TRUSTED
WIRELESS

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

User manual

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CONTACT

INSPIRING INNOVATIONS

User manual

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

Designation: UM EN RAD-...-IFS

Revision: 01

This user manual is valid for:

Wireless module:	Order No.
RAD-2400-IFS	**2901541**
RAD-868-IFS	**2904909**

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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1 Technical data for the wireless modules

Description	Type	Order No.	Pcs./Pkt.
2400 MHz wireless transceiver with RS-232, RS-485 2-wire interface, can be extended with I/O extension modules, with screw connection, antenna connection: RSMA (female), including DIN rail connector, without antenna	RAD-2400-IFS	2901541	1
868 MHz wireless transceiver with RS-232, RS-485 2-wire interface, can be extended with I/O extension modules, with screw connection, antenna connection: RSMA (female), including DIN rail connector, without antenna	RAD-868-IFS	2904909	1

Accessories

RS-485 front module	Type	Order No.	Pcs./Pkt.
Multipoint multiplexer for RS-485 bus system, can be extended with I/O extension modules. Can be used as Modbus/RTU bus coupler or combined with Radioline wireless system, screw connection. Up to 99 stations, including DIN rail connector	RAD-RS485-IFS	2702184	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, including DIN rail connector	RAD-AI4-IFS	2901537	1
Temperature I/O extension module with 4 Pt 100 inputs (-50 … +250°C), with screw connection, including 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, including DIN rail connector	RAD-AO4-IFS	2901538	1
Digital I/O extension module with 4 digital inputs (0 ... 250 V AC/DC), with screw connection, including DIN rail connector	RAD-DI4-IFS	2901535	1
Digital I/O extension module with 8 digital inputs (0 ... 30.5 V DC) or 2 pulse inputs (0 ... 100 Hz), with screw connection, including 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, including 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, including DIN rail connector	RAD-DO8-IFS	2902811	1
Analog/digital I/O extension module with 2 digital inputs/outputs (0 ... 250 V AC/DC) and 1 analog input (0/4 ... 20 mA) and output (0/4 ... 20 mA, 0 ... 10 V), with screw connection, including DIN rail connector	RAD-DAIO6-IFS	2901533	1

Mounting and configuration	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
Shield terminal for applying the shield on busbars	SKS 8-SNS35	3062786	10
Memory stick for saving individual configuration data for the Radioline wireless module	RAD-MEMORY	2902828	1
USB data cable (USB-A to IFS connector) for communicating between PCs and PHOENIX CONTACT devices with an IFS data port, e.g., RAD-2400-IFS. Energy supply for diagnostics and configuration via the USB port of the PC. Cable length: 2 m.	RAD-CABLE-USB	2903447	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

2.4 GHz CONFSTICKs	Type	Order No.	Pcs./Pkt.
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

868 MHz CONFSTICK	Type	Order No.	Pcs./Pkt.
CONFSTICK for easy and safe network addressing for the 868 MHz Radioline wireless module (RAD-868-IFS), unique network ID, RF band 1	RAD-868-CONF-RF1	2702197	1

2.4 GHz antennas	Type	Order No.	Pcs./Pkt.
Omnidirectional antenna, 2.4 GHz, 2 dBi, linear vertical, 1.5 m cable, RSMA (male), IP65, 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 protection, 1.5 m cable length, RSMA (male) connection, h/v 360°/85° opening angle. Appropriate mounting material is available for wall mounting.	RAD-ISM-2400-ANT-VAN-3-0-RSMA	2701358	1
Omnidirectional antenna, 2.4 GHz, 6 dBi, linear vertical, h/v 360°/30° opening angle, N (female), IP55, including mounting bracket and mast clips for 45 mm ... 100 mm diameter, stainless steel, ATEX/IECEx approval	RAD-ISM-2400-ANT-OMNI-6-0	2885919	1
Omnidirectional antenna, 2.4 GHz, 6 dBi, linear vertical, h/v 360°/20° opening angle, N (female), IP65, salt water resistant	RAD-2400-ANT-OMNI-6-0-SW	2903219	1
Omnidirectional antenna, 2.4 GHz, 9 dBi, linear vertical, N (female), IP65, 50 Ω impedance	RAD-ISM-2400-ANT-OMNI-9-0	2867623	1
Directional antenna, 2.4/5 GHz, 9 dBi, linear vertical, N (female), IP67, including mounting bracket and mast clips for 25 mm ... 85 mm diameter, stainless steel, ATEX/IECEx approval	ANT-DIR-2459-01	2701186	1
Parabolic antenna, IP65 protection, 19 dBi gain, linear vertical, N (female) connection, 50 Ω impedance, h/v 17°/11° opening angle	RAD-ISM-2400-ANT-PAR-19-0	2867885	1

868 MHz antennas	Type	Order No.	Pcs./Pkt.
Omnidirectional antenna, 868 MHz, 4 dBi, linear vertical, N (female), h/v 360°/30° opening angle, IP67, salt water resistant, including mounting bracket and mast clips for 30 mm ... 45 mm diameter, stainless steel, ATEX/IECEx approval	ANT-OMNI-868-01	2702136	1
Omnidirectional antenna, 868/900 MHz, 2 dBi, linear vertical polarization, N (female), IP66	RAD-900-ANT-OMNI-2-N	2904802	1
Directional antenna, 868 MHz, 3.5 dBi, circular polarized, N (female), IP67, including mounting bracket and mast clips for 25 mm ... 85 mm diameter, stainless steel, ATEX/IECEx approval	ANT-DIR-868-01	2702137	1
Yagi directional antenna, 868/900 MHz, 8.5 dBi, IP65 protection, linear vertical polarization, 0.6 m cable length, N (female) connection	RAD-ISM-900-ANT-YAGI-6.5-N	2867814	1
Yagi directional antenna, 868/900 MHz, 12.15 dBi, IP65 protection, linear vertical polarization, 0.6 m cable length, N (female) connection	RAD-ISM-900-ANT-YAGI-10-N	5606614	1

Antenna cables and adapters	Type	Order No.	Pcs./Pkt.
Adapter cable as control cabinet feed-through, N (female) -> RSMA (male), impedance: 50 Ω, length: 0.5 m	RAD-PIG-EF316-N-RSMA	2701402	1
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
Antenna cable, 5 m length, N (male) -> RSMA (male), 50 Ω impedance	RAD-PIG-RSMA/N-5	2702140	1
Antenna cable as accessory for leaky wave cable, 0.5 m length, N (male) -> N (male), attenuation approximately 0.93 dB at 2.4 GHz and 1.6 dB at 5 GHz	FL LCX PIG-EF142-N-N	2700677	1
For RAD-2400-IFS: 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
For RAD-868-IFS: attachment plug with Lambda/4 technology as surge protection for coaxial signal interfaces. Connection: N connectors (socket/socket).	CN-LAMBDA/4-2.2-BB	2800024	1
Adapter, N (female) -> N (female)	RAD-ADP-N/F-N/F	2867843	1
Adapter, RSMA (male) -> RSMA (female) 90°; insertion loss < 0.3 dB at 2.4 GHz	RAD-ADP-RSMA/M-RSMA/F-90	2904790	1
Antenna barrier for installation in Ex Zone 2, separates and transmits HF signals with intrinsic safety (Ex i) to an antenna in Zone 0, 1 or 2, 0.7 GHz ... 6 GHz frequency range, N (female) -> N (female), ATEX/IECEx approval	BAR-ANT-N-N-EX	2702198	1
2-way distributor for antenna signals (antenna splitter), N connection (socket) at the two upper ends and N connection (socket) at the lower end	RAD-SPL-2-N/N	2702293	1
Antenna cable, 3 m length, N (male) -> N (male), 50 Ω impedance	RAD-CAB-EF393- 3M	2867649	1
Antenna cable, 5 m length, N (male) -> N (male), 50 Ω impedance	RAD-CAB-EF393- 5M	2867652	1
Antenna cable, 10 m length, N (male) -> N (male), 50 Ω impedance	RAD-CAB-EF393-10M	2867665	1
Antenna cable, 15 m length, N (male) -> N (male), 50 Ω impedance	RAD-CAB-EF393-15M	2885634	1

Energy 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 (including 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 (including 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

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

Dimensions (nominal sizes in mm)
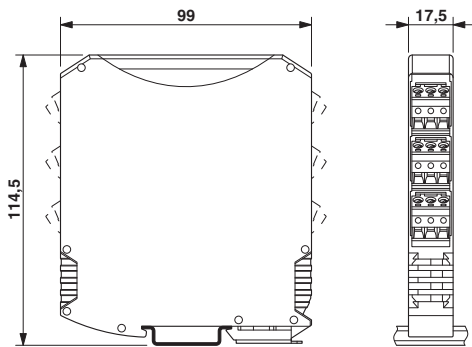
Dimensions W / H / D	17.5 mm / 99 mm / 114.5 mm

General data

Overvoltage category	II
Degree of protection	IP20
Pollution degree	2
Housing design	PA 6.6 FR, green
Flammability rating UL 94	V0

Supply

Supply voltage range	19.2 V DC ... 30.5 V DC
Maximum current consumption	≤ 65 mA (@ 24 V DC, @ 25°C, stand-alone)
	≤ 6 A (@ 24 V DC, with fully utilized DIN rail connector)
Transient surge protection	Yes

System limits	**RAD-2400-IFS**	**RAD-868-IFS**
Wireless module		
Number of supported devices	≤ 250 (addressing via PSI-CONF software) ≤ 99 (addressing via thumbwheel)	≤ 99 (per wireless network)
Number of possible extension modules	≤ 32 (per wireless module)	≤ 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)	

Wireless interface	RAD-2400-IFS	RAD-868-IFS
Antenna connection method	RSMA (female)	
Direction	Bidirectional	
Frequency	2.4 GHz	868 MHz
Frequency range	2.4002 GHz ... 2.4785 GHz	869.4 MHz ... 869.65 MHz
Number of channel groups	8	14
Number of channels per group	55	-
Channel distance	1.3 MHz	30 kHz (depending on the network structure and the data transmission speed)
Data transmission speed (adjustable)	16 kbps 125 kbps 250 kbps	1.2 kbps 9.6 kbps 19.2 kbps 60 kbps 120 kbps
Receiver sensitivity	-106.00 dBm (16 kbps) -96.00 dBm (125 kbps) -93.00 dBm (250 kbps)	-122 dBm (1.2 kbps) -114 dBm (9.6 kbps) -111 dBm (19.2 kbps) -104 dBm (60 kbps) -103 dBm (120 kbps)
Transmission power	≤ 20 dBm (outside of Europe, adjustable via software) ≤ 19 dBm (Europe, adjustable via software, depends on the data rate) ≤ 18 dBm (default setting)	≤ 27 dBm (default setting, 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)	

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 ... 187.5 kbps
Termination resistor (can be switched on 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	Change-over contact
Contact material	PdRu, gold-plated
Maximum switching voltage	30 V AC/DC / 60 V DC
Maximum switching current	500 mA (30 V AC/DC) / 300 mA (60 V DC)
Electrical service life	5×10^5 switching cycles with 0.5 A @ 30 V DC

Connection data

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

Status indicator

Status indicator	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 for receive quality, RSSI) Green LED (RS-232/RS-485 receive data, RX) Green LED (RS-232/RS-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

Approvals	RAD-2400-IFS	RAD-868-IFS
Conformity	CE compliance (R&TTE Directive 1999/5/EC)	
ATEX	⟨Ex⟩ II 3 G Ex nA nC IIC T4 Gc X	
IECEx	Ex nA nC IIC T4 Gc	
FCC	FCC Directive Part 15.247	-
ISC	ISC Directive RSS 210	-
UL, USA/Canada	UL 508 Listed Class I, Div. 2, Groups A, B, C, D T4A Class I, Zone 2, IIC T4	-

Conformity

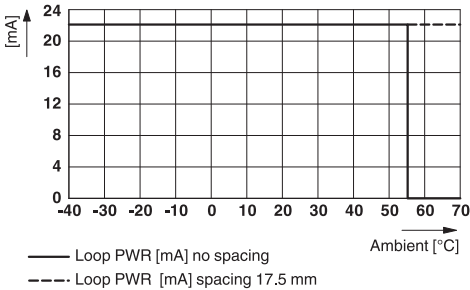|	
Effective use of the radio spectrum according to	EN 300328
Noise immunity according to	EN 61000-6-2
Noise emission according to	EN 61000-6-4
Health according to	EN 50385
Electrical safety according to	EN 60950-1

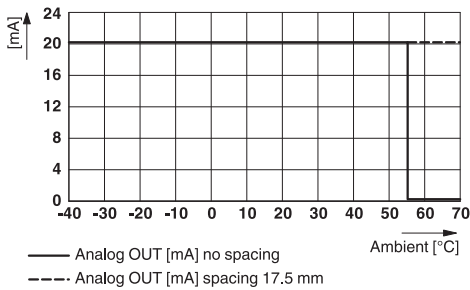## Operating conditions for the extended temperature range (+55°C ... 70°C)

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 available on request.

RAD-DAIO6-IFS (2901533):

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

Loop PWR [mA] no spacing
Loop PWR [mA] spacing 17.5 mm

Only use the analog voltage output (U1).

Analog OUT [mA] no spacing
Analog OUT [mA] spacing 17.5 mm

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

Digital I/O's [channels] no spacing
Digital I/O's [channels] spacing 17.5 mm
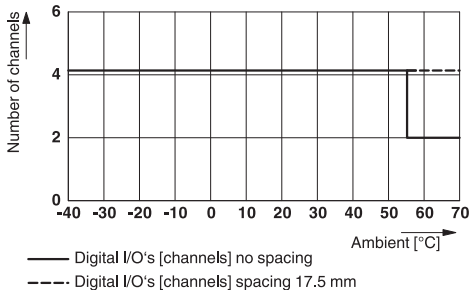
RAD-DOR4-IFS (2901536):

Maximum switching current: 1 A per channel

Relay current [A] no spacing
Relay current [A] spacing 17.5 mm
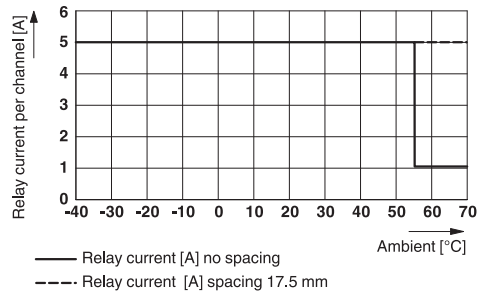
RAD-AI4-IFS (2901537):

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

Loop PWR [mA] no spacing
Loop PWR [mA] spacing 17.5 mm
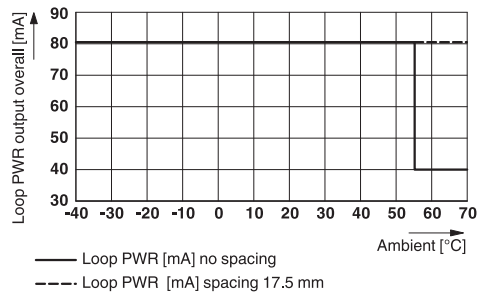
RAD-AO4-IFS (2901538):

Only use the analog voltage output (0 V ... 10 V).

Analog OUT [mA] no spacing
Analog OUT [mA] spacing 17.5 mm
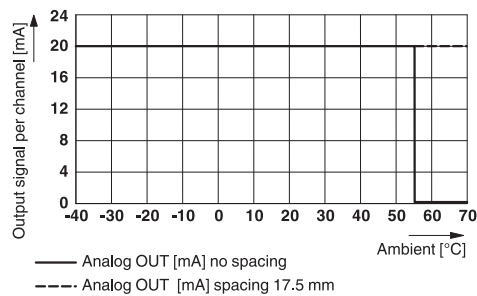
2 For your safety

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

2.1 Intended use

The devices are designed for use in industrial environments.

The Radioline wireless system is a Class A item of 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.

Operation of the wireless system is only permitted if accessories available from Phoenix Contact are used. The use of other accessory components could invalidate the operating license. You can find the approved accessories for this wireless system listed with the product at phoenixcontact.net/products.

2.1.1 RAD-868-IFS wireless module

| i | The RAD-868-IFS wireless module is only approved for use in Europe and South Africa. |

2.1.2 RAD-2400-IFS wireless module

| i | For the country registrations, please visit phoenixcontact.net/products. |

The RAD-2400-IFS devices comply with R&TTE equipment class 1, with the following usage restrictions 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 may only be operated with Phoenix Contact antennas in accordance with 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 (see "Transmission power" on page 46).

| i | Install the RAD-2400-IFS wireless module at least one meter away from other devices using the 2.4 GHz frequency band (e.g., WLAN, Bluetooth, microwave ovens). Otherwise, both the link quality and the data transmission speed 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.

– Provide a switch/circuit breaker close to the device, which is labeled as the disconnect device for this device or the entire control cabinet.

– Provide overcurrent protection (I ≤ 6 A) in the installation.

– Disconnect the device from all power sources during maintenance work and configuration (for SELV or PELV circuits the device can remain connected).

– The housing of the device provides basic insulation against the neighboring devices for 300 V_{rms}. If several devices are installed next to each other, this must be taken into consideration and additional insulation may have to be installed. If the neighboring device is equipped with basic insulation, no additional insulation is required.

- Phoenix Contact hereby declares that this wireless system complies with the basic requirements and other relevant regulations specified in Directive 1999/5/EC.
- **RAD-2400-IFS:** the category 3 device is designed for installation in Zone 2 potentially explosive areas. It meets the requirements of EN 60079-0:2009 and EN 60079-15:2010.
  RAD-868-IFS: the category 3 device is suitable for installation in Zone 2 potentially explosive areas. It meets the requirements of EN 60079-0:2012+A11:2013 and EN 60079-15:2010.
- Installation, operation, and maintenance must 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 general codes of practice, must be observed. The technical data is provided in the package slip and on the certificates (conformity assessment, additional approvals where applicable).
- Do not open or modify the device. Do not repair the device yourself; replace it with an equivalent device instead. Repairs may only be carried out by the manufacturer. The manufacturer is not liable for damage 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 device to mechanical and/or thermal loads that exceed the specified limits.
- To protect the device against mechanical or electrical damage, install it in suitable housing with an appropriate degree of protection according to IEC 60529.
- The device complies with the EMC regulations for industrial areas (EMC class A). When using the device in residential areas, it may cause radio interference.
- Only specified devices from Phoenix Contact may be connected to the 12-pos. S-PORT interface.
- This device is not designed for use in atmospheres with danger of dust explosions.
- If dust is present, the device must be installed in suitable approved housing, taking the surface temperature of the housing into consideration.

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 suitable approved housing (with at least IP54 protection) that meets the requirements of EN 60079-15. Also observe the requirements of EN 60079-14.
- In Zone 2, only connect devices to the supply and signal circuits that are suitable for operation in Ex Zone 2 and the conditions at the installation location.
- In potentially explosive areas, only snap the device onto or off the DIN rail connector and connect/disconnect cables 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 so 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

- Only use antennas approved for the ex area (see Section "Accessories" on page 9)
- The intrinsically safe antennas support universal communication in various HF areas. The antennas are intended for use in potentially explosive areas that require 1G equipment. Connection is via antenna barriers (Order No. 2702198) with separate approval as intrinsically safe equipment.
- Observe the safety notes in the documentation for the respective antenna.

2.4 Notes for individual I/O extension modules

For 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.

For RAD-AO4-IFS

Use either the current or voltage output per analog channel.

2.5 UL notes

For RAD-2400-IFS wireless module

INDUSTRIAL CONTROL EQUIPMENT FOR HAZARDOUS LOCATIONS 45FP

A   This equipment is suitable for use in Class I, Zone 2, IIC T4 and Class I, Division 2, Groups A, B, C, D T4A hazardous locations or non-hazardous locations only.

B   WARNING - EXPLOSION HAZARD - DO NOT DISCONNECT EQUIPMENT UNLESS POWER HAS BEEN SWITCHED OFF OR THE AREA IS KNOWN TO BE NON-HAZARDOUS.

C   WARNING - EXPLOSION HAZARD - SUBSTITUTION OF COMPONENTS MAY IMPAIR SUITABILITY FOR CLASS 1, DIVISION 2.

D   These devices are open-type devices that are to be installed in an enclosure suitable for the environment that is only accessible with the use of a tool.

E   WARNING - Exposure to some chemicals may degrade the sealing properties of materials used in relays within this device.

F   WARNING - EXPLOSION HAZARD - S-PORT IS FOR MAINTENANCE AND PROGRAMMING ONLY AND SHOULD ONLY BE USED WHEN THE AREA IS KNOWN TO BE NON-HAZARDOUS.

For the I/O extension modules

INDUSTRIAL CONTROL EQUIPMENT FOR HAZARDOUS LOCATIONS 45FP

A   This equipment is suitable for use in Class I, Zone 2, IIC T4 and Class I, Division 2, Groups A, B, C, D T4A hazardous locations or non-hazardous locations only.

B   WARNING - EXPLOSION HAZARD - DO NOT DISCONNECT EQUIPMENT UNLESS POWER HAS BEEN SWITCHED OFF OR THE AREA IS KNOWN TO BE NON-HAZARDOUS.

C   WARNING - EXPLOSION HAZARD - SUBSTITUTION OF COMPONENTS MAY IMPAIR SUITABILITY FOR CLASS 1, DIVISION 2.

D   These devices are open-type devices that are to be installed in an enclosure suitable for the environment that is only accessible with the use of a tool.

E   WARNING - Exposure to some chemicals may degrade the sealing properties of materials used in relays within this device.

2.6   Conformity (RAD-2400-IFS only)

FCC (RAD-2400-IFS only)

This device complies with Part 15 of the FCC rules. Operation is subject to the following two conditions:

This device may not cause harmful interference. This device must accept any interference received, including interference that may cause undesired operation.

> **NOTE: Interference**
>
> This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case, the user will be required to correct the interference at his own expense.

Any changes or modifications not explicitly approved by Phoenix Contact could cause the device to cease to comply with FCC rules Part 15, and thus void the user's authority to operate the equipment.

Radio frequency exposure:

The device contains a radio transmitter and receiver. During communication the device receives and transmits radio frequency (RF) electromagnetic fields (microwaves) in the frequency range of 2400 MHz to 2483.5 MHz.

RF Exposure Statement:

This equipment should be installed and operated with a minimum distance of 20 cm between the radiator and your body.

This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

This device contains:

FCC ID: YG3RAD2400A

Industry Canada (IC) (RAD-2400-IFS only)

Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

This device has been designed to operate with an antenna having a maximum gain of 9 dBi.

Having a higher gain is strictly prohibited per regulations of Industry Canada. The required antenna impedance is 50 ohms.

To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (EIRP) is not more than that permitted for successful communication.

This device contains:

IC certificate: 4720B-RAD2400A

3 Brief description

Wireless communication is based on Trusted Wireless 2.0 technology. The high requirements for interference-free data transmission are met in particular through the use of the FHSS (frequency-hopping spread spectrum) method and 128-bit data encryption (AES). The RAD-2400-IFS wireless module uses the license-free 2.4 GHz ISM band. The RAD-868-IFS wireless module uses the 868 MHz ISM band, which is license-free in Europe.

3.1 Wireless modules

In addition to an RS-232 and RS-485 2-wire interface, the **RAD-2400-IFS** and **RAD-868-IFS** wireless modules support 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 I/O 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 to set the RAD ID and the white thumbwheel on the extension 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.

In addition, the wireless network can be extended with up to 98 RS-485 stations (RAD-RS485-IFS, Order No. 2702184). I/O data can therefore be distributed across various media using the thumbwheel.

The PSI-CONF configuration and diagnostics software for special functions and diagnostics options of 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 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
– Can be combined with RS-485 stations

> The **RAD-RS485-IFS** RS-485 front module is not described in this user manual.
> For additional information, visit phoenixcontact.com/product/2702184.

3.2   Firmware versions

Make sure that all the wireless modules in a network have the same firmware version. Where possible, always use the latest firmware.

