

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

User manual
UM EN RAD-...-IFS

User manual

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

UM EN RAD-...-IFS, Revision 06

2021-07-30

This user manual is valid for:

Designation	Order No.
Wireless modules:	
RAD-2400-IFS	2901541
RAD-868-IFS	2904909
RAD-2400-IFS-JP	2702863
I/O extension modules:	
RAD-AI4-IFS	2901537
RAD-AI4-U-IFS	2702290
RAD-PT100-4-IFS	2904035
RAD-AO4-IFS	2901538
RAD-DI4-IFS	2901535
RAD-DI8-IFS	2901539
RAD-NAM4-IFS	2316275
RAD-DOR4-IFS	2901536
RAD-DO8-IFS	2902811
RAD-DAIO6-IFS	2901533

Table of contents

1	For your safety	6
1.1	Identification of warning notes	6
1.2	Qualification of users	6
1.3	Field of application of the product	7
1.4	Installation notes.....	8
1.5	Installation in zone 2	9
1.6	Notes for individual I/O extension modules.....	10
1.7	UL notes (RAD-2400-IFS and I/O extension modules only).....	10
1.8	Countries of use	11
2	Transport, storage, and unpacking	14
2.1	Transport.....	14
2.2	Storage.....	14
2.3	Unpacking	15
3	Brief description	16
3.1	Wireless modules	16
3.2	Firmware versions	17
3.3	I/O extension modules.....	18
3.4	Application examples	19
4	Installation	20
4.1	Wireless module structure.....	20
4.2	Basic circuit diagram	21
4.3	Mounting and removal.....	21
4.4	Connecting the cables.....	23
4.5	Connecting the power supply	24
4.6	Serial interfaces.....	26
4.7	Connecting the antenna	29
5	Configuration and startup	30
5.1	Factory default settings of the wireless module	30
5.2	Operating mode of the wireless module	32
5.3	Setting the address of the wireless module via the thumbwheel.....	36
5.4	Configuration using the configuration stick	36
5.5	Copying the device settings via a memory stick	38

5.6	Configuration via PSI-CONF software	39
5.7	Diagnostics on the wireless module	45
5.8	Diagnostics via PSI-CONF software	50
5.9	Starting up I/O extension modules.....	53
5.10	Startup time of the wireless station	55
6	Serial data mode	56
6.1	Frame-based data transmission	58
6.2	Setting telegram pauses, using Modbus/RTU as an example	59
7	PLC/Modbus RTU	60
7.1	PLC/Modbus RTU mode	60
7.2	PLC/Modbus RTU dual mode.....	63
7.3	Watchdog	66
7.4	Modbus function codes	67
7.5	Module type and error code registers for I/O extension modules.....	68
7.6	Modbus memory map.....	70
7.7	Error codes and formats for analog input and output values	86
7.8	Radioline function blocks.....	88
8	Description of I/O extension modules	89
8.1	RAD-AI4-IFS – analog extension module with four current inputs.....	89
8.2	RAD-AI4-U-IFS – analog extension module with four voltage inputs	93
8.3	RAD-PT100-4-IFS – extension module with four temperature inputs.....	99
8.4	RAD-AO4-IFS – analog extension module with four outputs.....	107
8.5	RAD-DI4-IFS – digital extension module with four inputs.....	111
8.6	RAD-DI8-IFS – digital extension module with eight inputs	115
8.7	RAD-NAM4-IFS – digital extension module with four NAMUR inputs	122
8.8	RAD-DOR4-IFS – digital extension module with four outputs	127
8.9	RAD-DO8-IFS – digital extension module with eight outputs	131
8.10	RAD-DAIO6-IFS – analog/digital extension module with six channels.....	137
9	Planning wireless systems	143
9.1	Delay time	143
9.2	Pulse transmission	144
9.3	Trusted Wireless 2.0.....	145
9.4	RF bands.....	148
9.5	Planning wireless paths.....	149

	9.6 Practical test.....	149
	9.7 Selecting antenna cables and antennas.....	150
	9.8 Installing antennas.....	151
	9.9 Level and attenuation of wireless modules and accessories.....	154
	9.10 Free space attenuation.....	156
	9.11 Propagation of radio waves.....	158
	9.12 Fresnel zone.....	161
	9.13 Range.....	163
	9.14 Effective isotropic radiated power (EIRP).....	164
	9.15 System calculation in free space.....	165
	9.16 Practical examples.....	166
10	Detecting and removing errors.....	167
	10.1 Loopback test during serial data transmission.....	173
11	Device replacement, device defects, and repairs.....	175
	11.1 Device replacement.....	175
	11.2 Device defects and repairs.....	175
12	Maintenance and disposal.....	176
	12.1 Maintenance.....	176
	12.2 Disposal.....	176
13	Technical data for the wireless modules.....	177
A	Technical appendix.....	188
	A 1 Typical combinations of antennas and adapter cables.....	188
	A 2 Control box for wireless systems.....	201
B	Appendixes.....	202
	B 1 List of figures.....	202
	B 2 List of tables.....	206
	B 3 Index.....	208

1 For your safety

Read this user manual carefully and keep it for future reference. The screenshots shown in this user manual may differ from your software version.

1.1 Identification of warning notes



This symbol indicates hazards that could lead to personal injury.

There are three signal words indicating the severity of a potential injury.

DANGER

Indicates a hazard with a high risk level. If this hazardous situation is not avoided, it will result in death or serious injury.

WARNING

Indicates a hazard with a medium risk level. If this hazardous situation is not avoided, it could result in death or serious injury.

CAUTION

Indicates a hazard with a low risk level. If this hazardous situation is not avoided, it could result in minor or moderate injury.



This symbol together with the **NOTE** signal word warns the reader of actions that might cause property damage or a malfunction.



Here you will find additional information or detailed sources of information.

1.2 Qualification of users

The use of products described in this user manual is oriented exclusively to electrically skilled persons or persons instructed by them. The users must be familiar with the relevant safety concepts of automation technology as well as applicable standards and other regulations.

1.3 Field of application of the product

1.3.1 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 any other accessory components may invalidate the operating license. You can find the approved accessories for this wireless system listed with the product at phoenixcontact.net/products.

1.3.1.1 RAD-2400-IFS wireless module

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 40).

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

1.3.1.2 RAD-2400-IFS-JP wireless module



The RAD-2400-IFS-JP wireless module is only approved for use in Japan.

The RAD-2400-IFS-JP wireless module does **not** have ATEX approval. It is **not** suitable for use in potentially explosive areas. Only install the wireless module in the safe area.

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

1.3.2 Product changes

Modifications to hardware and firmware of the device are not permitted.

Incorrect operation or modifications to the device can endanger your safety or damage the device. Do not repair the device yourself. If the device is defective, please contact Phoenix Contact.

1.4 Installation notes

**WARNING: Risk of electric shock**

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

- 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 ($I \leq 6 \text{ A}$) within 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 device housing provides basic insulation from neighboring devices for $300 \text{ V}_{\text{rms}}$. 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.

- **RAD-2400-IFS and RAD-868-IFS only:** Phoenix Contact hereby declares that this wireless system complies with the basic requirements and other relevant regulations specified in Directive 2014/53/EC.
- **RAD-2400-IFS and RAD-868-IFS only:** 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 may only be carried out by qualified electrical engineers. 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 general technical regulations must be observed. The technical data is provided in the packing slip and on the certificates (conformity assessment, additional approvals where applicable).
- Opening or modifying the device is prohibited. Do not repair the device yourself; replace it with an equivalent device. Repairs may only be carried out by the manufacturer. The manufacturer is not liable for damage resulting from non-compliance.
- 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 stress that exceeds the specified limits.
- To protect the device against mechanical or electrical damage, install it in suitable housing with an appropriate degree of protection in accordance with IEC 60529.
- The device complies with the EMC regulations for industrial areas (EMC class A). When used in residential areas, the device may cause radio interference.
- Only specified devices from Phoenix Contact may be connected to the 12-pos. S-PORT interface.
- The device is not designed for use in atmospheres with a danger of dust explosions.
- If dust is present, the device must be installed in suitable approved housing and the surface temperature of the housing must be taken into consideration.

1.5 Installation in zone 2

**WARNING: Explosion hazard when used in potentially explosive areas**

Make sure that the following notes and instructions are observed.

The RAD-2400-IFS-JP wireless module does **not** have ATEX approval. It is **not** suitable for use in potentially explosive areas. Only install this wireless module in the safe area.

- Use in potentially explosive areas is not permitted in China.
- Observe the specified conditions for use in potentially explosive areas. Install the device in suitable approved housing that meets the requirements of EN 60079-15 and has at least IP54 degree of protection. Also observe the requirements of EN 60079-14.
- Only connect devices to the supply and signal circuits in zone 2 that are suitable for operation in Ex zone 2 and for the conditions at the installation location.
- In potentially explosive areas, the device may only be snapped onto or off of the DIN rail connector and cables may only be connected or disconnected 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 decommissioned and immediately removed from the Ex area if it is damaged, has been 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 charge. Otherwise install the antenna in housing that meets the requirements of EN 60079-0 and EN 60079-15 and has at least IP54 degree of protection (EN 60529).

Notes for antennas

- Only use antennas approved for the Ex area (see [Section “Accessories” on page 177](#)).
- The intrinsically safe antennas support universal communication in various HF ranges. 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.

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

For RAD-AO4-IFS



Use either the current or voltage output at every analog channel.

1.7 UL notes (RAD-2400-IFS and I/O extension modules only)

For the 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.**

1.8 Countries of use

1.8.1 RAD-868-IFS wireless module

The RAD-868-IFS wireless module is only approved for use in Europe, South Africa, and the United Arab Emirates. The device uses the toll- and license-free 868 MHz ISM band.

The device satisfies all the requirements of Directive 2014/53/EU. Further information is available in the manufacturer's declaration at phoenixcontact.net/product/2904909

Depending on the maximum possible transmission power, you must register or apply for approval to operate the device in some countries. Furthermore, it may be necessary to limit the transmission power.

- Make sure you observe the regulations of the relevant regulatory body in all countries.

1.8.2 RAD-2400-IFS-JP wireless module

The RAD-2400-IFS-JP wireless module is only approved for use in Japan.

Japanese Radio Law and Japanese Telecommunications Business Law Compliance

The device is granted pursuant to the Japanese Radio Law (電波法) and the Japanese Telecommunications Business Law (電気通信事業法).

This device should not be modified (otherwise the granted designation number will become invalid).



1.8.3 RAD-2400-IFS wireless module

The RAD-2400-IFS wireless module is approved for license-free operation in Europe and other countries. The device uses the toll- and license-free 2.4 GHz ISM band.



A list of the country-specific approvals is available at phoenixcontact.net/product/2901541.

Additional country-specific approvals available on request.

The device satisfies all the requirements of Directive 2014/53/EU. Further information is available in the manufacturer's declaration at phoenixcontact.net/product/2901541

Depending on the maximum possible transmission power, you must register or apply for approval to operate the device in some countries. Furthermore, it may be necessary to limit the transmission power.

- Make sure you observe the regulations of the relevant regulatory body in all countries.

1.8.3.1 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

1.8.3.2 IFT, Instituto Federal de Telecomunicaciones México (RAD-2400-IFS only)

The operation of this equipment is subject to the following two conditions: (1) it is possible that this equipment or device may not cause harmful interference, and (2) this equipment or device must accept any interference including interference that may cause its undesired operation.

This equipment has been designed to operate with antennas listed below and for an antenna's maximum gain of 19 dBi. Use of this equipment with antennas not included in this list or having a higher gain than 19 dBi is prohibited. The required antenna impedance is 50 ohms.

Certificate number: IFT RCPPHRA17-1112

– Antennas: see Table “2.4 GHz antennas”

1.8.3.3 NCC (RAD-2400-IFS only)

第十二條

經型式認證合格之低功率射頻電機，非經許可，公司、商號或使用者均不得擅自變更頻率、加大功率或變更原設計之特性及功能。

第十四條

低功率射頻電機之使用不得影響飛航安全及干擾合法通信；經發現有干擾現象時，應立即停用，並改善至無干擾時方得繼續使用。前項合法通信，指依電信法規定作業之無線電通信。低功率射頻電機須忍受合法通信或工業、科學及醫療用電波輻射性電機設備之干擾。

ID: CCAJ18LP1990T7

Article 12

Without permission granted by the DGT, any company, enterprise, or user is not allowed to change frequency, enhance transmitting power or alter original characteristic as well as performance to approved low power radio-frequency devices.

Article 14

The low power radio-frequency devices shall not influence aircraft security and interfere legal communications. If found, the user shall cease operating immediately until no interference is achieved. The said legal communications means radio communications is operated in compliance with the Telecommunications Act. The low power radio-frequency devices must be susceptible with the interference from legal communications or ISM radio wave radiated devices.

ANATEL, Brazil (RAD-2400-IFS only)



06279-19-06497

“Este equipamento não tem direito à proteção contra interferência prejudicial e não pode causar interferência em sistemas devidamente autorizados.”

2 Transport, storage, and unpacking

2.1 Transport

The device is delivered in cardboard packaging.

- Only transport the device to its destination in its original packaging.
- Observe the instructions on how to handle the package, as well as the moisture, shock, tilt, and temperature indicators on the packaging.
- Observe the humidity specifications and the temperature range specified for transport (see [“Ambient conditions” on page 184](#)).
- Protect the surfaces as necessary to prevent damage.
- When transporting the equipment or storing it temporarily, make sure that the surfaces are protected from the elements and any external influences, and that they are kept dry and clean.

2.2 Storage

The storage location must meet the following requirements:

- Dry
- Protected from unauthorized access
- Protected from harmful environmental influences such as UV light
- For storage, observe the humidity and air pressure specifications, and the temperature range.

See [“Ambient conditions” on page 184](#)

2.3 Unpacking

The device is delivered in packaging together with a packing slip that provides installation instructions.

- Read the entire packing slip carefully.
- Retain the packing slip.

**NOTE: Electrostatic discharge**

Electrostatic discharge can damage or destroy components.

- When handling the device, observe the necessary safety precautions against electrostatic discharge (ESD) in accordance with EN 61340-5-1 and IEC 61340-5-1.

Checking the delivery

- Check the delivery for transport damage.

Damaged packaging is an indicator of potential damage to the device that may have occurred during transport. This could result in a malfunction.

- Immediately upon delivery, refer to the delivery note to ensure that the delivery is complete.
- Submit claims for any transport damage immediately, and inform Phoenix Contact or your supplier as well as the shipping company without delay.
- Enclose photos that clearly document the damage to the packaging and/or delivery together with your claim.
- Keep the box and packaging material in case you need to return the product.
- We strongly recommend using the original packaging to return the product.
- If the original packaging is no longer available, observe the following points:
 - Observe the humidity specifications and the temperature range specified for transport (see [“Ambient conditions” on page 184](#)).
 - If necessary, use dehumidifying agents.
 - Use suitable ESD packaging to protect components that are sensitive to electrostatic discharge.
 - Make sure that the packaging you select is large enough and sufficiently thick.
 - Only use plastic bubble wrap sheets as wadding.
 - Attach warnings to the transport packaging so that they are clearly visible.
 - Please be aware that the delivery note is to be placed inside the package if the package is sent within the same country. If the package is being sent abroad, the delivery note must be placed inside a delivery note pocket and attached to the outside so that it is clearly visible.

3 Brief description

Wireless communication is based on Trusted Wireless 2.0 technology. The wireless modules meet the high requirements for interference-free data transmission through, among other things, the use of the frequency-hopping spread spectrum (FHSS) method and 128-bit data encryption (AES).

Wireless modules

RAD-2400-IFS, RAD-2400-IFS-JP
RAD-868-IFS

Frequency band

License-free 2.4 GHz ISM band
868 MHz ISM band, license-free in Europe

3.1 Wireless modules

In addition to an RS-232 and RS-485 2-wire interface, the 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 modules and I/O mapping of the extension modules is carried out quickly and easily by means of the thumbwheel on the front. The yellow thumbwheel on the wireless module is used to set the RAD ID. The white thumbwheel on the extension modules is used 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 diagnostic software for special functions and diagnostic options of the wireless module is available free of charge.

Features

- Flexible network applications:
I/O data, serial data, PLC/Modbus RTU mode, dual mode
- Adjustable data rates for the wireless interface
- Easy point-to-point or network structures (star, mesh)
- Yellow thumbwheel for the unique addressing of wireless modules in the wireless network
- Integrated RS-232 and RS-485 interface
- Can be extended with up to 32 I/O modules per station via DIN rail connector (hot-swap capability)
- 128-bit AES data encryption and authentication
- Unique network addressing via plug-in configuration stick (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 (RAD-2400-IFS and RAD-868-IFS only)
- Can be combined with RS-485 stations



The **RAD-RS485-IFS** RS-485 front module is not described in this user manual. For further information, visit phoenixcontact.net/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
Initial version	1.00	1.00
PLC/Modbus RTU mode	1.30	1.00
Support for RAD-DI8-IFS and RAD-DO8-IFS I/O 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
PLC/Modbus RTU dual mode	1.80	1.80
Support for RAD-AI4-U-IFS and RAD-NAM4-IFS	1.90	1.90

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-swap capability)
- Depending on the module: channel-to-channel electrical isolation
- Depending on the module: analog inputs or outputs (0/4 mA ... 20 mA, 16-bit resolution, <0.1% accuracy)
- Depending on the module: digital wide-range inputs or outputs (0 V ... 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:

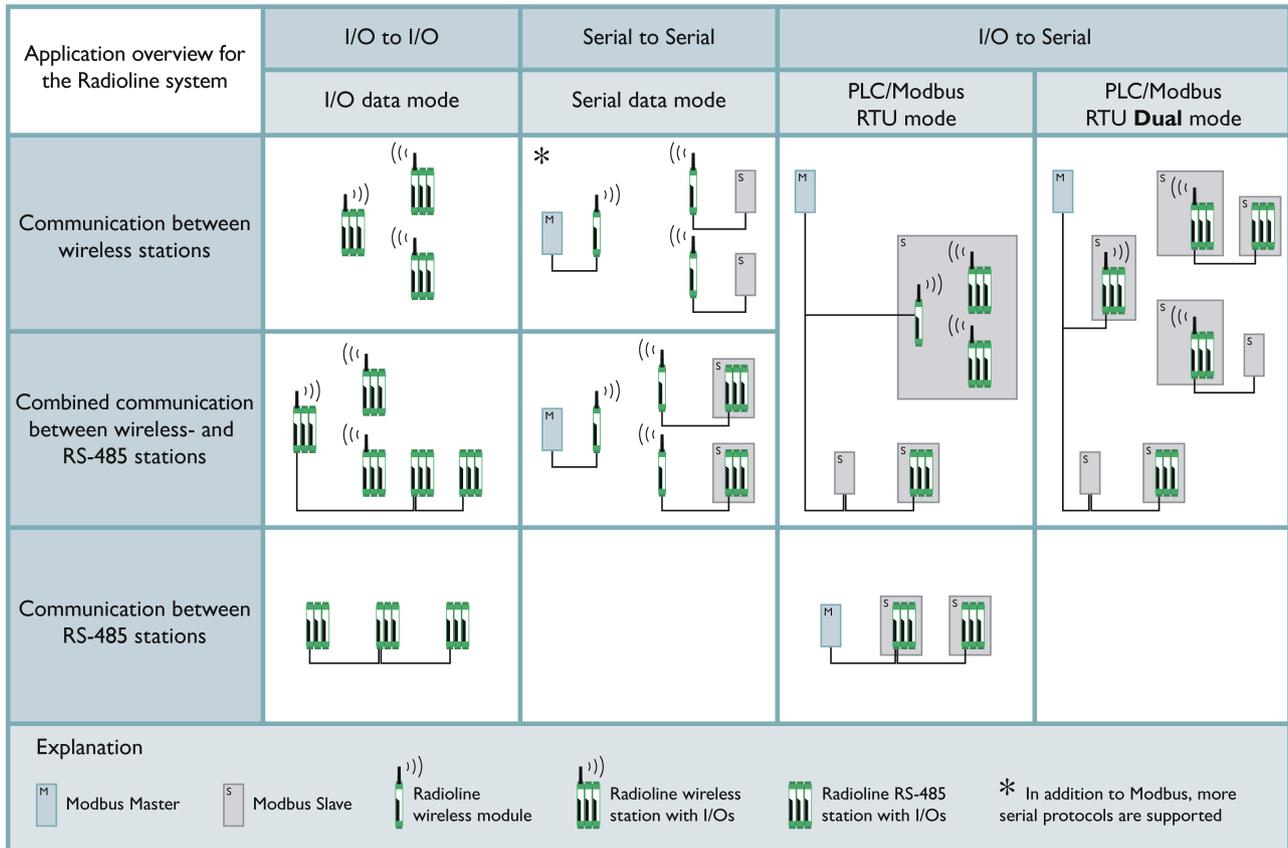
Table 3-2 Overview of I/O extension modules

Module type		Designation	Order No.	From page
Analog	4 analog current inputs	RAD-AI4-IFS	2901537	89
	4 analog voltage inputs	RAD-AI4-U-IFS	2702290	93
	4 Pt 100 inputs	RAD-PT100-4-IFS	2904035	99
	4 analog outputs	RAD-AO4-IFS	2901538	107
Digital	4 digital inputs	RAD-DI4-IFS	2901535	111
	8 digital inputs or 2 pulse inputs	RAD-DI8-IFS	2901539	115
	4 NAMUR inputs	RAD-NAM4-IFS	2316275	122
	4 digital relay outputs	RAD-DOR4-IFS	2901536	127
	8 digital transistor outputs	RAD-DO8-IFS	2902811	131
Analog/digital	1 analog input/output, 2 digital wide-range inputs/outputs	RAD-DAIO6-IFS	2901533	137

3.4 Application examples

The Radioline system offers a wide range of possible applications.

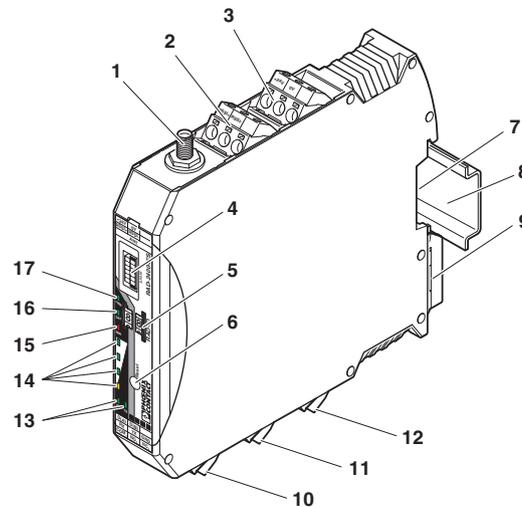
Figure 3-1 Application overview



4 Installation

4.1 Wireless module structure

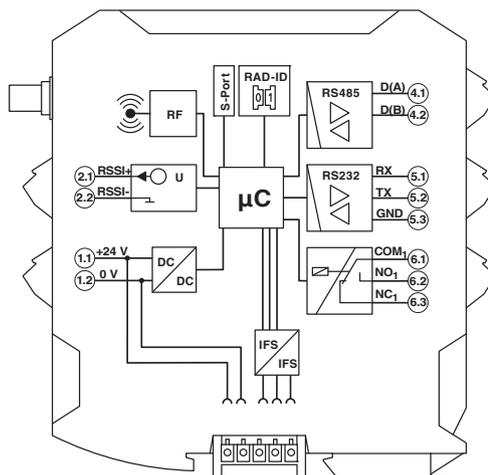
Figure 4-1 Wireless module structure



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 foot catch 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 changeover 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 Basic circuit diagram for the wireless module



4.3 Mounting and 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 **exclusively to the right** of the wireless module.
- The individual extension modules can be arranged in any order.
- **2.4 GHz wireless modules only:** Install the wireless module at least 1 m away from other devices using the 2.4 GHz frequency band (e.g., WLAN, Bluetooth, microwave ovens). Otherwise, both the link quality and the data transmission speed will be reduced.

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

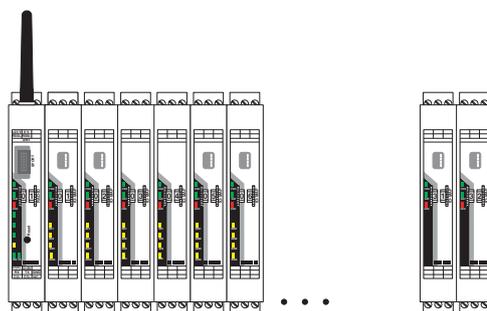
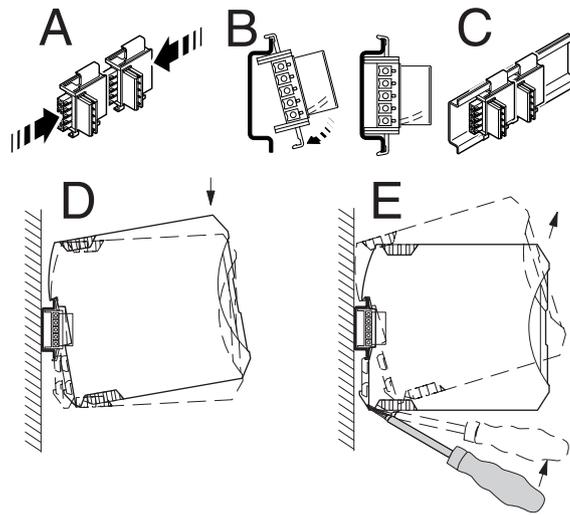


Figure 4-4 Mounting and removal



Mounting a connection station with DIN rail connectors:

- Connect the DIN rail connectors together for a connection station.
- Push the connected DIN rail connectors onto the DIN rail.
- Place the device onto the DIN rail from above (see [Figure 4-4, D](#)). Make sure that the device and DIN rail connector are aligned correctly.
- Holding the device by the housing cover, carefully push the device toward the mounting surface so that the device bus connector is fixed securely on the DIN rail connector.
- Once the snap-on foot has audibly snapped onto the DIN rail, check that it is attached 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.
- In order to meet the requirements for the protection class, install the device in suitable housing.
- 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 (female, 1803604)
 - IMC 1,5/5-ST-3,81 (male, 1857919)



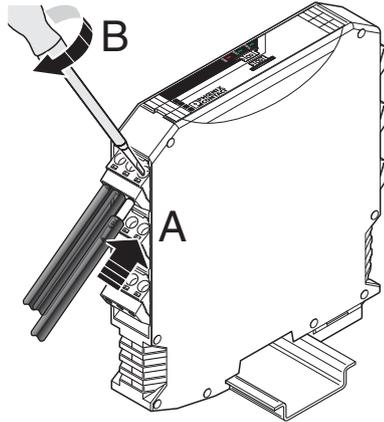
Device replacement is also possible during operation when outside the Ex area.

Removal

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

4.4 Connecting the cables

Figure 4-5 Connecting the cables



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 ferrules to the litz wires. Permissible cable cross-section: $0.2 \text{ mm}^2 \dots 2.5 \text{ mm}^2$
- Insert the conductor 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

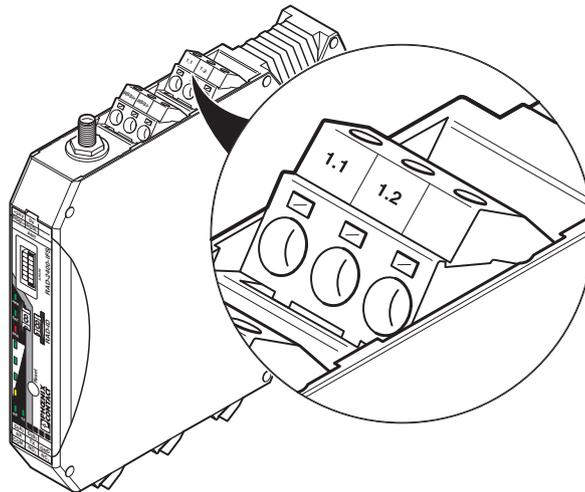
4.5.1 Via screw terminal blocks

- The power supply of the module must meet the conditions of class ES1 in accordance with EN/IEC 62368-1.
- 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.

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.

Figure 4-6 Connecting the power supply

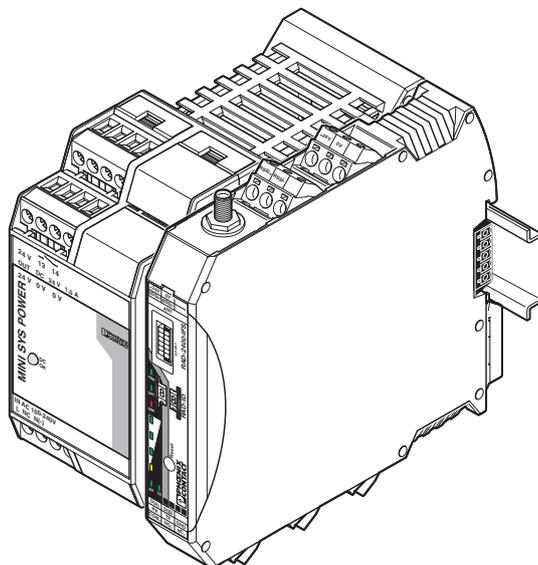


4.5.2 With a system power supply via the bus foot

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



- 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.



- Activate and configure the RS-232 or RS-485 interface using the PSI-CONF software (from [page 39](#) onwards).
- You can only use one interface per wireless module. Parallel operation of both interfaces is not possible.

4.6.1 Shielding of the RS-485 bus line

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



NOTE: Damage to the interface

If the shielding has been connected incorrectly, permanent, external interfering pulses may damage the interface.

- Observe the polarity of the RS-485 2-wire cable and make sure that the shielding is connected correctly.

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

- First, connect the shield on one side. This suppresses electrical fields.
- To suppress interference caused by alternating magnetic fields, connect the shield on both sides. When doing so, ground loops must be taken into consideration. Galvanic interference along the reference potential influences 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 clamps).

4.6.2 Terminating the RS-485 bus line

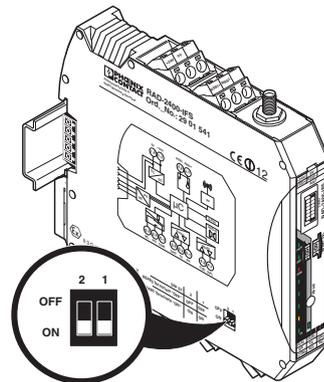
The wireless modules are operated on a 2-wire bus line. RS-485 bus connections must be terminated at both ends with a 390/150/390 Ω termination network.

- Depending on the position of the device on the RS-485 bus line, activate or deactivate the termination network.

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

Device position	Termination network	DIP switch	
		1	2
RS-485 end device	On	ON	ON
RS-485 device	Off	OFF	OFF

Figure 4-8 DIP switch

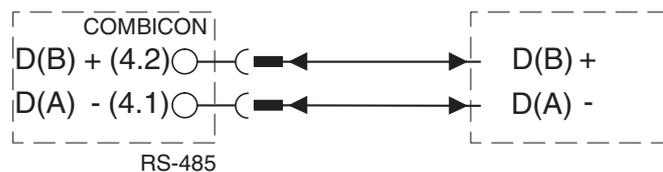


4.6.3 RS-485 pin assignment

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

- Connect the single-core 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 operating mode, point-to-point connections can be established.



