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Quick Start Guide
PN/MQTT Coupler

Order number: 700-162-3MQ02
For firmware V1.06 and above

Version
6 en

Content

1 Safety instructions

Target audience

This description is only intended for trained personnel qualified in control and automation engineering who are familiar with the applicable national standards. For installation, commissioning, and operation of the components, compliance with the instructions and explanations in this operating manual is essential. The specialist personnel is to ensure that the application or the use of the products described fulfills all safety requirements, including all applicable laws, regulations, provisions, and standards.

Intended use

The device has a protection rating of IP 20 (open type) and must be installed in an electrical operating room or a control box/cabinet in order to protect it against environmental influences. To prevent unauthorized operation, the doors of control boxes/cabinets must be closed and possibly locked during operation. The consequences of improper use may include personal injury to the user or third parties, as well as property damage to the control system, the product, or the environment. Use the device only as intended!.

Operation

Successful and safe operation of the device requires proper transport, storage, setup, assembly, installation, commissioning, operation, and maintenance. Operate the device only in flawless condition. The permissible operating conditions and performance limits (technical data) must be adhered to. Retrofits, changes, or modifications to the device are strictly forbidden.

Security

The device is a network infrastructure component and therefore an important element in the security consideration of a plant. When using the device, therefore, observe the relevant recommendations to prevent unauthorized access to installations and systems. Further information on this can be found in the device manual.

2 Introduction

This document explains the initial commissioning of the PN/MQTT Coupler. The latest version of the document and a detailed manual can be found at www.helmholz.de or scan the QR code directly.

3 Function of the PN/MQTT Coupler

The MQTT protocol has become established in recent years as a simple transmission protocol for messages in the IoT world. MQTT stands for "Message Queue Telemetry Transport Protocol" and is an OASIS standard. Information on the MQTT protocol can be found here: mqtt.org

The MQTT protocol always uses a central broker for communication between devices, which receives messages from e.g. a sensor and forwards them to interested devices, e.g. a control unit.

When a sensor sends data to the broker, this is called "publish". If a device needs data, it must subscribe to the broker ("Subscribe"). The broker delivers the data to all subscribers when new data has arrived from the publisher.

Data is always transmitted under a freely definable identifier - the "Topic". The "Topic" is a descriptive text, e.g. "Temperature". In order to distinguish between different topics of the same type, groupings are used, e.g. "Living room/temperature". The groupings are divided by a slash ('/'). Thus the data can be mapped into more complex structures: "Upper floor/Living room/Temperature" or "Upper floor/Living room/Humidity".

The data delivered via MQTT can be transmitted in binary format, text format or structured in JSON format.

With the PN/MQTT Coupler a transfer of values between a PROFINET controller (PLC) and a MQTT broker is possible. It is possible to send values from the PLC via PROFINET to a broker ("Publish") as well as to subscribe values from a MQTT broker and receive them in the PLC via PROFINET ("Subscribe").
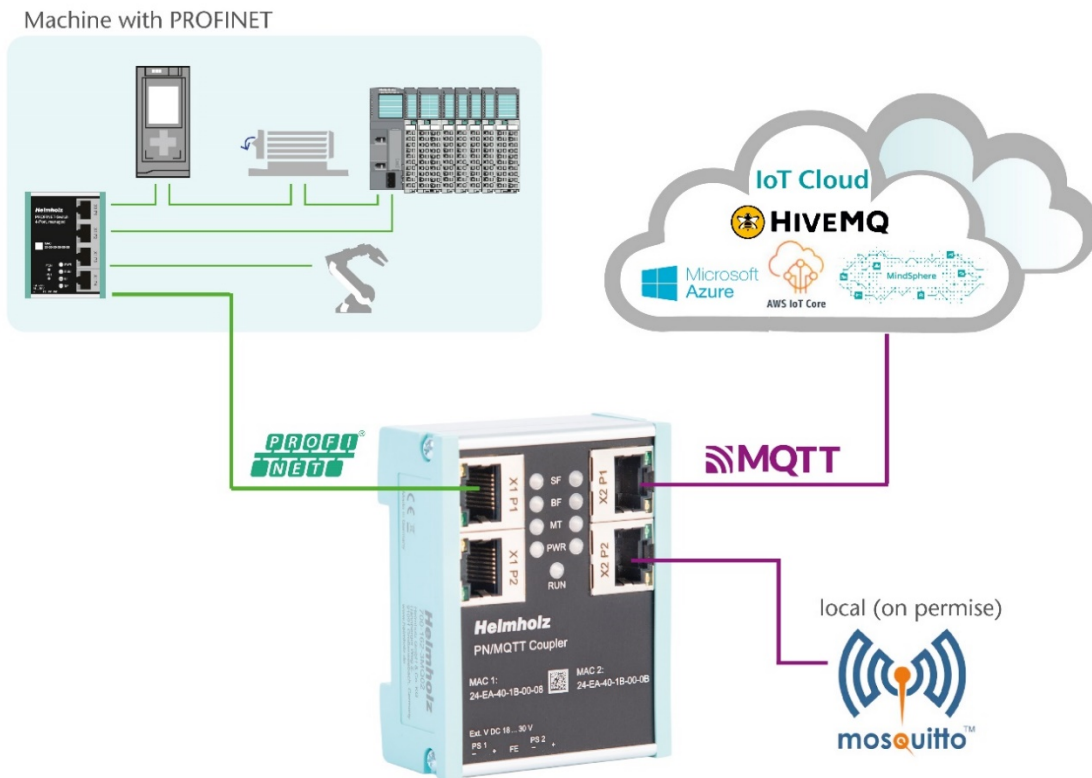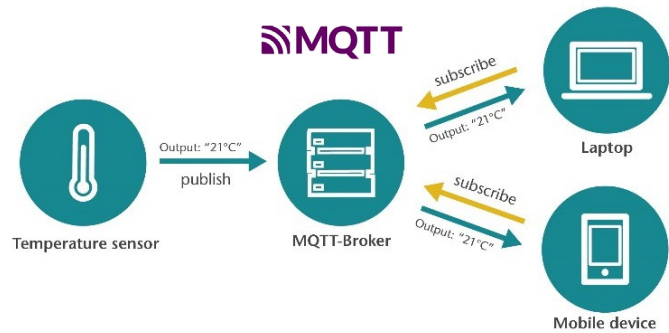
The integration into the PLC engineering tool is enabled by a GSDML file, an additional extra configuration software is not necessary. The configuration of the I/O data to be exchanged is done in the Siemens engineering tool. All settings for the MQTT connection can be done on the web page of the device.

