in the “system constant” tab in the inspector window of the “Device view”. 
2.	Assign the “INDEX” input to the desired data record number. The different possible data records are described in the manual in “E.1 overview of all measured value data records”. https://support.industry.siemens.com/cs/ww/en/view/109483435/88964832011
3.	Assign the maximum length of the data record to the “MLEN” input. This can also be found in the manual, for example, the first byte of data record DS 142 is “0” and the last one is “213”. Thus, “MLEN” corresponds to “214” byte. https://support.industry.siemens.com/cs/ww/en/view/109483435/88964849675
4.	Assign the “RECORD” input/output to a tag with a user-defined data type. This data type has to correspond to the structure of the selected data record. This structure can be found in the manual. https://support.industry.siemens.com/cs/ww/en/view/109483435/85350254347

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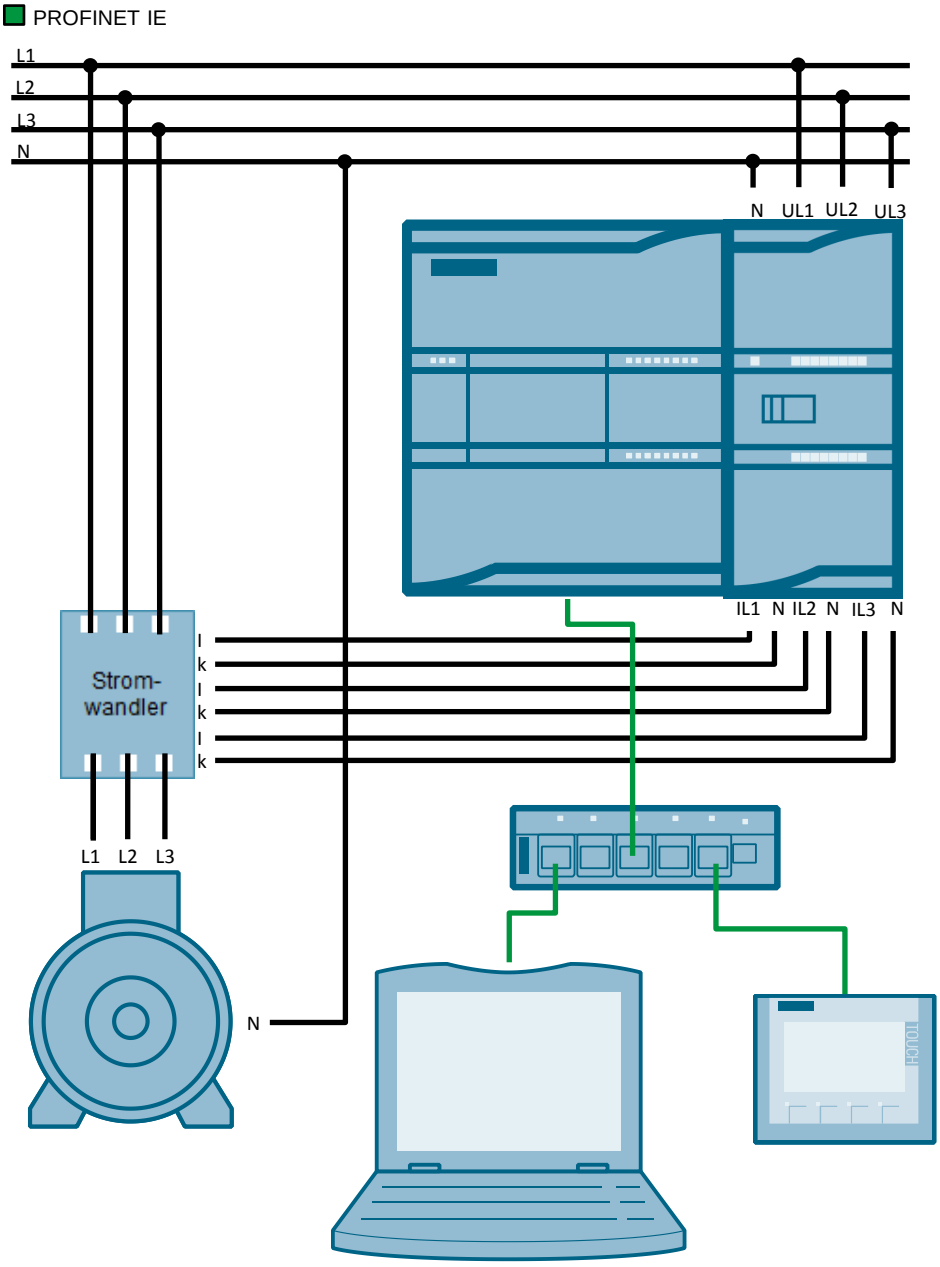
6 Installation and Commissioning

6.1 Installing the hardware

The figure below shows the hardware configuration of the application:

Figure 6-1: Wiring diagram



Note The setup guidelines of the devices must generally be followed.

