RFID SYSTEMS

SIMATIC RF600

System Manual · 05/2012

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System Manual

05/2012

J31069-D0171-U001-A13-7618

Legal information

Warning notice system

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

DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

CAUTION
with a safety alert symbol, indicates that minor personal injury can result if proper precautions are not taken.

CAUTION
without a safety alert symbol, indicates that property damage can result if proper precautions are not taken.

NOTICE
indicates that an unintended result or situation can occur if the relevant information is not taken into account.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

WARNING
Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

Disclaimer of Liability

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

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Table of contents

1 Introduction

1.1 Preface

Purpose of this document

This system manual contains the information needed to plan and configure the RF600 system.

It is intended both for programming and testing/debugging personnel who commission the system themselves and connect it with other units (automation systems, further programming devices), as well as for service and maintenance personnel who install expansions or carry out fault/error analyses.

Scope of this documentation

This documentation is valid for all supplied variants of the SIMATIC RF600 system and describes the products supplied as of May 2012. If you are using older firmware versions, please refer to the 08/2011 edition of the documentation.

Registered trademarks

SIMATIC ® is a registered trademark of the Siemens AG.

History

Edition	Comment
11/2005	First edition
03/2006	2nd revised edition
04/2006	3rd revised and extended edition Details in the technical descriptions were revised.
06/2006	4th revised and extended edition
07/2008	5th revised and extended edition
11/2008	6th revised and extended edition: new RF620R and RF630R readers
07/2009	7th revised and extended edition: FCC approval RF620R/RF630R
10/2009	8th revised and expanded edition for multitag mode
12/2009	9th revised and extended edition
06/2010	10th revised and extended edition
09/2010	11th revised edition

Edition	Comment
08/2011	12th revised and expanded edition New reader RF640R, new antennas RF640A and RF642A
05/2012	13th revised and extended edition

Declaration of conformity

The EC declaration of conformity and the corresponding documentation are made available to authorities in accordance with EC directives. Your sales representative can provide these on request.

Observance of installation guidelines

The installation guidelines and safety instructions given in this documentation must be followed during commissioning and operation.

1.2 Abbreviations and naming conventions

The following terms/abbreviations are used synonymously in this document:

Read/write device (SLG)	Reader
Mobile data memory, MDS, data carrier, smart label	Transponder, tag
Interface module, ASM	Communications module, CM

1.3 Navigating in the system manual

Structure of contents	Contents
Table of contents	Organization of the documentation, including the index of pages and sections
Introduction	Purpose, layout and description of the important topics.
Safety Information	Refers to all the valid technical safety aspects which have to be adhered to while installing, commissioning and operating the product/system and with reference to statutory regulations.
System overview	Overview of all RF identification systems, system overview of SIMATIC RF600.
RF600 system planning	Information about possible applications of SIMATIC RF600, support for application planning, tools for finding suitable SIMATIC RF600 components.
Readers	Description of readers which can be used for SIMATIC RF600.
Antennas	Description of antennas which can be used for SIMATIC RF600.
Transponder/tags	Description of transponders which can be used for SIMATIC RF600.
Integration into networks	Integration of the RF600 reader to higher-level systems, control.
System diagnostics	Description of the flash codes and error codes of the reader.
Accessories	Connecting cable, wide-range power supply unit, technical data, ordering lists, dimension drawings
Appendix	Service and support, contact partners, training centers.
List of abbreviations	List of all abbreviations used in the document.

2 Safety Information

2.1 General safety instructions

CAUTION
Please observe the safety instructions on the back cover of this documentation.

SIMATIC RFID products comply with the salient safety specifications to VDE/DIN, IEC, EN, UL and CSA. If you have questions about the admissibility of the installation in the designated environment, please contact your service representative.

CAUTION
Alterations to the devices are not permitted. Failure to observe this requirement shall constitute a revocation of the radio equipment approval, CE approval and manufacturer's warranty.

Repairs

Repairs may only be carried out by authorized qualified personnel.

WARNING
Unauthorized opening of and improper repairs to the device may result in substantial damage to equipment or risk of personal injury to the user.

System expansion

Only install system expansion devices designed for this device. If you install other upgrades, you may damage the system or violate the safety requirements and regulations for radio frequency interference suppression. Contact your technical support team or where you purchased your device to find out which system expansion devices may safely be installed.

CAUTION
If you cause system defects by improperly installing or exchanging system expansion devices, the warranty becomes void.

2.2 Safety instructions for third-party antennas as well as for modifications to the RF600 system

Always observe the following general safety instructions before selecting a component from a different vendor:

The manufacturer accepts no responsibility for functional suitability or legal implications for the installation of third-party components.

NOTICE
Loss of radio equipment approvals
Alterations to the SIMATIC RF600 devices themselves are not permitted. Failure to observe this requirement shall constitute a revocation of the CE, FCC, UL, CSA radio equipment approvals and the manufacturer's warranty.

Modifications to the SIMATIC RF600 system

CAUTION
Damage to the system
If you install unsuitable or unapproved extensions, you may damage the system or violate the safety requirements and regulations for radio frequency interference suppression. Contact your technical support team or where you purchased your device to find out which system extensions may safely be installed.

CAUTION
Loss of warranty
If you cause defects on the SIMATIC RF600 system by improperly installing or exchanging system expansions, the warranty becomes void.

NOTICE
Loss of validity for type tests and certificates
SIMATIC RFID products comply with the salient safety specifications to VDE/DIN, IEC, EN, UL and CSA. When using RFID components which do not belong to the RF600 range of products, the validity of all type tests as well as all certificates relevant to the RF600 are canceled: CE, FCC, UL, CSA.

Note

User responsibility for modified product

As a user of the modified product, you accept responsibility for use of the complete RFID product comprising both SIMATIC RF600 components and third-party RFID components. This particularly applies to modification or replacement of:

- Antennas
- Antenna cables
- readers
- Power supply units with connection cables

2.3 Safety distance to transmitter antenna

2.3.1 Safety distance between transmitter antenna and personnel

For antenna configurations where it is possible to be briefly or constantly within the transmission range of the antennas, as in loading ramps, for example, minimum distances must be maintained.

Limits

The ICRP (International Commission of Radiological Protection) has worked out limit values for human exposure to HF fields that are also recommended by the ICNIRP (International Commission of Non Ionizing Radiological Protection). In German legislation on emissions (since 1997), the following limit values apply. These can vary according to frequency:

Frequency f [MHz]	Electrical field strength E [V/m]	Magnetic field strength H [A/m]
10 - 400	27,5	0,073
400 - 2.000	1.375 x $f^{1/2}$	0.0037 x $f^{1/2}$
2.000 - 300.000	61	0,16

The limit values for the 900 MHz reader antenna alternating field are thus:

Electrical field strength: E = 41.25 V/m

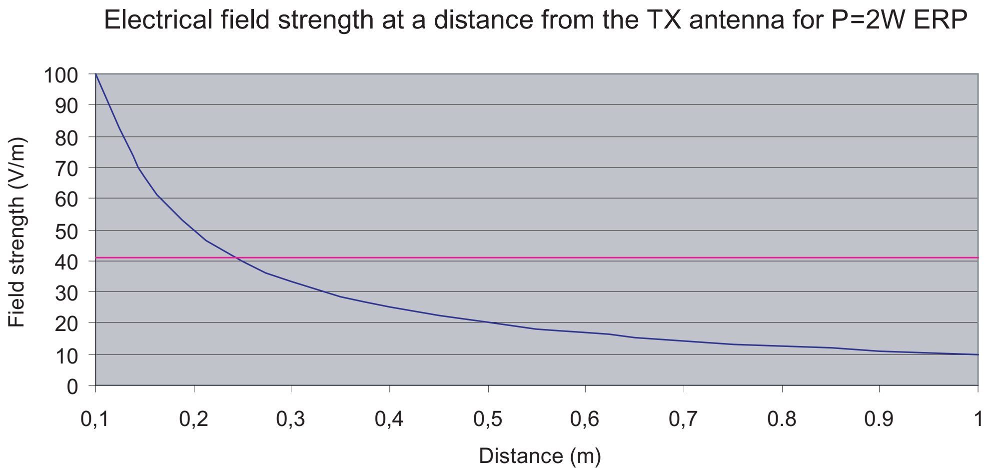
Magnetic field strength: H = 0.111 A/m

HF power density: E x H = 4.57 W/m^2

2.3.2 Minimum distance to antenna in accordance with ETSI

Minimum distance to antenna in accordance with ETSI (EU, EFTA, Turkey)

At a transmission frequency of 900 MHz, the wavelength of the electromagnetic wave λ is approximately 0.34 m. For distances less than 1 λ in the near field, the electrical field strength (1/r) diminishes exponentially to the power three over distance, and for distances greater than 1 λ, it diminishes exponentially to the power two over distance.



The horizontal line at 41.25V/m marks the "safety limit value".

For the maximum permissible transmit power ($1/r^2$) in accordance with ETSI (2W ERP), the "safety distance" d = 0.24 m. This means that personnel should not remain closer than 24cm to the transmitter antenna for extended periods (more than several hours without interruption). Remaining within the vicinity of the antenna for a brief period, even for repeated periods (at a distance < 0.24 m), is harmless according to current knowledge.

Distance to transmitter antenna [m]	Feld strength [V/m]	% of limit value
1	10	24
5	2	5

If the transmitter power is set lower than the highest permissible value (2 watts ERP), the "safety distance" reduces correspondingly.

The values for this are as follows:

Radiated power ERP [W]	Safety distance to transmitter antenna [m]
2.0	0.24
1.0	0.17
0.5	0.12

Note

Reduced maximum radiated power with RF620R/RF630R readers

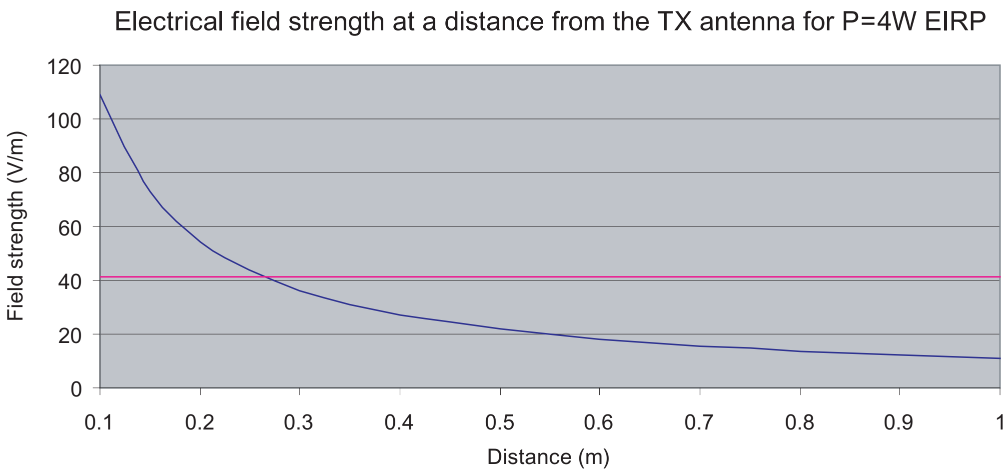
The SIMATIC RF620R (ETSI) reader has a maximum radiated power of 0.5 W ERP. The maximum safety distance is therefore 0.12 m.

The SIMATIC RF630R (ETSI) reader has a maximum transmitter power of 0.5 W. The radiated power therefore depends on the antenna cable and the type of antenna used, but must not exceed the 2 W ERP.

2.3.3 Minimum distance to antenna in accordance with FCC (USA)

Minimum distance to antenna in accordance with FCC (USA)

For the maximum permissible radiated power in accordance with FCC (4W EIRP), the "safety distance" d = 0.26 m. This means that personnel should not remain closer than 26 cm to the transmitter antenna for extended periods (several hours without interruption). Remaining within the vicinity of the antenna for brief period, even repeated periods (at a distance < 0.26 m) is harmless to health according to current knowledge.



The horizontal line at 41.25 V/m marks the "safety limit value".

Distance to transmitter antenna [m]	Feld strength [V/m]	% of limit value
1	10.9	26
5	2.2	5.3

If the transmit power is set lower than the highest permissible value (4 watts EIRP), the "safety distance" reduces correspondingly.

The values for this are as follows:

Radiated power EIRP [W]	Safety distance to transmitter antenna [m]
4.0	0.26
<2.5	>0.20

Generally a safety distance of at least 0.2 m must be maintained.

Note

Reduced maximum radiated power with RF620R/RF630R readers

The SIMATIC RF620R (FCC) reader has a maximum transmit power of 0.5 W. Thus the radiated power of 4 W EIRP cannot be exceeded with the internal antenna.

The SIMATIC RF630R (FCC) reader has a maximum transmit power of 0.5 W. The radiated power therefore depends on the antenna cable and the type of antenna used, but must not exceed the 4 W EIRP.

System overview 3

3.1 RF System SIMATIC RF600

SIMATIC RF600 is an identification system that operates in the UHF range. UHF technology supports large write/read distances with passive tags.

The SIMATIC RF670R readers (write/read devices), fitted for example on the gates of a warehouse, automatically record every movement of goods, and signal these to the higher-level systems. The data are filtered and compressed there by data management software at the control level in order, for example, to generate the receiving department transaction for the ERP (Enterprise Resource Planning) system at the business administration control level. At the same time, the delivery can be automatically checked for correctness and completeness prior to storage by means of the electronic delivery list.

The general automation and IT structure of a company is shown in the following figure. This comprises several different levels that are described in detail below.

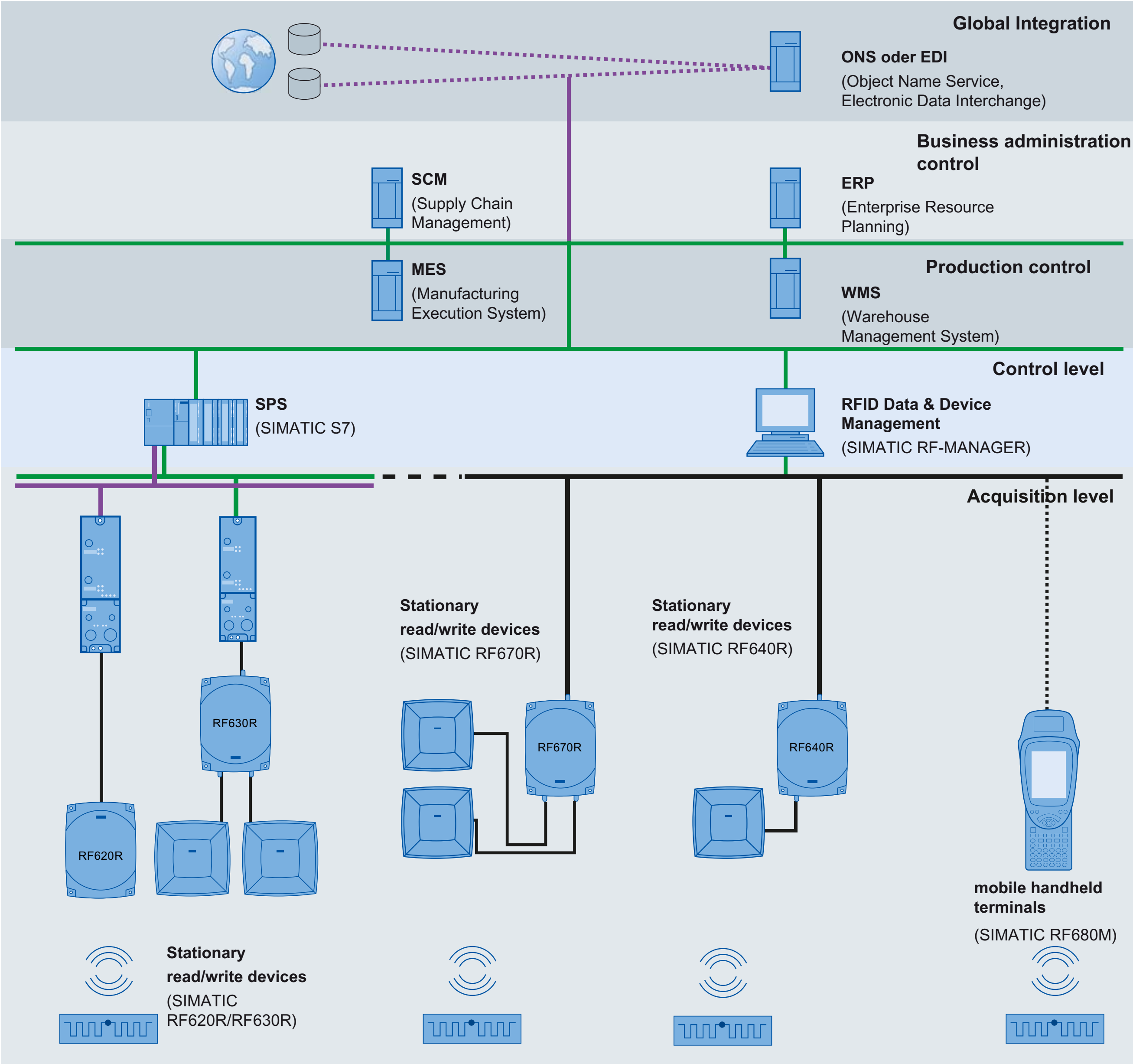


Figure 3-1 System overview of SIMATIC RF600

- **Acquisition level**
  This level contains the RFID readers that read the appropriate tag data and transfer them to the next highest level.
- **Control level**
  At the control level , the RFID data are collected, preprocessed and presented to the production control and business administration control levels for further processing.

- **Production control**
  The Manufacturing Execution System (MES) closes the gap between the data that arise in the automation environment (control level) and the logistical and commercial processes of the company (business administration control). MES solutions are used, for example, for defining and performing production processes.
- **Business administration control**
  This level covers planning and control of the equipment used. For this purpose, Enterprise Resource Planning (ERP) systems and Supply Chain Management (SCM) systems are used with modules for cost accounting, financial bookkeeping and personnel management.
- **Global integration**
  Product information can be exchanged here at an inter-company level. This can be performed over the Internet with the help of special services.

3.1.1 Application areas of RF600

RFID (radio frequency identification) permits interruption-free tracking and documentation of all delivered, stocked and shipped goods in the incoming goods, warehouse, production logistics and distribution departments. A small data medium - referred to as SmartLabel, transponder or tag - is attached to every item, package or pallet, and contains all important information. The data medium receives the power it requires via an antenna which is also used for data transmission.

3.1.2 System components (hardware/software)

RF600 products	Description
	Due to its compact format and high degree of protection, the RF670R reader is ideally suited to applications in production logistics and distribution. The integrated data processing makes it easier to use in complex scenarios and reduces the IT integration costs. Integration is performed using an XML protocol, TCP/IP and Ethernet.
	Due to its compact format and high degree of protection, the RF640R reader is ideally suited to applications in production logistics and distribution. The integrated data processing makes it easier to use in complex scenarios and reduces the IT integration costs. Integration is performed using an XML protocol, TCP/IP and Ethernet. It has an integrated circular polarized antenna.
	The RF620R reader creates with its connection to a SIMATIC controller optimum preconditions for production-related application scenarios and/or production-related logistics applications by RFID. It has an integrated circular polarized antenna.

RF600 products	Description
	The RF630R reader creates with its connection to a SIMATIC controller optimum preconditions for production-related application scenarios and/or production-related logistics applications by RFID. It has 2 connections for external antennas.
	SIMATIC RF680M expands the RF600 RF identification system with a powerful mobile reader for applications in the areas of logistics, production and service. In addition, it is an indispensable aid for startup and testing.
	Also the RF660A antennas are equipped for the harsh conditions in production and logistics environments due to their high IP67 degree of protection. Up to 4 antennas can be connected to the RF670R reader depending on the application and up to two can be connected to the RF630R reader. One antenna can be connected to the RF640R or RF620R readers as an alternative to the internal antenna.
	The SIMATIC RF640A is a circular antenna of medium size for universal applications, for example material flow and logistics systems. Depending on the application, up to 4 antennas can be connected to the RF670R reader and up to two antennas can be connected to the RF630R reader. One antenna can be connected to the RF640R or RF620R reader as an alternative to the internal antenna.