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

Table 3-1   Firmware versions

Function	As of firmware version...	
	RAD-2400-IFS	**RAD-868-IFS**
First version	1.00	1.00
PLC/Modbus RTU mode	1.30	1.00
Support for RAD-DI8-IFS and RAD-DO8-IFS extension modules	1.40	1.00
Support for RAD-PT100-4-IFS	1.50	1.00
Support for ETSI EN 300328: V1.8.1	1.60	-
Support for RAD-RS485-IFS RS-485 front module	1.70	1.70

3.3   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 the module: analog inputs or outputs (0/4 ... 20 mA / 16-bit resolution / < 0.1% accuracy)
– 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 3-2   Overview of I/O extension modules

Module type		Designation	Order No.	From page
Analog	4 analog inputs	RAD-AI4-IFS	2901537	89
	4 Pt 100 inputs	RAD-PT100-4-IFS	2904035	93
	4 analog outputs	RAD-AO4-IFS	2901538	100
Digital	4 digital inputs	RAD-DI4-IFS	2901535	104
	8 digital inputs or 2 pulse inputs	RAD-DI8-IFS	2901539	108
	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
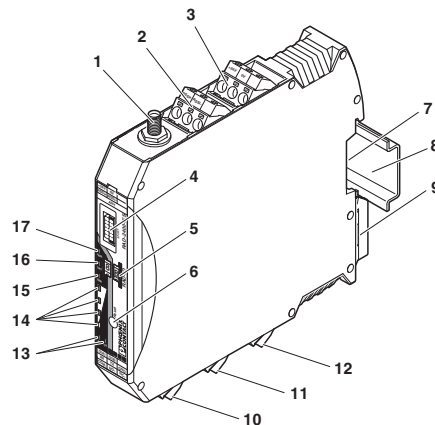
Figure 4-1   RAD-2400-IFS and RAD-868-IFS structure

Item	Terminal block	Designation
1		RSMA antenna connection (socket)
2	2.1/2.2	Test output RSSI (0 V ... 3 V DC) for evaluation of the wireless signal strength
3	1.1/1.2	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 base latch for DIN rail fixing
10	4.1/4.2	Connection terminal blocks for RS-485 interface
11	5.1/5.2/5.3	Connection terminal blocks for RS-232 interface
12	6.1/6.2/6.3	Relay output with floating change-over contact (RF link relay)
13		Status LED (RX/TX) for RS-232/RS-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
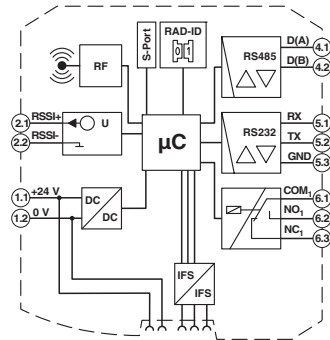
Figure 4-2   RAD-2400-IFS and RAD-868-IFS basic circuit diagram

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 DIN rail connector. Only use the DIN rail connector in conjunction with 24 V DC devices.

- Mount the wireless module to the left and the I/O extension modules **only to the right** of the wireless module.
- The individual extension modules can be arranged in any order.
- **RAD-2400-IFS wireless module only:** install the wireless module at least one meter away from other devices using the 2.4 GHz frequency band (e.g., WLAN, Bluetooth, microwave ovens). Otherwise, both the link quality and the data transmission speed will be reduced.

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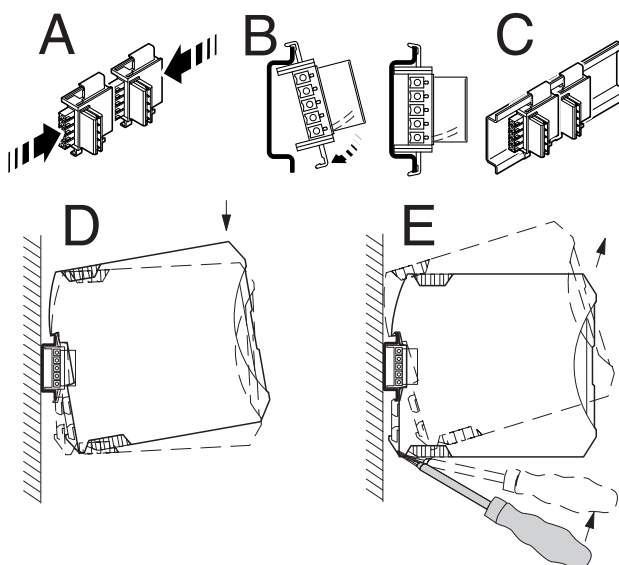
Figure 4-4   Assembly and removal

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

• To form a connection station, connect the DIN rail connectors together.

• 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.

• Install the device in suitable housing to meet the requirements for the protection class.

• During startup, check that the device is operating, wired, and marked correctly.

• A connection can be established between two DIN rail connectors using MINI COMBICON connectors:
  – MC 1,5/5-ST-3,81 (socket, 1803604)
  – IMC 1,5/5-ST-3,81 (pin, 1857919)

i	Device replacement is also possible during operation when outside the ex area.

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 cables
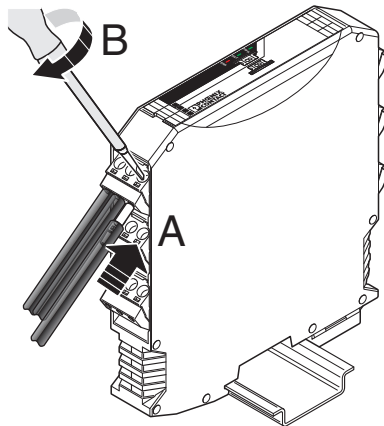
Figure 4-5   Connecting cables

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

- Fit the litz wires with ferrules. 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 terminal blocks 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.
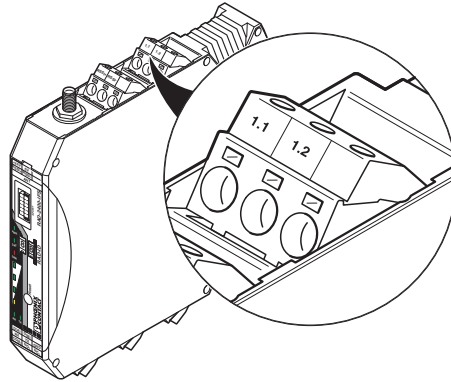
Figure 4-6   Connecting the power supply

In order to prevent damage to the wireless module, we recommend installing a surge protective device. Make sure the wiring between the surge protective device and the wireless module is as short as possible. Please also observe the manufacturer's specifications.

With a system power supply 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 (Order No. 2866983). Connect the system power supply using two DIN rail connectors to the left of the device.
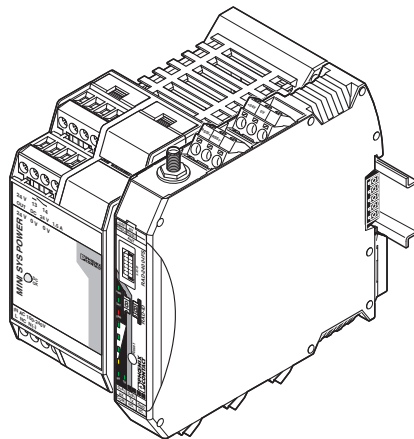
Figure 4-7   Supply via system power supply

i	– Parallel supply via the screw terminal blocks and with a system power supply via the bus foot is **not** possible. – For redundant supply, you can connect a second MINI-SYS-PS 100-240AC/24DC/1.5 system power supply.

4.6 Serial interfaces

The wireless modules have one RS-232 interface and one RS-485 2-wire interface. Connect the I/O device to the wireless module via the corresponding interface.

i	– Activate and configure the RS-232 or RS-485 interface using the PSI-CONF software (from page 45). – 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 line

• Connect the shield of the RS-485 bus line correctly via an external shield terminal (e.g. SKS 8-SNS35, Order No. 3062786).

(!)	**NOTE: Damage to the interface** If the shield has been connected incorrectly, permanent, external disturbing pulses may damage the interface. Observe the polarity of the RS-485 2-wire cable and make sure that the shield is connected correctly.

Choose the type of shield connection according to the expected interference:

– 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, ground loops must be taken into consideration. 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 terminals).

4.6.2 Terminating the RS-485 bus line

The wireless modules are operated on a 2-wire bus line. 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 line, the termination network must be activated or deactivated.

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
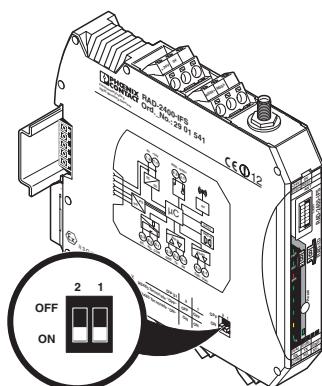
Figure 4-8   DIP switches

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 line to connect the I/O devices. Fit this bus line 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.
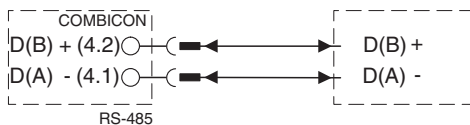
Figure 4-9   RS-485 interface pin assignment

4.6.4 RS-232 pin assignment

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

ℹ	– The RS-232 interface of the wireless module is of DTE type (Data Terminal Equipment). This means that terminal point 5.2 (Tx) is always used to transmit and terminal point 5.1 (Rx) is always used to receive. – 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 4-10). It is also possible to connect a DTE device using a crossed cable (Figure 4-11).
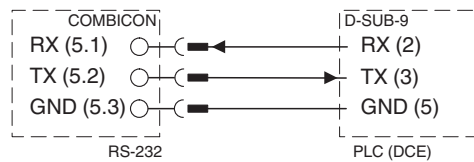
Figure 4-10   RS-232 interface pin assignment (DTE - DCE)
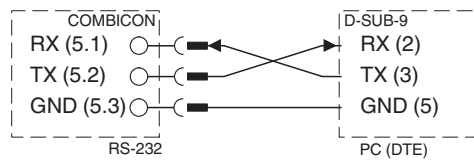
Figure 4-11   RS-232 interface pin assignment (DTE - DTE)

If you are not sure whether the device to be connected is of DTE or DCE type, you can also 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 has an RSMA antenna socket for an external antenna. Various installation examples can be found under "Typical combinations of antennas and adapter cables" on page 159.

i	– Install the antenna outside the control cabinet or building. – Please also observe the installation instructions for the antenna as well as Section "For your safety" on page 17. – For information on the transmission power, refer to "Transmission power" on page 46.
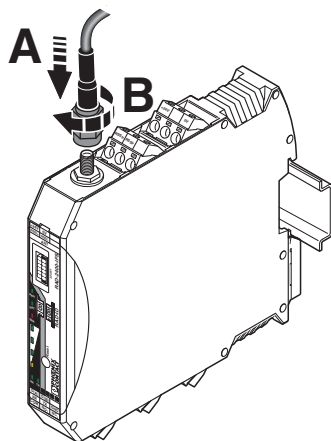
Figure 4-12   Connecting the antenna

5 Configuration and startup

5.1 Default settings of the wireless module

All wireless modules are configured to the same default settings when delivered or following a reset at a later stage.

Table 5-1   Default settings of the wireless module

Parameter	Setting	
	RAD-2400-IFS	**RAD-868-IFS**
Operating mode	I/O data (wire in/wire out)	
Wireless interface		
Net ID	127	
RF band	4	2
Encryption	Off	
Network structure	Mesh	
Device type	Repeater/slave	
Blacklisting	WLAN channel 6	-
Data rate of the wireless interface	125 kbps	9.6 kbps
Receive preamplifier	Activated	-
Transmission power	18 dBm	27 dBm

By default upon delivery, the receive preamplifier is activated and the transmission power is set so that the devices can cover the greatest possible distances (RAD-2400-IFS: 18 dBm, RAD-868-IFS: 27 dBm). Therefore, if the devices are operated directly next to one another the receiver may become overloaded. In this case, remove the antennas, increase the distance between the devices and antennas or reduce the transmission power using the PSI-CONF software.

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.

Manual reset

• 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.
• Hold down the SET button until the DAT LED flashes.

Reset via PSI-CONF software

• In the device selection area, select "Wireless, RAD-2400-IFS" or "Wireless, RAD-868-IFS".
• Select "Local device".
• Select "Set device to factory default configuration".

5.1.2 Firmware update

$\boxed{\mathbf{i}}$ 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.

• In the device selection area, select "Wireless, RAD-2400-IFS" or "Wireless, RAD-868-IFS".
• Select "Update firmware".

5.2 Operating mode of the wireless module

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

Table 5-2 Operating mode

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	

> **i** 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, then a configuration memory can be used (see "Configuration via CONFSTICK" on page 42). Extended settings of the wireless modules can also be configured using the PSI-CONF software (from page 45).

5.2.1 I/O data mode
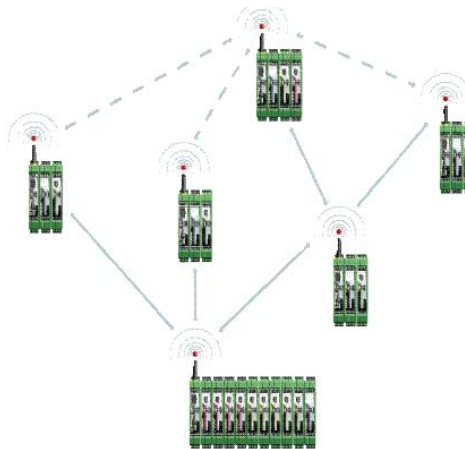
Figure 5-1 I/O data mode

By default upon delivery, all wireless modules are in 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 using the thumbwheel" on page 42 and "Setting the address of the extension modules using the thumbwheel" on page 60).

RS-485 front module

The **RAD-RS485-IFS** RS-485 front module for I/O extension modules allows Radioline stations to be operated via a 2-wire RS-485 bus system. The front module can be extended with up to 32 I/O extension modules via the DIN rail connector.

You can connect Radioline RS-485 stations to a Radioline wireless master and thereby extend the wireless network. All devices in the wireless network and in the RS-485 network form one system. All stations are addressed uniquely using the yellow thumbwheel.

The I/O signals can be distributed easily between all stations, regardless of the medium used.
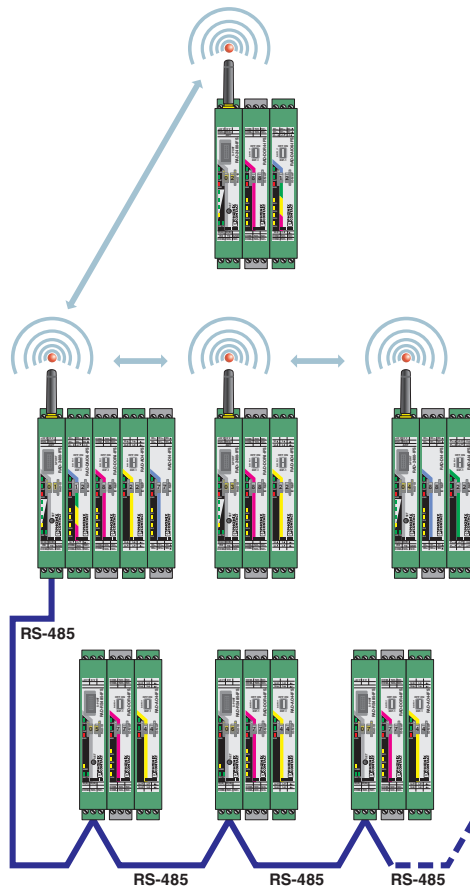
Figure 5-2   I/O-to-I/O, wireless, and RS-485

> The **RAD-RS485-IFS** RS-485 front module is not described in this user manual.
> For additional information, visit phoenixcontact.com/product/2702184.

5.2.2 Serial data mode
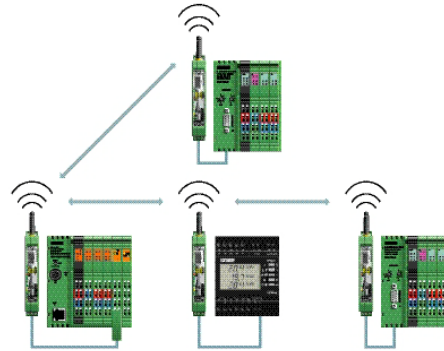
Figure 5-3   Serial data mode

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.

You need to configure each wireless module using the PSI-CONF software (from page 45).

5.2.3 PLC/Modbus RTU mode
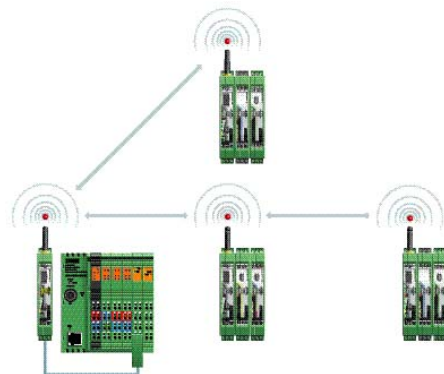
Figure 5-4   PLC/Modbus RTU mode

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 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 45).

5.3 Setting the address of the wireless module using the thumbwheel

- Start by setting 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.

ℹ️	– The addressing in a network must be unique. If two wireless modules in a network have the same address, the network will not function correctly. – 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:

Table 5-3   Yellow thumbwheel setting

Thumbwheel	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	
**	**Only for RAD-2400-IFS:** addressing wireless modules using the PSI-CONF software (address 1 ... 250)	

5.4 Configuration via CONFSTICK

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 can connect to one another.

You must configure each individual network device. Just one CONFSTICK is needed for all the wireless modules in the network. After configuration, you can remove the CONFSTICK from the wireless module.

The CONFSTICK also contains a preset frequency band (RF band). An RF band is a group of frequencies made up of individual frequencies from the entire frequency band. Different RF bands use different frequencies.

If you operate several Radioline wireless systems in parallel, you should select different RF bands.

ℹ️	**RAD-2400-IFS:** you can also set different RF bands from 1 ... 8 and network IDs from 1 ... 127 using the PSI-CONF software (see page 46).
	RAD-868-IFS: for additional information on the various RF bands in 868 MHz wireless systems, refer to "RF bands" on page 132.

Different CONFSTICKs are available for easy configuration without the need for software:

For RAD-2400-IFS:
– RAD-CONF-RF3 for RF band 3 (Order No. 2902814, yellow)
– RAD-CONF-RF5 for RF band 5 (Order No. 2902815, green)
– RAD-CONF-RF7 for RF band 7 (Order No. 2902816, blue)

For RAD-868-IFS:
– RAD-868-CONF-RF1 for RF band 1 (Order No. 2702197, red)

⚠️	**WARNING: Explosion hazard when used in potentially explosive areas**
	Do **not** insert or remove the CONFSTICK in a potentially explosive atmosphere.
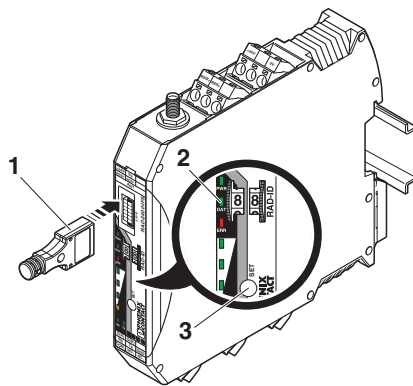
Figure 5-5   Configuration via CONFSTICK

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 a 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, white).

> **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 an earlier firmware version are not able to read the memory stick.
> – If an error is detected while saving or checking the data, the DAT and ERR LEDs flash simultaneously.

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

Copy common network parameters and individual device parameters to the memory stick:
• Press and hold down the SET button on the wireless module for at least six seconds.
• The four RSSI bar graph LEDs start a running light 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 running light 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 and hold down the SET button on the wireless module 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 and hold down the SET button on the wireless module 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.

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 Windows operating system is required in order to use the software. Use the RAD-CABLE-USB USB cable (Order No. 2903447) for configuration and diagnostics.

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

ℹ️	For additional information on the USB cable, please refer to the PACKB.RAD-CABLE-USB package slip. The latest documentation can be downloaded via the product 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 in an existing network project or creating a new project, the network settings can be modified under "Individual Settings". Here, the wireless network can be optimized and adapted to your specific requirements. When you move the mouse over the individual network parameters, you will see a short description under "Help".

ℹ️ If several wireless systems are operated in parallel and in close proximity, you must 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 42).
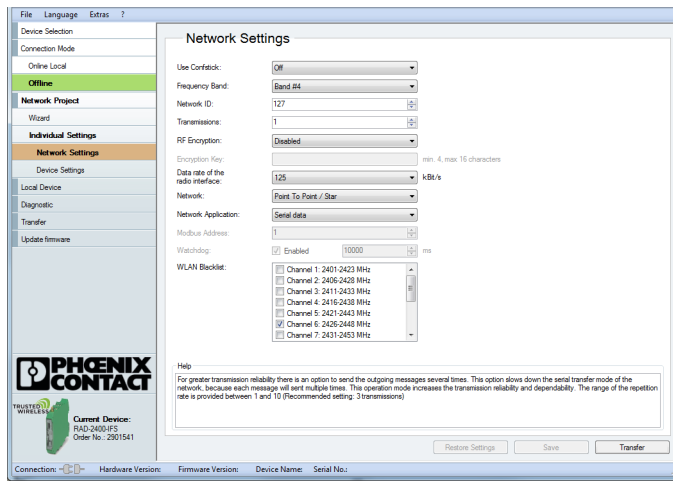
Figure 5-6   PSI-CONF software: Network Settings

5.6.2 Transmission power

Observe the maximum permissible radiated transmission power at the antenna (EIRP, see Table 5-4 or Table 5-5). If necessary, reduce the device transmission power via the PSI-CONF software.

The transmission power can be calculated as follows:
Device transmission power + Antenna gain - Cable attenuation

5.6.3 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 therefore the range.

> Adjust the data transmission speed of the wireless interface to the respective application using the PSI-CONF software (RAD-2400-IFS default setting = 125 kbps, RAD-868-IFS default setting = 9.6 kbps).

Table 5-4   Data transmission speed of the RAD-2400-IFS wireless interface

Data transmission speed	Typical receiver sensitivity	EIRP (max. radiated power)	Potential distance with line of sight and 12 dB system reserve
250 kbps	-93 dBm	20 dBm (Europe: 19 dBm)	1000 m
125 kbps	-96 dBm	20 dBm (Europe: 18 dBm)	3000 m (Europe: 2000 m)
16 kbps	-106 dBm	20 dBm (Europe: 11 dBm)	5000 m (Europe: 3000 m)

Table 5-5   Data transmission speed of the RAD-868-IFS wireless interface

Data transmission speed	Typical receiver sensitivity	EIRP (max. radiated power)	Potential distance with line of sight and 12 dB system reserve
120 kbps	-103 dBm		10 km
60 kbps	-104 dBm		15 km
19.2 kbps	-111 dBm	27 dBm	18 km
9.6 kbps	-114 dBm		20 km
1.2 kbps	-122 dBm		25 km

You can cover distances in the kilometer range using the wireless module if the following conditions are met:
– Suitable gain antennas are used
– Line of sight
– Adherence to the Fresnel zone

If you reduce the data transmission speed, obstacles such as walls or trees can be overcome much better. Please note, however, that the delay time increases when the data rate is reduced.
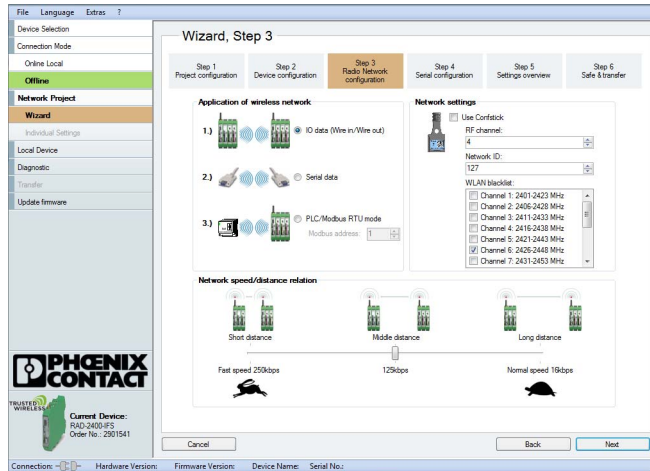
Figure 5-7   PSI-CONF software: Wizard, Step 3
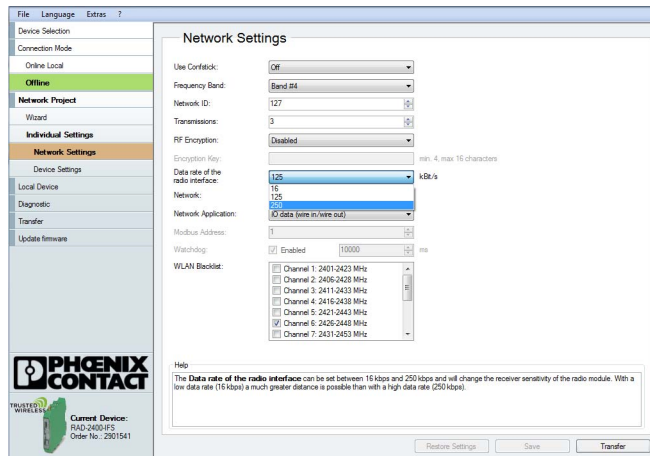
Figure 5-8   PSI-CONF software: Setting the data transmission speed

5.6.4 Device settings

ℹ By default upon delivery, the receive preamplifier is activated and the transmission power is set so that the devices can cover the greatest possible distances (RAD-2400-IFS: 18 dBm, RAD-868-IFS: 27 dBm). Therefore, if the devices are operated directly next to one another the receiver may become overloaded. In this case, remove the antennas, increase the distance between the devices and antennas or reduce the 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.
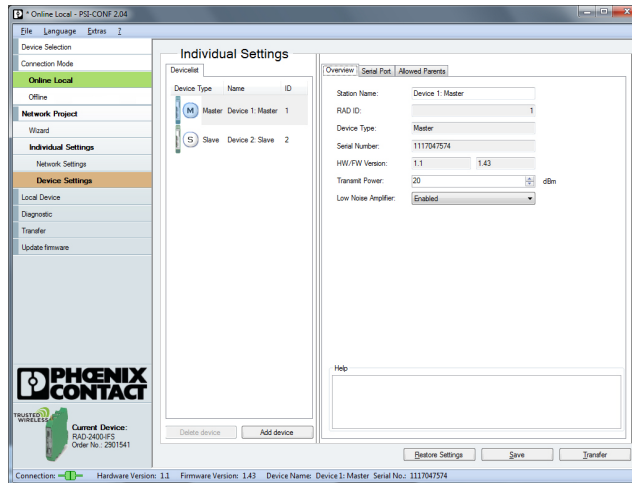
Figure 5-9   PSI-CONF software: Individual Settings, Overview

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

To activate the serial interface, select the "Serial data" or "PLC/Modbus RTU mode" network application under "Network Settings".

