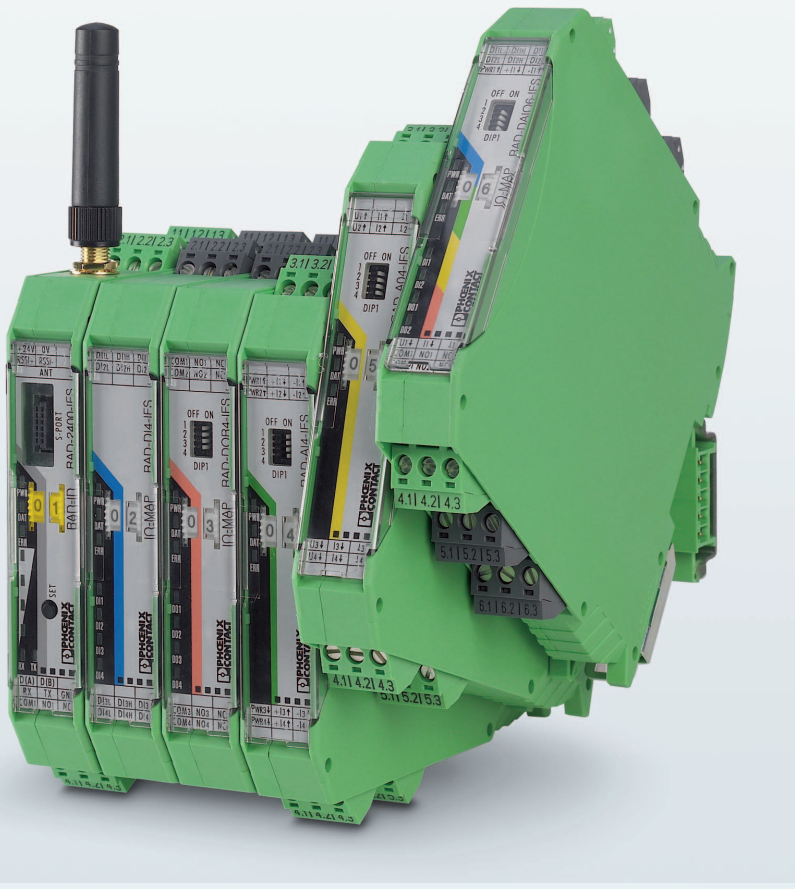

Radioline - Wireless transmission system for serial interfaces and I/O signals

User manual

UM EN RAD-2400-IFS

PHOENIX CONTACT
INSPIRING INNOVATIONS

User manual

Radioline - Wireless transmission system for serial interfaces and I/O signals

2013-11-22

Designation: UM EN RAD-2400-IFS

Revision: 00

This user manual is valid for:

Wireless module:	Order No.
RAD-2400-IFS	**2901541**
I/O extension modules:	
RAD-AI4-IFS	2901537
RAD-PT100-4-IFS	2904035
RAD-AO4-IFS	2901538
RAD-DI4-IFS	2901535
RAD-DI8-IFS	2901539
RAD-DOR4-IFS	2901536
RAD-DO8-IFS	2902811
RAD-DAIO6-IFS	2901533

Please observe the following notes

User group of this manual

The use of products described in this manual is oriented exclusively to qualified electricians or persons instructed by them, who are familiar with applicable standards and other regulations regarding electrical engineering and, in particular, the relevant safety concepts.

Explanation of symbols used and signal words

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety measures that follow this symbol to avoid possible injury or death.

There are three different categories of personal injury that are indicated with a signal word.

DANGER This indicates a hazardous situation which, if not avoided, will result in death or serious injury.

WARNING This indicates a hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION This indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

This symbol together with the signal word **NOTE** and the accompanying text alert the reader to a situation which may cause damage or malfunction to the device, hardware/software, or surrounding property.

This symbol and the accompanying text provide the reader with additional information or refer to detailed sources of information.

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Table of contents

1 Technical data

Description	Type	Order No.	Pcs. / Pkt.
2400 MHz wireless transceiver with RS-232, RS-485 2-wire interface, expandable with I/O extension modules, with screw connection, antenna connection: RSMA (female), incl. DIN rail connector	RAD-2400-IFS	2901541	1

Extension modules	Type	Order No.	Pcs. / Pkt.
Analog I/O extension module with 4 analog current inputs (0/4 mA ... 20 mA), with screw connection, incl. DIN rail connector	RAD-AI4-IFS	2901537	1
Temperature I/O extension module with 4 Pt 100 inputs (-50°C ... +250°C), with screw connection, incl. DIN rail connector	RAD-PT100-4-IFS	2904035	1
Analog I/O extension module with 4 analog current/voltage outputs (0/4 mA ... 20 mA, 0 ... 10 V), with screw connection, incl. DIN rail connector	RAD-AO4-IFS	2901538	1
Digital I/O extension module with 4 digital inputs (0 V ... 250 V AC/DC), with screw connection, incl. DIN rail connector	RAD-DI4-IFS	2901535	1
Digital I/O extension module with 8 digital inputs (0 V ... 30.5 V DC) or 2 pulse inputs (0 Hz ... 100 Hz), with screw connection, incl. DIN rail connector	RAD-DI8-IFS	2901539	1
Digital I/O extension module with 4 digital relay outputs (6 A, 250 V AC/ 24 V DC), with screw connection, incl. DIN rail connector	RAD-DOR4-IFS	2901536	1
Digital I/O extension module with 8 digital transistor outputs (30.5 V DC/200 mA), with screw connection, incl. DIN rail connector	RAD-DO8-IFS	2902811	1
Analog/digital I/O extension module with 2 digital inputs/outputs (0 V ... 250 V AC/DC) and 1 analog input (0/4 mA ... 20 mA) and output (0/4 mA ... 20 mA, 0 V ... 10 V), with screw connection, incl. DIN rail connector	RAD-DAIO6-IFS	2901533	1

Accessories	Type	Order No.	Pcs. / Pkt.
DIN rail connector for DIN rail power supply, gold-plated contacts, for DIN rail mounting, 5-pos.	ME 17,5 TBUS 1,5/ 5-ST-3,81 GN	2709561	10
CONFSTICK for easy and safe network addressing for the 2.4 GHz Radioline wireless module (RAD-2400-IFS), unique network ID, RF band 3	RAD-CONF-RF3	2902814	1
CONFSTICK for easy and safe network addressing for the 2.4 GHz Radioline wireless module (RAD-2400-IFS), unique network ID, RF band 5	RAD-CONF-RF5	2902815	1
CONFSTICK for easy and safe network addressing for the 2.4 GHz Radioline wireless module (RAD-2400-IFS), unique network ID, RF band 7	RAD-CONF-RF7	2902816	1
Memory stick for saving individual configuration data for the Radioline wireless module	RAD-MEMORY	2902828	1
USB data cable (USB-A on IFS plug) for communicating between PCs and PHOENIX CONTACT devices with an IFS data port, e.g., RAD-2400-IFS. Power supply for diagnostics and configuration via the USB port of the PC. Cable length: 2 m	RAD-CABLE-USB	2903447	1

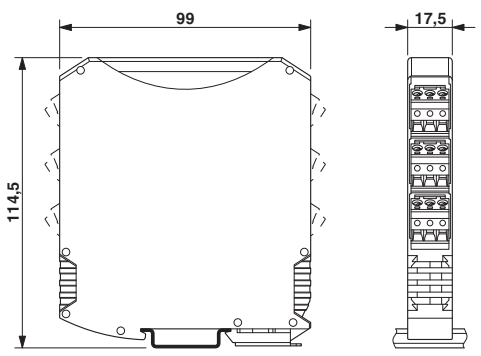
Antennas	Type	Order No.	Pcs. / Pkt.
Omnidirectional antenna, 2.4 GHz, 2 dBi, linear vertical, 1.5 m cable, RSMA (male), IP65 degree of protection, 50 Ω impedance	RAD-ISM-2400-ANT-OMNI-2-1-RSMA	2701362	1
Omnidirectional antenna with protection against vandalism, 2.4 GHz, 3 dBi gain, IP55 degree of protection, 1.5 m cable length, RSMA (male) connection, h/v 360°/85° apex angle Appropriate mounting material is available for wall mounting.	RAD-ISM-2400-ANT-VAN-3-0-RSMA	2701358	1
Omnidirectional antenna with protection against vandalism, 2.4 GHz, 3 dBi gain, IP55 degree of protection, 1.5 m cable length, SMA (male) connection, h/v 360°/85° apex angle Appropriate mounting material is available for wall mounting.	RAD-ISM-2400-ANT-VAN- 3-0-SMA	2885867	1
Omnidirectional antenna, 2.4 GHz, 6 dBi, linear vertical, N (female), IP55 degree of protection, 50 Ω impedance	RAD-ISM-2400-ANT-OMNI-6-0	2885919	1
Omnidirectional antenna, 2.4 GHz, 6 dBi, linear vertical, h/v 360°/20° apex angle, N (female), IP65 degree of protection, seawater-resistant	RAD-2400-ANT-OMNI-6-0-SW	2903219	1
Panel antenna, 2.4/5 GHz, 9 dBi, linear vertical, N (female), IP67 degree of protection	ANT-DIR-2459-01	2701186	1
Panel antenna, IP55 degree of protection, 8 dBi gain, linear vertical, SMA (female), 50 Ω impedance, h/v 75°/70° apex angle	RAD-ISM-2400-ANT-PAN- 8-0	2867610	1
Parabolic antenna, IP65 degree of protection, 19 dBi gain, linear vertical, N (female) connection, 50 Ω impedance, h/v 17°/11° apex angle	RAD-ISM-2400-ANT-PAR-19-0	2867885	1

Antenna cables and adapters	Type	Order No.	Pcs. / Pkt.
Antenna cable, 0.5 m length, N (male) -> RSMA (male), 50 Ω impedance	RAD-PIG-RSMA/N-0.5	2903263	1
Antenna cable, 1 m length, N (male) -> RSMA (male), 50 Ω impedance	RAD-PIG-RSMA/N-1	2903264	1
Antenna cable, 2 m length, N (male) -> RSMA (male), 50 Ω impedance	RAD-PIG-RSMA/N-2	2903265	1
Antenna cable, 3 m length, N (male) -> RSMA (male), 50 Ω impedance	RAD-PIG-RSMA/N-3	2903266	1
Adapter cable, pigtail 30 cm N (female) -> SMA (male), insertion loss 1.5 dB at 2.4 GHz; 50 Ω impedance	RAD-PIG-EF316-N-SMA	2867694	1
Adapter cable, pigtail 50 cm SMA (male) -> SMA (male), insertion loss 1.5 dB at 2.4 GHz; 50 Ω impedance	RAD-PIG-EF316-SMA-SMA	2885618	1
Attachment plug with LAMBDA/4 technology as surge protection for coaxial signal interfaces Connection: N connectors (socket/socket)	CN-LAMBDA/4-5.9-BB	2838490	1
Adapter, N (female) -> N (female); insertion loss <0.3 dB at 2.4 GHz	RAD-ADP-N/F-N/F	2867843	1
Adapter, RSMA (male) -> SMA (female); insertion loss <0.3 dB at 2.4 GHz	RAD-ADP-RSMA/F-SMA/F	2884538	1
Antenna cable, 3 m length; N (male) -> N (male), attenuation approx. 0.45 dB/m at 2.4 GHz; 50 Ω impedance	RAD-CAB-EF393- 3M	2867649	1
Antenna cable, 5 m length; N (male) -> N (male), attenuation approx. 0.45 dB/m at 2.4 GHz; 50 Ω impedance	RAD-CAB-EF393- 5M	2867652	1
Antenna cable, 10 m length; N (male) -> N (male), attenuation approx. 0.45 dB/m at 2.4 GHz; 50 Ω impedance	RAD-CAB-EF393-10M	2867665	1
Antenna extension cable, 15 m length, N (male) -> N (male), attenuation approx. 0.45 dB/m at 2.4 GHz; 50 Ω impedance	RAD-CAB-EF393-15M	2885634	1
Vulcanizing sealing tape for external protection of adapters, cable connections, etc. against the effects of weather, roll length: 3 m	RAD-TAPE-SV-19-3	2903182	1

Power supply	Type	Order No.	Pcs. / Pkt.
24 V/100 Wp solar system for worldwide use. Consisting of a solar panel, prewired control cabinet with charge controller, solar batteries, fuses, surge protection and mounting material (incl. mast clips).	RAD-SOL-SET-24-100	2885472	1
24 V/200 Wp solar system for worldwide use. Consisting of a solar panel, prewired control cabinet with charge controller, solar battery, fuses, surge protection and mounting material (incl. mast clips).	RAD-SOL-SET-24-200	2917722	1
DIN rail power supply unit, primary-switched, narrow design, output: 24 V DC/1.5 A	MINI-SYS-PS-100-240AC/24DC/1.5	2866983	1

Junction box	Type	Order No.	Pcs. / Pkt.
Junction box for rugged construction of wireless systems for industrial applications, IP65, 25 x 18 x 13 cm, polycarbonate material, gray, drilled, incl. DIN rail, plugs, and screw connections, without devices	FL RUGGED BOX	2701204	1

Dimensions (nominal sizes in mm)



Dimensions W/H/D	17.5 mm/99 mm/114.5 mm

General data

Surge voltage category	II
Degree of protection	IP20
Pollution degree	2
Housing type	PA 6.6-FR, green
Inflammability class according to UL 94	V0

Supply

Supply voltage range	19.2 V DC ... 30.5 V DC
Maximum current consumption	65 mA, maximum (at 24 V DC and 25°C)
Transient surge protection	Yes

Wireless interface	
Antenna connection method	RSMA (female)
Direction	Bidirectional
Frequency	2400 MHz
Frequency range	2.4002 GHz ... 2.4785 GHz
Number of channel groups	8
Channel number per group	55
Channel distance	1.3 MHz
Data transmission speed (adjustable)	16 kbps 125 kbps 250 kbps
Receiver sensitivity	-106.00 dBm (16 kbps) -96.00 dBm (125 kbps) -93.00 dBm (250 kbps)
Transmission power	100 mW, maximum (adjustable)
Security	128-bit data encryption
Operating mode	I/O data (default setting, configuration via thumbwheel) Serial data (activation and configuration via PSI-CONF software) PLC/Modbus RTU mode (activation and configuration via PSI-CONF software)

System restrictions	
Wireless module	
Number of supported devices	≤250 (addressing via PSI-CONF software) ≤99 (addressing via thumbwheel)
Number of possible extension modules	≤32 (per wireless module)
Wireless network	
I/O data mode	≤99 (I/O extension modules per wireless network, serial interface deactivated)
Serial data mode	0 (no I/O extension modules can be used)
PLC/Modbus RTU mode	≤99 (access to I/O extension modules via Modbus/RTU protocol)

RS-232 interface	
Connection method	COMBICON plug-in screw terminal block
Connection technology	3-wire
Data rate	0.3 ... 115.2 kbps

RS-485 interface	
Connection method	COMBICON plug-in screw terminal block
Connection technology	2-wire
Data rate	0.3 ... 115.2 kbps
Termination resistor (switchable via DIP switches)	390 Ω 150 Ω 390 Ω

Configuration interface	
Connection method	S port (socket)

RSSI output	
Number of outputs	1
Output signal, voltage	0 V ... 3 V

RF link relay output	
Number of outputs	1
Contact type	PDT
Contact material	PdRu, gold-plated
Maximum switching voltage	30 V AC 60 V DC
Maximum switching current	500 mA
Electrical service life	5 x 10^5 cycles with 0.5 A at 30 V DC

Connection data	
Connection method	Screw connection
Conductor cross section, solid	0.2 mm² ... 2.5 mm²
Conductor cross section, stranded	0.2 mm² ... 2.5 mm²
Conductor cross section, AWG/kcmil	24 ... 14
Stripping length	7 mm
Tightening torque	0.6 Nm

Status indicators	
Status indicators	Green LED (supply voltage, PWR) Green LED (bus communication, DAT) RED LED (I/O error, ERR) 3 x green, 1 x yellow LED (LED bar graph receive quality, RSSI) Green LED (RS-232/485 receive data, RX) Green LED (RS-232/485 transmit data, TX)

Ambient conditions	
Ambient temperature (operation)	-40°C ... 70°C (>55°C derating) -40°F ... 158°F (>131°F derating)
Ambient temperature (storage/transport)	-40°C ... 85°C -40°F ... 185°F
Permissible humidity (operation)	20% ... 85%
Permissible humidity (storage/transport)	20% ... 85%
Altitude	2000 m
Vibration (operation)	According to IEC 60068-2-6: 5g, 10 Hz ... 150 Hz
Shock	16g, 11 ms

Approvals	
Conformance	CE-compliant (R&TTE directive 1999/5/EC) FCC directive Part 15.247 ISC directive RSS 210
ATEX	Ex II 3 G Ex nA nC IIC T4 Gc X
IECEx	Ex nA nC IIC T4 Gc
UL, USA/Canada	UL 508 Listed

Conformance	
R&TTE directive 1999/5/EC	
Effective use of the radio spectrum according to	EN 300328
Noise immunity according to	EN 61000-6-2
Noise emission according to	EN 61000-6-4
Health according to	EN 50385
Electrical safety according to	EN 60950-1

Operating conditions for the extended temperature range (+55°C ... 70°C)

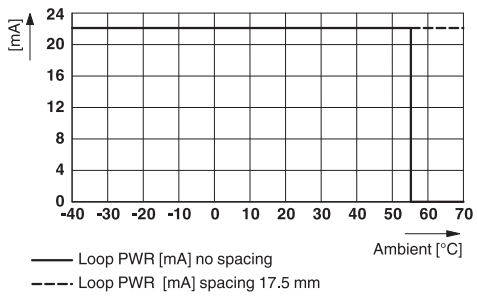
No function restrictions for the extended temperature range if you keep a minimum spacing of 17.5 mm between the modules. The minimum spacing is the width of a DIN rail connector.

Otherwise please observe the following restrictions:

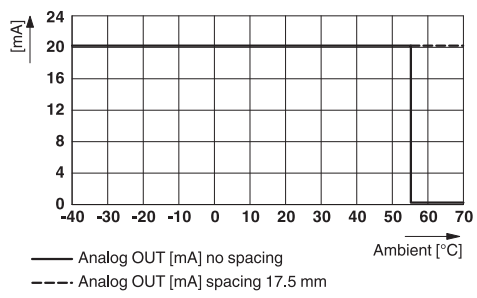
Individual operating conditions on request.

RAD-DAIO6-IFS (2901533):

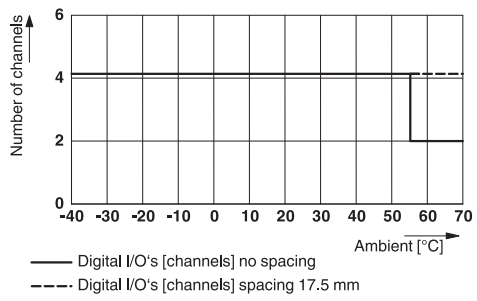
Do not use the analog loop power output (PWR1).



Only use the analog voltage output (U1).

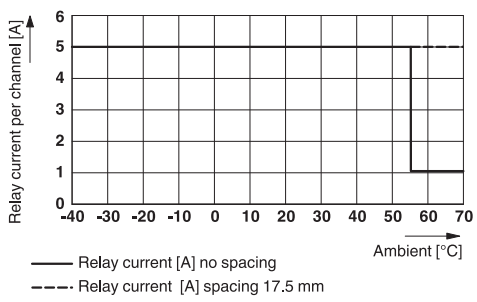


Do not use more than two of the four possible digital inputs and outputs.



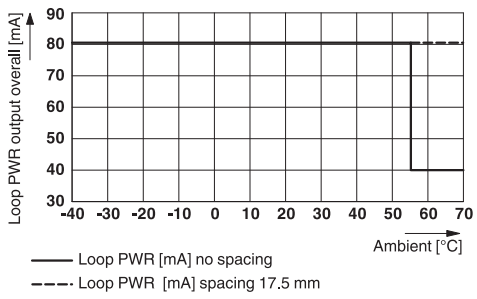
RAD-DOR4-IFS (2901536):

Maximum switching current: 2 A per channel



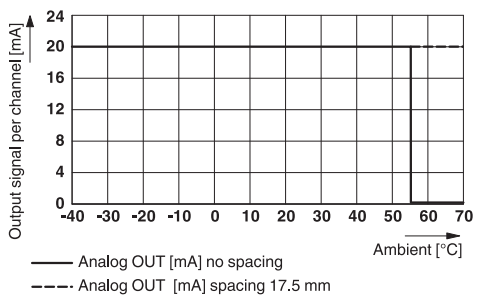
RAD-AI4-IFS (2901537):

Make sure that no more than 40 mA in total is drawn from the loop power outputs PWR_1 ... PWR_4.



RAD-AO4-IFS (2901538):

Use a maximum of two current outputs and/or any number of voltage outputs.



2 For your safety

We recommend that you read this user manual before starting up the Radioline wireless system. Keep this manual in a place where it is accessible to all users at any time.

2.1 Intended use

The devices are intended for application in industrial environments.

The Radioline wireless system is Class A equipment and may cause radio interference in residential areas. In this case, the operator may be required to implement appropriate measures and to pay the costs incurred as a result.

This device is approved for operation with a maximum transmission power of 100 mW (20 dBm) in the following countries:

Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, France, Finland, Germany, Greece, Great Britain, Hungary, Italy, Ireland, Iceland, Liechtenstein, Luxembourg, Latvia, Lithuania, Malta, the Netherlands, Norway*, Poland, Portugal, Romania, Russia, Sweden, Switzerland, Slovakia, Slovenia, Spain, Turkey*.

Additional country registrations can be found at phoenixcontact.com.

*The devices comply with R&TTE device class 2, with the following restrictions on use according to ERC recommendation 70-03:

Norway	The device must not be operated within 20 km of the Ny Ålesund town center.
Turkey	The device must only be operated with Phoenix Contact antennas (see “Wireless accessories” data sheet, Order No. 101580) - according to the “Short Range Radio Devices (SRD) Regulations” Gazette No. 26464 dated March 16, 2007.

Please note that, in combination with antennas, the maximum permissible transmission power may be exceeded. In this case, set the transmission power via the software.

Install the wireless module at least 1 m away from other devices using the 2.4 GHz frequency band (e.g., WLAN, Bluetooth, microwave ovens). Otherwise, both the transmission quality and data transmission rate will be reduced.

2.2 Installation notes

WARNING: Risk of electric shock

During operation, certain parts of the devices may carry hazardous voltages. Disregarding this warning may result in damage to equipment and/or serious personal injury.

- For applications with high operating voltages, ensure sufficient distance or insulation and provide shock protection.
- Provide a switch/circuit breaker close to the device, which is labeled as the disconnecting device for this device.
- Provide overcurrent protection (I ≤ 6 A) within the installation.
- During maintenance work, disconnect the devices from all effective power sources.

- Phoenix Contact hereby declares that this wireless system complies with the basic requirements and other relevant regulations specified in Directive 1999/5/EC.
- The category 3 devices are designed for installation in zone 2 potentially explosive areas. They meet the requirements of EN 60079-0:2009 and EN 60079-15:2010.
- Installation, operation, and maintenance may only be carried out by qualified electricians. Follow the installation instructions as described. When installing and operating the device, the applicable regulations and safety directives (including national safety directives), as well as the generally recognized rules of technology, must be observed. The safety data is provided in the package slip and on the certificates (conformity assessment, additional approvals where applicable).
- With the exception of configuring the DIP switches and the thumbwheel, opening or modifying the devices is not permitted. Do not repair the devices yourself but replace them with equivalent devices. Repairs may only be performed by the manufacturer. The manufacturer is not liable for harm resulting from noncompliance.
- The IP20 degree of protection (IEC 60529/EN 60529) of the device is intended for use in a clean and dry environment. Do not subject the devices to mechanical and/or thermal loads that exceed the specified limits.
- The devices are not designed for use in potentially dust-explosive atmospheres.
- If dust is present, it is necessary to install the devices into a suitable approved housing, whereby the surface temperature of the housing must be taken into consideration.
- Operation of the wireless system is only permitted if accessories available from Phoenix Contact are used. The use of any other components may lead to withdrawal of the operating license.

2.3 Installation in zone 2

WARNING: Explosion hazard when used in potentially explosive areas
Make sure that the following notes and instructions are observed.

- Observe the specified conditions for use in potentially explosive areas. Install the device in a suitable approved housing (with at least IP54 degree of protection) that meets the requirements of EN 60079-15. At the same time, observe EN 60079-14 requirements.
- Only connect devices to the supply and signal circuits in zone 2 that are suitable for operation in the Ex zone 2 and for the conditions at the installation location.
- In potentially explosive areas, snap the device on or off the DIN rail connector and connect or disconnect the cables only when the power is disconnected.
- The switches of the device that can be accessed may only be actuated when the power supply to the device is disconnected.
- The device must be stopped and immediately removed from the Ex area if it is damaged, was subjected to an impermissible load, stored incorrectly or if it malfunctions.
- Ensure that the radiated wireless power is neither bundled (focused) by the antenna itself nor by any inserts in the environment of the antenna, and that it cannot enter neighboring zones 1 or 0. Please refer to the technical data for the transmission power.
- The HF cable to the antenna must be suitable for the ambient conditions. Install the cable such that it is protected against mechanical damage, corrosion, chemical stress, and negative effects from heat or UV radiation. The same applies to the antenna which is connected to the cable and which functions as a cable termination.
- The antenna must meet the requirements of EN 60079-0 with regard to housing and electrostatic discharge. Otherwise install the antenna in housing that meets the requirements of EN 60079-0 and EN 60079-15 and has at least IP54 protection (EN 60529).

Notes for antennas

- Avoid electrostatic charges.
- Install the antenna outside the reach of persons.
- Only clean the antenna housing using a suitable damp cloth.
- The antenna must be stopped and immediately removed from the Ex area if it is damaged, was subjected to an impermissible load, stored incorrectly or if it malfunctions.

2.4 Notes relating to individual I/O extension modules

RAD-DI4-IFS, RAD-DOR4-IFS, RAD-DAIO6-IFS

WARNING: Risk of electric shock

Use the same phase for digital inputs and digital outputs. The isolating voltage between the individual channels must not exceed 300 V.

RAD-AO4-IFS

Use either a current or voltage output per analog channel.

RAD-DI8-IFS, RAD-DO8-IFS, RAD-PT100-4-IFS

Use the I/O extension modules in connection with the RAD-2400-IFS wireless module, firmware version 1.40 or later. The firmware can be updated free of charge using the PSI-CONF software, version 2.04 or later.

The firmware and software can be found on the Internet at phoenixcontact.net/products.

3 Short description

Wireless communication is based on Trusted Wireless 2.0 technology. The requirement for a high-quality interference-free data transmission is fulfilled by using, for example, the frequency hopping method (FHSS) and 128-bit data encryption (AES). The Radioline wireless system uses the license-free 2.4 GHz ISM band.

3.1 Wireless module

In addition to an RS-232 and RS-485 2-wire interface, the **RAD-2400-IFS** wireless module supports the option of directly connecting up to 32 I/O extension modules in the station structure via the DIN rail connector.

Addressing of the wireless module and I/O mapping of the extension modules is carried out quickly and easily by means of the thumbwheel on the front. You can use the yellow thumbwheel on the wireless module in order to set the RAD ID, and the white thumbwheel on the extensions modules to set the I/O-MAP address. Programming knowledge is not required. You can easily start up the wireless network without the need for software.

The PSI-CONF configuration and diagnostics software for special functions and diagnostics options in the wireless module is available free of charge.

Features

- Flexible network applications: I/O data, serial data, PLC/Modbus RTU mode
- Adjustable data rates for the wireless interface
- Easy point-to-point or network structures (star, mesh)
- Yellow thumbwheel for the unique addressing of wireless modules in the wireless network
- Integrated RS-232 and RS-485 interface
- Can be extended with up to 32 I/O modules per station via DIN rail connector (hot-swappable)
- 128-bit AES data encryption and authentication
- Unique network addressing via plug-in configuration memory (RAD-CONF) for secure, parallel operation of multiple networks with different RF bands
- Data rates and ranges can be configured using the PSI-CONF software
- International approvals
- Installation in Ex zone 2

3.2 I/O extension modules

Various I/O extension modules are available for setting up the wireless system quickly and easily. You can therefore adapt the number and type of signals to the respective application.

Features

- White thumbwheel for easy and tool-free assignment of device pairs (I/O mapping)
- Modular structure via DIN rail connector (hot-swappable)
- Depending on module: channel-to-channel electrical isolation
- Depending on module: analog inputs or outputs (0/4 ... 20 mA/resolution 16-bit/accuracy <0.1%)
- Depending on module: digital wide-range inputs or outputs (0 ... 250 V AC/DC)
- DIP switches for HOLD/RESET behavior of outputs
- Loop power function for passive sensors

For a detailed description of the available I/O extension modules, refer to the pages listed below:

Table 3-1 Overview of I/O extension modules

Module type		Designation	Order No.	From page
Analog	4 analog inputs	RAD-AI4-IFS	2901537	87
	4 Pt 100 inputs	RAD-PT100-4-IFS	2904035	91
	4 analog outputs	RAD-AO4-IFS	2901538	99
Digital	4 digital inputs	RAD-DI4-IFS	2901535	103
	8 digital inputs or 2 pulse inputs	RAD-DI8-IFS	2901539	106
	4 digital relay outputs	RAD-DOR4-IFS	2901536	113
	8 digital transistor outputs	RAD-DO8-IFS	2902811	117
Analog/digital	1 analog input/output, 2 digital wide-range inputs/outputs	RAD-DAIO6-IFS	2901533	122

4 Installation

4.1 Wireless module structure

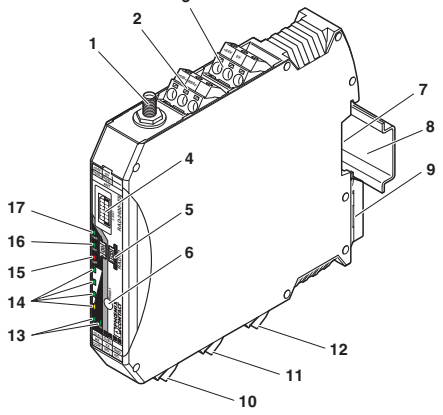


Figure 4-1 RAD-2400-IFS structure

Item	Designation
1	RSMA antenna connection (socket)
2	RSSI test output (0 V ... 3 V DC) for evaluation of the wireless signal strength
3	Device supply (+24 V DC, GND)
4	S port (12-pos. programming interface)
5	Yellow thumbwheel for setting the RAD ID
6	SET button
7	Connection option for DIN rail connector
8	DIN rail
9	Metal foot catch for DIN rail fixing
10	Connection terminal blocks for RS-485 interface
11	Connection terminal blocks for RS-232 interface
12	Relay output with floating PDT contact (RF link relay)
13	Status LED (RX/TX) for RS-232/485 serial interface
14	LED bar graph for displaying the wireless signal strength
15	ERR status LED, red (communication error)
16	DAT status LED, green (bus communication)
17	PWR status LED, green (supply voltage)

4.2 Basic circuit diagram

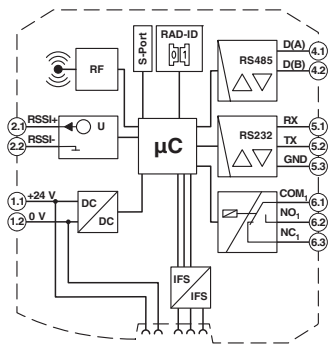


Figure 4-2 Basic circuit diagram of the RAD-2400-IFS

4.3 Mounting/removal

You can connect up to 32 different I/O extension modules to each wireless module via the DIN rail connector. Data is transmitted and power is supplied to the I/O extension modules via the bus foot.

When using the device in a connection station, use the supplied 17.5 mm wide DIN rail connector. Only use the DIN rail connector in connection with 24 V DC devices.

Install the wireless module at least 1 m away from other devices using the 2.4 GHz frequency band (e.g., WLAN, Bluetooth, microwave ovens). Otherwise, both the transmission quality and data transmission rate will be reduced.

Mount the wireless module to the left and the I/O extension modules **exclusively to the right** of the wireless module.

The individual extension modules can be arranged in any order.

Figure 4-3 Radioline connection station with up to 32 I/O extension modules

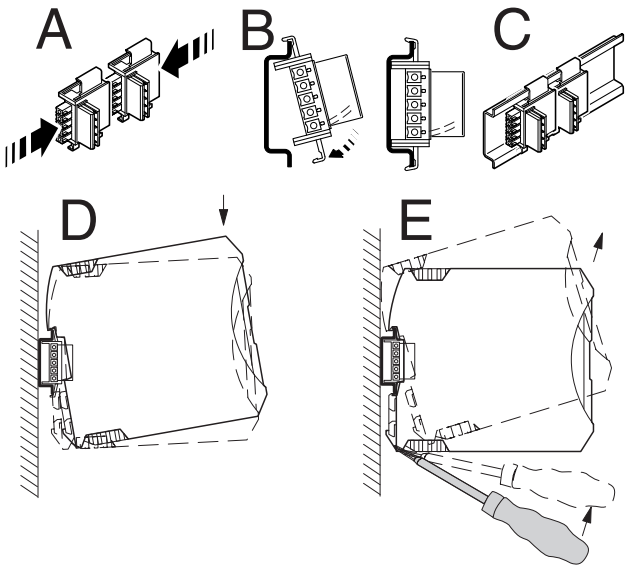


Figure 4-4 Mounting and removal

To mount a connection station with DIN rail connectors, proceed as follows:

- Connect the DIN rail connectors together for a connection station.
- Push the connected DIN rail connectors onto the DIN rail.
- Place the device onto the DIN rail from above (see Figure 4-4, D). Make sure that the device and DIN rail connector are aligned correctly.
- Holding the device by the housing cover, carefully push the device towards the mounting surface so that the device bus connector is fixed securely on the DIN rail connector.
- Once the snap-on foot snaps onto the DIN rail, check that it is fixed securely. The device is only mechanically secured via the DIN rail.
- Connect the desired number of I/O extension modules to the wireless module via the DIN rail connector.

Outside the Ex area, device replacement is also possible during operation.

Removal

- Use a suitable screwdriver to release the locking mechanism on the snap-on foot of the device (see Figure 4-4, E).
- Hold onto the device by the housing cover and carefully tilt it upwards.
- Carefully lift the device off the DIN rail connector and the DIN rail.