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.

- According to the standard, you can connect a DCE (Data Communication Equipment) device 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)

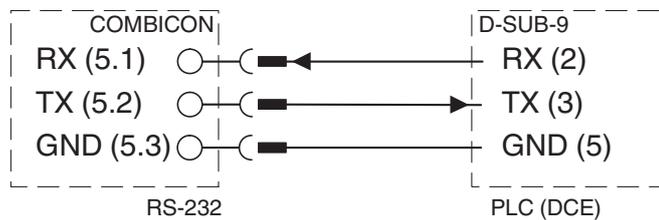
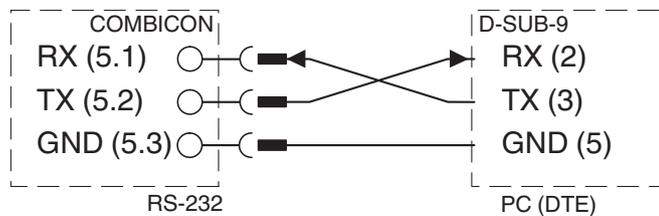


Figure 4-11 RS-232 interface pin assignment (DTE - DTE)



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:

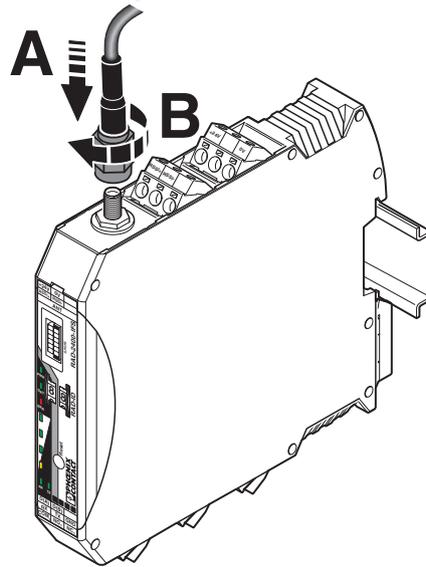
- Voltage of approximately -5 V: DTE device
- Voltage of approximately 0 V: DCE device

4.7 Connecting the antenna



- Install the antenna outside the control cabinet or building. See [Section 9.8, “Installing antennas”](#).
- Please also observe the installation instructions for the antenna as well as [Section “For your safety” on page 6](#).
- For information on the transmission power, please refer to [Section “Transmission power” on page 40](#).

Figure 4-12 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 188](#).

5 Configuration and startup

5.1 Factory default settings of the wireless module

All wireless modules are configured to the same factory default settings in the delivery state or following a reset at a later time.

Table 5-1 Factory default settings of the wireless module

Parameter	Setting		
	RAD-2400-IFS	RAD-2400-IFS-JP	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		
Denylist	WLAN channel 6		-
Data rate of the wireless interface	125 Kbps		9.6 Kbps
Receive preamplifier	Activated		-
Transmission power	18 dBm	20 dBm	27 dBm



The receive preamplifier is activated in the delivery state. The transmission power is set so that the devices can cover the greatest possible distances. 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 factory default settings

The device can be reset to the factory 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



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

You can update the firmware using the PSI-CONF software. The device is reset to the factory 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 four different options for signal and data transmission:

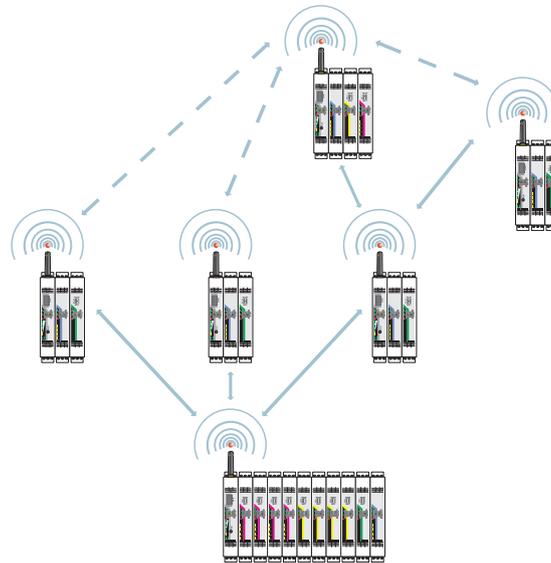
Table 5-2 Operating mode of the wireless module

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

- If the wireless system is operated in an environment where other networks are also present, e.g., additional Radioline networks, a configuration stick can be used (see [“Configuration using the configuration stick” on page 36](#)).
- Extended settings of the wireless modules can also be configured using the PSI-CONF software (from [page 39](#) onwards).

5.2.1 I/O data mode

Figure 5-1 I/O data mode



In the delivery state, all wireless modules are in I/O data mode. For simple I/O-to-I/O applications with extension modules, you can quickly set the addresses using the thumbwheel. You can therefore establish a wireless connection to other wireless modules without any programming effort (see [“Setting the address of the wireless module via the thumbwheel” on page 36](#) and [“Setting the address of the extension modules via the thumbwheel” on page 54](#)).

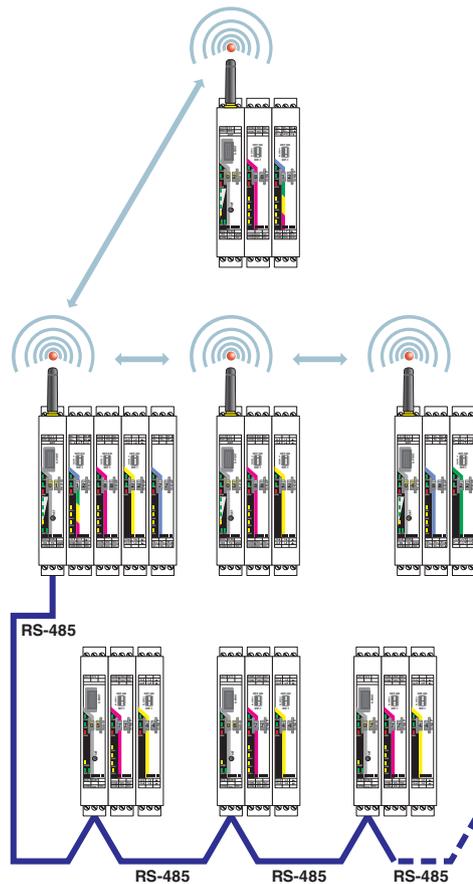
RS-485 front module

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 base station and thus 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 the stations, regardless of the medium used.

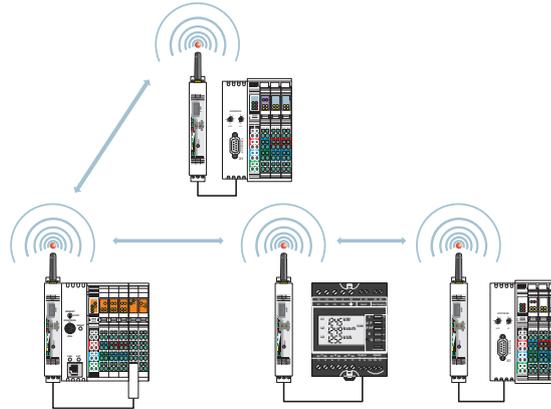
Figure 5-2 I/O-to-I/O, wireless, and RS-485



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

5.2.2 Serial data mode

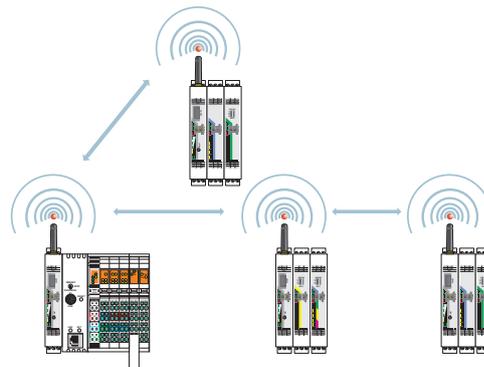
Figure 5-3 Serial data mode



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 39](#) onwards).

5.2.3 PLC/Modbus RTU mode

Figure 5-4 PLC/Modbus RTU mode



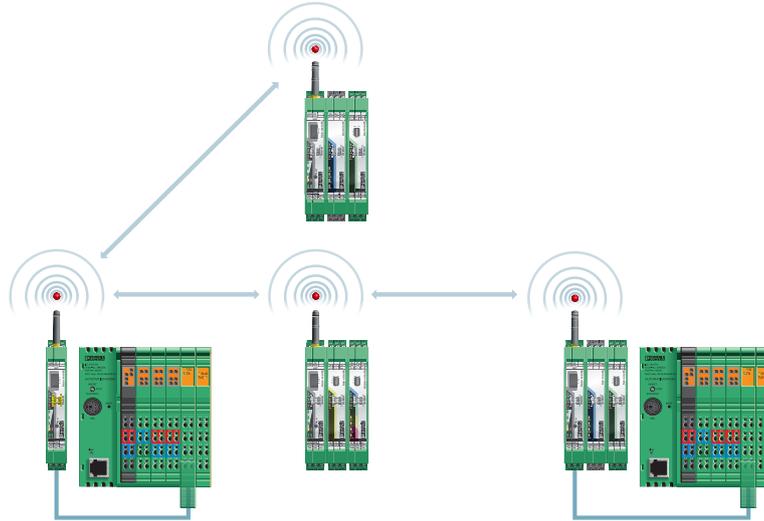
You can connect the I/O extension modules to the controller directly via the integrated RS-232 and RS-485 interface by means of wireless communication. In PLC/Modbus RTU mode, the Radioline base station (RAD ID = 01) operates as a Modbus server. The base station has its own Modbus address.

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 Radioline base station. 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 39](#) onwards).

5.2.4 PLC/Modbus RTU dual mode

Figure 5-5 PLC/Modbus RTU dual mode



Dual mode combines PLC/Modbus RTU mode and serial data mode. You can connect Radioline extension modules to the controller directly via the integrated RS-232 and RS-485 interface by means of wireless communication. You can also connect additional Modbus/RTU servers in parallel.

You need to configure each wireless module using the PSI-CONF software (from [page 39](#) onwards).

5.3 Setting the address of the wireless module via the thumbwheel

- Start by setting the desired station address with the yellow thumbwheel on the wireless module. There must be one base station (RAD-ID = 01) and at least one remote station (RAD-ID = 02 ... 99) in a network.



- Each address 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.

Table 5-3 Yellow thumbwheel settings

Thumbwheel	Description	
01	Base address	For networks with repeaters (mesh networks)
02 ... 99	Repeater address	
*1	Base address	For networks without repeaters (star networks)
*2 ... *9	Remote address	
00	Not permitted	
**	For 2.4 GHz wireless modules only: Addressing wireless modules using the PSI-CONF software (address 1 ... 250)	

5.4 Configuration using the configuration stick

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

The configuration stick 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. To this end, you only need one configuration stick for all the wireless modules in the network. After configuration, you can remove the stick from the wireless module.

In addition, the configuration stick 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.



- 2.4 GHz wireless modules:** You can also set different RF bands from 1 ... 8 and network IDs from 1 ... 127 using the PSI-CONF software (see [page 40](#)).
- 868 MHz wireless modules:** For further information on the various RF bands in 868 MHz wireless systems, refer to “[RF bands](#)” on [page 148](#).

Different sticks are available for easy configuration without the need for software.

For 2.4 GHz wireless modules:

- 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)

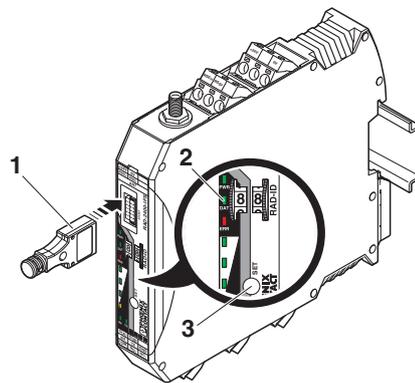
For 868 MHz wireless modules:

- 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 configuration stick in a potentially explosive atmosphere.

Figure 5-6 Configuration using the configuration stick



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

- Carefully insert the configuration stick 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 configuration stick from the wireless module.
- Repeat this process for **each** individual wireless module in the network.

5.5 Copying the 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 than the wireless module from which the configuration file was 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. Parameter copying 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. The read-in process 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 diagnostic software. The software can be downloaded at phoenixcontact.net/products.

- A PC with Windows® operating system is required to use the software.
- For configuration and diagnostics, use 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.



For further information on the USB cable, please refer to the PACKB.RAD-CABLE-USB packing slip. The latest documentation can be downloaded via the item at phoenixcontact.net/product/2903447.

- 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.

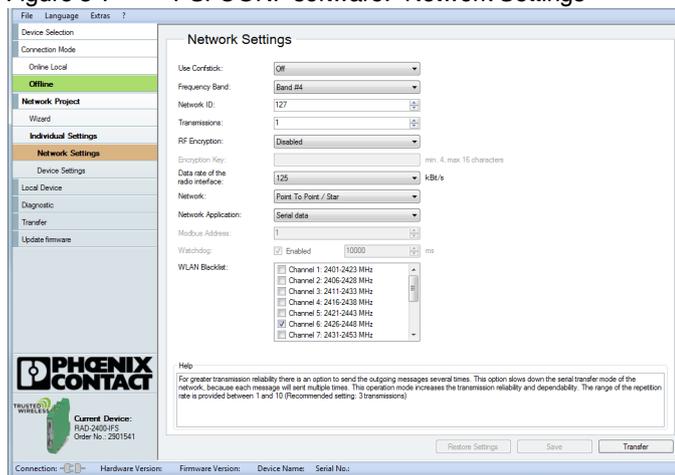
- When you move the mouse over the individual network parameters, a short description appears under “Help”.



If you operate several wireless systems in parallel and in close proximity, you should select different RF bands and network IDs in order to separate the wireless systems.

- These parameters can be set via the PSI-CONF software or by using a configuration stick (see “[Configuration using the configuration stick](#)” on page 36).

Figure 5-7 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:

$$\text{Device transmission power} + \text{Antenna gain} - \text{Cable attenuation}$$

5.6.3 Data transmission rate of the wireless interface

The range is an important parameter for industrial wireless applications, especially for 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 rate of the wireless interface, the higher the receiver sensitivity and therefore the range.



Adjust the data transmission rate of the wireless interface to the respective application using the PSI-CONF software.

Factory default setting:

- 2.4 GHz wireless modules = 125 Kbps
- 868 MHz wireless modules = 9.6 Kbps

Table 5-4 Data transmission rate of the wireless interface, 2.4 GHz

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

Table 5-5 Data transmission rate of the wireless interface, 868 MHz

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

You can cover distances of several kilometers 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 rate, obstacles such as walls or trees can be penetrated much better. Please note, however, that the delay time increases when the data rate is reduced.

Figure 5-8 PSI-CONF software: "Wizard, Step 3"

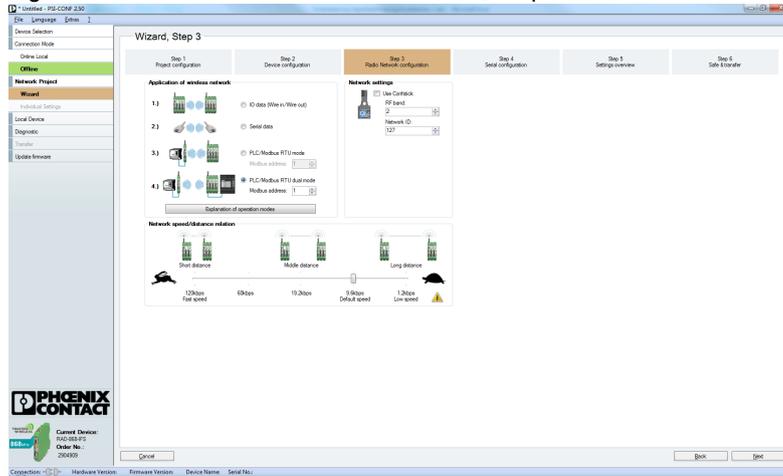
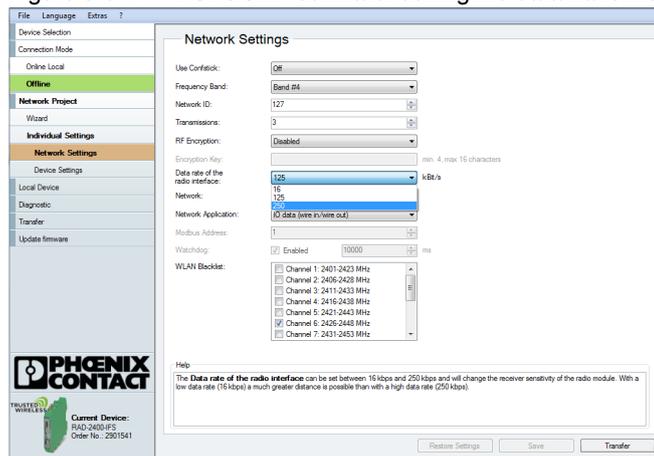


Figure 5-9 PSI-CONF software: setting the data transmission rate



5.6.4 Device settings



The receive preamplifier is activated in the delivery state. The transmission power is set so that the devices can cover the greatest possible distances:

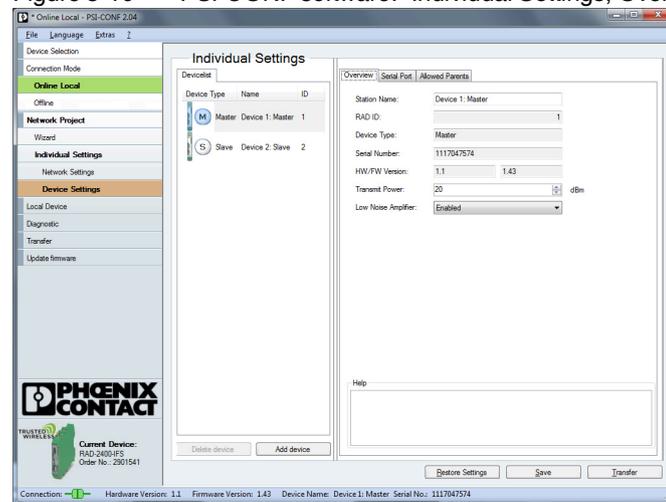
- RAD-2400-IFS: 18 dBm
- RAD-2400-IFS-JP: 20 dBm
- RAD-868-IFS: 27 dBm

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.

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

Figure 5-10 PSI-CONF software: “Individual Settings, Overview”



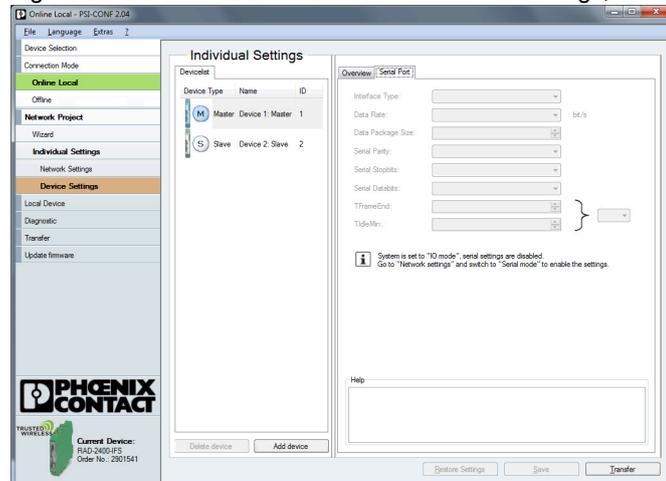
Depending on the operating mode, configure the serial interface under “Individual Settings” on the “Serial Port” tab.

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



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

Figure 5-11 PSI-CONF software: “Individual Settings, Serial Port”

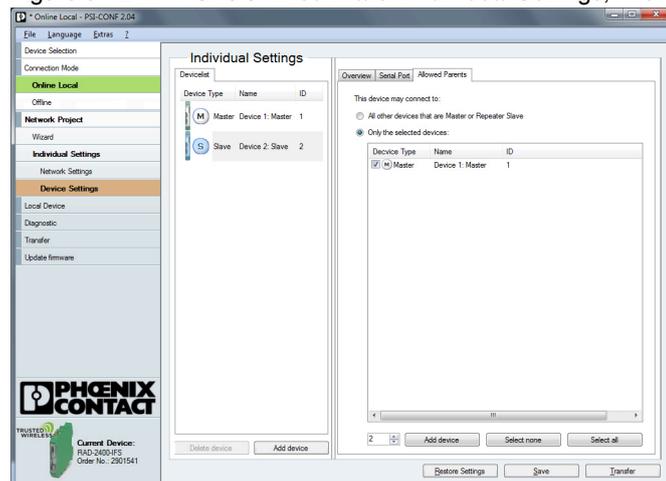


Define the wireless modules to which a connection may be established on the “Allowed Parents” tab under “Individual Settings”. This setting is required, for example, when creating repeater chains. Repeater chains are used to circumvent obstacles or to set up redundant wireless paths by means of several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



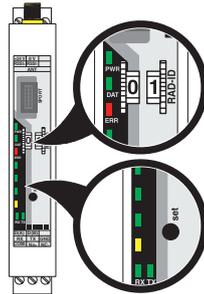
The “Allowed Parents” tab is only available if the “Line/Mesh” network type has been selected.

Figure 5-12 PSI-CONF software: “Individual Settings, Allowed Parents”



5.7 Diagnostics on the wireless module

Figure 5-13 Diagnostic LEDs on the wireless module



PWR LED

Green	Status of supply voltage
Off	No supply voltage
On	Supply voltage OK

DAT LED

Green	Status of bus communication
Off	No communication
Flashing	Configuration mode
On	Cyclic data communication

ERR LED

Red	Error status
Off	No error
Flashing	
Slow, 1.4 Hz	Wireless module in I/O data mode <ul style="list-style-type: none"> - 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 <ul style="list-style-type: none"> - 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 The receive preamplifier is activated in the delivery state. The transmission power is set so that the devices can cover the greatest possible distances. 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 (from [page 39](#) onwards).

Table 5-7 RSSI voltage, 2.4 GHz

	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 RSSI voltage, 868 MHz

	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:

- A firmware update or
- The wireless module is 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.

Firmware version 1.70 or later: In I/O data mode, the TX LED on the Radioline base station (RAD ID = 01) flashes. This indicates that the base station is continuously sending queries 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 configuration stick 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 drops out after a while. The relay picks up again automatically when the wireless connection is re-established. The relay has been designed as a changeover contact.



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

RSSI test socket

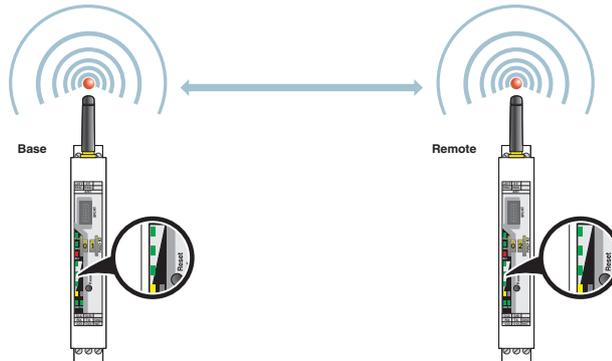
A voltage measuring device can be connected to the RSSI test socket (2.1/2.2) to measure the RSSI voltage from 0 V ... 3 V. You can use the table on [page 47](#) to determine the received signal strength based on the measured voltage. However, please note the small voltage fluctuation due to multipath 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

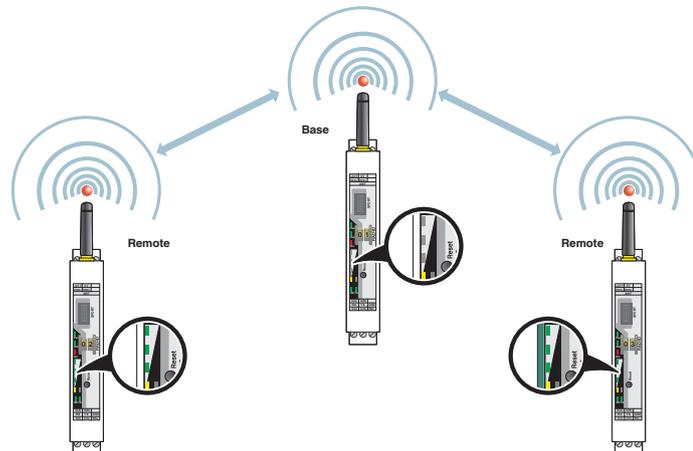
Figure 5-14 Bar graph for point-to-point connection



Point-to-point connection with just two wireless modules:

- The bar graph is active on the base station and on the remote station.

Figure 5-15 Bar graph for point-to-multipoint connection



Wireless network with more than one remote station:

- Only the yellow LED on the base station is permanently on
- The signal strength in the base station direction is indicated on the remote or repeater stations. The signal strength always relates to the directly connected, higher-level wireless module.

If several repeater stations are connected to a base station, the base station should theoretically indicate the signal strength for several wireless modules. This is not possible for technical reasons, however. This is why only the yellow bar graph LED lights up on the base station.

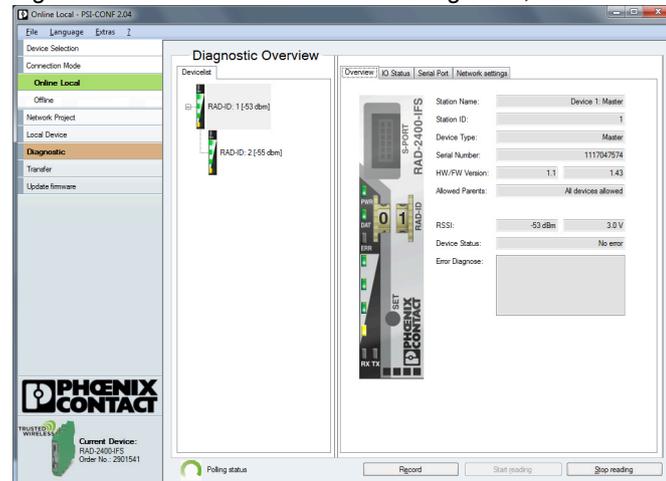
- You can read the RSSI values via the serial interface of the base station using Modbus/RTU commands (see [Section “RSSI signal and error code registers” on page 85](#)).

5.8 Diagnostics via PSI-CONF software

Display all current device settings for the station under “Diagnostic” on the “Overview” tab.

- Select the desired station from the device list.

Figure 5-16 PSI-CONF software: “Diagnostic, Overview”



- The entire wireless network can be diagnosed via the base station (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 167](#).

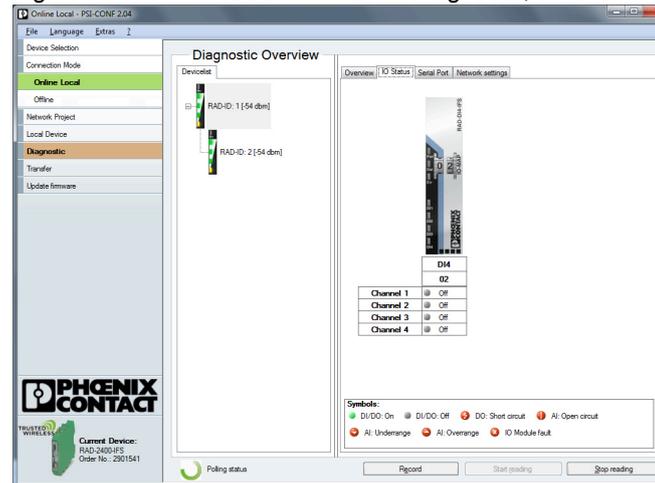
If an error occurs in the network, an error message is displayed under “Device Status”. If the error is no longer present, the error message is reset.

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
- Configuration stick has not yet been inserted

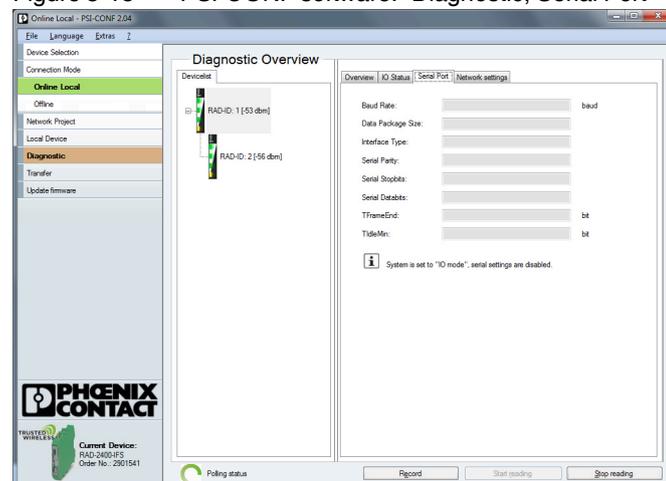
The “I/O Status” tab displays the status and the current values of the connected I/O extension modules.

Figure 5-17 PSI-CONF software: “Diagnostic, I/O Status”



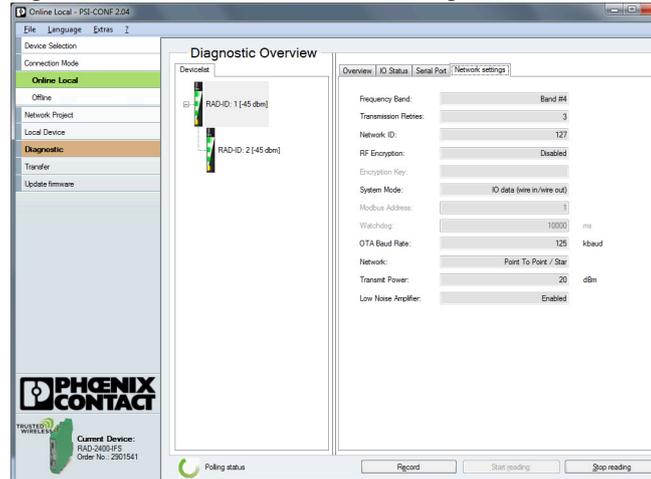
The “Serial Port” tab displays the parameters currently set for the RS-232/RS-485 interface.

Figure 5-18 PSI-CONF software: “Diagnostic, Serial Port”



The “Network settings” tab displays the network parameters currently set as well as the settings for the configuration stick, if used.

Figure 5-19 PSI-CONF software: “Diagnostic, Network settings”



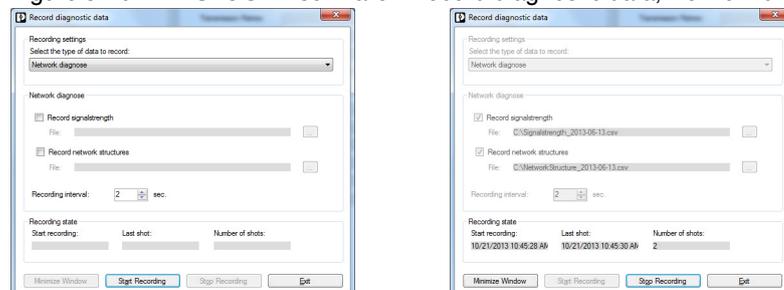
5.8.1 Recording parameters

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 diagnose” 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. Click on “Start Recording”.