ℹ️ You can only use one interface per wireless module. Parallel operation of both interfaces is not possible.
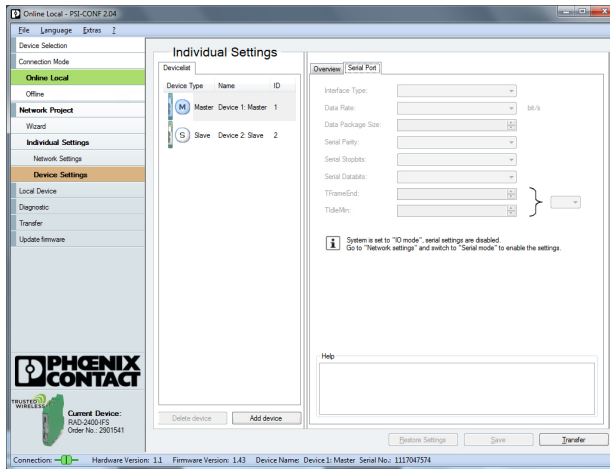
Figure 5-10   PSI-CONF software: Individual Settings, Serial Port

Under "Individual Settings" on the "Allowed Parents" tab, you can define the wireless modules to which a connection may be established. 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.

ℹ️ The "Allowed Parents" tab is only available if the "Line/Mesh" network type has been selected.
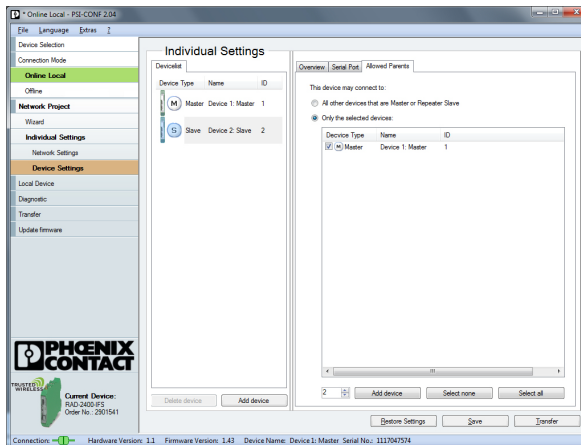
Figure 5-11   PSI-CONF software: Individual Settings, Allowed Parents

5.7 Diagnostics on the wireless module

A total of nine LEDs on the wireless module indicate the operating states.
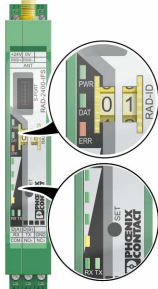
Figure 5-12   Diagnostics LEDs on the wireless module

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
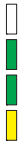
5.7.1 LED bar graph

The LED bar graph indicates the receive signal strength.

Table 5-6   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
	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]   By default upon delivery, the receive preamplifier is activated and the transmission power is set so that the devices can cover the greatest possible distances (RAD-2400-IFS: 18 dBm, RAD-868-IFS: 27 dBm). Therefore, if the devices are operated directly next to one another the receiver may 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 45 onwards).

Table 5-7   RAD-2400-IFS RSSI voltage

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

Table 5-8   RAD-868-IFS RSSI voltage

		1.2k	9.6k	19.2k	60k	120k	RSSI voltage
LED 3		-90 dBm	-85 dBm	-80 dBm	-75 dBm	-70 dBm	≥ 2.5 V
LED 2		-100 dBm	-95 dBm	-90 dBm	-85 dBm	-80 dBm	≥ 2.0 V
LED 1		-110 dBm	-105 dBm	-100 dBm	-95 dBm	-90 dBm	≥ 1.5 V
LINK LED		LINK	LINK	LINK	LINK	LINK	~1.0 V

LED bar graph - running light

The running light from bottom to top indicates:
– Firmware update or
– Wireless module in write mode for the memory stick

TX LED, transmit data

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

As of firmware Version 1.70: in I/O data mode, the TX LED on the wireless master flashes (RAD ID = 01). This indicates that the wireless master is continuously sending search requests to RS-485 stations.

RX LED, receive data

The green RX LED indicates communication on 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 having to perform 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 removing 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. The read-in process has been completed once the DAT LED stops flashing.

RF link relay

The RF link relay in the wireless module diagnoses the state of the wireless connection. If the device is no longer receiving the data packets correctly, the relay is deactivated after a while. The relay picks up again automatically when the wireless connection is re-established. The relay has been designed as a change-over 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 (2.1/2.2) to measure the RSSI voltage from 0 V ... 3 V. You can use the table on page 53 to determine the received signal strength based on the measured voltage. However, please note 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 1.5 V DC. This results in a power reserve of around 10 dB, which ensures communication even in unfavorable transmission conditions.

RSSI LED bar graph
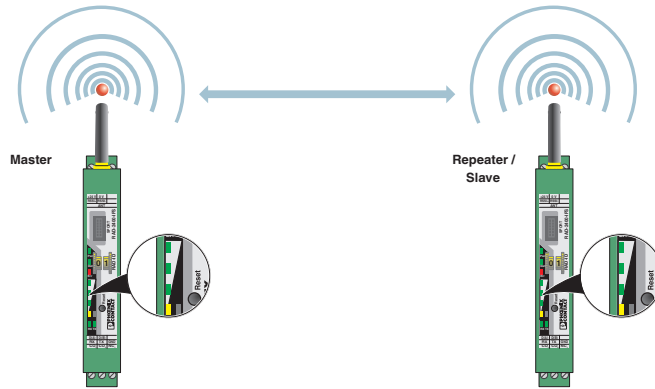
Figure 5-13   Bar graph for point-to-point connection

In a point-to-point connection with just two wireless modules, the LED bar graph is active on both the master and the repeater/slave.
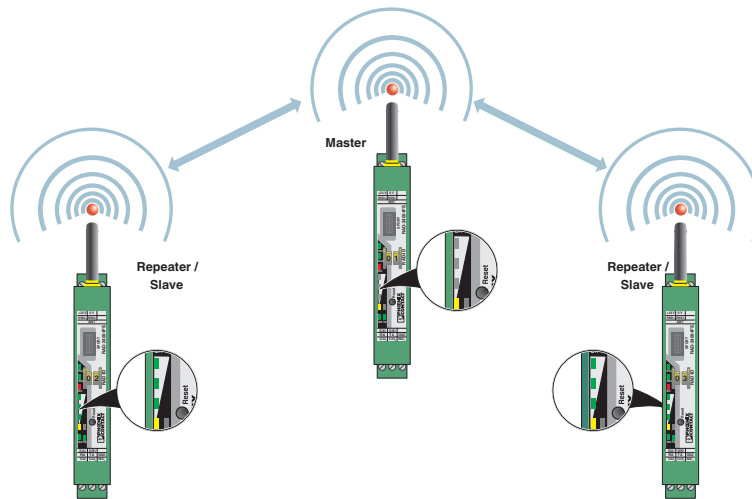
Figure 5-14   Bar graph for point-to-multipoint connection

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 indicated signal strength is always related to 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 and error code registers" on page 86).

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.
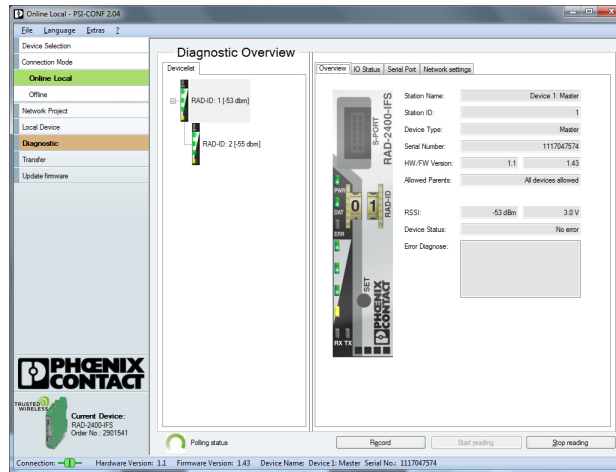
Figure 5-15   PSI-CONF software: Diagnostic, Overview

> **i**
>
> – 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 perform full diagnostics.
> – For information on troubleshooting, please refer to Section "Detecting and removing errors" on page 151.

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 messages:
- 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.
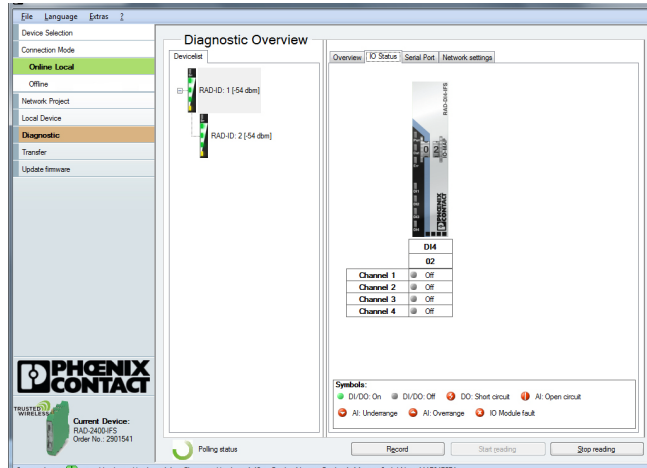
Figure 5-16   PSI-CONF software: Diagnostic, I/O Status

The "Serial Port" tab displays the parameters currently set for the RS-232/RS-485 interface.
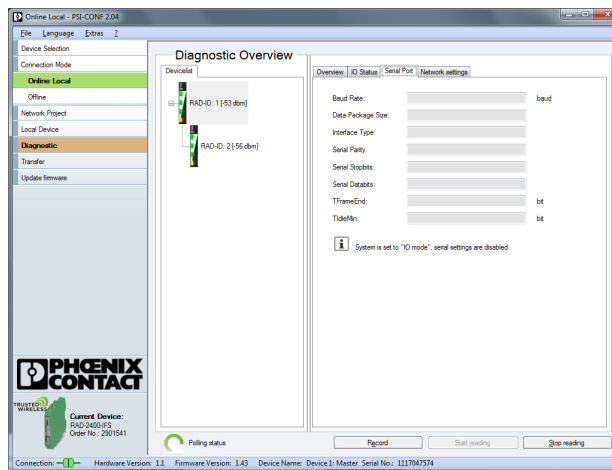
Figure 5-17   PSI-CONF software: Diagnostic, Serial Port

The "Network settings" tab displays the network parameters currently set as well as the settings for the CONFSTICK, if used.
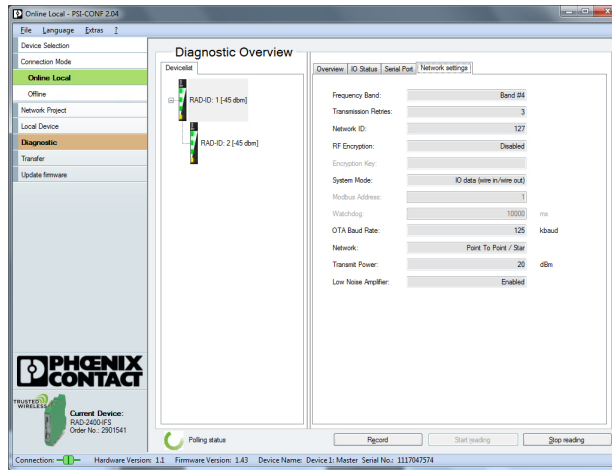
Figure 5-18   PSI-CONF software: Diagnostic, Network settings

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 on "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 with Excel, for example.
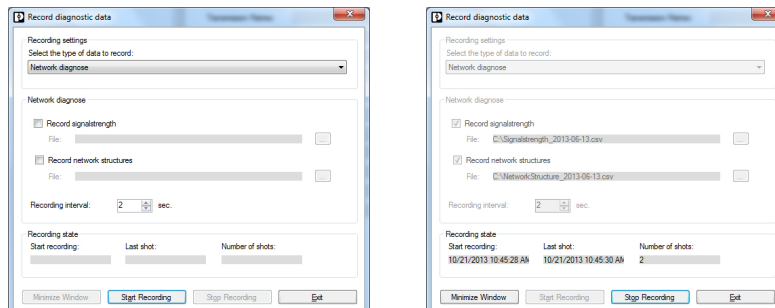
Figure 5-19   PSI-CONF software: Record diagnostic data, Network diagnostics

5.9 Starting up I/O extension modules

5.9.1 Combinations of extension modules

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

i	It is **not** possible to separately assign the individual input channels of an extension module to different output modules.
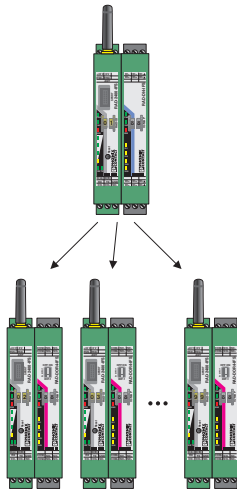
Figure 5-20   Assignment of digital inputs and digital outputs

The combined RAD-DAIO6-IFS extension modules can only be assigned in pairs, because each module has inputs and outputs. That is why only two modules in the network may have the same I/O MAP address.
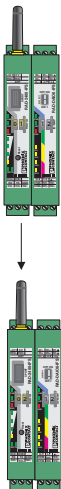
Figure 5-21   RAD-DAIO6-IFS assignment: analog/digital inputs and outputs

Table 5-9   Assignment of input modules 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	Static mode: RAD-DO8-IFS
		-	Pulse counter mode: no output module, can only be used in PLC/Modbus RTU mode
2901533	RAD-DAIO6-IFS	2901533	RAD-DAIO6-IFS

5.9.2   Setting the address of the extension modules using the thumbwheel

For 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 active configuration.

The following settings can be made using the white thumbwheel:

Table 5-10   White thumbwheel setting

Thumbwheel	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 master devices (IFS)

The following conditions must be met:

– Addresses 1 ... 99 (maximum) can be assigned for 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 another 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
...	→	...

> **i** It is **not** possible to individually assign the channels of the input and output modules.
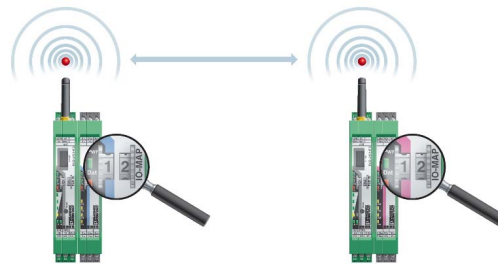
Figure 5-22   Input module and output module with the same address

Wireless module in PLC/Modbus RTU mode

– Output modules **must 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 several seconds until it is ready for operation. Each connected I/O extension module increases the startup time. Accordingly, a complete wireless station with 32 I/O extension modules may take several minutes to start up. Only after this 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.
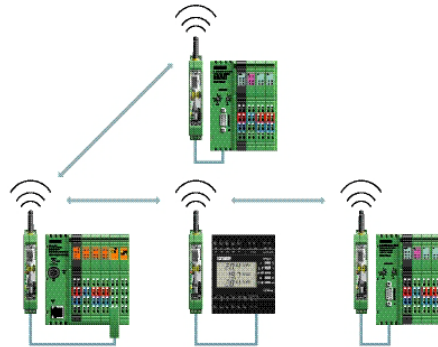
Figure 6-1   Serial data mode

You can configure the serial interface of the 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 perform full 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 performed all the steps in the wizard, you can save the project and transfer it to the wireless modules.
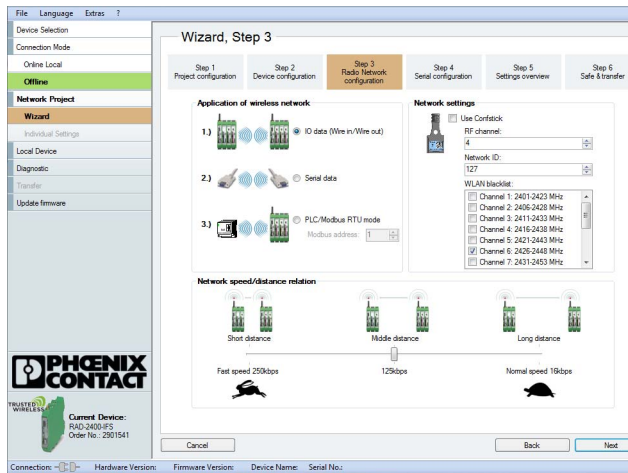
Figure 6-2   PSI-CONF software: Wizard, Step 3
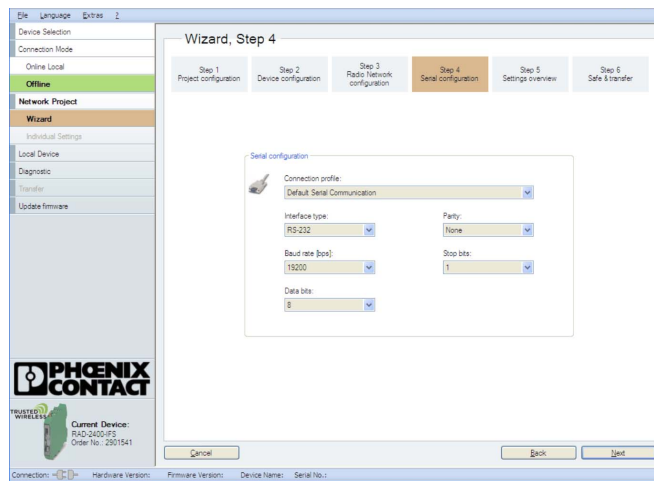
Figure 6-3   PSI-CONF software: Wizard, Step 4

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 the serial interface).
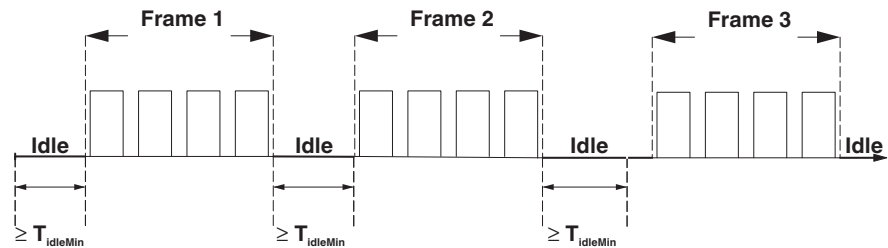
Figure 6-4   Frame-based data transmission: T$_{IdleMin}$ parameter

T$_{FrameEnd}$ parameter

T$_{FrameEnd}$ is the time maintained 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.
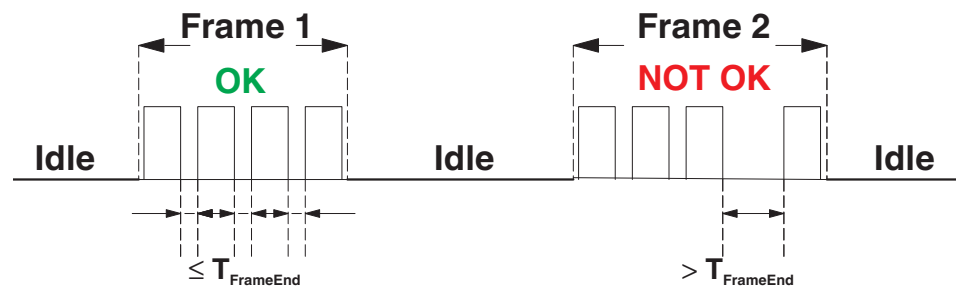
Figure 6-5   Frame-based data transmission: T$_{FrameEnd}$ parameter

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 stream of data. 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 communication is aborted, you must increase the minimum pause time ($T_{FrameEnd}$) between the individual characters of a telegram.

• To adapt data transmission to other protocols, you can adjust the $T_{FrameEnd}$ and $T_{IdleMin}$ parameters accordingly. Set the interface parameters under "Individual Settings".
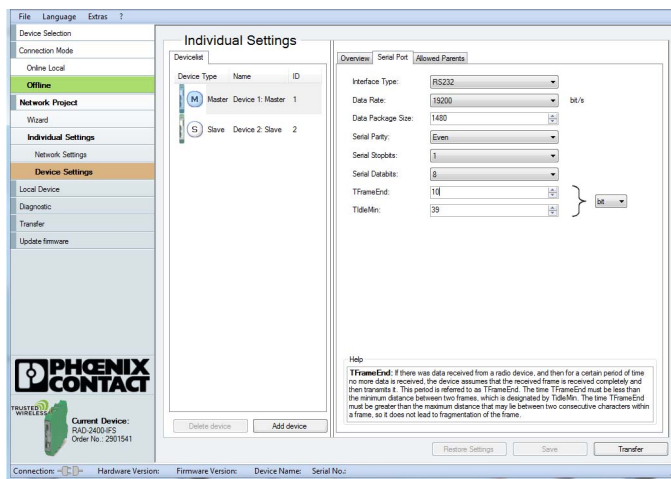
Figure 6-6   PSI-CONF software: Individual Settings

7 PLC/Modbus RTU mode

Activate PLC/Modbus RTU mode using the PSI-CONF software (from page 45). 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. In PLC/Modbus RTU mode, the master wireless module works as a Modbus slave and has its own Modbus slave address. The entire wireless network therefore behaves like a single Modbus slave.

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.
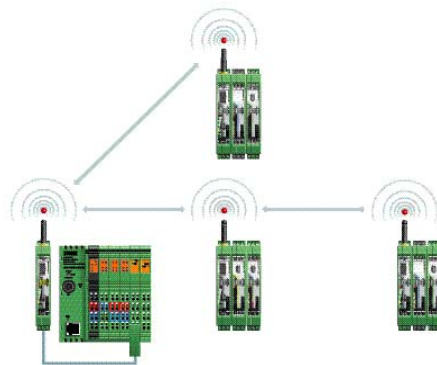
Figure 7-1   PLC/Modbus RTU mode

7.1   Configuration via PSI-CONF software

- Start the PSI-CONF software (see page 45).
- Create a new network project.
- Follow the software wizard.
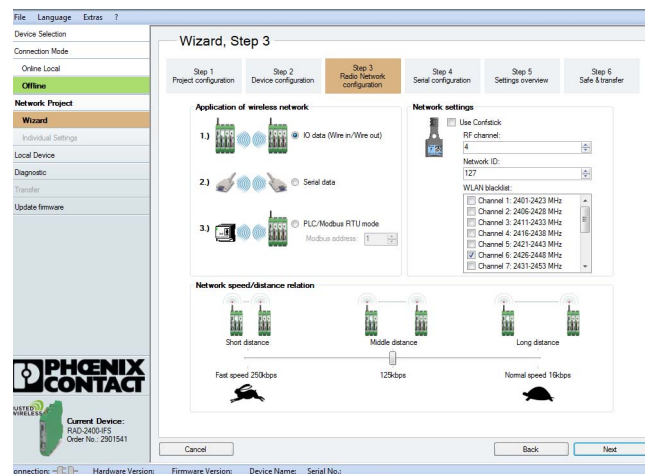
Figure 7-2   PSI-CONF software: Wizard, Step 3

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

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

In order to enable the master wireless module to communicate with a controller via the RS-232 or RS-485 interface, you must 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 ... 115200 bps	19200 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.

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 on page 60 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.

