steute Medizintechnik

# Handbook

# RF/BT module

## Wireless positioning devices with Bluetooth™


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# Contents

# 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 undefinite 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.

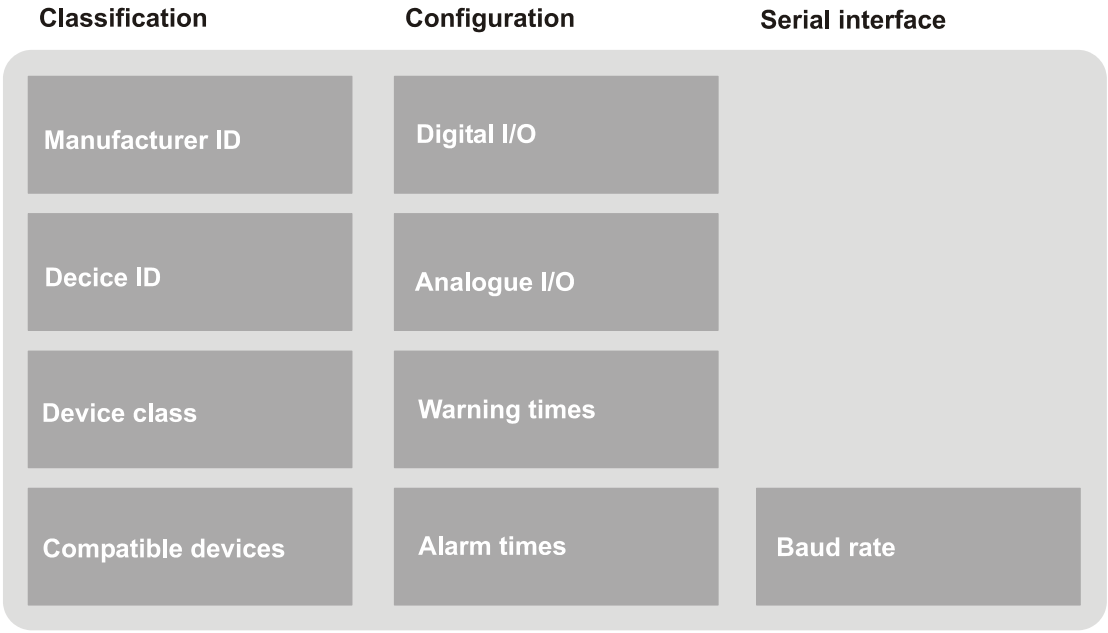



**Figure 2.1** Schematic chart of settings for the RF/BT module

# 3 Operation

In this chapter the handling of the RF/BT module is described. First the login procedure and the function principleof 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 successfull 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,

