WÜRTH ELEKTRONIK

TRITON REFERENCE MANUAL

AMB2220 / 2603011x21000

VERSION 4.6

APRIL 14, 2021

****

MUST READ

Check for firmware updates

Before using the product make sure you use the most recent firmware version, data sheet and user manual. This is especially important for Wireless Connectivity products that were not purchased directly from Würth Elektronik eiSos. A firmware update on these respective products may be required.

We strongly recommend to include in the customer system design, the possibility for a firmware update of the product.

Revision history

Manual version	FW version	HW version	Notes	Date
3.9	3.5.0	2.3	• Initial version	November 2017
4.0	3.6.0	2.3	• New corporate design and structure • Added examples • Added information for FCC and IC certification • Removed description of second *WAKE-UP* pin	November 2018
4.1	3.6.0	2.3	• Corporate design adaptation	December 2018
4.2	3.6.0	2.3	• Added chapter `Reference design` • Added chapter `Information for explosion protection`	February 2019
4.3	3.6.0	2.3	• Updated label in chapter `General labeling information` • Updated address of Division Wireless Connectivity & Sensors location	June 2020
4.4	3.6.0	2.3	• Updated firmware update chapter	October 2019
4.5	3.6.0	2.3	• Updated chapter `Radio characteristics`	January 2021
4.6	3.6.0	2.3	• Updated chapter `EU Declaration of conformity` • Removed 2603011021009 and 2603011121009 from `Ordering information` as there are no longer pre-cuts available. The modules are available in all quantities as cut tape.	March 2021

⋆ For firmware history see chapter `Firmware history`

Abbreviations and abstract

Abbreviation	Name	Description
ACK	Acknowledgement	Acknowledgement pattern confirming the reception of the transmitted data packet.
CS	Checksum	
FSE	Field Sales Engineer	
0xhh [HEX]	Hexadecimal	All numbers beginning with 0x are stated as hexadecimal numbers. All other numbers are decimal.
HIGH	High signal level	
LOW	Low signal level	
LPM	Low power mode	Operation mode for reduced power consumption.
LSB	Least significant Bit	
MSB	Most significant Bit	
PL	Payload	The real, non-redundant information in a frame/packet.
RF	Radio frequency	Describes everything relating to the wireless transmission.
UART	Universal Asynchronous Receiver Transmitter	Universal Asynchronous Receiver Transmitter allows communicating with the module of a specific interface.
US	UserSettings	Any relation to a specific entry in the UserSettings is marked in a special font and can be found in the respective chapter.
VCC	Supply voltage	

Contents

1. Introduction

1.1. Operational description

The Triton module is designed as a radio sub module to enable wireless communication between devices such as control systems, remote controls, sensors etc. and operates in the world-wide license-free 2.4 GHz frequency band.

The Triton can be deployed wherever the wireless exchange of small data packets between two or more parties is required, offering an extremely high range at a data rate of 1.5 kbps[1]. Data rates up to 72 kbps are supported.

The Triton has an integrated micro controller including a software stack designed by Würth Elektronik eiSos with exclusive access to the on-board RF chip. The micro controller offers enough free space to implement customer specific applications on request.

The control of the module is made via an UART based command interface.

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[1] The effective range is strongly dependent on the operating environment such as objects in the line of sight (like buildings, walls), objects in the Fresnel zone, temperature and humidity. Additionally, factors such as data rate and antenna used also impact the range. In general, higher the data rate, poorer the receive sensitivity resulting in reduced range.

1.2. Block diagram
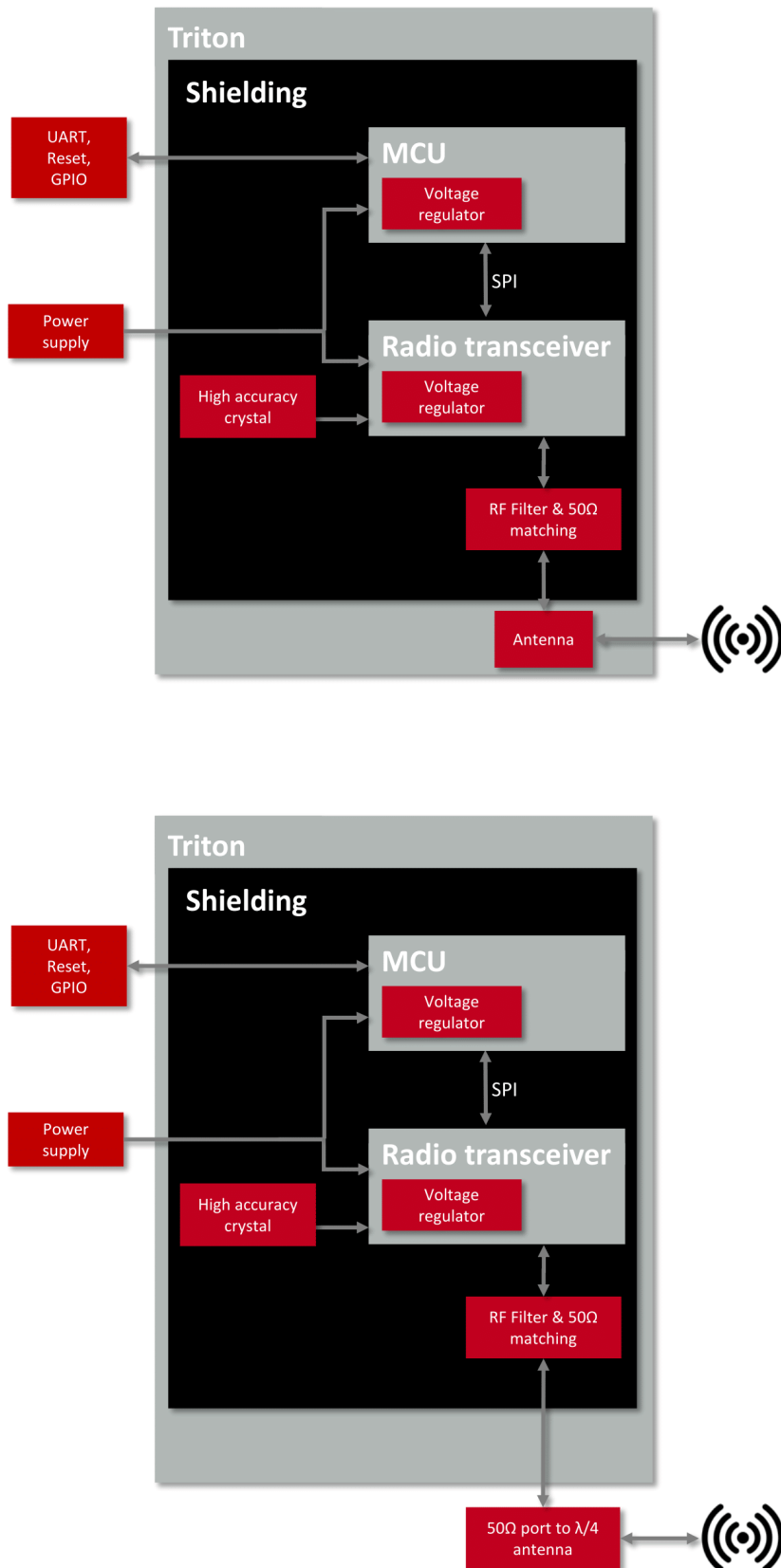
Figure 1: Block diagram with internal chip antenna and antenna pad

1.3. Ordering information

WE order code	Former order code	Description
2603011021000	AMB2220-TR	Radio module 2.4 GHz with integrated chip antenna, Tape & Reel
2603011121000	AMB2220-1-TR	Radio module 2.4 GHz with RF pad, Tape & Reel
2603019021001	AMB2220-EV	Evaluation kit with module AMB2220
2603019321001	AMB2220-1-EV	Evaluation kit with module AMB2220-1

Table 1: Ordering information

2. Electrical specifications

2.1. Recommended operating conditions

Description	Min.	Typ.	Max.	Unit
VCC	1.9	2.5^2	3.6	V
Temperature range	-40	25	85	℃

Table 2: Recommended operating conditions

2.2. Absolute maximum ratings

Description	Min.	Typ.	Max.	Unit
VCC	-0.3		3.8	V

Table 3: Absolute maximum ratings

2.3. Power consumption

2.3.1. Static

Description	Min	Typ.	Max	Unit
TX current consumption at max output power		37		mA
RX current consumption		9		mA
Low power mode		1		µA

Table 4: Power consumption

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[2]For battery powered applications the use of 2.5V power supply is recommended. Use of supply voltages above 2.7V results in significantly higher current consumption especially in low power modes.

2.4. Radio characteristics

Description	Min	Typ.	Max	Unit
Max output power		10		dBm
Input sensitivity at 1.5 kbps		-115		dBm
Input sensitivity at 72 kbps		-96		dBm
Frequencies	2.4015		2.4775	GHz

Table 5: Radio characteristics, module: 2603011121000, conducted

Description	Min	Typ.	Max	Unit
Max output power		0.2		dBm
Input sensitivity at 1.5 kbps		-105		dBm
Frequencies	2.4015		2.4775	GHz

Table 6: Radio characteristics, module: 2603011021000

2.5. Pin characteristics

Property	Min	Typ.	Max	Unit
VCC rise time rate	0		1000	µs/V
VCC fall time rate	0		1000	µs/V
Pin input voltage	- 0.2		VCC + 0.2	V
Pin output current sunk by any I/O and control pin			25	mA
Pin output current sourced by any I/O and control pin			25	mA
Pin total output current sunk by sum of all I/Os and control pins			60	mA
Pin total output current sourced by sum of all I/Os and control pins			60	mA

Table 7: Pin characteristics

3. Pinout

Pin	Signal		Pin	Signal
1	GND		33	GND
	RESERVED			RESERVED
	GND			RESERVED
	RESERVED			RESERVED
	RESERVED			RESERVED
	RESERVED			RESERVED
	VCC			RESERVED
	/RESET			RESERVED
	RESERVED			RESERVED
	WAKE_UP			RESERVED
	RESERVED			RESERVED
	RESERVED			URXD
	RESERVED			UTXD
14	RESERVED		21	RESERVED