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

Figure 5-20 PSI-CONF software: “Record diagnostic data, Network diagnose”



5.9 Starting up I/O extension modules

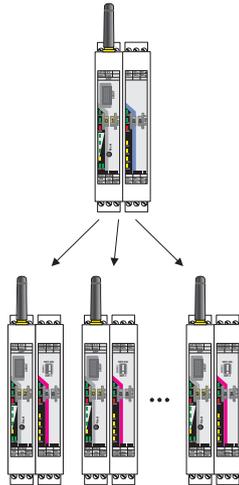
5.9.1 Combinations of extension modules

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



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

Figure 5-21 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 5-22 RAD-DAIO6-IFS assignment: analog/digital inputs and outputs

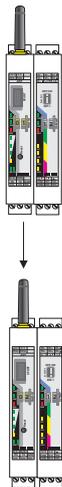


Table 5-9 Assignment of input and output modules

Input module		Output module		
2901537	RAD-AI4-IFS	2901538	RAD-AO4-IFS	
2702290	RAD-AI4-U-IFS			
2904035	RAD-PT100-4-IFS	2901538	RAD-AO4-IFS	
2901535	RAD-DI4-IFS	2901536	RAD-DOR4-IFS	
2901539	RAD-DI8-IFS	Static mode	2902811	RAD-DO8-IFS
		Pulse counter mode	-	No output module, can only be used in PLC/Modbus RTU mode or dual mode
2316275	RAD-NAM4-IFS	2902811	RAD-DO8-IFS	
2901533	RAD-DAIO6-IFS	2901533	RAD-DAIO6-IFS	

5.9.2 Setting the address of the extension modules via the thumbwheel

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

Addressing extension modules

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

Table 5-10 White thumbwheel settings

Thumbwheel	Description
01 ... 99	I/O MAP address
00	Delivery state
**	Setting not permitted
1* ... 9*	
*1 ... *9	

- Addresses 1 ... 99 (maximum) can be assigned for the extension modules in the entire wireless network.

Wireless module in I/O data mode

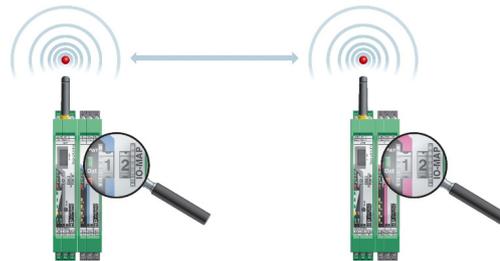
- The input module **must** be provided with the same I/O MAP address as the assigned output module at another station (I/O mapping). Output modules with the same I/O MAP address may appear several times in the network at different stations.
- The I/O MAP address of an input module may appear only once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

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



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

Figure 5-23 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 appear only once in the network.
- The input and output data is saved in a Modbus memory map in the base station. You can read or write the process data via the serial interface of the base station (RAD ID = 01) using Modbus/RTU commands. The process data tables can be found starting at [page 70](#).

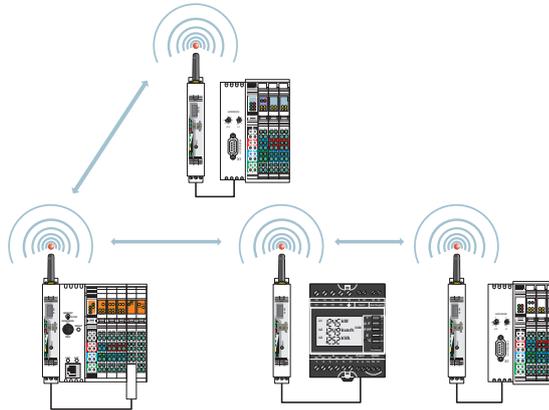
5.10 Startup time of the wireless station

Once a wireless station has been started up (power “ON”), it will take the wireless module several seconds until it is ready for operation. Every 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 period of time has elapsed is the wireless station ready for operation.

6 Serial data mode

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

Figure 6-1 Serial data mode



You can configure the serial interface of the wireless module using the PSI-CONF software. In order to connect the wireless module to the PC, use 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 run through all steps of the wizard, save the project and transfer it to the wireless modules.

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

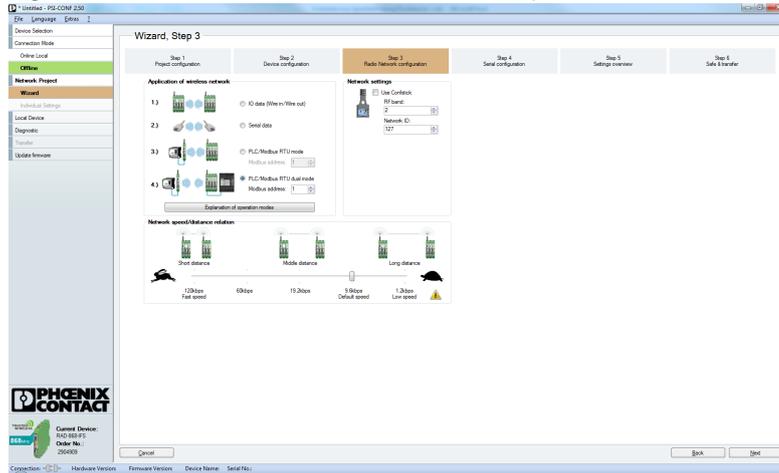
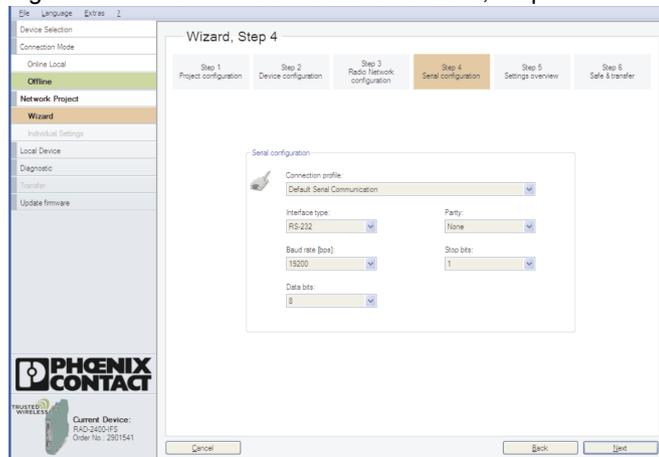


Figure 6-3 PSI-CONF software: “Wizard, Step 4”

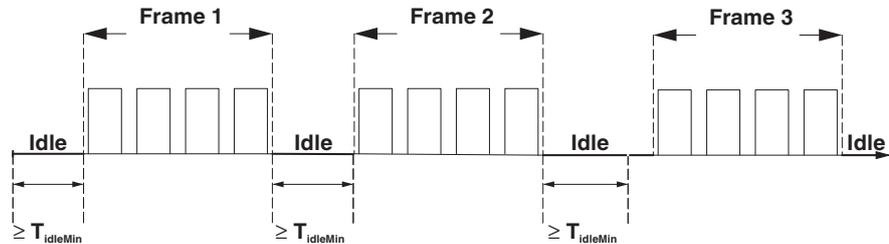


6.1 Frame-based data transmission

$T_{IdleMin}$ parameter

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



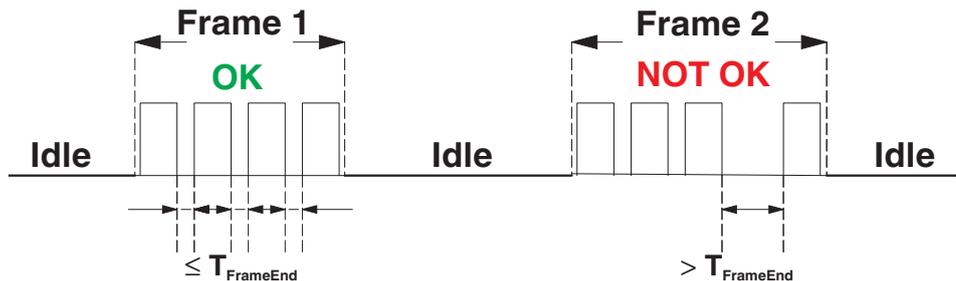
$T_{FrameEnd}$ parameter

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

If the wireless module receives data then for a certain period of time receives no further data, the wireless module assumes that the whole frame has arrived. 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



6.2 Setting telegram pauses, using Modbus/RTU as an example

A frame is also referred to as a telegram. The length of the transmission pause between the telegrams depends on the data rate that has been set. 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 server address.

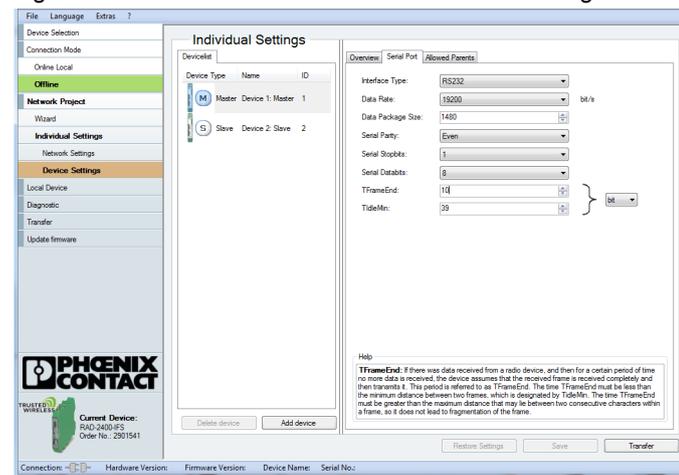
A telegram must therefore be sent as a continuous stream of data. If there is an interruption of more than 1.5 characters within a telegram, the data will be discarded by the receiver.

If the Radioline base station 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.

You can adapt data transmission to other protocols by adjusting the T_{FrameEnd} and T_{IdleMin} parameters.

- Set the interface parameters under “Individual Settings”.

Figure 6-6 PSI-CONF software: “Individual Settings”



Individual settings for frame-based data transmission

Table 6-1 Verified parameters for frame-based data transmission

Manufacturer	Product	Protocol	T_{IdleMin} [bit]	T_{FrameEnd} [bit]
-	-	PROFIBUS	11	7
-	-	Modbus/RTU	39	20
Phoenix Contact	EMpro	Modbus/RTU	56	12
Phoenix Contact	SOLAR-CHECK	Modbus/RTU	56	12
Delta	RPI-M20A	Modbus/RTU	3	20

Not all of the I/O devices available on the market are verified. In this case, the parameters must be determined by tests based on the connected I/O device and on the protocol. As precise protocol knowledge is required, you may need to ask an expert for support.

7 PLC/Modbus RTU

7.1 PLC/Modbus RTU mode

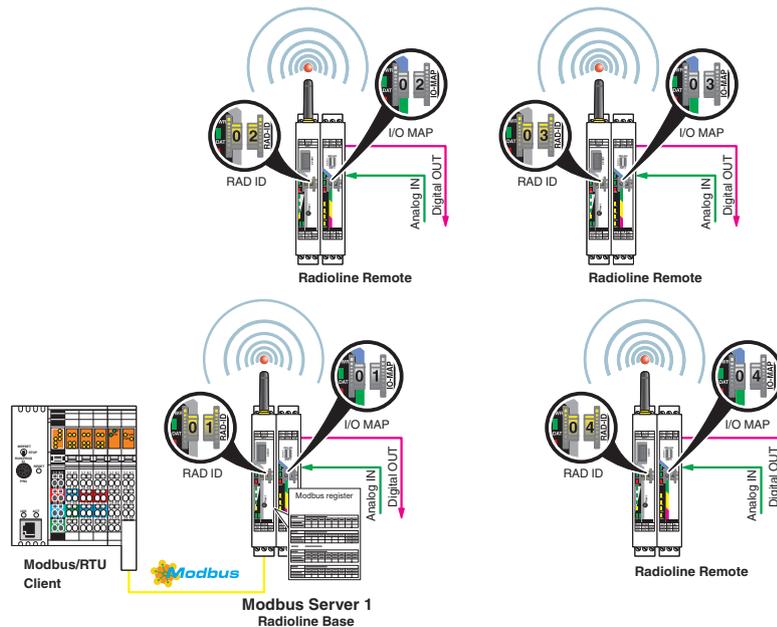
In PLC/Modbus RTU mode, you can wirelessly connect I/O extension modules directly to a controller (I/O-to-serial). The wireless module provides an RS-232 or RS-485 interface for this purpose.

In PLC/Modbus RTU mode, the Radioline base station operates as a Modbus server. The base station has its own Modbus server address. The entire wireless network therefore behaves like a single Modbus server.

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.

- Set the I/O MAP address using the white thumbwheel on the I/O extension module.
- You can find information on addressing extension modules from [page 54](#) onwards.

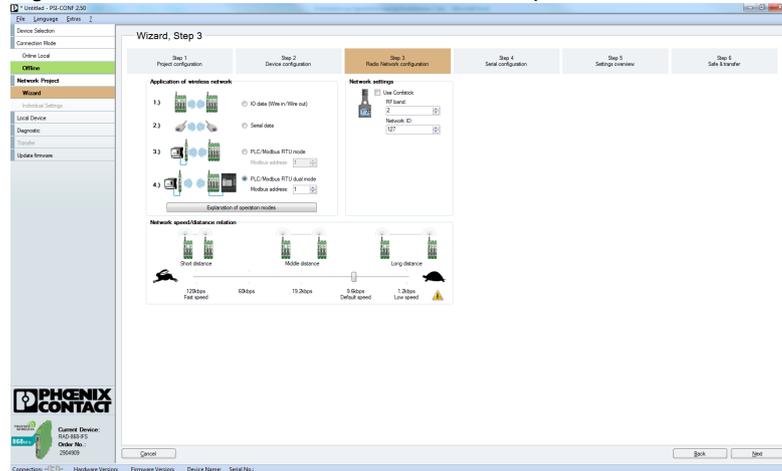
Figure 7-1 Configuration example: PLC/Modbus RTU mode



7.1.1 Configuration via PSI-CONF software

- Start the PSI-CONF software (see page 39).
- Create a new network project.
- Follow the software wizard.

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



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



The Modbus address is a unique address in the Modbus network. It is only assigned for the base station (RAD ID = 01). You can assign an address between 1 ... 247.

To enable the base station 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	Factory 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

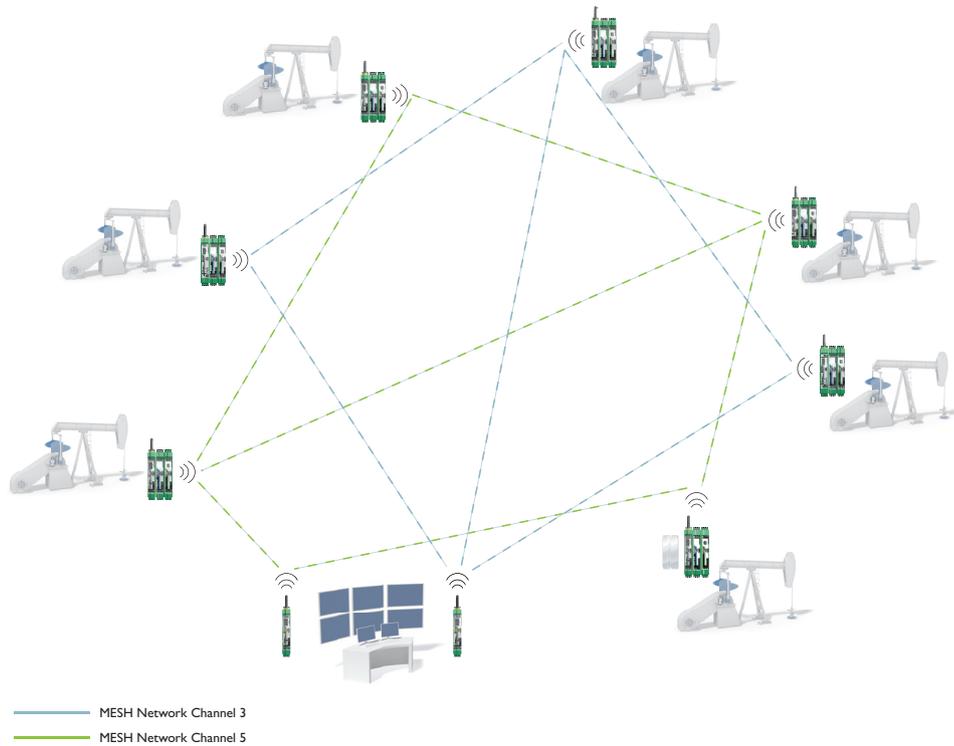
You can monitor the Modbus connection between the controller and the wireless module via a watchdog.

7.1.2 Application example: Monitoring of oil pumps

At each oil pump, sensors acquire various analog and digital signals. The monitoring system (well pad monitoring system) is divided into two meshed networks. As a result, the delay time in the network is kept to a minimum.

The distributed remote stations transmit the data to the base stations in the control center. In the control center, the data is transmitted to a higher-level system via the Modbus/RTU interface. In addition, the data is conditioned and displayed on a monitor.

Figure 7-3 Monitoring of oil pumps



7.2 PLC/Modbus RTU dual mode



PLC/Modbus RTU dual mode is available for firmware version 1.80 or later. You can update the firmware free of charge using PSI-CONF software version 2.50 or later.

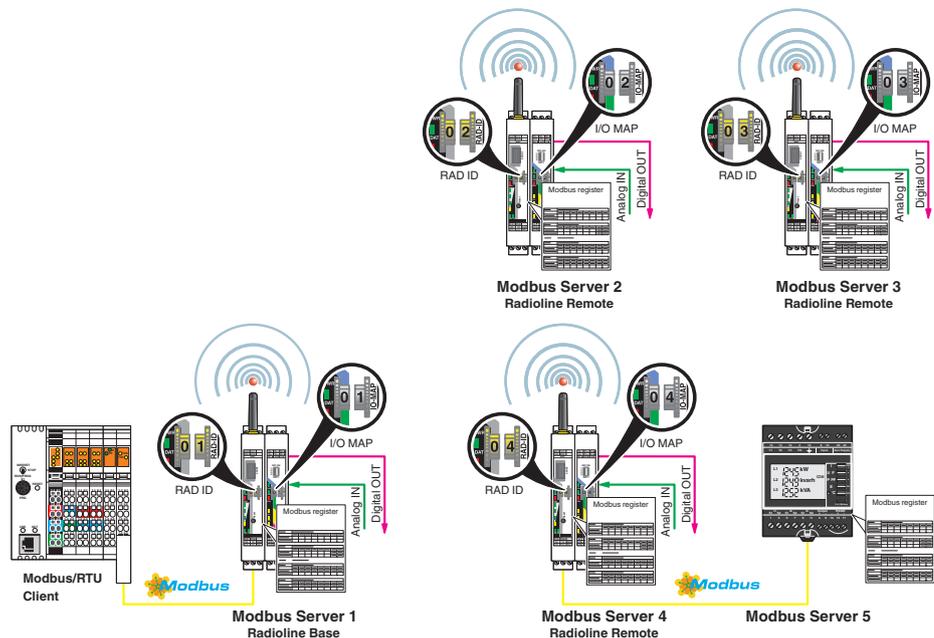
The firmware and software can be found on the Internet at phoenixcontact.net/products.

Dual mode combines PLC/Modbus RTU mode and serial data mode. You can connect Radioline extension modules to the controller directly via the integrated RS-232 and RS-485 interface by means of wireless communication. You can also connect additional Modbus/RTU servers in parallel.

In dual mode, each station in the wireless network acts as an independent Modbus server. The yellow RAD ID corresponds to the Modbus address. The Modbus address of the Radioline base station (RAD ID = 01) can be changed in order to integrate the wireless system into an existing Modbus network with Modbus address 01.

You can connect I/O extension modules to each station in the network. All I/O data from the extension modules is stored locally in the Modbus memory map of the respective station. At the same time, additional Modbus servers can be connected to each wireless station via RS-232 or RS-485, and addressed via the respective Modbus address. All diagnostic data of the wireless network can be read from the base station (RAD ID = 01) via Modbus/RTU.

Figure 7-4 Configuration example: PLC/Modbus RTU dual mode



- Activate dual mode as described here: [“Configuration via PSI-CONF software” on page 61](#).
- Set the Modbus ID of each wireless module using the yellow thumbwheel.
- You can connect a maximum of 32 I/O extension modules to a wireless station. Set the I/O MAP address using the white thumbwheel on the I/O extension module. You can find information on addressing extension modules from [page 54](#) onwards.
- A wireless network can have a maximum of 99 I/O extension modules.



The function codes, error codes, and registers are the same as those in PLC/Modbus RTU mode. For further information, please refer to [page 67](#) onwards.

7.2.1 Configuration via PSI-CONF software

- Start the PSI-CONF software (see [page 39](#)).
- Create a new network project.
- Follow the software wizard.



- The Modbus address is a unique address in the Modbus network. In dual mode, the Modbus address is the RAD ID.
- If Modbus server address “01” has already been assigned to another Modbus device, the address of the Radioline base station can only be changed via the PSI-CONF software. You can assign an address between 1 ... 247.

To enable the Radioline base station 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 7-2 Configuration via PSI-CONF software

Parameter	Possible values	Factory 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

You can monitor the Modbus connection between the controller and the wireless module via a watchdog.

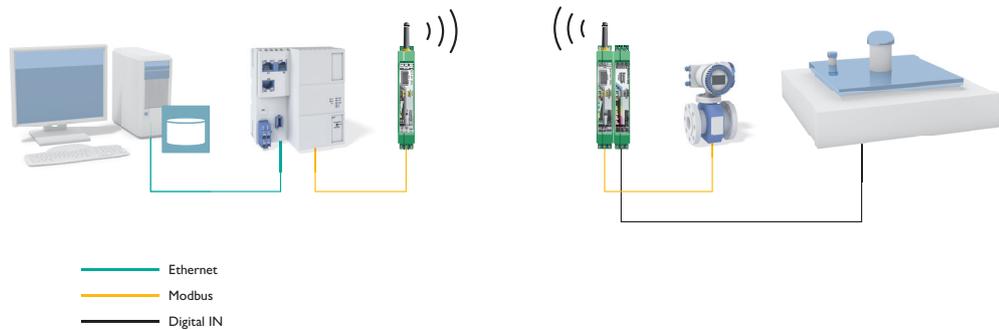
7.2.2 Application examples

To wirelessly connect an existing Modbus/RTU device and additional inputs and outputs to a controller, dual mode is required.

Flow meter

The flow meter is installed in a shaft of the water treatment plant as a Modbus/RTU server. An additional digital input is required to monitor the shaft cover. A wireless system in dual mode can meet both requirements.

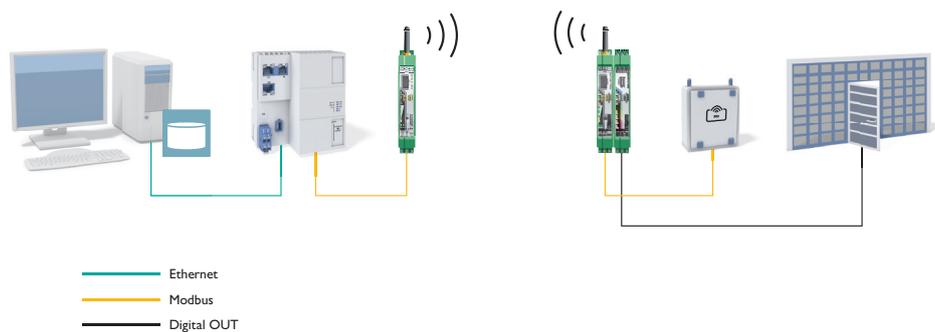
Figure 7-5 Flow meter



Access control with door opener

The card reader on the door is a Modbus/RTU server, the door opener is a digital output. Until now, either two Modbus servers and a wireless system were required or two separate wireless systems for serial transmission and I/O transmission. Dual mode enables cost-effective implementation with just one wireless system.

Figure 7-6 Access control with door opener

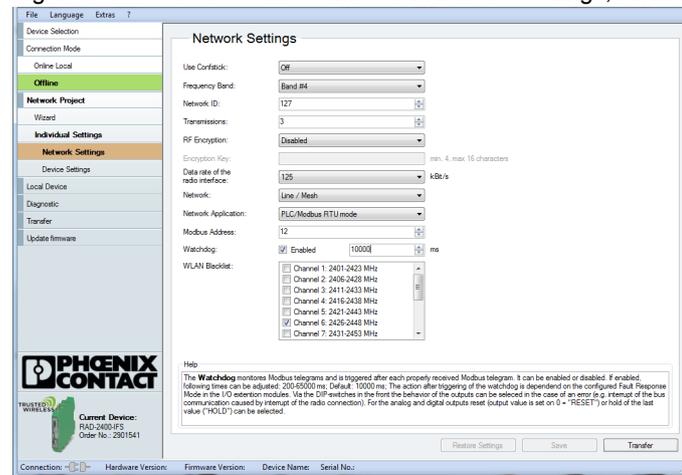


7.3 Watchdog

The Modbus telegram watchdog monitors the connection between the Radioline base station 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 7-7 PSI-CONF software: “Individual Settings, Network Settings”



If the watchdog is triggered, an action will be performed on the I/O output modules. You can set 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 on 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 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 7-3 Supported Modbus function codes

Code number	Function code	Description
fc 03	Read Holding Register	Read output process data (address range 40010 ... 40999)
fc 04	Read Input Register	Read input process data (address range 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. Address range 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 registers 40032 ... 40039. Address range 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 7-4 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 7-5 Module type IDs

Module type	Order No.	Module type ID
Analog inputs		
RAD-AI4-IFS	2901537	20 _{hex}
RAD-AI4-U-IFS	2702290	22 _{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)
RAD-NAM4-IFS	2316275	03 _{hex}
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 not available, then the register value is 0.

“Currentness of data” register value

If the data in the register is not current, the register value is 1. This is the case, for example, if the wireless connection to an input module fails. The input process data is then retained in the Modbus table, but is no longer updated.

In the case of an output module, the “Currentness of data” register value is set to 1 until the output process data has been written to the Modbus registers. The read I/O data is only valid and current if a valid module type value is returned by the Radioline base station (Modbus server) and the “Currentness of data” register value is 0.

7.5.1 Assigning I/O extension modules to the register

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

Table 7-6 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 base station with RAD ID = 01. The data here can be read or written by a Modbus client.

The following process data tables for the individual extension modules show where the I/O data is stored in the Modbus memory map. You can find a general overview of the Modbus memory map from [page 82](#) onwards.

The RSSI signal register can be found starting on [page 85](#).

Table 7-7 RSSI voltage, 2.4 GHz

LED 3 
 LED 2 
 LED 1 
 LINK LED 

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

Table 7-8 RSSI voltage, 868 MHz

LED 3 
 LED 2 
 LED 1 
 LINK LED 

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

7.6.1 RAD-AI4-IFS and RAD-AI4-U-IFS process data

I/O module	Module type ID	Register	Address range	Function code
RAD-AI4-IFS	20 _{hex}	06 _{hex}	30xx0 ... 30xx5 ¹	fc 04
RAD-AI4-U-IFS	22 _{hex}			

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

Table 7-9 RAD-AI4-IFS and RAD-AI4-U-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 current, the register value is 1. This is the case, for example, if the wireless connection or communication to an input module fails. In this case, the input process data is retained in the Modbus table, but is no longer updated.

³ If the module type in the register is invalid or not available, 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 range	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 7-10 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 current, the register value is 1. This is the case, for example, if the wireless connection or communication to an input module fails. In this case, the input process data is retained in the Modbus table, but is no longer updated.

³ If the module type in the register is invalid or not available, 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 range	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 7-11 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 current, the register value is 1. If the process data has been written to one of the registers, 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 not available, 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 range	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 7-12 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 current, the register value is 1. This is the case, for example, if the wireless connection or communication to an input module fails. In this case, the input process data is retained in the Modbus table, but is no longer updated.

³ If the module type in the register is invalid or not available, 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 range	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 values	40xx0 ... 40xx1 ¹	fc 03, 16

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

Table 7-13 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 current, the register value is 1. This is the case, for example, if the wireless connection or communication to an input module fails. In this case, the input process data is retained in the Modbus table, but is no longer updated.

³ If the module type in the register is invalid or not available, 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 value 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 value 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 value 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 value DI7, high word															

30xx6 ... 30xx9	Reserved
-----------------	----------

40xx1 Reset of counter values 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 value DI7 reset to 0

² Bit 0 = 1: Counter value DI1 reset to 0

40xx2 ... 40xx9	Reserved
-----------------	----------

7.6.6 RAD-NAM4-IFS process data

I/O module	Module type ID	Register	Address range	Function code
RAD-NAM4-IFS	03 _{hex}	02 _{hex}	30xx0 ... 30xx1 ¹	fc 04

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

Table 7-14 RAD-NAM4-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 current, the register value is 1. This is the case, for example, if the wireless connection or communication to an input module fails. In this case, the input process data is retained in the Modbus table, but is no longer updated.

³ If the module type in the register is invalid or not available, the register value is 0.

30xx1 Digital inputs ¹															
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
								E4	E3	E2	E1	DI4	DI3	DI2	DI1
Terminal point												5.x	4.x	3.x	2.x

¹ E1 ... E4 = error (wire break, short circuits), only when the DIP switch for the channel is set to ON
 DI1 ... DI4 = NAMUR inputs

30xx2 ... 30xx9	Reserved
-----------------	----------

7.6.7 RAD-DOR4-IFS process data

I/O module	Module type ID	Register	Address range	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 7-15 RAD-DOR4-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 current, the register value is 1. If process data has been written to one of the registers, 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 not available, 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
-----------------	----------

7.6.8 RAD-DO8-IFS process data

I/O module	Module type ID	Register	Address range	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 7-16 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 current, the register value is 1. If 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 current. This is the case, for example, if communication to an input module fails. In this case, the input process data is retained in the Modbus table, but is no longer updated.

³ If the module type in the register is invalid or not available, 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 or more outputs 5 ... 8.

² **Bit 0 = 1:** Short circuit detected at one or more 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	DO	DO	DO	DO	DO	DO	DO
								8	7	6	5	4	3	2	1
Terminal point															
								5.x	5.x	4.x	4.x	3.x	3.x	2.x	2.x
40xx2 ... 40xx9		Reserved													

7.6.9 RAD-DAIO6-IFS process data

I/O module	ModuleTypeID	Register	Address range	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 7-17 RAD-DAIO6-IFS module type and currentness of data

30xx0, 40xx0¹ 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 current, the register value is 1. If 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 input process data is retained in the Modbus table, but is no longer updated.