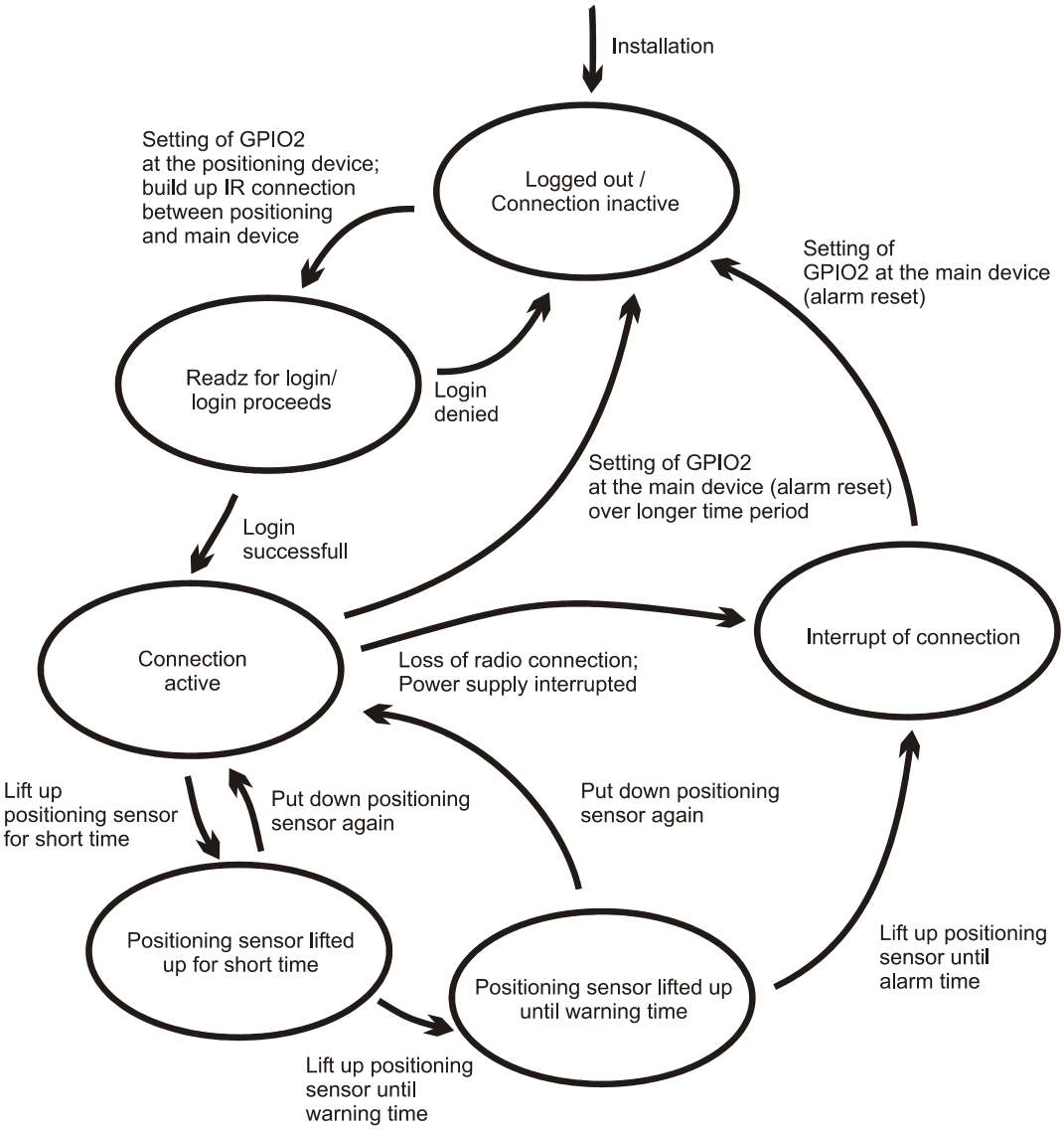



**Figure 3.1** Status and status transitions during communication between positioning and main device

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 *login state* | LED *interference* | 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 | $I^2C$-SCL | 14 | reserved |
| 15 | $I^2C$-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 ± 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 ± 5 %). The maximum current consumption of the RF/BT module is about 150 mA.

### 4.1.2 $I^2C$ connection

| Pin | Signal name | Description |
|---|---|---|
| 13 | $I^2C$-SCL | Output clock signal for $I^2C$ |
| 15 | $I^2C$-SDA | Output data signal for $I^2C$ |
| 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 $I^2C$ 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 $I^2C$ interface.

### 4.1.3 Operating status display

| Pin | Signal name | Polarity | Description |
|---|---|---|---|
| 2 | GPIO1 | Low active | *only positioning device:* Output Power Down |
| 6 | GPIO5 | High active | LED *login status* |
| 7 | GPIO6 | High active | LED *interference* |
| 8 | GPIO7 | Low active | *Only main device:* 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 | *Positioning device:* Aufwecken aus Power-Down<br><br>*Main device:* 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 rest button at the module. It can at the same time be used as output for resetting further conponents of the positioning device or the main device.

### 4.1.5 Positioning sensor

| Pin | Signal name | Description |
|---|---|---|
| 1 | GPIO0 | *Positioning device:* Input positioning sensor<br><br>*Main device:* Output positioning sensor for positioning device 1 |
| 2 | GPIO1 | *Main device:* 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 | *Positioning device:* Input BATT2 (Battery status Bit 1)<br><br>*Main device:* Output BATT2 (Battery status Bit 1) for positioning device 1 |
| 5 | GPIO4 | *Positioning device:* Input BATT1 (Battery status Bit 0)<br><br>*Main device:* 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 $I^2C$ 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 $I^2C$ 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 dat directon 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 das Stellsignal 3 is deactivated at the first positioning signal.