Bottom pins (left to right): RESERVED, RESERVED, TX_IND, RX_IND, RESERVED, RESERVED
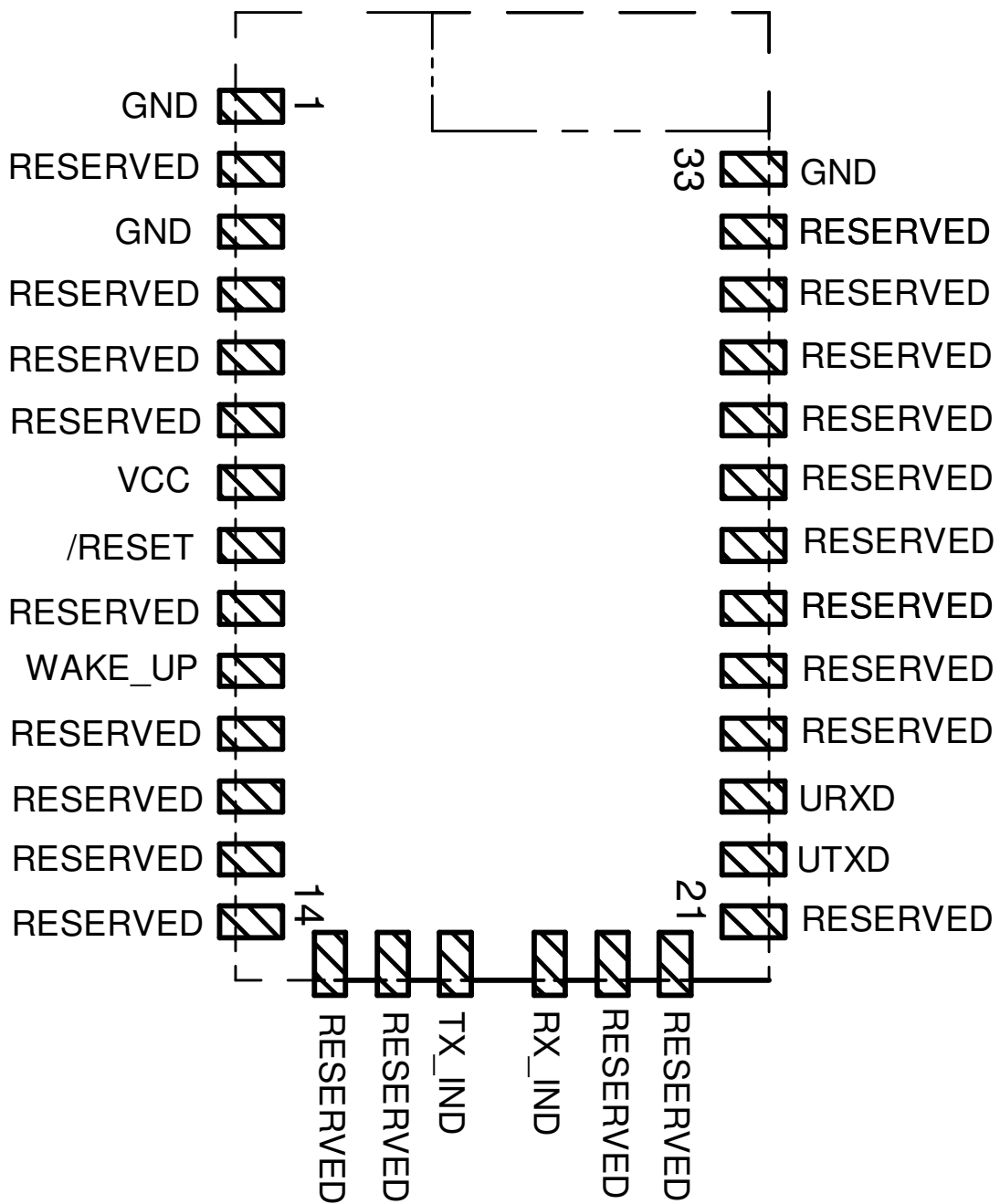
Figure 2: Pinout (top view)

No	Designation	I/O	Description
1	*GND*	I/O	Ground
2	*RF*	I/O	RF-Pad for module variant 260301112100x, connect with 50Ω RF-line and customer antenna, not used in 260301102100x
3	*GND*	I/O	Ground
4	*BOOT0*	Input	First boot pin. It must be switchable to LOW and HIGH for firmware update via UART. Application starts up when level is LOW (see chapter `13.2`). Has internal 10 kΩ pull down
5	*RESERVED*	I/O	Reserved for coming features. Do not connect
6	*RESERVED*	I/O	Reserved for coming features. Do not connect
7	*VCC*	Input	Power supply
8	*/RESET*	Input	LOW active */RESET* pin. Pull down for hardware reset. Has internal 10 kΩ pull up
9	*RESERVED*	I/O	Reserved for coming features. Do not connect
10	*WAKE-UP*	Input	LOW active *WAKE-UP* pin. Has internal 10 kΩ pull up. For more info see chapter `10`
11	*RESERVED*	I/O	Reserved for coming features. Do not connect
12	*RESERVED*	I/O	Reserved for coming features. Do not connect
13	*RESERVED*	I/O	Reserved for coming features. Do not connect
14	*RESERVED*	I/O	Reserved for coming features. Do not connect

No	Designation	I/O	Description
15	*RESERVED*	I/O	Reserved for coming features. Do not connect
16	*RESERVED*	I/O	Reserved for coming features. Do not connect
17	*LED_TX*	Output	LED indicating radio packet transmission. Active LOW. Can be disabled/enabled (see chapter `8.2.6`)
18	*LED_RX*	Output	LED indicating radio packet reception. Active LOW. Can be disabled/enabled (see chapter `8.2.6`)
19	*BOOT1*	Input	Second boot pin. It must be switchable to LOW and HIGH for firmware update over UART. Has internal 10 kΩ pull down
20	*RESERVED*	I/O	Reserved for coming features. Do not connect

No	Designation	I/O	Description
21	*RESERVED*	I/O	Reserved for coming features. Do not connect
22	*UART_TX*	Output	UART TX line
23	*UART_RX*	Input	UART RX line
24	*RESERVED*	I/O	Reserved for coming features. Do not connect
25	*RESERVED*	I/O	Reserved for coming features. Do not connect
26	*SWDIO*	Input	SWD SWDIO line for flasher
27	*SWCLK*	Input	SWD SWCLK line for flasher
28	*RESERVED*	I/O	Reserved for coming features. Do not connect
29	*SWO*	Input	SWD SWO line for flasher
30	*RESERVED*	I/O	Reserved for coming features. Do not connect
31	*RESERVED*	I/O	Reserved for coming features. Do not connect
32	*RESERVED*	I/O	Reserved for coming features. Do not connect
33	*GND*	I/O	Ground

Table 8: Pinout

4. Quick start

4.1. Minimal pin configuration

In factory state the module is immediately ready for operation. The following pins are required in the minimal configuration:
/RESET, *VCC*, *GND*, *UART_TX* and *UART_RX*

If the module is connected to a PC, a converter (TTL to RS-232 or TTL to USB) is necessary to achieve interface compatibility. The Triton-EV already implements such a USB converter to be connected to a PC.
For enabling a quick wake-up from sleep mode the pin *WAKE-UP* has to be connected in addition.
For enabling a firmware update via UART bootloader the pins *BOOT0* and *BOOT1* have to be connected in addition.

4.2. Power up

Recommended procedure for starting the module into normal operation:
Set and hold the pins *BOOT0* and *Boot1* to LOW. After supply voltage is applied to the module, the */RESET* pin shall be held at LOW level for another Δt of at least 200ms after the *VCC* is stable to ensure a safe start-up. The module will send a `CMD_STATUS_IND` message over the UART as soon it is booted into application.
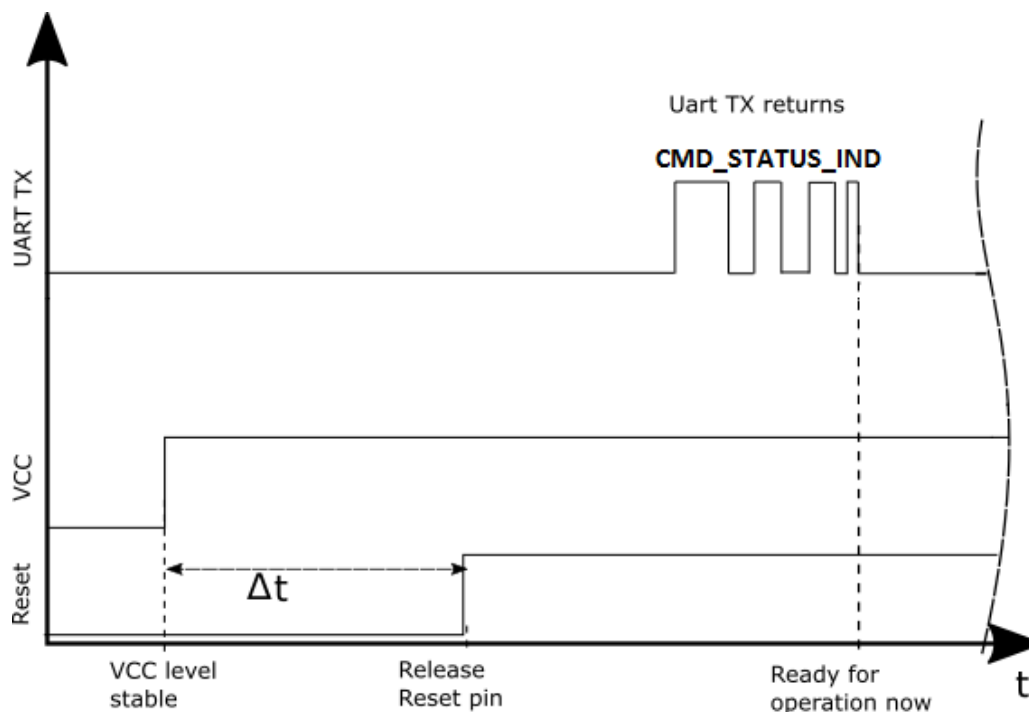
Figure 3: Power up

4.3. Quickstart example

Sending and receiving: Hello World
Connect the two devices (modules, EV-boards or USB dongles) to a PC.

A terminal program, for example *hterm*, is used to perform the communication via COM ports. The two corresponding COM ports have to be selected and opened with a default configuration of 9600 baud, 8 Data Bits, 1 Stop Bit and Parity set to none (8n1).

Make sure the received data is shown also as hex by enabling the corresponding checkbox:

As soon as the module is ready for operation (at start-up or after a reset), the device sends a `CMD_STATUS_IND` message on the UART. Eventually the reset button has to be pushed (or `CMD_RESET_REQ` performed) to trigger a reset and see this message.
Next, the command interface can be used to configure the module or to transmit data.
To send the string "Hello World!" the corresponding `CMD_DATAEX_REQ` has to be inserted into the input line of hterm. The "Type" needs to be change from "ASC" to "HEX" before entering the first Byte. The command `CMD_DATAEX_REQ` has the following structure:

Start signal	Command	Length	Addr. target	Payload	CS
0x02	0x01	1 Byte	1 Byte	(Length - 1) Bytes	1 Byte

In this example the payload 0x48 0x65 0x6C 0x6C 0x6F 0x20 0x57 0x6F 0x72 0x6C 0x64 0x21 (Hello World!) has a length of 12 (0x0C) Bytes. In addition we use the broadcast address 0xFF to broadcast this "Hello World" message to all receiving Triton within the same subnet and radio channel. The checksum CS is a XOR conjunction of all previous Bytes, which is 0xF0 in this case.

Using the "ASend" button followed by pushing the "Start" button sends the data once. The second module receiving this packet outputs a `CMD_DATAEX_IND` message containing the transmitted payload data and the corresponding RSSI value.

The format of the `CMD_DATAEX_IND` is as follows:

Start signal	Command	Length	Addr. source	Payload	RSSI	CS
0x02	0x81	1 Byte	1 Byte	(Length - 2) Bytes	1 Byte	1 Byte

Thus, the `CMD_DATAEX_IND` message informs us that we received a packet with payload of 14 (0x0E) Bytes. 12 Bytes of these are the transmitted user payload 0x48 0x65 0x6C 0x6C 0x6F 0x20 0x57 0x6F 0x72 0x6C 0x64 0x21 (Hello World!), one Byte the sender address 0x00 and one Byte is the RSSI value, here 0x09 (=-48dBm).

5. Functional description

The Triton can be configured to operate in several modes at the physical, MAC as well as the network layer. This chapter describes all the available modes of operation.

5.1. Physical layer

At the physical layer, the Triton can be configured to use one of the following data rates:

RF_Rate	Data rate (gross) [kbps]
1	1.5
2	3
3	6
4	12
5	24
6	48
7	72

Additionally, the frequency channel of operation is configurable to avoid interference between several subnets of radio devices (see `RF_Channel`). The radio parameters need to be chosen for optimal performance based on the required range, data rate, keeping in mind the compliance with valid regulatory requirements. A detailed description can be found in chapter 8.

5.2. MAC and network layer

In order to interconnect several modules and build a network or to send data to specific devices, the Triton supports addressing at MAC and network level. Each device can be configured with an address and a network id that is defined by the UserSettings `RF_Address_Source` and `RF_Subnet` respectively.