³ If the module type in the register is invalid or not available, 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
-----------------	----------

7.6.10 General overview of the Modbus memory map

I/O input data, address range 30010 ... 30999			
Modbus function code 04			
RAD-DAIO6-IFS			
IO MAP	High byte 15 ... 8	Low byte 7 ... 0	
30 xx 0	Currentness of data	Module type ID	
	X X X X X X X X	X X X X X X X X	
30 xx 1			DI 2 1 X X
30 xx 2	AI1		
	X X X X X X X X	X X X X X X X X	
30xx3 ... 30xx9 Reserved			

I/O output data, address range 40010 ... 40999			
Modbus function code 03, 16			
RAD-DAIO6-IFS			
IO MAP	High byte 15 ... 8	Low byte 7 ... 0	
40 xx 0	Currentness of data	Module type ID	
	X X X X X X X X	X X X X X X X X	
40 xx 1			DO 2 1 X X
40 xx 2	AO1		
	X X X X X X X X	X X X X X X X X	
40xx3 ... 40xx9 Reserved			

RAD-DI4-IFS			
IO MAP	High byte 15 ... 8	Low byte 7 ... 0	
30 xx 0	Currentness of data	Module type ID	
	X X X X X X X X	X X X X X X X X	
30 xx 1			DI4 ... DI1 X X X X
30xx2 ... 30xx9 Reserved			

RAD-DOR4-IFS			
IO MAP	High byte 15 ... 8	Low byte 7 ... 0	
40 xx 0	Currentness of data	Module type ID	
	X X X X X X X X	X X X X X X X X	
40 xx 1			DO4 ... DO1 X X X X
40xx2 ... 40xx9 Reserved			

RAD-NAM4-IFS			
IO MAP	High byte 15 ... 8	Low byte 7 ... 0	
30 xx 0	Currentness of data	Module type ID	
	X X X X X X X X	X X X X X X X X	
30 xx 1	E4 ... E1		DI4 ... DI1 1 X X X X X X X X
30xx2 ... 30xx9 Reserved			

7.6.11 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 Radioline base station (RAD ID = 01) using Modbus/RTU commands. The RSSI values of all wireless modules in the network are within the address range 35001 ... 35250.

Table 7-18 RSSI signal and error code registers

Address range		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 (base)	Reserved							IFS	X	X	X	X	X	X	X	X	X
35002	RSSI - RAD ID = 2	Reserved								X	X	X	X	X	X	X	X	X
...	...	Reserved								X	X	X	X	X	X	X	X	X
35250	RSSI - RAD ID = 250	Reserved								X	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 7-19 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	Wire break	-	<3.2 mA
8080	Underrange	<0 mA	-

RAD-AI4-U-IFS analog inputs

Table 7-20 Representation of RAD-AI4-U-IFS analog values

Data word			
hex	dec/error code	0 V ... 5 V	0 V ... 10 V
0000	0	0 V	0 V
7530	30000	5 V	10 V
7F00	32512	5.42 V	10.82 V
8001	Overrange	5.43 V	10.83 V
8002	Wire break	-	-
8080	Underrange	-	-

RAD-AO4-IFS analog outputs

Table 7-21 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 7-22 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	Wire break	-	<3.2 mA	-
8080	Underrange	<0 mA	-	-

Error codes and formats for Pt 100 values

Table 7-23 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	Wire break				Sensor wired incorrectly, measuring cable too long, cable resistance too high
8080	Underrange				

7.8 Radioline function blocks



The function blocks can be found at phoenixcontact.net/products via the corresponding Radioline front module.

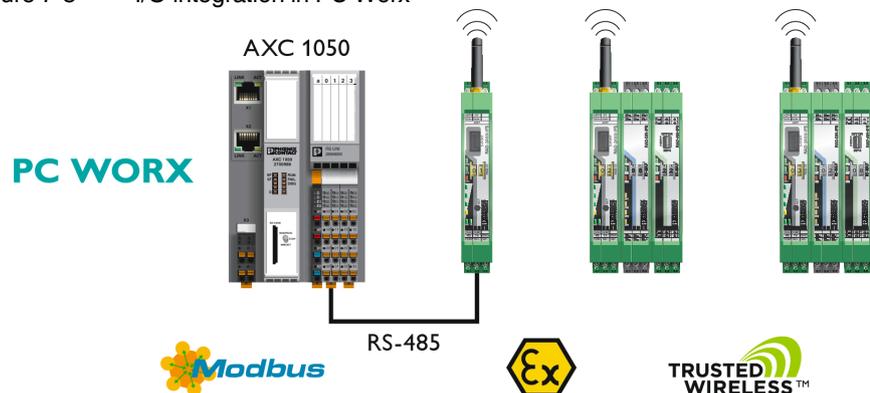
In widely distributed outdoor system structures, measured values and operating messages are often communicated to a control center from many remote stations. This includes, for example, the consistent recording of pump performance and flow rates. In the control center, the process data is transmitted to a higher-level system via a standardized software interface or displayed on a monitor. Yet something that sounds relatively simple demands a great deal of programming effort.

Function blocks can be used to integrate new functions quickly and easily or transform devices into a full-fledged part of your control system.

The Radioline function blocks are suitable for PC Worx. Using modern wireless technology, it is very easy to integrate I/O signals from distributed sensors and actuators into a controller from Phoenix Contact.

7.8.1 I/O integration in Phoenix Contact controllers

Figure 7-8 I/O integration in PC Worx



Required components:

- Radioline front module
- Radioline I/O extension modules
- Inline or AxioLine controllers
- Inline or AxioLine RS-485 communication module
- PC Worx
- PC Worx function blocks
 - PCW_6_RadiolineBasic
 - PCW_6_ComSerial
 - PCW_6_Modbus

8 Description of I/O extension modules

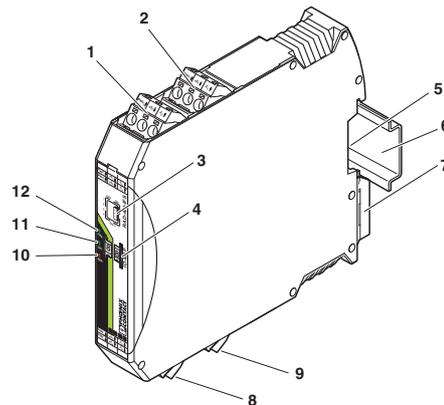
8.1 RAD-AI4-IFS – analog extension module with four current inputs

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 PWR₁ for passive sensors (see [Figure 8-1](#), item 2).

8.1.1 Structure

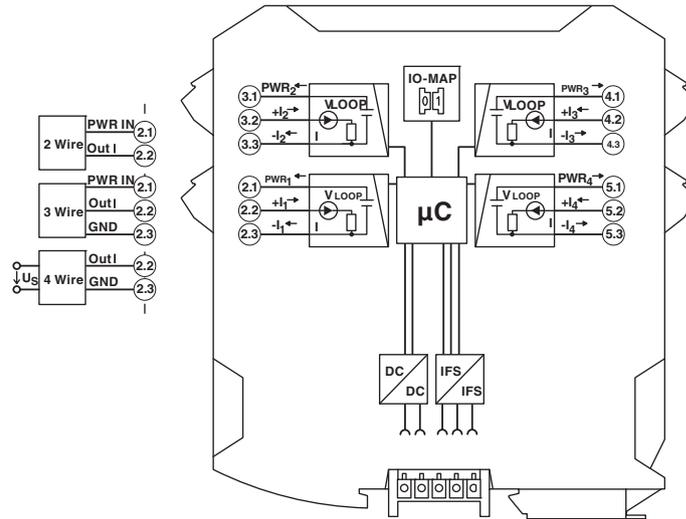
Figure 8-1 RAD-AI4-IFS structure



Item	Terminal block	Designation
1	3.1/3.2/3.3	Analog input 2 for 2-, 3-, 4-wire measuring transducer
2	2.1/2.2/2.3	Analog input 1 for 2-, 3-, 4-wire measuring transducer
3		DIP switches for configuring the analog inputs (0 mA ... 20 mA, 4 mA ... 20 mA)
4		White thumbwheel for setting the I/O MAP address
5		Connection option for DIN rail connector
6		DIN rail
7		Metal foot catch for DIN rail fixing
8	4.1/4.2/4.3	Analog input 3 for 2-, 3-, 4-wire measuring transducer
9	5.1/5.2/5.3	Analog input 4 for 2-, 3-, 4-wire measuring transducer
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 (0 mA ... 20 mA or 4 mA ... 20 mA) using the DIP switches on the front. 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 a wire break.

Figure 8-3 RAD-AI4-IFS DIP switches

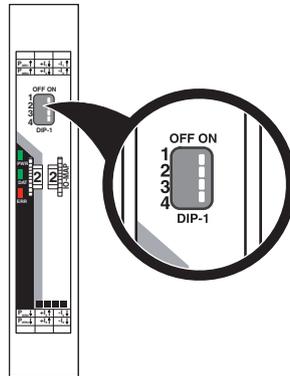
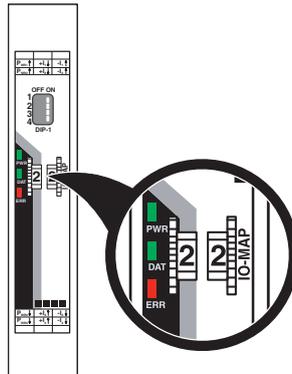


Table 8-1 RAD-AI4-IFS DIP switches

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

8.1.4 Diagnostic LEDs

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



PWR LED

Green	Status of supply voltage
Off	No supply voltage
On	Supply voltage OK

DAT LED

Green	Status of bus communication
Off	No communication
Flashing	Configuration and addressing mode
On	Cyclic data communication

ERR LED

Red	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
**	Setting not permitted
1* ... 9*	
*1 ... *9	

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 further information, please refer to [Section "RAD-AI4-IFS and RAD-AI4-U-IFS process data" on page 71](#).

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

8.2 RAD-AI4-U-IFS – analog extension module with four voltage inputs



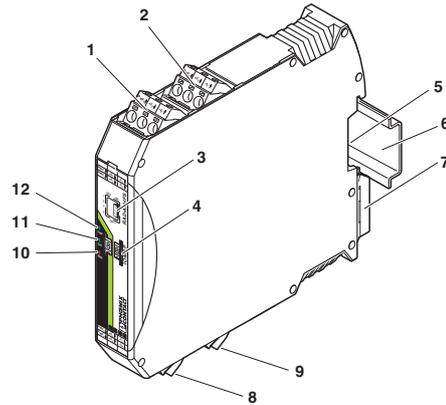
The RAD-AI4-U-IFS extension module is supported by firmware version 1.90 or later.

The RAD-AI4-U-IFS analog I/O extension module can process up to four input signals with 0 V ... 5 V or 0 V ... 10 V. 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 and 30 mA maximum is available at connection terminal block PWR1 for passive sensors (see [Figure 8-5](#), item 2).

8.2.1 Structure

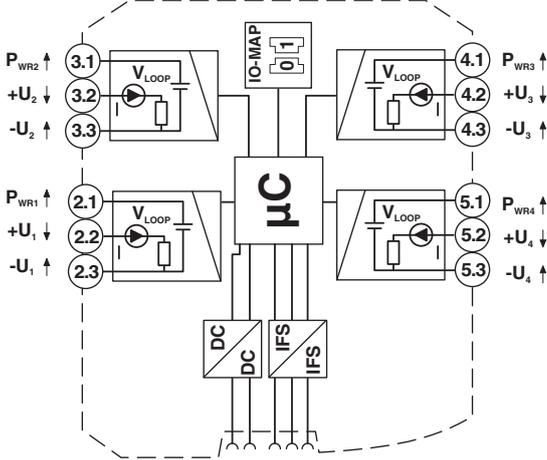
Figure 8-5 RAD-AI4-U-IFS structure



Item	Terminal block	Designation
1	3.1/3.2/3.3	Analog input 2 for 2-, 3-, 4-wire measuring transducer
2	2.1/2.2/2.3	Analog input 1 for 2-, 3-, 4-wire measuring transducer
3		DIP switches for configuring the analog inputs
4		White thumbwheel for setting the I/O MAP address
5		Connection option for DIN rail connector
6		DIN rail
7		Metal foot catch for DIN rail fixing
8	4.1/4.2/4.3	Analog input 3 for 2-, 3-, 4-wire measuring transducer
9	5.1/5.2/5.3	Analog input 4 for 2-, 3-, 4-wire measuring transducer
10		ERR status LED, red (communication error)
11		DAT status LED, green (bus communication)
12		PWR status LED, green (supply voltage)

8.2.2 Basic circuit diagram

Figure 8-6 Basic circuit diagram for the RAD-AI4-U-IFS



8.2.3 Setting the DIP switches

You can configure the input signals (0 V ... 5 V or 0 V ... 10 V) using the DIP switches on the front.

Figure 8-7 RAD-AI4-U-IFS DIP switches

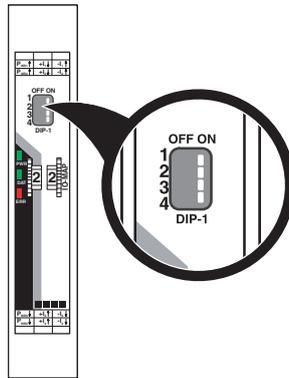
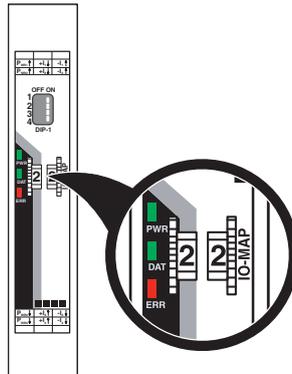


Table 8-3 RAD-AI4-U-IFS DIP switches

Setting	Input signal	DIP switch			
		1	2	3	4
Analog IN1	0 V ... 5 V	OFF			
	0 V ... 10 V	ON			
Analog IN2	0 V ... 5 V		OFF		
	0 V ... 10 V		ON		
Analog IN3	0 V ... 5 V			OFF	
	0 V ... 10 V			ON	
Analog IN4	0 V ... 5 V				OFF
	0 V ... 10 V				ON

8.2.4 Diagnostic LEDs

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



PWR LED

Green	Status of supply voltage
Off	No supply voltage
On	Supply voltage OK

DAT LED

Green	Status of bus communication
Off	No communication
Flashing	Configuration and addressing mode
On	Cyclic data communication

ERR LED

Red	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

8.2.5 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 8-4 Setting the I/O MAP address for the RAD-AI4-U-IFS

Thumbwheel	Description
01 ... 99	I/O MAP address
00	Delivery state
**	Setting not permitted
1* ... 9*	
*1 ... *9	

8.2.6 Process data in PLC/Modbus RTU mode

The process image of the I/O extension module consists of six data words. For further information, please refer to [Section "RAD-AI4-IFS and RAD-AI4-U-IFS process data" on page 71](#).

I/O module	Module type ID	Register	Address range	Function code
RAD-AI4-U-IFS	22 _{hex}	06 _{hex}	30xx0 ... 30xx5	fc 04

8.3 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 ... $+250^{\circ}\text{C}$. 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 other electronics.

Pt 100 resistance temperature detectors can be connected to the RAD-PT100-4-IFS I/O extension module. The temperature detectors change their resistance according to the temperature. The RAD-PT100-4-IFS acquires the Pt 100 input signals. The input signals are 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 8-5 Pt 100 input

Pt 100 input	Analog output
-50°C	0 mA or 0 V
$+250^{\circ}\text{C}$	20 mA or 10 V

8.3.1 Connecting the sensors

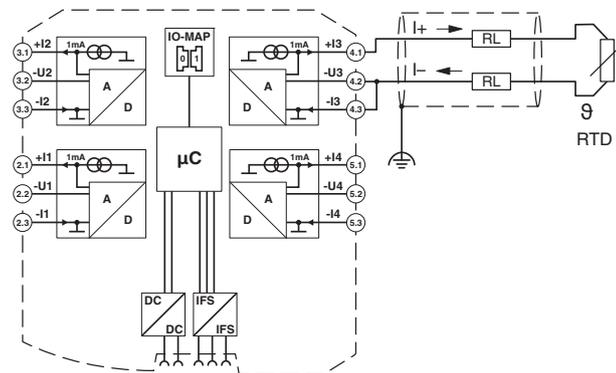
You can connect 2-conductor or 3-conductor sensors to the extension module. The measuring errors associated with the various measuring methods should be taken into consideration.

2-conductor connection technology

2-conductor connection technology is the most cost-effective connection technology. The temperature-related voltage is not measured directly 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 with 2-conductor connection technology"](#) on page 101.

For 2-conductor connection technology, you need an insertion bridge between terminal blocks x.2 and x.3.

Figure 8-9 2-conductor connection technology

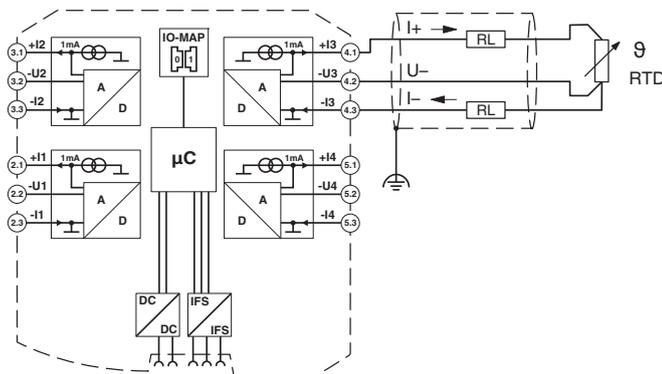


3-conductor connection technology

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

The cable resistances R_L at terminal blocks +1 and -1 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 8-10 3-conductor connection technology

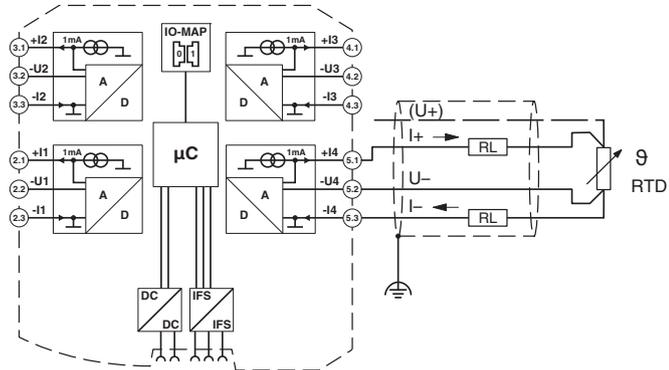


4-conductor connection technology

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

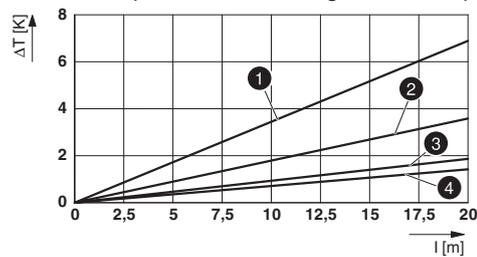
- If you want to use a 4-conductor sensor, only connect three of the four cables.
- The fourth cable should be left unwired. Otherwise there will be a different resistance in the +I and -I cables owing to the parallel connection of two cable resistances.

Figure 8-11 4-conductor connection technology



8.3.2 Measuring errors with 2-conductor connection technology

Figure 8-12 Systematic temperature measuring error ΔT depending on the cable length



Curves depending on cable cross-section A

- ① $A = 0.25 \text{ mm}^2$
- ② $A = 0.5 \text{ mm}^2$
- ③ $A = 1.0 \text{ mm}^2$
- ④ $A = 1.5 \text{ mm}^2$

Measuring error valid for: Copper cable $\chi = 57 \text{ m}/\Omega\text{mm}^2$, $T_A = 25^\circ\text{C}$, and Pt 100 sensor

Figure 8-13 Systematic temperature measuring error ΔT depending on cable cross-section A

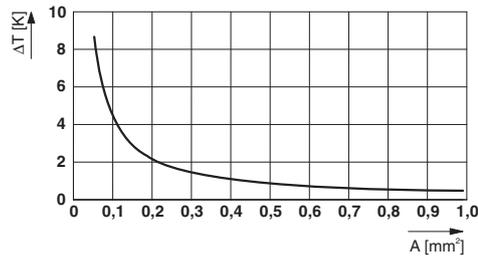
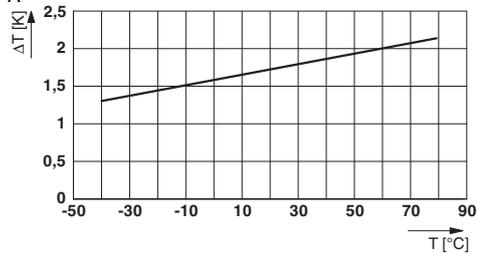


Figure 8-14 Systematic temperature measuring error ΔT depending on cable temperature T_A



Measuring error valid for: Copper cable $\chi = 57 \text{ m}/\Omega\text{mm}^2$, $T_A = 25^\circ\text{C}$, 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:

$$R_L = R_{L20} \times \left[1 + 0.0039 \frac{1}{\text{K}} \times (T_A - 20^\circ\text{C}) \right]$$

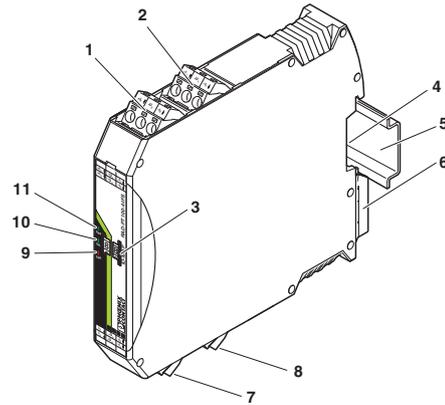
$$R_L = \frac{l}{\chi \times A} \times \left[1 + 0.0039 \frac{1}{\text{K}} \times (T_A - 20^\circ\text{C}) \right]$$

- 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 $\text{m}/\Omega\text{mm}^2$
- 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 $^\circ\text{C}$

Due to there being two cable resistances in the measuring system, the value must be doubled. Using the average temperature coefficient $\alpha = 0.385 \text{ } \Omega/\text{K}$ for Pt 100, the absolute measuring error in Kelvin can be determined for platinum sensors in accordance with DIN standards.

8.3.3 Structure

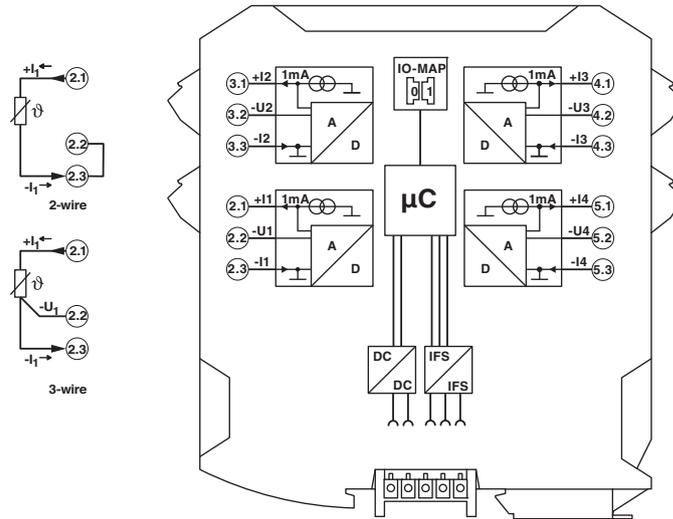
Figure 8-15 RAD-PT100-4-IFS structure



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 foot catch 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)

8.3.4 Basic circuit diagram

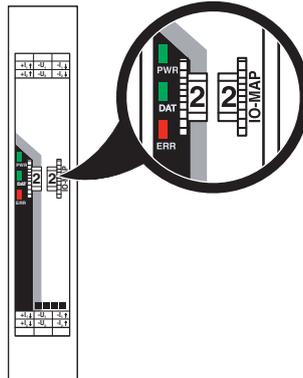
Figure 8-16 Basic circuit diagram for the RAD-PT100-4-IFS



For 2-conductor connection technology, you need an insertion bridge between terminal blocks x.2 and x.3. In this case, the measuring accuracy is reduced (see [“Measuring errors with 2-conductor connection technology”](#) on page 101).

8.3.5 Diagnostic LEDs

Figure 8-17 Diagnostic LEDs of the RAD-PT100-4-IFS



PWR LED

Green	Status of supply voltage
Off	No supply voltage
On	Supply voltage OK

DAT LED

Green	Status of bus communication
Off	No communication
Flashing	Configuration and addressing mode
On	Cyclic data communication

ERR LED

Red	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

8.3.6 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 8-6 Setting the I/O MAP address for the RAD-PT100-4-IFS

Thumbwheel	Description
01 ... 99	I/O MAP address
00	Delivery state
**	Setting not permitted
1* ... 9*	
*1 ... *9	

8.3.7 Process data in PLC/Modbus RTU mode

The process image of the I/O extension module consists of six data words. For further information, please refer to [Section "RAD-PT100-4-IFS process data" on page 72](#).

I/O module	ModuleTypeID	Register	Address range	Function code
RAD-PT100-4-IFS	21 _{hex}	06 _{hex}	30xx0 ... 30xx5	fc 04

8.4 RAD-AO4-IFS – analog extension module with four outputs

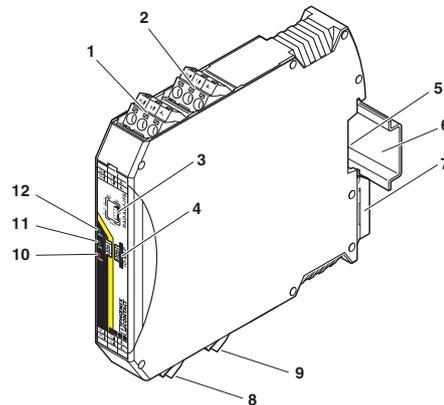
The RAD-AO4-IFS analog I/O extension module can output up to four signals with 0/4 mA ... 20 mA. All outputs are electrically isolated from one another, from the supply voltage, and from the electronics.



Use either the current or voltage output at every analog channel.

8.4.1 Structure

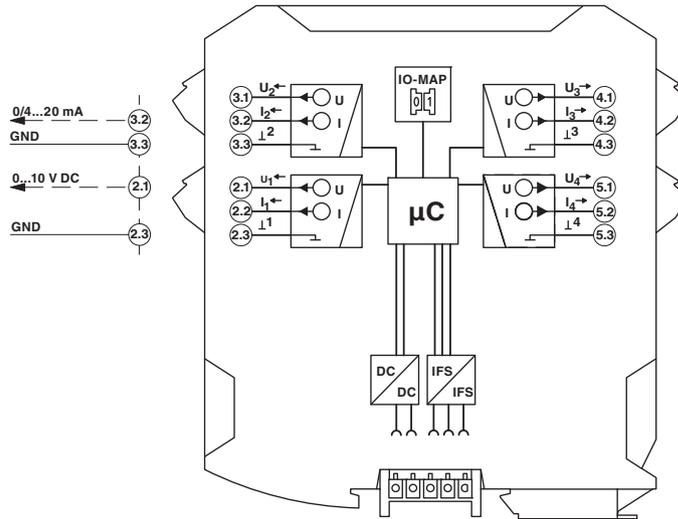
Figure 8-18 RAD-AO4-IFS structure



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 foot catch 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)

8.4.2 Basic circuit diagram

Figure 8-19 Basic circuit diagram for the RAD-AO4-IFS



8.4.3 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 the last valid output value

Figure 8-20 RAD-AO4-IFS DIP switches

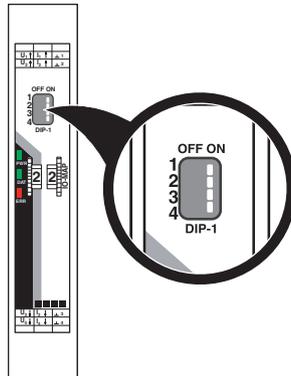
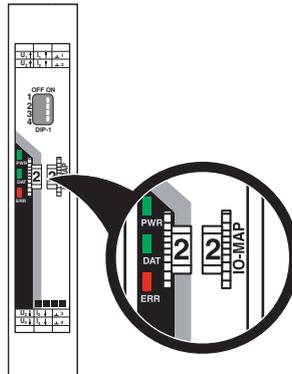


Table 8-7 RAD-AO4-IFS DIP switches

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

8.4.4 Diagnostic LEDs

Figure 8-21 Diagnostic LEDs of the RAD-AO4-IFS



PWR LED

Green	Status of supply voltage
Off	No supply voltage
On	Supply voltage OK

DAT LED

Green	Status of bus communication
Off	No communication
Flashing	Configuration and addressing mode
On	Cyclic data communication

ERR LED

Red	Error status
Off	No error
Flashing	
Slow, 1.4 Hz	I/O MAP address changed
Fast, 2.8 Hz	Wireless module in I/O data mode <ul style="list-style-type: none"> - Missing input module - No bus communication Wireless module in PLC/Modbus RTU mode <ul style="list-style-type: none"> - No Modbus communication (safe state of outputs, depending on DIP switch settings)
On	Critical internal error

8.4.5 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 8-8 Setting the I/O MAP address for the RAD-AO4-IFS

Thumbwheel	Description
01 ... 99	I/O MAP address
00	Delivery state
**	Setting not permitted
1* ... 9*	
*1 ... *9	

8.4.6 Process data in PLC/Modbus RTU mode

The process image of the I/O extension module consists of six data words. For further information, please refer to [Section "RAD-AO4-IFS process data" on page 73](#).

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

8.5 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.

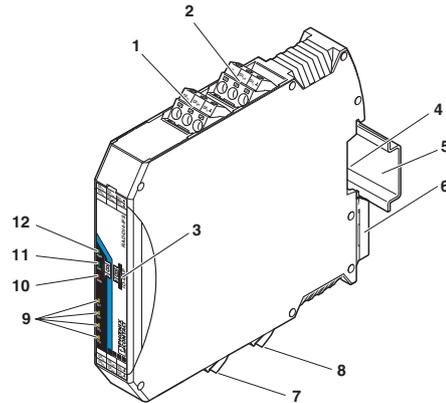
The RAD-DI4-IFS digital I/O extension module can process up to four input signals. The digital inputs process the following voltages:

- 0 V ... 50 V AC/DC at the low voltage input
- 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.