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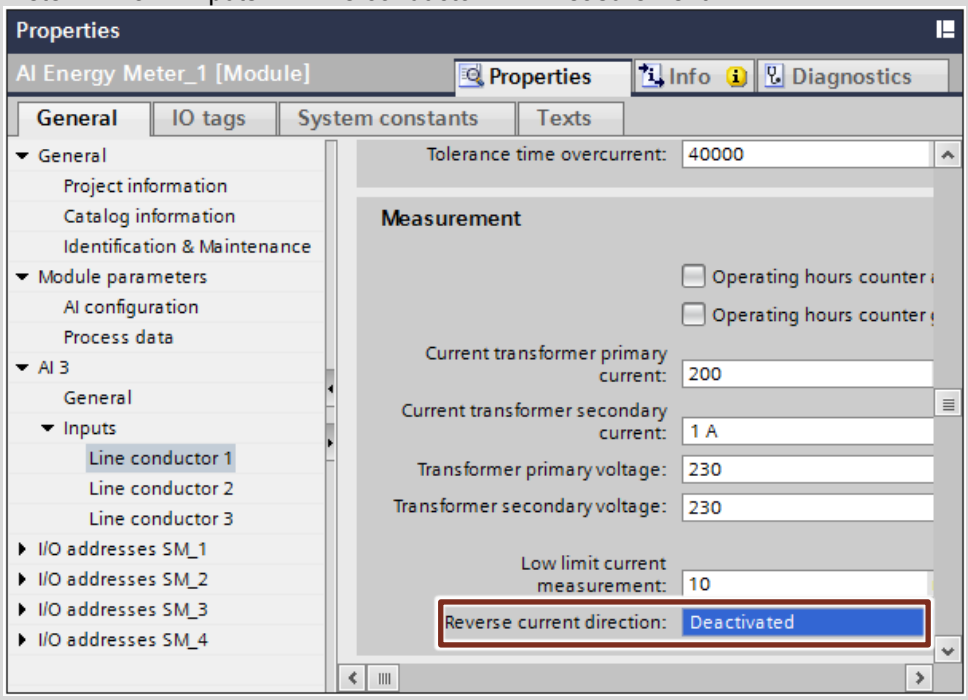
Note

If the respective phase active power is not shown in the graph on the panel, the connections of the converter on the energy meter may have been reversed. If this is the case, you do not have to rewire.
The current direction can be inverted in the hardware properties of the energy meter in AI3 > “Inputs” > “Line conductor1” > “Measurement”.



6.2 Installing the software

This chapter describes the steps for the installation of the required software.

Note

It is recommended to use the latest versions of any installed software.

TIA Portal with STEP 7 and WinCC

Table 6-1

No.	Action	Remark
1.	Install STEP 7 V13 SP1 on your programming device.	To do this, follow the instructions of the program.
2.	Install the hardware support package (HSP) of the energy meter.	In the following entry, all HSPs are ready for download: https://support.industry.siemens.com/cs/ww/en/view/72341852
3.	Install WinCC V13 SP1 on your programming device.	To do this, follow the instructions of the program.

