RIFTEK
Sensors & Instruments

PIPE ID CONTROL SYSTEM

RF096-35/55-100 Series

User's manual

Contents

1. Safety precautions

- Use supply voltage and interfaces indicated in the system specifications.
- In connection/disconnection of cables, the system power must be switched off.
- Do not use the system in locations close to powerful light sources.

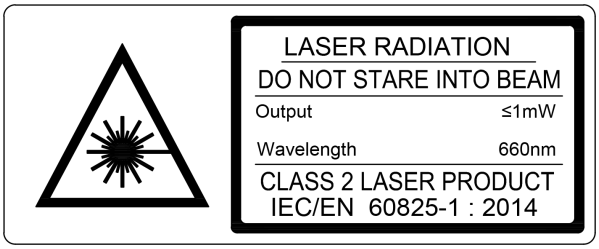
2. CE compliance

The system has been developed for use in industry and meets the requirements of the following Directives:

- EU directive 2014/30/EU. Electromagnetic compatibility (EMC).
- EU directive 2011/65/EU, “RoHS“ category 9.

3. Laser safety

The system makes use of an c.w. 660 nm wavelength semiconductor laser. Maximum output power is 1 mW. The system belongs to the 2 laser safety class according to IEC/EN 60825-1:2014. The following warning label is placed on the housing:



The following safety measures should be taken while operating the system:

- Do not target the laser beam to humans.
- Do not disassemble the laser sensor.
- Avoid staring into the laser beam.

4. General information

The system is designed for non-contact scanning and inner diameter measurement of the pipes.

5. Basic technical data

Parameter		Value
Measured ID range, mm		35...55
ID measurement accuracy, mm		±0.05
Angle scan resolution, points for turnover		3200
Pipe depth, mm		100
Linear translation accuracy, mm		±0.05
Laser sensor linearity, µm		±15
Laser sensor resolution, µm		3
Laser sensor sample frequency, Hz		9400
Light source		red semiconductor laser, 660 nm wavelength
Laser sensor output power, mW		1
Laser safety class		2 (IEC60825-1)
Interface		Ethernet and PROFINET
Power supply, V		220
Measurement time, s		<5
Environmental resistance	Vibration	20 g / 10…1000 Hz, 6 hours for each of XYZ axes
	Shock	30 g / 6 ms
	Permissible ambient light, lx	30000
	Relative humidity, %	5-95 (no condensation)
	Operating ambient temperature, °C	0…+45
	Storage temperature, °C	-20…+70
Weight (without cables), gram		6800

Note: System parameters can be changed for a specific task.

6. Example of item designation when ordering

RF096-Dmin/Dmax-L

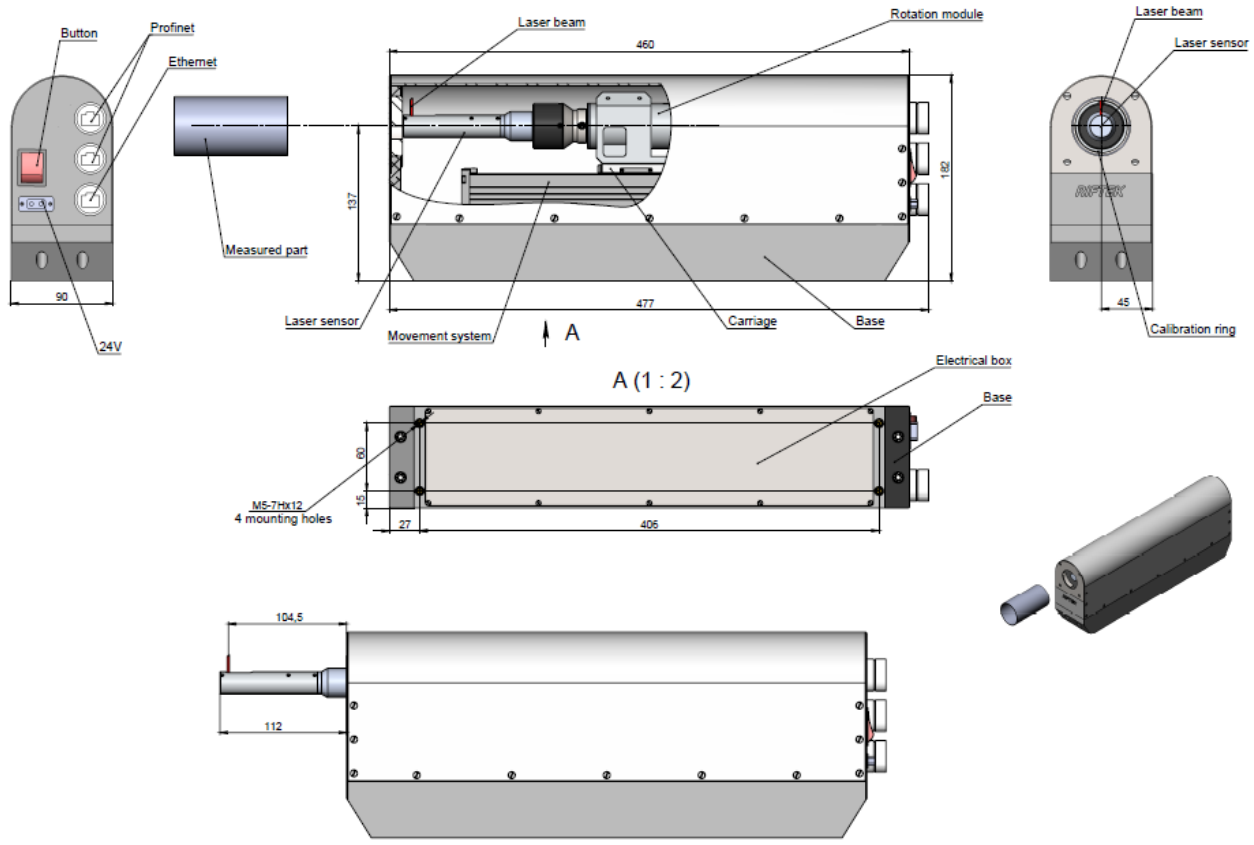
Symbol	Description
Dmin/Dmax	ID measurement range, mm.
L	Measurement depth, mm.

Example: RF096-35/55-100 - Pipe ID Control System, ID measurement range - 35...55 mm, measurement depth - 100 mm.

7. Structure and operating principle

Operation of the system is based on scanning the pipe inner surface with a rotating triangulation laser sensor.

The system contains a base on which the linear translation mechanism, the controller and the interface module are installed. The linear translation mechanism carries the rotation module on which the laser sensor is mounted. On the back of the system there are four connectors for power and interfaces.



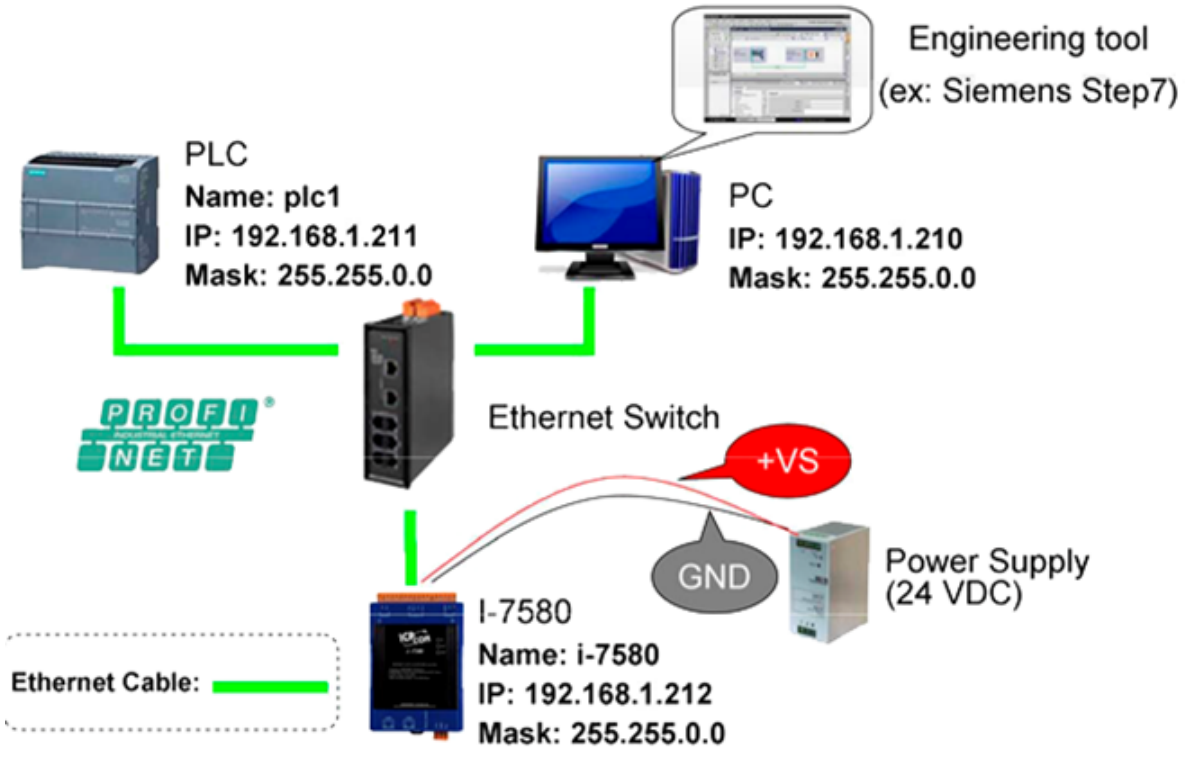
The system operates as follows.

The measured pipe is installed coaxially with the laser sensor. At the command of an external controller, the laser sensor moves into the hole. The sensor begins to rotate and scans the inner surface of the pipe, transmits the polar coordinates of the surface (distance from the axis of rotation measured by the sensor and the corresponding angle of rotation) to the built-in computer to calculate the required geometric parameters. The result is transmitted to the external controller via PROFINET.

8. Connection

- Connect the system to your controller.
- Connect the power cable to the system.
- Connect the system to 24V DC by using the special power cable.

The block diagram is shown below. In this diagram, I-7580 module is PROFINET IO device of the system, and PLC is S7-1200 from Siemens. The program «Step 7 V11» provided by Siemens does the configuration and communication.



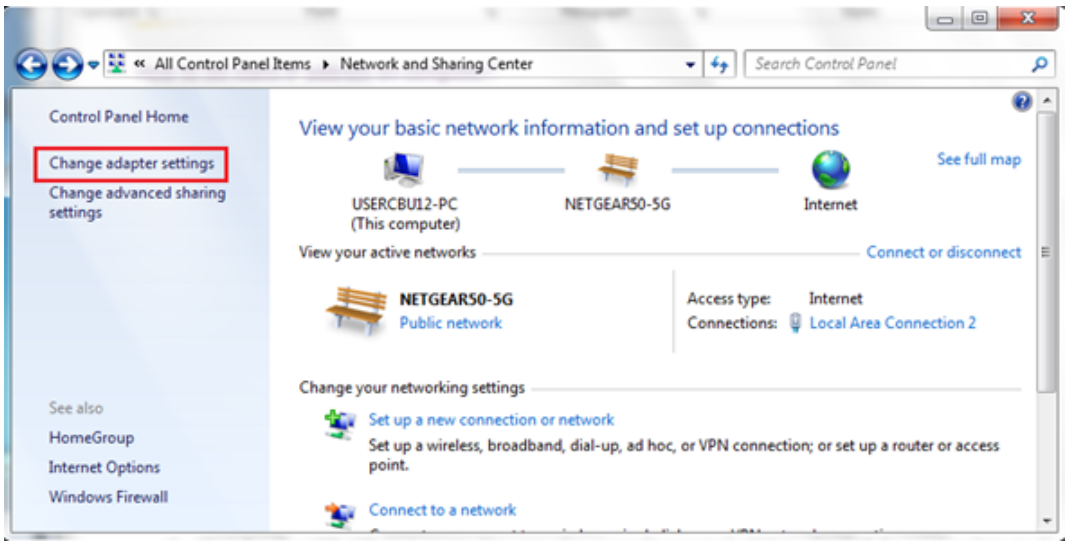
9. Network configuration

Configure the network as shown below:

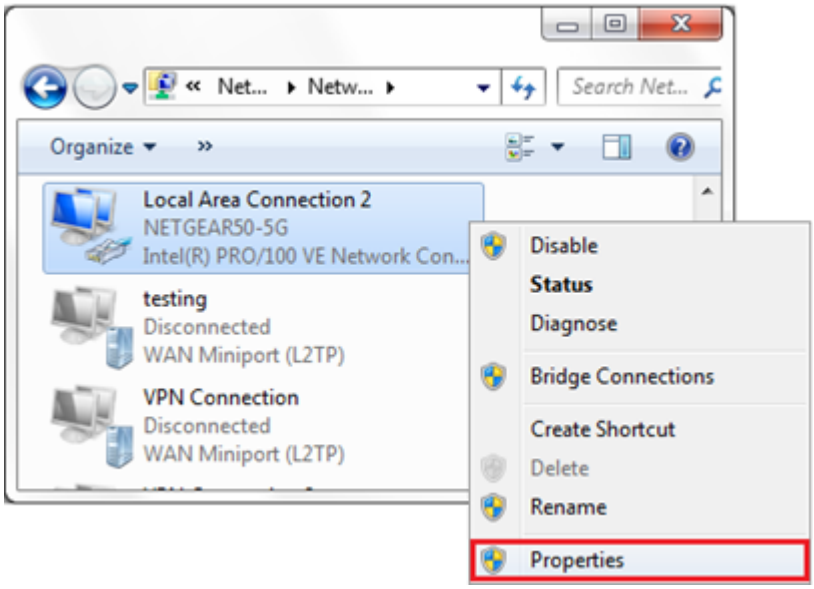
PC	PLC	I-7580
–	Device name: PLC_1	Device name: i-7580
IP: 192.168.1.210	IP: 192.168.6.211	IP: 192.168.1.212
Mask: 255.255.0.0	Mask: 255.255.0.0	Mask: 255.255.0.0

9.1. PC

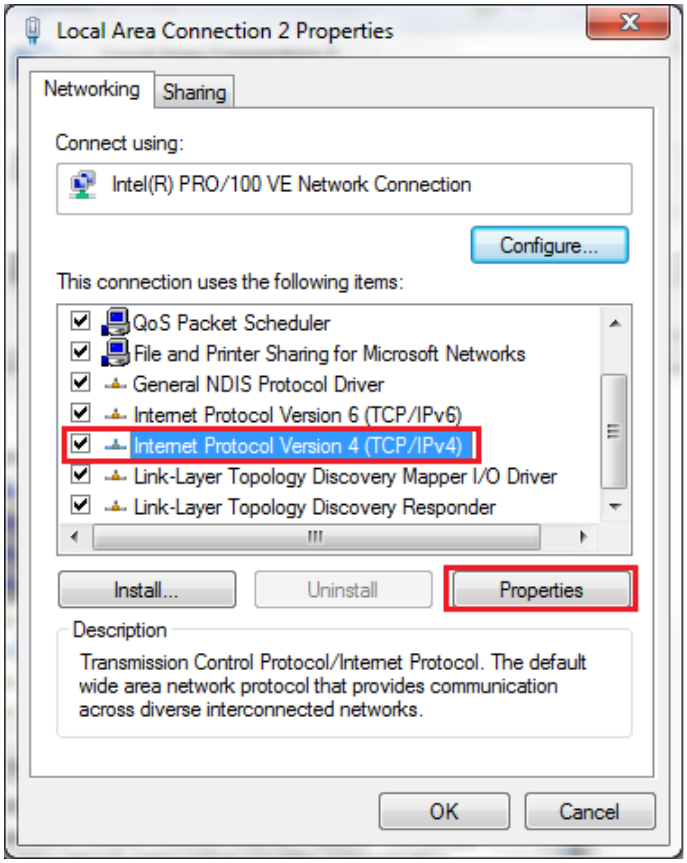
1. Select **Start Menu** > **Control Panel** > **Network and Sharing Center**. (For Windows 8 and higher, search for **Control Panel**, and select **Network and Internet**).
2. Click **Change adapter settings**.