- Under "Individual Settings", select the "Network Settings" item. You can set a watchdog time of 200 ms ... 65000 ms here.
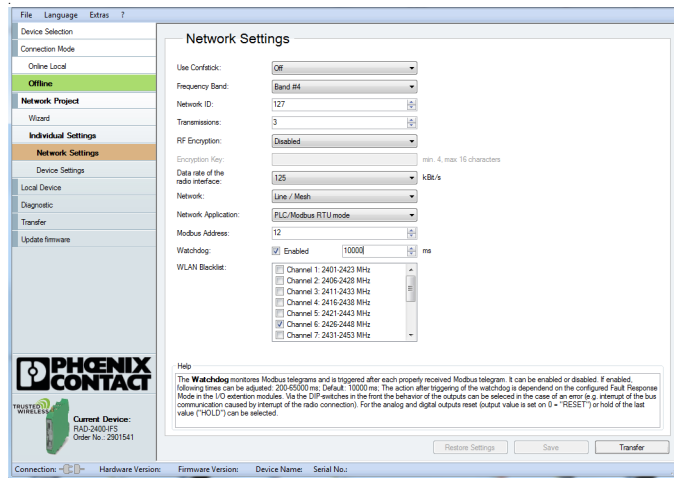
Figure 7-3   PSI-CONF software: Individual Settings, Network Settings

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

– OFF = RESET: the output value is set to 0
– ON = HOLD: hold the last output value

For more information about setting the DIP switches for the different extension modules, please refer to Section "Description of I/O extension modules" on page 89.

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

Table 7-2 Supported Modbus function codes

Code number	Function code	Description
fc 03	Read Holding Register	Read OUT process data (address area 40010 ... 40999)
fc 04	Read Input Register	Read IN process 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.
– Registers 1 ... 123 can be read or written with a command.

7.4.1 Addressing registers

ⓘ
Please note that a distinction is made in the Modbus telegram between the register number and register address:
– The register number starts with 1.
– The register address starts with 0.

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

You must enter 0031 (hex001F) as the start address in order to read or write register 40032 ... 40039. The address area 4xxxx is already defined by the function code field.

7.5 Module type and error code registers for I/O extension modules

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

Table 7-3 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
							Y[2]				Module type				

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

[2] Y = 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 7-4 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, then the register value is 1. This is the case, for example, if the wireless connection to an input module fails. The IN 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 OUT 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 is 0.

7.5.1 Assigning I/O extension modules to the register

You can 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 I/O MAP address = 01, the register assignment is 30010.

Table 7-5   Setting the white thumbwheel for register 30010 (read)

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

7.6   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 located in the master wireless module with 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 point the I/O data is stored in the Modbus memory map. You can find a complete overview of the Modbus memory map on page 83 onwards.

The RSSI signal register can be found on page 86 onwards.

Table 7-6   RAD-2400-IFS RSSI voltage

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

Table 7-7   RAD-868-IFS RSSI voltage

	1.2k	9.6k	19.2k	60k	120k	RSSI voltage
LED 3	-90 dBm	-85 dBm	-80 dBm	-75 dBm	-70 dBm	≥ 2.5 V
LED 2	-100 dBm	-95 dBm	-90 dBm	-85 dBm	-80 dBm	≥ 2.0 V
LED 1	-110 dBm	-105 dBm	-100 dBm	-95 dBm	-90 dBm	≥ 1.5 V
LINK LED	LINK	LINK	LINK	LINK	LINK	~1.0 V

7.6.1   RAD-AI4-IFS process data

I/O module	Module type ID	Register	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 white thumbwheel

Table 7-8   RAD-AI4-IFS module type and currentness of data

30xx0[1]							Module type and currentness of data								
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
							Y[2]	Module type[3]							

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

[2]   Y = Currentness of data, bit 8
If the data in the register is not up to date, then the register value is 1. This is the case, for example, if the wireless connection or communication with an input module fails. In this case, the IN process data is retained in the Modbus table, but is no longer updated.

[3]   If the module type in the register is invalid or unavailable, then the register value is 0

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

7.6.2 RAD-PT100-4-IFS process data

I/O module	Module type ID	Register	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 white thumbwheel

Table 7-9   RAD-PT100-4-IFS module type and currentness of data

$30xx0^1$							Module type and currentness of data								
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
							Y^2	Module type^3							

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

2   Y = Currentness of data, bit 8
If the data in the register is not up to date, then the register value is 1. This is the case, for example, if the wireless connection or communication with an input module fails. In this case, the IN process data is retained in the Modbus table, but is no longer updated.

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

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

7.6.3 RAD-AO4-IFS process data

I/O module	Module type ID	Register	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 white thumbwheel

Table 7-10   RAD-AO4-IFS module type and currentness of data

40xx0[1]						Module type and currentness of data									
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
							Y^2				Module type[3]				

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

[2] Y = Currentness of data, bit 8
     If the data in the register is not up to date, then the register value is 1. If the process data has been written to one of the registers, then the register value is 0. The register value then remains 0 for the entire operating time of the device.

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

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

7.6.4 RAD-DI4-IFS process data

I/O module	Module type ID	Register	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 white thumbwheel

Table 7-11   RAD-DI4-IFS module type and currentness of data

30xx0[1]							Module type and currentness of data								
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
							Y[2]	Module type[3]							

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

[2]   Y = Currentness of data, bit 8
If the data in the register is not up to date, then the register value is 1. This is the case, for example, if the wireless connection or communication with an input module fails. In this case, the IN process data is retained in the Modbus table, but is no longer updated.

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

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

7.6.5   RAD-DI8-IFS process data

I/O module	Module type ID	Register	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 white thumbwheel

Table 7-12   RAD-DI8-IFS module type and currentness of data

30xx0[1]							Module type and currentness of data								
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
							Y[2]	Module type[3]							

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

[2]   Y = Currentness of data, bit 8
If the data in the register is not up to date, then the register value is 1. This is the case, for example, if the wireless connection or communication with an input module fails. In this case, the IN process data is retained in the Modbus table, but is no longer updated.

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

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 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

7.6.6 RAD-DOR4-IFS process data

I/O module	Module type ID	Register	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 white thumbwheel

Table 7-13   RAD-DOR4-IFS module type and currentness of data

30xx0[1]							Module type and currentness of data								
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
							Y^2	Module type[3]							

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

[2]   Y = Currentness of data, bit 8
      If the data in the register is not up to date, then the register value is 1. If the process
      data has been written to one of the registers, then the register value is 0. The value
      then remains 0 for the entire operating time of the device.

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

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

7.6.7 RAD-DO8-IFS process data

I/O module	Module type ID	Register	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 white thumbwheel

Table 7-14   RAD-DO8-IFS 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
							Y[2]				Module type[3]				

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

[2] Y = Currentness of data, bit 8
If the data in the register is not up to date, then the register value is 1. If the process data has been written to one of the registers, bit 8 in 40xx0 is set to 0. The value in register 40xx0 then remains 0 for the entire operating time of the device.
However, in register 30xx0 bit 8 is reset to 1 as soon as the status of short-circuit detection is not up to date. This is the case, for example, if communication with an input module fails. In this case, the IN process data is retained in the Modbus table, but is no longer updated.

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

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 output or several outputs 5 ... 8.

[2] **Bit 0 = 1:** short circuit detected at one output 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

7.6.8   RAD-DAIO6-IFS process data

I/O module	Module type ID	Register	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 white thumbwheel

Table 7-15   RAD-DAIO6-IFS module type and currentness of data

30xx0[1]								**Module type and currentness of data**							
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
							Y[2]	Module type[3]							

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

[2]   Y = Currentness of data, bit 8
If the data in the register is not up to date, then the register value is 1. If the process data has been written to one of the registers, bit 8 in 40xx0 is set to 0. The value in register 40xx0 then remains 0 for the entire operating time of the device. This is the case, for example, if the wireless connection fails. The IN process data is retained in the Modbus table, but is no longer updated.

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

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

7.6.9 Complete overview of the Modbus memory map

I/O input data, address area 30010 ... 30999

Modbus function code 04

RAD-DAIO6-IFS

30	xx	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		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

40	xx	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 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

30	xx	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		DI4 ... DI1
				X X X X

30xx2 ... 30xx9 reserved

RAD-DOR4-IFS

40	xx	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		DO4 ... DO1
				X X X X

40xx2 ... 40xx9 reserved

RAD-DI8-IFS

30	xx	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	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

40	xx	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	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
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
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
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
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				

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

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

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

....			. . .
....			. . .
40	99	0	
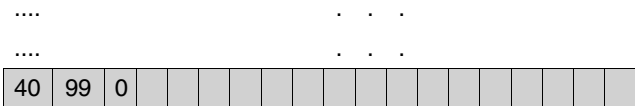
7.6.10 RSSI signal and error code registers

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 in the network are within address area 35001 ... 35250.

Table 7-16   RSSI signal and error code registers

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							IFS	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

Bit 08 = error on IFS bus

If an error is present on the IFS bus, the register value is 1 (e.g., local bus error, because the input or output module is disconnected from the DIN rail connector). If no error is present on the IFS bus, the register value is 0.

–   Bits 9 ... 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)

7.7 Error codes and formats for analog input and output values

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

RAD-AI4-IFS analog inputs

Table 7-17   Representation of RAD-AI4-IFS analog 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	-

RAD-AO4-IFS analog outputs

Table 7-18   Representation of RAD-AO4-IFS analog 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

RAD-DAIO6-IFS analog inputs and outputs

Table 7-19   Representation of RAD-DAIO6-IFS analog 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 7-20   Representation of 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 cable too long, cable resistance too high
8080	Underrange				

8 Description of I/O extension modules

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

The RAD-AI4-IFS analog I/O extension module can process up to four input signals with 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 at least 12 V DC is available at connection terminal block PWR_1 for passive sensors (see Figure 8-1, item 1).

8.1.1 Structure
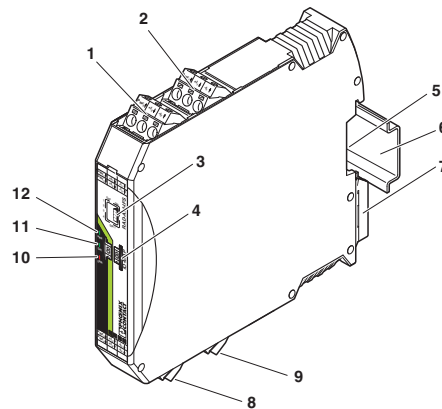
Figure 8-1   RAD-AI4-IFS structure

Item	Terminal block	Designation
1	3.1/3.2/3.3	Analog input 2 for 2, 3, 4-wire measuring transducers
2	2.1/2.2/2.3	Analog input 1 for 2, 3, 4-wire measuring transducers
3		DIP switches for configuring the analog inputs (0 ... 20 mA, 4 ... 20 mA)
4		White thumbwheel for setting the I/O MAP address
5		Connection option for DIN rail connector
6		DIN rail
7		Metal base latch for DIN rail fixing
8	4.1/4.2/4.3	Analog input 3 for 2, 3, 4-wire measuring transducers
9	5.1/5.2/5.3	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
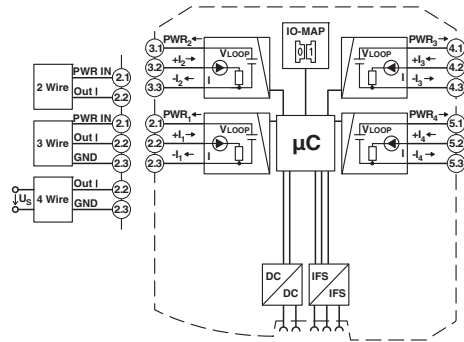
Figure 8-2   Basic circuit diagram for the RAD-AI4-IFS

8.1.3 Setting the DIP switches

You can configure the input signals using the DIP switches on the front (0 mA ... 20 mA or 4 mA ... 20 mA). Any changes to the DIP switch settings will be applied immediately. In PLC/Modbus RTU mode, the setting of the input signals is evaluated for error diagnostics. When set to 4 mA ... 20 mA, for example, it is possible to detect an open circuit.
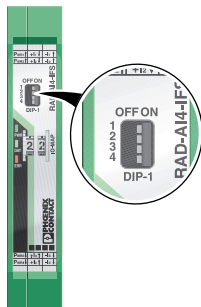
Figure 8-3   DIP switches of the RAD-AI4-IFS

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

		DIP switches			
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 Diagnostics LEDs

The RAD-AI4-IFS I/O extension module uses a total of three LEDs to indicate the operating states.
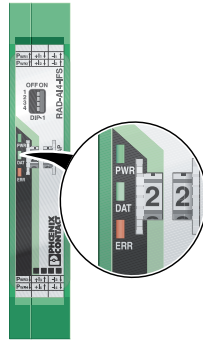
Figure 8-4   Diagnostics LEDs of the RAD-AI4-IFS

PWR LED

The green PWR LED indicates the status of the supply voltage.

Off	No supply voltage
On	Supply voltage OK

DAT LED

The green DAT LED indicates the status of bus communication.

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. Addresses 01 ... 99 (maximum) can be assigned for 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	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 master devices (IFS)

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	Register	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

The RAD-PT100-4-IFS analog I/O extension module has four Pt 100 inputs for temperatures from -50°C ... +250°C. Pt 100 inputs T1 ... T4 can be mapped to analog outputs I1/U1 ... I4/U4 of the RAD-AO4-IFS extension module. All 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 according to 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 a temperature of -50°C at the Pt 100 input, a current of 0 mA or a voltage of 0 V is output at the output module. At a temperature of 250°C at the Pt 100 input, a current of 20 mA or a voltage of 10 V is output at the output.

Table 8-3   Pt 100 input

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. Take the measuring errors of the different measuring methods into consideration.

2-wire connection technology

2-wire connection technology is the most cost-effective connection technology. The temperature-related voltage is not directly measured at the sensor and is therefore falsified by the two cable resistances R_L. The measuring errors that occur may render the entire measurement useless. Please observe the diagrams in Section "Measuring errors when using 2-wire connection technology" on page 95.

For 2-wire connection technology, an insertion bridge is required between terminal blocks x.2 and x.3.
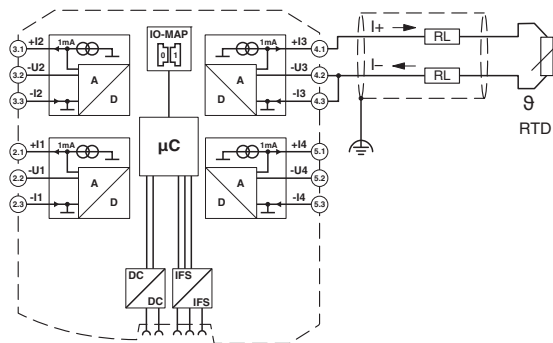
Figure 8-5   2-wire connection technology

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 with 4-wire connection technology.

The cable resistances R_L at terminal blocks +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.
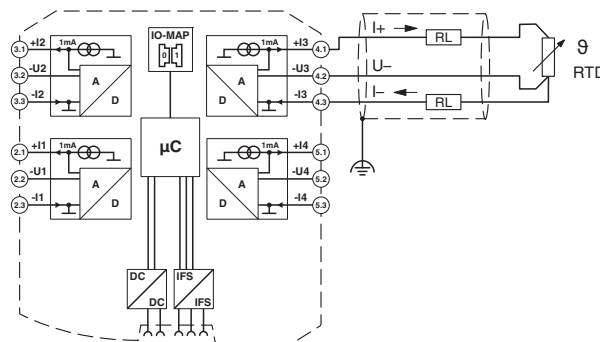
Figure 8-6   3-wire connection technology

4-wire connection technology

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

- If you want to use a 4-wire sensor, only connect three of the four cables.
- The fourth cable 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.
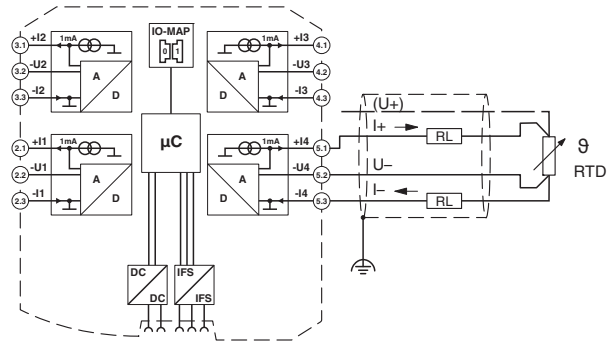
Figure 8-7   4-wire connection technology

8.2.2   Measuring errors when using 2-wire connection technology
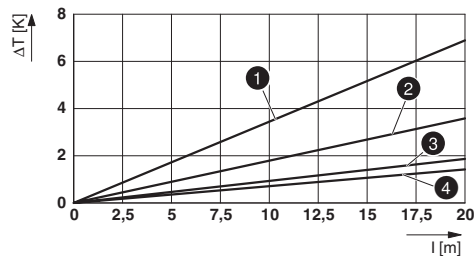
Figure 8-8   Systematic temperature measuring error ΔT depending on cable length l

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 $\chi = 57$ m/Ωmm^2, $T_A = 25°C$, and Pt 100 sensor)
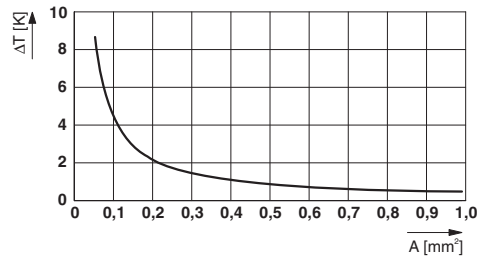
Figure 8-9   Systematic temperature measuring error ΔT depending on cable cross section A
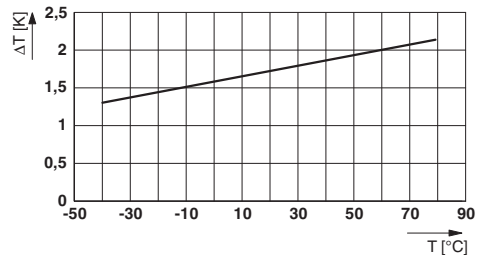
Figure 8-10   Systematic temperature measuring error ΔT depending on cable temperature T_A

(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 cable 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	Cable 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.

8.2.3   Structure
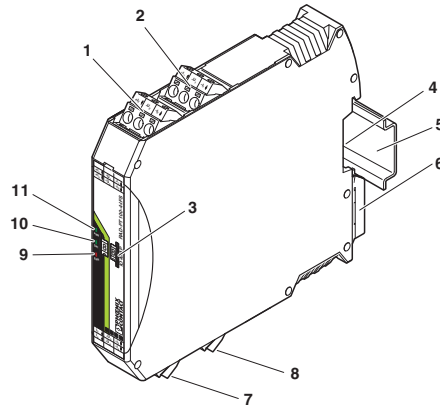
Figure 8-11   RAD-PT100-4-IFS structure

Item	Terminal block	Designation
1	3.1/3.2/3.3	Pt 100 input 2 for 2 and 3-wire sensors
2	2.1/2.2/2.3	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 base latch for DIN rail fixing
7	4.1/4.2/4.3	Pt 100 input 3 for 2 and 3-wire sensors
8	5.1/5.2/5.3	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)

8.2.4   Basic circuit diagram
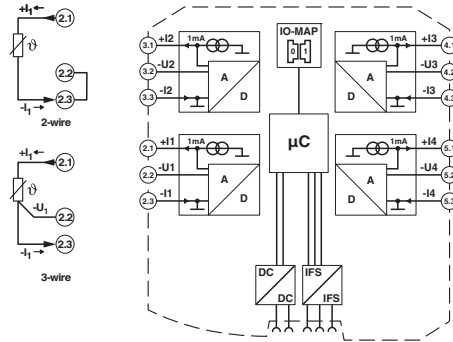
Figure 8-12   Basic circuit diagram for the RAD-PT100-4-IFS

For 2-wire connection technology, an insertion bridge is required between terminal blocks x.2 and x.3. In this case, the measuring accuracy is reduced (see "Measuring errors when using 2-wire connection technology" on page 95).

8.2.5   Diagnostics LEDs

The RAD-PT100-4-IFS I/O extension module uses a total of three LEDs to indicate the operating states.
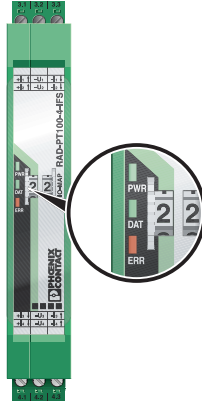
Figure 8-13   Diagnostics LEDs of the RAD-PT100-4-IFS

PWR LED

The green PWR LED indicates the status of the supply voltage.

Off	No supply voltage
On	Supply voltage OK

DAT LED

The green DAT LED indicates the status of bus communication.

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

8.2.6   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. Addresses 01 ... 99 (maximum) can be assigned for the I/O extension modules in the entire wireless network.

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

Thumbwheel	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 master devices (IFS)

8.2.7   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	Register	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

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

$\boxed{\mathbf{i}}$ Use either the current or voltage output at every analog channel.

8.3.1 Structure
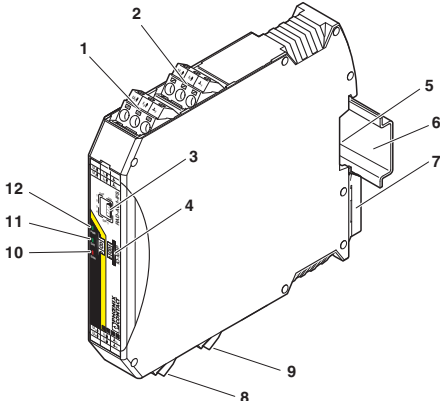
Figure 8-14   RAD-AO4-IFS structure

| Item	Terminal block	Designation
1	3.1/3.2/3.3	Analog output 2 (either current or voltage)
2	2.1/2.2/2.3	Analog output 1 (either 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 base latch for DIN rail fixing	
8	4.1/4.2/4.3	Analog output 3 (either current or voltage)
9	5.1/5.2/5.3	Analog output 4 (either 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
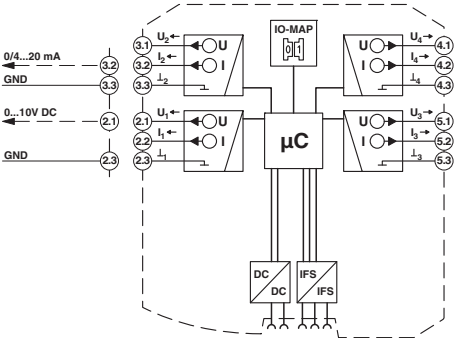
Figure 8-15   Basic circuit diagram for the RAD-AO4-IFS

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 to the DIP switch settings will be applied immediately.

– RESET = Output value is set to 0

– HOLD = Hold last valid output value
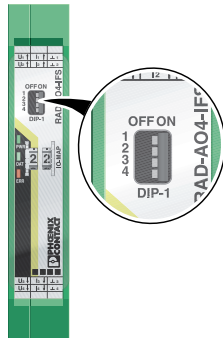
Figure 8-16   DIP switches of the RAD-AO4-IFS

Table 8-5   DIP switches of the RAD-AO4-IFS

		DIP switches			
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   Diagnostics LEDs

The RAD-AO4-IFS I/O extension module uses a total of three LEDs to indicate the operating states.
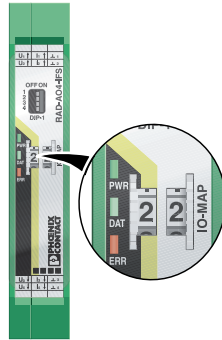
Figure 8-17   Diagnostics LEDs of the RAD-AO4-IFS

PWR LED

The green PWR LED indicates the status of the supply voltage.

Off	No supply voltage
On	Supply voltage OK

DAT LED

The green DAT LED indicates the status of bus communication.

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 the 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. Addresses 01 ... 99 (maximum) can be assigned for the I/O extension modules in the entire wireless network.

Table 8-6   Setting the I/O MAP address for the RAD-AO4-IFS

Thumbwheel	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 master devices (IFS)

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	Register	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 outputs. The isolating voltage between the individual channels must not exceed 300 V.

The RAD-DI4-IFS digital I/O extension module can process up to four input signals. The digital inputs process voltages of 0 V ... 50 V AC/DC at the low voltage input and voltages of 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
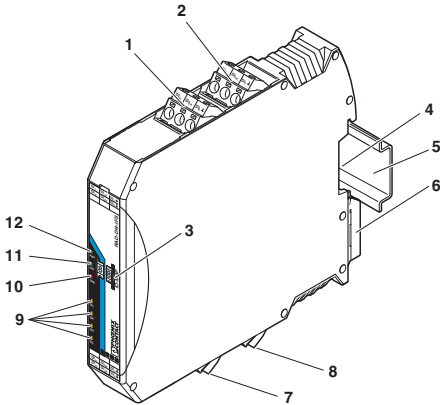
Figure 8-18   RAD-DI4-IFS structure

Item	Terminal block	Designation
1	2.1/2.2/2.3	Digital input as wide-range input
2	1.1/1.2/1.3	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 base latch for DIN rail fixing
7	5.1/5.2/5.3	Digital input as wide-range input
8	6.1/6.2/6.3	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
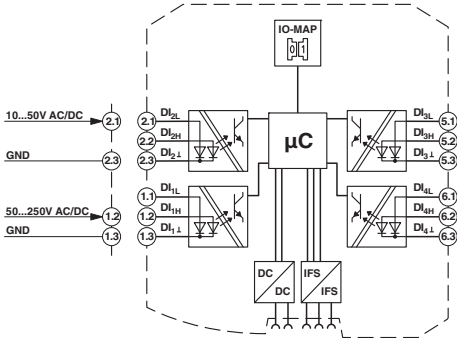
Figure 8-19   Basic circuit diagram for the RAD-DI4-IFS

8.4.3 Diagnostics LEDs

The RAD-DI4-IFS I/O extension module uses a total of seven LEDs to indicate the operating states.
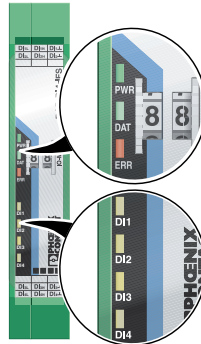
Figure 8-20   Diagnostics LEDs of the RAD-DI4-IFS

PWR LED

The green PWR LED indicates the status of the supply voltage.