RF600 products	Description
	SIMATIC RF642A is a linear antenna of medium size for environments where a lot of metal occurs. Depending on the application, up to 4 antennas can be connected to the RF670R reader and up to two antennas can be connected to the RF630R reader. One antenna can be connected to the RF640R or RF620R reader as an alternative to the internal antenna.
	The SIMATIC RF620A is an antenna of compact, industry-standard design. It is suitable for UHF transponders with normal (far field) antenna characteristics. Depending on the application, up to 4 antennas can be connected to the RF670R reader and up to two antennas can be connected to the RF630R reader. One antenna can be connected to the RF640R or RF620R reader as an alternative to the internal antenna.
	The RF600 tag family offers the right solution for every application: The RF640T tool tag for industrial requirements is highly resistant to oils and can be directly mounted on metal. The RF620T container tag for industrial requirements is rugged and highly resistant to detergents. The RF630L Smart Labels made of plastic or paper can be used in many different applications: The application areas range from simple identification such as electronic barcode replacement/supplementation, through warehouse and distribution logistics, right up to product identification

3.1.3 Features

The RF600 identification system has the following performance features:

RFID system RF600	
Type	Contactless RFID (Radio Frequency IDentification) system in the UHF band

RF620R reader	
Transmission frequency	865-868 MHz (EU, EFTA, Turkey) 902-928 MHz (USA) 920.125 - 924.875 MHz (CHINA)
Writing/reading range	Internal antenna: < 2 m External antenna: < 2.5 m
Standards	EPCglobal Class 1, Gen 2

RF630R reader	
Transmission frequency	865-868 MHz (EU, EFTA, Turkey) 902-928 MHz (USA) 920.125 - 924.875 MHz (CHINA)
Writing/reading range	0.1 - 2 m
Standards	EPCglobal Class 1, Gen 2

RF640R reader	
Transmission frequency	865-868 MHz (ETSI: EU; EFTA, Turkey) 902-928 MHz (FCC: USA) 920.125 - 924.875 MHz (CMIIT: CHINA)
Writing/reading range	Internal antenna: < 3,5 m External antenna: < 4 m
Standards	EPCglobal Class 1, Gen 2

RF670R reader	
Transmission frequency	865-868 MHz (ETSI: EU; EFTA, Turkey) 902-928 MHz (FCC: USA) 920.125 - 924.875 MHz (CMIIT: CHINA)
Writing/reading range	< 4 m
Standards	EPCglobal Class 1, Gen 2

RF680M mobile handheld terminal	
Transmission frequency	865-868 MHz (EU, EFTA, Turkey) 902-928 MHz (USA)
Writing/reading range	Europe < 2 m USA < 1 m
Standards	EPCglobal Class 1, Gen 2

Transponder/tags			
Version	Tags / Smart Labels	Designation	Standards supported
	Smart Labels	RF630L	EPCglobal Class 1, Gen 2
	Smart Label	RF680L	EPCglobal Class 1, Gen 2
	ISO card	RF610T	EPCglobal Class 1, Gen 2
	Container tag	RF620T	EPCglobal Class 1, Gen 2
	Disc tag	RF625T	EPCglobal Class 1, Gen 2
	Powertrain tag	RF630T	EPCglobal Class 1, Gen 2
	Tool tag	RF640T (Gen 2)	EPCglobal Class 1, Gen 2
	Heat-resistant tag	RF680T	EPCglobal Class 1, Gen 2

Software	
RF-MANAGER Basic V2	PC software for assigning parameters to the RF670R and RF640R readers System requirement: Windows XP, SP2 and higher

RF600 system planning 4

4.1 Overview

You should observe the following criteria for implementation planning:

- Possible system configurations
- Antenna configurations
- Environmental conditions for transponders
- The response of electromagnetic waves in the UHF band
- Regulations applicable to frequency bands
- EMC Directives

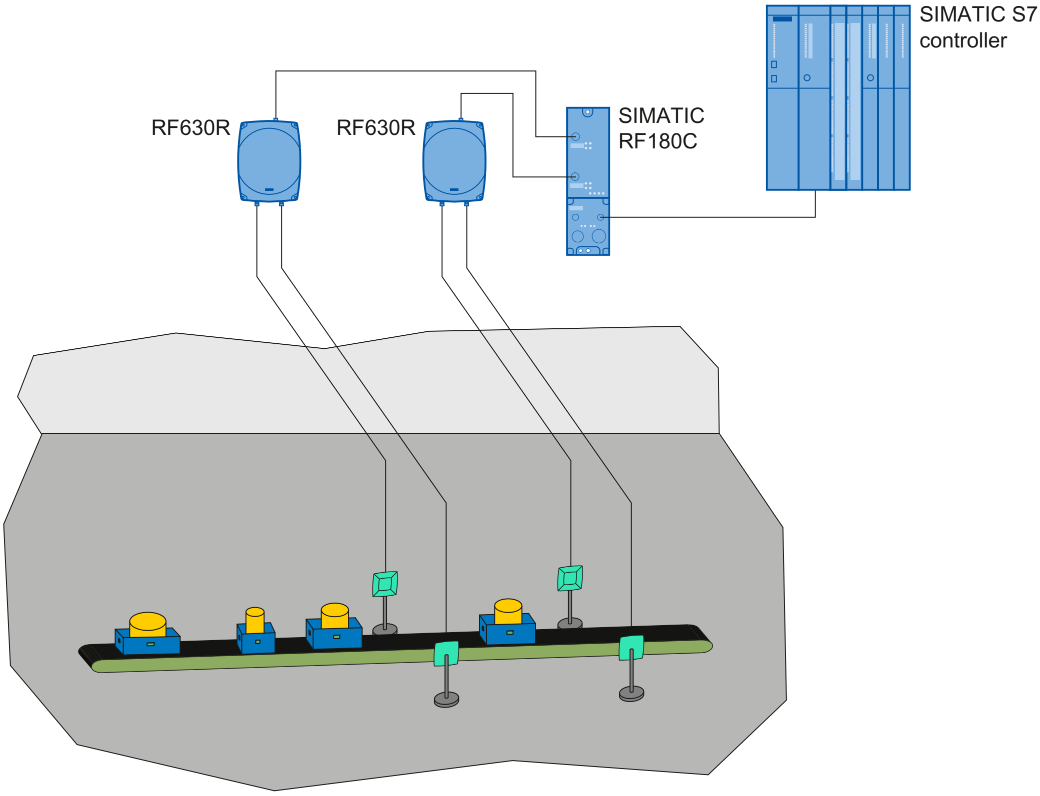
4.2 Possible system configurations

The SIMATIC RF600 system is characterized by a high level of standardization of its components. This means that the system follows the TIA principle throughout: Totally Integrated Automation. It provides maximum transparency at all levels with its reduced interface overhead. This ensures optimum interaction between all system components.

The RF600 system with its flexible components offers many possibilities for system configuration. This chapter shows you how you can use the RF600 components on the basis of various example scenarios.

4.2.1 Scenario for material handling control

This scenario shows a possible solution for monitoring and controlling the infeed of material to a production line. The objective is to provide the right material at the right time. This can be particularly useful in plants with frequently changing manufacturing scenarios for ensuring that incorrect infeed and downtimes are minimized.



Features of the scenario

The conveyor moves different transport containers past the readers in an arbitrary alignment. The RFID tag is, however, always applied to the transport containers with the same alignment. The tags in this scenario are transponders of type SIMATIC RF620T.

The conveyor has a maximum width of 80 cm in this example. The transport velocity is up to 2 m/s. With this arrangement only a single RFID tag has to be detected each time (single-tag).

In this scenario a SIMATIC RF630R is used as the reader. Optimum reading reliability is ensured by two external SIMATIC RF660A antennas in a portal arrangement. Where the distances to, or between, the materials containers are extremely short the SIMATIC RF620A is an excellent alternative. The SIMATIC°RF630R reader reads the information from the tags on the transport containers and transfers it via a communication module to the SIMATIC S7 controller which controls the process in accordance with the tag information.

Summary of the features

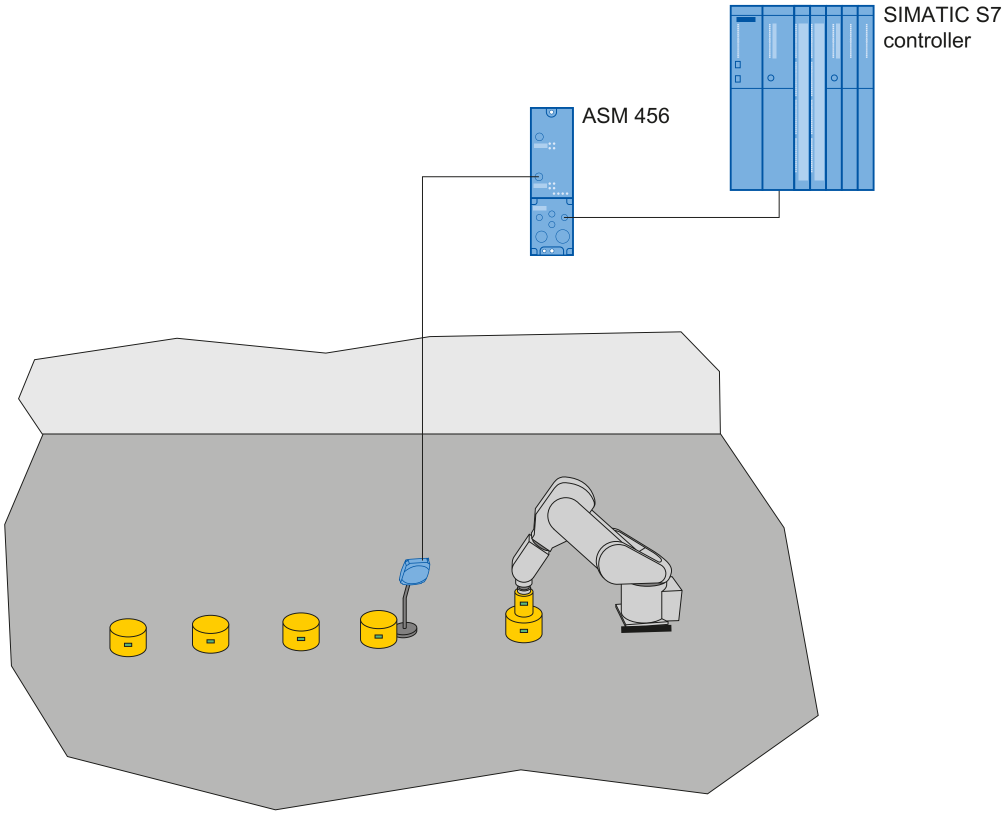
Note

Note that the following features show sample values for the scenario. The specific data for your application may deviate from these values.

Feature	
Single-tag	Yes
Multi-tag	No
Read velocity	Max. 2 m/s
Orientation of the RFID tag	Not defined
Carrier material of the tag	Metal or non-metal
Reading range	Approx. 1 m
Reader density	High
Interference	High

4.2.2 Scenario for workpiece identification

A typical characteristic of modern manufacturing scenarios is their multitude of variations. The individual data and production steps are stored in the tag of a toolholder or product. These data are read by the machining stations during a production process and, if necessary, tagged with status information. This can be used to dynamically identify which production step is the next in the series. This has the advantage that the production line can work automatically without the need to access higher system components. The use of RFID therefore increases the availability of the plant.



Features of the scenario

RFID tags are attached to workpiece holders. Their spatial orientation is always identical. With this arrangement, only a single tag has to be detected each time (single-tag). The tags in this scenario are transponders of type SIMATIC RF640T.

The SIMATIC RF620R reader reads the information from the tags with its integrated antenna and transfers it to the SIMATIC S7 controller via a communication module. Depending on the stored tag information, the SIMATIC-S7 performs different control tasks, for example, automatically providing a suitable tool for an industrial robot at the correct time.

Summary of the features

Note

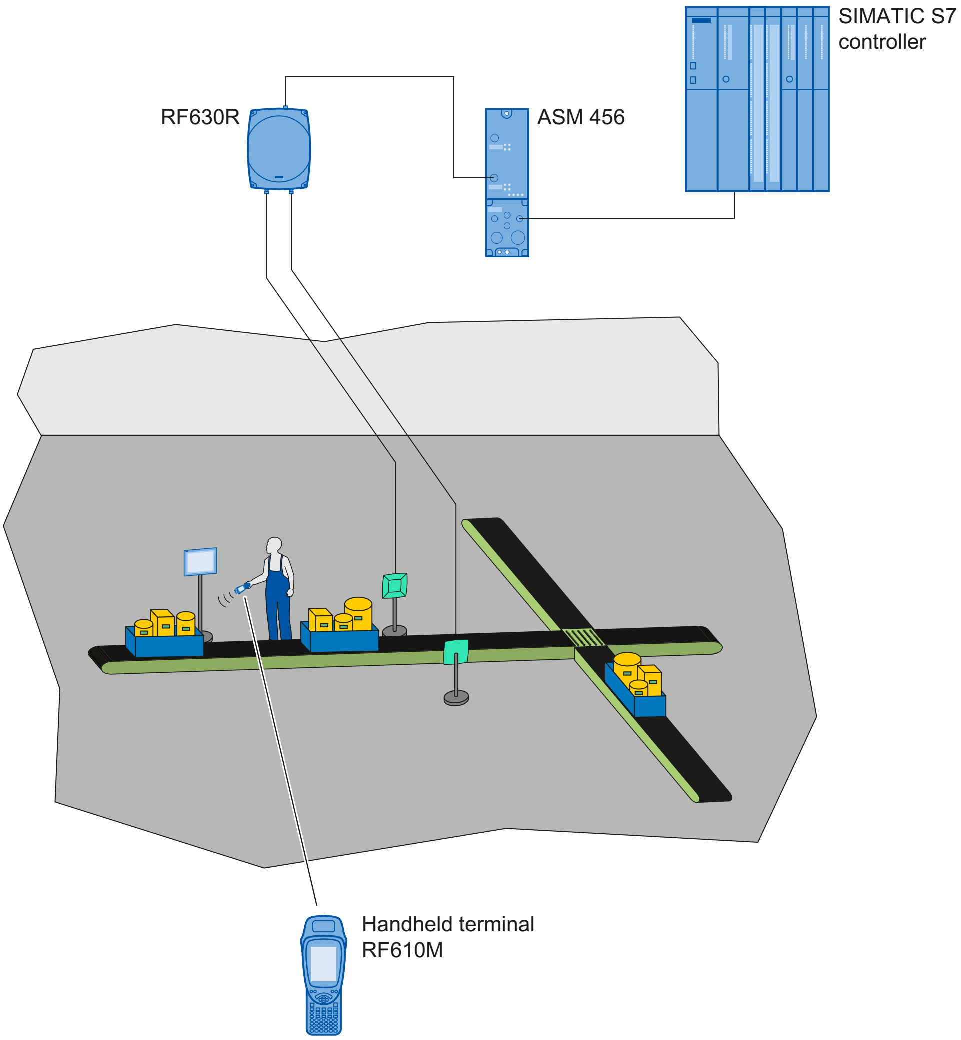
Note that the following features show sample values for the scenario. The specific data for your application may deviate from these values.

Features	
Single-tag	Yes
Multi-tag	No
Reading velocity	Not applicable
Orientation of the RFID tag	Same alignment for all the tags
Carrier material of the tag	Metal
Reading distance	Approx. 1 m
Reader density	High
Interference	High

4.2.3 Scenario for Intra logistics

Intra logistics comprises all logistical procedures that are required on a production site as well as within the overall company. The main task of Intra logistics is to control the subsequent processes:

- Transporting goods from the incoming goods bay into the warehouse
- Management of stock
- Conveyance of goods from the warehouse for production
- Order picking
- Packing



Features of the scenario

In this example scenario. items must be distributed to the correct storage location in a transport container via a separating filter. The RFID tags of type SIMATIC RF630L are directly attached to the item. The maximum transport velocity of the conveyor is 2 m/s.

In this scenario, bulk acquisition is necessary because several objects must be detected at the same time.

The SIMATIC RF630R reader uses two external antennas in a portal arrangement to read the information from the tags on the passing items and transfers it to the SIMATIC S7 controller via a communication module. The SIMATIC S7 controls the separating filter of the conveyor system depending on the tag information.

If only one simple evaluation of the tag ID is required, and the data will not undergo further processing, the SIMATIC RF670R offers this function without interfacing to the controller.

The SIMATIC RF680M mobile handheld terminal is used in this example for additional analysis and visualization of the item data directly on site.

Summary of the features

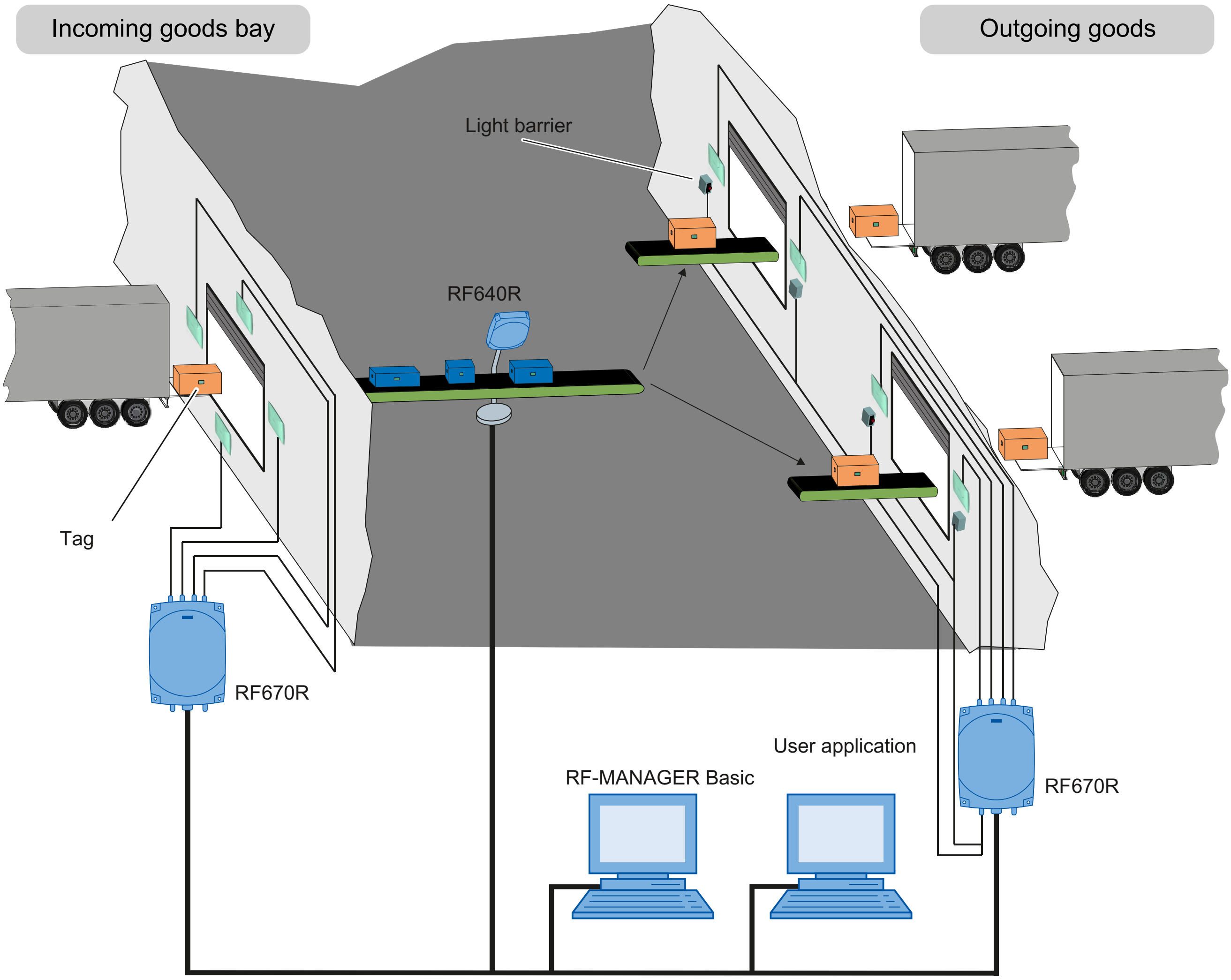
Note

Note that the following features show sample values for the scenario. The specific data for your application may deviate from these values.