3. Right-click on **Local Area Connection** and select **Properties**.

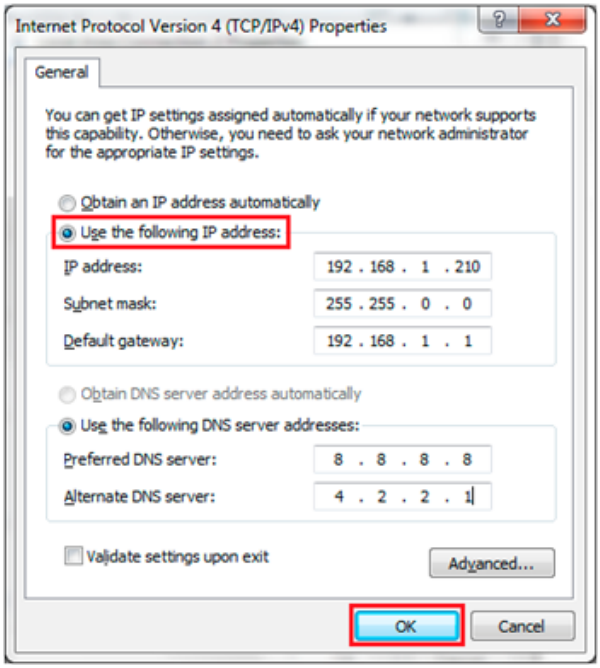


4. Select **Internet Protocol Version 4 (TCP/IPv4)** and click on **Properties**.



5. Select **Use the following IP address** and enter the IP address, Subnet Mask, Default Gateway and DNS server.

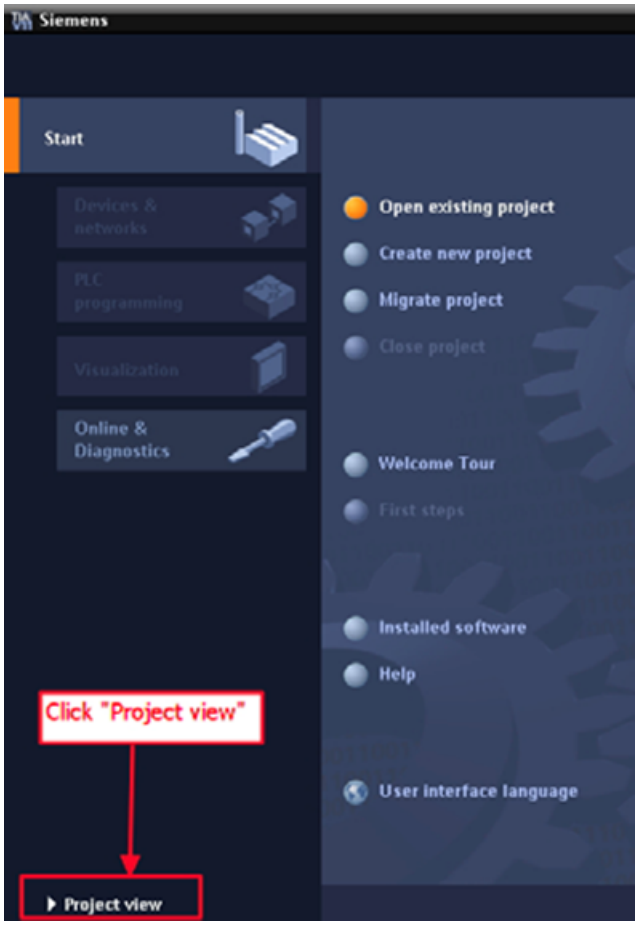
Click **OK** and close the **Local Area Connection Properties** window.



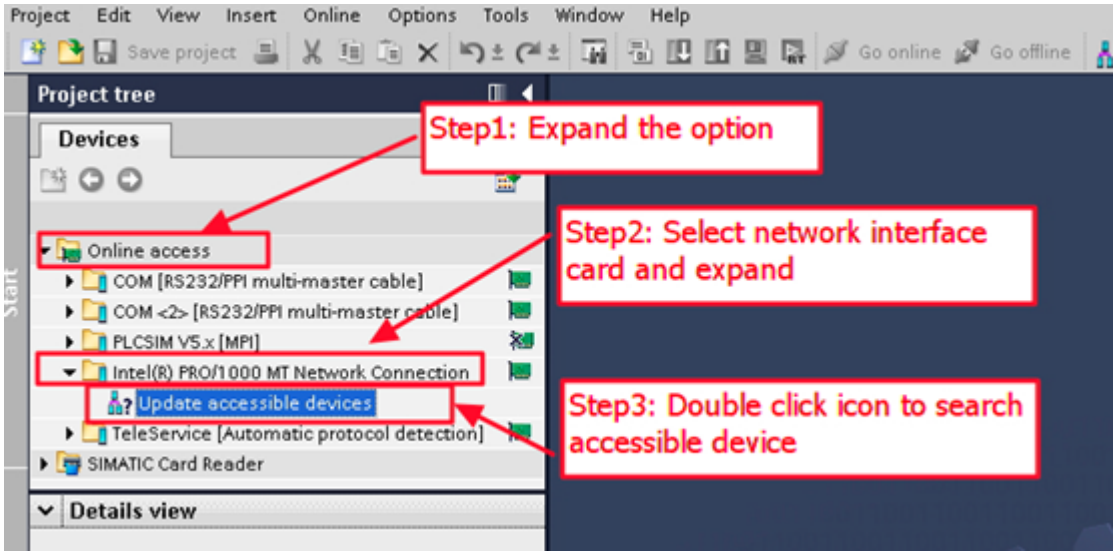
9.2. PLC

1. Double-click the **TIA** icon to start **Step 7 V11**.

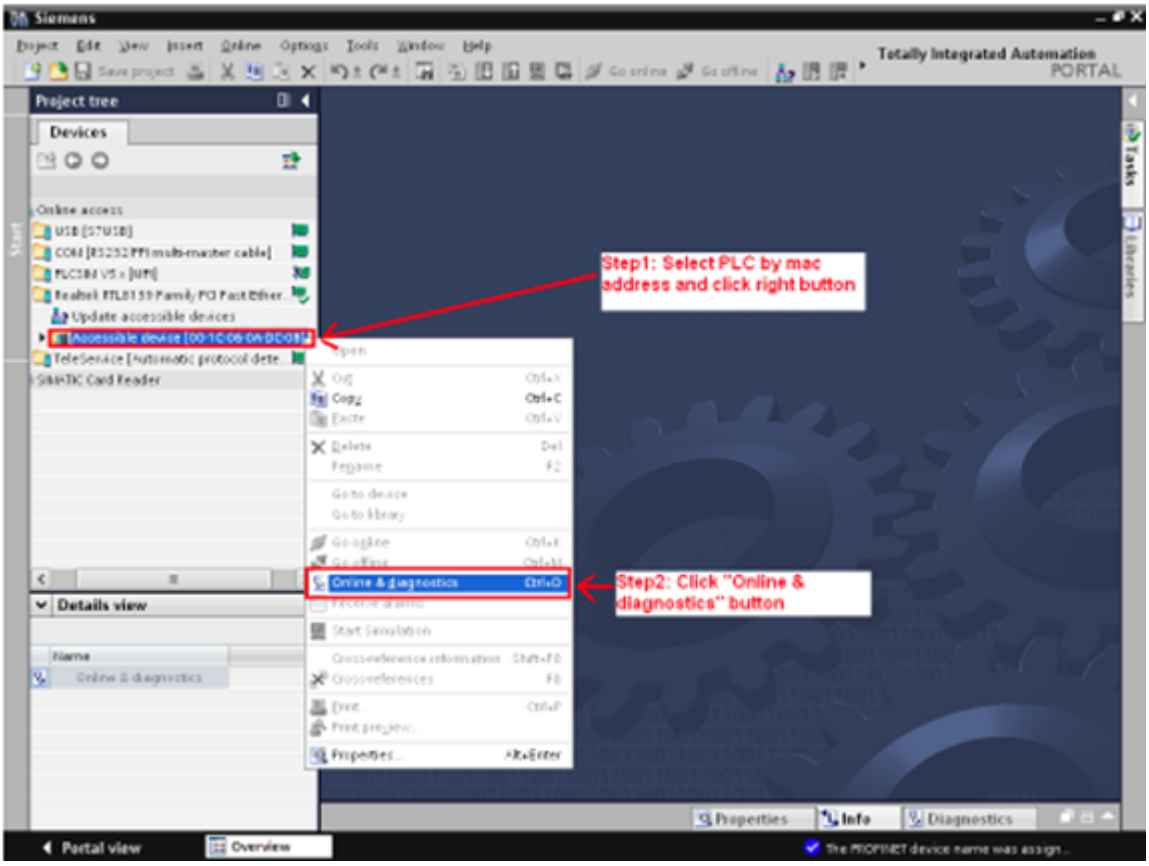
2. Click **Project view**.



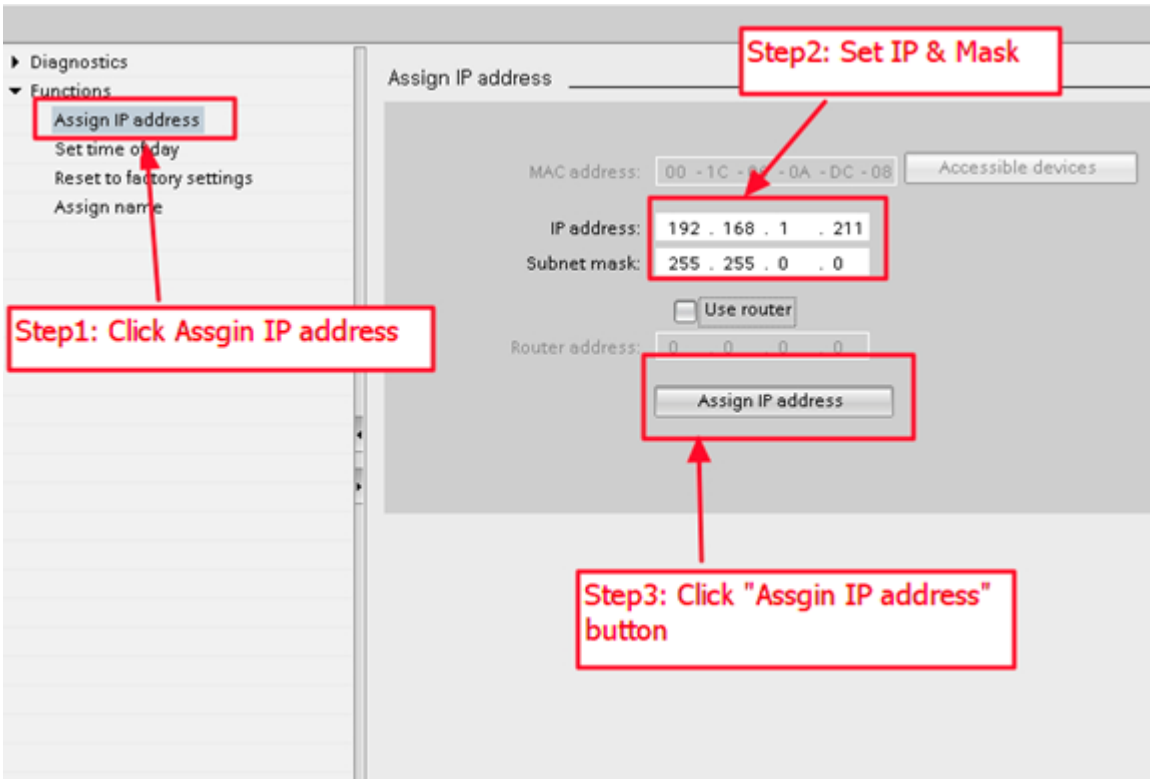
3. Search for accessible devices.



