Connecting the S7-1500 CPU to MindSphere

S7-1500 CPU / V2.5 or higher

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

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1 Introduction

1.1 Overview

Using the library "MindConnectFB" you can connect a SIMATIC S7-1500 CPU with MindSphere.

The user must implement the library blocks in his user program, e.g. as a state machine in a function block (FB), in order to execute the following functions:

- Execution of the "Onboarding" process
- Execution of the Key rotation" process
- Transfer data sources and data points (data source model) to the data buffer
- Transfer data source model to MindSphere
- Regularly record the actual values of the variables, e.g. every 10 s, and store them in the data buffer.
- Copy the recorded data (time series) regularly from the data buffer into the send buffer and transfer it to MindSphere, e.g. every 60 s.

This state machine must be implemented again and again by each user in his user program. To facilitate this, there is a function block (FB) in SCL. You can use the FB as a template to connect your SIMATIC S7-1500 CPU with MindSphere.

The application example provides the following information:

- Library for STEP 7 (TIA Portal) containing the FB
- Description of the FB to realize the MindSphere connection

1.2 Principle of operation

Realization as a state machine

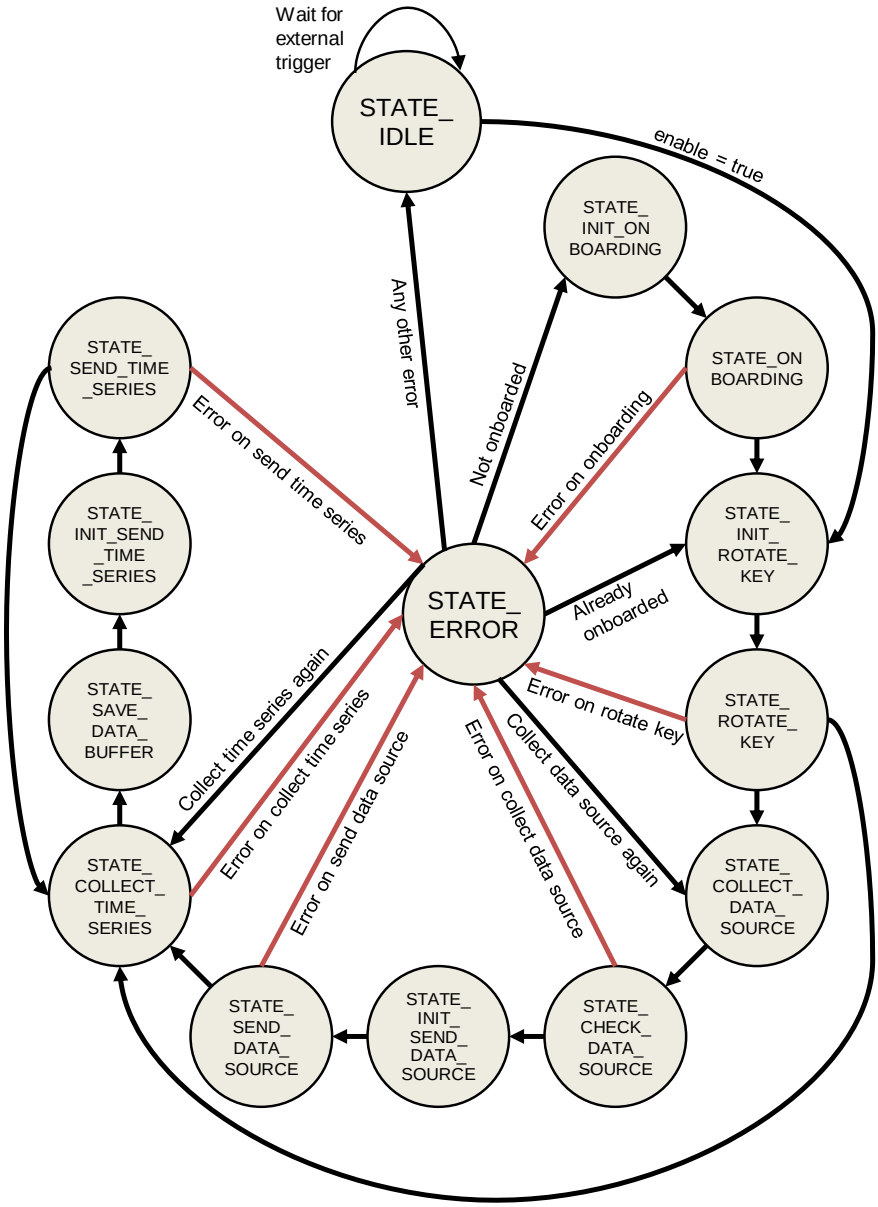
The FB for the realization of the MindSphere connection is realized as a state machine. The design model of a state machine is particularly suitable for modeling complex asynchronous processes, e.g. onboarding, key rotation, data acquisition and data transfer, which are executed in different time cycles.

A certain state is run through cyclically until a transition condition is fulfilled and the machine switches to the next subsequent state. This not only improves the clarity compared to conventional link control, but also makes it easier to find any errors in the program logic more quickly.

State creation in the FB "CommMindSphereHandler"

The following figure shows the states that are implemented in this FB.

Figure 1-1



Description of the states

The following table provides an overview of the realized states and possible transitions. For more information, see the documented code.

Table 1-1

Status	Description	
STATE_IDLE(1)	In idle state, the FB has the following properties: • No communication with MindSphere • Status variables are reset	The idle state "STATE_IDLE" is only left if communication with MindSphere is started via a parameter (enable).
STATE_INIT_ONBOARDING(2)	The job for onboarding the S7-1500 CPU is started.	The FB immediately changes to the state "STATE_ONBOARDING" without any transition condition.
STATE_ONBOARDING(3)	Check of the onboarding process	The state "STATE_ONBOARDING" is left if one of the following conditions is fulfilled: • If the onboarding of the S7-1500 CPU is successfully completed, the FB changes to the state "STATE_INIT_ROTATE_KEY". • If an error occurs while onboarding the S7-1500 CPU, the FB changes to the state "STATE_ERROR".
STATE_INIT_ROTATE_KEY(4)	The key rotation job is started. A timer is started to restart the key rotation job after the timer has expired. The job is executed every 50 minutes.	The FB immediately changes to the state "STATE_KEY_ROTATION" without any transition condition.

Status	Description	
STATE_ROTATE_KEY(5)	Check of the key rotation process.	The state "STATE_ROTATE_KEY" is left if one of the following conditions is fulfilled: • If the key rotation has been successfully completed and the data model has not yet been transferred, the FB changes to the state "STATE_COLLECT_ DATA_SOURCE". • If the key rotation has been successfully completed and the data model has already been transferred, the FB changes to the state "STATE_COLLECT_ TIME_SERIES". • If an error occurs during key rotation, the FB changes to the "STATE_ERROR" state."
STATE_COLLECT_DATA_ SOURCE(6)	The data sources and data points are recorded.	The FB immediately changes to the state "STATE_CHECK_ DATA_SOURCE" without any transition condition.
STATE_CHECK_DATA_ SOURCE(7)	Check the collection of data sources and data points.	Der state "STATE_CHECK_DATA_ SOURCE" is left if one of the following conditions is fulfilled: • When the data sources and data points have been successfully collected, the FB changes to the state "STATE_INIT_SEND_ DATA_SOURCE"." • If an error occurs during the collection of the data sources and data points, the FB changes to the state "STATE_ERROR".
STATE_INIT_SEND_DATA_ SOURCE(8)	The job to transfer the data sources and data points to MindSphere is started.	The FB immediately changes to the state "STATE_SEND_ DATA_SOURCE" without any transition condition.

Status	Description	
STATE_SEND_DATA_ SOURCE(9)	Check the transfer of data sources and data points to MindSphere.	Der state "STATE_SEND_DATA_ SOURCE" is left if one of the following conditions is fulfilled: • When the data sources and data points have been successfully transferred to MindSphere, the FB changes to the state "STATE_COLLECT_ TIME_SERIES". • If an error occurs while transferring the data sources and data points to MindSphere, the FB changes to the state "STATE_ERROR".
STATE_COLLECT_TIME_ SERIES(10)	Collecting data from time series, i.e. the actual value of the defined variable is retrieved and logged every 10 seconds. A timer is started to start the order to send the time series to MindSphere after the timer has expired. The order is executed every 60 seconds.	Der state "STATE_COLLECT_TIME_ SERIES" is left if one of the following conditions is fullfilled: • If an error occurs while collecting the data of time series, the FB changes to the state "STATE_ERROR". • When the timer for sending the time series has expired, the FB changes to the state "STATE_SAVE_ DATA_BUFFER". **Note** The time series are sent to MindSphere every 60 seconds. • When the timer for key rotation has expired, the FB changes to the state "STATE_INIT_ROTATE_ KEY". **Note** The key rotation is performed every 50 minutes.
STATE_SAVE_DATA_ BUFFER(11)	The time series data is stored so that you can send it to MindSphere a second time if an error occurs while sending the time series.	The FB immediately changes to the state "STATE_INIT_SEND_TIME_ SERIES" without any transition condition.

Status	Description	
STATE_INIT_SEND_TIME_ SERIES(12)	The job to send the time series to MindSphere is started.	The FB immediately changes to the state "STATE_SEND_TIME_ SERIES" without any transition condition.
STATE_SEND_TIME_ SERIES(13)	Check the sending of time series to MindSphere.	Der state "STATE_SEND_TIME_ SERIES" is left if one of the following conditions is fulfilled: • If the time series were successfully sent to MindSphere, the FB changes to the state "STATE_COLLECT_ TIME_SERIES". • If an error occurs when sending the time series to MindSphere, the FB changes to the state "STATE_INIT_ SEND_TIME_SERIES" to start a second send job. • If an error occurs during the second send job, the FB changes to the state "STATE_ERROR".

Status	Description	
STATE_ERROR(14)	In the state "STATE_ERROR" the FB executes the following actions: • It decides whether an attempt is made to remedy an error within the FB independently by calling up other states. • It supplies the output parameters with the error information.	The state "STATE_ERROR" is left if one of the following conditions is fulfilled: • If an error occurs during the onboarding process, the FB changes to the state "STATE_IDLE". **Note:** If the onboarding process has already been successfully executed, the FB changes to the state "STATE_INIT_ROTATE_KEY". • If an error occurs during the key rotation process, the FB changes to the state "STATE_IDLE". **Note** If the onboarding process has not yet been executed, the FB changes to the state "STATE_INIT_ONBOARDING". If an undefined error occurs, the FB changes to the state "STATE_COLLECT_DATA_SOURCE". • If an error occurs while collecting the data sources and data points, the FB changes to the state "STATE_COLLECT_DATA_SOURCE". • If an error occurs while sending the data sources and data points, the FB goes into the state "STATE_IDLE". • If an error occurs when collecting data from time series, the FB changes to the state "STATE_COLLECT_TIME_SERIES". • If an error occurs during transmission of the time series, the FB changes to the state "STATE_IDLE". **Note** When the key has expired, the FB changes to the state "STATE_INIT_ROTATE_KEY".

1.3 Components used

The following hardware and software components were used to create this application example:

Table 1-2

Component	Quantity	Article number	Note
CPU 1513-1 PN	1	6ES7513-1AL01-0AB0	Alternatively, you can use any S7-1500 CPU, ET 200SP CPU or ET 200pro CPU with firmware V2.5 or higher.
STEP 7 Professional V15 Update 3	1	Package: 6ES7822-1AA05-0YA5 Download: 6ES7822-1AE05-0YA5	

2 Engineering

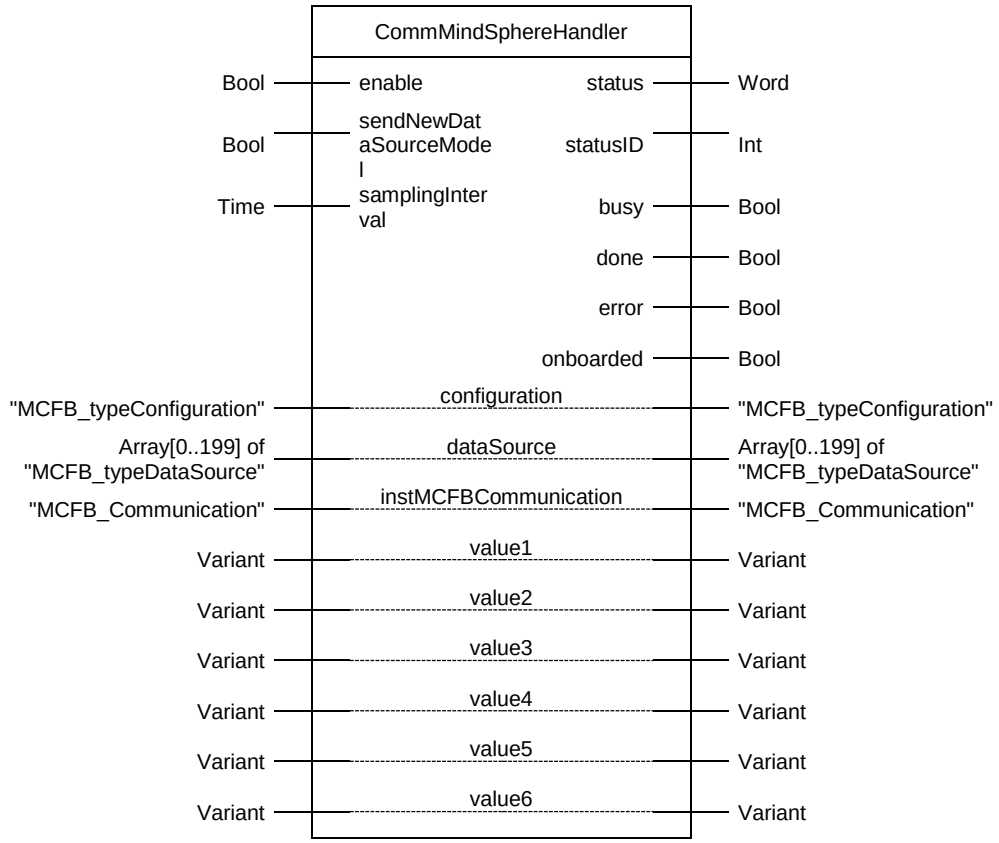
2.1 Interface description

Functional description

The library "LMindSphereHandler" provides the function block FB "CommMindSphereHandler", in which a complete connection of a SIMATIC S7-1500 CPU to MindSphere is implemented. It encapsulates all library blocks of the "MindConnectFB" library in a user-friendly shell to perform the following functions:

- Control processing of FB "CommMindSphere" via "enable" input
- Execute onboarding process
- Execute key rotation
- Collect data source model and tranfer it to MindSphere
- Collect values of six variables (parameters from "value1" to "value6") and transfer them to MindSphere.
- Output the status of the following processes at the output parameter "status":
  - Onboarding
  - Key rotation
  - Collecting the data source model
  - Sending the Data Source Model
  - Collecting values of variables (time series)
  - Transfer values of variables (time series) to MindSphere

Figure 2-1



The following table shows the input and output parameters of the "CommMindSphereHandler" function block

Table 2-1

Name	P type	Data type	Comment
enable	IN	Bool	Control input 1: With a positive edge at the "enable" input, FB processing is started. 0: With a negative edge at the "enable" input, FB processing is stopped.
sendNewDataSourceModel	IN	Bool	Capture new data source model and transfer to MindSphere 1: If there is a positive edge at the "sendNewDataSourceModel" input, the new data source model is collected and transferred to MindSphere. **Requirement** enable = 1: FB is in preparation.
samplingInterval	IN	Time	Time interval in which the values of the variables (time series) are collected.

