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

SIMATIC S7-1200

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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.
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.
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:
Hardware components

Table 2-1

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

Software components

Table 2-2

<table>
<thead>
<tr>
<th>Component</th>
<th>Qty.</th>
<th>Article number</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEP 7 BASIC V13 SP1</td>
<td>1</td>
<td>6ES7822-0AA03-0YA5</td>
<td>Alternatively, STEP 7 Professional V13 SP1 can also be used.</td>
</tr>
<tr>
<td>WinCC BASIC V13 SP1</td>
<td>1</td>
<td>6AV2100-0AA03-0AA5</td>
<td>Alternatively, WinCC Advanced V13 SP1 can also be used.</td>
</tr>
</tbody>
</table>

Example files and projects

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

Table 2-3

<table>
<thead>
<tr>
<th>Component</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>109739414_EnergyMeterS71200_CODE_v10.zip</td>
<td>This zip file contains the STEP 7 project.</td>
</tr>
<tr>
<td>109739414_EnergyMeterS71200_DOKU_v10_en.pdf</td>
<td>This document</td>
</tr>
</tbody>
</table>
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
4 Mode of Operation

4.1 General overview

Figure 4-1: Program structure
4.2 Functioning of OB1 “Main”

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 Converting and calculating energy data)

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

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>energyMeterData</td>
<td>typeSM1238DS142</td>
<td>Read energy data of the “RDREC” instruction</td>
</tr>
</tbody>
</table>

Output parameter
Table 4-2: Output parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>energyMeterDataAdvanced</td>
<td>typeEnergyMeterAdvanced</td>
<td>Converted and newly calculated energy data.</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>FB CalcAvgPower</th>
</tr>
</thead>
<tbody>
<tr>
<td>LREAL energyCounterValue</td>
</tr>
<tr>
<td>LREAL maximumEnergyCounter</td>
</tr>
<tr>
<td>ARRAY_OF_REAL avgPowerArchive</td>
</tr>
</tbody>
</table>

Input parameter
Table 4-3: Input parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>energyCounterValue</td>
<td>LREAL</td>
<td>Current value of the energy counter.</td>
</tr>
<tr>
<td>maximumEnergyCounter</td>
<td>LREAL</td>
<td>Configured maximum value of the energy counter from the hardware settings of the energy meter.</td>
</tr>
</tbody>
</table>

Output parameter
Table 4-4: Output parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>energyCounter15min</td>
<td>typeEnergyMeterAdvanced</td>
<td>Value of the energy counter at defined times (a quarter past, half past, a quarter to, or at the full hour).</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>avgPowerArchive</td>
<td>ARRAY_OF_REAL</td>
<td>Ring buffer in which the average power is saved every quarter hour.</td>
</tr>
</tbody>
</table>
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.
4.4.1 Structure of the 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”.

Figure 4-6: Ring buffer
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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>LREAL</td>
<td>Value that is to be saved in the data log.</td>
</tr>
<tr>
<td>dateAndTime</td>
<td>DTL</td>
<td>Current time stamp.</td>
</tr>
</tbody>
</table>

Input parameter

Table 4-6: Input parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>LREAL</td>
<td>Value that is to be saved in the data log.</td>
</tr>
<tr>
<td>dateAndTime</td>
<td>DTL</td>
<td>Current time stamp.</td>
</tr>
</tbody>
</table>

Input/Output parameters (InOut)

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

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

Status and error displays

Table 4-8: Status/error codes

<table>
<thead>
<tr>
<th>statusID</th>
<th>status</th>
<th>Meaning</th>
<th>Remedy/notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-</td>
<td>Error of subordinate “DataLogOpen” block</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>-</td>
<td>Error of subordinate “DataLogOpen” block</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>-</td>
<td>Error of subordinate “DataLogOpen” block</td>
<td>-</td>
</tr>
</tbody>
</table>

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.
### 5 Configuration and Settings

#### 5.1 Configuring the energy meter.

<table>
<thead>
<tr>
<th>No.</th>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Add the energy meter to your hardware configuration.</td>
</tr>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Open the hardware properties of the energy meter.</td>
</tr>
<tr>
<td><img src="image2.png" alt="Image" /></td>
<td></td>
</tr>
</tbody>
</table>
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"
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”.

