"MindConnectFB" Library for SIMATIC S7-1500

MindSphere

https://support.industry.siemens.com/cs/ww/en/view/109756878

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Table of contents

1 Preface

1.1 MindSphere Documentation

This document is valid for "MindConnectFB" library, version V3.0.

1.2 Scope of this document

The complete documentation for MindSphere can be found under following link:

https://support.industry.siemens.com/cs/ww/en/view/109742256

1.3 Basic knowledge requirements

A solid background in personal computer is required. In addition, general knowledge in the field of automation engineering is required to understand this documentation.

1.4 Conventions

Screenshots and graphics which are used in this document shall be seen as examples. They are not able to show all combinations of possible inputs, but have an informational character and serve for a better understanding. The configuration parameters shall be extracted out of the text or tables and depend respectively on the needs and constellation of the individual system.

Please refer to the glossary section for a list of vocabulary used in the documentation.

2 Introduction

2.1 Overview

This library documentation provides you with information on how to connect SIMATIC S7-1500 to MindSphere by using the "MindConnectFB" library.

This manual does not cover the project creation and hardware configuration of the SIMATIC S7-1500 in STEP 7 (TIA Portal). Refer to the S7-1500 PLC and STEP 7 (TIA Portal) documentation (see \7\, \8\ and \9\). This manual explains basic functions and call procedure of the blocks. Separate documentation with an implementation as applications example will be provided.

2.2 Components used

This library has been created with the following hardware and software components:

- S7-1500 PLC with firmware V2.0 or above
  - It is strongly recommended to use a PLC with 2 integrated Ethernet interfaces (i.e. 2 separated IP addresses). S7-1500 PLCs must support secure open user communication and SHA2.
- STEP 7 Professional V14 or above
- Internet connection and browser for online user interface. Browser supporting HTML5.
- Standard HTTPs capabilities for "MindConnectFB" library and outbound HTTPs connections on port 443.
- Link to the online Launchpad with user and password data as it was submitted by Siemens (Tenant Access).
- Device (PC, Tablet) with minimum screen resolution of 1024x768.

This list summarizes the Siemens SIMATIC PLC list, on which the "MCFB_MondConnectFB" library was tested.

Table 2-1

Component	Article number	Note
CPU 1511-1 PN	6ES7511-1AK01-0AB0 6ES7511-1AK02-0AB0	Firmware V2.0 or above
CPU 1511F-1 PN	6ES7511-1FK01-0AB0 6ES7511-1FK02-0AB0	Firmware V2.0 or above
CPU 1511T-1 PN	6ES7511-1TK01-0AB0	Firmware V2.0 or above
CPU 1511TF-1 PN	6ES7511-1UK01-0AB0	Firmware V2.0 or above
CPU 1511C-1 PN	6ES7511-1CK01-0AB0	Firmware V2.0 or above
CPU 1512C-1 PN	6ES7512-1CK01-0AB0	Firmware V2.0 or above
CPU 1513-1 PN	6ES7513-1AL01-0AB0 6ES7513-1AL02-0AB0	Firmware V2.0 or above
CPU 1513F-1 PN	6ES7513-1FL01-0AB0 6ES7513-1FL02-0AB0	Firmware V2.0 or above
CPU 1515-2 PN	6ES7515-2AM01-0AB0	Firmware V2.0 or above
CPU 1515F-2 PN	6ES7515-2FM01-0AB0	Firmware V2.0 or above
CPU 1515T-2 PN	6ES7515-2TM01-0AB0	Firmware V2.0 or above
CPU 1515TF-2 PN	6ES7515-2UM01-0AB0	Firmware V2.0 or above
CPU 1516-3 PN/DP	6ES7516-3AN01-0AB0	Firmware V2.0 or above
CPU 1516F-3 PN/DP	6ES7516-3FN01-0AB0	Firmware V2.0 or above
CPU 1516T-3 PN/DP	6ES7516-3TN00-0AB0	Firmware V2.0 or above
CPU 1516TF PN/DP	6ES7516-3UN00-0AB0	Firmware V2.0 or above
CPU 1517-3 PN/DP	6ES7517-3AP00-0AB0	Firmware V2.0 or above
CPU 1517F-3 PN/DP	6ES7517-3FP00-0AB0	Firmware V2.0 or above
CPU 1517T-3 PN/DP	6ES7517-3TP00-0AB0	Firmware V2.0 or above
CPU 1517TF-3 PN/DP	6ES7517-3UP00-0AB0	Firmware V2.0 or above
CPU 1518-4 PN/DP	6ES7518-4AP00-0AB0	Firmware V2.0 or above

Component	Article number	Note
CPU 1518F-4 PN/DP	6ES7518-4FP00-0AB0	Firmware V2.0 or above
CPU 1518-4 PN/DP MFP	6ES7518-4AX00-1AC0	Firmware V2.0 or above
CPU 1518F-4 PN/DP MFP	6ES7518-4FX00-1AC0	Firmware V2.0 or above
CPU 1518-4 PN/DP ODK	6ES7518-4AP00-3AB0	Firmware V2.0 or above
CPU 1512SP-1 PN	6ES7512-1DK01-0AB0	Firmware V2.0 or above
CPU 1510SP-1 PN	6ES7510-1DJ01-0AB0	Firmware V2.0 or above

NOTE The library blocks of "MindConnectFB" library don`t work on the SIMATIC CPU 1507S.

This application example consists of the following components:

Table 2-2

Component	File name	Note
"MindConnectFB" library for STEP 7 V14	109756878_MindConnectFBV14_LIB_v30.zip	library blocks for STEP 7 V14
"MindConnectFB" library for STEP 7 V15	109756878_MindConnectFBV15_LIB_v30.zip	library blocks for STEP 7 V15

3 Engineering

3.1 Project integration

This section provides you with information on how to add the "MindConnectFB" library to your project. This library contains the function blocks and functions that you have to add to your S7-1500 project in order to enable the connection and data transfer between the S7-1500 PLC and MindSphere.

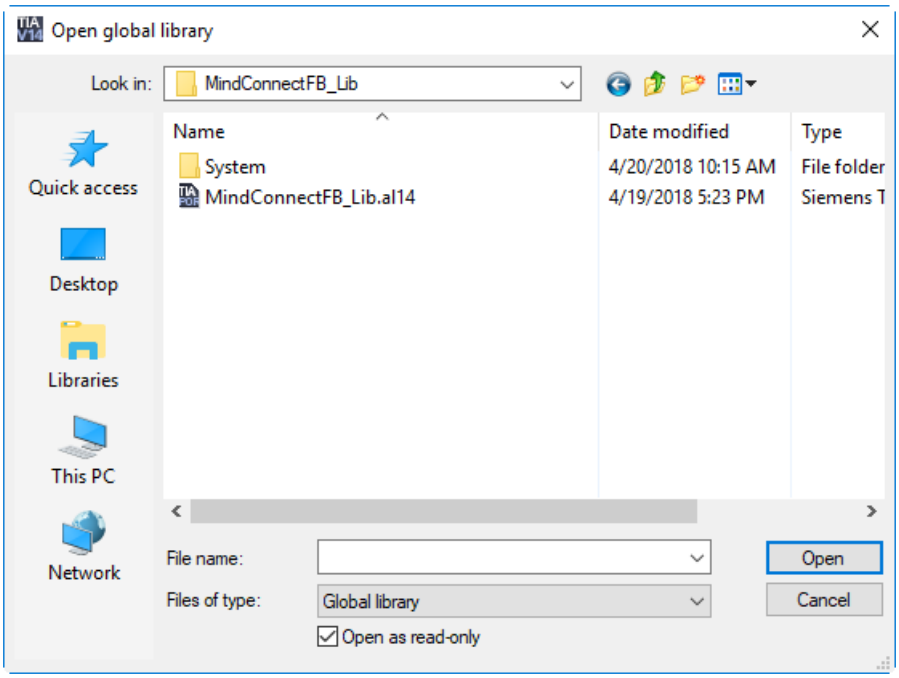
3.1.1 Requirements

- "MindConnectFB" library is saved and unpacked in a separate directory on your hard disk.
- S7-1500 PLC is prepared, running and connected to your PC. Refer to SIMATIC documentation collection (see \6\) and online help for STEP 7 (TIA Portal).
- A STEP 7 project with a S7-1500 PLC is created. Refer to the SIMTIC S7-1500 manual (see \9\) or online help for STEP 7 (TIA Portal).

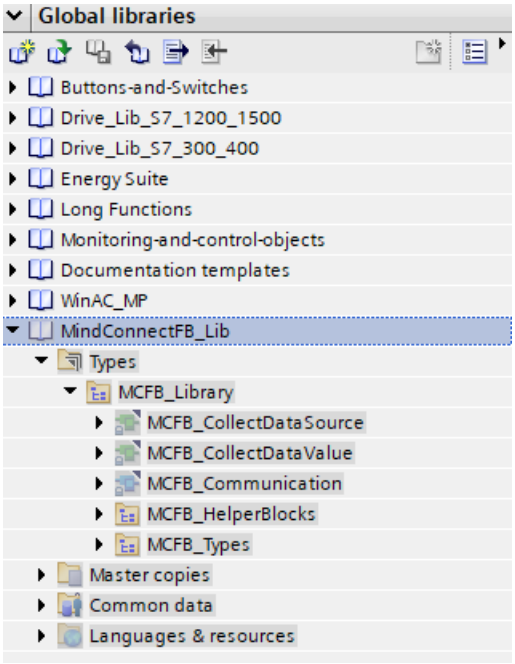
3.1.2 Procedure

Open "MindConnectFB" library

1. Open your STEP 7 project with a S7-1500 PLC, for example "MindConnect_FB_Example".
2. Select the menu "Options > Global Libraries > Open Library". The "Open global library" dialog is opened.
3. Navigate to the directory with your library and open the already unpacked library. Click the "Open" button".



4. The blocks of the "MindConnectFB" library can be seen in the task bar "Libraries" under "Global libraries".



5. Move the following library blocks to the "Program blocks" folder of your project in the "Project tree". The library appears in the "Program blocks" folder and consists of following components:
   - "MCFB_CollectDataSource" function (FC)
   - "MCFB_CollectDataValue" function (FC)
   - "MCFB_Communication" function block (FB)
   - "HelperBlocks" folder used by the MindConnect function blocks to establish and maintain connection
6. Move the "Types" library folder to the "PLC data types" folder of your project in the "Project tree". The "Types" library folder appears in the "PLC data type" folder and consists of following PLC data types (UDTs):
   - MCFB_typeDataSource
   - MCB_typeDataSourceArray
   - MCFB_typeConfiguration
7. The "MindConnectFB" library is included in your STEP 7 project. You may now use it.

3.2 "MindConnectFB" library in detail

The section gives you a detailed description of the "MindConnectFB" library functions which include different parameters and their purpose.

The "MindConnectFB" library consists of a set of functions and function blocks enabling the SIMATIC S7-1500 to configure and send data encrypted to MindSphere.

3.2.1 List of functions and functions blocks

The following table shows the functions and functions blocks of "MindConnectFB" library.

Table 3-1

Function (FC) / Function Block (FB)	Description
FB "MCFB_Communication"	FB "MCFB_Communication" is responsible for communication between SIMATIC S7-1500 and Mindsphere.
FC "MCFB_CollectDataSource"	FC "MCFB_CollectDataSource" is used for defining the data source (data points) of MindSphere which correspond to the variables in STEP 7 (TIA Portal).
FC "MCFB_CollectDataValue"	FC "MCFB_CollectDataValue" is used to collect value of each variable.