> ⓘ Please note that the RF settings (e.g. data rate, radio channel, network id) must be the same for all nodes in the network.
> Violation may cause interrupted transmission, or received packets that cannot to be interpreted correctly.

5.2.1. Unicast

A module can use the command `CMD_DATAEX_REQ` to send data to a pre-defined destination address within the same subnet.

5.2.2. Multicast/Broadcast

If the destination address 0xFF is used in the `CMD_DATAEX_REQ` command, the message is broadcasted to all nodes in the same subnet.

5.2.3. Fragmentation mode

By default the payload of a radio packet is restricted to maximum 26 Bytes. To allow the transmission of larger data packets the so called fragmentation mode was introduced (see chapter 11). Using this mode data packets up to 240 Bytes can be transmitted by splitting the data packet into fragments and sending the fragments of appropriate size one after the other. On the receiver side, the packet fragments are detected and combined to form a complete packet after all data fragments have been received successfully.

5.3. System configuration parameters

The parameters that determine the functionality of the module are classified into two categories. The non-volatile UserSettings (see chapter 8) values can be modified using the `CMD_SET_REQ` command retain their values after a reset.

> **!** Please note that each `CMD_SET_REQ` will consume one flash erase/write cycle, which are limited due to the hardware.

On the other hand, the volatile settings (called "RuntimeSettings") can be accessed by explicit commands (see chapter 7.4) and used to quickly (but temporarily) modify specific parameters without using flash cycles. These settings are only valid until a reset is performed and shall be used when frequent updates of settings are necessary.

6. Host connection

6.1. Serial interface: UART

The configuration in factory state of the UART is 9600 baud with data format of 8 data Bits, no parity and 1 stop Bit ("8n1"). The baud rate of the UART can be configured by means of the UserSetting `UART_Baudrate`. The data format is fixed to 8n1.

Since the UART speed is derived from a digitally calibrated oscillator, variations of up to $\pm$ 2 % may occur.

7. The command interface

7.1. Overview

The module acts as a slave and can be fully controlled by an external host. The configuration as well as the operation of the module can be managed by predefined commands that are sent as telegrams over the UART interface of the module.

The commands of the command interface can be divided into 3 groups:

- Requests: The host requests the module to trigger any action, e.g. in case of the request `CMD_RESET_REQ` the host asks the module to perform a reset.

- Confirmations: On each request, the module answers with a confirmation message to give a feedback on the status of the requested operation. In case of a `CMD_RESET_REQ`, the module answers with a `CMD_RESET_CNF` to tell the host whether the reset will be performed or not.

- Indications and Responses: The module indicates spontaneously when a special event has occurred. The `CMD_DATAEX_IND` indicates for example that data was received via radio.

Start signal	Command	Length	Payload	CS
0x02	1 Byte	1 Byte	Length Bytes	1 Byte

Start signal 0x02 (1 Byte)

Command One of the predefined commands (1 Byte), the module implements new and modified commands in comparison to other radio compatible modules.

Length Specifies the number of payload data in the following field.

Payload Variable number (defined by the length field) of data or parameters.

Checksum Byte wise XOR combination of all preceding Bytes including the start signal, i.e. 0x02 ˆ Command ˆ Length ˆ Payload = CS

> Host integration example codes for checksum calculation and command frame structure can be found in annex `A` and `B`, as well as in the *Wireless Connectivity SDK*.

All commands of type Request must obey the following rules:

- Only one request at a time may be active. Wait for confirmation of the previous request and implement a suiting timeout (depends on the command or action that was requested, 500ms should cover the worst-case time).

- Indications are spontaneous messages, they may occur in between a command request and its confirmation.

7.2. Data transfer and reception in the command mode

This group of commands include the commands that either are used to request a radio telegram to be send or indicates a received frame.

7.2.1. CMD_DATAEX_REQ

This command serves data transfer to a specified destination address within the configured subnet. The maximum number of payload data is limited to 26 Bytes, as long the fragmentation mode is not used. In fragmentation mode the maximum packet length is 240 Bytes (see chapter 11). The entered destination address is loaded into the volatile RuntimeSettings and thus is kept until the system is reset or these values are modified again.
Format:

Start signal	Command	Length	Addr.Target	Payload	CS
0x02	0x01	1 Byte	1 Byte	(Length - 1) Bytes	1 Byte

Response:

Start signal	CMD_DATAEX_REQ | 0x40	Length	Status	CS
0x02	0x41	0x01	1 Byte	1 Byte

Status:

0x00: Request successfully received and processed, packet has been sent

0x01: Error during processing

7.2.2. CMD_DATAEX_IND

This telegram indicates the reception of data Bytes and represents the counterpart to the command `CMD_DATAEX_REQ`. Apart from the RX field strength, this telegram also displays the source address of the sending device.
Format:

Start signal	Command	Length	Addr. source	Payload	Field strength (RSSI)	CS
0x02	0x81	1 Byte	1 Byte	(Length - 2) Bytes	1 Byte	1 Byte

The received RSSI Byte has to be interpreted as follows:

$$P[dBm] = -120 + RSSIByte \times 8$$

7.2.3. CMD_DATAFRAG_IND

This indication message occurs when a valuable radio packet fragment has been received successfully. It returns the source address of the sending device, the sequence number of the RF packet, the fragment number of the current RF packet and the fragment number of the last RF packet that has to be received to complete the full RF packet.

This message can be enabled/disabled using the `Cfg_Flags`.
The full RF packet is indicated using the `CMD_DATAEX_IND` as soon as the last packet fragment has been received.
Format:

Start signal	Command	Length	Addr. source	Sequence number	Fragment number	Number of last fragment	CS
0x02	0x82	0x04	1 Byte	1 Byte	1 Byte	1 Byte	1 Byte

STOP If a `CMD_DATAFRAG_IND` has been received, we strongly recommend to wait for the packet completion before performing other actions with the module. The module reception has been completed as soon as `CMD_DATAEX_IND` was sent to the host or the timeout occurred.
In case of error, e.g. if one or several packet fragments have been lost during transmission and thus no `CMD_DATAEX_IND` was sent, the module reverts to operate in normal mode after 500ms.

7.3. Requesting parameters, actions and events

This group includes all commands that will return read-only parameters or request actions in the module.

7.3.1. CMD_FWVERSION_REQ

This command is used to request the firmware version of the module. The main version number is returned first, followed by the secondary version number and the revision number. Format:

Start signal	Command	Length	CS
0x02	0x0C	0x00	0x0E

Response (`CMD_FWVERSION_CNF`):

Start signal	Command	0x40	Length	Firmware version	CS
0x02	0x4C	0x03	3 Bytes	1 Byte

7.3.2. CMD_SERIALNO_REQ

This command can be used to query the individual serial number and product ID (PID) of the module.
Format:

Start signal	Command	Length	CS
0x02	0x0B	0x00	0x09

Response (`CMD_SERIALNO_CNF`):

Start signal	Command	0x40	Length	PID	Serial Number (MSB first)	CS
0x02	0x4B	0x04	1 Byte	3 Bytes	1 Byte

7.3.3. CMD_RESET_REQ

This command triggers a software reset of the module. The reset is performed after the acknowledgment is transmitted. All volatile settings are initialized with their defaults. As soon as the module has restarted a `CMD_STATUS_IND` is printed on the UART.
Format:

Start signal	Command	Length	CS
0x02	0x05	0x00	0x07

Response (`CMD_RESET_CNF`):

Start signal	Command | 0x40	Length	Status	CS
0x02	0x45	0x01	1 Byte	1 Byte

Status:

0x00: Request successfully received and processed

0x01: Request not successful

7.3.4. CMD_STATUS_IND

This indication shows the current state of the module, when module enters or leaves low power mode (LPM).

Start signal	Command	Length	Mode	CS
0x02	0xC0	0x01	1 Byte	1 Byte

Mode:

0x00: Run mode

0x01: LPM

> (!) This message also indicates when the module ready after start-up.

7.3.5. CMD_RSSI_REQ

This command returns the RX signal strength of the last received packet determined by the transceiver IC. The current RSSI value of the radio IC ("live RSSI value") cannot be requested by means of this command.
Format:

Start signal	Command	Length	CS
0x02	0x0D	0x00	0x0F

Response (`CMD_RSSI_CNF`):

Start signal	Command | 0x40	Length	Field strength (RSSI)	CS
0x02	0x4D	0x01	1 Byte	1 Byte

The received RSSI Byte has to be interpreted as follows:

$$P[dBm] = -120 + RSSIByte \times 8$$

If no packet was received yet the return value will be 0x00.

7.3.6. CMD_BOOTLOADER_REQ

This command resets the module and starts the internal bootloader, such that a new firmware can be flashed (see chapter 13.2). To start the Triton application after this command has been used, a reset using the */RESET* pin is required.
Format:

Start signal	Command	Length	CS
0x02	0x12	0x00	0x10

Response (CMD_BOOTLOADER_CNF):

Start signal	Command | 0x40	Length	Status	CS
0x02	0x52	0x01	1 Byte	1 Byte

Status:

0x00: Request successfully received and processed, bootloader can be accessed after automatic reset

0x01: Error during processing

7.3.7. CMD_SET_OPMODE_REQ

This command lets the module enter the low power mode (LPM). For further information about the LPM, see chapter 10.
Format:

Start signal	Command	Length	LPM	CS
0x02	0x28	0x01	0x01	0x2A

Response (CMD_SET_OPMODE_CNF):

Start signal	Command | 0x40	Length	Status	CS
0x02	0x68	0x01	0x01	1 Byte

Status:

0x01: LPM entered

7.4. Modification of volatile parameters

This group contains all functions that will modify RuntimeSettings while the module is running. These settings are volatile and will be reset to their default values (see chapter 8) on a reset of the module.

7.4.1. CMD_SET_TMP_CHANNEL_REQ

This command changes the runtime setting of the RF channel to a specific value. The channel Byte is valuable from "0x00" (0) to "0x13" (19). Check table 9 for more information about the channel assignment.
Format:

Start signal	Command	Length	Channel	CS
0x02	0x20	0x01	1 Byte	1 Byte

Response (`CMD_SET_TMP_CHANNEL_CNF`):

Start signal	Command	0x40	Length	Status	CS
0x02	0x60	0x01	1 Byte	1 Byte

Status:

0x00: Request successfully received and processed

0x01: Error during processing

7.4.2. CMD_SET_TMP_S_ADDR_REQ

This command changes the runtime setting source address to a specific value. The address source Byte is valuable from "0x00" (0) to "0xFE" (254), "0xFF" (255) is the broadcast address which shall not be used as a source address.
Format:

Start signal	Command	Length	Addr. source	CS
0x02	0x21	0x01	1 Byte	1 Byte

Response (`CMD_SET_TMP_S_ADDR_CNF`):

Start signal	Command	0x40	Length	Status	CS
0x02	0x61	0x01	1 Byte	1 Byte

Status:

0x00: Request successfully received and processed

0x01: Error during processing

7.4.3. CMD_SET_TMP_SUBNET_REQ

This command changes the runtime setting of the RF subnet to a specific value. The subnet Byte is value from "0x00" (0) to "0xFF" (255), but due to restrictions of the RF chip, the following subnets cannot be used: "0x00" (0), "0x30" (48), "0x33" (51), "0x63" (99), "0x66" (102), "0x92" (146), "0x99" (153) and "0xCC" (204).
Format:

Start signal	Command	Length	Subnet	CS
0x02	0x22	0x01	1 Byte	1 Byte

Response (`CMD_SET_TMP_SUBNET_CNF`):

Start signal	Command | 0x40	Length	Status	CS
0x02	0x62	0x01	1 Byte	1 Byte

Status:

0x00: Request successfully received and processed

0x01: Error during processing

7.4.4. CMD_SET_TMP_PWRLVL_REQ

This command changes the runtime settings of the RF power level to a specific value. The power level Byte is valuable from "0x00" (0) to "0x0A" (10).
Format:

Start signal	Command	Length	Power level	CS
0x02	0x23	0x01	1 Byte	1 Byte

Response (`CMD_SET_TMP_PWRLVL_CNF`):

Start signal	Command | 0x40	Length	Status	CS
0x02	0x63	0x01	1 Byte	1 Byte

Status:

0x00: Request successfully received and processed

0x01: Error during processing

7.5. Modification of non-volatile parameters

The non-volatile parameters are also called UserSettings and are stored in a special flash location.

