1 Introduction

With the BioProTT™ FlowMCP, em-tec offers a **M**ulti-**C**hannel **P**latform that enables the monitoring and display of flow values for GMP-oriented and industrial bioprocessing technology. Available with 1, 2, or 4 flow channels, the BioProTT™ FlowMCP is fully compatible with our BioProTT™ Clamp-On SL sensors and can be integrated into existing systems and equipment within the industrial field.
Designed for the use inside process control cabinets, the devices within the BioProTT™ FlowMCP Series are space-saving and equipped with a standard DINrail mounting. To display and import the measurement data to your host system, the Modbus TCP interface is connected to a PLC, where the flow data can then be displayed and read out.

To connect the BioProTT™ FlowMCP, the following items are needed:

- the BioProTT™ Flow MCP
- a computer for the configuration
- a PLC (Programmable Logic Controller);
  i.e. a specialized computer consisting of the power supply and rack, the central processing unit (CPU) and the in- and output section.

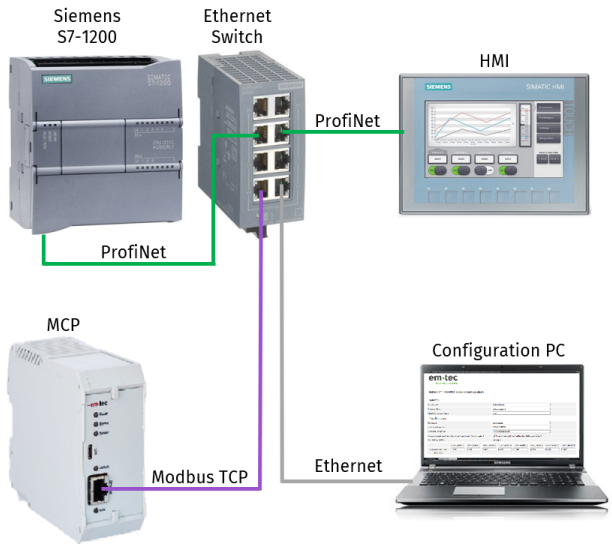

Figure 1: Example Set Up

Optional:

- an Ethernet switch
- an HMI (Human Machine Interface),
  i.e. a software application where information regarding the state of a process is displayed

2 General Description

Before setting up the BioProTT™ FlowMCP, please be aware that, given the number of different PLCs, the majority of which are programmed according to customer and/or process requirements, the following information can serve as example only. As a result, the set up steps here refer to our specific programming of the PLC SIMATIC S7-1212C by Siemens, meaning that the steps and screens might differ for your system. The PLC used here includes an Ethernet (PROFINET) connection, so devices such as an PC or a Modbus TCP device can be connected over an Ethernet switch at the same time.
The Modbus TCP (short for: Transmission Control Protocol) is a standard network communication protocol that uses the PROFINET connector on the PLC for TCP/IP communication. There is no additional communication hardware module required for the PLC S7-1200 series (and later variants).

The software used for the PLC programming is Siemen's TIA V14 portal. Within this portal, it is possible to either create a new project or to modify an existing one.

The example describes the integration of the BioProTT™ FlowMCP with a Modbus TCP interface into an industrial automation system based on a Siemens SIMATIC environment.

3 Configuration

First, all devices need to be connected. For information regarding the installation of the BioProTT™ FlowMCP (e.g. power supply connection), please refer to the respective user manual. For other instructions concerning device installation, please refer to the manual of the respective device. When only one BioProTT™ FlowMCP is used within an industrial automation system with an Ethernet connection, the BioProTT™ MCP can be directly connected to the Ethernet (ProfiNet) port of the PLC S7-1212C. When more than one Ethernet device is used, all devices can be connected to the PLC Ethernet (PROFINET) port with an Ethernet switch.

The default IP address for the BioProTT™ FlowMCP is 192.168.0.12. This address can be changed throughout the configuration of the device, which is described in the user manual. In this example, the default IP address is used.

Once the devices are connected, the PLC needs to be configurated. For this, the used PLC is added in the TIA V14 portal. The PLC used is the PLC 6ES7 212-1BE40-0XB0.

