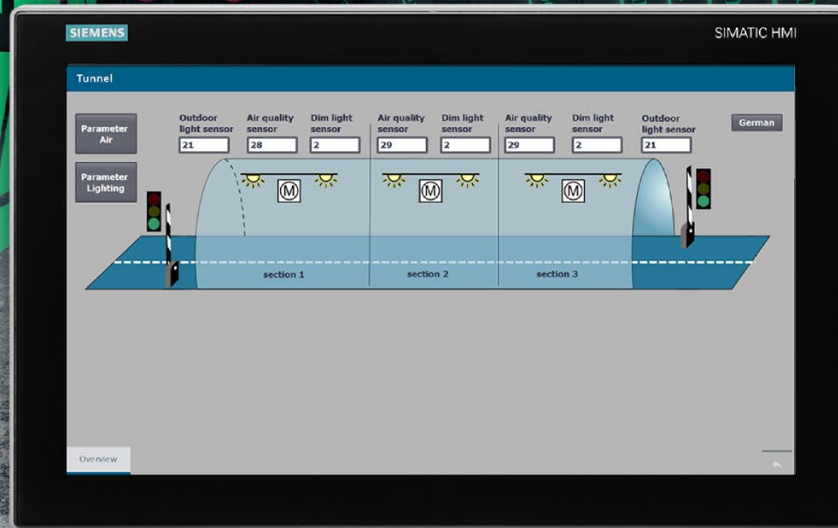


# SIEMENS



Getting Started

# SIMATIC

## S7-1500

S7-1500R/H redundant system

Edition

10/2018

<https://support.industry.siemens.com>

# SIEMENS

## SIMATIC

### S7-1500 S7-1500R/H redundant system

Getting Started

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## Legal information

### Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

<b>⚠ DANGER</b>
indicates that death or severe personal injury <b>will</b> result if proper precautions are not taken.
<b>⚠ WARNING</b>
indicates that death or severe personal injury <b>may</b> result if proper precautions are not taken.
<b>⚠ CAUTION</b>
indicates that minor personal injury can result if proper precautions are not taken.
<b>NOTICE</b>
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The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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## Introduction to the example

Redundant automation systems are used in practice to achieve greater availability. In redundantly operated systems, failure or malfunction of individual automation components must not impede the operation of the plant.

### S7-1500R/H redundant system

For the S7-1500R/H redundant system, the CPUs are duplicated, in other words redundant. The two CPUs process the same project data and the same user program in parallel. The two CPUs are synchronized over redundancy connections. If one CPU fails, the other CPU maintains control of the process.

### Basic knowledge required

The Getting Started guides you through the configuration and programming of an S7-1500H redundant system using a concrete example. The following knowledge is required in order to understand the Getting Started:

- General knowledge of automation technology
- Knowledge of requirements for high availability of automation systems
- Knowledge of the engineering system STEP 7 V15.1

#### WARNING

##### **Personal injury and damage to property may occur.**

The S7-1500 as a component of plants or systems is governed by specific standards and regulations, based on the relevant field of application. Please observe the applicable safety and accident prevention regulations such as IEC 60204-1 (general machine safety requirements).

The example in this Getting Started serves as an introduction to the configuration and programming of an S7-1500H redundant system. It cannot always and in every case be transferred to effective live operations. Before you do this, you are urgently advised to consult the current version of the system manual "SIMATIC S7-1500R/H redundant system" and the device manuals of the modules used. The warnings and other information there must be observed, even if they are not repeated in this Getting Started.

Failure to observe these regulations can result in serious injuries and damages to machinery and facilities.

## 1.1 Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (<https://www.siemens.com/industrialsecurity>).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (<https://www.siemens.com/industrialsecurity>).

## 1.2 Structure and task of the example

### Automation task light and fan control in a tunnel

The continuing increase in traffic volumes coupled with growing safety requirements demand state-of-the-art tunnel systems. At the same time, equipment requirements for these constructions are rising, especially when it comes to maximum safety and availability.

The example below comprises three subtasks:

- Control of the safety ventilation as a function of the air pollution level in the tunnel
- Control of the traffic lights and the barriers as a function of the air pollution level in the tunnel
- Control of the lighting in the tunnel as a function of the illuminance of the outdoor light

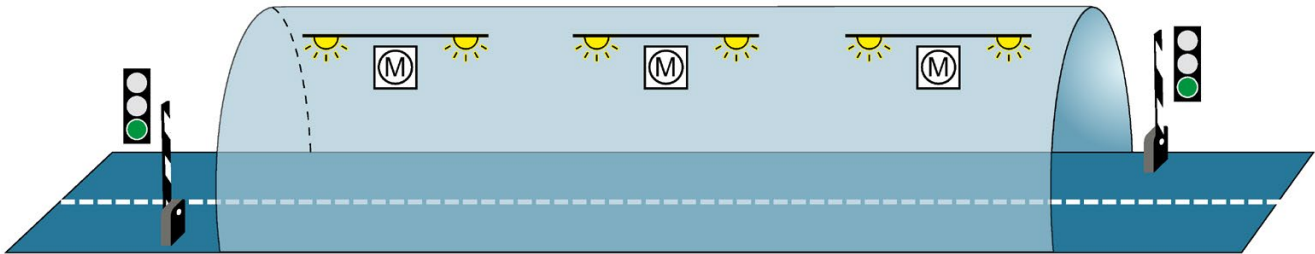


Figure 1-1 Example Light and fan control tunnel

#### Control of the safety ventilation as a function of the air pollution level in the tunnel

Fans are used in the tunnel to extract harmful exhaust gases and supply fresh air.

Uninterrupted operation of the ventilation system is required to keep the concentration of pollutants below a set level. Constant availability must be ensured for the event that individual automation components fail, for example because of a fire in the tunnel. The S7-1500H redundant system with two redundant H-CPU's is used to ensure fan availability. Three fans ventilate the tunnel.

#### Control of the traffic lights and the barriers as a function of the air pollution level in the tunnel

The tunnel entries are controlled via two traffic lights. The traffic light control also requires higher availability for safety reasons.

If the pollutant concentration exceeds a maximum limit for more than 2 minutes in a tunnel section, then the tunnel is blocked.

#### Control of the lighting in the tunnel as a function of the illuminance of the outdoor light

The abrupt transition between light and dark at the entry to the tunnel is compensated for by tunnel lighting in the various tunnel sections. Two light sensors measure the light intensity outside the tunnel. The light intensity of the entry lights in the tunnel is controlled accordingly.

The interior lights in the tunnel are controlled by the prevailing daytime / nighttime.



### Technology diagram

The technology diagram below shows the structure of the automation solution.

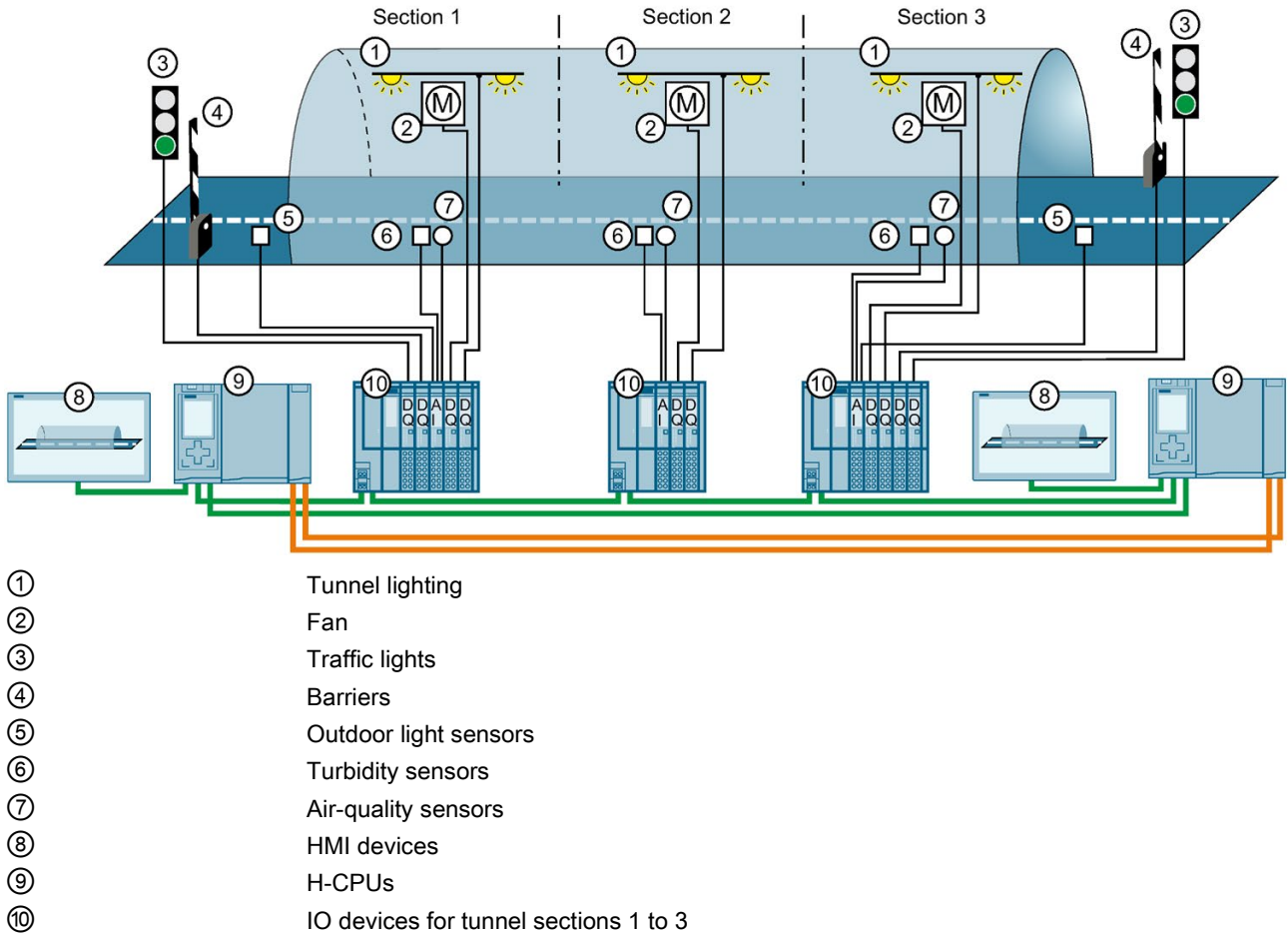


Figure 1-2 Technology diagram



## **Automation components of the example**

The configuration consists of:

### **2 S7-1500 H-CPU**

- When a CPU fails in redundant operation, the other CPU maintains control over the tunnel operation.

### **3 ET 200SP as IO devices in the PROFINET ring**

An ET 200SP (IO device) distributed I/O system is found in every tunnel section (1 to 3). Sensors and actuators are connected to each IO device for the following tasks:

- Measurement of the pollutant concentration and as a function thereof:
  - Control of the fan speed and air flow
  - Control of the traffic lights and barriers
- Measurement of the light outside the tunnel:
  - Control of the entry lights
- Control of the interior lights in the tunnel, depending on the day / night time.

### **2 Comfort Panels**

The Comfort Panels are used by operators as a control center for monitoring tunnel operation.

## Principle of operation

### **Controlling the speed of the fans and controlling the traffic lights and barriers**

Every fan:

- has two speeds (stages), which are switched on or off depending on the measured pollutant concentration.
- has 2 directions of rotation. Depending on whether pollution is measured, the fan must blow or suck.

The H-CPU measures the pollutant concentrations in the tunnel via analog input modules and air-quality sensors.

If the pollutant concentration exceeds the maximum limit, the H-CPU responds in ET 200SP via digital output modules as follows:

- It increases the speed of the fan motors
- It switches the traffic light system to red after two minutes
- It closes the barriers after two minutes

If the pollutant concentration falls below an average limit, the H-CPU responds in ET 200SP via digital output modules as follows:

- It switches the ventilation motors to stop
- It switches the traffic lights to green
- It opens the barriers

### **Controlling the lighting in the tunnel**

The H-CPU measures the light intensity outside and inside the tunnel using analog input modules. Depending on the outdoor light, digital output modules adjust the brightness of the entry lights in the tunnel to the optimum vision conditions. The digital output modules also control the interior lights in the tunnel, depending on the day / night time.

**The user program** in the CPU specifies limits and controls the input and output modules of the ET 200SP.

**The Comfort Panels** visualize the S7-1500H redundant system in an HMI screen. If required, the operator can switch to manual operation via the HMI screen and change limit values.

## **S7-1500H versus S7-1500R**

As an alternative to S7-1500H, you can use an S7-1500R redundant system for the solution to the automation task. In this example, the S7-1500H redundant system is used as it offers the following advantages for tunnel automation:

- much higher performance than S7-1500R with:
  - separate redundancy connections over fiber-optic cable
  - high computing power
  - a higher number of PROFINET devices can be used
- distance between the two H CPUs up to 10 km

## **Advantages and benefits of the solution**

- High availability of the system: If an H-CPU fails or is being maintained, the lighting and fan control continues to function. The tunnel does not need to be blocked.
- Reliable monitoring and control of the tunnel facilities over large distances, up to 10 km between the two H-CPU's
- Monitoring of the system and targeted information of the operating engineers in real time
- Signals are recorded and output directly in the ET 200SP distributed I/O systems in the tunnel. There are no long cable runs.