7.5.1. CMD_SET_REQ

This command enables direct manipulation of the parameters in the module's non-volatile UserSettings. The respective parameters are accessed by means of the memory positions (Offset) described in table 14.

> **!** Parameters of 2 or more Bytes (e.g. `UART_Baudrate`) have to be transferred with the least significant Byte (LSB) first unless noted otherwise for a specific parameter.

> **!** The changed parameters only take effect after a restart or a reset of the module. This can be done by a `CMD_RESET_REQ`.

> **STOP** The validity of the specified parameters is not verified. Incorrect values can result in device malfunction!

> **STOP** To save the parameters in the flash memory of the module, the particular memory segment must first be flushed entirely and then restored from RAM. If a reset occurs during this procedure (e.g. due to a supply voltage drop), the entire memory area may be destroyed. In this case, the module may no longer be operable, which means that the firmware must be re-installed via the JTAG, SWD interface or UART Bootloader. Recommendation: First verify the configuration of the module by reading the current settings with a `CMD_GET_REQ` and only write a `CMD_SET_REQ` if required.

Format:

Start signal	Command	Length	Offset	Parameter	CS
0x02	0x09	1 Byte	1 Byte	(Length - 1) Bytes	1 Byte

Response (`CMD_SET_CNF`):

Start signal	Command	0x40	Length	Status	CS
0x02	0x49	0x01	1 Byte	1 Byte

Status:

0x00: Request successfully received and processed

0x01: Operation failed due to invalid parameter

7.5.1.1. Example: Set the TX power level

Setting the TX power level `RF_Power_Level` to 2.

Start signal	Command	Length	Offset	Parameter	CS
0x02	0x09	0x02	0x04	0x02	0x0F

Response:

Start signal	Command | 0x40	Length	Status	CS
0x02	0x49	0x01	0x00	0x4A

Setting was set successfully.

7.5.2. CMD_GET_REQ

This command can be used to query individual or multiple UserSettings parameters. The respective parameters are accessed by means of the memory positions (Offset) described in table 14, The requested number of Bytes from the specified memory position are returned.

> Parameters of 2 or more Bytes will be transmitted LSB first unless noted otherwise in their parameter description.

Format:

Start signal	Command	Length	Offset	Length of parameters	CS
0x02	0x0A	0x02	1 Byte	1 Byte	1 Byte

Response (`CMD_GET_CNF`):

Start signal	Command | 0x40	Length	Offset/Status	Parameter	CS
0x02	0x4A	1 Byte	1 Byte	(Length - 1) Bytes	1 Byte

Offset/Status:

Length = 1

0x01: Request not successful

Length $\neq$ 1

Offset of the setting

7.5.2.1. Example: Request the source address

Request the current source address `RF_Address_Source` using offset 3 and length of parameters 1.

Start signal	Command	Length	Offset	Length of parameters	CS
0x02	0x0A	0x02	0x03	0x01	0x08

Response: The current `RF_Address_Source` in flash is 0.

Start signal	Command | 0x40	Length	Offset	Parameter	CS
0x02	0x4A	0x02	0x03	0x00	0x49

7.5.3. CMD_FACTORY_RESET_REQ

This command restores the default UserSettings of the module. If this was successful, a software reset of the module is performed in addition.
Format:

Start signal	Command	Length	CS	
0x02	0x11	0x00	0x13	

Response (`CMD_FACTORY_RESET_CNF`):

Start signal	Command | 0x40	Length	Status	CS
0x02	0x51	0x01	1 Byte	1 Byte

Status:

0x00: Request successfully received and processed

0x01: Request not successful

8. UserSettings - Module configuration values

8.1. Difference between volatile and non-volatile settings

The so-called UserSettings are stored permanently into the internal flash of the module. At start-up, these UserSettings are loaded as start values into the volatile settings ("RuntimeSettings"). Some of the RuntimeSettings can be modified by special commands (see chapter `7.4`). These RuntimeSettings are lost and replaced by the UserSettings content when the module is restarted.

> **(!)** See chapters `7.4` and `7.5` for methods to change volatile and/or non-volatile settings.

The non-volatile UserSettings can be modified by means of specific commands in the configuration mode (`CMD_SET_REQ`) of the module. These parameters are stored permanently in the module's flash memory. All settings are described on the following pages. After changing those parameters, a reset will be necessary to make use of the new settings.

> **STOP** The validity of the specified parameters given with a `CMD_SET_REQ` is not verified. Incorrect values can result in device malfunction and may even result in the need of re-flashing the entire module firmware!

8.2. Modifying the UserSettings

The following chapters will give examples for the modification for many parameters using the commands `CMD_SET_REQ` and `CMD_GET_REQ`.

8.2.1. RF_Channel: Configure the radio channel

Designation	Permissible values	Default value	Offset	Number of Bytes
RF_Channel	0 - 19	6	0x00	1

This UserSetting determines the wireless channel of the module to be used after a reset. The dependence between channel and frequency is as follows:

$$Channel_{RF} = \frac{Frequency_{RF} - 2401.5GHz}{4MHz} \tag{1}$$

> **STOP** The user is responsible for adhering to the statutory regulations for the frequency use when using this module.

RF_Channel	Frequency [MHz]		RF_Channel	Frequency [MHz]
0	2401.5		10	2441.5
1	2405.5		11	2445.5
2	2409.5		12	2449.5
3	2413.5		13	2463.5
4	2417.5		14	2457.5
5	2421.5		15	2461.5
6	2425.5		16	2465.5
7	2429.5		17	2469.5
8	2433.5		18	2473.5
9	2437.5		19	2477.5

Table 9: Channel table
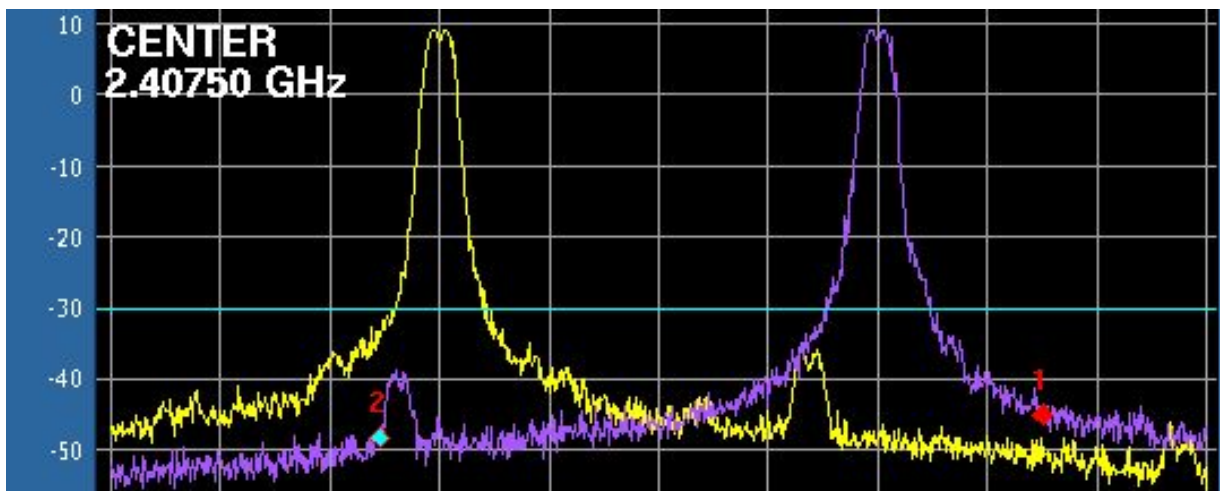
Figure 4: Spectrum of two signals next to each other, 72 kbps data rate.

8.2.1.1. Example 1

Set the radio channel to 10 (0x0A) using the `CMD_SET_REQ`:

Start signal	Command	Length	Offset	Parameter	CS
0x02	0x09	0x02	0x00	0x0A	0x03

Response:

Start signal	Command | 0x40	Length	Status	CS
0x02	0x49	0x01	0x00	0x4A

Setting was set successfully.

8.2.1.2. Example 2

Request the radio channel using `CMD_GET_REQ`:

Start signal	Command	Length	Offset	Length of parameters	CS
0x02	0x0A	0x02	0x00	0x01	0x0B

Response: The current `RF_Channel` in flash is 0x0A (10).

Start signal	Command | 0x40	Length	Offset	Parameter	CS
0x02	0x4A	0x02	0x00	0x0A	0x40

8.2.2. RF_Rate: Configure the RF data rate

Designation	Permissible values	Default value	Offset	Number of Bytes
RF_Rate	1 - 7	1	0x01	1

This UserSetting determines the data rate of the module to be used after a reset.

Data rate [kbps]	RF_Rate	Sensitivity [dBm]
1.5	1	-115
3	2	-113
6	3	-111
12	4	-107
24	5	-102
48	6	-98
72	7	-96

Table 10: Selectable data rates

> ! The sensitivity of the receiver is a essential parameter for the range of the module. A lower sensitivity results in a higher range.

8.2.2.1. Example 1

Set the data rate to 7 (72 kbps) using the CMD_SET_REQ:

Start signal	Command	Length	Offset	Parameter	CS
0x02	0x09	0x02	0x01	0x07	0x0F

Response:

Start signal	Command | 0x40	Length	Status	CS
0x02	0x49	0x01	0x00	0x4A

Setting was set successfully.

8.2.2.2. Example 2

Request the current data rate using CMD_GET_REQ:

Start signal	Command	Length	Offset	Length of parameters	CS
0x02	0x0A	0x02	0x01	0x01	0x0A

Response: The current RF_Rate in flash is 1 (1.5 kbps).

Start signal	Command | 0x40	Length	Offset	Parameter	CS
0x02	0x4A	0x02	0x01	0x01	0x4A

8.2.3. RF_Power_Level: Configure the radio TX power

Designation	Permissible values	Default value	Offset	Number of Bytes
RF_Power_Level	-5 - 10	10	0x04	1

This UserSetting determines the TX power level of the module to be used after a reset.

RF_Power_Level	Output power[1] [dBm]	DC total current consumption [mA]
10	8.9	33.0
9	8.2	26.4
8	7.4	23.25
7	7.0	21.15
6	5.9	19.75
5	4.9	19.26
4	4.1	17.75
3	2.9	15.95
2	2.66	14.62
1	1.65	13.7
0	0.6	12.9
-1	-0.83	11.98
-2	-2.39	11.16
-3	-4.39	10.35
-4	-7.1	9.6
-5	-12.02	8.83

Table 11: Selectable radio power levels

STOP For FCC- and IC-compliance, please note that the RF_Power_Level must not be set higher than 6 in case of Triton (260301102100x) using the integrated chip antenna, and not higher than -1 in case of Triton (260301112100x) using a λ/4 wire antenna.

8.2.3.1. Example 1

Set the output power to 0 using the CMD_SET_REQ:

---

[1]Measured on a EV board in a cable-bound environment. Results may vary in customer application, different antennas and with different VCC values and different environmental conditions.

Start signal	Command	Length	Offset	Parameter	CS
0x02	0x09	0x02	0x04	0x00	0x0D

Response:

Start signal	Command | 0x40	Length	Status	CS
0x02	0x49	0x01	0x00	0x4A

Setting was set successfully.