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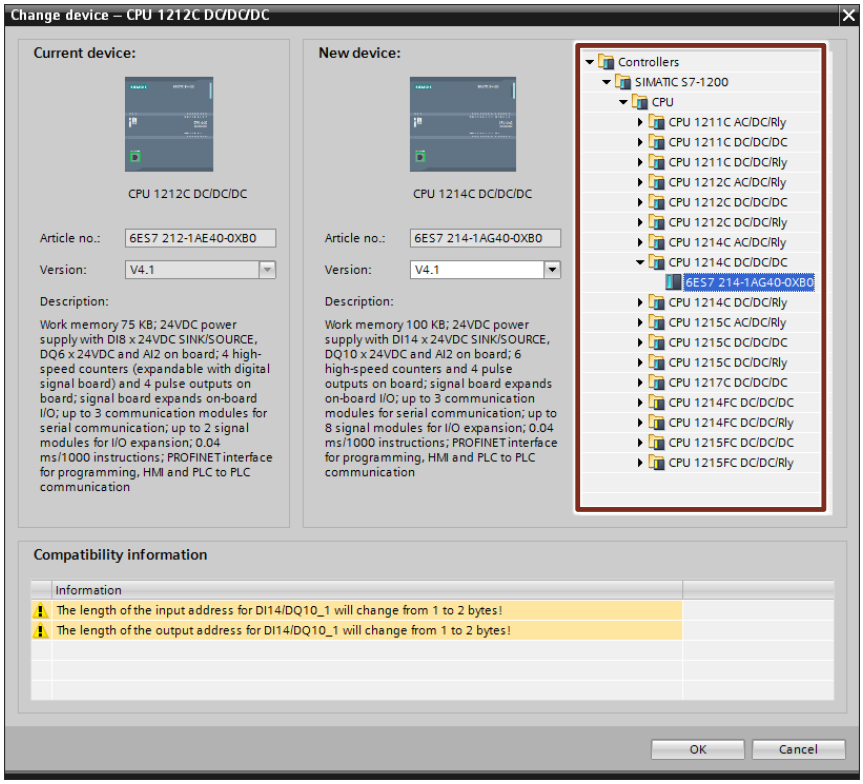
6.3 Commissioning

Note When assigning the IP addresses to your devices, make sure that they are all located in the same subnet and each IP is only assigned once in the subnet.

Controller

The following table shows the commissioning of the controller

Table 6-2

No.	Action
1.	Download the file with the program of the user example to your programming device and unzip it.
2.	Open the example project. “109739414_EnergyMeterS71200_CODE_v10.ap13”
3.	Open the “Device Configuration” of the “CPU 1212C DC/DC/DC” controller If you are using the same controller as in the example, you can skip step 4.
4.	Open the context menu by right clicking the controller and select “Change device”. Select your S7-1200 from the tree and click “OK”. 

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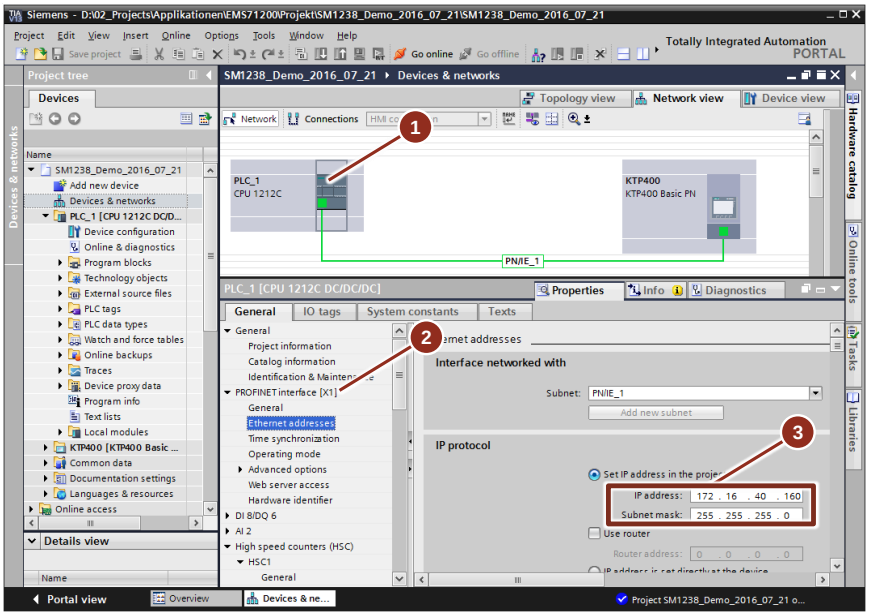
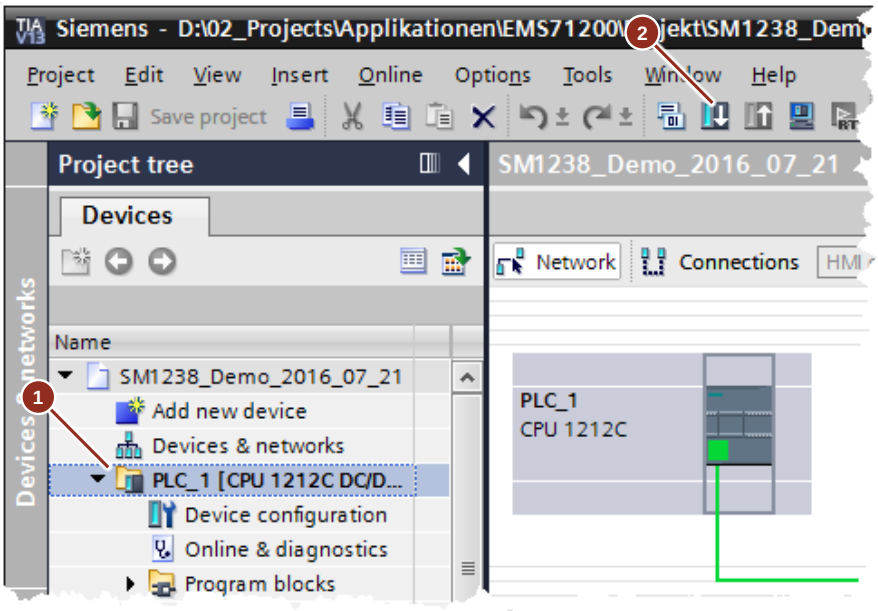
No.	Action
5.	Select the controller (1) in the “Network view”. Select the following in the inspector window “Properties” > “General” > “PROFINET interface” > “Ethernet addresses” (2) Enter an IP address and subnet mask in “IP protocol”. (3) Please note here that it matches the IP address and subnet mask of the project and of the PG/PC interface. 
6.	Select the controller in the project navigation (1) and download the program into the controller (2) by clicking on the “Download to device” button.  The configuration of the controller has been completed.