MQTT brokers can be connected both locally ("On premise") and via the Internet ("Cloud"). A local broker can be operated, for example, with the open-source software "Mosquitto" in the company network on a PC/server or also on a small computer, such as a Raspberry PI. Such an application is described in this QuickStart Guide.
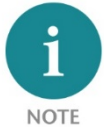
> **NOTE** *The PN/MQTT coupler can only establish a connection with one broker! If the data is also to be distributed to other brokers, the connection must be established between the brokers (Multi Broker).*

In the cloud, IoT systems such as HiveMQ, Amazon IoT, Microsoft Azure or Siemens Mind-sphere (in preparation) can be connected directly. For more information on these applications, refer to the manual or ask the Helmholz support for white papers.

4 Connection

4.1 Power supply

The PN/MQTT coupler must be supplied with DC 24 V at the wide-range input DC 18 ... 30 V via the supplied connector plug. The power supply is redundant, at least one supply path PS 1 or PS 2 must be connected.

> **NOTE** *The housing of the PN/MQTT Coupler is not grounded. Please connect the functional earth terminal (FE) of the PN/MQTT Coupler properly to the reference gantry.*

4.2 Network

The left RJ45 sockets "X1 P1" and "X1 P2" are used to connect the PROFINET network, the right RJ45 sockets "X2 P1" and "X2 P2" are used to connect the Ethernet network in which the MQTT broker is accessible. The ports X1 P1 and X1 P2, as well as X2 P1 and X2 P2 are each internally connected to a switch.

The interfaces X1 and X2 are logically separate networks and not physically connected. Thus a clear separation between the machine data (PROFINET) and the MQTT data connection is possible. A network penetration with other functions by the PN/MQTT coupler is not possible.

The configured values are exchanged in the PN/MQTT coupler only as IO data between both network sides.

| X1: PROFINET-Stack	Internal Memory	X2: MQTT Client
Outputs	→	Publish
Inputs	←	Subscribe

> **NOTE** *If the MQTT broker needs to be placed in the same network (subnet) as the PROFINET PLC, the network X2 can be configured in the same subnet as the network X1.*
> *The interface X2 then needs its own IP address and must be connected to the network X1 with an Ethernet cable.*