8.2.3.2. Example 2

Request the current output power using `CMD_GET_REQ`:

Start signal	Command	Length	Offset	Length of parameters	CS
0x02	0x0A	0x02	0x04	0x01	0x0F

Response: The current `RF_Power_Level` in flash is 10.

Start signal	Command | 0x40	Length	Offset	Parameter	CS
0x02	0x4A	0x02	0x04	0x0A	0x44

8.2.4. RF_Subnet: Configure the subnet ID of the network

Designation	Permissible values	Default value	Offset	Number of Bytes
RF_Subnet	See description	169	0x02	1

This UserSetting determines the subnet of the wireless network to be used after a reset. In each channel up to 248 different subnets can be defined. Only modules in the same subnet and same RF_Channel can communicate with each other.

> **!** Using different subnets does not avoid radio collisions as it does not avoid overlaying of two signals at the same time in the same radio channel.

All subnets from 0 to 255 can be used **except** of the following:

Hexadecimal	Decimal
0x00	0
0x30	48
0x33	51
0x63	99
0x66	102
0x92	146
0x99	153
0xCC	204

Table 12: Not allowed subnets

8.2.4.1. Example 1

Set the subnet to 1 using the CMD_SET_REQ:

Start signal	Command	Length	Offset	Parameter	CS
0x02	0x09	0x02	0x02	0x01	0x0A

Response:

Start signal	Command	0x40	Length	Status	CS
0x02	0x49	0x01	0x00	0x4A

Setting was set successfully.

8.2.4.2. Example 2

Request the current subnet using CMD_GET_REQ:

Start signal	Command	Length	Offset	Length of parameters	CS
0x02	0x0A	0x02	0x02	0x01	0x09

Response: The current `RF_Subnet` in flash is 169 (0xA9).

Start signal	Command | 0x40	Length	Offset	Parameter	CS
0x02	0x4A	0x02	0x02	0xA9	0xE1

8.2.5. RF_Address_Source: Configure the source address

Designation	Permissible values	Default value	Offset	Number of Bytes
RF_Address_Source	0 - 254	0	0x03	1

This UserSetting determines the device address in the wireless network to be used after a reset. This parameter defines the address of the current module and it is copied into sending RF packets to identify the sender. It is also used to filter incoming RF packets (i.e. decide whether an incoming packet is supposed to be received by the current module).

> A subnet shall not contain multiple modules with the same address and in radio range to each other.

> Remember that 0xFF (255) is the broadcast address. Any module in range on that radio channel and in the same subnet will receive this packet.

8.2.5.1. Example 1

Set the address to 1 using the CMD_SET_REQ:

Start signal	Command	Length	Offset	Parameter	CS
0x02	0x09	0x02	0x03	0x01	0x0B

Response:

Start signal	Command | 0x40	Length	Status	CS
0x02	0x49	0x01	0x00	0x4A

Setting was set successfully.

8.2.5.2. Example 2

Request the current address using CMD_GET_REQ:

Start signal	Command	Length	Offset	Length of parameters	CS
0x02	0x0A	0x02	0x03	0x01	0x08

Response: The current RF_Address_Source in flash is 0.

Start signal	Command | 0x40	Length	Offset	Parameter	CS
0x02	0x4A	0x02	0x03	0x00	0x49

8.2.6. Cfg_Flags: Configure the module configuration flags

Designation	Permissible values	Default value	Offset	Number of Bytes
Cfg_Flags	0 - 255	9	0x05	1

This UserSetting is a 8-Bit field in which the use of individual pins, functions or signals can be configured. Table 13 represents a description of the respective flags. To use multiple settings, add the Bit values (logical OR) and choose the result as value for Cfg_Flags.

Bit no.	Bit value	Description
0	0x0001	If enabled ('1'), *LED_TX* outputs LOW when transmitting a packet and *LED_RX* outputs LOW when receiving a packet over radio.
1	0x0002	If enabled ('1'), the fragmentation mode is enabled (see chapter 11).
2	0x0004	Reserved, must be set to '0' to prevent conflicts in the future.
3	0x0008	If enabled ('1'), the reception of single packet fragments is indicated using the CMD_DATAFRAG_IND. This Bit is only active if fragmentation mode is also enabled (Bit 1 of Cfg_Flags = '1').
4 to 15	0x0010 to 0x8000	Reserved, must be set to '0' to prevent conflicts in the future.

Table 13: Configuration flags

8.2.6.1. Example 1

Set the configuration flags to default 9 using the CMD_SET_REQ:

Start signal	Command	Length	Offset	Parameter	CS
0x02	0x09	0x02	0x05	0x09	0x05

Response:

Start signal	Command | 0x40	Length	Status	CS
0x02	0x49	0x01	0x00	0x4A

Setting was set successfully.

8.2.6.2. Example 2

Request the current configuration flags using CMD_GET_REQ:

Start signal	Command	Length	Offset	Length of parameters	CS
0x02	0x0A	0x02	0x05	0x01	0x0E

Response: The current Cfg_Flags in flash is 9, meaning that the LEDs are enabled, fragmentation mode is off and the CMD_DATAFRAG_IND message is enabled.

Start signal	Command	0x40	Length	Offset	Parameter	CS
0x02	0x4A	0x02	0x05	0x09	0x49

8.2.7. UART_Baudrate: Configure the UART speed

Designation	Permissible values	Default value	Offset	Number of Bytes
UART_Baudrate	300 - 115200	9600	0x3C	4

This 4-Byte field defines the UART baud rate used by the module. In the `CMD_SET_REQ` it has to be entered as LSB first.

> ⓘ At module start-up, the default UART baud rate is used, if the configured baud rate is invalid.

8.2.7.1. Example 1

Set the UART baud rate to default 115200 Baud (0x0001C200) using the `CMD_SET_REQ`:

Start signal	Command	Length	Offset	Parameter	CS
0x02	0x09	0x05	0x3C	0x00 0xC2 0x01 0x00	0xF1

Response:

Start signal	Command | 0x40	Length	Status	CS
0x02	0x49	0x01	0x00	0x4A

Setting was set successfully.

8.2.7.2. Example 2

Request the current UART baud rate using `CMD_GET_REQ`:

Start signal	Command	Length	Offset	Length of parameters	CS
0x02	0x0A	0x02	0x3C	0x04	0x32

Response: The current `UART_Baudrate` in flash is 9600 Baud (0x00002580)

Start signal	Command | 0x40	Length	Offset	Parameter	CS
0x02	0x4A	0x02	0x3C	0x80 0x25 0x00 0x00	0xD4

Designation	Summary	Permissible values	Default value	Offset	Number of Bytes
RF_Channel	Radio channel	0 - 19	6	0x00	1
RF_Rate	RF data rate	1 - 7	1	0x01	1
RF_Subnet	Subnet of the wireless network	See description	169	0x02	1
RF_Address_Source	Address of the device	0 - 254	0	0x03	1
RF_Power_Level	TX power level	-5 - 10	10	0x04	1
Cfg_Flags	Configuration flags	0 - 255	9	0x05	1
UART_Baudrate	UART baud rate	300 - 115200	9600	0x3C	4

Table 14: Table of settings

9. Timing parameters

9.1. Reset behavior

The module will signalize over UART with a `CMD_STATUS_IND` when it is ready. Until then, no UART communication should be exchanged. A full module start-up after `CMD_RESET_REQ` or using the */RESET* pin may take up to 1s.

9.1.1. Power-on reset

After switching the supply voltage on and releasing the */RESET* pin (if wired), the time until the module is ready for operation may last up to 1s.

9.1.2. Reset via */RESET* pin

To force a module restart by means of the */RESET* pin, it must first be drawn to low level for at least 10 ms and then reverting back to high level (e.g. by the internal pull-up resistor). After going back to high level the μC will perform the start-up procedure. During this time, the processor clock-rate will be calibrated, which takes between 2 and 20 ms depending on the supply voltage and temperature.

> **!** Recommended procedure: Wait for `CMD_STATUS_IND` over UART after the */RE-SET* pin is high again.

9.2. Latencies during data transfer / packet generation

The data transfer is always buffered, i.e. data received via UART is buffered in the module until a specific event occurs. Subsequently, the UART reception is interrupted until the response of the module and the payload data is passed to the internal memory of the wireless transceiver.
The wireless transmission starts as soon as the complete data is available in the transceiver memory, which has to be initialized internally. The radio connection itself is a half-duplex channel based connection. On the receiver side, the FIFO is read as soon as an incoming and intact packet is detected.

10. Low power mode (LPM)

The stop mode is the lowest sleep mode the micro controller offers. In this mode the Triton consumes less than 1 µA of current The UART and radio are switched off.

To enter this sleep mode, the command `CMD_SET_OPMODE_REQ` must be sent to the module. To leave the sleep mode and wake up the module a falling edge must be applied to the *WAKE-UP* pin. After wake-up, the RAM content and thus the RuntimeSettings are preserved and still active.

11. Fragmentation mode

In normal mode the payload of a data packet can be maximal 26 Bytes. To allow the transmission of larger data packets the fragmentation mode was introduced (enabling via `Cfg_Flags`). Using this mode data packets up to 240 Bytes can be transmitted by splitting the data packet into fragments and sending the fragments of appropriate size one after each other. On the receiver side, the packet fragments are detected and combined to the full packet after all data fragments have been received successfully.

To experience maximum flexibility the user shall prefer implementing the fragmentation in his host and use the 26 Byte MTU (maximum transfer unit).

Sender:

The time needed to send a fragmented packet consists of the time the single fragments are transmitted plus the timeouts between the single transmissions. After the successful transmission a response on the `CMD_DATAEX_REQ` is printed via UART.

Receiver:

Depending on the `Cfg_Flags` a `CMD_DATAFRAG_IND` message is sent via UART indicating the reception of single packet fragments to inform the user to wait for the packet completion.

To be able to send and receive fragmented packets over RF both the sending and receiving device have to operate in fragmentation mode. Devices that are not in fragmentation mode will discard fragmented radio packets.

In fragmentation mode there is a much higher probability of RF packet collisions. If one or several fragments are lost during transmission, the whole data packet is discarded.

12. Custom firmware

12.1. Custom configuration of standard firmware

The configuration of the standard firmware includes adoption of the non-volatile Usersettings (see chapter 8) to customer requirements and creating a customized product on base of the standard product.

This variant will result in a customer exclusive module with a unique ordering number. It will also freeze the firmware version to a specific and customer tested version and thus results in a customer exclusive module with a unique ordering number.

Further scheduled firmware updates of the standard firmware will not be applied to this variant automatically. Applying updates or further functions require a customer request and release procedure.

12.2. Customer specific firmware

A customer specific firmware may include "Custom configuration of standard firmware" plus additional options or functions and tasks that are customer specific and not part of the standard firmware.

Further scheduled firmware updates of the standard firmware will not be applied to this variant automatically. Applying updates or further functions require a customer request and release procedure.

This also results in a customer exclusive module with a unique ordering number.

An example for this level of customization are functions like host-less operation where the module will perform data generation (e.g. by reading a SPI or I^{2}C sensor) and cyclic transmission of this data to a data collector, while sleeping or being passive most of the time.

Also replacing UART with SPI as host communication interface is classified such a custom specific option.

Certification critical changes need to be re-evaluated by an external qualified measurement laboratory. These critical changes may occur when e.g. changing radio parameters, the channel access method, the duty-cycle or in case of various other functions and options possibly used or changed by a customer specific firmware.

12.3. Customer firmware

A customer firmware is a firmware written and tested by the customer himself or a 3rd party as a customer representative specifically for the hardware platform provided by a module.

This customer firmware (e.g. in form of a Intel hex file) will be implemented into the module's production process at our production side.

This also results in a customer exclusive module with a unique ordering number.

The additional information needed for this type of customer firmware, such as hardware specific details and details towards the development of such firmware are not available for the public and can only be made available to qualified customers.