8.5.1 Structure

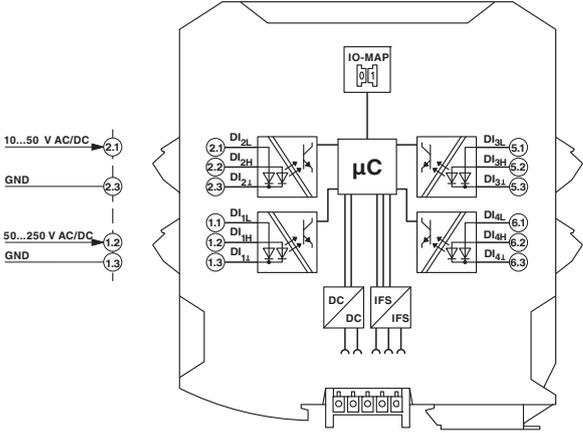
Figure 8-22 RAD-DI4-IFS structure



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 foot catch 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 of 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)

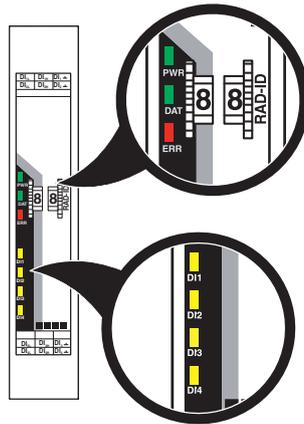
8.5.2 Basic circuit diagram

Figure 8-23 Basic circuit diagram for the RAD-DI4-IFS



8.5.3 Diagnostic LEDs

Figure 8-24 Diagnostic LEDs of the RAD-DI4-IFS



PWR LED

Green	Status of supply voltage
Off	No supply voltage
On	Supply voltage OK

DAT LED

Green	Status of bus communication
Off	No communication
Flashing	Configuration and addressing mode
On	Cyclic data communication

ERR LED

Red	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

DI1 ... DI4

State of the digital inputs

8.5.4 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 8-9 Setting the I/O MAP address for the RAD-DI4-IFS

Thumbwheel	Description
01 ... 99	I/O MAP address
00	Delivery state
**	Setting not permitted
1* ... 9*	
*1 ... *9	

8.5.5 Process data in PLC/Modbus RTU mode

The process image of the I/O extension module consists of two data words. For further information, please refer to [Section "RAD-DI4-IFS process data" on page 74](#).

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

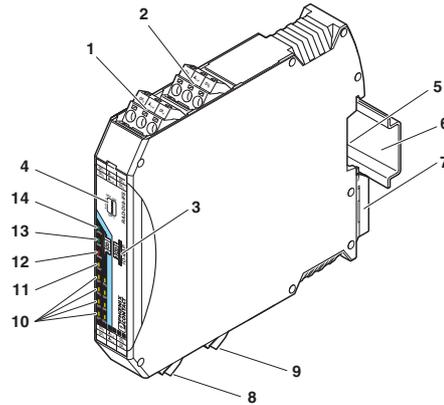
8.6 RAD-DI8-IFS – digital extension module with eight inputs

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 118](#).

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.

8.6.1 Structure

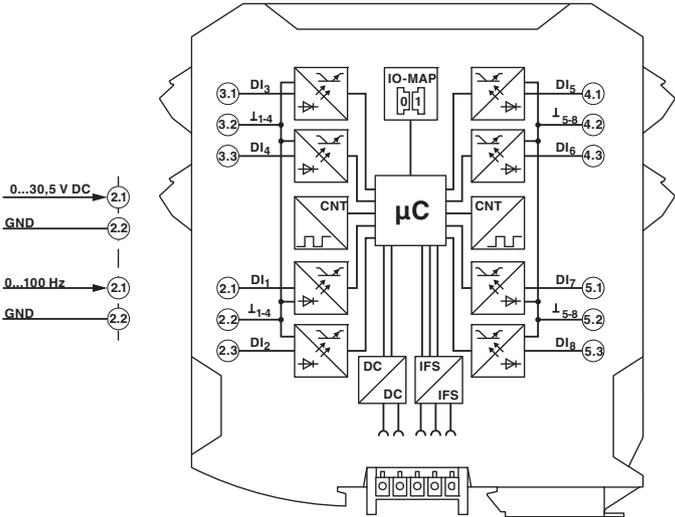
Figure 8-25 RAD-DI8-IFS structure



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 foot catch 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 of 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)

8.6.2 Basic circuit diagram

Figure 8-26 Basic circuit diagram for the RAD-DI8-IFS



8.6.3 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 and in dual mode.

- Set the operating mode using the PSI-CONF software (from [page 36](#) onwards).

Figure 8-27 RAD-DI8-IFS DIP switches

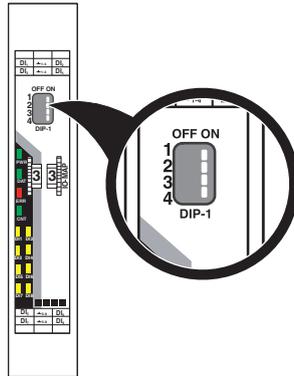


Table 8-10 RAD-DI8-IFS DIP switches

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

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

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

8.6.4 Functions in pulse counter mode

The counter value can only increase consecutively. When the maximum counter value of 4,294,967,295 is reached, the counter value is automatically reset to 0.

There are also three ways to reset the counter value manually:

Via power up

- Disconnect and then reconnect the device power supply.

Via Modbus/RTU register

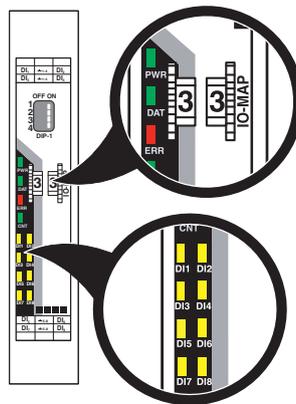
- Reset the counter values via Modbus/RTU as follows:
 - DI1: Bit 0 = 1 (register 40xx1)
 - DI7: Bit 1 = 1 (register 40xx1)

By setting the inputs

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

8.6.5 Diagnostic LEDs

Figure 8-28 Diagnostic LEDs of the RAD-DI8-IFS



PWR LED

Green	Status of supply voltage
Off	No supply voltage
On	Supply voltage OK

DAT LED

Green	Status of bus communication
Off	No communication
Flashing	Configuration and addressing mode
On	Cyclic data communication

ERR LED

Red	Error status
Off	No error
Flashing	
Slow, 1.4 Hz	<ul style="list-style-type: none"> - I/O MAP address changed - Mode switched using DIP switch 1, but not yet read via wireless module
Fast, 2.8 Hz	No bus communication
On	Critical internal error

CNT LED

Green	Pulse counter mode
Off	Static mode of digital inputs DI1 ... DI8
Flashing	Mode switched using DIP switch 1, but not yet read via wireless module
On	Pulse counter mode of digital inputs DI1 and DI7

DI1 ... DI8

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 value is reset.

DI3	On (0.5 seconds)	Counter value DI1 reset to 0
DI5	On (0.5 seconds)	Counter value DI7 reset to 0

8.6.6 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 8-11 Setting the I/O MAP address for the RAD-DI8-IFS

Thumbwheel	Description
01 ... 99	I/O MAP address
00	Delivery state
**	Setting not permitted
1* ... 9*	
*1 ... *9	

8.6.7 Process data in PLC/Modbus RTU mode

The process image of the I/O extension module consists of eight data words. For further information, please refer to [Section "RAD-DI8-IFS process data" on page 75](#).

I/O module	Module type ID	Register	Address range	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 values	40xx0 ... 40xx1	fc 03, 16

8.7 RAD-NAM4-IFS – digital extension module with four NAMUR inputs



The RAD-NAM4-IFS extension module is supported by firmware version 1.90 or later.

The RAD-NAM4-IFS digital I/O extension module supplies power to and processes digital inputs from proximity switches (NAMUR) and switch contacts.

The NAMUR input module has four supervised digital input channels that each have two signals.

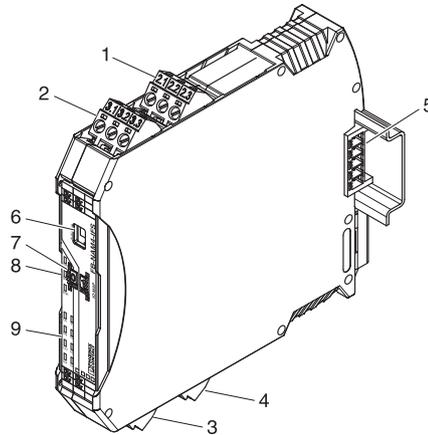
- The first signal is a value signal: digital input On or Off
- The second signal is an error signal which represents either a short circuit or wire break

You can modify the error checking behavior for each channel via the DIP switches on the front.

The four NAMUR digital inputs are electrically isolated from one another, from the supply voltage (via the bus foot), and from other electronics.

8.7.1 Structure

Figure 8-29 RAD-NAM4-IFS structure



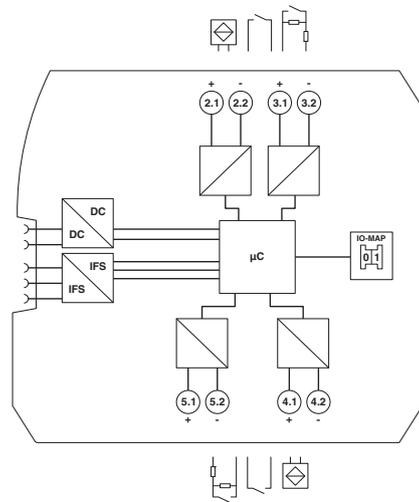
Item	Designation	
1	2.1/2.2/2.3	Digital input 1
2	3.1/3.2/3.3	Digital input 2
3	4.1/4.2/4.3	Digital input 3
4	5.1/5.2/5.3	Digital input 4
5	Connection for DIN rail connector	
6	DIP switch	
7	White thumbwheel for setting the I/O MAP address	
8	Diagnostic and status indicators of the module	
9	Diagnostic and status indicators of the digital inputs	

Table 8-12 RAD-NAM4-IFS pin assignment

Connector	Item	Designation	Function
DI1	1	2.1	NAMUR supply +
	2	2.2	NAMUR supply -
	3	2.3	-
DI2	1	3.1	NAMUR supply +
	2	3.2	NAMUR supply -
	3	3.3	-
DI3	1	4.1	NAMUR supply +
	2	4.2	NAMUR supply -
	3	4.3	-
DI4	1	5.1	NAMUR supply +
	2	5.2	NAMUR supply -
	3	5.3	-

8.7.2 Basic circuit diagram

Figure 8-30 Basic circuit diagram for the RAD-NAM4-IFS



8.7.3 Diagnostic LEDs

PWR LED

Green	Status of supply voltage
Off	No supply voltage
On	Supply voltage OK

DAT LED

Green	Status of bus communication
Off	No communication
Flashing	Configuration mode
On	Data communication

ERR LED

Red	Error status
Off	No error
Flashing	Configuration error
On	Critical internal error

DI1 ... DI4

State of the digital inputs, value LED

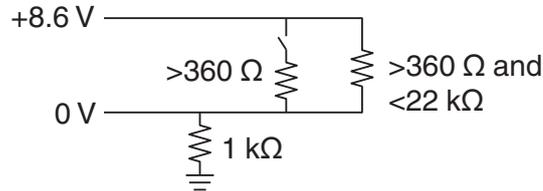
E1 ... E4

Indication of short circuit or wire break, error LED

8.7.4 Supervised digital inputs

Supervised digital inputs are standard inputs with components for detecting different input states. In addition to detecting the On/Off state, a distinction is also made between a short circuit and wire break.

Figure 8-31 Example of supervised digital inputs



The NAMUR input module has four supervised digital input channels that each have two signals:

- The first signal is a value signal: digital input On or Off
- The second signal is an error signal which represents either a short circuit or wire break

You can modify the error checking behavior for each channel via the DIP switches on the front.

Setting the DIP switches

Each DIP switch controls the corresponding digital input (DIP 1 = digital input 1, etc.).

- Off: Error checking deactivated
- On: Error checking activated

Assignment of the inputs and outputs

- On the RAD-DO8-IFS, the value signals for NAMUR inputs 1 ... 4 are represented via output channels 1 ... 4.
- On the RAD-DO8-IFS, the error signals are represented via output channels 5 ... 8.

Table 8-13 Assignment of the inputs and outputs for RAD-NAM4-IFS

Signal	RAD-NAM4-IFS, input		RAD-DO8-IFS, output	
Value signal	DI1	2.x	DO1	2.1
	DI2	3.x	DO2	2.3
	DI3	4.x	DO3	3.1
	DI4	5.x	DO4	3.3
Error signal	E1		DO5	4.1
	E2		DO6	4.3
	E3		DO7	5.1
	E4		DO8	5.3

Behavior of the error channels on the RAD-DO8-IFS

The error LEDs on the RAD-NAM4-IFS input module are inverted on the RAD-DO8-IFS output module. This behavior prevents a voltage failure on the I/O module from being interpreted as a safe system state, for example.

An error (short circuit or wire break) is indicated by a flashing LED on the RAD-NAM4-IFS. The LED and the digital output on the RAD-DO8-IFS are set to Off as long as the error is present.

- **DIP switch on the RAD-NAM4-IFS Off:** Error checking deactivated
The error status of channels 5 ... 8 on the RAD-DO8-IFS always remains "On" for the LED and digital output (no error).
- **DIP switch on the RAD-NAM4-IFS On:** Error checking activated
On the RAD-DO8-IFS, the error status is indicated via channels 5 ... 8.
 - No error: LED and digital output = On
 - In the event of a short circuit or wire break on the NAMUR input channel: LED and digital output = Off

Table 8-14 Example behavior of the diagnostic LEDs, RAD-NAM4-IFS

LEDs	Value LED	Error LED
D11/E1	On	Off
D12/E2	Off	Off
D13/E3	On	On (short circuit)
D14/E4	Off	On (wire break)

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 8-15 Setting the I/O MAP address for the RAD-DI4-IFS

Thumbwheel	Description
01 ... 99	I/O MAP address
00	Delivery state
**	Setting not permitted
1* ... 9*	
*1 ... *9	

8.7.6 Process data in PLC/Modbus RTU mode

The process image of the I/O extension module consists of two data words. For further information, please refer to [Section "RAD-NAM4-IFS process data" on page 77](#).

I/O module	Module type ID	Register	Address range	Function code
RAD-NAM4-IFS	03 _{hex}	02 _{hex}	30xx0 ... 30xx1	fc 04

8.8 RAD-DOR4-IFS – digital extension module with four outputs



WARNING: Risk of electric shock

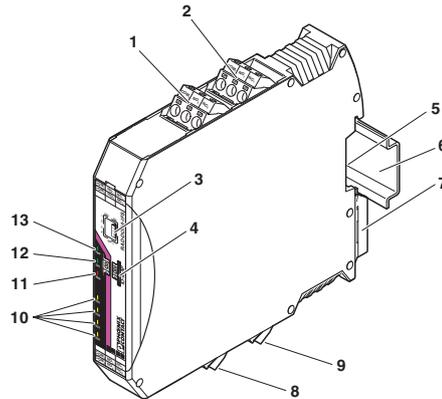
Use the same phase for digital inputs and outputs. The isolating voltage between the individual channels must not exceed 300 V.

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.

8.8.1 Structure

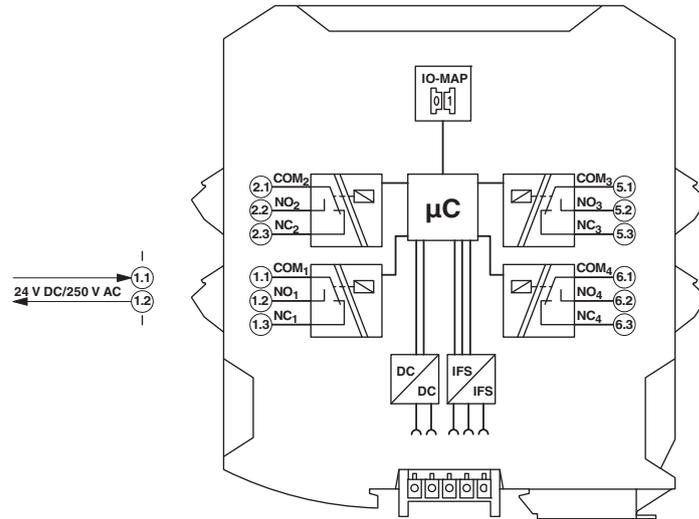
Figure 8-32 RAD-DOR4-IFS structure



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 foot catch 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 of 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)

8.8.2 Basic circuit diagram

Figure 8-33 Basic circuit diagram for the RAD-DOR4-IFS



8.8.3 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 the last output value

Figure 8-34 RAD-DOR4-IFS DIP switches

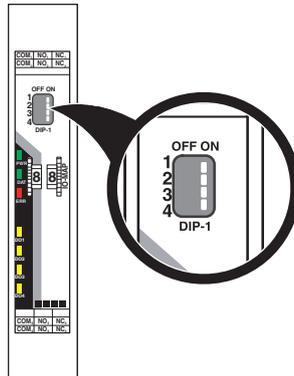
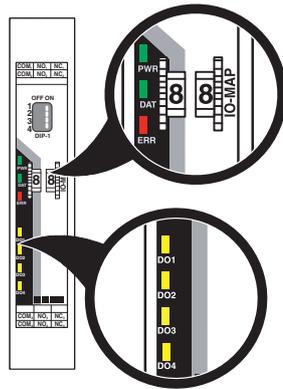


Table 8-16 RAD-DOR4-IFS DIP switches

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

8.8.4 Diagnostic LEDs

Figure 8-35 Diagnostic LEDs of the RAD-DOR4-IFS



PWR LED

Green	Status of supply voltage
Off	No supply voltage
On	Supply voltage OK

DAT LED

Green	Status of bus communication
Off	No communication
Flashing	Configuration and addressing mode
On	Cyclic data communication

ERR LED

Red	Error status
Off	No error
Flashing	
Slow, 1.4 Hz	I/O MAP address changed
Fast, 2.8 Hz	Wireless module in I/O data mode <ul style="list-style-type: none"> - Missing input module - No bus communication Wireless module in PLC/Modbus RTU mode <ul style="list-style-type: none"> - No Modbus communication (safe state of outputs, depending on DIP switch settings)
On	Critical internal error

DO1 ... DO4

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 8-17 Setting the I/O MAP address for the RAD-DOR4-IFS

Thumbwheel	Description
01 ... 99	I/O MAP address
00	Delivery state
**	Setting not permitted
1* ... 9*	
*1 ... *9	

Process data in PLC/Modbus RTU mode

The process image of the I/O extension module consists of two data words. For further information on process data, please refer to [Section "RAD-DOR4-IFS process data" on page 78](#).

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

8.9 RAD-DO8-IFS – digital extension module with eight outputs

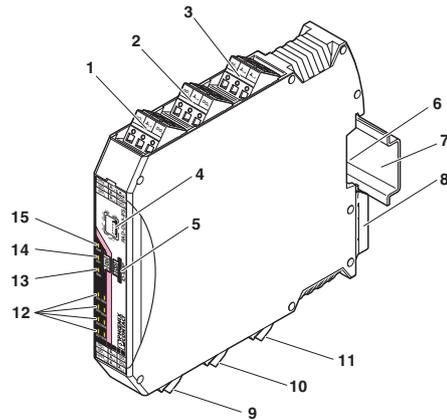
The RAD-DO8-IFS digital I/O extension module processes up to eight digital output signals that are switched via transistor outputs. The eight outputs are arranged in two groups of four outputs each with a common supply. The two output groups are electrically isolated from one another, from the supply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

Since output groups DO1 ... DO4 and DO5 ... DO8 are electrically isolated, the outputs must be supplied externally (see [Figure 8-37](#)).

- 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)

8.9.1 Structure

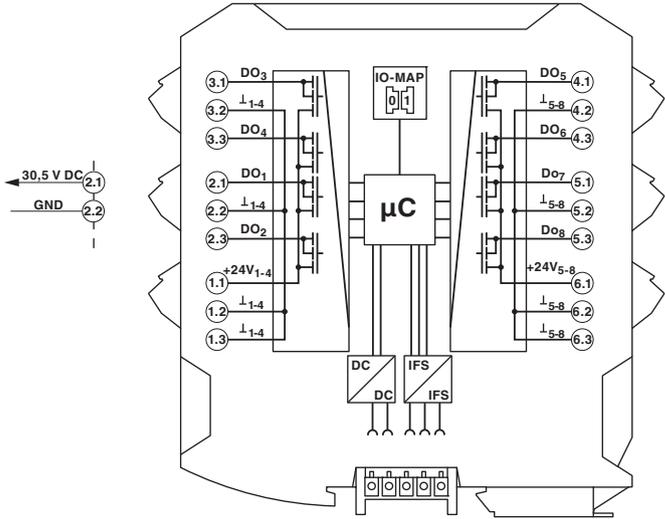
Figure 8-36 RAD-DO8-IFS structure



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 foot catch 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)

8.9.2 Basic circuit diagram

Figure 8-37 Basic circuit diagram for the RAD-DO8-IFS



8.9.3 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 the last output value

Figure 8-38 RAD-DO8-IFS DIP switches

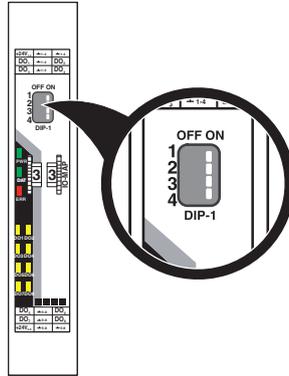


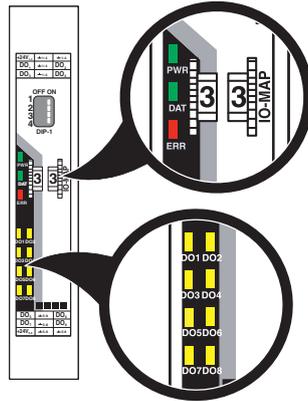
Table 8-18 RAD-DO8-IFS DIP switches

Setting	Output signal	DIP switch			
		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

8.9.4 Diagnostic LEDs

Figure 8-39 Diagnostic LEDs of the RAD-DO8-IFS



PWR LED

Green	Status of supply voltage
Off	No supply voltage
On	Supply voltage OK

DAT LED

Green	Status of bus communication
Off	No communication
Flashing	Configuration and addressing mode
On	Cyclic data communication

ERR LED

Red	Error status
Off	No error
Flashing	
Slow, 1.4 Hz	I/O MAP address changed
Fast, 2.8 Hz	Wireless module in I/O data mode <ul style="list-style-type: none"> – Missing input module – No bus communication Wireless module in PLC/Modbus RTU mode <ul style="list-style-type: none"> – No Modbus communication (safe state of outputs, depending on DIP switch settings) – Short circuit at one or more outputs
On	Critical internal error

DO1 ... DO8

State of the digital outputs

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

8.9.5 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 8-19 Setting the I/O MAP address for the RAD-DO8-IFS

Thumbwheel	Description
01 ... 99	I/O MAP address
00	Delivery state
**	Setting not permitted
1* ... 9*	
*1 ... *9	

8.9.6 Process data in PLC/Modbus RTU mode

The process image of the I/O extension module consists of four data words. For further information, please refer to [Section "RAD-DO8-IFS process data" on page 79](#).

I/O module	Module type ID	Register	Address range	Function code
RAD-DO8-IFS	11 _{hex}	02 _{hex} Outputs	40xx0 ... 40xx1	fc 03, 16
		02 _{hex} Short-circuit de- tection	30xx0 ... 30xx1	fc 04

8.10 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 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/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 PWR₁ for passive sensors.

Analog output

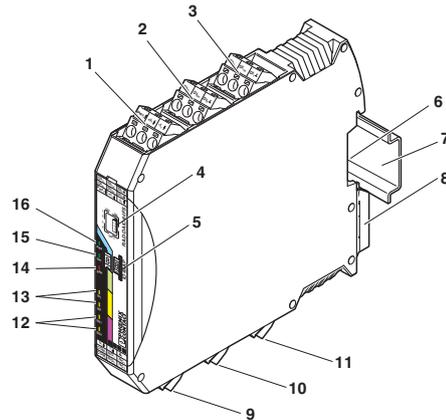
The analog output is designed as an active output. You can either select a current signal of 0/4 mA ... 20 mA or a voltage signal of 0 V ... 10 V.



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

8.10.1 Structure

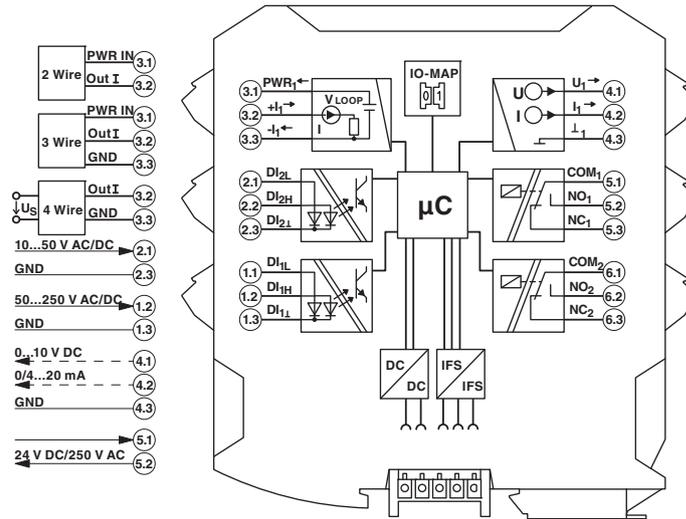
Figure 8-40 RAD-DAIO6-IFS structure



Item	Terminal block	Designation
1	3.1/3.2/3.3	Analog input for 2-, 3-, 4-wire measuring transducer
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 foot catch 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)

8.10.2 Basic circuit diagram

Figure 8-41 Basic circuit diagram for the RAD-DAIO6-IFS



8.10.3 Setting the DIP switches

You can use the DIP switches on the front to configure the input signal 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 the last output value

Digital outputs

- RESET = relay drops out
- HOLD = hold last valid state

Figure 8-42 RAD-DAIO6-IFS DIP switches

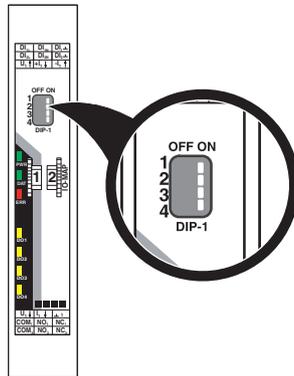
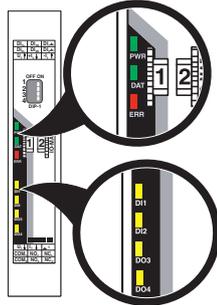


Table 8-20 RAD-DAIO6-IFS DIP switches

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

8.10.4 Diagnostic LEDs

Figure 8-43 Diagnostic LEDs of the RAD-DAIO6-IFS



PWR LED

Green	Status of supply voltage
Off	No supply voltage
On	Supply voltage OK

DAT LED

Green	Status of bus communication
Off	No communication
Flashing	Configuration and addressing mode
On	Cyclic data communication

ERR LED

Red	Error status
Off	No error
Flashing	
	Slow, 1.4 Hz
	I/O MAP address changed
	Fast, 2.8 Hz
	Wireless module in I/O data mode
	– Missing input module
	– No bus communication
	Wireless module in PLC/Modbus RTU mode
	– No Modbus communication (safe state of outputs, depending on DIP switch settings)
On	Critical internal error

DI1/DI2

State of the digital inputs

DO1/DO2

State of the digital outputs

8.10.5 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 8-21 Setting the I/O MAP address for the RAD-DAIO6-IFS

Thumbwheel	Description
01 ... 99	I/O MAP address
00	Delivery state
**	Setting not permitted
1* ... 9*	
*1 ... *9	

8.10.6 Process data in PLC/Modbus RTU mode

The process image of the I/O extension module consists of six data words. For further information, please refer to [Section "RAD-DAIO6-IFS process data" on page 80](#).

I/O module	ModuleTypeID	Register	Address range	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

Delay time is understood to mean:

- **In I/O data mode:** The delay until an input signal of the input module is output at the associated output module.
- **In serial data mode:** The delay until a serial telegram is completely output at the second wireless module via RS-232/RS-485 using the serial interface.

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

Frequency band	Network application	Data rate of the serial interface [Kbps]	Data rate of the wireless interface [Kbps]	Typical delay time	Telegram length ¹
2.4 GHz	I/O data mode	-	250	150 ms	49 bytes
			125	200 ms	
			16	500 ms	
	Serial data mode	19.2	250	20 ms	
			125	25 ms	
			16	120 ms	
868 MHz	I/O data mode	-	120	300 ms	49 bytes
			60	500 ms	17 bytes
			19.2	1 s	
			9.6	2 s	
			1.2	10 s	
	Serial data mode	19.2	120	60 ms	49 bytes
			60	120 ms	17 bytes
			19.2	200 ms	
			9.6	390 ms	
			1.2	2.8 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 end devices that are connected to the serial interface.

9.2 Pulse transmission

Due to the delay times in the wireless network, 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%.

RAD-DI8-IFS in pulse counter mode

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 118). You can record pulses up to 100 Hz in pulse counter mode.

The pulse counter function is only available in PLC/Modbus RTU mode or in dual mode. Set the operating mode using the PSI-CONF software (from page 36 onwards).

In pulse counter mode, the base station maintains a central 32-bit Modbus register with the counter value of the relevant pulse input. The Modbus register can be read and written by any PLC 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 with 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 due to high receiver sensitivity and variable data transmission rate
- Flexible network structure with automatic connection management
- Distributed network management
- Comprehensive diagnostic 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, for 2.4 GHz only

A denylist (blacklisting) means that certain frequencies are specifically excluded. 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. It is therefore better protected against attacks. In addition, two security mechanisms have been implemented with 128-bit AES data encryption and authentication.

- 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.

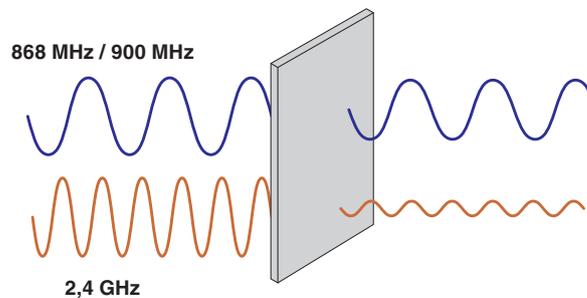
Range

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. You can increase the sensitivity of the receiver and therefore the range by reducing the data rate.

The relationship between range and data rate can be illustrated by the energy per transmitted bit. 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: $\text{energy per bit} = \text{transmission power} / \text{data rate}$

2.4 GHz and 868 MHz wireless systems have different characteristics due to the wavelength. Lower frequencies can overcome obstacles more easily. They also 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 (100 mW) maximum may be transmitted in the 2.4 GHz frequency band.
- In the 868 MHz frequency band, the transmission power may reach 27 dBm (500 mW). 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

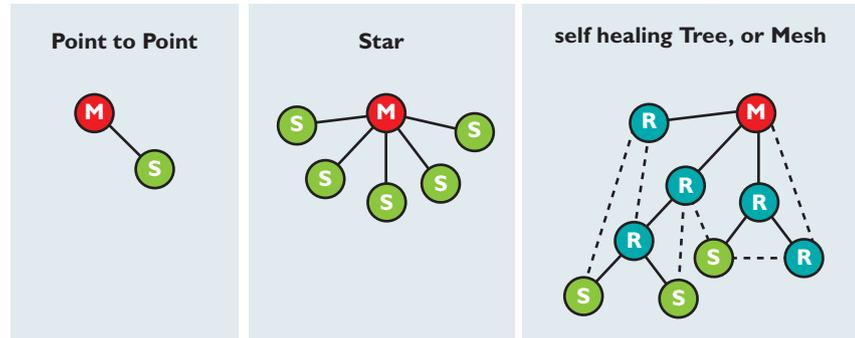
The duty cycle or holding period refers to the legally regulated period of use for the 869.4 MHz ... 869.65 MHz frequency band. The aim of this regulation is to ensure the function of all devices operating in this frequency band. The maximum transmission time is 10% of one hour (6 minutes). Usually, the duty cycle is not reached during operation, since only low volumes of 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 create various structures flexibly.