5 Install GSDML file

Please download the GSDML file ("GSDML-V2.35-Helmholz-PN-MQTT-coupler-____.xml") at www.helmholz.de or scan the QR code. Install the GSDML file in the "Tools" / "Manage device description file (GSD)" menu in the TIA Portal.
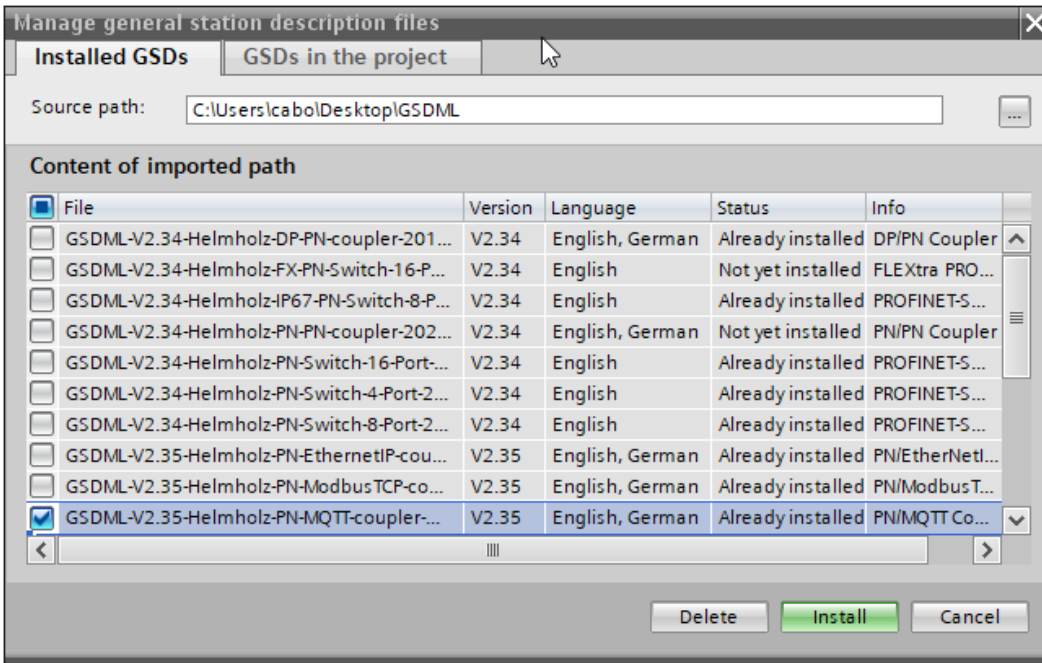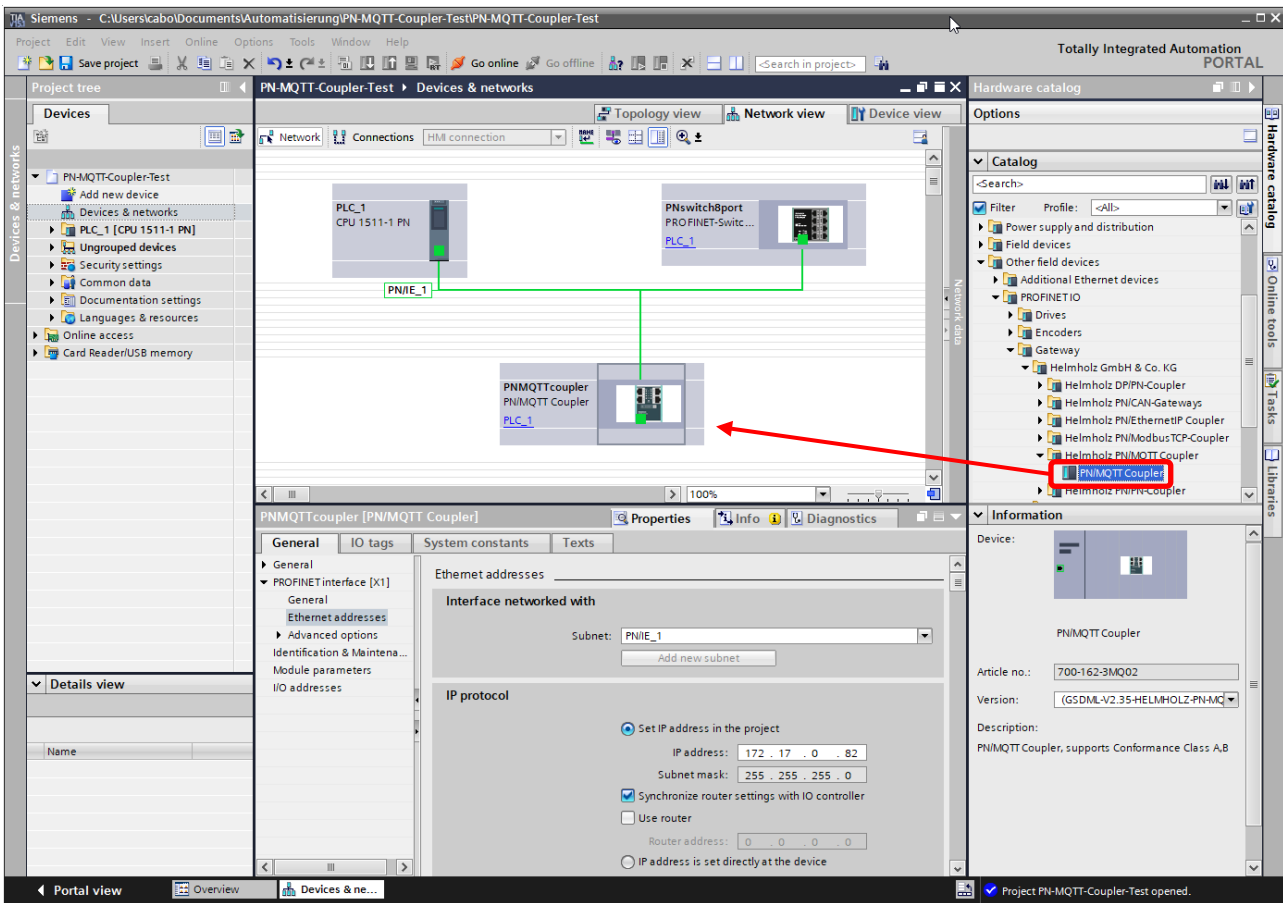

The PN/MQTT Coupler can be found in the hardware catalog at "Other field devices / PROFINET IO / Gateway / Helmholz GmbH & Co. KG".
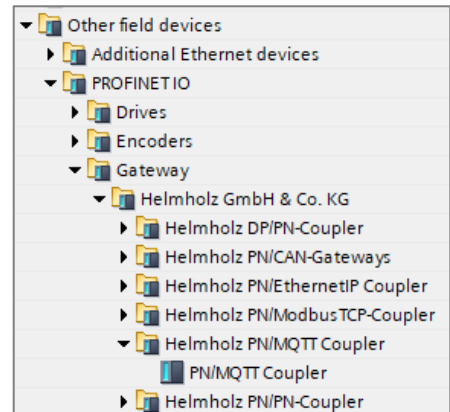
6 Configuration in TIA Portal

Add the PN/MQTT coupler to the project and connect the coupler to the PROFINET network.

Name the device name and check the Ethernet address for the device.

6.1 Parameterization of the PN/MQTT coupler

The parameterization of the PN/MQTT coupler is performed via the PROFINET hardware configurator (e.g. TIA Portal). The PROFINET parameters and the I/O data to be transmitted via MQTT are defined here. The configuration of the MQTT network connection (connection to the MQTT broker) is set via the web page of the device.

Static IP address: If the address mode is set to "Static IP", the static IP address of the X2 network can be specified here.

Static IP subnet mask: If the address mode has been set to "Static IP", the subnet mask of the X2 network can be specified here.

Static IP gateway: If the address mode has been set to "Static IP", the gateway of the X2 network can be specified here.

Hostname mode: "From PROFINET configuration" or "From webpage".

DHCP hostname: Name of the device

Webpage: On which network interfaces should the web page be displayed.