## 1.3 Procedure

### Tasks

Perform the following tasks for implementation of the example:

Table 1- 1 Procedure for tunnel automation

Step	Procedure	Further information
1	Configure hardware in STEP 7: Configure the assembly with 2 H-CPU's, 3 ET 200SP stations with their I/O modules and 2 Comfort Panels.	Section Configuring (Page 19)
2	Creating a user program in STEP 7: <ul style="list-style-type: none"> <li>• Program the user program in an organization block.</li> <li>• You create an HMI screen.</li> </ul>	Section Programming (Page 34)
3	Installing modules and wiring the assembly: <ul style="list-style-type: none"> <li>• Install all modules.</li> <li>• Wire the load current supply, the modules in the PROFINET ring, the redundancy connections and the Comfort Panels.</li> </ul>	Redundant System S7-1500R/H ( <a href="https://support.industry.siemens.com/cs/ww/en/view/109754833">https://support.industry.siemens.com/cs/ww/en/view/109754833</a> ) system manual ET 200SP Distributed I/O System ( <a href="https://support.industry.siemens.com/cs/ww/en/view/58649293">https://support.industry.siemens.com/cs/ww/en/view/58649293</a> ) system manual Chapter Wiring diagram for a tunnel section (Page 13)
4	Commissioning the example: <ul style="list-style-type: none"> <li>• Insert the SIMATIC memory cards in the H-CPU's.</li> <li>• Switch on the load current supply and the CPU's.</li> <li>• Assign redundancy IDs to the CPU's in the configuration on commissioning.</li> <li>• Load the project data (hardware configuration and user program) to the CPU's.</li> <li>• Check the LEDs and evaluate the information on the CPU displays.</li> <li>• Test how the example works.</li> </ul>	Chapter Commissioning (Page 48)

## 1.4 Requirements

### Requirements for the Example

The following hardware and software is available for processing the example:

Table 1- 2 Hardware/software requirements

Hardware/software	Modules/Versions
2 H-CPU's with synchronization modules and SIMATIC Memory Cards	<ul style="list-style-type: none"> <li>• 2 identical 1517H-3 PN CPU's with identical article numbers, function versions and firm-ware version</li> <li>• 4 synchronization modules for cables up to 10 km in length (6ES7960-1FB00-0AA5)</li> <li>• 2 SIMATIC Memory Cards e.g. with 256 Mbyte capacity (6ES7954-8LL02-0AA0)</li> </ul>
3 ET 200SP distributed I/O systems	<p><b>2 ET 200SP for tunnel sections 1 and 3 each consisting of:</b></p> <ul style="list-style-type: none"> <li>• 1 interface module IM 155-6 PN HF (6ES7155-6AU01-0CN0), FW version V4.2 or later (with system redundancy S2)</li> <li>• 4 digital output modules: <ul style="list-style-type: none"> <li>– 2 DQ 4x24VDC/2A ST each with a light-colored BaseUnit, BU type A0: BU15-P16+A0+2D</li> <li>– 1 DQ 4x24VDC/2A ST with a dark-colored BaseUnit, BU type A0: BU15-P16+A0+2B</li> <li>– 1 DQ 4x24..230VAC/2A HF with a light-colored BaseUnit, BU type U0: BU20-P16+A0+2D</li> </ul> </li> <li>• 1 analog input module: <ul style="list-style-type: none"> <li>– AI 4xU/I 2-wire ST with a dark-colored BaseUnit, BU type A0: BU15-P16+A0+2B</li> </ul> </li> <li>• 1 server module</li> </ul> <p><b>1 ET 200SP for tunnel section 2 consisting of:</b></p> <ul style="list-style-type: none"> <li>• 1 interface module IM 155-6 PN HF (6ES7155-6AU01-0CN0), FW version V4.2 or later (with system redundancy S2)</li> <li>• 2 digital output modules: <ul style="list-style-type: none"> <li>– 1 DQ 4x24VDC/2A ST with a light-colored BaseUnit, BU type A0: BU15-P16+A0+2D</li> <li>– 1 DQ 4x24..230VAC/2A HF with a light-colored BaseUnit, BU type U0: BU20-P16+A0+2D</li> </ul> </li> <li>• 1 analog input module: <ul style="list-style-type: none"> <li>– AI 4xU/I 2-wire ST with a dark-colored BaseUnit, BU type A0: BU15-P16+A0+2B</li> </ul> </li> <li>• 1 server module</li> </ul>
2 HMI devices	TP1900 Comfort
2 load current supplies for S7-1500R/H	PM 190 W 120/230 V AC
3 load current supplies for ET 200SP	Load current supplies with 24 V DC output voltage (with safe electrical isolation)
Accessories	1 mounting rail, 2 fiber-optic cables, PROFINET cables
PC/PG with Engineering-System	PG/PC with Ethernet interface and the following correctly installed software package: <ul style="list-style-type: none"> <li>• SIMATIC STEP 7 Professional, V15.1 or later</li> </ul>
Switch for the connection of the PG/PC	SCALANCE X-204IRT

## Additional requirement

The PG/PC is connected to a switch via the PROFINET interface. The switch is a device in the PROFINET ring during commissioning.

## Installing modules and wiring the assembly

You can set up and wire the hardware before or after configuration and programming of the user program.

You can find additional information on installation and wiring of an ET 200SP in the ET 200SP distributed I/O system

(<https://support.industry.siemens.com/cs/ww/en/view/58649293>) system manual .

The wiring diagram for an ET 200SP for a tunnel section can be found in the section Wiring diagram for a tunnel section (Page 13).

The procedure for installation and wiring of an S7-1500R/H redundant system is available in the S7-1500R/H redundant system

(<https://support.industry.siemens.com/cs/ww/en/view/109754833>) system manual.

## Conventions

Steps and settings which are specific for configuration and programming of an S7-1500H redundant system will be dealt with in detail in the following sections. Procedures which you are already familiar with from configuring and programming a SIMATIC S7-1500 will only be briefly outlined.

# 1.5 Wiring diagram for a tunnel section

## Introduction

The figures below show the wiring of the I/O modules of an ET 200SP distributed I/O system for tunnel section 1 or 3.

When wiring the tunnel section 2, there is no wiring of the digital output modules for the traffic lights control and barrier control nor of the outdoor light sensor on the analog input module.

### Connecting the supply voltage, PROFINET cables and grounding

The following figure shows the wiring of the supply voltage, the PROFINET cables and the grounding on the ET 200SP.

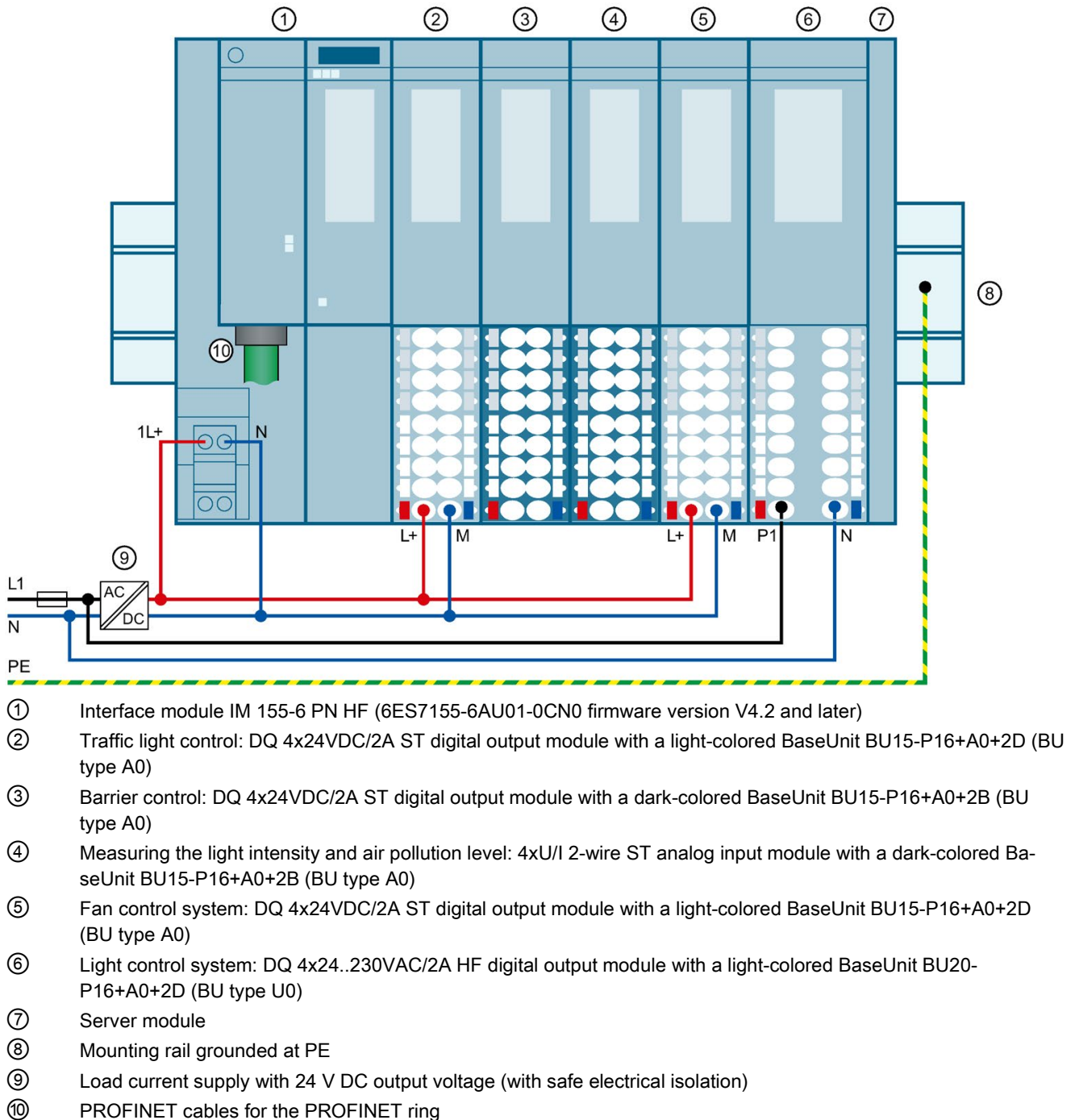


Figure 1-3 Wiring diagram



### Connecting traffic light control

The following figure shows the wiring of the traffic lights on the DQ 4x24VDC/2A ST digital output module ②.

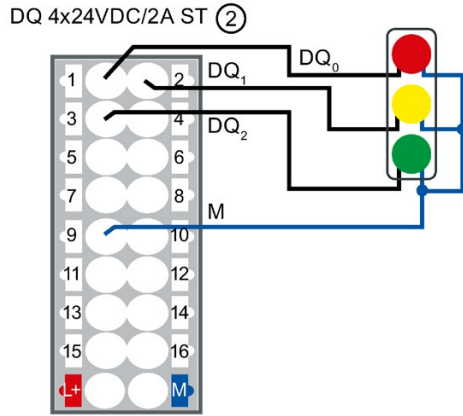


Figure 1-4 Wiring of the traffic lights

### Connecting barrier control

The following figure shows the wiring of the barrier control on the DQ 4x24VDC/2A ST digital output module ③.

The barrier is opened and closed via a three-phase motor. The direction of rotation of the three-phase motor is controlled via a reversing contactor:

- Open barrier → Contactor K1 actuated
- Close barrier → Contactor K2 actuated

If the barriers have reached their respective end position, they automatically switch off via limit switches.

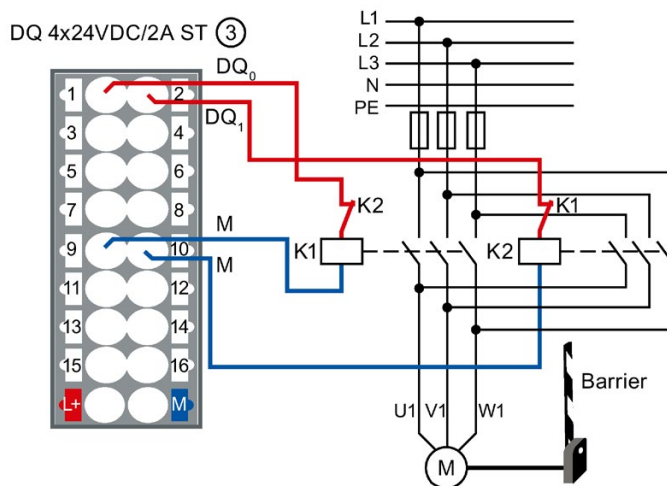


Figure 1-5 Wiring of the barrier control

### Connecting sensors for light intensity and air pollution level

The following figure shows the wiring of the sensors for measuring the light intensity and air pollution level on the AI 4xU/I 2-wire ST analog input module ④.

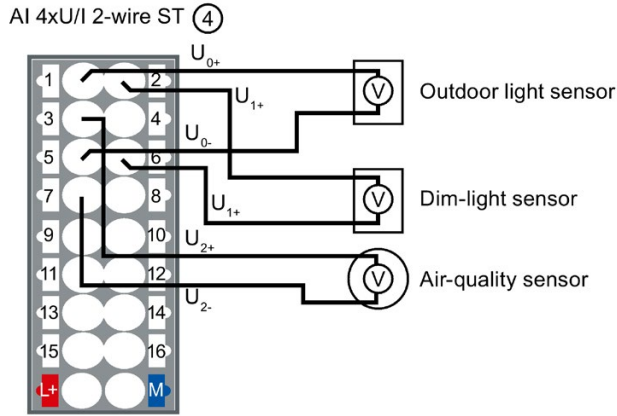


Figure 1-6 Wiring of sensors for light intensity and air pollution level

### Connect light control function

The following figure shows the wiring of the fan control on the DQ 4x24VDC/2A ST digital output module (5).