### 4.1.8 Ouptut 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 sjort 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 powerfull 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 $I^2C$ 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 $I^2C$ 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 kΩ pull-up-resistors. Table 4.2 shows the required $I^2C$ 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 | $I^2C$ address |
|---|---|---|---|
| MAX6956AAI | 20x GPIO Ext. | Positioning signal 4 to 13,<br>LEDs and battery status for the second positioning device chtung | 1000 000 $^{R}/_{W}$ |

| Pin | Data direction | Description | Pin | Data direc-tion | 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 | *only main device:* LED *login state* of Slave 2 |
| 11 | bidir. | Positioning signal 10 | 21 | Output; high active | *only main device:* LED *interference* of Slave 2 |
| 12 | bidir. | Positioning signal 11 | 22 | Output | *only main device:* BATT1 of Slave 2 |
| 13 | bidir. | Positioning signal 12 | 23 | Output | *only main device:* 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 $I^2C$ 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 | $I^2C$ address |
|---|---|---|---|
| PCF8591 #1 | 2x A/D Differenz<br>1x D/A | Analogeingänge Kanal 1 und 2<br>Analogausgang Kanal 1 | 1001 000 $^{R}/_{W}$ |
| PCF8591 #2 | 2x A/D Differenz<br>1x D/A | unbenutzt<br>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.

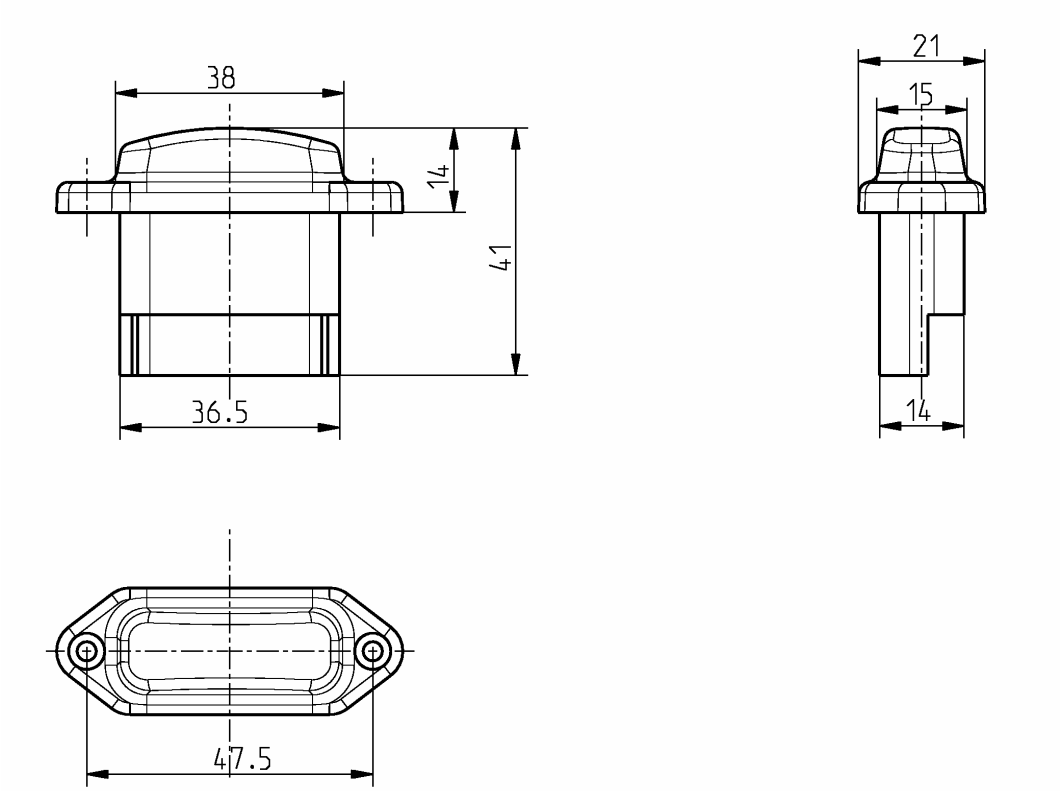



**Figure 4.2** Dimensions of the RF/BT module

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 $I^2C$ 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 µs 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 correspoding connections GPIO3 and GPIO4.