> **STOP** The qualification(s) and certification(s) of the standard firmware cannot be applied to this customer firmware solution without a review and verification.

12.4. Contact for firmware requests

Please contact your local field sales engineer (FSE) or wireless-sales@we-online.com for quotes regarding this topics.

13. Firmware updates

All products will experience maintenance, security and/or feature updates from time to time. For the standard products these maintained via the PCN process.
Customers can request the creation of a customized product including a "firmware freeze" to ensure that they will receive their verified product even if the standard product is updated.

13.1. Firmware flashing using the production interface

Most Würth Elektronik eiSos wireless connectivity modules offer a production interface (e.g. JTAG, SWD, Spy-Bi-Wire) for module flash access. Depending on the product, this interface can be used by customers to erase the entire chip and install their own firmware.

Using the production interface is not intended to perform updates of Würth Elektronik eiSos standard product firmware.

Production firmware images and binary files for Würth Elektronik eiSos wireless connectivity modules are not publicly available.

> **STOP** Any certification, declaration, listing and qualification becomes invalid if the production interface is used by a customer. Some products, in their documentation, state exceptions to this invalidation under certain conditions.

Customers shall make the product specific firmware update interface available to their application. These methods will use a wired (UART, SPI, etc.) or wireless (Bluetooth® LE, Wi-Fi, etc.) communication interface of the module to allow updating the product's firmware. Details are described in the next sections.

13.2. Using the STM32 UART bootloader

Please refer to the application notes AN3155 and AN2606 from ST Microelectronic for the bootloader commands and syntax in case you plan your own implementation of accessing the bootloader. The UART baud rate in bootloader mode can be selected between 1200 and 115200 baud, "8E1". We recommend using 115200 Baud.
To use the internal bootloader the following pins need to be accessible with different logic levels:

- *BOOT0*, *BOOT1*

BOOT0	BOOT1	Function
LOW	LOW or HIGH	Normal start-up, the application firmware starts
HIGH	LOW	Bootloader starts after a reset, a new firmware can be flashed over UART and the ST Bootloader Protocol.

- */RESET* needs to be pulled to GND for a short time (>10ms) to perform a reset

- *UART_RX* needs to be connected to a PC by means of a TTL to USB-Converter

- *UART_TX* needs to be connected to a PC by means of a TTL to USB-Converter

> ⚠ The memory area of the factory settings must not be deleted or overwritten during a firmware-update: Factorysettings are placed at the address 0x08080000 - 0x0808001F

The Triton firmware version 2.0.0 or newer implements the command `CMD_BOOTLOADER_REQ` that can be used to reboot the internal micro controller so that the bootloader is selected without using the pins *BOOT0*, *BOOT1* and */RESET*. After receiving the confirmation Bytes the bootloader is selected and can be started using the so called "USART Bootloader code sequence" (see AN3155).

14. Firmware history

Version 1.0.0

- First release

Version 2.0.0

- Better transmission reliability, thus payload size decreased to 26 Bytes
- New command `CMD_BOOTLOADER_REQ`
- Firmware version 2.0.0 is not RF-compatible to 1.0.x

Version 3.0.0

- New UART command interface, incompatible to firmware before 3.0.0
- Introduced the fragmentation mode to send larger packets
- UserSetting `Cfg_Flags` updated
- Broadcast address changed from 0x01 to 0xFF

Version 3.1.1

- New TX power levels
- Bug fix in length field of `CMD_DATAEX_IND`

Version 3.2.2

- Added the user setting `UART_Baudrate` that determines the UART baud rate of the module

Version 3.3.0

- Added higher RF data rates
- Improved internal timings resulting in faster data processing
- Reduced sleep current to about 1µA

Version 3.5.0

- Ported to default firmware design scheme
- Optimizations in RAM requirements and timings
- Minor bug fixes
- Added temperature calibration for the radio TX power and radio frequency

Version 3.6.0

- FCC and IC compliant
- Added additional TX power profiles to be conform with FCC and IC requirements
- Improvements around low power mode and wake-up

15. Design in guide

15.1. Advice for schematic and layout

For users with less RF experience it is advisable to closely copy the relating evaluation board with respect to schematic and layout, as it is a proven design. The layout should be conducted with particular care, because even small deficiencies could affect the radio performance and its range or even the conformity.
The following general advice should be taken into consideration:

- A clean, stable power supply is strongly recommended. Interference, especially oscillation can severely restrain range and conformity.

- Variations in voltage level should be avoided.

- LDOs, properly designed in, usually deliver a proper regulated voltage.

- Blocking capacitors and a ferrite bead in the power supply line can be included to filter and smoothen the supply voltage when necessary.

> **!** No fixed values can be recommended, as these depend on the circumstances of the application (main power source, interferences etc.).

> **STOP** The use of an external reset IC should be considered if one of the following points is relevant:

> **!**
> - The slew rate of the power supply exceeds the electrical specifications.
>
> - The effect of different current consumptions on the voltage level of batteries or voltage regulators should be considered. The module draws higher currents in certain scenarios like start-up or radio transmit which may lead to a voltage drop on the supply. A restart under such circumstances should be prevented by ensuring that the supply voltage does not drop below the minimum specifications.
>
> - Voltage levels below the minimum recommended voltage level may lead to malfunction. The /Reset pin of the module shall be held on LOW logic level whenever the VCC is not stable or below the minimum operating Voltage.
>
> - Special care must be taken in case of battery powered systems.

- Elements for ESD protection should be placed on all pins that are accessible from the outside and should be placed close to the accessible area. For example, the RF-pin is accessible when using an external antenna and should be protected.

- ESD protection for the antenna connection must be chosen such as to have a minimum effect on the RF signal. For example, a protection diode with low capacitance such as the 8231606A or a 68 nH air-core coil connecting the RF-line to ground give good results.

- Placeholders for optional antenna matching or additional filtering are recommended.

- The antenna path should be kept as short as possible.

> ⚠ Again, no fixed values can be recommended, as they depend on the influencing circumstances of the application (antenna, interferences etc.).
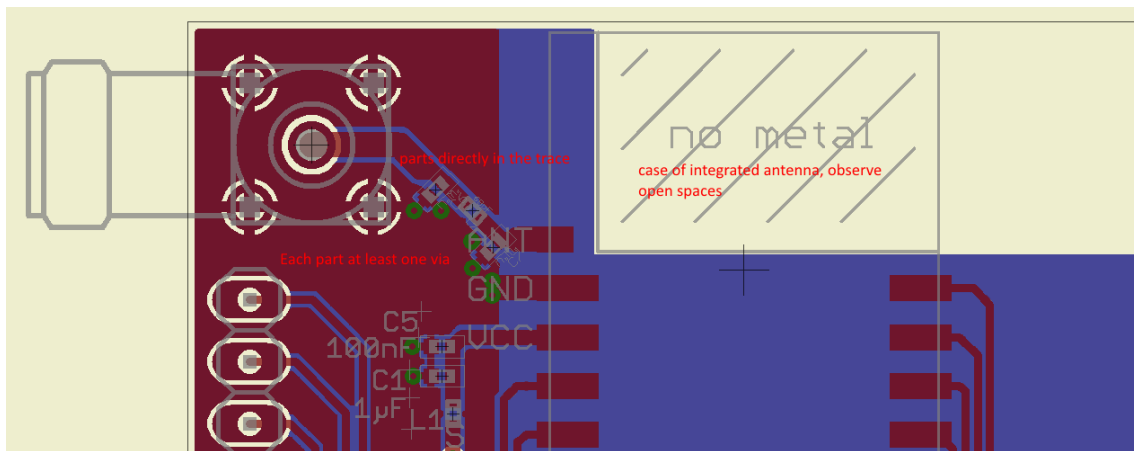
Figure 5: Layout

- To avoid the risk of short circuits and interference there should be no routing underneath the module on the top layer of the baseboard.

- On the second layer, a ground plane is recommended, to provide good grounding and shielding to any following layers and application environment.

- In case of integrated antennas it is required to have areas free from ground. This area should be copied from the evaluation board.

- The area with the integrated antenna must overlap with the carrier board and should not protrude, as it is matched to sitting directly on top of a PCB.

- Modules with integrated antennas should be placed with the antenna at the edge of the main board. It should not be placed in the middle of the main board or far away from the edge. This is to avoid tracks beside the antenna.

- Filter and blocking capacitors should be placed directly in the tracks without stubs, to achieve the best effect.

- Antenna matching elements should be placed close to the antenna / connector, blocking capacitors close to the module.

- Ground connections for the module and the capacitors should be kept as short as possible and with at least one separate through hole connection to the ground layer.

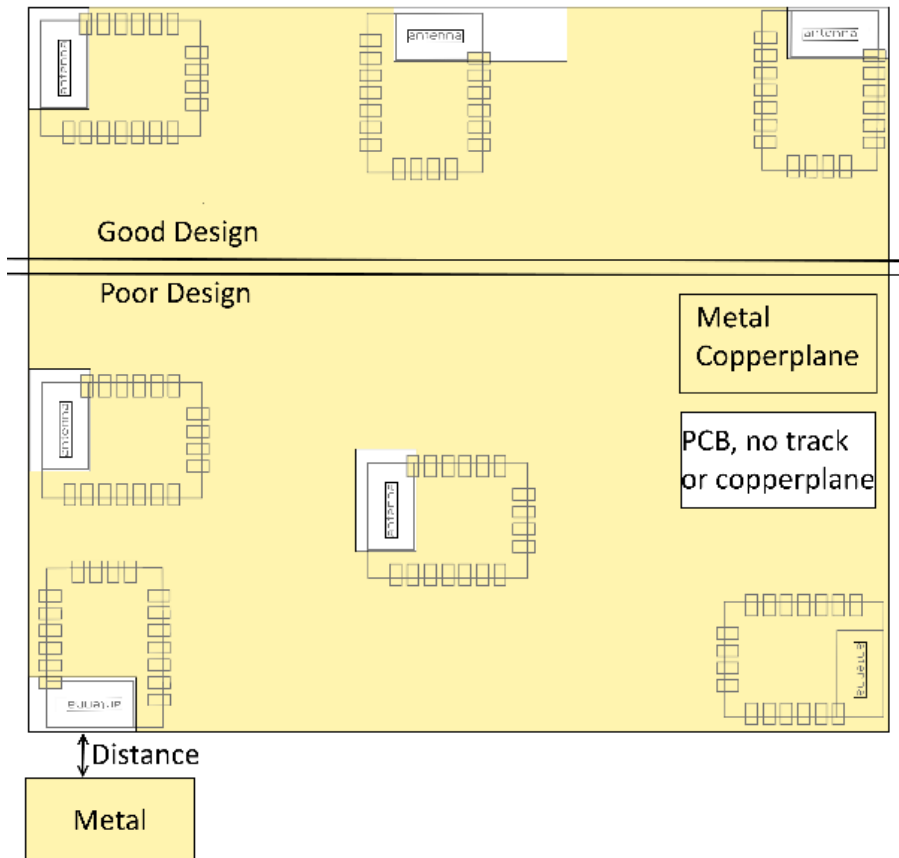- ESD protection elements should be placed as close as possible to the exposed areas.