6.2 Operating principle of the PN/MQTT coupler

The data exchange between the PLC and the MQTT broker is organized via individual values. A value can be 1, 2 or 4 bytes in size and is in the I/O area of the PROFINET controller. Depending on the data direction, the value is writable to outputs (MQTT Publish) or readable from inputs (MQTT Subscribe).
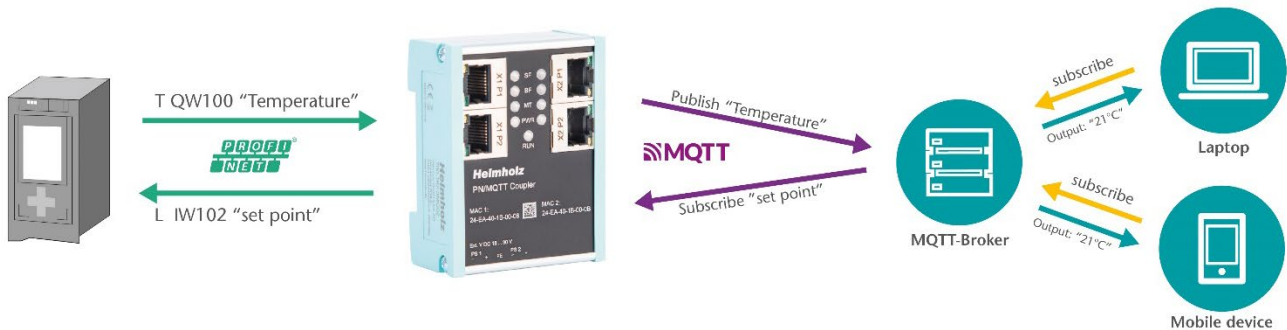

A module always represents exactly one value, which is exchanged with the broker via an MQTT topic name. A value is usually sent via MQTT in a readable form (direct text or JSON formatted). For this reason, there are different representation forms for each value size (1, 2, 4 bytes): hexadecimal, unsigned decimal, signed decimal.

Configuration example:

Slot	Modul	EA	Type	Direction	Topic name (Exampe)	Value (Example)
1	Output Byte (1 Byte, hex.)	1 Byte Output	Byte	Publish →	"Output QB10"	"0x12"
2	Output Unsigned Int (2 Bytes, dez.)	2 Bytes Outputs	Unsigned Integer	Publish →	"Speed"	"65534"
3	Output Signed dInt (4 Bytes, dez.)	4 Bytes Outputs	Signed double Integer	Publish →	"Output QD14"	"-12345678"
4	Input Word (2 Bytes, hex.)	2 Bytes Inputs	Word	← Subscribe	„Control word "	„0xFFEE"
5	Input Unsigned sInt (1 Bytes, dez.)	1 Byte Inputs	Unsigned short Int	← Subscribe	„Set point "	„255"
6	Input Double Word (4 Byte, hex.)	4 Bytes Inputs	Double Word	← Subscribe	„Configuration "	„0x11223344"
7	Output Signed Int (2 Byte, dez.)	2 Bytes Outputs	Signed Integer	Publish →	„Temperature"	„25"
...						

The value of the input modules is initialized with 0 after restarting the coupler and is permanently taken over into the input area when a new value is received via MQTT. A bit additionally indicates the reception of a value in the PLC.
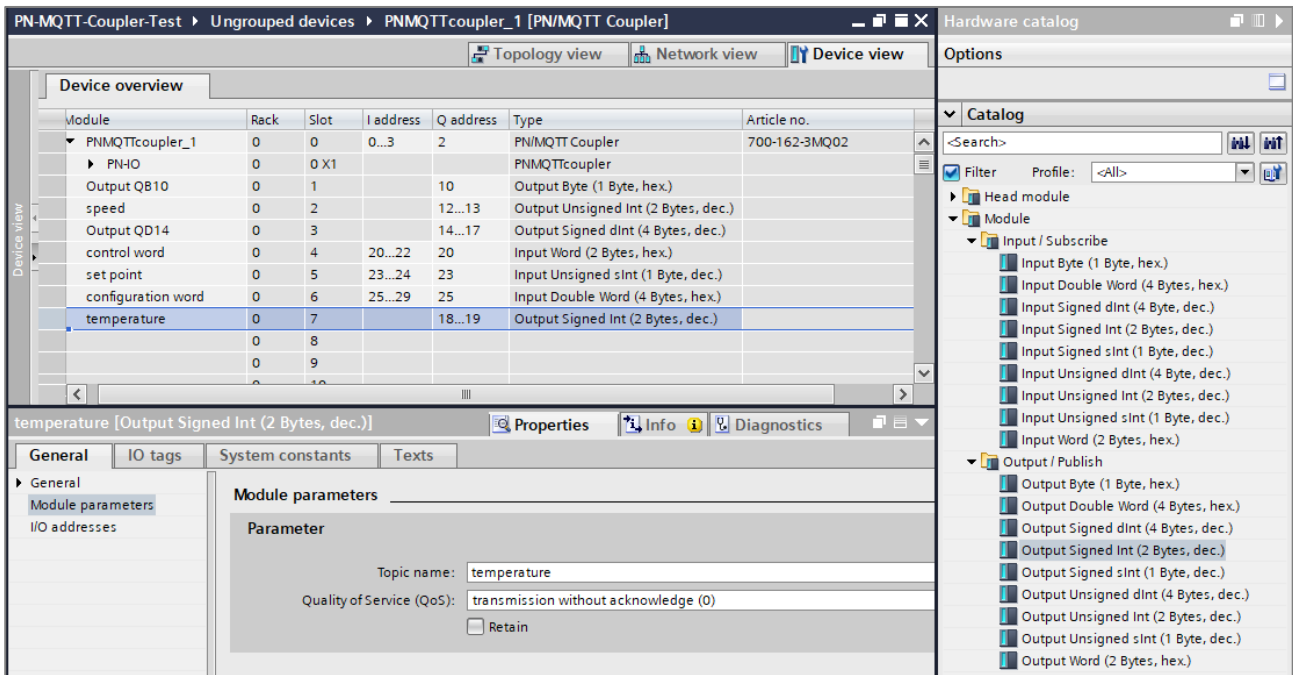
For each module, the **Topic name** must be defined unambiguously in the module parameters. The name can be chosen suitable to the symbolic name of the PLC value. Up to 40 characters are available.