4.4 Connecting wires

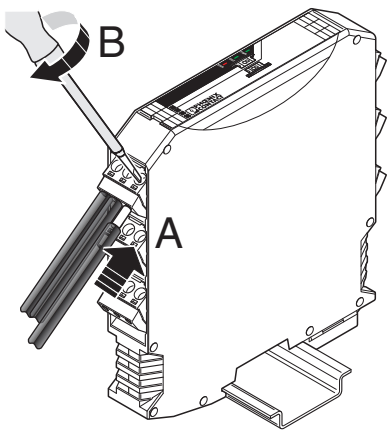


Figure 4-5 Connecting wires

For easy installation, it is also possible to pull out the screw terminal block from the device and to re-insert it after having connected the wires.

- Crimp ferrules to the wires. Permissible cable cross section: 0.2 mm^2 ... 2.5 mm^2
- Insert the wire with ferrule into the corresponding connection terminal block.
- Use a screwdriver to tighten the screw in the opening above the connection terminal block. Tightening torque: 0.6 Nm

4.5 Connecting the power supply

Via screw terminal blocks

Connect a DC voltage source (19.2 V ... 30.5 V DC) to the wireless module. The nominal voltage is 24 V DC. Supply voltage to the device via the terminals 1.1 (24 V) and 1.2 (0 V). In the case of a connection station, it is sufficient to supply the first device in the group.

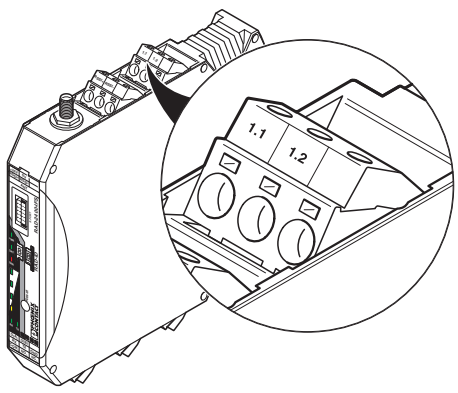


Figure 4-6 Connecting the power supply

In order to prevent damage to the wireless module, we recommend the installation of a surge arrester. Wiring between the surge arrester and the wireless module should be as short as possible. Please also observe the manufacturer's specifications.

With a system power supply unit via the bus foot

If DIN rail connectors are used, you can use the MINI-SYS-PS 100-240AC/24DC/1.5 system power supply unit (Order No. 2866983). Connect the system power supply unit using two DIN rail connectors to the left of the device.

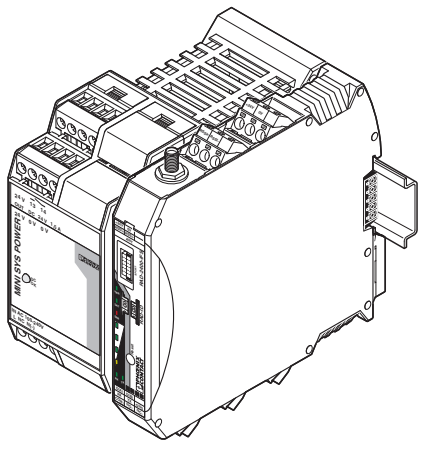


Figure 4-7 Supply via the system power supply unit

Parallel supply via screw terminal blocks and a system power supply unit via the bus foot is **not** possible.

For redundant power supply, you can connect a second MINI-SYS-PS 100-240AC/24DC/1.5 system power supply unit.

4.6 Serial interfaces

The RAD-2400-IFS wireless module has one RS-232 interface and one RS-485 2-wire interface. Connect the I/O device to the wireless module via the corresponding serial interface.

Both serial interfaces are deactivated by default. Activate and configure the RS-232 or RS-485 interface using the PSI-CONF software (from page 40 onwards).

You can only use one interface per wireless module. Parallel operation of both interfaces is not possible.

4.6.1 Shielding of the RS-485 bus cable

- Connect the shield of the RS-485 bus cable correctly via an external shield connection clamp.

NOTE: Damage to the interface

If the shield has been incorrectly connected, permanent, external disturbing pulses may damage the interface.

Observe the polarity of the RS-485 2-wire cable and ensure that the shield is connected correctly.

Choose the type of shield connection depending on the interferences to be expected:

– Firstly, connect the shield on one side. This suppresses electrical fields.
– To suppress disturbances caused by alternating magnetic fields, connect the shield on both sides. When doing so, the ground loops must be taken into account. Galvanic disturbances along the reference potential can interfere with the useful signal, and the shielding effect is reduced.
– If several devices are connected to a single bus, the shield must be connected to each device (e.g., by means of clamps).
– Connect the bus shield to a central PE point using short, low-impedance connections with a large surface area (e.g., by means of shield connection clamps).

4.6.2 Terminating the RS-485 bus cable

The RAD-2400-IFS wireless module is operated on a 2-wire bus cable. RS-485 bus connections must be terminated at both ends with a 390/150/390 Ω termination network.

- Depending on the position of the device on the RS-485 bus cable, the termination network must be activated or deactivated. The DIP switches 1 and 2 are located on the side of the wireless module.

Table 4-1 DIP switches 1 and 2: termination network

		DIP switch	
Device position	**Termination network**	**1**	**2**
RS-485 termination device	ON	ON	ON
RS-485 device	OFF	OFF	OFF

4.6.3 RS-485 pin assignment

In RS-485 mode, you can create a network with several I/O devices. Use a twisted pair bus cable to connect the I/O devices. Fit this bus cable with a termination network at the two furthest points.

- Connect the single wires of the data cable to the COMBICON plug-in screw terminal block (Figure 4-1, item 10).
- Make sure the signal assignment is correct.

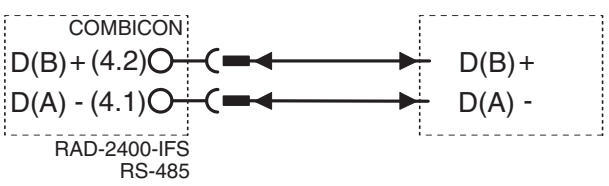


Figure 4-8 RS-485 interface pin assignment

4.6.4 RS-232 pin assignment

In RS-232 mode, point-to-point connections can be established.

The RS-232 interface of the wireless module is a DTE type (Data Terminal Equipment). This means that terminal point 5.2 (Tx) is always used for transmission and terminal point 5.1 (Rx) is always used for reception.

Only connect the wireless module to devices which meet the requirements of EN 60950.

According to the standard, you can connect a DCE device (Data Communication Equipment) to the RS-232 interface using a 1:1 cable (Figure 4-9). It is also possible to connect a DTE device using a crossed cable (Figure 4-10).

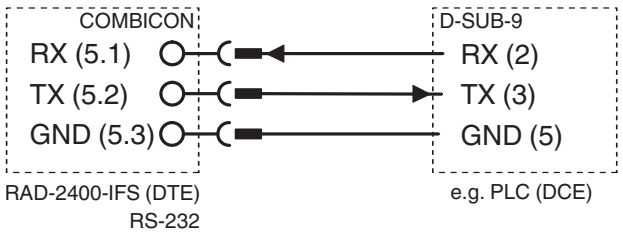


Figure 4-9 RS-232 interface pin assignment (DTE - DCE)

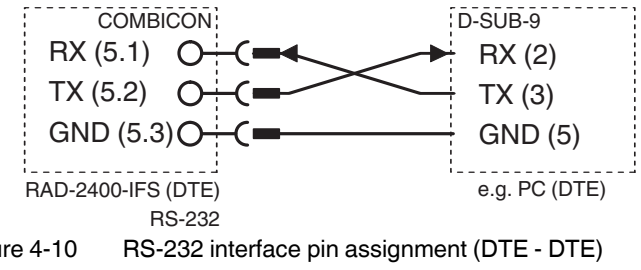


Figure 4-10 RS-232 interface pin assignment (DTE - DTE)

If you are not sure whether the device to be connected is of DTE or DCE type, you can measure the voltage. Measure the voltage between Tx and GND in the idle state.

– If the voltage measures approximately -5 V, it is a DTE device.
– If the voltage measures approximately 0 V, it is a DCE device.

4.7 Connecting the antenna

The wireless module is provided with an RSMA antenna socket for an external antenna. Various installation examples can be found in Section “Typical combinations of antennas and adapter cables” on page 157.

Install the antenna outside the control cabinet or building.

Observe the installation instructions of the antenna and Section “For your safety” on page 17.

Observe the maximum permissible emitted transmission power of 20 dBm. The transmission power can be calculated from:
device transmission power + antenna gain - cable attenuation

Reduce the device transmission power, if necessary.

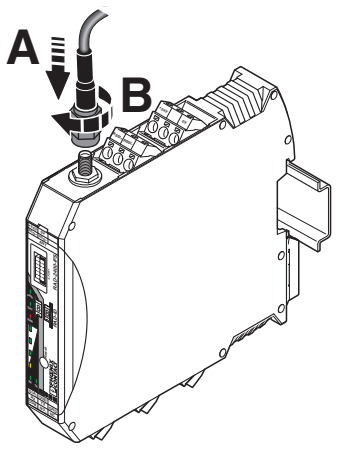


Figure 4-11 Connecting the antenna

5 Configuration and startup

5.1 Default settings of the wireless module

All RAD-2400-IFS wireless modules have the same configuration by default upon delivery or by resetting to the default settings at a later stage.

Table 5-1 Default settings of the wireless module

Parameter	Setting
Operating mode	I/O data (wire in/wire out)
Wireless interface	
Net ID	127
RF band	4
Encryption	OFF
Network structure	Mesh
Device type	Repeater/slave
Blacklisting	WLAN channel 6
Data rate of the wireless interface	125 kbps
Receive preamplifier	Activated
Transmission power	100 mW (20 dBm)

In order to be able to cover the largest possible distances, the preamplifier has been activated and transmission power set to 20 dBm by default. When operating the devices directly next to one another, the receiver might become overloaded. In this case, remove the antennas, increase the distance between the devices and antennas or reduce transmission power using the PSI-CONF software (from page 40 onwards).

5.1.1 Resetting to the default settings

The device can be reset to the default settings either manually or using the PSI-CONF software.

Resetting manually

- Disconnect the device from the supply voltage.
- Hold down the SET button located on the front of the device and switch the supply voltage on.
- Press and hold the SET button until the DAT LED flashes.

Resetting via PSI-CONF software

- Select “Wireless, RAD-2400-IFS” on the “Device Selection” page.
- Select “Local Device”.
- Select “Set device to factory default configuration”.

5.1.2 Firmware update

You can download the latest firmware free of charge at phoenixcontact.net/products.

The firmware can be updated using the PSI-CONF software. The device is reset to the default settings after a firmware update.

- Select “Wireless, RAD-2400-IFS” on the “Device Selection” page.
- Select “Update firmware”.

5.2 Operating mode of the wireless module

The Radioline wireless system offers three different options for signal and data transmission:

Operating mode	Configuration
I/O data mode	Default setting, configuration only possible via thumbwheel
Serial data mode	Configuration via PSI-CONF software
PLC/Modbus RTU mode	

You can select only one operating mode. It is **not** possible to simultaneously transmit I/O signals and serial data.

If the wireless system is operated in an environment where other networks are also present (e.g., additional Radioline networks in the 2.4 GHz band), then a configuration memory can be used (see “Configuration via CONFSTICK” on page 37). For configuring extended settings of the wireless modules, it is also possible to use the PSI-CONF software (from page 40 onwards).

I/O data mode

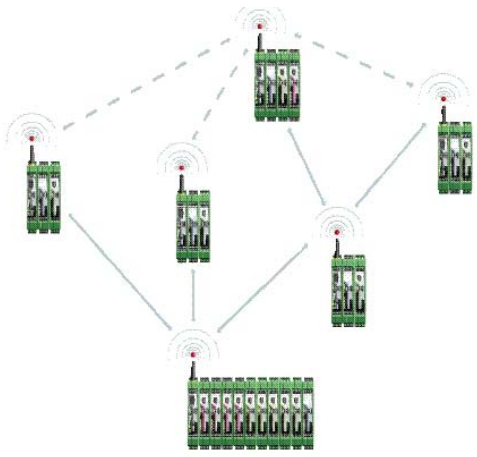


Figure 5-1 I/O data mode

By default, all wireless modules are in the I/O data mode. For simple I/O-to-I/O applications with extension modules, you can easily set the addresses using the thumbwheel. You can therefore establish a wireless connection to other wireless modules without any programming effort (see “Setting the address of the wireless module via the thumbwheel” on page 37 and “Setting the address of the extension modules via the thumbwheel” on page 54).

Serial data mode

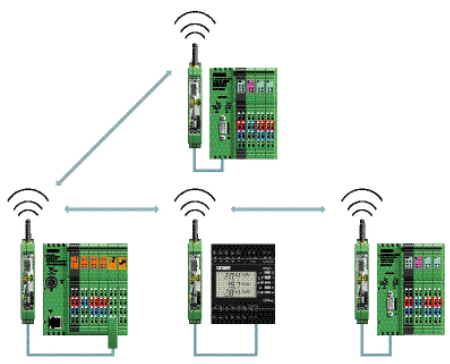


Figure 5-2 Serial data mode

In serial data mode, multiple controllers or serial I/O devices are networked easily and quickly using wireless technology. In this way, serial RS-232 or RS-485 cables can be replaced.

You need to configure each wireless module using the PSI-CONF software (from page 40 onwards).

PLC/Modbus RTU mode

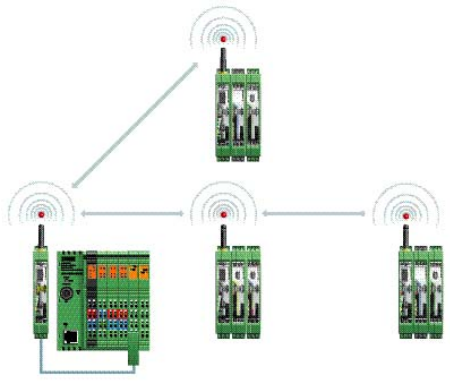


Figure 5-3 PLC/Modbus RTU mode

You can connect the I/O extension modules to the controller directly via the integrated RS-232 and RS-485 interface by means of wireless communication. In PLC/Modbus RTU mode, the master wireless module (RAD ID = 01) operates as a Modbus slave. The master wireless module has its own Modbus address.

You can connect I/O extension modules to each wireless module in the network. The I/O data of the extension module is stored in the internal Modbus memory map of the master wireless module. In addition, the diagnostic data from all wireless devices is stored here.

You need to configure each wireless module using the PSI-CONF software (from page 40 onwards).

5.3 Setting the address of the wireless module via the thumbwheel

- Firstly, set the desired station address with the yellow thumbwheel on the wireless module. There must be one master (RAD ID = 01) and at least one repeater/slave (RAD ID = 02 ... 99) in a network.

Unique addressing is required in a network. If two wireless modules have the same address in a network, the network will not function properly.

Setting the address via the thumbwheel has priority over setting the address via the PSI-CONF software.

After making any change to the module address, press the SET button for one second to apply the setting.

The following settings can be made using the yellow thumbwheel:

Thumbwheel setting	Description	
01	Master address	for networks with repeaters (mesh networks)
02 ... 99	Repeater/slave address	
*1	Master address	for networks without repeater (star networks)
*2 ... *9	Slave address	
00	Not permitted	
**	Addressing wireless modules using the PSI-CONF software (address 1 ... 250)	

5.4 Configuration via CONFSTICK

WARNING: Explosion hazard when used in potentially explosive areas
Do **not** insert or remove the CONFSTICK in a potentially explosive atmosphere.

By default upon delivery, all wireless modules have the same network ID and the same RF band. Using a configuration memory (CONFSTICK), you can configure a unique and secure network without the need for software.

The CONFSTICK is used as a network key. Its network address (network ID) is unique and cannot be assigned via the PSI-CONF software. Only wireless modules with the same network ID are allowed to connect with each other.

You have to configure each individual network device. To this end, you only need one CONFSTICK for all wireless modules in the network. After configuration, you can remove the CONFSTICK from the wireless module.

In addition, the CONFSTICK contains a preset frequency band (RF band). An RF band is a group of frequencies compiled of individual frequencies of the entire 2.4 GHz band. Different RF bands use different frequencies.

In order to operate several Radioline wireless systems, you should select different RF bands.

You can also set different RF bands between 1 ... 8 and network IDs between 1 ... 127 by using the PSI-CONF software (see page 41).

Three different CONFSTICKS are available for easy configuration without the need for software:

– RAD-CONF-RF3 for RF band 3 (Order No. 2902814)
– RAD-CONF-RF5 for RF band 5 (Order No. 2902815)
– RAD-CONF-RF7 for RF band 7 (Order No. 2902816)

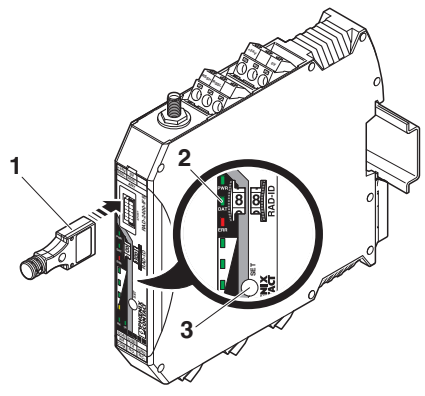


Figure 5-4 Configuration via CONFSTICK

Item	Description
1	RAD-CONF-RF CONFSTICK
2	Status LEDs
3	SET button

- Carefully insert the CONFSTICK with the 12-pos. IFS connector into the S port of the wireless module.
- Press the SET button on the wireless module for one second. Parameter read in is started. Read in has been completed when the DAT LED lights up once. The new parameters are activated.
- Remove the CONFSTICK from the wireless module.
- Repeat this process for **each** individual wireless module in the network.

5.5 Copying device settings via memory stick

In order to transfer the configuration of a wireless module to another wireless module, you can save the configuration to a memory stick (RAD-MEMORY, Order No. 2902828).

WARNING: Explosion hazard when used in potentially explosive areas
Do **not** insert or remove the memory stick in a potentially explosive atmosphere.

Pay attention to the firmware version of the wireless modules before using the memory stick. In order to ensure that a wireless module is capable of reading the memory stick, it must have the same or later firmware version as the wireless module whose configuration file is to be copied. Wireless modules with a lower firmware version are not able to read the memory stick.

Common network parameters

- Operating mode
- Network ID
- RF band
- Data rate of the wireless interface
- Encryption
- Network type

Individual device parameters

- Station name
- RAD ID
- Transmission power
- List of permitted connections
- Receive preamplifier ON/OFF
- Serial interface parameters

5.5.1 Saving parameters from the wireless module to the memory stick

Copying common network parameters and individual device parameters to the memory stick:

- Press the SET button located on the wireless module and hold down for at least six seconds.
- The four RSSI bar graph LEDs start a light sequence from bottom to top.
- Insert the memory stick in the S port of the wireless module. The copying of parameters is started automatically.
- Wait until the light sequence stops. The write process has been completed.
- Remove the memory stick from the wireless module.

5.5.2 Reading the memory stick

Reading in common network parameters via the memory stick

- Insert the memory stick in the S port of the wireless module.
- Press the SET button located on the wireless module and hold down for at least one second. Parameter read in is started. Read in has been completed when the DAT LED lights up once. The new parameters are activated.
- Remove the memory stick from the wireless module.

Reading in common network parameters and individual device parameters via the memory stick

This function enables all common network parameters and individual device parameters to be read into the wireless module. A full copy of devices can be created, e.g., as a backup copy.

- Insert the memory stick in the S port of the wireless module.
- Press the SET button located on the wireless module and hold down for at least six seconds. Parameter read in is started, the DAT LED flashes.
- The read in process has been completed once the DAT LED stops flashing. The new parameters are activated.
- Remove the memory stick from the wireless module.

If an error is detected while saving or checking the data, the DAT and ERR LEDs flash simultaneously.

5.6 Configuration via PSI-CONF software

You can make special settings using the PSI-CONF configuration and diagnostics software. The software is available to download at phoenixcontact.net/products. A PC with a Windows operating system is required to use the software. Use the RAD-CABLE-USB (Order No. 2903447) USB cable for configuration and diagnostics.

WARNING: Explosion hazard when used in potentially explosive areas
The USB cable must **not** be used in potentially explosive areas.

For additional information on the USB cable, please refer to the PACKB.RAD-CABLE-USB package slip. The latest documentation can be downloaded at phoenixcontact.net/products.

- Install the software and the USB driver for the RAD-CABLE-USB cable. Follow the software wizard.

5.6.1 Extended configuration, individual settings

After reading an existing network project or creating a new project, the network settings can be modified under “Individual Settings”. The wireless network can be optimized and adapted to your special requirements. When moving the mouse over the individual network parameters, you obtain a short description under “Help”.

If several wireless systems are operated parallel and in close proximity, you are required to set the RF band and the network ID. These parameters can be set via the PSI-CONF software or by using a CONFSTICK (see “Configuration via CONFSTICK” on page 37).

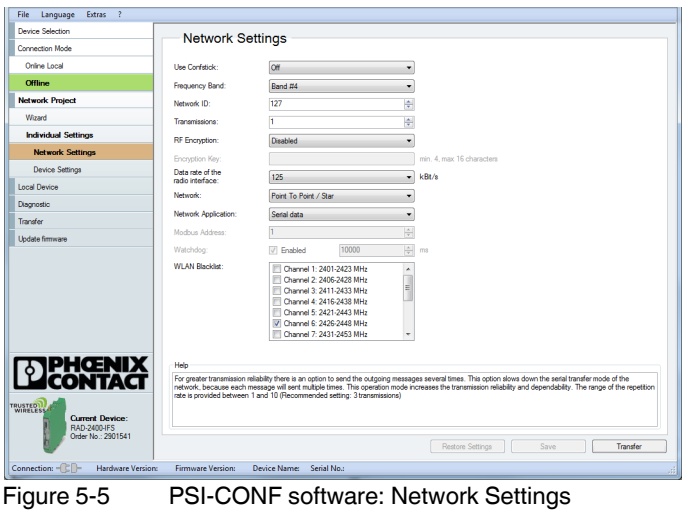


Figure 5-5 PSI-CONF software: Network Settings

5.6.2 Data transmission speed of the wireless interface

The range is an important parameter in industrial wireless applications, especially in outdoor applications. Even in cases where long ranges do not have to be covered, good receiver sensitivity enables transmission in harsh outdoor conditions, e.g., when there is no direct line of sight.

The receiver sensitivity determines the signal amplitude which can just about be received by the wireless module. The lower the data transmission speed of the wireless interface, the higher the receiver sensitivity and thereby the range.

Adjust the data transmission speed of the wireless interface to the respective application using the PSI-CONF software (default setting = 125 kbps).

Table 5-2 Data transmission speed of the wireless interface

Data transmission speed	Typical receiver sensitivity	Typical link budget	Potential distance with line of sight and a system reserve of 12 dB
250 kbps	-93 dBm	-112 dBm	1000 m
125 kbps	-96 dBm	-115 dBm	1500 m (default setting)
16 kbps	-106 dBm	-125 dBm	5000 m

You can achieve transmission within the kilometer range using the wireless module if the following conditions are fulfilled:

– Suitable gain antennas are used
– Line of sight
– Adherence to the Fresnel zone

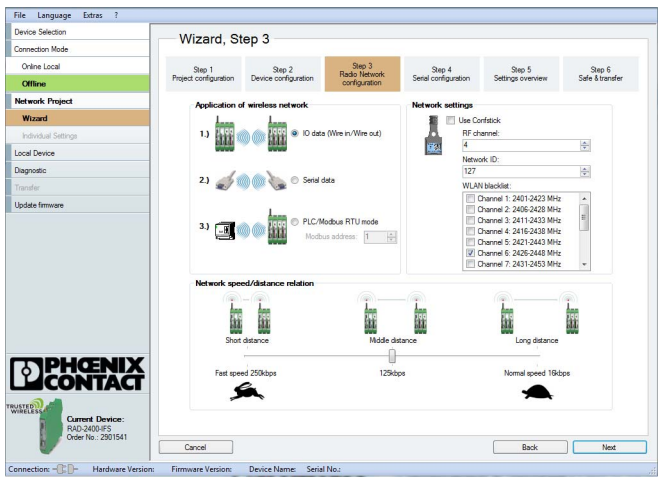


Figure 5-6 PSI-CONF software: Wizard, Step 3

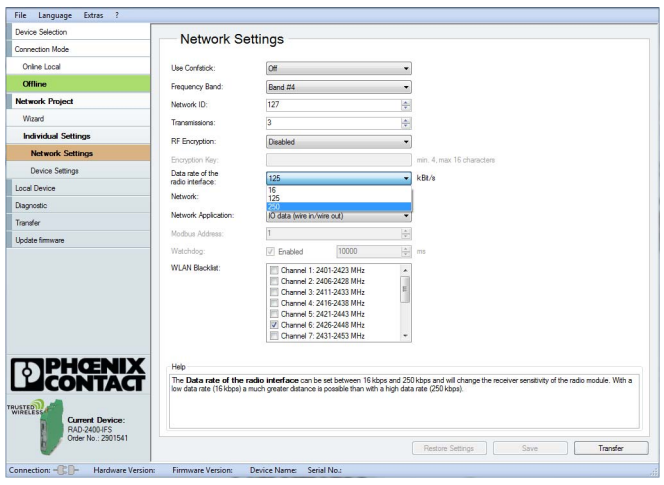


Figure 5-7 PSI-CONF software: Setting the data transmission speed

5.6.3 Device settings

In order to be able to cover the largest possible distances, the preamplifier has been activated and transmission power set to 20 dBm by default. When operating the devices directly next to one another, the receiver might become overloaded. In this case, remove the antennas, increase the distance between the devices and antennas or reduce transmission power using the PSI-CONF software.

You can assign a device name or set the transmission power under “Device Settings”. All device parameters are listed on the “Overview” tab.

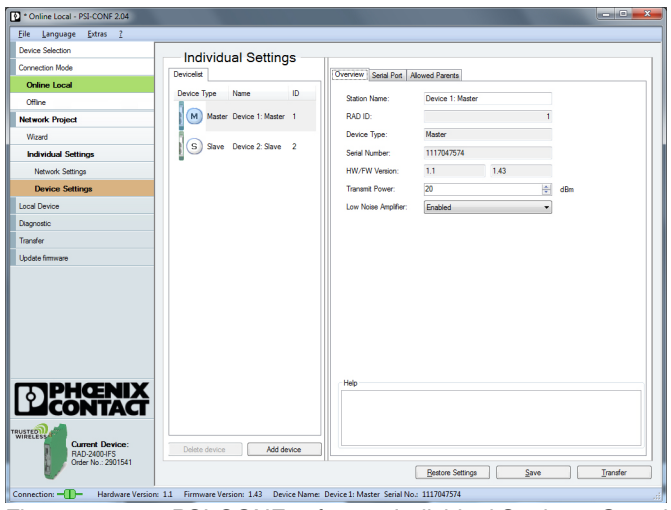


Figure 5-8 PSI-CONF software: Individual Settings, Overview

Depending on the operating mode, you can configure the serial interface under “Individual Settings” on the “Serial Port” tab.

In I/O data mode (default upon delivery), both interfaces are deactivated. To activate the serial interface, select the “Serial data” or “PLC/Modbus RTU mode” network application under “Network Settings”.

You can only use one interface per wireless module. Parallel operation of both interfaces is not possible.

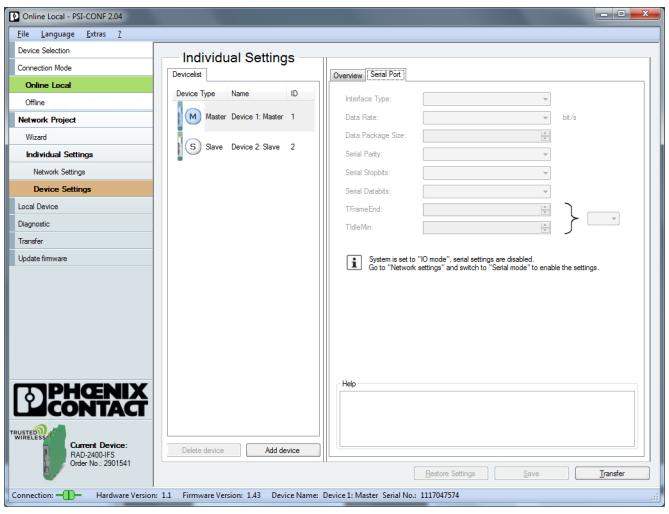


Figure 5-9 PSI-CONF software: Individual Settings, Serial Port

You can define the wireless modules to which a connection may be established on the “Allowed Parents” tab under “Individual Settings”. This setting is required, for example, when creating repeater chains. Repeater chains are used to circumvent obstacles or to set up redundant wireless paths by means of several repeaters.

The “Allowed Parents” tab is only available if the “Line/Mesh” network type has been selected.

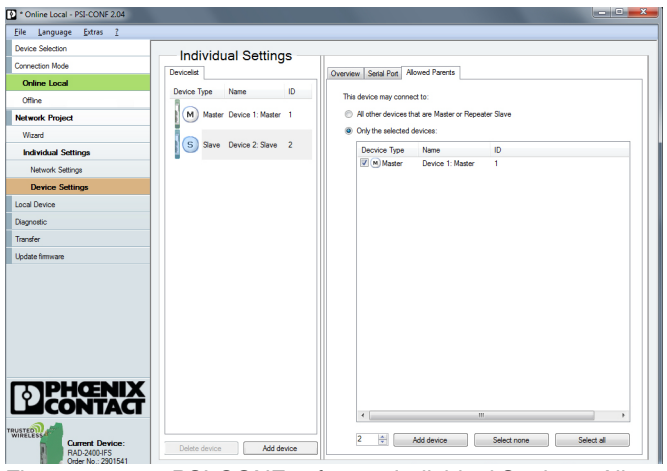


Figure 5-10 PSI-CONF software: Individual Settings, Allowed Parents

5.7 Diagnostics on the wireless module

5.7.1 Diagnostic LEDs

A total of nine LEDs on the wireless module indicate the operating states.

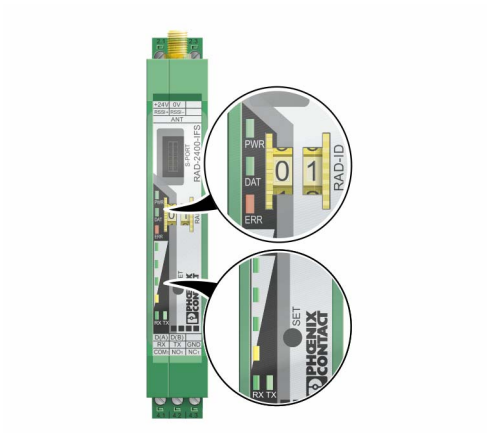


Figure 5-11 Diagnostic LEDs of the RAD-2400-IFS

PWR LED

The green PWR LED indicates the supply voltage status.

OFF	No supply voltage
ON	Supply voltage OK

DAT LED

The green DAT LED indicates the bus communication status.

OFF	No communication
Flashing	Configuration mode
ON	Cyclic data communication

ERR LED

The red ERR LED indicates the error status.

OFF	No error	
Flashing	Slow (1.4 Hz)	**Wireless module in I/O data mode** – Double assignment of I/O-MAP address (e.g., two input modules with the same I/O-MAP address) – Missing input module – Missing output module – RAD ID changed **Wireless module in PLC/Modbus RTU mode** – Double assignment of I/O-MAP address (e.g., two input modules with the same I/O-MAP address) – RAD ID changed – No Modbus communication
	Fast (2.8 Hz)	Wireless connection interrupted
ON	Local bus error (e.g., input or output module not read)	

5.7.2 LED bar graph

The LED bar graph indicates the receive signal strength.

Table 5-3 LED bar graph

Bar graph	LEDs	Receive signal	RSSI voltage
	All LEDs light up	Connection with maximum receive signal	2.5 V ... 3 V
	One yellow and two green LEDs light up	Connection with very good receive signal	2 V ... 2.5 V

Bar graph	LEDs	Receive signal	RSSI voltage
	One yellow and one green LED light up	Connection with good receive signal	1.5 V ... 2 V
	One yellow LED lights up	Connection with weak receive signal	1 V ... 1.5 V
	OFF	Not connected, configuration mode or overload[1]	0 V

1 In order to be able to cover the largest possible distances, the preamplifier has been activated and transmission power set to 20 dBm by default. When operating the devices directly next to one another, the receiver might become overloaded. In this case, remove the antennas, increase the distance between the devices and antennas or reduce transmission power using the PSI-CONF software (from page 40 onwards).

Table 5-4 RSSI voltage (Received Signal Strength Indicator)

		16k	125k	250k	500k	RSSI voltage
LED 3		-70 dBm	-65 dBm	-60 dBm	-55 dBm	≥2.5 V
LED 2		-80 dBm	-75 dBm	-70 dBm	-65 dBm	≥2.0 V
LED 1		-90 dBm	-85 dBm	-80 dBm	-75 dBm	≥1.5 V
LINK LED		LINK	LINK	LINK	LINK	~1.0 V

LED bar graph - light sequence

The light sequence from bottom to top signalizes:

– Firmware update or
– Wireless module is in write mode for the memory stick

TX LED, transmit data

The green TX LED indicates communication with the RS-232/RS-485 interface. The wireless module is transmitting data.

RX LED, receive data

The green RX LED indicates communication with the RS-232/RS-485 interface. The wireless module is receiving data.

SET button

You can confirm a station change with the SET button, without performing a power up. Station changes include:

– Changing the RAD ID address of the wireless module
– Changing the I/O-MAP address of the extension module
– Adding or remove an I/O extension module
– Using a CONFSTICK or memory stick

After making any change, press the SET button for at least one second to apply the settings. The DAT LED starts flashing. Read in has been completed when the DAT LED stops flashing.

RF link relay

The RF link relay in the wireless module diagnoses the state of the wireless connection. The relay picks up when the wireless connection is established. If the wireless module does not receive a data packet correctly over a period of 10 seconds, the relay drops out. The relay picks up again automatically when the wireless connection is re-established.

The RF link relay has been designed as a PDT contact.

The RF link relay can be used as a fault message contact to indicate the failure of the wireless connection to the controller.

RSSI test socket

A voltage measuring device can be connected to the RSSI test socket to measure the RSSI voltage between 0 V ... 3 V. You can use the table on page 47 to determine the received signal strength via the measured voltage. Please observe the small voltage fluctuation due to multipath propagation.

The RSSI voltage depends on the data rate set for the wireless interface. The higher the RSSI voltage, the better the wireless connection.