The picture below shows the device configuration in the TIA V14 portal. For a detailed description on how to add the PLC into the TIA V14 portal, please refer to the instructions from Siemens.

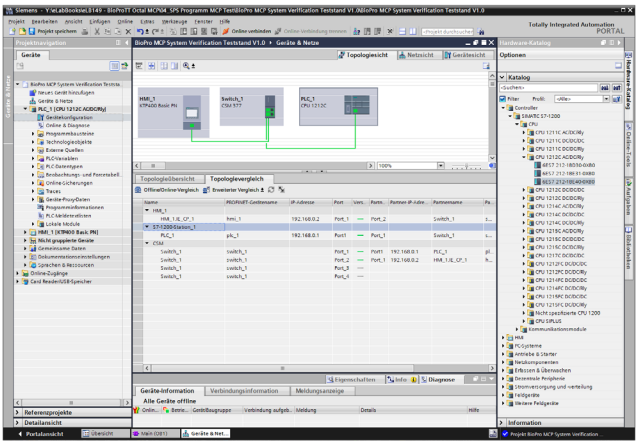

Figure 2: Configuration example of PLC in TIA V14 portal

Here, an HMI and an Ethernet switch were added.

Please note:

Neither an HMI nor an Ethernet switch are necessary for the BioProTT™ FlowMCP to run and function.

When the PLC is added into the portal, the PLC IP address must be configured so that IP address is different from the address of the BioProTT™ FlowMCP. In this example, the PLC address was set to 192.168.0.1. Once everything is configured correctly and the program is transferred to the PLC, you can proceed with the steps described in the following chapters.

3.1 PLC Program for Modbus TCP Communication

This TechNote describes the programming language SCL (Structured Control Language). For detailed information regarding the programming and the programming language, please refer to the manual of the used PLC.

Before anything else, a new network should be created in the “main” program or in a new “functional block“ (=FB). This, however, depends on the programming style. In the following example, only the “main” function is used since the example program is a rather small one.

3.1.1 Program Structure

For this example, the program sequence is realized with states. Consequently, a state variable is added in the main program. The sequence can also be realized with another mechanism. The following process illustration shows one possible sequence:

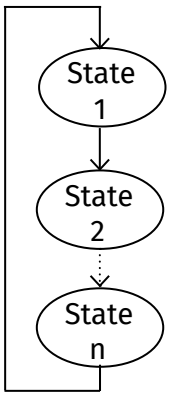

Figure 3: Possible Sequence

3.1.2 Adding the Modbus TCP Function

To access the Modbus client function, the Modbus TCP client function block must be added to your program. To do so, select the MB_CLIENT function from the communication instruction in the TIA V14 portal following this path:

Communication→ further→ MODBUS TCP→ MB_CLIENT

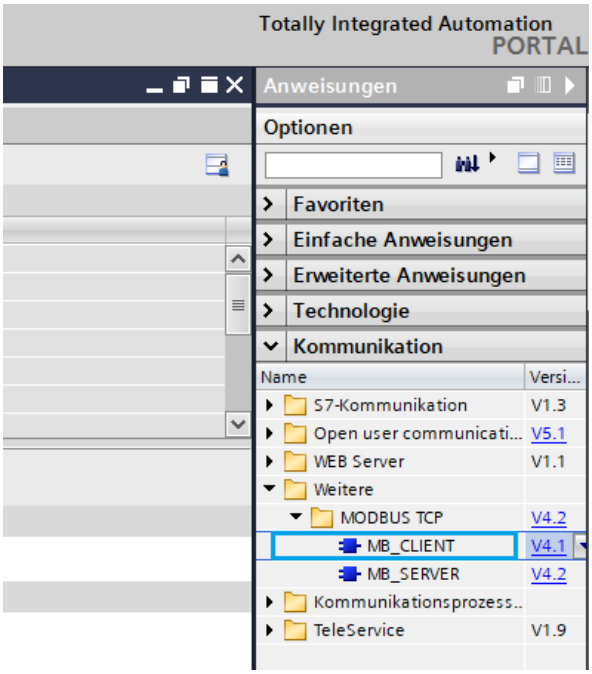

Figure 4: MB_CLIENT function

When selecting the MB_CLIENT function block, a pop up will open to generate a data block (DB).

