

Handbook

RF/BT module

Wireless positioning devices with Bluetooth™



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Contents

1	Introduction	1
2	Product description	2
2.1	Application field	2
2.2	Special technical features	2
2.3	The configuration	3
3	Operation	4
3.1	The login procedure	4
3.2	Function of the positioning sensor	5
3.3	Status displays	6
3.4	Parallel operation of two modules (as option)	7
4	The hardware	8
4.1	Pin configuration	9
4.1.1	Voltage supply	9
4.1.2	I ² C connection	9
4.1.3	Operating status display	10
4.1.4	Changing the operation mode	10
4.1.5	Positioning sensor	11
4.1.6	Battery status	12
4.1.7	Digital positioning signals	12
4.1.8	Ouput infrared signal	13
4.1.9	Serial interface	14
4.2	Circuitry of the I ² C interface	14
4.2.1	Digital channels and status displays	14
4.2.2	Analogue channels	15
4.2.2	Analogue channels	16
4.3	Dimensions and circuitry	16
5	Technical data	20
6	Regulatory Information	21
6.1	FCC Statement	21
6.2	Caution	21
6.3	FCC Warning	21

6.4	RF-exposure Statement.....	22
6.5	Labeling requirements for the End Product.....	22
7	Suffix	23

1 Introduction

This handbook describes the application field, wiring options and the technical specifications of the steute Bluetooth module RF/BT.

The RF/BT module can be used in different positioning devices and is suitable for radio-supported transmission of positioning signals. This is based on the Bluetooth technology, that works in the frequency range of 2.4 GHz and is worldwide license-free available.

The information on the following pages is addressed to persons who would like to integrate the RF/BT module in a positioning device (e.g. foot switch). In the following chapters the product features are described.

Section 3 contains the operation of the module: The login procedure, the function of the positioning sensor and the meaning of the LEDs are the main topics.

In a further abstract the hardware is described. This comprises besides the description of the contact configuration the mounting dimensions and information for the connection.

Please observe that some functions can be different depending on the configuration of the module. This concerns especially the parallel operation of two modules (section 3.4) and the battery operation (section 4.2). In the handbook the reference to it is the keyword „as option“. A datasheet contains the special features of the module.

This documentation is a recommendation to the best of our knowledge. Steute does not assume any liability for the information in this documentation nor for any damages related to or caused by the use of this Design Guide.

2 Product description

The RF/BT module can be used for the wireless data transmission between a positioning device and the main device. While the data exchange is carried out via Bluetooth, the infrared interface serves to generate a definite addressing of transmitter and receiver.

The power supply of the positioning devices is applied with conventional batteries. Depending on the version operation times of 20 hours are possible.

2.1 Application field

With a sensing range of approx. 10 m the RF/BT module is suitable as replacement for conventional wired workplace devices in the medical technology. Wireless positioning devices as e.g. foot switches for switching pillars, microscopes or videorecorders allow for more freedom of movement for doctors and nurses meeting all safety regulations.

2.2 Special technical features

With wireless positioning devices the addressing to the main device is not “physically” given. The RF/BT modules exclude the risks of indefinite addressing by different intelligent measurements:

- Permanent verification of the radio path.
- The operating position of the positioning device is monitored by a position sensor.
- The logout of a positioning device is carried out automatically after a set time.
- A fail-safe parallel operation of several positioning devices is secured.
- A logout procedure provides a definite addressing of positioning device and main device and allows for a problem-free replacement of defective components.

2.3 The configuration

So that positioning and main device match, a corresponding configuration must be carried out for each device. This is factory-set, so that the user receives components adapted to his own application. Figure 2.1 shows an overview of the adjustment features. While the classification of the module is set, the warning and alarm times can be set in the configuration section (see section 3.2). In addition, the analogue and digital channels are authorised as well as parallel operation (section 3.4) and data direction are set (see section 4.1.7). When the serial interface is available as data channel, the baud rate is set here.