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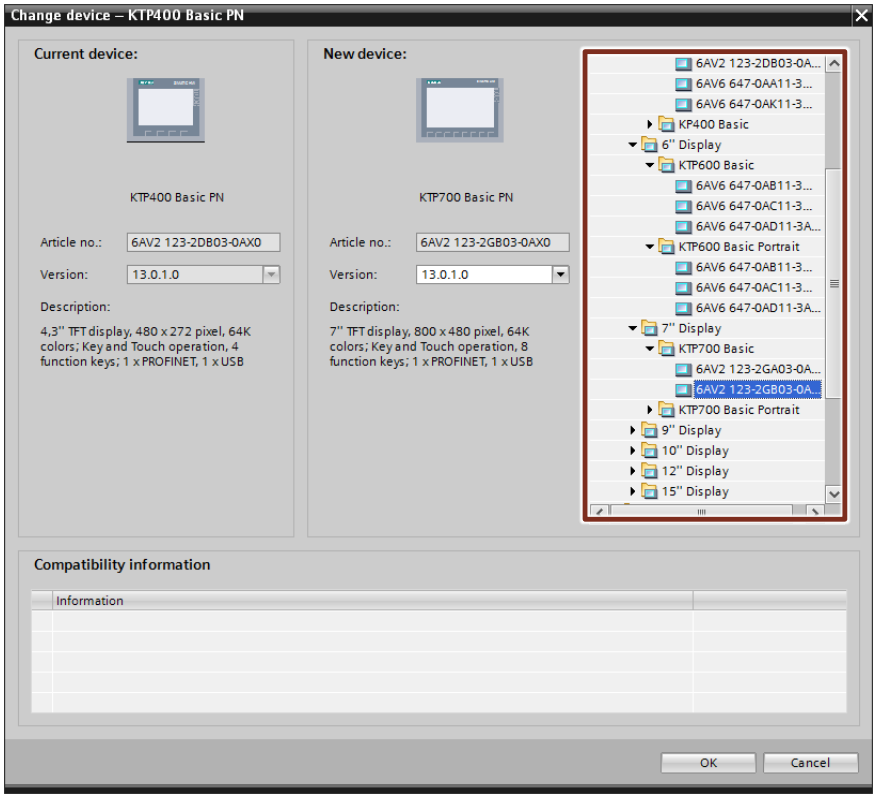
HMI

Table 6-3

No.	Action
1.	Open the “Device Configuration” of the HMI “KTP 400 Basic PN” If you want to have the same HMI as in the example or you want to work with the simulation, you can skip step 2.
2.	Open the context menu by right-clicking on the HMI and select “Change device”. Select your HMI from the tree and click “OK”. 