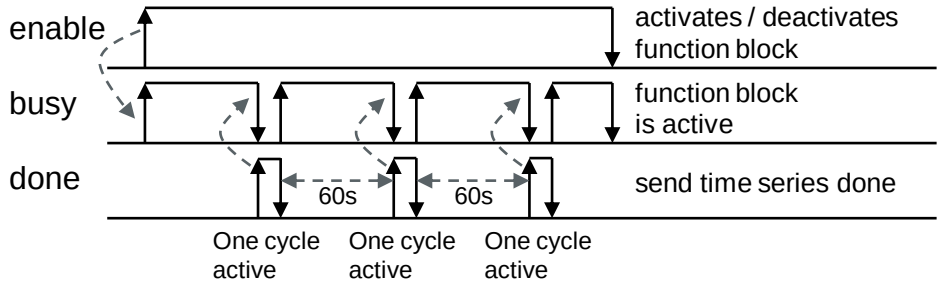
Name	P type	Data type	Comment
status	OUT	Word	Status display of the following processes: • Onboarding • Key rotation • Collecting the data source model • Sending the Data Source Model • Collecting time series • Sending time series Detailed information can be found in the section 2.3.
statusID	OUT	Int	Parameter indicates which process returns the error. Detailed information can be found in the section 2.3.
busy	OUT	Bool	FB is in preparation.
done	OUT	Bool	1: Time series have been successfully transferred to MindSphere. 0: Time series are collected, or FB is not prepared.
error	OUT	Bool	Error display
onboarded	OUT	Bool	Status display: Onboarding process successfully completed. **Note** The onboarding process is executed only once.
configuration	IN_OUT	"MCFB_typeConfiguration"	This parameter is used to pass on the important information for the onboarding process. The structure of the configuration "MCFB_typeConfiguration" is provided as PLC data type in the library "MindConnectFB". You can find more information in the section 2.2.3.
dataSource	IN_OUT	Array[0..199] of "MCFB_typeDataSource"	This parameter must be set to an array of the PLC data type "MCFB_typeDataSource". This parameter is used to define the data sources that are then created in the MindSphere backend. You can find more information in the section 2.2.4.

Name	P type	Data type	Comment
instMCFBCommunication	IN_OUT	"MCFB_Communication"	You use this parameter to specify the instance DB of the FB "MCFB_Communication". You can find more information in the section 2.2.5.
value1	IN_OUT	Variant	A pointer to the variable for which you have defined a value that is queried every 5 s and stored in the data buffer.
value2	IN_OUT	Variant	A pointer to the variable for which you have defined a value that is queried every 5 s and stored in the data buffer.
value3	IN_OUT	Variant	A pointer to the variable for which you have defined a value that is queried every 5 s and stored in the data buffer.
value4	IN_OUT	Variant	A pointer to the variable for which you have defined a value that is queried every 5 s and stored in the data buffer.
value5	IN_OUT	Variant	A pointer to the variable for which you have defined a value that is queried every 5 s and stored in the data buffer.
value6	IN_OUT	Variant	A pointer to the variable for which you have defined a value that is queried every 5 s and stored in the data buffer.

Function diagrams

The following function diagram shows how the most important output parameters are set depending on the input parameters.

Figure 2-2



2.2 Integration into the user project

2.2.1 Open library in STEP 7 (TIA Portal)

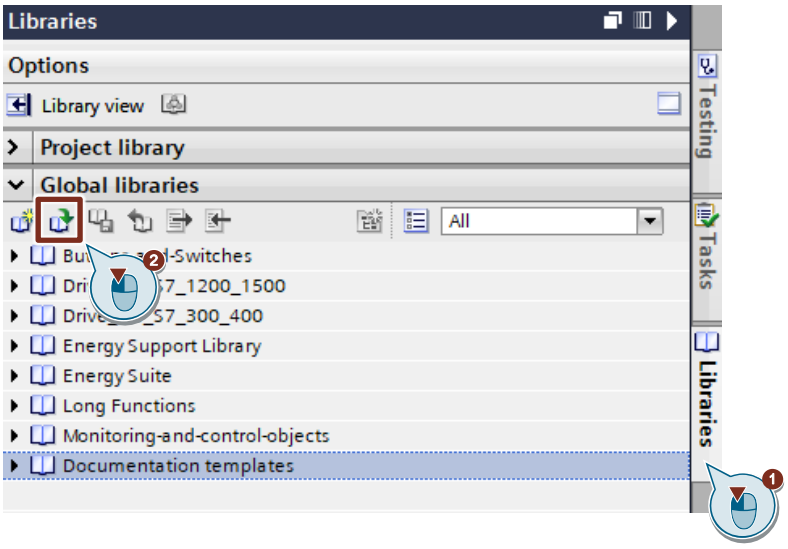
To open the LMindSphereHandler library in STEP 7 (TIA Portal), follow these instructions.

Requirement

- STEP 7 (TIA Portal) is open.
- You have created a new project in STEP 7 (TIA Portal) or have opened an existing project.
- You have integrated the blocks of the "MindConnectFB" library into your user program. The library "MindConnectFB" is available for download in the following article:
  https://support.industry.siemens.com/cs/ww/en/view/109756878
- You have imported the certificates for MindSphere into your STEP 7 project. Instructions on how to import the certificates into STEP 7 (TIA Portal) can be found in the sections 2.2.7 and 2.2.8:
  - QuoVadis Root CA 2 G3.cer
  - QuoVadis Enterprise Trust CA 2 G3.cer
  - Siemens Issuing CA Internet Server 2017.cer

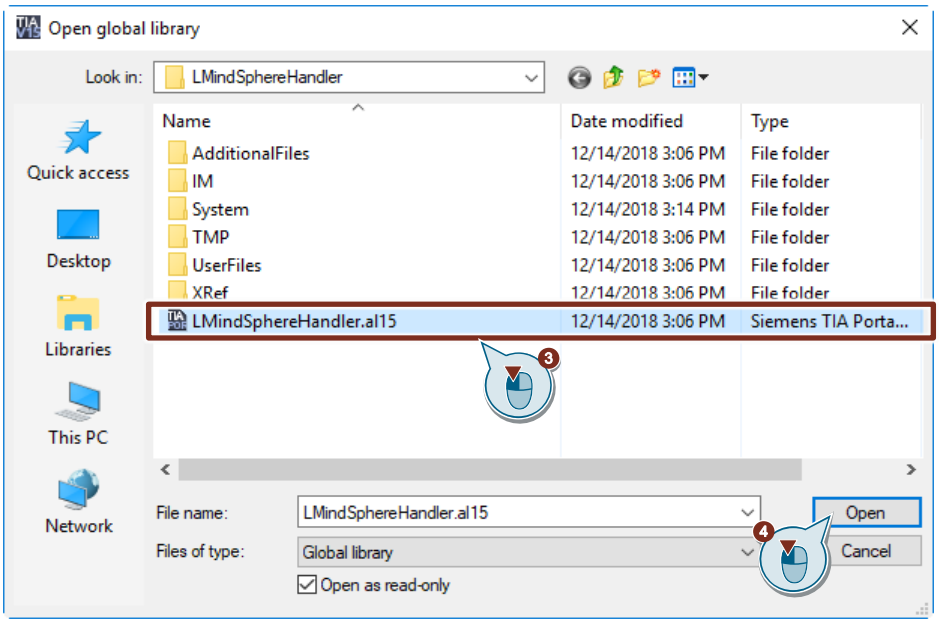
Instructions

1. Open the "Libraries" task card.
2. In the "Global Libraries" palette, click the "Open global library" button. The "Open global library" dialog is opened.

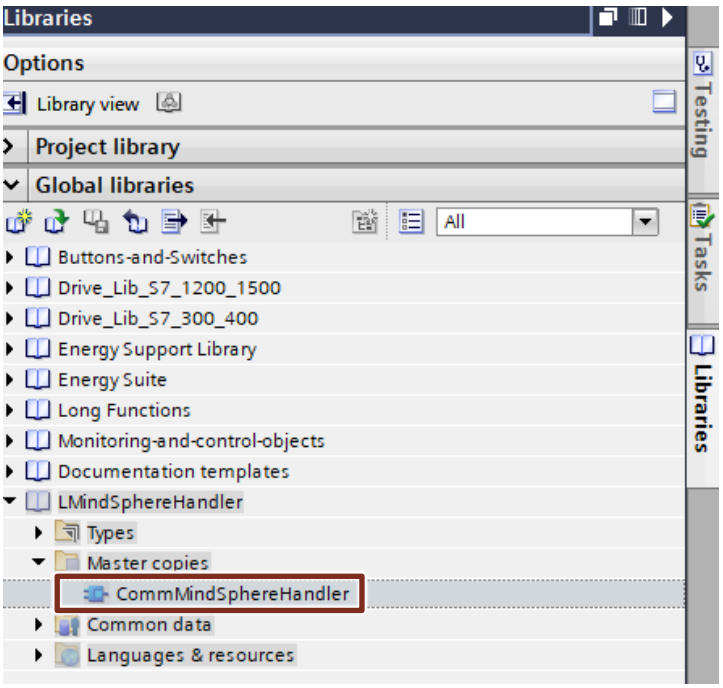


3. Select the "LMindSphereHandler" library.
4. Click on the "Open" button. The library "LMindSphereHandler" is opened in the palette "Global Libraries".

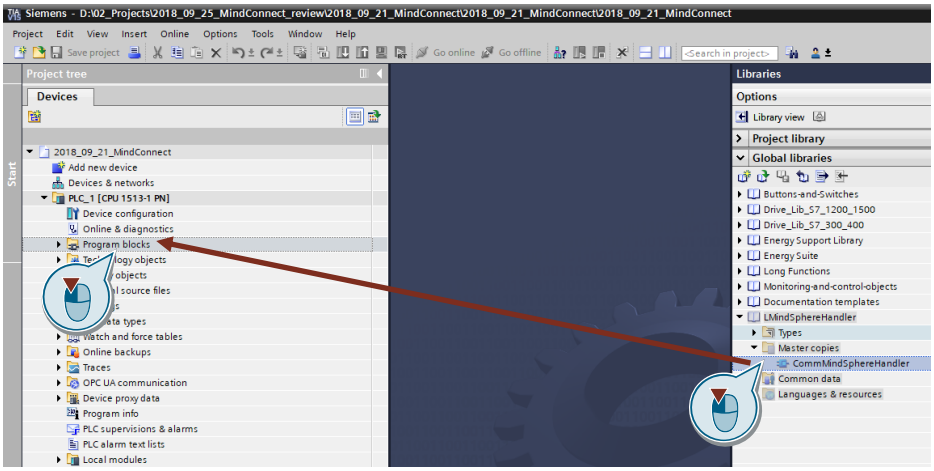
Figure 2-3



5. The function block "CommMindSphereHandler" can be found in the library "LMindSphereHandler" under "Master copies".



6. Insert the function block "CommMindSphereHandler" by drag & drop from the library into the folder "Program blocks" of your CPU.



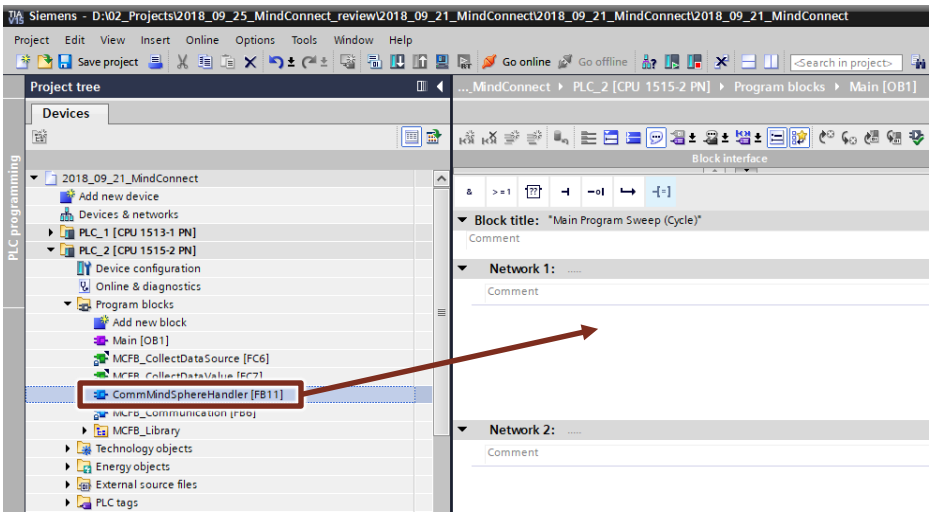
7. Integrate the function block "CommMindSphereHandler" into the user program of your CPU (see section 2.2.2).

2.2.2 Integrating the "CommMindSphereHandler" function block into the user program

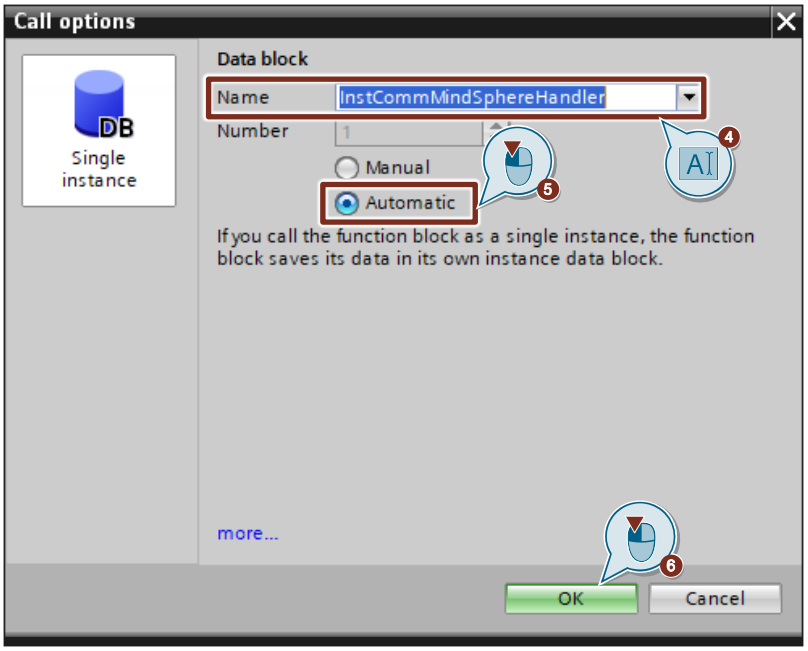
Proceed according to the following instructions to integrate the function block "CommMindSphereHandler" into the user program of your CPU.

Call the function block "CommMindSphereHandler" cyclically in OB 1.

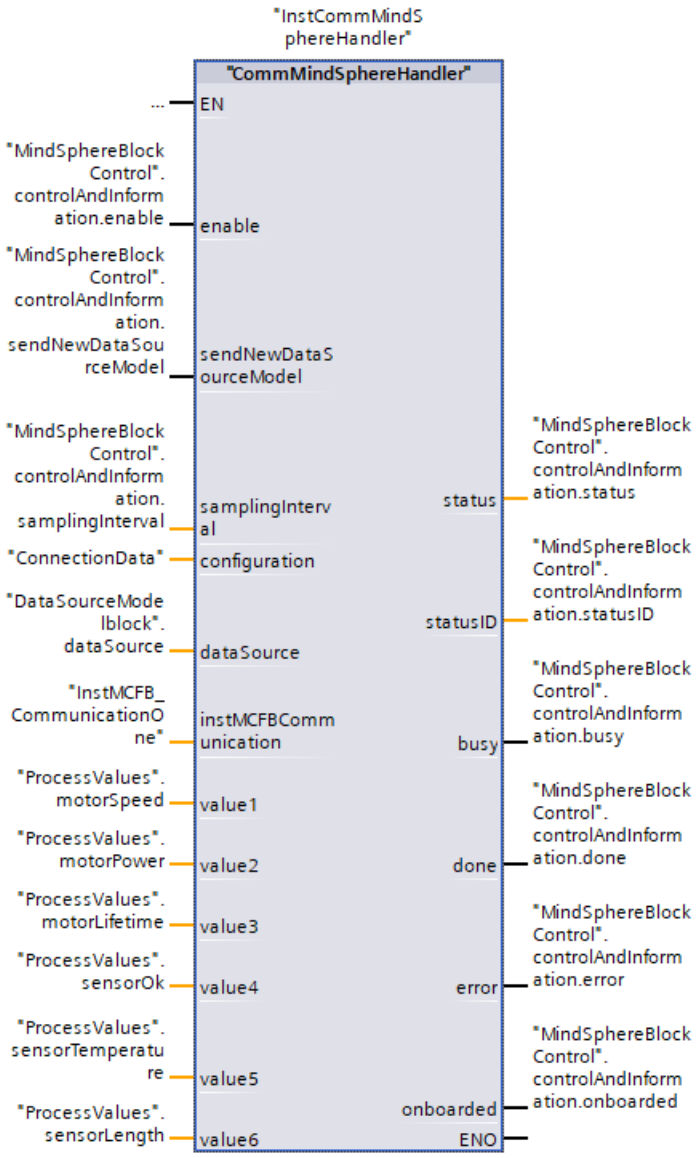
1. Double-click in the project navigation in the folder "Program blocks" of your CPU on the block "Main [OB1]". OB 1 is opened in the work area.
2. Mark the function block "CommMindSphereHandler" in the project navigation in the folder "Program blocks" of your CPU.
3. Insert the function block "CommMindSphereHandler" via drag & drop into a network of OB 1. The dialog "Call options" is opened automatically to create the instance data block of the function block "CommMindSphereHandler".