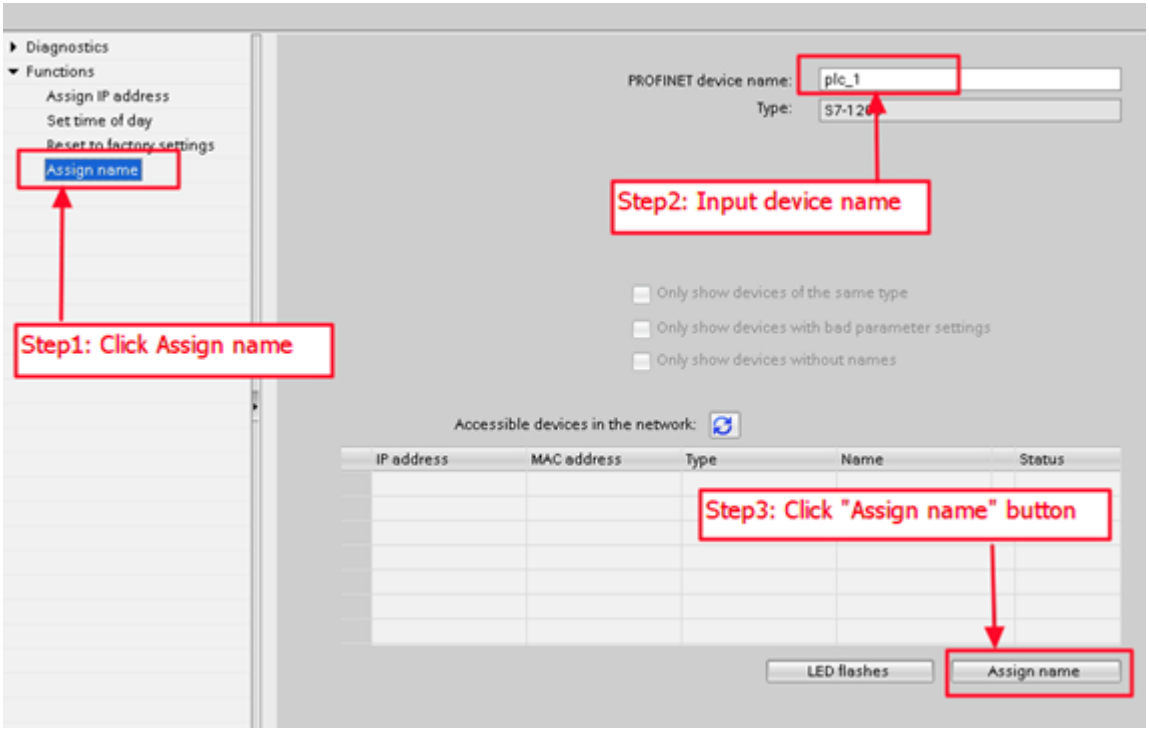
4. Select **PLC** and click the **Online & diagnostics** button.



5. Set the IP address and the subnet mask.

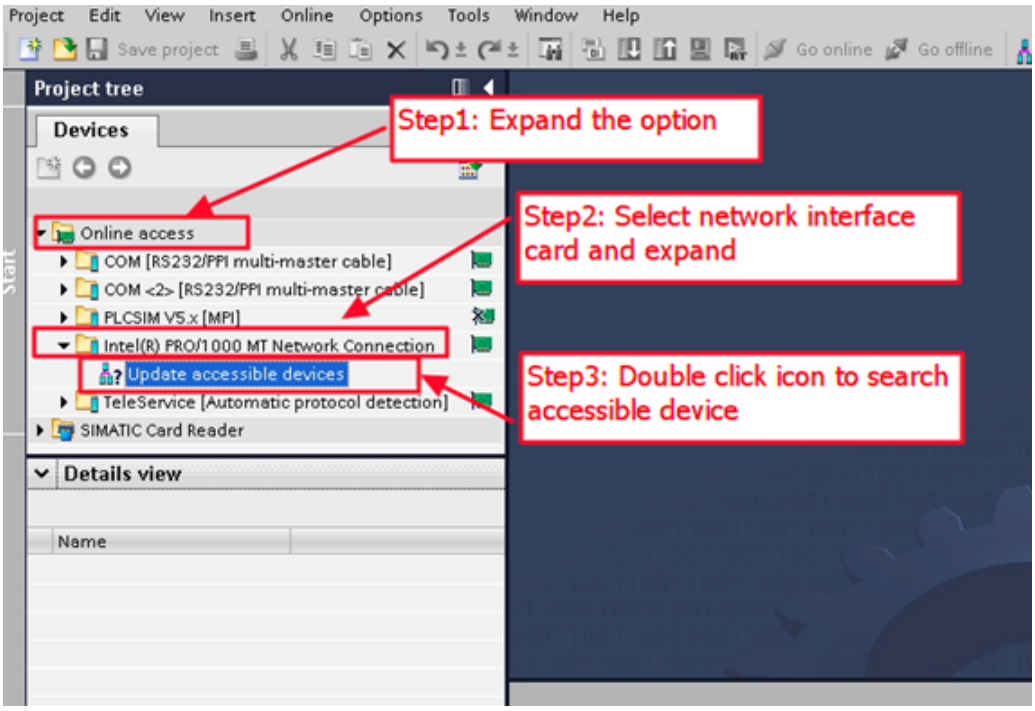


6. Set the device name.

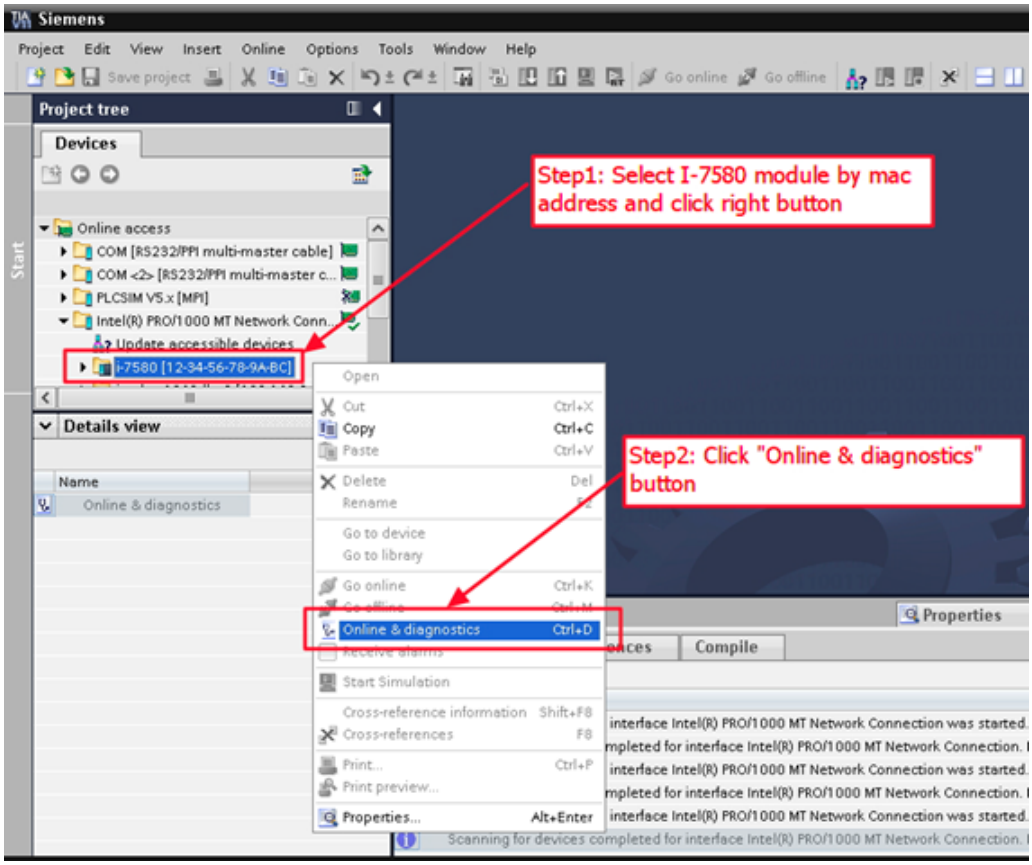


9.3. I-7580 module

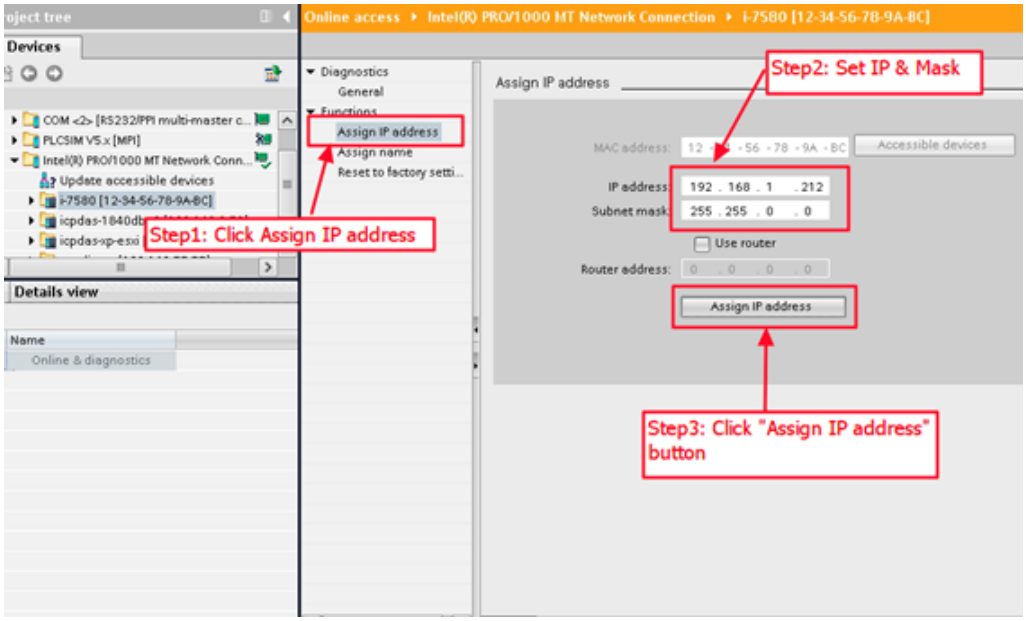
1. Search for accessible devices.



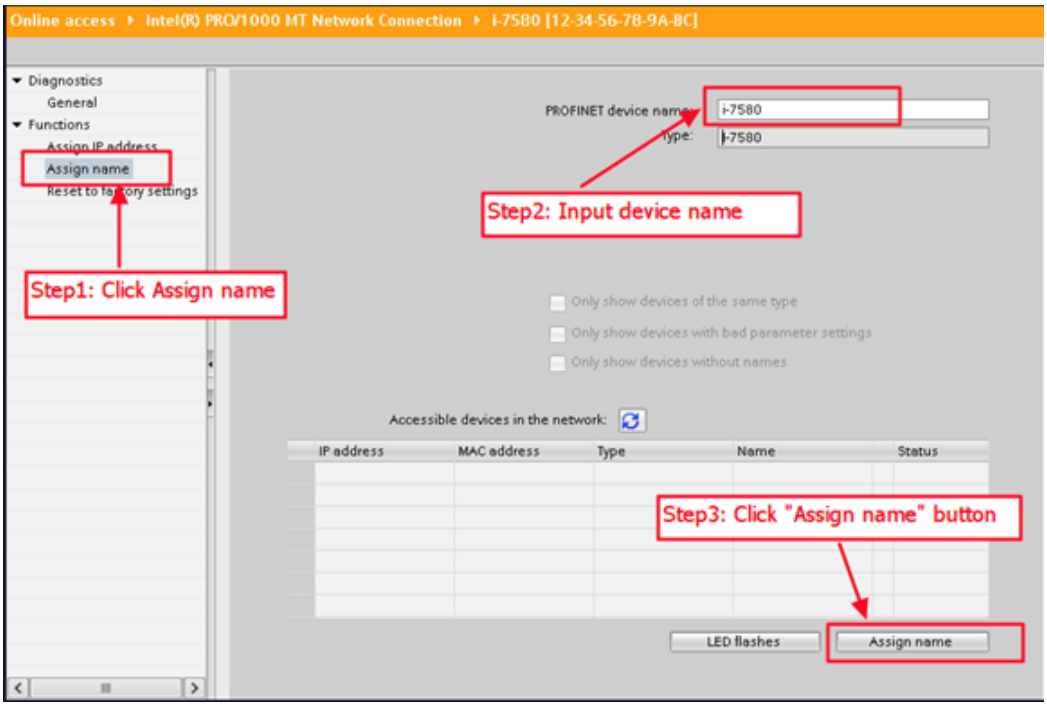
2. Select I-7580 module and click the **Online & diagnostics** button.



3. Set the IP address and the subnet mask.



4. Set the device name.



10. GSD import

Please follow the steps to import the GSD file:

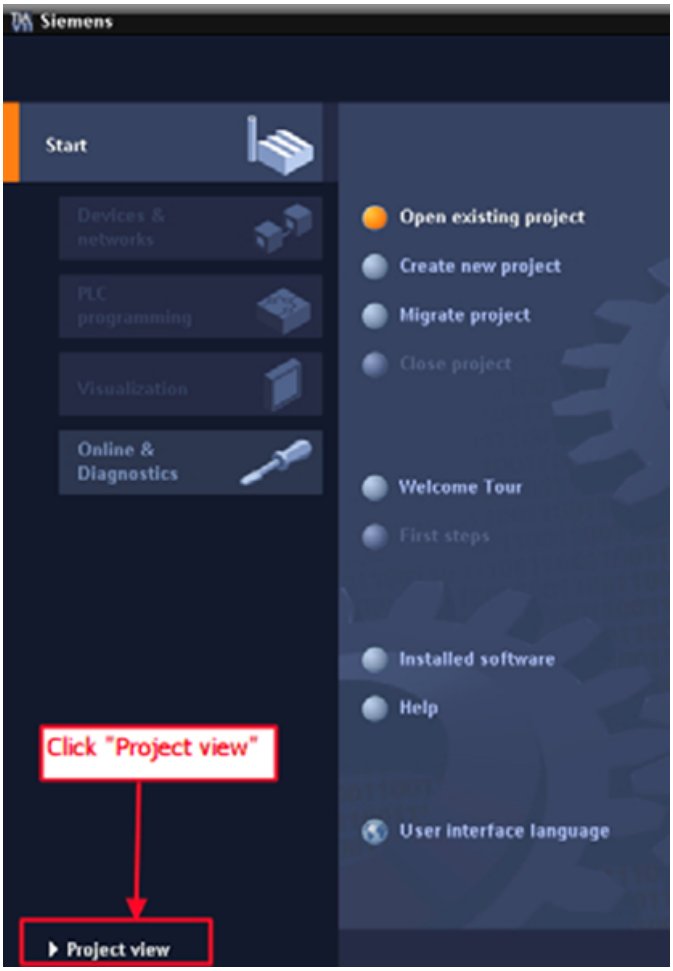
Step 1: Get the GSD file

The GSD file can be downloaded from an FTP site:
ftp://ftp.icpdas.com/pub/cd/fieldbus_cd/profinet/converter/i-7580/gsd/