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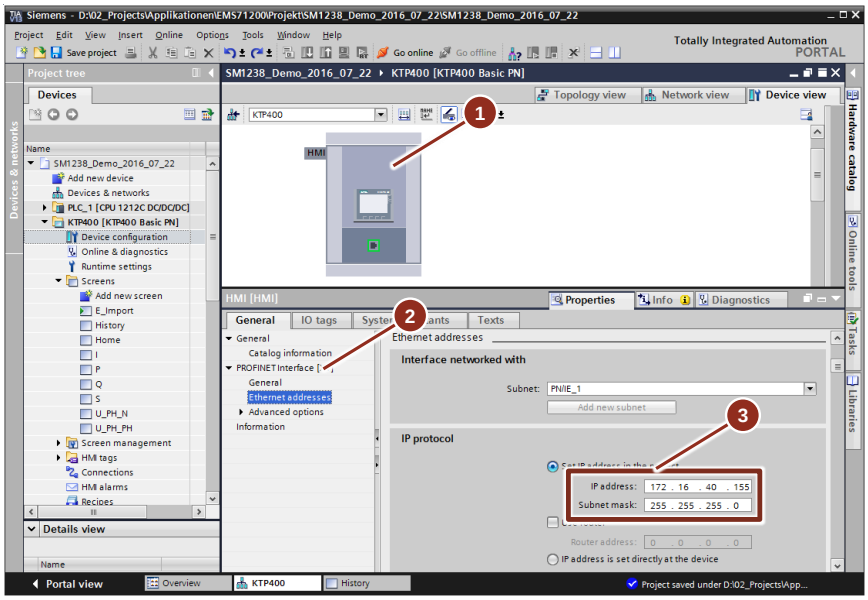
No.	Action
3.	Select the HMI (1) in the device view. Select the following in the inspector window “Properties” > “General” > “PROFINET interface” > “Ethernet addresses”. (2) Enter an IP address and subnet mask in “IP protocol”. (3) Please note here that it matches the IP address and subnet mask of the project and of the PG/PC interface. 
4.	Open the “History” image in “Screens”

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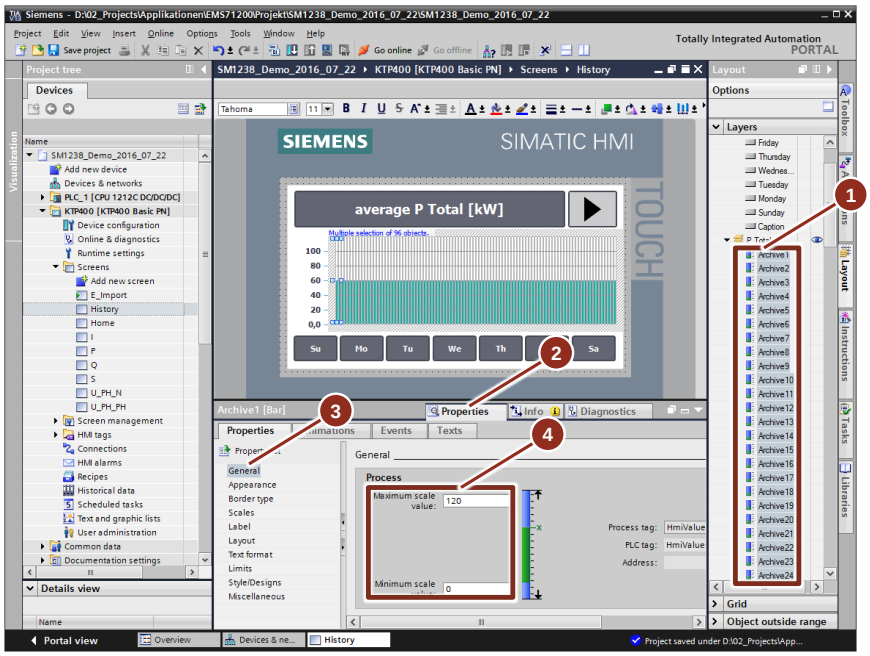
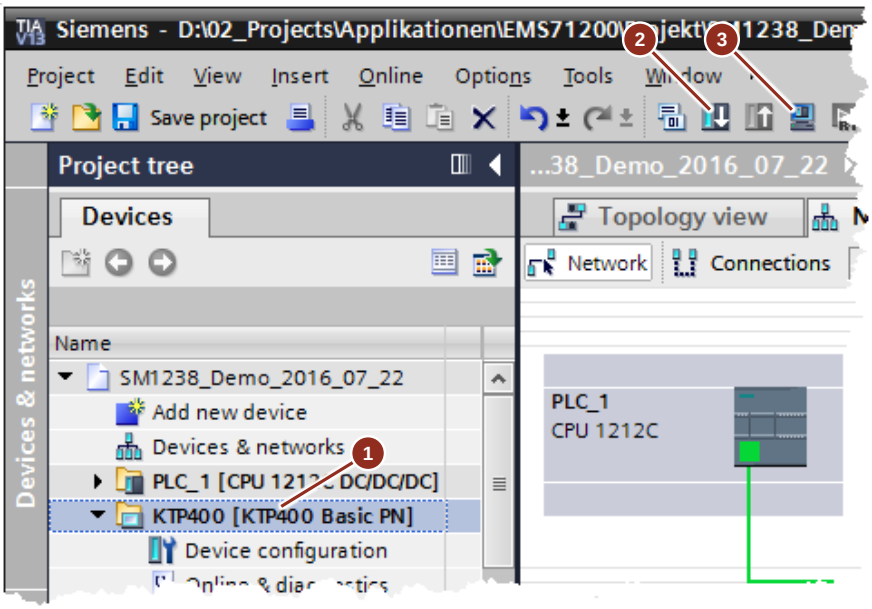
No.	Action
5.	Click “Layout” in the task cards and select all bar charts (“Archive1” to “Archive96”). (1) Then click “Properties”. (2) Select “General” in the column on the left. (3) Adjust the “Maximum scale value” and the “Minimum scale value” to your consumer. (4) 
6.	Select the HMI in the project navigation (1) and download the program into your HMI (2) by clicking the “Download to device” button. Alternatively, you can also simulate the HMI on your PG/PC. (3) 