3.2.2 FB "MCFB_Communication"

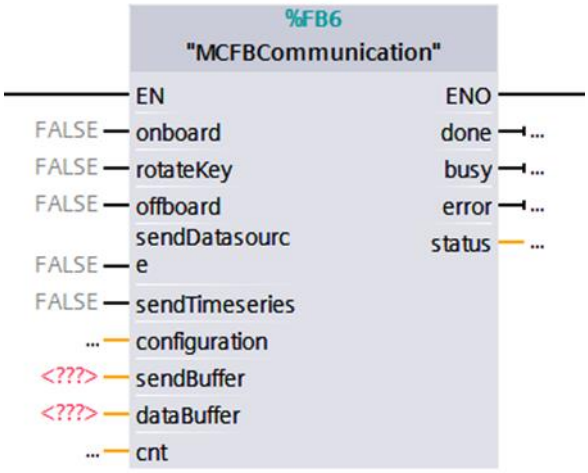
FB "MCFB_Communication" is responsible for communication between SIMATIC S7-1500 and Mindsphere. It can be used for the following functions:

- Onboarding
- Key Rotating (Key renewal)
- Off-boarding
- Data transfer (Data Source Model) to MindSphere
- Data transfer (Time Series) to MindSphere

NOTE Only one job (one input) is allowed at a time. Do not trigger multiple inputs at the same time or when another job is still in progress (busy output).

Overview

Figure 3-1



Input Parameters

The following table shows the input parameters of FB "MCFB_Communication".

Table 3-2

Input Parameter	Data Type	Description
onboard	Bool	A positive edge on this input starts the onboarding process for communication between SIMATIC S7-1500 and MindSphere. • Establishment of secure connection with MindSphere (SSL/TLS) • SIMATIC S7-1500 sends onboarding request with IAT and Registration URI. Reset this input to false when onboarding is completed.
rotateKey	Bool	A positive edge on this input renews an authentication key that is calculated during onboarding. Reset this input to false when "rotate Key" job is completed. **Note** Currently authentication key expires - about every 60 minutes. Then the "rotate Key" job has to be executed again.
offboard	Bool	A positive edge on this input starts the off-boarding process to remove the local authentication key from S7-1500 PLC that is calculated during onboarding. Reset this input to false when off-boarding is completed.
sendDatasource	Bool	Use this input to upload the data source model defined in the local data block of the S7-1500 PLC to the MindSphere backend. A positive edge on this input triggers the job to send data source model. Reset this input to false when the job is

Input Parameter	Data Type	Description
		completed. **Note** Before sending data source model, it has to be generated by the FC "MCFB_CollectDataSource".
sendTimeseries	Bool	A positive edge on this input starts the upload process of the data values collected. Reset this input to false when the job is competed. **Note** Before sending time series, the data has to be collected using the FC "MCFB_CollectDataValue".
configuration	MCFB_typeConfiguration	This input is used to pass the crucial information for the onboarding process. The "MCFB_typeConfiguration" configuration structure is provided as PLC data type in the "MindConnectFB" library. It`s explained below.
sendBuffer	Any	This is the local pointer to the send buffer array. Upon triggering the "sendTimeseries" job, data from the data buffer is copied to the send buffer to ensure buffer consistency during upload. **Note** The data buffer has to be the same size as the send buffer.
dataBuffer	Any	This is the local pointer to the data buffer array. The data buffer contains data collected by the following FCs: • MCFB_CollectDataSource • MCFB_CollectDataValue **Note** The data buffer has to be the same size as the send buffer.
cnt	UInt	This is the local pointer to store the amount (length) of the data collected by the following FCs: • MCFB_CollectDataSource • MCFB_CollectDataValue **Note** It shouldn’t be modified anywhere else by the user program. This should point to the same variable as the "cnt" parameter used by the FCs.

PLC data type "MCFB_typeConfiguration"

The PLC data type "MCFB_typeConfiguration" is used to ensure correct data input by the user.

Table 3-3

Parameter		Data Type	Description
connection		Struct	Connection configuration
	connectionId	CONN_ANY	The reference for the establishment of connection with MindSphere. It must be defined as a word type value between 1 and 4095. This TCP connection ID must only be used for this connection.
	url	String	The address of MindSphere in the form of "https://hostname:port/path" and port number is optional. When it is not defined, default port number will be 443 for https type addresses. **Example** https://southgate.eu1.mindsphere.io/
	certificateRef	Byte	ID of certificate for MindSphere to be used to verify MindSphere during secure connection establishment. A certificate ID can be obtained from global security setting manager in STEP 7 (TIA Portal) after importing MindSphere service certificates. It must point to "QuoVadis Root CA 2 G3".
Asset		Struct	Asset configuration
	IAT	WString[1024]	Initial Authentication Token The initial authentication token is obtained from MindSphere UI Website and used for onboarding, after establishing secure connection with MindSphere backend.
	Tenant	String	Tenant name Use the prefix of Mindsphere URL that is shown in web browser.
	userAgent	String	User Agent Information This parameter is optional and currently not used. It can be set for identification of the machine or asset.
charset		String	Charset Information Set this parameter when a special character is used in data model. This parameter can be set to empty for regular users. This is a placeholder for future customers from different geo areas.

Output Parameters

The following table shows the output parameters of FB "MCFB_Communication".

Table 3-4

Output Parameter	Data Type	Description
done	Bool	This parameter will be set, when a job is successfully completed. Values: • 0: job not yet started or still in progress. • 1: job executed without error. This state remains until another request.
busy	Bool	One of the following jobs is in process: • onboarding • rotate key • off-boarding • send data source • send time series Values: • 0: job not yet started or already completed. • 1: job not yet completed. Another job cannot be started as long as a job is in process.
error	Bool	One of the jobs failed to execute: • onboarding • rotate key • off-boarding • send data source • send time series Values: • 0: No error • 1: Error occurred during job execution See the detailed description below.
status	Word	This output will display an error code, when a job failed to execute. See the detailed description in chapter 3.3.1.

3.2.3 FC "MCFB_CollectDataSource"

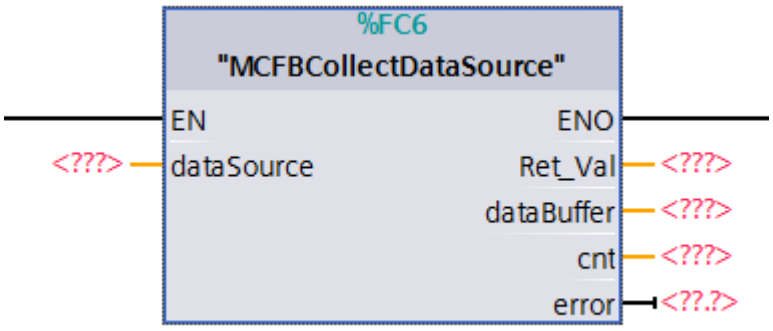
FC "MCFB_CollectDataSource" is used for defining the data source (data points) of MindSphere which correspond to the variables in STEP 7 (TIA Portal).

When the FC "MCFB_CollectDataSource" is executed, the data source model set by the user is collected from the “dataSource” input. The data source model is prepared and written to the data buffer. This function has to be executed before using the send data source job of the FB "MCFB_Communication".

When the data source model at the input exceeds about 6000 bytes, this function returns an error. Than the data source model should be reduced. The data buffer has to be at least 6000 bytes in size, to store the maximum data model.

Overview

Figure 3-2



Input Parameters

The following table shows the input parameter of FC "MCFB_CollectDataSource.

Table 3-5

Input Parameter	Data Type	Description
dataSource	Array[*] of "MCFB_typeDataSource"	This input shall be set to an array of the "MCFB_typeDataSource" PLC data type. The parameter is used for defining the data sources, which then are created in MindSphere backend.

PLC data type "MCFB_typeDataSource"

The "MCFB_typeDataSource" PLC data type is a preset valid structure for the data source model. The user can set the values, but has to keep the provided structure. The data will be used for the data source model generated and send to MindSphere.

The user shall create an array of the "MCFB_typeDataSource" PLC data type to specify his data model. Up to 200 points can be defined.

Be aware, that up to a number of 200 Points can be defined, however they shall not exceed 6000 bytes in total.

Table 3-6

Parameter	Data Type	Description
dataPointId	Byte	An individual id for each data point has to be set, e.g. 16#0, 16#1 and so on.
dataSourceName	String	The name that describes the device, where the value originates from, e.g. Motor, Valve, Temperature, Sensor and so on.
dataPointName	String	The name that describes the single data point, which belongs to the data source, e.g. Voltage, Current, Position of the Valve.
dataPointType	String	This describes the data type of the data value for MindSphere. The following input values are allowed and valid: • BOOLEAN • INT • LONG • DOUBLE For the correct assignment of S7-1500 data types to MindSphere data types, see chapter 4.1, e.g. data type "DOUBLE".
dataPointUnit	String	This describes the unit of the data point for MindSphere. You can specify any unit, but no special characters, e.g. "%", "V", "C" and "'m/s".

Output Parameters

The following table shows the output parameters of FC "MCFB_CollectDataSource".

Table 3-7

Output Parameter	Data Type	Description
Ret_Val	Word	Output for error code status See the detailed description on error code delivered by the "Ret_Val" parameter in chapter 3.3.2.
dataBuffer	Any	Pointer to a memory area, where the collected data will be saved. The data buffer shall be an array of byte. The maximum size which can be used for the data buffer is 6000 bytes. If the data source model exceeds 6000 bytes, an error will be generated upon execution.

Output Parameter	Data Type	Description
cnt	UInt	Pointer to the counter for the size of the data buffer. This parameter shows the number of bytes written to the data buffer.
error	Bool	Error output Values: • 0: no error • 1: Error occurred during connection establishment, data transmission See the detailed description on error code delivered by the "Ret_Val" parameter in chapter 3.3.2.

3.2.4 FC "MCFB_CollectDataValue"

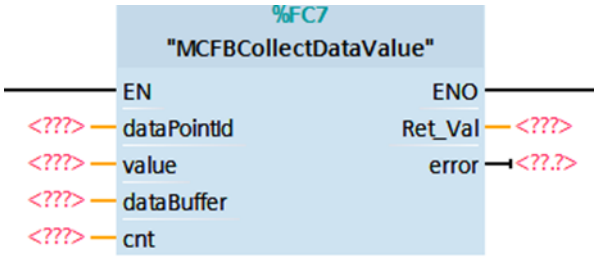
The FC "MCFB_CollectDataValue" is used to collect value of each variable. The FC "MCFB_CollectDataValue" puts the collected data to the buffer defined by the data buffer area set to the "dataBuffer" input parameter.

When the FC "MCFB_CollectDataValue" is executed, it writes the value including a time stamp to the data buffer.

The maximum size for the data buffer area, where data is stored, can be about 8 Mbyte. The maximum data block size is 16 MByte.

Overview

Figure 3-3



Input Parameters

The following table shows the input parameters of FB "MCFB_CollectDataValue".

Table 3-8

Input Parameter	Data Type	Description
dataPointId	Byte	For referencing data point index which corresponds to the data model created with FC "MCFB_CollectDataSource". The data type of the value to be collected should be the same as the data type referenced in the data model.
value	Variant	A pointer to the variable, defining a value of the variable, which shall be sampled whenever FC "MCFB_CollectDataValue" is executed.
dataBuffer	Array[*] of Byte	Buffer pointer Is used for defining a memory area for data to be collected. The data collection buffer will be copied to the send buffer when executing the "send time series" job at FC "MCFB_Communication". Size of data buffer corresponds to "cnt" parameter to check if limit is exceeded.
cnt	UInt	Count of bytes which are written to the data buffer area.