The direction of rotation of the fan (right/left) is controlled via a reversing contactor:

- Fan rotates clockwise → Contactor K1 actuated
- Fan rotates counterclockwise → Contactor K2 actuated

The speed (high/low) of the fan is controlled via a Dahlander circuit:

- Fan low speed → Contactor K5 actuated
- Fan high speed → Contactors K3 and K4 actuated

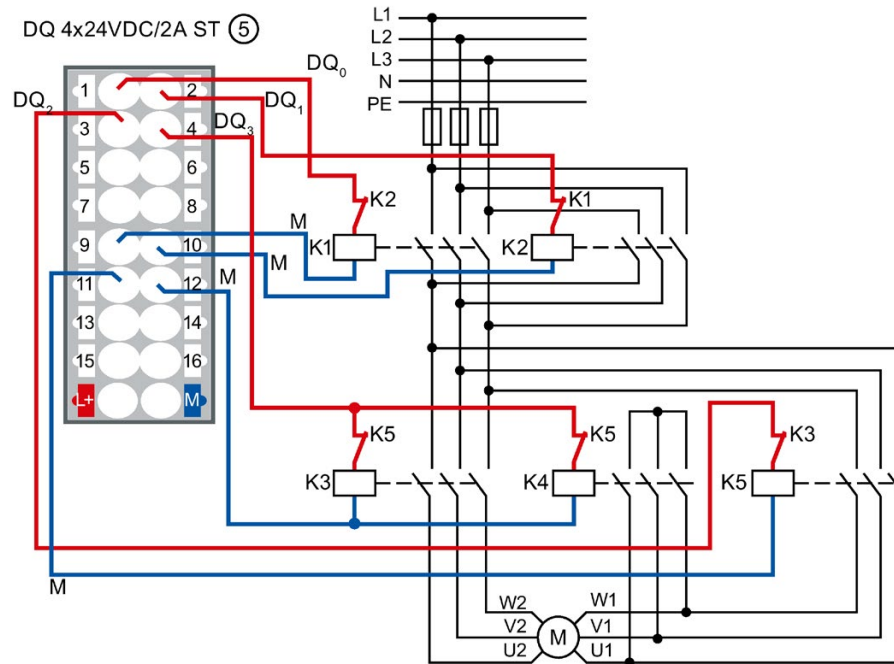


Figure 1-7 Wiring of fan control

### Connect light control function

The following figure shows the wiring of the light control on the DQ 4x24..230VAC/2A HF digital output module ⑥.

The lamps are dimmed via the Phase angle control - Phase angle proportional function of the digital output mode:

- L1 → Entry light
- L2 → Interior light

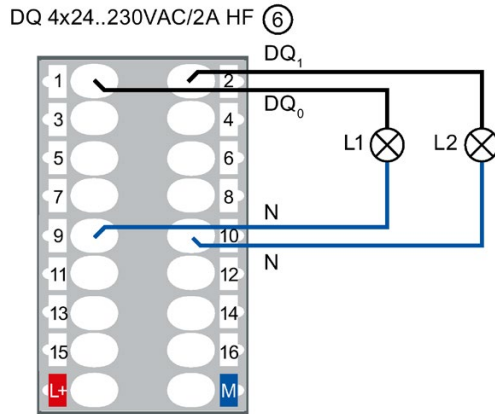


Figure 1-8 Wiring of the traffic lights

# Configuration

## 2.1 Configuring the assembly

### Introduction

Create a new project and add the CPU 1517H-3 PN and the 3 ET 200SP distributed I/O systems. Network the assembly to a PROFINET ring.

Add 2 HMI devices TP1900 Comfort to the assembly.

You do not configure the PM 190 W 120/230 V AC load current supplies.

### Requirement

You have set the IP address of the PG/PC, 192.168.0.50 in the example.

### Creating a project and assigning hardware

1. Create a new project in STEP 7. Give the project the name "S7-1500H\_GS".

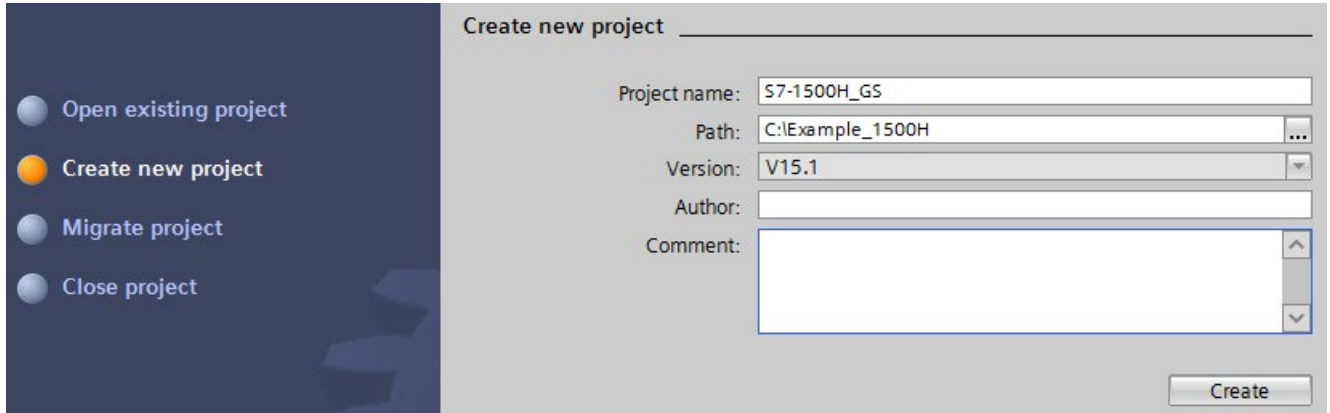


Figure 2-1 Creating a new project

2. Select "Configure a device" and then "Configure networks".

The network view opens.

3. Select CPU 1517H-3 PN from the hardware catalog in the network view.

4. Drag and drop the CPU to the task window in the network view.

**Results:**

- STEP 7 automatically creates both 1517H-3 PN CPUs for the redundant system.
- STEP 7 automatically assigns the MRP role "Manager (auto)" to the PROFINET interfaces X1 of both CPUs.
- STEP 7 displays both CPUs in the network view graphically.

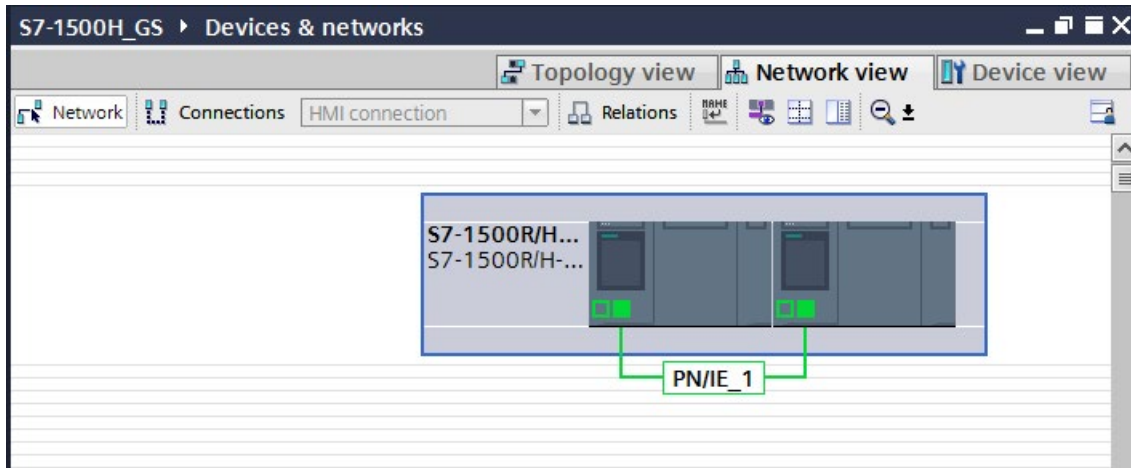


Figure 2-2 CPUs in the network view

5. Select an ET 200SP interface module IM 155-6 PN HF (article number 6ES7155-6AU01-0CN0) from the hardware catalog.
6. Drag and drop the interface module to the task window in the network view.
7. Drag and drop 2 further IM 155-6 PN HF interface modules to the task window in the network view.
8. Select a SIMATIC Comfort Panel TP1900 Comfort from the hardware catalog as an HMI device.  
**Recommendation:** Configure the HMI devices with the HMI Device Wizard (Page 30).
9. Drag and drop the TP1900 Comfort to the task window in the network view.
10. Drag and drop a further TP1900 Comfort to the task window in the network view.

**Results:** The project has been created. The hardware components have been inserted. IP addresses for the PROFINET interfaces of the devices have been automatically assigned.

## Assign ET 200SP with system redundancy S2

To assign the ET 200SP distributed I/O systems to S7-1500H on a system-redundant basis, connect every IM 155-6 PN HF interface module to every CPU.

To do so, proceed as follows:

1. Drag-and-drop a line between the PROFINET interface of IM 155-6 PN HF and PROFINET interface X1 of the left-hand CPU.
2. Drag-and-drop a line between the PROFINET interface of IM 155-6 PN HF and PROFINET interface X1 of the right-hand CPU.
3. Assign the two other IM 155-6 PN HF devices to the two CPUs in exactly the same way.

**Result:** The distributed I/O system ET 200SP are connected to S7-1500H on a system-redundant basis.

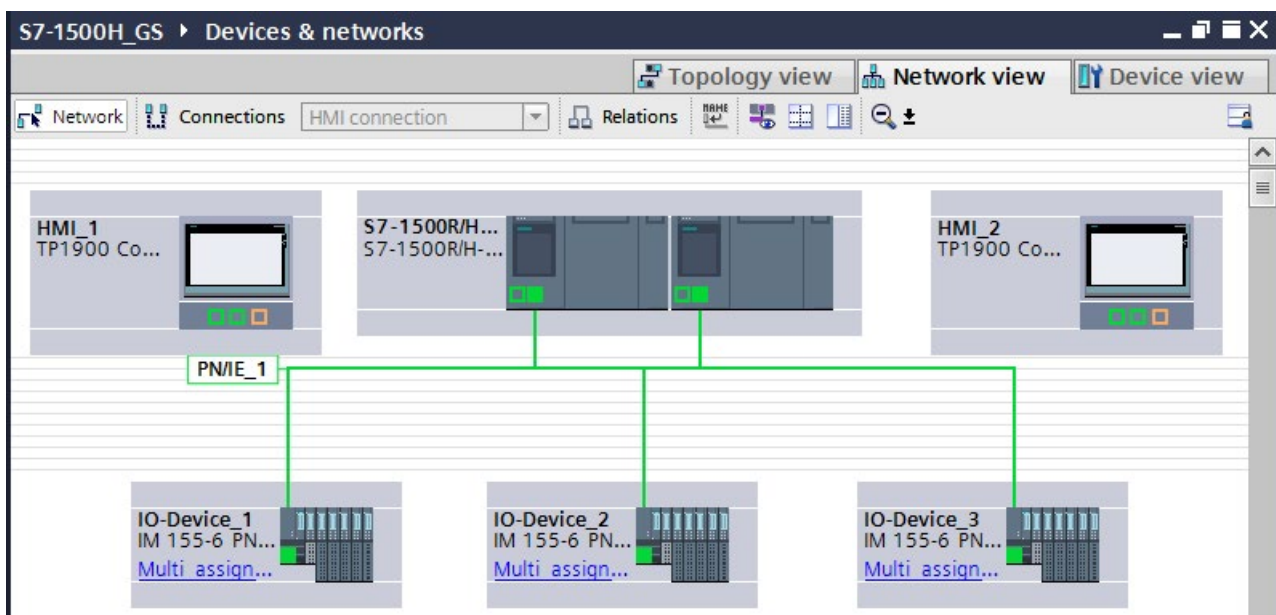


Figure 2-3 ET 200SP assigned to S7-1500H on a system-redundant basis



## 2.2 Configuring H CPUs

### Introduction

You create two redundancy connections between the H-CPU's via fiber-optic cables using a total of four synchronization modules (two in each H-CPU). You replace the synchronization modules (for cables up to 10 km in length) in STEP 7.

STEP 7 automatically assigns an IP address to each PROFINET interface of a CPU. You can also assign the IP addresses manually. For PROFINET interface X1 of the CPUs, the IP addresses must be located in the same subnet. In the example you accept the preset IP addresses.

STEP 7 assigns default values for the minimum and maximum cycle times. Select the minimum scan cycle time so that the cyclic program does not have to be executed more frequently than your process requires.

### Assigning synchronization modules to the H-CPU

In STEP 7 synchronization modules for 10 m length are assigned to the H-CPU (default setting).

For the tunnel application, assign synchronization modules for cables up to 10 km in length (6ES7960-1FB00-0AA5) to the H-CPU as follows:

1. Change to the device view of an H-CPU.
2. From the hardware catalog, drag and drop the synchronization module with the article number 6ES7960-1FB00-0AA5 to the interface for a synchronization module of the H-CPU.
3. The "Replace device- Synchronization module" dialog opens. Confirm the replacement with "OK".

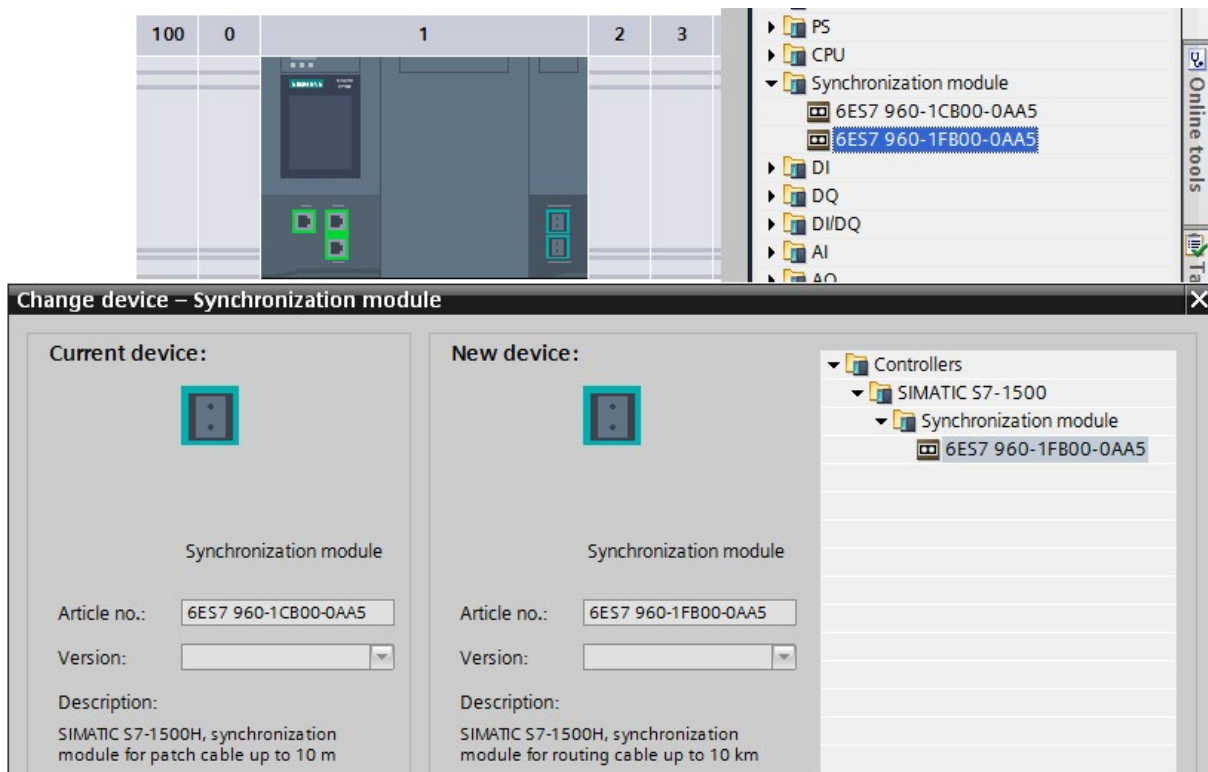


Figure 2-4 Assigning a synchronization module to the H-CPU

**Result:** The four synchronization modules for cables up to 10 km in length have been assigned to the H-CPU of the redundant system.