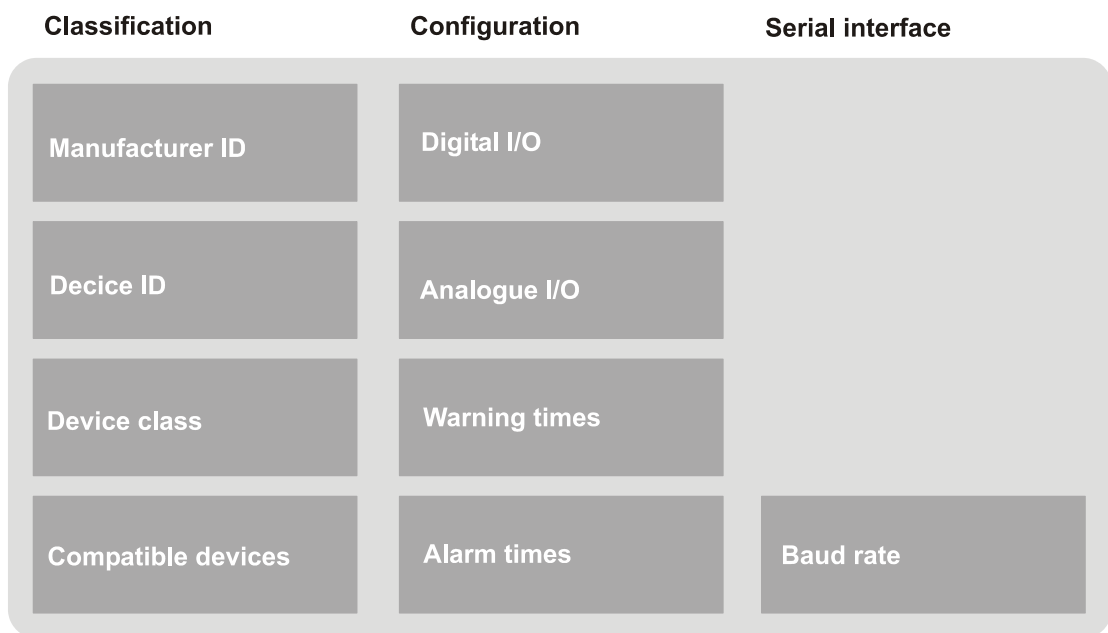


Figure 2.1 Schematic chart of settings for the RF/BT module

3 Operation

In this chapter the handling of the RF/BT module is described. First the login procedure and the function principle of the positioning sensor are explained. The possible modes of operation and the corresponding status displays are described in a further section.

3.1 The login procedure

When the positioning device is not used, it is in Power-Down-Mode. For the activation, as shown in 3.1, at first GPIO2 must be set. The positioning device is now ready for login for the configured time (e.g. one minute) (the LED *login state* flashes). For login it must be brought into the infrared range of the main device. The configuration data is exchanged via infrared connection. With the configuration data it is checked if positioning and main device are compatible. If the result is positive, the Bluetooth connection is carried out (the LED *login state* is on permanent).

If the positioning device is not brought into the infrared range of the main device within the set time or is not compatible to the main device, it will go back to Power-Down-Mode.

After successful connection the connection can be carried out at the main device by actuation of GPIO2. If the connection is interrupted by an interference (e.g. the failure of a positioning device or an interruption of the radio path), the indicated alarm can be confirmed by actuation of GPIO2 and the main device can set back to login state.

3.2 Function of the positioning sensor

The positioning device can be equipped with a positioning sensor, that monitors the correct positioning of the device. If it is e.g. a foot switch that is lifted up from the floor, the positioning sensor will react on this. The RF/BT module distinguishes three states,