Output parameters

The following table shows the output parameters of FB "MCFB_CollectDataValue".

Table 3-9

Output Parameter	Data Type	Description
Ret_Val	Word	Output for error code status See the detailed description on error code delivered by the "Ret_Val" parameter in chapter
error	Bool	Error output Values: • 0: no error • 1: Error occurred during connection establishment, data transmission See the detailed description on error code delivered by the "Ret_Val" parameter in chapter 3.3.3.

3.3 Error handling

3.3.1 Error Codes for FB "MCFB_Communication"

The following table shows an overview of errors and possible causes with solutions for FB "MCFB_Communication".

Table 3-10

Status	Description	Possible Cause	Possible Remedy
16#0000	No error		
16#8000	Server doesn`t respond	Network connection problems: • Company's router might have some network problems or unplugged cables. • Invalid internet configuration, e.g. IP address or DNS. • Server is not available due to some internal errors.	• Check physical connection: - Company`s router - Ethernet cables etc. • Check internet connection: - IP address - DNS configuration etc.
16#8001	Communication error	Connection failed with valid certificate	Check internet connection: • IP address • DNS configuration etc.
16#8012	Server identity isn`t proved	• Internal error is occurred • Key is expired	• Make sure that the instance data block is not modified by software • Renew authentication key with rotate Key job.
16#8015	Data point ID is invalid	Data source model or time series are sent without data points configured	• First call FC "MCFB_CollectDataSource" to collect the data model. • Make sure that the data is correctly written to the data buffer area.

Status	Description	Possible Cause	Possible Remedy
16#8004	S7-1500 PLC is already onboarded	• Status of FB "MCFB_ Communication" in Asset configuration is "onboarded" • Onboarding data (IAT, registration URL) are still inserted into FB "MCFB_ Communication" • Input parameter "onboard" is true	• Check status of an asset in MindSphere to be onboarded • Check configuration of communication , whether it contains IAT and registration URL • Check the "onboard" input parameter. If the "onboard" input parameter is true reset it to "false".
		• Asset is onboarded but still has "off-boarded" status in MindSphere • Asset has "onboarded" status in Mindsphere	• Make sure that the instance data block is not modified by software • If S7-1500 PLC was already onboarded and the project is downloaded to S7-1500 PLC and the instance data block of FB "MCFB_Communication" was changed, you have to do the following things: - Offboard Asset in MindSphere UI - Create a new IAT in MindSphere UI - Onboard the S7-1500 PLC again with the new IAT
16#8002	TSEND or TRCV provides an error	• Data upload failed	• Check connection between FB "MCFB_Communication" and your data source • Check data source configuration - FC "MCFB_ CollectDataSource" - FC "MCFB_ CollectDataValue" • Check address of each data point
		• Connection ID parameter was changed after onboarding • Internal error	• Make sure that the connection ID parameter is not changed after onboarding.

Status	Description	Possible Cause	Possible Remedy
16#8003	Request error	• More than one request at once is executed - Onboarding - Off-boarding - Send data source - Send time series - Rotate key	• Check in the watch table, what requests are active at the same time: - Onboarding - Off-boarding - Send data source - Send time series - Rotate key • Only one job request is allowed at the same time. Do not set multiple inputs to true at the same time.
16#8005	S7-1500 PLC is already off-boarded	IAT and registration URL are not applied into the communication DB yet.	• Check whether the FB "MCFB_Communication" has IAT and registration URL. • Perform the onboarding configurations.
16#8007	Connection ID is invalid	Connection ID is invalid	Change the "connectionId" parameter. To do this go to "configuration > connection > connectionId" parameter of FB "MCFB_Communication".
16#8011	IAT is invalid	IAT is invalid	Check the IAT string.
16#8009	Certificate reference ID is invalid	Certificate reference ID is invalid	Check certificate ID in STEP 7 (TIA Portal) under certificate manager.
16#8008	URL is invalid	An addressed URL type is invalid or unsupported.	Check the type of URL which you have entered. Following types of URLs are supported: • https://host/path • https://host:port/path • host/path • host:port/path
16#8006	S7-1500 PLC isn`t onboarded	IAT and registration URL are not applied into the communication DB yet.	• Check whether the FB "MCFB_Communication" has IAT and registration URL. • Perform the steps to onboard the S7-1500 PLC.
16#8111	Data source model is too large	Buffer size limitation is reached and no data can be sent.	• The maximum data source model is 200 data points or about 6000 bytes. • Try to use less data points or shrink data size by using shorter strings.
16#80EE	Internal error	Instance DB is being modified	Make sure that the instance data block is not modified.

3.3.2 Error codes for FC "MCFB_CollectDataSource"

The following table shows an overview of errors and possible causes with solutions for FC "MCFB_CollectDataSource".

Table 3-11

Ret_Val	Description	Possible Cause	Possible Remedy
16#8000	No error		
16#8101	Buffer is full	Collected data reached the allowed limits of the buffer memory area.	Increase buffer memory area up to 6000 bytes or use a smaller data source model.
16#8102	Buffer limit is exceeded	The "cnt" parameter is negative or more than buffer length.	Don`t modify the "cnt" parameter.
16#8104	Data source name is invalid	The string length of aspect name is zero.	Specify an aspect name.
16#8105	Data point type is invalid	A variable with unsupported data type is connected to FC "MCFB_ CollectDataValue"	Check the data types supported by S7-1500 PLC and MindSphere, see chapter 4.1.
16#8106	Data point name is invalid	Length and characters of a variable name are invalid.	Check length and characters of variable name. The string length of variable name must be at least 1. The variable name must start with "a to z" or "A to Z". It`s allowed to include numbers and spaces characters, e.g. "(", ")", "_". Quotation marks are not allowed.
16#8107	Data point unit is invalid	The string length of unit is zero.	Specify a unit for a value.
16#8111	Data source model is too large	Limitation for the data source model is reached and no data can be sent.	• Create a data source model that is smaller than 6000 bytes. • Increase the buffer size to 6000 bytes.

3.3.3 Error Codes for FC "MCFB_CollectDataValue"

The following table shows an overview of errors and possible causes with solutions for FC "MCFB_CollectDataValue".

Table 3-12

Ret_Val	Description	Possible Cause	Possible Remedy
16#8000	No error		
16#8101	Buffer is full	Collected data reached the allowed limits of the buffer memory area.	• Increase buffer memory area of data buffer data block • Send the data with the "sendTimeseries" input of FB "MCFB_Communication", before collecting more data
16#8102	Buffer limit is exceeded	The "cnt" parameter is negative or more than buffer length.	Do not modify the "cnt" parameter.
16#8109	Value type is invalid	The value string length is zero.	• Specify a valid type of a variable. • Refer to allowed S7-1500 data types (see chapter 4.1)

3.4 Mandatory blocks

The following mandatory blocks are not included in the library. The blocks have to be created by the user.

3.4.1 Data buffer DB "MCFB_DemoBuffer"

A buffer with specified size for collected and uploaded data needs to be defined. There are two ways to define a buffer:

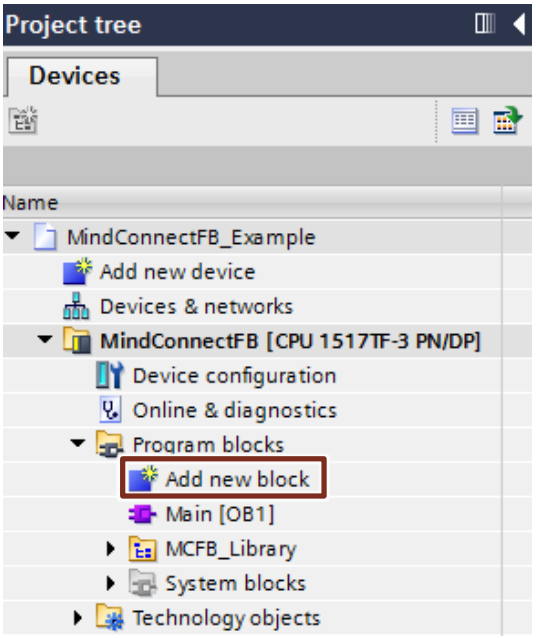
- As a tag in the PLC tags
- As a separate global data block

In this document, an example for a buffer using a global data block is provided.

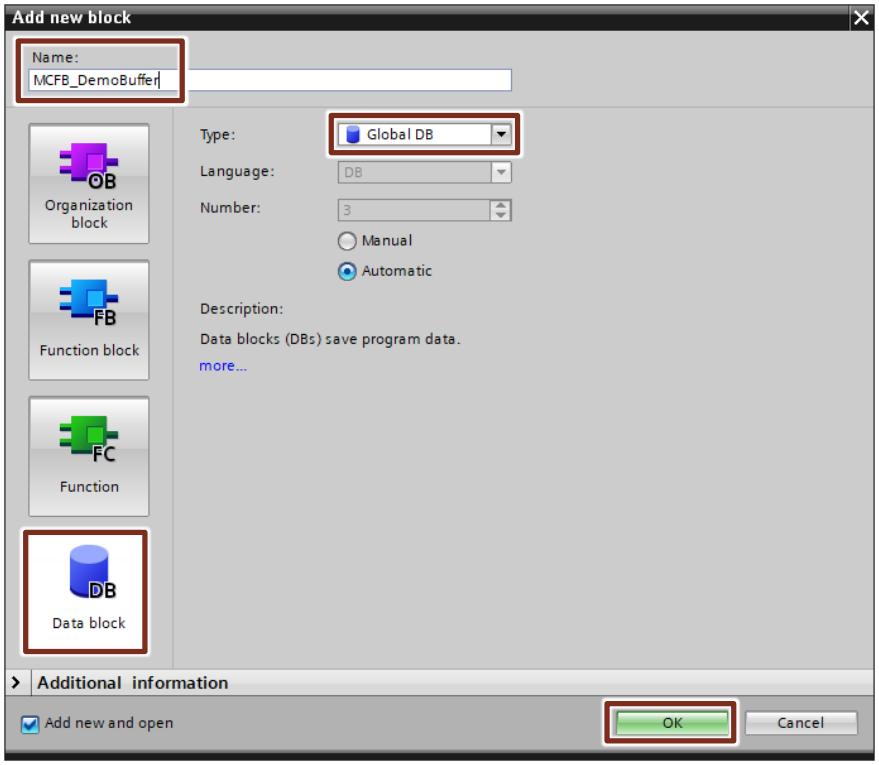
Creating a global data block (DB) for a data buffer

To create a global data block for a buffer, proceed as follows:

1. In the project tree of your project go to "Program blocks" folder of the S7-1500 PLC

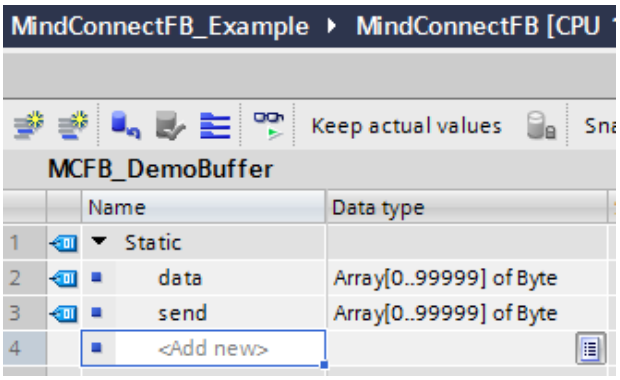


2. Double-click "Add new block". The "Add new block" dialog opens.



3. Select the "Data block" button.
4. Define a name of the data block e.g. "MCFB_DemoBuffer".
5. Select "Global DB" type and confirm creation of the buffer with "OK":

6. Open the data block view and define two variables which shall not contain an initial value, e. g.
   - data as "array of byte" or "array of char"
   - send as "array of byte" or "array of char"



Result

The "data" array is the area where data is stored from FC "MCFB_CollectDataSource" and FC "MCFB_CollectDataValue". By the "cnt" parameter of the corresponding function block is defined how much data is stored in this area.