Features	
Single-tag	Yes
Multi-tag	No
Reading velocity	Max. 2 m/s
Orientation of the RFID tag	Same alignment for all the tags
Carrier material of the tag	Metal
Reading range	Approx. 1 m
Reader density	High
Interference	High

4.2.4 Scenario incoming goods, distribution of goods and outgoing goods

The scenario comprises an RFID system with three readers. The SIMATIC RF670R reader with its four antennas monitors the incoming goods gate of a factory building hall through which pallets are delivered. Each pallet is fitted with a tag. The tags contain user data that provides information about the sender and receiver of the goods. This data is read out and passed on. The goods supplied on the pallets are processed in the factory and then exit the factory through the outgoing goods gate.



in this example, the SIMATIC RF640R reader is controlled by a light barrier and monitors a conveyor belt; the conveyor belt transports the goods towards two output gates that are assigned to different recipients. Each item has a tag that is always fitted at the same position and with the same alignment on the item. These tags also contain user data that provides information about the sender and receiver of the goods. There is a separator at the end of the conveyor belt that determines the output gate to which the goods should be directed. The separator is set according to the results from the reader and the goods are distributed.

After the separator, the goods are loaded onto pallets - each pallet is fitted with a tag. These tags also contain user data that provides information about the sender and receiver of the goods. Based on the data read by the SIMATIC RF670R reader, the pallets at the outgoing goods gate are checked to make sure that they are intended for the receiver to which the gate is assigned. Light barriers are installed to control the reader. Depending on the read results of the reader, the outgoing portal opens, or it remains closed.

Summary of the features

Note

Note that the following features show sample values for the scenario. The specific data for your application may deviate from these values.

Feature	
Single-tag	No
Multi-tag	Yes
Read velocity	2 m/s
Tag orientation	Specified and not specified
Material characteristics	Non-metal
Reading ranges	Approx. 3.5°m
Reader density	High
Interference	High

4.3 Antenna configurations

Note

Validity of antenna configuration

The following specifications for the antenna configuration only apply to the RF660A antenna. See Section Guidelines for selecting RFID UHF antennas (Page 54) for specifications for the configuration of third-party antennas.

4.3.1 Antenna configuration example

The following diagram shows an application example for an antenna configuration of the RF670R. The antennas are positioned at the height at which the tags are expected which are to be identified. The maximum width of the portal that is recommended for reliable operation is 4 m.

The diagram shows a configuration with three antennas. Up to four antennas can be used depending on the local conditions.

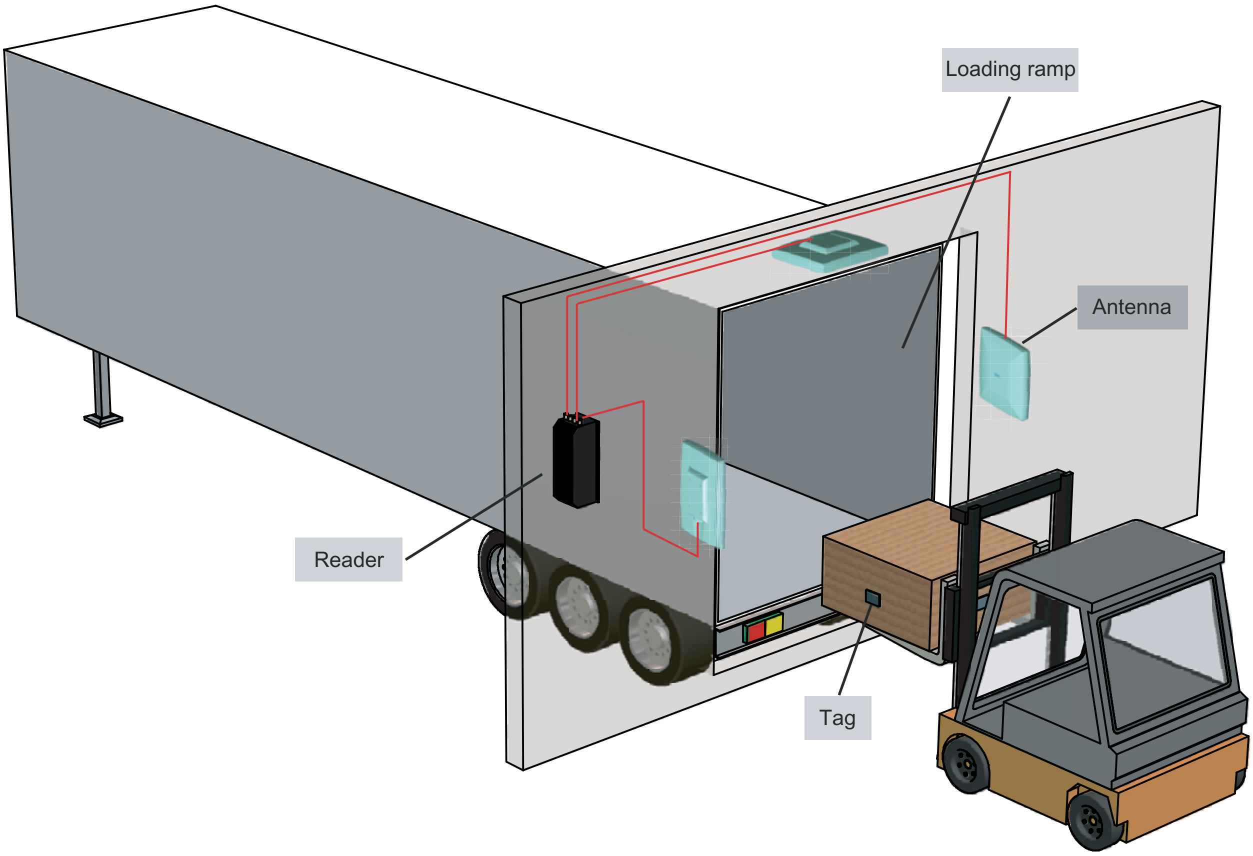
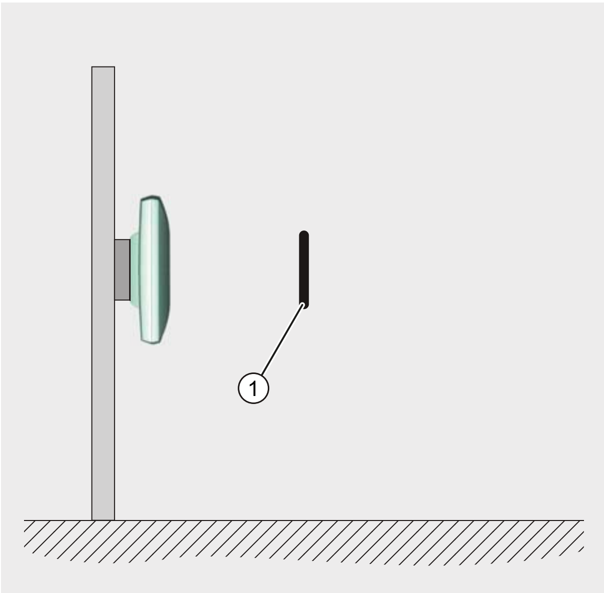
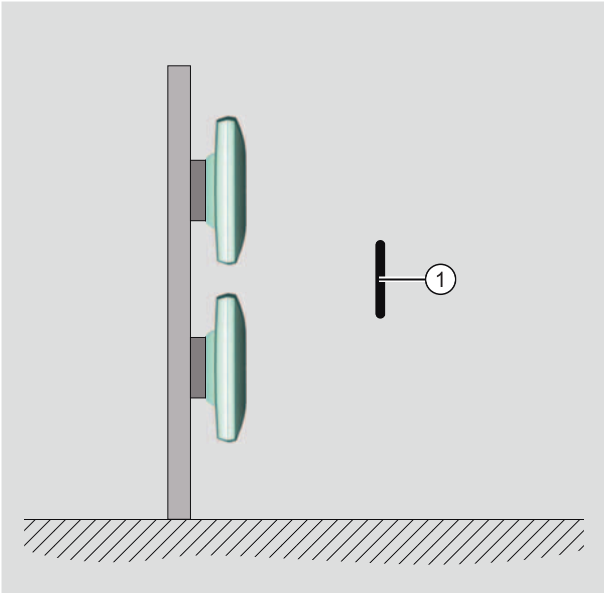


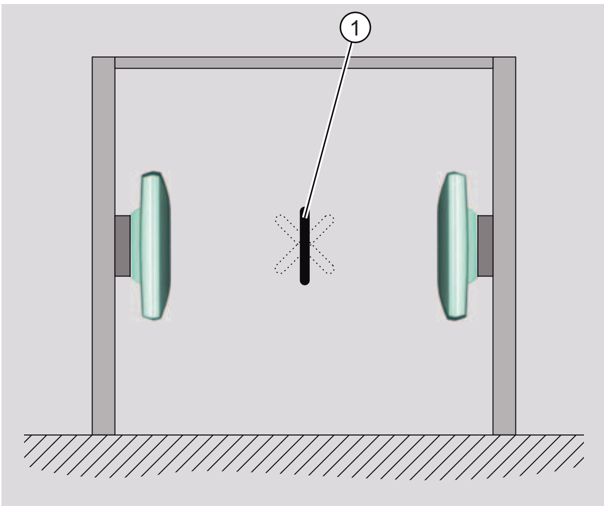
Figure 4-1 Example of an antenna configuration with three antennas

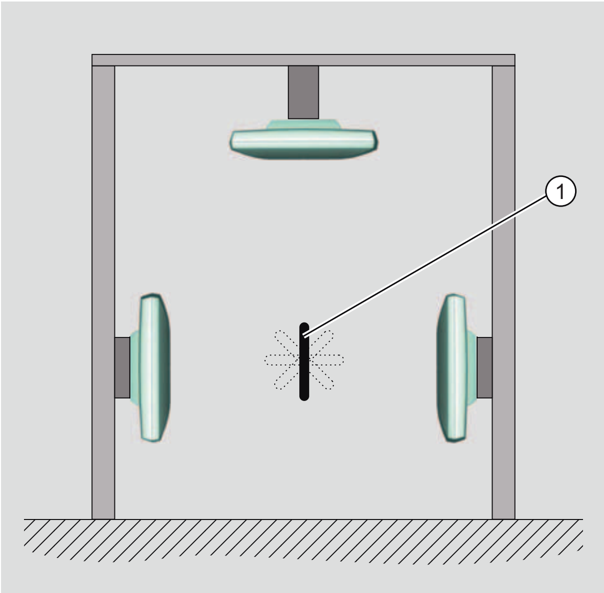
4.3.2 Possibilities and application areas for antenna configurations

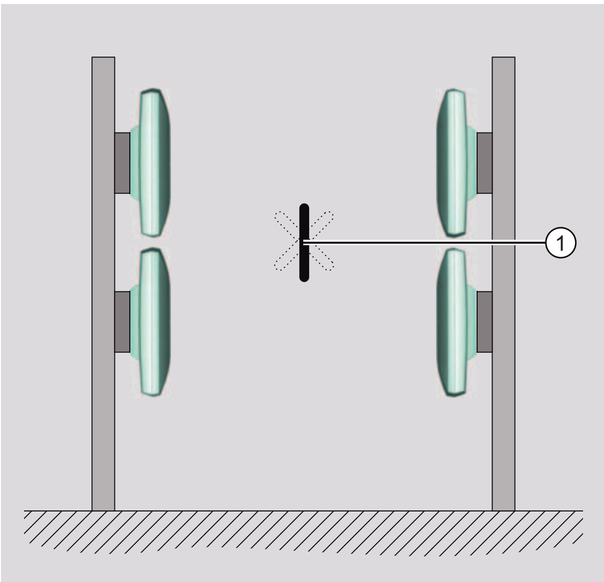
Some basic antenna configurations and possible fields of application are shown below. With the various configurations, please note that up to four external antennas can be connected to the RF670R reader, up to two can be connected to the RF630R reader and one external antenna can be connected to the RF640R or RF620R reader. The RF640R and RF620R readers also have an internal antenna.

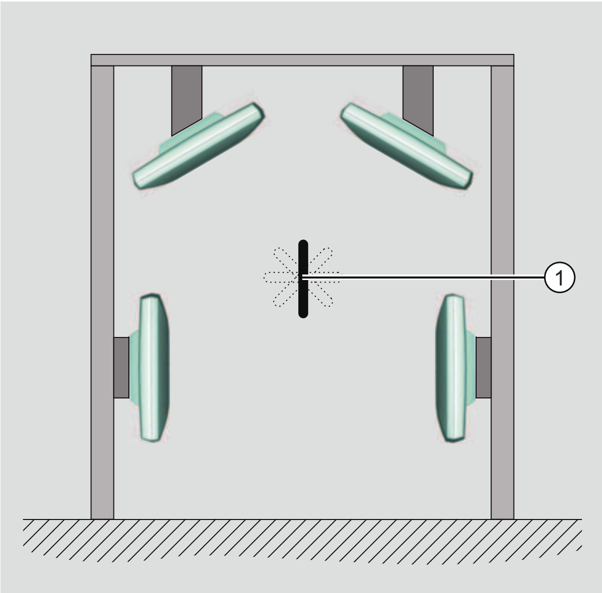
Antenna configuration 1	Description/ application areas
	This arrangement of antennas is appropriate when the tags to be read are only located on one side of the goods to be acquired, for example, if a conveyor with passing goods has to be monitored during production and it is precisely defined on which side the tags to be read are attached. ① Tag This antenna configuration is possible with the following readers: • RF670R with one antenna • RF640R with integrated or with external antenna • RF630R with one antenna • RF620R with integrated or with external antenna

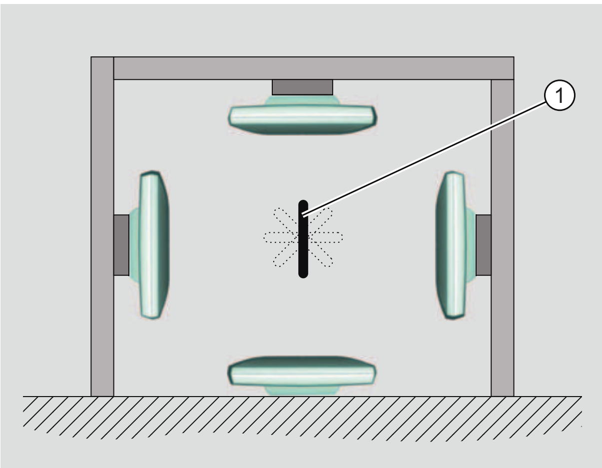
Antenna configuration 2	Description/ application areas
	This arrangement of antennas is appropriate when the tags to be read are only located on one side of the items to be identified, e.g. when pallets are to be identified on which the tags to be read must be on a prespecified side. ① Tag This antenna configuration is possible with the following readers: • RF670R with two antennas • RF630R with two antennas

Antenna configuration 3	Description/ application areas
	Preferred for the identification of goods at loading portals: The tag is located in the field of radiation of two antennas; for reliable tag reading, the height of the tag above floor level must therefore be known with reasonable accuracy. ① Tag This antenna configuration is possible with the following readers: • RF670R with two antennas • RF630R with two antennas

Antenna configuration 4	Description/ application areas
	Preferred for the identification of goods at loading portals: Similar to configuration 2, but with additional reading reliability when the tag is at an angle to the vertical. ① Tag This antenna configuration is possible with the following readers: • RF670R with three antennas

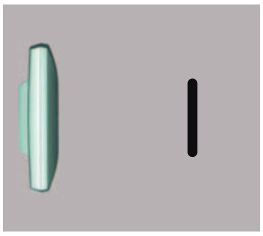
Antenna configuration 5	Description/ application areas
	Preferred for the identification of goods at loading portals: The tag is located in the field of radiation of all four antennas, so the tag position can vary more than in configuration 2 for reliable tag identification. ① Tag This antenna configuration is possible with the following readers: • RF670R with four antennas

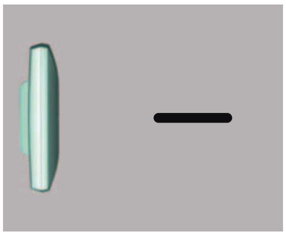
<table>
<tr><th>Antenna configuration 6</th><th>Description/ application areas</th></tr>
<tr><td></td><td>Preferred for the identification of goods at loading portals: Similar to configuration 4, but the reliability of tag identification is improved as a result of the four antennas at separate locations, so the tag position is not critical.
① Tag
This antenna configuration is possible with the following readers:
• RF670R with four antennas</td></tr>
</table>

<table>
<tr><th>Antenna configuration 7</th><th>Description/ application areas</th></tr>
<tr><td></td><td>This tunnel configuration is suitable for conveyor belt applications. The goods with the tags to be read are moving forwards on a conveyor belt but the alignment of the tags relative to the antennas is not clearly defined. One of the antenna is located on the floor and radiates vertically upwards in the direction of the conveyor belt. A relatively high reading reliability is achieved due to the use of four antennas.
① Tag
This antenna configuration is possible with the following readers:
• RF670R with four antennas</td></tr>
</table>

4.3.3 Tag orientation in space

The alignment of the tag antenna to the antenna of the reader affects the reading range. For maximum performance and to achieve the maximum reading range, the tag antenna should therefore be aligned in parallel with the reader antenna:

Parallel tag alignment	Large reading range
	Maximum probability of identification of tags.

Vertical tag alignment	Minimal reading range
	Minimum probability of identification of tags.

4.3.4 Specified minimum and maximum spacing of antennas

Specified minimum spacing of antennas

The following diagram shows the specified minimum and maximum spacings for mounting antennas:

A minimum spacing of 50 cm is necessary between the antenna and liquids or metals.
The distance between the antenna and the floor should also be at least 50 cm.

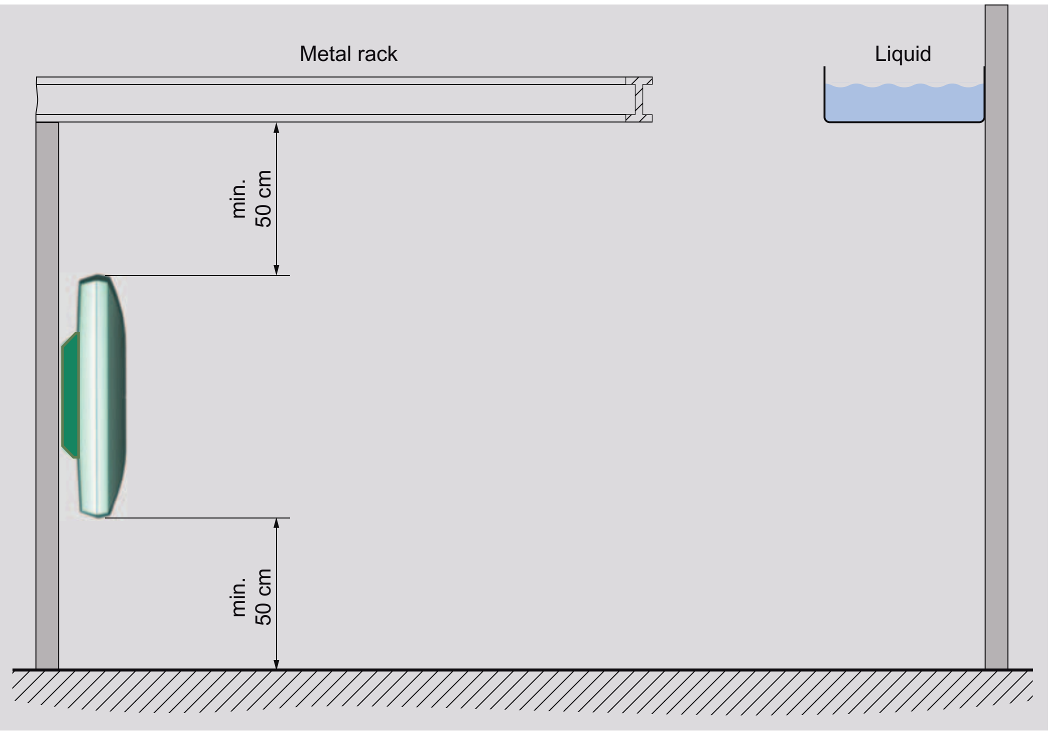


Figure 4-2 Minimum distance to the environment

The distance between two antennas mounted alongside each other or one above the other that are operated be one reader should be at least 20 cm, but a distance of more than 50 cm is better.