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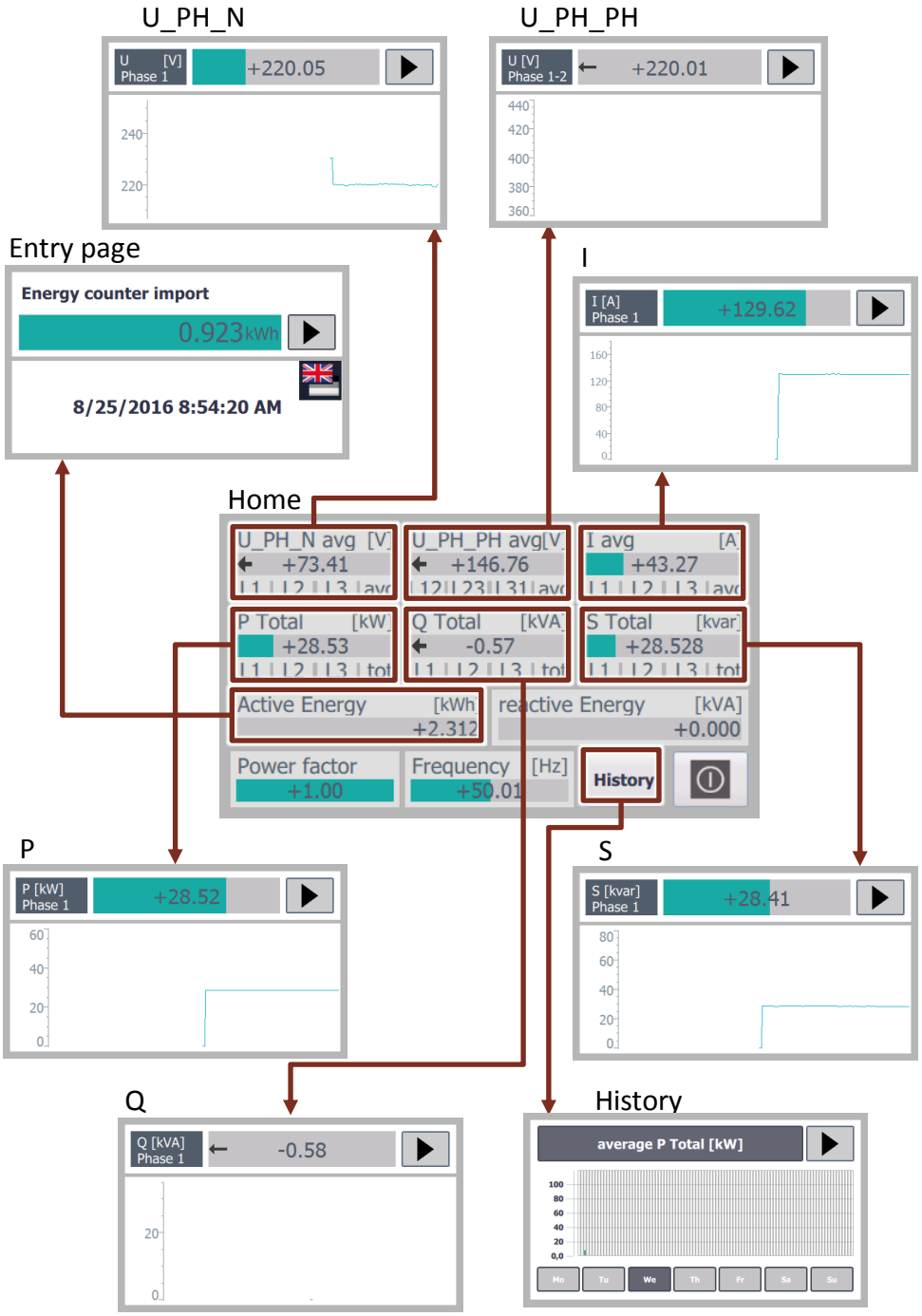
7 Operating the Application