The same data array is used as the input for FB "MCFB_Communication" as reference. When the "sendTimeseries" input or "sendDatasource" input is used, the data is copied from the data array to the send array, to ensure data consistency.

The size of the data array in byte defines how many data can be sampled, before uploading to Mindsphere. It depends on available data storage on PLC.

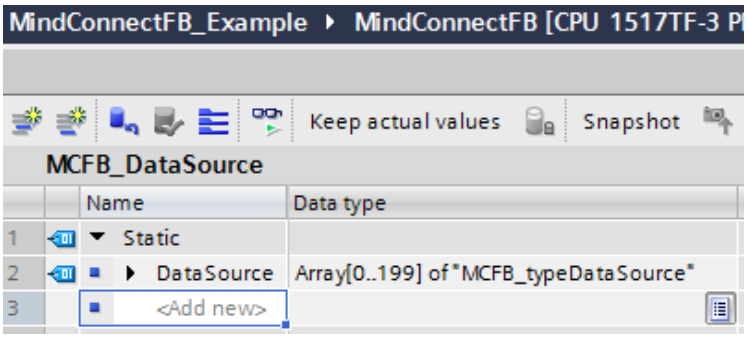
3.4.2 Data Source DB "MCFB_DataSource".

A global data block has to be created. This data block will contain all the necessary information about the kind of data source the user wants to send to the MindSphere.

Configuring data sources

To add a block, proceed as follows:

1. Create a new data block, and specify a name, e.g. "MCFB_DataSource"
2. Specify a static variable as an array of the "MCFB_typeDataSource" PLC data type.
3. The array boundaries are allowed from 0 to 199 (total of 200 data points).



Result

The created "DataSource" array can be used by the user to define data points for the data model, which is then created in the MindSphere.

For valid entries refer to chapter 3.2.3.

The "DataSource" array shall be assigned to the “dataSource” input of the FC "MCFB_CollectDataSource". For more information refer to chapter 3.2.3.

NOTE You can define several data point names for each data source name. When creating your data source model, make sure that you store data points from the same data sources one after the other in the data block. This way they are also clustered in the MindSphere under a common data source.

The following example shows several successively defined data points with the same data source name and a data point defined after another data source name ("Motor1" to "Frequency"). This is stored in the MindSphere under a separate data source.

Table 3-13

Declaration in data block		Result in Mindsphere	
Data source name	**Data point name**	**Data source**	
Motor1	Temperature	Motor1	Temperature
Motor1	Voltage		Voltage
Motor1	Current		Current
Valve1	ActualPosition	Valve1	ActualPosition
Valve1	SetPosition		SetPosition
Motor1	Frequency	Motor1	Frequency

4 Additional information

4.1 Overview of S7-1500 data types mapping to MindSphere data types

This table shows S7-1500 data types which can be used for mapping to MindSphere data types.

Table 4-1

S7-1500 data type	MindSphere data type
BOOL	BOOLEAN
BYTE	INT
INT	INT
SINT	INT
UINT	INT
DINT	INT
UDINT	INT
LINT	LONG
ULINT	LONG
WORD	INT
DWORD	INT
LWORD	LONG
REAL	DOUBLE
LREAL	DOUBLE

4.2 Preconfiguration for the "MindConnectFB" library

This chapter explains how the user can utilize the provided library, to connect to the Mindsphere

4.2.1 Configuring network settings of S7-1500 PLC

This section describes the network configuration of S7-1500 PLC in the STEP 7 (TIA Portal). Although this description does not contain the whole network configuration, it provides you with MindSphere specific information.

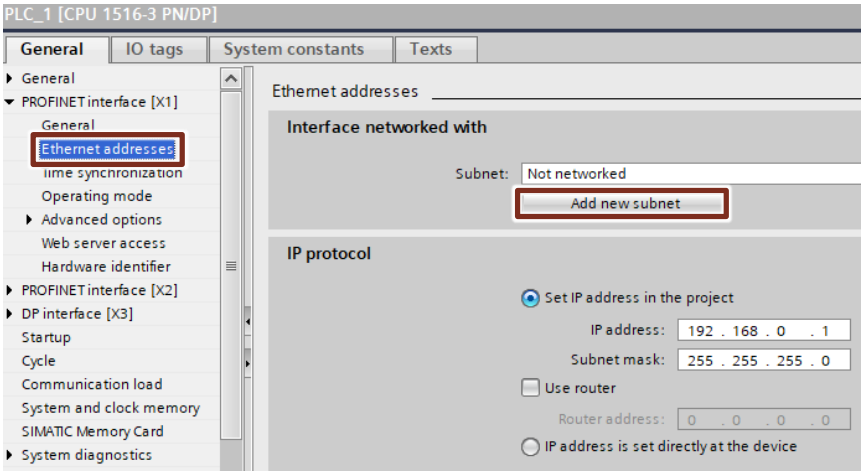
For more information about network configuration, refer to the SIMATIC S7-1500 PLC documentation (see \9\) or TIA Portal online help.

Configuring the network

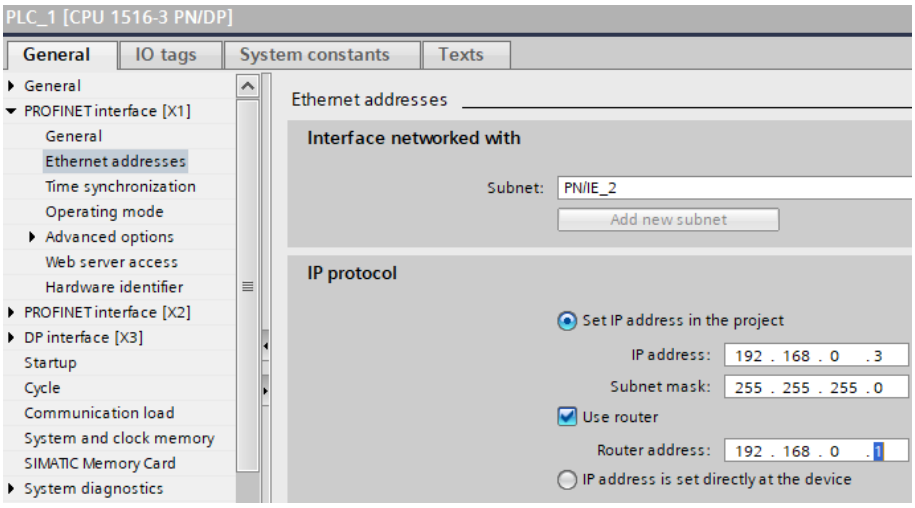
To configure the network settings of S7-1500, perform the following steps:

1. In the project tree double-click "Devices & networks".
2. Select the "Device view" of S7-1500 PLC.
3. The properties of S7-1500 PLC are shown in the inspector window.
4. Click "General > PROFINET interface [X1] > Ethernet addresses".

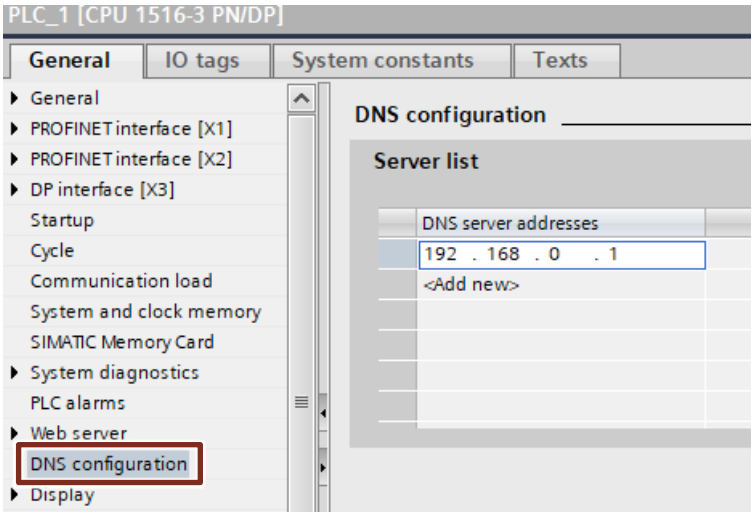
5. Select an existing subnet or click the "Add new subnet" button to create a new subnet.



6. Configure IP address, subnet mask and router IP address.



7. Click "General > DNS configuration". In the "Server list", enter one or more DNS server addresses.

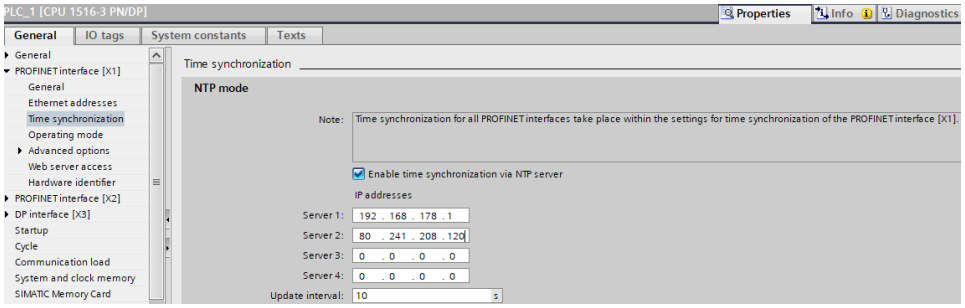


4.2.2 Configuring Time on PLC

The user has to set time on PLC correctly to work with the "MindConnectFB" library. Therefore the "Enable time synchronization via NTP server" function should be set. Other possibility is to set PLC Time with online connection.

The user can enable time synchronization via NTP server in the properties of S7-1500 PLC. Go to "General > PROFINET interface [X1] > Time synchronization". In this case an own DNS server would be referenced, for example if a router provides DNS service. You can also use public DNS servers.

Figure 4-1



4.2.3 Certificates for MindSphere

Configuring Certificates

The certificate files are not project specific and issued by Siemens IT. MindSphere certificates can be downloaded from MindSphere Web platform.

For further information on downloading certificates, refer to MindSphere documentation (see \10\).

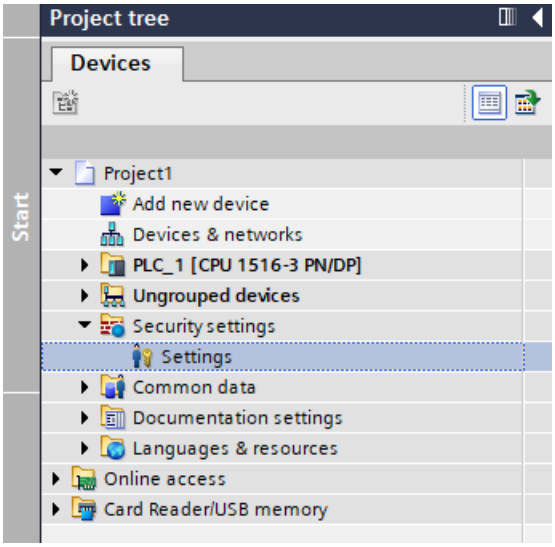
For reasons of security, you also have to protect your project from unauthorized access by setting a user login and password.