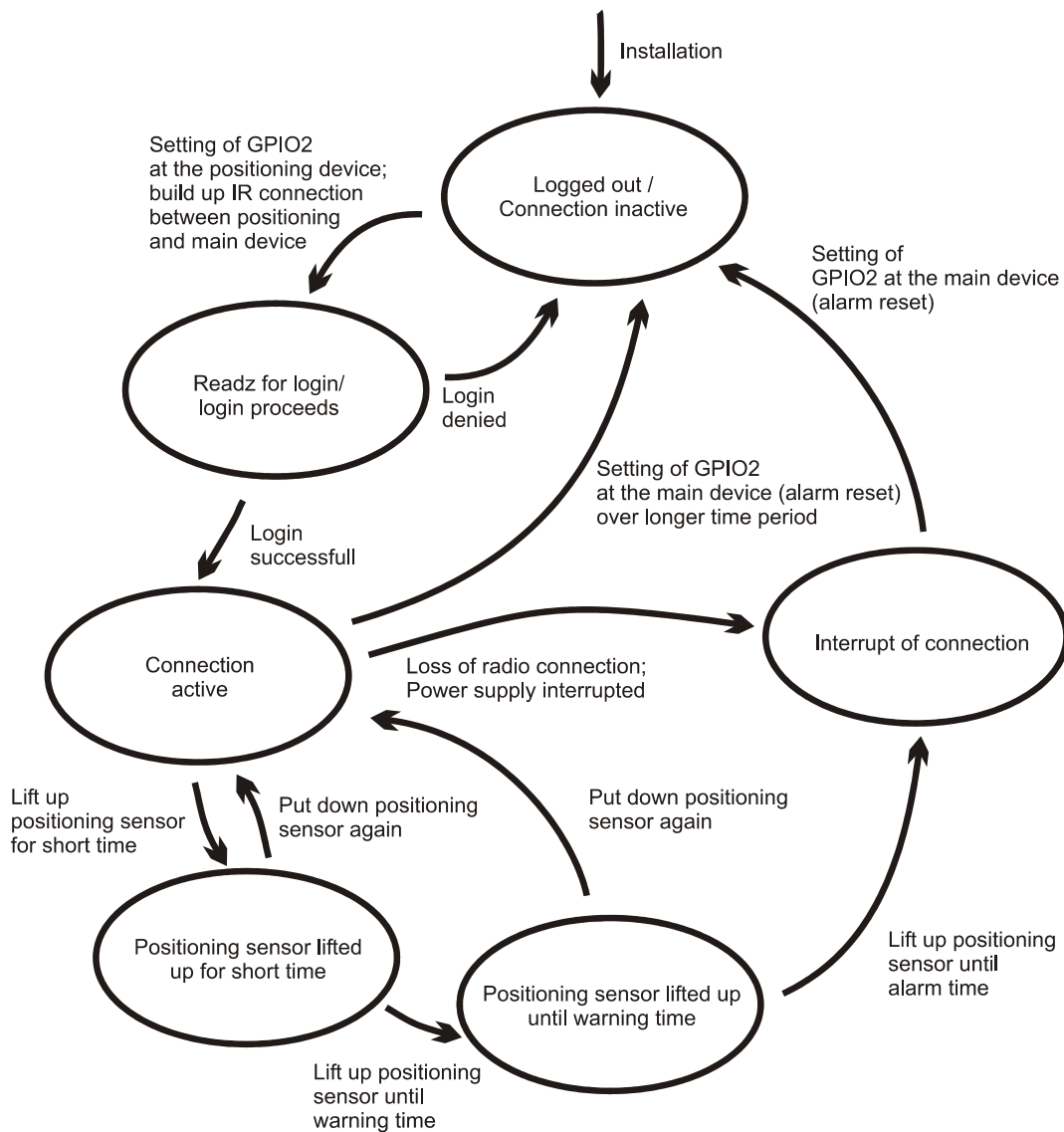


Figure 3.1 Status and status transitions during communication between positioning and main device

depending how long the positioning sensor is lifted up. Therefore in the configuration a warning and an alarm time constant are set. With an active connection a lifting of the positioning sensor leads to a short acoustic signal. If the warning time passes before the positioning device is put back on the floor, a further warning signal occurs. After termination of the warning time the connection is interrupted. In order to avoid unintentional actuation of the push buttons during positioning of the foot switch, all switching functions are blocked during this time.

3.3 Status displays

In table 3.1 the described status are attached to the displays of the LEDs *login state* and *interference* as well as to the acoustic signalling device.

Please refer also to section 4.1.3 for the control of the status displays.