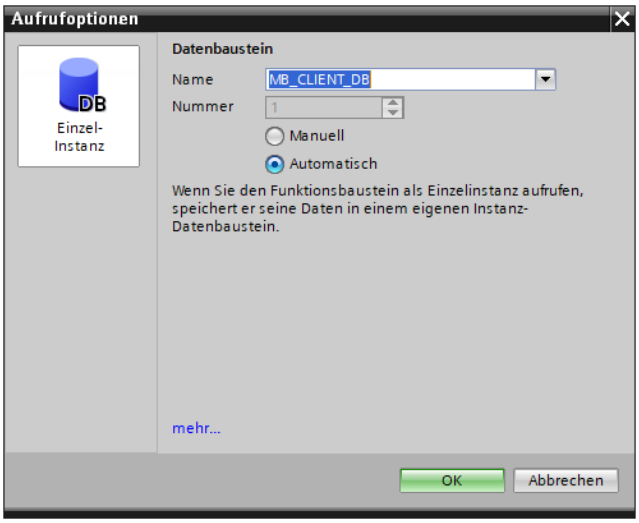

Figure 5: Data block for MB_CLIENT function

This data block is needed for the MB_CLIENT functional block. The data block must not be changed as it is generated as a system component. Once the MB_CLIENT function is added to the program, the program looks like this:

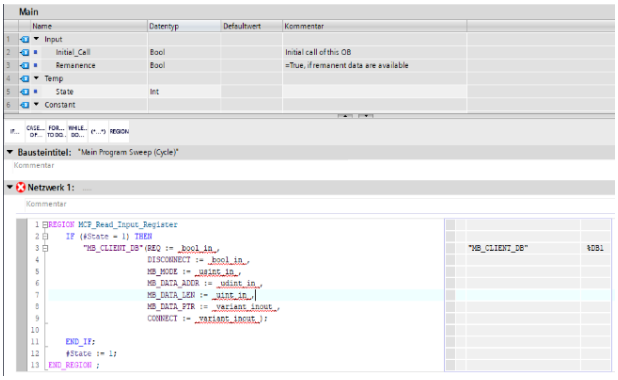

Figure 6: TIA V14 program with MB_CLIENT function

3.1.3 Creating a Data Block for the Data of the BioProTT™ FlowMCP

The next step is to create a data block to store the data from the BioProTT™ FlowMCP and to set the MC_CLIENT parameters such as the ID address. This can be realized by adding a new function within the program components of the TIA V14. Here, the data block was called MCP_Read_Input_Register:

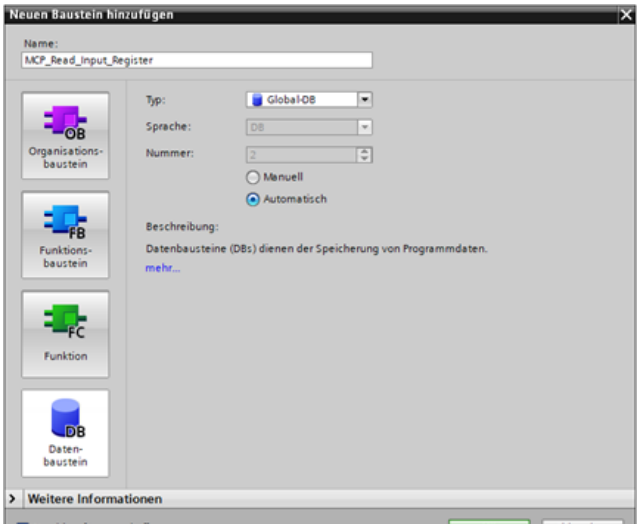

Figure 7: Data Block for data of the BioProTT™ FlowMCP

In the data block, the following values are generated:

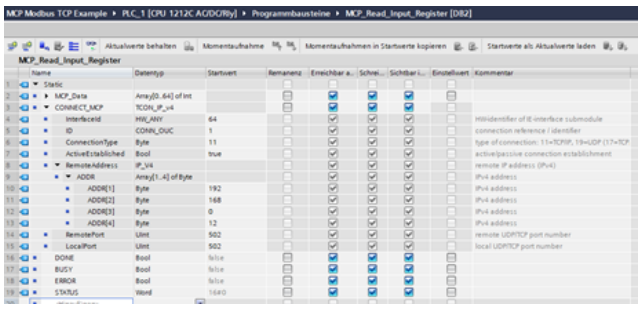

Figure 8: Data block values of the BioProTT™ FlowMCP

The MCP_Data consists of a number of values ranging from 0 to 105; i.e. 106 values in total. In this range, all data of the BioProTT™ FlowMCP—taken from the read input register (Function Code: 0x04)—will be stored. For details concerning the read input register of the BioProTT™ FlowMCP, please refer to the user manual.

The CONNECT_MCP values are needed to set the MB_CLIENT function. The IP adress (192.168.0.12) of the BioProTT™ FlowMCP device is set here as well. In addition, the correct IP port needs to be set to 502—the default value of the BioProTT™ FlowMCP.

The messages DONE, BUSY, ERROR and STATUS are sent from the Modbus TCP interface to the host system.

3.2 Setting the MB_CLIENT Function

The MB_CLIENT_DB function can be set in the main program cycle. This sample uses the following mapping and settings:

„MB_CLIENT_DB“(REQ := TRUE,
DISCONNECT := 0,
MB_MODE := #Read,
MB_DATA_ADDR := 30001,
MB_DATA_LEN := 65,
MB_DATA_PTR:=“MCP_Read_Input_Register“.MCP_Data,
CONNECT:=“MCP_Read_Input_Register“.CONNECT_MCP);

- When the REQ-parameter is set to TRUE, it represents a request to communicate with a Modbus TCP server (= the BioProTT™ FlowMCP).
- If the parameter DISCONNECT = 0 and there is no connection, then the MB_CLIENT attempts to connect to the assigned IP address and port number.
- With the MB_MODE-parameter, the Modbus client is set to read or to write. In this example, the main function constant parameter was set to either #Read or #Write.
- With the MB_DATA_ADDR parameter, the data address of the Modbus function is set. When reading the functional code 0x04 of the Modbus, the start address needs to be set to 30001.
- The table below shows the addresses used in the Siemens PLC linked to the functional codes of the Modbus. It also lists the MB_MODE (read “0”, or write “1”):

Modbus functions

MB_MODE	Modbus function	Data length	Operation and data	MB_DATA_ADDR
0	01	1 to 2000	Read output bits: 1 to 2000 bits per request	1 to 9999
0	02	1 to 2000	Read input bits: 1 to 2000 bits per request	10001 to 19999
0	03	1 to 125	Read Holding registers: 1 to 125 words per request	40001 to 49999 or 400001 to 465535
0	04	1 to 125	Read input words: 1 to 125 words per request	30001 to 39999
1	05	1	Write one output bit: One bit per request	1 to 9999
1	06	1	Write one holding register: 1 word per request	40001 to 49999 or 400001 to 465535
1	15	2 to 1968	Write multiple output bits: 2 to 1968 bits per request	1 to 9999
1	16	2 to 123	Write multiple holding registers: 2 to 123 words per request	40001 to 49999 or 400001 to 465535

Figure 9:
MB_DATA_ADDR linked to the functional codes of the Modbus TCP Interface

- With the MB_DATA_LEN-parameter, the length of the read data package is set. Here, the length is 65 because there are 106 values that should be read within the functional code 0x04 of the BioProTT™ Flow MCP.
- With MB_DATA_PTR, the storage location of the read data is set.
- With CONNECT, the Modbus client functional block is configured, such as, for example, the IP address of the BioProTT™ FlowMCP.

3.2.1 Loading the Program to the PLC and Starting the Program in the TIA V14 Portal

Compile the program and transfer it to the PLC. In the TIA V14 portal, the transferred program can be run with starting the observation in the portal by pressing this button “  “.