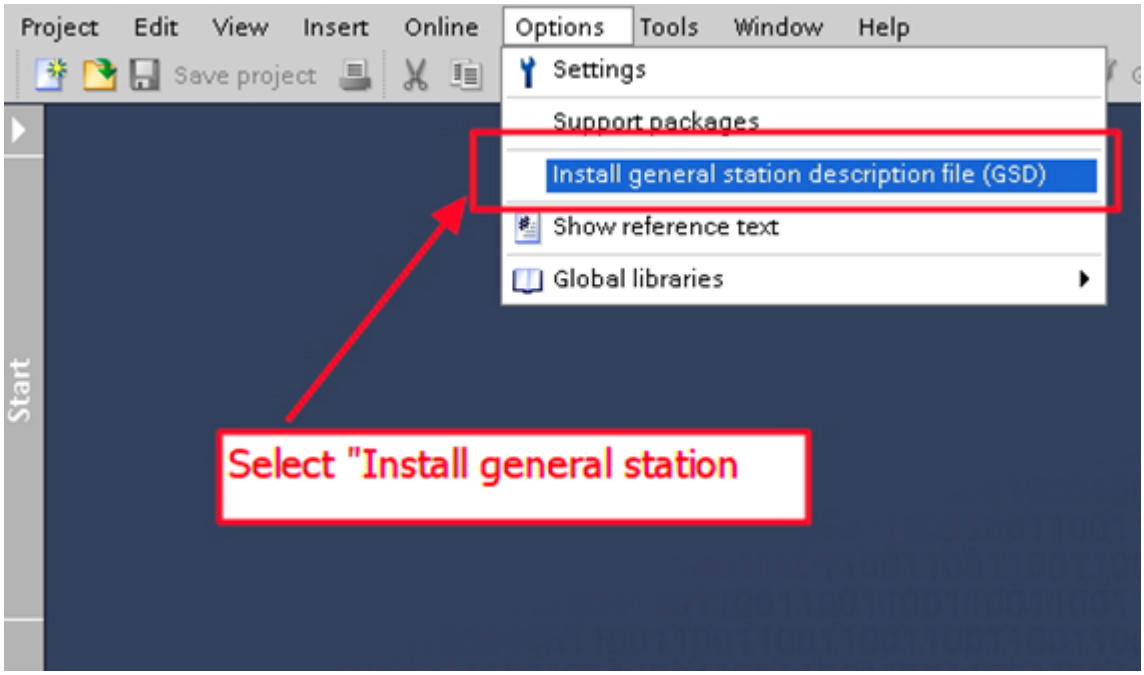
Step 2: Import the GSD file

1. Double-click the **TIA** icon to start **Step 7 V11**.

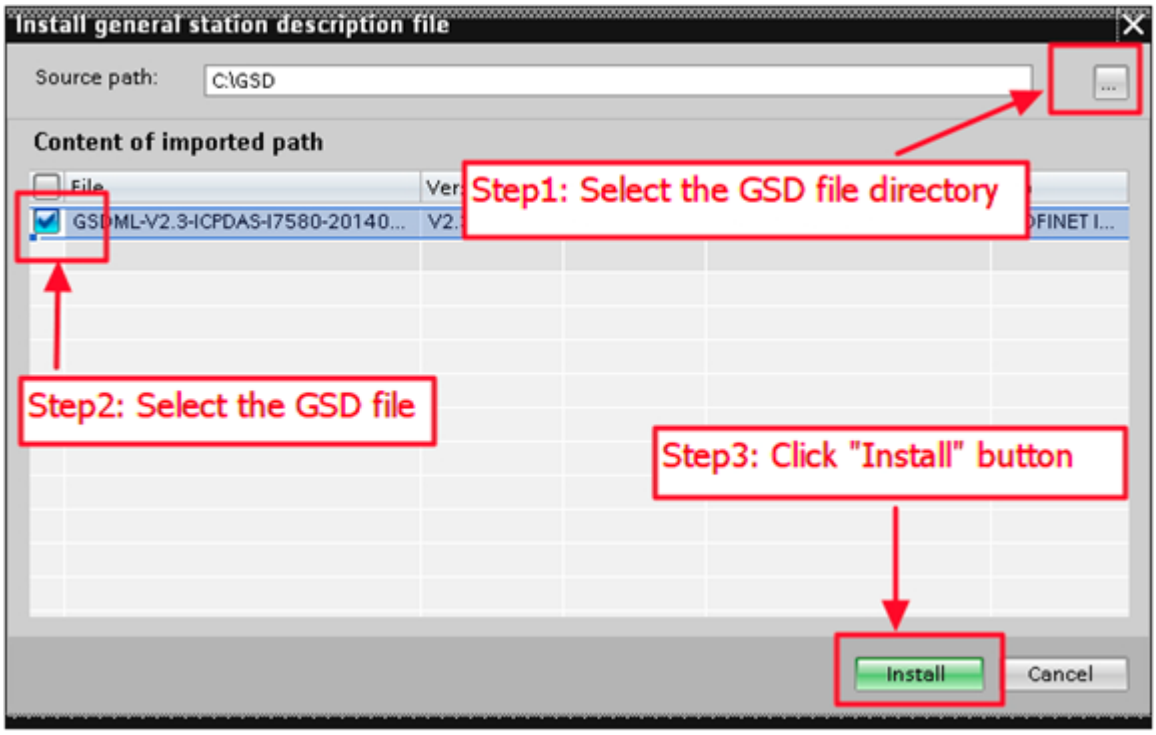
2. Click **Project view**.



3. Select **Menu** > **Options** > **Install general station description file (GSD)**.



4. Select and install the GSD file.



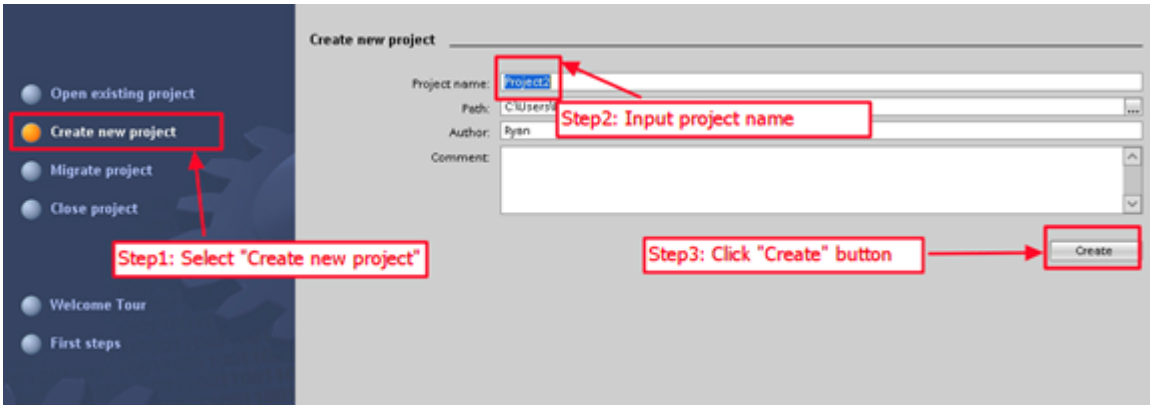
11. Project setup

Please follow the steps to setup the project:

Step 1: Create the project

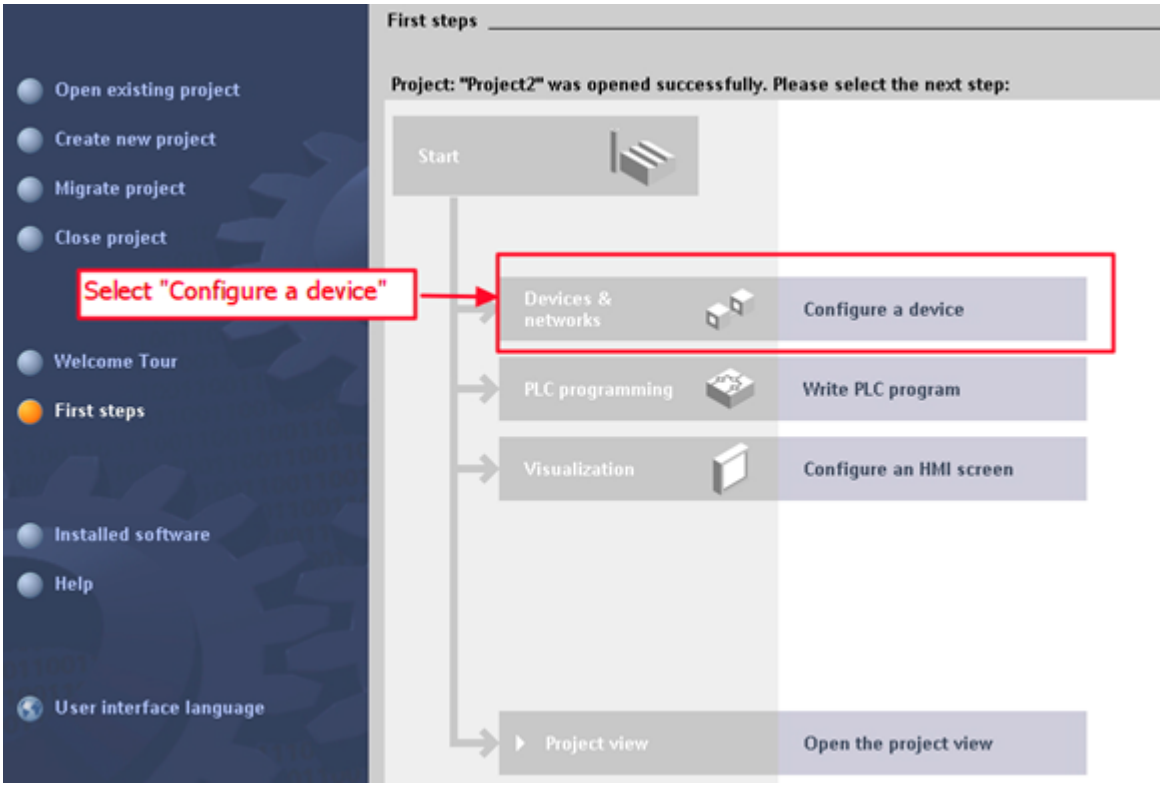
1. Double-click the **TIA** icon to start **Step 7 V11**.

2. Create the project.

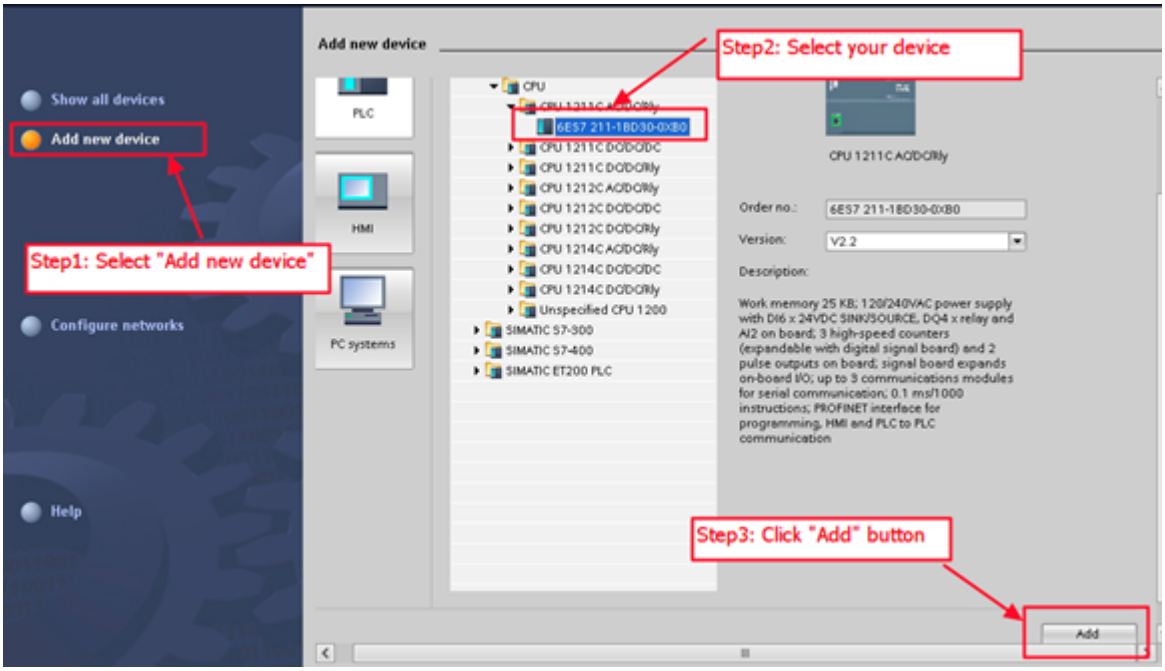


Step 2: Project configuration

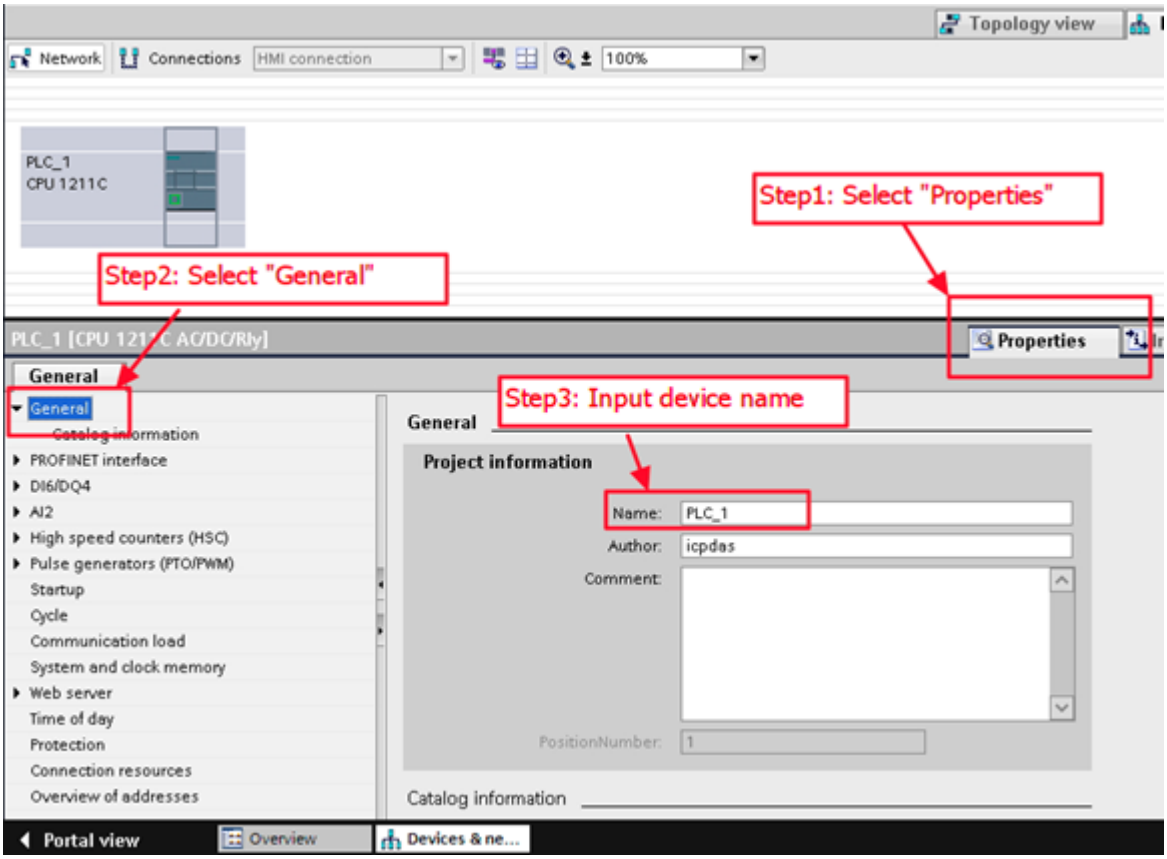
1. Add the PLC device.