Table 3.1 Status display via LEDs and acoustic signalling device

Status of module	LED <i>login state</i>	LED <i>interference</i>	Signalling device
Logged out / connection active	off	off	off
Ready for login/ login procedes	flashes	off	off
connection active	on	off	off
Positioning sensor lifted up short time	flashes	off	Short pemanent sound
Positioning sensor lifted up until warning time	flashes	off	3x Short pemanent sound
Positioning sensor lifted up until alarm time / connection interrupt	flashes	An	Intervall sound until setting of GPIO2
Module in configuration mode	flashes	flashes	off

3.4 Parallel operation of two modules (as option)

Two positioning devices can be connected to one main device with the corresponding configuration. This means that special preparations must be made for the case of two positioning devices carrying out one switching operation on the same channel. Therefore in the main device it is set on which channels this is allowed. Im Hauptgerät ist deshalb festgelegt, auf welchen Kanälen dies zulässig ist. Depending on the case login is denied.

Example: A main device is configured for operation with two foot switches, but in such a way that switching channel 1 only allows data from **one** foot switch. If now two foot switches should be logged in, which both have one active switching channel, the login of the second foot switch is denied.

4 The hardware

In this section the technical details are explained, which are required for the installation of the RF/BT module. Beside the contact configuration and the mechanical dimensions hints for the circuitry are given. werden auch Hinweise zur Beschaltung gegeben.

For each data transmission there are at least two RF/BT modules required: One is built in as socalled *master* into the main device (e.g. the microscope); the other one is integrated into the corresponding positioning device (e.g. the foot switch) and is also called *slave*. Both modules are identical and only vary in the factory-set configuration, as described in the following sections. With the correct configuration one master also supports two slaves.

Table 4.1 Contact configuration of the RF/BT module

Pin	Signal	Pin	Signal
1	GPIO0	2	GPIO1
3	GPIO2	4	GPIO3
5	GPIO4	6	GPIO5
7	GPIO6	8	GPIO7
9	GPIO8	10	GPIO9
11	GPIO10	11	GPIO11
13	I ² C-SCL	14	reserved
15	I ² C-SDA	16	/EXT_INT
17	IR_TXD1	18	/RESET
19	reserviert	20	reserved
21	SV_TX	22	SV_RX
23	GND	24	reserved
25	V3.3	26	GND

4.1 Pin configuration

All in- and output signals are available on a 26 pole plug-in connector at the edge of the circuit board. For the operation a stable voltage supply is required. Table 4.1 shows the contact configuration. In the following sub-sections the signals are described according to their application.

4.1.1 Voltage supply

Pin	Signal name	Description
23	GND	ground
25	V3.3	3.3 V $\pm$ 5 %; 150 mA
26	GND	ground

Connect the pins 25 and 23/26 of the plug-in connector to a stable voltage of 3.3 V (with a tolerance of $\pm$ 5 %). The maximum current consumption of the RF/BT module is about 150 mA.

4.1.2 I²C connection

Pin	Signal name	Description
13	I ² C-SCL	Output clock signal for I ² C
15	I ² C-SDA	Output data signal for I ² C
16	/EXTINT	Interrupt input

The 26 connection are not sufficient in order to realise all possible circuitries. The configuration is carried out so that for *one* connected positioning device with four digital positioning signals all functions can be directly connected. The missing connection possibilities are realised using the I²C bus. Beside the additional positioning signal this also concerns on the main device side the signal outputs for the LEDs and the battery

status of the *second* positioning device. Please read section 4.2, for details concerning the circuitry of the I²C interface.

4.1.3 Operating status display

Pin	Signal name	Polarity	Description
2	GPIO1	Low active	<i>only positioning device</i> : Output Power Down
6	GPIO5	High active	LED <i>login status</i>
7	GPIO6	High active	LED <i>interference</i>
8	GPIO7	Low active	<i>Only main device</i> : Signalling device

The operating status of the positioning and the main device are indicated via two LEDs (GPIO5 and GPIO6). The positioning devices also have an output that indicates the Power-Down-Mode (GPIO1). For the main device it is possible to connect an acoustic signalling device (GPIO7). Loads of up to 2 mA can be connected to the pins 6 to 8. In section 3.3 the possible states of the LEDs and the signalling device are explained in details.