For example, the RSSI voltage may be helpful when positioning and aligning the antenna. The recommended minimum signal strength is 2.0 V DC. This results in a power reserve of approximately 10 dB which ensures communication even in the event of unfavorable transmission conditions.

RSSI LED bar graph

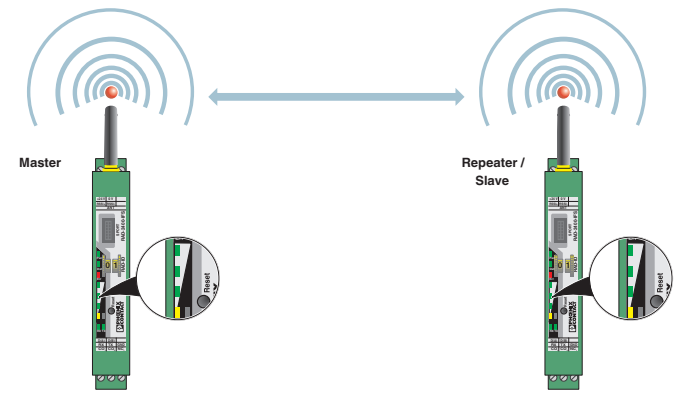


Figure 5-12 Bar graph for point-to-point connection

In a point-to-point connection with only two wireless modules, the LED bar graph is active on both the master and repeater/slave.

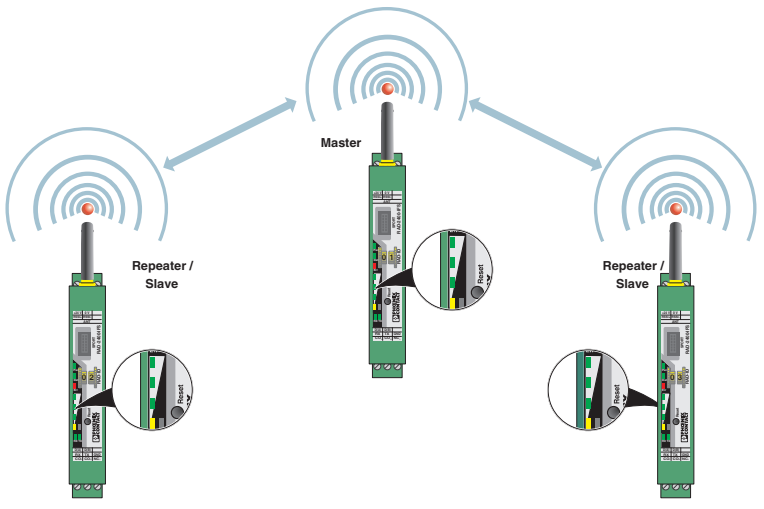


Figure 5-13 Bar graph for point-to-multipoint connection

In a wireless network with more than one repeater/slave, only the yellow LED on the master is permanently on. The signal strength is displayed on the repeaters/slaves. The signal strength indicated is always that of the next wireless module in the direction of the master (parents).

You can read the RSSI values via the serial interface of the master wireless module using Modbus RTU commands (see Section “RSSI signal register” on page 85).

5.8 Diagnostics via PSI-CONF software

You can display all current device settings for the station under “Diagnostic” on the “Overview” tab.

- Select the desired station from the device list.

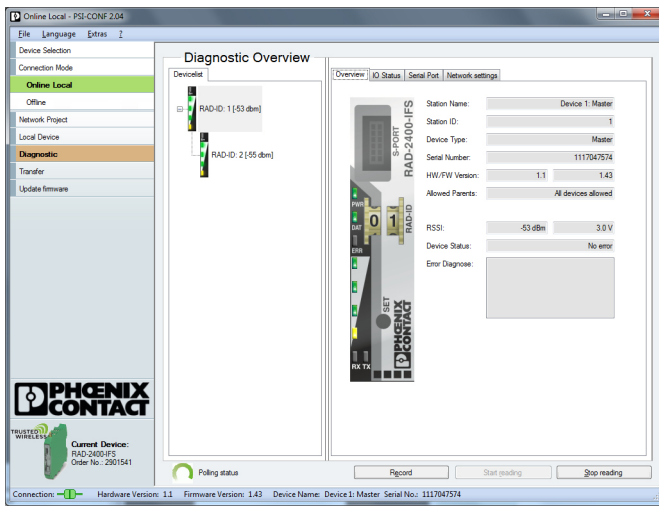


Figure 5-14 PSI-CONF software: Diagnostic, Overview

> The entire wireless network can be diagnosed using the master wireless module (RAD ID = 01).
>
> When operating the network in serial data mode, it may not be possible to diagnose all devices. In this case, stop the serial application in order to allow for complete diagnostics.
>
> For information on troubleshooting, please refer to Section “Detecting and removing errors” on page 147.

If an error occurs in the network, an error message is displayed under “Device Status”. If the error is no longer present, the error message is reset.

Possible error message:

– Missing input module
– Missing output module
– Double assignment of I/O-MAP address
– Error on IFS bus
– Wireless connection interrupted
– RAD ID changed
– CONFSTICK has not yet been inserted

The “I/O Status” tab displays the status and the current values of the connected I/O extension modules.

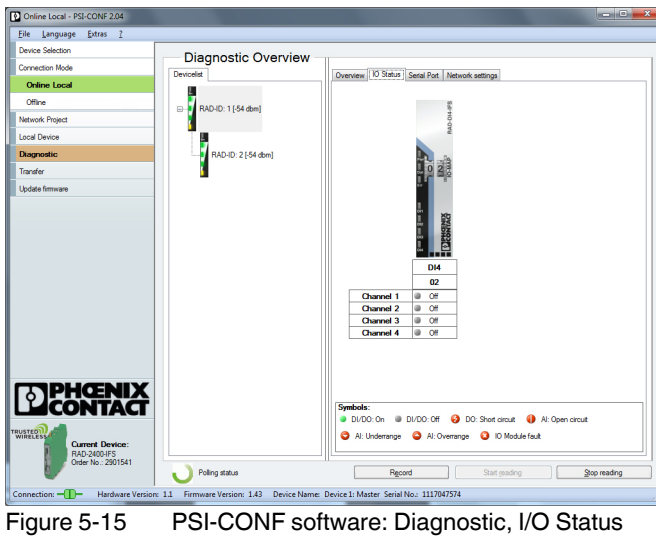


Figure 5-15 PSI-CONF software: Diagnostic, I/O Status

The “Serial Port” tab indicates the currently set parameters of the RS-232/RS-485 interface.

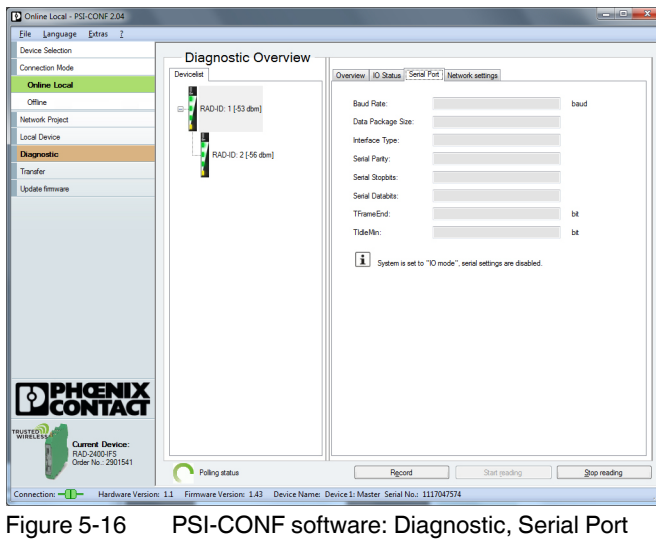


Figure 5-16 PSI-CONF software: Diagnostic, Serial Port

The “Network Settings” tab shows the currently set network parameters as well as the settings of the CONFSTICK, if used.

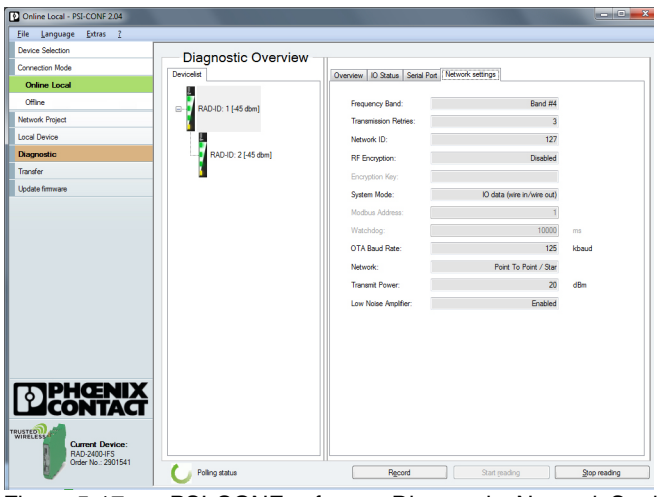


Figure 5-17 PSI-CONF software: Diagnostic, Network Settings

5.8.1 Recording parameters

The following parameters can be recorded using the PSI-CONF software:

– Signal strength
– Network structure
– Status and current values of the connected extension modules

- Click “Record” under “Diagnostic”.
- Select “Network diagnostics” or “I/O diagnostics” under “Select the type of data to record”.
- Under “Recording interval”, you can specify how often the values should be recorded.
- **For network diagnostics:** Activate “Record signal strength” or “Record network structures”.
  For I/O diagnostics: Select the desired stations.
- Select a storage location and click on “Start Recording”.

Diagnostic data is now written to a CSV file which can be opened, for example, with Excel.

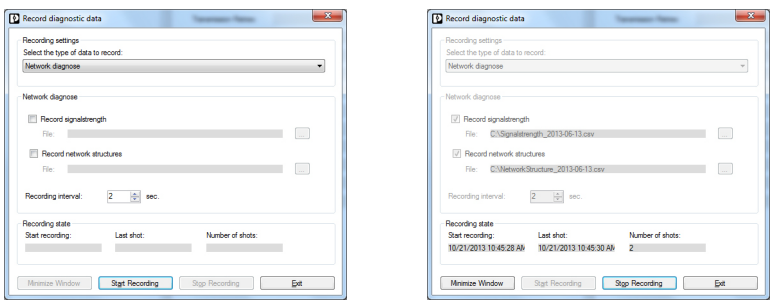


Figure 5-18 PSI-CONF software: Record diagnostic data, Network diagnostics

5.9 Starting up I/O extension modules

5.9.1 Combinations of extension modules

Several appropriate output modules at different stations can be assigned to one digital or analog input module. The inputs are transmitted in parallel to the outputs. The channels of the input module are mirrored to the channels of the output module.

It is **not** possible to separately assign the individual input channels of an extension module to different output modules.

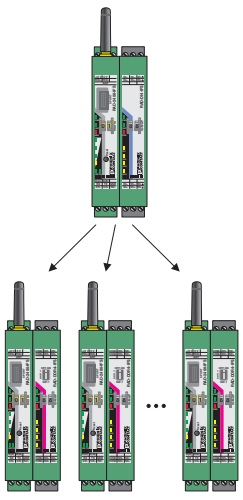


Figure 5-19 Assignment of digital inputs and digital outputs

The combined RAD-DAIO6-IFS extension modules can only be assigned in pairs, because each module is provided with inputs and outputs. That is why only two modules in the network may have the same I/O MAP address.

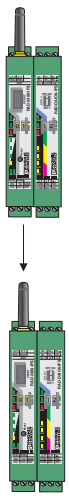


Figure 5-20 RAD-DAIO6-IFS assignment: analog/digital inputs and outputs

Table 5-5 Assignment of input and output modules

Input module		Output module	
2901537	RAD-AI4-IFS	2901538	RAD-AO4-IFS
2904035	RAD-PT100-4-IFS	2901538	RAD-AO4-IFS
2901535	RAD-DI4-IFS	2901536	RAD-DOR4-IFS
2901539	RAD-DI8-IFS	2902811	RAD-DO8-IFS
2901533	RAD-DAIO6-IFS	2901533	RAD-DAIO6-IFS

5.9.2 Setting the address of the extension modules via the thumbwheel

For an I/O-to-I/O transmission of signals, you must assign a corresponding output module to the input module. Set the I/O-MAP address (01 ... 99) using the white thumbwheel on the I/O extension module.

Addressing extension modules

- Use the thumbwheel to set the address.
- Press the SET button on the front of the wireless module to read the current configuration.

The following settings can be made using the white thumbwheel:

Thumbwheel setting	Description
01 ... 99	I/O-MAP address
00	Delivery state
**, 1* ... 9*	Setting not permitted
*1 ... *9	Interface System slave address, for use with other Interface System (IFS) master devices

The following conditions must be met:

– You can assign a maximum of 1 ... 99 addresses to the extension modules in the entire wireless network.

Wireless module in I/O data mode

– The input module **must** be provided with the same I/O-MAP address as the assigned output module at the other wireless station (I/O mapping). Output modules with the same I/O-MAP address may appear several times in the network at different stations.
– The I/O-MAP address of an input module may only appear once in the network.
– The channels of the input module are directly assigned to the channels of the output module:

Input module		Output module
Channel 1	→	Channel 1
Channel 2	→	Channel 2
...	→	...

It is **not** possible to individually assign the channels of the input and output modules.

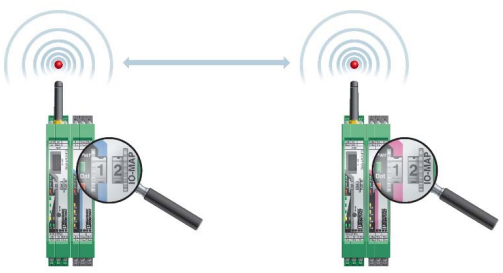


Figure 5-21 Input module and output module with the same address

Wireless module in PLC/Modbus RTU mode

– Output modules **may not have** the same I/O-MAP address as input modules. Exception: Output modules with the same I/O-MAP address may appear several times in the network at different stations.
– The I/O-MAP address of an input module may only appear once in the network.
– The input and output data is saved in a Modbus memory map in the master wireless module. You can read or write the process data via the serial interface of the master wireless module (RAD ID = 01) using the Modbus RTU command. The process data tables can be found starting on page 72.

5.10 Startup time of the wireless station

Once a wireless station has been started up (power “ON”), the wireless module will take 15 seconds to be ready for operation. Each linked I/O extension module increases the startup time by 3 seconds.

Startup time of a wireless station =
15 seconds + (number of I/O modules x 3 seconds)

Accordingly, a complete wireless station with 32 I/O extension modules requires a startup time of 111 seconds. Only after this period of time has elapsed is the wireless station ready for operation.

6 Serial data mode

In serial data mode, multiple controllers or serial I/O devices are networked quickly and easily using wireless technology. In this way, serial RS-232 or RS-485 cables can be replaced.

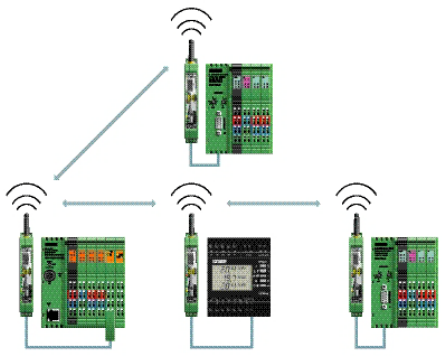


Figure 6-1 Serial data mode

You can configure the serial interface of the RAD-2400-IFS wireless module using the PSI-CONF software. In order to connect the wireless module to the PC, you need the RAD-CABLE-USB cable (Order No. 2903447).

WARNING: Explosion hazard when used in potentially explosive areas

The USB cable must **not** be used in potentially explosive areas.

When operating the network in serial data mode, it may not be possible to diagnose all devices. In this case, stop the serial application in order to allow for complete diagnostics.

Using the PSI-CONF software, you can assign different serial settings to the devices under “Individual Settings”.

- Start the PSI-CONF software.
- Follow the software wizard.
- Once you have run through all steps of the wizard, you can save the project and transmit it to the wireless modules.

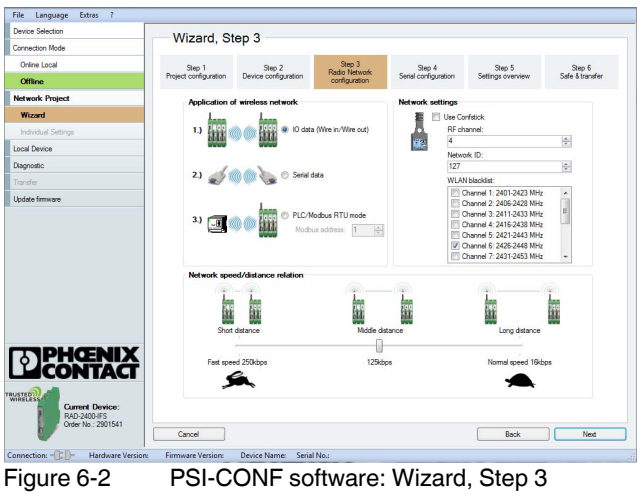


Figure 6-2 PSI-CONF software: Wizard, Step 3

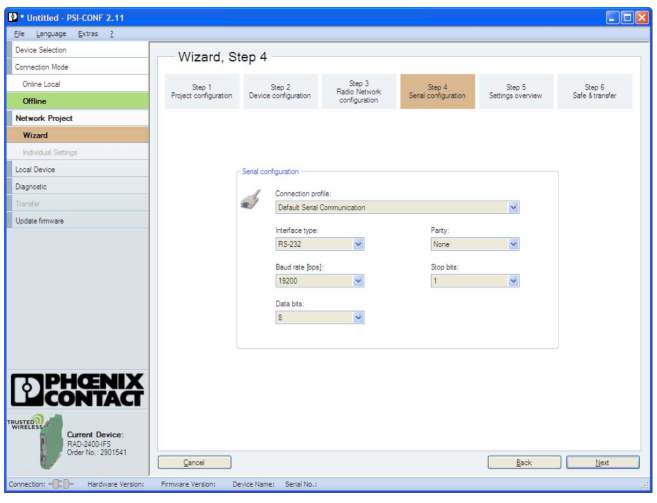


Figure 6-3 PSI-CONF software: Wizard, Step 4

6.1 Frame-based data transmission

$T_{IdleMin}$ parameter (minimum pause between two frames)

The $T_{IdleMin}$ parameter refers to the minimum pause that must elapse between two frames on the output side (wireless module is transmitting data via serial interface).

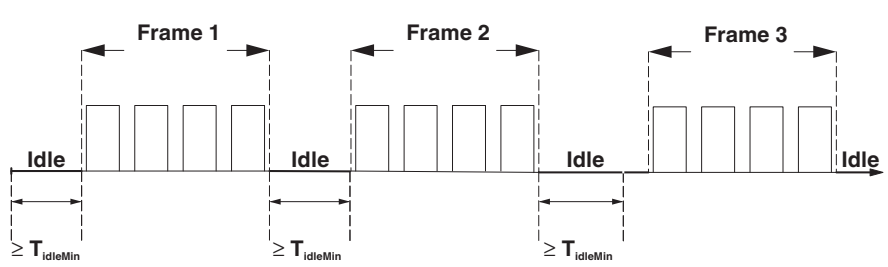


Figure 6-4 Frame-based data transmission: $T_{IdleMin}$ parameter

$T_{FrameEnd}$ parameter

$T_{FrameEnd}$ is the time which is kept by the transmitting wireless module between two frames.

If the data received by the wireless module is followed by a certain period of time where no further data is received, the wireless module assumes that the frame has arrived in its entirety. The frame is then transmitted. This period of time is referred to as $T_{FrameEnd}$.

$T_{FrameEnd}$ must be shorter than the minimum interval between two frames ($T_{FrameEnd} < T_{IdleMin}$). $T_{FrameEnd}$ must, however, also be greater than the maximum interval that is permitted between two characters in a frame. Otherwise the frame might be fragmented.

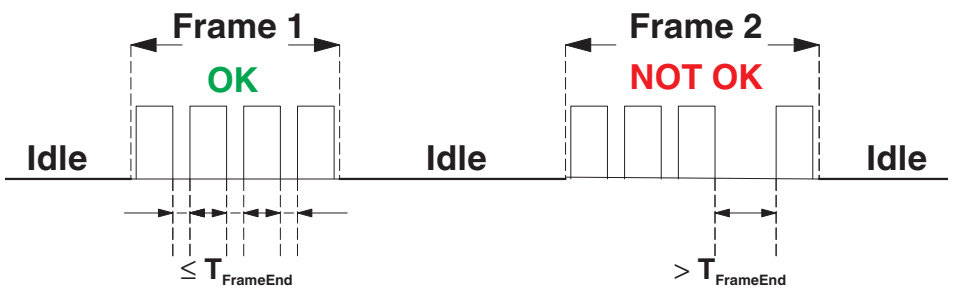


Figure 6-5 Frame-based data transmission: $T_{FrameEnd}$ parameter

Setting telegram pauses, based on the example of Modbus/RTU

A frame is also referred to as a telegram. The length of the transmission pause between the telegrams depends on the set data rate. The beginning and end of a telegram is recognized by means of a time condition. A pause of 3.5 characters means that the telegram is complete and the next character is to be interpreted as the slave address. A telegram must therefore be sent as a continuous data flow. If there is an interruption of more than 1.5 characters within a telegram, the data will be discarded by the receiver.

If the master is not able to transmit the successive characters quickly enough and the communication is aborted, you must increase the minimum pause time ($T_{FrameEnd}$) between the individual characters of a telegram. Frames with a length of 1480 characters can be transmitted by the Radioline wireless system.

- In order to adapt data transmission to other protocols, it is possible to adapt the $T_{FrameEnd}$ and $T_{IdleMin}$ parameters. Set the interface parameters under “Individual Settings”.

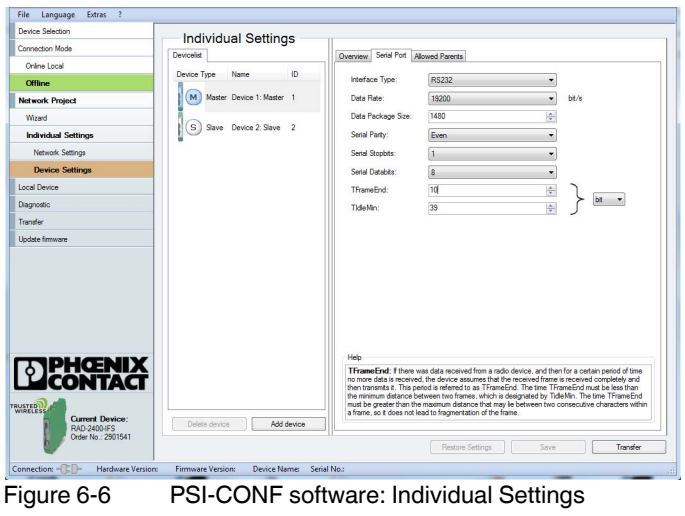


Figure 6-6 PSI-CONF software: Individual Settings

7 PLC/Modbus RTU mode

The PLC/Modbus RTU mode is available for firmware version 1.30 or later. If necessary, start an update using the PSI-CONF software (version 2.03 or later).

Activate the PLC/Modbus RTU mode using the PSI-CONF software (from page 40 onwards).

In PLC/Modbus RTU mode, you can wirelessly connect I/O extension modules directly to a controller (I/O to serial). The wireless module provides an RS-232 or RS-485 interface for this purpose. In PLC/Modbus RTU mode, the master wireless module works as a Modbus slave and has its own Modbus slave address.

You can connect I/O extension modules to each wireless device in the network. A wireless network can have a maximum of 99 extension modules. Use the white thumbwheel to set the I/O-MAP addresses.

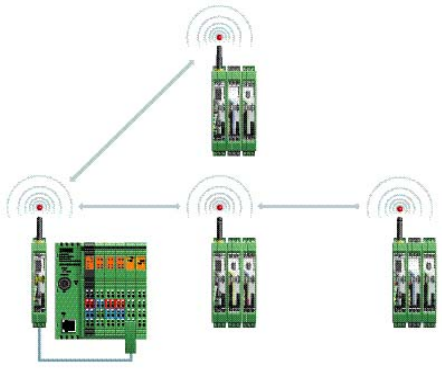


Figure 7-1 PLC/Modbus RTU mode

7.1 Configuration via PSI-CONF software

- Start the PSI-CONF software (see page 40).
- Create a new network project.
- Follow the software wizard.

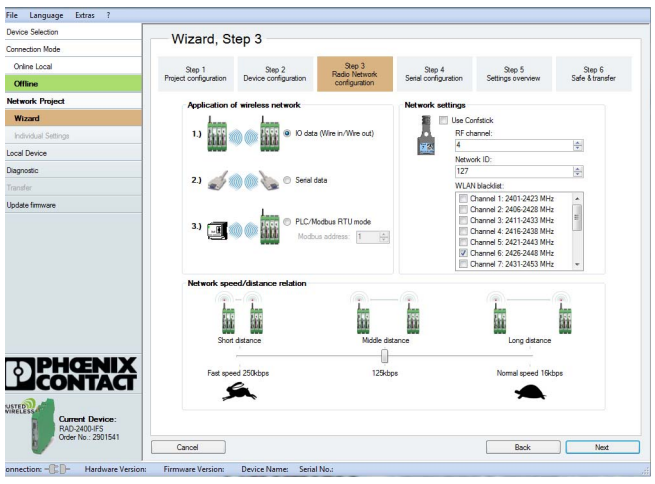


Figure 7-2 PSI-CONF software: Wizard, Step 3

- Select “PLC/Modbus RTU mode” and assign a Modbus address.
- Follow the software wizard.

The Modbus address is a unique address in the Modbus network. It is only assigned to the master wireless module (RAD ID = 01). You can assign an address between 1 ... 247.

In order to enable the master wireless module to communicate with a controller via the RS-232 or RS-485 interface, you are required to set the interface parameters. Please note that the controller settings must match the settings of the wireless module.

Table 7-1 Configuration via PSI-CONF software

Parameter	Possible values	Default setting
Interface type	RS-232, RS-485	RS-232
Data rate	300 ... 115,200 bps	19,200 bps
Parity	None, even, odd	None
Number of stop bits	1; 2	1
Number of data bits	8	8
Modbus address	1 ... 247	1

The Modbus connection between the controller and the wireless module can be monitored via a watchdog. For additional information on the watchdog, refer to page 63.

7.2 Addressing I/O extension modules

In PLC/Modbus RTU mode, a wireless network can have a maximum of 99 I/O extension modules.

- Use the white thumbwheel on the I/O extension module to set the I/O-MAP address. You can find information on addressing extension modules from page 54 onwards.

7.3 Watchdog

The Modbus telegram watchdog monitors the connection between the master wireless module and the controller. It is triggered each time a Modbus telegram is received correctly. You can activate the watchdog using the PSI-CONF software.

- Select the “Network Settings” item under “Individual Settings”. You can set a watchdog time between 200 ms ... 65,000 ms.

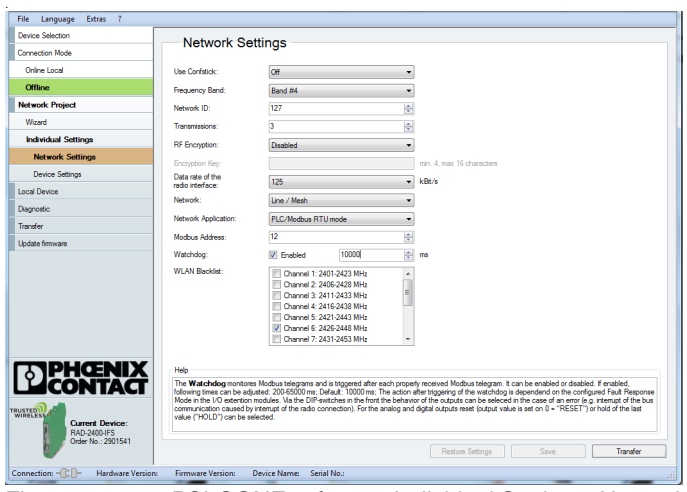


Figure 7-3 PSI-CONF software: Individual Settings, Network Settings

If the watchdog is triggered, an action will be performed on the I/O output modules. You can set this behavior in the event of an error using the DIP switches on the front.

– OFF = RESET: Output value is set to 0
– ON = HOLD: Hold last output value

For more detailed information regarding switch setting for the different extension modules, please refer to Section “Description of I/O extension modules” on page 87.

If the watchdog is activated and Modbus communication interrupted, the red ERR LED will flash on all wireless modules in the network. Depending on the DIP switch settings, the output modules issue the corresponding hold or reset value.

7.4 Modbus function codes

In the Modbus protocol, the function codes define which data is to be read or written. With a single request, the registers 1 ... 123 can be read or written.

Table 7-2 Supported Modbus function codes

Code number	Function code	Description
fc 03	Read Holding Register	Read process output data (address area 40010 ... 40999)
fc 04	Read Input Register	Read process input data (address area 30010 ... 30999)
fc 16	Write Multiple Registers	Write multiple output registers word by word

Other function codes exist in the Modbus protocol, but they are not supported.

7.5 Modbus protocol

The data is transmitted using the Modbus/RTU (Remote Terminal Unit) protocol. Communication takes place according to the master/slave method. The Modbus master initiates communication with a request to the slave. If the slave detects that its address has been accessed by the master, the slave always sends a response.

Only the master is able to initiate communication. The slaves are not able to initiate communication and do not communicate with each other.

The connected extension modules write the analog or digital input and output values to an internal register. The Modbus master (e.g., a PLC) can read the individual registers using the Modbus address of the slaves. The data to be transmitted is always included in a defined frame. The frame is referred to as telegram.

The Modbus protocol defines the format of the telegrams. If an error occurs when the telegram is received on the slave side, or if the slave is unable to carry out the master request, an error telegram is sent back to the master.

Request from master

The function code in the request informs the addressed slave which action is to be carried out. The address and data bytes contain all additional information that the slave requires in order to carry out the action.

Example: The master uses function code 03 to request the slave to read the process output data and send its content to the master. The data and address bytes need to include the following information: from which register reading should start and how many registers should be read. Using the CRC check value, the slave is able to detect whether the complete telegram has been received.

Response from slave

If the response from a slave is valid, the function code will match the request from the master. The address and data field contains the data recorded by the slave (e.g., register values).

The function code is modified in the event of an error. The address and data field then contains a code that describes the error. By using the CRC check value, the master is able to determine whether the telegram content is valid or not.

The Modbus/RTU telegrams are separated by telegram pauses known as end-of-frame times. The end-of-frame time must be at least 3.5 x as long as the time required for one transmitted character. The end-of-frame time cannot be changed.

Table 7-3 Modbus protocol: structure of telegrams (frames)

Frame	Description	Size
Slave address	Slave address, valid area 1 ... 247	8 bits
Function code	Definition whether the parameter is to be read or written	8 bits
Address	Register address	16 bits
Data	– E.g., from the master: Which parameters are requested? – E.g., from the slave: Content of the requested parameters	N x 16 bits
CRC (Cyclic Redundancy Check)	Test value for the cyclic redundancy check in order to detect errors in data transmission	16 bits

7.6 Examples for reading and writing registers

Function code fc 03

Table 7-4 Function code fc 03 - Read Holding Register

Request		
Function code	1 byte	03_{hex}
Start address	2 bytes	0000 hex ... FFFF hex
Number of registers	2 bytes	1 ... 125 (7D hex)

Response		
Function code	1 byte	03_{hex}
Number of bytes	1 byte	2 x N[1]
Register values	N[1] x 2 bytes	

1 N = Number of registers

Error		
Error code	1 byte	83_{hex}
Exception code	1 byte	01 or 02 or 03 or 04

Request to read analog outputs

The following example shows a request to read the analog outputs of three RAD-AO4-IFS I/O extension modules with the I/O-MAP addresses:

– 03 → Modbus register address 40030 ... 40039
– 04 → Modbus register address 40040 ... 40049
– 05 → Modbus register address 40050 ... 40055

Table 7-5 Example: Request to read analog outputs

Request		
Field name	**hex**	**dec**
Function code	03	0003
Start address (high byte)	00	0000
Start address (low byte)	1D	0029
Number of registers (high byte)	00	0000
Number of registers (low byte)	1A	0026

Response		
Field name	**hex**	**dec**
Function code	03	0003
Number of bytes	34	52
Register value 40030 (high byte)	00	0000
Register value 40030 (low byte)	00	0000
Number of registers (low byte)	02	0002
...		
Register value 40032 (high byte)	75	0003
Register value 40032 (low byte)	30	0000
...		
Register value 40042 (high byte)	00	0000
Register value 40042 (low byte)	01	0001
...		
Register value 40052 (high byte)	3A	0001
Register value 40052 (low byte)	98	5000
...		

Function code fc 04

Table 7-6 Function code fc 04 - Read Input Register

Request		
Function code	1 byte	04_{hex}
Start address	2 bytes	0000 hex ... FFFFhex
Number of registers	2 bytes	1 ... 125 (7D hex)

Response		
Function code	1 byte	04_{hex}
Number of bytes	1 byte	2 x N[1]
Register values	N[1] x 2 bytes	

1 N = Number of registers

Error		
Error code	1 byte	84_{hex}
Exception code	1 byte	01 or 02 or 03 or 04

Request to read digital inputs

The following example shows a request to read the digital inputs of an RAD-DI4-IFS I/O extension module with I/O-MAP address 02 (30020 ... 30021):

Table 7-7 Example: Request to read digital inputs

Request		
Field name	**hex**	**dec**
Function code	04	0004
Start address (high byte)	00	0000
Start address (low byte)	13	0019
Number of registers (high byte)	00	0000
Number of registers (low byte)	02	0002

Response		
Field name	**hex**	**dec**
Function code	04	0004
Number of bytes	04	0004
Register value 30020 (high byte)	00	0000
Register value 30020 (low byte)	03	0003
Register value 30021 (high byte)	00	0000
Register value 30021 (low byte)	0F	0015

Function code fc 16

Table 7-8 Function code fc 16 - Write Multiple Registers

Request		
Function code	1 byte	10_{hex}
Start address	2 bytes	0000 hex ... FFFFhex
Number of registers	2 bytes	1 ... 123 (7B hex)
Number of bytes	1 byte	2 x N[1]
Register values	N[1] x 2 bytes	

[1] N = Number of registers

Response		
Function code	1 byte	10_{hex}
Start address	2 bytes	0000 hex ... FFFFhex
Number of registers	2 bytes	1 ... 123 (7B hex)

Error		
Error code	1 byte	90_{hex}
Exception code	1 byte	01 or 02 or 03 or 04

Request to write digital outputs

The following example shows a request to write the digital outputs of an RAD-DOR4-IFS I/O extension module with the I/O-MAP addresses:

– 02 → Modbus register address 40020 ... 40029
– 03 → Modbus register address 40030 ... 40035

Table 7-9 Example: Request to write digital outputs

Request		
Field name	**hex**	**dec**
Function	10	0016
Start address (high byte)	00	0000
Start address (low byte)	13	0019
Number of registers (high byte)	00	0000
Number of registers (low byte)	10	0016
Number of bytes	20	0032
Register value 40020 (high byte)	00	0000
Register value 40020 (low byte)	00	0000
Register value 40021 (high byte)	00	0000
Register value 40021 (low byte)	0F	0015
...		
Register value 40030 (high byte)	00	0000
Register value 40030 (low byte)	00	0000
Register value 40031 (high byte)	00	0000
Register value 40031 (low byte)	0C	0012

Response		
Field name	**hex**	**dec**
Function	10	0010
Start address (high byte)	00	0000
Start address (low byte)	13	0019
Number of registers (high byte)	00	0000
Number of registers (low byte)	10	0016

7.6.1 Addressing registers

Function code 04

You must enter 0000 (hex0000) as the start address in order to read register 30001. The address area 3xxxx is already defined by the function code field.