### Setting the cycle monitoring time

The default values are displayed in the "Cycle" area of the CPU properties.

1. Set a maximum cycle time of 6000 ms and a minimum cycle time of 10 ms for the example.
2. Adopt the presets for the other parameters.

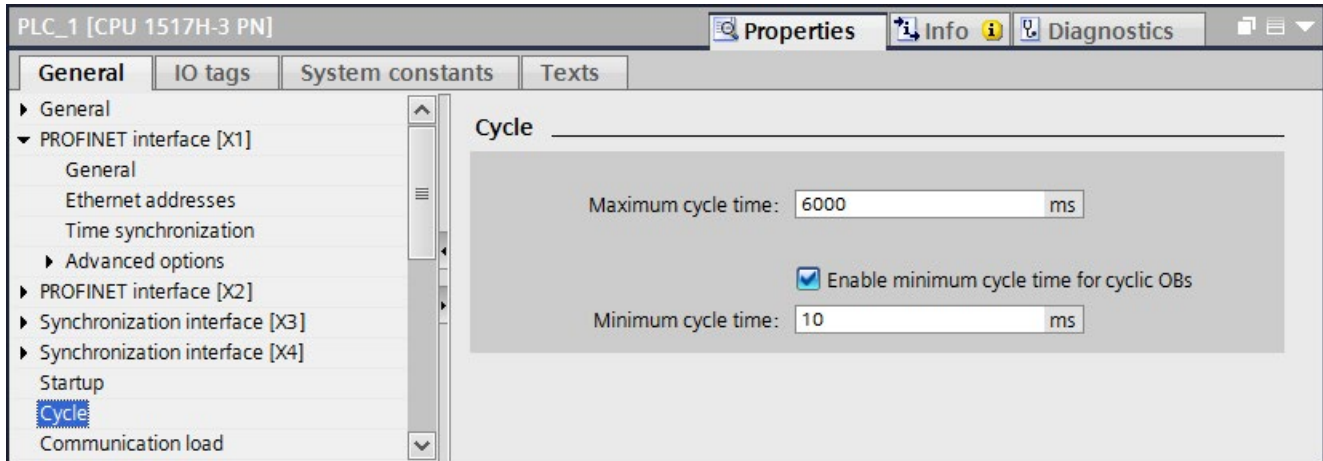


Figure 2-5 Setting the cycle monitoring time

**Result:** When you change the parameters described above for a CPU, the parameters are automatically adopted in STEP 7 for the other CPU of the redundant system.

## 2.3 Configuring ET 200SP

### Introduction

In the S7-1500H redundant system the devices communicate in a PROFINET ring via MRP. Define the media redundancy role of the devices.

Assign the I/O modules for the various automation tasks in the three tunnel sections to the three ET 200SP distributed I/O systems.

Set the watchdog time for each ET 200SP. If you set a higher watchdog time, then a failure of the IO device on interruption of the PROFINET ring can be avoided.

### Defining MRP role for ET 200SP in the PROFINET ring

Proceed as follows to define the media redundancy role for the ET 200SP distributed I/O systems as devices in the ring:

1. In the network view of STEP 7, select PROFINET interface X1 of one of the two CPUs.
2. In the Inspector window, navigate to "Properties" > "General" > "Advanced options" > "Media redundancy".

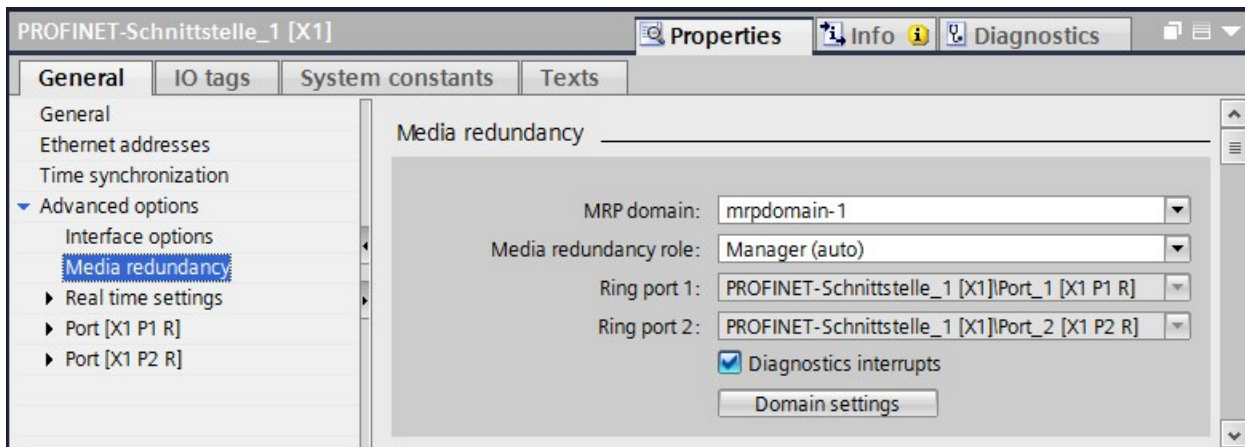


Figure 2-6 Media redundancy domain settings

3. Click the "Domain settings" button.

4. In the Inspector window, STEP 7 displays the properties of the MRP domain in which PROFINET interface X1 of the CPU is located. The CPU has the role "Manager (auto)" in a redundant system.
5. In the "MRP role" column of the "Devices" table, assign the MRP role "Client" to all other devices.

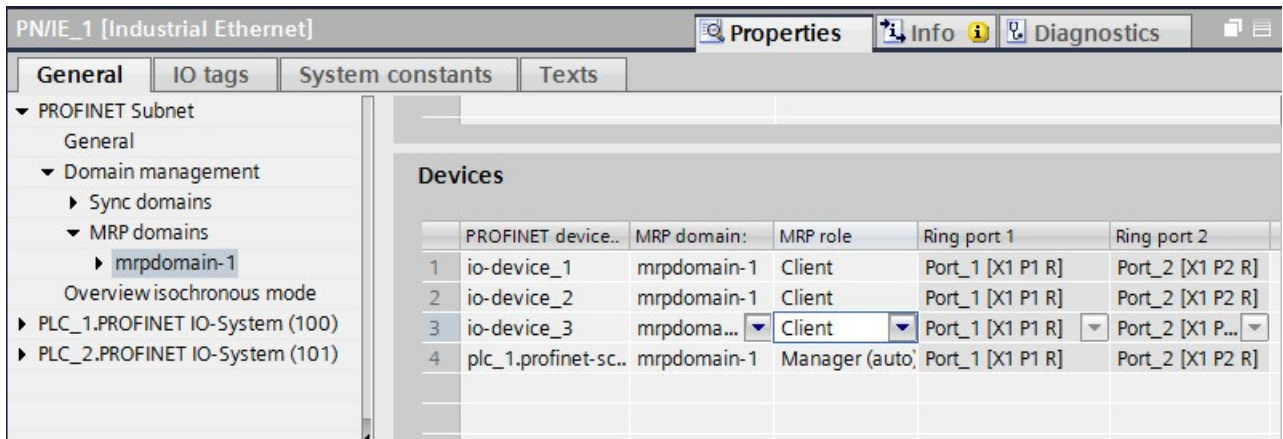


Figure 2-7 Assigning MRP roles to the ET 200SP

### Assign I/O modules to the ET 200SP and set parameters

1. Change to the device view of an IM 155-6 PN HF.
2. In the properties of the interface module in the "General" area, assign "Section1" as the name for tunnel section 1.
3. Select the following modules in succession from the hardware catalog. Assign the modules to the interface module from slot 1 to 6:
  - DQ 4x24VDC/2A ST (for traffic lights)
  - DQ 4x24VDC/2A ST (for barrier)
  - AI 4xU/I 2-wire ST (for outdoor light, indoor light and air-quality sensors)
  - DQ 4x24VDC/2A ST (for fans)
  - DQ 4x24..230VAC/2A HF (for tunnel lighting)
  - 1 server module (as termination of the configuration)

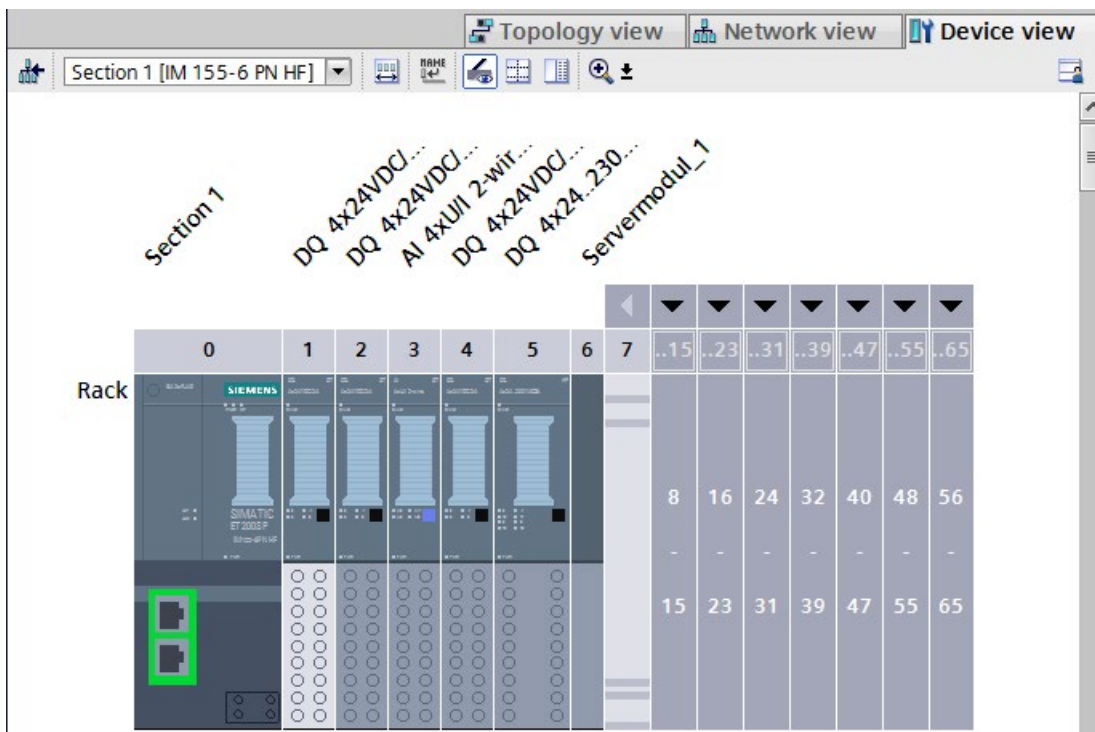


Figure 2-8 Assigning ET 200SP I/O modules

4. Double-click on the 3rd module DQ 4x24VDC/2A ST in the configuration (for fan).
5. In the module properties "General" > "Potential group", select "Enable new potential group (light-colored BaseUnit)".
6. Double-click on the module DQ 4x24..230VAC/2A HF (for tunnel lighting).
7. In the module properties "General" > "Potential group", select "Enable new potential group (light-colored BaseUnit)".
8. Double-click on the module AI 4xU/I 2-wire ST.

9. In the module properties, set the measurement type "Voltage" and measuring range "0..10 V" under "Inputs" for channels 0 to 2 in each case.

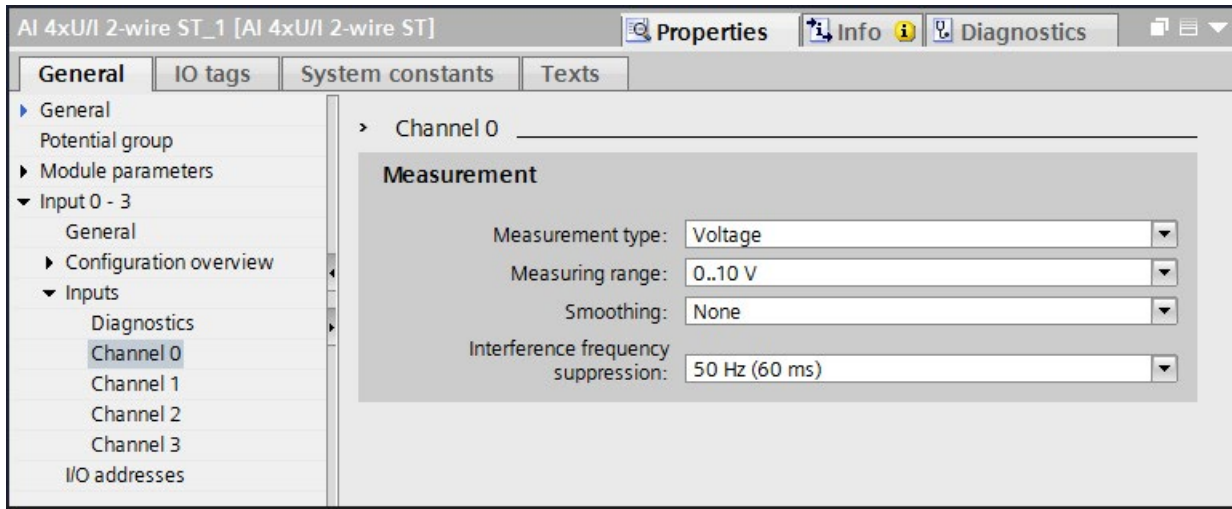


Figure 2-9 Setting the measurement type and measuring ranges

10. Set the measurement type to "Disabled" for channel 3.
11. For the module DQ 4x24..230VAC/2A HF retain the defaults, in particular the "Phase angle control - phase angle proportional" mode.
12. Proceed in exactly the same way according to steps 1 to 11 for tunnel section 3. For tunnel section 2, the two digital output modules DQ 4x24VDC/2A ST for barrier and traffic lights control are not required.