As another parameter, the method of **Quality of Service (QoS)** of the topic can be specified.

Transmission without acknowledge (0): The topic is sent without an acknowledgement from the broker („fire-and-forget")

Transmission with acknowledge (1): The topic is sent, and an acknowledgement ("PUBACK") is expected from the broker. If no acknowledgement is received, the topic is sent again.

Transmission with acknowledge and confirmation (2): Provides the guarantee that a message has been "delivered exactly once". In order to be able to keep this guarantee, MQTT uses a two-stage acknowledgement of receipt.

Retain: This option tells the broker to save the last message or value in the broker even if the connection to the MQTT client fails.

6.3 Assign a name to the PN/MQTT coupler

When the configuration of the PN/MQTT coupler is completed in the hardware configurator of the engineering tool, it can be imported into the PLC.

To enable the PN/MQTT Coupler to be found by the PROFINET controller, the PROFINET device name must be assigned to the PN/MQTT Coupler. To do this, use the "Assign device name" function, which you can access with the right mouse button or in the Online menu if the PN/MQTT Coupler is selected.

Use the "Update list" button to search the network for PROFINET stations. With "Assign name" the PROFINET device name can be assigned to the device.
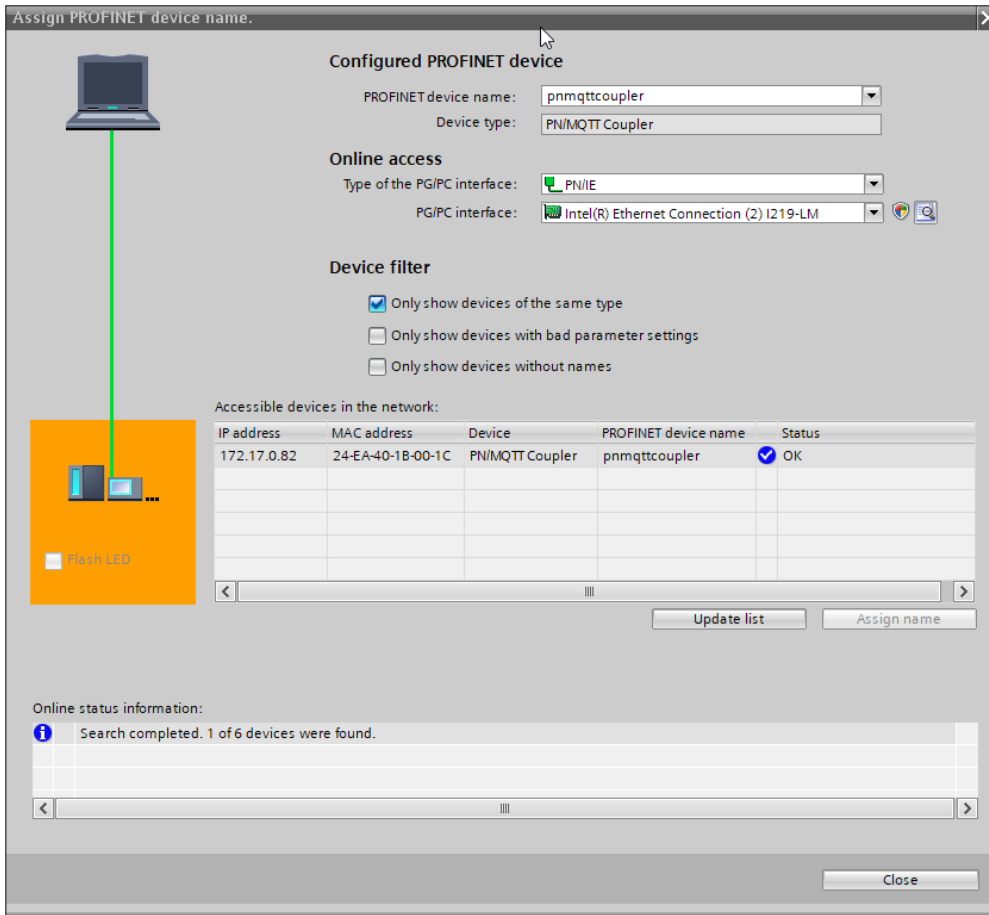
If the PN/MQTT coupler has received the correct PROFINET name, it is recognized and configured by the PLC. If the configuration is correct, the PROFINET "BF" LED should be off.

To set the PROFINET name, the Helmholz IPSet Tool can also be used, which can be downloaded free of charge from the Helmholz website.
Scan the following QR code to download the IPSet Tool:

7 Configuration of MQTT connection

7.1 Access to the web page

As soon as the PN/MQTT coupler has been configured via the PROFINET PLC, the web page of the device is accessible via the PROFINET network. If the IP address is also available on the MQTT network page (static IP, DHCP successful), the web page is also accessible via the MQTT network. When accessing the device for the first time, a password must be assigned for the user "admin". After logging in, you will see the "Overview" view:
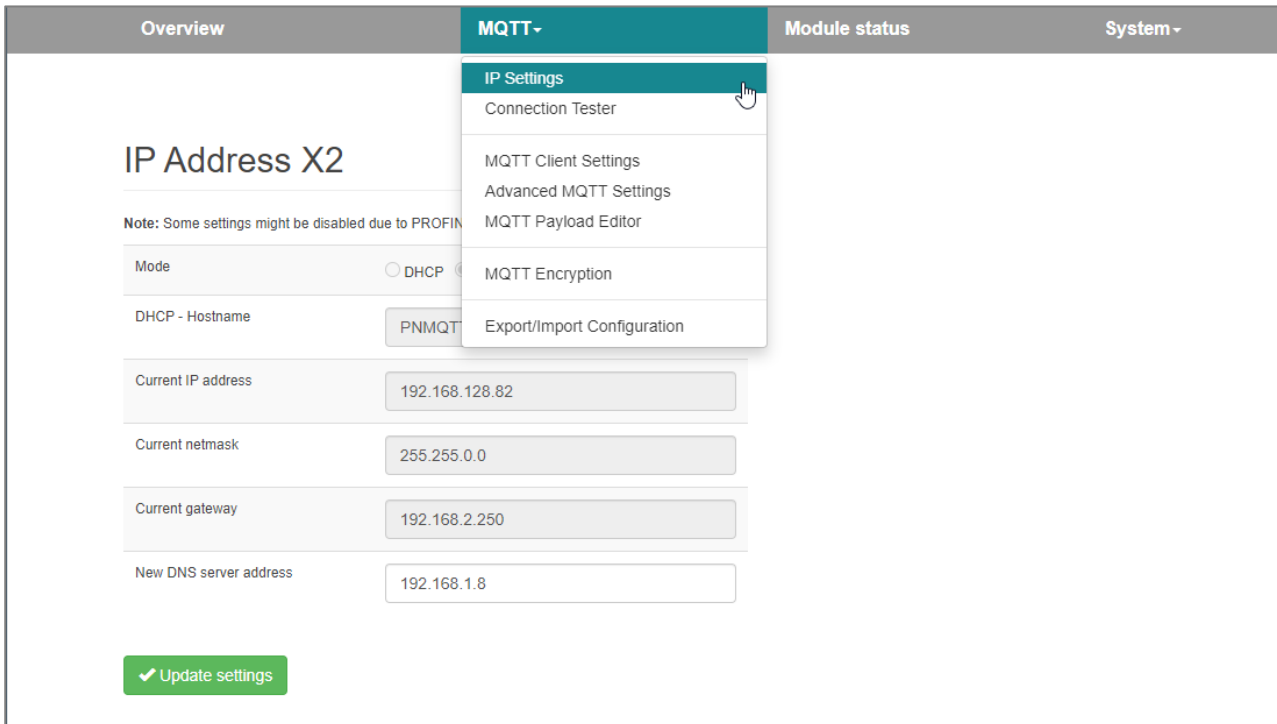
The error "System error (SF)" on the PROFINET page is also displayed due to the unconfigured MQTT connection.

If the web page of the device is not available, please check the "Web page" parameter in the PROFINET configuration. (see chap. 6.1).

7.2 MQTT Configuration

After the configuration of the PROFINET side, the connection to the MQTT broker must still be configured on the web page of the PN/MQTT coupler. The configuration can be done in the "**MQTT**" menu. First select the "**IP Settings**".

In the section "IP Address X2" the IP address of the right network port "X2" of the PN/MQTT Coupler is displayed. This can be set if it was not specified via the PROFINET configuration or received via DHCP.

The MQTT broker is addressed via interface X2. If the MQTT broker is located in the same network as the PROFINET PLC, see note in chapter 4.2.

The necessary settings for connecting to a local MQTT broker can be made on in the menu "**MQTT Client Settings**".

MQTT version: The PN/MQTT Coupler supports the MQTT standard "3.1.1" and the new standard "V5". Since the two standards are not compatible, the MQTT version must be set to match the broker.
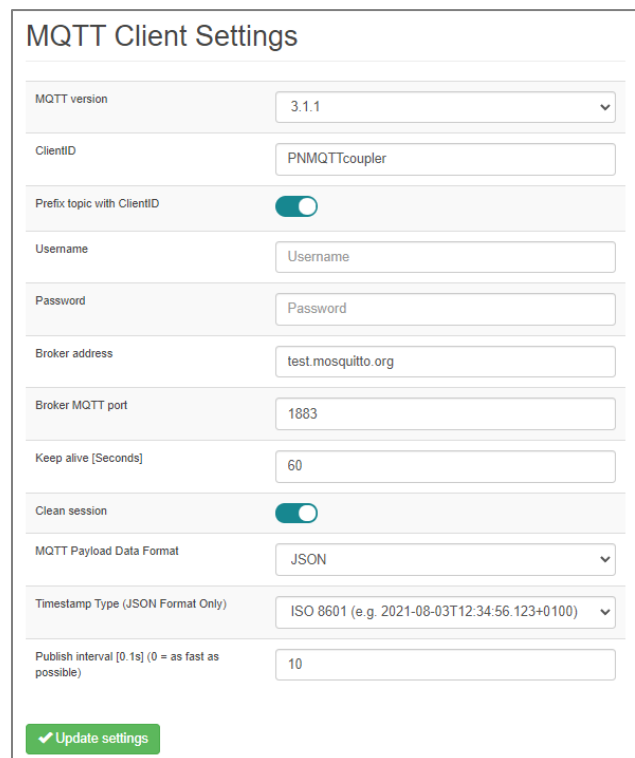
ClientID: Name of the MQTT client when logging on to a broker

Username/Password: Authentication at the broker

Broker address: IP address of the broker. The broker must be in the same subnet as the IP address of the coupler's X2 network.

Broker TCP Port: Port for the MQTT connection to the broker. Common are "1883" for unencrypted and "8883" for TLS encrypted connections.