In the example, the following data is present:

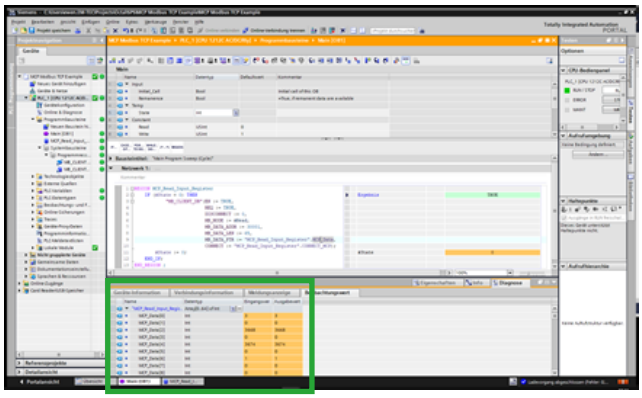

Figure 10: PLC simulation results

In the overview above, in the lower area of the TIA V14 portal, the MB_DATA_PTR data, which is stored in MCP_Read_Input_Register“.MCP_Data is displayed in the part that is marked as „read“. This is the measurement data from the BioProTT™ FlowMCP.

For example,

- MCP_Data [0] is the RSS (coupling) value from channel 1.
- MCP_Data [1] is the high 16-bit word of the slow flow value of channel 1
  and
- MCP_Data [2] is the low 16-bit word of the slow flow value of channel 1, etc.

For the detailed data mapping, please refer to the user manual of the BioProTT™ FlowMCP.

3.2.2 Additional Read Functions

In this current version, it is possible to include an additional read and write function in the program. The example shows an additional MB_CLIENT function to read the Modbus register with the function code 0x02. In this register, the status information of the BioProTT™ FlowMCP such as sensor connection or channel availability is included

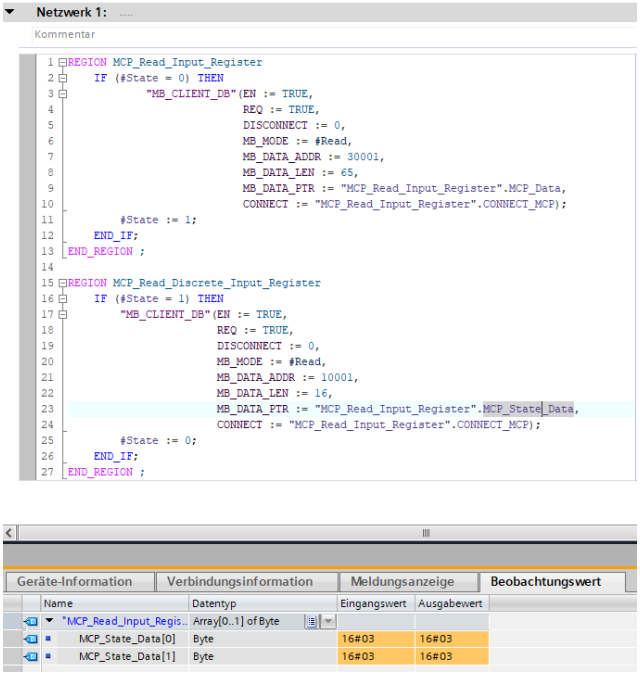

Figure 11: Additional MB_CLIENT read function

In the image above, the sensor connection information is shown in MCP_State_Data[0] and the channel availability information is shown in MCP_State_Data[1].

→ Both are for a MCP2
(16#03 is the hexadecimal value from the byte 0000 0011 → channel 0 and 1 are available).

All of the examples above use a simple program style. The information that is not included is the busy state of the Modbus. Therefore, when integrating the MB_CLIENT function, it is suggested to read the data in a specific time interval and to include the Modbus busy information in the program to prevent the loss of data during a transfer.

In the same way as for the read data above, the transfer of the write data can be realized. For this, only the MB_CLIENT function needs to be set to #write mode: MB_MODE := #Write.

In addition, the corresponding Modbus write register (for the functional code of the Modbus refer to Figure 9) needs to be set. Then, when assigning data to the MB_DATA_PTR, the BioProTT™ FlowMCP can be set; e.g. set sensor on channel 1 to zero (Modbus functional code 0x05, parameter 0 set to 1).

4 Contact

If there are any questions concerning the information in this document or if you are having trouble at any point during the integration and setup of the Modbus TCP interface, please contact em-tec GmbH.

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