4.1.4 Changing the operation mode

Pin	Signal name	Polarity	Description
3	GPIO2	Low active	<i>Positioning device</i> : Aufwecken aus Power-Down <i>Main device</i> : Alarm confirmation; with longer activation the connection to the positioning devices will be build up.
18	/RESET	Low active	Resetting the module

A positioning device can be called back from the Power-Down-Mode with input GPIO2. The main device has got no Power-Down-Mode. Here pin 3 is assigned for the confirmation of an alarm signal that is indicated via GPIO7.

Example: A buzzer is connected to GPIO7 of the main device. When the connection to a positioning device is interrupted an acoustic signal occurs. The user can now reset the alarm by actuating the confirmation button (pin 3), the acoustic signal grows silent and the main device goes back to its basic state.

By longer setting of GPIO2 the Bluetooth connection to the positioning devices can be manually interrupted from the main device.

Pin 18 is the input for the reset button at the module. It can at the same time be used as output for resetting further components of the positioning device or the main device.

4.1.5 Positioning sensor

Pin	Signal name	Description
1	GPIO0	<i>Positioning device:</i> Input positioning sensor <i>Main device:</i> Output positioning sensor for positioning device 1
2	GPIO1	<i>Main device:</i> Output positioning sensor for positioning device 2

GPIO0 at the positioning device is used for the connection of the positioning sensor input. At the main device here the positioning sensor signal for the first positioning device is available. The possibly logged in second positioning device is read out at the main device via GPIO1.

4.1.6 Battery status

Pin	Signal name	Description
4	GPIO3	<i>Positioning device:</i> Input BATT2 (Battery status Bit 1) <i>Main device:</i> Output BATT2 (Battery status Bit 1) for positioning device 1
5	GPIO4	<i>Positioning device:</i> Input BATT1 (Battery status Bit 0) <i>Main device:</i> Output BATT1 (Battery status Bit 0) for positioning device 1

The battery status can be verified via these both pins at the first positioning device by applying the corresponding signal and reading it out one to one in the main device. Four different states can be coded with the two bits.

There are no direct connections available at the main device for reading out the battery status of the second positioning device. Therefore the I²C port extension must be used.

4.1.7 Digital positioning signals

Pin	Signal name	Description
9	GPIO8	Positioning signal 0
10	GPIO9	Positioning signal 1
11	GPIO10	Positioning signal 2
12	GPIO11	Positioning signal 3

In total 14 different positioning signals can be transmitted, but only the lower four, as shown above, are directly available. The other ten are only available via I²C port extension (section 4.2).

Each signal channel has got – depending on the configuration of the module – a defined data direction: Normally the signal is transmitted from the positioning device to the main

device (Master). The opposite direction can also be set. The signal generator uses the pin as input for the switch, while the signal receiver can abgreifen?? the positioning signal there for further processing.

Example: A foot switch is used in a operating theatre; its switching pulse is transmitted on actuation via „positioning signal 0“ to the main device. For this channel the positioning device must be switched as input, while the main device must be switched as output where the switching pulse can be further processed.

Contradictory configurations of positioning and main device are recognised at login trial and lead to failure. That is how incompatibilities can be excluded.

Example: The before described foot switch is accidentally brought into a second operating theatre. There it is tried to address it to a main device which has got a different configuration and its „positioning signal 0“ is switched as input (and not as output). This configuration is not allowed and leads to interruption of the login process.

Via the internal configuration the signal channels can also be deactivated. This is required when two positioning devices are connected to one main device, but should not be operated equally.

Example: For a Kernspin-Tomograph there are two positioning devices available. One may only be used for the moving of the bed (positioning signal 0, 1 and 2), while the other one can also be used for starting the photo??Aufnahme (positioning signal 3). Therefore the positioning signal 3 is deactivated at the first positioning signal.