4. Enter the name of the instance DB e.g. "InstCommMindSphereHandler".
5. Select the "Automatic" option so that the instance DB number is automatically assigned by STEP 7.
6. Accept the settings with "OK".



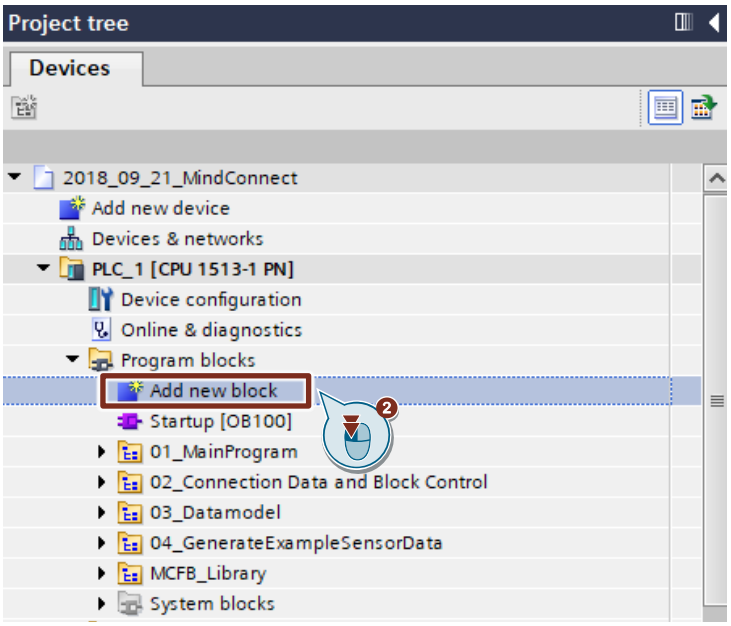
7. Assign the corresponding variables to the inputs and outputs of the function block "CommMindSphereHandler".



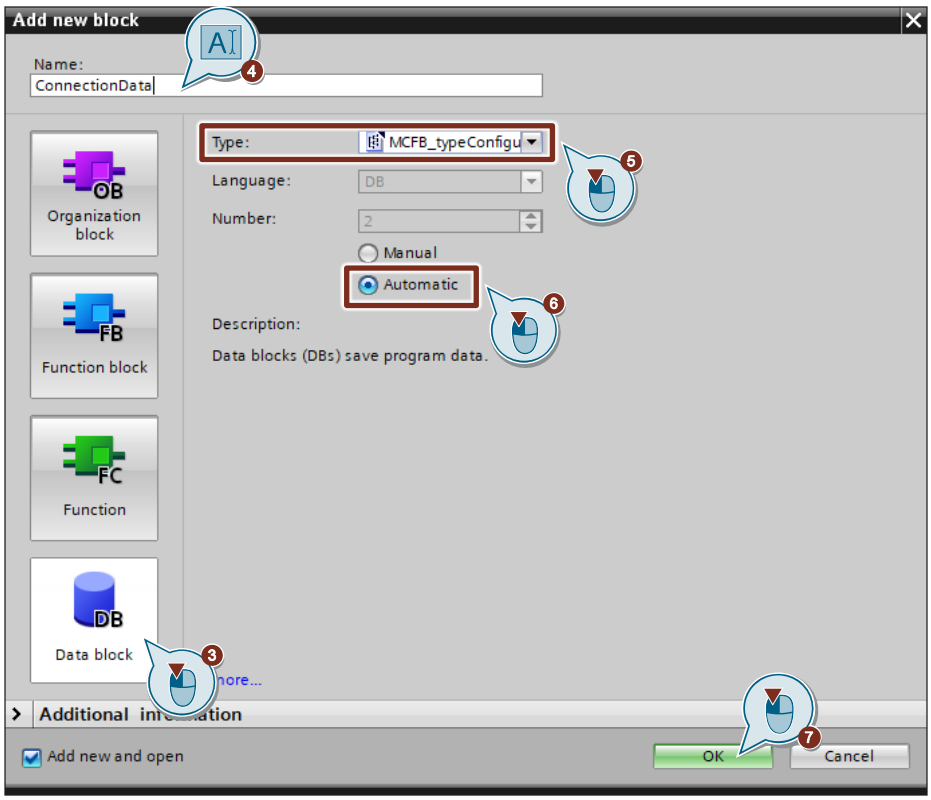
2.2.3 Create the data block with configuration structure "MCFB_typeConfiguration"

Create a data block with the structure of the configuration "MCFB_typeConfiguration" to transfer all information for the onboarding process to the FB "CommMindSphereHandler".

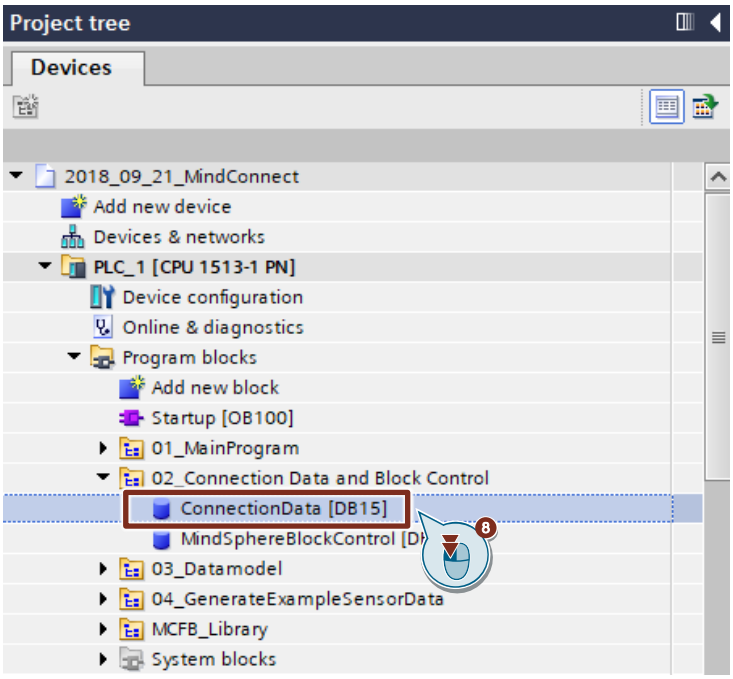
1. Open the project navigation.
2. Double-click in the folder "Program blocks" of your CPU on the entry "Add new block". The dialog "Add new block" opens.



3. Click on the "Data block" icon.
4. Enter the name of the data block (DB), e.g. "ConnectionData".
5. Under "Type" select the PLC data type "MCFB_typeConfiguration".
6. Select the "Automatic" option so that the DB number is automatically assigned by STEP 7.
7. Accept the settings with "OK".



8. In the project navigation, double-click the newly added data block to open it in the workspace.



9. Enter the start values of the connection parameters.

Table 2-2

Parameters	Description
connectionId	Reference for establishing the connection to MindSphere
url	MindSphere address
certificateRef	ID of the certificate for MindSphere. A certificate ID can be retrieved from the Global Security Settings Manager in STEP 7 (TIA Portal) after importing MindSphere Service certificates. It must point to "QuoVadis Root CA 2 G3".
IAT	First authentication token
Tenant	Tenant name
userAgent	Information about the User Agent **Note** This parameter is optional and is currently not used. In this example, it is used to identify the asset.
charset	Character set information **Note** Specify this parameter if a special character is used in the data model. This parameter can be set to "empty" for regular users.

10. At the parameter "configuration" of the FB "CommMindSphereHandler" refer to the DB with the structure of the configuration "MCFB_typeConfiguration".

Note When you generate the connection key in MindSphere when you create the asset, you get the values for the url, IAT, and Tenant parameters.

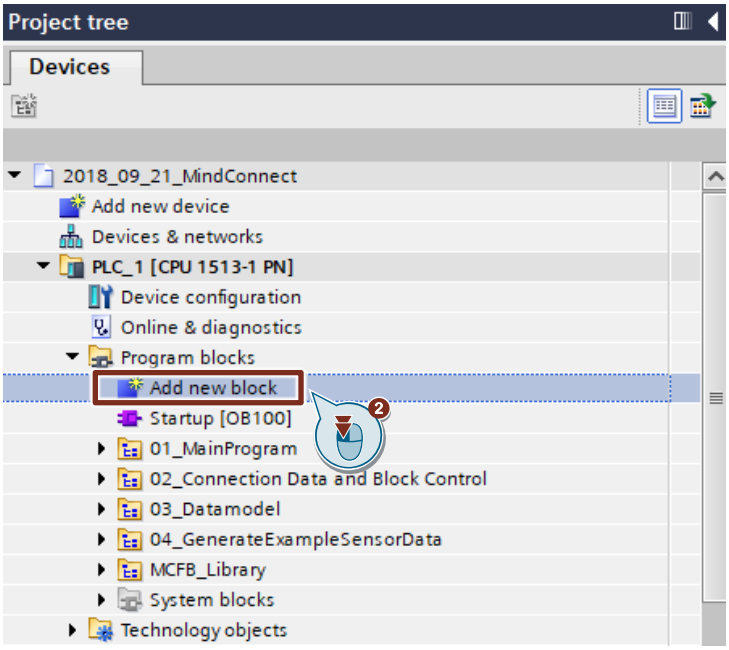
For detailed information on creating an asset and generating the connection key, see the following article:

https://support.industry.siemens.com/cs/ww/en/view/109755908

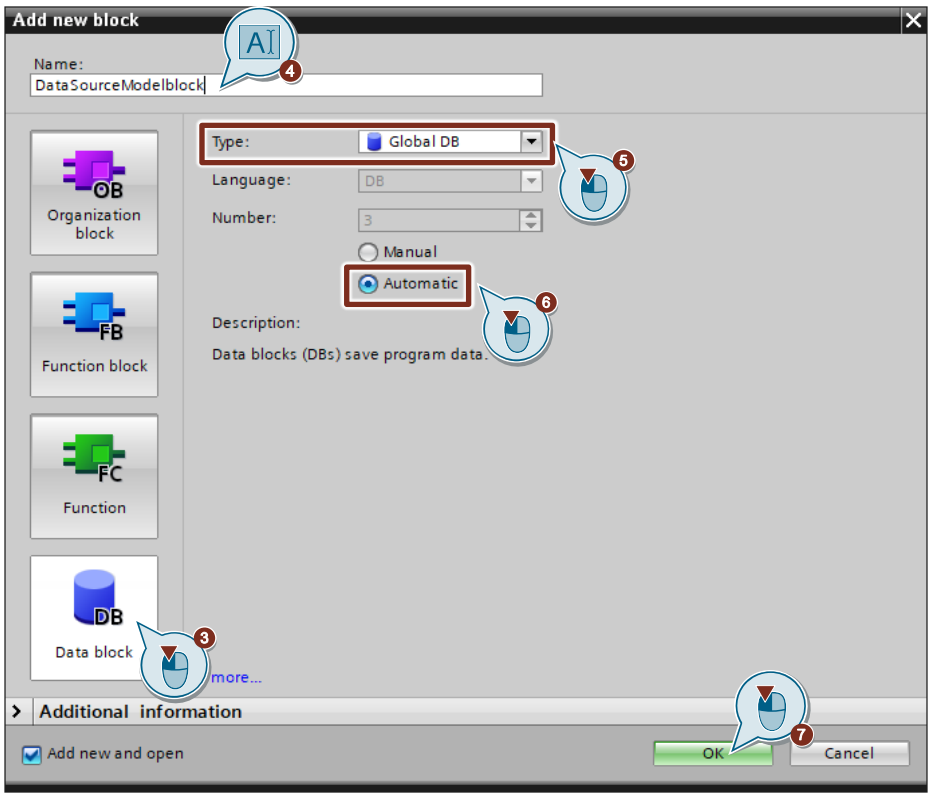
2.2.4 Create the data block with array of the PLC data type "MCFB_typeDataSource"

Create a data block that contains an array of the PLC data type "MCFB_typeDataSource". In this DB, you define the data model that is transferred to MindSphere.

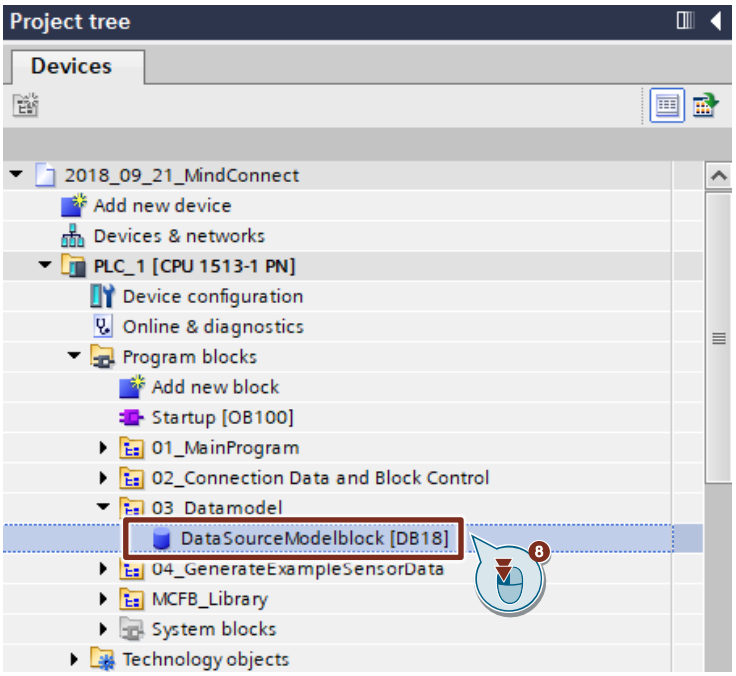
1. Open the project navigation.
2. Double-click in the folder "Program blocks" of your CPU on the entry "Add new block". The dialog "Add new block" opens.



3. Click on the "Data block" icon.
4. Enter the name of the data block (DB), e.g. "DataSourceModelblock".
5. Under "Type", select the entry "Global DB".
6. Select the "Automatic" option so that the DB number is automatically assigned by STEP 7.
7. Accept the settings with "OK".