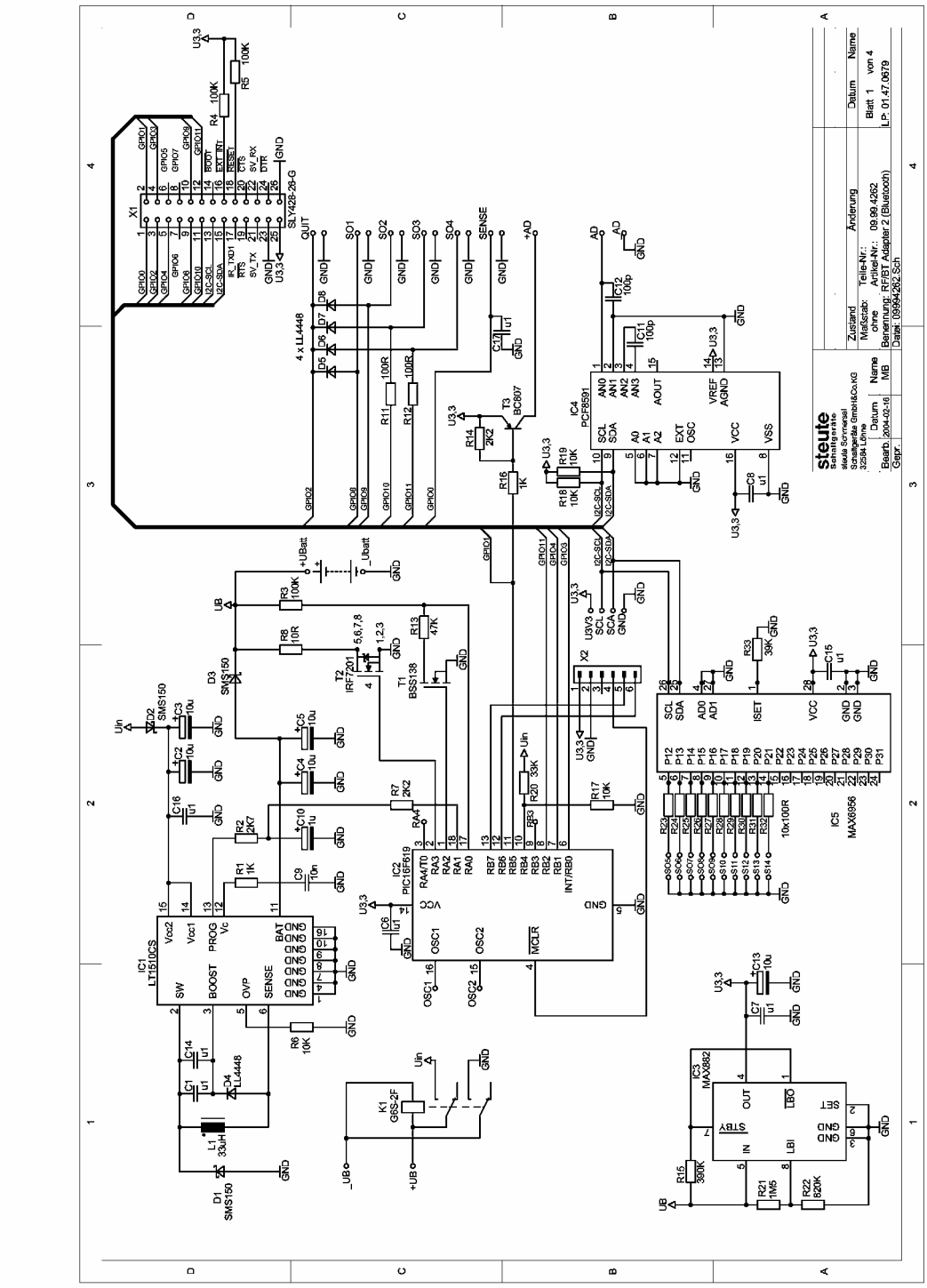


**Figure 4.3** Example of a circuitry for the RF/BT module

# 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 ± 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: | - $I^2C$<br>- 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 my 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

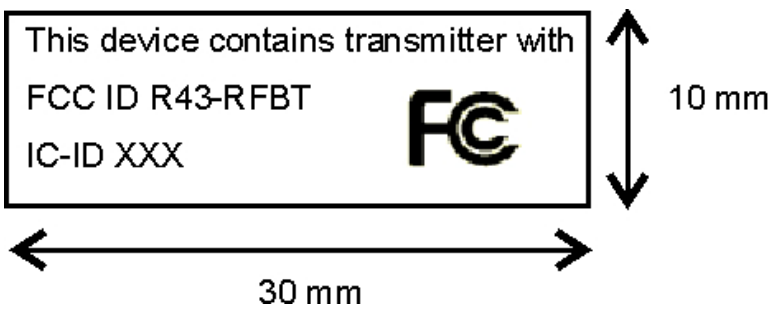
## 6.4 RF-exposure Statement

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