4.1.8 Output infrared signal

Pin	Signalname	Beschreibung
17	IR_TXD1	Ausgang für zusätzliche IR-Diode

The RF/BT module has got an integrated infrared diode, that is used for login of positioning devices at the main device. This infrared diode has been designed for short sensing ranges (approx. 10 cm). If in case of a special application long distances must be bridged, it is possible to connect a further, more powerful infrared diode to pin 17. The data signal of the IR module is directly available and can be amplified via a FET.

4.1.9 Serial interface

Pin	Signal name	Description
21	SV_RXD	Receiving data serial (RXD)
22	SV_TXD	Transmitting data serial (TXD)

Depending on the configuration of the module a serial interface can be used for the data transmission. The settings (baud rate, parity, stop bits) are installed fixed in the module.

4.2 Circuitry of the I²C interface

The evaluation of analogue signals and the ten additional digital channels must be realised outside the RF/BT module in the positioning or main device (in the main device the status displays for the possible second positioning device must be additionally evaluated). The connection for these cases is carried out via the I²C bus.

4.2.1 Digital channels and status displays

In order to use the further 10 digital channels and the status displays, that the second positioning device transmits to the main device, the module MAX6956AAI must be used and 3.3 VDC supply voltage must be applied.

All active inputs of the MAX6956AAI have to be provided with 47 Ω serial resistors, the outputs with 47 k Ω pull-up-resistors. Table 4.2 shows the required I²C address and the ports, that are available at the MAX6956AAI.

4.2.2

Table 4.2 Implementation of the additional digital positioning signals

Module	Function	Description	I ² C address
MAX6956AAI	20x GPIO Ext.	Positioning signal 4 to 13, LEDs and battery status for the second positioning device chtung	1000 000 ^{R/W}

Pin	Data direction	Description	Pin	Data direction	Description
5	bidir.	Positioning signal 4	15		unused
6	bidir.	Positioning signal 5	16		unused
7	bidir.	Positioning signal 6	17		unused
8	bidir.	Positioning signal 7	18		unused
9	bidir.	Positioning signal 8	19		unused
10	bidir.	Positioning signal 9	20	Output; high active	<i>only main device:</i> LED <i>login state</i> of Slave 2
11	bidir.	Positioning signal 10	21	Output; high active	<i>only main device:</i> LED <i>interference</i> of Slave 2
12	bidir.	Positioning signal 11	22	Output	<i>only main device:</i> BATT1 of Slave 2
13	bidir.	Positioning signal 12	23	Output	<i>only main device:</i> BATT2 of Slave 2
14	bidir.	Positioning signal 13	24		unused

Analogue channels

Two bidirectional analogue channels can be assigned. The following A/D- and D/A converter with I²C connection are supported by the RF/BT module:

1. **Philips PCF8591** – 2 differential channel A/D, 1 channel D/A
2. **Analogue Devices AD5301** – 1 channel D/A

In order to build up two analogue channels, there are two variants available: Either two modules type PCF8591 from Philips are applied (two A/D channels remain unused), or a module type PCF8591 and one type AD5301 are used. Table 4.3 shows the connection data for both configurations.

Table 4.3 Implementation of two analogue channels

Module	Function	Description	I ² C address
PCF8591 #1	2x A/D Differenz 1x D/A	Analogeingänge Kanal 1 und 2 Analogausgang Kanal 1	1001 000 ^R / _W
PCF8591 #2	2x A/D Differenz 1x D/A	unbenutzt Analogausgang Kanal 2	1001 001 ^R / _W
AD5301	1 x D/A	Analogausgang Kanal 2 (alternativ)	0001 100 ^R / _W

4.3 Dimensions and circuitry

For the connection of the RF/BT module a 26 pole pin socket is used. The module has got a thermoplastic housing; it is mounted with two screws at the positioning or main device. The detailed dimensions can be found in figure 4.2.