Figure 9-2 Point-to-point connection, star network, self-healing mesh network

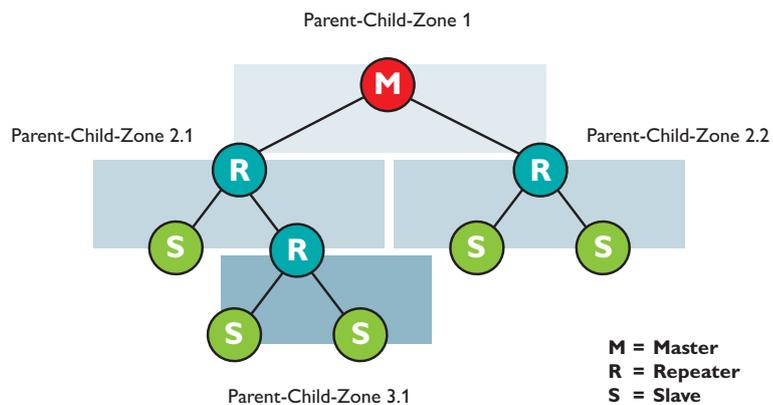


Distributed network management

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

Trusted Wireless 2.0, on the other hand, 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 therefore does not have to be directed through the central manager. This reduces message traffic and speeds up data exchange.

Figure 9-3 Distributed network management with parent-child zones

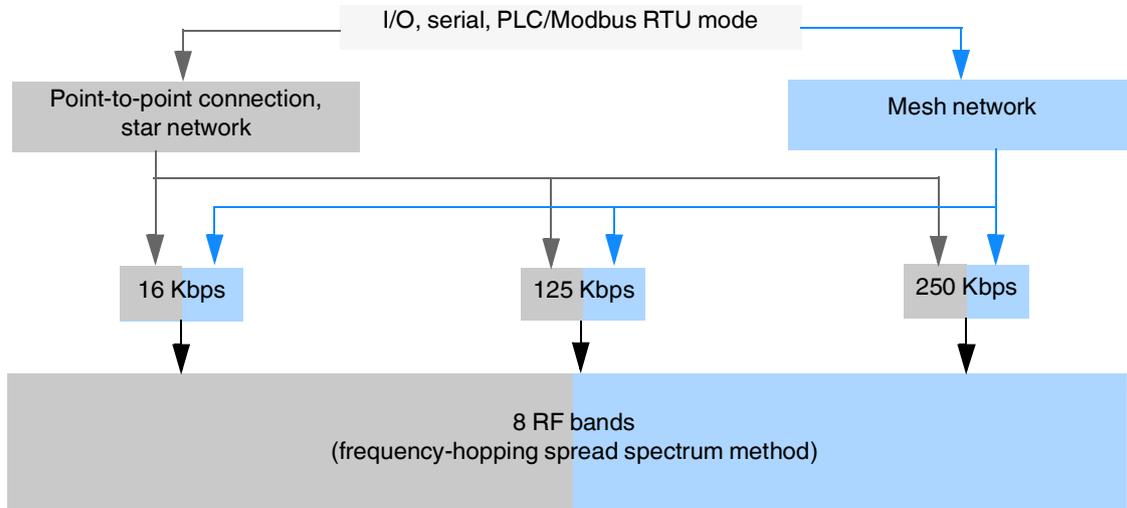


9.4 RF bands

2.4 GHz

Data rates and RF bands do not depend on the network topology.

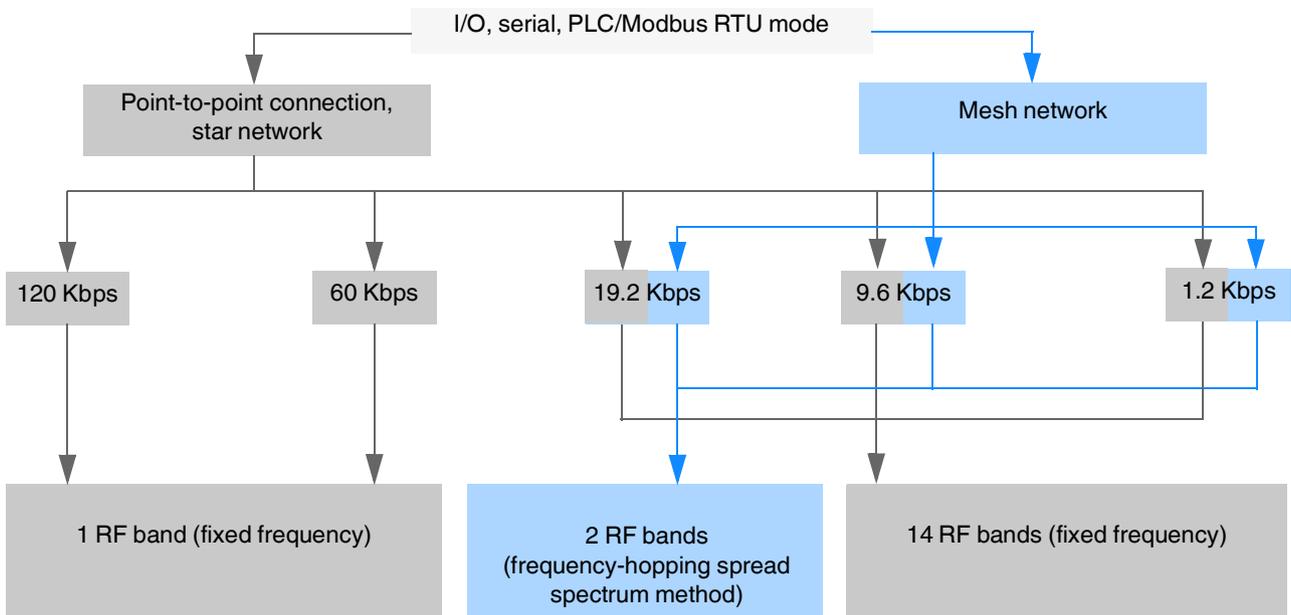
Figure 9-4 RF bands in the 2.4 GHz wireless system



868 MHz

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 waypoints. 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. An example calculation can be found from [page 165](#) 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 base, remote, and repeater stations based on the following criteria in order to achieve the best possible wireless connection:

- Position of the antenna with a line of sight and adequate 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 ideal. 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, 2.4 GHz	Antenna, 868 MHz
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 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: Danger to life from electric shock

Antennas are electrically conductive. Contact with live cables can lead to death or serious injuries.

- The antenna and the mast must not be in the vicinity of live cables.
- Never carry out work on antennas during a storm.
- Observe the safety notes in the documentation for the antenna.



WARNING: Explosion hazard when used in potentially explosive areas

Observe the installation instructions for the antenna as well as [Section “For your safety” on page 6](#).



NOTE: Malfunction

- The wireless module must be at least 3 cm away from the installed antenna.
- 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:

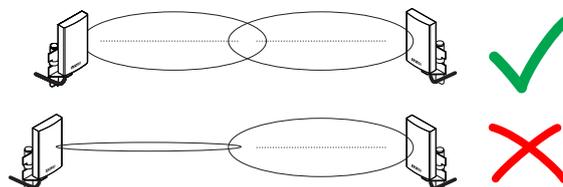
- Install the antenna in an open area as far away as possible from any obstacles such as buildings, dense deciduous forest, or metal objects. Select a location that ensures a free signal path in the direction of the partner antenna.
- If two antennas are located in the same place, the distance between 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	Laser pointer

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

Figure 9-6 Antenna polarization



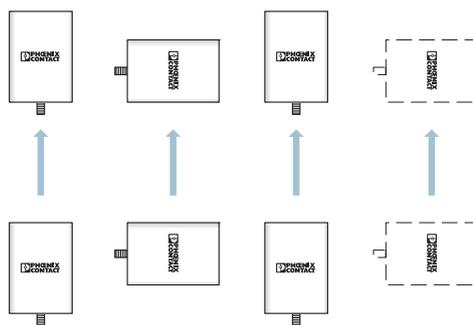
- In a highly reflective environment: Use antennas with circular polarization. This will avoid polarization losses. You can also combine circular and vertically polarized antennas.

Table 9-4 Polarization of transmitter/receiver antennas

Polarization	Horizontal 	Vertical 	Circular clock-wise 	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 clock-wise 	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 of wireless paths due to directivity and different polarization levels



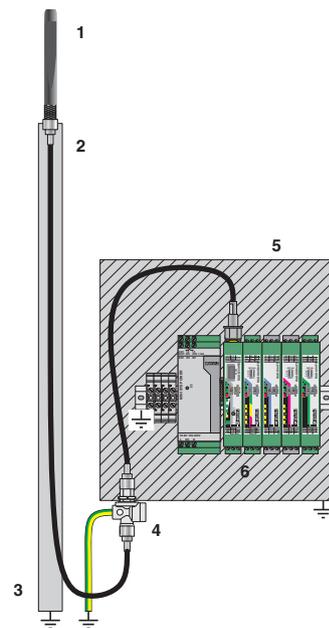
9.8.1 Outdoor installation of antennas

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. They are suitable for all commonly used transmission systems. Low attenuation and high bandwidth are simultaneously achieved by means of low-capacitance protective circuits. Thanks to excellent impedance matching, surge protection does not distort the useful signal.

- Use surge protection for outdoor installations.
 - For RAD-2400-IFS...: CN-LAMBDA/4-5.9-BB, Order No. 2838490
 - For RAD-868-IFS: CN-UB-70DC-6-BB, Order No. 2803166
- The antenna is grounded via the surge protection.
- The antenna mast must be grounded in accordance with national regulations.
- In outdoor installations, 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 ties.

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

In this way, you can find the alignment point even if there is no direct line of sight.

- 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 further information on the RSSI voltage, please refer to [page 48](#).
- You must always align both antennas with each other, because the radio waves need to radiate into the antennas.
- With directional antennas, it is particularly 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 level 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 Level and attenuation of the wireless devices and accessories

Trusted Wireless	Wireless module	Order No.	Max. transmission power	Connection
2,4 GHz	RAD-2400-IFS	2901541	20 dBm	RSMA (f)
	RAD-2400-IFS-JP	2702863		
868 MHz	RAD-868-IFS	2904909	27 dBm	

Adapter and cable	Connection	Order No.	Attenuation at 2.4 GHz	Attenuation at 868 MHz	Length
Pigtail, adapter					
RAD-PIG-EF316-N-RSMA, EF316	N(f) - RSMA(m)	2701402	-0.9 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	-2.9 dB	10 m
RAD-CAB-EF393-15M	N(m)	2885634	-8.3 dB	-4.3 dB	15 m
Antenna cable - LMR195					
RAD-PIG-RSMA/N-0.5	RSMA - N(m)	2903263	-0.5 dB	-0.4 dB	0.5 m

Adapter and cable [...]	Connection [...]	Order No. [...]	Attenuation at 2.4 GHz	Attenuation at 868 MHz	Length [...]
RAD-PIG-RSMA/N-1	RSMA - N(m)	2903264	-0.8 dB	-0.5 dB	1 m
RAD-PIG-RSMA/N-2	RSMA - N(m)	2903265	-1.3 dB	-0.9 dB	2 m
RAD-PIG-RSMA/N-3	RSMA - N(m)	2903266	-2 dB	-1.2 dB	3 m
RAD-PIG-RSMA/N-5	RSMA - N(m)	2702140	-3.3 dB	-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	
Surge protection, 2.4 GHz					
CN-LAMBDA/4-5.9-BB	N(f) - N(f)	2838490	< -0.15 dB	< -0.15 dB	
Surge protection, 868 MHz					
CN-UB-70DC-6-BB	N(f) - N(f)	2803166	< -0.15 dB	< -0.15 dB	

Antenna	Connection	Order No.	Gain	Remark
Omnidirectional antenna, 2.4 GHz				
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	N(f)	2702898	6 dBi	
RAD-ISM-2400-ANT-OMNI-6-0	N(f)	2885919	6 dBi	
RAD-ISM-2400-ANT-OMNI-9-0	N(f)	2867623	9 dBi	
Omnidirectional antenna, 868 MHz				
ANT-OMNI-868-01	N(f)	2702136	4 dBi	
ANT-OMNI-VAN-868-01	N(f)	1090616	2.5 dBi	
RAD-900-ANT-OMNI-2-N	N(f)	2904802	2 dBi	
Directional antenna, 2.4 GHz				
ANT-DIR-2459-01	N(f)	2701186	9 dBi	
Directional antenna, 868 MHz				
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 attenuation

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 attenuation

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 attenuation

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 attenuation [dB] = 32.4 + 20 x log(f) + 20 x log(d)**

Formula for 2.4 GHz: **Free space attenuation [dB] = 100 + 20 x log(d)**

Formula for 868 MHz: **Free space attenuation [dB] = 91.17 + 20 x log(d)**

f = transmission frequency in MHz

d = distance between the antennas in km

The free space attenuation is later included in the system calculation (see [Section "Effective isotropic radiated power \(EIRP\)" on page 164](#)).

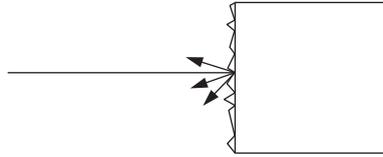
9.11 Propagation of radio waves

In addition to free space attenuation, 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

Dispersion of the wireless signal, e.g., at a tree, means that the wireless signal is dispersed in several directions. A bare tree will let signals through almost completely. However, a tree with leaves will scatter the signals considerably. The leaf surfaces disperse the wireless signal in many different directions.

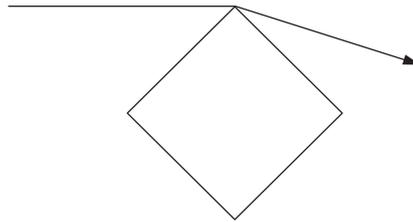
Figure 9-9 Dispersion on a rough surface



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.

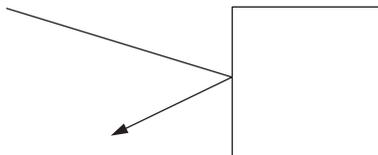
Figure 9-10 Diffraction on an edge



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:

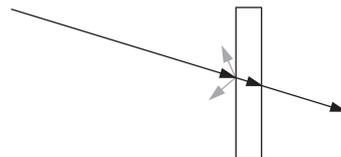
- Hollow lightweight walls with aluminum-lined insulation
- False ceilings with metal or carbon fiber panels
- Lead glass
- Insulation glass (Thermopen)
- Glass with a metal coating
- Steel objects
- Fire walls
- Elevator shafts and staircases

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

Table 9-7 Attenuation of different materials

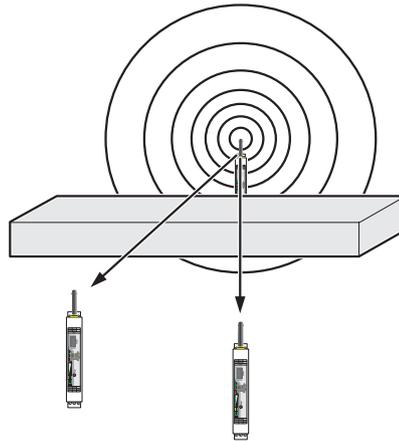
Obstacle	Typical attenuation at 2.4 GHz [dB]	Typical attenuation at 868 MHz [dB]
Wood, plaster, glass, plastic, uncoated, without metal	3 ... 4	1 ... 2
Brick, chip board	3 ... 5	1 ... 3
Brick wall, 16 cm	6 ...8	2 ... 4
Concrete wall, 16 cm	15 ... 20	9 ... 11
Reinforced concrete wall, 16 cm	20 ... 30	11 ... 20
Forest, 1 m, see 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.

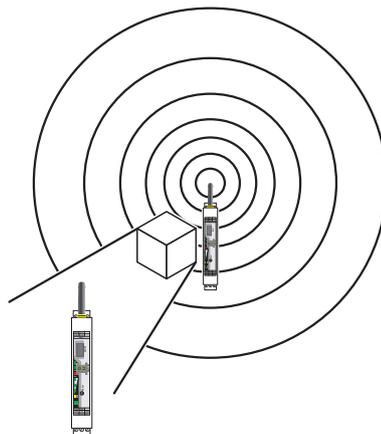
Figure 9-13 Angle of the transmitter and receiver



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

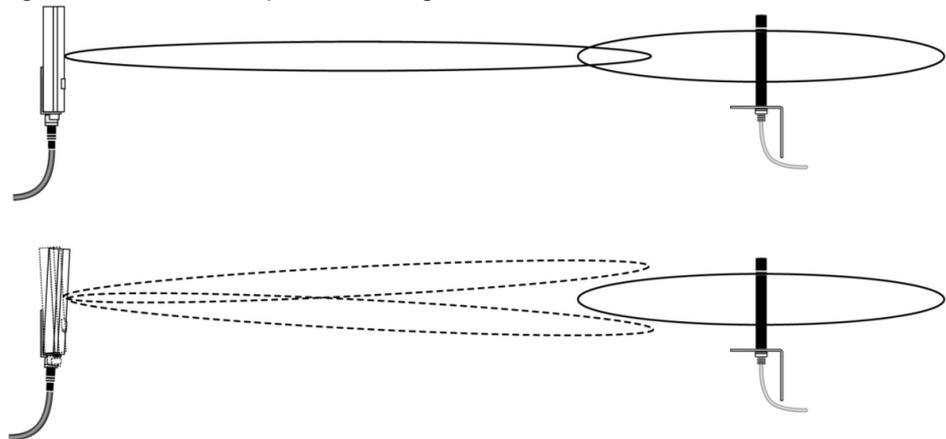


Weather influences

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. Moving the antenna away from its original position, by even just a few centimeters, may result in partial loss of the wireless signal on long transmission paths.

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 large distances. In order to stay within the Fresnel zone, it might 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 real-life 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 figure below 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

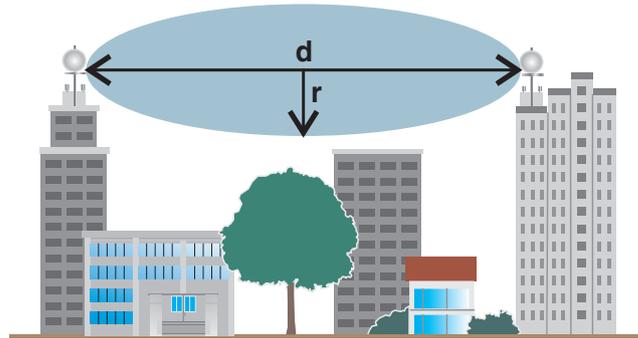


Table 9-8 Radius of the Fresnel zone depending on the distance

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 guide values. They may be significantly higher or lower depending on the actual application.

The range depends on the following:

- Set data rate
 - 2.4 GHz: factory default setting of 125 Kbps
 - 868 MHz: factory default setting of 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		
Omnidirectional antenna, 2 dBi	≤250 Kbps	50 ... 100 m
	≤125 Kbps	100 ... 200 m
Outside buildings, with a free line of sight		
Omnidirectional antenna, 2 dBi	≤250 Kbps	50 ... 100 m
	≤125 Kbps	100 ... 200 m
Omnidirectional antenna, 6 dBi	≤125 Kbps	≤1500 m (Europe: ≤ 1000 m)
Panel directional antenna, 8 dBi or 9 dBi	≤125 Kbps	≤3000 m (Europe: ≤ 2000 m)
	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		
Omnidirectional antenna, 4 dBi	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 [...]
Panel directional antenna, 4 dBi	120 Kbps	5 km
	60 Kbps	6 km
	19.2 Kbps	9 km
	9.6 Kbps	10 km
	1.2 Kbps	13 km
Yagi directional antenna, 8 dBi	120 Kbps	7 km
	60 Kbps	8 km
	19.2 Kbps	12 km
	9.6 Kbps	15 km
	1.2 Kbps	18 km
Yagi directional antenna, 12 dBi	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 Effective isotropic radiated power (EIRP)

The effective isotropic 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

- $EIRP = 14 \text{ dBm} + 8 \text{ dBi} - 2.85 \text{ dB} = 19.15 \text{ dBm}$

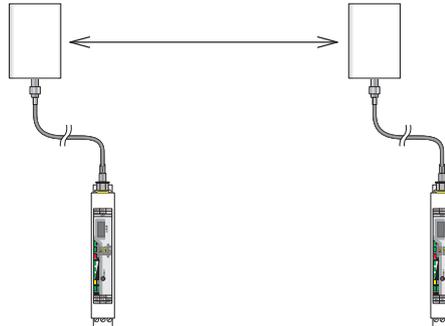
The EIRP depends on the frequency used. For legal reasons, you must not exceed the following maximum EIRP.

- 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 as necessary.

9.15 System calculation in free space

Figure 9-17 Free space attenuation



- 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 attenuation, 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]
 - loss of the transmitter cable [dB]

Incoming power for the receiver [dBm] =
 transmitter power [dBm]
 - loss of the transmitter cable [dB]
 + gain of the transmitting antenna [dBi]
 - free space attenuation [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 attenuation, D_L [dB]:
 $D_L = 32.4 + 20\log(R[\text{km}]) + 20\log(f[\text{MHz}]) = 32.4 + 20\log(0.4 \text{ km}) + 20 \log(2400 \text{ MHz})$
 $= -92 \text{ dB}$
- Incoming power for the receiver = -67.7 dBm
- Receiver sensitivity = -96 dB (with a data rate of 125 Kbps)
- System reserve = $|-96 \text{ dBi} - |-67.7 \text{ dBi} = 28.3 \text{ dB}$
 $28.3 \text{ dB} > 10 \text{ dB}$

Conclusion: The loss of -67.7 dB is 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 on the wireless path as the obstacles and applications will vary too much. The practical examples given below are for guidance only. They cannot be directly transferred to other applications.

- The bush illustrated below is 2 m wide and has an attenuation of approximately 15 dB at 2.4 GHz.
- At 868 MHz, the attenuation is around 8 dB.

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 cm to 20 cm.

- In our test, the 2.4 GHz wireless signal was transmitted through a 25 m forest. The attenuation was around 40 dB.
- At 868 MHz, the attenuation is around 22 dB.

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



10 Detecting and removing errors

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

- First, ensure you have a good wireless signal:
 - A green bar graph LED or
 - RSSI voltage ≥ 1.5 V
- Check the status of the individual stations:
 - If the PSI-CONF software is installed, check the device status of all network devices via online diagnostics.
 - If the PSI-CONF software has **not** been installed, check the bar graph LEDs on the front of each device.
- Find the error using the tables from [page 168](#) onwards.



- Avoid contact between the antennas of two wireless modules. Otherwise, the receiver will be overloaded.
- Ground loops are caused by the grounding of the antenna via the antenna fixing unit, the grounding of the power supply, and the grounding of 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 base station and on the remote station.
- In a wireless network with more than one remote station, only the yellow LED on the base station is permanently on. The signal strength in the base station direction is indicated on the remote stations. The signal strength always relates to the directly connected, higher-level wireless module.

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 note 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 base station to a PC, you can read the RSSI voltages in the entire wireless network. On a remote or repeater station, it is only possible to read the RSSI voltage of the connected wireless module.



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.	<ul style="list-style-type: none"> • Make sure power is supplied to the wireless module. • Make sure that you are using the correct cable: <ul style="list-style-type: none"> – RAD-CABLE-USB (Order No. 2903447) for energy supply via the USB port on the PC – IFS-USB-DATACABLE (Order No. 2320500) for external energy supply • Install the USB driver. The driver is installed automatically during PSI-CONF software installation (see page 39).
PWR off	No power supply, mains probably switched off.	<ul style="list-style-type: none"> • 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” operating mode.	<ul style="list-style-type: none"> • 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 be in “I/O data”, “PLC/Modbus RTU” mode, or in dual mode (see page 39). • Reset the wireless module to the factory default settings (I/O data mode), if necessary. To do this, disconnect the device from the supply voltage. Hold the SET button down and switch the supply voltage on again (see page 31).
ERR on	Local bus error The input or output module is disconnected from the DIN rail connector and the bus.	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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
<p>ERR flashing quickly (2.8 Hz), bar graph does not light up</p>	<p>No wireless connection, even though the wireless modules are not far apart</p>	<ul style="list-style-type: none"> • Make sure that, in a network, only one wireless module is configured as the base station (RAD ID = 01) and all other wireless modules are remote or repeater stations. 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: The receive preamplifier is activated in the delivery state. The transmission power is set so that the devices can cover the greatest possible distances. 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 (from page 39 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 39 onwards). • Reset the wireless module to the factory default settings (I/O data mode), if necessary. To do this, disconnect the device from the supply voltage. Hold the SET button down and switch the supply voltage on again (see page 31).
	<p>No wireless connection, the wireless modules are far apart</p>	<ul style="list-style-type: none"> • 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 there is sufficient power supply. • 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 on	Connection with low receive signal	<ul style="list-style-type: none"> • 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 there is sufficient power supply. • Make sure that there is no connection between the core and the shield of the cable in the connected antenna system.
	Several remote or repeater stations on the base station	<ul style="list-style-type: none"> • No action required, normal display for a wireless network with more than one remote station. The signal strength is indicated on the remote stations. The signal strength always relates to the directly connected, higher-level wireless module.
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.	<ul style="list-style-type: none"> • The I/O MAP address of an input module may appear only once in the network. Use the white thumbwheel to set different I/O MAP addresses.
	Missing input module Example: An output module does not have the corresponding input module with the same I/O MAP address.	<ul style="list-style-type: none"> • Check whether an input module with the same I/O MAP address has been assigned to each output module. • Set the I/O MAP address (01 ... 99) using the white thumbwheel on the extension module. The input module must be provided with the same I/O MAP address as the assigned output module at another station.
	Missing output module Example: An input module does not have the corresponding output module with the same I/O MAP address.	<ul style="list-style-type: none"> • Check whether an output module with the same I/O MAP address has been assigned to each input module. • Set the I/O MAP address (01 ... 99) using the white thumbwheel on the extension module. The output module must be provided with the same I/O MAP address as the assigned input module at another station.
	RAD ID changed Example: The yellow thumbwheel setting has been modified accidentally. The modification has not yet been confirmed via the SET button.	<ul style="list-style-type: none"> • Check the RAD ID setting on the yellow thumbwheel of the wireless module. • If necessary, set the correct RAD ID. 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	<ul style="list-style-type: none"> The I/O MAP address of an input module may appear only once in the network. Use the white thumbwheel to set different I/O MAP addresses.
	RAD ID changed Example: The yellow thumbwheel setting has been modified accidentally. The modification has not yet been confirmed via the SET button.	<ul style="list-style-type: none"> Check the RAD ID setting on the yellow thumbwheel of the wireless module. If necessary, set the correct RAD ID. Press the SET button.
	No Modbus communication (only if watchdog is activated) Example: The communication line between the Modbus/RTU controller and the Radioline base station has been interrupted.	<ul style="list-style-type: none"> Check the communication line between the Modbus/RTU controller and the base station 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 end devices. Check whether the I/O extension module is properly snapped onto the DIN rail connector. Use the PSI-CONF software to check whether the wireless module is in "PLC/Modbus RTU" mode or in dual mode (see page 39). 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" operating mode		
RX, TX off	Wireless connection present, but application is not transmitting any data	<ul style="list-style-type: none"> 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 end devices (from page 39 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	<ul style="list-style-type: none"> 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" operating mode.	<ul style="list-style-type: none"> 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 be in "I/O data", "PLC/Modbus RTU" mode, or in dual mode (see page 39). Reset the wireless module to the factory default settings (I/O data mode, see page 31), if necessary.
ERR on	Critical internal error Example: Technical defect	<ul style="list-style-type: none"> Please contact Phoenix Contact technical support.
ERR flashing slowly (1.4 Hz)	I/O MAP address changed Example: The white thumbwheel setting has been modified accidentally. The modification has not yet been confirmed via the SET button on the wireless module.	<ul style="list-style-type: none"> 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. Press the SET button on the wireless module.
In I/O data mode		
ERR flashing quickly (2.8 Hz)	Missing input module Example: An output module does not have the corresponding input module with the same I/O MAP address.	<ul style="list-style-type: none"> Check whether an input module with the same I/O MAP address has been assigned to each output module. Set the I/O MAP address (01 ... 99) using the white thumbwheel on the extension module. The input module must be provided with the same I/O MAP address as the assigned output module at another station.
	No bus communication, no wireless connection present	<ul style="list-style-type: none"> See measures for the wireless module, page 169
In PLC/Modbus RTU mode		
ERR flashing quickly (2.8 Hz)	No Modbus communication (safe state of outputs, depending on DIP switch settings)	<ul style="list-style-type: none"> Check the communication line between the Modbus/RTU controller and the Radioline base station with RAD ID 01. Check the wiring of the RS-232/RS-485 connections on the base station and the PLC. Check the serial interface settings (baud rate, parity, data bits, and stop bits) on the base station and the PLC (from page 39 onwards). Check whether the I/O extension module is properly snapped onto the DIN rail connector. Use the PSI-CONF software to check whether the wireless module is in "PLC/Modbus RTU" mode or in dual mode (see page 39). 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	<ul style="list-style-type: none"> See measures for the wireless module, page 169

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 base station to the remote station and back again. To do this, you need to short circuit two terminal points of the RS-232 interface on the remote station. You can then transmit characters to the base station using a terminal program (e.g., HyperTerminal). The characters are echoed back to the terminal program.



Note for users of Windows 7 or more recent Windows operating systems:

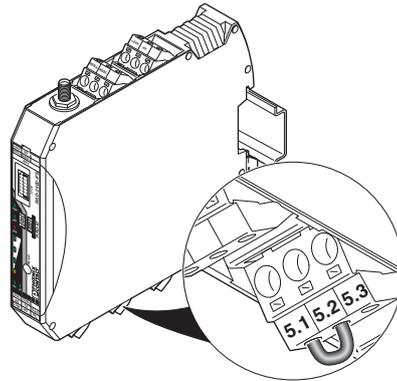
HyperTerminal is no longer available as of Windows 7. Instead, you can use any other terminal program.

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 base station.
- Start HyperTerminal via "Start, All Programs, Accessories, Communication, HyperTerminal".
- The COM port settings on the PC must correspond to the interface settings on the base station.

- Connect terminal points 5.1 and 5.2 of the RS-232 interface on the remote wireless module to be tested.

Figure 10-1 Loopback test with 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.