Off	No supply voltage
On	Supply voltage OK

DAT LED

The green DAT LED indicates the status of bus communication.

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 state 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. Addresses 01 ... 99 (maximum) can be assigned for the I/O extension modules in the entire wireless network.

Table 8-7 Setting the I/O MAP address for the RAD-DI4-IFS

Thumbwheel	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 master devices (IFS)

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	Register	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

The RAD-DI8-IFS digital I/O extension module processes 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 109.

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

8.5.1 Structure
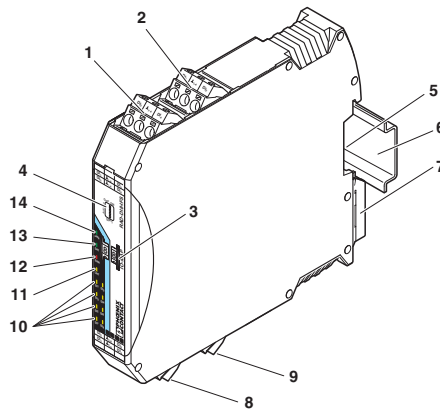
Figure 8-21   RAD-DI8-IFS structure

Item	Terminal block	Designation
1	3.1/3.2/3.3	Digital inputs 3 + 4
2	2.1/2.2/2.3	Digital inputs 1 + 2, DI1: pulse input 1
3	White thumbwheel for setting the I/O MAP address	
4	DIP switches for switching between static mode and pulse counter mode for digital inputs	
5	Connection option for DIN rail connector	
6	DIN rail	
7	Metal base latch for DIN rail fixing	
8	4.1/4.2/4.3	Digital inputs 5 + 6
9	5.1/5.2/5.3	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
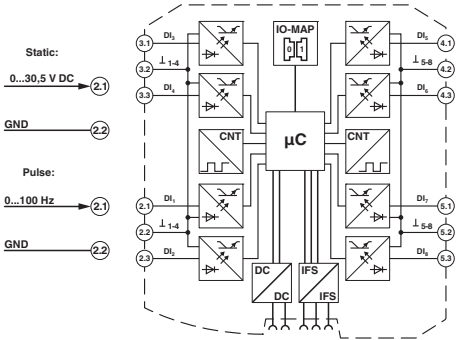
Figure 8-22   Basic circuit diagram for the RAD-DI8-IFS

8.5.3 Setting the DIP switches

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

– In static mode, inputs DI1 ... DI8 are activated, 0 V ... 30.5 V DC voltage
– In pulse counter mode, pulse inputs DI1 and DI7 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 45).
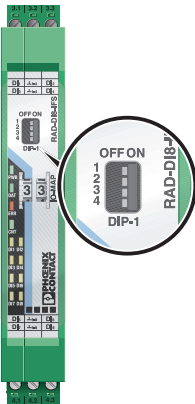
Figure 8-23   DIP switches of the RAD-DI8-IFS

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

		DIP switches			
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

- Select static mode or pulse counter mode using DIP switch 1.
- 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 state is automatically reset to 0. There are also three ways in which you can reset the counter state manually:

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 input **DI3** in order to reset counter state **DI1**.
    - Set input **DI5** in order to reset counter state **DI7**.

8.5.5   Diagnostics LEDs

The RAD-DI8-IFS I/O extension module uses a total of twelve LEDs to indicate the operating states.
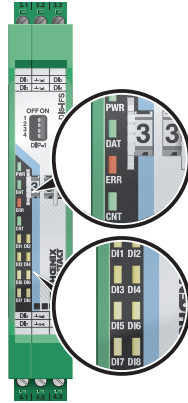
Figure 8-24   Diagnostics LEDs of the RAD-DI8-IFS

PWR LED

The green PWR LED indicates the status of the supply voltage.

Off   No supply voltage
On   Supply voltage OK

DAT LED

The green DAT LED indicates the status of bus communication.

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 state 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 seconds)	Counter state DI1 reset to 0
DI5	On (0.5 seconds)	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. Addresses 01 ... 99 (maximum) can be assigned for the I/O extension modules in the entire wireless network.

Table 8-9   Setting the I/O MAP address for the RAD-DI8-IFS

Thumbwheel	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 master devices (IFS)

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 77.

I/O module	Module type ID	Register	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 outputs. The isolating voltage between the individual channels must not exceed 300 V.

The RAD-DOR4-IFS digital 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 (changeover contacts). All outputs are electrically isolated from one another, from the supply voltage, and from the electronics.

8.6.1 Structure
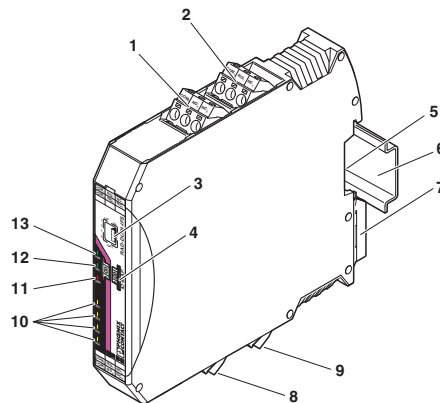
Figure 8-25   RAD-DOR4-IFS structure

Item	Terminal block	Designation
1	2.1/2.2/2.3	Relay output 2 with floating changeover contact
2	1.1/1.2/1.3	Relay output 1 with floating changeover 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 base latch for DIN rail fixing
8	5.1/5.2/5.3	Relay output 3 with floating changeover contact
9	6.1/6.2/6.3	Relay output 4 with floating changeover contact
10		Status LEDs for 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
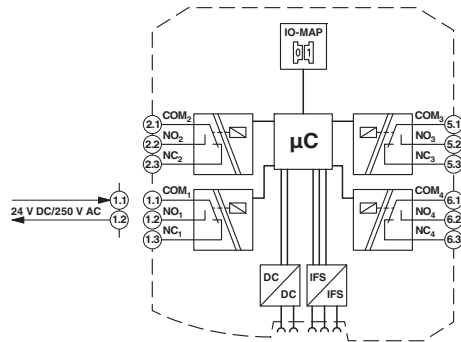
Figure 8-26   Basic circuit diagram for the RAD-DOR4-IFS

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 to the DIP switch settings will be applied immediately.

– RESET = Output value is set to 0
– HOLD = Hold last output value
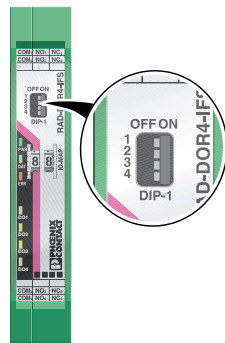
Figure 8-27   DIP switches of the RAD-DOR4-IFS

Table 8-10   DIP switches of the RAD-DOR4-IFS

		DIP switches			
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   Diagnostics LEDs

The RAD-DOR4-IFS I/O extension module uses a total of seven LEDs to indicate the operating states.
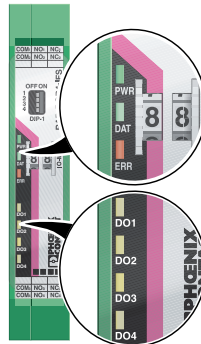
Figure 8-28   Diagnostics LEDs of the RAD-DOR4-IFS

PWR LED

The green PWR LED indicates the status of the supply voltage.

Off   No supply voltage

On   Supply voltage OK

DAT LED

The green DAT LED indicates the status of bus communication.

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 the outputs, depending on DIP switch setting)
On	Critical internal error

DO1 ... DO4

The yellow DO1 ... DO4 LEDs indicate the state 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. Addresses 01 ... 99 (maximum) can be assigned for the I/O extension modules in the entire wireless network.

Table 8-11   Setting the I/O MAP address for the RAD-DOR4-IFS

Thumbwheel	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 master devices (IFS)

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 the process data, please refer to Section "RAD-DOR4-IFS process data" on page 79.

I/O module	Module type ID	Register	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

The RAD-DO8-IFS digital 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 supply. The two output groups are electrically isolated from one another, from the supply voltage, and from the electronics.

Since output groups DO1 ... DO4 and DO5 ... DO8 are electrically isolated, the outputs must be supplied externally (see Figure 8-30).
- Outputs DO1 ... DO4 are supplied via:
    - Terminal block 1.1 (12 V DC ... 30.5 V DC)
    - Terminal blocks 1.2/1.3 (GND)
- Outputs DO5 ... DO8 are supplied via:
    - Terminal block 6.1 (12 V DC ... 30.5 V DC)
    - Terminal blocks 6.2/6.3 (GND)

8.7.1   Structure
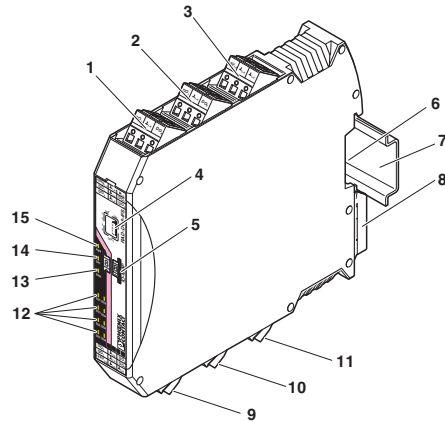
Figure 8-29   RAD-DO8-IFS structure

Item	Terminal block	Designation
1	3.1/3.2/3.3	Transistor outputs 3 + 4
2	2.1/2.2/2.3	Transistor outputs 1 + 2
3	1.1/1.2/1.3	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 base latch for DIN rail fixing	
9	4.1/4.2/4.3	Transistor outputs 5 + 6
10	5.1/5.2/5.3	Transistor outputs 7 + 8
11	6.1/6.2/6.3	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
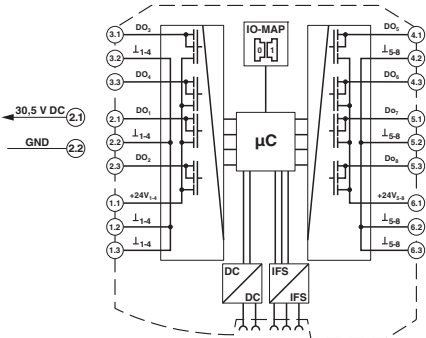
Figure 8-30   Basic circuit diagram for the RAD-DO8-IFS

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 to the DIP switch settings will be applied immediately.

– RESET = Output value is set to 0
– HOLD = Hold last output value
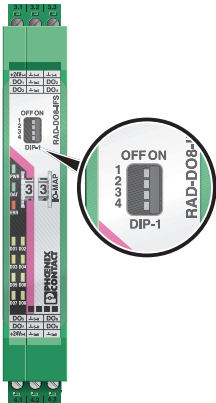
Figure 8-31   DIP switches of the RAD-DO8-IFS

Table 8-12   DIP switches of the RAD-DO8-IFS

		DIP switches			
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   Diagnostics LEDs

The RAD-DO8-IFS I/O extension module uses a total of eleven LEDs to indicate the operating states.
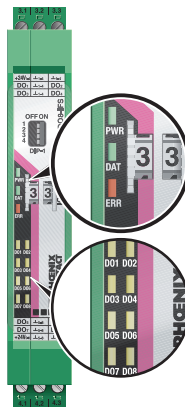
Figure 8-32   Diagnostics LEDs of the RAD-DO8-IFS

PWR LED

The green PWR LED indicates the status of the supply voltage.

Off   No supply voltage

On   Supply voltage OK

DAT LED

The green DAT LED indicates the status of bus communication.

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 the 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 state 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. Addresses 01 ... 99 (maximum) can be assigned for the I/O extension modules in the entire wireless network.

Table 8-13   Setting the I/O MAP address for the RAD-DO8-IFS

Thumbwheel	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 master devices (IFS)

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 80.

I/O module	Module type ID	Register	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 outputs. The isolating voltage between the individual channels must not exceed 300 V.

The RAD-DAIO6-IFS analog/digital I/O extension module has a total of six channels. The device can 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 of 0 V ... 50 V AC/DC at the low voltage input and voltages of 0 V ... 250 V AC/DC at the high voltage input.

Two digital outputs

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

Analog input

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

Analog output

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

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

8.8.1 Structure
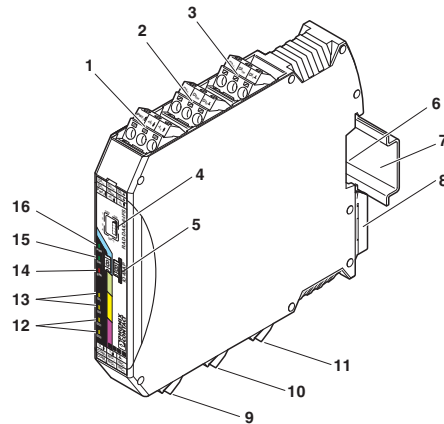
Figure 8-33   RAD-DAIO6-IFS structure

Item	Terminal block	Designation
1	3.1/3.2/3.3	Analog input for 2, 3, 4-wire measuring transducers
2	2.1/2.2/2.3	Digital input as wide-range input
3	1.1/1.2/1.3	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 base latch for DIN rail fixing
9	4.1/4.2/4.3	Analog output, either current or voltage
10	5.1/5.2/5.3	Relay output with floating changeover contact
11	6.1/6.2/6.3	Relay output with floating changeover contact
12		Status LEDs of digital outputs DO1 ... DO2
13		Status LEDs of digital inputs DI1 ... DI2
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
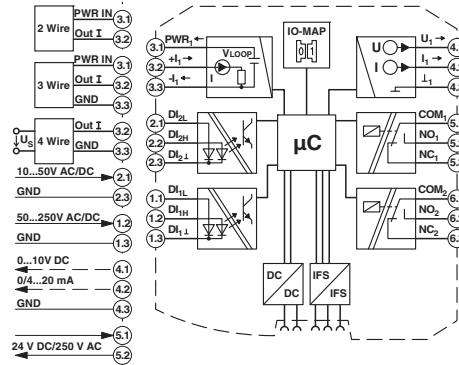
Figure 8-34   Basic circuit diagram for the RAD-DAIO6-IFS

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 to the DIP switch settings will be applied immediately.

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
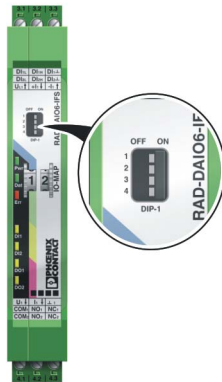
Figure 8-35   DIP switches of the RAD-DAIO6-IFS

Table 8-14   DIP switches of the RAD-DAIO6-IFS

Setting	Output signal	DIP switches			
		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   Diagnostics LEDs

The RAD-DAIO6-IFS I/O extension module uses a total of seven LEDs to indicate the operating states.
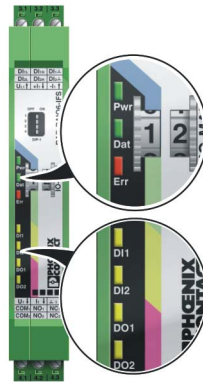
Figure 8-36   Diagnostics LEDs of the RAD-DAIO6-IFS

PWR LED

The green PWR LED indicates the status of the supply voltage.

Off   No supply voltage

On   Supply voltage OK

DAT LED

The green DAT LED indicates the status of bus communication.

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 the outputs, depending on DIP switch setting)
On	Critical internal error

DI1 / DI2

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

DO1 / DO2

The yellow DO1 and DO2 LEDs indicate the state 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. Addresses 01 ... 99 (maximum) can be assigned for the I/O extension modules in the entire wireless network.

Table 8-15   Setting the I/O MAP address for the RAD-DAIO6-IFS

Thumbwheel	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 master devices (IFS)

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 81.

I/O module	Module type ID	Register	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 Delay time

Among other things, the delay time depends on the following factors:
– Frequency band used (2.4 GHz or 868 MHz, the higher the frequency, the lower the delay time)
– Capacity of the frequency band (the more wireless networks operating in the same frequency band, the higher the delay time)
– Network structure (e.g., star or mesh network, the larger the network, the higher the delay time)
– Distance and set data rate of the wireless interface (the lower the data rate via the wireless interface, the higher the delay time)
– Data encryption (if data encryption is activated, the delay time increases)

The table below shows typical delay times that have been determined under laboratory conditions for frequency bands without any interference. The delay times may be higher or lower in practice. The delay time is roughly doubled with each repeater in the network.

Table 9-1   Typical delay times

Telegram length[1]	Frequency band	Network application	Data rate of the serial interface [kbps]	Data rate of the wireless interface [kbps]	Typical delay time
50 bytes	2.4 GHz	I/O data mode	-	250	150 ms
				125	200 ms
				16	500 ms
		Serial data mode	19.2	250	30 ms
				125	50 ms
				16	400 ms
	868 MHz	I/O data mode	-	120	300 ms
				60	500 ms
				19.2	1 s
				9.6	2 s
				1.2	10 s
		Serial data mode	19.2	120	200 ms
				60	400 ms
				19.2	1 s
				9.6	2 s
				1.2	20 s

[1] I/O data mode: the telegram length depends on the number of I/O extension modules.
Serial data mode: the telegram length depends on the protocol used and the terminal devices that are connected to the serial interface.

9.2   Pulse transmission

Due to the delay times in the wireless network (see "Delay time" on page 127), in I/O data mode the digital inputs and outputs are only suitable for transmitting the state. The pulses should therefore be very slow and transmitted with a fixed duty cycle of 50%.

For fast pulse transmissions, e.g., in the case of flow meters, use the RAD-DI8-IFS I/O extension module in pulse counter mode (see "Setting the DIP switches" on page 109). You can record pulses up to 100 Hz in pulse counter mode.

The pulse counter function is only available in PLC/Modbus RTU mode. Set the operating mode using the PSI-CONF software (from page 45).

In pulse counter mode, the wireless master maintains a central 32-bit Modbus register with the counter state of the relevant pulse input. The Modbus register can be read and written by any PLC controller via Modbus/RTU.

9.3   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 or 868 MHz frequency bands.

Features

– Robust communication thanks to the frequency hopping spread spectrum (FHSS) method
– 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 can be made to the relevant application

Frequency hopping spread spectrum (FHSS) method

Trusted Wireless 2.0 uses the frequency hopping spread spectrum (FHSS) method. In the 2.4 GHz frequency band, a selection of up to 127 channels from the entire spectrum of the frequency band is used. In the 868 MHz frequency band, up to 14 channels are available.

The wireless module "hops" between these channels on the basis of a pseudo-random pattern. This results in more robust and more reliable communication.

RF bands

Trusted Wireless 2.0 can be operated on different RF (radio frequency) bands. This enables the simultaneous use of several Trusted Wireless 2.0 systems.

Coexistence management (only with RAD-2400-IFS)

Blacklisting means that certain frequencies can be hidden selectively. For example, this method allows you to operate several WLAN systems in parallel with Trusted Wireless 2.0 systems without any performance limitations.

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 message that has been tampered with will be recognized as not valid and discarded.

Range

Distances up to several kilometers can be covered with Trusted Wireless 2.0. You can set the data rate of the wireless interface and adapt it to the relevant application. By reducing the data rate, you can increase the sensitivity of the receiver and therefore the range.

The relationship between range and data rate can be illustrated by the energy per bit transmitted. The higher the energy per bit, the greater the achievable range. The energy per bit results from the ratio between transmission power and data rate:
energy per bit = transmission power / data rate

2.4 GHz and 868 MHz wireless systems have different characteristics due to the wavelength. Lower frequencies can overcome obstacles more easily and support longer ranges.
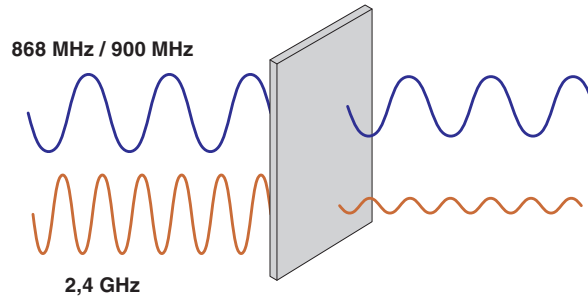
Figure 9-1   Penetration of obstacles at different frequencies

The 2.4 GHz and 868 MHz frequency bands are subject to various directives. 20 dBm maximum may be transmitted in the 2.4 GHz frequency band. In the 868 MHz frequency band, the transmission power may reach 27 dBm. Due to the higher transmission power in the 868 MHz frequency band, longer ranges can also be achieved.

Duty cycle in the 868 MHz band

The duty cycle or holding period refers to the legally regulated period of use for the medium (869.4 MHz ... 869.65 MHz frequency band). The aim of this regulation is to ensure the function of all devices operating in the 868 MHz band. In the 869.4 MHz ... 869.65 MHz frequency band, the maximum transmission time is 10% of one hour (6 minutes). The duty cycle is not usually reached during operation, since only low volumes of data (I/O signals or serial data) are transmitted.