Function codes 03 and 16

In order to read/write registers 40032 ... 40039, you must enter 0031 (hex001F) as the start address. The address area 4xxxx is already defined by the function code field.

7.7 Module type and error code register

You can read the module type and data currentness of the I/O extension modules from the registers 30xx0 and 40xx0.

Table 7-10 Module type and currentness of data

30xx0, 40xx0[1]							Module type and currentness of data								
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
							X[2]	Module type							

1 xx = I/O-MAP address set using the thumbwheel

2 X = Currentness of data, bit 8

The individual I/O extension modules can be clearly distinguished by the module type. The module type ID of the extension module can be read in the Modbus register.

Table 7-11 Module type IDs

Module type	Order No.	Module type ID
Analog inputs		
RAD-AI4-IFS	2901537	20_{hex}
RAD-PT100-4-IFS	2904035	21_{hex}
Analog outputs		
RAD-AO4-IFS	2901538	30_{hex}
Digital inputs		
RAD-DI4-IFS	2901535	01_{hex}
RAD-DI8-IFS	2901539	02_{hex} (static mode) 40_{hex} (pulse counter mode)
Digital outputs		
RAD-DOR4-IFS	2901536	10_{hex}
RAD-DO8-IFS	2902811	11_{hex}
Analog/digital inputs and outputs		
RAD-DAIO6-IFS	2901533	60_{hex}

“Module type” register value

If the module type in the register is invalid or unavailable, then the register value is 0.

“Currentness of data” register value

If the data in the register is not up-to-date, the register value is 1. This is, for example, the case if the wireless connection to an input module fails. The input process data is then retained in the Modbus table, but is no longer updated. In the case of an output module, the “Currentness of data” register value is set to 1 until the output process data has been written to the Modbus registers.

The read I/O data is only valid and current if a valid module type value is returned by the slave and the “Currentness of data” register value equals 0.

7.7.1 Assigning I/O extension modules to the register

Use the white thumbwheel on the I/O extension module to assign an I/O-MAP address in the Modbus memory map. Example: If you set the thumbwheel of an input module to the I/O-MAP address = 01, the register assignment is 30010.

Table 7-12 Setting the white thumbwheel for register 30010 (read)

Read register	I/O-MAP address (white thumbwheel)	Consecutive number 0 ... 9
30	**01**	**0**

7.8 Modbus memory map

The I/O data from the extension modules is stored in an internal register, the Modbus memory map. The Modbus memory map is contained in the master wireless module with the RAD ID = 01. The data contained here can be read or written by a Modbus master.

The following process data tables for the individual extension modules show at what position the I/O data is stored in the Modbus memory map. You can find a complete overview of the Modbus memory map from page 81 onwards.

The RSSI signal register can be found starting on page 85.

7.8.1 RAD-AI4-IFS process data

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-AI4-IFS	20_{hex}	06_{hex}	30xx0 ... 30xx5[1]	fc 04

[1] xx = I/O-MAP address set using the thumbwheel

30xx1	Reserved

30xx2	Analog input 1 (terminal point 2.x)															
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
AI1															

30xx3	Analog input 2 (terminal point 3.x)															
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
AI2															

30xx4	Analog input 3 (terminal point 4.x)															
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
AI3															

30xx5	Analog input 4 (terminal point 5.x)															
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
AI4															

30xx6 ... 30xx9	Reserved

7.8.2 RAD-PT100-4-IFS process data

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-PT100-4-IFS	21_{hex}	06_{hex}	30xx0 ... 30xx5[1]	fc 04

[1] xx = I/O-MAP address set using the thumbwheel

30xx1	Reserved

30xx2	Pt 100 input 1 (terminal point 2.x)															
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
T1															

30xx3	Pt 100 input 2 (terminal point 3.x)															
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
T2															

30xx4	Pt 100 input 3 (terminal point 4.x)															
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
T3															

30xx5	Pt 100 input 4 (terminal point 5.x)															
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
T4															

30xx6 ... 30xx9	Reserved

7.8.3 RAD-AO4-IFS process data

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-AO4-IFS	30_{hex}	06_{hex}	40xx0 ... 40xx5[1]	fc 03, 16

[1] xx = I/O-MAP address set using the thumbwheel

40xx1	Reserved

40xx2	Analog output 1 (terminal point 2.x)															
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
AO1															

40xx3	Analog output 2 (terminal point 3.x)															
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
AO2															

40xx4	Analog output 3 (terminal point 4.x)															
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
AO3															

40xx5	Analog output 4 (terminal point 5.x)															
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
AO4															

40xx6 ... 40xx9	Reserved

7.8.4 RAD-DI4-IFS process data

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-DI4-IFS	01_{hex}	02_{hex}	30xx0 ... 30xx1[1]	fc 04

[1] xx = I/O-MAP address set using the thumbwheel

30xx1								Digital inputs							
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
												DI4	DI3	DI2	DI1
Terminal point															
												6.x	5.x	2.x	1.x

30xx2 ... 30xx9	Reserved

7.8.5 RAD-DI8-IFS process data

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-DI8-IFS	02_{hex} Static mode	02_{hex} Static inputs	30xx0 ... 30xx1[1]	fc 04
	40_{hex} Pulse counter mode	06_{hex} Pulse inputs	30xx0 ... 30xx5[1]	fc 04
	40_{hex} Pulse counter mode	02_{hex} Reset counter states	40xx0 ... 40xx1[1]	fc 03, 16

[1] xx = I/O-MAP address set using the thumbwheel

30xx1								Digital inputs DI1 ... DI8 (static mode)							
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
								DI8	DI7	DI6	DI5	DI4	DI3	DI2	DI1
Terminal point															
								5.x	5.x	4.x	4.x	3.x	3.x	2.x	2.x

30xx2								DI1: 32-bit pulse input, pulse counter mode (terminal point 2.x)							
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Counter state DI1, low word															

30xx3								DI1: 32-bit pulse input, pulse counter mode (terminal point 2.x)							
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Counter state DI1, high word															

30xx4								DI7: 32-bit pulse input, pulse counter mode (terminal point 5.x)							
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Counter state DI7, low word															

30xx5								DI7: 32-bit pulse input, pulse counter mode (terminal point 5.x)							
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Counter state DI7, high word															

30xx6 ... 30xx9	Reserved

40xx1								Reset of counter states DI1/DI7							
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
														X[1]	X[2]

1 **Bit 1 = 1:** counter state DI7 reset to 0

2 **Bit 0 = 1:** counter state DI1 reset to 0

40xx2 ... 40xx9	Reserved

7.8.6 RAD-DOR4-IFS process data

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-DOR4-IFS	10_{hex}	02_{hex}	40xx0 ... 40xx1[1]	fc 03, 16

[1] xx = I/O-MAP address set using the thumbwheel

40xx1				**Digital outputs**											
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
												DO 4	DO 3	DO 2	DO 1
Terminal point															
												6.x	5.x	2.x	1.x

40xx2 ... 40xx9	**Reserved**

7.8.7 RAD-DO8-IFS process data

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-DO8-IFS	11_{hex}	02_{hex} Outputs	40xx0 ... 40xx1[1]	fc 03.16
		02_{hex} Short-circuit detection	30xx0 ... 30xx1[1]	fc 04

1 xx = I/O-MAP address set using the thumbwheel

30xx1	Short-circuit detection at the digital outputs															
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Reserved														X[1]	X[2]

1 **Bit 1 = 1:** Short circuit detected at one or several outputs 5 ... 8.

2 **Bit 0 = 1:** Short circuit detected at one or several outputs 1 ... 4.

30xx2 ... 30xx9	Reserved

40xx1	Digital outputs DO1 ... DO8															
Channel (high byte)								Channel (low byte)							
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Reserved								DO 8	DO 7	DO 6	DO 5	DO 4	DO 3	DO 2	DO 2
Terminal point															
								5.x	5.x	4.x	4.x	3.x	3.x	2.x	2.x

40xx2 ... 40xx9	Reserved

7.8.8 RAD-DAIO6-IFS process data

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-DAIO6-IFS	60_{hex}	03_{hex} (inputs)	30xx0 ... 30xx2[1]	fc 04
		03_{hex} (outputs)	40xx0 ... 40xx2[1]	fc 03, 16

[1] xx = I/O-MAP address set using the thumbwheel

30xx1	Digital inputs														
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
														DI2	DI1
Terminal point															
														2.x	1.x

30xx2	Analog input (terminal point 3.x)														
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
AI1															

30xx3 ... 30xx9	Reserved

40xx1	Digital outputs														
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
														DO 2	DO 1
Terminal point															
														6.x	5.x

40xx2	Analog output (terminal point 4.x)														
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
AO1															
Terminal point															
															4.x

40xx3 ... 40xx9	Reserved

7.8.9 Complete overview of the Modbus memory map

I/O input data, address area 30010 ... 30999, Modbus function code 04

RAD-DAIO6-IFS

	I/O-MAP		High byte 15 ... 8	Low byte 7 ... 0
30	xx	0	Currentness of data	Module type ID
			X X X X X X X X	X X X X X X X X
30	xx	1		DI 2 1
				X X
30	xx	2	AI1	
			X X X X X X X X X X X X X X X X	

30xx3 ... 30xx9 reserved

I/O output data, address area 40010 ... 40999 Modbus function code 03, 16

RAD-DAIO6-IFS

	I/O-MAP		High byte 15 ... 8	Low byte 7 ... 0
40	xx	0	Currentness of data	Module type ID
			X X X X X X X X	X X X X X X X X
40	xx	1		DO 2 1
				X X
40	xx	2	AO1	
			X X X X X X X X X X X X X X X X	

40xx3 ... 40xx9 reserved

RAD-DI4-IFS

	I/O-MAP		High byte 15 ... 8	Low byte 7 ... 0
30	xx	0	Currentness of data	Module type ID
			X X X X X X X X	X X X X X X X X
30	xx	1		DI4 ... DI1
				X X X X

30xx2 ... 30xx9 reserved

RAD-DOR4-IFS

	I/O-MAP		High byte 15 ... 8	Low byte 7 ... 0
40	xx	0	Currentness of data	Module type ID
			X X X X X X X X	X X X X X X X X
40	xx	1		DO4 ... DO1
				X X X X

40xx2 ... 40xx9 reserved

RAD-DI8-IFS

	I/O-MAP		High byte 15 ... 8	Low byte 7 ... 0
30	xx	0	Currentness of data	Module type ID
			X X X X X X X X	X X X X X X X X
30	xx	1		DI8 ... DI1
				X X X X X X X X
30	xx	2	Counter state DI1 (low word)	
			X X X X X X X X X X X X X X X X	
30	xx	3	Counter state DI1 (high word)	
			X X X X X X X X X X X X X X X X	
30	xx	4	Counter state DI7 (low word)	
			X X X X X X X X X X X X X X X X	
30	xx	5	Counter state DI7 (high word)	
			X X X X X X X X X X X X X X X X	

30xx6 ... 30xx9 reserved

RAD-DI8-IFS

	I/O-MAP		High byte 15 ... 8	Low byte 7 ... 0
40	xx	0	Currentness of data	Module type ID
			X X X X X X X X	X X X X X X X X
40	xx	1	Bit 0 = 1: Reset DI1 Bit 1 = 1: Reset DI7	
				X X

40xx2 ... 40xx9 reserved

I/O input data, address area 30010 ... 30999 Modbus function code 04																	
RAD-DO8-IFS																	
	I/O-MAP		High byte 15 ... 8								Low byte 7 ... 0							
30	xx	0	Currentness of data								Module type ID							
										X	X	X	X	X	X	X	X	X
30	xx	1	Short-circuit detection Bit 0: DO 1 ... 4, Bit 1: 5 ... 8															
																	X	X
30xx2 ... 30xx9 reserved																		

I/O output data, address area 40010 ... 40999 Modbus function code 03, 16																	
RAD-DO8-IFS																	
	I/O-MAP		High byte 15 ... 8								Low byte 7 ... 0							
40	xx	0	Currentness of data								Module type ID							
										X	X	X	X	X	X	X	X	X
40	xx	1									DO							
											9	8	7	6	5	4	3	2	1
										X	X	X	X	X	X	X	X	X
40xx2 ... 40xx9 reserved																		

RAD-AI4-IFS																	
	I/O-MAP		High byte 15 ... 8								Low byte 7 ... 0							
30	xx	0	Currentness of data								Module type ID							
										X	X	X	X	X	X	X	X	X
30	xx	1	Reserved															
30	xx	2	AI1															
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
30	xx	3	AI2															
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
30	xx	4	AI3															
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
30	xx	5	AI4															
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
30xx6 ... 30xx9 reserved																		

RAD-AO4-IFS																	
	I/O-MAP		High byte 15 ... 8								Low byte 7 ... 0							
40	xx	0	Currentness of data								Module type ID							
										X	X	X	X	X	X	X	X	X
40	xx	1	Reserved															
40	xx	2	AO1															
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
40	xx	3	AO2															
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
40	xx	4	AO3															
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
40	xx	5	AO4															
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
40xx6 ... 40xx9 reserved																		

I/O input data, address area 30010 ... 30999 Modbus function code 04																				
RAD-PT100-4-IFS																				
	I/O-MAP		High byte 15 ... 8								Low byte 7 ... 0									
30	xx	0	Currentness of data								Module type ID									
										X	X	X	X	X	X	X	X	X		
30	xx	1	Reserved																	
30	xx	2	T1																	
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
30	xx	3	T2																	
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
30	xx	4	T3																	
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
30	xx	5	T4																	
			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
30xx6 ... 30xx9 reserved																				

I/O output data, address area 40010 ... 40999 Modbus function code 03, 16

Example for reading the temperature T1 (I/O-MAP = 02):
function code 04, start address 21 (hex15)

....								.	.	.										
....								.	.	.										
30	99	0																		

....								.	.	.										
....								.	.	.										
40	99	0																		

RSSI signals - address area 35001 ... 35250, function code 04

	RAD ID		15...4	3	2	1	0	Bit
35	001							RSSI: RAD ID = 01 - Master
		.						RSSI: RAD ID = 02
		.						RSSI: RAD ID = 03
		.						...
35	250							RSSI: RAD ID = 250

Example for reading an RSSI register of the station with RAD ID = 02:
function code 04, start address 5001 (hex1389)

7.9 Error codes and formats for analog input and output values

The measured value is represented in bits 0 ... 15. Values higher than 8000_{hex} indicate an error.

Analog RAD-AI4-IFS inputs

Table 7-13 Representation of analog RAD-AI4-IFS values

Data word			
hex	**dec / error code**	**0 mA ... 20 mA**	**4 mA ... 20 mA**
0000	0	0 mA	-
1770	6000	4 mA	4 mA
7530	30000	20 mA	20 mA
7F00	32512	21.67 mA	21.67 mA
8001	Overrange	>21.67 mA	>21.67 mA
8002	Open circuit	-	<3.2 mA
8080	Underrange	< 0 mA	-

Analog RAD-AO4-IFS outputs

Table 7-14 Representation of analog RAD-AO4-IFS values

Data word			
hex	**dec / error code**	**0 mA ... 20 mA**	**0 V ... 10 V**
0000	0	0 mA	0 V
7530	30000	20 mA	10 V
7F00	32512	21.67 mA	10.84 V

Analog RAD-DAIO6-IFS inputs and outputs

Table 7-15 Representation of analog RAD-DAIO6-IFS values

Data word				
hex	**dec / error code**	**0 ... 20 mA**	**4 ... 20 mA**	**0 V ... 10 V**
0000	0	0 mA	-	0 V
1770	6000	4 mA	4 mA	2 V
7530	30000	20 mA	20 mA	10 V
7F00	32512	21.67 mA	21.67 mA	10.84 V
8001	Overrange	>21.67 mA	>21.67 mA	-
8002	Open circuit	-	<3.2 mA	-
8080	Underrange	< 0 mA	-	-

Error codes and formats for Pt 100 values

Table 7-16 Representation of the RAD-PT100-4-IFS Pt 100 values

Data word		RAD-PT100-4-IFS Pt 100 input	RAD-AO4-IFS analog output		
hex	**dec / error code**	**-50°C ... +250°C**	**0 mA ... 20 mA**	**0 V ... 10 V**	**Possible cause**
0000	0	-50°C	0 mA	0 V	
7530	30000	+250°C	20 mA	10 V	
7F00	32512	+275.12°C	21.67 mA	10.84 V	
8001	Overrange				
8002	Open circuit				Sensor wired incorrectly, measuring line too long, cable resistance too high
8080	Underrange				

7.10 RSSI signal register

The RSSI values indicate the received signal strength on the wireless module. You can read the RSSI values via the serial interface of the master wireless module (RAD ID = 01) using Modbus/RTU commands. The RSSI values of all wireless modules are within the address area 35001 ... 35250.

Table 7-17 RSSI signal register

Address area		**35001 ... 35250**															
Modbus function code		**fc 04**															
Address	Wireless module	High byte								Low byte, RSSI value							
		15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
35001	RSSI - RAD ID = 1 (master)	Reserved								X	X	X	X	X	X	X	X
35002	RSSI - RAD ID = 2	Reserved								X	X	X	X	X	X	X	X
...	...	Reserved								X	X	X	X	X	X	X	X
35250	RSSI - RAD ID = 250	Reserved								X	X	X	X	X	X	X	X

- Bits 8 ... 15 are reserved.
- Values < 255 indicate the RSSI value in -dBm.
- The value 255 means that the RSSI value is invalid or the device cannot be reached.

Example for reading the RSSI register of the station with RAD ID = 2:
function code 04, start address 5001 (hex1389)

8 Description of I/O extension modules

8.1 RAD-AI4-IFS - analog extension module with four inputs

The analog RAD-AI4-IFS I/O extension module can process up to four input signals between 0/4 mA ... 20 mA. All inputs are electrically isolated from one another, from the supply voltage, and from the electronics.

A supply voltage of 12 V DC, minimum, is available at the PWR_1 connection terminal block for passive sensors (see Figure 8-1, item 1).

8.1.1 Structure

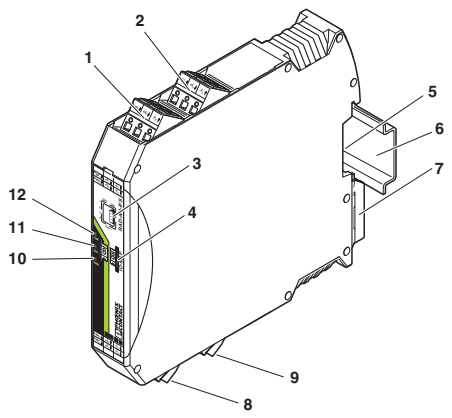


Figure 8-1 RAD-AI4-IFS structure

Item	Designation
1	Analog input 2 for 2-, 3-, 4-wire measuring transducers
2	Analog input 1 for 2-, 3-, 4-wire measuring transducers
3	DIP switches for configuring the analog inputs (current/voltage input)
4	White thumbwheel for setting the I/O-MAP address
5	Connection option for DIN rail connector
6	DIN rail
7	Metal foot catch for DIN rail fixing
8	Analog input 3 for 2-, 3-, 4-wire measuring transducers
9	Analog input 4 for 2-, 3-, 4-wire measuring transducers
10	ERR status LED, red (communication error)
11	DAT status LED, green (bus communication)
12	PWR status LED, green (supply voltage)

8.1.2 Basic circuit diagram

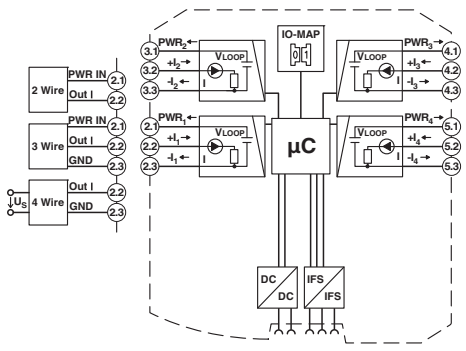


Figure 8-2 Basic circuit diagram for the RAD-AI4-IFS

8.1.3 Setting the DIP switches

Using the DIP switches on the front, you can configure the inputs signals (0 mA ... 20 mA or 4 mA ... 20 mA). Any changes in the setting of the DIP switches will be directly applied.

In PLC/Modbus RTU mode, the setting of the input signals is evaluated for error diagnostics. With the setting 4 mA ... 20 mA, it is, for example, possible to detect an open circuit.

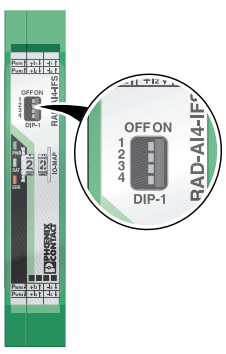


Figure 8-3 DIP switches of the RAD-AI4-IFS

Table 8-1 DIP switches of the RAD-AI4-IFS

		DIP switch			
Setting	**Input signal**	**1**	**2**	**3**	**4**
Analog IN1	0 mA ... 20 mA	OFF			
Analog IN1	4 mA ... 20 mA	ON			
Analog IN2	0 mA ... 20 mA		OFF		
Analog IN2	4 mA ... 20 mA		ON		
Analog IN3	0 mA ... 20 mA			OFF	
Analog IN3	4 mA ... 20 mA			ON	
Analog IN4	0 mA ... 20 mA				OFF
Analog IN4	4 mA ... 20 mA				ON

8.1.4 Diagnostic LEDs

The RAD-AI4-IFS I/O extension module uses a total of three LEDs to indicate the operating states.

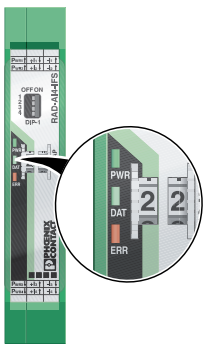


Figure 8-4 Diagnostic LEDs of the RAD-AI4-IFS

PWR LED

The green PWR LED indicates the supply voltage status.

OFF	No supply voltage
ON	Supply voltage OK

DAT LED

The green DAT LED indicates the bus communication status.

OFF	No communication
Flashing	Configuration and addressing mode
ON	Cyclic data communication

ERR LED

The red ERR LED indicates the error status.

OFF	No error
Flashing	
Slow (1.4 Hz)	I/O-MAP address changed
Fast (2.8 Hz)	No bus communication
ON	Critical internal error

8.1.5 Setting the I/O-MAP address

Use the thumbwheel to set the I/O-MAP address. The extension module in the Radioline wireless system is addressed using the I/O-MAP address. You can assign a maximum of 01 ... 99 addresses to the I/O extension modules in the entire wireless network.

Table 8-2 Setting the I/O-MAP address for the RAD-AI4-IFS

Thumbwheel setting	Description
01 ... 99	I/O-MAP address
00	Delivery state
**, 1* ... 9*	Setting not permitted
*1 ... *9	Interface System slave address, for use with other Interface System (IFS) master devices

8.1.6 Process data in PLC/Modbus RTU mode

The process image of the I/O extension module consists of six data words. For additional information, please refer to Section “RAD-AI4-IFS process data” on page 73.

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-AI4-IFS	20_{hex}	06_{hex}	30xx0 ... 30xx5	fc 04

8.2 RAD-PT100-4-IFS - extension module with four temperature inputs

Use the I/O extension modules in connection with the RAD-2400-IFS wireless module, firmware version 1.40 or later. You can update the firmware free of charge using the PSI-CONF software, Version 2.04 or later.

The firmware and software can be found on the Internet at phoenixcontact.net/products.

The analog RAD-PT100-4-IFS I/O extension module has four Pt 100 inputs for temperatures between -50°C ... +250°C. The Pt 100 inputs T1 ... T4 can be mapped to the analog outputs I1/U1 ... I4/U4 of the RAD-AO4-IFS extension module. All the inputs are electrically isolated from one another, from the supply voltage, and from the remaining electronics.

Pt 100 resistance thermometers can be connected to the RAD-PT100-4-IFS I/O extension module. The thermometers change their resistance depending on the temperature. The Pt 100 input signals are acquired by the RAD-PT100-4-IFS and can be mapped to proportional, analog voltage or current signals of the RAD-AO4-IFS output module.

Example: At the Pt 100 input, a current of 0 mA or a voltage of 0 V is released at the output module at a temperature of -50°C. At the Pt 100 input, a current of 20 mA or a voltage of 10 V is released at the output at a temperature of 250°C.

Pt 100 input	Analog output
-50°C	0 mA or 0 V
+250°C	20 mA or 10 V

8.2.1 Connecting sensors

You can connect 2-wire or 3-wire sensors to the extension module. Observe the measuring errors depending on the different measuring methods.

2-wire connection technology

2-wire connection technology is the most cost-effective connection method. The temperature-related voltage is not directly measured at the sensor and therefore falsified by the two cable resistances R_L. The measuring errors that occur may lead to the entire measurement to become useless. Please observe the diagrams in Section “Measuring errors using 2-wire connection technology” on page 93.

With 2-wire technology, you need an insertion bridge between terminals x.2 and x.3.

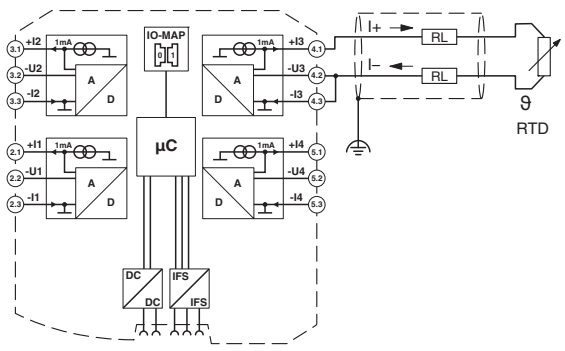


Figure 8-5 2-wire connection technology

3-wire connection technology

With 3-wire connection technology, the temperature-related voltage is measured several times. Corresponding calculations additionally reduce the effect of the cable resistance on the measurement result. The results are almost as good as those achieved using the 4-wire technology.

The cable resistances R_L at the terminals +I and -I must have the same value. This allows you to subtract the established cable resistance from the measurement result and to get the Pt 100 platinum resistance value.

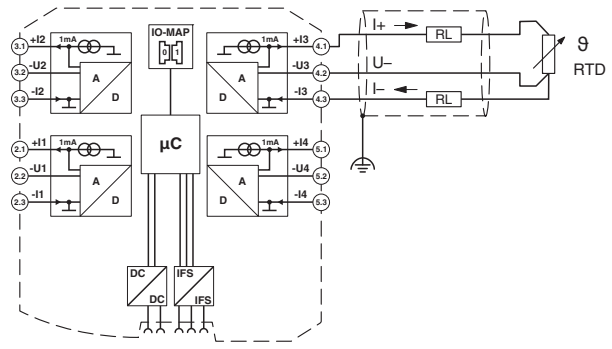


Figure 8-6 3-wire connection technology

4-wire connection technology

The RAD-PT100-4-IFS does not support the 4-wire connection technology.

- If you want to use a 4-wire sensor, only connect three of the four wires.
- The fourth wire should be left unwired. Otherwise there will be a different resistance in the +I and -I cables owing to the parallel connection of two cable resistances.

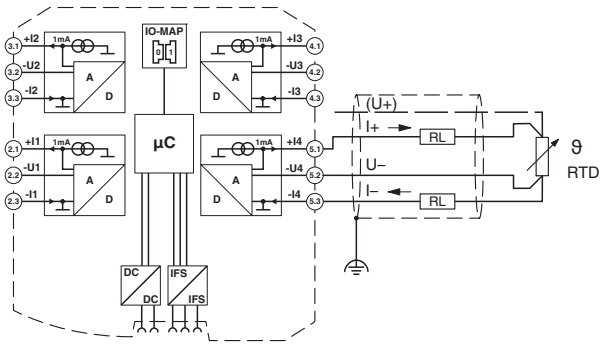


Figure 8-7 4-wire connection technology

8.2.2 Measuring errors using 2-wire connection technology

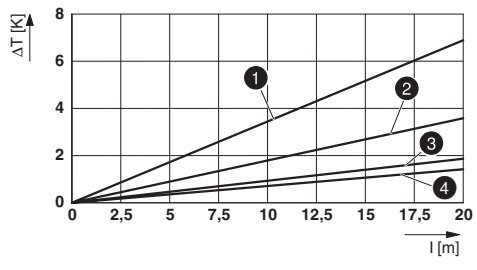


Figure 8-8 Systematic temperature measuring error ΔT depending on the cable length l

Curves depending on cable cross section A

1 Temperature measuring error for A = 0.25 mm^2

2 Temperature measuring error for A = 0.5 mm^2

3 Temperature measuring error for A = 1.0 mm^2

4 Temperature measuring error for A = 1.5 mm^2

(Measuring error valid for: copper cable χ = 57 m/Ωmm^2, T_A = 25°C and Pt 100 sensor)

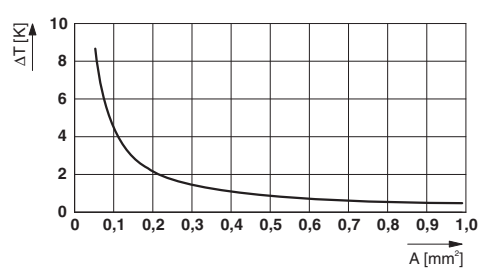


Figure 8-9 Systematic temperature measuring error ΔT depending on the cable cross section A

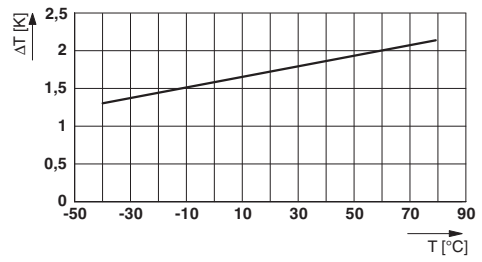


Figure 8-10 Systematic temperature measuring error ΔT depending on the cable temperature T_A

(Measuring error valid for: copper cable χ = 57 m/Ωmm^2, T_A = 25°C and Pt 100 sensor)

Make sure that the cable resistance and therefore the measuring error is as low as possible.

- Use sensor cables that are as short as possible.
- Avoid conductor cross sections smaller than 0.5 mm^2.

The temperature has only a small influence on the cable resistance.

You can calculate the cable resistance as follows:

$$R_L = R_{L20} \times [1 + 0.0039 \frac{1}{K} \times (T_A - 20°C)]$$

$$R_L = \frac{l}{\chi \times A} \times [1 + 0.0039 \frac{1}{K} \times (T_A - 20°C)]$$

R_L	Cable resistance in Ω
R_{L20}	Cable resistance at 20°C in Ω
l	Line length in m
χ	Specific resistance of copper in m/Ωmm^2
A	Cable cross section in mm^2
0.0039 1/K	Temperature coefficient for copper (degree of purity of 99.99%)
T_A	Ambient temperature (cable temperature) in °C

Due to there being two cable resistances in the measuring system, the value must be doubled. Using the average temperature coefficient α = 0.385 Ω/K for Pt 100, the absolute measuring error in Kelvin can be determined for platinum sensors according to DIN standards.

8.2.3 Shielding of the sensor cables

Always connect the analog sensors using shielded, twisted pair cables (e.g., LiYCY, TP 2 x 2 x 0.5 mm^2).

- Immediately following entry in the control cabinet, connect the cable shields to the corresponding shield connection clamps.

Please note that the electrical isolation between the channels may no longer occur when connecting the shields. The isolating distances between the individual channels need to be re-evaluated after connecting the shields. The distances between the individual wires and the common shields are crucial in this respect.