7.1 Overview and description of the user interface

The following figure shows images of the user interface and how you can access it, starting from the “Home” screen.

Note The values shown in the following screenshots are only exemplary.

Figure 7-1: User interface in HMI



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In the following table the buttons are described.

Table 7-1

Button	Description
	You find this button on the entry page. Using this button, you can switch the language.
	This button can be found in the “Home” screen. You can terminate HMI Runtime with it.
	You find this button in all images apart from “Home”. With it, you can go to the “Home” screen.
	With the images “U_PH_N”, “U_PH_PH”, “I”, “P”, “S” and “Q”, you can look at the course of conductor 1 with this button.
	With the images “U_PH_N”, “U_PH_PH”, “I”, “P”, “S” and “Q”, you can look at the course of conductor 2 with this button.
	With the images “U_PH_N”, “U_PH_PH”, “I”, “P”, “S” and “Q”, you can look at the course of conductor 3 with this button.
	With the images “U_PH_N”, “U_PH_PH” and “I”, you can look at the course of the average value from all three conductors with this button. With the images “P”, “S” and “Q”, you can look at the course of the overall value from all three conductors with this button.
	Below the diagram on the “History” screen there is a button for each weekday. Via this button you can look at the course of the energy counter of the selected day.

On the “Home” screen, an overview of the currently measured average is displayed. By clicking on one of these values, the course of this value can be viewed.
By clicking the “History” button the course of the average power for the current day is output. Via the buttons below the diagram the course of a past day of the last seven days can be displayed. The values displayed are stored in a data block on the controller. Therefore the course of the average power is not reset by restarting the panel.

Note

Please note that the time of the controller and of the HMI is set correctly.
You can synchronize the time of the HMI with the time of the controller. For further information, please refer to the following entry:
https://support.industry.siemens.com/cs/ww/en/view/39182145

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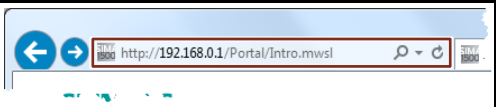
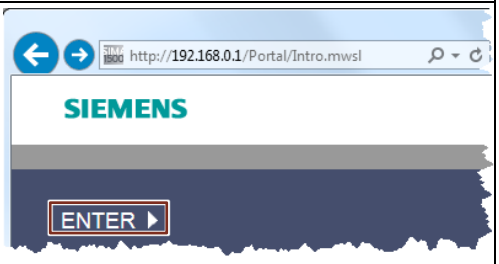
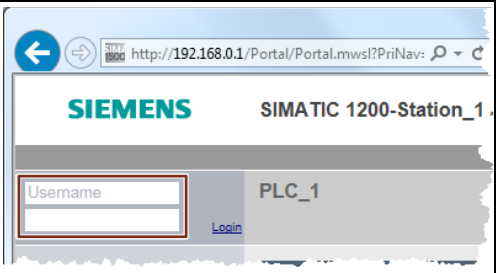
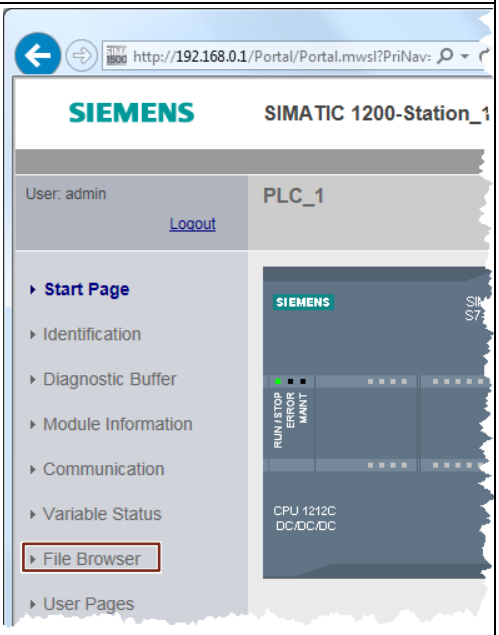
7.2 Overview and description of the Web interface