Figure 6: Placement of the module with integrated antenna

15.2. Dimensioning of the micro strip antenna line

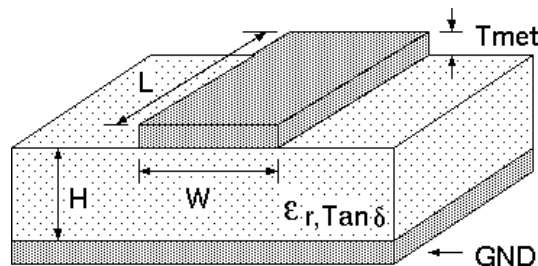The antenna track has to be designed as a 50Ω feed line. The width W for a micro strip can

Figure 7: Dimensioning the antenna feed line as micro strip

be calculated using the following equation:

$$W = 1.25 \times \left(\frac{5.98 \times H}{e^{\frac{50 \times \sqrt{\epsilon_r + 1.41}}{87}}} - T_{met} \right) \qquad (2)$$

Example:

A FR4 material with ε_r = 4.3, a height H = 1000 µm and a copper thickness of T_{met} = 18 µm will lead to a trace width of W ~ 1.9 mm. To ease the calculation of the micro strip line (or e.g. a coplanar) many calculators can be found in the internet.

- As rule of thumb a distance of about 3×W should be observed between the micro strip and other traces / ground.

- The micro strip refers to ground, therefore there has to be the ground plane underneath the trace.

- Keep the feeding line as short as possible.

15.3. Antenna solutions

There exist several kinds of antennas, which are optimized for different needs. Chip antennas are optimized for minimal size requirements but at the expense of range, PCB antennas are optimized for minimal costs, and are generally a compromise between size and range. Both usually fit inside a housing.

Range optimization in general is at the expense of space. Antennas that are bigger in size, so that they would probably not fit in a small housing, are usually equipped with a RF connector. A benefit of this connector may be to use it to lead the RF signal through a metal plate (e.g. metal housing, cabinet).

As a rule of thumb a minimum distance of $\lambda/10$ (which is 3.5 cm @ 868 MHz and 1.2 cm @ 2.44 GHz) from the antenna to any other metal should be kept. Metal placed further away will not directly influence the behaviour of the antenna, but will anyway produce shadowing.

> **!** Keep the antenna away from large metal objects as far as possible to avoid electromagnetic field blocking.

> **!** The choice of antenna might have influence on the safety requirements.

In the following chapters, some special types of antenna are described.

15.3.1. Wire antenna

An effective antenna is a $\lambda/4$ radiator with a suiting ground plane. The simplest realization is a piece of wire. It's length is depending on the used radio frequency, so for example 8.6 cm 868.0 MHz and 3.1 cm for 2.440 GHz as frequency. This radiator needs a ground plane at its feeding point. Ideally, it is placed vertically in the middle of the ground plane. As this is often not possible because of space requirements, a suitable compromise is to bend the wire away from the PCB respective to the ground plane. The $\lambda/4$ radiator has approximately 40 Ω input impedance. Therefore, matching is not required.

15.3.2. Chip antenna

There are many chip antennas from various manufacturers. The benefit of a chip antenna is obviously the minimal space required and reasonable costs. However, this is often at the expense of range. For the chip antennas, reference designs should be followed as closely as possible, because only in this constellation can the stated performance be achieved.

15.3.3. PCB antenna

PCB antenna designs can be very different. The special attention can be on the miniaturization or on the performance. The benefits of the PCB antenna are their small / not existing (if PCB space is available) costs, however the evaluation of a PCB antenna holds more risk of failure than the use of a finished antenna. Most PCB antenna designs are a compromise of range and space between chip antennas and connector antennas.

15.3.4. Antennas provided by Würth Elektronik eiSos

15.3.4.1. 2600130021 - Himalia - 2.4 GHz dipole antenna

Figure 8: 2.4 GHz dipole-antenna

Due to the fact, that the antenna has dipole topology there is no need for an additional ground plane. Nevertheless the specification was measured edge mounted and 90° bent on a 100 x 100 mm ground plane.

Specification	Value
Frequency range [GHz]	2.4 − 2.5
Impedance [Ω]	50
VSWR	≤ 2:1
Polarization	Linear
Radiation	Omni-Directional
Peak Gain [dBi]	2.8
Average Gain [dBi]	-0.6
Efficiency	85 %
Dimensions (L x d) [mm]	83.1 x 10
Weight [g]	7.4
Connector	SMA plug
Operating temp. [℃]	-40 − +80

Special care must be taken for FCC certification when using this external antenna to fulfil the requirement of permanently attached antenna or unique coupling for example by using the certified dipole antenna in a closed housing, so that only through professional installation it is possible to remove it.

16. Reference design

Triton was tested and certified on the corresponding Triton evaluation board. For the compliance with the EU directive 2014/53/EU Annex I, the evaluation board serves as reference design.
This is no discrepancy due to the fact that the evaluation board itself does not fall within the scope of the EU directive 2014/53/EU Annex I as the module is tested on the evaluation board, which is also the recommended use.

Further information concerning the use of the evaluation board can be found in the manual of the Triton evaluation board.

16.1. Schematic
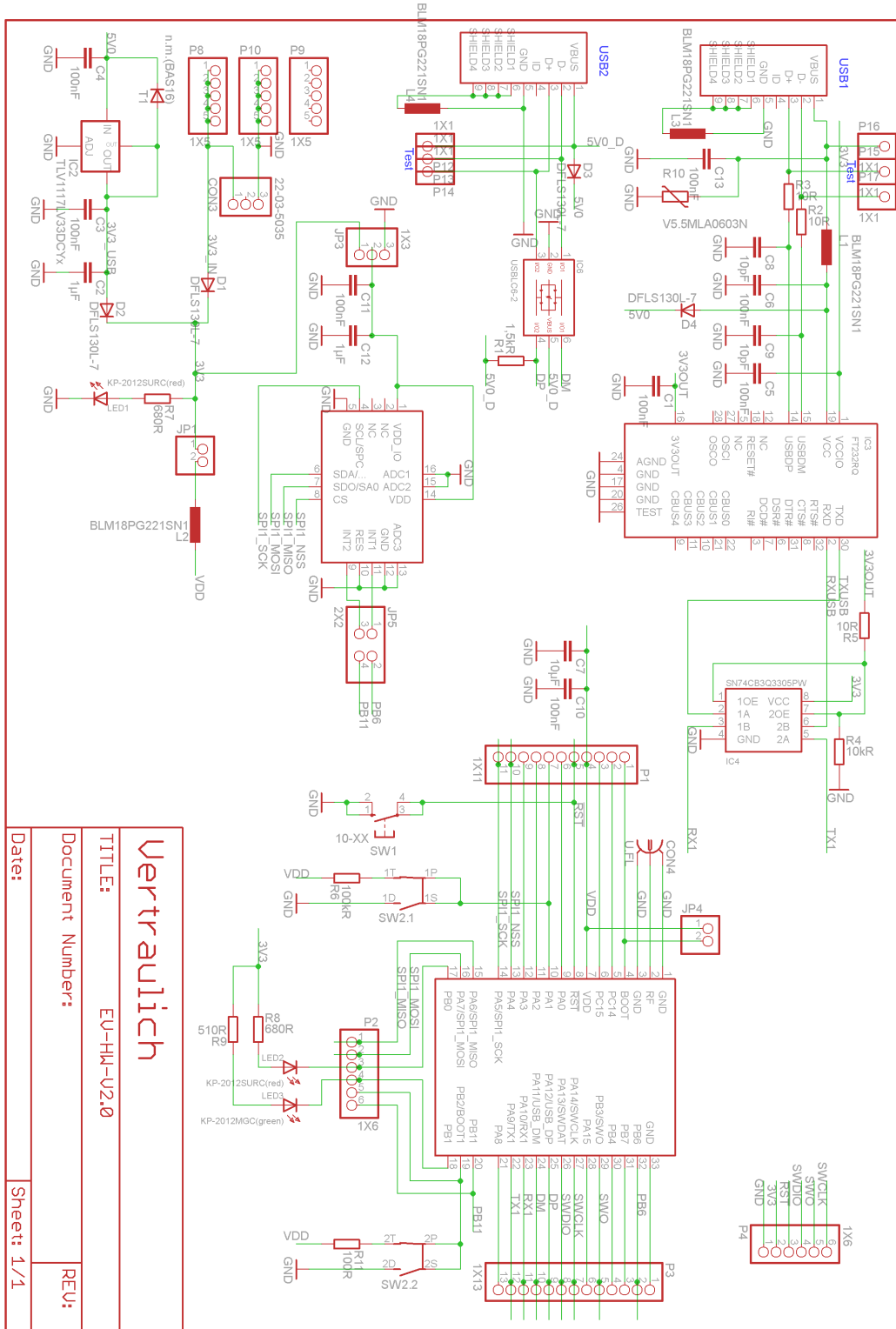
Figure 9: Wiring diagram

16.2. Layout
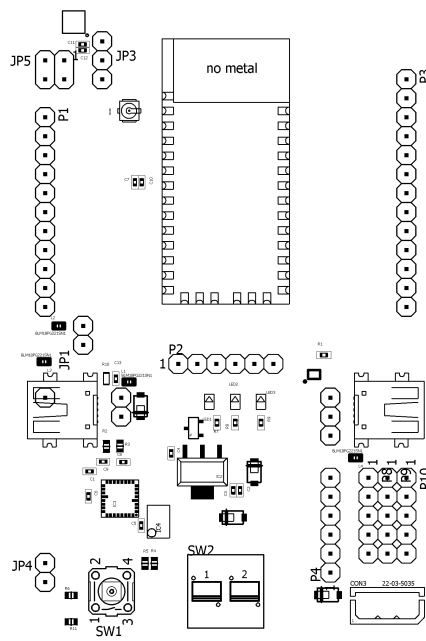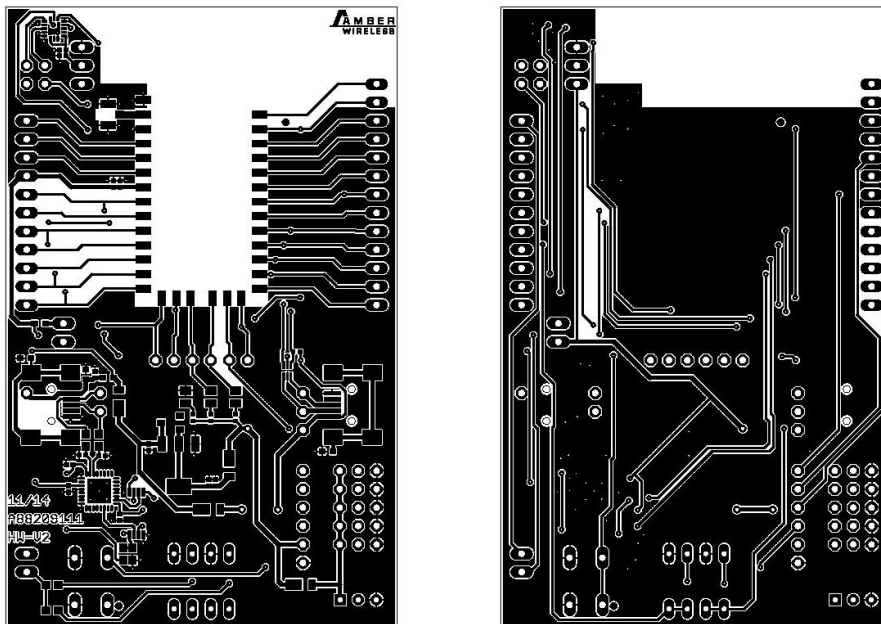

Figure 10: Assembly diagram

Figure 11: Top and Bottom Layer

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17. Manufacturing information

17.1. Moisture sensitivity level

This wireless connectivity product is categorized as JEDEC Moisture Sensitivity Level 3 (MSL3), which requires special handling.

More information regarding the MSL requirements can be found in the IPC/JEDEC J-STD-020 standard on www.jedec.org.

More information about the handling, picking, shipping and the usage of moisture/reflow and/or process sensitive products can be found in the IPC/JEDEC J-STD-033 standard on *www.jedec.org*.

17.2. Soldering

17.2.1. Reflow soldering

Attention must be paid on the thickness of the solder resist between the host PCB top side and the modules bottom side. Only lead-free assembly is recommended according to JEDEC J-STD020.