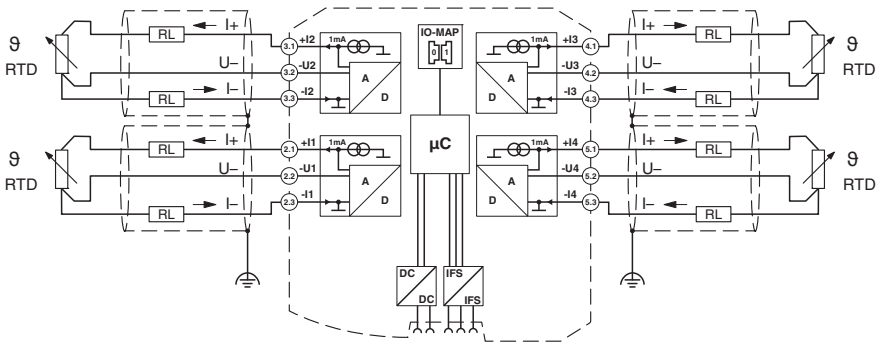


Figure 8-11 Shielding with 3-wire connection technology

2-wire connection technology with twisted pair cables and shielding

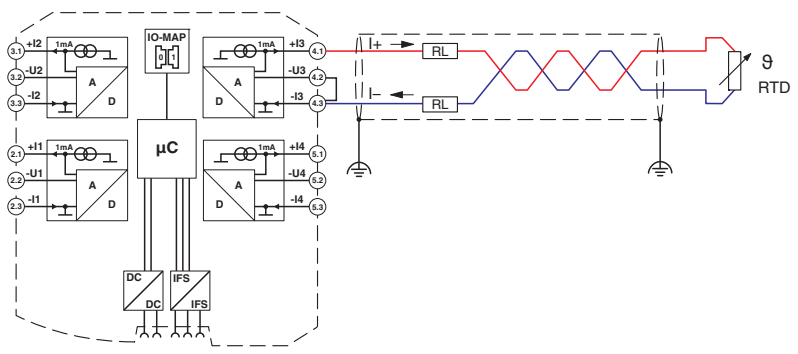


Figure 8-12 2-wire connection technology with twisted pair cables and shielding

3-wire connection technology with twisted pair cables and shielding

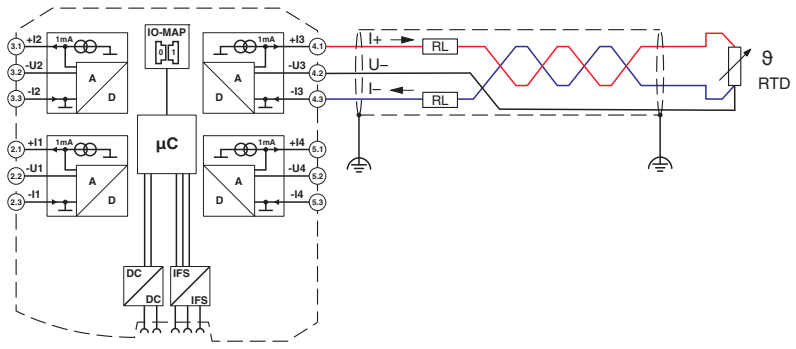


Figure 8-13 3-wire connection technology with twisted pair cables and shielding

8.2.4 Structure

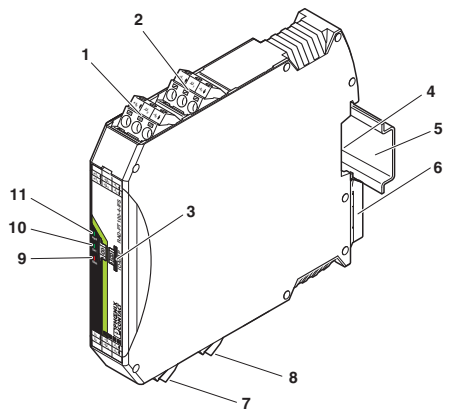


Figure 8-14 RAD-PT100-4-IFS structure

Item	Designation
1	Pt 100 input 2 for 2- and 3-wire sensors
2	Pt 100 input 1 for 2- and 3-wire sensors
3	White thumbwheel for setting the I/O-MAP address
4	Connection option for DIN rail connector
5	DIN rail
6	Metal foot catch for DIN rail fixing
7	Pt 100 input 3 for 2- and 3-wire sensors
8	Pt 100 input 4 for 2- and 3-wire sensors
9	ERR status LED, red (communication error)
10	DAT status LED, green (bus communication)
11	PWR status LED, green (supply voltage)

8.2.5 Basic circuit diagram

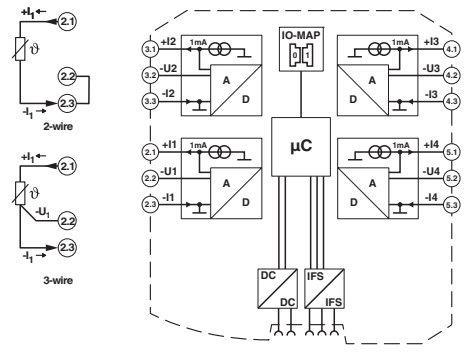


Figure 8-15 Basic circuit diagram for the RAD-PT100-4-IFS

With 2-wire technology, you need an insertion bridge between terminals x.2 and x.3. In this case, the measuring accuracy is reduced (see “Measuring errors using 2-wire connection technology” on page 93).

8.2.6 Diagnostic LEDs

The RAD-PT100-4-IFS I/O extension module uses a total of three LEDs to indicate the operating states.

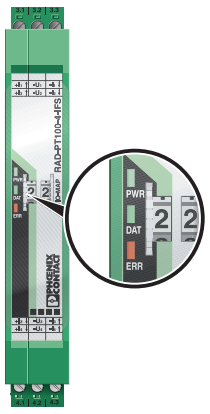


Figure 8-16 Diagnostic LEDs of the RAD-PT100-4-IFS

PWR LED

The green PWR LED indicates the supply voltage status.

OFF	No supply voltage
ON	Supply voltage OK

DAT LED

The green DAT LED indicates the bus communication status.

OFF	No communication
Flashing	Configuration and addressing mode
ON	Cyclic data communication

ERR LED

The red ERR LED indicates the error status.

OFF	No error
Flashing	
Slow (1.4 Hz)	I/O-MAP address changed
Fast (2.8 Hz)	No bus communication
ON	Critical internal error

8.2.7 Setting the I/O-MAP address

Use the thumbwheel to set the I/O-MAP address. The extension module in the Radioline wireless system is addressed using the I/O-MAP address. You can assign a maximum of 01 ... 99 addresses to the I/O extension modules in the entire wireless network.

Table 8-3 Setting the I/O-MAP address for the RAD-PT100-4-IFS

Thumbwheel setting	Description
01 ... 99	I/O-MAP address
00	Delivery state
**, 1* ... 9*	Setting not permitted
*1 ... *9	Interface System slave address, for use with other Interface System (IFS) master devices

8.2.8 Process data in PLC/Modbus RTU mode

The process image of the I/O extension module consists of six data words. For additional information, please refer to Section “RAD-PT100-4-IFS process data” on page 74.

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-PT100-4-IFS	21_{hex}	06_{hex}	30xx0 ... 30xx5	fc 04

8.3 RAD-AO4-IFS - analog extension module with four outputs

Using the analog RAD-AO4-IFS I/O extension module, up to four signals between 0/4 mA ... 20 mA can be output. All the outputs are electrically isolated from one another, from the supply voltage, and from the electronics.

Use either the current or voltage output per analog channel.

8.3.1 Structure

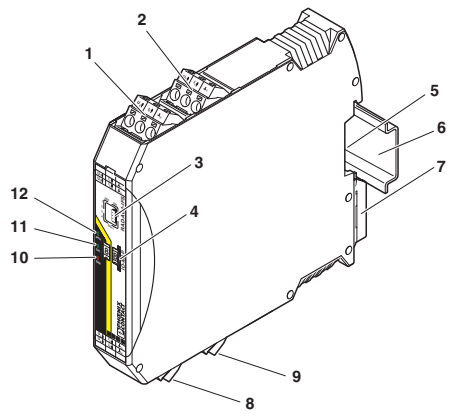


Figure 8-17 RAD-AO4-IFS structure

Item	Designation
1	Analog output 2 (alternatively current or voltage)
2	Analog output 1 (alternatively current or voltage)
3	DIP switches for configuring the outputs (current/voltage output)
4	White thumbwheel for setting the I/O-MAP address
5	Connection option for DIN rail connector
6	DIN rail
7	Metal foot catch for DIN rail fixing
8	Analog output 3 (alternatively current or voltage)
9	Analog output 4 (alternatively current or voltage)
10	ERR status LED, red (communication error)
11	DAT status LED, green (bus communication)
12	PWR status LED, green (supply voltage)

8.3.2 Basic circuit diagram

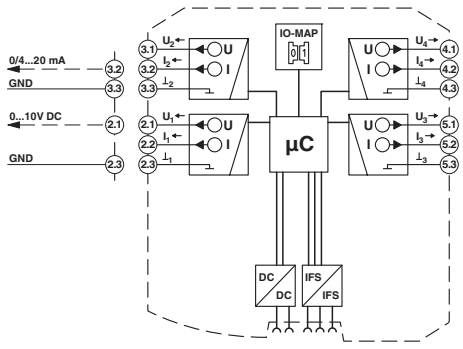


Figure 8-18 Basic circuit diagram for the RAD-AO4-IFS

8.3.3 Setting the DIP switches

You can use the DIP switches on the front to set the behavior of the outputs in the event of an error (e.g., interruption of the wireless connection). Any changes in the setting of the DIP switches will be directly applied.

– RESET = Output value is set to 0
– HOLD = Hold last valid output value

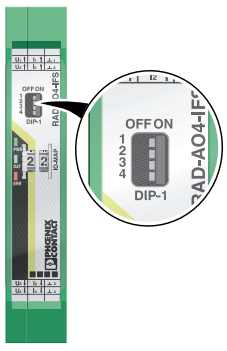


Figure 8-19 DIP switches of the RAD-AO4-IFS

Table 8-4 DIP switches of the RAD-AO4-IFS

		DIP switch			
Input	**Output signal**	**1**	**2**	**3**	**4**
Analog OUT1	RESET	OFF			
Analog OUT1	HOLD	ON			
Analog OUT2	RESET		OFF		
Analog OUT2	HOLD		ON		
Analog OUT3	RESET			OFF	
Analog OUT3	HOLD			ON	
Analog OUT4	RESET				OFF
Analog OUT4	HOLD				ON

8.3.4 Diagnostic LEDs

The RAD-AO4-IFS I/O extension module uses a total of three LEDs to indicate the operating states.

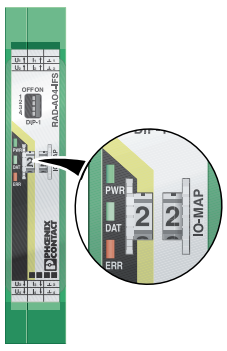


Figure 8-20 Diagnostic LEDs of the RAD-AO4-IFS

PWR LED

The green PWR LED indicates the supply voltage status.

OFF	No supply voltage
ON	Supply voltage OK

DAT LED

The green DAT LED indicates the bus communication status.

OFF	No communication
Flashing	Configuration and addressing mode
ON	Cyclic data communication

ERR LED

The red ERR LED indicates the error status, e.g., if a corresponding input module has not been found.

OFF	No error
Flashing	
Slow (1.4 Hz)	I/O-MAP address changed
Fast (2.8 Hz)	**Wireless module in I/O data mode** – Missing input module – No bus communication **Wireless module in PLC/Modbus RTU mode** – No Modbus communication (safe state of outputs, depending on DIP switch setting)
ON	Critical internal error

8.3.5 Setting the I/O-MAP address

Use the thumbwheel to set the I/O-MAP address. The extension module in the Radioline wireless system is addressed using the I/O-MAP address. You can assign a maximum of 01 ... 99 addresses to the I/O extension modules in the entire wireless network.

Table 8-5 Setting the I/O-MAP address for the RAD-AO4-IFS

Thumbwheel setting	Description
01 ... 99	I/O-MAP address
00	Delivery state
**, 1* ... 9*	Setting not permitted
*1 ... *9	Interface System slave address, for use with other Interface System (IFS) master devices

8.3.6 Process data in PLC/Modbus RTU mode

The process image of the I/O extension module consists of six data words. For additional information, please refer to Section “RAD-AO4-IFS process data” on page 75.

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-AO4-IFS	30_{hex}	06_{hex}	40xx0 ... 40xx5	fc 03, 16

8.4 RAD-DI4-IFS - digital extension module with four inputs

WARNING: Risk of electric shock

Use the same phase for digital inputs and digital outputs. The isolating voltage between the individual channels must not exceed 300 V.

The digital RAD-DI4-IFS I/O extension module can process up to four input signals. The digital inputs process voltages between 0 V ... 50 V AC/DC at the low-voltage input and voltages between 0 V ... 250 V AC/DC at the high-voltage input. All inputs are electrically isolated from one another, from the supply voltage, and from the electronics.

8.4.1 Structure

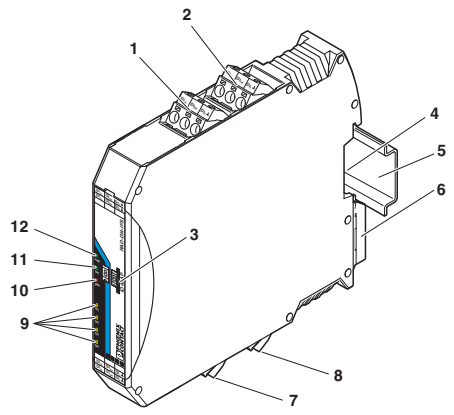


Figure 8-21 RAD-DI4-IFS structure

Item	Designation
1	Digital input as wide-range input
2	Digital input as wide-range input
3	White thumbwheel for setting the I/O-MAP address
4	Connection option for DIN rail connector
5	DIN rail
6	Metal foot catch for DIN rail fixing
7	Digital input as wide-range input
8	Digital input as wide-range input
9	Status LEDs for digital inputs DI1 ... DI4
10	ERR status LED, red (communication error)
11	DAT status LED, green (bus communication)
12	PWR status LED, green (supply voltage)

8.4.2 Basic circuit diagram

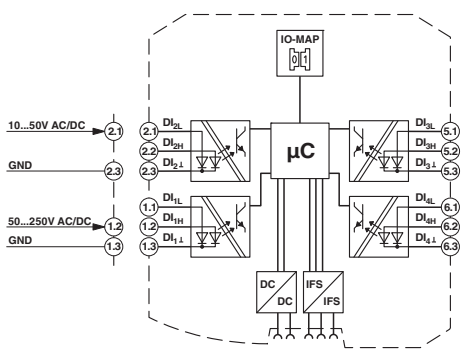


Figure 8-22 Basic circuit diagram for the RAD-DI4-IFS

8.4.3 Diagnostic LEDs

The RAD-DI4-IFS I/O extension module uses a total of seven LEDs to indicate the operating states.

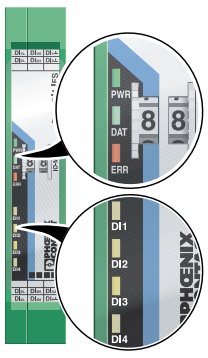


Figure 8-23 Diagnostic LEDs of the RAD-DI4-IFS

PWR LED

The green PWR LED indicates the supply voltage status.

OFF	No supply voltage
ON	Supply voltage OK

DAT LED

The green DAT LED indicates the bus communication status.

OFF	No communication
Flashing	Configuration and addressing mode
ON	Cyclic data communication

ERR LED

The red ERR LED indicates the error status, e.g., if a corresponding output module has not been found.

OFF	No error
Flashing	
Slow (1.4 Hz)	I/O-MAP address changed
Fast (2.8 Hz)	No bus communication
ON	Critical internal error

DI1 ... DI4

The yellow DI1 ... DI4 LEDs indicate the status of the digital inputs.

8.4.4 Setting the I/O-MAP address

Use the thumbwheel to set the I/O-MAP address. The extension module in the Radioline wireless system is addressed using the I/O-MAP address. You can assign a maximum of 01 ... 99 addresses to the I/O extension modules in the entire wireless network.

Table 8-6 Setting the I/O-MAP address for the RAD-DI4-IFS

Thumbwheel setting	Description
01 ... 99	I/O-MAP address
00	Delivery state
**, 1* ... 9*	Setting not permitted
*1 ... *9	Interface System slave address, for use with other Interface System (IFS) master devices

8.4.5 Process data in PLC/Modbus RTU mode

The process image of the I/O extension module consists of two data words. For additional information, please refer to Section “RAD-DI4-IFS process data” on page 76.

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-DI4-IFS	01_{hex}	02_{hex}	30xx0 ... 30xx1	fc 04

8.5 RAD-DI8-IFS - digital extension module with eight inputs

Use the I/O extension modules in connection with the RAD-2400-IFS wireless module, firmware version 1.40 or later. You can update the firmware free of charge using the PSI-CONF software, Version 2.04 or later.

The firmware and software can be found on the Internet at phoenixcontact.net/products.

The digital RAD-DI8-IFS I/O extension module can process up to eight digital input signals or two pulse signals. You can use DIP switch 1 to set the operating mode. For more detailed information on setting the DIP switch, please refer to page 108.

The eight digital inputs are arranged in two groups of four inputs each with a common reference potential (GND). The two DC groups are electrically isolated from one another, from the supply voltage, and from the electronics.

8.5.1 Structure

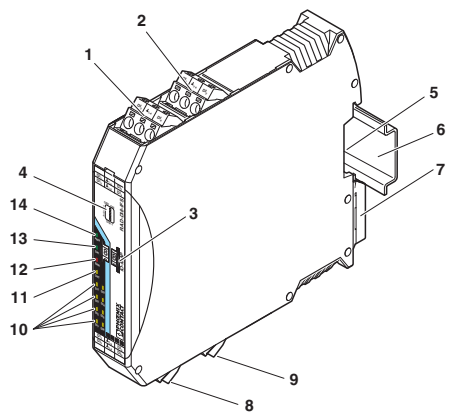


Figure 8-24 RAD-DI8-IFS structure

Item	Designation
1	Digital inputs 3 + 4
2	Digital inputs 1 + 2, DI1: pulse input 1
3	White thumbwheel for setting the I/O-MAP address
4	DIP switch for switching between static mode and pulse counter mode for digital inputs
5	Connection option for DIN rail connector
6	DIN rail
7	Metal foot catch for DIN rail fixing
8	Digital inputs 5 + 6
9	Digital inputs 7 + 8, DI7: pulse input 2
10	Status LEDs for digital inputs DI1 ... DI8
11	CNT status LED, green (pulse counter mode)
12	ERR status LED, red (communication error)
13	DAT status LED, green (bus communication)
14	PWR status LED, green (supply voltage)

8.5.2 Basic circuit diagram

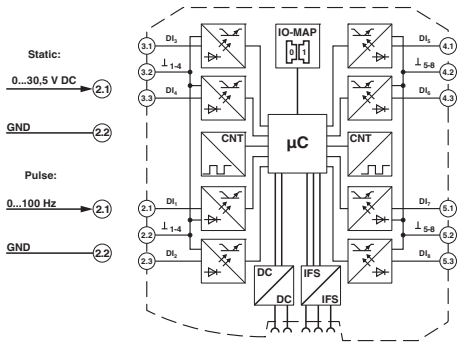


Figure 8-25 Basic circuit diagram for the RAD-DI8-IFS

8.5.3 Setting the DIP switches

You can use the DIP switches on the front to select between static mode or pulse counter mode.

– In static mode, the DI1 ... DI8 inputs are activated, 0 V ... 30.5 V DC voltage.
– In pulse counter mode, the DI1 and DI7 pulse inputs are activated, 0 Hz ... 100 Hz pulses.

The pulse counter function is only available in PLC/Modbus RTU mode. Set the operating mode using the PSI-CONF software (from page 40 onwards).

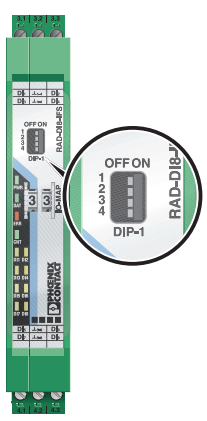


Figure 8-26 DIP switches of the RAD-DI8-IFS

Table 8-7 DIP switches of the RAD-DI8-IFS

		DIP switch			
Input	**Output signal**	**1**	**2**	**3**	**4**
Digital IN DI1 ... DI8	Static mode	OFF	n.c.	n.c.	n.c.
Counter IN DI1 + DI7	Pulse counter mode	ON	n.c.	n.c.	n.c.

n. c. = not connected, DIP switches 2 ... 4 have no function

- Use DIP switch 1 to select between static mode and pulse counter mode.
- Disconnect the device from the supply voltage.
- Switch the supply voltage back on.
- The selected mode is now active.

8.5.4 Functions in pulse counter mode

The counter state can only increase consecutively. When the maximum counter limit of 4,294,967,295 is reached, the counter is automatically set back to 0. In addition, you can manually reset the counter states in three different ways:

Reset counter state via power up

- Disconnect the device power supply and then reconnect the voltage.

Reset counter state via the Modbus RTU register

- Reset the counter states via Modbus RTU as follows:
  - DI1: bit 0 = 1 (register 40xx1)
  - DI7: bit 1 = 1 (register 40xx1)

Reset counter state by setting the inputs

- Set the corresponding input for at least 0.5 seconds:
  - Set the **DI3** input in order to reset the **DI1** counter state.
  - Set the **DI5** input in order to reset the **DI7** counter state.

8.5.5 Diagnostic LEDs

The RAD-DI8-IFS I/O extension module uses a total of twelve LEDs to indicate the operating states.

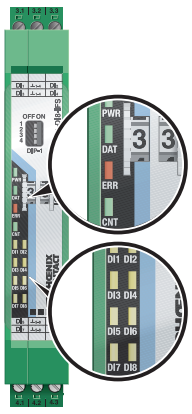


Figure 8-27 Diagnostic LEDs of the RAD-DI8-IFS

PWR LED

The green PWR LED indicates the supply voltage status.

OFF	No supply voltage
ON	Supply voltage OK

DAT LED

The green DAT LED indicates the bus communication status.

OFF	No communication
Flashing	Configuration and addressing mode
ON	Cyclic data communication

ERR LED

The red ERR LED indicates the error status.

OFF	No error
Flashing	
Slow (1.4 Hz)	I/O-MAP address changed or mode switched using DIP switch 1, but not yet applied
Fast (2.8 Hz)	No bus communication
ON	Critical internal error

CNT LED

The green CNT LED indicates that pulse counter mode is activated.

OFF	No error
Flashing	Mode switched using DIP switch 1, but not yet applied
ON	Pulse counter mode of digital inputs DI1 and DI7

DI1 ... DI8

The yellow DI1 ... DI8 LEDs indicate the status of the digital inputs.

In pulse counter mode: The DI1 and DI7 LEDs flash in time with the recorded pulses. The DI3 and DI5 LEDs light up when the counter state is reset.

DI3	ON (0.5 second)	Counter state DI1 reset to 0
DI5	ON (0.5 second)	Counter state DI7 reset to 0

8.5.6 Setting the I/O-MAP address

Use the thumbwheel to set the I/O-MAP address. The extension module in the Radioline wireless system is addressed using the I/O-MAP address. You can assign a maximum of 01 ... 99 addresses to the I/O extension modules in the entire wireless network.

Table 8-8 Setting the I/O-MAP address for the RAD-DI8-IFS

Thumbwheel setting	Description
01 ... 99	I/O-MAP address
00	Delivery state
**, 1* ... 9*	Setting not permitted
*1 ... *9	Interface System slave address, for use with other Interface System (IFS) master devices

8.5.7 Process data in PLC/Modbus RTU mode

The process image of the I/O extension module consists of eight data words. For additional information, please refer to Section “RAD-DI8-IFS process data” on page 76.

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-DI8-IFS	02_{hex} Static mode	02_{hex} Static inputs	30xx0 ... 30xx1	fc 04
	40_{hex} Pulse counter mode	06_{hex} Pulse inputs	30xx0 ... 30xx5	fc 04
	40_{hex} Pulse counter mode	02_{hex} Reset counter states	40xx0 ... 40xx1	fc 03, 16

8.6 RAD-DOR4-IFS - digital extension module with four outputs

WARNING: Risk of electric shock
Use the same phase for digital inputs and digital outputs. The isolating voltage between the individual channels must not exceed 300 V.

The digital RAD-DOR4-IFS I/O extension module can process up to four input signals that are switched via relay outputs. The digital outputs are designed as floating relay contacts (PDT). All outputs are electrically isolated from one another, from the supply voltage, and from the electronics.

8.6.1 Structure

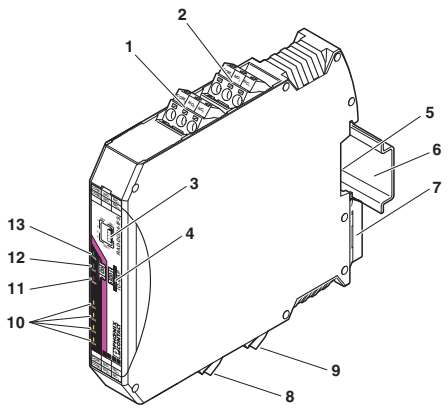


Figure 8-28 RAD-DOR4-IFS structure

Item	Designation
1	Relay output 2 with floating PDT contact
2	Relay output 1 with floating PDT contact
3	DIP switches for configuring the output behavior of the relay outputs (hold/reset)
4	White thumbwheel for setting the I/O-MAP address
5	Connection option for DIN rail connector
6	DIN rail
7	Metal foot catch for DIN rail fixing
8	Relay output 3 with floating PDT contact
9	Relay output 4 with floating PDT contact
10	Status LEDs for the relay outputs DO1 ... DO4
11	ERR status LED, red (communication error)
12	DAT status LED, green (bus communication)
13	PWR status LED, green (supply voltage)

8.6.2 Basic circuit diagram

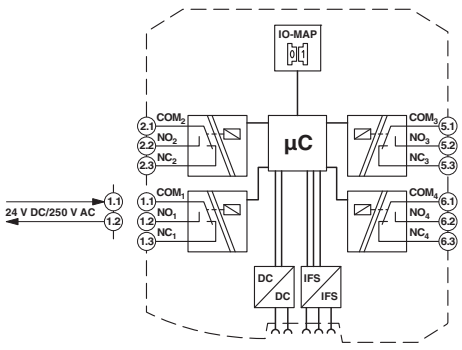


Figure 8-29 Basic circuit diagram for the RAD-DOR4-IFS

8.6.3 Setting the DIP switches

You can use the DIP switches on the front to set the behavior of the outputs in the event of an error (e.g., interruption of the wireless connection). Any changes in the setting of the DIP switches will be directly applied.

– RESET = Output value is set to 0
– HOLD = Hold last output value

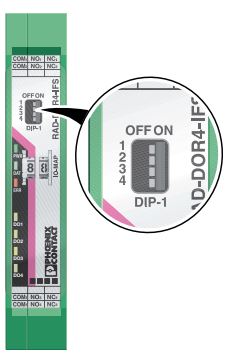


Figure 8-30 DIP switches of the RAD-DOR4-IFS

Table 8-9 DIP switches of the RAD-DOR4-IFS

		DIP switch			
Setting	**Output signal**	**1**	**2**	**3**	**4**
Digital OUT1	RESET	OFF			
Digital OUT1	HOLD	ON			
Digital OUT2	RESET		OFF		
Digital OUT2	HOLD		ON		
Digital OUT3	RESET			OFF	
Digital OUT3	HOLD			ON	
Digital OUT4	RESET				OFF
Digital OUT4	HOLD				ON

8.6.4 Diagnostic LEDs

The RAD-DOR4-IFS I/O extension module uses a total of seven LEDs to indicate the operating states.

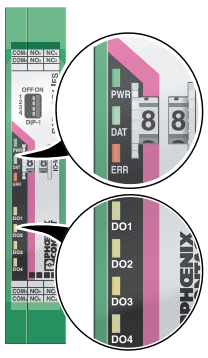


Figure 8-31 Diagnostic LEDs of the RAD-DOR4-IFS

PWR LED

The green PWR LED indicates the supply voltage status.

OFF	No supply voltage
ON	Supply voltage OK

DAT LED

The green DAT LED indicates the bus communication status.

OFF	No communication
Flashing	Configuration and addressing mode
ON	Cyclic data communication

ERR LED

The red ERR LED indicates the error status, e.g., if a corresponding input module has not been found.

OFF	No error
Flashing	
Slow (1.4 Hz)	I/O-MAP address changed
Fast (2.8 Hz)	**Wireless module in I/O data mode** – Missing input module – No bus communication **Wireless module in PLC/Modbus RTU mode** – No Modbus communication (safe state of outputs, depending on DIP switch setting)
ON	Critical internal error

DO1 ... DO4

The yellow LEDs DO1 ... DO4 LEDs indicate the status of the digital outputs.

8.6.5 Setting the I/O-MAP address

Use the thumbwheel to set the I/O-MAP address. The extension module in the Radioline wireless system is addressed using the I/O-MAP address. You can assign a maximum of 01 ... 99 addresses to the I/O extension modules in the entire wireless network.

Table 8-10 Setting the I/O-MAP address for the RAD-DOR4-IFS

Thumbwheel setting	Description
01 ... 99	I/O-MAP address
00	Delivery state
**, 1* ... 9*	Setting not permitted
*1 ... *9	Interface System slave address, for use with other Interface System (IFS) master devices

Process data in PLC/Modbus RTU mode

The process image of the I/O extension module consists of two data words. For additional information on process data, please refer to Section “RAD-DOR4-IFS process data” on page 78.

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-DOR4-IFS	10_{hex}	02_{hex}	40xx0 ... 40xx1	fc 03, 16

8.7 RAD-DO8-IFS - digital extension module with eight outputs

Use the I/O extension modules in connection with the RAD-2400-IFS wireless module, firmware version 1.40 or later. You can update the firmware free of charge using the PSI-CONF software, Version 2.04 or later.

The firmware and software can be found on the Internet at phoenixcontact.net/products.

The digital RAD-DO8-IFS I/O extension module processes up to eight digital output signals that are switched via transistor outputs. The eight outputs are arranged in two groups of four outputs each with a common electrical supply. The two output groups are electrically isolated from one another, from the supply voltage, and from the electronics.

Since the DO1 ... DO4 and DO5 ... DO8 output groups are electrically isolated, the digital outputs must be externally supplied (see Figure 8-33).

- The DO1 ... DO4 outputs are supplied via:
  - Terminal 1.1 (12 V DC ... 30.5 V DC)
  - Terminals 1.2/1.3 (GND)
- The DO5 ... DO8 outputs are supplied via:
  - Terminal 6.1 (12 V DC ... 30.5 V DC)
  - Terminals 6.2/6.3 (GND)

8.7.1 Structure

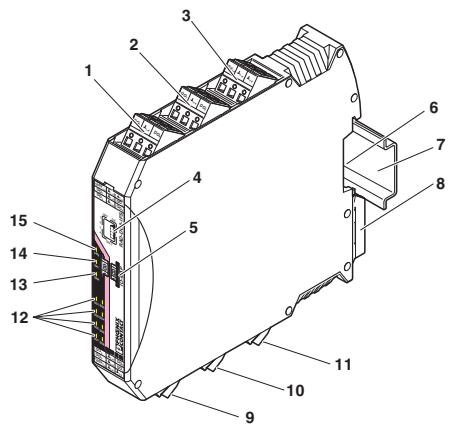


Figure 8-32 RAD-DO8-IFS structure

Item	Designation
1	Transistor outputs 3 + 4
2	Transistor outputs 1 + 2
3	Supply voltage for outputs 1 ... 4
4	DIP switches for setting the output behavior of the transistor outputs (hold/reset)
5	White thumbwheel for setting the I/O-MAP address
6	Connection option for DIN rail connector
7	DIN rail
8	Metal foot catch for DIN rail fixing
9	Transistor outputs 5 + 6
10	Transistor outputs 7 + 8
11	Supply voltage for outputs 5 ... 8
12	Status LEDs of transistor outputs DO1 ... DO8
13	ERR status LED, red (communication error)
14	DAT status LED, green (bus communication)
15	PWR status LED, green (supply voltage)

8.7.2 Basic circuit diagram

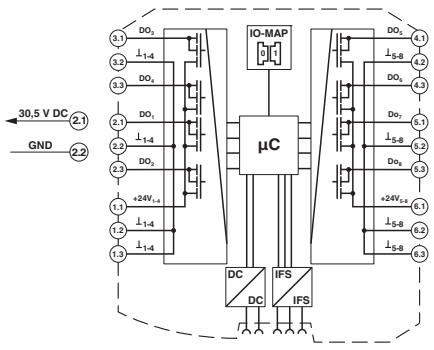


Figure 8-33 Basic circuit diagram for the RAD-DO8-IFS

8.7.3 Setting the DIP switches

You can use the DIP switches on the front to set the behavior of the outputs in the event of an error (e.g., interruption of the wireless connection). Any changes in the setting of the DIP switches will be directly applied.

– RESET = Output value is set to 0
– HOLD = Hold last output value

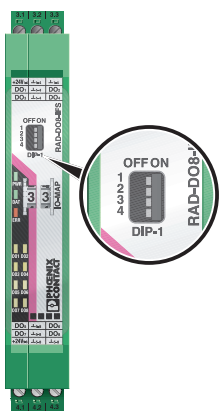


Figure 8-34 DIP switches of the RAD-DO8-IFS

Table 8-11 DIP switches of the RAD-DO8-IFS

		DIP switch			
Setting	**Output signal**	**1**	**2**	**3**	**4**
Digital OUT 1 ... 4	RESET	OFF		n. c.	n. c.
Digital OUT 1 ... 4	HOLD	ON		n. c.	n. c.
Digital OUT 5 ... 8	RESET		OFF	n. c.	n. c.
Digital OUT 5 ... 8	HOLD		ON	n. c.	n. c.

n. c. = not connected, DIP switches 3 and 4 have no function

8.7.4 Diagnostic LEDs

The RAD-DO8-IFS I/O extension module uses a total of eleven LEDs to indicate the operating states.

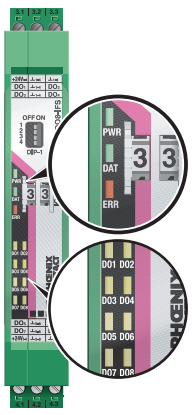


Figure 8-35 Diagnostic LEDs of the RAD-DO8-IFS

PWR LED

The green PWR LED indicates the supply voltage status.

OFF	No supply voltage
ON	Supply voltage OK

DAT LED

The green DAT LED indicates the bus communication status.

OFF	No communication
Flashing	Configuration and addressing mode
ON	Cyclic data communication

ERR LED

The red ERR LED indicates the error status, e.g., if a corresponding input module has not been found.

OFF	No error
Flashing	**Wireless module in I/O data mode** – Missing input module – No bus communication **Wireless module in PLC/Modbus RTU mode** – No Modbus communication (safe state of outputs, depending on DIP switch setting) – Short circuit at one output or several outputs
ON	Critical internal error

DO1 ... DO8

The yellow DO1 ... DO8 LEDs indicate the status of the digital outputs.

DO1 ... DO4	Flashing	Short circuit at one output or several outputs 1 ... 4
DO5 ... DO8	Flashing	Short circuit at one output or several outputs 5 ... 8

8.7.5 Setting the I/O-MAP address

Use the thumbwheel to set the I/O-MAP address. The extension module in the Radioline wireless system is addressed using the I/O-MAP address. You can assign a maximum of 01 ... 99 addresses to the I/O extension modules in the entire wireless network.

Table 8-12 Setting the I/O-MAP address for the RAD-DO8-IFS

Thumbwheel setting	Description
01 ... 99	I/O-MAP address
00	Delivery state
**, 1* ... 9*	Setting not permitted
*1 ... *9	Interface System slave address, for use with other Interface System (IFS) master devices

8.7.6 Process data in PLC/Modbus RTU mode

The process image of the I/O extension module consists of four data words. For additional information, please refer to Section “RAD-DO8-IFS process data” on page 79.