8. In the project navigation, double-click the newly added data block to open it in the workspace.



9. Define the parameters of the data source model:
   - ID of data point
   - Name of the data source
   - Name of the data point
   - Data type of data point
   - Unit of data point

DataSourceModelblock

	Name	Data type	Start value
1	Static		
2	dataSource	Array[0..199] of "MCFB_typeDataSource"	
3	dataSource[0]	"MCFB_typeDataSource"	
4	dataPointId	Byte	16#1
5	dataSourceName	String	'Motor'
6	dataPointName	String	'speed'
7	dataPointType	String	'INT'
8	dataPointUnit	String	'km/h'
9	dataSource[1]	"MCFB_typeDataSource"	
10	dataPointId	Byte	16#2
11	dataSourceName	String	'Motor'
12	dataPointName	String	'power'
13	dataPointType	String	'DOUBLE'
14	dataPointUnit	String	'kW'
15	dataSource[2]	"MCFB_typeDataSource"	
16	dataSource[3]	"MCFB_typeDataSource"	
17	dataSource[4]	"MCFB_typeDataSource"	
18	dataSource[5]	"MCFB_typeDataSource"	
19	dataSource[6]	"MCFB_typeDataSource"	
20	dataSource[7]	"MCFB_typeDataSource"	

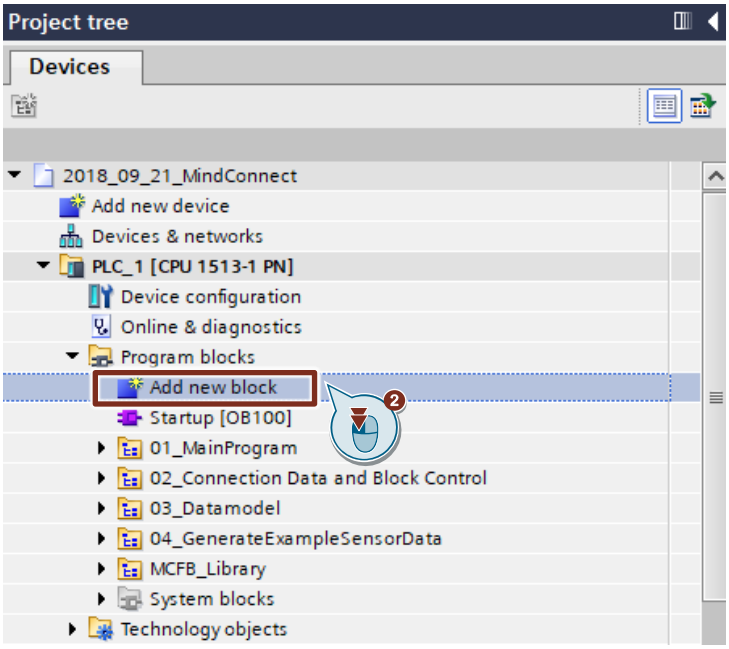
10. Reference at the parameter "dataSource" of the FB "CommMindSpherHandler" to the array of the PLC data type "MCFB_typeDataSource", which you have created and configured in a global DB.

Note The maximum number of data points is 200.

2.2.5 Create the data block of the type "MCFB_Communication"

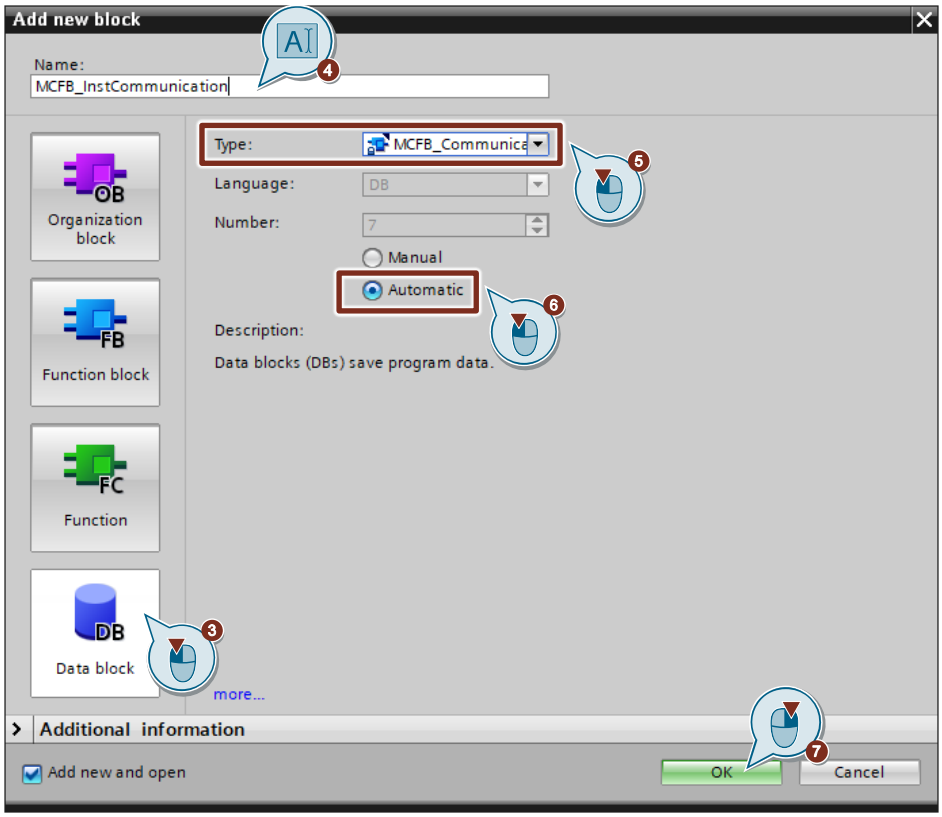
Create a data block of type "MCFB_Communication" to create the instance DB of the FB "MCFB_Communication". You specify the instance DB of the FB "MCFB_Communication" at the parameter "instMCFBCommunication" of the FB "CommMindSphereHandler".

1. Open the project navigation.
2. Double-click in the folder "Program blocks" of your CPU on the entry "Add new block". The dialog "Add new block" opens.



3. Click on the "Data block" icon.
4. Enter the name of the data block (DB), e.g. "MCFB_InstCommunication".
5. Under "Type", select the entry "MFCB_Communication".
6. Select the "Automatic" option so that the DB number is automatically assigned by STEP 7.

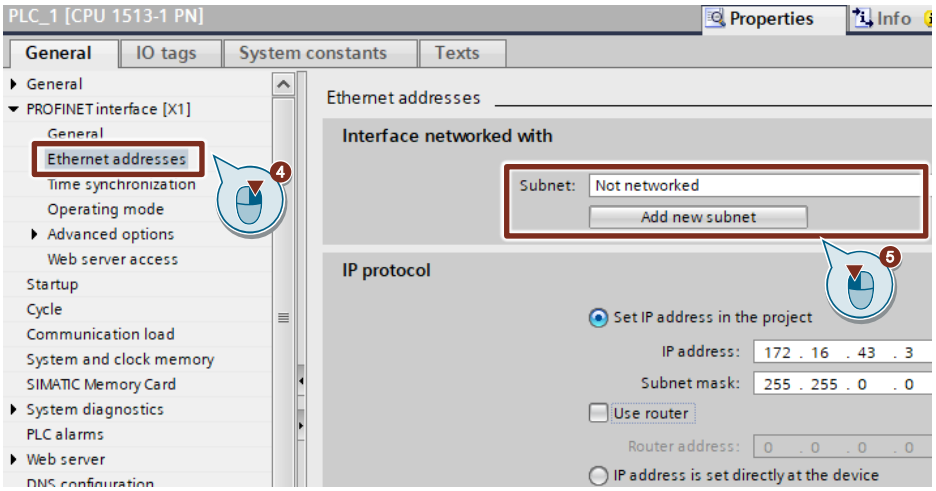
7. Accept the settings with "OK".



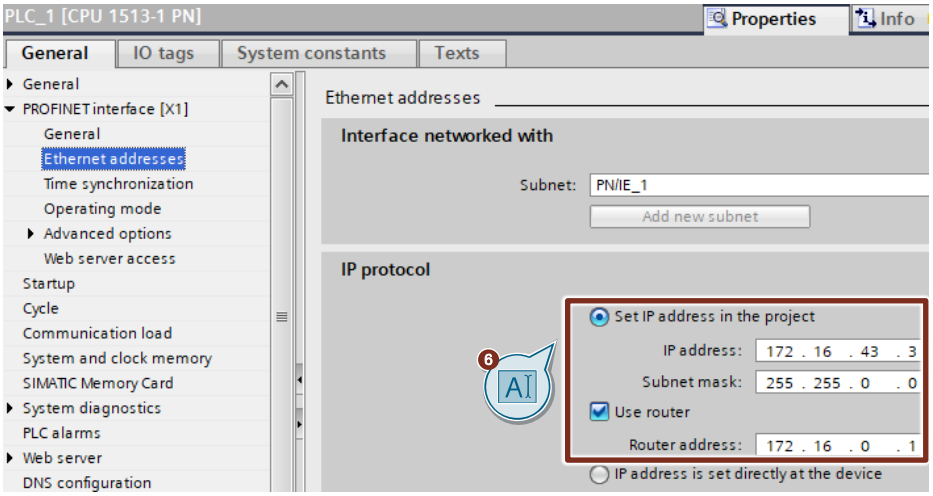
2.2.6 Configuring the network

Proceed as follows to configure the network settings of the S7-1500 CPU:

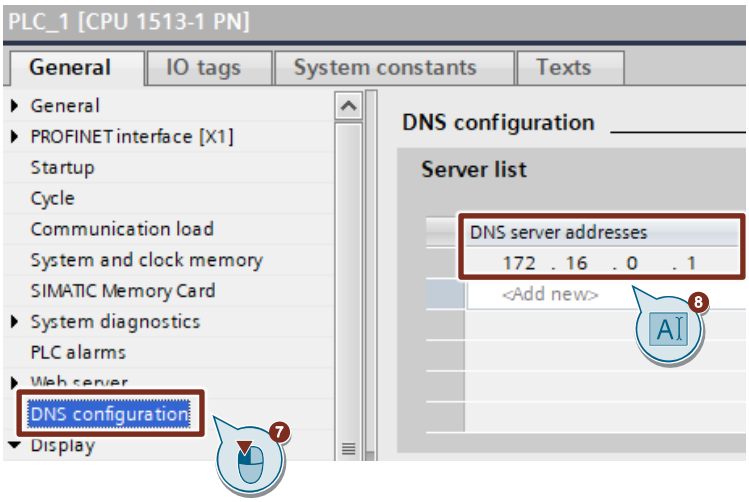
1. Double-click on the entry "Devices & networks" in the project navigation. The hardware and network editor opens in the workspace.
2. Select the "Device view" of the S7-1500 CPU.
3. The properties of the S7-1500 CPU are displayed in the Inspector window.
4. Click on "General > PROFINET interface [X1] > Ethernet addresses".
5. Click on the "Add new subnet" button or select an existing subnet from the drop-down list.



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



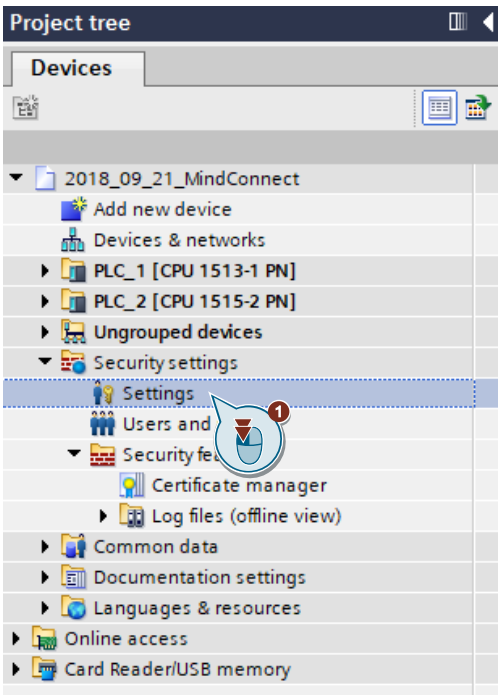
7. Click on "General > DNS configuration".
8. Specify one or more DNS server addresses in the server list.



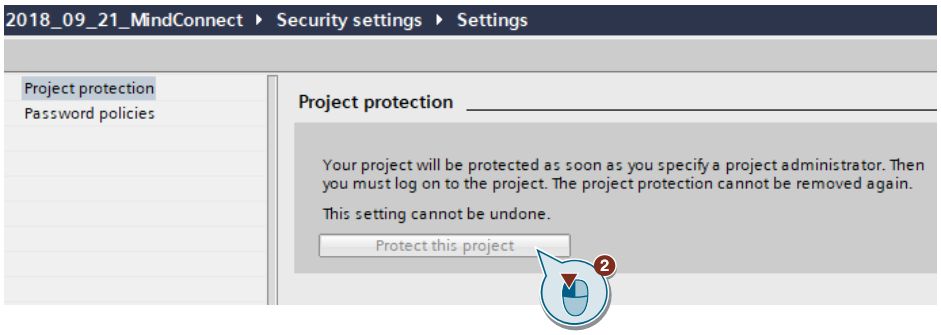
2.2.7 Importing Certificates into STEP 7 (TIA Portal)

To import the MindSphere certificates into STEP 7 (TIA Portal), proceed as follows:

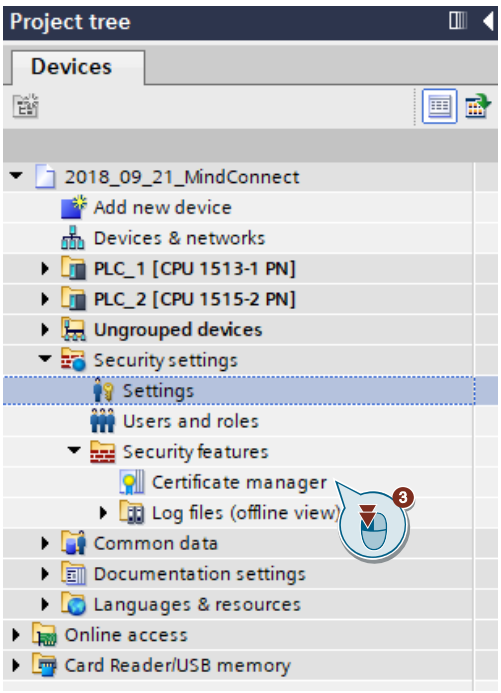
1. Navigate to "Security settings" in the project navigation and double-click on the "Settings" entry to open the security settings in the workspace.



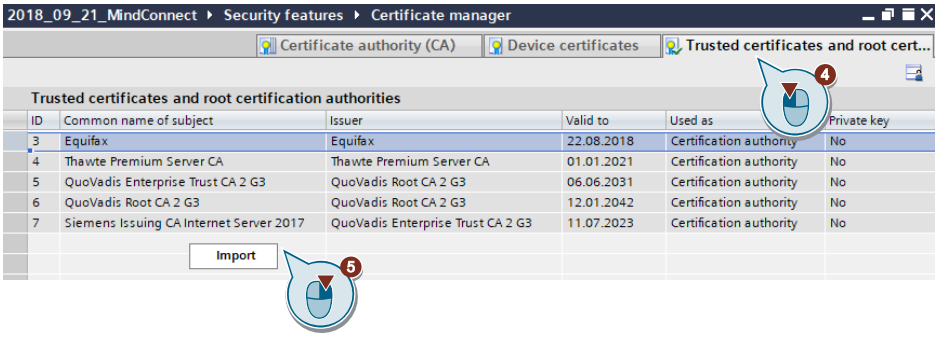
2. Click on the "Protect this project" button or log in.



3. In the project navigation, navigate to "Security settings > Security features" and double-click the "Certificate manager" entry to open the certificate manager in the workspace.