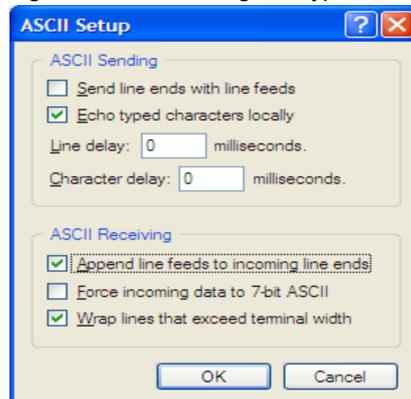
HyperTerminal transmits these characters over the wireless path.

- The characters are output on the remote side, e.g., at terminal point 5.1, RX cable of the RS-232 interface.
- The characters are read in 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 thus 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
 - Append line feeds to incoming line ends

Figure 10-2 Settings in HyperTerminal



11 Device replacement, device defects, and repairs

11.1 Device replacement

**NOTE: Device damage**

Only mount and remove devices when the power supply is disconnected.

You can replace the device if necessary.

- Disconnect the device from the power supply.
- Remove all cables.
- Remove the device as described in [“Removal” on page 22](#).
- Replace the device with an identical device (same order number).

11.2 Device defects and repairs

Repairs may only be carried out by Phoenix Contact.

- Send defective devices back to Phoenix Contact for repair or to receive a replacement device.
- We strongly recommend using the original packaging to return the product.
- Include a note in the packaging indicating that the contents are returned goods.
- Include an error description with the returned product.
- If the original packaging is no longer available, observe the following points:
 - Observe the humidity specifications and the temperature range specified for transport (see [“Ambient conditions” on page 184](#)).
 - If necessary, use dehumidifying agents.
 - Use suitable ESD packaging to protect components that are sensitive to electrostatic discharge.
 - Make sure that the packaging you select is large enough and sufficiently thick.
 - Only use plastic bubble wrap sheets as wadding.
 - Attach warnings to the transport packaging so that they are clearly visible.
 - Please be aware that the delivery note is to be placed inside the package if the package is sent within the same country. If the package is being sent abroad, the delivery note must be placed inside a delivery note pocket and attached to the outside so that it is clearly visible.

12 Maintenance and disposal

12.1 Maintenance

The device is maintenance-free.

12.2 Disposal



Dispose of the device separately from other waste, i.e., via an appropriate collection site.

- Dispose of packaging materials that are no longer needed (cardboard packaging, paper, bubble wrap sheets, etc.) with household waste in accordance with the currently applicable national regulations.

13 Technical data for the wireless modules

Description	Type	Order No.	Pcs./Pkt.
Wireless transceiver with RS-232/RS-485 interface, can be extended with I/O modules, RSMA (female) antenna connection, point-to-point, star, and mesh networks			
2.4 GHz, up to 250 stations, up to 5 km, worldwide use	RAD-2400-IFS	2901541	1
868 MHz, up to 99 stations, up to 20 km, use in Europe	RAD-868-IFS	2904909	1
2.4 GHz, up to 250 stations, up to 5 km, use in Japan	RAD-2400-IFS-JP	2702863	1

Accessories

RS-485 front module	Type	Order No.	Pcs./Pkt.
RS-485 multipoint multiplexer, can be extended with I/O modules, can be used as Modbus/RTU bus coupler, or can be combined with Radioline wireless system, up to 99 stations, range of up to 1.2 km on in-house copper cables	RAD-RS485-IFS	2702184	1

Switchgear and controlgear assembly	Type	Order No.	Pcs./Pkt.
Radioline switchgear and controlgear assembly in shock-proof IP66 outdoor housing, with 100 ... 240 V AC universal power supply, surge protection, and antenna feed-through	RAD-RUGGED-BOX-CONF	1091638	1
Type of wireless module (frequency band) and type and number of I/O extension modules are configurable			

Extension modules	Type	Order No.	Pcs./Pkt.
4 analog current inputs (0/4 mA ... 20 mA)	RAD-AI4-IFS	2901537	1
4 analog voltage inputs (0 V ... 5 V, 0 V ... 10 V)	RAD-AI4-U-IFS	2702290	1
4 Pt 100 inputs (-50°C ... +250°C)	RAD-PT100-4-IFS	2904035	1
4 analog current or voltage outputs (0/4 mA ... 20 mA, 0 V ... 10 V)	RAD-AO4-IFS	2901538	1
4 digital inputs (0 ... 250 V AC/DC)	RAD-DI4-IFS	2901535	1
8 digital inputs (0 ... 30.5 V DC) or 2 pulse inputs up to 100 Hz	RAD-DI8-IFS	2901539	1
4-channel NAMUR digital input module for use in Radioline and PROFIBUS PA MUX I/O systems. Conforms to NAMUR proximity sensor standard EN 60947-5-6 and communicates with the head stations for Radioline systems and the FB-MUX/HS...PA	RAD-NAM4-IFS	2316275	
4 digital relay outputs (5 A, 250 V AC/DC)	RAD-DOR4-IFS	2901536	1
8 digital transistor outputs (30.5 V DC/200 mA)	RAD-DO8-IFS	2902811	1
2 digital inputs and outputs (0 ... 250 V AC/DC) and 1 analog input (0/4 ... 20 mA) and output (0/4 ... 20 mA, 0 ... 10 V)	RAD-DAIO6-IFS	2901533	1

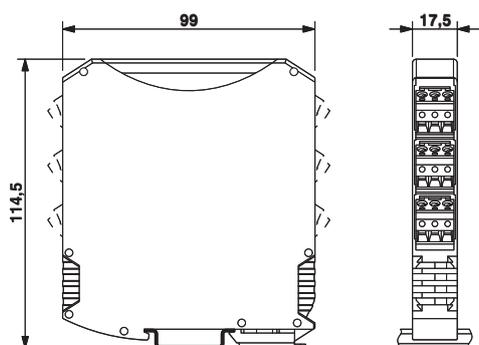
RAD-...-IFS

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-connection clamp for applying the shield on bus-bars	SKS 8-SNS35	3062786	10
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
Memory stick for saving custom configuration data	RAD-MEMORY	2902828	1
USB data cable for communication between the PC and Radioline devices, energy supply for diagnostics, and configuration via the USB port of the PC, cable length: 2 m	RAD-CABLE-USB	2903447	1
Configuration sticks	Type	Order No.	Pcs./Pkt.
Configuration stick for easy and secure network addressing, unique network ID			
2.4 GHz, RF band 3	RAD-CONF-RF3	2902814	1
2.4 GHz, RF band 5	RAD-CONF-RF5	2902815	1
2.4 GHz, RF band 7	RAD-CONF-RF7	2902816	1
868 MHz, RF band 1	RAD-868-CONF-RF1	2702197	1
2.4 GHz antennas	Type	Order No.	Pcs./Pkt.
Omnidirectional antenna, 2.4 GHz, gain: 2 dBi, polarization: linear, opening angle: h/v 360°/75°, degree of protection: IP65, connection: RSMA (male), including 1.5 m connecting cable and mounting bracket for wall mounting	RAD-ISM-2400-ANT-OMNI-2-1-RSMA	2701362	1
Omnidirectional antenna with protection against vandalism, 2.4 GHz, gain: 3 dBi, polarization: linear, opening angle: h/v 360°/85°, degree of protection: IP55, connection: RSMA (male), for control cabinet mounting (wall mounting as an option), including 1.5 m connecting cable	RAD-ISM-2400-ANT-VAN-3-0-RSMA	2701358	1
Omnidirectional antenna, 2.4 GHz, gain: 6 dBi, polarization: linear, opening angle: h/v 360°/30°, degree of protection: IP67, seawater-resistant, connection: N (female), including mounting bracket and mast clamps, ATEX and IECEx approval	RAD-ISM-2400-ANT-OMNI-6-0	2885919	1
Directional antenna, 2.4 GHz/5 GHz, gain: 9 dBi, polarization: linear, opening angle: h/v 75°/55°, degree of protection: IP67, seawater-resistant, connection: N (female), including mounting bracket and mast clamps, ATEX and IECEx approval	ANT-DIR-2459-01	2701186	1

868 MHz antennas	Type	Order No.	Pcs./Pkt.
Omnidirectional antenna, 868 MHz/900 MHz, gain: 2 dBi, polarization: linear, opening angle: h/v 360°/50°, degree of protection: IP66, connection: N (female), for control cabinet mounting (wall mounting as an option)	RAD-900-ANT-OMNI-2-N	2904802	1
Omnidirectional antenna with protection against vandalism, 868 MHz, gain: 2.5 dBi, polarization: linear vertical, opening angle: h/v 360°/55°, degree of protection: IP67, shock resistance: IK08, connection: N (female), for control cabinet mounting, wall mounting as an option	ANT-OMNI-VAN-868-01	1090616	1
Omnidirectional antenna, 868 MHz, gain: 4 dBi, polarization: linear, opening angle: h/v 360°/30°, degree of protection: IP67, seawater-resistant, connection: N (female), including mounting bracket and mast clamps, ATEX and IECEx approval	ANT-OMNI-868-01	2702136	1
Directional antenna, 868 MHz, gain: 3.5 dBi, polarization: circular, opening angle: h/v 135°/90°, degree of protection: IP67, seawater-resistant, connection: N (female), including mounting bracket and mast clamps, ATEX and IECEx approval	ANT-DIR-868-01	2702137	1
Directional antenna, 868 MHz/900 MHz, gain: 8.5 dBi, polarization: linear, opening angle: h/v 100°/62°, degree of protection: IP65, connection: N (female), including mounting bracket and mast clamps	RAD-ISM-900-ANT-YAGI-6.5-N	2867814	1
Directional antenna, 868 MHz/900 MHz, gain: 12 dBi, polarization: linear, opening angle: h/v 56°/46°, degree of protection: IP65, connection: N (female), including mounting bracket and mast clamps	RAD-ISM-900-ANT-YAGI-10-N	5606614	1
Antenna cables and adapters			
Antenna cable for control cabinet feed-through, outside diameter: 3.2 mm, inner conductor: flexible, attenuation: 0.6/0.9/1.4 dB at 0.9/2.4/5.8 GHz, connection: N (female) -> RSMA (male), cable length: 0.5 m	RAD-PIG-EF316-N-RSMA	2701402	1
Antenna cable, outside diameter: 5 mm, inner conductor: rigid, connection: N (male) -> RSMA (male)			
Length: 0.5 m, attenuation: 0.4/0.5/0.6 dB at 0.9/2.4/5.8 GHz	RAD-PIG-RSMA/N-0.5	2903263	1
Length: 1 m, attenuation: 0.5/0.8/1.1 dB at 0.9/2.4/5.8 GHz	RAD-PIG-RSMA/N-1	2903264	1
Length: 2 m, attenuation: 0.9/1.3/2.0 dB at 0.9/2.4/5.8 GHz	RAD-PIG-RSMA/N-2	2903265	1
Length: 3 m, attenuation: 1.2/2.0/3.0 dB at 0.9/2.4/5.8 GHz	RAD-PIG-RSMA/N-3	2903266	1
Length: 5 m, attenuation: 2.0/3.3/4.8 dB at 0.9/2.4/5.8 GHz	RAD-PIG-RSMA/N-5	2702140	1

RAD-...-IFS

Antenna cables and adapters	Type	Order No.	Pcs./Pkt.
Antenna cable, outside diameter: 5 mm, inner conductor: flexible, attenuation: 0.3/0.5/0.8 dB at 0.9/2.4/5.8 GHz, connection: 2 x N (male), cable length: 0.5 m	FL LCX PIG-EF142-N-N	2700677	1
Intermediate plug with LAMBDA/4 technology as surge protection for coaxial signal interfaces, connection: N connectors socket-socket			
For RAD-2400-IFS	CN-LAMBDA/4-5.9-BB	2838490	1
For RAD-868-IFS	CN-UB-70DC-6-BB	2803166	1
Antenna adapter for control cabinet feed-through, frequency range: 0.3 GHz ... 6 GHz, degree of protection: IP65, connection: 2 x N (female)	RAD-ADP-N/F-N/F	2867843	1
Antenna adapter, frequency range: 0.3 GHz ... 6 GHz, connection: RSMA (male) -> RSMA (female), 90° angled	RAD-ADP-RSMA/M-RSMA/F-90	2904790	1
Antenna barrier for control cabinet feed-through, type of protection: Ex i, degree of protection: IP65, barrier installation: zone 2/22, antenna installation: in dust and gas Ex area, frequency range: 0.3 GHz ... 6 GHz, connection: 2 x N (female), ATEX, EAC Ex, and IECEx approval	BAR-ANT-N-N-EX	2702198	1
Antenna splitter, frequency range: 0.3 GHz ... 6 GHz, degree of protection: IP65, connection: 3 x N (female), corresponding connecting cable for antenna connection (Order No. 2700677)	RAD-SPL-2-N/N	2702293	1
Antenna cable, outside diameter: 10 mm, inner conductor: flexible, connection: 2 x N (male)			
Length: 3 m, attenuation: 1.0/1.8/3.1 dB at 0.9/2.4/5.8 GHz	RAD-CAB-EF393-3M	2867649	1
Length: 5 m, attenuation: 1.6/2.9/5.0 dB at 0.9/2.4/5.8 GHz	RAD-CAB-EF393-5M	2867652	1
Length: 10 m, attenuation: 2.9/5.6/9.9 dB at 0.9/2.4/5.8 GHz	RAD-CAB-EF393-10M	2867665	1
Length: 15 m, attenuation: 4.3/8.3/14.8 dB at 0.9/2.4/5.8 GHz	RAD-CAB-EF393-15M	2885634	1
Antenna adapter, frequency range: 0.3 GHz ... 6 GHz, connection: RSMA (male) -> RSMA (female), 90° angled	RAD-ADP-RSMA/M-RSMA/F-90	2904790	1
Energy supply	Type	Order No.	Pcs./Pkt.
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

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 in accordance with UL 94	V0

Supply

Supply voltage range	19.2 V DC ... 30.5 V DC
Maximum current consumption	≤65 mA (at 24 V DC, at 25°C, stand-alone) ≤6 A (at 24 V DC, with DIN rail connector at full capacity)
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 thumb-wheel)	≤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)	

RAD-...-IFS

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 data transmission rate)
Data transmission rate (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 (factory default setting)	≤27 dBm (factory default setting, adjustable)
Security	128-bit data encryption	
Operating mode	I/O data (factory default setting, configuration via thumbwheel) Serial data PLC/Modbus RTU mode, PLC/Modbus RTU dual mode (activation and configuration via PSI-CONF software)	
RS-232 interface		
Connection method	COMBICON plug-in screw terminal block	
Connection technology	3-conductor	
Data rate	300 bps / 600 bps / 1.2 Kbps / 2.4 Kbps / 4.8 Kbps / 9.6 Kbps / 19.2 Kbps / 38.4 Kbps / 57.6 Kbps / 93.75 Kbps / 115.2 Kbps	
Transmission distance	≤15 m	

RS-485 interface

Connection method	COMBICON plug-in screw terminal block
Connection technology	2-conductor
Data rate	300 bps / 600 bps / 1.2 Kbps / 2.4 Kbps / 4.8 Kbps / 9.6 Kbps / 19.2 Kbps / 38.4 Kbps / 57.6 Kbps / 93.75 Kbps / 115.2 Kbps / 187.5 Kbps
Transmission distance	≤1200 m
Termination resistor (can be switched via DIP switches)	390 Ω / 150 Ω / 390 Ω

Configuration interface

Connection method	S-PORT (socket)
-------------------	-----------------

RSSI voltage output

Number of outputs	1
Voltage output signal	0 V ... 3 V

RF link relay output

Number of outputs	1
Contact type	Changeover 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 x 10 ⁵ switching cycles with 0.5 A at 30 V DC

Connection data

Connection method	Screw connection
Conductor cross-section, rigid	0.2 mm ² ... 2.5 mm ²
Conductor cross-section, flexible	0.2 mm ² ... 2.5 mm ²
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 reception quality, RSSI) Green LED (RS-232/RS-485 receive data, RX) Green LED (RS-232/RS-485 transmit data, TX)
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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)	In accordance with IEC 60068-2-6: 5g, 10 Hz ... 150 Hz
Shock	16g, 11 ms

Approvals	RAD-2400-IFS	RAD-868-IFS	RAD-2400-IFS-JP
Corrosive gas test	ISA-S71.04-1985 G3 Harsh Group A		
CE conformity	RED directive 2014/53/EU		No
ATEX	⊕ II 3 G Ex nA nC IIC T4 Gc (IBExU 15 ATEX B008 X)		No
IECEX	Ex nA nC IIC T4 Gc (IECEX IBE 13.0019X)		No
EAC Ex	2ExnAnCIIC T4 GcX (RU C-DE.HB49.B. 00033/20)	No	No
UL, USA/Canada	UL 508 Listed, Class I, Div. 2, Groups A, B, C, D T4A Class I, Zone 2, IIC T4	No	No
FCC	FCC directive, part 15.247	No	No
ISC	ISC directive RSS 210	No	No
IFT Mexico	IFT RCPHRA17- 1112	No	No
ANATEL (Brazil)	06279-19-06497	No	No



The RAD-2400-IFS wireless module is approved for use in numerous countries around the world. A list of the country-specific approvals is available at phoenixcontact.net/product/2901541. Additional country-specific approvals available on request.

Conformance with EMC directive 2014/30/EU (RAD-2400-IFS and RAD-868-IFS)

Immunity in accordance with EN 61000-6-2

Electrostatic discharge	EN 61000-4-2	
	Contact discharge	±6 kV (test intensity 3)
	Air discharge	±8 kV (test intensity 3)
	Indirect discharge	±6 kV
	Comment	Criterion B
Electromagnetic HF field	EN 61000-4-3	
	Frequency range	26 MHz ... 3 GHz (test intensity 3)
	Field strength	10 V/m
	Comment	Criterion A
Fast transients (burst)	EN 61000-4-4	
	Input	±2 kV (test intensity 3)
	Signal	±2 kV
	Comment	Criterion B
Surge current loads (surge)	EN 61000-4-5	
	Input	±0.5 kV (symmetrical) ±1 kV (asymmetrical)
	Signal	±1 kV (asymmetrical)
	Comment	Criterion B
Conducted interference	EN 61000-4-5	
	Frequency range	0.15 MHz ... 80 MHz
	Voltage	10 V
	Comment	Criterion A

Noise emission in accordance with EN 61000-6-4 (RAD-2400-IFS and RAD-868-IFS)

Emitted radio interference in accordance with EN 55011 EN 55016-2-3 Class A, industrial area of application

Criterion A Normal operating behavior within the specified limits

Criterion B Temporary adverse effects on the operating characteristics that the device corrects automatically.

RED directive 2014/53/EU	RAD-2400-IFS	RAD-868-IFS
EMC – immunity to interference (electromagnetic compatibility of wireless systems)	EN 61000-6-2, generic standard for industrial environments	
Safety – protection of personnel with regard to electrical safety	EN 60950	
Health – limiting public exposure to electromagnetic fields	EN 62311	
Radio – effective use of the frequency spectrum and avoidance of radio interference	EN 300328	EN 300220

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

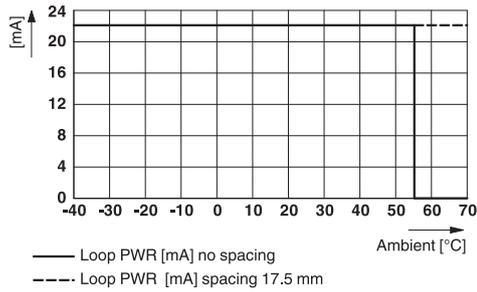


No function restrictions for the extended temperature range if you maintain a minimum distance of 17.5 mm between the modules. The minimum distance is the width of a DIN rail connector.

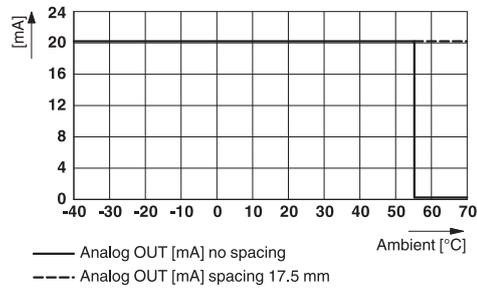
Otherwise, please observe the following restrictions. Individual operating conditions available on request.

RAD-DAIO6-IFS (2901533):

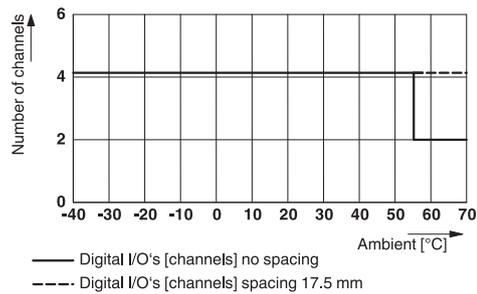
Do not use the analog loop power output (PWR1).



Only use the analog voltage output (U1).

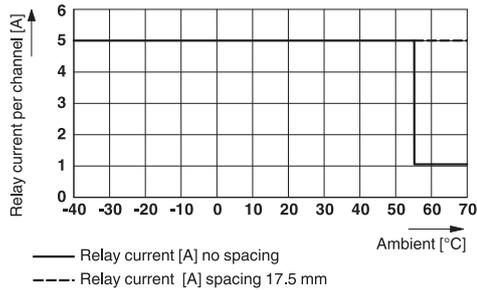


Do not use more than two of the four possible digital inputs and outputs.



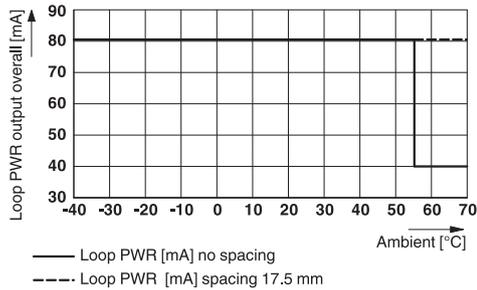
RAD-DOR4-IFS (2901536):

Maximum switching current: 1 A per channel



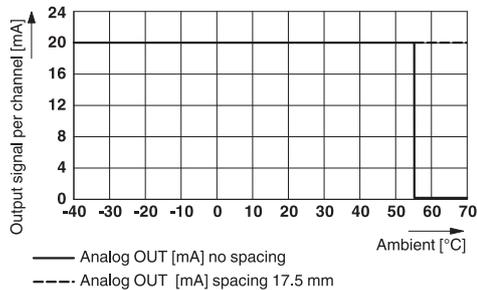
RAD-AI4-IFS (2901537):

Make sure that no more than 40 mA in total is drawn from loop power outputs PWR₁ ... PWR₄.



RAD-AO4-IFS (2901538):

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



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.

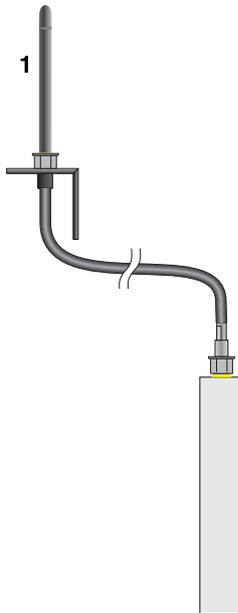


- Install the antenna outside the control cabinet or building. See [Section 9.8, "Installing antennas"](#).
- Please also observe the installation instructions for the antenna as well as [Section "For your safety" on page 6](#).
- For information on the transmission power, please refer to Section ["Transmission power" on page 40](#).

A 1.1 2.4 GHz antennas

Omnidirectional antenna, 2 dBi

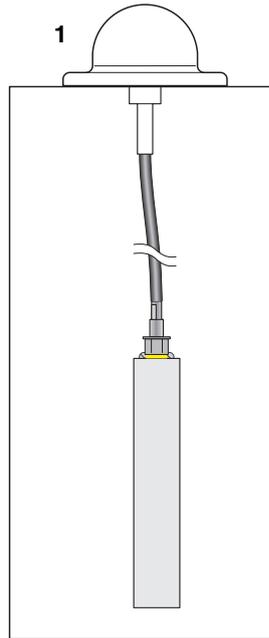
Figure A-1 Omnidirectional antenna, 2 dBi



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 degree of protection	RSMA (male)	2701362

Omnidirectional antenna with protection against vandalism, 3 dBi

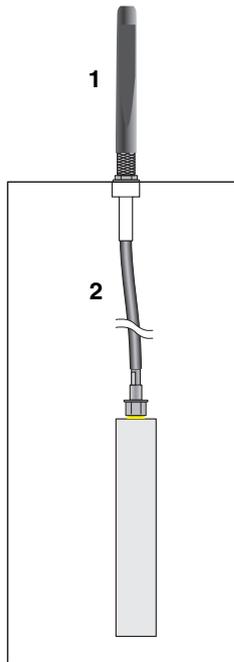
Figure A-2 Omnidirectional antenna with protection against vandalism, 3 dBi



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

Omnidirectional antenna, 2.5 dBi

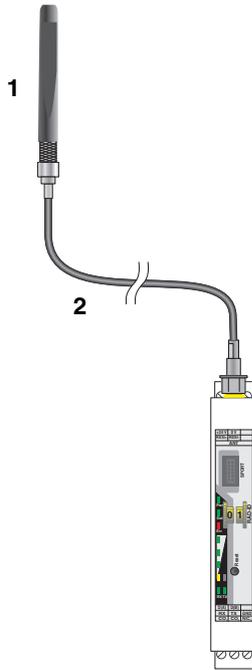
Figure A-3 Omnidirectional antenna, 2.5 dBi



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

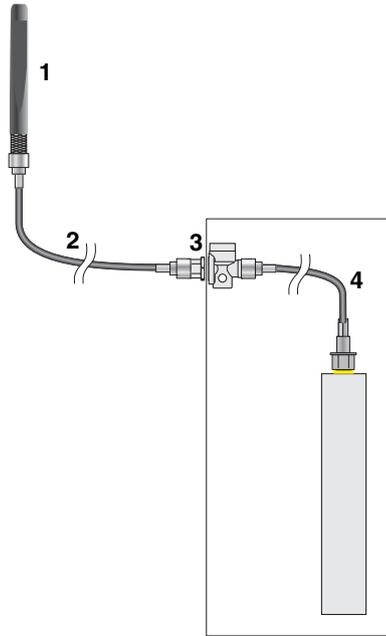
Figure A-4 Omnidirectional antenna, 6 dBi, without surge protection



Item	Product	Description	Connection	Order No.
1	RAD-ISM-2400-ANT-OMNI-6-0	Omnidirectional antenna, 2.4 GHz, 6 dBi gain, linear vertical polarization, h/v 360°/30° opening angle, IP67 degree of protection, seawater-resistant	N (female)	2885919
2	RAD-PIG-RSMA/N-0.5	Antenna cable, 0.5 m length, 50 Ω impedance	N (male) → RSMA (male)	2903263
	Alternatively:			
	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

Omnidirectional antenna, 6 dBi, with surge protection

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

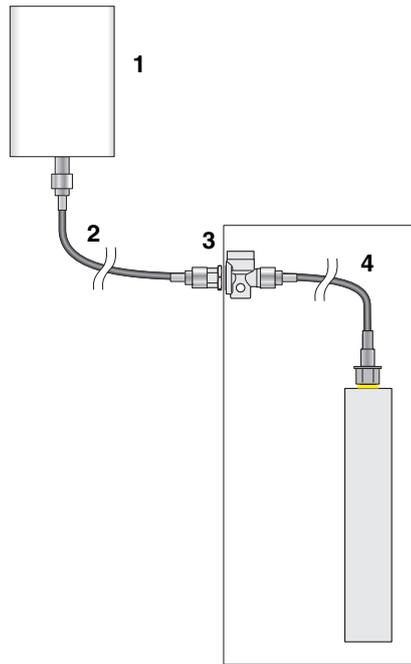


Items 2 and 3 are optional.

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, IP67 degree of protection, seawater-resistant	N (female)	2885919
2 (opt.)	RAD-CAB-EF393- 3M Alternatively: RAD-CAB-EF393- 5M RAD-CAB-EF393-10M RAD-CAB-EF393-15M	Antenna cable, 3 m length, 50 Ω impedance Antenna cable, 5 m length Antenna cable, 10 m length Antenna cable, 15 m length	N (male) → N (male) N (male) → N (male)	2867649 2867652 2867665 2885634
3 (opt.)	CN-LAMBDA/4-5.9-BB	Intermediate plug with LAMBDA/4 technology as surge protection for coaxial signal interfaces	N (female) → N (female)	2838490
4	RAD-PIG-RSMA/N-0.5 Alternatively: 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

Directional antenna, 9 dBi, with surge protection for outdoor installation

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



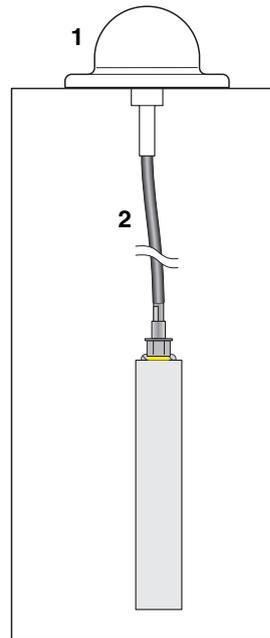
Items 2 and 3 are optional.

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 degree of protection	N (female)	2701186
2 (opt.)	RAD-CAB-EF393- 3M	Antenna cable, 3 m length, 50 Ω impedance	N (male) → N (male)	2867649
	Alternatively: 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
3 (opt.)	CN-LAMBDA/4-5.9-BB	Intermediate 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
	Alternatively: 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 with protection against vandalism, 2.5 dBi

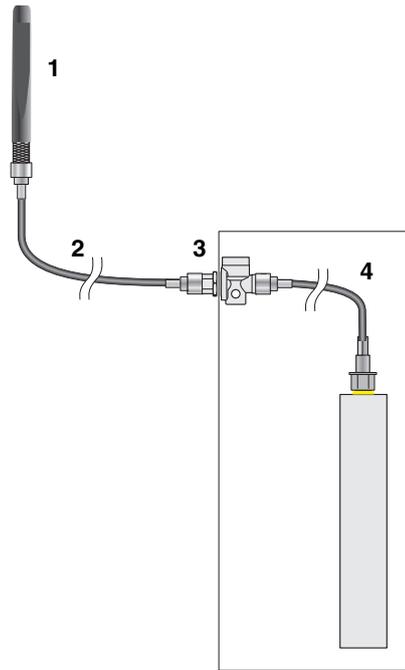
Figure A-7 Omnidirectional antenna with protection against vandalism, 2.5 dBi



Item	Product	Description	Connection	Order No.
1	ANT-OMNI-VAN-868-01	Omnidirectional antenna with protection against vandalism, 868 MHz, 2.5 dBi, linear vertical, h/v 360°/55° opening angle, IP67, shock resistance: IK08, wall mounting as an option, 0.5 m antenna cable	N (female)	1090616
2	RAD-PIG-RSMA/N-0.5	Antenna cable, 0.5 m length, 50 Ω impedance	N (male) → RSMA (male)	2903263

Omnidirectional antenna, 4 dBi, with surge protection

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



Items 2 and 3 are optional.