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-DO8-IFS	11_{hex}	02_{hex} Outputs	40xx0 ... 40xx1	fc 03.16
		02_{hex} Short-circuit detection	30xx0 ... 30xx1	fc 04

8.8 RAD-DAIO6-IFS - analog/digital extension module with six channels

WARNING: Risk of electric shock
Use the same phase for digital inputs and digital outputs. The isolating voltage between the individual channels must not exceed 300 V.

The analog/digital RAD-DAIO6-IFS I/O extension module has a total of six channels. The device is able to process two digital input and output signals as well as one analog input signal and one analog output signal. All inputs and outputs are electrically isolated from one another, from the supply voltage, and from the electronics.

Two digital inputs

The digital inputs process voltages between 0 V ... 50 V AC/DC at the low-voltage input and 0 V ... 250 V AC/DC at the high-voltage input.

Two digital outputs

The digital outputs are designed as floating relay contacts (PDT). The switching capacity is 2 A at 250 V AC/24 V DC.

Analog input

The analog input is able to process standard signals between 0/4 mA ... 20 mA. A supply voltage of at least 12 V DC is available at the PWR_1 connection terminal block for the use of passive sensors.

Analog output

The analog output is designed as active output. You can either select a current signal 0/4 mA ... 20 mA or a voltage signal 0 V ... 10 V.

Use either a current or voltage output at the analog output.

8.8.1 Structure

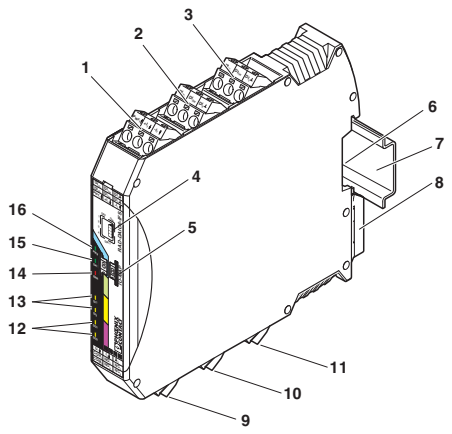


Figure 8-36 RAD-DAIO6-IFS structure

Item	Designation
1	Analog input for 2-, 3-, 4-wire measuring transducers
2	Digital input as wide-range input
3	Digital input as wide-range input
4	DIP switches for configuring the inputs and outputs
5	White thumbwheel for setting the I/O-MAP address
6	Connection option for DIN rail connector
7	DIN rail
8	Metal foot catch for DIN rail fixing
9	Analog output, alternatively current or voltage
10	Relay output with floating PDT contact
11	Relay output with floating PDT contact
12	Status LEDs of the digital DO1 ... DO2
13	Status LEDs of the digital DI1 ... DI2 inputs
14	ERR status LED, red (communication error)
15	DAT status LED, green (bus communication)
16	PWR status LED, green (supply voltage)

8.8.2 Basic circuit diagram

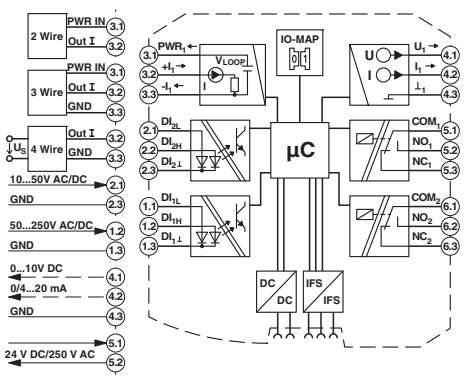


Figure 8-37 Basic circuit diagram for the RAD-DAIO6-IFS

8.8.3 Setting the DIP switches

The DIP switches on the front can be used to configure the input signals ranges. In addition, you can set the behavior of the outputs in the event of an error (e.g., interruption of the wireless connection). Any changes in the setting of the DIP switches will be directly applied.

Analog output

– RESET = Output value is set to 0
– HOLD = Hold last output value

Digital outputs

– RESET = Relay drops out
– HOLD = Hold last valid state

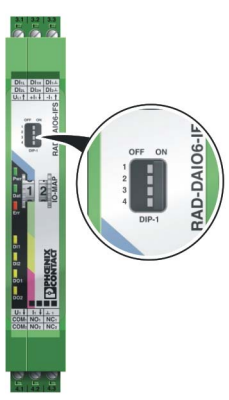


Figure 8-38 DIP switches of the RAD-DAIO6-IFS

Table 8-13 DIP switches of the RAD-DAIO6-IFS

		DIP switch			
Setting	**Output signal**	**1**	**2**	**3**	**4**
Analog IN	0 ... 20 mA	OFF			
Analog IN	4 ... 20 mA	ON			
Analog OUT	RESET		OFF		
Analog OUT	HOLD		ON		
Digital OUT1	RESET			OFF	
Digital OUT1	HOLD			ON	
Digital OUT2	RESET				OFF
Digital OUT2	HOLD				ON

8.8.4 Diagnostic LEDs

The RAD-DAIO6-IFS I/O extension module uses a total of seven LEDs to indicate the operating states.

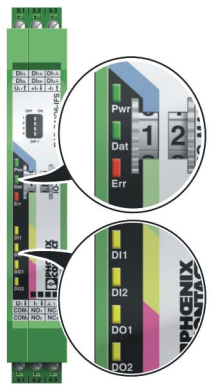


Figure 8-39 Diagnostic-LEDs of the RAD-DAIO6-IFS

PWR LED

The green PWR LED indicates the supply voltage status.

OFF	No supply voltage
ON	Supply voltage OK

DAT LED

The green DAT LED indicates the bus communication status.

OFF	No communication
Flashing	Configuration and addressing mode
ON	Cyclic data communication

ERR LED

The red ERR LED indicates the error status, e.g., if a corresponding output module has not been found.

OFF	No error
Flashing	
Slow (1.4 Hz)	I/O-MAP address changed
Fast (2.8 Hz)	**Wireless module in I/O data mode** – Missing input module – No bus communication **Wireless module in PLC/Modbus RTU mode** – No Modbus communication (safe state of outputs, depending on DIP switch setting)
ON	Critical internal error

DI1 / DI2

The yellow DI1 and DI2 LEDs indicate the status of the digital inputs.

DO1/DO2

The yellow DO1 and DO2 LEDs indicate the status of the digital outputs.

8.8.5 Setting the I/O-MAP address

Use the thumbwheel to set the I/O-MAP address. The extension module in the Radioline wireless system is addressed using the I/O-MAP address. You can assign a maximum of 01 ... 99 addresses to the I/O extension modules in the entire wireless network.

Table 8-14 Setting the I/O-MAP address for the RAD-DAIO6-IFS

Thumbwheel setting	Description
01 ... 99	I/O-MAP address
00	Delivery state
**, 1* ... 9*	Setting not permitted
*1 ... *9	Interface System slave address, for use with other Interface System (IFS) master devices

8.8.6 Process data in PLC/Modbus RTU mode

The process image of the I/O extension module consists of six data words. For additional information, please refer to Section “RAD-DAIO6-IFS process data” on page 80.

I/O module	Module type ID	Number of registers	Address area	Function code
RAD-DAIO6-IFS	60_{hex}	03_{hex} (inputs)	30xx0 ... 30xx2	fc 04
		03_{hex} (outputs)	40xx0 ... 40xx2	fc 03, 16

9 Planning wireless systems

9.1 Trusted Wireless 2.0

Phoenix Contact has developed Trusted Wireless 2.0 technology specifically for industrial applications. Trusted Wireless 2.0 operates in the license-free 2.4 GHz frequency band.

Features

- Rugged communication via the frequency hopping spread spectrum (FHSS)
- Automatic and manual mechanisms for coexistence with other systems transmitting in the same frequency band
- Secure data encryption and authentication
- Long range thanks to high receiver sensitivity and variable data transmission speed
- Flexible network structure with automatic connection management
- Distributed network management
- Comprehensive diagnostics options
- Adaptations to the required application are possible

Frequency hopping spread spectrum (FHSS) method

In the license-free 2.4 GHz frequency band, Trusted Wireless 2.0 uses the FHSS method. This method uses a selection of up to 127 channels from the entire spectrum of the frequency band. The wireless module “hops” between these channels on the basis of a pseudo-random pattern. This leads to a more robust and more reliable communication.

Coexistence management

Black listing means that certain frequencies can be hidden selectively. For example, this method allows you to operate several WLAN systems in parallel to Trusted-Wireless 2.0 systems without any performance limitations. In addition, different RF (Radio Frequency) bands are used, enabling the simultaneous use of several Trusted Wireless 2.0 systems.

Data encryption and authentication

Trusted Wireless 2.0 is a proprietary technology. The protocol has not been published. Therefore it is better protected against attacks. In addition, two security mechanisms have been implemented with 128-bit AES data encryption and authentication. The data encryption makes sure that intercepted data packets are not “understood”. The authentication process checks the sender’s authenticity. For this, a continuous code is added to the message, which must not be repeated. A manipulated message will be recognized as not valid and discarded.

Range

You can set the data rate of the wireless interface and adapt it to the respective application (16 kbps ... 250 kbps). By reducing the data rate, you can increase the sensitivity of the receiver and therefore the range. Distances from a few hundred meters to several kilometers can be covered using Trusted Wireless 2.0.

Network structures

Wireless modules can be used to create network structures with up to 250 devices. In this case, each device has a repeater function for forwarding data. In addition, the Trusted Wireless network is able to self-heal connection aborts (self-healing network). Alternative connection paths are initiated automatically. From a simple point-to-point connection to complex mesh networks, you can flexibly create various structures.

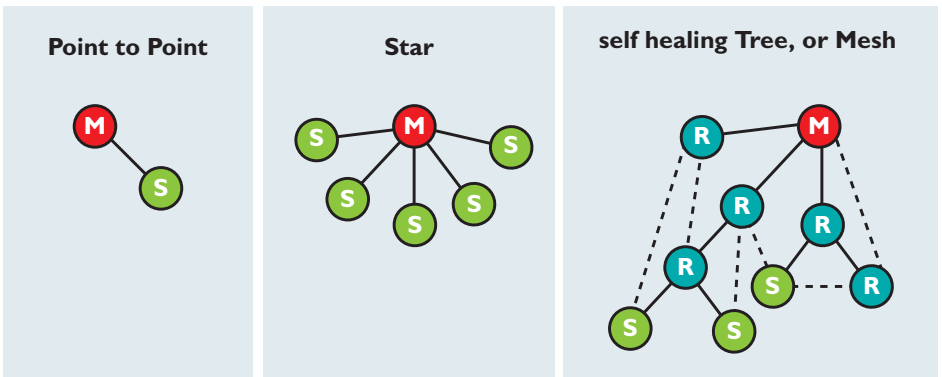


Figure 9-1 Point-to-point connection, star network, self-healing mesh network

Distributed network management

Technologies such as WirelessHART or ZigBee use a central network management. That means that all messages pass through a central manager, which can lead to significant volume of wireless network traffic.

Trusted Wireless 2.0, however, uses a distributed network management. For this purpose, “parent-child zones” are created in the wireless network, where the higher-level wireless module is referred to as the “parent” and the modules connected to it as “children”. All network management takes place within the parent-child zone and does not have to be directed through a central manager. This reduces the message traffic volume and accelerates the data exchange.

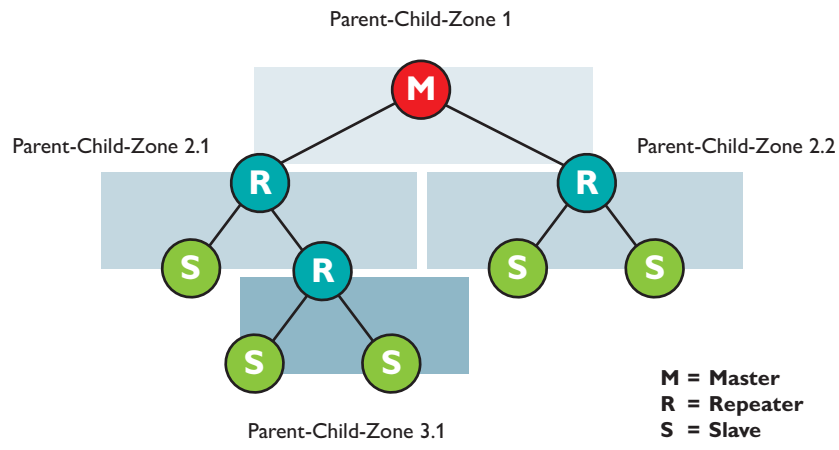


Figure 9-2 Distributed network management with parent-child zones

9.2 Planning wireless paths

When planning wireless paths over large distances, you need to consider height variations. A topographic map or a GPS device are very helpful in this regard. Using GPS devices, you can indicate variations in height and measure distances by means of way points. You can use the GPS devices as a direction indicator when later aligning the antennas.

Theoretical planning

The following questions should be taken into account when doing the theoretical planning:

– Which signals are to be transmitted?
– What points are the signals to be transmitted between?
– What is the distance between these points?
– Are there any topographic or structural obstacles?
– Are you able to circumnavigate these obstacles, e.g., by means of a repeater of higher mast?

When evaluating the data, you can carry out a system calculation to determine whether the wireless path is theoretically possible. You can find a calculation example from page 143 onwards.

9.3 Practical test

To check the theoretical results, you should carry out an on-site practical test before purchasing a wireless system. Check the location for master, slave and repeater/slave modules on the basis of the following criteria in order to achieve the optimum wireless connection:

– Antenna is positioned ensuring a line of sight and a sufficient signal strength
– Primary power source for energy supply is available
– Protection of wireless modules against any influences of weather and extreme ambient conditions
– Adequate connections for antenna, surge protection, interface and other required cables

These requirements can be quickly assessed in most applications. However, it is often difficult to position the antenna. Of course, a connection path without any obstacles would be perfect. However, small obstacles in the Fresnel zone will not necessarily disturb communication. In general, obstacles on long wireless paths have a greater influence than on short ones.

9.4 Selecting antenna cables and antennas

Antenna cable

When installing a wireless system, it is very important that you use low-loss coaxial cables. Using an unsuitable cable may lead to considerable loss in performance which can neither be compensated by a high antenna gain nor by a high transmission power. For every 3 dB of coaxial cable loss, half the transmitter power will be lost before reaching the antenna. The received signal will also be reduced.

Consider the following factors when selecting the cable:

– Cable length to the antenna
– Acceptable signal loss
– Cable installation options

Antenna

Select the antenna depending on the application:

Application	Antenna
Short range and direct line of sight without any obstacles	Small omnidirectional antenna
Medium range	Large omnidirectional antenna (observe the vertical apex angle)
Wide range	Panel antenna (observe the horizontal apex angle)

For additional information on omnidirectional and panel antennas, please refer to the DB EN WIRELESS ACCESSORIES data sheet. The latest documentation can be downloaded at phoenixcontact.net/products.

9.5 Installing antennas

WARNING: Explosion hazard when used in potentially explosive areas

Observe the safety notes in Section 2, “For your safety” on page 19.

NOTE: Malfunction

The wireless module must be at least 3 cm away from the installed antenna (according to R&TTE directive 1999/5/EC).

Observe the installation notes from the antenna manufacturer to ensure that the panel or omnidirectional antennas will function properly.

The following recommendations apply to all antenna installations:

Install the antenna in an open area as far away as possible from any obstacles such as buildings, dense deciduous forest or metal objects. Choose a location that provides a clear signal path in the direction of the opposite antenna. If two antennas are located in the same place, they should have a distance between them of at least 0.6 m in the vertical direction and 1 m in the horizontal direction.

Pay attention to antenna polarization. Most systems use a vertically polarized omnidirectional antenna at the master station. The opposite antennas must therefore also be polarized vertically. Vertical polarization means that the elements are aligned vertically to the horizon. Crossing polarization between the stations results in a signal loss of 20 dB, minimum.

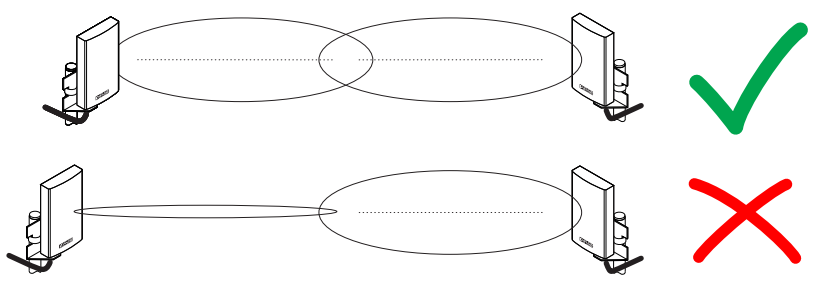


Figure 9-3 Antenna polarization

9.5.1 Aligning panel antennas

- First, align the antennas roughly. Use the following:
  - Topographic map
  - GPS device or compass
  - LED bar graph on the wireless module

Even if there is no direct line of sight, you can find the alignment point:

- Having carried out a rough alignment, you can now finely align the antenna via the RSSI voltage. Measure the RSSI voltage at the RSSI test socket of the wireless module (2.1/2.2) using a multimeter. For additional information on the RSSI voltage, please refer to page 48.
- You always have to align both antennas with each other, because the radio waves need to radiate into the antennas.
- In particular with regard to panel antennas, it is important to ensure that the antenna is properly fixed. If the antenna sways in the wind, the transmission or reception beam can move out of its target area.

9.6 Level and attenuation of wireless modules and accessories

Keep the connection between wireless module and antenna as short as possible. Every extension or adapter cable (pigtail) will cause higher attenuation. A 10 m long RAD-CAB-EF393-10M extension cable results in a loss of 5 dB. The connectors have a typical attenuation of 0.2 dB, i.e., the attenuation value is 0.4 dB + cable length per extension or adapter cable.

You can calculate the levels and attenuation of the wireless devices and accessories using the following table:

Table 9-1 Levels and attenuation of the wireless devices and accessories

Wireless technology	Wireless module	Connection	Max. power: level at the antenna connection	Settable to
Trusted Wireless	RAD-2400-IFS	RSMA (f)	20 dBm at 2.4 GHz	1 ... 20 dBm (in steps of 1 dB)

Adapter/cable	Connection	Order No.	Attenuation	Length
Pigtail/adapter - EF316				
RAD-PIG-EF316-MCX-SMA	MCX(m) - SMA(m)	2867678	1.9 dB	1 m
RAD-PIG-EF316-MCX-N	MCX(m) - N(m)	2867681	0.95 dB	0.5 m
RAD-PIG-EF316-N-SMA	N(f) - SMA(m)	2867694	0.57 dB	0.3 m
RAD-PIG-EF316-N-N	N(f) - N(m)	2867704	0.95 dB	0.5 m
RAD-PIG-EF316-SMA-SMA	SMA(m) - SMA(m)	2885618	0.95 dB	0.5 m
Antenna cable - EF393				
RAD-PIG-EF316-N-RSMA	N(f) - RSMA(m)	2701402	0.95 dB	0.5 m

Adapter/cable [...]	Connection [...]	Order No. [...]	Attenuation [...]	Length [...]
RAD-CAB-EF393-3M	N(m)	2867649	1.9 dB	3 m
RAD-CAB-EF393-5M	N(m)	2867652	2.9 dB	5 m
RAD-CAB-EF393-10M	N(m)	2867665	5.4 dB	10 m
RAD-CAB-EF393-15M	N(m)	2885634	7.9 dB	15 m
Antenna cable - LMR195				
RAD-PIG-RSMA/N-0.5	RSMA - N(m)	2903263	0.3 dB	0.5 m
RAD-PIG-RSMA/N-1	RSMA - N(m)	2903264	0.6 dB	1 m
RAD-PIG-RSMA/N-2	RSMA - N(m)	2903265	1.2 dB	2 m
RAD-PIG-RSMA/N-3	RSMA - N(m)	2903266	1.8 dB	3 m
Adapter				
RAD-ADP-SMA/F-SMA/F	SMA(f) - SMA(f)	2884541	0.3 dB	-
RAD-ADP-N/M-SMA/F	SMA(f) - N(m)	2917036	0.3 dB	-
RAD-ADP-N/F-N/F	N(f) - N(f)	2867843	0.3 dB	-
RAD-ADP-RSMA/F-SMA/F	RSMA(m) - SMA(f)	2884538	0.3 dB	-
Surge protection				
CN-LAMBDA/4-5.9-BB	N(f) - N(f)	2838490	0.15 dB	-

Antenna	Connec-tion	Order No.	Gain	Remark
Omnidirectional antenna				
RAD-ISM-2400-ANT-OMNI-2-1-RSMA	RSMA(m)	2701362	0 dBi	2.1 dBi - 2.1 dB (1.5 m cable)
RAD-ISM-2400-ANT-VAN-3-0-RSMA	RSMA(m)	2701358	1.5 dBi	3 dBi - 1.5 dB (1.5 m cable)
RAD-ISM-2400-ANT-VAN-3-0-SMA	SMA(m)	2885876	1.5 dBi	3 dBi - 1.5 dB (1.5 m cable)
RAD-ISM-2459-ANT-FOOD-6-0	N(f)	2692526	6 dBi	-
RAD-ISM-2400-ANT-OMNI-6-0	N(f)	2885919	6 dBi	-
RAD-ISM-2400-ANT-OMNI-6-0-SW	N(f)	2903219	6 dBi	-
RAD-ISM-2400-ANT-OMNI-9-0	N(f)	2867623	9 dBi	-
Panel antenna				
RAD-ISM-2400-ANT-PAN-8-0	SMA(f)	2867610	8 dBi	
RAD-ISM-2400-ANT-CIR-8-0	SMA(f)	2864936	8 dBi	-
ANT-DIR-2459-01	N(f)	2701186	9 dBi	-
RAD-ISM-2400-ANT-PAR-19-0	N(f)	2867885	19 dBi	-

9.7 Free space path loss

When using wireless transmission technology, the signal between sender and receiver is attenuated through the air. The following table lists loss values for different distances with a free Fresnel zone at 2.4 GHz.

Table 9-2 Free space path loss

Distance	Attenuation
5 m	54 dB
10 m	60 dB
20 m	66 dB
30 m	69.5 dB
50 m	74 dB
100 m	80 dB
110 m	80.8 dB
120 m	81.6 dB
150 m	83.5 dB
200 m	86 dB
250 m	88 dB
300 m	89.5 dB
350 m	90.9 dB
400 m	92 dB
450 m	93.1 dB
500 m	94 dB
550 m	94.8 dB
600 m	95.6 dB
650 m	96.3 dB
700 m	96.9 dB
750 m	97.5 dB
800 m	98.1 dB
850 m	98.6 dB
900 m	99.1 dB
950 m	99.6 dB
1000 m	100 dB

General formula: **free space path loss [dB] = 32.4 + 20 x log(f) + 20 x log(d)**

Formula at 2.4 GHz: **free space loss path [dB] = 100 + 20 x log(d)**

f = transmission frequency in MHz

d = distance between the antennas in km

The free space path loss is later included in the system calculation (see Section “Equivalent isotropically radiated power (EIRP)” on page 143).

9.8 Propagation of radio waves

In addition to the free space path loss, there are other factors which influence the wireless path. Dispersion, diffraction, and reflection represent types of interference that occur when the wireless signal encounters obstacles. They result in multipath propagation.

Dispersion

The dispersion of the wireless signal (e.g., at a tree) means that the wireless signal is dispersed in several directions. A tree without any leaves virtually allows all signals to completely pass through, whereas a tree with foliage results in a considerable degree of dispersion. The leaf surfaces disperse the wireless signal in all possible directions.

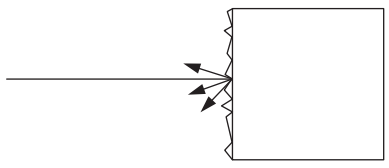


Figure 9-4 Dispersion on a rough surface

Diffraction

Diffraction of the wireless signal, e.g., on edges and obstacles, involves the signal being refracted around the edge. The signal then changes its direction. This is similar to the refraction of light in a crystal.

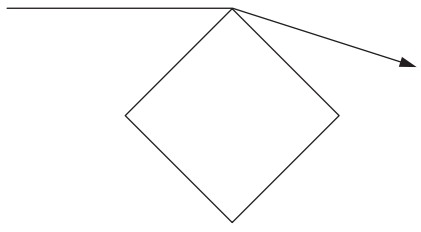


Figure 9-5 Diffraction on an edge

Reflection

Reflection on a smooth metal surface involves virtually the entire wireless signal being reflected at the same angle. In certain applications, the reflection may have a positive effect (e.g., if there is no line of sight). Reflections mainly occur in buildings.

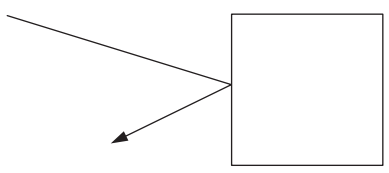


Figure 9-6 Reflection on a metal surface

Penetration

The type of wall encountered also influences the attenuation of the wireless signal. For example, the following constructions adversely affect the wireless signal:

- Hollow lightweight walls with aluminum-lined insulation
- False ceilings with metal or carbon fiber panels
- Lead glass
- Insulation glass (Thermopen)
- Glass with a metal coating
- Steel objects
- Fire walls
- Elevator shafts and stairwells

Each material has a different degree of attenuation. However, the following typical values provide a rough orientation.

Table 9-3 Attenuation with regard to different materials

Obstacle	Typical attenuation at 2.4 GHz [dB]
Thin wall	2 ... 5
Wooden wall	5
Brick wall	6 ... 12
Concrete wall	10 ... 20
Concrete ceiling	20
Elevator	20 ... 30

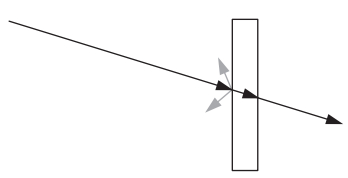


Figure 9-7 Reduction of radio waves when penetrating a wall

Also observe the angle between transmitter and receiver. Depending on the angle, the radio waves have to penetrate more or less material.

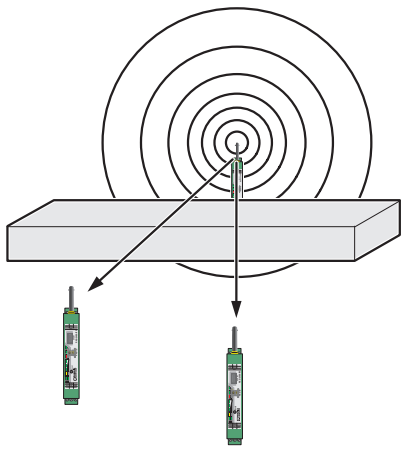


Figure 9-8 Angle of the transmitter and receiver

Radio dead spot

Radio dead spots are caused by impenetrable obstacles in the wireless path. The radio dead spot can be compared to the shadow cast by the sun. If the receiver is located in a radio dead spot, no direct radio waves can reach it, it can only receive reflections or diffracted waves.

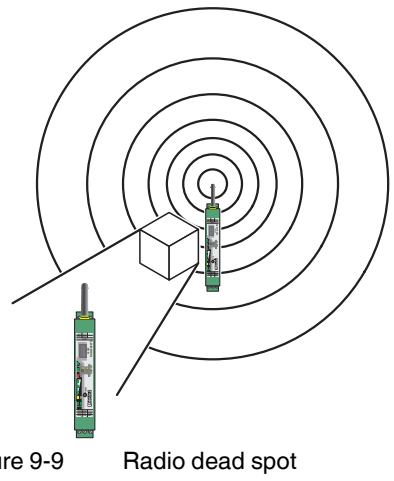


Figure 9-9 Radio dead spot

Weather influences

Snow, rain or hail only have a small effect on the wireless signal in the 2.4 GHz range.

Heavy rain, for example, only has a minimal effect on the wireless signal. With a rainfall of 50 liters per square meter, a cloudburst, there only occurs an attenuation of around 0.02 dB/km at a frequency of 2.4 GHz.

A strong wind does not influence the wireless signal, however, it places high requirements on the secure fixing of the antenna. In particular when using panel antennas with a small apex angle, you should ensure that the antenna cannot be shifted by the wind. If the antenna is moved by just 1 cm from its original position, this can result in a partial loss of the wireless signal, especially when it has a long transmission path.

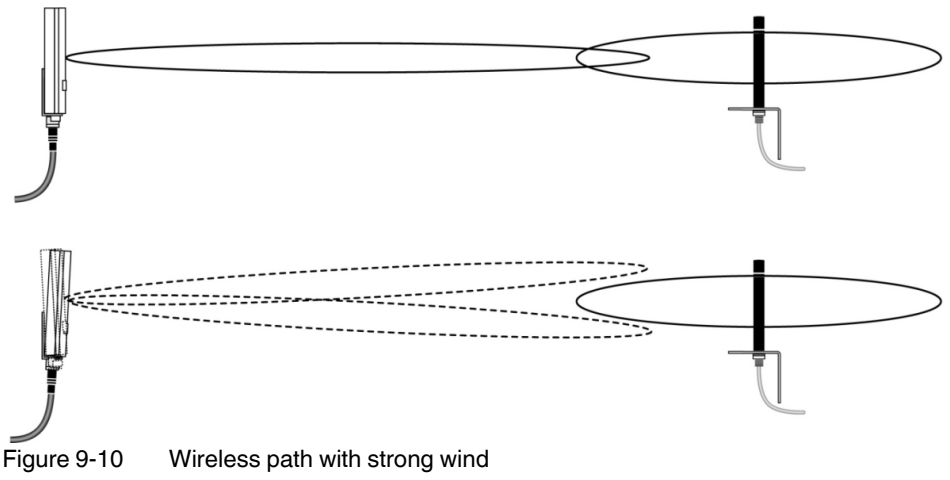


Figure 9-10 Wireless path with strong wind

9.9 Fresnel zone

A certain area between the transmitting and receiving antennas on the wireless path is referred to as the Fresnel zone. There should be a line of sight, especially in the event of longer distances, between the antennas. To adhere to the Fresnel zone, you might be required to install the antennas at a height of a few meters. This area should also be free from any other obstacles.

The ideal wireless path with a direct line of sight between transmitter and receiver is not always possible. In applications, obstacles often have to be taken into consideration, which affect the wireless channel. The wireless path may also work if obstacles (house, tree, etc.) are within the Fresnel zone. The decisive factor is the number of obstacles and the area they occupy in the Fresnel zone. In this case, you should carry out test measurements.

Inside buildings, e.g., in conventional automation environments, there is a predominance of reflections. They contribute to a good wireless connection even if the Fresnel zone is not free from obstacles.

The following figure shows the Fresnel zone between two antennas. The required mounting height for the antennas depends on the radius of the Fresnel zone.

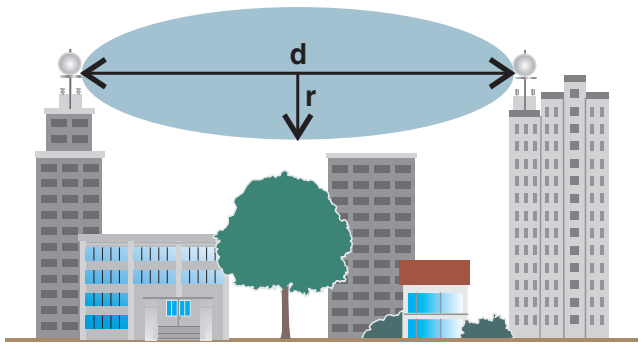


Figure 9-11 Fresnel zone

Table 9-4 Radius of the Fresnel zone depending on the distance

Wireless path distance (d)	Radius of the Fresnel zone (r) at 2.4 GHz
200 m	1.5 m
500 m	4 m
1000 m	5 m
2000 m	8 m
4000 m	11 m

General formula for calculating the diameter of the Fresnel zone:

$$r = 0.5 \times \sqrt{\lambda \times d}$$

r = radius of the Fresnel zone

λ = wavelength (0.125 m at 2.4 GHz)

d = distance between the antennas in km

Radius of the Fresnel zone with d = 3000 m:

$$r = 0.5 \times \sqrt{0.125 \times 3000}$$

r = 9.68 m

Result: The radius of the Fresnel zone is 9.68 m at a wavelength of 0.125 m (2.4 GHz) and a distance of 3000 m between the antennas.

9.10 Range

It is very difficult to specify a range due to the influence of various factors. Based on practical tests, it is possible to provide guideline values. These can be clearly exceeded or fallen below depending on the actual application:

The range depends on the following:

– Data rate set (default setting: 125 kbps)
– Antenna cable length
– Antenna used

Table 9-5 Ranges for different antennas

Antenna	Data rate of the wireless interface [kbps]	Range [m]
Inside buildings		
2 dBi omnidirectional antenna	≤250 ≤125	50 ... 100 100 ... 200
Outside buildings, with a free line of sight		
2 dBi omnidirectional antenna	≤250 ≤125	50 ... 100 100 ... 200
6 dBi omnidirectional antenna	≤125	≤1500
8 dBi or 9 dBi panel antenna	≤125	≤3000
	16	≤5000
19 dBi panel antenna	16	>5000

9.11 Equivalent isotropically radiated power (EIRP)

The equivalent isotropically radiated power is a gauge of the radiation power of an antenna. The EIRP value is the sum of the transmission power in dBm and the antenna gain in dBi.