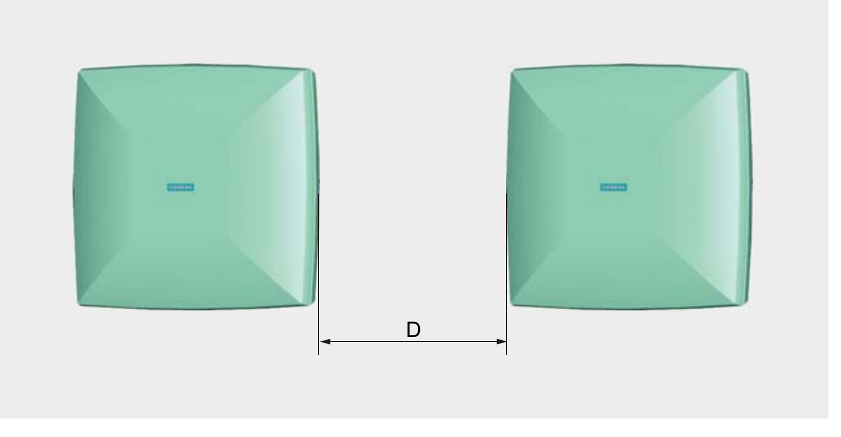


Figure 4-3 Antennas mounted adjacently horizontally or vertically

Readers	Minimum spacing D
A reader with 2 antennas	20-50 cm
Two different reader/reader antennas	80 cm *)

*) The specified spacing applies only if the various readers/reader antennas are not active at the same time. Otherwise the minimum spacing from the following section applies.

The minimum spacing between antennas mounted alongside each other or one above the other depends on the transmit power of the reader and the sensing range of the transponders.

For a portal configuration, the maximum distance between two antennas that are connected to the same reader is 8 m.

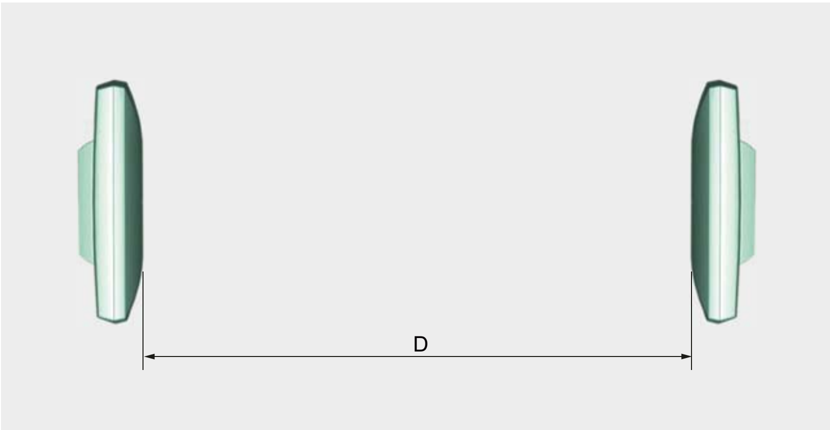


Figure 4-4 Portal configuration, maximum distance

Readers	Maximum distance D
RF670R with RF660A	8 m *)
RF630R with RF660A	4 m

*) A portal spacing of up to 10 m is possible. The probability of a read must be checked.

The specified distances are recommended minimum or maximum values for configuration.

See also

Mutual interference of readers (antennas) (Page 48)

4.3.5 Mutual interference of readers (antennas)

Using more than one reader

When several RFID readers are used, there is a danger that RFID tags can also be read by other readers. It must be ensured that the tag can only be identified by the appropriate reader.

Technical disruptions between readers then occur particularly when they transmit on the same channel (on the same frequency). You will find more detailed information in the section "The response of electromagnetic waves in the UHF band (Page 72)".

To prevent this, readers used in Europe and China must operate on different channels with "frequency hopping" activated. "Frequency hopping" is permanently set in the USA.

Antenna alignment and antenna spacing with an external antenna

The minimum distance required between antennas that use the same frequency and that are connected to different readers depends on the maximum radiated power set (RF670R with RF660A = 2000 mW ERP; RF640R with RF660A = 2000 W ERP; RF620R/RF630R = 500 mW ERP) and the antenna alignment.

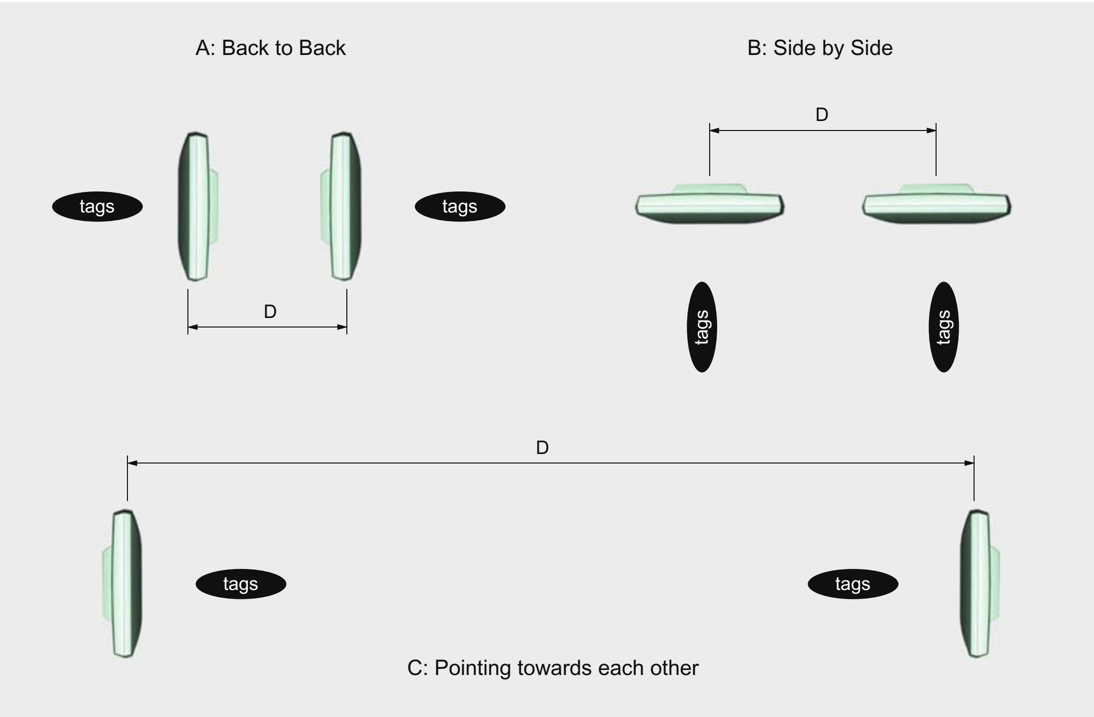
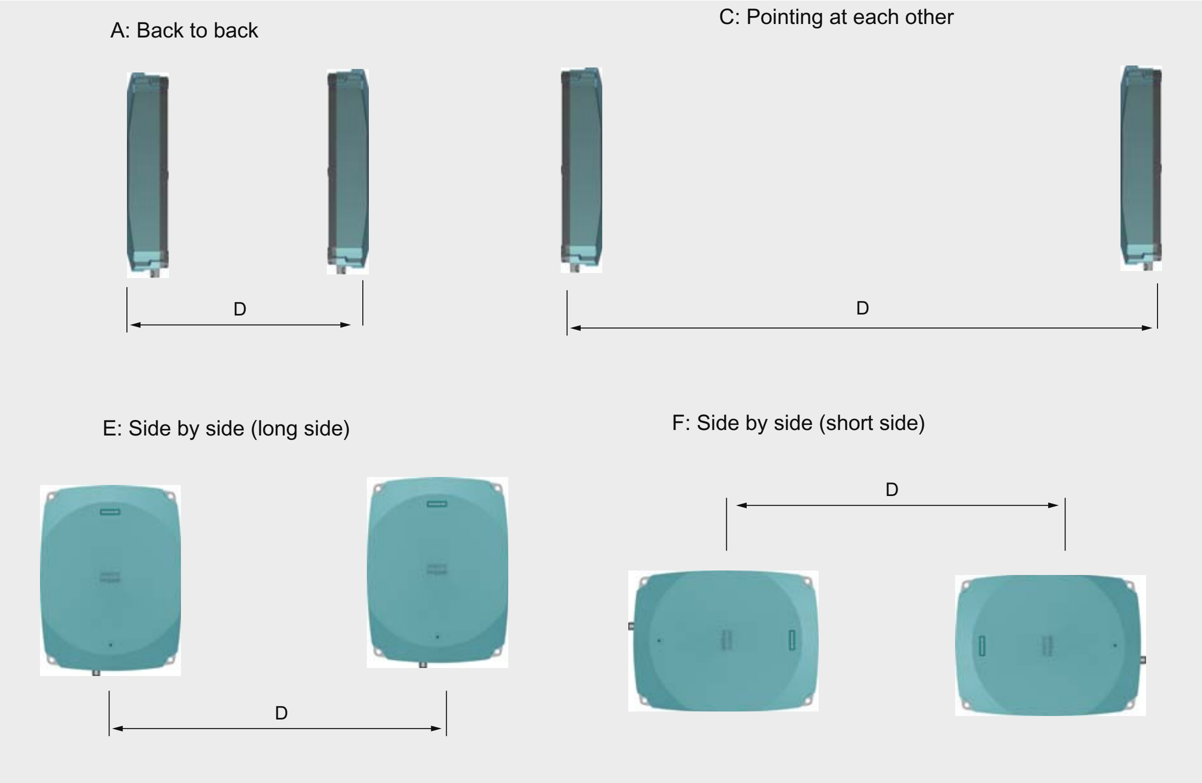


Figure 4-5 Antenna distances for different readers and identical frequencies

Antenna configuration	Antenna alignment	Minimum spacing required = D RF640R/RF670R with RF660A	Minimum spacing required = D RF620R/RF630R with RF660A
A	With backs to each other	0.5 m	0.3 m
B	Arranged laterally	1 m	0.8 m
C	Antennas point toward each other	6 m	6 m

Antenna alignment and antenna spacing for the RF620R and RF640R with an internal antenna



Antenna configuration	Antenna alignment	Minimum spacing required = D RF620R with internal antenna
A	Back to back	0.4 m
C	Pointing at each other	5.8 m
E	Side by side (long side)	1.4 m
F	Side by side (short side)	1.8 m

Antenna alignment and antenna spacing for the RF640R with an internal antenna

Antenna configuration	Antenna alignment	Minimum spacing required = D RF640R with internal antenna
A	Back to back	0.4 m
C	Pointing at each other	4.0 m
E	Side by side (long side)	1.4 m
F	Side by side (short side)	2.0 m

Optimization of the antenna arrangement

SIMATIC RF620R, RF640R with internal antenna

The RF620R and RF640R have an integrated, circular polarized antenna. This means that the type of antenna cannot be freely selected. This means that the interference spacing in arrangement E is greater than in arrangement F (see section Auto-Hotspot).

Note

Rotation of the reader through 90° around the z axis

Since the horizontal electrical aperture angle of the RF620R antenna is greater than the vertical aperture angle, the effects on adjacent readers can be reduced by using the reader as shown in arrangement F (see arrangements E and F in section Auto-Hotspot).

With the SIMATIC RF660A antenna

The electrical aperture angles (vertical and horizontal) of the RF660A antenna are identical. Therefore, the robustness of the readers' access to transponder data cannot be optimized further by rotating them around the antenna axis.

With the RF640A/RF642A antenna

The electrical aperture angles (vertical and horizontal) of the RF640A/RF642A antenna are similar. Therefore, the robustness of the readers' access to transponder data can be optimized only to a limited extent by rotating around the antenna axis.

Application example for RF620R/RF630R

The following example illustrates measures for increasing the reliability of data access to transponders for readers with internal antennas:

- The antennas are placed next to each other and are aligned parallel to each other (see arrangement B in section Auto-Hotspot).
- The readers have been rotated through 90° around the z axis.

The table below provides you with an overview of the minimum spacing to be maintained at a radiated power of 27 dBm with a maximum number of reachable transponders:

Mode	Max. number of tags	Min. distance [m] between - two readers with internal antennas - two RF660A antennas
Single tag mode: Read	1	3
Single tag mode: Write	1	3
Multitag mode: Read	40	6
Multitag mode: Write	10	6

4.3.6 Read and write range

The read/write range between the reader/antenna and the transponder is influenced by the following factors:

The reading range depends on	Description
Transmit power of the reader	The higher the transmit power of the reader, the larger the reading range.
Tag size and type	The larger the tag antenna, the larger the power input area and therefore the larger the reading range.
Absorption factor of the materials	The higher the absorption of the surrounding material, the smaller the reading range.
Production quality of the tag	The better the tag has been matched to the operating frequencies during manufacturing, the greater the reading range.
Reflection characteristics of the environment	In a multiple-reflection environment (e.g., in rooms with reflecting surfaces, machinery, or concrete walls), the reading range can be significantly higher than in a low-reflection environment.
Number of transponders in the antenna field	The typical ranges always relate to a transponder installed at the maximum possible distance from the antenna. If there is more than one transponder in the antenna field, the distance to all other transponders must be less to allow them to be acquired in the antenna field. The width and height of the antenna field within which its transponders can be arranged at a certain distance from the antenna depend on the following: • The radiated power, • Only reading or reading and writing the transponders (writing requires more power, typically double the power) • The aperture angle (horizontal) • The aperture angle (vertical)

You will find detailed information about the reading range of the individual readers in the "Technical specifications" in the sections for the various readers.

4.3.7 Static/dynamic mode

Reading or writing can be either static or dynamic.

- Reading/writing is counted as being **static** if the tag does not move in front of the antenna and is read or written.
- Reading/writing is counted as being **dynamic** if the tag moves past the antenna during reading/writing.

The following overview shows which environments are suitable for which read or write mode:

Operating mode	Read	Write
Static	Recommended in normal UHF environments	Recommended in normal UHF environments
Dynamic	Recommended under difficult UHF conditions	Not recommended in difficult UHF environments

4.3.8 Operation of several readers within restricted space

4.3.8.1 Dense Reader Mode

A special operating mode according to the standard EPC Global Class 1, Gen 2 in Dense Reader Mode allows several RF600 readers to be operated without interference in close proximity to each other. All RF600 readers operate in Dense Reader Mode according the standard EPC Global Class 1, Gen 2.

Dense Reader Mode allows physically adjacent readers to use the same frequency when Gen 2 tags are being used.

Special features for ETSI

In accordance with EPC Global as well as ETSI EN 302 208 V1.3.1, the four transmit channels are used for transmission with the RF670R, with the RF640R as of firmware version V1.3, and with the RF620R/RF630R (see section Regulations for UHF frequency bands in Europe (Page 74)) and the tag response appears on the associated neighboring channels. As a result of the large difference in level between the transmitter channels and the tag response channels, this technology provides great advantages for frequency reuse. However, a prerequisite is that a certain minimum distance, and thus minimum decoupling, is observed between the antennas of adjacent readers.

4.3.8.2 Optimizing tag reading accuracy

An improvement in the tag reading accuracy in an environment with a high density of readers can be achieved by aligning the antennas toward the relevant tag field, in other words by rotating them horizontally and vertically.

In addition, the transmitter power of the readers can be reduced down to the minimum at which the tags are still just detected accurately.

This greatly reduces the probability of interference.

4.3.8.3 Optimization of robustness of tag data accesses for readers that are operated simultaneously

Parameter data access reliability

If several readers are to be operated simultaneously in an environment, then the following settings affect the reliability of the reader's access to transponder data:

- Electromagnetic environment (see section The response of electromagnetic waves in the UHF band (Page 72))
- Type of transponder (see section Transponder/tags (Page 265))
- Number of transponders to be detected by an antenna at a time
- Type of antenna (see section Antennas (Page 187), section Guidelines for selecting RFID UHF antennas (Page 54), and section Planning application (Page 99))
- Transponders' distance from and orientation toward antennas (see section Transponder/tags (Page 265))
- Distances and orientation of antennas of different readers to each other
- Radiated power of antennas

The robustness of tag data accesses is improved for readers whenever distances to adjacent readers are increased, radiated power is reduced, and a channel plan (for ETSI readers) is implemented. Adjacent readers are parameterized in the channel plan such that they cannot use the same channels.

A channel plan can be created for ETSI readers; for FCC readers, it is assumed that the probability of two readers accidentally using the same channel is very low.

4.3.8.4 Frequency hopping

This technique is intended to prevent mutual interference between readers. The reader changes its transmission channel in a random or programmed sequence (FHSS).

Procedure for FCC

Frequencyhopping is always active with FCC. The 50 available channels mean that the probability is low that two readers will be operating on the same frequency (see Section Regulations for UHF frequency bands in the USA (Page 81)). In China, one reader operates on at least 2 channels, e.g. 16 channels of 2 W (see Section Regulations for UHF frequency bands in China (Page 76)).

Procedure for ETSI

Frequencyhopping is optional with ETSI. According to ETSI EN 203 208 V1.2.1, Frequencyhoppingis advisable, however this is should preferably be multichannel operation with Frequencyhopping. Without Frequencyhopping, only single channel operation is possible for which the standard specifies a pause of 100 ms after each 4 s of sending.

4.3.9 Guidelines for selecting RFID UHF antennas

4.3.9.1 Note safety information

WARNING

Before planning how to use third-party components, as the operator of a system that comprises both RF600 components and third-party components, you must comply with the safety information in Section Safety instructions for third-party antennas as well as for modifications to the RF600 system (Page 18).

4.3.9.2 Preconditions for selecting RFID UHF antennas

Target group

This chapter has been prepared for configuration engineers who thoroughly understand and wish to carry out the selection and installation of an external antenna or an external cable for the SIMATIC RF600 system. The various antenna and cable parameters are explained, and information is provided on the criteria you must particularly observe. Otherwise this chapter is equally suitable for theoretical and practice-oriented users.

Purpose of this chapter

This chapter enables you to select the appropriate external antenna or cable with consideration of all important criteria and to carry out the corresponding settings in the configuration software of the SIMATIC RF600 system. Correct and safe integration into the SIMATIC RF600 system is only possible following adaptation of all required parameters.

4.3.9.3 General application planning

Overview of the total SIMATIC RF600 system and its influencing factors

The following graphic shows the design of the total SIMATIC RF600 system and the factors which have an influence on the total system.

You must be aware of these influencing factors and also consider them if you wish to integrate third-party components such as antennas or cables into the system. These influencing factors are described in more detail in Sections Auto-Hotspot and Auto-Hotspot.