Network structures

2.4 GHz wireless modules can be used to create network structures with up to 250 devices. Up to 99 devices are possible with 868 MHz wireless modules. In these network structures, 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.
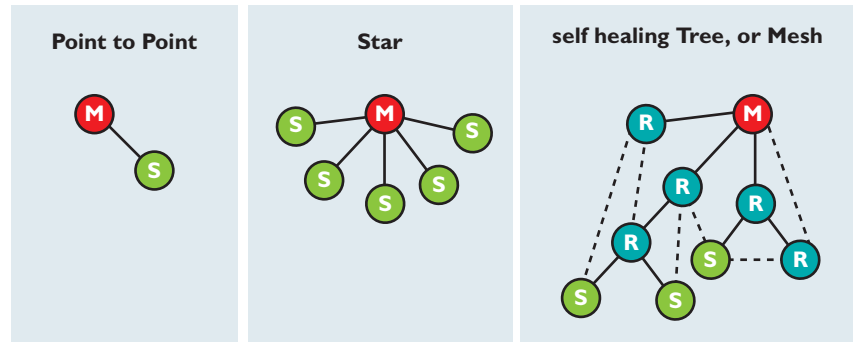
Figure 9-2   Point-to-point connection, star network, self-healing mesh network

Distributed network management

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

Trusted Wireless 2.0, however, uses distributed network management. This involves creating "parent-child zones" in the wireless network where the higher-level wireless module is referred to as the "parent" and the wireless 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 speeds up data exchange.
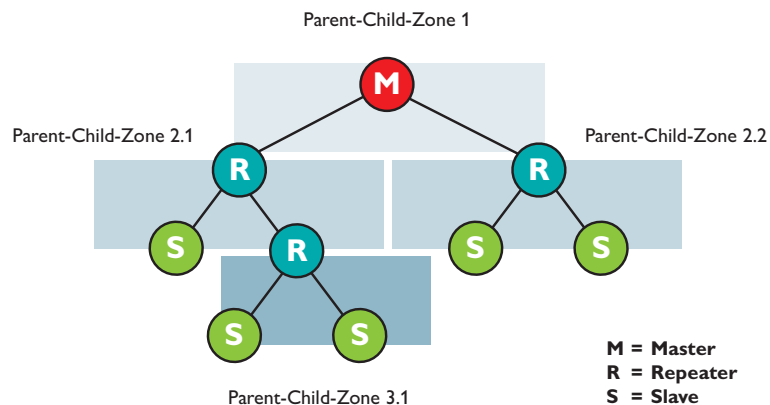
Figure 9-3   Distributed network management with parent-child zones

9.4   RF bands

RAD-2400-IFS

Data rates and RF bands do not depend on the network topology.
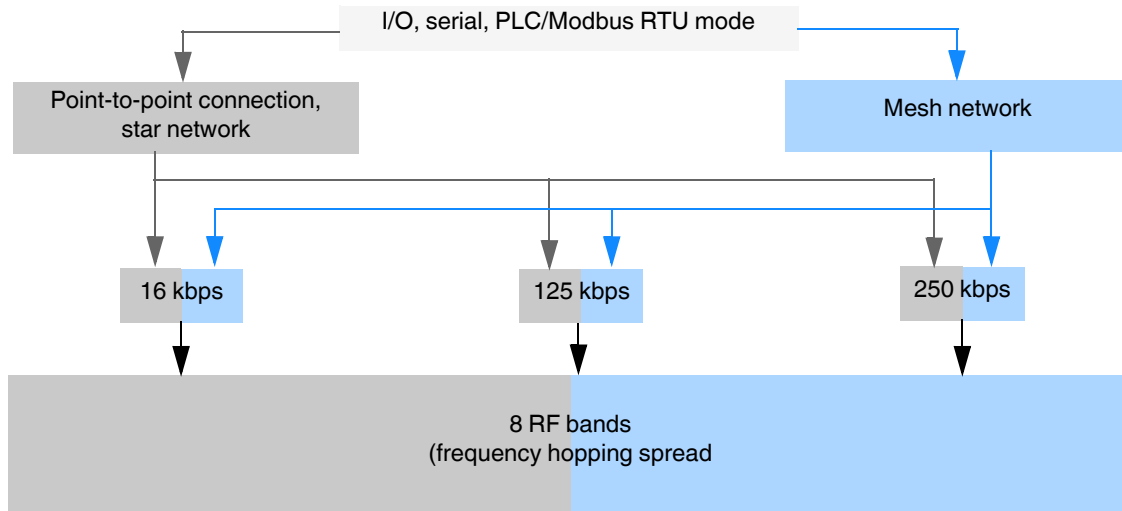
Figure 9-4   RF bands in the 2.4 GHz wireless system

RAD-868-IFS

The number of RF bands depends on the network topology and the over-the-air (OTA) data rate.
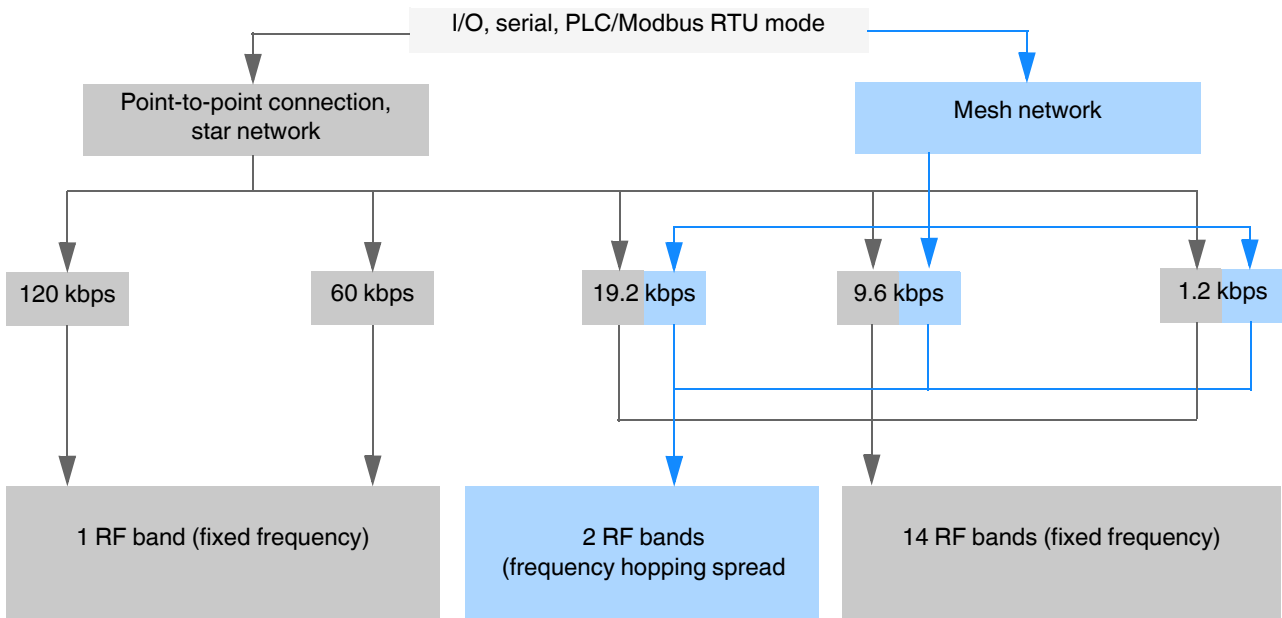
Figure 9-5   RF bands in the 868 MHz wireless system

9.5 Planning wireless paths

Wireless planning enables you to determine whether the wireless system is suitable for the intended application. The three essential requirements for wireless systems are:
– Range
– Data rate
– Stability

These three factors influence one another.

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

Theoretical planning

The following questions should be considered during theoretical planning:
– What 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 circumvent these obstacles, e.g., by means of a repeater or higher mast?

When evaluating the data, a system calculation can be carried out to determine whether the wireless path is theoretically possible. A calculation example can be found on page 149 onwards.

9.6 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 based on the following criteria in order to achieve the best possible wireless connection:
– Position of the antenna with a line of sight and sufficient signal strength
– A primary power source for energy supply is available
– Protection of wireless modules against the effects of weather and extreme ambient conditions
– Adequate access to the antenna, surge protection, interface, and other required cables

These requirements can be quickly assessed in most applications. Positioning the antenna is usually the only difficult task. 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 in the way on long wireless paths have a greater influence than those on short ones.

9.7 Selecting antenna cables and antennas

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 cannot be compensated by high antenna gain or by high transmission power. For every 3 dB of coaxial cable loss, half the transmission 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
– Options for routing the cables

Antennas

• Select the antenna according to the wireless system and the required range.

Table 9-2   Application of antennas

Range	Antenna - RAD-2400-IFS	Antenna - RAD-868-IFS
Short range and direct line of sight without any obstacles	Small omnidirectional antenna	-
Medium range	Large omnidirectional antenna (note the vertical opening angle)	
Long range	Directional antenna (note the small horizontal opening angle)	

In addition, the different antenna types are suitable for the following areas of application:

Omnidirectional antenna

– Numerous devices in different directions, e.g., in mesh networks or networks with repeaters
– Freely mobile applications
– Applications without a line of sight (in reflective environments the signal can be received via an indirect route)

Directional antenna

– Large distances
– Point-to-point connections
– Stationary or linear mobile applications
– Multiple point-to-point paths, decoupling due to directivity and different polarization levels (see Figure 9-7)

9.8 Installing antennas

⚠️ **WARNING: Explosion hazard when used in potentially explosive areas**
Observe the installation instructions for the antenna and the Section "For your safety" on page 17.

🛈 **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 instructions from the antenna manufacturer to ensure that the directional antennas 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 partner antenna.
– If two antennas are located in the same place, the distance between them should be at least 0.6 m in the vertical direction and 1 m in the horizontal direction. In the case of 868 MHz wireless systems, the required minimum distance should be even greater as the transmission power is higher.
– Make sure that you select the correct antenna characteristics at both ends of the wireless path. You can also combine omnidirectional antennas and directional antennas.

Table 9-3　　Antenna characteristics

Antenna	Comparable to ...
Omnidirectional antenna	Light bulb
Directional antenna	Flashlight
Powerful directional antenna, e.g., Yagi or parabolic antenna	Laser pointer

– Note the polarization of the antenna. Most systems use a vertically polarized omnidirectional antenna at the master station. The partner antennas must therefore be polarized vertically. Vertical polarization means that the elements are aligned vertically to the horizon. Crossing polarization between the stations results in signal loss (see also Table 9-4).
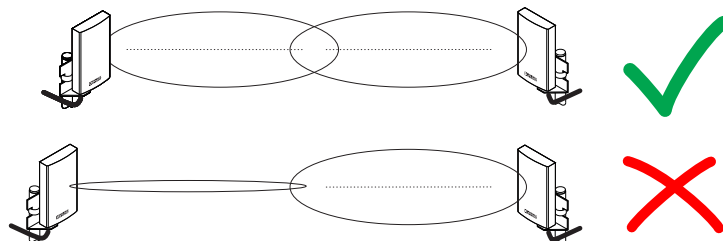
Figure 9-6　　Antenna polarization

– In a highly reflective environment: use antennas with circular polarization. This will avoid polarization losses. You can also combine circularly and vertically polarized antennas.

Table 9-4   Polarization of transmitter/receiver antennas

Polarization	Horizontal ▶	Vertical ▲	Circular clockwise	Circular counterclockwise
Horizontal ▶	Yes	No	Yes, but 3 dB loss	Yes, but 3 dB loss
Vertical ▲	No	Yes	Yes, but 3 dB loss	Yes, but 3 dB loss
Circular clockwise	Yes, but 3 dB loss	Yes, but 3 dB loss	Yes	No
Circular counterclockwise	Yes, but 3 dB loss	Yes, but 3 dB loss	No	Yes

– If you operate several wireless paths directly next to one another in parallel, you can alternately align directional antennas horizontally and vertically. The signals of the various wireless paths will therefore be decoupled.
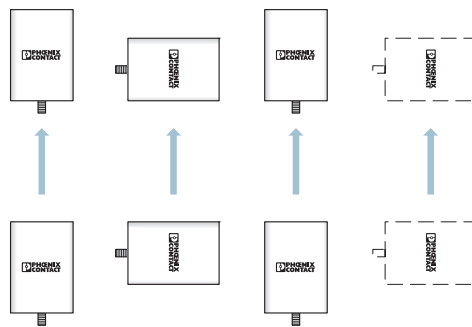
Figure 9-7   Decoupling wireless paths due to directivity and different polarization levels

9.8.1 Outdoor installation of antennas

Antenna cables and antennas are directly exposed to atmospheric discharge. The antennas and the entire infrastructure should therefore be protected against discharge. Protective devices with Lambda/4 technology are usually used for this. These surge protective devices have a coaxial design and are suitable for all common transmission systems. Low attenuation and high bandwidth are simultaneously achieved by means of low-capacitance protective circuits. Thanks to excellent impedance matching, the surge protection does not distort the useful signal.

- Use surge protection for installation outdoors.
    - For RAD-2400-IFS: CN-LAMBDA/4-5.9-BB, Order No. 2838490
    - For RAD-868-IFS: CN-LAMBDA/4-2.2-BB, Order No. 2800024
- The antenna is grounded via the surge protection.
- The antenna mast must be grounded in accordance with the national regulations.
- In outdoor applications, use RAD-TAPE-SV-19-3 vulcanizing sealing tape (Order No. 2903182) to protect adapters, cable connections, etc.
- Run the antenna cable inside the mast or fasten it to the outside of the mast with UV-resistant cable binders.
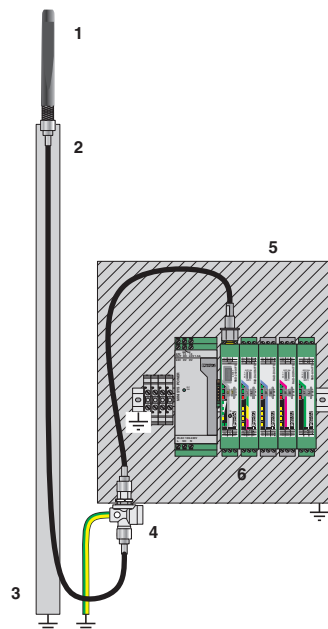
Figure 9-8   Outdoor installation of antennas

1 Omnidirectional antenna
2 Antenna cable
3 Antenna mast
4 Antenna surge protection
5 Control cabinet
6 Power supply, wireless module, and I/O extension modules

9.8.2 Aligning directional 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 align the antenna precisely using 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 54.

• 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 directional antennas, it is important to ensure that the antenna is properly secured. If the antenna sways in the wind, the transmission or reception beam can move out of its target area (see Figure 9-15).

9.9 Level and attenuation of wireless modules and accessories

Keep the connection between the wireless module and the antenna as short as possible. Every extension or adapter cable (pigtail) will cause higher attenuation.

You can calculate the levels and attenuation of the wireless devices and accessories using the table below. The total cable attenuation including connectors is specified in the table.

Table 9-5   Levels and attenuation of the wireless devices and accessories

Trusted Wireless	Wireless module	Connection	Order No.	Max. transmission power
2.4 GHz	RAD-2400-IFS	RSMA (f)	2901541	20 dBm
868 MHz	RAD-868-IFS		2904909	27 dBm

Adapter/cable	Connection	Order No.	Attenuation at 2.4 GHz	Attenuation at 868 MHz	Length
Pigtail/adapter					
RAD-PIG-RSMA-N-EX/ATEX, RG316	N(f) - RSMA(m)	2904788	-1.3 dB	-0.6 dB	0.76 m
RAD-PIG-EF316-N-RSMA, EF316	N(f) - RSMA(m)	2701402	-1 dB	-0.6 dB	0.5 m
FL LCX PIG-EF142-N-N, EF142	N(m) - N(m)	2700677	-0.5 dB	-0.3 dB	0.5 m
Antenna cable - EF393					
RAD-CAB-EF393-3M	N(m)	2867649	-1.8 dB	-1 dB	3 m
RAD-CAB-EF393-5M	N(m)	2867652	-2.9 dB	-1.6 dB	5 m
RAD-CAB-EF393-10M	N(m)	2867665	-5.6 dB	-2.3 dB	10 m
RAD-CAB-EF393-15M	N(m)	2885634	-8.3 dB	-4.3 dB	15 m

Adapter/cable [...]	Connection [...]	Order No. [...]	Attenuation at 2.4 GHz	Attenuation at 868 MHz	Length [...]
Antenna cable - LMR195					
RAD-PIG-RSMA/N-0.5	RSMA - N(m)	2903263	-0.5 dB	-0.37 dB	0.5 m
RAD-PIG-RSMA/N-1	RSMA - N(m)	2903264	-0.8 dB	-0.55 dB	1 m
RAD-PIG-RSMA/N-2	RSMA - N(m)	2903265	-1.35 dB	-0.87 dB	2 m
RAD-PIG-RSMA/N-3	RSMA - N(m)	2903266	-1.95 dB	-1.2 dB	3 m
RAD-PIG-RSMA/N-5	RSMA - N(m)	2702140	-3.32 dB	-1.2 dB	5 m
Adapter					
RAD-ADP-N/F-N/F	N(f) - N(f)	2867843	-0.3 dB	-0.3 dB	-
RAD-ADP-RSMA/M-RSMA/F-90	RSMA(m) - RSMA(f), angled 90°	2904790	-0.3 dB	-0.3 dB	-
Splitter					
RAD-SPL-2-N/N	3 x N(f)	2702293	-0.3 dB	-0.3 dB	
2.4 GHz surge protection					
CN-LAMBDA/4-5.9-BB	N(f) - N(f)	2838490	< -0.15 dB	< -0.15 dB	-
868 MHz surge protection					
CN-LAMBDA/4-2.2-BB	N(f) - N(f)	2800024	< -0.15 dB	< -0.15 dB	

Antenna	Connection	Order No.	Gain	Remark
2.4 GHz omnidirectional antenna				
RAD-ISM-2400-ANT-OMNI-2-1-RSMA	RSMA(m)	2701362	2.1 dBi	2.1 dBi - 2.1 dB (1.5 m cable, RG316)
RAD-ISM-2400-ANT-VAN-3-0-RSMA	RSMA(m)	2701358	3 dBi	3 dBi - 1.5 dB (1.5 m cable, EF316)
ANT-OMNI-2459-02	N(m)	2701408	2.5 dBi	
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-2400-ANT-OMNI-6-0-SW	N(f)	2903219	6 dBi	-
RAD-ISM-2400-ANT-OMNI-9-0	N(f)	2867623	9 dBi	-
868 MHz omnidirectional antenna				
ANT-OMNI-868-01	N(f)	2702136	4 dBi	
RAD-900-ANT-OMNI-2-N	N(f)	2904802	2 dBi	
2.4 GHz directional antenna				
ANT-DIR-2459-01	N(f)	2701186	9 dBi	-
RAD-ISM-2400-ANT-PAR-19-0	N(f)	2867885	19 dBi	-
868 MHz directional antenna				
ANT-DIR-868-01	N(f)	2702137	3.5 dBi	
RAD-ISM-900-ANT-YAGI-6.5-N	N(f)	2867814	8.5 dBi	
RAD-ISM-900-ANT-YAGI-10-N	N(f)	5606614	12 dBi	

9.10   Free space path loss

When using wireless transmission technology, the signal between the transmitter and receiver is attenuated by the air. The following table lists attenuation values for different distances with a free Fresnel zone.

Table 9-6   Free space path loss

Distance	Attenuation at 2.4 GHz	Attenuation at 868 MHz
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	-71.2 dB
110 m	-80.8 dB	...
120 m	-81.6 dB	...
150 m	-83.5 dB	...
200 m	-86 dB	-77.2 dB
250 m	-88 dB	...
300 m	-89.5 dB	-80.7 dB
350 m	-90.9 dB	...
400 m	-92 dB	-83.2 dB
450 m	-93.1 dB	...
500 m	-94 dB	-85.1 dB
550 m	-94.8 dB	...
600 m	-95.6 dB	-86.7 dB
650 m	-96.3 dB	...
700 m	-96.9 dB	-88.1 dB
750 m	-97.5 dB	...
800 m	-98.1 dB	-89.2 dB
850 m	-98.6 dB	...
900 m	-99.1 dB	-90.3 dB
950 m	-99.6 dB	...
1000 m	-100 dB	-91.2 dB
2000 m	-	-97.2 dB
3000 m	-	-100.7 dB
4000 m	-	-103.2 dB
5000 m	-	-105.1 dB
6000 m	-	-106.7 dB
7000 m	-	-108.1 dB
8000 m	-	-109.2 dB

Table 9-6   Free space path loss

Distance [...]	Attenuation at 2.4 GHz [...]	Attenuation at 868 MHz [...]
9000 m	-	-110.3 dB
10 km	-	-111.2 dB
11 km	-	-112 dB
12 km	-	-112.8 dB
13 km	-	-113.4 dB
14 km	-	-114.1 dB
15 km	-	-114.7 dB
16 km	-	-115.3 dB
17 km	-	-115.8 dB
18 km	-	-116.3 dB
19 km	-	-116.7 dB
20 km	-	-117.2 dB
21 km	-	-117.6 dB
22 km	-	-118.1 dB
23 km	-	-118.5 dB
24 km	-	-118.8 dB
25 km	-	-119.2 dB

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

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

Formula for 868 MHz: **free space path loss [dB] = 91.17 + 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 148).

9.11 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 many different directions.
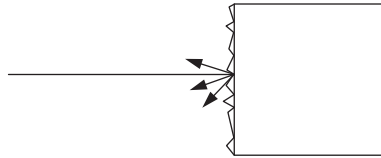
Figure 9-9   Dispersion on a rough surface

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.
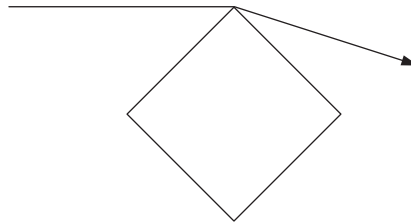
Figure 9-10   Diffraction on an edge

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.
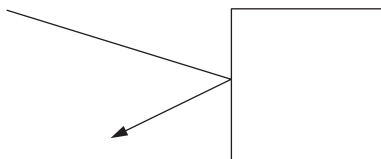
Figure 9-11   Reflection on a metal surface

Penetration

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

– 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 staircases

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

Table 9-7   Attenuation of different materials

Obstacle	Typical attenuation at 2.4 GHz [dB]	Typical attenuation at 868 MHz [dB]
Wood, plaster, glass, plastic, uncoated, without metal	3 ... 4	1 ... 2
Brick, chip board	3 ... 5	1 ... 3
Brick wall, 16 cm	6 ...8	2 ... 4
Concrete wall, 16 cm	15 ... 20	9 ... 11
Reinforced concrete wall, 16 cm	20 ... 30	11 ... 20
Forest, 1 m, see also 9.16 "Practical examples"	9 ... 14	4 ... 8
Heat-absorbing glass with metal coating	40 ... 50	30 ... 40
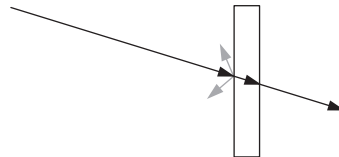
Figure 9-12   Reduction of radio waves when penetrating a wall

Also observe the angle between the transmitter and receiver. Depending on the angle, the radio waves have to penetrate more or less material.
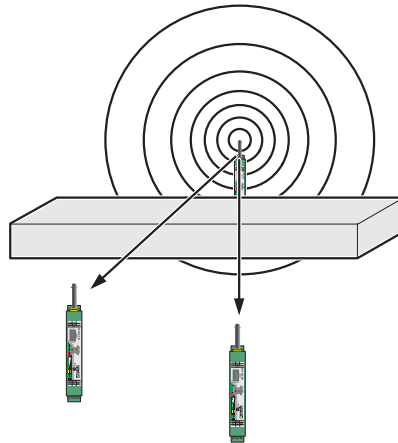
Figure 9-13   Angle of the transmitter and receiver

Radio dead spot

Radio dead spots are caused by impenetrable obstacles in the wireless path. A 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.
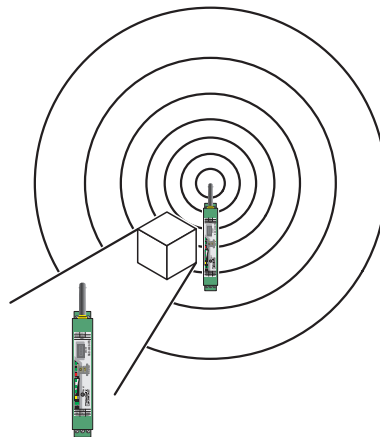
Figure 9-14   Radio dead spot

Weather influences

Snow, rain or hail only have a small effect on the wireless signal. With rainfall of 50 liters per square meter, i.e., a cloudburst, attenuation of around 0.02 dB/km occurs at a frequency of 2.4 GHz, for example.

Strong wind does not influence the wireless signal, however, it does mean that the antenna must be securely fixed in place. Especially when using directional antennas with a small opening angle, you should make sure that the antenna cannot be moved by the wind. If the antenna is moved by just one centimeter from its original position, this may result in partial loss of the wireless signal, especially in the case of a long transmission path.
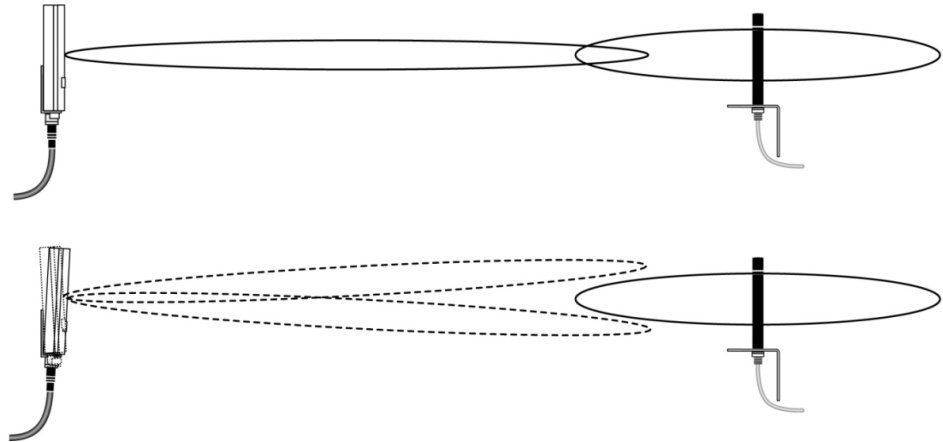
Figure 9-15   Wireless path with strong wind

9.12   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 between the antennas, especially when covering with large distances. In order to stay within the Fresnel zone, it may be necessary 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 that affect the wireless channel often have to be taken into account. The wireless path can work even if obstacles such as houses and trees 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, test measurements should be performed.

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.
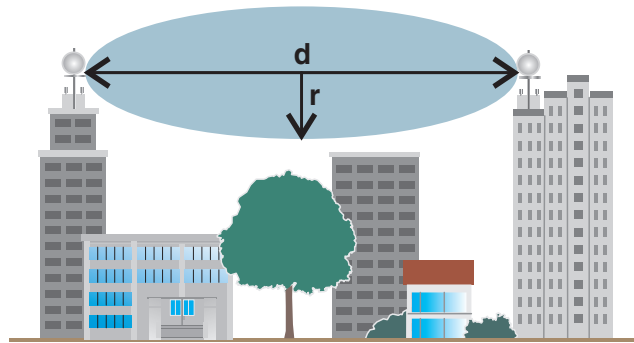
Figure 9-16   Fresnel zone

Table 9-8   Radius of the Fresnel zone depending on the distance

Wireless path distance (d)	Radius of the Fresnel zone (r) for 2.4 GHz	Radius of the Fresnel zone (r) for 868 MHz
200 m	1.5 m	4.2 m
500 m	4 m	6.6 m
1000 m	5 m	9.3 m
2000 m	8 m	13.1 m
4000 m	11 m	18.6 m
5000 m	-	20.8 m
10 km	-	24.4 m
15 km	-	36 m
20 km	-	41.5 m
25 km	-	46 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 for 2.4 GHz, 0.345 m for 868 MHz)
d = Distance between the antennas in m

Radius of the Fresnel zone for 2.4 GHz and 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.