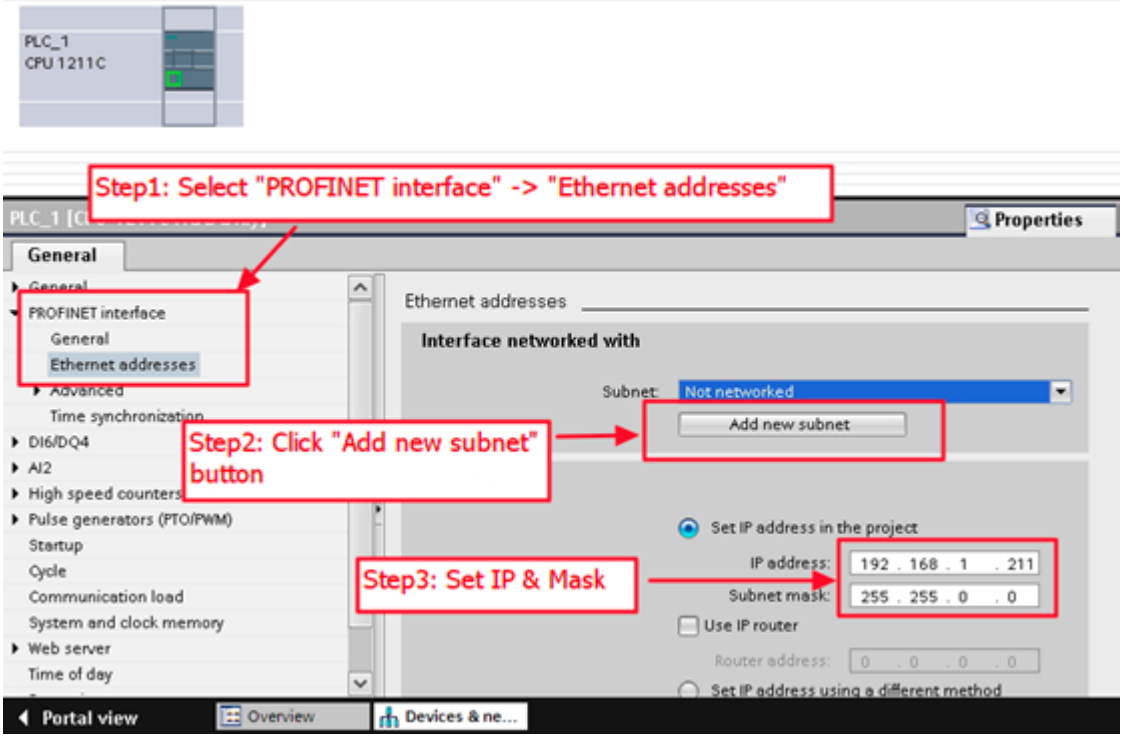
2. Select **Add new device**.



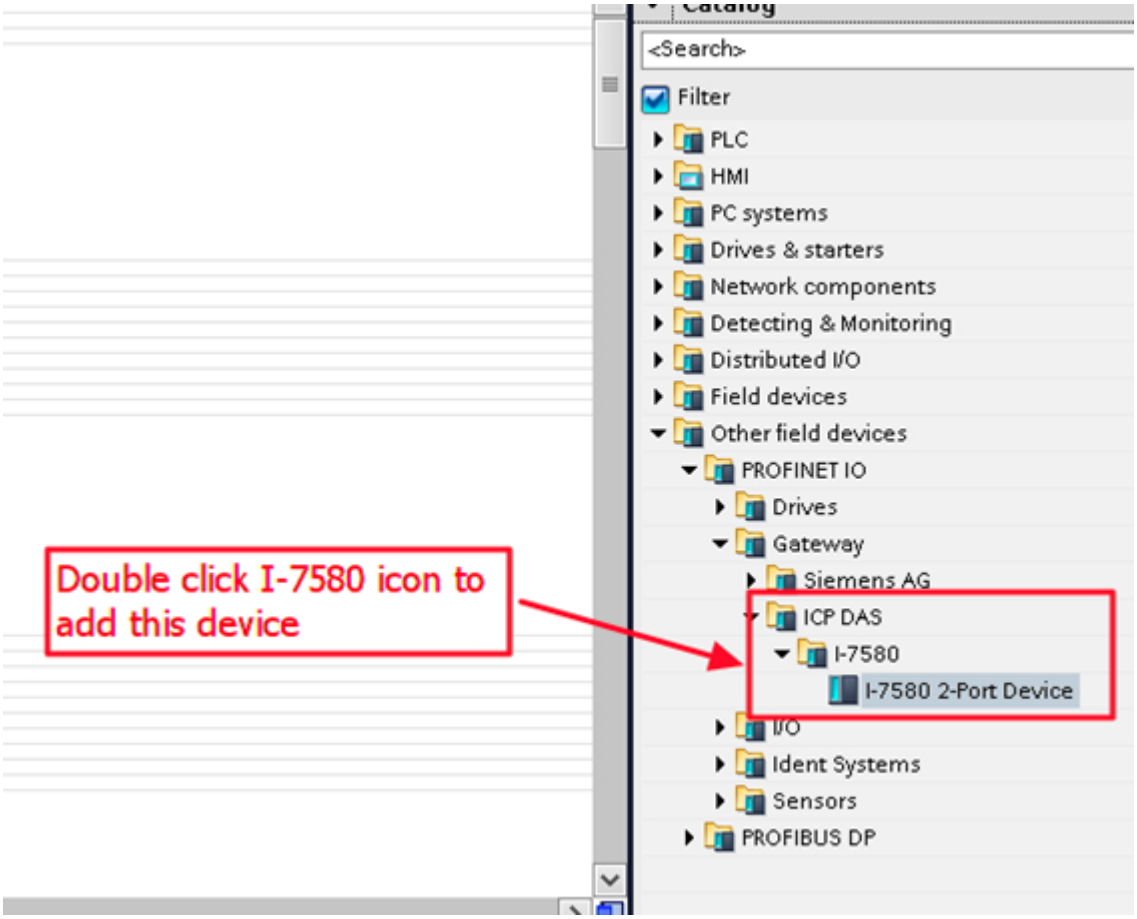
3. Set the PLC name to «PLC_1».



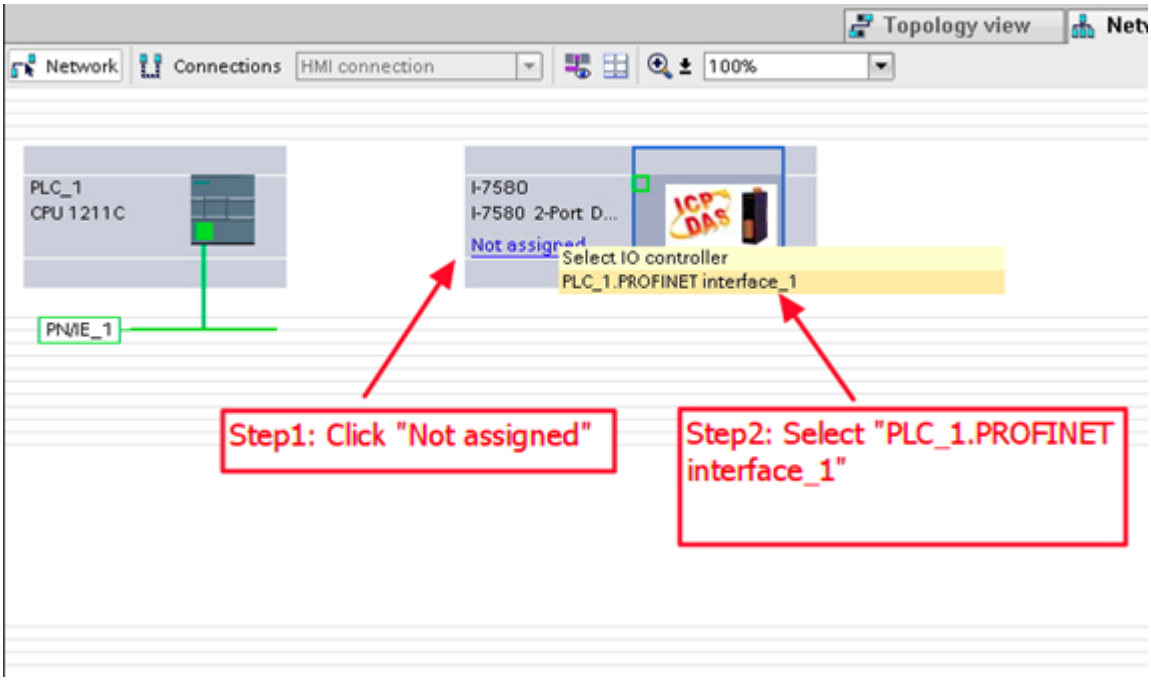
4. Set the IP address and the subnet mask for PLC and add the new subnet.



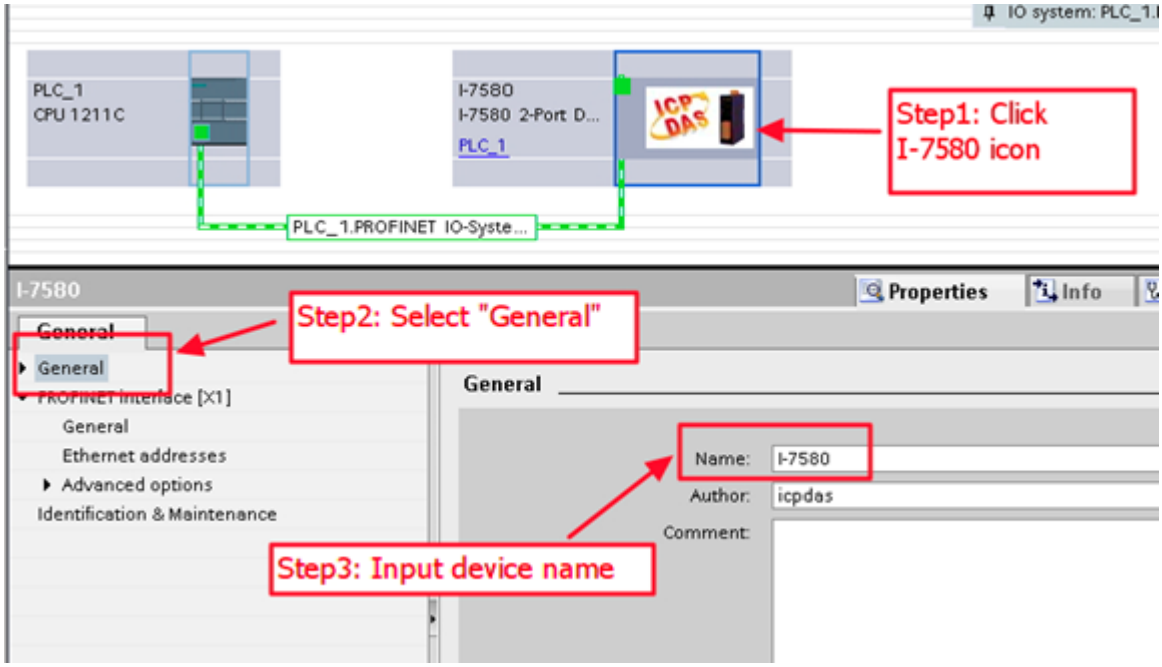
5. Add the I-7580 module.



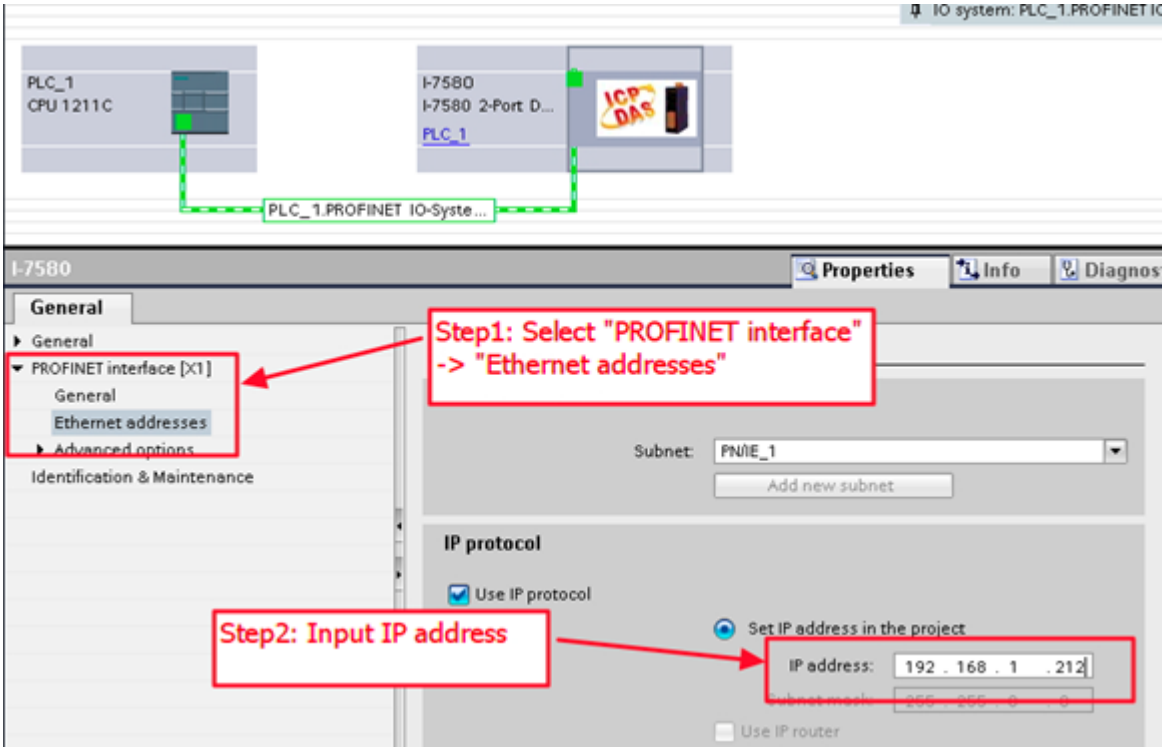
6. Select the PROFINET interface.