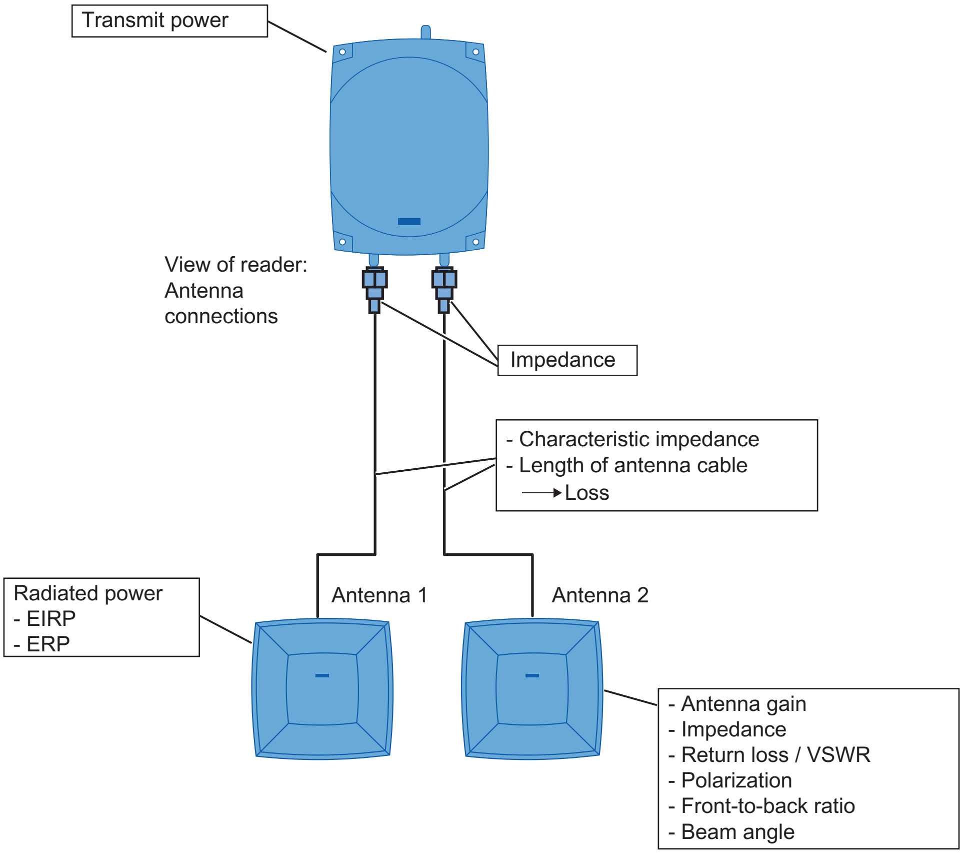


Figure 4-6 Overview of total system and influencing factors

When operating the RF600 system, additional influencing factors must also be observed such as minimum spacing between antennas in the room.

Environmental conditions

CAUTION
Damage to the device In line with the application, you must take into consideration the mechanical loads (shock and vibration) as well as environmental demands such as temperature, moisture, UV radiation. The device could be damaged if these factors are not considered.

General procedure

Depending on whether you want to use a third-party antenna or antenna cable (or both) in a combination with the RF600 system, these instructions will help you to select the components and to set the important parameters in the RF MANAGER Basic.

There are two different application cases:

- Selection of third-party components:
  you wish to select appropriate third-party components for the SIMATIC RF600 system and to subsequently configure the reader for these components.
- Configuration of existing third-party components:
  you already have third-party components (antenna, antenna cable or both) and wish to appropriately configure the reader for these components.

Procedure for selecting third-party components

Always proceed in the following order during your considerations and the practical implementation:

1. Consider which third-party components you wish to use in the SIMATIC RF600 system.
2. Depending on the third-party component required, refer either to Section Auto-Hotspot or Section Auto-Hotspot for the important criteria for selection of your components. The selection criteria/parameters are sorted in descending relevance.
3. Use the specified equations to calculate your missing parameters, and check whether the required values are reached (e.g. antenna gain) and that important secondary values (e.g. cable loss) are not exceeded or undershot.
4. Configure the reader with the parameters of your third-party components. Normally, you can do this with the RF MANAGER Basic. Depending on the reader, the values can alternatively also be set via XML protocol or SIMATIC protocol. You will find an overview of the information for the parameter assignment of all RF600 system readers in the section Overview of parameterization of RF600 reader (Page 377).

Procedure for configuration of existing third-party components

If you already have third-party components which you wish to integrate into the SIMATIC RF600 system, proceed as follows:

1. Depending on the third-party component, refer either to Section "Antennas" or Section "Antenna cables" for the important criteria of your components. The parameters are sorted in descending relevance.
2. Compare the limits with the data of your antenna or cable vendor.
3. Subsequently proceed exactly as described above in "Procedure for selecting third-party components" from Paragraph 3. onwards.

4.3.9.4 Antennas

Types of antenna and properties

Basically all types of directional antennas can be considered as third-party antennas for integration into the SIMATIC RF600 system. Directional antennas have a preferred direction in which more energy is radiated than in other directions.

RF600 antennas on the other hand, are optimized for operation with RF600 readers and have all the required approvals.

Antenna parameters

Overview

The properties of an antenna are determined by a large number of parameters. You must be aware of these properties in order to make the correct selection for your appropriate UHF antenna. The most important parameters are described below. These important parameters are described in detail in the following sections. The following parameters describe both the send and receive functions of the antenna (reciprocity). The antenna is a passive antenna. A two-way relationship exists.

- Radiated power
- Antenna gain
- Impedance
- Return loss / VSWR
- Power rating
- Polarization
- Front-to-back ratio
- Beam width

Radiated power

In order to comply with national directives with regard to the radiated power (which differ depending on the location or country of use), the RF600 readers together with the antenna cable(s) and antenna(s) must be exactly parameterized or configured.

This means that the product of the transmitted power P_0 of the reader and the antenna gain G_i must always have the correct ratio with regard to the radiated power "EIRP" depending on the location of use or the permissible frequency band.

Calculation of the radiated power is briefly described below.

Calculation of the radiated power

The radiated power is the total power radiated by the antenna in the room. The isotropic radiator serves as the physical computing model which uniformly radiates the power into the room (spherically, i.e. isotropic).

EIRP

Directional antennas combine the radiation, and therefore have a higher power density in the main beam direction compared to an isotropic radiator. To enable antennas of different design or Directional characteristic to be compared with one another, the equivalent isotropic radiated power (EIRP) has been introduced which represents the effective power which must be applied to an isotropic radiator in order to deliver the same power density in the main beam direction of the antenna.

"EIRP" is the product of the transmitted power P_0 and the antenna gain G_i:

$EIRP = P_0 * G_i$

ERP

Also common is specification of the equivalent radiated power referred to the half-wave dipole "ERP" (effective radiated power):

$$ERP = P_0 * G_d = P_0 * \frac{G_i}{1{,}64}$$

Logarithmic and standardized data

Approximate calculations are easier to carry out as additions than as products, therefore the logarithms are taken for the above equations and the power data standardized to 1 mW and specified in decibels (dBm or dBi).

$$\frac{EIRP}{dBm} = \frac{P_0}{dBm} + \frac{G_i}{dBi}$$
$$= \frac{P_0}{dBm} + \frac{G_d}{dBd} + 2{,}15 - \frac{a_k}{dB}$$
$$\frac{ERP}{dBm} = \frac{P_0}{dBm} + \frac{G_d}{dBd}$$
$$= \frac{P_0}{dBm} + \frac{G_i}{dBi} - 2{,}15$$

Calculation of the radiated power with consideration of the cable loss a_k

If the transmitted power is not applied directly but via a cable with loss a_K, this loss should be compensated such that the same radiated power is obtained.

$$\frac{EIRP}{dBm} = \frac{P_0}{dBm} + \frac{G}{dBi} - \frac{a_k}{dB} \text{ if } \quad a_k > 0$$
$$\frac{ERP}{dBm} = \frac{P_0}{dBm} + \frac{G_d}{dBd} - \frac{a_k}{dB}$$
$$= \frac{P_0}{dBm} + \frac{G_i}{dBi} - 2{,}15 - \frac{a_k}{dB} \text{ if } \quad a_k > 0$$

If the loss is not appropriately compensated, the radiated power is too small.

General preliminary information on the unit "dB"

Requirements

This section provides you with information on the unit "decibel". This knowledge is a requirement for optimum understanding of the following section. You can ignore this section if you already have the appropriate knowledge.

Definition

When specifying decibels, the ratios between powers or voltages are not defined directly but as logarithms. The decibel is therefore not a true unit but rather the information that the specified numerical value is the decimal logarithm of a ratio of two power or energy variables P1 and P2 of the same type.

This ratio is defined by the following equation:

$$a = 10 * \log_{10}\left(\frac{P_1}{P_2}\right) \text{dB}$$

Example

If P1 = 200 W and P2 = 100 mW, how large is the ratio a in dB?

$$a = 10 * \log_{10}\left(\frac{P_1}{P_2}\right) \text{dB} =$$

$$= 10 * \log_{10}(2000)\,\text{dB} =$$

$$= 33{,}01 \text{ dB}$$

Use with other units

As with other units, there are also different versions of the unit for decibel depending on the reference variable. With this reference, the logarithmic power ratio becomes an absolute variable. The following table lists the most important combinations in this context with other units:

Versions of decibel	Description
0 dBm	Power level with the reference variable 1 mW.
dBi	Power level with the reference variable on the isotropic spherical radiator (see also Section Antenna gain (Page 60)). The relationship between dBi and dBic is as follows: dBi = dBic - 3
dBd	Power level with the reference variable on the dipole radiator. The relationship between dBd and dBi is as follows: dBd = dBi - 2.15
dBic	Power level with the reference variable on the isotropic radiator for circular antennas. The relationship between dBi and dBic is as follows: dBic = dBi + 3

Antenna gain

Definition

The antenna gain specifies the degree to which the antenna outputs or receives its power in the preferred angle segment.

With this theoretical variable, a comparison is always made with an isotropic spherical radiator, a loss-free antenna which does not exist in reality. It describes how much power has to be added to the isotropic spherical radiator so that it outputs the same radiated power in the preferred direction like the antenna to be considered. The unit for the antenna gain is therefore specified in dBi (dB isotropic).

The antenna gain is defined for the receive case as the ratio between the power received in the main beam direction and the received power of the isotropic spherical radiator.

Specifications

You must know the antenna gain in the corresponding frequency band or range. You can obtain the value of the antenna gain from the technical specifications of your antenna vendor.

- With a cable loss of 4 dB, a gain ≥ 6 dBi(L) is required since otherwise the maximum radiated power will not be achieved.
- In the case of antennas used in the FCC area of approval, a gain of at least 6 dBi(L) is required since otherwise the permissible radiated power of 4 W EIRP will not be reached.
- If the gain is > 6 dBi(L)*, the difference is compensated in accordance with the directives by reducing the transmitted power.

* (L) is the reference to the linear polarization.

Dependencies

- Frequency dependency:
  if a frequency dependency exists in the frequency band used, you must apply the highest value in each case for the antenna gain. With the cable loss, on the other hand, you must select the smallest value in each case it frequency dependency exists.
  This procedure means that the permissible radiated power will not be exceeded in the extreme case.
- Dependency on the plane
  If the data for the antenna gain are different in the horizontal and vertical planes, you must use the higher value in each case.

Impedance

Definition

Impedance is understood as the frequency-dependent resistance. The impedances of the antenna, reader and antenna cables should always be the same. Differences in the impedance result in mismatching which in turn means that part of the applied signal is reflected again and that the antenna is not fed with the optimum power.

Specifications

- Only antennas can be used whose connection has a characteristic impedance of Z = 50 Ohm.
- The mechanical design of the coaxial antenna connection is of secondary importance; N, TNC and SMA plug connectors are usual.

Return loss / VSWR

Definition

Since the impedance at the antenna connection is frequency-dependent, mismatching automatically occurs with broadband use. This mismatching can be reflected by two parameters:

- The voltage standing wave ratio VSWR
- The return loss

Voltage standing wave ratio VSWR

The power sent by the transmitter cannot flow unhindered to the antenna and be radiated as a result of the mismatching described by the VSWR. Part of the power is reflected at the antenna and returns to the transmitter. The powers in the forward and reverse directions produce a standing wave which has a voltage maximum and a voltage minimum. The ratio between these two values is the VSWR (voltage standing wave ratio).

Return loss

The return loss parameter is based on the reflection factor which describes the voltage ratio between the forward and reverse waves.

Specifications

So that the smallest possible transmitted and received powers are reflected by the antenna under ideal conditions, you should observe the following data for the VSWR and the return loss $|S_{11}|$/ dB in the respective frequency band (865-870 MHz or 902-928 MHz):

- VSWR < 1.24:1 or
- $|S_{11}|$/ dB ≥ 20 dB

Power rating

Definition

The power rating is understood as the maximum power defined by the vendor with which the device may be operated.

Specifications

Third-party antennas must be dimensioned for an effective power applied to the antenna connection of at least 4 Watt.

Polarization

Definition

The polarization parameter describes how the electromagnetic wave is radiated by the antenna. A distinction is made between linear and circular polarization. With linear polarization, a further distinction is made between vertical and horizontal polarization.

Specifications

UHF transponders usually have a receive characteristic similar to that of a dipole antenna which is linearly polarized. Horizontal or vertical polarization is then present depending on the transponder mounting.

Selection of circular polarized antenna

If the orientation of the transponder is unknown, or if an alternating orientation can be expected, the transmit and receive antennas must have circular polarization.

When selecting a circular antenna, the polarization purity must be observed in addition to the polarization direction. A differentiation is made between left-hand and right-hand circular polarization (LHCP and RHCP). The two types cannot be combined in the same system. On the other hand, selection of the polarization direction is insignificant if the antenna system of a transponder is linearly polarized. With actual antennas, elliptical polarization is encountered rather than the ideal circular polarization. A measure of this is the ratio between the large and small main axes of the ellipse, the axial ratio (AR), which is frequently specified as a logarithm.

Axial ratio	AR
Ideal	0 dB
Real	2-3 dB

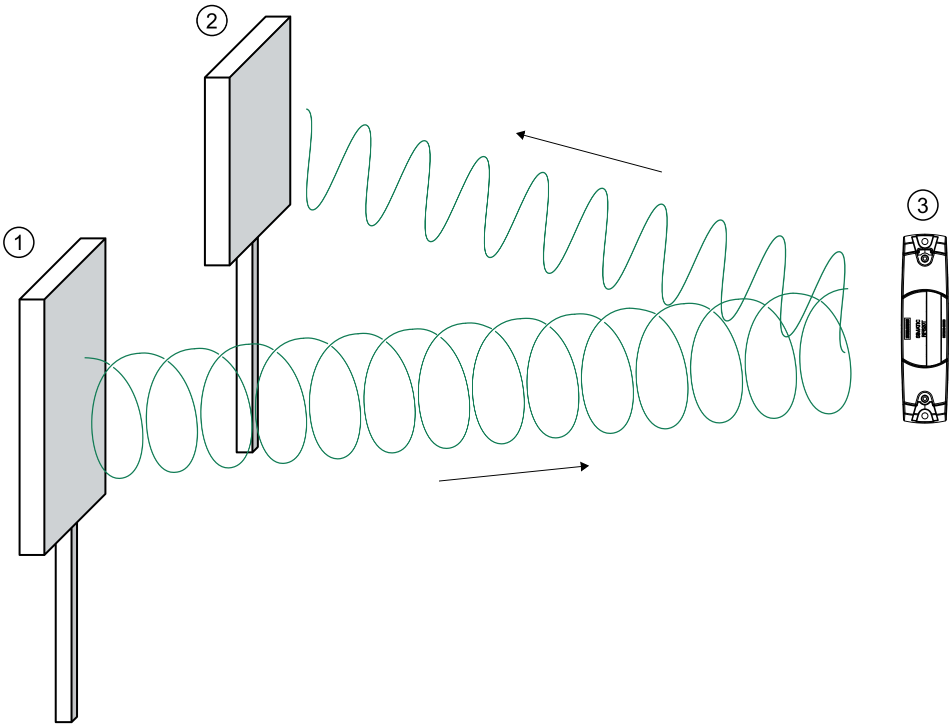
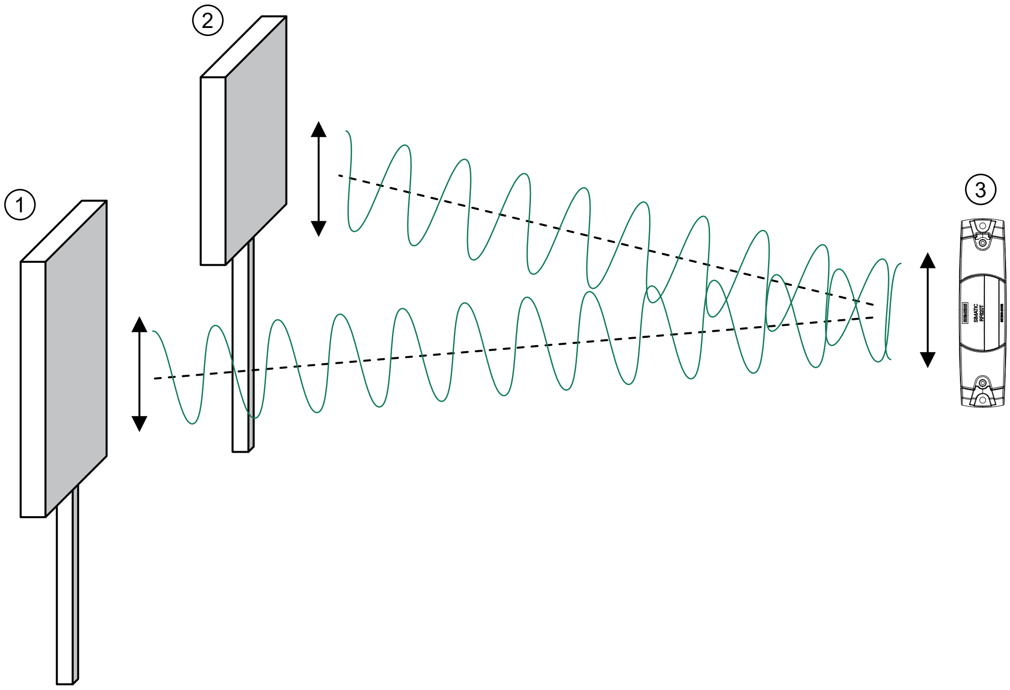


Figure 4-7 Circular polarization of antenna system and transponder

Selection of linear polarized antenna

When using linear polarized antennas, you must always make sure that the transmitter antenna, receiver antenna and transponder have identical polarizations (vertical or horizontal). As a result of the principle used, no special requirements need be observed to suppress the orthogonal components (cross-polarization).



① Transmitter antenna, vertical polarization
② Receiver antenna, vertical polarization
③ Transponder dipole

Figure 4-8 Homogenous vertical polarization of antenna system and transponder

Front-to-back ratio

Definition

As a result of their design, directional antennas not only transmit electromagnetic waves in the main beam direction but also in other directions, particularly in the reverse direction. The largest possible suppression of these spurious lobes is expected in order to reduce faults and to keep the influence on other radio fields low. This attenuation of spurious lobes in the opposite direction to the main beam is called the front-to-back ratio.

Specifications

Requirement: The front-to-back ratio must be ≥ 10 dB. This requirement also applies to spurious lobes illustrated by the following graphics in Section Half-value width (Page 65).

Half-value width

Definition

A further description of the directional characteristic is the beam width. The beam width is the beam angle at which half the power (-3 dB) is radiated referred to the maximum power. The antenna gain is directly related to the beam width. The higher the antenna gain, the smaller the beam angle.

Coupling in ETSI

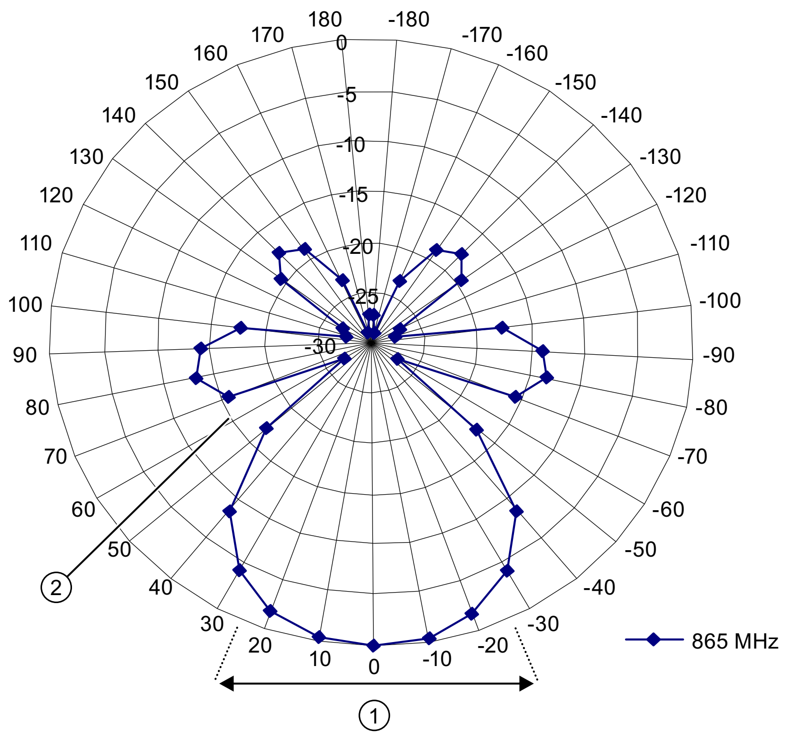
In ETSI EN 302 208 (release version V1.2.1 2008-06), the radiated power is coupled to the beam width, i.e.