9.13   Range

Specifying ranges is very difficult due to the influence of various factors. Based on practical tests, it is possible to provide the following guideline values. They may be significantly higher or lower depending on the actual application.

The range depends on the following:
–   Set data rate
    (default setting for RAD-2400-IFS: 125 kbps, for RAD-868-IFS: 9.6 kbps)
–   Length of the antenna cable
–   Antenna used
–   Line of sight
–   Adherence to the Fresnel zone

Table 9-9   Ranges for different antennas at 2.4 GHz

Antenna - 2.4 GHz	Data rate of the wireless interface	Range
Inside buildings		
2 dBi omnidirectional antenna	≤ 250 kbps	50 ... 100 m
	≤ 125 kbps	100 ... 200 m
Outside buildings, with a free line of sight		
2 dBi omnidirectional antenna	≤ 250 kbps	50 ... 100 m
	≤ 125 kbps	100 ... 200 m
6 dBi omnidirectional antenna	≤ 125 kbps	≤ 1500 m (Europe: ≤ 1000 m)
8 dBi or 9 dBi panel antenna	≤ 125 kbps	≤ 3000 m (Europe: ≤ 2000 m)
	16 kbps	≤ 5000 m (Europe: ≤ 3000 m)
19 dBi parabolic antenna	16 kbps	> 5000 m (Europe: > 3000 m)

Table 9-10   Ranges for different antennas at 868 MHz

Antenna - 868 MHz	Data rate of the wireless interface	Maximum range
Outside buildings, with a free line of sight		
4 dBi omnidirectional antenna	120 kbps	4 km
	60 kbps	5 km
	19.2 kbps	8 km
	9.6 kbps	9 km
	1.2 kbps	11 km

Table 9-10   Ranges for different antennas at 868 MHz

Antenna - 868 MHz [...]	Data rate of the wireless interface	Maximum range [...]
4 dBi panel antenna	120 kbps	5 km
	60 kbps	6 km
	19.2 kbps	9 km
	9.6 kbps	10 km
	1.2 kbps	13 km
8 dBi Yagi directional antenna	120 kbps	7 km
	60 kbps	8 km
	19.2 kbps	12 km
	9.6 kbps	15 km
	1.2 kbps	18 km
12 dBi Yagi directional antenna	120 kbps	8 km
	60 kbps	10 km
	19.2 kbps	15 km
	9.6 kbps	20 km
	1.2 kbps	25 km

9.14   Equivalent isotropically radiated power (EIRP)

The equivalent isotropically radiated power (EIRP) 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 for 2.4 GHz:
– Transmission power = 14 dBm
– Antenna gain = 8 dBi
– Cable attenuation (3 m EF 142) = 2.85 dB

– EIRP = 14 dBm + 8 dBi - 2.85 dB = 19.15 dBm

The EIRP depends on the frequency used. The following maximum EIRP must not be exceeded for legal reasons.
– For 2.4 GHz:
  – Maximum of 20 dBm outside Europe
  – Maximum of 19 dBm in Europe, depending on the set transmission speed
– For 868 MHz:
  – Maximum of 27 dBm

• If the maximum EIRP is exceeded, adapt the cable, adapter or transmission power if necessary.

9.15 System calculation in free space
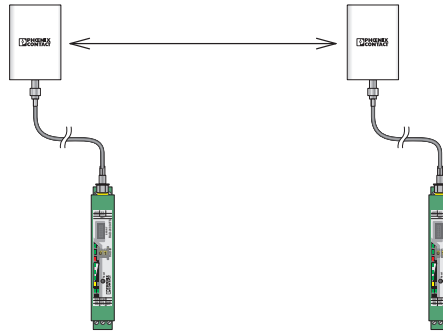
Figure 9-17   Free space path loss

– 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 for 2.4 GHz with optimum free space:

– Length of the wireless path: 400 m
– Device transmission power + Antenna gain - Cable attenuation (EIRP): ≤ 20 dBm

EIRP [dBm] =
Transmitter power [dBm]
+ Gain of transmitting 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 transmitting 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, D_L [dB]:
  D_L = 32.4 + 20log(R[km]) + 20log(f[MHz]) = 32.4 + 20log(0.4 km) + 20 log(2400 MHz) = -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
  28.3 dB > 10 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.

9.16   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.

The bush illustrated below is two meters wide and has an attenuation of approximately 15 dB for 2.4 GHz.

Figure 9-18   Bush with an attenuation of approximately 15 dB

The forest illustrated below consists of dense undergrowth with a trunk diameter of approximately 5 to 20 centimeters. In our test, the 2.4 GHz wireless signal was transmitted through a 25 m forest. The attenuation was around 40 dB.

Figure 9-19   Forest with an attenuation of around 40 dB

10 Detecting and removing errors

If your wireless system does not function properly, proceed as follows:
- First, make sure 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 on page 152 onwards.

i	– Avoid contact between the antennas of two wireless modules, otherwise the receiver might become overloaded. – Ground loops are caused by grounding the antenna via the antenna fixing, grounding the power supply, and grounding the 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 indicated signal strength always relates to the next wireless module in the direction of the master (parent).

The RSSI indicator is a voltage output in the range from 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 around 10 dB, which ensures communication even in 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 connected wireless module.

i	For more information on the RSSI voltage, please refer to Table 5-7 and Table 5-8.

Table 10-1   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), energy supply via the USB port on the PC – IFS-USB-DATACABLE (Order No. 2320500), external energy supply • Install the USB driver. The driver is installed automatically during PSI-CONF software installation (see page 45).
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 probably in "Serial data" 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 45). • Reset the wireless module to the default settings (I/O data mode), if necessary. Disconnect the device from the supply voltage, hold down the SET button, and switch the supply voltage on again (see page 38).
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 is read in again.
ERR flashing DAT flashing	Writing to the memory stick did not work	• Repeat the process in order to correctly write to the memory stick.

Table 10-1   Detecting and removing errors: wireless module

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 may be an overload problem: by default upon delivery, the receive preamplifier is activated and the transmission power is set so that the devices can cover the greatest possible distances (RAD-2400-IFS: 18 dBm, RAD-868-IFS: 27 dBm). Therefore, if the devices are operated directly next to one another the receiver may 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 45 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 45 onwards). • Reset the wireless module to the default settings (I/O data mode), if necessary. Disconnect the device from the supply voltage, hold down the SET button, and switch the supply voltage on again (see page 38).
	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.

Table 10-1   Detecting and removing errors: wireless module

LED, wireless module	Current state and possible cause	Solution
LED bar graph, only yellow LED is on	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. 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.
	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 always relates to the next wireless module in the direction of the master (parent).
In I/O data mode		
ERR flashing slowly (1.4 Hz)	Double assignment of the 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 only appear 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. • Use the white thumbwheel on the I/O extension module to set the I/O MAP address (01 ... 99). The input module must be provided with the same I/O MAP address as the assigned output module at another 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. • Use the white thumbwheel on the I/O extension module to set the I/O MAP address (01 ... 99). The output module must be provided with the same I/O MAP address as the assigned input module at another 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.

Table 10-1   Detecting and removing errors: wireless module

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 only appear 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 has been interrupted.	• 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/RS-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 terminal 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 45). • 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/RS-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 terminal devices (from page 45 onwards).

Table 10-2   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. The wireless module is probably in "Serial data" 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 45). • Reset the wireless module to the default settings (I/O data mode, see page 38), if necessary.
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 I/O 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. • Use the white thumbwheel on the I/O extension module to set the I/O MAP address (01 ... 99). The input module must be provided with the same I/O MAP address as the assigned output module at another station.
	No bus communication, no wireless connection present	• See measures for the wireless module, page 153

Table 10-2   Detecting and removing errors: I/O extension module

LED, I/O module	Current state and possible cause	Solution
In PLC/Modbus RTU mode		
ERR flashing fast (2.8 Hz)	No Modbus communication (safe state of the 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/RS-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 45 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 45). • 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 153

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 do this, you need to short-circuit two terminal points of the RS-232 interface on the slave wireless module. You can then transmit characters to the master wireless module using a terminal program (e.g., HyperTerminal). The characters are echoed back to the terminal program.

> **i**
>
> Note for users of Windows 7 or newer Windows operating systems:
>
> As of Windows 7, HyperTerminal is no longer included. Instead you can use any other terminal program.

To carry out a loopback test, proceed as follows:

• Close all 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 terminal points 5.1 and 5.2 of the RS-232 interface on the slave module that you need to test.
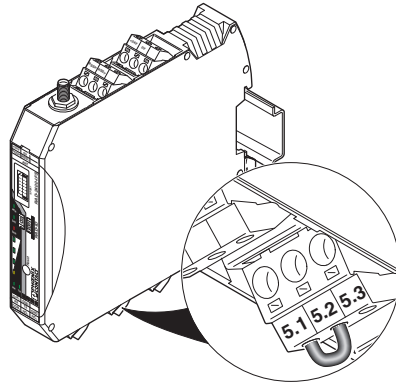
Figure 10-1   Loopback test on an RS-232 interface

 • 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. The characters are output on the slave side (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 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 determine the point up to which data has been transmitted.
   – If 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"
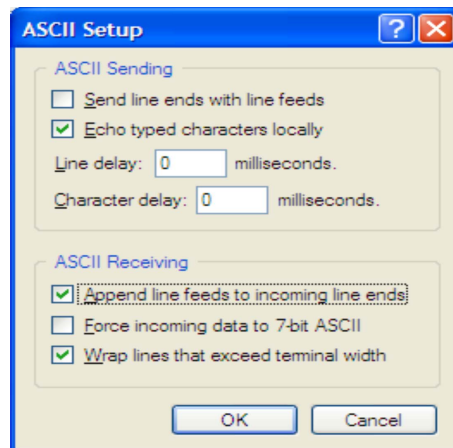
Figure 10-2   Settings in HyperTerminal

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 installation with or without a control cabinet.

i	– Install the antenna outside the control cabinet or building.
	– Observe the installation instructions for the antenna and the Section "For your safety" on page 17.
	– For information on the transmission power, refer to "Transmission power" on page 46.

A 1.1 2.4 GHz antennas

Omnidirectional antenna, 2 dBi
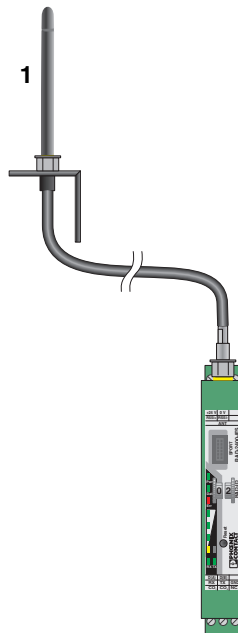
Figure A-1   Omnidirectional antenna, 2 dBi

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° opening angle, IP65 protection	RSMA (male)	2701362

Omnidirectional antenna with protection against vandalism, 3 dBi
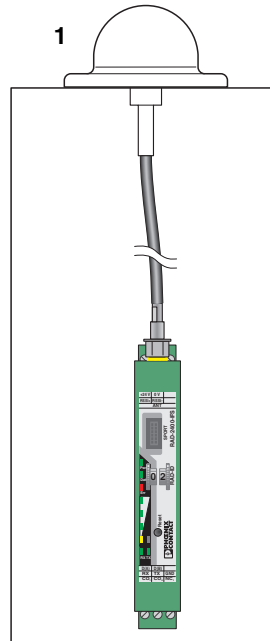
Figure A-2   Omnidirectional antenna with protection against vandalism, 3 dBi

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 protection, 1.5 m cable length, h/v 360°/85° opening angle. Appropriate mounting material is available for wall mounting.	RSMA (male)	2701358

Omnidirectional antenna, 2.5 dBi
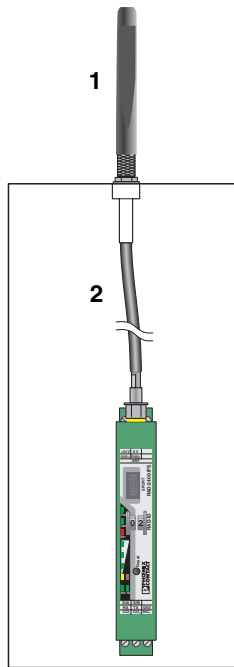
Figure A-3   Omnidirectional antenna, 2.5 dBi

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, opening angle: h/v 360°/30° for 2.4 GHz, h/v 360°/16° for 5 GHz, IP68	N (male)	2701408
2	RAD-PIG-EF316-N-RSMA	Adapter cable, 50 cm pigtail, 50 Ω impedance	N (female) → RSMA (male)	2701402

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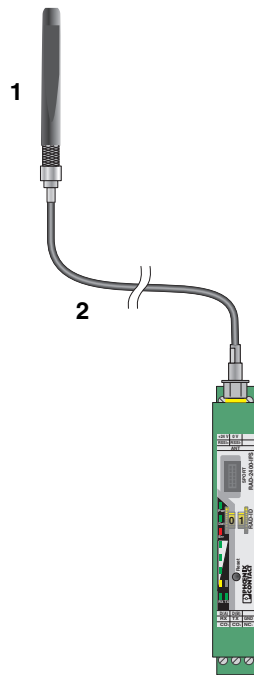
Figure A-4   Omnidirectional antenna, 6 dBi, without surge protection

Item	Product	Description	Connection	Order No.
1	RAD-ISM-2400-ANT-OMNI-6-0 **Alternative:** RAD-2400-ANT-OMNI-6-0-SW	Omnidirectional antenna, 2.4 GHz, 6 dBi gain, linear vertical polarization, h/v 360°/30° opening angle, IP55 protection Omnidirectional antenna, 2.4 GHz, 6 dBi gain, linear vertical polarization, h/v 360°/20° opening angle, IP65 protection, salt water resistant	N (female) N (female)	2885919 2903219
2	RAD-PIG-RSMA/N-0.5 **Alternative:** RAD-PIG-RSMA/N-1 RAD-PIG-RSMA/N-2 RAD-PIG-RSMA/N-3 RAD-PIG-RSMA/N-5	Antenna cable, 0.5 m length, 50 Ω impedance Antenna cable, 1 m length Antenna cable, 2 m length Antenna cable, 3 m length Antenna cable, 5 m length	N (male) → RSMA (male) N (male) → RSMA (male)	2903263 2903264 2903265 2903266 2702140

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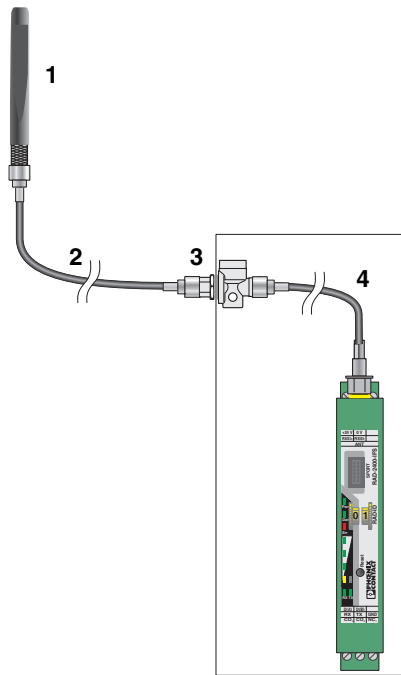
Figure A-5   Omnidirectional antenna, 6 dBi, with surge protection

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° opening angle, IP55 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° opening angle, IP65 protection, salt water resistant	N (female)	2903219
2 (opt.)	RAD-CAB-EF393- 3M	Antenna cable, 3 m length, 50 Ω impedance	N (male) → N (male)	2867649
	Alternative:			
	RAD-CAB-EF393- 5M	Antenna cable, 5 m length	N (male) → N (male)	2867652
	RAD-CAB-EF393-10M	Antenna cable, 10 m length		2867665
	RAD-CAB-EF393-15M	Antenna cable, 15 m length		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, 50 Ω impedance	N (male) → RSMA (male)	2903263
	Alternative:			
	RAD-PIG-RSMA/N-1	Antenna cable, 1 m length		2903264
	RAD-PIG-RSMA/N-2	Antenna cable, 2 m length	N (male) → RSMA (male)	2903265
	RAD-PIG-RSMA/N-3	Antenna cable, 3 m length		2903266
	RAD-PIG-RSMA/N-5	Antenna cable, 5 m length		2702140

Directional antenna, 9 dBi, with outdoor surge protection

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

Items 2 and 3 are optional.

Item	Product	Description	Connection	Order No.
1	ANT-DIR-2459-01	Directional antenna, 2.4/5 GHz, 9 dBi gain, linear vertical polarization, h/v 75°/55° opening angle for 2.4 GHz, IP67 protection	N (female)	2701186
2 (opt.)	RAD-CAB-EF393- 3M	Antenna cable, 3 m length, 50 Ω impedance	N (male) → N (male)	2867649
	Alternative:			
	RAD-CAB-EF393- 5M	Antenna cable, 5 m length	N (male) → N (male)	2867652
	RAD-CAB-EF393-10M	Antenna cable, 10 m length		2867665
	RAD-CAB-EF393-15M	Antenna cable, 15 m length		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
4	RAD-PIG-RSMA/N-0.5	Antenna cable, 0.5 m length, 50 Ω impedance	N (male) → RSMA (male)	2903263
	Alternative:			
	RAD-PIG-RSMA/N-1	Antenna cable, 1 m length		2903264
	RAD-PIG-RSMA/N-2	Antenna cable, 2 m length	N (male) → RSMA (male)	2903265
	RAD-PIG-RSMA/N-3	Antenna cable, 3 m length		2903266
	RAD-PIG-RSMA/N-5	Antenna cable, 5 m length		2702140

Parabolic antenna, 19 dBi, with outdoor surge protection

Figure A-7   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° opening angle, IP65 protection	N (female)	2867885
2 (opt.)	RAD-CAB-EF393- 3M	Antenna cable, 3 m length, 50 Ω impedance	N (male) → N (male)	2867649
	Alternative:			
	RAD-CAB-EF393- 5M	Antenna cable, 5 m length	N (male) → N (male)	2867652
	RAD-CAB-EF393-10M	Antenna cable, 10 m length		2867665
	RAD-CAB-EF393-15M	Antenna cable, 15 m length		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
4	RAD-PIG-RSMA/N-0.5	Antenna cable, 0.5 m length, 50 Ω impedance	N (male) → RSMA (male)	2903263
	Alternative:			
	RAD-PIG-RSMA/N-1	Antenna cable, 1 m length		2903264
	RAD-PIG-RSMA/N-2	Antenna cable, 2 m length	N (male) → RSMA (male)	2903265
	RAD-PIG-RSMA/N-3	Antenna cable, 3 m length		2903266
	RAD-PIG-RSMA/N-5	Antenna cable, 5 m length		2702140

A 1.2   868 MHz antennas

Omnidirectional antenna, 4 dBi, with surge protection

Figure A-8   Omnidirectional antenna, 4 dBi, with surge protection

Items 2 and 3 are optional.

Item	Product	Description	Connection	Order No.
1	ANT-OMNI-868-01	Omnidirectional antenna, 868 MHz, 4 dBi, linear vertical, h/v 360°/30° opening angle, IP67, salt water resistant, including mounting bracket and mast clips for 30 mm ... 45 mm diameter, stainless steel, ATEX/IECEx approval	N (female)	2702136
2 (opt.)	RAD-CAB-EF393- 3M	Antenna cable, 3 m length, 50 Ω impedance	N (male) → N (male)	2867649
	Alternative:			
	RAD-CAB-EF393- 5M	Antenna cable, 5 m length	N (male) → N (male)	2867652
	RAD-CAB-EF393-10M	Antenna cable, 10 m length		2867665
	RAD-CAB-EF393-15M	Antenna cable, 15 m length		2885634
3 (opt.)	CN-LAMBDA/4-2.2-BB	Attachment plug with Lambda/4 technology as surge protection for coaxial signal interfaces.	N (female) → N (female	2800024

Item	Product	Description	Connection	Order No.
4	RAD-PIG-RSMA/N-0.5	Antenna cable, 0.5 m length, 50 Ω impedance	N (male) → RSMA (male)	2903263
	Alternative:			
	RAD-PIG-RSMA/N-1	Antenna cable, 1 m length		2903264
	RAD-PIG-RSMA/N-2	Antenna cable, 2 m length	N (male) → RSMA (male)	2903265
	RAD-PIG-RSMA/N-3	Antenna cable, 3 m length		2903266
	RAD-PIG-RSMA/N-5	Antenna cable, 5 m length		2702140

Directional antennas, with surge protection
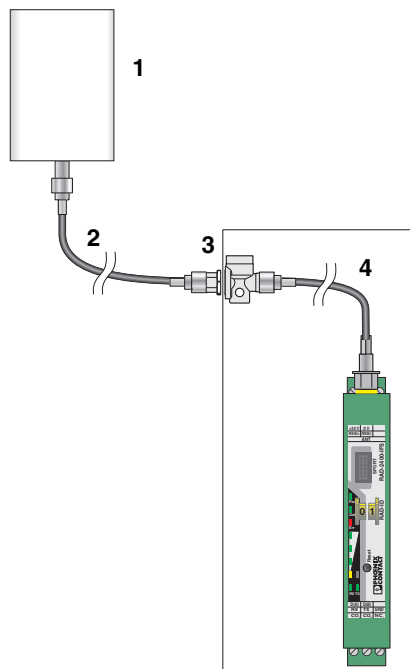
Figure A-9   Directional antenna, with surge protection

Items 2 and 3 are optional.

Item	Product	Description	Connection	Order No.
1	ANT-DIR-868-01	Directional antenna, 868 MHz, 3.5 dBi, circular polarized, IP67, including mounting bracket and mast clips for 25 mm ... 85 mm diameter, stainless steel, ATEX/IECEx approval	N (female)	2702137
	Alternative:			
	RAD-ISM-900-ANT-YAGI-6.5-N	Yagi antenna, IP65, 8.5 dBi gain, 0.6 m cable length		2867814
	RAD-ISM-900-ANT-YAGI-10-N	Yagi antenna, IP65, 12.15 dBi gain, 0.6 m RG-213 cable	N (female)	5606614

Item	Product	Description	Connection	Order No.
2 (opt.)	RAD-CAB-EF393- 3M	Antenna cable, 3 m length, 50 Ω impedance	N (male) → N (male)	2867649
	Alternative:			
	RAD-CAB-EF393- 5M	Antenna cable, 5 m length	N (male) → N (male)	2867652
	RAD-CAB-EF393-10M	Antenna cable, 10 m length		2867665
	RAD-CAB-EF393-15M	Antenna cable, 15 m length		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
4	RAD-PIG-RSMA/N-0.5	Antenna cable, 0.5 m length, 50 Ω impedance	N (male) → RSMA (male)	2903263
	Alternative:			
	RAD-PIG-RSMA/N-1	Antenna cable, 1 m length	N (male) → RSMA (male)	2903264
	RAD-PIG-RSMA/N-2	Antenna cable, 2 m length		2903265
	RAD-PIG-RSMA/N-3	Antenna cable, 3 m length		2903266
	RAD-PIG-RSMA/N-5	Antenna cable, 5 m length		2702140

A 1.3 Antenna splitter

Directional antennas, 8 dBi, with 2-way outdoor antenna splitter
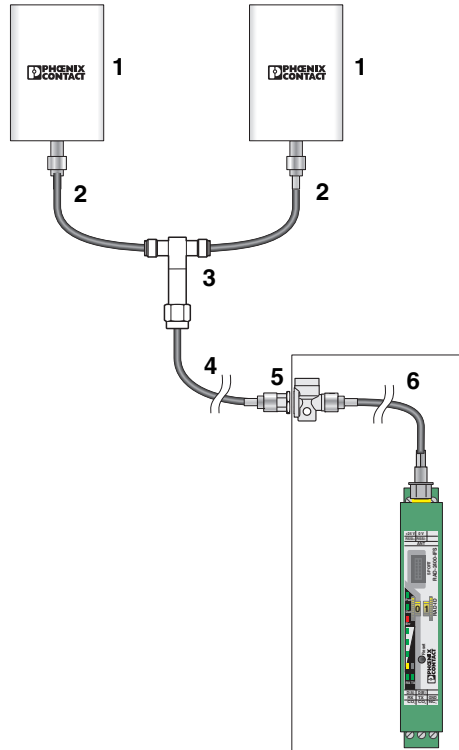
Figure A-10   Directional antennas, 8 dBi, with 2-way outdoor antenna splitter

Items 4 and 5 are optional.