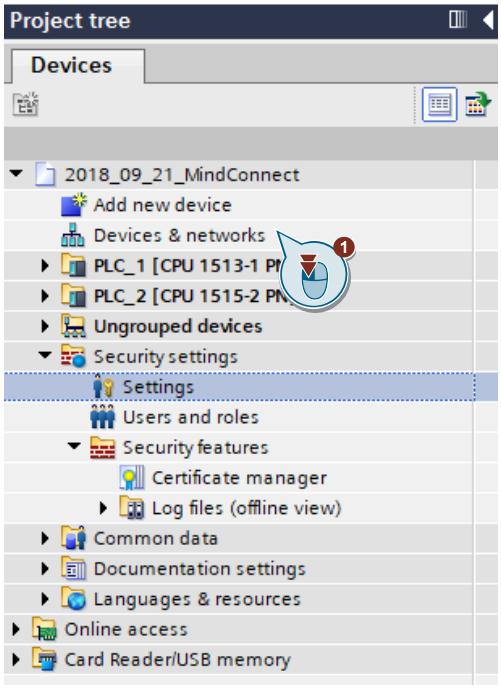
4. Switch to the "Trusted certificates and root certification authorities" tab.
5. Import the following certificates.
   - QuoVadis Root CA 2 G3.cer
   - QuoVadis Enterprise Trust CA 2 G3.cer
   - Siemens Issuing CA Internet Server 2017.cer



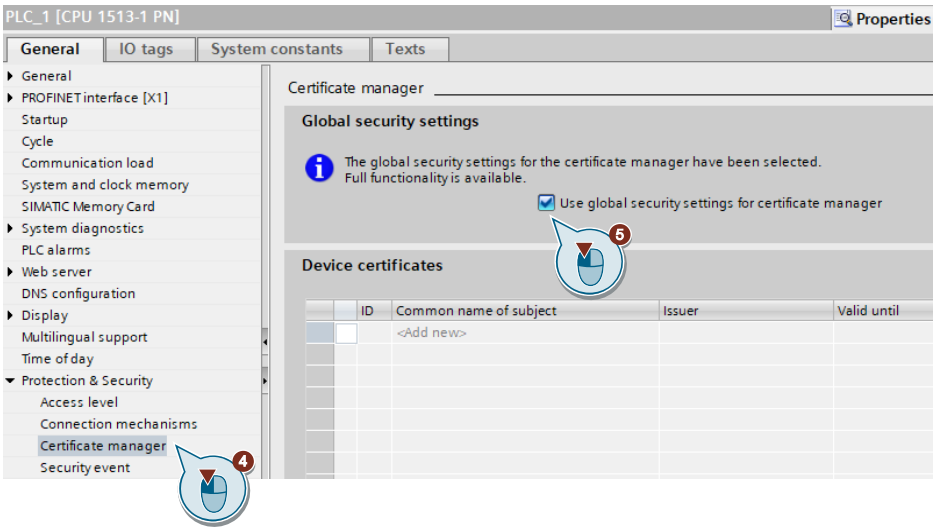
2.2.8 Assign the certificates to the CPU

To assign the MindSphere certificates to your S7-1500 CPU, proceed as follows:

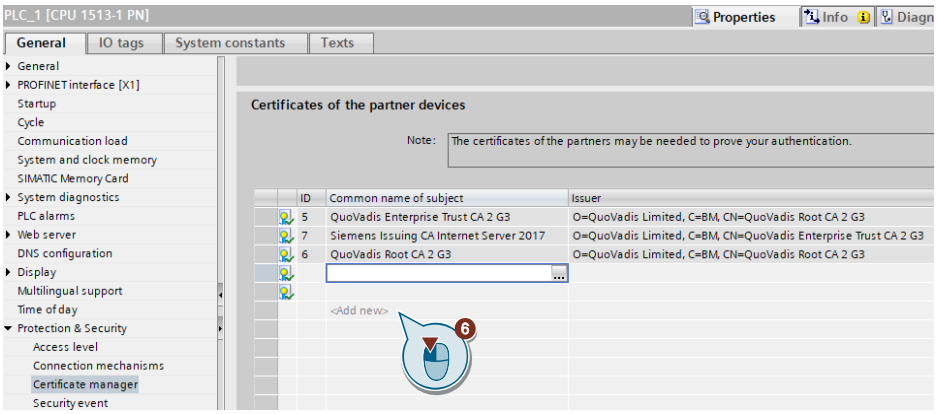
1. Double-click "Devices & Networks" in the project navigation to open the Hardware and Network Editor in the workspace.



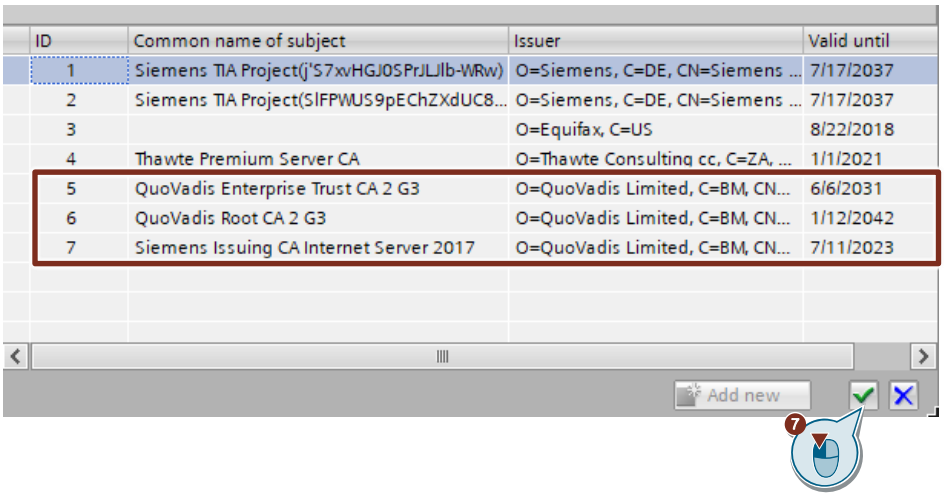
2. Select the "Device view" of the S7-1500 CPU.
3. The properties of the S7-1500 CPU are displayed in the Inspector window.
4. Click on "General > Protection & Security > Certificate manager".
5. Activate the function "Use global security settings for certificate manager".



6. Under "Certificates of the partner devices", click "Add new".



7. Select and add the MindSphere certificates.



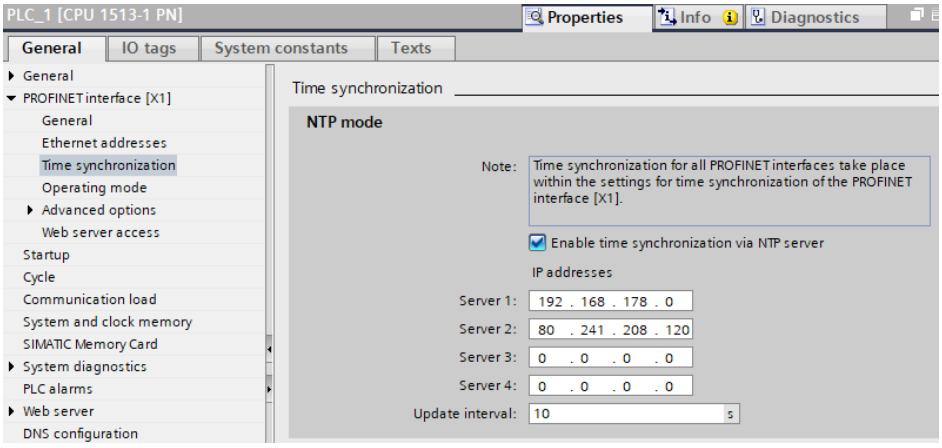
8. The certificates are assigned to your S7-1500 CPU project.
9. The ID of the certificates will be used later. Write them down for later use.

2.2.9 Configuring CPU time

For the connection of the S7-1500 CPU to MindSphere the time of the CPU must be set correctly. Therefore, you must set the "Enable clock synchronization via NTP server" function. Another possibility is to set the CPU time via the online connection.

Time synchronization via NTP server is activated in the properties of the S7-1500 CPU.

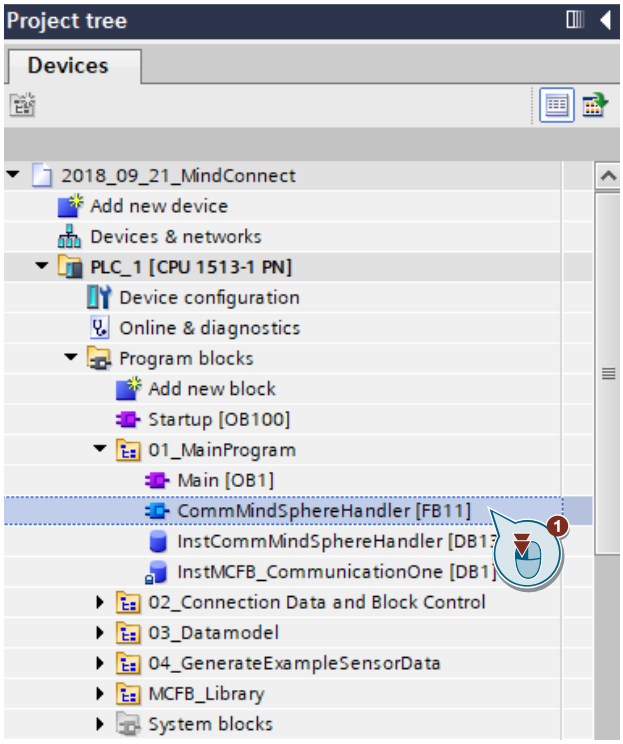
1. Select "General > PROFINET interface [X1] > Time synchronization".
2. Activate the function "Enable time synchronization via NTP server".
3. Reference your own DNS server, for example, if a router provides DNS services, or use a public DNS server.



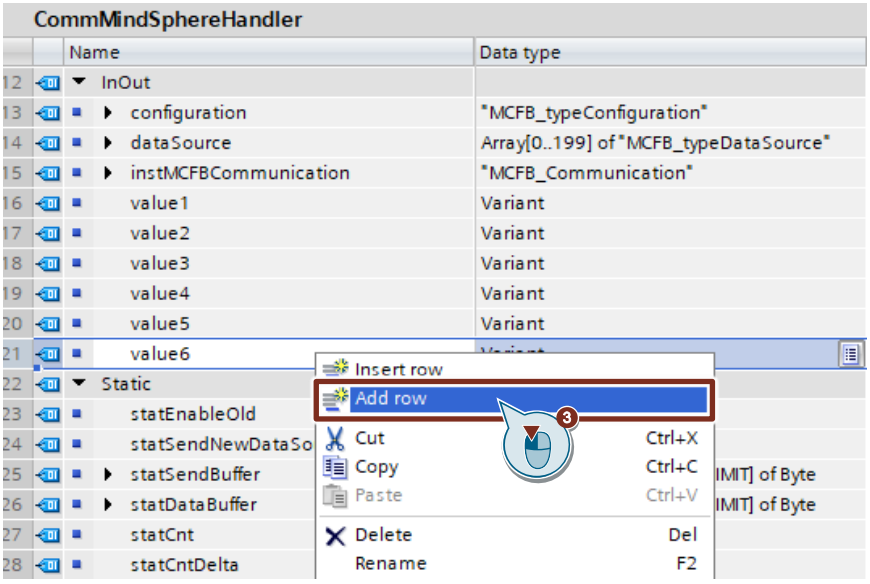
2.2.10 Adjust number of time series

In this application example, six time series are collected and sent to MindSphere. To adjust the number of time series to your application, proceed as follows:

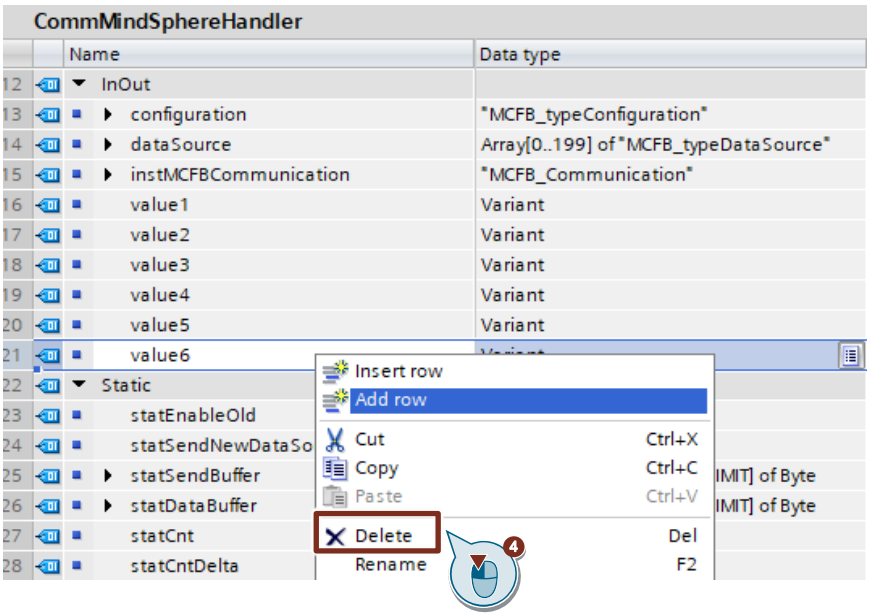
1. Double-click the FB "CommMindSphereHandler" in the project navigation. FB is opened in the work area.



2. In the interface of the FB "CommMindSphereHandler", adapt the number of InOut parameters "value1" to "value6" to your application, i.e. delete or add InOut parameters.
3. To add an InOut parameter, right-click the InOut parameter "value6" and choose the context menu "Add row".



4. To delete an InOut parameter, right-click the InOut parameter you want to delete and choose the "Delete" context menu.



5. Adjust the number of calls of the function "MCFB_CollectDataValue" to your application, i.e. delete or add calls. The function FC "MCFB_CollectDataValue" is called in the region "stateMachine" in the state "STATE_COLLECT_TIME_SERIES". The function FC "MCFB_CollectDataValue" is called for each time series. Information on the parameterization of the function "MCFB_CollectDataValue" can be found in section 3.1.2.

```
#STATE_COLLECT_TIME_SERIES: //collect time series
    REGION Start Collecting Time Series Data
      #statTriggerSendTimeSeries := true;
      #statDone := false;
      #statBusy := true;

      IF #instTimerCollectTimeSeries.Q
      THEN
        REGION Collect Input Process Values
          #statTriggerTimerCollectTimeSeries := false;
          #statCollectTimeSeriesOk := true;
          #statStatusCollectTimeSeries := "MCFB_CollectDataValue"(dataPointId := #dataSource[0].dataPointId,
                                                                  value := #value1,
                                                                  error => #statErrorCollectTimeSeries,
                                                                  dataBuffer := #statDataBuffer,
                                                                  cnt := #statCnt);
          IF #statErrorCollectTimeSeries = TRUE
          THEN
            #statCollectTimeSeriesOk := false;
            #statError := true;
            #statStatus := #statStatusCollectTimeSeries;
            #statStatusId := #STATUS_ID_COLLECT_TIME_SERIES;
            #statIndex := #STATE_ERROR;
          END_IF;

          #statStatusCollectTimeSeries := "MCFB_CollectDataValue"(dataPointId := #dataSource[1].dataPointId,
                                                                  value := #value2,
                                                                  error => #statErrorCollectTimeSeries,
                                                                  dataBuffer := #statDataBuffer,
                                                                  cnt := #statCnt);
```

2.2.11 Adjust size of data buffer and send buffer

In this example, the data buffer and transmit buffer are parameterized with a size of 8000 bytes. You can adjust the size of the data buffer and send buffer in the FB "CommMindSphereHandler" with the value of the constant "LOCAL_BUFFER_LIMIT".

2.3 Error handling

In the FB "CommMindSphereHandler" the error states of the blocks of the "MindConnectFB" library are intercepted and reactions are programmed.

2.3.1 Overview

The following table shows the values and meaning of the output parameters "status" and "statusId" of the FB "CommMindSphereHandler".

Table 2-3

statusId Value (dec)	Meaning	Status Value (hex)	Comment
1	Onboarding error	-	The output parameter "status" of the FB "CommMindSphereHandler" outputs the "status" of the FB "MCFB_Communication". Detailed information can be found in the section 2.3.2.
2	Error during key rotation	-	The output parameter "status" of the FB "CommMindSphereHandler" outputs the "status" of the FB "MCFB_Communication". Detailed information can be found in the section 2.3.3.
3	Error when collecting the data source model	-	The output parameter "status" of the FB "CommMindSphereHandler" outputs the "status" of the FC "MCFB_CollectDataSource". Detailed information can be found in the section 2.3.6.
4	Error when sending the data source model	-	The output parameter "status" of the FB "CommMindSphereHandler" outputs the "status" of the FB "MCFB_Communication". Detailed information can be found in the section 2.3.4.
5	Error when collecting time series	-	The output parameter "status" of the FB "CommMindSphereHandler" outputs the "status" of the FC "MCFB_CollecDataValue". Detailed information can be found in the section 2.3.7.

statusId Value (dec)	Meaning	Status Value (hex)	Comment
6	Error when sending time series	-	The output parameter "status" of the FB "CommMindSphereHandler" outputs the "status" of the FB "MCFB_Communication". Detailed information can be found in the section 2.3.5.
7	Internal error in function module	-	MindSphere not reachable (watchdog timer (5min) expired) Detailed information can be found in the section 2.3.8.

2.3.2 Onboarding error

Server does not respond

If the server does not respond, the output parameters of the FB "CommMindSphereHandler" are set for one cycle as in Table 2-4. Possible causes for this error are network connection problems:

- The company's router may have network problems or Ethernet cables are not plugged in.
- The Internet configuration is invalid, such as IP address or DNS configuration.
- The server is not available due to internal errors.