Three MindSphere SSL certificates have to be saved on your PC to continue:

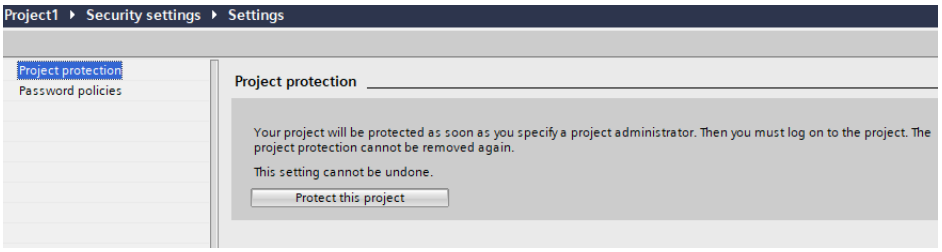
- QuoVadis Root CA 2 G3.cer
- QuoVadis Enterprise Trust CA 2 G3.cer
- Siemens Issuing CA Internet Server 2017.cer

Import Certificates in STEP 7 V15

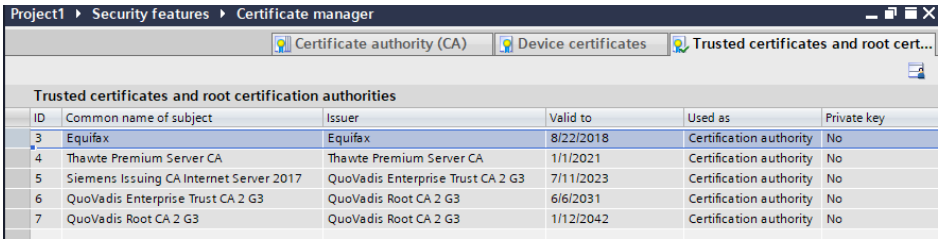
1. Navigate to "Security settings > Settings" in the project tree.



2. Click "Protect this project" or login.



3. After logging in, navigate to "Certificate manager".
4. Switch to "Trusted certificates and root certification authorities".
5. Import the following certificates:
   - QuoVadis Root CA 2 G3.cer
   - QuoVadis Enterprise Trust CA 2 G3.cer
   - Siemens Issuing CA Internet Server 2017.cer

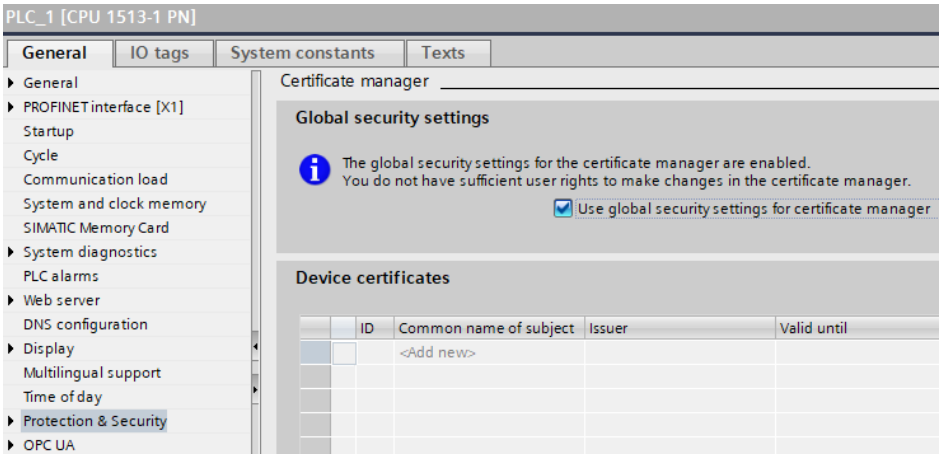


ID	Common name of subject	Issuer	Valid to	Used as	Private key
3	Equifax	Equifax	8/22/2018	Certification authority	No
4	Thawte Premium Server CA	Thawte Premium Server CA	1/1/2021	Certification authority	No
5	Siemens Issuing CA Internet Server 2017	QuoVadis Enterprise Trust CA 2 G3	7/11/2023	Certification authority	No
6	QuoVadis Enterprise Trust CA 2 G3	QuoVadis Root CA 2 G3	6/6/2031	Certification authority	No
7	QuoVadis Root CA 2 G3	QuoVadis Root CA 2 G3	1/12/2042	Certification authority	No

Import Certificates in STEP 7 V14

In order to enable global security settings, proceed as follows:

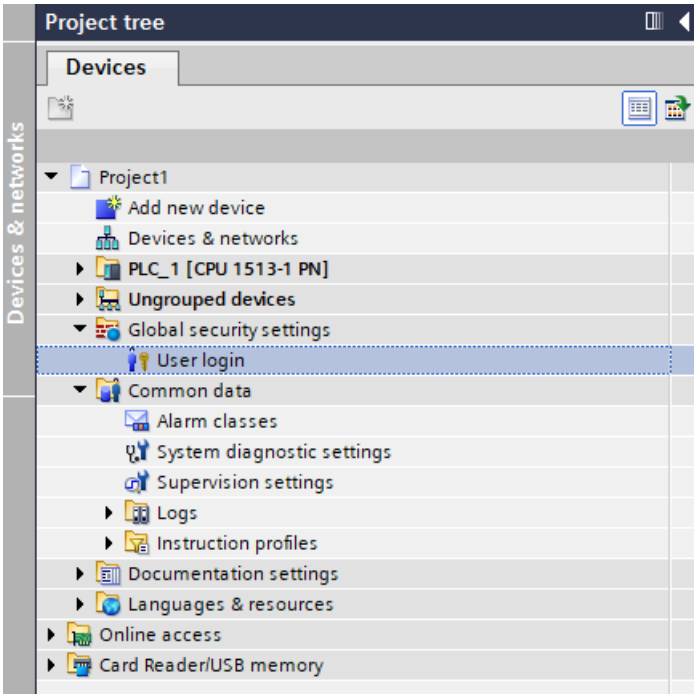
1. In the project tree double-click "Devices & networks".
2. Select the "Device view" of S7-1500 PLC.
3. The properties of S7-1500 PLC are shown in the inspector window.
4. Click "General > Protection & Security > Certificate manager".
5. Select the "Use global security settings for certificate manager" check button.



6. The "Global security settings" entry appears in the project tree.

To set user login and password, proceed as follows:

1. Double-click "Global security settings > User login" in the project tree.

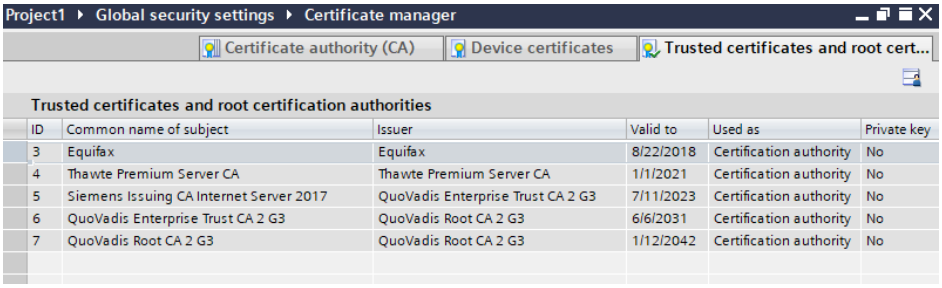


2. In the "User login" area, specify user name and password.

For more information, refer to the SIMATIC S7-1500 documentation (see \9\) and STEP 7 documentation (see \7\).

In order to install certificates, proceed as follows:

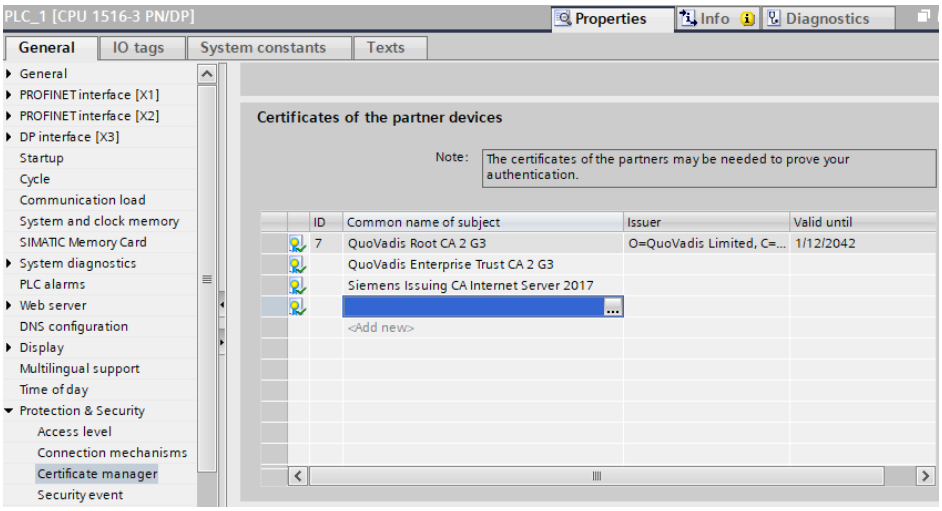
1. After logging in, navigate to "Global security settings > Certificate manager" in the project tree.
2. Switch to "Trusted certificates and root certification authorities".
3. Import the following certificates:
   - QuoVadis Root CA 2 G3.cer
   - QuoVadis Enterprise Trust CA 2 G3.cer
   - Siemens Issuing CA Internet Server 2017.cer



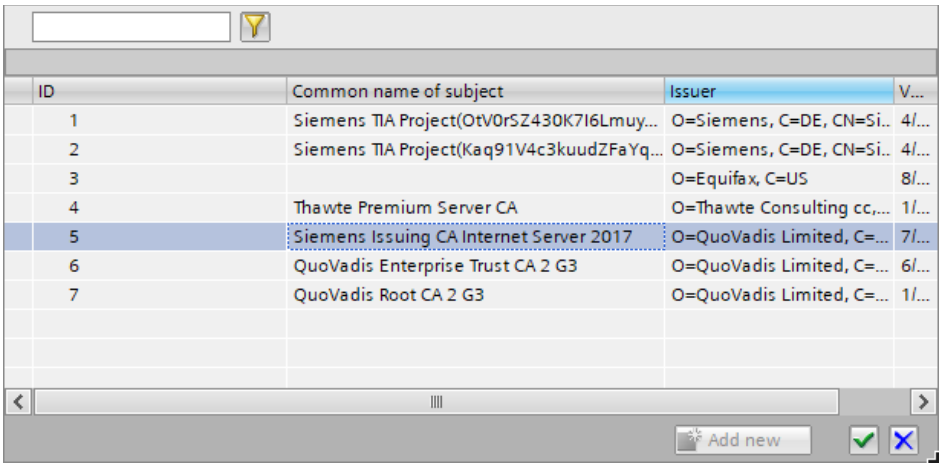
Assign the imported Certificates to PLC

In order to assign certificates to your S7-1500 PLC, proceed as follows:

1. In the project tree double-click "Devices & networks".
2. Select the "Device view" of S7-1500 PLC.
3. The properties of S7-1500 PLC are shown in the inspector window.
4. Click "General > Protection & Security > Certificate manager".
5. Select the "Use global security settings for certificate manager" check button.
6. In "Certificates of the partner devices", click "Add new".