Example:

- Transmission power = 14 dBm
- Antenna gain = 8 dBi
- Attenuation through a 3 m long cable = 2.85 dB
- EIRP = 14 + 8 - 2.85 dBm = 19.15 dBm

9.12 System calculation in free space

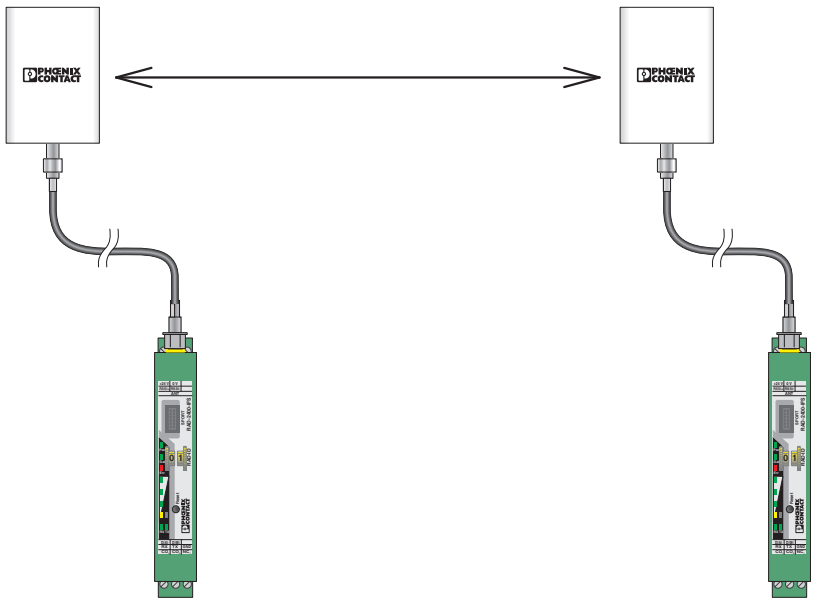


Figure 9-12 Free space path loss

Antenna gain per antenna: 8 dBi

Transmission power per wireless module: 14 dBm

Cable attenuation per cable (3 m EF 142): 2.85 dB

Free space path loss 400 m: 92 dB

Example calculation with optimal free space

– Wireless technology: Trusted Wireless
– Wireless path length: 400 m
– Device transmission power + antenna gain - cable attenuation (EIRP): ≤20 dBm
(20 dBm must not be exceeded for legal reasons, adapt the cable, adapter or transmission power, if required)

EIRP [dBm] =
transmitter power [dBm]
+ gain of sending antennas [dBi]
- losses of the transmitter cable [dB]

Incoming power for the receiver [dBm] =
transmitter power [dBm]
- losses of the transmitter cable [dB]
+ gain of the sending antenna [dBi]
- free space path loss [dB]
+ gain of the receiving antenna [dBi]
- attenuation of the antenna cable at the receiver [dBm]

System reserve =
receiver sensitivity [dBm]
- incoming power for the receiver [dBm]
(recommended system reserve >10 dB)

EIRP = 19.15 dBm

Free space path loss [dB] =
32.4 + 20 log(f[MHz]) + 20 log(R[km]) = 32.4 + 20 log(2400) + 20 log(0.4) = 92 dB

Incoming power for the receiver = -67.7 dBm

Receiver sensitivity = -96 dB (with a data rate of 125 kbps)

System reserve = 96 dB - 67.7 dB = 28.3 dB

Conclusion: The losses of 67.7 dB are significantly lower than the receiver sensitivity of -96 dB. The desired wireless connection is therefore possible in mathematical terms.

9.13 Practical examples

It is not possible to provide basic calculation principles for obstacles in the wireless path as the obstacles and applications will vary too much. The practical examples given below are for guidance only and cannot be directly transferred to other applications.

Bushes

The bush illustrated below is two meters wide and has an attenuation of approximately 15 dB.

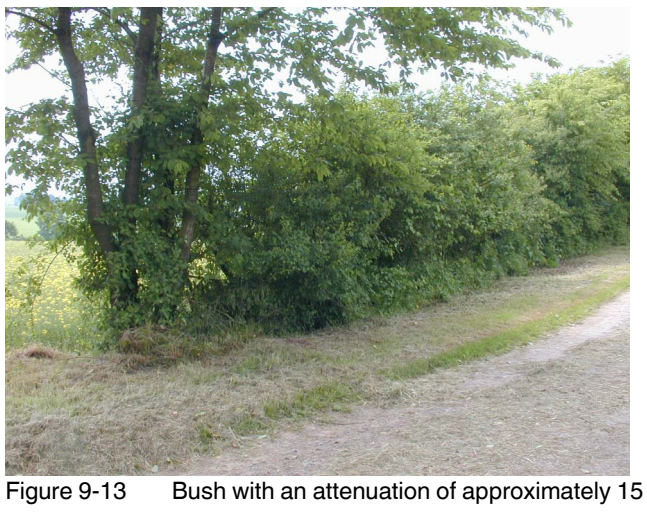


Figure 9-13 Bush with an attenuation of approximately 15 dB

Forest

The forest illustrated below consists of dense undergrowth with a trunk diameter of approx. 5 to 20 centimeters. In our test, the wireless signal was transmitted through a 25 m wide forest. Attenuation was roughly 40 dB.

Figure 9-14 Forest with an attenuation of about 40 dB

10 Detecting and removing errors

If your wireless system does not function properly, proceed as follows:

- First, ensure that you have a good wireless signal (2 green bar graph LEDs or RSSI voltage ≥1.5 V).
- Check the status of the individual stations:
  - If the PSI-CONF software is installed, check the device status of all network devices via online diagnostics.
  - If the PSI-CONF software has **not** been installed, check the bar graph LEDs on the front of each device.
- Find the error using the tables from page 149 onwards.

Avoid contact between the antennas of two wireless module, otherwise the receiver might become overloaded.

Ground loops are caused by the grounding of the antenna via the antenna fixing unit, grounding the power supply or serial interface. To avoid ground loops, connect these components to a single ground point.

Strength of the receive signal

You can determine the strength of the receive signal by means of the RSSI voltage. The signal strength is displayed on the LED bar graph on the wireless module.

– In a point-to-point connection, the LED bar graph is active on the master and on the repeater/slave.
– In a wireless network with more than one repeater/slave, only the yellow LED on the master is permanently on. The signal strength is displayed on the repeaters/slaves. The displayed signal strength is always related to the next wireless module in direction of the master (parents).

The RSSI indicator is a voltage output in the range between 0 V DC ... 3 V DC. The higher the voltage, the better the wireless connection. The measured voltage is directly related to the receive signal in -dB. However, please observe the small voltage fluctuation due to multipath propagation.

The recommended minimum signal strength is 1.5 V DC. This results in a power reserve of approximately 10 dB which ensures communication even in the event of unfavorable transmission conditions.

You can measure the RSSI voltage at the RSSI test socket or read it using the PSI-CONF software. When connecting the master wireless module to a PC, you can read the RSSI voltages in the entire wireless network. At a slave or repeater, it is only possible to read the RSSI voltage of the specific wireless module connected.

Table 10-1 RSSI voltage

		16k	125k	250k	500k	RSSI voltage
LED 3		-70 dBm	-65 dBm	-60 dBm	-55 dBm	2.5 V
LED 2		-80 dBm	-75 dBm	-70 dBm	-65 dBm	2.0 V
LED 1		-90 dBm	-85 dBm	-80 dBm	-75 dBm	1.5 V
LINK LED		LINK	LINK	LINK	LINK	~1.0 V

Table 10-2 Detecting and removing errors: wireless module

LED, wireless module	Current state and possible cause	Solution
-	Wireless module cannot be configured using the PSI-CONF software	• Make sure that the wireless module is supplied with power. • Make sure that you are using the correct cable: – RAD-CABLE-USB (Order No. 2903447), power supply via the USB port on the PC – IFS-USB-DATACABLE (Order No. 2320500), external power supply • Install the USB driver. The driver is installed automatically during PSI-CONF software installation (see page 40).
PWR off	No power supply, mains probably switched off.	• Switch the mains on, restore the power supply.
DAT off	No communication between wireless module and I/O extension module. Wireless module possibly in “Serial data” operating mode.	• Check whether the I/O extension module is properly snapped onto the DIN rail connector and whether it is connected to the wireless module. • Check the operating mode of the wireless module using the PSI-CONF software. The wireless module must either be in “I/O data” or “PLC/Modbus RTU” mode (see page 40). • Reset the wireless module to the default settings (I/O data mode), if required. Disconnect the device from the supply voltage, hold down the SET button and switch the supply voltage on again (see page 33).
ERR on	Local bus error The input or output module is disconnected from the DIN rail connector and the bus.	• Check whether the I/O extension module is properly snapped onto the DIN rail connector. • Press the SET button on the front of the wireless module or carry out a power up. The data of the I/O extension modules are read in again.
ERR + DAT flashing	Writing to the memory stick has not been possible	• Repeat the process in order to correctly write to the memory stick.

LED, wireless module	Current state and possible cause	Solution
ERR flashing fast (2.8 Hz), bar graph does not light up	No wireless connection, even though the wireless modules are **not** far away from each other	• Make sure that, in a network, only one wireless module is configured as the master (RAD ID = 01) and all other wireless modules are slaves or repeaters. Reconfigure the wireless network, if necessary. • Check whether the set RAD ID is a permitted address. • Make sure that each RAD ID (yellow thumbwheel) only occurs once in the network. • There could be an overload problem: In order to be able to cover the largest possible distances, the preamplifier has been activated and transmission power set to 20 dBm by default. When operating the devices directly next to one another, the receiver might become overloaded. In this case, remove the antennas, increase the distance between the devices/antennas or reduce transmission power using the PSI-CONF software (from page 40 onwards). • Using the PSI-CONF software, check whether the network parameters have the same settings on all wireless modules (operating mode, network ID, RF band, data rate of the wireless interface, encryption, network type, from page 40 onwards). • Reset the wireless module to the default settings (I/O data mode), if required. Disconnect the device from the supply voltage, hold down the SET button and switch the supply voltage on again (see page 33).
	No wireless connection, the wireless modules are far away from each other	• Check whether the antennas are connected and aligned properly. • Make sure that the antenna connections are tight and free from corrosion. • Install the antenna at a higher point. Adhere to the Fresnel zone. • Use a different antenna with higher antenna gain or use shorter cables with lower signal attenuation. • Check whether there is another transmitting antenna in close proximity. Position the antenna further away from all other antennas (at least 1 m in the horizontal direction or 0.6 m in the vertical direction). • Make sure that the power supply is sufficient. • Make sure that there is no connection between the core and the shield of the cable in the connected antenna system.

LED, wireless module	Current state and possible cause	Solution
LED bar graph, yellow LED is on only	Connection with low receive signal	• Check whether the antennas are connected and aligned properly. • Make sure that the antenna connections are tight and free from corrosion. • Install the antenna at a higher point. Observe the Fresnel zone. • Use a different antenna with higher antenna gain or use shorter cables with lower signal attenuation. • Check whether there is another transmitting antenna in close proximity. Position the antenna further away from all other antennas (at least 1 m in the horizontal direction or 0.6 m in the vertical direction). • Make sure that the power supply is sufficient. • Make sure that there is no connection between the core and the shield of the cable in the connected antenna system.
	Several repeaters/slaves at the wireless master	• No action required, normal display for a wireless network with more than one repeater/slave. The signal strength is indicated on the repeaters/slaves and is always related to the next wireless module in the direction of the master (parents).
In I/O data mode		
ERR flashing slowly (1.4 Hz)	Double assignment of IO-MAP address, two input modules have the same I/O-MAP address in a network	• The I/O MAP address of an input module may appear only once in the network. Use the white thumbwheel to set different I/O-MAP addresses.
	Missing input module Example: An output module does not have the corresponding input module with the same I/O-MAP address.	• Check whether an input module with the same I/O-MAP address has been assigned to each output module. • Set the I/O-MAP address (01 ... 99) using the white thumbwheel on the extension module. The input module must be provided with the same I/O-MAP address as the assigned output module at the other wireless station.
	Missing output module Example: An input module does not have the corresponding output module with the same I/O-MAP address.	• Check whether an output module with the same I/O-MAP address has been assigned to each input module. • Set the I/O-MAP address (01 ... 99) using the white thumbwheel on the extension module. The output module must be provided with the same I/O-MAP address as the assigned input module at the other wireless station.
	RAD ID changed Example: The yellow thumbwheel setting has accidentally been modified and the modification has not yet been confirmed via the SET button.	• Check the RAD ID setting on the yellow thumbwheel of the wireless module. • If necessary, set the correct RAD ID and press the SET button.

LED, wireless module	Current state and possible cause	Solution
In PLC/Modbus RTU mode		
ERR flashing slowly (1.4 Hz)	Double assignment of I/O-MAP address, two input modules have the same I/O-MAP address in a network	• The I/O MAP address of an input module may appear only once in the network. Use the white thumbwheel to set different I/O-MAP addresses.
	RAD ID changed Example: The yellow thumbwheel setting has accidentally been modified and the modification has not yet been confirmed via the SET button.	• Check the RAD ID setting on the yellow thumbwheel of the wireless module. • If necessary, set the correct RAD ID and press the SET button.
	No Modbus communication (only if watchdog is activated) Example: The communication line between the Modbus/RTU controller and the master wireless module is broken.	• Check the communication line between the Modbus/RTU controller and the master wireless module with RAD ID 01. • Check the wiring of the RS-232/485 connections on the wireless modules. • Check the serial interface settings (baud rate, parity, data bits and stop bits) for the wireless modules and serial termination devices. • Check whether the I/O extension module is properly snapped onto the DIN rail connector. • Check whether the wireless module is in PLC/Modbus RTU mode using the PSI-CONF software (see page 40). • Press the SET button on the wireless module or carry out a power up in order to read in the station structure.
In “Serial data” or “PLC/Modbus RTU” mode		
RX, TX off	Wireless connection present, but application does not transmit any data	• Check the wiring of the RS-232/485 connections on the wireless modules. • Check the serial interface settings (baud rate, parity, data bits and stop bits) for the wireless modules and serial termination devices (from page 40 onwards).

Table 10-3 Detecting and removing errors: I/O extension module

LED, I/O module	Current state and possible cause	Solution
PWR off	No power supply. Mains probably switched off.	• Switch the mains on, restore the power supply.
DAT off	No communication between wireless module and I/O extension module. Wireless module possibly in “Serial data” operating mode.	• Check whether the I/O extension module is properly snapped onto the DIN rail connector and whether it is connected to the wireless module. • Check the operating mode of the wireless module using the PSI-CONF software. The wireless module must either be in “I/O data” or “PLC/Modbus RTU” mode (see page 40). • Reset the wireless module to the default settings (I/O data mode, see page 33), if required.
ERR on	Critical internal error Example: Technical defect	• Please contact Phoenix Contact technical support.
ERR flashing slowly (1.4 Hz)	I/O-MAP address changed Example: The white thumbwheel setting has accidentally been modified and the modification has not yet been confirmed via the SET button.	• Check the IO-MAP address setting on the white thumbwheel of the I/O extension module. • If necessary, set the correct I/O-MAP address and press the SET button on the wireless module.
In I/O data mode		
ERR flashing fast (2.8 Hz)	Missing input module Example: An output module does not have the corresponding input module with the same I/O-MAP address.	• Check whether an input module with the same I/O-MAP address has been assigned to each output module. • Set the I/O-MAP address (01 ... 99) using the white thumbwheel on the extension module. The input module must be provided with the same I/O-MAP address as the assigned output module at the other wireless station.
	No bus communication, no wireless connection present	• See measures for the wireless module, page 150
In PLC/Modbus RTU mode		
ERR flashing fast (2.8 Hz)	No Modbus communication (safe state of outputs, depending on DIP switch setting)	• Check the communication line between the Modbus/RTU controller and the master wireless module with RAD ID 01. • Check the wiring of the RS-232/485 connections on the master and the PLC. • Check the serial interface settings (baud rate, parity, data bits and stop bits) for the master and the PLC (from page 40 onwards). • Check whether the I/O extension module is properly snapped onto the DIN rail connector. • Check whether the wireless module is in PLC/Modbus RTU mode using the PSI-CONF software (see page 40). • Press the SET button on the wireless module or carry out a power up in order to read in the station structure.
	No bus communication, no wireless connection present	• See measures for the wireless module, page 150

10.1 Loopback test during serial data transmission

With an RS-232 interface, you can use the loopback test to check the data path from the master to the slave and back again. To this end, you need to short-circuit two terminal points of the RS-232 interface on the slave wireless module. It is then possible to transmit characters to the master wireless module using a terminal program (e.g., HyperTerminal). The characters are echoed back to the terminal program.

Note for Windows 7 users:

HyperTerminal is no longer available in Windows 7. Instead you can use any other terminal program.

To carry out a loopback test, proceed as follows:

- Close all PC programs on your PC, including the PSI-CONF software.
- Connect the PC to the master wireless module and start HyperTerminal via “Start, All Programs, Accessories, Communication, HyperTerminal”. The COM port settings on the PC must correspond to the interface settings on the master wireless module.
- Connect the terminal points 5.1 and 5.2 of the RS-232 interface on the slave module you need to test.

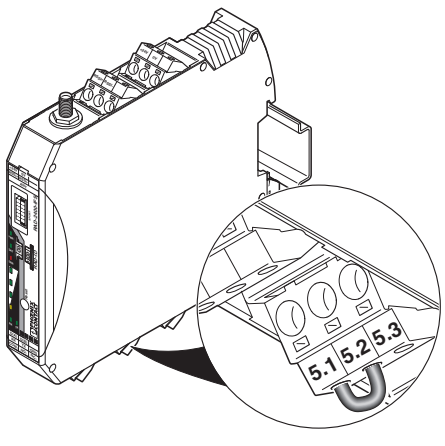


Figure 10-1 Loopback test for an RS-232 interface

- Connect both wireless modules to the power supply.
- Check the wireless connection via the LED bar graph.
- Enter several characters of your choice. HyperTerminal transmits these characters over the wireless path. On the slave side the characters are output (e.g., at terminal point 5.1, RX cable of the RS-232 interface) and immediately read again using the bridge (e.g., at terminal point 5.2, TX cable of the RS-232 interface). This returns the already transmitted characters and they appear twice on the HyperTerminal screen.
  – The screen remains blank if the check was not successful. Monitor the TX and RX LEDs on every wireless module. You can thereby determine the point up to which data has been transmitted.
  – In case the characters only appear once, check the HyperTerminal settings for hidden outgoing characters. The following options must be enabled under
  “File, Properties, Settings, ASCII Setup”:
  “Echo typed characters locally” and
  “Append line feeds to incoming line ends”

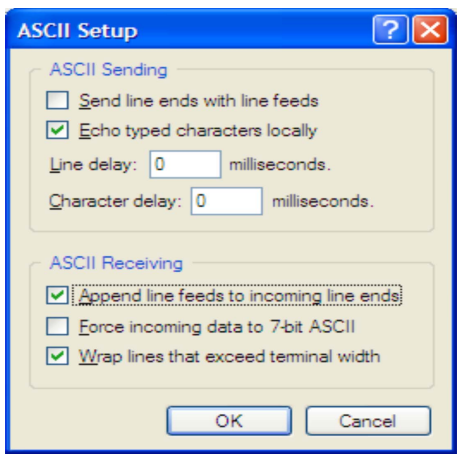


Figure 10-2 Settings in HyperTerminal

A Technical appendix

A 1 Typical combinations of antennas and adapter cables

In this section, you will find typical combinations of wireless modules, antennas and adapter cables for the installation with or without control cabinet.

Mount the antenna outside the control cabinet or building.

Observe the installation instructions of the antenna and Section “For your safety” on page 17.

Observe the maximum radiated transmission power of 20 dBm. The transmission power can be calculated from:
device transmission power + antenna gain - cable attenuations

Reduce the device transmission power, if necessary.

Omnidirectional antenna, 2 dBi

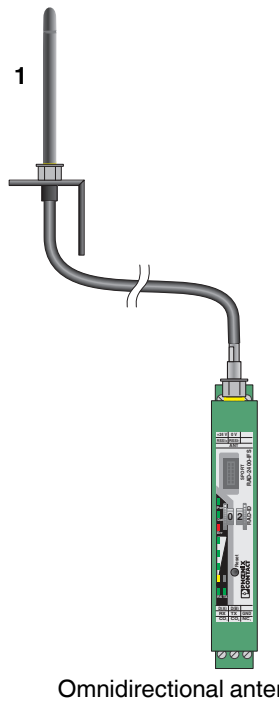


Figure A-1 Omnidirectional antenna, 2 dBi

Item	Product	Description	Connection	Order No.
1	RAD-ISM-2400-ANT-OMNI-2-1-RSMA	Omnidirectional antenna, 2.4 GHz, 2 dBi gain, 1.5 m cable length, linear vertical polarization, h/v 360°/75° apex angle, IP65 degree of protection	RSMA (male)	2701362

Omnidirectional antenna with protection against vandalism, 2.5 dBi

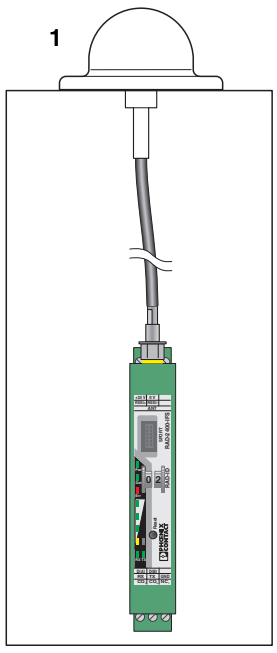


Figure A-2 Omnidirectional antenna with protection against vandalism, 2.5 dBi

Item	Product	Description	Connection	Order No.
1	RAD-ISM-2400-ANT-VAN-3-0-RSMA	Omnidirectional antenna with protection against vandalism, 2.4 GHz, 3 dBi gain, IP55 degree of protection, 1.5 m cable length, h/v 360°/85° apex angle. Appropriate mounting material is available for wall mounting.	RSMA (male)	2701358

Omnidirectional antenna, 2.5 dBi

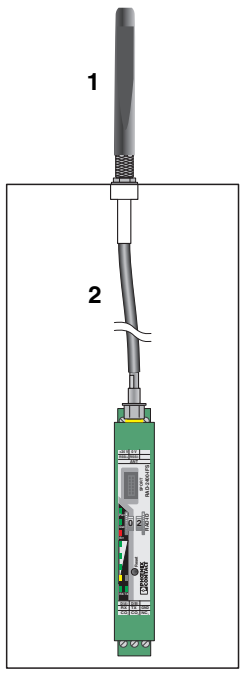


Figure A-3 Omnidirectional antenna, 2.5 dBi

Item	Product	Description	Connection	Order No.
1	ANT-OMNI-2459-02	Omnidirectional antenna, 2.4 GHz/5 GHz, 2.5/5 dBi gain, linear vertical polarization, apex angle 2.4 GHz h/v 360°/30°, 5 GHz h/v 360°/16°, IP68 degree protection	N (male)	2701408
2	RAD-PIG-EF316-N-RSMA	Adapter cable, pigtail 50 cm, insertion loss 0.75 dB at 2.4 GHz; 1.25 dB at 5 GHz	N (female) → RSMA (male)	2701402

Omnidirectional antenna, 6 dBi, without surge protection

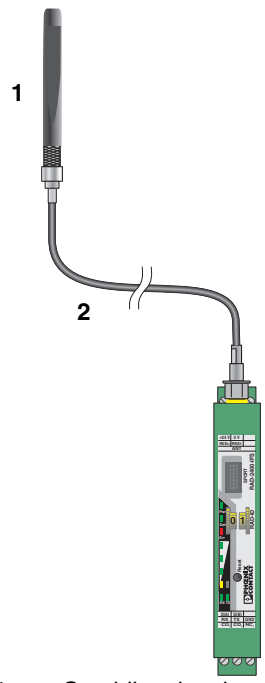


Figure A-4 Omnidirectional antenna, 6 dBi, without surge protection

Item	Product	Description	Connection	Order No.
1	RAD-ISM-2400-ANT-OMNI-6-0	Omnidirectional antenna, 2.4 GHz, 6 dBi gain, linear vertical polarization, h/v 360°/30° apex angle, IP55 degree of protection	N (female)	2885919
	Alternative:			
	RAD-2400-ANT-OMNI-6-0-SW	Omnidirectional antenna, 2.4 GHz, 6 dBi gain, linear vertical polarization, h/v 360°/20° apex angle, IP65 degree of protection, seawater-resistant	N (female)	2903219
2	RAD-PIG-RSMA/N-0.5	Antenna cable, 0.5 m length, insertion loss 0.5 dB at 2.4 GHz	N (male) → RSMA (male)	2903263
	Alternative:			
	RAD-PIG-RSMA/N-1	Antenna cable, 1 m length, insertion loss 0.8 dB at 2.4 GHz	N (male) → RSMA (male)	2903264
	RAD-PIG-RSMA/N-2	Antenna cable, 2 m length, insertion loss 1.35 dB at 2.4 GHz	N (male) → RSMA (male)	2903265
	RAD-PIG-RSMA/N-3	Antenna cable, 3 m length, insertion loss 1.95 dB at 2.4 GHz	N (male) → RSMA (male)	2903266

Omnidirectional antenna, 6 dBi, with outdoor surge protection

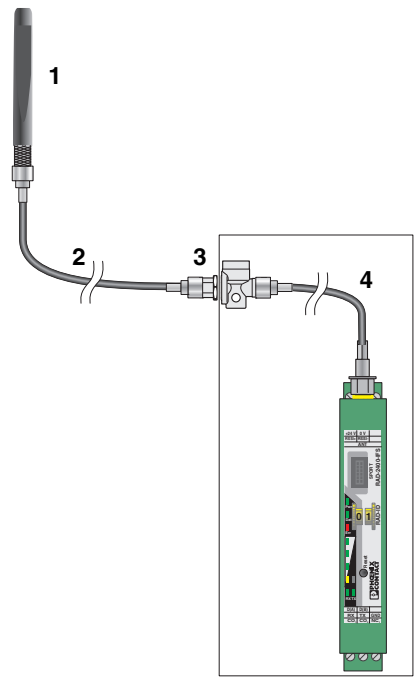


Figure A-5 Omnidirectional antenna, 6 dBi, with outdoor surge protection

Items 2 and 3 are optional.

Item	Product	Description	Connection	Order No.
1	RAD-ISM-2400-ANT-OMNI-6-0	Omnidirectional antenna, 2.4 GHz, 6 dBi gain, linear vertical polarization, h/v 360°/30° apex angle, IP55 degree of protection	N (female)	2885919
	Alternative:			
	RAD-2400-ANT-OMNI-6-0-SW	Omnidirectional antenna, 2.4 GHz, 6 dBi gain, linear vertical polarization, h/v 360°/20° apex angle, IP65 degree of protection, seawater-resistant	N (female)	2903219
2 (opt.)	RAD-CAB-EF393- 3M	Antenna cable, 3 m length, insertion loss approx. 0.45 dB/m at 2.4 GHz	N (male) → N (male)	2867649
	Alternative:			
	RAD-CAB-EF393- 5M	Antenna cable, 5 m length, insertion loss approx. 0.45 dB/m at 2.4 GHz	N (male) → N (male)	2867652
	RAD-CAB-EF393-10M	Antenna cable, 10 m length, insertion loss approx. 0.45 dB/m at 2.4 GHz	N (male) → N (male)	2867665
	RAD-CAB-EF393-15M	Antenna extension cable, 15 m length, insertion loss approx. 0.45 dB/m at 2.4 GHz	N (male) → N (male)	2885634

Item	Product	Description	Connection	Order No.
3 (opt.)	CN-LAMBDA/4-5.9-BB	Attachment plug with Lambda/4 technology as surge protection for coaxial signal interfaces	N (female) → N (female	2838490
4	RAD-PIG-RSMA/N-0.5	Antenna cable, 0.5 m length, insertion loss 0.5 dB at 2.4 GHz	N (male) → RSMA (male)	2903263
	Alternative:			
	RAD-PIG-RSMA/N-1	Antenna cable, 1 m length, insertion loss 0.8 dB at 2.4 GHz	N (male) → RSMA (male)	2903264
	RAD-PIG-RSMA/N-2	Antenna cable, 2 m length, insertion loss 1.35 dB at 2.4 GHz	N (male) → RSMA (male)	2903265
	RAD-PIG-RSMA/N-3	Antenna cable, 3 m length, insertion loss 1.95 dB at 2.4 GHz	N (male) → RSMA (male)	2903266

Panel antenna, 9 dBi, with outdoor surge protection

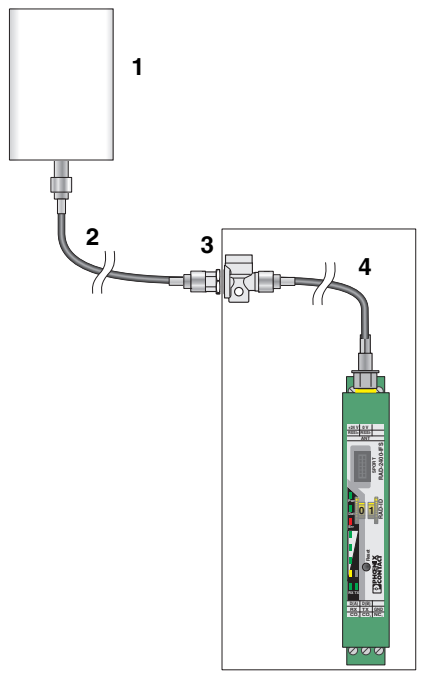


Figure A-6 Panel antenna, 9 dBi, with outdoor surge protection

Items 2 and 3 are optional.

Item	Product	Description	Connection	Order No.
1	ANT-DIR-2459-01	Panel antenna, 2.4/5 GHz, 9 dBi gain, linear vertical polarization, h/v 75°/55° apex angle at 2.4 GHz, IP67 degree of protection	N (female)	2701186
2 (opt.)	RAD-CAB-EF393- 3M	Antenna cable, 3 m length, insertion loss approx. 0.45 dB/m at 2.4 GHz	N (male) → N (male)	2867649
	Alternative:			
	RAD-CAB-EF393- 5M	Antenna cable, 5 m length, insertion loss approx. 0.45 dB/m at 2.4 GHz	N (male) → N (male)	2867652
	RAD-CAB-EF393-10M	Antenna cable, 10 m length, insertion loss approx. 0.45 dB/m at 2.4 GHz	N (male) → N (male)	2867665
	RAD-CAB-EF393-15M	Antenna cable, 15 m length, insertion loss approx. 0.45 dB/m at 2.4 GHz	N (male) → N (male)	2885634
3 (opt.)	CN-LAMBDA/4-5.9-BB	Attachment plug with LAMBDA/4 technology as surge protection for coaxial signal interfaces	N (female) → N (female)	2838490

Item	Product	Description	Connection	Order No.
4	RAD-PIG-RSMA/N-0.5	Antenna cable, 0.5 m length, insertion loss 0.5 dB at 2.4 GHz	N (male) → RSMA (male)	2903263
	Alternative:			
	RAD-PIG-RSMA/N-1	Antenna cable, 1 m length, insertion loss 0.8 dB at 2.4 GHz	N (male) → RSMA (male)	2903264
	RAD-PIG-RSMA/N-2	Antenna cable, 2 m length, insertion loss 1.35 dB at 2.4 GHz	N (male) → RSMA (male)	2903265
	RAD-PIG-RSMA/N-3	Antenna cable, 3 m length, insertion loss 1.95 dB at 2.4 GHz	N (male) → RSMA (male)	2903266

Panel antennas, 8 dBi, with 2-way outdoor antenna splitter

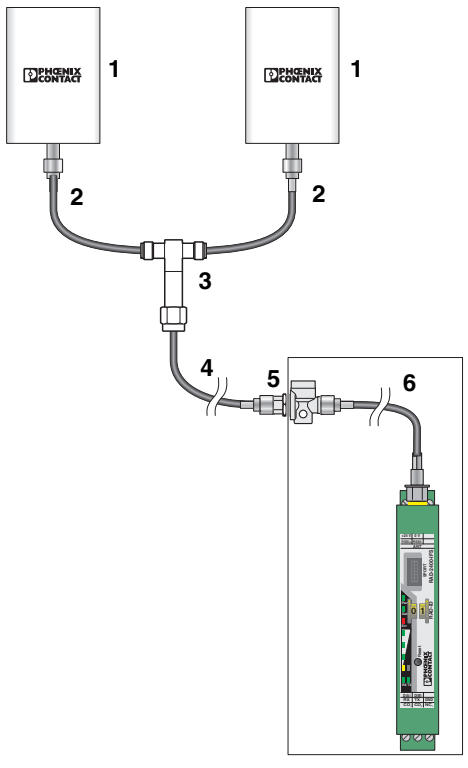


Figure A-7 Panel antennas, 8 dBi, with 2-way outdoor antenna splitter

Items 4 and 5 are optional.

Item	Product	Description	Connection	Order No.
1	RAD-ISM-2400-ANT-PAN- 8-0	Panel antenna, 2.4 GHz, 8 dBi gain, linear vertical polarization, h/v 75°/70° apex angle, IP55 degree of protection	SMA (female)	2867610
2	RAD-PIG-EF316-SMA-SMA	Adapter cable, pigtail 50 cm, insertion loss 1.5 dB at 2.4 GHz	SMA (male) → SMA (male)	2885618
3	RAD-ISM-2400-SPL-2-SMA	2-way distributor for antenna signals (antenna splitter), insertion loss per path 3 dB at 2.4 GHz	2 x SMA (female) → SMA (male)	2885595

Item	Product	Description	Connection	Order No.
4 (opt.)	RAD-CAB-EF393- 3M	Antenna cable, 3 m length, insertion loss approx. 0.45 dB/m at 2.4 GHz	N (male) → N (male)	2867649
	Alternative:			
	RAD-CAB-EF393- 5M	Antenna cable, 5 m length, insertion loss approx. 0.45 dB/m at 2.4 GHz	N (male) → N (male)	2867652
	RAD-CAB-EF393-10M	Antenna cable, 10 m length, insertion loss approx. 0.45 dB/m at 2.4 GHz	N (male) → N (male)	2867665
	RAD-CAB-EF393-15M	Antenna cable, 15 m length, insertion loss approx. 0.45 dB/m at 2.4 GHz	N (male) → N (male)	2885634
5 (opt.)	CN-LAMBDA/4-5.9-BB	Attachment plug with LAMBDA/4 technology as surge protection for coaxial signal interfaces	N (female) → N (female)	2838490
6	RAD-PIG-RSMA/N-0.5	Antenna cable, 0.5 m length, insertion loss 0.5 dB at 2.4 GHz	N (male) → RSMA (male)	2903263
	Alternative:			
	RAD-PIG-RSMA/N-1	Antenna cable, 1 m length, insertion loss 0.8 dB at 2.4 GHz	N (male) → RSMA (male)	2903264
	RAD-PIG-RSMA/N-2	Antenna cable, 2 m length, insertion loss 1.35 dB at 2.4 GHz	N (male) → RSMA (male)	2903265
	RAD-PIG-RSMA/N-3	Antenna cable, 3 m length, insertion loss 1.95 dB at 2.4 GHz	N (male) → RSMA (male)	2903266

Parabolic antenna, 19 dBi, with outdoor surge protection

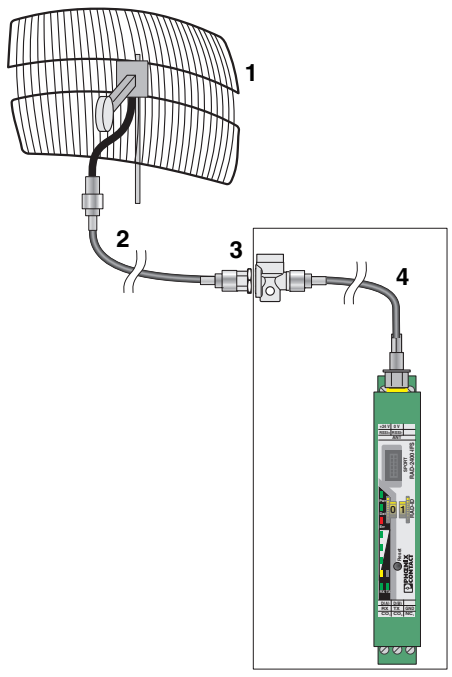


Figure A-8 Parabolic antenna, 19 dBi, with outdoor surge protection

Items 2 and 3 are optional.