Table 2-4

Output parameters	Value	Description	Remedy
status	16#8000	Status display of the FB "MCFB_Communication": Server does not respond	• Check the physical connection: - Router of the company - Ethernet cable and so on. • Check your Internet connection: - IP address - DNS configuration etc.
statusId	1	Error during onboarding with FB "MCFB_Communication".	
error	1	Error display: 1: Error identified	

Communication error

The communication error occurs when the connection with a valid certificate fails. The output parameters of the FB "CommMindSphereHandler" are set for one cycle as follows.

Table 2-5

Output parameters	Value	Description	Remedy
status	16#8001	Status display of the FB "MCFB_Communication": Communication error	• Check your Internet connection: - IP address - DNS configuration etc.
statusId	1	Error during onboarding with FB "MCFB_Communication".	
error	1	Error display: 1: Error identified	

Server identity is not verified

If the server identity is not proven, the output parameters of the FB "CommMindSphereHandler" are set for a cycle as in Table 2-6. The following causes lead to this error:

- Internal error.
- The key has expired.

Table 2-6

Output parameters	Value	Description	Remedy
status	16#8012	Status display of the FB "MCFB_Communication": Server identity not verified	• Make sure that the instance data block has not been modified by the software. • Renew the authentication key with a key rotation job.
statusId	1	Error during onboarding with FB "MCFB_Communication".	
error	1	Error display: 1: Error identified	

Onboarding for S7-1500 CPU already finished

If the onboarding for the S7-1500 CPU has already been done, the output parameters of the FB "CommMindSphereHandler" are set for one cycle as in Table 2-7 and Table 2-8. The following causes lead to this error:

- Status of the FB "MCFB_Communication" in asset configuration is "onboarded".
- Onboarding data, such as IAT and registration URL, are added to the FB "MCFB_Communication".

Table 2-7

Output parameters	Value	Description	Remedy
status	16#8004	Status display of the FB "MCFB_Communication": Onboarding for S7-1500 already done	• Check the onboarding status of an asset in MindSphere. • Check that the communication configuration includes IAT and registration URL.
statusId	1	Error during onboarding with FB "MCFB_Communication".	
error	1	Error display: 1: Error identified	

Other possible causes lead to this error:

- Asset is "onboarded", but still has the status "off-boarded" in MindSphere.
- Asset has the status "onboarded" in MindSphere.

Table 2-8

Output parameters	Value	Description	Remedy
status	16#8004	Status display of the FB "MCFB_Communication": Onboarding for S7-1500 already done	• Make sure that the instance data block has not been modified by the software. • If the onboarding for the S7-1500 CPU has already been done, the project has been loaded into the S7-1500 CPU and the instance DB of the FB "MCFB_ Communication" has been changed, you have to perform the following: - Execute the offboarding for the asset in the MindSphere user interface. - Create a new IAT in the MindSphere user interface. - Execute the onboarding of the S7-1500 CPU again with the new IAT.
statusId	1	Error during onboarding with FB "MCFB_Communication".	
Error	1	Error display: 1: Error identified	

Connection ID is invalid

If the connection ID is invalid, the output parameters of the FB "CommMindSphereHandler" for one cycle are set as follows.

Table 2-9

Output parameters	Value	Description	Remedy
status	16#8007	Status display of the FB "MCFB_Communication": Connection ID is invalid	Change the parameter "conenctionId" in the data block with the structure of the configuration "MCFB_typeConfiguration".
statusId	1	Error during onboarding with FB "MCFB_Communication".	
Error	1	Error display: 1: Error identified	

IAT is invalid

If the IAT is invalid, the output parameters of the FB "CommMindSphereHandler" for one cycle are set as follows.

Table 2-10

Output parameters	Value	Description	Remedy
status	16#8011	Status display of the FB "MCFB_Communication": IAT is invalid	Check the IAT character string.
statusId	1	Error during onboarding with FB "MCFB_Communication".	
Error	1	Error display: 1: Error identified	

Certificate reference ID is invalid

If the certificate reference ID is invalid, the output parameters of the FB "CommMindSphereHandler" for one cycle are set as follows.

Table 2-11

Output parameters	Value	Description	Remedy
status	16#8009	Status display of the FB "MCFB_Communication": Certificate reference ID is invalid	Check the certificate ID in STEP 7 (TIA Portal) in the certificate manager.
statusId	1	Error during onboarding with FB "MCFB_Communication".	
Error	1	Error display: 1: Error identified	

URL is invalid.

If an addressed URL type is invalid or not supported, the output parameters of the FB "CommMindSphereHandler" for a cycle are set as follows.

Table 2-12

Output parameters	Value	Description	Remedy
status	16#8008	Status display of the FB "MCFB_Communication": URL is invalid.	Check the URL type you entered. The following URL types are supported: • https://host/path • https://host:port/path • host/path • host:port/path
statusId	1	Error during onboarding with FB "MCFB_Communication".	
Error	1	Error display: 1: Error identified	

Internal error

The internal error occurs when the instance data block of the FB "MCFB_Communication" is changed. The output parameters of the FB "CommMindSphereHandler" are set for one cycle as follows.

Table 2-13

Output parameters	Value	Description	Remedy
status	16#80EE	Status display of the FB "MCFB_Communication": Internal error	Make sure that the instance data block of the FB "MCFB_Communication" has not been changed.
statusId	1	Error during onboarding with FB "MCFB_Communication".	
Error	1	Error display: 1: Error identified	

2.3.3 Error during key rotation

Server does not respond

If the server does not respond, the output parameters of the FB "CommMindSphereHandler" are set for one cycle as in Table 2-14. Possible causes for this error are network connection problems:

- The company's router may have network problems or Ethernet cables are not plugged in.
- The Internet configuration is invalid, such as IP address or DNS configuration.
- The server is not available due to internal errors.

Table 2-14

Output parameters	Value	Description	Remedy
status	16#8000	Status display of the FB "MCFB_Communication": Server does not respond	• Check the physical connection: - Router of the company - Ethernet cable and so on. • Check your Internet connection: - IP address - DNS configuration etc.
statusId	2	Error during key rotation with FB "MCFB_Communication".	
error	1	Error display: 1: Error identified	

Communication error

The communication error occurs when the connection with a valid certificate fails. The output parameters of the FB "CommMindSphereHandler" are set for one cycle as follows.

Table 2-15

Output parameters	Value	Description	Remedy
status	16#8001	Status display of the FB "MCFB_Communication": Communication error	• Check your Internet connection: - IP address - DNS configuration etc.
statusId	2	Error during key rotation with FB "MCFB_Communication".	
error	1	Error display: 1: Error identified	

Onboarding for S7-1500 CPU has not been performed yet

As long as the IAT and registration URL have not yet been included in the communication DB, the onboarding for the S7-1500 CPU has not yet taken place. The output parameters of the FB "CommMindSphereHandler" are set for one cycle as follows.

Table 2-16

Output parameters	Value	Description	Remedy
status	16#8006	Status display of the FB "MCFB_Communication": Onboarding for S7-1500 CPU has not been performed yet	• Check whether the FB "MCFB_Communication" has IAT and registration URL. • Follow the steps to onboard the S7-1500 CPU.
statusId	2	Error during key rotation with FB "MCFB_Communication".	
error	1	Error display: 1: Error identified	

Internal error

The internal error occurs when the instance data block of the FB "MCFB_Communication" is changed. The output parameters of the FB "CommMindSphereHandler" are set for one cycle as follows.

Table 2-17

Output parameters	Value	Description	Remedy
status	16#80EE	Status display of the FB "MCFB_Communication": Internal error	Make sure that the instance data block of the FB "MCFB_Communication" has not been changed.
statusId	2	Error during key rotation with FB "MCFB_Communication".	
Error	1	Error display: 1: Error identified	

2.3.4 Error when sending the data source model

Server does not respond

If the server does not respond, the output parameters of the FB "CommMindSphereHandler" are set for one cycle as in Table 2-18. Possible causes for this error are network connection problems:

- The company's router may have network problems or Ethernet cables are not plugged in.
- The Internet configuration is invalid, such as IP address or DNS configuration.
- The server is not available due to internal errors.

Table 2-18

Output parameters	Value	Description	Remedy
status	16#8000	Status display of the FB "MCFB_Communication": Server does not respond	• Check the physical connection: - Router of the company - Ethernet cable and so on. • Check your Internet connection: - IP address - DNS configuration etc.
statusId	4	Error when sending the data source model with FB "MCFB_Communication".	
error	1	Error display: 1: Error identified	

Communication error

The communication error occurs when the connection with a valid certificate fails. The output parameters of the FB "CommMindSphereHandler" are set for one cycle as follows.

Table 2-19

Output parameters	Value	Description	Remedy
status	16#8001	Status display of the FB "MCFB_Communication": Communication error	• Check your Internet connection: - IP address - DNS configuration etc.
statusId	4	Error when sending the data source model with FB "MCFB_Communication".	
error	1	Error display: 1: Error identified	

Server identity is not verified

If the server identity is not proven, the output parameters of the FB "CommMindSphereHandler" are set for a cycle as in Table 2-20. The following causes lead to this error:

- Internal error.
- The key has expired.

Table 2-20

Output parameters	Value	Description	Remedy
status	16#8012	Status display of the FB "MCFB_Communication": Server identity not verified	• Make sure that the instance data block has not been modified by the software. • Renew the authentication key with a key rotation job.
statusId	4	Error when sending the data source model with FB "MCFB_Communication".	
error	1	Error display: 1: Error identified	

Data point ID is invalid

If a data source model or time series is sent without configured data points, the output parameters of the FB "CommMindSphereHandler" are set for a cycle as follows.

Table 2-21

Output parameters	Value	Description	Remedy
status	16#8015	Status display of the FB "MCFB_Communication": Data point ID is invalid	Make sure that the data is written correctly to the data buffer area.
statusId	4	Error when sending the data source model with FB "MCFB_Communication".	
error	1	Error display: 1: Error identified	

TSEND or TRCV returns an error

TSEND or TRCV returns an error if the upload failed. The output parameters of the FB "CommMindSphereHandler" are set for one cycle as follows.

Table 2-22

Output parameters	Value	Description	Remedy
status	16#8002	Status display of the FB "MCFB_Communication": TSEND or TRCV returns an error	• Check the connection between the FB "MCFB_Communication" and your data source. • Check the configuration of the data source: - FC "MCFB_CollectData Source" - FC "MCFB_CollectData Value" • Check the address of each data point.
statusId	4	Error when sending the data source model with FB "MCFB_Communication".	
error	1	Error display: 1: Error identified	

Other possible causes lead to this error:

- Connection ID parameter changed after onboarding.
- Internal error

Table 2-23

Output parameters	Value	Description	Remedy
status	16#8002	Status display of the FB "MCFB_Communication": TSEND or TRCV returns an error	Make sure that the Connection ID parameter is not changed after onboarding.
statusId	4	Error when sending the data source model with FB "MCFB_Communication".	
error	1	Error display: 1: Error identified	

Onboarding for S7-1500 CPU has not been performed yet

As long as the IAT and registration URL have not yet been included in the communication DB, the onboarding for the S7-1500 CPU has not yet taken place. The output parameters of the FB "CommMindSphereHandler" are set for one cycle as follows.

Table 2-24

Output parameters	Value	Description	Remedy
status	16#8006	Status display of the FB "MCFB_Communication": Onboarding for S7-1500 CPU has not been performed yet	• Check whether the FB "MCFB_Communication" has IAT and registration URL. • Follow the steps to onboard the S7-1500 CPU.
statusId	4	Error when sending the data source model with FB "MCFB_Communication".	
error	1	Error display: 1: Error identified	

Data source model is too large.

If the buffer size limit is reached and no data can be sent, the output parameters of the FB "CommMindSphereHandler" are set for one cycle as follows.

Output parameters	Value	Description	Remedy
status	16#8111	Status display of the FB "MCFB_Communication": Data source model is too large.	• The maximum data source model includes 200 data points or approx. 6000 bytes. • Try using fewer data points or reduce the data size by using shorter strings.
statusId	4	Error when sending the data source model with FB "MCFB_Communication".	
error	1	Error display: 1: Error identified	

Internal error

The internal error occurs when the instance data block of the FB "MCFB_Communication" is changed. The output parameters of the FB "CommMindSphereHandler" are set for one cycle as follows.

Table 2-25

Output parameters	Value	Description	Remedy
status	16#80EE	Status display of the FB "MCFB_Communication": Internal error	Make sure that the instance data block of the FB "MCFB_Communication" has not been changed.
statusId	4	Error when sending the data source model with FB "MCFB_Communication".	
Error	1	Error display: 1: Error identified	

2.3.5 Error when sending time series

Server does not respond

If the server does not respond, the output parameters of the FB "CommMindSphereHandler" are set for one cycle as in Table 2-26. Possible causes for this error are network connection problems:

- The company's router may have network problems or Ethernet cables are not plugged in.
- The Internet configuration is invalid, such as IP address or DNS configuration.
- The server is not available due to internal errors.

Table 2-26

Output parameters	Value	Description	Remedy
status	16#8000	Status display of the FB "MCFB_Communication": Server does not respond	• Check the physical connection: - Router of the company - Ethernet cable and so on. • Check your Internet connection: - IP address - DNS configuration etc.
statusId	6	Error when sending the time series with FB "MCFB_Communication".	
error	1	Error display: 1: Error identified	

Communication error

The communication error occurs when the connection with a valid certificate fails. The output parameters of the FB "CommMindSphereHandler" are set for one cycle as follows.

Table 2-27

Output parameters	Value	Description	Remedy
status	16#8001	Status display of the FB "MCFB_Communication": Communication error	• Check your Internet connection: - IP address - DNS configuration etc.
statusId	6	Error when sending the time series with FB "MCFB_Communication".	
error	1	Error display: 1: Error identified	

Server identity is not verified

If the server identity is not proven, the output parameters of the FB "CommMindSphereHandler" are set for a cycle as in Table 2-28 . The following causes lead to this error:

- Internal error.
- The key has expired.

Table 2-28

Output parameters	Value	Description	Remedy
status	16#8012	Status display of the FB "MCFB_Communication": Server identity not verified	• Make sure that the instance data block has not been modified by the software. • Renew the authentication key with a key rotation job.
statusId	6	Error when sending the time series with FB "MCFB_Communication".	
error	1	Error display: 1: Error identified	

Data point ID is invalid

If a data source model or a time series is sent without configured data points, then the output parameters of the FB "CommMindSphereHandler" are set for a cycle as follows.

Output parameters	Value	Description	Remedy
status	16#8015	Status display of the FB "MCFB_Communication": Data point ID is invalid	Make sure that the data is written correctly to the data buffer area.
statusId	6	Error when sending the time series with FB "MCFB_Communication".	
error	1	Error display: 1: Error identified	

TSEND or TRCV returns an error

TSEND or TRCV returns an error if the upload failed. The output parameters of the FB "CommMindSphereHandler" are set for one cycle as follows.

Table 2-29

Output parameters	Value	Description	Remedy
status	16#8002	Status display of the FB "MCFB_Communication": TSEND or TRCV returns an error	• Check the connection between the FB "MCFB_Communication" and your data source. • Check the configuration of the data source: - FC "MCFB_CollectData Source" - FC "MCFB_CollectData Value" • Check the address of each data point.
statusId	6	Error when sending the time series with FB "MCFB_Communication".	
error	1	Error display: 1: Error identified	

Other possible causes lead to this error:

- Connection ID parameter changed after onboarding.
- Internal error

Table 2-30

Output parameters	Value	Description	Remedy
status	16#8002	Status display of the FB "MCFB_Communication": TSEND or TRCV returns an error	Make sure that the Connection ID parameter is not changed after onboarding.
statusId	6	Error when sending the time series with FB "MCFB_Communication".	
error	1	Error display: 1: Error identified	

Onboarding for S7-1500 CPU has not been performed yet

As long as the IAT and registration URL have not yet been included in the communication DB, the onboarding for the S7-1500 CPU has not yet taken place. The output parameters of the FB "CommMindSphereHandler" are set for one cycle as follows.