7. Select the imported MindSphere certificates.



8. The certificates are assigned to your S7-1500 PLC project.
9. The ID of the certificates will be used later. Note it for later use.

5 Using the "MindConnectFB" library blocks in STEP 7 (TIA Portal)

5.1.1 Fulfill requirements

Before starting with the FBs, make sure you have fulfilled all the requirements:

Requirements

- S7-1500 PLC prepared, running and connected to your PC. Refer to SIMATIC S7-1500 documentation (see \9\) and online help for STEP 7 (TIA Portal).
- Three MindSphere SSL certificates are included and assigned to your PLC:
  - QuoVadis Root CA 2 G3.cer
  - QuoVadis Enterprise Trust CA 2 G3.cer
  - Siemens Issuing CA Internet Server 2017.cer
- Library FB is included to your S7-1500 project. Refer to chapter 3.1.
- Set up and ready to use a global data block as data buffer, containing a buffer array (see chapter 3.4.1).
- Set up and ready to use a global data block as data source (see chapter 3.4.2).
- Network and Time configuration correctly set on PLC (see chapter 4.2.2).

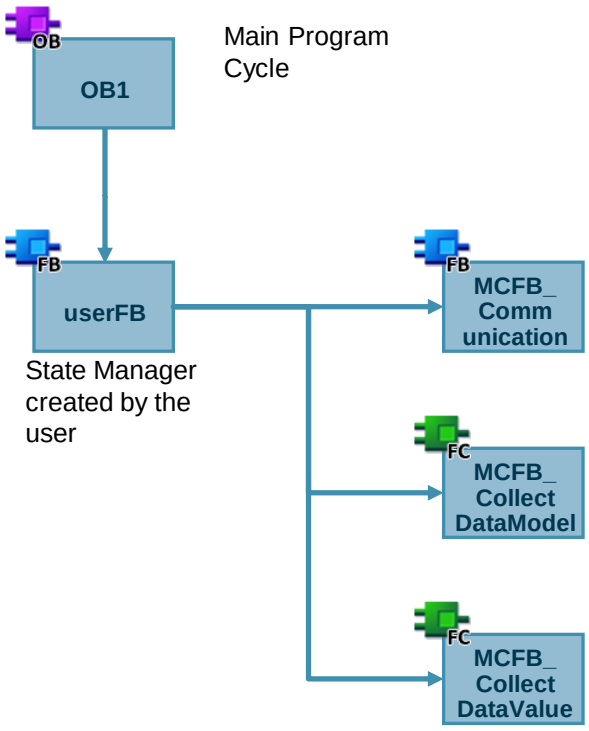
5.1.2 General usage and important notice

The library blocks need an external function block with a state machine for example, that coordinates the correct execution of each step.

This function block has to be created and programmed by the user.

An example procedure for the main call sequence is provided in figure below.

Figure 5-1



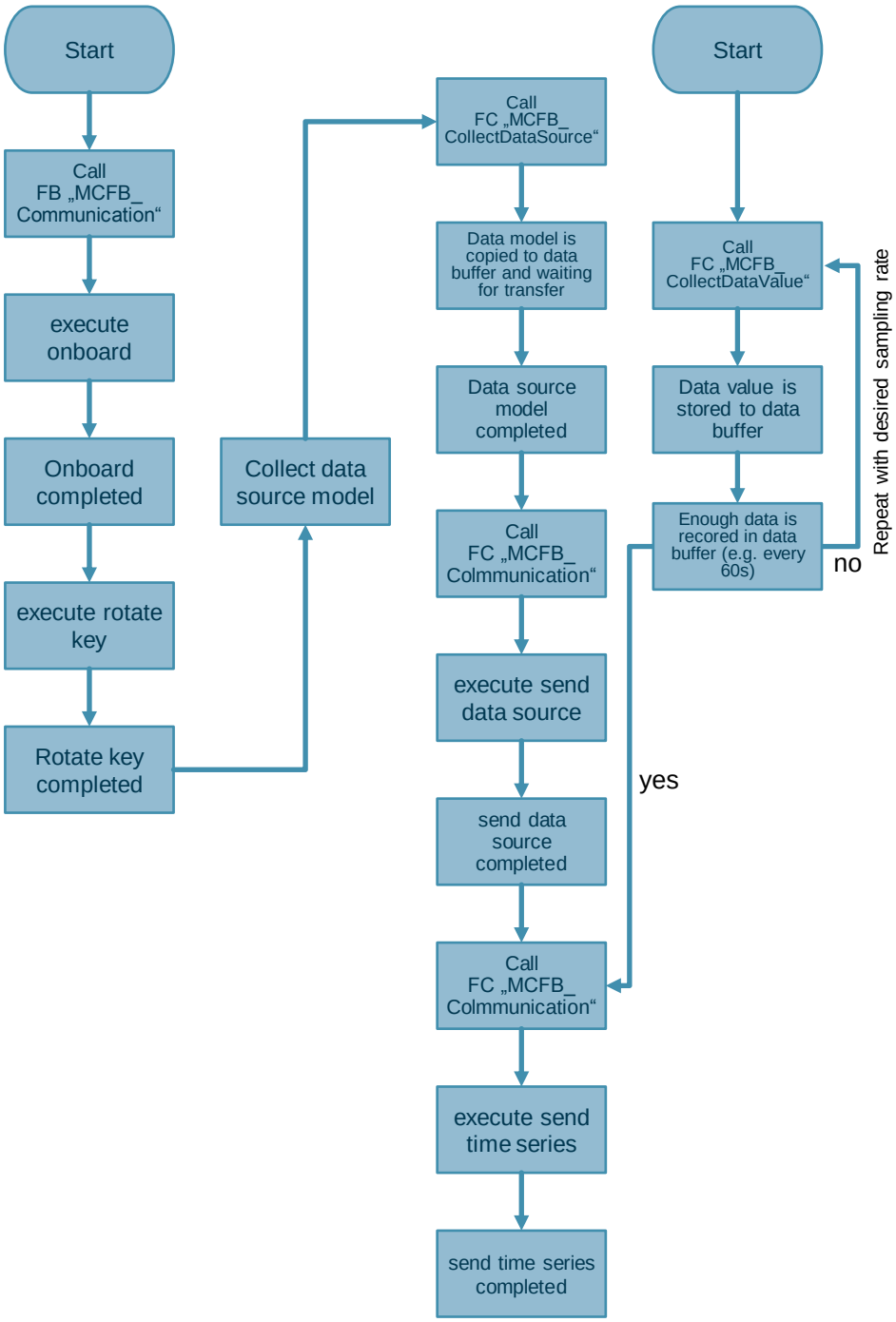
Implement a state machine in a function block, e. g. FB "userFB", to operate the MindSphere Connection.

The FB "userFB" has to handle following functions:

- Call FB "MCFB_Communication" and execute the "onboarding" job
- When the "onboarding" job is completed, call FB "MCFB_Communication" and execute the "rotate key" job.
- When the "rotate key" job is completed, call FC "MCFB_CollectDataSource". The data source model is transferred from the “dataSource” input to the data buffer and waiting for transfer.
- When FC "MCFB_CollectDataSource" is complete, call FB "MCFB_Communication" and execute the "send data source" job.
- When sending completed call FC "MCFB_CollectDataValue" periodically, e.g. every 1s, with the corresponding data point ID for each data value that shall be recorded.
- Data is sampled and stored to the data buffer.
- After a set period of time, e.g. every 30s, call FB "MCFB_Communication" and execute the "send time series" job.
- The recorded data is copied from data buffer to send buffer and transmit to MindSphere starts.

- After "Send time series" job was triggered call FC "MCFB_CollectDataValue" again to start recording data again, while upload is in progress.

Figure 5-2



"cnt" parameter

The "cnt" parameter is used by all blocks to maintain the length of data in bytes that are stored and transferred.

Therefore, it is advised to set the "cnt" parameter of all blocks to the same parameter and not modify it elsewhere in the PLC program.

Data buffer

As for the "cnt" parameter, the data buffer is used by all "MindConnectFB" library blocks. It is advised to set the data buffer parameter of all blocks to the data buffer array created in chapter 3.4.1.

5.1.3 Onboard

To onboard the S7-1500 PLC, you have to create an Asset first in the MindSphere UI.

For Onboarding, the FC "MCFB_Communication" is used. Onboarding should always be the first step.

Creating Onboard Information in Mindsphere

To onboard, the user needs to obtain an IAT and onboarding URL from MindSphere.

For this information refer to Mindsphere documentation (see \10\)

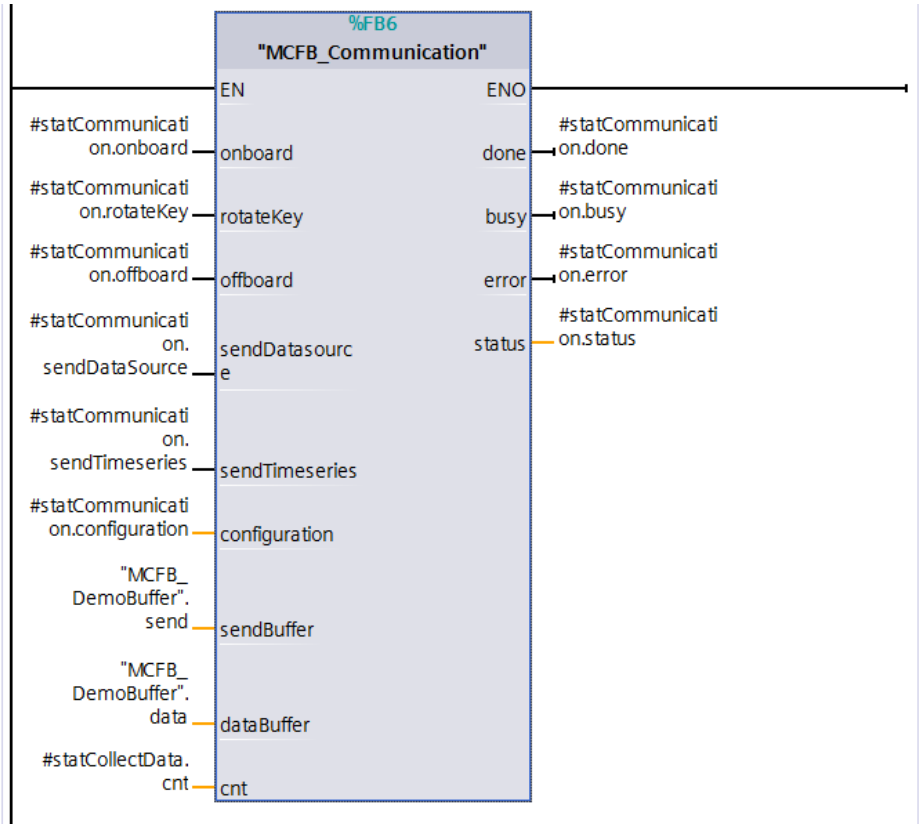
Perform the following steps:

1. Login to Mindsphere Tenant.
2. Go to Asset Manager.
3. Create a new Asset of "core.mclib" type
4. Set a name for your Asset.
5. Switch to MindConnect Lib Tab.
6. Select Security Profile SHARED_SECRET.
7. Generate onboarding key.
8. Copy all information provided to a local text file as it is needed later.

Set up FB "MCFB_Communication" parameters

Use the FB "MCFB_Communication" and assign all parameters. The assignment of parameters depends on the customer`s user program.