In order to open the user-defined web page, proceed as follows:

Table 7-2

No.	Action	Remark
1.	Enter the IP address of your CPU in the browser on your programming device. The S7-1200 intro web page is opened.	
2.	Click on "ENTER". The start page is opened.	
3.	Log on with the user name "admin" and password "s7". The user name and the password can be set in the hardware properties of the S7-1200 in “Webserver” > “User management”.	
4.	In “File Browser” > “DataLogs” you will find the CSV files with the saved energy data.	

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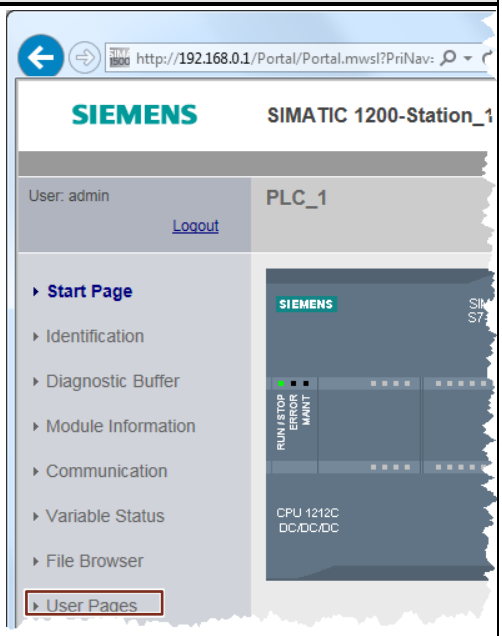
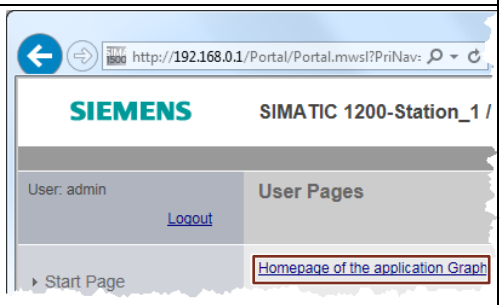
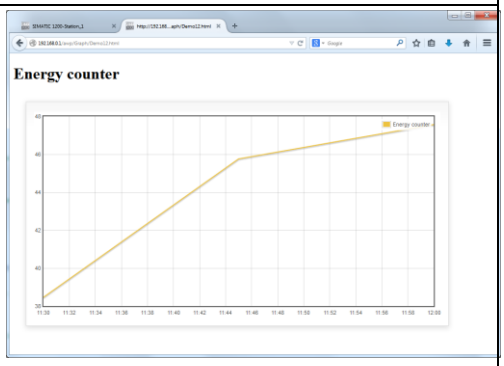
No.	Action	Remark
5.	Click on “User Pages”.	
6.	Click on the link displayed. The user-defined web page is opened. The graph shows the course of the energy counter.	
7.	The graph shows the course of the energy counter.	

Note

For further information on how to create a graph on the user pages, refer to the following entry:
https://support.industry.siemens.com/cs/ww/en/view/68011496
How to create a graph is described in “Simple examples for the webserver of SIMATIC S7-1200 / S7-1500” in example 12.

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8 References

Table 8-1

	Topic
\1\	Siemens Industry Online Support https://support.industry.siemens.com/cs/ww/en/
\2\	Download page of the entry https://support.industry.siemens.com/cs/ww/en/view/109739414
\3\	Manual of the Energy Meter https://support.industry.siemens.com/cs/ww/en/view/109483435
\5\	Entry: Creating and using user-defined web pages on S7-1200 / S7-1500 https://support.industry.siemens.com/cs/ww/en/view/68011496
\6\	Entry: How do you synchronize the time of the HMI Basic Panel with an S7-1200 PLC? https://support.industry.siemens.com/cs/ww/en/view/39182145
\7\	Support packages for the hardware catalog in the TIA Portal (HSP) https://support.industry.siemens.com/cs/ww/en/view/72341852
\8\	S7-1200 manual https://support.industry.siemens.com/cs/ww/en/view/109478121

9 History

Table 9-1

Version	Date	Modifications
V1.0	08/2016	First version

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