**Result:** The ET 200SP I/O modules are fully configured for the tunnel application.



## Setting the watchdog time

Do not enter the watchdog time directly, but as "Accepted number of update cycles when IO data is missing". The resulting watchdog time is automatically calculated from the "Accepted number of update cycles when IO data is missing".

1. Select an interface module IM 155-6 PN HF.
2. Navigate to "Properties" > "Advanced options" > "Real time settings" > "IO cycle" > "Watchdog monitoring".
3. Set the update cycles for the example to 112 (224 ms).

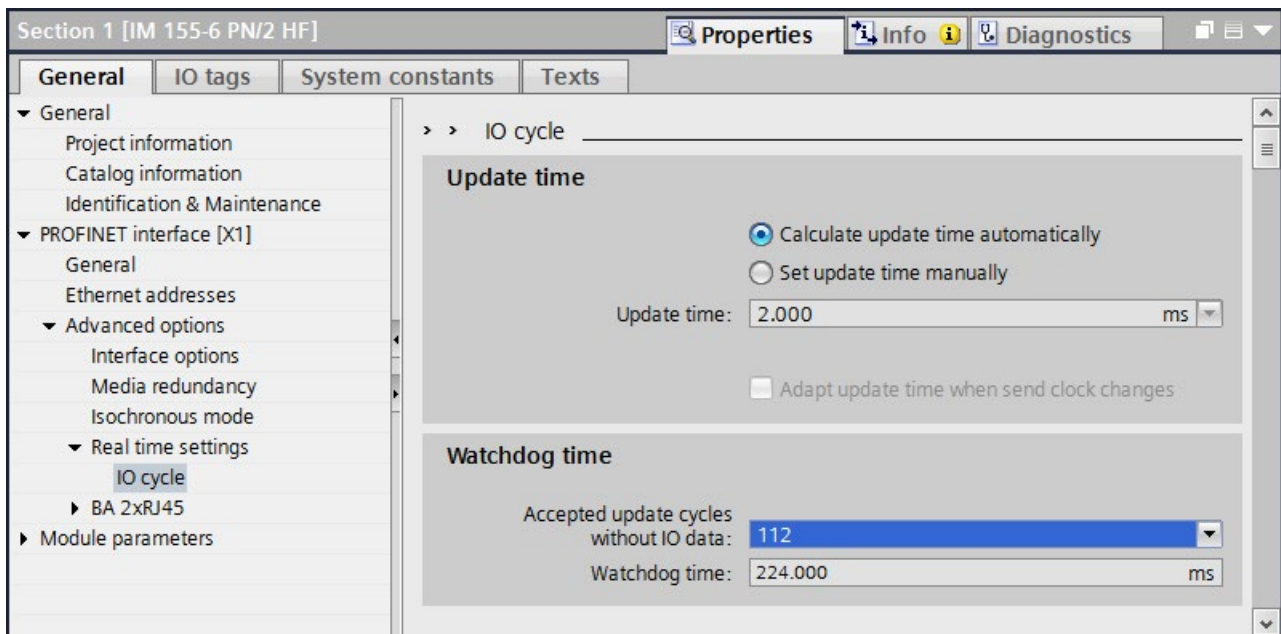


Figure 2-10 Setting the watchdog time

4. Follow steps 1. to 3. for the other two interface modules IM 155-6 PNHF (tunnel sections 2 and 3).

## 2.4 Configuring HMI devices

### Introduction

Assign names for the two HMI devices.

Connect the HMI devices to the redundant system as follows:

- Network the HMI devices with an H-CPU in each case.
- Configure two HMI connections.
- Assign the system IP address of a PROFINET interface of the H-CPU or
- Use the device IP address of the respective PROFINET interface of the two H-CPU's

### HMI device wizard

Recommendation: Configure the HMI devices with the HMI Device Wizard. The HMI device wizard will guide you through each dialog step by step and help you set up an HMI device. The HMI device wizard will automatically start when you create a new HMI device in your project via the project navigation.

### Connection via a device IP address:

When connecting via the device IP address, the HMI device always communicates with the connected CPU. Communication is independent of the system state. The connected CPU then synchronizes the data with the other CPU.

Requirements: Each HMI device is connected to a CPU via a separate subnet.

In the example, the TP1900 Comforts communicate in each case via the devices IP address of the PROFINET interface with the directly connected CPU.

### Assigning names for HMI devices

1. Select the left-hand TP1900 Comfort in the network view.
2. Change to the device view.
3. In the properties in the "General" area, assign the name "HMI left".
4. Assign the name "HMI right" for the TP1900 Comfort of the CPU on the right.

## Setting up HMI connections

Connect the HMI devices to the CPUs via separate PROFINET subnets.

1. Using drag-and-drop, draw a line between the PROFINET interface X1 of the "HMI left" and the PROFINET interface X2 of the left-hand CPU.
2. Using drag-and-drop, draw a line between the PROFINET interface X1 of the "HMI right" and the PROFINET interface X2 of the right-hand CPU.

**Result:** The HMI devices are networked with the CPUs.

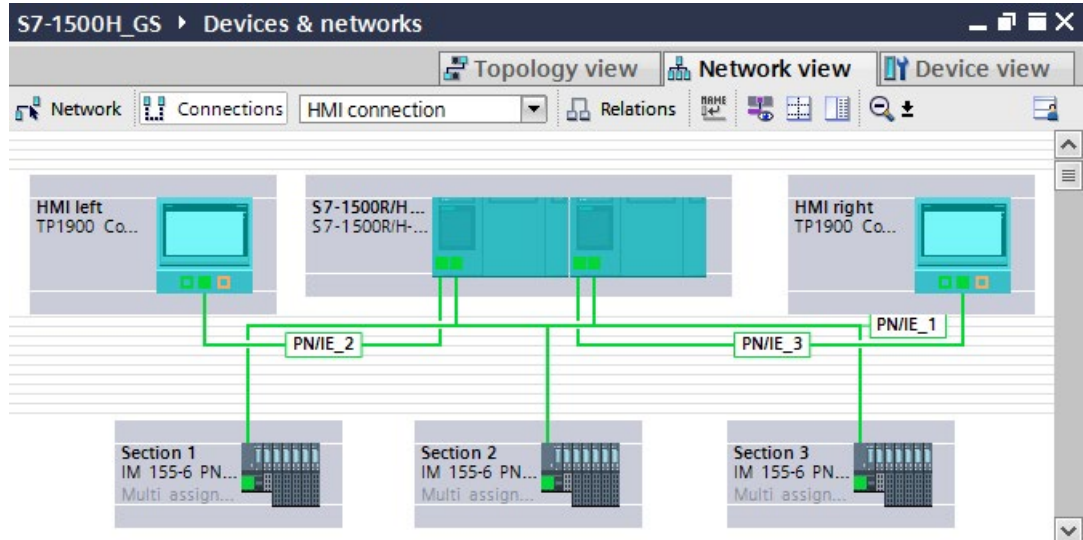


Figure 2-11 HMI devices networked with CPUs

3. In the network view, click on "Connections". This activates connection mode.
4. Using drag-and-drop, draw a line between the networked PROFINET interfaces of "HMI left" and the left-hand CPU. The "Connection partners" list opens.

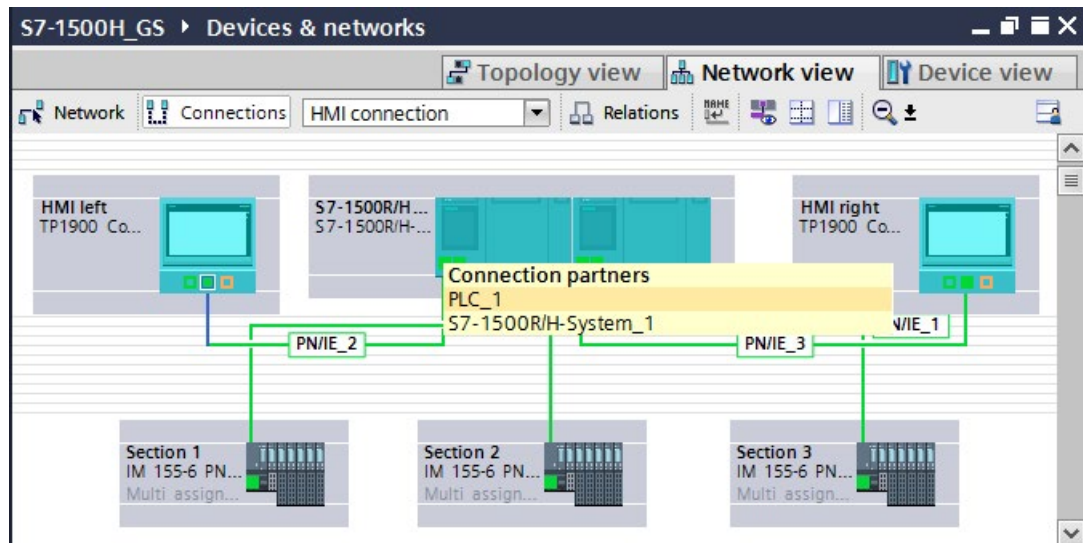


Figure 2-12 Assign HMI connection\_1 connection partner

5. In the "Connection partner" list, select the CPU "PLC\_1".
6. Using drag-and-drop, draw a line between the networked PROFINET interfaces of "HMI right" and the right-hand CPU. The "Connection partners" list opens.
7. In the "Connection partner" list, select the CPU "PLC\_2".

**Result:** You have set up the HMI connections from the HMI devices TP1900 Comfort to the CPUs.

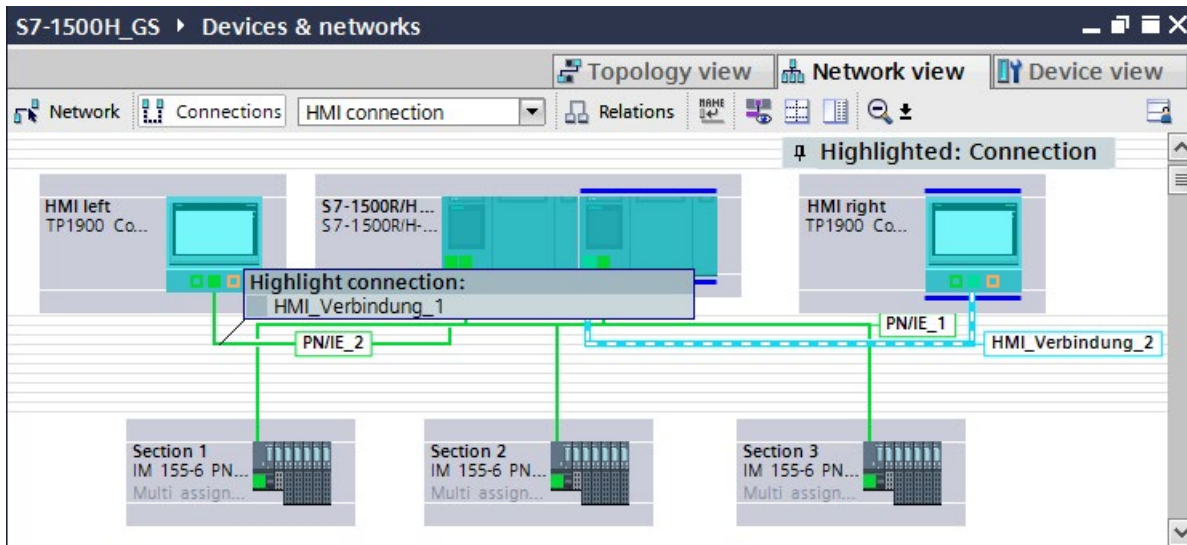


Figure 2-13 HMI connections set up

## Setting devices IP addresses for the HMI connections

Change the IP addresses of the PROFINET interfaces of the HMI devices and the CPUs for the PROFINET subnets 2 and 3 (PN/IE\_2/3).

1. Select the respective PROFINET interface of the device in the network view.
2. Change the IP address into a valid one in the subnet in the properties in the "Ethernet addresses" area.