Keep alive: Time grid for the cyclic life message of the coupler to the broker. If this message is missing, the broker assumes a failure of the coupler.

Clean session (MQTT V3.1.1): Information to the broker when establishing the connection whether old messages should be deleted or saved.

Clean start (MQTT V5): If Clean Start is enabled, the client and broker must discard all existing sessions and start a new session when a connection is established.
If Clean Start is disabled and a session is associated with this client ID, the server must resume communication with the client based on the state of the session. If no session is associated with this client ID, the server must create a new session.

Session expiry interval [Seconds] (MQTT 5.0 only): In the context of "Clean start", if "Session expiry interval" is set to 0, the session is terminated when the network connection is closed. Otherwise, the session is kept open until the time expires.

MQTT payload data format:
The value of a topic is always sent in simple text form.

> Example: `-12345`

Some MQTT applications expect a structured form in JSON format.

> Example: `{`
> `    "value": "-12345"`
> `}`

Timestamp Type: The PN/MQTT coupler can (only for JSON formatted messages) add a timestamp to the message.

Publish interval: An MQTT message is sent automatically when the output value in the PLC changes. If PLC values are sent that change very fast it is possible to limit the send interval. '0' tells the coupler to send as fast as possible and a number greater than zero tells it not to send faster than x * 0.1 seconds.

7.3   Connection Tester

To test the MQTT Broker connection, the PN/MQTT Coupler provides a "Connection Tester" in the "MQTT" menu.

The Connection Tester tests in 4 subsequent steps if a connection to the internet can be established if the name resolution and the time server works and if the MQTT Broker port is reachable.
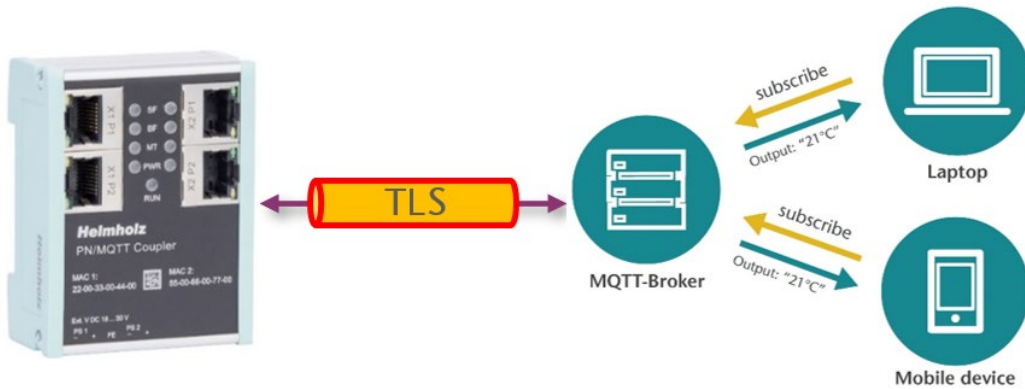
7.4 MQTT encryption and authentication

The transmission between the client and the broker can be encrypted and the devices can authenticate each other, i.e. verify their identity.

In the "MQTT" menu under "MQTT Encryption", encryption can be activated, certificates can be stored, and self-generated certificates can also be created.

Enabled – Encryption only:
Enables encryption without authentication. This option does not require a CA or client certificate or client key.

Encryption + Broker authentication: enables encryption with broker authentication done by the client. With this option, a CA must be uploaded for broker verification (see below).

Enabled + Broker & Client authentication: enables encryption with mutual broker and client authentication. This option requires a CA and client certificate. In addition to broker verification by the client, the broker can also verify the client as it sends its certificate during the TLS handshake.
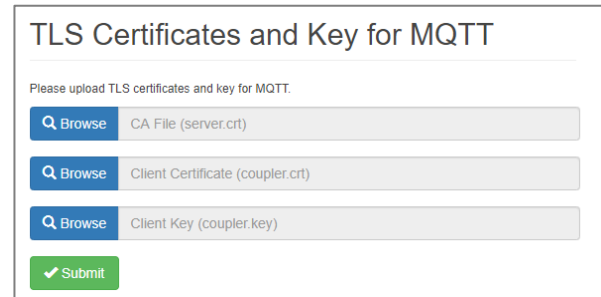
Verify broker certificate (SNTP must be active): Certificates contain an expiration date and must be updated regularly. This option checks whether the broker certificate is still valid.

For encryption and authentication, certificates and keys must be provided (uploaded) to the PN/MQTT Coupler.

CA File: certificate of broker

Client Certificate: Certificate for the PN/MQTT Coupler
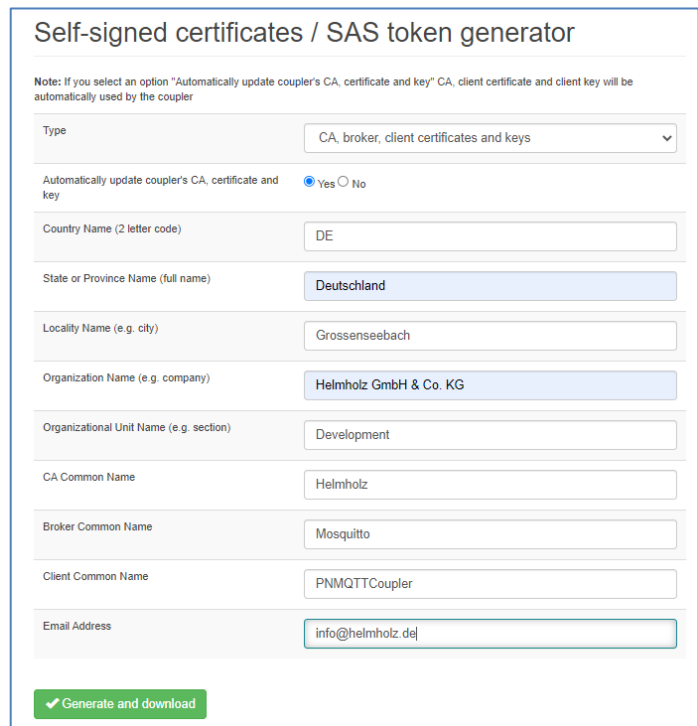
Client Key: Private Key File for the PN/MQTT Coupler

For an encrypted and authenticated connection with a broker - whether "on premise" or in the cloud - the certificate of the broker and the certificate of the parent certification authority ('CA') should be downloadable or generated by IT for the own network.