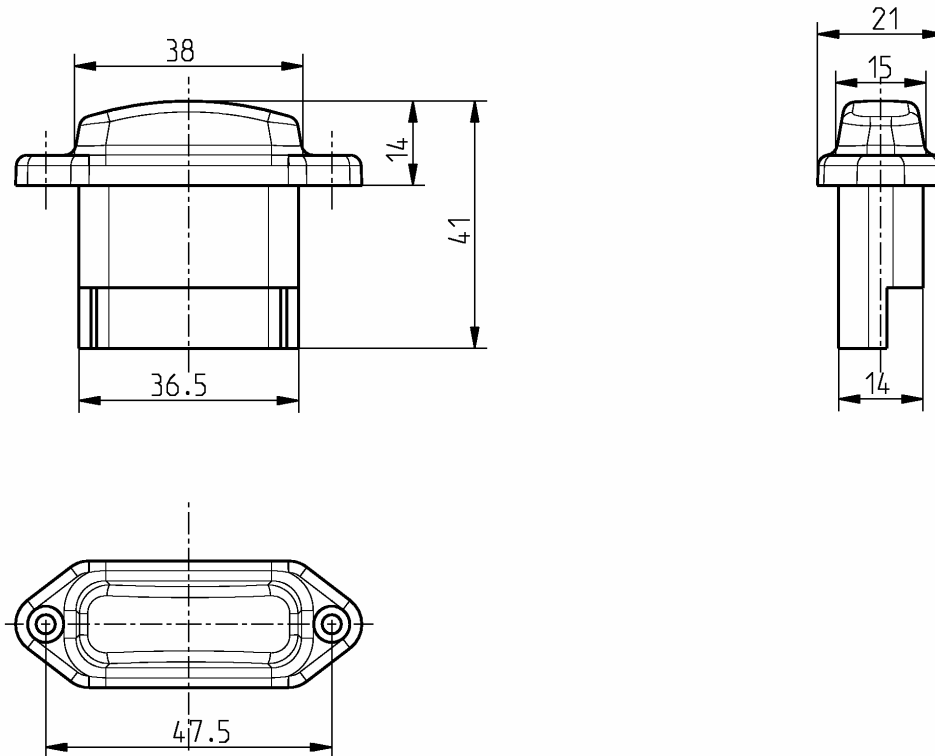


Figure 4.2 Dimensions of the RF/BT module

Figure 4.3 shows an example of the external circuitry of a BT/RF module in a foot switch.

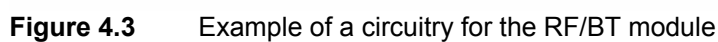
The 14 buttons (switching inputs) are connected to the inputs SO1 to SO4 (GPIO8 to GPIO11) and SO5 to SO14. SO5 to SO14 are available via the I²C module MAX6956 (IC5). An analogue channel is realised using the PCF8591 (IC4).

The positioning sensor at the connection SENSE (GPIO0) recognises inclinations over 10° in all directions. The activation of the foot switch can be realised with one of the buttons SO1 to SO4. To decouple the switching inputs they are connected via the diodes D5 to D8 to GPIO2.

The voltage provided by the batteries is regulated by the low-drop-voltage controller MAX882 (IC3). It stabilises its output voltage to 3.3 VDC and switches off latest at 3.3 VDC battery voltage, in order to prevent total discharge of the batteries. The used

microcontroller PIC16F619 (IC2) serves to charge and monitor the batteries. If the controller detects a connected power supply and a switched off Bluetooth module, it will start charging the batteries according to Delta-Peak. Therefore the controller interrupts once per second the charging current, that is supplied by the charging IC LT1510CS (IC1), and measures the battery voltage. If it drops after 10 measurements for 1 mV/cell or if the charging time exceeds 4 hours, charging is terminated.

If the Bluetooth module is called back from its Power-Down state, the microcontroller monitors the charging state of the batteries. Therefore the battery voltage is measured every 7 seconds. With a voltage below 1.27 VDC per cell a rest capacity of less than 25 % is estimated. In addition, a load current of approx. 330 mA is drawn from the batteries for 30 μ s every 10 measurements via a FET (T2). If the voltage drops for more than 30 mV, an increased internal resistance is assumed and a battery capacity of less than 25 % is indicated. The output of the battery state is indicated in 25 percent steps to the corresponding connections GPIO3 and GPIO4.