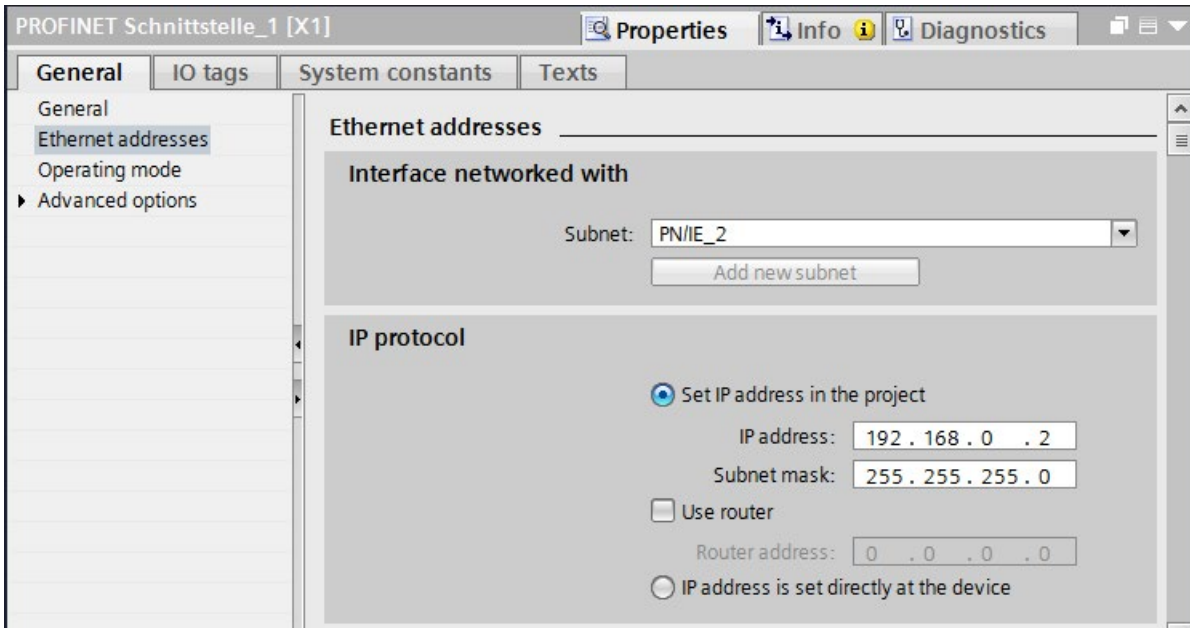


Figure 2-14 IP address for HMI connection to "HMI left" changed

The table below shows all the IP addresses used for the example:

Table 2- 1 IP addresses used in the example

PROFINET interface	Subnet	IP address
PG/PC	PN/IE1	192.168.0.50
X1 at CPU left	PN/IE1	192.168.0.1
X1 at CPU right	PN/IE1	192.168.0.2
at ET 200SP "section 1"	PN/IE1	192.168.0.3
at ET 200SP "section 2"	PN/IE1	192.168.0.4
at ET 200SP "section 3"	PN/IE1	192.168.0.5
X2 at CPU left	PN/IE_2	192.168.2.1
X1 at HMI left	PN/IE_2	192.168.2.2
X2 at CPU right	PN/IE_3	192.168.3.1
X1 at HMI right	PN/IE_3	192.168.3.2

## Introduction

The example consists of three parts:

- The air quality measurement and fan control in the tunnel
- The traffic light and barrier control
- The lighting control in the tunnel

The following section explains, based on flow diagrams, how the user program works.

Using an HMI screen, you can switch the fans and the lighting in the tunnel from automatic to manual mode and, if necessary, change limit values.

The user program runs on a CPU 1517H-3 PN with SIMATIC STEP 7 Professional, Version V15.1.

The executable user program for the example can be found in the annex to the entry on the Internet (<https://support.industry.siemens.com/cs/us/en/view/109757712>).

## States in the tunnel

The user program implements 3 states in the tunnel:

**Everything is OK: The air quality sensors measure values within the permissible range:**

- The traffic lights are green.
- The barriers are open.
- The motors for ventilation are in Stop mode, only the flow of air moves the fans.

**The air quality sensors measure an increased concentration of pollutants between mean and maximum value:**

- The fans immediately run at low level (slow) for at least 30 seconds. The direction of rotation of the fans depends on the extent of the load in the tunnel section and the distance to the exit.
- The traffic lights are still green.
- The barriers are still open.

**The air quality sensors measure a pollutant concentration above the maximum value:**

- The fans run immediately at the highest level (fast) for at least 30 seconds. The direction of rotation of the fans depends on the affected tunnel section and the distance to the exit.
- If the fans did not provide sufficient air within 2 minutes, the tunnel will be blocked:
  - The traffic lights are first yellow, then red.
  - The barriers close.

## Default tag table

The standard tag table contains the PLC tags for the 3 parts of the user program.

Name	Data type	Address	Description
<b>Air quality measurement and fan control in tunnel section 1</b>			
sectionOneAirVisibility	Int	IW3	Input word for turbidity sensor in section 1
sectionOneAirPollution	Int	IW5	Input word for air quality sensor in section 1
sectionOneVentBlowRight	Bool	Q2.0	Output bit for clockwise rotation fan in section 1
sectionOneVentDrawLeft	Bool	Q2.1	Output bit for anticlockwise rotation fan in section 1
sectionOneVentSlow	Bool	Q2.2	Output bit for low speed fan in section 1
sectionOneVentFast	Bool	Q2.3	Output bit for high speed fan in section 1
<b>Traffic light and cabinet control in tunnel section 1</b>			
section1TrafficLightRed	Bool	Q0.0	Output bit for red traffic light in section 1
section1TrafficLightYellow	Bool	Q0.1	Output bit for yellow traffic light in section 1
sectionOneTrafficLightGreen	Bool	Q0.2	Output bit for green traffic light in section 1
sectionOneBarrierUp	Bool	Q1.0	Output bit for barrier in section 1
sectionOneBarrierDown	Bool	Q1.1	Output bit for barrier in section 1

Name	Data type	Address	Description
<b>Lighting control in tunnel section 1</b>			
sectionOneLuminance	Int	IW1	Input word for outdoor light sensor in section 1
sectionOneLightEntry	Word	QW21	Output word for brightness of the entry light in section 1
sectionOneLightPassage	Word	QW23	Output word for brightness of the interior luminance in section 1
<b>Air quality measurement and fan control in tunnel section 2</b>			
sectionTwoAirVisibility	Int	IW21	Input word for turbidity sensor in section 2
sectionTwoAirPollution	Int	IW23	Input word for outdoor light sensor in section 2
sectionTwoVentBlowRight	Bool	Q6.0	Output bit for clockwise rotation fan in section 2
sectionTwoVentDrawLeft	Bool	Q6.1	Output bit for anticlockwise rotation fan in section 2
sectionTwoVentSlow	Bool	Q6.2	Output bit for low speed fan in section 2
sectionTwoVentFast	Bool	Q6.3	Output bit for high speed fan in section 2
<b>Lighting control in tunnel section 2</b>			
sectionTwoRight-LightPassage	Word	QW13	Output word for brightness of the right interior luminance in section 2
sectionTwoLeftLightPassage	Word	QW15	Output word for brightness of the left interior luminance in section 2
<b>Air quality measurement and fan control in tunnel section 3</b>			
sectionThreeAirVisibility	Int	IW11	Input word for turbidity sensor in section 3
sectionThreeAirPollution	Int	IW13	Input word for air quality sensor in section 3
sectionThreeVentBlowRight	Bool	Q10.0	Output bit for clockwise rotation fan in section 3
sectionThreeVentDrawLeft	Bool	Q10.1	Output bit for anticlockwise rotation fan in section 3
sectionThreeVentSlow	Bool	Q10.2	Output bit for low speed fan in section 3
sectionThreeVentFast	Bool	Q10.3	Output bit for high speed fan in section 3
<b>Traffic light and cabinet control in tunnel section 3</b>			
sectionThreeTrafficLightRed	Bool	Q4.0	Output bit for red traffic light in section 3
sectionThreeTrafficLightYellow	Bool	Q4.1	Output bit for yellow traffic light in section 3
sectionThreeTrafficLightGreen	Bool	Q4.2	Output bit for green traffic light in section 3
sectionThreeBarrierUp	Bool	Q8.0	Output bit for barrier in section 3
sectionThreeBarrierDown	Bool	Q8.1	Output bit for barrier in section 3
<b>Lighting control in tunnel section 3</b>			
sectionThreeLuminance	Int	IW9	Input word for outdoor light sensor in section 3
sectionThreeLightPassage	Word	QW29	Output word for brightness of the interior luminance in section 3
sectionThreeLightEntry	Word	QW31	Output word for brightness of the entry light in section 3



### Flow diagram of the user program OB30

The OB30 contains the user program of the tunnel application with three function blocks for:

- The fan control in the tunnel (FB10)
- The traffic light and barrier control (FB20)
- The lighting control in the tunnel (FB30)
- DB1 contains the HMI tags for the HMI screen.

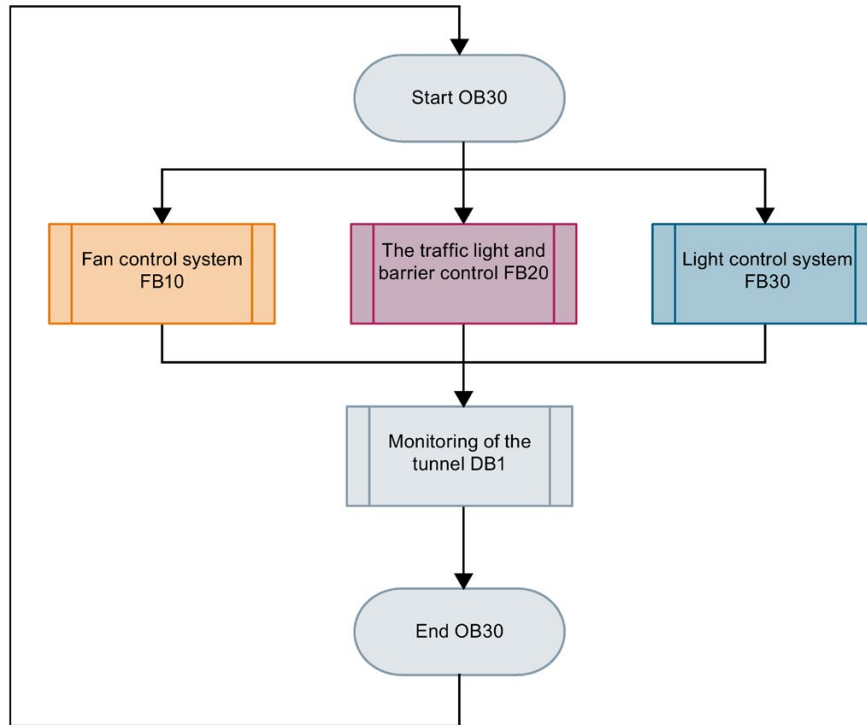


Figure 3-1 Flow diagram for user program in OB30

### Flow diagram for fan control in FB10

**Turbidity measurement and air quality measurement:**

FB10 calls FB11. FB11 reports:

- The status of the air pollution level
- A pollutant concentration above the maximum value, which lasts longer than 2 minutes, to block the tunnel

**Ventilation in tunnel sections 1, 2 and 3:**

FB12 switches the speed and direction of rotation of the fans according to the status of the air pollution level (FB13) in the tunnel sections.

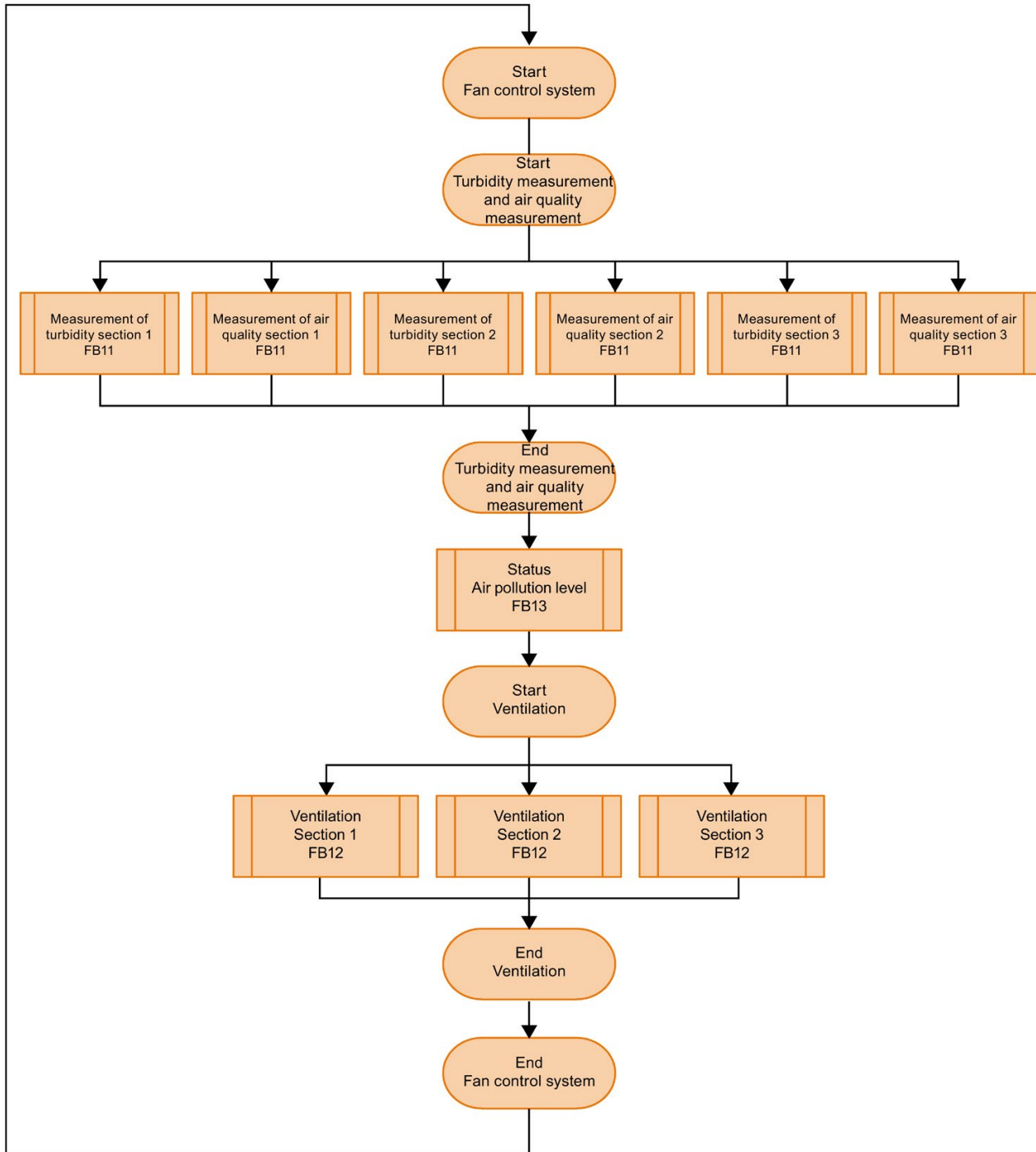


Figure 3-2 Flow diagram for fan control in FB10

### Flow diagram for traffic light and cabinet control FB20

FB20 calls FB21. Depending on the status of the air pollution level (FB13) in the tunnel sections, both traffic lights are set to green, yellow or red and the barriers are opened or closed.