Item	Product	Description	Connection	Order No.
1	ANT-DIR-2459-01 **Alternative:** ANT-DIR-868-01 Or other directional antennas from Phoenix Contact	Directional antenna, 2.4 GHz/5 GHz, 9 dBi gain, linear vertical polarization, h/v 75°/55° opening angle for 2.4 GHz, IP67 protection Directional antenna, 868 MHz, 3.5 dBi, circular polarized, IP67, including mounting bracket and mast clips for 25 mm ... 85 mm diameter, stainless steel, ATEX/IECEx approval	N (female) N (female)	2701186 2702137
2	FL LCX PIG-EF142-N-N	Antenna cable, 50 cm length, 50 Ω impedance	N (male) → N (male)	2700677
3	RAD-SPL-2-N/N	2-way distributor for antenna signals (antenna splitter)	3 x N (male)	2702293

Item	Product	Description	Connection	Order No.
4 (opt.)	RAD-CAB-EF393- 3M	Antenna cable, 3 m length, 50 Ω impedance	N (male) → N (male)	2867649
	Alternative:			
	RAD-CAB-EF393- 5M	Antenna cable, 5 m length	N (male) → N (male)	2867652
	RAD-CAB-EF393-10M	Antenna cable, 10 m length		2867665
	RAD-CAB-EF393-15M	Antenna cable, 15 m length		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, 50 Ω impedance	N (male) → RSMA (male)	2903263
	Alternative:			
	RAD-PIG-RSMA/N-1	Antenna cable, 1 m length		2903264
	RAD-PIG-RSMA/N-2	Antenna cable, 2 m length	N (male) → RSMA (male)	2903265
	RAD-PIG-RSMA/N-3	Antenna cable, 3 m length		2903266
	RAD-PIG-RSMA/N-5	Antenna cable, 5 m length		2702140

A 1.4 Installation example: antennas in potentially explosive areas

WARNING: Explosion hazard when used in potentially explosive areas
Observe the installation instructions for the antenna and the Section "For your safety" on page 17.
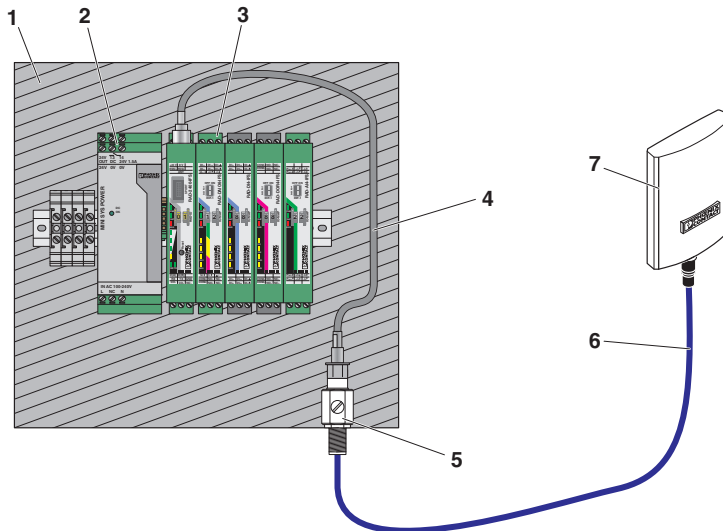
Figure A-11   Antenna installation in Zone 2

Item	Product	Description	Connection	Order No.
1	IP54 stainless steel housing		-	-
2	Power supply		-	-
3	Wireless module and I/O extension modules		-	-
4	RAD-PIG-RSMA/N-0.5 **Alternative:**	Antenna cable, 0.5 m length, 50 Ω impedance	N (male) → RSMA (male)	2903263
	RAD-PIG-RSMA/N-1	Antenna cable, 1 m length		2903264
	RAD-PIG-RSMA/N-2	Antenna cable, 2 m length	N (male) → RSMA (male)	2903265
	RAD-PIG-RSMA/N-3	Antenna cable, 3 m length		2903266
	RAD-PIG-RSMA/N-5	Antenna cable, 5 m length		2702140
5	BAR-ANT-N-N-EX	Antenna barrier for installation in Ex Zone 2, separates and transmits HF signals with intrinsic safety (Ex i) to an antenna in Zone 0, 1 or 2, 0.7 GHz ... 6 GHz frequency range	N (female) → N (female)	2702198
6	RAD-CAB-EF393- 3M **Alternative:**	Antenna cable, 3 m length, 50 Ω impedance	N (male) → N (male)	2867649
	RAD-CAB-EF393- 5M	Antenna cable, 5 m length		2867652
	RAD-CAB-EF393-10M	Antenna cable, 10 m length	N (male) → N (male)	2867665
	RAD-CAB-EF393-15M	Antenna cable, 15 m length		2885634
7	ANT-DIR-2459-01 **Alternative:**	Directional antenna, 2.4/5 GHz, 9 dBi, linear vertical, IP67, including mounting bracket and mast clips for 25 mm ... 85 mm diameter, stainless steel, ATEX/IECEx approval	N (female)	2701186
	RAD-ISM-2400-ANT-OMNI-6-0	Omnidirectional antenna, 2.4 GHz, 6 dBi, linear vertical, h/v 360°/30° opening angle, IP55, including mounting bracket and mast clips for 45 mm ... 100 mm diameter, stainless steel, ATEX/IECEx approval		2885919
	ANT-DIR-868-01	Directional antenna, 868 MHz, 3.5 dBi, circular polarized, IP67, including mounting bracket and mast clips for 25 mm ... 85 mm diameter, stainless steel, ATEX/IECEx approval	N (female)	2702137
	ANT-OMNI-868-01	Omnidirectional antenna, 868 MHz, 4 dBi, linear vertical, h/v 360°/30° opening angle, IP67, salt water resistant, including mounting bracket and mast clips for 30 mm ... 45 mm diameter, stainless steel, ATEX/IECEx approval		2702136

A 2 Control box for wireless systems

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

Features:
– IP66 protection class
– Mounting suitable for industrial applications
– Bore holes already present, screw connections are included as standard

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).
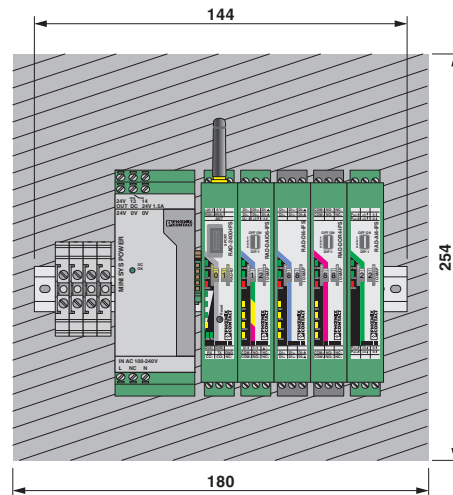
Figure A-12   Control box with wireless system

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**
Load	RAD-2400-IFS / RAD-868-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 3   Configuring a PROFIBUS connection

> **i** PROFIBUS connections are only possible with the RAD-2400-IFS 2.4 GHz wireless module.

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-13   PSI-CONF software

- In the "Wireless" folder, select the device.
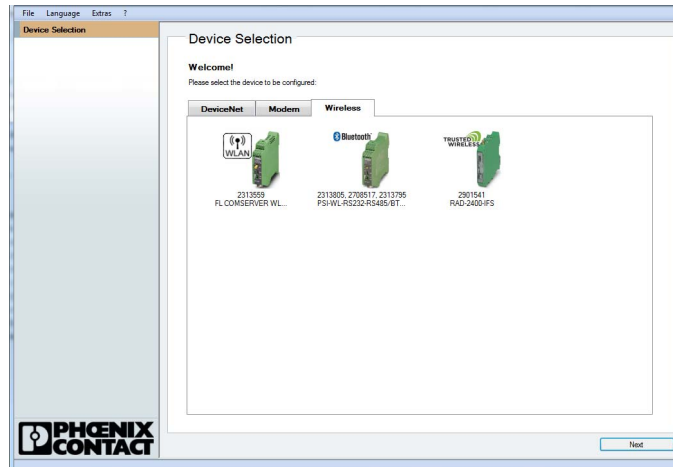
Figure A-14   PSI-CONF software: Device Selection

- Select "Create new network project".
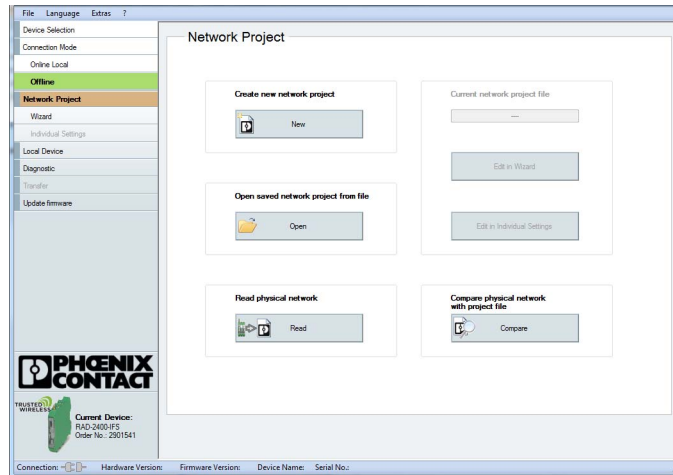
Figure A-15   PSI-CONF software: Network Project

• In step 1 of the wizard, select "Point to Point / Star" and confirm with "Next".
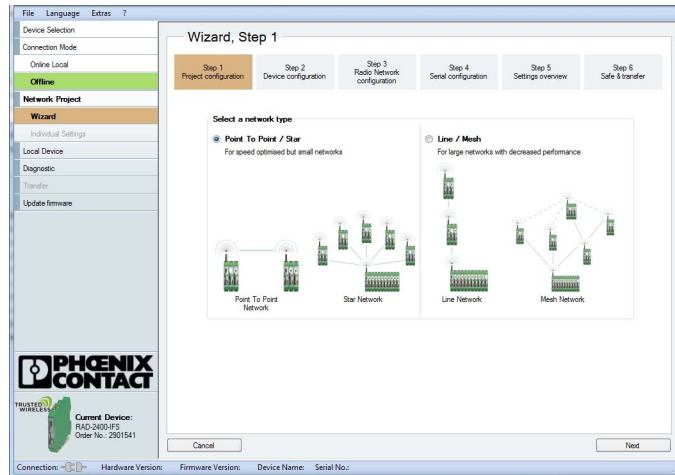
Figure A-16   PSI-CONF software: Wizard, Step 1

• Follow the software wizard. Specify the number of network devices. Confirm with "OK" and "Next".
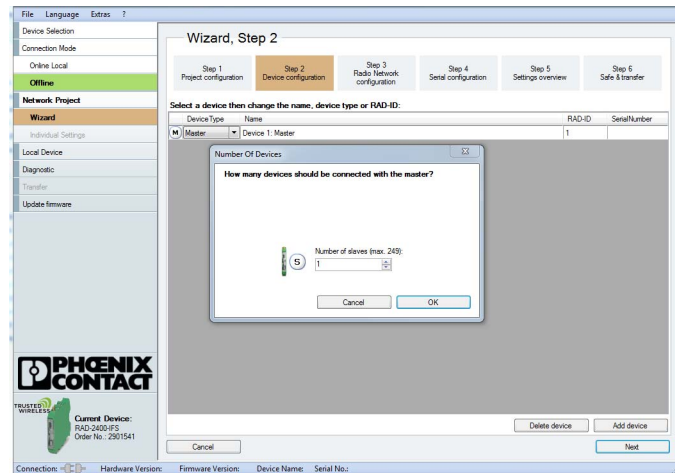
Figure A-17   PSI-CONF software: Wizard, Step 2

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

> ℹ️ For additional information on the relationship between speed and distance, please refer to Table 5-4.

- Then confirm with "Next".
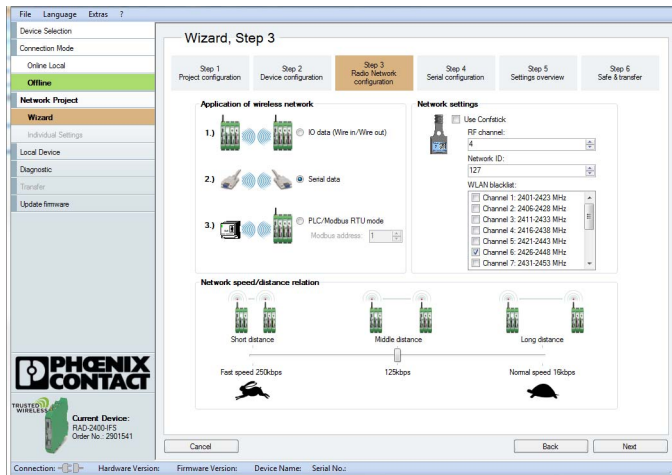
Figure A-18   PSI-CONF software: Wizard, Step 3

- 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 necessary. Confirm with "Next".

> ℹ️ Due to the increased delay time, PROFIBUS transmission with 16 kbps is **not** possible.
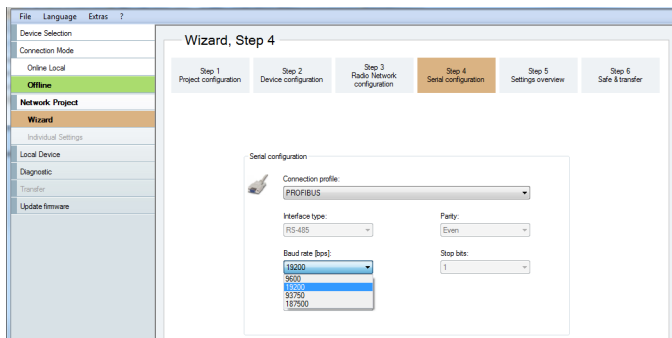
Figure A-19   PSI-CONF software: Wizard, Step 4

- In step 5, you will see an overview of the settings that have already been made. Check these settings and confirm with "Next".
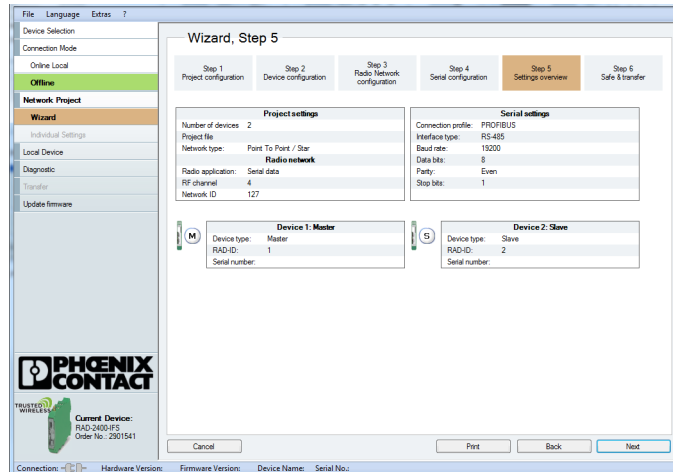
Figure A-20   PSI-CONF software: Wizard, Step 5

- Save the project in step 6.
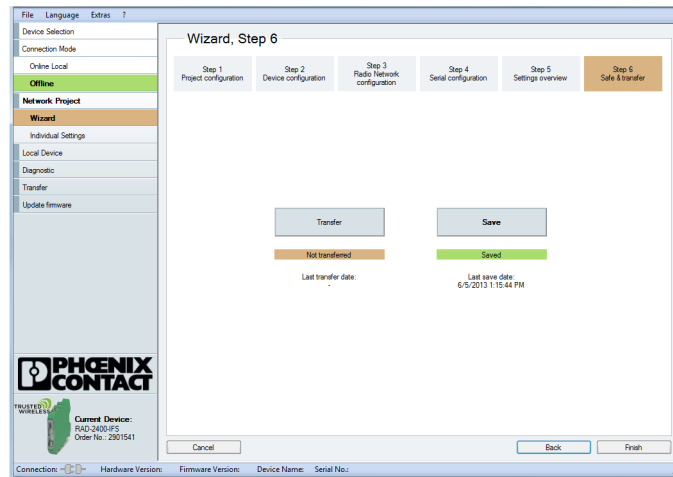
Figure A-21   PSI-CONF software: Wizard, Step 6

- Open "Individual Settings" and set "Transmissions" to 2. Save the settings again and click on "Transfer" to transfer them to the devices.
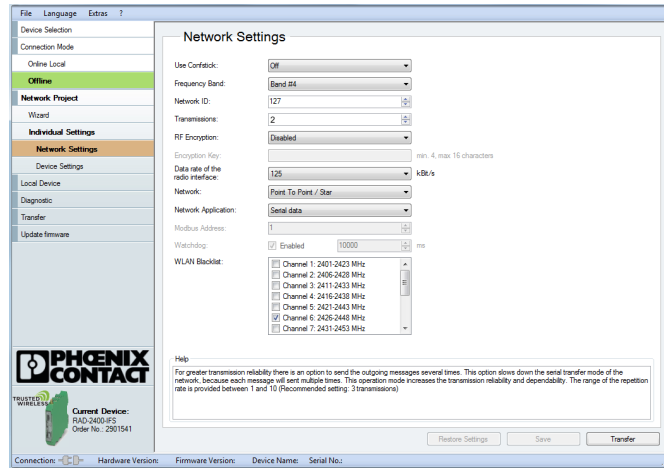
Figure A-22   PSI-CONF software: Network Settings

Connecting the PROFIBUS cable

- Connect the PROFIBUS cable to both wireless modules:
    - Negative data conductor (green) to terminal block D(A) 4.1
    - Positive data conductor (red) to terminal block 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 this, set DIP switches 1 and 2 to ON. The DIP switches are located on the side of the wireless module.

Configuring the PROFIBUS master

- Adjust the 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 optimum 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 that also cause a delay time, the delay times must be added together. Remember to take into account long cables, repeaters, fiber optics, other wireless components, etc.

The additional delay time may be increased in the event of a poor wireless connection or the connection may be terminated completely. In the event of a poor connection, the wireless module would not discard PROFIBUS telegrams but repeatedly try to send 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 PROFIBUS 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**
    Response monitoring time (watchdog) parameter
  - The telegram length depends on the data transmission speed

Table A-1   Possible PROFIBUS telegram lengths

		PROFIBUS			
		9.6 kbps	**19.2 kbps**	**93.75 kbps**	**187.5 kbps**
Wireless	250 kbps	255	255	220	110
	125 kbps	255	255	110	0

  - 1 analog value = 1 word = 2 bytes
    $\Rightarrow$ OTA125k@PB93.75k = 110 bytes = 55 analog values
  - 1 digital value = 1 bit = 8 values per byte
    $\Rightarrow$ OTA125k@PB93.75k = 110 bytes = 880 digital values
- 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** – enter the bus parameters directly under "User-defined, Bus Parameters". In this case, deactivate automatic calculation, otherwise the sum of automatic and manual entry will be used.

We recommend that you use manual entry:
- Entry: Tslot_Init > 13000 t_bit
- Entry: Retry limit > 3
- Recalculate
- Entry: response monitoring time, depending on the application

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

The Tslot_Init parameter is expressed in t_bit. The maximum value for a Siemens S7 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 your user project. Select "Options, Configure Network" from the pull-down menu.
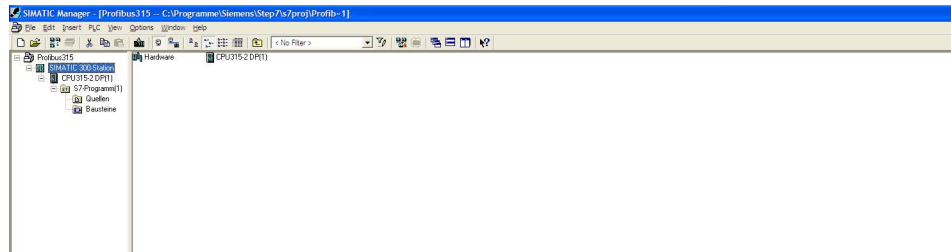
Figure A-23   SIMATIC Manager

- In the "NetPro" window, right-click on the PROFIBUS line. In the context menu, select "Object Properties".
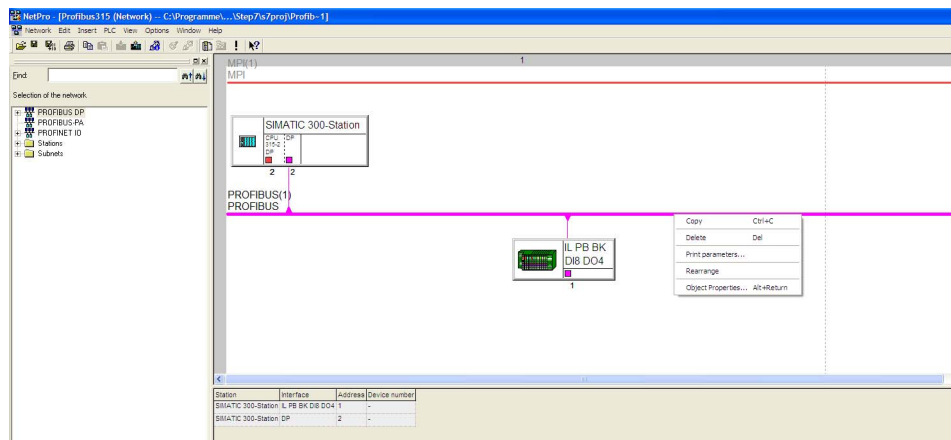
Figure A-24   "NetPro" window

- In the "Network Settings" tab, select a transmission speed of 93.75 kbps.
- Click on "Options".
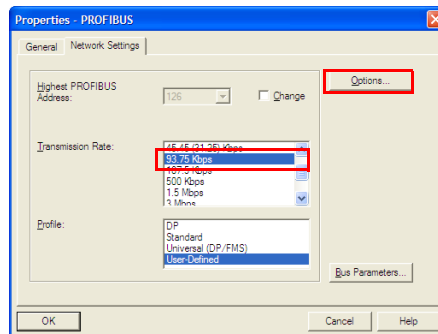
Figure A-25   "Network Settings" tab, transmission speed

• In the "Cables" tab, deactivate the "Take into account the following cable configuration" check box. Confirm with "OK".
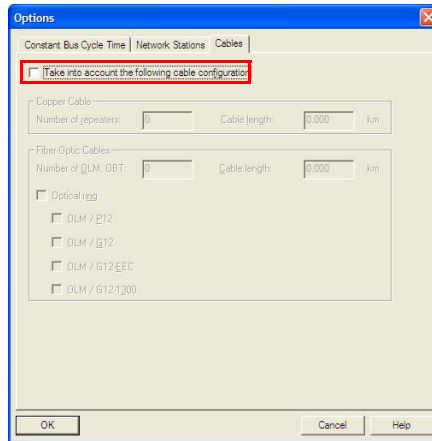
Figure A-26   "Cables" tab

• In the "Network Settings" tab, select the "User-Defined" profile and the "Bus Parameters" option.
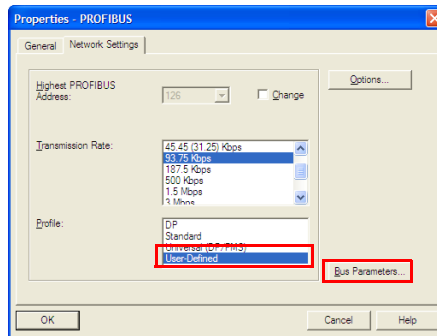
Figure A-27   "Network Settings" tab, Profile

• The most recently valid bus parameters are shown in the "Bus Parameters" tab. Enter the following values:

ℹ	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".
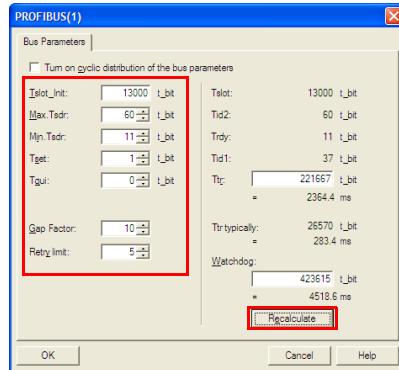
Figure A-28   "Bus Parameters" tab

• Calculating the bus parameters also modifies the response monitoring (watchdog) value. Enter 93750 t_bit here to achieve a response monitoring time of 1 second for the PROFIBUS slave. Confirm with "OK".
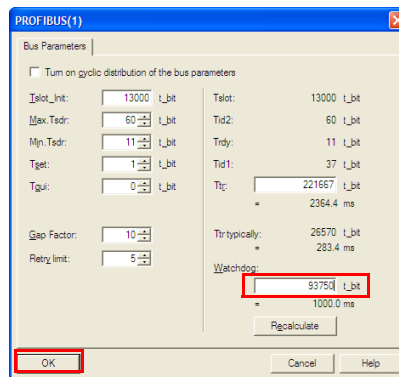
Figure A-29   "Bus Parameters" tab, response monitoring

• Go back to "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" check 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-30   "Properties - DP" tab

B Appendixes

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