5 Technical data

Data transmission:	Bluetooth
Data transmission during login:	Infrared
Switching functions:	max. 14 digital and 2 analogue channels
Supply voltage:	3.3 VDC $\pm$ 5 %; 150 mA
Operating time:	approx. 20 hours (depending on the battery type)
Transmission power Bluetooth:	1 mW
Sensing range Bluetooth:	ca. 10 m
Response time:	< 50 ms
Analogue transmission:	8 Bit resolution
Interfaces:	- I ² C - serial (max. 115 KB/s)

6 Regulatory Information

6.1 FCC Statement

This device complies with Part 15 of the FCC Rules and with RSS-210 of Industry Canada. Operation is subject to the following two conditions:

1. this device may not cause harmful interference, and
2. this device must accept any interference received, including interference that may cause undesired operation.

6.2 Caution

Warning: Changes or modifications made to this equipment not expressly approved by steute Schaltgeräte GmbH & Co. KG could void the user's authority to operate the equipment.

6.3 FCC Warning

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.

- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

Consult the dealer or an experienced radio/TV technician for help.

The radiated output power of BlueRS+E and BlueRS+I is far below the FCC radio frequency exposure limits. Nevertheless, the BlueRS+E and BlueRS+I shall be used in such a manner that the potential for human contact during normal operation is minimized

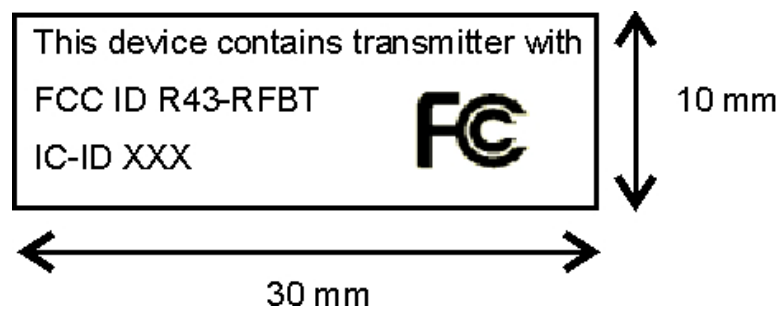
6.4 RF-exposure Statement

The RF/BT module contains a portable modular transmitter. Thus it must have a separation of at least 2.5 cm between the antenna and the body of the user or nearby persons, excluding hands, wrists, feet, and ankles.

Any notification to the end user of installation or removal instructions about the integrated radio module is **not** allowed.

6.5 Labeling requirements for the End Product

Any End Product integrating the RF/BT module must be labeled with at least the following information:



7 Suffix

A

A/D converter	16
Acoustic signal	6
Alarm	4
Alarm time	6
Alarm times	3
Application field	2
Analogue channel	3, 16
As option	1

B

Battery	2
Battery capacity	18
Battery status	12
Baud rate	3
Blocking of the switching functions	6
Bluetooth	1

C

Circuitry	16, 17
Classification	3
Configuration	3
Contact configuration	9

D

D/A converter	16
Data direction	3
Data sheet	1
Delta-Peak	18
Digital channel	3, 14

Dimensions	16, 17
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E

Application field	2
-------------------------	---

F

Factory-set	3
Frequency range	1
Foot switch	1

G

GPIO0	11
GPIO1	10, 11
GPIO10	12
GPIO11	12
GPIO2	4, 10, 11
GPIO3	12
GPIO4	12
GPIO5	10
GPIO6	10
GPIO7	10
GPIO8	12
GPIO9	12

H

Hardware	8
Housing	16

I

I ² C connection	9
I ² C bus	14

Interference	4	Positioning sensor	5, 11
Infrared interface	2	Power-Down-mode	4, 10, 18
Infrared signal	13	Pull-up resistor	14
L		R	
LED <i>login state</i>	4, 6	Radio-supported	1
LED <i>interference</i>	6	Ready for login	4
M		S	
Main device	2	Safety regulations	2
MAX6956AAI	14	Sensing range	2
Medical technology field	2	Serial interface	3, 14
O		Status displays	14
Operating time	2	Supply voltage	9
Operating state displays	10	T	
P		Total discharge	18
Parallel mode	1, 3, 7	W	
Pin socket	16	Warning times	3, 6
Plug-in connector	9		
Positioning device	2		