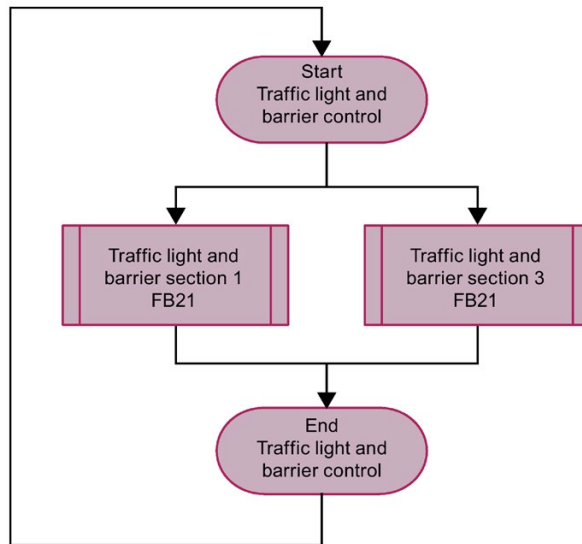


Figure 3-3 Flow diagram for traffic light and cabinet control FB20

### Flow diagram for lighting control in FB30

Control of the entry and interior lights in the tunnel sections.

FB30 calls FB31. The user program controls the turn-on light according to the status of the outdoor light sensor.

The user program controls the interior lights according to the respective time of day or enables manual mode:

- Daylight: 8:00 am to 6:00 pm
- Night light: 8:00 pm to 6:00 am
- Twilight light: 6:00 am to 8:00 am and 6:00 pm to 8:00 pm

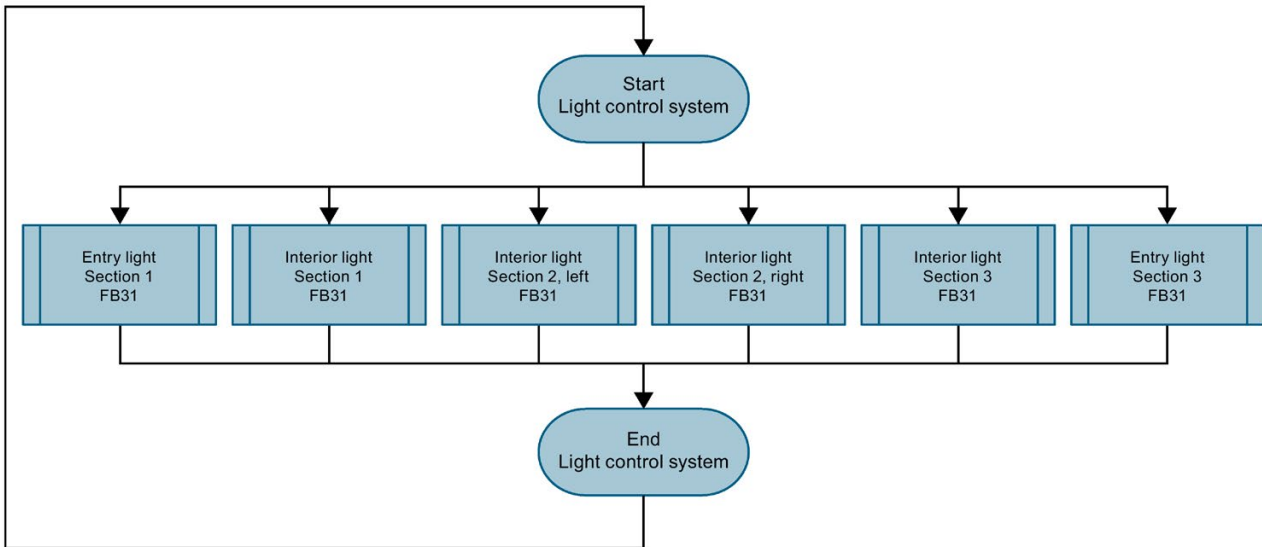


Figure 3-4 Flow diagram for lighting control in FB30

## Display the status of the tunnel on the panel

An HMI screen is used to display the status of the tunnel on both Comfort Panels and to set parameters. The white fields are used to show the current measured values of the sensors.

By double-clicking on the "Air parameters" and "Lighting parameters" buttons, you can display and change the parameter settings.

By double-clicking on the symbols for lamp and motor, you access the automatic / manual operating mode.

By double-clicking on a box for the sensors, you access the automatic / manual operating mode for specifying sensor values.

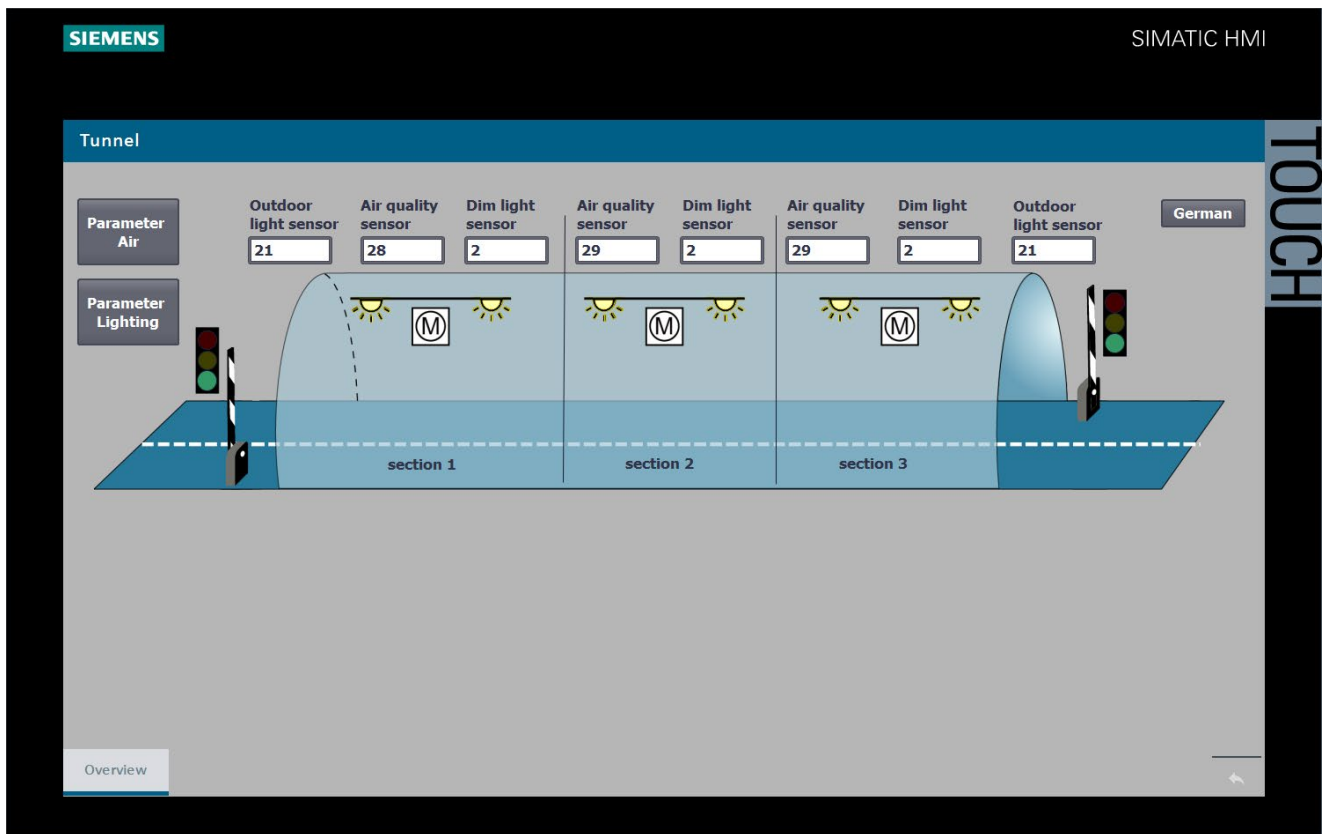


Figure 3-5 HMI overview screen of tunnel

## Adjustable limits and parameters in the HMI screen

**You can use the HMI screen to change the following limit values during user program runtime:**

- The limit values for air pollution (carbon monoxide and turbidity) in the tunnel sections
- The light intensity limit value for the outdoor light sensors at the tunnel

**You can use the HMI screen to change the following limit values in manual operation:**

- Switch the fans in the tunnel sections to stop / slow / fast
- Change the clockwise / anticlockwise direction of rotation of the fans in the tunnel sections
- Change the light intensity for the dimmer control of the lighting in the tunnel
- The lamps in the tunnel individually control day, twilight or night mode with different light intensities
- For test purposes, set the values for the outdoor light, air quality and turbidity sensors

## Limit values for air pollution

The "Air parameters" button is used to display the air pollution limit values (carbon monoxide and turbidity) in the tunnel sections.

### If a maximum value is exceeded after 2 minutes:

- The traffic lights are red
- The barriers close
- The fan sucks in / blows out air in the tunnel section at high speed, in the example in the left direction (tunnel exit)

In the example in the screen, the air quality sensor measures the value 28 in tunnel section 1, the maximum limit value is 25.

In the example in the screen, the turbidity sensor measures the value 2. The value is below the mean, therefore the view is in the normal range.

### As soon as a mean value is exceeded:

- The traffic lights are green
- The barriers remain open
- The fan sucks in / blows out air in the tunnel section at low speed

You can change the mean and maximum value limits for each tunnel section.

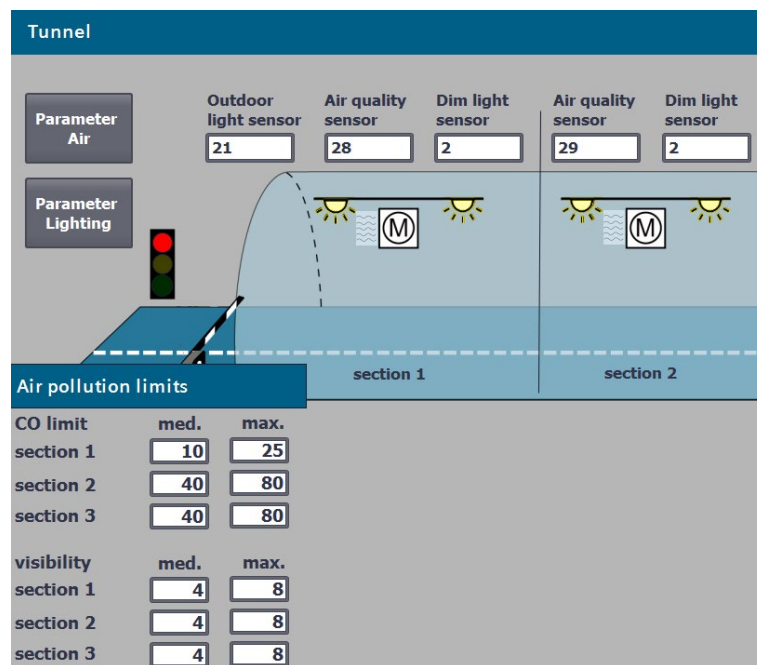


Figure 3-6 HMI screen for air pollution limit value

### The light intensity limit value for the exterior light sensors and light intensity

Using the "Lighting parameters" button you display the following:

- The limit value for outdoor light sensors
- The limit values for day / twilight / night light
- The light intensity in the tunnel according to the time of day

The outdoor light sensors on the tunnel control the respective entrance light in the tunnel. The interior lights are controlled by the time of day.

In the example, the outdoor light sensor measures 1, the night light setting (subdued light) is thus effective for the entry into the tunnel.

You can change the limit values for the tunnel.

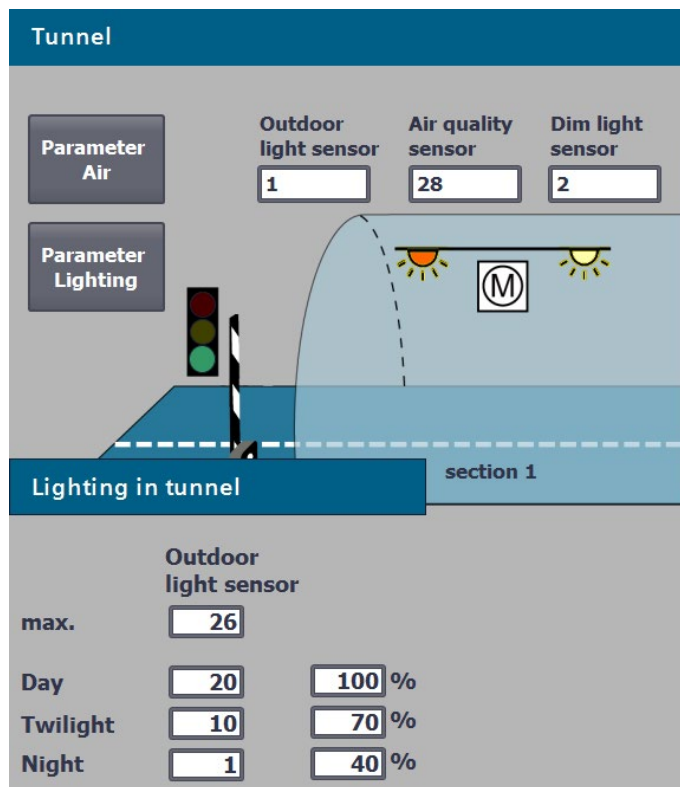


Figure 3-7 HMI screen for light limit value



## Change manual mode speed and direction of rotation of the fans

By double-clicking on a symbol for a motor, you access the automatic / manual operating mode for the fan in the corresponding tunnel section.