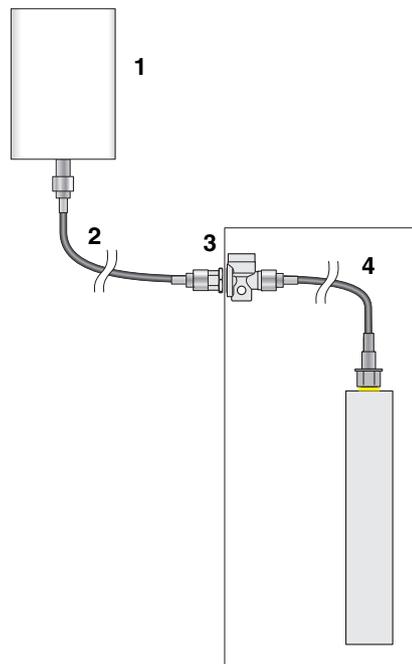
Item	Product	Description	Connection	Order No.
1	ANT-OMNI-868-01	Omnidirectional antenna, 868 MHz, 4 dBi, linear vertical, h/v 360°/30° opening angle, IP67, seawater-resistant, including mounting bracket and mast clamps for 30 mm ... 45 mm diameter, stainless steel, ATEX and IECEx approval	N (female)	2702136
2 (opt.)	RAD-CAB-EF393- 3M Alternatively: RAD-CAB-EF393- 5M RAD-CAB-EF393-10M RAD-CAB-EF393-15M	Antenna cable, 3 m length, 50 Ω impedance Antenna cable, 5 m length Antenna cable, 10 m length Antenna cable, 15 m length	N (male) → N (male) N (male) → N (male)	2867649 2867652 2867665 2885634
3 (opt.)	CN-UB-70DC-6-BB	Intermediate plug with surge protection for coaxial signal interfaces	N (female) → N (female)	2803166

RAD-...-IFS

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
	Alternatively:			
	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 clamps for 25 mm ... 85 mm diameter, stainless steel, ATEX and IECEx approval	N (female)	2702137
	Alternatively:			
	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 dBi gain, 0.6 m RG-213 cable	N (female)	5606614

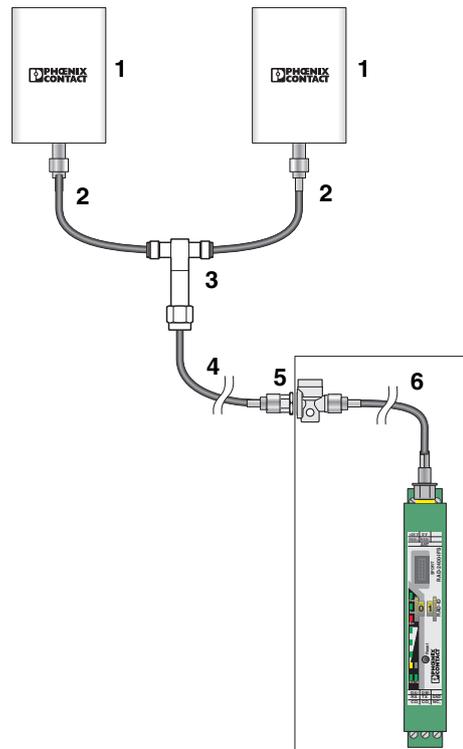
Typical combinations of antennas and adapter cables

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
	Alternatively:			
	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
3 (opt.)	CN-UB-70DC-6-BB	Intermediate plug with surge protection for co-axial signal interfaces	N (female) → N (female)	2803166
4	RAD-PIG-RSMA/N-0.5	Antenna cable, 0.5 m length, 50 Ω impedance	N (male) → RSMA (male)	2903263
	Alternatively:			
	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 1.3 Antenna splitter

Directional antennas, 8 dBi, with 2-way antenna splitter for outdoor installation

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



Items 4 and 5 are optional.

Item	Product	Description	Connection	Order No.
1	ANT-DIR-2459-01	Directional antenna, 2.4 GHz/5 GHz, 9 dBi gain, linear vertical polarization, h/v 75°/55° opening angle for 2.4 GHz, IP67 degree of protection	N (female)	2701186
	Alternatively: ANT-DIR-868-01	Directional antenna, 868 MHz, 3.5 dBi, circular polarized, IP67, including mounting bracket and mast clamps for 25 mm ... 85 mm diameter, stainless steel, ATEX and IECEx approval	N (female)	2702137
	Or other directional antennas from Phoenix Contact			
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

Typical combinations of antennas and adapter cables

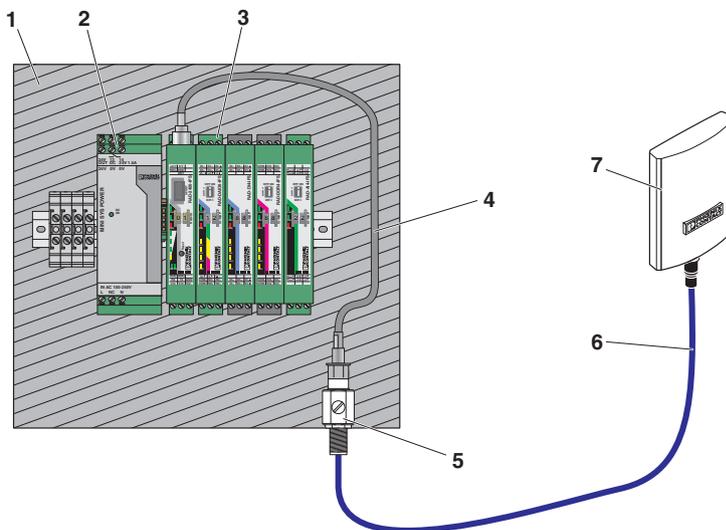
Item	Product	Description	Connection	Order No.
4 (opt.)	RAD-CAB-EF393- 3M	Antenna cable, 3 m length, 50 Ω impedance	N (male) → N (male)	2867649
	Alternatively: RAD-CAB-EF393- 5M	Antenna cable, 5 m length		2867652
	RAD-CAB-EF393-10M	Antenna cable, 10 m length	N (male) → N (male)	2867665
	RAD-CAB-EF393-15M	Antenna cable, 15 m length		2885634
5 (opt.)	CN-LAMBDA/4-5.9-BB	Intermediate 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
	Alternatively: 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 as well as [Section “For your safety” on page 6](#).

Figure A-11 Antenna installation in zone 2



RAD-...-IFS

Item	Product	Description	Connection	Order No.
1	IP54 stainless steel housing		-	-
2	Power supply		-	-
3	RAD-2400-IFS or RAD-868-IFS wireless module and I/O extension modules		-	-
4	RAD-PIG-RSMA/N-0.5	Antenna cable, 0.5 m length, 50 Ω impedance	N (male) → RSMA (male)	2903263
	Alternatively:			
	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
5	RAD-PIG-RSMA/N-5	Antenna cable, 5 m length		2702140
	BAR-ANT-N-N-EX	Antenna barrier for control cabinet feed-through, type of protection: Ex i, degree of protection: IP65, barrier installation: zone 2, antenna installation: zone 0, 1, or 2, frequency range: 0.3 GHz ... 6 GHz, ATEX and IECEx approval	N (female) → N (female)	2702198
	RAD-CAB-EF393- 3M	Antenna cable, 3 m length, 50 Ω impedance	N (male) → N (male)	2867649
	Alternatively:			
6	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	Directional antenna, 2.4 GHz/5 GHz, gain: 9 dBi, polarization: linear, opening angle: h/v 75°/55°, degree of protection: IP67, seawater-resistant, including mounting bracket and mast clamps, ATEX and IECEx approval	N (female)	2701186
	Alternatively:			
	RAD-ISM-2400-ANT-OMNI-6-0	Omnidirectional antenna, 2.4 GHz, gain: 6 dBi, polarization: linear, opening angle: h/v 360°/30°, degree of protection: IP67, seawater-resistant, including mounting bracket and mast clamps, ATEX and IECEx approval		2885919
	ANT-DIR-868-01	Directional antenna, 868 MHz, gain: 3.5 dBi, polarization: circular, opening angle: h/v 135°/90°, degree of protection: IP67, seawater-resistant, including mounting bracket and mast clamps, ATEX and IECEx approval	N (female)	2702137
	ANT-OMNI-868-01	Omnidirectional antenna, 868 MHz, gain: 4 dBi, polarization: linear, opening angle: h/v 360°/30°, degree of protection: IP67, seawater-resistant, including mounting bracket and mast clamps, ATEX and IECEx approval		2702136

A 2 Control box for wireless systems

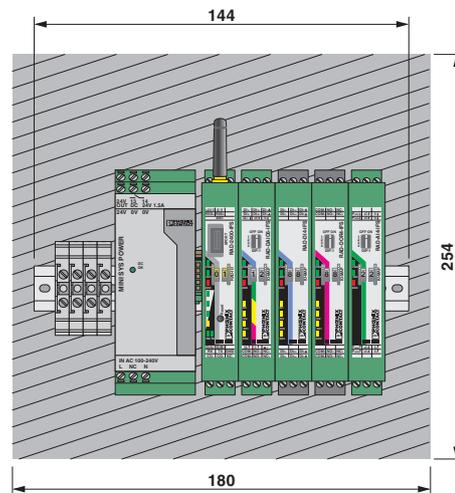
The FL RUGGED BOX control box (Order No. 2701204) is suitable for use in industrial applications. The control box provides space for the power supply, the wireless module, and the I/O extension modules.

Features:

- IP66 protection class
- Mounting suitable for industrial applications
- Bore holes already available, screw connections are included as standard

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

Figure A-12 Control box with wireless system



Installation 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	Wireless module	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

B Appendixes

B 1 List of figures

Figure 3-1:	Application overview	19
Figure 4-1:	Wireless module structure	20
Figure 4-2:	Basic circuit diagram for the wireless module	21
Figure 4-3:	Radioline connection station with up to 32 I/O extension modules	21
Figure 4-4:	Mounting and removal	22
Figure 4-5:	Connecting the cables	23
Figure 4-6:	Connecting the power supply	24
Figure 4-7:	Supply via system power supply	25
Figure 4-8:	DIP switch	27
Figure 4-9:	RS-485 interface pin assignment	27
Figure 4-10:	RS-232 interface pin assignment (DTE - DCE)	28
Figure 4-11:	RS-232 interface pin assignment (DTE - DTE)	28
Figure 4-12:	Connecting the antenna	29
Figure 5-1:	I/O data mode	32
Figure 5-2:	I/O-to-I/O, wireless, and RS-485	33
Figure 5-3:	Serial data mode	34
Figure 5-4:	PLC/Modbus RTU mode	34
Figure 5-5:	PLC/Modbus RTU dual mode	35
Figure 5-6:	Configuration using the configuration stick	37
Figure 5-7:	PSI-CONF software: "Network Settings"	40
Figure 5-8:	PSI-CONF software: "Wizard, Step 3"	42
Figure 5-9:	PSI-CONF software: setting the data transmission rate	42
Figure 5-10:	PSI-CONF software: "Individual Settings, Overview"	43
Figure 5-11:	PSI-CONF software: "Individual Settings, Serial Port"	44
Figure 5-12:	PSI-CONF software: "Individual Settings, Allowed Parents"	44
Figure 5-13:	Diagnostic LEDs on the wireless module	45
Figure 5-14:	Bar graph for point-to-point connection	49
Figure 5-15:	Bar graph for point-to-multipoint connection	49
Figure 5-16:	PSI-CONF software: "Diagnostic, Overview"	50
Figure 5-17:	PSI-CONF software: "Diagnostic, I/O Status"	51
Figure 5-18:	PSI-CONF software: "Diagnostic, Serial Port"	51
Figure 5-19:	PSI-CONF software: "Diagnostic, Network settings"	52
Figure 5-20:	PSI-CONF software: "Record diagnostic data, Network diagnose"	52

Figure 5-21:	Assignment of digital inputs and digital outputs	53
Figure 5-22:	RAD-DAIO6-IFS assignment: analog/digital inputs and outputs	53
Figure 5-23:	Input module and output module with the same address	55
Figure 6-1:	Serial data mode	56
Figure 6-2:	PSI-CONF software: "Wizard, Step 3"	57
Figure 6-3:	PSI-CONF software: "Wizard, Step 4"	57
Figure 6-4:	Frame-based data transmission: $T_{IdleMin}$ parameter	58
Figure 6-5:	Frame-based data transmission: $T_{FrameEnd}$ parameter	58
Figure 6-6:	PSI-CONF software: "Individual Settings"	59
Figure 7-1:	Configuration example: PLC/Modbus RTU mode	60
Figure 7-2:	PSI-CONF software: "Wizard, Step 3"	61
Figure 7-3:	Monitoring of oil pumps	62
Figure 7-4:	Configuration example: PLC/Modbus RTU dual mode	63
Figure 7-5:	Flow meter	65
Figure 7-6:	Access control with door opener	65
Figure 7-7:	PSI-CONF software: "Individual Settings, Network Settings"	66
Figure 7-8:	I/O integration in PC Worx	88
Figure 8-1:	RAD-AI4-IFS structure	89
Figure 8-2:	Basic circuit diagram for the RAD-AI4-IFS	90
Figure 8-3:	RAD-AI4-IFS DIP switches	91
Figure 8-4:	Diagnostic LEDs of the RAD-AI4-IFS	92
Figure 8-5:	RAD-AI4-U-IFS structure	94
Figure 8-6:	Basic circuit diagram for the RAD-AI4-U-IFS	95
Figure 8-7:	RAD-AI4-U-IFS DIP switches	96
Figure 8-8:	Diagnostic LEDs of the RAD-AI4-U-IFS	97
Figure 8-9:	2-conductor connection technology	100
Figure 8-10:	3-conductor connection technology	100
Figure 8-11:	4-conductor connection technology	101
Figure 8-12:	Systematic temperature measuring error ΔT depending on the cable length	101
Figure 8-13:	Systematic temperature measuring error ΔT depending on cable cross-section A	102
Figure 8-14:	Systematic temperature measuring error ΔT depending on cable temperature T_A	102
Figure 8-15:	RAD-PT100-4-IFS structure	103
Figure 8-16:	Basic circuit diagram for the RAD-PT100-4-IFS	104
Figure 8-17:	Diagnostic LEDs of the RAD-PT100-4-IFS	105
Figure 8-18:	RAD-AO4-IFS structure	107

Figure 8-19:	Basic circuit diagram for the RAD-AO4-IFS	108
Figure 8-20:	RAD-AO4-IFS DIP switches	109
Figure 8-21:	Diagnostic LEDs of the RAD-AO4-IFS	110
Figure 8-22:	RAD-DI4-IFS structure	112
Figure 8-23:	Basic circuit diagram for the RAD-DI4-IFS	113
Figure 8-24:	Diagnostic LEDs of the RAD-DI4-IFS	114
Figure 8-25:	RAD-DI8-IFS structure	116
Figure 8-26:	Basic circuit diagram for the RAD-DI8-IFS	117
Figure 8-27:	RAD-DI8-IFS DIP switches	118
Figure 8-28:	Diagnostic LEDs of the RAD-DI8-IFS	119
Figure 8-29:	RAD-NAM4-IFS structure	122
Figure 8-30:	Basic circuit diagram for the RAD-NAM4-IFS	123
Figure 8-31:	Example of supervised digital inputs	125
Figure 8-32:	RAD-DOR4-IFS structure	127
Figure 8-33:	Basic circuit diagram for the RAD-DOR4-IFS	128
Figure 8-34:	RAD-DOR4-IFS DIP switches	129
Figure 8-35:	Diagnostic LEDs of the RAD-DOR4-IFS	130
Figure 8-36:	RAD-DO8-IFS structure	132
Figure 8-37:	Basic circuit diagram for the RAD-DO8-IFS	133
Figure 8-38:	RAD-DO8-IFS DIP switches	134
Figure 8-39:	Diagnostic LEDs of the RAD-DO8-IFS	135
Figure 8-40:	RAD-DAIO6-IFS structure	138
Figure 8-41:	Basic circuit diagram for the RAD-DAIO6-IFS	139
Figure 8-42:	RAD-DAIO6-IFS DIP switches	140
Figure 8-43:	Diagnostic LEDs of the RAD-DAIO6-IFS	141
Figure 9-1:	Penetration of obstacles at different frequencies	146
Figure 9-2:	Point-to-point connection, star network, self-healing mesh network .	147
Figure 9-3:	Distributed network management with parent-child zones	147
Figure 9-4:	RF bands in the 2.4 GHz wireless system	148
Figure 9-5:	RF bands in the 868 MHz wireless system	148
Figure 9-6:	Antenna polarization	151
Figure 9-7:	Decoupling of wireless paths due to directivity and different polarization levels	152
Figure 9-8:	Outdoor installation of antennas	153
Figure 9-9:	Dispersion on a rough surface	158
Figure 9-10:	Diffraction on an edge	158
Figure 9-11:	Reflection on a metal surface	158
Figure 9-12:	Reduction of radio waves when penetrating a wall	159

Figure 9-13:	Angle of the transmitter and receiver	160
Figure 9-14:	Radio dead spot	160
Figure 9-15:	Wireless path with strong wind	161
Figure 9-16:	Fresnel zone	162
Figure 9-17:	Free space attenuation	165
Figure 9-18:	Bush with an attenuation of approximately 15 dB	166
Figure 9-19:	Forest with an attenuation of around 40 dB	166
Figure 10-1:	Loopback test with an RS-232 interface	174
Figure 10-2:	Settings in HyperTerminal	174
Figure A-1:	Omnidirectional antenna, 2 dBi	188
Figure A-2:	Omnidirectional antenna with protection against vandalism, 3 dBi ...	189
Figure A-3:	Omnidirectional antenna, 2.5 dBi	190
Figure A-4:	Omnidirectional antenna, 6 dBi, without surge protection	191
Figure A-5:	Omnidirectional antenna, 6 dBi, with surge protection	192
Figure A-6:	Directional antenna, 9 dBi, with surge protection for outdoor installation 193	
Figure A-7:	Omnidirectional antenna with protection against vandalism, 2.5 dBi	194
Figure A-8:	Omnidirectional antenna, 4 dBi, with surge protection	195
Figure A-9:	Directional antenna, with surge protection	196
Figure A-10:	Directional antennas, 8 dBi, with 2-way antenna splitter for outdoor instal- lation	198
Figure A-11:	Antenna installation in zone 2	199
Figure A-12:	Control box with wireless system	201

B 2 List of tables

Table 3-1:	Firmware versions	17
Table 3-2:	Overview of I/O extension modules	18
Table 4-1:	DIP switches 1 and 2: Termination network	27
Table 5-1:	Factory default settings of the wireless module	30
Table 5-2:	Operating mode of the wireless module	32
Table 5-3:	Yellow thumbwheel settings	36
Table 5-4:	Data transmission rate of the wireless interface, 2.4 GHz.....	41
Table 5-5:	Data transmission rate of the wireless interface, 868 MHz	41
Table 5-6:	LED bar graph	46
Table 5-7:	RSSI voltage, 2.4 GHz.....	47
Table 5-8:	RSSI voltage, 868 MHz	47
Table 5-9:	Assignment of input and output modules	54
Table 5-10:	White thumbwheel settings.....	54
Table 6-1:	Verified parameters for frame-based data transmission	59
Table 7-1:	Configuration via PSI-CONF software	61
Table 7-2:	Configuration via PSI-CONF software	64
Table 7-3:	Supported Modbus function codes	67
Table 7-4:	Module type and currentness of data.....	68
Table 7-5:	Module type IDs.....	68
Table 7-6:	Setting the white thumbwheel for register 30010 (read).....	69
Table 7-7:	RSSI voltage, 2.4 GHz.....	70
Table 7-8:	RSSI voltage, 868 MHz	70
Table 7-9:	RAD-AI4-IFS and RAD-AI4-U-IFS module type and currentness of data.....	71
Table 7-10:	RAD-PT100-4-IFS module type and currentness of data.....	72
Table 7-11:	RAD-AO4-IFS module type and currentness of data	73
Table 7-12:	RAD-DI4-IFS module type and currentness of data	74
Table 7-13:	RAD-DI8-IFS module type and currentness of data	75
Table 7-14:	RAD-NAM4-IFS module type and currentness of data	77
Table 7-15:	RAD-DOR4-IFS module type and currentness of data	78
Table 7-16:	RAD-DO8-IFS module type and currentness of data	79
Table 7-17:	RAD-DAIO6-IFS module type and currentness of data.....	80
Table 7-18:	RSSI signal and error code registers	85
Table 7-19:	Representation of RAD-AI4-IFS analog values.....	86
Table 7-20:	Representation of RAD-AI4-U-IFS analog values	86
Table 7-21:	Representation of RAD-AO4-IFS analog values	86

Table 7-22:	Representation of RAD-DAIO6-IFS analog values	87
Table 7-23:	Representation of RAD-PT100-4-IFS Pt 100 values	87
Table 8-1:	RAD-AI4-IFS DIP switches	91
Table 8-2:	Setting the I/O MAP address for the RAD-AI4-IFS	93
Table 8-3:	RAD-AI4-U-IFS DIP switches	96
Table 8-4:	Setting the I/O MAP address for the RAD-AI4-U-IFS	98
Table 8-5:	Pt 100 input.....	99
Table 8-6:	Setting the I/O MAP address for the RAD-PT100-4-IFS	106
Table 8-7:	RAD-AO4-IFS DIP switches	109
Table 8-8:	Setting the I/O MAP address for the RAD-AO4-IFS	111
Table 8-9:	Setting the I/O MAP address for the RAD-DI4-IFS.....	115
Table 8-10:	RAD-DI8-IFS DIP switches	118
Table 8-11:	Setting the I/O MAP address for the RAD-DI8-IFS.....	121
Table 8-12:	RAD-NAM4-IFS pin assignment.....	123
Table 8-13:	Assignment of the inputs and outputs for RAD-NAM4-IFS	125
Table 8-14:	Example behavior of the diagnostic LEDs, RAD-NAM4-IFS	126
Table 8-15:	Setting the I/O MAP address for the RAD-DI4-IFS.....	126
Table 8-16:	RAD-DOR4-IFS DIP switches.....	129
Table 8-17:	Setting the I/O MAP address for the RAD-DOR4-IFS	131
Table 8-18:	RAD-DO8-IFS DIP switches	134
Table 8-19:	Setting the I/O MAP address for the RAD-DO8-IFS.....	136
Table 8-20:	RAD-DAIO6-IFS DIP switches.....	140
Table 8-21:	Setting the I/O MAP address for the RAD-DAIO6-IFS	142
Table 9-1:	Typical delay times	144
Table 9-2:	Application of antennas	150
Table 9-3:	Antenna characteristics	151
Table 9-4:	Polarization of transmitter/receiver antennas.....	152
Table 9-5:	Level and attenuation of the wireless devices and accessories	154
Table 9-6:	Free space attenuation	156
Table 9-7:	Attenuation of different materials	159
Table 9-8:	Radius of the Fresnel zone depending on the distance	162
Table 9-9:	Ranges for different antennas at 2.4 GHz.....	163
Table 9-10:	Ranges for different antennas at 868 MHz.....	163
Table 10-1:	Detecting and removing errors: Wireless module	168
Table 10-2:	Detecting and removing errors: I/O extension module.....	172

B 3 Index

A

Access control with door opener	65
Accessories	188
Ordering data	177, 178, 179, 180
Adapter cables	188
Addressing	
Extension module	54
I/O data mode	55
Modbus register	67
PLC/Modbus RTU mode	55
Wireless module	36
Analog extension module	89, 93, 99, 107
Analog/digital extension module	137
Antenna	
Accessories	188
Alignment	154
Connection	29
Installation	151
Selection	150, 188
Antenna cable	
See Cable	
Antenna socket	29
Application examples for dual mode	65
Approvals	184
Assignment	
See Pin assignment	
ATEX	184
Attenuation	154, 165

B

Bar graph	46, 167
Point-to-multipoint connection	49
Point-to-point connection	49
Base address	36
Basic circuit diagram	
See Circuit diagram	
Blacklisting	145
Bus connector	
See DIN rail connector	

C

Cables	150, 188
Checking the delivery	15

Checking the location	149
Circuit diagram	
RAD-AI4-IFS	90
RAD-AI4-U-IFS	95
RAD-AO4-IFS	108
RAD-DAIO-6-IFS	139
RAD-DI4-IFS	113
RAD-DI8-IFS	117
RAD-DO8-IFS	133
RAD-DOR4-IFS	128
RAD-NAM4-IFS	123
RAD-PT100-4-IFS	100, 104
Wireless module	21
Circular polarized antenna	152
Class A	7
Coexistence management	145
Configuration software	
See PSI-CONF	
Configuration stick	36, 178
CONFSTICK	36, 178
Connection	
Antenna	29
Cables	23
Power supply	24
Connection station	21
Control box	199
Countries of use	11
Country-specific approvals	11

D

Data Communication Equipment (DCE)	28
Data transmission rate	41
DCE (Data Communication Equipment)	28
Decoupling of wireless paths	152
Delay time	143
Delivery state	30
Denylist	145
Device defect	175
Device replacement	175

-
- Diagnostic LED
- RAD-AI4-IFS 92
 - RAD-AI4-U-IFS..... 97
 - RAD-AO4-IFS..... 110
 - RAD-DAIO6-IFS 141
 - RAD-DI4-IFS 114
 - RAD-DI8-IFS 119
 - RAD-DO8-IFS 135
 - RAD-DOR4-IFS..... 130
 - RAD-NAM4-IFS..... 124
 - RAD-PT100-4-IFS 105
 - Wireless module..... 45
- Diagnostics
- On the wireless module 45
 - Via PSI-CONF software..... 50
- Diffraction 158
- Digital extension module 111, 115, 122, 127, 131
- DIN rail connector 21
- DIP switches
- RAD-AI4-IFS 91
 - RAD-AI4-U-IFS..... 96
 - RAD-AO4-IFS..... 109
 - RAD-DAIO6-IFS 140
 - RAD-DI8-IFS 118
 - RAD-DO8-IFS 134
 - RAD-DOR4-IFS..... 129
 - RAD-NAM4-IFS..... 125
 - Wireless module..... 27
- Directional antenna 150
- Dispersion..... 158
- Disposal 176
- Distributed network management 147
- Dual mode..... 63
- Duty cycle 146
- E**
- EAC Ex 184
- Effective isotropic radiated power 40, 164
- EIRP (effective isotropic radiated power)
- See Effective isotropic radiated power
- Error code 86
- Extended temperature range
- See Temperature range
- Extension module
- Combinations 53
 - Product description 89
- F**
- Factory default setting..... 30
- Fault signaling contact 48
- FCC 12
- Firmware update 31
- Flow meter 65, 144
- Formats
- Analog input and output values 86
 - Pt 100 values..... 87
- Frame-based data transmission..... 57
- Free space attenuation 156, 165
- Frequency-hopping spread spectrum method 145
- Fresnel zone 161
- Function block..... 88
- Function code 67
- G**
- GPS device 149
- H**
- Holding period
- See Duty cycle
- I**
- I/O extension module
- See Extension module
- I/O integration
- Phoenix Contact controller 88
- I/O MAP address..... 54
- RAD-DAIO6-IFS 53
- IECEX..... 184
- IFT 13
- Industry Canada (IC)..... 12
- Input and output module 137
- Input module 89, 93, 99, 111, 115, 122
- L**
- LED
- See Diagnostic LED
- LED bar graph
- See Bar graph
- Level 154
- Loopback test 173

M

Maintenance 176
 Measuring error (Pt 100) 101
 Memory stick 38
 Mexico 13
 Modbus 60
 Modbus function code
 See Function code
 Modbus memory map 70
 General overview 82
 Modbus register 67
 Modbus telegram watchdog
 See Watchdog
 Monitoring of oil pumps 62
 Mounting 21
 Multipath propagation 48, 158

N

NAMUR 122
 NCC 13
 Network key 36
 Network management
 See Distributed network management

O

Oil pump 62
 Omnidirectional antenna 150
 Output module 107, 127, 131

P

PC Worx 88
 Penetration 159
 Pin assignment
 RS-232 28
 RS-485 27
 PLC/Modbus RTU dual mode 63
 PLC/Modbus RTU mode 60
 Polarization 151, 152
 Potentially explosive area 9, 151, 199
 Practical test 149

Process data table

RAD-AI4-IFS 71
 RAD-AI4-IU-IFS 71
 RAD-AO4-IFS 73
 RAD-DAIO-6-IFS 80
 RAD-DI4-IFS 74
 RAD-DI8-IFS 75
 RAD-DO8-IFS 79
 RAD-DOR4-IFS 78
 RAD-NAM4-IFS 77
 RAD-PT100-4-IFS 72

PSI-CONF

Configuration 39
 Configuration in PLC/Modbus RTU mode 61
 Diagnostics 50
 Pt 100 values 87
 Pt 100 input 99
 Pulse counter mode 118
 Pulse transmission 144

R

RAD ID 36
 RAD-AI4-IFS 89
 RAD-AI4-U-IFS 93
 RAD-AO4-IFS 107
 RAD-DAIO6-IFS 137
 RAD-DI4-IFS 111
 RAD-DI8-IFS 115
 RAD-DO8-IFS 131
 RAD-DOR4-IFS 127
 Radiated power
 See Effective isotropic radiated power
 Radio dead spot 160
 Radio waves 158
 Radioline function blocks 88
 RAD-NAM4-IFS 122
 RAD-PT100-4-IFS 99
 RAD-RS485-IFS 33
 Range 163
 Receiver sensitivity 41
 Recording parameters 52
 Redundant power supply 25
 Reflection 158
 Register 67
 Relay output 129

Relay, wireless module		Temperature sensor	
See RF link relay		2-conductor sensor	100
Remote address.....	36	3-conductor sensor	102
Removal.....	21	4-conductor sensor	101
Repairs	175	Termination network	27
Repeater address	36	Termination resistor	27
Repeater chain.....	44	Thumbwheel, white	54
Reset		Thumbwheel, yellow	36
Counter value (pulse counter mode)	119	Transport	14
To factory default settings	31	Troubleshooting	167
Residential areas	7		
RF band	36	U	
RAD-2400-IFS.....	148	UL notes	10
RAD-868-IFS.....	148	Update	31
RF link relay	48	USB cable.....	39
RS-232 interface	26		
RS-485 front module	18	W	
RS-485 interface	26	Watchdog	62
RS-485 station	33	Weather influences	161
RSMA antenna socket	29	Well pad monitoring system	62
RSSI signal register.....	87	Wind	161
RSSI test socket.....	48	Wireless module	
RSSI voltage	47, 167	Configuration.....	32
		Installation.....	21
		Product description	20
S			
Safety notes	6	Z	
Saving the configuration.....	38	Zone 2.....	9
Serial data mode	56		
Serial interface	26		
SET button	48		
Shield connection	26		
Signal strength			
See RSSI voltage			
Startup time.....	55		
Storage	14		
Supply voltage	24		
System calculation	165		
System power supply	25		
T			
Taiwan	13		
Technical data.....	177		
Temperature input.....	99		
Temperature measuring error			
See Measuring error			
Temperature range	186		

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