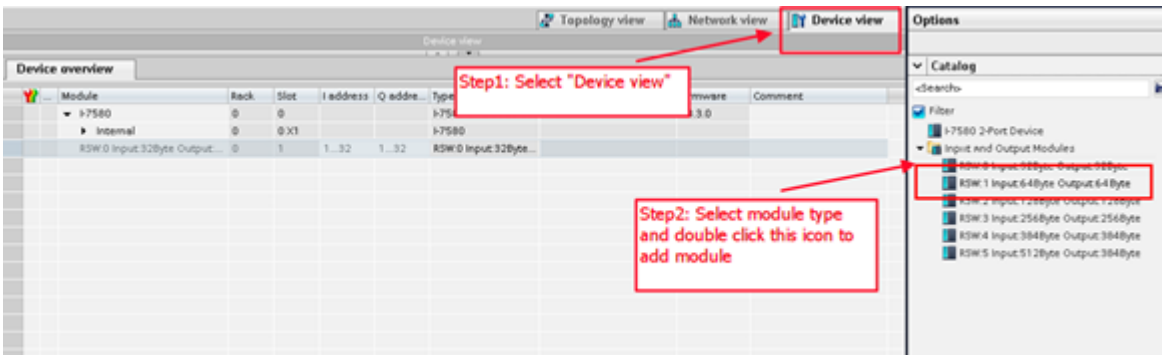
7. Set the device name to «i-7580».



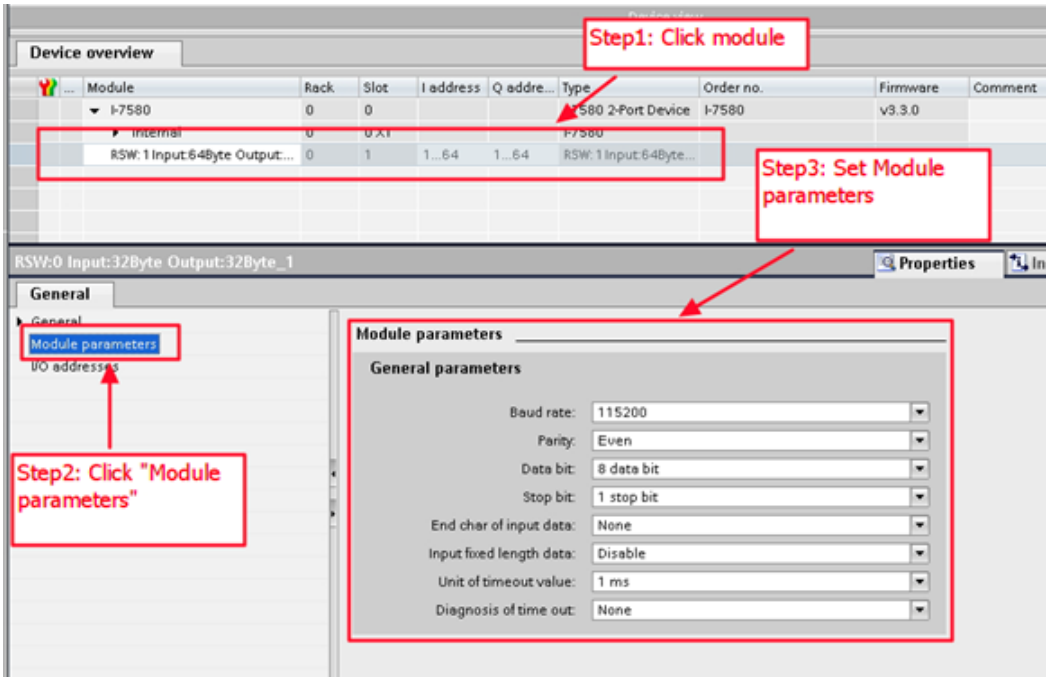
8. Set the IP address for the I-7580 module.



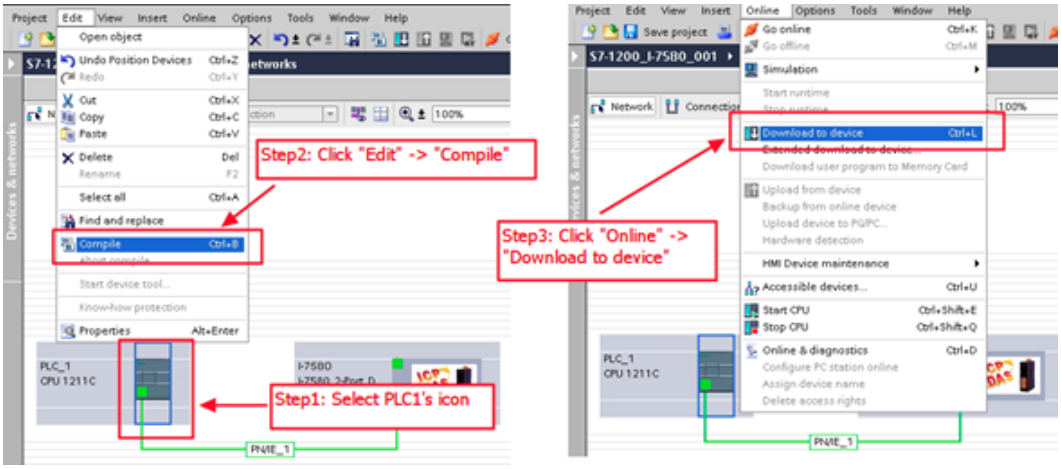
9. Set the module type for the I-7580 module.

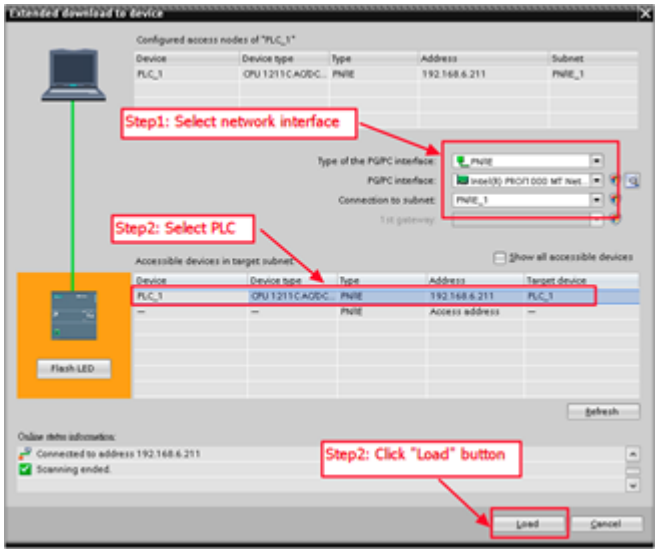


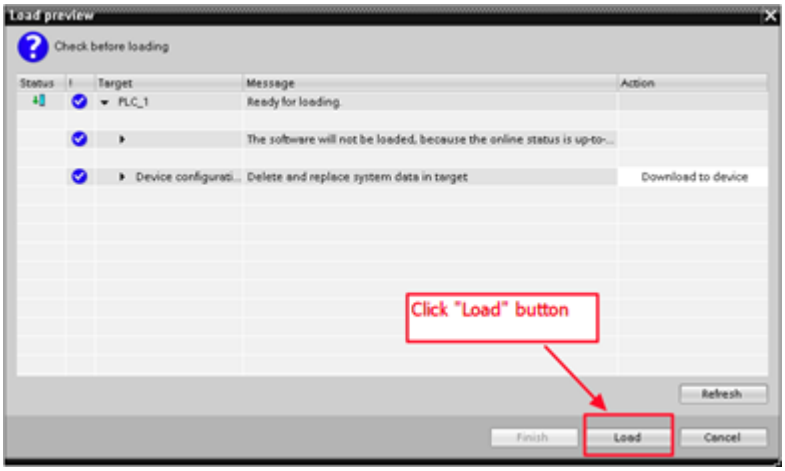
10. Set parameters for the I-7580 module.

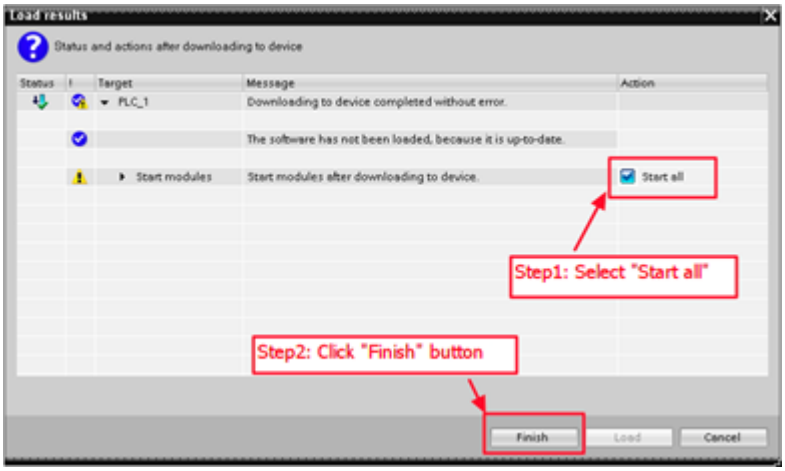


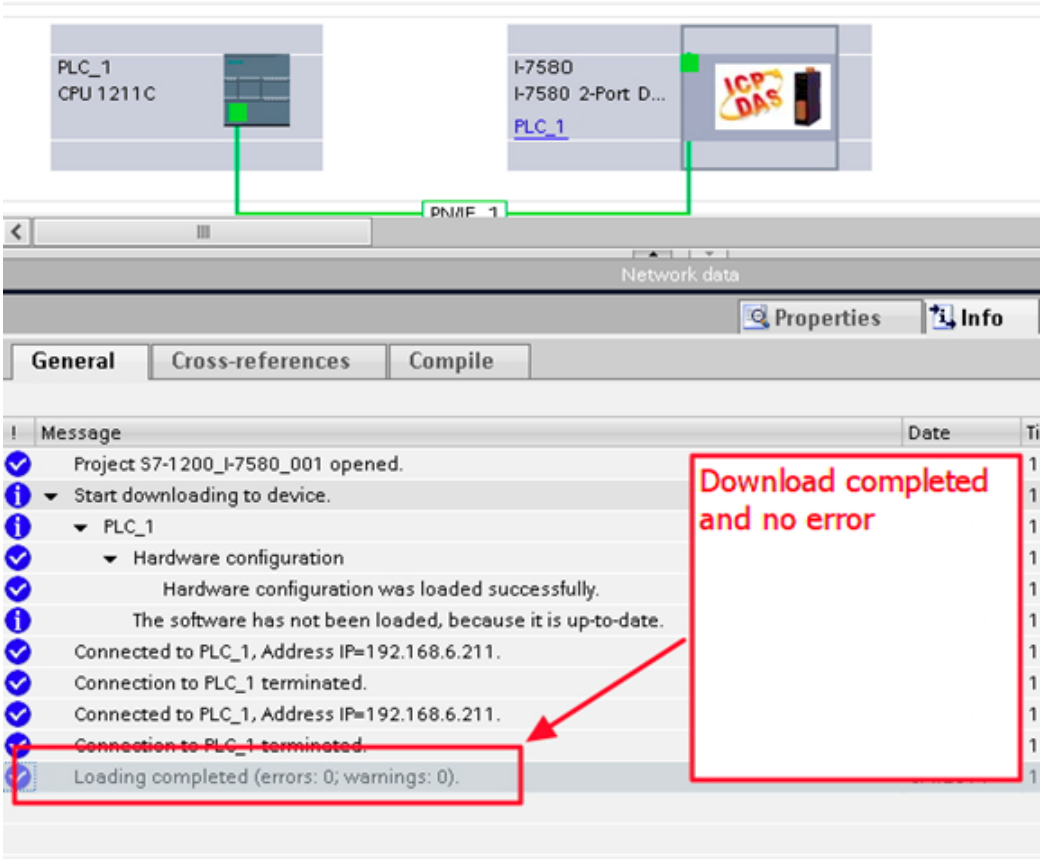
11. Compile and download to the device.






Load preview
Check before loading
Status
!
Target
Message
Action
PLC_1
Ready for loading.
The software will not be loaded, because the online status is up-to-...
Device configurati...
Delete and replace system data in target
Download to device
Click "Load" button
Refresh
Finish
Load
Cancel


Load results
Status and actions after downloading to device
Status
!
Target
Message
Action
PLC_1
Downloading to device completed without error.
The software has not been loaded, because it is up-to-date.
Start modules
Start modules after downloading to device.
Start all
Step1: Select "Start all"
Step2: Click "Finish" button
Finish
Load
Cancel


PLC_1
CPU 1211C
I-7580
I-7580 2-Port D...
PLC_1
ICP DAS
PN/IE_1
Network data
Properties
Info
General
Cross-references
Compile
!
Message
Date
Project S7-1200_I-7580_001 opened.
Start downloading to device.
PLC_1
Hardware configuration
Hardware configuration was loaded successfully.
The software has not been loaded, because it is up-to-date.
Connected to PLC_1, Address IP=192.168.6.211.
Connection to PLC_1 terminated.
Connected to PLC_1, Address IP=192.168.6.211.
Connection to PLC_1 terminated.
Loading completed (errors: 0; warnings: 0).
Download completed and no error

12. Communication

12.1. Communication sequence

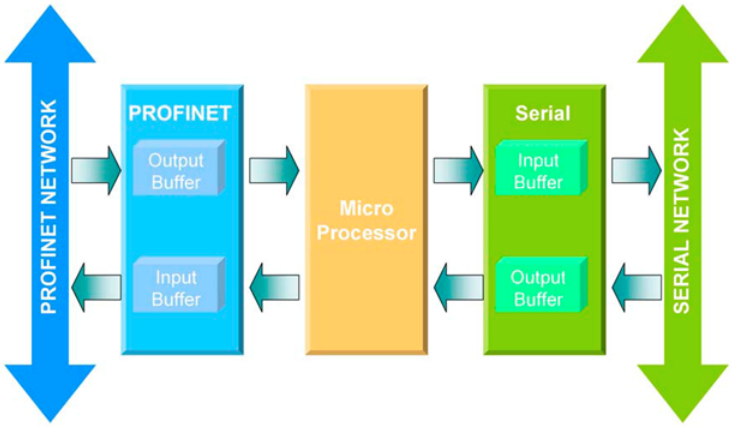
The I-7580 module basically contains 4 buffers:

- PROFINET IO device input buffer.
- PROFINET IO device output buffer.
- COM port input buffer.
- COM port output buffer.