Figure 5-3



For the "configuration" input of FB "MCFB_Communication", you have to fill in data according to "MCFB_typeConfiguration" PLC data type.

An example for the configuration data is provided in the figure below.

Figure 5-4

configuration	"MCFB_typeConfiguration"	
connection	Struct	
connectionId	CONN_ANY	16#02
url	String	'https://southgate.eu1.mindsphere.io/'
certificateRef	Byte	16#06
asset	Struct	
IAT	WString[1024]	WSTRING#''
Tenant	String	''
userAgent	String	''
charset	String	''

Set the "connectionId" parameter to an available connection ID, that is not used elsewhere.

Set the "certificateRef" parameter to the certificate ID of the "QuoVadis Root CA 2 G3" certificate. A certificate ID is obtained from global security setting manager in STEP 7 after importing MindSphere service certificates. Refer to chapter 4.2.3 for certificates.

Set the "url" parameter to the url provided at the “baseURL” in the onboarding information from previous step.

IAT: Set to the IAT Token provided in the onboarding information from previous step.

For "Tenat" parameter enter information about tenant provided in the onboarding information from previous step.

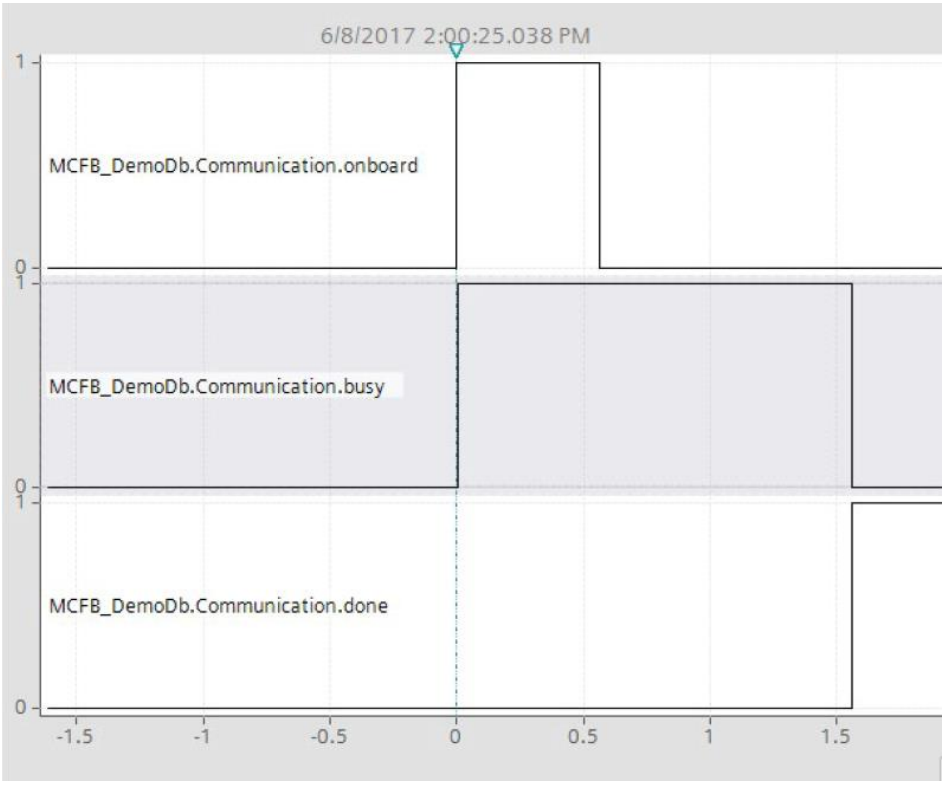
The "userAgent" and "charset" parameter can be left empty (optional).

Start onboarding

To start onboarding process, trigger the "onboard" input of FB "MCFB_Communication" with positive edge.

The following trace shows the onboard process.

Figure 5-5



When the "onboard" job is started, the FB "MCFB_Communication" switches to busy.

When job finishes without error, the "done" output of FB "MCFB_Communication" is set to true and remains true, until another job is issued.

When job fails with error, error is set to true and remains, true until another job is issued.

5.1.4 Rotate Key

This function can be triggered by the "rotateKey" input of FB "MCFB_Communication".

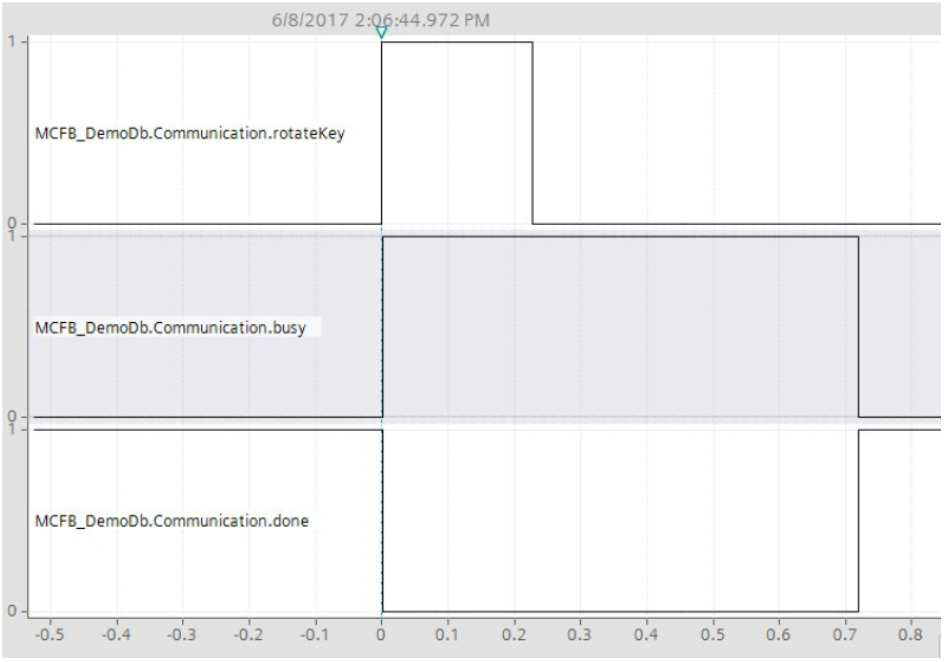
It's necessary to update security handshakes between MindSphere and PLC Function block.

It should be executed by the user after onboarding.

Afterwards, it has to be executed at least every 50 minutes, as the access Key expires after about 1 hour.

The following trace shows the rotate key process.

Figure 5-6



When the job is started, the FB "MCFB_Communication" switches to busy.

When job finishes without error, the "done" output is set to true and remains true, until another job is issued.

When job fails with error, error is set to true and remains true, until another job is issued.

5.1.5 Collect and send data source model

For this step, the setup of two global data blocks (DB) has to be completed:

- DB "MCFB_DataSource" as data source (refer to chapter 3.4.1)
- DB "MCFB_DemoBuffer" as data buffer (refer to chapter 3.4.2)

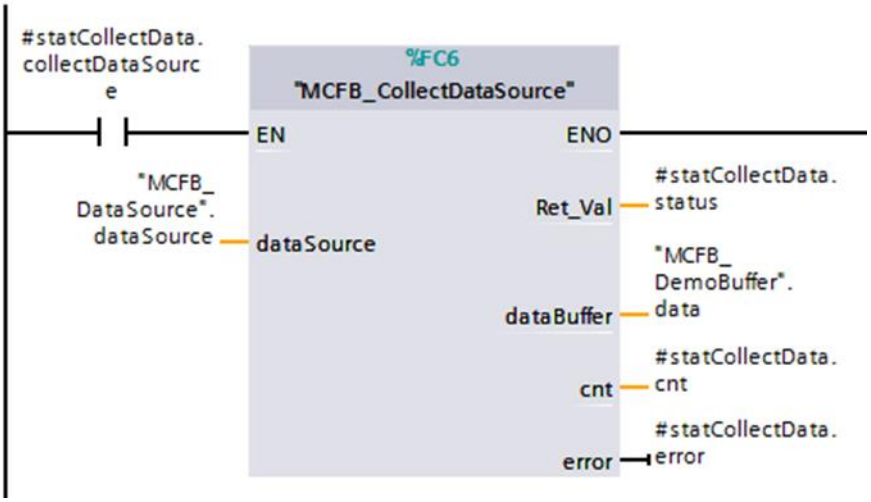
Collect data source model

To collect data source model, use the FC "MCFB_CollectDataSource".

Collecting data source is initiated by a positive edge (transition from "0" to "1") at "EN" input.

Another edge may only be generated after the command has been completed.

Figure 5-7



Assign the global data block DB "MCFB_DataSource" with the "DataSource" array to the "dataSource" input of the FC "MCFB_CollectDataSource".

The "cnt" parameter used by the block stores the amount of data written to the "data" array in global data block DB "MCFB_DemoBuffer".

Send data source model to MindSphere

When the data model was collected successfully, it is stored in the "data" array of the global data block DB "MCFB_DemoBuffer". Then this data model can be sent to MindSphere.

To execute the job, trigger the "sendDataSource" input of the FB "MCFB_Communication" with a positive edge.

Make sure, that the "databuffer" parameter of FB "MCFB_Communication" points to the same data buffer array as the FC "MCFB_CollectDataSource".

Make sure, that both use the same "cnt" variable.

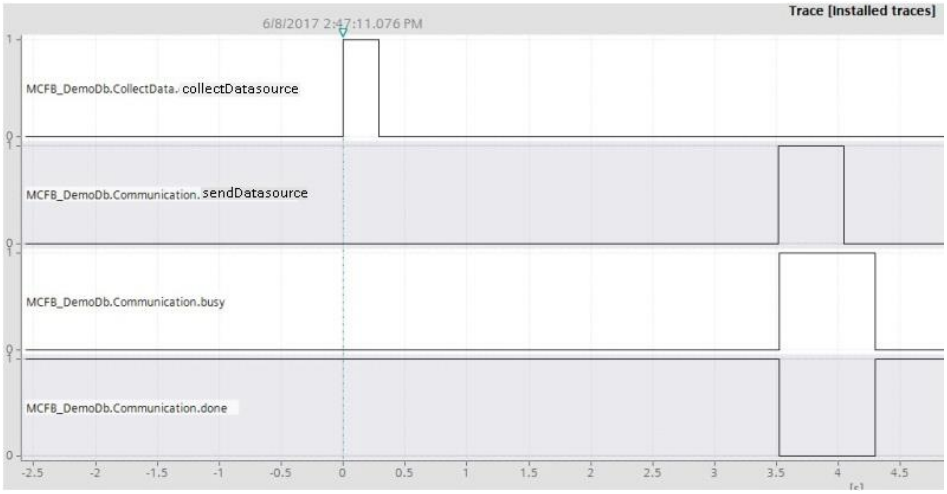
When the job is completed successfully, the MCFBCommunication done output will be set to true.

If an error occurs, the "error" output is set to true and stays true, until a new job is issued.

Tracing the collection and sending data model

The following traces show the collection and sending of data source model to help using the function.