Item	Product	Description	Connection	Order No.
1	RAD-ISM-2400-ANT-PAR-19-0	Parabolic antenna, 2.4 GHz, 19 dBi gain, linear vertical polarization, h/v 17°/11° apex angle, IP65 degree of protection	N (female)	2867885
2 (opt.)	RAD-CAB-EF393- 3M	Antenna cable, 3 m length, insertion loss approx. 0.45 dB/m at 2.4 GHz	N (male) → N (male)	2867649
	Alternative:			
	RAD-CAB-EF393- 5M	Antenna cable, 5 m length, insertion loss approx. 0.45 dB/m at 2.4 GHz	N (male) → N (male)	2867652
	RAD-CAB-EF393-10M	Antenna cable, 10 m length, insertion loss approx. 0.45 dB/m at 2.4 GHz	N (male) → N (male)	2867665
	RAD-CAB-EF393-15M	Antenna extension cable, 15 m length, insertion loss approx. 0.45 dB/m at 2.4 GHz	N (male) → N (male)	2885634
3 (opt.)	CN-LAMBDA/4-5.9-BB	Attachment plug with Lambda/4 technology as surge protection for coaxial signal interfaces	N (female) → N (female)	2838490

Item	Product	Description	Connection	Order No.
4	RAD-PIG-RSMA/N-0.5	Antenna cable, 0.5 m length, insertion loss 0.5 dB at 2.4 GHz	N (male) → RSMA (male)	2903263
	Alternative:			
	RAD-PIG-RSMA/N-1	Antenna cable, 1 m length, insertion loss 0.8 dB at 2.4 GHz	N (male) → RSMA (male)	2903264
	RAD-PIG-RSMA/N-2	Antenna cable, 2 m length, insertion loss 1.35 dB at 2.4 GHz	N (male) → RSMA (male)	2903265
	RAD-PIG-RSMA/N-3	Antenna cable, 3 m length, insertion loss 1.95 dB at 2.4 GHz	N (male) → RSMA (male)	2903266

A 2 Autonomous power supply

Phoenix Contact offers a variety of solar systems for supplying power autonomously to wireless modules. You can therefore place the wireless modules anywhere.

Solar systems available as a set:

- RAD-SOL-SET-24-100 (Order No. 2885472)
- RAD-SOL-SET-24-200 (Order No. 2917722)

Each solar system is fitted with a battery for storing power. If the sun is not shining, the wireless module will be supplied via the battery. All components which are required to supply the loads are located in a prewired control cabinet.

Features:

- Easy mounting with the supplied mounting material
- Prewired control cabinet for outdoor use, white powder-coated finish, lockable, with charge controller, fuses, and surge protection
- Mounting on standard masts with a diameter of 76 mm

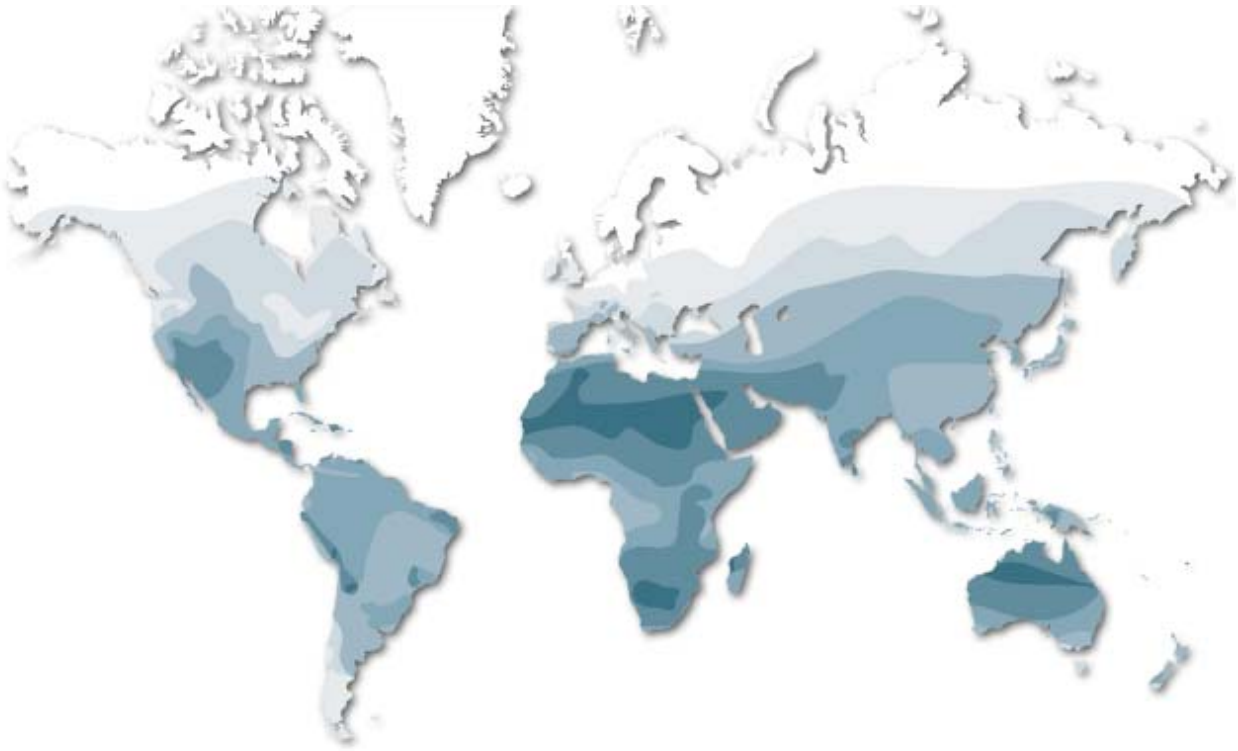


Figure A-9 Maximum connected load for year-round constant load, in relation to power reserve

RAD-SOL-SET-24-100				RAD-SOL-SET-24-200				Region	Global radiation [kWh/m²/day]
Power reserve				Power reserve					
2 days	3 days	4 days	5 days	2 days	3 days	4 days	5 days		
-	-	1.3 W	1.3 W	-	-	2.8 W	3 W	Oslo	0.51
-	-	1.3 W	1.3 W	-	-	2.8 W	3 W	Moscow	0.51
-	-	2.6 W	2.6 W	-	-	5.8 W	5.8 W	Kiev	0.96
-	-	3.2 W	3 W	-	-	6.8 W	6.8 W	Hanover	1.13
-	-	3.2 W	3 W	-	-	7 W	7 W	Brussels	1.16
-	-	3.4 W	3 W	-	-	7.4 W	7.2 W	Cologne	1.22
-	-	3.6 W	3 W	-	-	8.2 W	8 W	Dresden	1.36
-	-	3.6 W	3 W	-	-	8.4 W	8 W	London	1.42
-	-	3.6 W	3 W	-	-	9.6 W	8 W	Munich	1.59
-	4.8 W	3.8 W	3 W	-	10.5 W	9.8 W	8 W	Istanbul	1.75
-	4.8 W	3.8 W	3 W	-	11 W	10 W	8 W	Bordeaux	1.91
-	4.8 W	3.8 W	3 W	-	13 W	10 W	8 W	Rome	2.34
-	4.8 W	3.8 W	3 W	-	13 W	10 W	8 W	Madrid	2.75
7 W	5 W	3.8 W	3 W	18.5 W	13 W	10 W	8 W	Seville	3.13
7 W	5 W	3.8 W	3 W	20 W	13 W	10 W	8 W	Nanjing	3.37
7 W	5 W	3.8 W	3 W	20 W	13 W	10 W	8 W	Singapore City	3.48
7 W	5 W	3.8 W	3 W	20 W	13 W	10 W	8 W	New Delhi	3.96

Criteria for yield calculations:

Location:	Unobstructed sunlight throughout the year
Alignment:	Solar modules facing south (locations in northern hemisphere)
Tilt angle:	Solar modules (optimum tilt angle in winter is 60°)
Shading:	Consideration of shading caused by buildings or trees in future
Load calculation:	All loads are taken into account (including charge controller, about 0.3 W)
Operation time:	For example: 24 hours a day, 7 days a week
Season:	The solar systems have been calculated for the season with the poorest weather (winter). During this time, the solar panels only provide around a quarter of the daily yield that they provide in the summer months
Recommended power reserve:	Four to five days in the north; two to three days in the south
System losses:	For yield losses due to system components such as cables or charge controller, a rate of 35% is calculated.
Global radiation:	Lowest regional sun radiation for the period of use (kWh/m²/day)

Example 1: Germany (Hanover)

Maximum connected load in winter at constant load and with a power reserve amounting to approximately five days:

RAD-SOL-SET-…	
…-24-100	…-24-200
2.6 W*	6.8 W*

* Solar modules facing south, 60° tilt angle, year-round operation

Example 2: Spain (Madrid)

Maximum connected load in winter at constant load and with a power reserve amounting to approximately five days:

RAD-SOL-SET-…	
…-24-100	…-24-200
3 W*	8 W*

* Solar modules facing south, 60° tilt angle, year-round operation

A 3 Junction box for wireless systems

FL RUGGED BOX junction box (Order No. 2701204) is suitable for use in industrial applications. The junction box offers space for the power supply, the wireless module and the I/O extension modules.

Features:

- IP66 protection class
- Mounting suitable for industrial use
- Bore holes already exist, screw connections are included in scope of supply

A set for mast mounting including screw clamps for masts up to 89 mm in diameter is available as an accessory (FL RUGGED BOX POLE SET, Order No. 2701205).

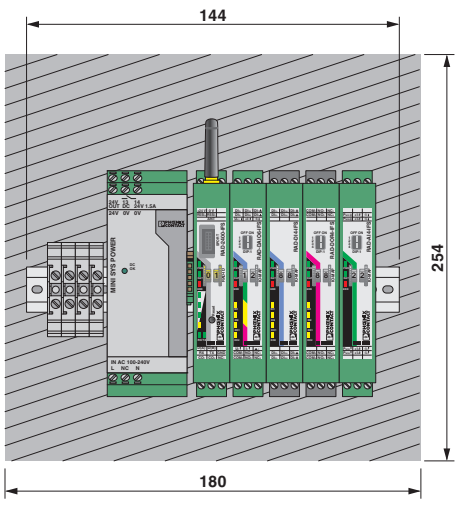


Figure A-10 Junction box with wireless system

Mounting example with a 35 mm power supply and five 17.5 mm devices and terminal blocks

Power supply	**MINI-SYS-PS-100-240AC/24DC/1.5**	**1500 mA**
Loads	RAD-2400-IFS	65 mA
	RAD-DAIO6-IFS	95 mA
	RAD-DI4-IFS	11 mA
	RAD-DOR4-IFS	55 mA
	RAD-DI8-IFS	18 mA
	RAD-DO8-IFS	22 mA
	RAD-AI4-IFS	120 mA
	RAD-AO4-IFS	115 mA

A 4 Configuring a PROFIBUS connection

In order to configure a point-to-point or star connection for PROFIBUS transmission, proceed as follows:

- Download the latest PSI-CONF software from the Internet at phoenixcontact.net/products.
- Install the software on your computer.

WARNING: Explosion hazard when used in potentially explosive areas
The USB cable must **not** be used in potentially explosive areas.

- Use the RAD-CABLE-USB cable (Order No. 2903447) to connect the wireless module to the PC.

Configuring the connection

- Start the PSI-CONF software.

Figure A-11 PSI-CONF software

- In the “Wireless” folder, select the device.

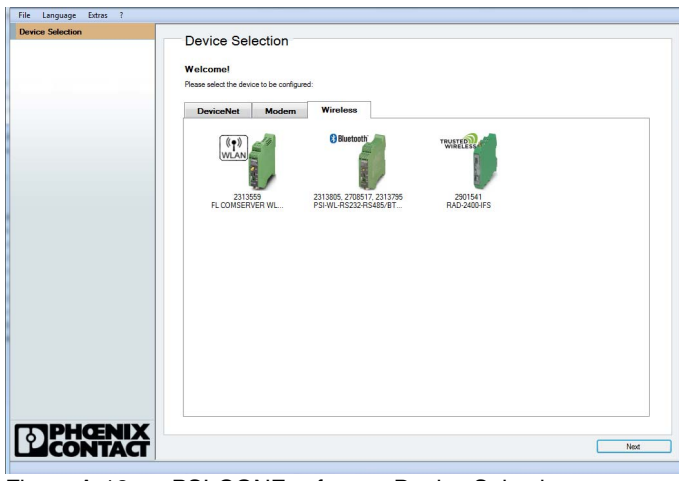


Figure A-12 PSI-CONF software: Device Selection

- Select “Create new network project”.

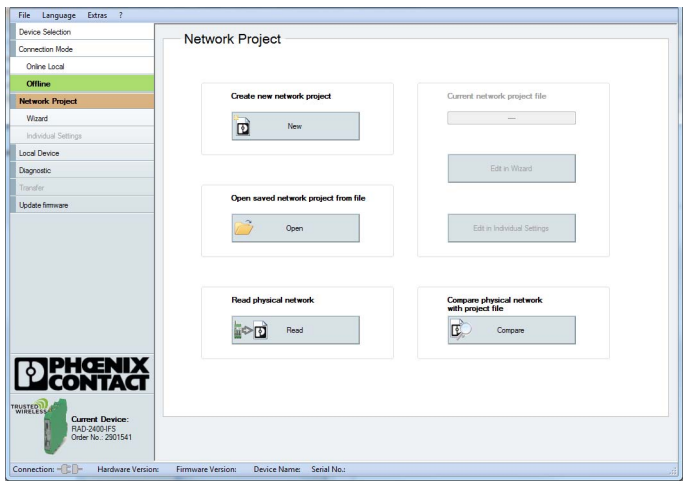


Figure A-13 PSI-CONF software: Network Project

- In step 1 of the wizard, select “Point to Point / Star” and confirm with “Next”.

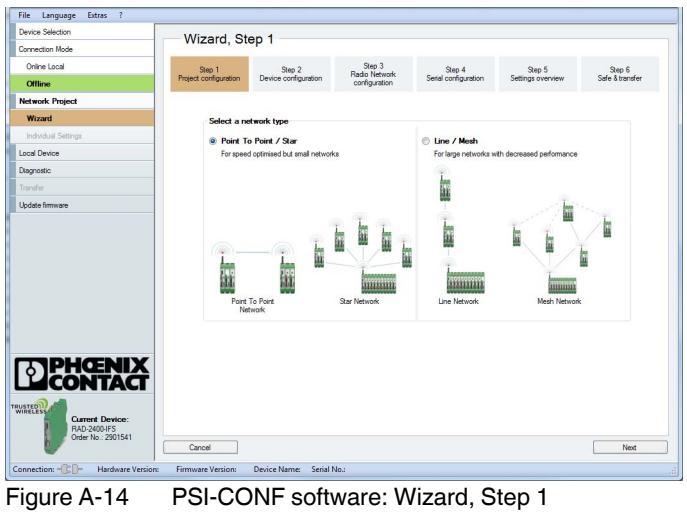


Figure A-14 PSI-CONF software: Wizard, Step 1

- Follow the software wizard. Specify the number of network devices. Confirm with “OK” and “Next”.

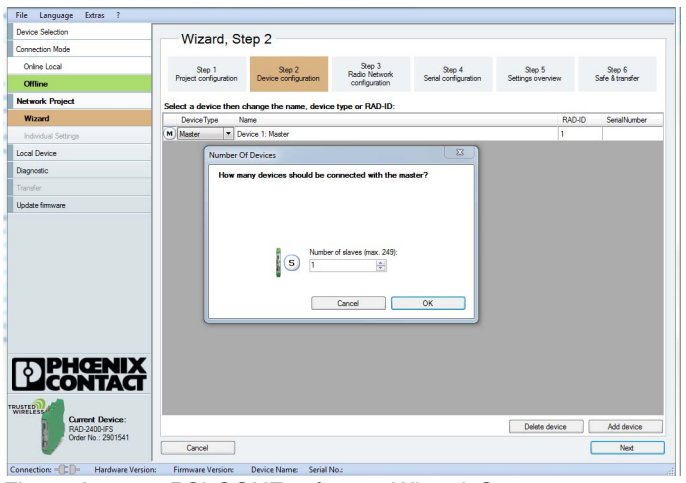


Figure A-15 PSI-CONF software: Wizard, Step 2

- In step 3, select the “Serial data” network application. Configure the network settings:
  - RF band
  - Network ID
  - Optional: showing/hiding WLAN channels
- Depending on the distance between the wireless modules, you can set the desired data rate under “Network speed/distance relation”.

Data transmission speed	Typical receiver sensitivity	Typical link budget	Potential distance with line of sight and a system reserve of 12 dB
250 kbps	-93 dBm	-112 dBm	1000 m
125 kbps	-96 dBm	-115 dBm	1500 m
16 kbps	-106 dBm	-125 dBm	5000 m

You can achieve transmission within the kilometer range using the wireless module if the following conditions are fulfilled:

– Suitable gain antennas are used
– Line of sight
– Adherence to the Fresnel zone

- Then confirm with “Next”.

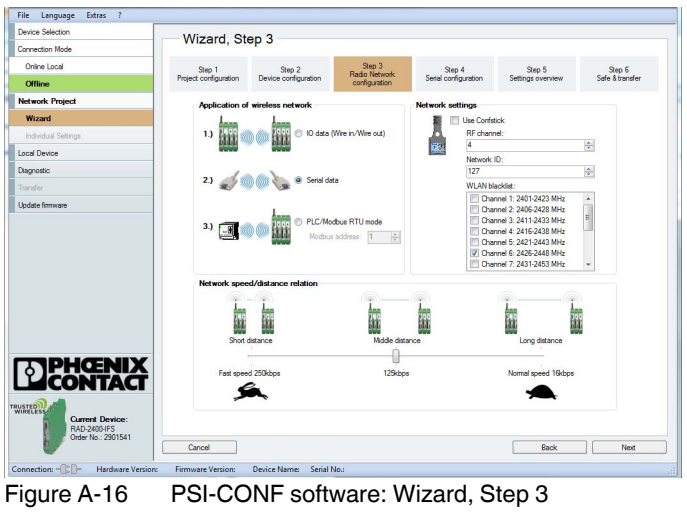


Figure A-16 PSI-CONF software: Wizard, Step 3

- In step 4, select the PROFIBUS connection profile and set the desired data rate. Depending on the distance to be covered, reduce the serial data rate (wireless interface 125 kbps or 250 kbps), if required. Confirm with “Next”.

Owing to the increased delay time, PROFIBUS transmission with 16 kbps is **not** possible.

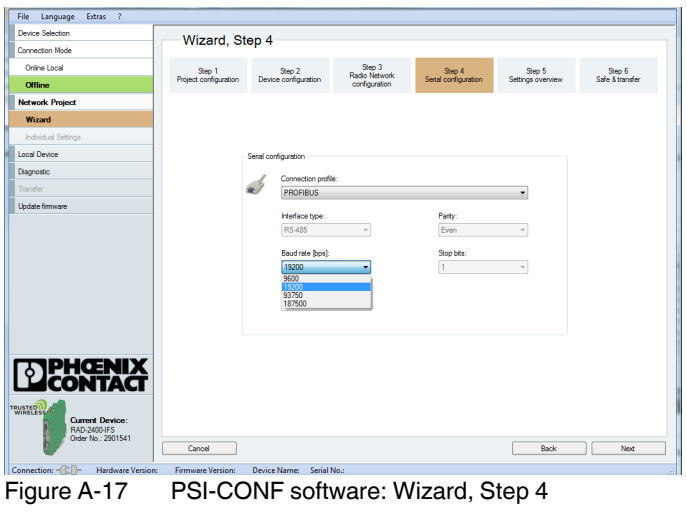


Figure A-17 PSI-CONF software: Wizard, Step 4

- In step 5, you will see an overview of the settings that have already been made. Check these settings and confirm with “Next”.

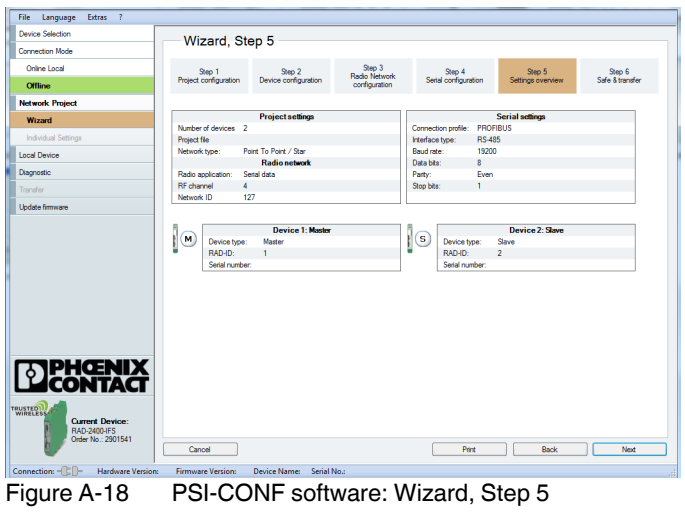


Figure A-18 PSI-CONF software: Wizard, Step 5

- Save the project in step 6.

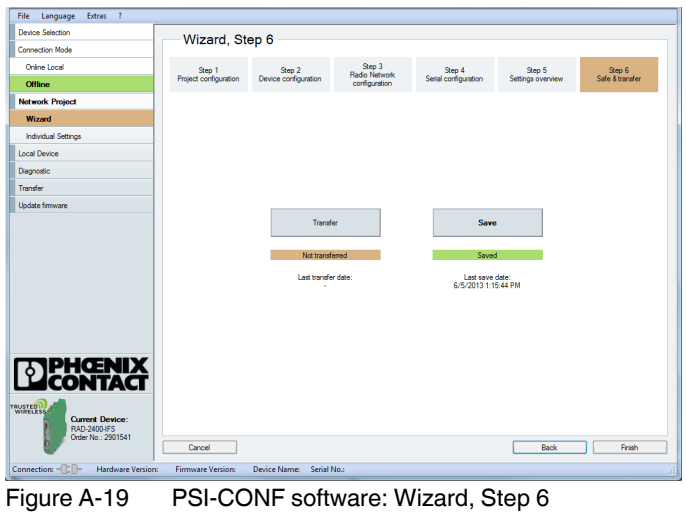


Figure A-19 PSI-CONF software: Wizard, Step 6

- Open “Individual Settings” and set “Transmissions” to 1. Save the settings again and click “Transfer” to transfer them to the devices.

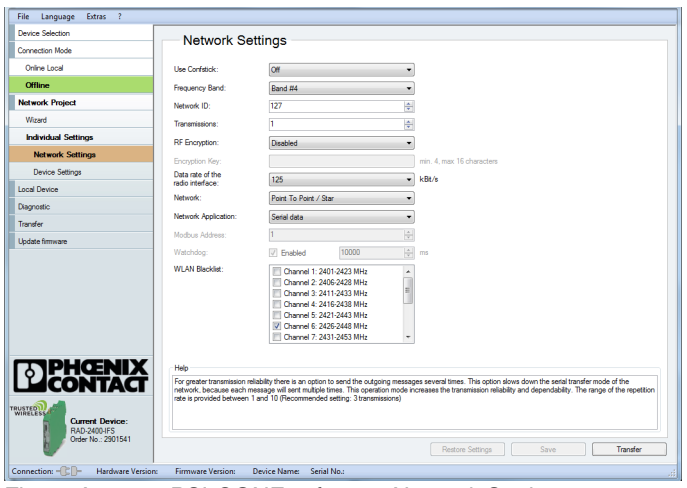


Figure A-20 PSI-CONF software: Network Settings

Connecting the PROFIBUS cable

- Connect the PROFIBUS cable to both wireless modules:
  - Negative data wire (green) to terminal D(A) 4.1
  - Positive data wire (red) to wire D(B) 4.2
- Activate bus termination if the wireless module is located at the start or the end of the electrical PROFIBUS segment. To do so, set the DIP switches 1 and 2 to ON. The DIP switches are located on the side of the wireless module.

Configuring the PROFIBUS master

- Adjust timing in the PROFIBUS master to the signal runtime over the wireless path.

This setting is shown here using the SIMATIC Manager, Version 5.x as an example:

The wireless modules do not modify the PROFIBUS telegram (transparent transmission, “Tunneling”). They only modify the PROFIBUS cycle time. In the case of an optimal wireless connection, the wireless modules will cause a delay time of approximately 50 ms, unidirectionally approximately 25 ms.

If the wireless component is connected in series with other components, then the delay time of each component needs to be added together. Remember to take into account long cables, repeaters, fiber optics, other wireless components, etc.

The additional delay time may increase in the event of a poor wireless connection. Alternatively, the connection may be terminated completely. In the case of a bad connection, the wireless module will not discard PROFIBUS telegrams but try to repeatedly transmit them.

- For the wireless connection, consider the following PROFIBUS situations:
  - **In the PROFIBUS master - minimum delay time of 50 ms**
    Tslot_Init parameter (maximum wait time for receipt)
  - **In the ROFIBUS master - short interruption of the wireless connection**
    Retry-Limit parameter (maximum number of connection retries)
  - **In the PROFIBUS slave - permanent interruption of the wireless connection**
    Watchdog time parameter
  - Telegram size: 40 bytes user data, maximum
- You have two options for setting the Tslot_Init parameter (maximum wait time for receipt):
  - **Automatically** - Enter the number of repeaters and the cable length under “Options, Cables”.
  - **Manually** - Directly enter the bus parameters under “User-defined, Bus Parameters”. In this case, deactivate the automatic calculation, otherwise the sum of the automatic and manual entry will be used.

We recommend that you use the manual entry:

– Entry: Tslot_Init > 13000 t_bit
– Entry: Retry-Limit > 3
– Recalculate
– Entry: Watchdog time, depending on the application

In certain circumstances, it may be required that the Tslot_Init value is greater than 13000 t_bit. For example, this may occur, if there is a poor wireless connection or the components are connected in series. The value of 50 ms will increase by the factor x.

The Tslot_Init parameter is expressed in t_bit. The maximum value for a Siemens S7 PLC is 16383 t_bit (S5: 9999 t_bit). The maximum wait time for receipt is therefore 93.75 kbps = 174 ms. In this case, the value 13000 t_bit is the minimum delay time of the wireless module + reserve.

- Start the SIMATIC Manager and open you user project. Select “Extras, Configure network” from the pull-down menu.

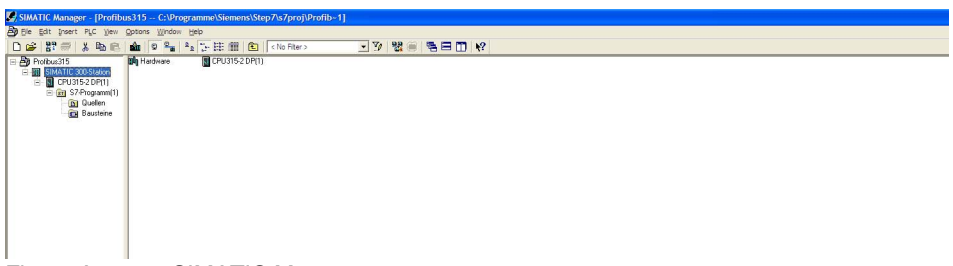


Figure A-21 SIMATIC Manager

- In the “NetPro” window, right-click the PROFIBUS line. In the context menu, open “Object Properties”.

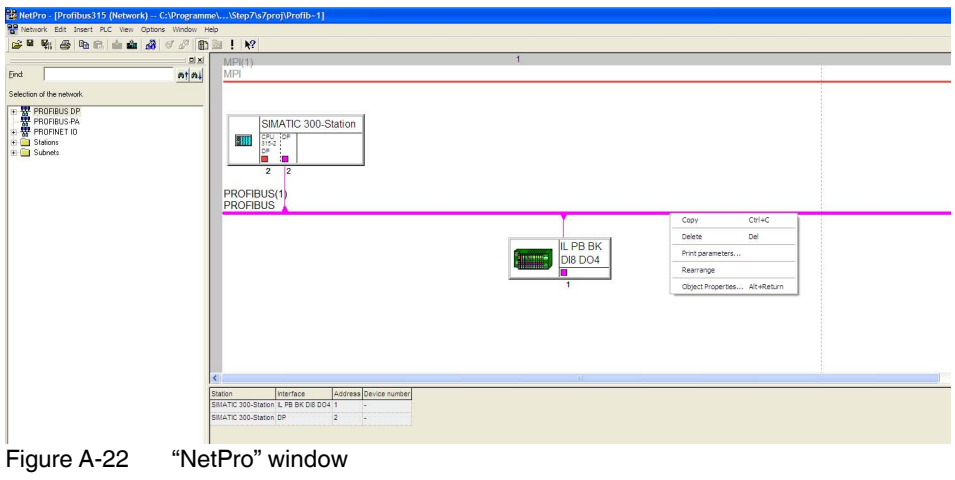


Figure A-22 “NetPro” window

- In the “Network Settings” tab, select the transmission speed of 93.75 kbps.
- Click “Options”.

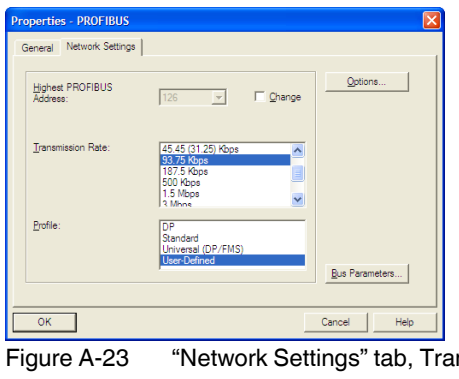


Figure A-23 “Network Settings” tab, Transmission Rate

- In the “Cables” tab, deactivate the “Take into account the following cable configuration” option. Confirm with “OK”.

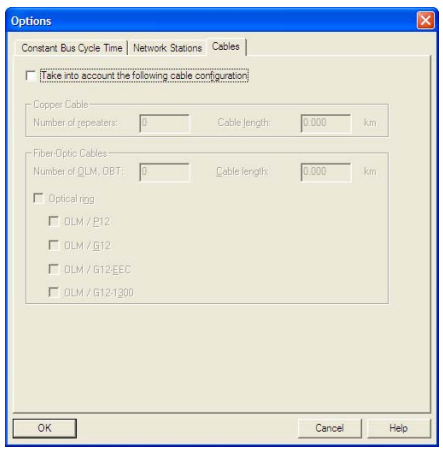


Figure A-24 “Cables” tab

- In the “Network Settings” tab, select the “User-Defined” profile and the “Bus Parameters” option.

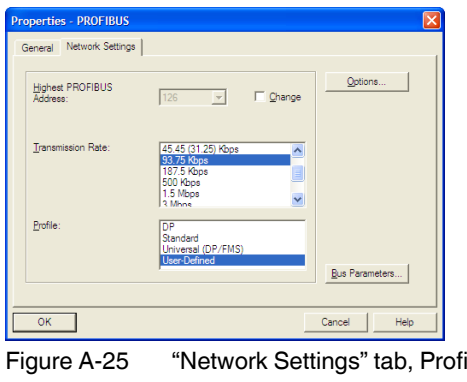


Figure A-25 “Network Settings” tab, Profile

- In the “Bus Parameters” tab, the most recently valid bus parameters are shown. Enter the following values:

The value for the Tslot time and the telegram runtime of PROFIBUS depend on your application. Start with 13000 t_bit in order to achieve the smallest possible telegram runtime. Increase the value if bus errors occur.

Tslot_Init	13000 t_bit ... 16383 t_bit
Max. Tsdr	60
Min. Tsdr	11
Tset	1
Tqui	0
Gap factor	10
Retry_Limit	5

- Confirm the entry with “Recalculate”.

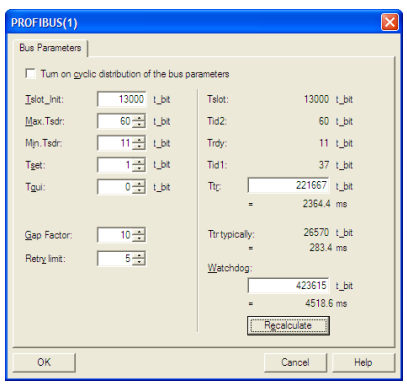


Figure A-26 “Bus Parameters” tab

- Recalculating the bus parameters also modifies the watchdog value. Enter 93750 t_bit here to achieve a watchdog time of 1 second for the PROFIBUS slave. Confirm with “OK”.

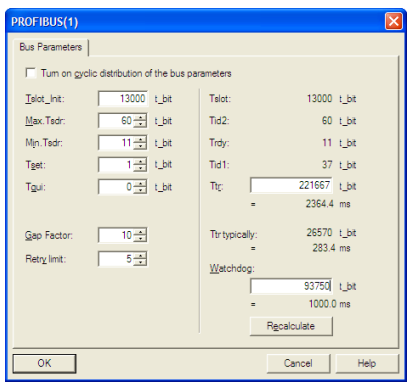


Figure A-27 “Bus Parameters” tab, Watchdog

- Go back to the “NetPro” view. Save and compile the changes.
- Transfer all settings to the PROFIBUS master.
- Test the accessibility of the PROFIBUS devices via the wireless path.

PROFIBUS controller in DP slave mode

You can change the operating mode of the PROFIBUS controller under “Properties - DP”. The DP controller can be operated as a master or slave.

To ensure error-free operation, the “Test, commissioning, routing” box must **not** be enabled. If this option is activated, the interface becomes an active PROFIBUS device and takes part in the token rotation of PROFIBUS.

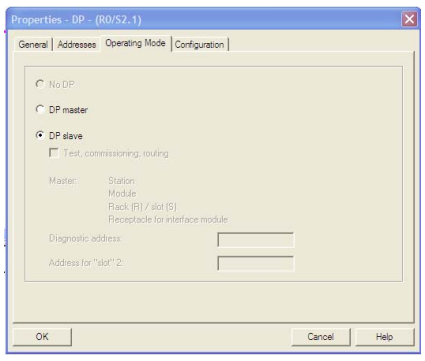


Figure A-28 ”Properties - DP” tab

B Appendixes

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