- Radiated power 500-2000 mW ERP: beam width ≤ 70 degrees

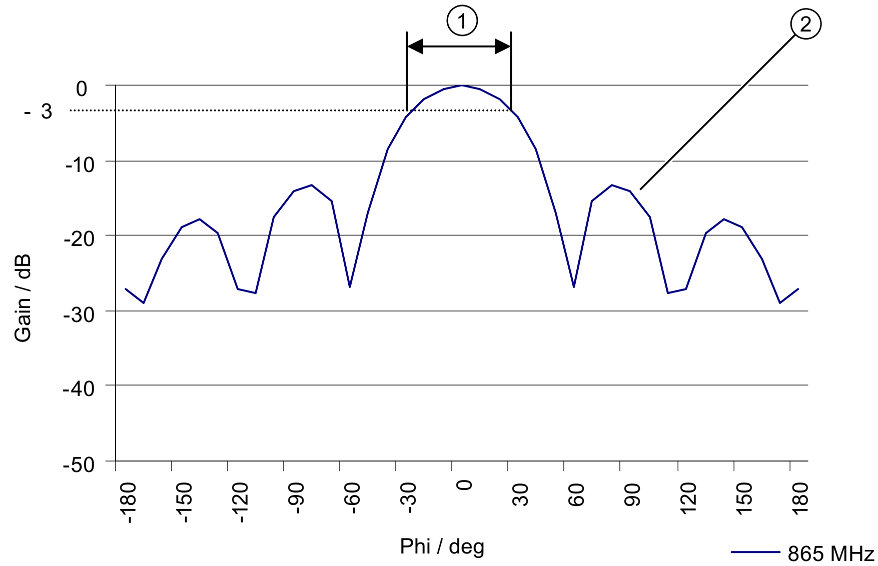
The beam width requirement applies to both the horizontal and vertical planes. The FCC directives do not envisage coupling with the beam width.

The following graphics show examples of the directional radiation pattern of an antenna in polar and linear representations for which both the horizontal and vertical planes must be considered.

Directional radiation pattern in polar representation



①	Beam width
②	Spurious lobe

Directional radiation pattern in linear representation	
	
①	Beam width
②	Spurious lobe

Interpretation of directional radiation patterns

The following overview table will help you with the interpretation of radiation patterns.

The table shows which dBi values correspond to which read/write ranges (in %): You can read the radiated power depending on the reference angle from the directional radiation patterns, and thus obtain information on the read/write range with this reference angle with regard to a transponder.

The dBr values correspond to the difference between the maximum dBi value and a second dBi value.

Deviation from maximum antenna gain [dBr]	Read/write range [%]
0	100
-3	70
-6	50
-9	35
-12	25
-15	18
-18	13

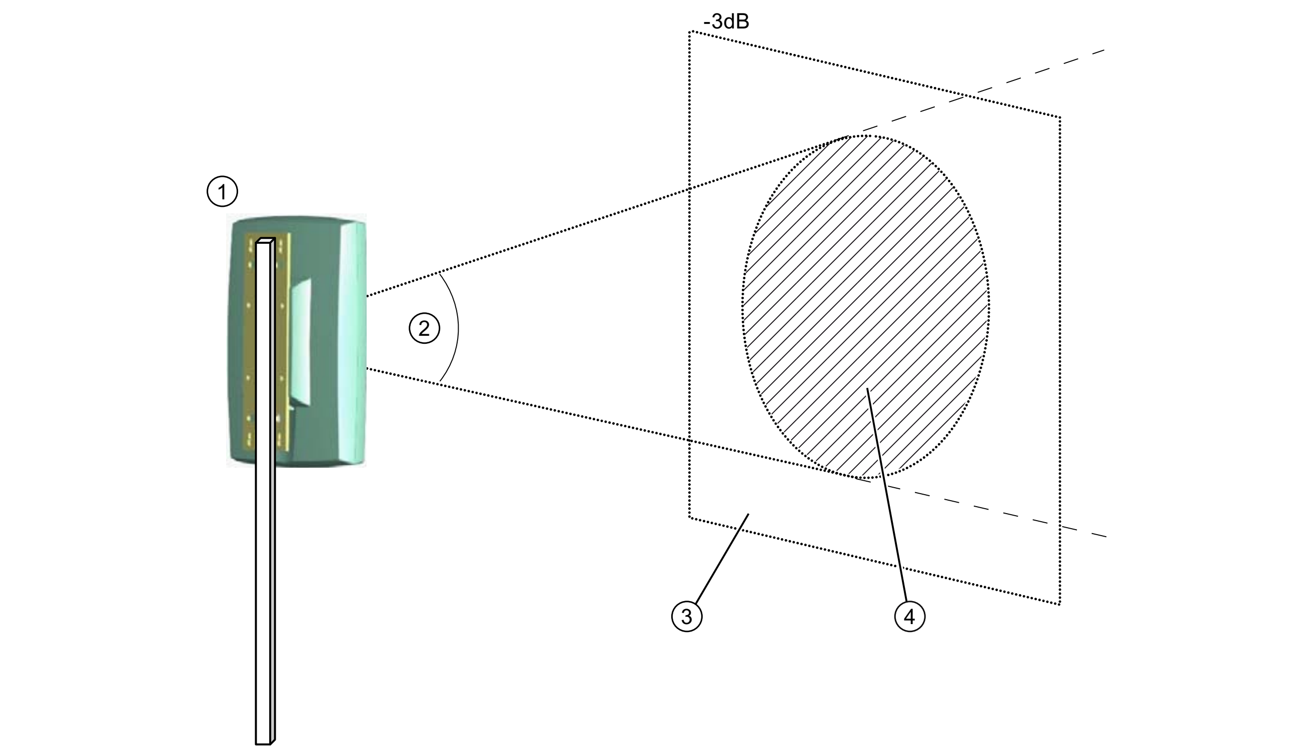
Example

As one can see in the antenna diagrams (polar or linear) above, the maximum antenna gain 0 dB is standardized. The dBr value -3 is shown graphically in both diagrams. At angles of Phi = ± 35°, the range of the antenna is only 50% of the maximum range.

Specifications

Selection of the beam angle within the approval directives also has effects on the field of application, since a larger beam angle allows a larger area to be covered by RFID transponders. The following graphic clarifies the cross-section of the beam cone with the covered area.

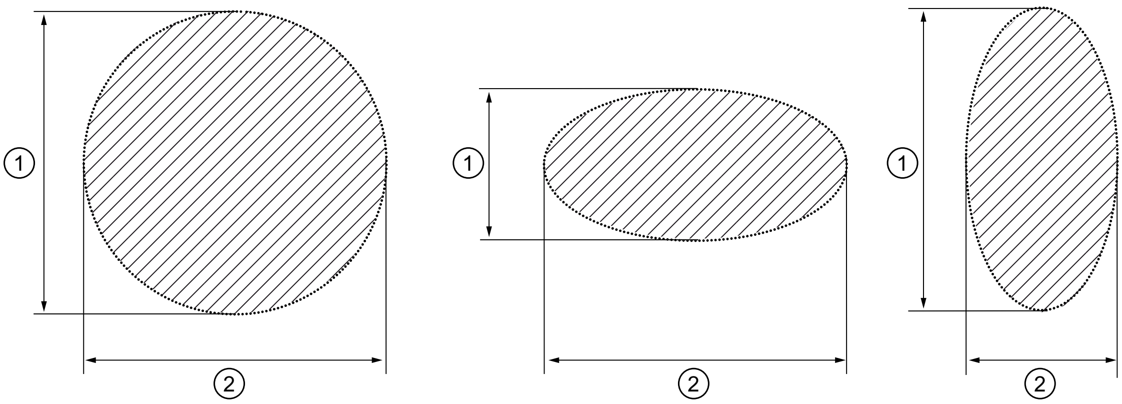
Beam angle: cross-section of the beam cone with the covered area



①	Third-party antenna
②	Beam angle
③	Covered area
④	Activation or reading range

The reading range depends on the horizontal and vertical beam widths in the case of equal distances from the transmitter antenna. Depending on the mechanical mounting and the ratio between the vertical beam width ① and the horizontal beam width ②, read areas result as shown in the following graphic:

Read area depending on the beam width



①	Vertical beam width
②	Horizontal beam width

4.3.9.5 Antenna cables

Selection criteria

You must observe the criteria listed below when selecting the appropriate antenna cable for your third-party antenna.

Characteristic impedance

Definition

If the input impedance of a device does not agree with the cable impedance, reflections occur which reduce the power transmission and can result in the appearance of resonance and thus to a non-linear frequency response.

Specifications

- You must only use coaxial antenna cables when connecting a third-party antenna.
- This antenna cable must have a nominal characteristic impedance of Z = 50 Ohm.

Antenna cable loss

In order to be able to transmit the available UHF power from the RF600 reader to the antenna(s), the antenna cable loss must not exceed a value of approx. 4 dB.

Dependency of the cable loss

The cable loss depends on two important factors:

- External characteristics of cable. These includes the cable length, diameter and design.
- As a result of the physical principle, the cable loss is also frequency-dependent, i.e. the cable loss increases at higher transmitter frequencies. Therefore the cable loss must be specified in the frequency band from 860 to 960 MHz.

Cable vendors usually provide tables or calculation aids for their types of cable which usually include the transmitter and receiver frequencies as well as the cable length. Therefore contact your cable vendor in order to determine the appropriate type of cable using the approximate value referred to above.

Notes on use

Shielding of the antenna cable

Coaxial antenna cables always have a shielded design and therefore radiate little of the transmitted power to the environment.

Note

Cable with double shielding

You should therefore preferentially select cable with double shielding since this provides the best damping.

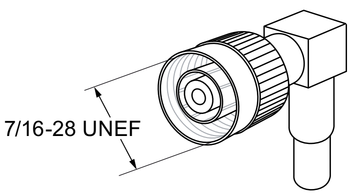
Bending radius of the antenna cable

The properties of the cable shield are influenced by mechanical loading or bending. You must therefore observe the static and dynamic bending radii specified by the cable vendor.

Connectors and adapters

You must use connectors and adapters of type "Reverse Polarity R-TNC" (male connector) for your antenna cables from a third-party supplier in order to ensure correct connection to the RF600 reader interface.

The figure below shows the standard for a suitable thread:



You can find more information in the catalog data of your cable vendor.

4.3.9.6 Application example

This section contains an example with specific values. Using this example it is possible to understand how the complete selection procedure for antennas, cables, and adapters as well as the settings could be carried out on an RF600 system reader.

In the example, it is assumed that you want to use your SIMATIC RF600 system with your third-party components in Germany (ETSI EN 302 208 V1.3.1).

Procedure

1. Compare the technical specifications of your antenna with the values required by the SIMATIC RF600 system.

Values	Example antenna	Required values	OK?
Frequency range	865 to 870 MHz	865 to 868 MHz	OK
Impedance	50 ohms	50 ohms	OK
VSWR	<1,5	<1,24	Not OK
Polarization	Circular, right		OK
Antenna gain	8.5 dBi	>6 dBi	OK
Half-value width horizontal/vertical	63°	≤70°	OK
Front-to-back ratio	-18 dB	≥10 dB	OK
Spurious lobe suppression	-16 dB	≥10 dB	OK
Axial ratio	2 dB	≤3 dB	OK
Maximum power	6 W	≥4 W	OK

   Since the specific VSWR value of the antenna does not agree with the value required by the system, you must have this value checked. Therefore contact your antenna vendor or an EMC laboratory.

2. Compare the technical specifications of your cables and connectors with the values required by the system.
   For example, you can use cables of type "LMR-195" from the company "TIMES MICROWAVE SYSTEMS". Suitable cables have e.g. an outer diameter of 5 mm. The company offers various designs of cables depending on the requirements. Numerous connectors are also available for their cables.

Values	Example cable	Required values	OK?
Cable attenuation	36.5 dB / 100 m at 900 MHz With an assumed length of 10 m, this results in a loss of 3.65 dB.	≤4 dB	OK
Impedance	50 ohms	50 ohms	OK

Values		Example connector	OK?
Type of plug on reader side	R-TNC socket	R-TNC plug	OK
Type of plug on antenna side	N socket	N plug	OK

3. Set the following parameter values depending on the reader you are using:
   – **Assigning parameters for the RF640R/RF670R using the RF-MANAGER Basic V2**
     Antenna gain: 8.5 dBi
     Cable loss: 4 dB (due to adaptation and damping losses of the connectors)
   – **Set parameters for the RF640R/RF670R using the XML command "setAntennaConfig"**
     In the XML command "setAntenneConfig", the following must be set for the antenna port being used:
     (antenna number="1 ... 4"), antenna gain (gain="8.5") and cable loss (cableLoss="4.0").
     Cable loss: 4 dB (due to adaptation and damping losses of the connectors)
   – **Setting parameters for RF620R/RF630R using SIMATIC commands**
     Since according to ETSI EN 302 208 V1.3.1 the maximum permissible radiated power is 2 W ERP, none of the transmit power settings available to the user (distance_limiting) can cause the required maximum permitted radiated power value to be exceeded. The exact radiated power of the reader, together with the antenna cables and antenna used, results from the value used in distance_limiting 0-F and the calculation in the section "Antenna parameters".
4. You must subsequently have your desired system requirements measured and verified according to EN 302 308 in an absorber chamber.
   You may only use your SIMATIC RF600 system with the new third-party components when this has been carried out.

4.4 Environmental conditions for transponders/tags

Basic rules

The transponder/tag must not be placed directly on metal surfaces or on containers of liquid. For physical reasons, a minimum distance must be maintained between the tag antenna and conductive material. A minimum distance of 5 cm is recommended. The tag operates better when the distance is greater (between 5 and 20 cm).

- Tag assembly on non-conductive material (plastic, wood) has a tendency to be less critical than assembly even on poorly conductive material.
- The best results are achieved on the materials specified by the tag manufacturer.
- You can obtain more detailed information from the tag manufacturer.

4.5 The response of electromagnetic waves in the UHF band

4.5.1 The effect of reflections and interference

Reflections and interference

Electromagnetic waves in the UHF band behave and propagate in a similar manner to light waves, that is they are reflected from large objects such as ceilings, floors, walls and windows and interfere with each other. Due to the nature of electromagnetic waves, interference can lead to wave amplification which can produce an increased reading range. In the worst case, interference can also result in waves being extinguished which causes holes in reader coverage.

Reflections can also be beneficial when they cause electromagnetic waves to be routed around objects to a certain extent (deflection). This can increase the reading probability.

Due to these electromagnetic characteristics, it is extremely difficult in the multiple-reflection environment that is usually found in the real environment on site, to determine propagation paths and field strengths for a particular location.

Reducing the effect of reflections/interference on tag identification

- Reducing the transmit power:
  To reduce interference to a minimum, we recommend that the transmitter power of the reader is reduced until it is sufficient for an identification rate of 100%.
- Increasing the number of antennas to 3 or 4:
  More antennas in a suitable antenna configuration can prevent gaps in reader coverage.

4.5.2 Influence of metals

Metal can have an effect on the electromagnetic field depending on the arrangement or environment. The effect ranges from a hardly determinable influence through to total blocking of communication. The term metal in this context also includes metallized materials that are either coated with metal or shot through with metal to such an extent that UHF radiation cannot penetrate or only to a minimal extent.

The effect of metal on the electromagnetic field can be prevented as follows:

- Do not mount tags on metal.
- Do not place metallic or conducting objects in the propagation field of the antenna and transponder.

Tags mounted directly onto metal

In general, tags must not be mounted directly onto metallic surfaces. Due to the nature of the magnetic field, a minimum distance must be maintained between the tag antenna and conductive materials. For further details on the special case of attaching transponders to electrically conducting materials, see Section Auto-Hotspot and SectionAuto-Hotspot .

In the case of transponders that are not designed for mounting on metallic materials, the minimum permissible distance from metal is 5 cm. The larger the distance between the transponder and the metallic surface, the better the function of the transponder.

4.5.3 Influence of liquids and non-metallic substances

Non-metallic substances can also affect the propagation of electromagnetic waves.

When non-metallic substances or objects are located in the propagation field that can absorb UHF radiation, these can alter the antenna field depending on their size and distance and can even extinguish the field entirely.

The high-frequency damping effect of water and materials with a water content, ice and carbon is high. Electromagnetic energy is partly reflected and absorbed.

Liquids and petroleum-based oils have low HF damping. Electromagnetic waves penetrate the liquid and are only slightly weakened.

4.5.4 Influence of external components

The R&TTE guideline and the relevant standards govern the electromagnetic compatibility requirements. This also concerns the external components of the RF600 system. Even though the requirements for electromagnetic compatibility have been specified, various components will still interfere with each other.

The performance of the RF600 system is highly dependent on the electromagnetic environment of the antennas.

Reflections and interference

On the one hand, antenna fields will be weakened by absorbing materials and reflected by conducting materials. When electromagnetic fields are reflected, the antenna field and reflecting fields overlap (interference).

External components in the same frequency band

On the other hand, external components can transmit on the same frequency band as the reader. Or the external components can transmit in different frequency bands with side bands that overlap with the frequency band of the reader. This results in a reduction of the "signal-to-noise" ratio which reduces the performance of an RF600 system.

If a DECT station that is transmitting in the 2 GHz band, for example, is located in the receiving range of an antenna of the RF600 system, the performance of the write and read accesses to the transponder will be affected.

4.6 Regulations applicable to frequency bands

The following section describes the regulations for frequency bands which apply in different regions with reference to RFID. It presents the definition of the applicable standard, the precise channel assignments as well as the applicable technique.

4.6.1 Regulations for UHF frequency bands in Europe

This revision of the standard EN 302 208 also supports RFID systems with multiple readers operating simultaneously. Within the frequency spectrum, 4 exclusive RFID channels are defined.

Regulations for frequency ranges according to EN 302 208 as of V1.2.1

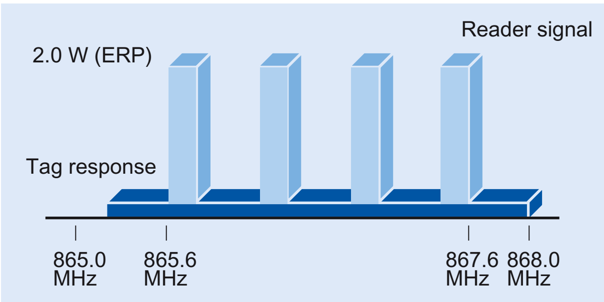
ETSI (European Telecommunications Standards Institute)

Specifications according to European standard EN 302 208:

- UHF band: 865 to 868 MHz
- Radiated power: max. 2 W (ERP)
- Channel bandwidth: 200 KHz, channel spacing 600 kHz
- Number of channels: 4
  - 865.7
  - 866.3
  - 866,9
  - 867,5

Channel assignment

- The UHF band from 865 to 868 MHz with 4 RFID channels occupies:



Validity

Note that readers are operated with this setting since November 4, 2008 (publication of the standard in the Official Journal of the European Union).

4.6.2 Regulations for UHF frequency ranges in Argentina

The regulations for the UHF frequency range in Argentina are identical to the Regulations for UHF frequency bands in the USA (Page 81).

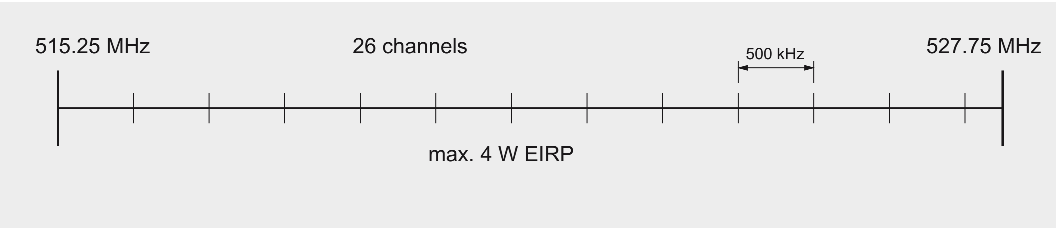
4.6.3 Regulations for UHF frequency ranges in Bolivia

The regulations for the UHF frequency range in Bolivia are identical to the Regulations for UHF frequency bands in the USA (Page 81).