Figure 5-8



5.1.6 Collect and send time series data

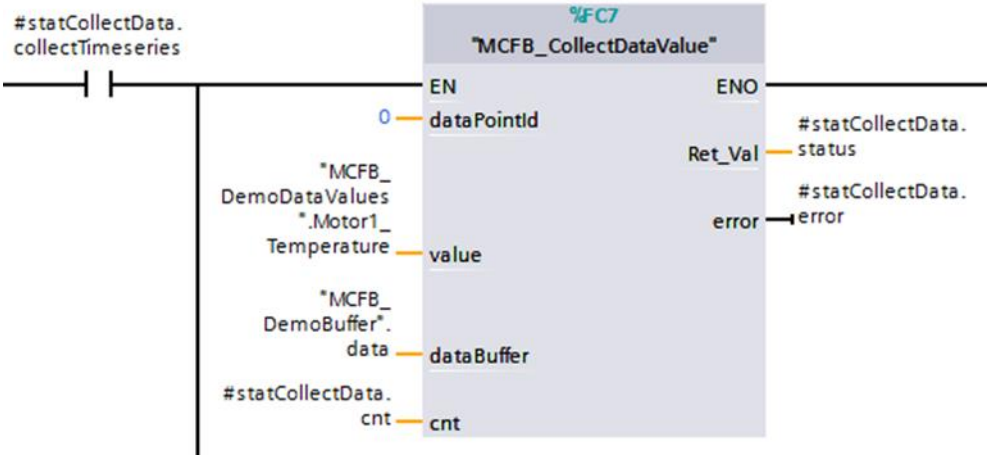
This chapter explains how data can be record at the PLC and then send to MindSphere.

Call the FC "MCFB_CollectDataValue" on a periodic basis, to sample and log the actual data. The data is stored in the "data" array of DB "MCFB_DemoBuffer. Make sure to send data to MindSphere with FB "MCFB_Communication", before the data buffer is full. Upon sending data, data is copied to send buffer.

Collect data values

For recording data and saving it with a timestamp to the data buffer, the FC "MCFB_CollectDataValue" is used.

Figure 5-9



Collecting time series is initiated by a positive edge (transition from "0" to "1") at "EN" input. Another edge may only be generated after the command has been completed.

The "dataPointId" input is a reference for the variable and must be unique, e.g. 0 to 10 (number of variables).

Make sure, the referenced data point ID fits the data type of the data source model of the configured data source model.

At the "value" input specify the variable that shall be recorded and saved to the data buffer. You define an address for any data sources from the S7-1500. A constant value cannot be entered.

For each variable that shall be recorded, a single call of the FC "MCFB_CollectDataValue" has to be done.

Send time series

After saving data to the data buffer multiple times, the user should send the data to the MindSphere.

Use the FB "MCFBCommunication" for this task.

To execute the job, set a positive edge on the "sendTimeseries" input of FB "MCFB_Communication".

The data values from "data" array of DB "MCFB_DemoBuffer" (data buffer) are copied to the "send" array of DB "MCFB_DemoBuffer" (send buffer). Then the data is sent to Mindsphere.

When the FB "MCFB_Communication" switches from busy to done, no error occurred.

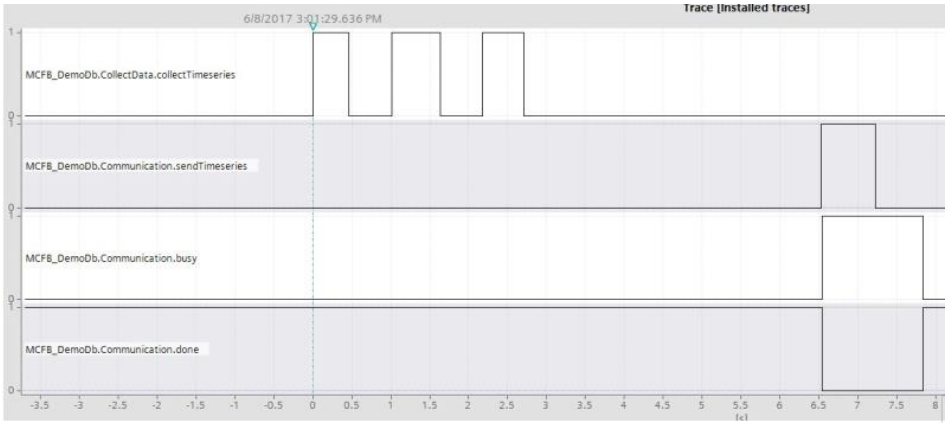
When an error occurs, the data is lost and error output is set to true.

It’s advised to store data buffer somewhere else by the user, to prevent loss of data in error case.

Tracing the collection and sending of the data

The following trace helps the user to understand the feature.

Figure 5-10



5.1.7 Visualize the data

In order to visualize the data that is send to MindSphere, the data has to be mapped in the Mindsphere UI.

Use the Fleetmanager to show data in the MindSphere, Refer to Mindsphere documentation (see \10\).

5.1.8 Offboard

Use the "Offboard" button in to off-board asset in MindSphere UI.

Refer to Mindsphere documentation (see \10\).

The "offboard" input of FB "MCFB_Communication" only deletes local data at the FB. There is no way to off-board the PLC using the FB itself, as MindSphere is missing this function.

6 Troubleshoot

6.1 FB "MCFB_Communication" shows error 16#8012 when sending time series

Solution

Execute the "rotate key" function at least every 50 minutes, as the key expires after about 1 Hour.

6.2 Error occurs after project is changed and downloaded

Solution

When the instance DB of the FB "MCFB_Communication" is changed after onboarding, you have to do a new onboarding.

First off-board asset, create a new IAT and then onboard again. Afterwards you have to send data source model again, before sending time series is possible.

Remember to recreate data mapping in Mindsphere UI, as sending data source model deletes the mapping.

This process can be prevented, if you take a snapshot of the instance DB and restore this information after the download to keep the actual values.

7 Appendix

7.1 List of Abbreviations

Table 7-1

Abbreviation	Description
CP	Communication Processor (I/O module type)
CPU	Central Processing Unit
DB	Data Block (PLC)
FB	Function Block (PLC)
FC	Function (PLC)
GUI	Graphical User Interface
HTTPS	Hyper Text Transfer Protocol Secure
IAT	Initial Access Token
IP	Internet Protocol
PC	Personal Computer
PLC	Programmable Logical Control: Controller PLC
SSL	Secure Sockets Layer (Authentication Protocol)
TIA	Totally Integrated Automation
UI	User Interface
URI	Uniform Resource Identifier
URL	Uniform Resource Locator

7.2 Service and Support

Industry Online Support

Do you have any questions or need assistance?

Siemens Industry Online Support offers round the clock access to our entire service and support know-how and portfolio.

The Industry Online Support is the central address for information about our products, solutions and services.

Product information, manuals, downloads, FAQs, application examples and videos – all information is accessible with just a few mouse clicks at:
https://support.industry.siemens.com

Technical Support

The Technical Support of Siemens Industry provides you fast and competent support regarding all technical queries with numerous tailor-made offers – ranging from basic support to individual support contracts. You send queries to Technical Support via Web form:
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SITRAIN – Training for Industry

With our globally available training courses for our products and solutions, we help you achieve with practical experience, innovative learning methods and a concept that's tailored to the customer's specific needs.

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Our range of services includes the following:

- Plant data services
- Spare parts services
- Repair services
- On-site and maintenance services
- Retrofitting and modernization services
- Service programs and contracts

You can find detailed information on our range of services in the service catalog:
https://support.industry.siemens.com/cs/sc

Industry Online Support app

You will receive optimum support wherever you are with the "Siemens Industry Online Support" app. The app is available for Apple iOS, Android and Windows Phone:
https://support.industry.siemens.com/cs/ww/en/sc/2067

7.3 Links and Literature

Table 7-2

No.	Topic
\1\	Siemens Industry Online Support https://support.industry.siemens.com
\2\	Link to this entry page of this application example https://support.industry.siemens.com/cs/ww/en/view/109756878
\3\	Technical Support https://support.industry.siemens.com/cs/ww/en/sc/2090
\4\	Support Request https://support.industry.siemens.com/cs/ww/en/sc/2100
\5\	Siemens Industry Mall https://mall.industry.siemens.com
\6\	SIMATIC Documentation Collection https://support.industry.siemens.com/cs/ww/en/view/109742705
\7\	STEP 7 V14 SP1 (TIA Portal) https://support.industry.siemens.com/cs/ww/en/view/109747136
\8\	STEP 7 V15 (TIA Portal) https://support.industry.siemens.com/cs/ww/en/view/109755202
\9\	SIMATIC S7-1500 https://support.industry.siemens.com/cs/ww/en/view/59191792
\10\	Mindsphere https://documentation.mindsphere.io/

7.4 Change documentation

Table 7-3

Version	Date	Modifications
V1.0	04/2018	First version

8 Glossary

Area

Area is also an asset with significantly reduced functionalities. Within an area, one or more assets can be configured. See Asset definition below.

Aspect

Aspects are a data modeling mechanism for assets. Aspects group the data points based on logical sense. For example: The pump skid has the aspect "Energy_Management" that contains following data points

- "power"
- "current"
- "voltage"

The aspect is specified in the IoT Data Modeler and its name can be freely chosen, but should have conjunction to data points and a physical asset.

Asset

An asset is a digital representation of a machine or an automation system with one or multiple automation units (e.g. PLC) connected to MindSphere. MindSphere data collection and data provisioning is based on so called (virtual) assets. This can be anything like a pump, motor, PLC, an entire tool machine, a production line, a robot, a crane, a car, a windmill and so on. The data of an asset is collected and sent to MindSphere to make that data available for further processing and analytics.

Asset Identifier

Asset Identifier is a serial number assigned by the manufacturer to a device, to which the SIMATIC S7-1500 will be connected. After the onboarding Process, MindConnect FB 1500 is connected to this device. The serial number identifies the asset to which the data belongs.

Asset Type

Asset type is a sort or kind of a product line made by one manufacturer. The following asset types are asset types of Siemens products:

- SIMATIC
- SIMOTION
- SINAMICS
- SINUMERIK

Core Apps

Core Apps are the applications providing the main different functionalities of MindSphere.

- IoT Data Modeler
- Fleet Manager
- Application Manager
- UTC reporting

For the complete list and description of Core Apps, refer to the MindSphere Overview.

Data Point

Data points are in reference to elements (variables), which values can be obtained from data sources. The same data are combined into a relevant aspect.

For example "temperature" and "torque" are data points of an aspect "PowerManagement".

Data points are configured in the IoT Data Modeler. In the Cor App "Fleet Manager", their values are then visualized as time series.

Data Source

Data source is a physical element of a device containing data, which can be monitored by MindSphere. For example

- OPC UA server
- S7 Protocol.Core

MindSphere

MindSphere is the Siemens Industrial IoT operation system comprising the core cloud services and applications (Core Apps, MindApps), whereas the MindConnect element provides secure and easy connectivity from the field or machine to MindSphere. For more information, refer to MindSphere Overview.

Off-boarding Process

The off-boarding process is the stopping process of the connection between MindSphere and MindConnect element and asset.

Onboarding Process

The Onboarding process is required to connect a new SIMATIC S7-1500 PLC.

It basically consists of an authentication of the new device and an assignment to the owner's user space. During authentication, onboarding data, IAT and registration URI, are generated in MindSphere and transmitted (manually) to SIMATIC S7-1500. After a successful exchange of onboarding data, SIMATIC S7-1500 is on-boarded to MindSphere.

Online and Offline Mode

Online indicates internet connection, when SIMATIC S7-1500 sends the data to the server. Offline mode means the absence of the internet connection and the SIMATIC S7-1500 does not send any data to the server any longer.

Time series

Time series is a sequence of measurements, which are produced by data sources over time. In IoT Data Modeler the measurements, that have to be collected, can be specified. Analysis and visualization tool like Fleet Manager can retrieve collected time series and present it to the user after processing.