In the example, the following was set for tunnel section 2:

- Manual operation for the fan
- Low speed (slow)
- Clockwise

The fan blows at slow speed in clockwise direction.

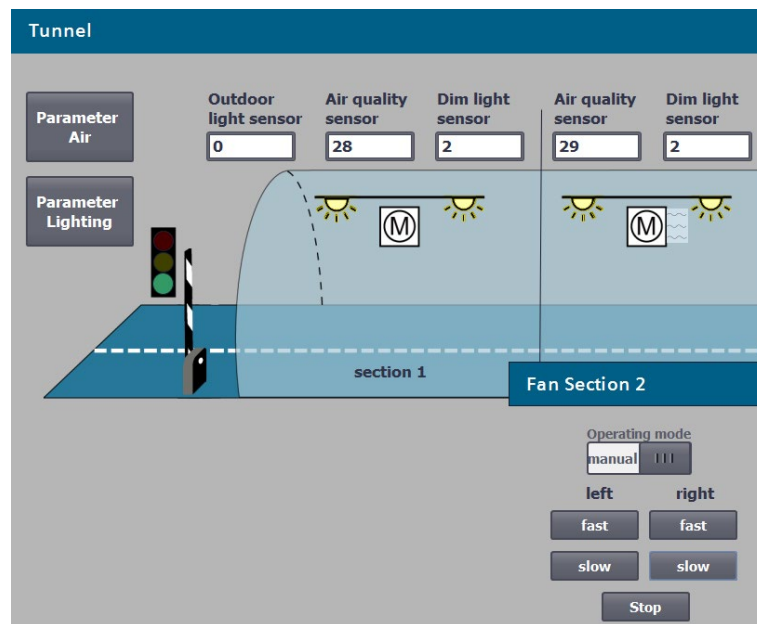


Figure 3-8 HMI screen manual mode fan speed and direction of rotation

### Controlling manual operation of the lamps individually

For maintenance tasks, it may be advisable to manually set the brightness in the tunnel. By double-clicking on a symbol for a lamp, you access the automatic / manual operating mode for the lighting in the corresponding tunnel section.

In the example, for the left interior light was set in tunnel section 2:

- Manual mode
- Night light

The lamp emits subdued light.

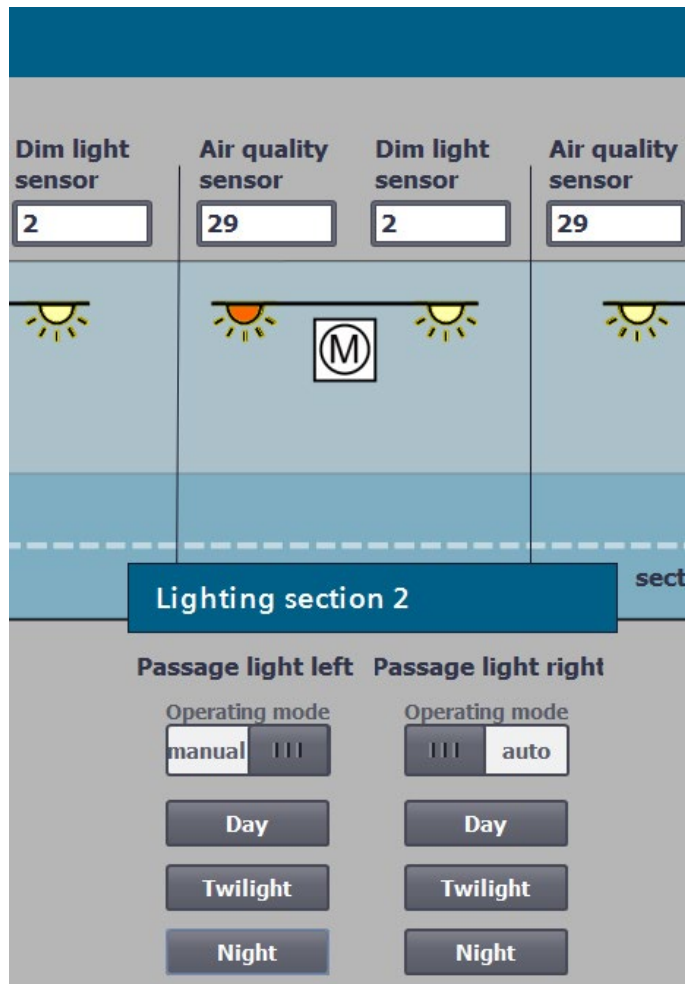


Figure 3-9 Controlling the HMI screen lamps individually

## Specifying manual operation sensor values

By specifying the sensor values, you can test the function of the tunnel application. By double-clicking on a box for the sensors, you access the automatic / manual operating mode.

In the example, the following was set for tunnel section 1:

- Manual operation for setting the CO limit value (air quality sensor)
- CO limit value of 28
- Manual operation for specifying the limit value for the vision (turbidity sensor)
- Value for the vision of 2

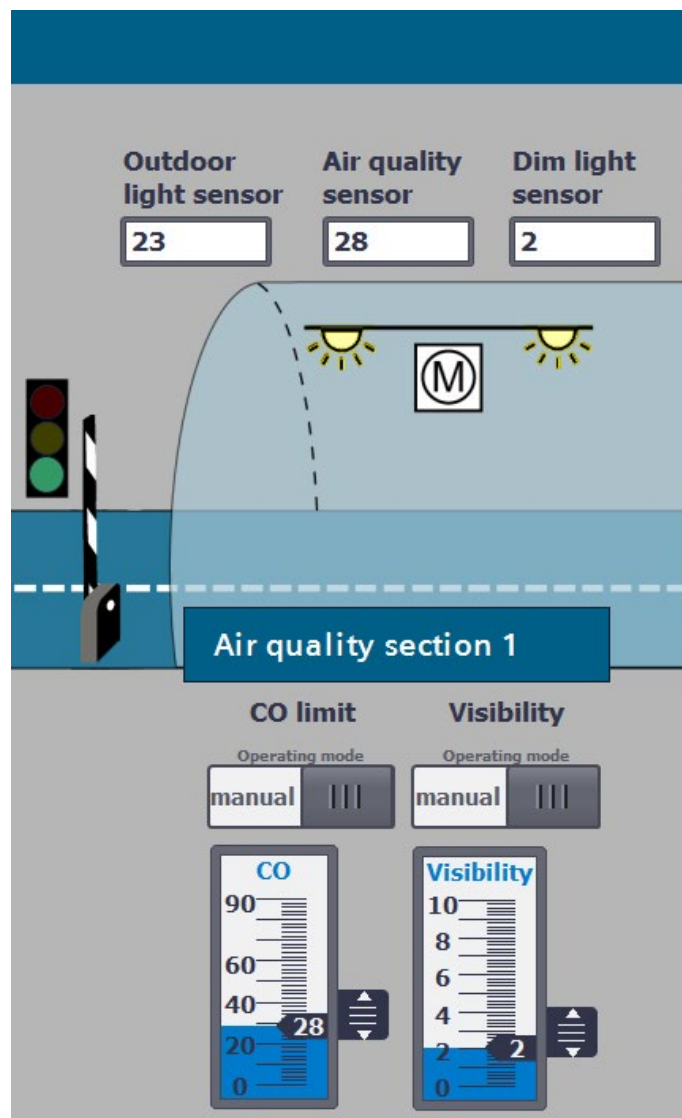


Figure 3-10 Specifying HMI screen sensor values

# Commissioning

## Introduction

You have configured and programmed the tunnel application. The following sections describe how to commission the tunnel application.

Further information on commissioning is available in the system manual of Redundant System S7-1500R/H (<https://support.industry.siemens.com/cs/ww/en/view/109754833>).

## Inserting SIMATIC memory cards

### Requirement:

The CPUs only support pre-formatted SIMATIC memory cards. If required, format the SIMATIC memory cards before using them in the CPU.

**Procedure:** Insert a SIMATIC memory card into the left-hand CPU as follows.

1. Open the front cover of the CPU.
2. Ensure that the CPU is either switched off or in STOP mode.
3. Insert the SIMATIC memory card, as shown on the CPU, into the slot for the SIMATIC memory card.
4. Carefully insert the SIMATIC memory card into the CPU, pushing gently, until the card clicks into place.
5. Insert the other SIMATIC memory card into the right-hand CPU as described in steps 1 to 4.

## Switching on load current supply and CPUs

### Requirements:

The SIMATIC S7-1500R/H redundant system has been installed. The system has been wired. The SIMATIC memory cards are in the CPUs. The load current supply is connected to the power supply.

### Procedure:

Turn on the load current supply.

### Result:

- The CPUs run a flash test and on completion of system initialization goes to STOP. The RUN/STOP LEDs on both CPUs are yellow.
- The two CPUs implement pairing. The ERROR LEDs are flashing red. In STEP 7 in the diagnostic status (Online & diagnostics) of the S7-1500R/H system, check successful pairing. "Paired" is shown in the "Pairing state" field.

## Assigning redundancy IDs to CPUs in the configuration

Redundant operation is only possible if the two CPUs have different redundancy IDs. The redundancy IDs can have values of 1 and 2. Both CPUs have redundancy ID 1 in the configuration as the default:

The redundancy ID is used to assign a project tree to the real CPU in STEP 7. The upper CPU of the two in the tree always has a redundancy ID of 1. The lower CPU of the two always has the redundancy ID 2.

### Requirements:

Both CPUs are in STOP. There is pairing between the two CPUs.

### Procedure:

1. On the CPU display of the right CPU, select the menu item "Overview> Redundancy".
2. Assign the CPU redundancy ID 2.

**Result:** The right-hand CPU in the configuration is assigned redundancy ID 2.

## Downloading project data to the primary CPU

In the example, download the project data from the PG/PC to the primary CPU via an online connection. The project data (all configuration data and the complete user program) can only be downloaded when a CPU is in STOP operating state.

### Procedure:

1. Right-click to select the S7-1500R/H system in the project tree.
2. Select the "Download to device" > "Hardware and software (changes only)" command from the shortcut menu.

**Result:** The "Extended download" dialog window opens.

3. Select the PG/PC interface.
4. Select the interface to which the PG/PC is connected.
5. Click on the "Start search" button.

**Result:** The "Choose target device" table shows the CPUs in the S7-1500H system. The primary CPU is already selected.

6. Click "Load".

**Result:** The "Load preview" dialog window sets out the key information on the load process to be run:

7. If the S7-1500R/H system is not in STOP, stop the system. To do so, select "Stop RH system" in the "Action" column of the drop-down menu.
8. Click the "Download" button to start the download.

The "Results of loading" dialog window displays the results of the loading process.

## Starting CPUs after downloading

### Requirement:

The CPU mode selector is in the RUN position.

### Procedure:

1. To start the primary CPU after loading is complete, select "Start module" in the "Action" column.
2. To complete loading, click "Finish".

**Result:** The primary CPU switches to the RUN operating state.

3. Switch the backup CPU to the RUN operating state.

**Result:** After successful synchronization between the primary and backup CPU, the S7-1500R/H system switches to redundant mode (system state RUN=Redundant).

## Evaluating LEDs and displays at the CPUs

If the CPUs are in the "target" system state RUN-Redundant and there are no events, requirements and errors, then the two CPUs show the following LED screens:

- the RUN/STOP LED lights up green
- the ERROR-LED is off
- the MAINT LED is off

The status information of the CPU is displayed on the display. In the system state RUN-Redundant, "RUN-Redundant" is displayed in a green bar on the two CPU displays.

## Result

You have fully created and downloaded the configuration and the user program in accordance with the task of the example.

## Additional information

### Further information

Below is a collection of links:

- for additional information on the systems and components which were used in the Getting Started
- to tunnel automation

Table 5- 1 Collection of links

Topics	Further information
Components, failure scenarios, setup, installation, wiring and commissioning of S7-1500R/H	Redundant System S7-1500R/H ( <a href="https://support.industry.siemens.com/cs/ww/en/view/109754833">https://support.industry.siemens.com/cs/ww/en/view/109754833</a> ) system manual
Components, setup, installation, wiring and commissioning of ET 200SP	System manual ET 200SP Distributed I/O System ( <a href="https://support.industry.siemens.com/cs/ww/en/view/58649293">https://support.industry.siemens.com/cs/ww/en/view/58649293</a> )
PM 190 W 120/230 V AC load current supply	PM 190 W 120/230 V AC load current supply ( <a href="https://support.industry.siemens.com/cs/ww/en/view/68022506">https://support.industry.siemens.com/cs/ww/en/view/68022506</a> ) manual
HMI devices TP1900 Comfort	SIMATIC HMI Comfort Panels ( <a href="https://support.industry.siemens.com/cs/de/en/view/49313233">https://support.industry.siemens.com/cs/de/en/view/49313233</a> ) operating instructions
SIMATIC STEP 7 Professional: Configuration, programming, HMI visualization, diagnostics	In the STEP 7 online help
PROFINET at S7-1500R/H, system redundancy S2, media redundancy (MRP)	PROFINET ( <a href="https://support.industry.siemens.com/cs/ww/en/view/49948856">https://support.industry.siemens.com/cs/ww/en/view/49948856</a> ) function manual
HMI communication to S7-1500R/H, System IP address	Communication ( <a href="https://support.industry.siemens.com/cs/ww/en/view/59192925">https://support.industry.siemens.com/cs/ww/en/view/59192925</a> ) function manual
Diagnostics of S7-1500R/H on the CPU display and in STEP 7	Function manual Diagnostics ( <a href="https://support.industry.siemens.com/cs/ww/en/view/59192926">https://support.industry.siemens.com/cs/ww/en/view/59192926</a> )
Siemens tunnel automation	on the Internet ( <a href="https://w3.siemens.com/topics/global/en/tunnelautomatisierung/Seiten/Default.aspx">https://w3.siemens.com/topics/global/en/tunnelautomatisierung/Seiten/Default.aspx</a> )