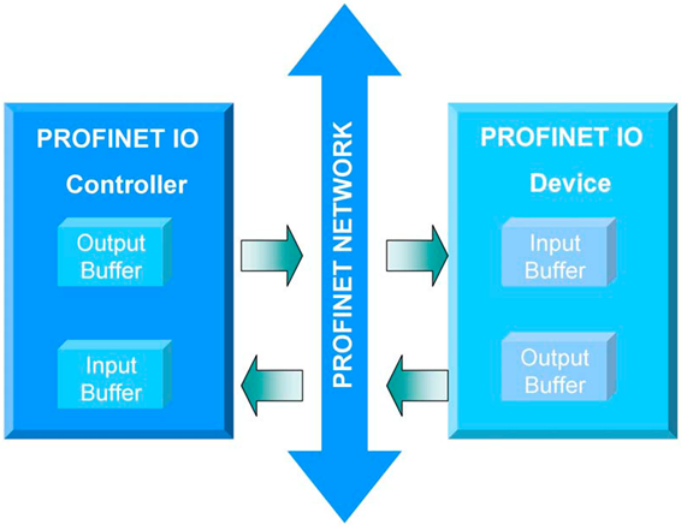
The PROFINET IO controller basically contains 2 buffers:

- PROFINET IO controller input buffer.
- PROFINET IO controller output buffer.

In the I-7580 module, data is transferred from the COM port input buffer to the PROFINET IO device output buffer, and from the PROFINET IO device input buffer to the COM port output buffer. The data flow is illustrated below.



During each message cycle, the PROFINET IO controller writes the content of its output buffer to the PROFINET IO device input buffer and reads the content of the PROFINET IO device output buffer to its input buffer. The exchange cycle is taking place even though the content of the PROFINET IO controller and PROFINET IO device output buffer has not changed. The data flow between the PROFINET IO controller and the I-7580 module is shown below.



12.2. PROFINET Input Data Area

The maximum input data length of I-7580 is 512 bytes. The first 8 bytes of the received input data are reserved for the communication status. The remaining data in the input data area represents the data packet received from the serial network. The 9th byte therefore shows the first byte of the received serial data.

Byte	Data	Description
0	0x00	I-7580 does not transmit I/O data.
	0x01	I-7580 transmits data to the COM port.
	0x02	I-7580 receives data from the COM port.
1	Error State	Bit 0: Output FIFO overflow Bit 1 : Input FIFO overflow Bit 2 : Output Data loss Bit 3 : Input Data loss Bit 4 : Input Data overflow
2	Length	Received data length (High byte)
3		Received data length (Low byte)
4	Input	Received data count (High byte)
5	Count	Received data count (Low byte)
6	Output	Transmitted data count (High byte)
7	Count	Transmitted data count (Low byte)
8～511	Data	Receive data from the COM port

The I-7580 module has three modes to identify data from two batches of data packet. These modes are: (1) Interval time, (2) Fixed data length, and (3) End character of data.

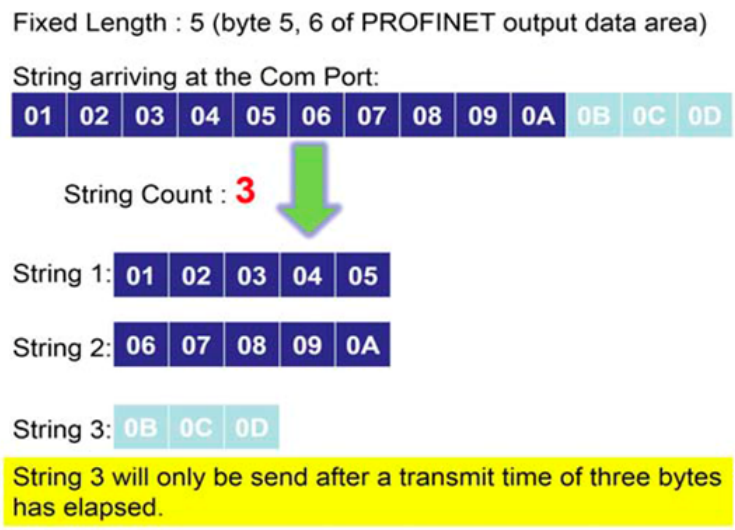
12.2.1. "Interval time" mode

If the time between two consecutive bytes exceeds the timeout value, the module transfers the data from the COM port input buffer to the PROFINET IO device output buffer. The default timeout value is set to the duration needed to send one data byte. That means if after a time period of one byte no additional data arrives, then the data that is already in the COM port input buffer will be regarded as a data packet.

The interval time between messages arriving at the COM port must be greater than 2 milliseconds.

12.2.2. "Fixed data length" mode

The converter counts the number of bytes arriving at the COM port. If the specified amount of data has entered the serial input buffer, the content is removed from the input buffer and transferred to the PROFINET IO device output buffer. The last string will only be send after a transmit time of three bytes has elapsed. To use this feature, you need to set the “Input fixed length data” parameter to “Enable”. The data length has to be defined in bytes 5-6 of the PROFINET output data area (please refer to section "PROFINET Output Data Area").

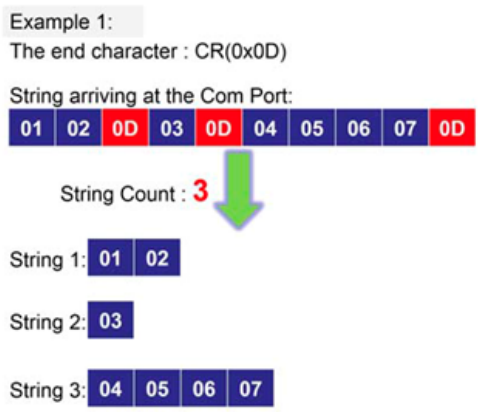


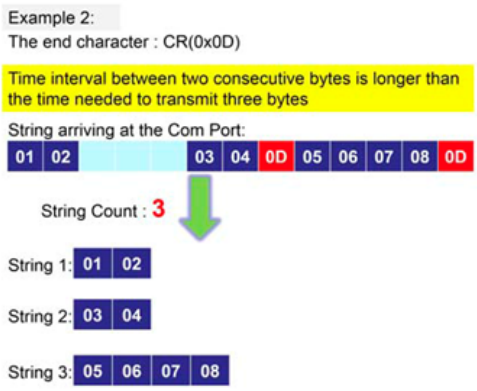
12.2.3. "End character" mode

As soon as the converter detects the end characters of the incoming serial data stream, it removes the data from the serial receive buffer and transfers it to the PROFINET IO device output buffer of the converter.

If the time interval between two consecutive bytes is longer than the time needed to transmit three bytes, then the module treats this situation as an end of a string.

To use this feature, the "End char of input data" parameter must not be set to "None".





12.3. PROFINET Output Data Area

The maximum output data length of I-7580 is 384 bytes. The first 8 bytes are needed to set the communication behavior of the converter.

Byte	Data	Description
1	0～255	Data output command.
2	0x01	Control bit – clear all diagnostic messages.
	0x02	Control bit – clear Received data count.
	0x04	Control bit – clear Transmitted data count.
3	Length	Output data length (High byte).
4		Output data length (Low byte).

5	Length	Fixed data length (High byte).
6		Fixed data length (Low byte).
7	0~255	Interval time between the two batches of the data.
8	0~255	Timeout value.
9~384	Data	Output data to COM port.

12.3.1. Data output command (byte 1)

The PROFINET IO Controller is cyclically polling the I-7580 module. The PROFINET IO Controller sends data from its output buffer to the input buffer of the converter. If no new data is put on the PROFINET IO Controller output buffer, the PROFINET IO Controller sends the same data in each polling cycle. Therefore, it is necessary for the converter to detect whether the data arriving at its PROFINET IO device input buffer has already been sent before or is new. The converter recognizes a new data packet when the value of the first byte differs from the previous data packet. A change of the first byte results in an immediate output of the newly arrived data (at the PROFINET IO device input buffer) to the serial COM port.

When the user wants to send a new data packet to the converter, the user should increase progressively the first byte (ex: 0->1, 1->2, 2->3, …, 255->0), and the converter will send the new data packet to the serial COM port. If the user changes the first byte but doesn't increase progressively it (ex: 0->2, 1->3, 2->5), the converter will send a diagnostic message "Output data - data loss". This message informs the user that the PROFINET data may be loss.

ATTENTION!
The converter will send no data to the connected serial devices if the content of the first byte of two consecutive PROFINET messages is identical. Even if the remaining bytes differ, no message will be forwarded to the COM port. The converter detects a new data packet only by checking the first byte.

12.3.2. Control bit (byte 2)

Bit 0: When this bit is set, all diagnostic messages sent by the I-7580 module will be cleared.

Bit 1: When this bit is set, the I-7580 module sets the **Received data count** to zero (please refer to section "PROFINET Input Data Area").

Bit 2: When this bit is set, the I-7580 module sets the **Transmitted data count** to zero (please refer to section "PROFINET Input Data Area").

Bit 3~7: The remaining bits have to be set to zero.

12.3.3. Output data length (byte 3, byte 4)

The default value for the output data length is 0. It has to be set for every single output command, otherwise no data will be sent to the COM port.

These two bytes determine the number of bytes copied from the I-7580 PROFINET IO device input buffer to the COM port output buffer. This means that regardless of the data length sent by the master, only the number of bytes specified in the third byte will be forwarded to the COM port.

12.3.4. Fixed data length (byte 5, byte 6)

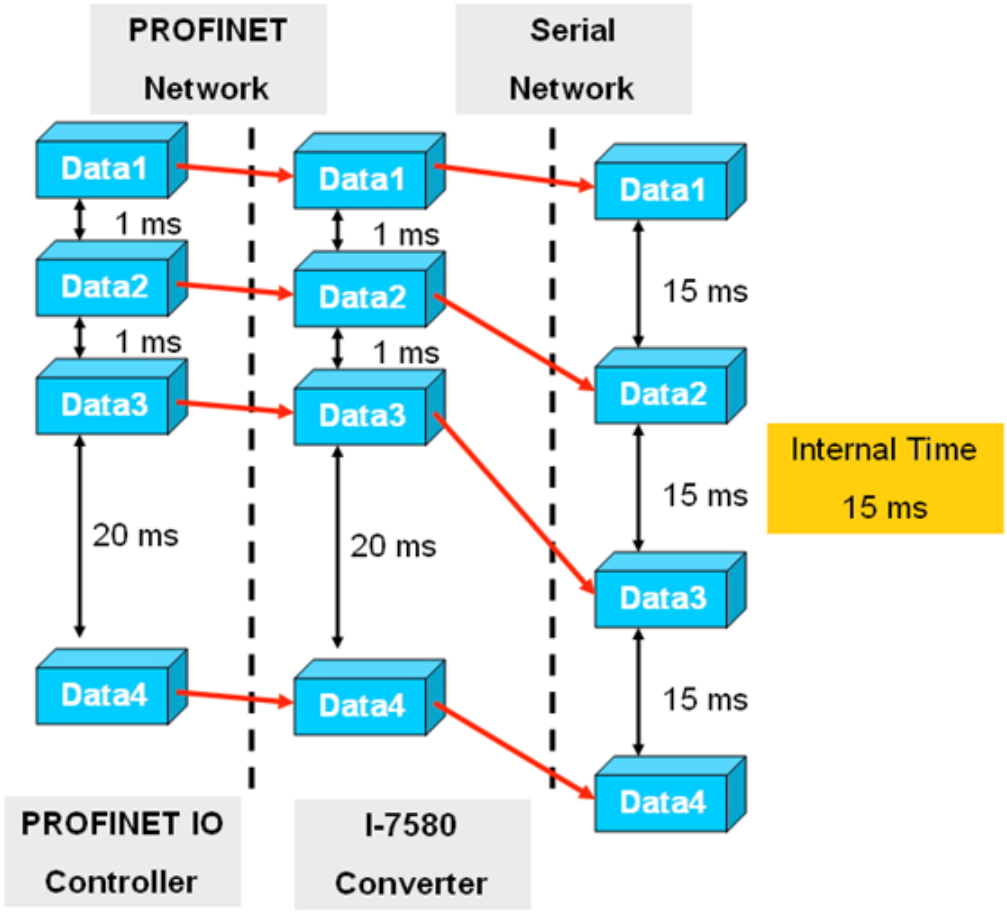
These two bytes determine the length of the response data string. The converter waits until the data arriving at the COM port buffer has reached the specified length.

To use this feature, the "Input fixed length data" parameter has to be set to "Enable".

12.3.5. Interval time (byte 7)

This byte can increase the interval time between two batches of the data packet. It means the converter can delay the data output from PROFINET to the COM port.

Example: Interval time – 15 ms.



12.3.6. Timeout value (byte 8)

The timeout is only relevant for the communication between the I-7580 converter and the serial network. The converter receives the response of the device at the COM port as a continuous data stream. A silent interval in the data stream exceeding the timeout value signals the converter the end of the message and forwards this message to its PROFINET IO device output buffer.

Valid values for the timeout: 0 to 255.

The value "0" represents the minimum value which equals the transmission time of one byte [(start bit+data bit+parity bit+stop bit)/Baudrate].

The value "1" assigns a timeout value of either 1 or 10 milliseconds depending on the chosen unit (1 or 10 ms).

The value "255" represents either 255 milliseconds (time unit: 1 ms) or 2550 milliseconds (time unit:10 ms).

This byte specifies the timeout for the data stream of the serial response. If the multiply responses are expected for every request sent by the converter, then the timeout applies to all these messages.