Table 2-31

Output parameters	Value	Description	Remedy
status	16#8006	Status display of the FB "MCFB_Communication": Onboarding for S7-1500 CPU has not been performed yet	• Check whether the FB "MCFB_Communication" has IAT and registration URL. • Follow the steps to onboard the S7-1500 CPU.
statusId	6	Error when sending the time series with FB "MCFB_Communication".	
error	1	Error display: 1: Error identified	

Internal error

The internal error occurs when the instance data block of the FB "MCFB_Communication" is changed. The output parameters of the FB "CommMindSphereHandler" are set for one cycle as follows.

Table 2-32

Output parameters	Value	Description	Remedy
status	16#80EE	Status display of the FB "MCFB_Communication": Internal error	Make sure that the instance data block of the FB "MCFB_Communication" has not been changed.
statusId	6	Error when sending the time series with FB "MCFB_Communication".	
Error	1	Error display: 1: Error identified	

2.3.6 Error when collecting the data source model

Buffer is full

The buffer is full when the collected data has reached the allowable limit of the buffer area. The output parameters of the FB "CommMindSphereHandler" are set for one cycle as follows.

Table 2-33

Output parameters	Value	Description	Remedy
status	16#8101	Status display of the FC "MCFB_CollectDataSource": Buffer is full	Increase the buffer memory area to a maximum of 6000 bytes or use a smaller data source model.
statusId	3	Error when collecting the data model with FC "MCFB_CollectDataSource"	
Error	1	Error display: 1: Error identified	

Buffer limit exceeded

The buffer limit is exceeded if the parameter "cnt" is negative or greater than the buffer length. The output parameters of the FB "CommMindSphereHandler" are set for one cycle as follows.

Table 2-34

Output parameters	Value	Description	Remedy
status	16#8102	Status display of the FC "MCFB_CollectDataSource": Buffer limit exceeded	Do not change the "cnt" parameter.
statusId	3	Error when collecting the data model with FC "MCFB_CollectDataSource"	
Error	1	Error display: 1: Error identified	

Name of the data source is invalid

The data source name is invalid if the string length of the aspect name is zero. The output parameters of the FB "CommMindSphereHandler" are set for one cycle as follows.

Table 2-35

Output parameters	Value	Description	Remedy
status	16#8104	Status display of the FC "MCFB_CollectDataSource": Name of the data structure is invalid	Specify an aspect name.
statusId	3	Error when collecting the data model with FC "MCFB_CollectDataSource"	
Error	1	Error display: 1: Error identified	

Data point type is invalid

The datapoint type is invalid if a variable of unsupported datatype is associated with the FC "MCFB_CollectDataValue" function. The output parameters of the FB "CommMindSphereHandler" are set for one cycle as follows.

Table 2-36

Output parameters	Value	Description	Remedy
status	16#8105	Status display of the FC "MCFB_CollectDataSource": Data point type is invalid	Check the data types supported by the S7-1500 CPU and MindSphere (see section 3.1.1).
statusId	3	Error when collecting the data model with FC "MCFB_CollectDataSource"	
Error	1	Error display: 1: Error identified	

Data point name is invalid

The data point name is invalid if the length and characters of a variable name are invalid. The output parameters of the FB "CommMindSphereHandler" are set for one cycle as follows.

Table 2-37

Output parameters	Value	Description	Remedy
status	16#8106	Status display of the FC "MCFB_CollectDataSource": Data point name is invalid	Check the length and characters of the variable name. • The string length of the variable name must be at least 1. • The variable name must begin with a letter "a to z" or "A to Z". • It is permissible to include numbers and spaces, e.g. "(", ")", "_". Question marks are not allowed.
statusId	3	Error when collecting the data model with FC "MCFB_CollectDataSource"	
Error	1	Error display: 1: Error identified	

Unit of data point is invalid

The unit of the data point is invalid if the string length of the unit is zero. The output parameters of the FB "CommMindSphereHandler" are set for one cycle as follows.

Table 2-38

Output parameters	Value	Description	Remedy
status	16#8107	Status display of the FC "MCFB_CollectDataSource": Unit of data point is invalid	Specify a unit for a value.
statusId	3	Error when collecting the data model with FC "MCFB_CollectDataSource"	
Error	1	Error display: 1: Error identified	

Data source model is too large

The data source model is too large if the limit for the data source model is reached and no data can be sent. The output parameters of the FB "CommMindSphereHandler" are set for one cycle as follows.

Table 2-39

Output parameters	Value	Description	Remedy
status	16#8111	Status display of the FC "MCFB_CollectDataSource": Data source model is too large	• Create a data source model smaller than 6000 bytes. • Increase the buffer size to 6000 bytes.
statusId	3	Error when collecting the data model with FC "MCFB_CollectDataSource"	
Error	1	Error display: 1: Error identified	

2.3.7 Error when collecting time series

Buffer is full

The buffer is full when the collected data has reached the allowable limit of the buffer area. The output parameters of the FB "CommMindSphereHandler" are set for one cycle as follows.

Table 2-40

Output parameters	Value	Description	Remedy
status	16#8111	Status display of the FC "MCFB_CollectDataValue": Buffer is full	• Increase the buffer memory area of the data buffer data block. • Send the data with the input "sendTimeseries" of the FB "MCFB_ Communication" before you enter further data.
statusId	5	Error when collecting time series with FC "MCFB_CollectDataValue".	
Error	1	Error display: 1: Error identified	

Buffer limit exceeded

The buffer limit is exceeded if the parameter "cnt" is negative or greater than the buffer length. The output parameters of the FB "CommMindSphereHandler" are set for one cycle as follows.

Table 2-41

Output parameters	Value	Description	Remedy
status	16#8102	Status display of the FC "MCFB_CollectDataValue": Buffer limit excedded	Do not change the "cnt" parameter.
statusId	5	Error when collecting time series with FC "MCFB_CollectDataValue".	
Error	1	Error display: 1: Error identified	

The data type of the value is invalid.

The data type of the value is invalid if the length of the string of the value is zero. The output parameters of the FB "CommMindSphereHandler" are set for one cycle as follows.

Table 2-42

Output parameters	Value	Description	Remedy
status	16#8109	Status display of the FC "MCFB_CollectDataValue": Data type of value is invalid	• Specify a valid data type of a variable. • Inform yourself about the permitted S7-1500 data types (see section 3.1.1).
statusId	5	Error when collecting time series with FC "MCFB_CollectDataValue".	
Error	1	Error display: 1: Error identified	

2.3.8 MindSphere not reachable (Watchdog)

If an error occurs while executing one of the following processes, the watchdog timer is started.

- Onboarding
- Key rotation
- Sending data source model
- Sending time series

If one of the above processes is successfully executed within 5 minutes, the watchdog timer is reset again. The FB "CommMindSphereHandler" internally tries to reinitiate the processing every 60 seconds.

If MindSphere cannot be reached for 5 minutes, the output parameters of the FB "CommMindSphereHandler" are set for one cycle as follows.

Table 2-43

Output parameters	Value	Description	Remedy
status	16#8701	MindSphere not reachable (watchdog timer (5 min) expired)	Check which process started the watchdog timer and which error caused the watchdog timer to start. Correct the cause of the error and start the processing of the FB "CommMindSphereHandler" again via the parameter "enable=1". For information on the causes and troubleshooting, refer to the following sections: • Onboarding error: Section 2.3.2 • Key rotation error: Section 2.3.3 • Error when sending the data source model: Section 2.3.4 • Error when sending time series: Section 2.3.5
statusId	7	internal error in function module	
Error	1	Error display: 1: Error identified	

3 Useful information

3.1 Basics

3.1.1 Using data of a MindConnect element, e.g. S7-1500 CPU or S7-1200 CPU, in MindSphere

After onboarding a MindConnect element, you must configure the data in the Asset Manager. To receive data from your MindConnect element, you must establish a data connection.

To use the data from your MindConnect element in MindSphere, you must map the received data to the Asset Manager data model.

The Asset Manager uses the following areas:

- Assets
- Types
- Aspects

To configure data in the Asset Manager, you must perform the following steps:

- Creating aspects and variables
  In this step, you create aspects and variables that you want to use in MindSphere.
- Creating a type in the asset manager
  In this step, you create an asset type to enable data mapping.
- Adding a data source
  The data source defines the reading of the data from the MindConnect element.
  Note
  The data source model is transferred to MindSphere via the FB "CommMindSphereHandler".
- Assigning an aspect to a data source
  In this last step, you map the data of the MindConnect element to the Aspects and Variables in MindSphere.

For detailed information about using the data of a MindConnect element in MindSphere, see the following manual:

https://support.industry.siemens.com/cs/ww/en/view/109755908

3.1.2 Basics on the library "MindConnectFB"

The library "MindConnectFB" provides the following library blocks to connect the S7-1500 CPU to MindSphere.

- FB "MCFB_Communication"
- FC "MCFB_CollectDataSource"
- FC "MCFB_CollectDataValue"

A description and information on the parameterization of the above mentioned library blocks can be found in the following article:

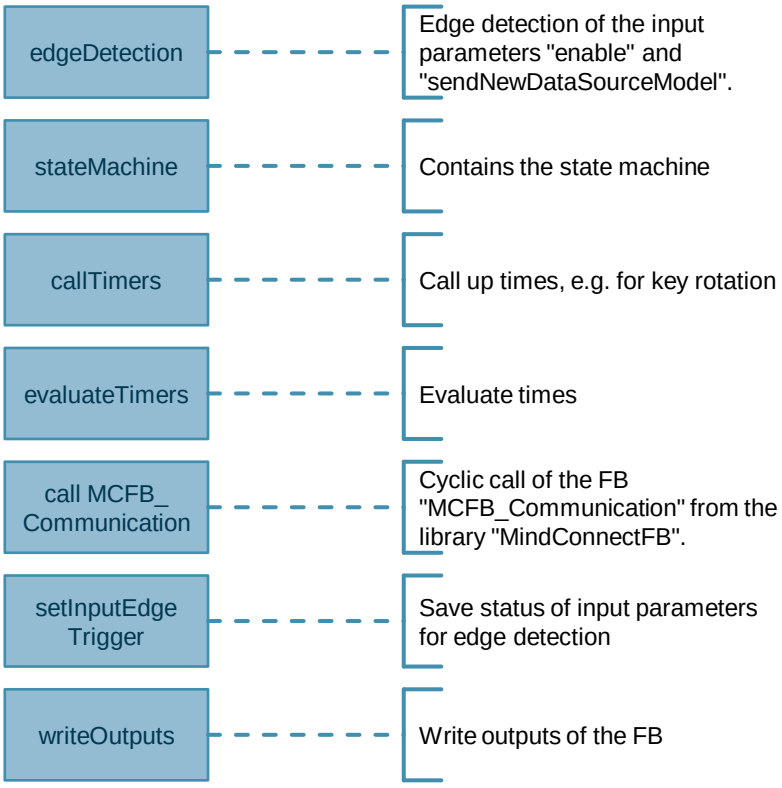
https://support.industry.siemens.com/cs/ww/en/view/109756878

3.2 Details on functionality

3.2.1 Structure of the program

The following figure shows the structure of the FB "CommMindSphereHandler". The program consists of several regions.

Figure 3-1



3.2.2 Explanation of the region "edgeDetection"

The region "edgeDetection" contains the edge evaluation of the following input parameters:

- "enable": Positive and negative edges are evaluated
- "sendNewDataSourceModel": Positive edge are evaluated

If a positive edge is detected at the input parameter "enable", the following actions are executed in the FB "CommMindSphereHandler":

- Output parameter "busy" is set to the value "1".
- State machine is initialized with the state "STATE_INIT_ROTATE_KEY" in order to initiate a job for key rotation.

If a negative edge is detected at the input parameter "enable", the state machine is initialized with the state "STATE_IDLE" in order to put the FB "CommMindSphereHandler" into the idle state and to terminate the processing of the FB "CommMindSphereHandler".

If a positive edge is detected at the input parameter "sendNewDataSourceModel", the state machine is initialized with the state "STATE_COLLECT_DATA_SOURCE" in order to acquire the new data source model and transfer it to MindSphere.

3.2.3 Explanation of the region "stateMachine"

The state machine contains the following states:

- STATE_IDLE
- STATE_INIT_ONBOARDING
- STATE_ONBOARDING
- STATE_INIT_ROTATE_KEY
- STATE_ROTATE_KEY
- STATE_COLLECT_DATA_SOURCE
- STATE_CHECK_DATA_SOURCE
- STATE_INIT_SEND_DATE_SOURCE
- STATE_SEND_DATA_SOURCE
- STATE_COLLECT_TIME_SERIES
- STATE_SAVE_DATA_BUFFER
- STATE_INIT_SEND_TIME_SERIES
- STATE_SEND_TIME_SERIES
- STATE_ERROR

STATE_IDLE

In the idle state "STATE_IDLE" all parameters (static variables and outputs of the FB "CommMindSphereHandler") are reset.

The FB "CommMindSphereHandler" waits in the state "STATE_IDLE" until it detects a positive edge at the input parameter "enable".

STATE_INIT_ONBOARDING

The order to execute the onboarding process is started.

The FB "CommMindSphereHandler" changes to the state "STATE_ONBOARDING" without any transition condition.

STATE_ONBOARDING

The execution of the onboarding process is evaluated.

If the onboarding process was successful, the FB "CommMindSphereHandler" changes to the STATE_INIT_ROTATE_KEY state. The onboarding process is executed only once. The connection is maintained until the asset is disconnected in MindSphere.

If an error occurs during the onboarding process, the following actions are performed in the FB "CommMindSphereHandler":

- The error information is stored in the static variable "statStatus" of the data type "Word".
- The state in which the error occurs is stored in the static variable "statStatusId" of the data type "Int".
- The FB changes to the state "STATE_ERROR".

The values of the variables "statStatus" and "statStatusId" are transferred to the output parameters "status" and "statusId" of the FB "CommMindSphereHandler" in the region "writeOutputs".

The Table 2-3 shows the values and meaning of the output parameters "status" and "statusId".

STATE_INIT_ROTATE_KEY

The timer and job for executing the key rotation are started.

After the timer (50 min) has expired, the order to execute the key rotation is restarted.

The FB "CommMindSphereHandler" changes to the state "STATE_ROTATE_KEY" without any transition condition.

STATE_ROTATE_KEY

The execution of the key rotation is evaluated.

If the key rotation was executed successfully and the data source model has not yet been transferred to MindSphere, the FB "CommMindSphereHandler" changes to the state "STATE_COLLECT_DATA_SOURCE". The data source model only needs to be transferred to MindSphere once.

If the key rotation was successful and the data source model was already transferred to MindSphere, the FB "CommMindSphereHandler" changes to the state "STATE_COLLECT_TIME_SERIES" to collect time series and transfer them to MindSphere.

If an error occurs during key rotation, the following actions are executed in the FB "CommMindSphereHandler":

- The error information is stored in the static variable "statStatus" of the data type "Word".
- The state in which the error occurs is stored in the static variable "statStatusId" of the data type "Int".
- The FB changes to the state "STATE_ERROR".

The values of the variables "statStatus" and "statStatusId" are transferred to the output parameters "status" and "statusId" of the FB "CommMindSphereHandler" in the region "writeOutputs".

The Table 2-3 shows the values and meaning of the output parameters "status" and "statusId".

STATE_COLLECT_DATA_SOURCE

To collect the data source model, the function FC "MCFB_CollectDataSource" is called.

Note Detailed information on the library block "MCFB_CollectDataSource" can be found in section 3.1.2.

The FB "CommMindSphereHandler" changes to the state "STATE_CHECK_DATA_SOURCE" without any transition condition.

STATE_CHECK_DATA_SOURCE

The collection of the data source model is checked.

If the data source model was successfully collected, the FB "CommMindSphereHandler" changes to the state "STATE_INIT_SEND_DATA_SOURCE" to transfer the data model to MindSphere.

If an error occurs during the acquisition of the data source model, the following actions are executed in the FB "CommMindSphereHandler":

- The error information is stored in the static variable "statStatus" of the data type "Word".
- The state in which the error occurs is stored in the static variable "statStatusId" of the data type "Int".
- The FB changes to the state "STATE_ERROR".