4.6.4 Regulations for UHF frequency ranges in Brazil

FCC subband (Federal Communications Commission)

- UHF band: 515.25 to 527.75 MHz
- Radiated power: max. 4 W (EIRP)
- Number of channels: 26
- Frequency hopping



Frequency hopping

This technique is intended to prevent mutual interference between readers. The reader changes its transmission channel in a random or programmed sequence (FHSS). 26 available channels mean that the probability is low that two readers will be operating on the same frequency.

4.6.5 Regulations for UHF frequency ranges in Canada

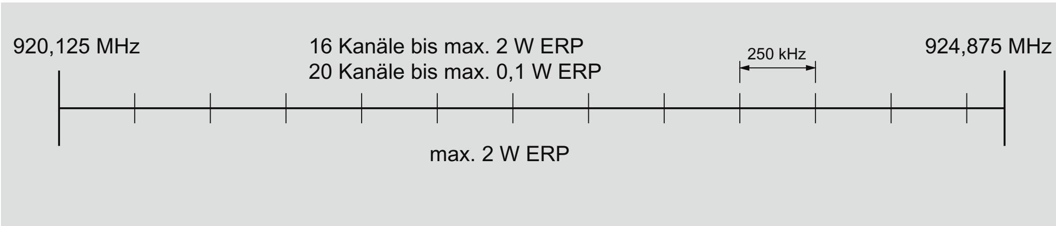
Regulations for UHF frequency ranges in Canada are identical to the Regulations for UHF frequency bands in the USA (Page 81).

4.6.6 Regulations for UHF frequency bands in China

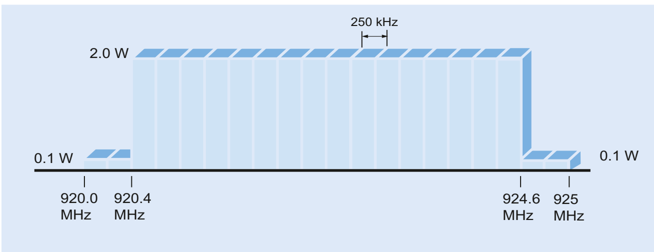
Regulations for UHF frequency ranges in China

FCC subband (Federal Communications Commission)

- UHF band: 920.125 to 924.875 MHz in 250 kHz channel blocks.
- Radiated power: max. 2 W (ERP)
- Number of channels: 16 to max. 2 W (ERP), 20 to max. 0.1 W (ERP)
- Frequency hopping



Channel assignment

<table>
<tr><th>Sub bands</th><th>Frequency range</th><th>Power</th></tr>
<tr><td rowspan="3">
</td><td>920.125 to 920.375 MHz</td><td>0.1 W ERP</td></tr>
<tr><td>920.625 to 924.375 MHz</td><td>2.0 W ERP</td></tr>
<tr><td>924.625 to 924.875 MHz</td><td>0.1 W ERP</td></tr>
</table>

Frequency hopping

This technique is intended to prevent mutual interference between readers. The reader changes its transmission channel in a random or programmed sequence (FHSS). With 16 available channels that can be used simultaneously at up to 2000 mW (ERP) and with 20 channels that can be used simultaneously at up to 100 mW, the probability of two readers operating on the same frequency is reduced.

4.6.7 Regulations for UHF frequency ranges in India

This regulation for UHF frequencies in India operates based on the standard ETSI EN 302 208 V1.3.1. It also supports RFID systems with multiple readers operating simultaneously. Within the frequency spectrum, 10 exclusive RFID channels are defined.

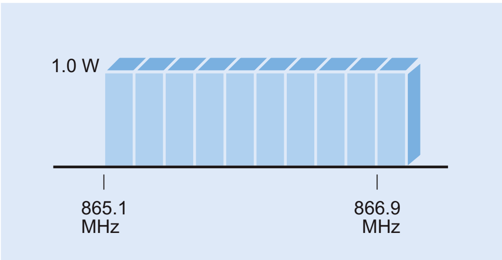
Regulations for frequency ranges in India

Based on European standard ETSI EN 302 208 V1.3.1:

- UHF band: 865 to 866 MHz
- Transmit power: max. 1 W
- Radiated power: < 4 W (EIRP)
- Channel bandwidth: 200 KHz, channel spacing 200 kHz
- Number of channels: 10
  - 865,1
  - 865,3
  - 865,5
  - 865,7
  - 865,9
  - 866,1
  - 866,3
  - 866,5
  - 866,7
  - 866,9

Channel assignment

- The UHF band from 865 to 866 MHz is occupied with 10 RFID channels:



4.6.8 Regulations for UHF frequency ranges in Mexico

Regulations for UHF frequency ranges in Mexico are identical to the Regulations for UHF frequency bands in the USA (Page 81).

4.6.9 Regulations for UHF frequency ranges in Russia

This regulation for UHF frequencies in Russia operates based on the standard ETSI EN 302 208 V1.3.1. It also supports RFID systems with multiple readers operating simultaneously. Within the frequency spectrum, 8 exclusive RFID channels are defined.

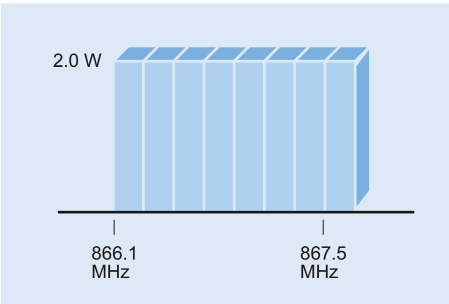
Regulations for frequency ranges according to EN 302 208 V1.3.1

Based on European standard ETSI EN 302 208 V1.3.1:

- UHF band: 866 to 867 MHz
- Radiated power: max. 2 W (ERP)
- Channel bandwidth: 200 KHz, channel spacing 200 kHz
- Number of channels: 8
  - 866,1
  - 866,3
  - 866,5
  - 866,7
  - 866,9
  - 867,1
  - 867,3
  - 867,5

Channel assignment

- The UHF band from 866 to 867 MHz is occupied with 8 RFID channels:

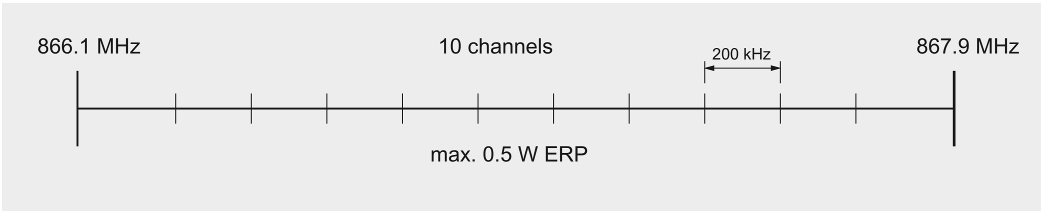


4.6.10 Regulations for UHF frequency bands in Singapore (866-869 MHz band)

Regulations applicable to frequency ranges

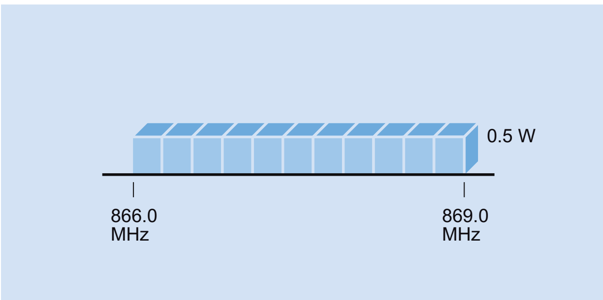
Based on European standard ETSI EN 302 208 V1.3.1:

- UHF band: 866.1 to 867.9 MHz
- Radiated power: max. 0.5 W (ERP)
- Channel bandwidth: 200 kHz
- Number of channels: 10



NOTICE
Exceeding the maximum permitted radiated power of 0.5 W ERP If you want to use this profile with a RF600 reader, during configuration you must make sure tha a maximum of 0.5 W (ERP) is used. Also ensure that you use no channels outside of the specified frequency band.

Channel assignment

Sub bands	Frequency range	Power
	866.1 to 867.9 MHz	0.5 W ERP

4.6.11 Regulations for UHF frequency ranges in South Africa

Regulations for UHF frequency ranges in South Africa are identical to the Regulations for UHF frequency bands in Europe (Page 74).

4.6.12 Regulations for UHF frequency ranges in South Korea

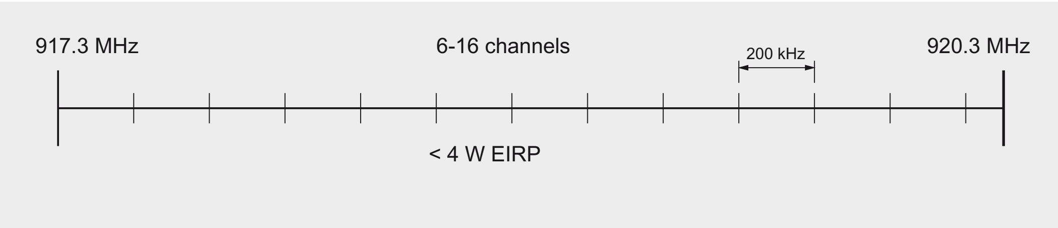
This regulation for UHF frequency ranges in South Korea operates in the FCC subband. It also supports RFID systems with multiple readers operating simultaneously. Within the frequency spectrum, 16 exclusive RFID channels are defined. The maximum channel dwell time is 400 ms.

FCC subband (Federal Communications Commission):

- UHF band: 917.3 to 920.3 MHz
- Radiated power: < 4 W (EIRP)
- Channel bandwidth: 200 kHz
- Number of channels: > 6 (max. 16)

Channel assignment

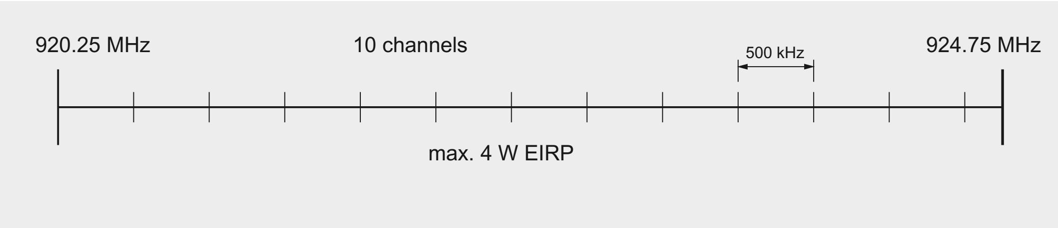
- The UHF band of 917.3 to 920.3 MHz is occupied with up to 16 RFID channels of which at least 7 channels must be used:



4.6.13 Regulations for UHF frequency bands in Thailand

FCC (Federal Communications Commission)

- UHF band: 920.25 to 924.75 MHz
- Radiated power: max. 4 W (EIRP)
- Number of channels: 10
- Frequency hopping



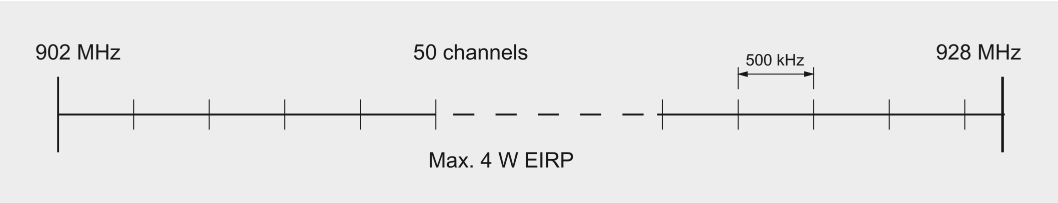
Frequency hopping

This technique is intended to prevent mutual interference between readers. The reader changes its transmission channel in a random or programmed sequence (FHSS). 10 available channels mean that the probability is low that two readers will be operating on the same frequency.

4.6.14 Regulations for UHF frequency bands in the USA

FCC (Federal Communications Commission)

- UHF band: 902 to 928 MHz
- Radiated power: max. 4 W (EIRP)
- Number of channels: 50
- Frequency hopping



Frequency hopping

This technique is intended to prevent mutual interference between readers. The reader changes its transmission channel in a random or programmed sequence (FHSS). 50 available channels mean that the probability is low that two readers will be operating on the same frequency.

4.7 Guidelines for electromagnetic compatibility (EMC)

4.7.1 Overview

These EMC Guidelines answer the following questions:

- Why are EMC guidelines necessary?
- What types of external interference have an impact on the system?
- How can interference be prevented?
- How can interference be eliminated?
- Which standards relate to EMC?
- Examples of interference-free plant design

The description is intended for "qualified personnel":

- Project engineers and planners who plan system configurations with RFID modules and have to observe the necessary guidelines.
- Fitters and service engineers who install the connecting cables in accordance with this description or who rectify defects in this area in the event of interference.

NOTICE
Failure to observe notices drawn to the reader's attention can result in dangerous conditions in the plant or the destruction of individual components or the entire plant.

4.7.2 What does EMC mean?

The increasing use of electrical and electronic devices is accompanied by:

- Higher component density
- More switched power electronics
- Increasing switching rates
- Lower power consumption of components due to steeper switching edges

The higher the degree of automation, the greater the risk of interaction between devices.

Electromagnetic compatibility (EMC) is the ability of an electrical or electronic device to operate satisfactorily in an electromagnetic environment without affecting or interfering with the environment over and above certain limits.

EMC can be broken down into three different areas:

- Intrinsic immunity to interference:
  immunity to internal electrical disturbance
- Immunity to external interference:
  immunity to external electromagnetic disturbance
- Degree of interference emission:
  emission of interference and its effect on the electrical environment

All three areas are considered when testing an electrical device.

The RFID modules are tested for conformity with the limit values required by the CE and RTTE guidelines. Since the RFID modules are merely components of an overall system, and sources of interference can arise as a result of combining different components, certain guidelines have to be followed when setting up a plant.

EMC measures usually consist of a complete package of measures, all of which need to be implemented in order to ensure that the plant is immune to interference.

Note

The plant manufacturer is responsible for the observance of the EMC guidelines; the plant operator is responsible for radio interference suppression in the overall plant.

All measures taken when setting up the plant prevent expensive retrospective modifications and interference suppression measures.

The plant operator must comply with the locally applicable laws and regulations. They are not covered in this document.

4.7.3 Basic rules

It is often sufficient to follow a few elementary rules in order to ensure electromagnetic compatiblity (EMC).

The following rules must be observed:

Shielding by enclosure

- Protect the device against external interference by installing it in a cabinet or housing. The housing or enclosure must be connected to the chassis ground.
- Use metal plates to shield against electromagnetic fields generated by inductances.
- Use metal connector housings to shield data conductors.

Wide-area ground connection

- Plan a meshed grounding concept.
- Bond all passive metal parts to chassis ground, ensuring large-area and low-HF-impedance contact.
- Establish a large-area connection between the passive metal parts and the central grounding point.
- Don't forget to include the shielding bus in the chassis ground system. That means the actual shielding busbars must be connected to ground by large-area contact.
- Aluminium parts are not suitable for ground connections.

Plan the cable installation

- Break the cabling down into cable groups and install these separately.
- Always route power cables, signal cables and HF cables through separated ducts or in separate bundles.
- Feed the cabling into the cabinet from one side only and, if possible, on one level only.
- Route the signal cables as close as possible to chassis surfaces.
- Twist the feed and return conductors of separately installed cables.
- Routing HF cables:
  avoid parallel routing of HF cables.
- Do not route cables through the antenna field.

Shielding for the cables

- Shield the data cables and connect the shield at both ends.
- Shield the analog cables and connect the shield at one end, e.g. on the drive unit.
- Always apply large-area connections between the cable shields and the shielding bus at the cabinet inlet and make the contact with clamps.
- Feed the connected shield through to the module without interruption.
- Use braided shields, not foil shields.

Line and signal filter

- Use only line filters with metal housings
- Connect the filter housing to the cabinet chassis using a large-area low-HF-impedance connection.
- Never fix the filter housing to a painted surface.
- Fix the filter at the control cabinet inlet or in the direction of the source.

4.7.4 Propagation of electromagnetic interference

Three components have to be present for interference to occur in a system:

- Interference source
- Coupling path
- Interference sink

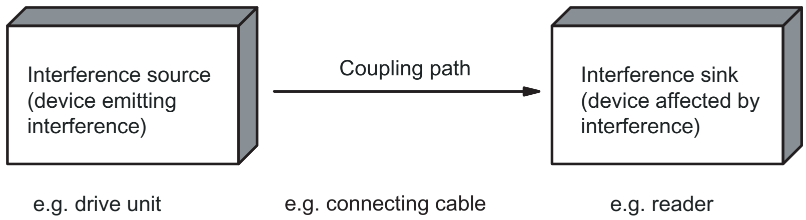


Figure 4-9 Propagation of interference

If one of the components is missing, e.g. the coupling path between the interference source and the interference sink, the interference sink is unaffected, even if the interference source is transmitting a high level of noise.

The EMC measures are applied to all three components, in order to prevent malfunctions due to interference. When setting up a plant, the manufacturer must take all possible measures in order to prevent the occurrence of interference sources:

- Only devices fulfilling limit class A of VDE 0871 may be used in a plant.
- Interference suppression measures must be introduced on all interference-emitting devices. This includes all coils and windings.
- The design of the system must be such that mutual interference between individual components is precluded or kept as small as possible.

Information and tips for plant design are given in the following sections.

Interference sources

In order to achieve a high level of electromagnetic compatibility and thus a very low level of disturbance in a plant, it is necessary to recognize the most frequent interference sources. These must then be eliminated by appropriate measures.

Table 4- 1 Interference sources: origin and effect

Interference source	Interference results from	Effect on the interference sink
Contactors, electronic valves	Contacts	System disturbances
	Coils	Magnetic field
Electrical motor	Collector	Electrical field
	Winding	Magnetic field
Electric welding device	Contacts	Electrical field
	Transformer	Magnetic field, system disturbance, transient currents
Power supply unit, switched-mode	Circuit	Electrical and magnetic field, system disturbance

Interference source	Interference results from	Effect on the interference sink
High-frequency appliances	Circuit	Electromagnetic field
Transmitter (e.g. service radio)	Antenna	Electromagnetic field
Ground or reference potential difference	Voltage difference	Transient currents
Operator	Static charge	Electrical discharge currents, electrical field
Power cable	Current flow	Electrical and magnetic field, system disturbance
High-voltage cable	Voltage difference	Electrical field

What interference can affect RFID?