The certificate for the client should then also either be generated by the broker application or also created by IT.

To make it easier to work with certificates during internal testing, the PN/MQTT Coupler includes a built-in generator for self-signed certificates or SAS tokens (Microsoft Azure).

Please refer to the PN/MQTT Coupler manual for the use of these functions.

7.5 Module status

If all parameters were set correctly and accepted with "Update settings", the PN/MQTT Coupler should automatically connect to the MQTT broker and the red LEDs should go off.

The status can be checked in the "Overview" view:

On the web page "Module status" the configured module configuration and the current IO data are displayed. If there is a configuration error, the error is displayed in the "Diagnostic message" column.

8 Status and control via the PLC

8.1 Status of PN/MQTT Coupler

The PN/MQTT Coupler provides a status (4 bytes) via the PROFINET input image:

Byte/Bit	7	6	5	4	3	2	1	0
Input Byte 0	PROFINET configuration OK	0	PS 1 Voltage available	PS 2 Voltage available	0	0	X2 network IP address available	X2 network cable detected
Input Byte 1	0	0	0	0	0	0	0	MQTT Broker connection active
Input Byte 2	Last MQTT error code (MQTT V5) or Connect Return/Reason-Code							
Input Byte 3	*Reserved*							

8.2 Control of PN/MQTT Coupler

The PN/MQTT coupler can be controlled via the following control bits (1 byte) in the PROFINET output image:

Byte/Bit	7	6	5	4	3	2	1	0
Output- Byte 0	Clear MQTT Error Code		-	-	-	-	MQTT Disconnect connection	MQTT lock data exchange

8.3 Subscribe Module

In addition to the input data for the actual value, the subscriber modules additionally have a status byte and a control byte.

Status bits of Subscribe Module:

Byte/Bit	7	6	5	4	3	2	1	0
Input Byte 0	1 = new data received	Receive counter						

Control bits of Subscribe Module:

Byte/Bit	7	6	5	4	3	2	1	0
Output Byte 0	1 = Reset data receive bit	-	-	-	-	-	-	-

To be able to detect the reception of MQTT messages, the receive bit 7 can be used, which must always be reset in the output byte of the module. Alternatively, the receive counter can be checked for changes.

Attention: the receive counter runs until 0x7F and is then reset to 0x00.

9 Technical data

Order no.	700-162-3MQ02
Article designation	PN/MQTT Coupler
PROFINET interface (X1)	
Connection	2x RJ45, integrated switch
Protocol	PROFINET IO Device as defined in IEC 61158-6-10
Transmission rate	100 Mbit/s full duplex
I/O image size	Up to 1024 Byte of input and output data
Number of configurable slots	100
Features	PROFINET Conformance Class B, media redundancy (MRP-Client), automatic addressing, Topology detection (LLDP, DCP), diagnosis alarms
MQTT interface (X2)	
Connection	2x RJ45, integrated switch
Protocol	MQTT V3.1.1 & MQTT V5
Transmission rate	10/100 Mbit/s, full-/half duplex
Status indicator	9 LEDs function status, 8 LEDs Ethernet-status
Voltage supply	DC 24 V (18 - 28 V DC)
Current draw	max. 210mA
Power dissipation	max. 5 W
Dimensions (D x W x H)	35 x 58 x 72 mm
Weight	approx. 135 g
Certifications	PROFINET Conformance Class B
Ambient conditions	
Ambient temperature	0° C to 60° C
Transport and storage temperature	-20° C to 80° C
Protection rating	IP 20
Relative humidity	95% non-condensing
Mounting position	any

10 LED status information

	X1 PROFINET (left side)	X2 MQTT network (right side)
SF (red)		
Off	Configuration correct	Configuration correct
On	PROFINET diagnostic alarm pending	PROFINET side not configured or failed
Flashing	PROFINET function "LED flashing" for finding the device is executed	-
BF (red)		
Off	Connection to PROFINET controller is established	MQTT broker connection is active
On	The device has no configuration, the PROFINET device name is incorrect, or there is no connection with the PROFINET controller	No connection to the MQTT broker can be established
Flashing	PROFINET function "LED flashing" for finding the device is executed	-
MT (yellow)		
Flashing	A firmware update is being carried out	A firmware update is being carried out
Flashing with SF and BF	PROFINET function "LED flashing" for finding the device is being carried out	-
PWR (green)		
On	PS1 Power supply present	PS2 Power supply present
RUN (green)		
Off	Firmware or device defective. Please contact Support	
On	The device is ready to operate	
RJ45 LEDs	X1 P1/P2 und X2 P1/P2	
Green (Link)	Connected	
Orange (Act)	Data transfer at the port active	

The contents of this Quick Start Guide have been checked by us so as to ensure that they match the hardware and software described.

However, we assume no liability for any existing differences, as these cannot be fully ruled out. The information in this Quick Start Guide is, however, updated on a regular basis. When using your purchased products, please make sure to use the latest version of this Quick Start Guide, which can be viewed and downloaded on the Internet from www.helmholz.de.

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