The values of the variables "statStatus" and "statStatusId" are transferred to the output parameters "status" and "statusId" of the FB "CommMindSphereHandler" in the region "writeOutputs".

The Table 2-3 shows the values and meaning of the output parameters "status" and "statusId".

STATE_INIT_SEND_DATA_SOURCE

The job for sending the data source model is started.

The FB "CommMindSphereHandler" changes to the state "STATE_SEND_DATA_SOURCE" without any transition condition.

STATE_SEND_DATA_SOURCE

The execution of the request to send the data source model is evaluated.

If the sending of the data source model was successfully executed, the FB "CommMindSphereHandler" changes to the state "STATE_COLLECT_TIME_SERIES" to collect the time series.

If an error occurs while sending the data source model, the following actions are executed in the FB "CommMindSphereHandler":

- The error information is stored in the static variable "statStatus" of the data type "Word".
- The state in which the error occurs is stored in the static variable "statStatusId" of the data type "Int".
- The FB changes to the state "STATE_ERROR".

The values of the variables "statStatus" and "statStatusId" are transferred to the output parameters "status" and "statusId" of the FB "CommMindSphereHandler" in the region "writeOutputs".

The Table 2-3 shows the values and meaning of the output parameters "status" and "statusId".

STATE_COLLECT_TIME_SERIES

To collect the time series, the function FC "MCFB_CollectDataValue" is called.

Note Detailed information on the library block "MCFB_CollectDataValue" can be found in section 3.1.2.

The function "MCFB_CollectDataValue" is called in the interval that you have defined via the input parameter "samplingInterval". In this example, the time series are collected every 5 seconds.

If an error occurs while collecting the time series, the following actions are executed in the FB "CommMindSphereHandler":

- The error information is stored in the static variable "statStatus" of the data type "Word".
- The state in which the error occurs is stored in the static variable "statStatusId" of the data type "Int".
- The FB changes to the state "STATE_ERROR".

The values of the variables "statStatus" and "statStatusId" are transferred to the output parameters "status" and "statusId" of the FB "CommMindSphereHandler" in the region "writeOutputs".

The Table 2-3 shows the values and meaning of the output parameters "status" and "statusId".

The timer for sending the time series is started. After the timer has expired (60 s), the data buffer is stored, and the time series are transferred to MindSphere.

If the following conditions are fulfilled, the state "STATE_COLLECT_TIME_SERIES" is left:

- The timer for sending the time series has expired so that the job for sending the time series can be started. The FB changes to the state "STATE_SAVE_DATA_BUFFER".
- The timer of the key rotation has expired, so that a new key rotation must be executed. The FB changes to the state "STATE_INIT_ROTATE_KEY".
- The data buffer is full, so that the job for sending the time series must be started. The FB changes to the state "STATE_SAVE_DATA_BUFFER".

STATE_SAVE_DATA_BUFFER

Before the recorded time series are transferred to MindSphere, they are saved for a second send attempt in case the first send job could not be executed successfully.

The FB "CommMindSphereHandler" changes to the state "STATE_INIT_SEND_TIME_SERIES" without any transition condition.

STATE_INIT_SEND_TIME_SERIES

The job for sending the time series is started.

The FB "CommMindSphereHandler" changes to the state "STATE_SEND_TIME_SERIES" without any transition condition.

STATE_SEND_TIME_SERIES

The execution of the request to send the time series is evaluated.

If the sending of the time series has been successfully executed, the FB "CommMindSphereHandler" changes back to the state "STATE_COLLECT_TIME_SERIES" in order to collect new time series.

If an error occurs while sending the time series, a second send attempt is started. The FB changes to the state "STATE_INIT_SEND_TIME_SERIES".

If the second send attempt could not be executed successfully, the following actions are executed in the FB "CommMindSphereHandler":

- The error information is stored in the static variable "statStatus" of the data type "Word".
- The state in which the error occurs is stored in the static variable "statStatusId" of the data type "Int".
- The FB changes to the state "STATE_ERROR".

The values of the variables "statStatus" and "statStatusId" are transferred to the output parameters "status" and "statusId" of the FB "CommMindSphereHandler" in the region "writeOutputs".

The Table 2-3 shows the values and meaning of the output parameters "status" and "statusId".

STATE_ERROR

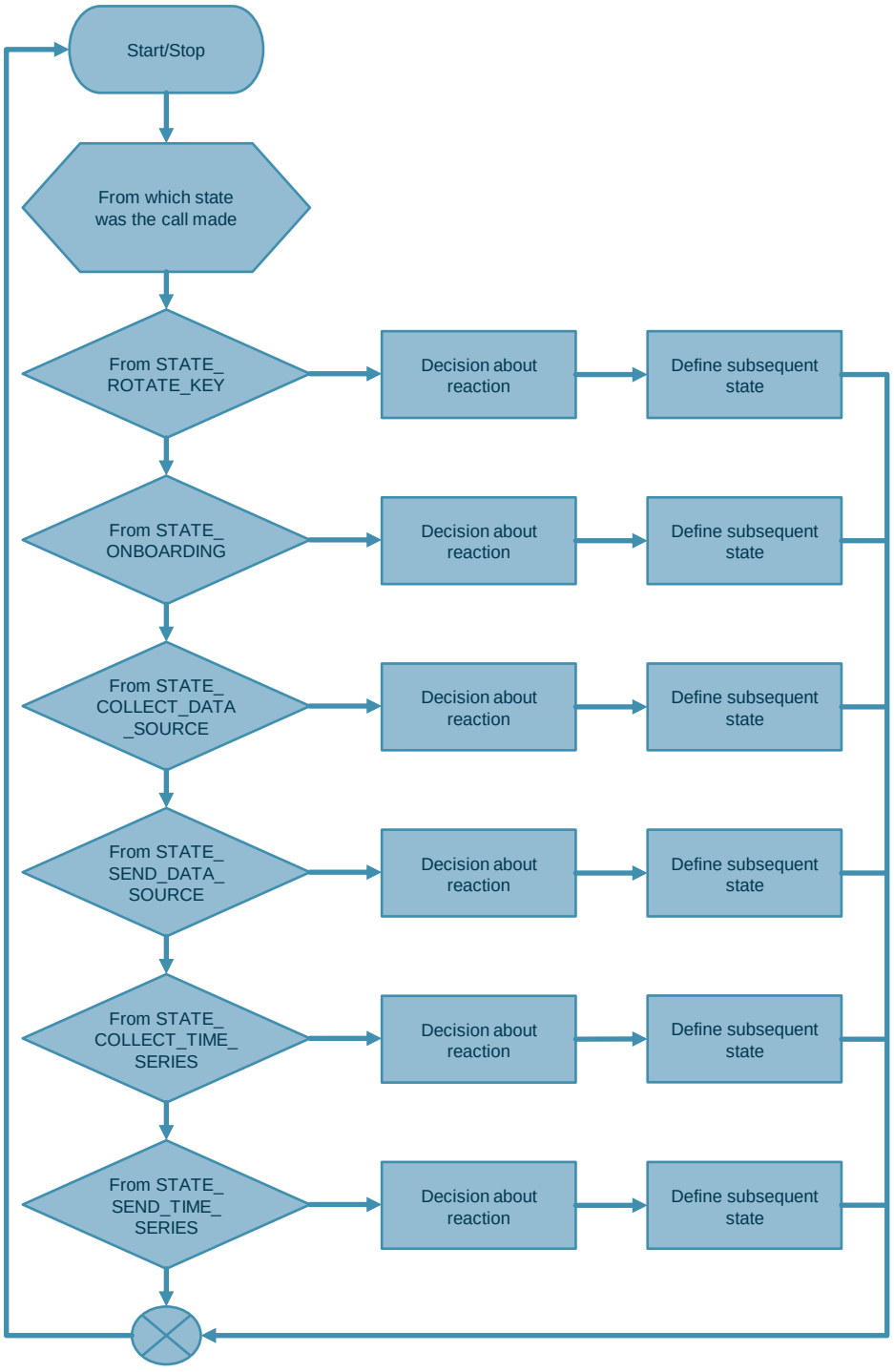
The "STATE_ERROR" state evaluates the most important error information of the "MindConnectFB" library blocks and shows the user how to react to this error information.

The user has the option of extending the "STATE_ERROR" state according to this schema as follows:

- Analyze further error states of the "MindConnectFB" library blocks and realize individual reactions.
- Perform your own user-specific error analyses.

The following figure shows the general scheme according to which this state is realized.

Figure 3-2



The program block "Decision on reaction" defines how the FB "CommMindSphereHandler" reacts in the event of an error. The reaction depends on the state in which the error occurred. In this example, the following reactions are possible, depending on the cause of the error:

- Reactions during the onboarding process
- Reactions during key rotation
- Reactions when sending the data source model
- Reactions when sending time series
- Reactions when collecting the data source model
- Reactions when collecting the time series

Reactions during the onboarding process

If an error occurs during the onboarding process, the following reactions are realized in the FB "CommMindSphereHandler".

- If the onboarding process for the S7-1500 CPU has already been successfully completed, the FB changes to the state "STATE_INIT_ROTATE_KEY" to execute the key rotation.
- If an error occurs which must be corrected by the user, the FB changes to the idle state "STATE_IDLE" and the timer for the watchdog error (5 min) is started.
  As long as the timer for the watchdog error has not expired, the FB changes every 60 s from the idle state "STATE_IDLE" to the state "STATE_INIT_ROTATE_KEY" in order to be able to restart the processing of the FB internally as soon as the error has been corrected. After expiration of the timer for the watchdog error (5 min), the user must restart the processing of the FB "CommMindSphereHandler" via the parameter "enable".
  The following errors, among others, must be corrected by the user:
  - Network connection problems
  - Connection fails with valid certificate

Reactions during key rotation

If an error occurs during key rotation, the following reactions are realized in the FB "CommMindSphereHandler":

- If the onboarding process has not yet been successfully completed, the FB changes to the state "STATE_INIT_ONBOARDING" to start the onboarding process.
- If an error occurs which must be corrected by the user, the FB changes to the idle state "STATE_IDLE" and the timer for the watchdog error (5 min) is started.
  As long as the timer for the watchdog error has not expired, the FB changes every 60 s from the idle state "STATE_IDLE" to the state "STATE_INIT_ROTATE_KEY" in order to be able to restart the processing of the FB internally as soon as the error has been corrected. After expiration of the timer for the watchdog error (5 min), the user must restart the processing of the FB "CommMindSphereHandler" via the parameter "enable".
  The following errors, among others, must be corrected by the user:
  - Network connection problems
  - Connection fails with valid certificate
  - Internal error, because the instance DB of the FB "MCFB_Communication" was changed.
- If an undefined error occurs, the FB changes to the state "STATE_COLLECT_DATA_SOURCE" to continue processing the FB.

Reactions when sending the data source model

If an error occurs which must be corrected by the user, the FB changes to the idle state "STATE_IDLE" and the timer for the watchdog error (5 min) is started.
As long as the timer for the watchdog error has not expired, the FB changes every 60 s from the idle state "STATE_IDLE" to the state "STATE_INIT_ROTATE_KEY" in order to be able to restart the processing of the FB internally as soon as the error has been corrected. After expiration of the timer for the watchdog error (5 min), the user must restart the processing of the FB "CommMindSphereHandler" via the parameter "enable".
The following errors, among others, must be corrected by the user:

- Network connection problems
- Connection fails with valid certificate
- Data source model is sent without configured data points
- Upload of data failed
- Data source model is too large.
- Connection ID parameter changed after onboarding
- Internal error, because the instance DB of the FB "MCFB_Communication" was changed.

Reactions from sending time series

If an error occurs while sending the time series, the following reactions are realized in the FB "CommMindSphereHandler":

- If the server identity cannot be verified because the key has expired, the FB changes to the state "STATE_INIT_ROTATE_KEY" to execute the key rotation.
- If an error occurs which must be corrected by the user, the FB changes to the idle state "STATE_IDLE" and the timer for the watchdog error (5 min) is started.
  As long as the timer for the watchdog error has not expired, the FB changes every 60 s from the idle state "STATE_IDLE" to the state "STATE_INIT_ROTATE_KEY" in order to be able to restart the processing of the FB internally as soon as the error has been corrected. After expiration of the timer for the watchdog error (5 min), the user must restart the processing of the FB "CommMindSphereHandler" via the parameter "enable".
  The following errors, among others, must be corrected by the user:
  - Network connection problems
  - Connection fails with valid certificate
  - Time series is sent without configured data points
  - Upload of data failed
  - Connection ID parameter changed after onboarding
  - Internal error, because the instance DB of the FB "MCFB_Communication" was changed.

Reactions when collecting the data source model

If an error occurs when collecting the data source model, the FB changes to the state "STATE_COLLECT_DATA_SOURCE" to collect the data model again.

Reactions when collecting the time series

If an error occurs when collecting the time series, the FB changes to the state "STATE_COLLECT_DATA_SOURCE" in order to record the time series again.

3.2.4 Explanation of the region "callTimers"

The region "callTimers" contains the call of the timers. The following table shows an overview of the timers used. The time of the timers can be adjusted via constants in the FB "CommMindSphereHandler".

Table 3-1

Timer	Description	Constant	Value
instTimerRotateKey	The timer is used to execute the key rotation every 50 minutes.	ROTATE_KEY_CYCLE	T#50m
instTimerCollectTimeSeries	The timer determines the interval at which the time series are collected.	You specify the interval via a variable or constant at the input parameter "samplingInterval".	T#5s
instTimerSendTimeSeries	The timer is used to send the time series to MindSphere every 60 seconds.	SEND_CYCLE	T#60s
instTimerWatchdog	The timer for watchdog errors is started if MindSphere is not reachable. If MindSphere cannot be reached for more than 5 minutes, the FB remains in the idle state "STATE_IDLE". The processing of the FB must be restarted via the input parameter "enable".	RETRY_IDLE_CYCLE_WATCHDOG	T#5m
instTimerNewInit	The timer is used to restart the processing of the FB internally every 60 s in the event of an error, as long as the timer for the watchdog error has not expired.	NEW_INIT_CYCLE	T#60s

3.2.5 Explanation of the region "evaluateTimers"

In the "evaluateTimers" region, the timers are evaluated in order to execute the following actions:

- If the timer "instTimerNewInit" has expired, the processing of the FB is newly initiated as long as the timer "instTimerWatchdog" has not yet expired.
- If the timer "instTimerWatchdog" has expired, the FB "CommMindSphereHandler" changes to the idle state "STATE_IDLE" in order to be able to initiate the processing of the FB again via the input parameter "enable".
- When the timer "instTimerRotateKey" has expired, a key rotation job is started. The key rotation is executed every 50 minutes.

Note The timers "instCollectTimeSeries" and "instSendTimeSeries" are evaluated in the region "stateMachine".

3.2.6 Explanation of the region "call MCFB_Communication"

In the region "call MCFB_Communication" the library block FB "MCFB_Communication" is called cyclically.

Note Detailed information on the FB "MCFB_Communication" can be found in the section 3.1.2.

3.2.7 Explanation of the region "setInputEdge"

In order to recognize a negative and positive edge at the input parameters "enable" and "sendDataSourceModel", the states of these input parameters are stored cyclically.

3.2.8 Explanation of the region "writeOutputs"

The values of the output parameters of the FB "CommMindSphereHandler" are written cyclically.

4 Appendix

4.1 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:
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. Please send queries to Technical Support via Web form:
www.siemens.com/industry/supportrequest

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- Plant data services
- Spare parts services
- Repair services
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- Retrofitting and modernization services
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You can find detailed information on our range of services in the service catalog web page:
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:
support.industry.siemens.com/cs/ww/en/sc/2067

4.2 Links and literature

Table 4-1

No.	Topic
\1\	Siemens Industry Online Support https://support.industry.siemens.com
\2\	Link to the article page of the application example https://support.industry.siemens.com/cs/ww/de/view/109756878
\3\	Getting connected to MindSphere V3 (AWS) https://support.industry.siemens.com/cs/ww/en/view/109755908

4.3 Change documentation

Table 4-2

Version	Date	Change
V1.0	03/2019	First version