Interference source	Cause	Remedy
Switched-mode power supply	Interference emitted from the current infeed	Replace the power supply
Interference injected through the cables connected in series	Cable is inadequately shielded	Better cable shielding
	The reader is not connected to ground.	Ground the reader
HF interference over the antennas	caused by another reader	• Position the antennas further apart. • Erect suitable damping materials between the antennas. • Reduce the power of the readers. Please follow the instructions in the section *Installation guidelines/reducing the effects of metal*

Coupling paths

A coupling path has to be present before the disturbance emitted by the interference source can affect the system. There are four ways in which interference can be coupled in:

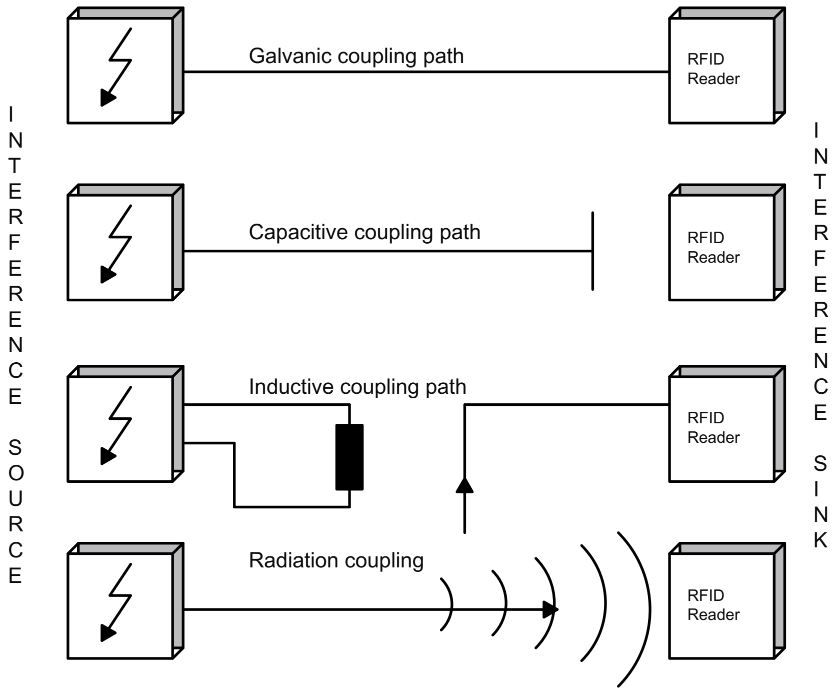


Figure 4-10 Ways in which interference can be coupled in

When RFID modules are used, different components in the overall system can act as a coupling path:

Table 4- 2 Causes of coupling paths

Coupling path	Invoked by
Conductors and cables	• Incorrect or inappropriate installation • Missing or incorrectly connected shield • Inappropriate physical arrangement of cables
Control cabinet or housing	• Missing or incorrectly wired equalizing conductor • Missing or incorrect earthing • Inappropriate physical arrangement • Components not mounted securely • Unfavorable cabinet configuration

4.7.5 Prevention of interference sources

A high level of immunity to interference can be achieved by avoiding interference sources. All switched inductances are frequent sources of interference in plants.

Suppression of inductance

Relays, contactors, etc. generate interference voltages and must therefore be suppressed using one of the circuits below.

Even with small relays, interference voltages of up to 800 V occur on 24 V coils, and interference voltages of several kV occur on 230 V coils when the coil is switched. The use of freewheeling diodes or RC circuits prevents interference voltages and thus stray interference on conductors installed parallel to the coil conductor.

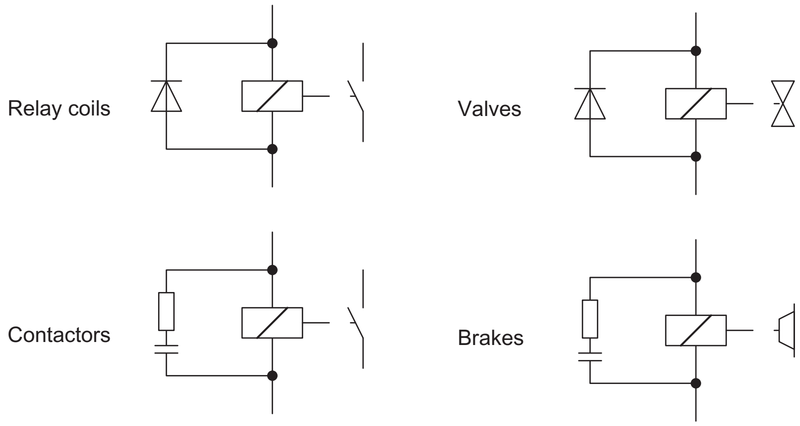


Figure 4-11 Suppression of inductance

Note

All coils in the cabinet should be suppressed. The valves and motor brakes are frequently forgotten. Fluorescent lamps in the control cabinet should be tested in particular.

4.7.6 Equipotential bonding

Potential differences between different parts of a plant can arise due to the different design of the plant components and different voltage levels. If the plant components are connected across signal cables, transient currents flow across the signal cables. These transient currents can corrupt the signals.

Proper equipotential bonding is thus essential.

- The equipotential bonding conductor must have a sufficiently large cross section (at least 10 mm^2).
- The distance between the signal cable and the associated equipotential bonding conductor must be as small as possible (antenna effect).
- A fine-strand conductor must be used (better high-frequency conductivity).

- When connecting the equipotential bonding conductors to the centralized equipotential bonding strip (EBS), the power components and non-power components must be combined.
- The equipotential bonding conductors of the separate modules must lead directly to the equipotential bonding strip.

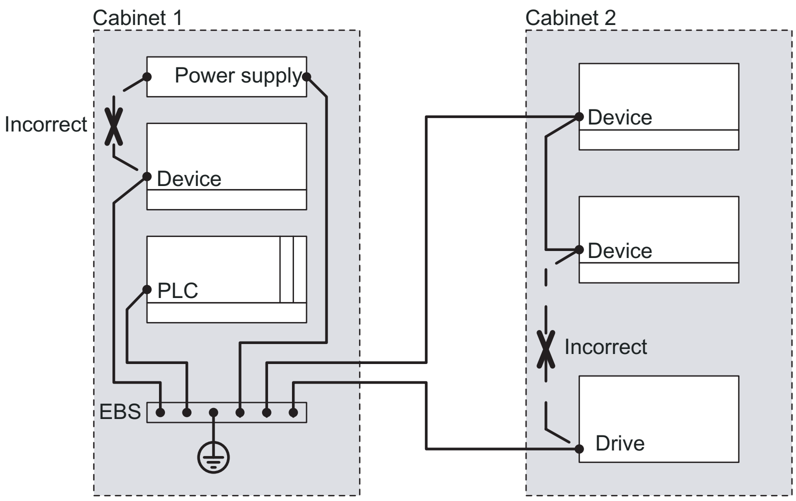


Figure 4-12 Equipotential bonding (EBS = Equipotential bonding strip)

The better the equipotential bonding in a plant, the smaller the chance of interference due to fluctuations in potential.

Equipotential bonding should not be confused with protective earthing of a plant. Protective earthing prevents the occurrence of excessive shock voltages in the event of equipment faults whereas equipotential bonding prevents the occurrence of differences in potential.

4.7.7 Cable shielding

Signal cables must be shielded in order to prevent coupling of interference.

The best shielding is achieved by installing the cables in steel tubes. However, this is only necessary if the signal cable is routed through an environment prone to particular interference. It is usually adequate to use cables with braided shields. In either case, however, correct connection is vital for effective shielding.

Note

An unconnected or incorrectly connected shield has no shielding effect.

As a rule:

- For analog signal cables, the shield should be connected at one end on the receiver side
- For digital signals, the shield should be connected to the enclosure at both ends
- Since interference signals are frequently within the HF range (> 10 kHz), a large-area HF-proof shield contact is necessary

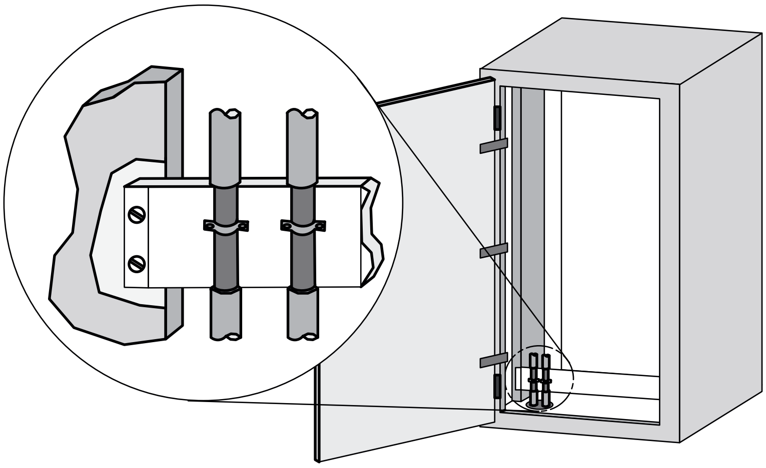


Figure 4-13 Cable shielding

The shielding bus should be connected to the control cabinet enclosure in a manner allowing good conductance (large-area contact) and must be situated as close as possible to the cable inlet. The cable insulation must be removed and the cable clamped to the shielding bus (high-frequency clamp) or secured using cable ties. Care should be taken to ensure that the connection allows good conductance.

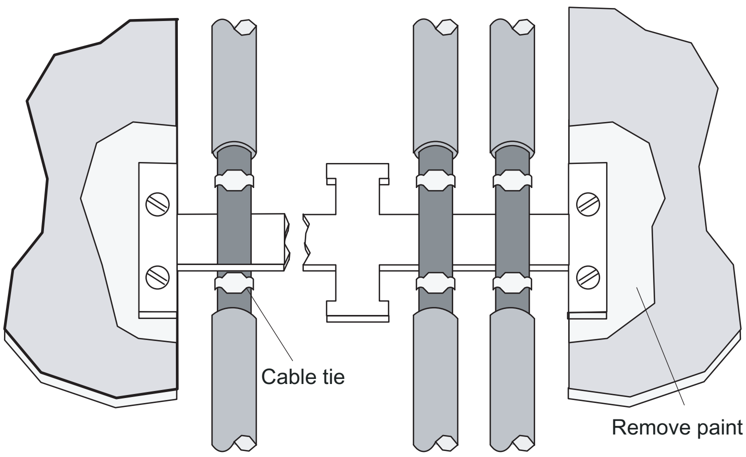


Figure 4-14 Connection of shielding bus

The shielding bus must be connected to the PE busbar.

If shielded cables have to be interrupted, the shield must be continued via the corresponding connector housing. Only suitable connectors may be used for this purpose.

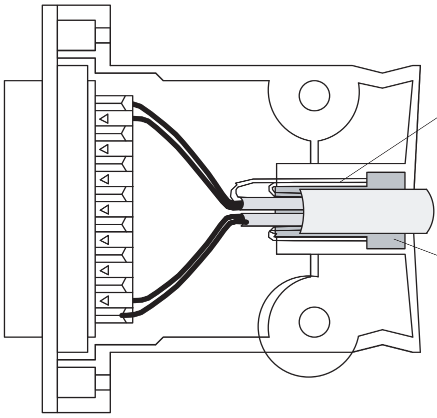


Figure 4-15 Interruption of shielded cables

If intermediate connectors, which do not have a suitable shield connection, are used, the shield must be continued by fixing cable clamps at the point of interruption. This ensures a large-area, HF-conducting contact.

Readers 5

The following table shows the most important features of the stationary RF600 readers at a glance:

Features		SIMATIC RF670R	SIMATIC RF640R	SIMATIC RF630R	SIMATIC RF620R
Air interface / standards supported		EPCglobal Class 1 Gen 2	EPCglobal Class 1 Gen 2	EPCglobal Class 1 Gen 2	EPCglobal Class 1 Gen 2
ETSI variant		Available	Available	Available	Available
FCC variant		Available	Available	Available	Available
CMIIT variant		Available	Available	Available	Available
LEDs		1	1	1	1
Interfaces					
	Number of external antennas via RTNC	4	1	2	1
	Available internal antennas	-	1	-	1
	Ethernet	1 x RJ-45 connection according to IEC PAS 61076-3-117	1 x RJ-45 connection according to IEC PAS 61076-3-117	-	-
	RS232	-	-	-	-
	RS422	-	-	1 x plug (8-pin M12)	1 x plug (8-pin M12)
	Digital inputs	4 (12-pin M12) log "0": 0…7 V log "1": 15…24 V	2 (8-pin M12) log "0": 0…7 V log "1": 15…24 V	-	-
	Digital outputs (short-circuit proof)	4 (12-pin M12) 24 V; 0.5 A each	2 (8-pin M12) 24 V; 0.5 A each	-	-
	Power supply	24 VDC (4-pin M12) 20 to 30 V (2.2 A) external	24 VDC (4-pin M12) 20 to 30 V (2.2 A) external	via CM	via CM
Max. radiated power ETSI and CMIIT in ERP		2 W ERP	1.6 W ERP 1) 2 W ERP	1.2 W ERP	0.8 W ERP 1) 1.2 W ERP
Max. radiated power FCC in EIRP		4 W EIRP	3.3 W EIRP 1) 4 W EIRP	2.0 W EIRP	1.3 W EIRP 1) 2 W EIRP)
max. transmit power ETSI and CMIIT		30 dBm 1 W	30 dBm 1 W	27 dBm 0.5 W	27 dBm 0.5 W
max. transmit power FCC		31 dBm 1.25 W	31 dBm 1.25 W	29 dBm 0.5 W	29 dBm 0.5 W

Features	SIMATIC RF670R	SIMATIC RF640R	SIMATIC RF630R	SIMATIC RF620R
Max. transmission rate of the communication interface	10/100 Mbps	10/100 Mbps	115.2 kbps	115.2 kbps
Max. data rate reader-to-tag	80 Kbps (ETSI) 160 Kbps (FCC)	80 Kbps (ETSI) 160 Kbps (FCC)	40 kbps	40 kbps
Max. data rate tag-to-reader	160 kbps (ETSI) 320 kbps (FCC)	160 kbps (ETSI) 320 kbps (FCC)	160 kbps	160 kbps

1) internal antenna

5.1 RF620R reader

5.1.1 Description

The SIMATIC RF620R is an active stationary reader in the UHF frequency range with an integrated circular polarized antenna. For readers with the new hardware version (MLFB: 6GT2811-5BA00-xAA1), a maximum of one external UHF RFID antenna can be connected via a TNC reverse connector as an alternative to the integrated antenna.

The maximum HF power output is 0.5 W at the reader output. The SIMATIC RF620R is connected to a SIMATIC S7 controller via an ASM interface module. The degree of protection is IP65.

	Pos.	Description
	(1)	TNC-reverse interface for connection of ANT
	(2)	LED status indicator
	(3)	RS 422 interface (8-pin M12 connector)

Highlights

- The tags are read in accordance with the requirements of the EPCglobal Class 1, Gen 2 and ISO/IEC 18000-6C standards
- Supports low-cost SmartLabels as well as reusable, rugged data media
- High reading speed: Depending on the function block (multitag mode), many tags can be detected simultaneously (bulk reading), rapidly moving tags are reliably acquired.
- The RF620R (ETSI) "6GT2811-5BA00-0AAx" is suitable for the frequency band 865 to 868 MHz UHF (EU, EFTA, Turkey). The reader supports the ETSI EN 302 208 V1.2.1 (4-channel plan) standard as well as the ETSI EN 302 208 V1.3.1 standard (4-channel plan).
- The RF620R (FCC) "6GT2811-5BA00-1AAx" is suitable for the frequency bands 902 to 928 MHz.
- The RF620R (CMIIT) "6GT2811-5BA00-2AA1" is suitable for the frequency band 920.125 to 924.875 MHz (China)
- An external antenna can be connected and configured as an alternative to the internal antenna for RF620R "6GT2811-5BA00-xAA1"
- IP65 degree of protection for reader
- Can be used for a high temperature range
- Dense Reader Mode (DRM) for environments in which many readers are operated in close proximity to each other
- TIA system interface:
  - RS 422

5.1.1.1 Ordering data

Ordering data RF620R

Product	Order number
RF620R (ETSI) reader for EU, EFTA, Turkey	6GT2811-5BA00-0AA0 6GT2811-5BA00-0AA1
RF620R (FCC) reader for North America	6GT2811-5BA00-1AA0 6GT2811-5BA00-1AA1
RF620R (CMIIT) reader for China	6GT2811-5BA00-2AA1

Ordering data for antennas and antenna cables

For readers with an external antenna connector (MLFB: 6GT2811-5BA00-xAA1), the following antennas and antenna cables are available:

Product	Order number
Antennas • RF620A antenna for EU, EFTA, Turkey (868 MHz) • RF620A antenna for China and USA (915 MHz) • RF640A antenna (865 to 928 MHz) • RF642A antenna (865 to 928 MHz) • RF660A antenna for EU, EFTA, Turkey (868 MHz) • RF660A antenna for China and USA (915 MHz)	 • 6GT2812-1EA00 • 6GT2812-1EA01 • 6GT2812-0GA08 • 6GT2812-1GA08 • 6GT2812-0AA00 • 6GT2812-0AA01
Antenna cable • 3 m (cable attenuation: 1.0 dB) • 5 m (cable attenuation: 1.25 dB, suitable for drag chains) • 10°m (cable attenuation: 2.0 dB) • 10°m (cable attenuation: 4.0 dB) • 15 m (cable attenuation: 4.0 dB, suitable for drag chains) • 20 m (cable attenuation: 4.0 dB)	 • 6GT2815-0BH30 • 6GT2815-2BH50 • 6GT2815-1BN10 • 6GT2815-0BN10 • 6GT2815-2BN15 • 6GT2815-0BN20

Ordering data (accessories)

Product	Order number
Connecting cable • RS°422, M12 plug, 8-pin socket: 2 m • RS°422, M12 plug, 8-pin socket: 5 m • RS°422, M12 plug, 8-pin socket: 10 m • RS°422, M12 plug, 8-pin socket: 20 m • RS°422, M12 plug, 8-pin socket: 50 m	 • 6GT2891-0FH20 • 6GT2891-0FH50 • 6GT2891-0FN10 • 6GT2891-0FN20 • 6GT2891-0FN50
Antenna mounting kit	6GT2890-0AA00
Set of protective caps Contains 3 protective caps for antenna output and one protective cap for digital I/O interface (required for IP65 degree of protection when some connectors are unused)	6GT2898-4AA00
RFID DVD "Software & Documentation"	6GT2080-2AA20

5.1.1.2 Status display

The device is equipped with a three colored LED. The LED can be lit in green, red or yellow. The meaning of the indication changes in accordance with the color and state (on, off, flashing) of the LED:

Green LED	Red LED	Yellow LED	Meaning
Off	Off	Off	The device is starting up.
Flashing	Off	Off	The device is ready. The antenna is switched off.
On	Off	Off	The device is ready. The antenna is switched on.
Off	Off	On	"With presence": At least one tag is in the field. "Without presence": Communication with a tag is active.
Off	Flashing	Off	Reader is not active, a serious error has occurred. In addition, this LED also indicates the fault status through the number of flashing pulses. Reboot (operating voltage Off → On is necessary). The LED flashes once for the 'INACTIVE' status, rebooting is **not** necessary in this case.

For more detailed information on the flash codes of the reader see section Error messages and flash codes for RF620R/RF630R (Page 386)

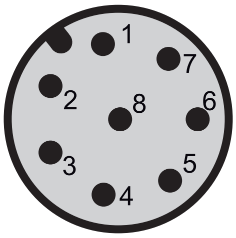
Note

LED not lit yellow?

If the LED does not light up yellow even though a tag is located within the field, common causes are:

- Incorrect configuration in the init_run command, or init_run command was not executed (see "Configuration Manual RF620R/RF630R")
- Parameter assignment is incorrect (black list, RSSI threshold)
- Antenna is switched off
- A tag is used, that is not compatible with the reader protocol (EPC Global Class 1 Gen 2).
- Tag is defective
- Reader or antenna has a defect
- Tag is not in the field of radiation of the transmit antenna

5.1.1.3 Pin assignment of the RS422 interface

Pin	Pin Device end 8-pin M12	Assignment
	1	+ 24 V
	2	- Transmit
	3	0 V
	4	+ Transmit
	5	+ Receive
	6	- Receive
	7	Free
	8	Earth (shield)

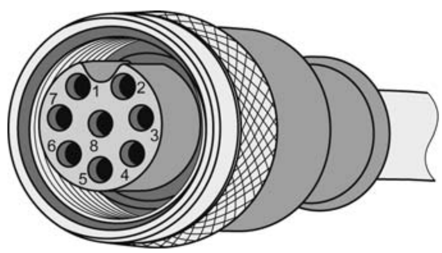
The knurled bolt of the M12 plug is not connected to the shield (on the reader side).

Note

You must therefore not use any SIMATIC connecting cables that use the angled M12 plug.

5.1.1.4 Pin assignment of the connecting cable

Table 5- 1 RS 422 - on reader side

M12 pin	Core color	Pin assignment	View of M12 socket
1	white	24 VDC	
2	brown	TX neg	
3	green	GND	
4	yellow	TX pos	
5	Gray	RX pos	
6	pink	RX neg	
7	blue	Not assigned	
8	red	Earth (shield)	