12.4. Communication between PLC and system

Communication between PLC and system:

Area byte	Data from PLC to System		Data from System to PLC	
	Description	Var Type	Description	Var Type
0	Calibration diameter	Real	Last diameter read average	Real
4		Real	Last diameter read minimum	Real
8		Real	Last diameter read maximum	Real
12	Measurement position (from a zero point of a pipe)	Real		Real
16		Int		Int
18		Int		Int
20		Int		Int
22		Int		Int
24.0	Start calibration command	Bool	Calibration running	Bool
24.1		Bool	Calibration Done	Bool
24.2		Bool	Calibration error	Bool
24.3	Start measure command	Bool	Measure running	Bool
24.4		Bool	Measure Done	Bool
24.5		Bool	Measure error	Bool
24.6	New data transfer	Bool	New data transfer request read	Bool
24.7		Bool	New transfer data read	Bool
25.0	Abort measure	Bool	System error	Bool
25.1	Move to zero	Bool	Move to zero running	Bool
25.2		Bool	Move to zero Done	Bool
25.3		Bool	Move to zero error	Bool
25.4		Bool		Bool
25.5		Bool		Bool
25.6		Bool		Bool
25.7		Bool		Bool

12.4.1. General information

Every system error of the pipe control system must set the **System error** variable.

If this bit is raised up during any measurement, every cycle will be interrupted and measurement results will not be read.

If for any reason PLC sets the **Abort measure** variable during the measurement cycle, the pipe control system must finish the running procedure and move a laser sensor into a safe position. This can be done if the operator checks for any anomaly during the measurement cycle.

12.4.2. Data transfer

- PLC prepares variables with the new data according to production requirements: **Calibration diameter**, **Measurement position**.
- PLC requires to save the new data in the pipe control system by setting the **New data transfer** flag = TRUE and waits until the process is complete.
- The pipe control system sets **New data transfer request read** = TRUE and holds it until all data is read.
- When the pipe control system has finished reading the new data from PLC, it sets **New transfer data read** = TRUE and holds this flag waiting a reply from PLC.
- PLC reads that the pipe control system has completed the procedure and resets **New data transfer** = FALSE.
- The pipe control system resets variables **New data transfer request read** = FALSE and **New transfer data read** = FALSE.

12.4.3. Calibration

- PLC requires to perform the calibration procedure for the pipe control system by **Start calibration command** = TRUE and holds this flag until the process is complete.
- When the pipe control system starts the calibration cycle, it sets **Calibration running** = TRUE and holds it until the process is complete.
- When the pipe control system has completed the calibration process, it sets **Calibration Done** = TRUE and holds it waiting a reply from PLC.
- PLC reads that the pipe control system has completed the procedure and resets **Start calibration command** = FALSE.
- The pipe control system resets variables **Calibration running** = FALSE , **Calibration Done** = FALSE.

12.4.4. Measurement

- PLC requires to make a new measurement by **Start Measure command** = TRUE and holds the flag until the process is complete.
- The pipe control system starts the measurement cycle, sets **Measure running** = TRUE and holds it until the process is complete.
- When the pipe control system has completed the measurement process, it writes variables **Last diameter average**, **Last diameter read minimum**, **Last diameter read maximum,** sets **Measure Done** = TRUE and holds this flag until all the measurement data is read by PLC.
- PLC reads that the pipe control system has completed the measurement procedure and resets **Start Measure command** = FALSE.
- The pipe control system resets variables **Measure running** = FALSE, **Measure Done** = FALSE.

12.4.5. Go to zero

- PLC requires the pipe control system to go to a zero position, sets **Move to zero** = TRUE and holds this flag until the process is complete.
- The pipe control system starts to move a laser sensor to a zero position, sets **Move to zero running** = TRUE and holds the flag until the process is complete.
- When the pipe control system has completed the process, it sets **Move to zero Done** = TRUE and holds it waiting a reply from PLC.

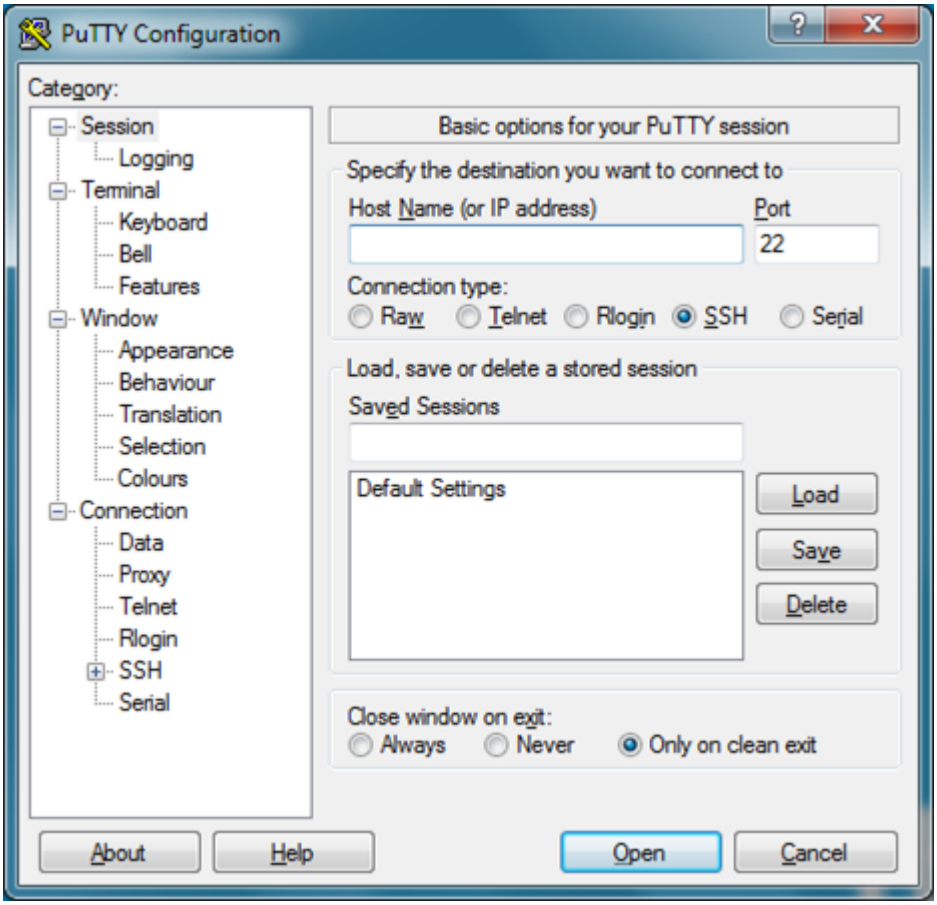
- PLC reads that the pipe control system has completed the procedure and resets **Move to zero** = FALSE.
- The pipe control system resets variables **Move to zero running** = FALSE, **Move to zero Done** = FALSE.

12.5. Communication tests

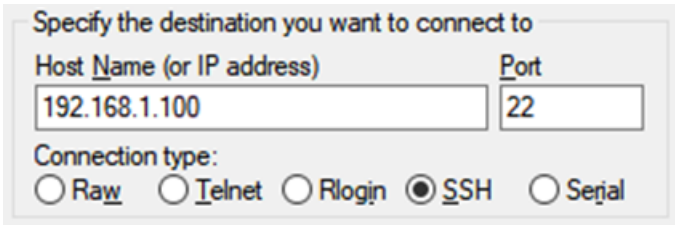
The user can perform communication tests by connecting the system to the PC using the Ethernet connector.

Step 1: Run SSH client

1. On the PC, we use "PuTTY" to test.

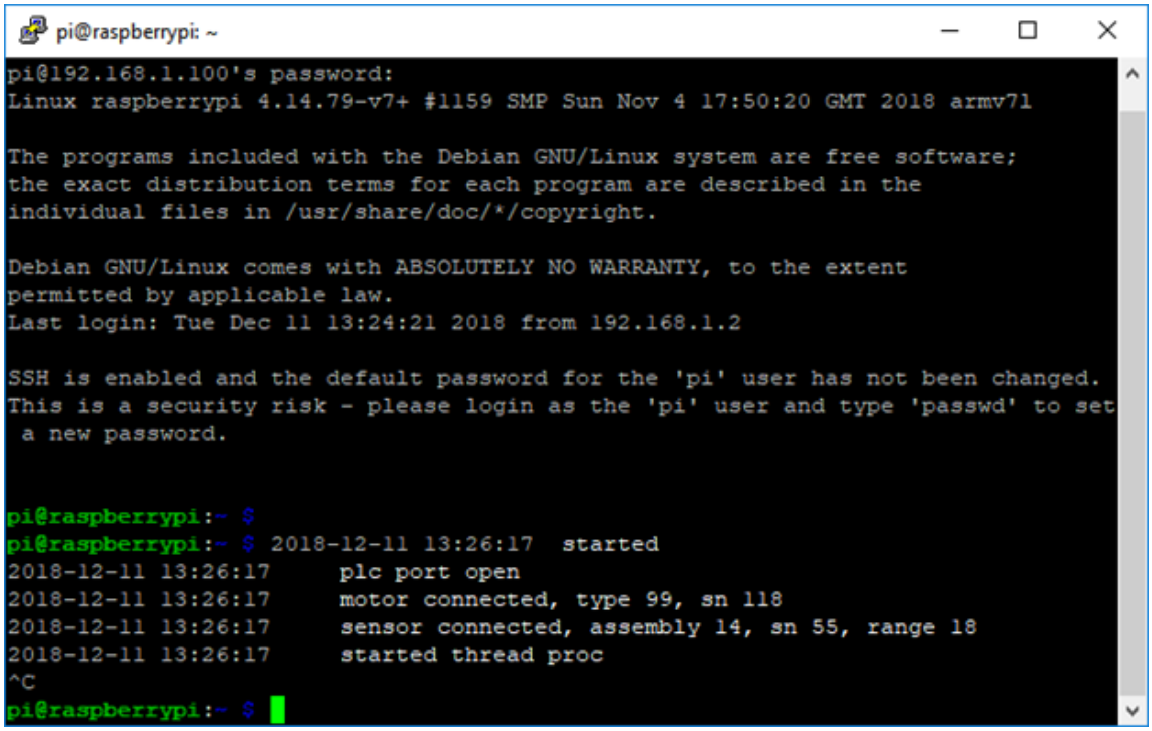


2. Enter a host name 192.168.1.100 as shown below, and click **Connect** (**Open**).

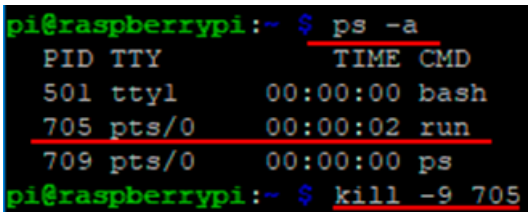


Step 2: Work with terminal

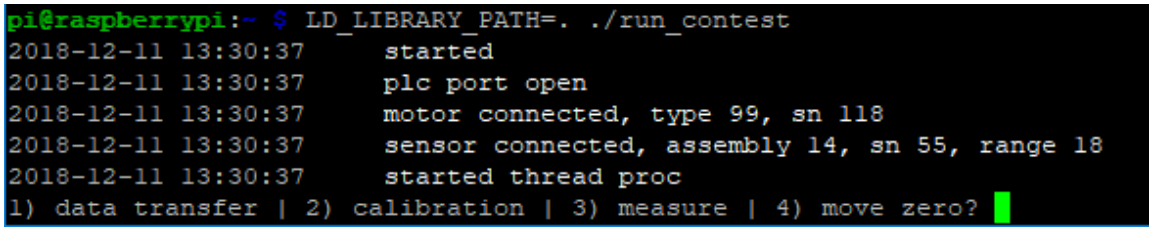
1. Write Login and Password:
   Login: pi
   Password: raspberry
2. After 5-10 seconds, when you see a picture as shown below (the process is restarted for a new session), press **Ctrl+C** to end it.



3. Enter the command «ps -a» to check if the «run» process is exited. If the process still works, kill it by the command «kill -9 XXX», where XXX – the number of the «run» process.



4. Run the test process: «LD_LIBRARY_PATH=. ./run_contest».



5. Make a selection by typing a number [1-4]:

1 - Test the data transfer command by setting the measurement position to 10.5 mm.

2 - Test the calibration process.

3 - Test the measurement process.

4 - Test the "move to zero" process.

12.6. Diagnostic messages

The I-7580 module has two types of diagnostic messages: "Output Data Error" and "Input Data Error".

Type	Description
Output Data Error	FIFO overflow.
	Data loss.
Input Data Error	FIFO overflow.

12.6.1. Output Data Error

1. When the PROFINET network speed is higher than the serial network speed and the PROFINET IO controller continuously transmits data to the I-7580 module, the output buffer of the I-7580 module will overflow, and the I-7580 module will send a diagnostic message "Output Data Error – FIFO overflow".
2. When the I-7580 module receives the data output command (first byte of the output data area, please refer to section "PROFINET Output Data Area") from the PROFINET IO controller and the command is not increased continuously (for example: 0->1, 1->2 ... 254->255, 255->0), the I-7580 module will send a diagnostic message "Output Data Error – Data loss" to the PROFINET IO controller.

12.6.2. Input Data Error

1. When the serial network speed is higher than the PROFINET network speed and the serial device continuously transmits data to the I-7580 module, the input buffer of the I-7580 module will overflow, and the I-7580 module will send a diagnostic message "Input Data Error – FIFO overflow".
2. When the I-7580 module cannot receive data in time from the COM port, it will send a diagnostic message "Input Data Error – Data loss". Please refer to section "PROFINET Input Data Area".
3. The maximum input data length for the COM port of the I-7580 module is 506 bytes. When the COM port of the I-7580 module receives data larger than 506 bytes, it will send a diagnostic message "Input Data Error – Data overflow".

13. Intended use

13.1. Preparation for use

- Check the condition of the output window of a laser sensor and, if necessary, wipe it with a soft cloth.
- Rotate a laser sensor by hand and check the smooth progress.
- Check the cables and power supply.
- Make sure that the network settings are correct.
- Switch on the system.
- Run the test procedures. Please refer to section 12.5. "Communication tests".

13.2. Measurements

Run the sequence of commands described in section 12.4. "Communication between PLC and system".

14. Technical support

Technical assistance related to incorrect operation of the system and to problems with a service program is free. Requests for technical assistance should be addressed at support@riftek.com.

15. Warranty policy

Warranty assurance for the Pipe ID Control System RF096-35/55-100 Series - 24 months from the date of putting in operation; warranty shelf-life - 12 months.

16. Revisions

Date	Version	Description
12.12.2018	1.0.0	Starting document.