---

No. 5. Click on “Process data”.

---

No. 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.

---

No. 7. Click on AI3 -> "Inputs" -> "Line conductor1".
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

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Assign the system constant with hardware ID of the signal module to the “ID” input. The system constants can be found in “PLC tags” &gt; “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”.</td>
</tr>
<tr>
<td>2.</td>
<td>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”.</td>
</tr>
<tr>
<td>3.</td>
<td>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.</td>
</tr>
<tr>
<td>4.</td>
<td>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.</td>
</tr>
</tbody>
</table>
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.
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 AI 3 > "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

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

<table>
<thead>
<tr>
<th>No.</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Download the file with the program of the user example to your programming device and unzip it.</td>
</tr>
<tr>
<td>2.</td>
<td>Open the example project. “109739414_EnergyMeterS71200_CODE_v10.ap13”</td>
</tr>
<tr>
<td>3.</td>
<td>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.</td>
</tr>
<tr>
<td>4.</td>
<td>Open the context menu by right clicking the controller and select “Change device”. Select your S7-1200 from the tree and click “OK”.</td>
</tr>
</tbody>
</table>
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.
HMI

Table 6-3

<table>
<thead>
<tr>
<th>No.</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Open the “Device Configuration” of the HMI “KTP 400 Basic PN”&lt;br&gt;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.</td>
</tr>
<tr>
<td>2.</td>
<td>Open the context menu by right-clicking on the HMI and select “Change device”. Select your HMI from the tree and click “OK”.</td>
</tr>
</tbody>
</table>
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”
### 5. Action

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)

![Image of layout and properties settings]

### 6. Action

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)

![Image of project navigation and download process]
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
In the following table the buttons are described.

Table 7-1

<table>
<thead>
<tr>
<th>Button</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="language.png" alt="Language Button" /></td>
<td>You find this button on the entry page. Using this button, you can switch the language.</td>
</tr>
<tr>
<td><img src="home.png" alt="Home Button" /></td>
<td>This button can be found in the “Home” screen. You can terminate HMI Runtime with it.</td>
</tr>
<tr>
<td><img src="play.png" alt="Play Button" /></td>
<td>You find this button in all images apart from “Home”. With it, you can go to the “Home” screen.</td>
</tr>
<tr>
<td>F1</td>
<td>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.</td>
</tr>
<tr>
<td>F2</td>
<td>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.</td>
</tr>
<tr>
<td>F3</td>
<td>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.</td>
</tr>
<tr>
<td>F4</td>
<td>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.</td>
</tr>
<tr>
<td><img src="history.png" alt="History Button" /></td>
<td>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.</td>
</tr>
</tbody>
</table>

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:

### 7.2 Overview and description of the Web interface

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

#### Table 7-2

<table>
<thead>
<tr>
<th>No.</th>
<th>Action</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Enter the IP address of your CPU in the browser on your programming device. The S7-1200 intro web page is opened.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Click on &quot;ENTER&quot;. The start page is opened.</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Log on with the user name &quot;admin&quot; and password &quot;s7&quot;. The user name and the password can be set in the hardware properties of the S7-1200 in &quot;Webserver&quot; &gt; &quot;User management&quot;.</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>In &quot;File Browser&quot; &gt; &quot;DataLogs&quot; you will find the CSV files with the saved energy data.</td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Action</td>
<td>Remark</td>
</tr>
<tr>
<td>-----</td>
<td>------------------------------------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>5.</td>
<td>Click on &quot;User Pages&quot;.</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Click on the link displayed. The user-defined web page is opened.</td>
<td>The graph shows the course of the energy counter.</td>
</tr>
<tr>
<td>7.</td>
<td>The graph shows the course of the energy counter.</td>
<td></td>
</tr>
</tbody>
</table>

**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](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.
8 References

Table 8-1

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

9 History

Table 9-1

<table>
<thead>
<tr>
<th>Version</th>
<th>Date</th>
<th>Modifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1.0</td>
<td>08/2016</td>
<td>First version</td>
</tr>
</tbody>
</table>