Profile feature		Value
Preheat temperature Min	$T_{S\ Min}$	150 °C
Preheat temperature Max	$T_{S\ Max}$	200 °C
Preheat time from $T_{S\ Min}$ to $T_{S\ Max}$	t_S	60 - 120 seconds
Ramp-up rate (T_L to T_P)		3 °C / second max.
Liquidous temperature	T_L	217 °C
Time t_L maintained above T_L	t_L	60 - 150 seconds
Peak package body temperature	T_P	see table below
Time within 5 °C of actual peak temperature	t_P	20 - 30 seconds
Ramp-down Rate (T_P to T_L)		6 °C / second max.
Time 20 °C to T_P		8 minutes max.

Table 15: Classification reflow soldering profile, Note: refer to IPC/JEDEC J-STD-020E

Package thickness	Volume mm^3 <350	Volume mm^3 350-2000	Volume mm^3 >2000
< 1.6 mm	260 °C	260 °C	260 °C
1.6 mm - 2.5 mm	260 °C	250 °C	245 °C
> 2.5 mm	250 °C	245 °C	245 °C

Table 16: Package classification reflow temperature, PB-free assembly, Note: refer to IPC/-JEDEC J-STD-020E

It is recommended to solder this module on the last reflow cycle of the PCB. For solder paste use a LFM-48W or Indium based SAC 305 alloy (Sn 96.5 / Ag 3.0 / Cu 0.5 / Indium 8.9HF / Type 3 / 89%) type 3 or higher.

The reflow profile must be adjusted based on the thermal mass of the entire populated PCB, heat transfer efficiency of the reflow oven and the specific type of solder paste used. Based on the specific process and PCB layout the optimal soldering profile must be adjusted and verified. Other soldering methods (e.g. vapor phase) have not been verified and have to be validated by the customer at their own risk. Rework is not recommended.
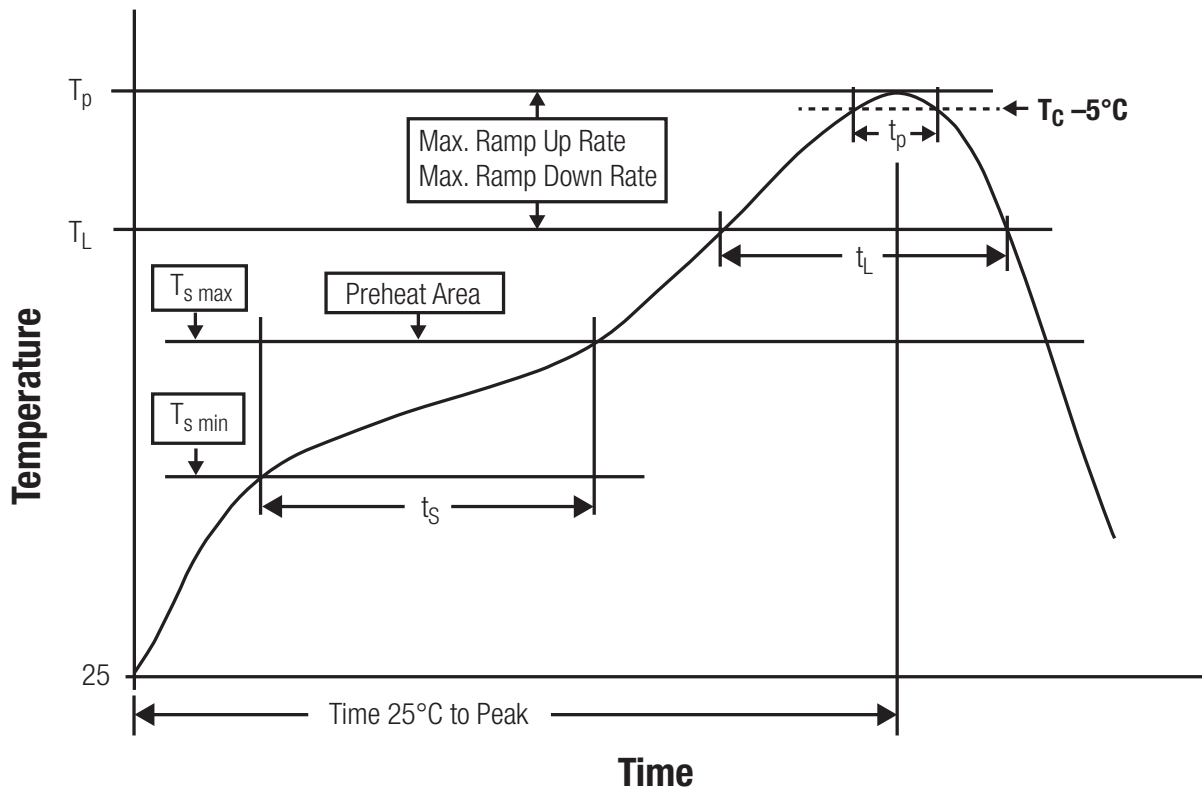

Figure 12: Reflow soldering profile

After reflow soldering, visually inspect the board to confirm proper alignment

17.2.2. Cleaning

Do not clean the product. Any residue cannot be easily removed by washing. Use a "no clean" soldering paste and do not clean the board after soldering.

- Do not clean the product with water. Capillary effects can draw water into the gap between the host PCB and the module, absorbing water underneath it. If water is trapped inside, it may short-circuit adjoining pads. The water may also destroy the label and ink-jet printed text on it.

- Cleaning processes using alcohol or other organic solvents may draw solder flux residues into the housing, which won't be detected in a post-wash inspection. The solvent may also destroy the label and ink-jet printed text on it.

- Do not use ultrasonic cleaning as it will permanently damage the part, particularly the crystal oscillators.

17.2.3. Other notations

- Conformal coating of the product will result in the loss of warranty. The RF shields will not protect the part from low-viscosity coatings.

- Do not attempt to improve the grounding by forming metal strips directly to the EMI covers or soldering on ground cables, as it may damage the part and will void the warranty.

- Always solder every pad to the host PCB even if some are unused, to improve the mechanical strength of the module.

- The part is sensitive to ultrasonic waves, as such do not use ultrasonic cleaning, welding or other processing. Any ultrasonic processing will void the warranty.

17.3. ESD handling

This product is highly sensitive to electrostatic discharge (ESD). As such, always use proper ESD precautions when handling. Make sure to handle the part properly throughout all stages of production, including on the host PCB where the module is installed. For ESD ratings, refer to the module series' maximum ESD section. For more information, refer to the relevant chapter 2. Failing to follow the aforementioned recommendations can result in severe damage to the part.

- the first contact point when handling the PCB is always between the local GND and the host PCB GND, unless there is a galvanic coupling between the local GND (for example work table) and the host PCB GND.

- Before assembling an antenna patch, connect the grounds.

- While handling the RF pin, avoid contact with any charged capacitors and be careful when contacting any materials that can develop charges (for example coaxial cable with around 50-80 pF/m, patch antenna with around 10 pF, soldering iron etc.)

- Do not touch any exposed area of the antenna to avoid electrostatic discharge. Do not let the antenna area be touched in a non ESD-safe manner.

- When soldering, use an ESD-safe soldering iron.

17.4. Safety recommendations

It is your duty to ensure that the product is allowed to be used in the destination country and within the required environment. Usage of the product can be dangerous and must be tested and verified by the end user. Be especially careful of:

- Use in areas with risk of explosion (for example oil refineries, gas stations).

- Use in areas such as airports, aircraft, hospitals, etc., where the product may interfere with other electronic components.

It is the customer's responsibility to ensure compliance with all applicable legal, regulatory and safety-related requirements as well as applicable environmental regulations. Disassembling the product is not allowed. Evidence of tampering will void the warranty.

- Compliance with the instructions in the product manual is recommended for correct product set-up.

- The product must be provided with a consolidated voltage source. The wiring must meet all applicable fire and security prevention standards.

- Handle with care. Avoid touching the pins as there could be ESD damage.

Be careful when working with any external components. When in doubt consult the technical documentation and relevant standards. Always use an antenna with the proper characteristics.

> Würth Elektronik eiSos radio modules with high output power of up to 500 mW, as for example the radio module Thebe-II, generate a high amount of warmth while transmitting. The manufacturer of the end device must take care of potentially necessary actions for his application.

18. Physical dimensions

18.1. Dimensions

Dimensions
30.8 x 17 x 4 mm

Table 17: Dimensions

18.2. Weight

Weight
3 g

Table 18: Weight
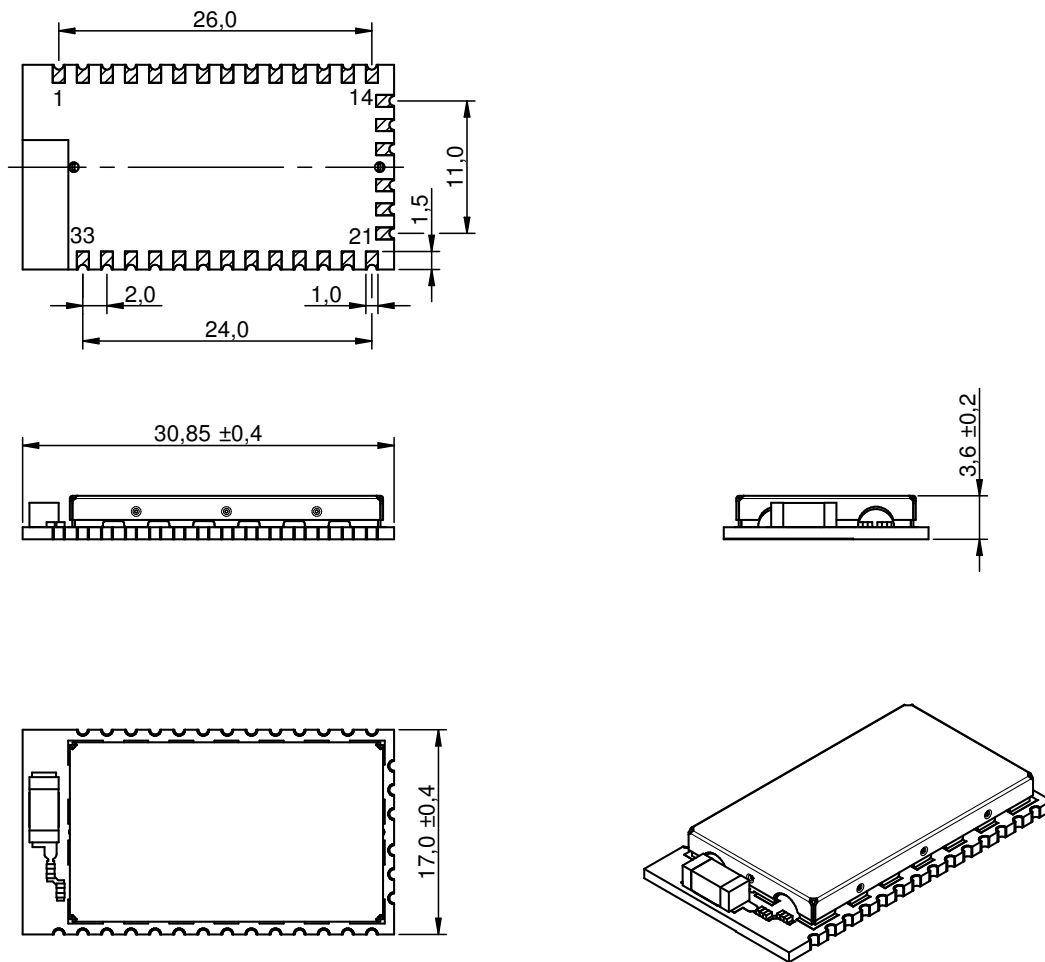
18.3. Module drawing

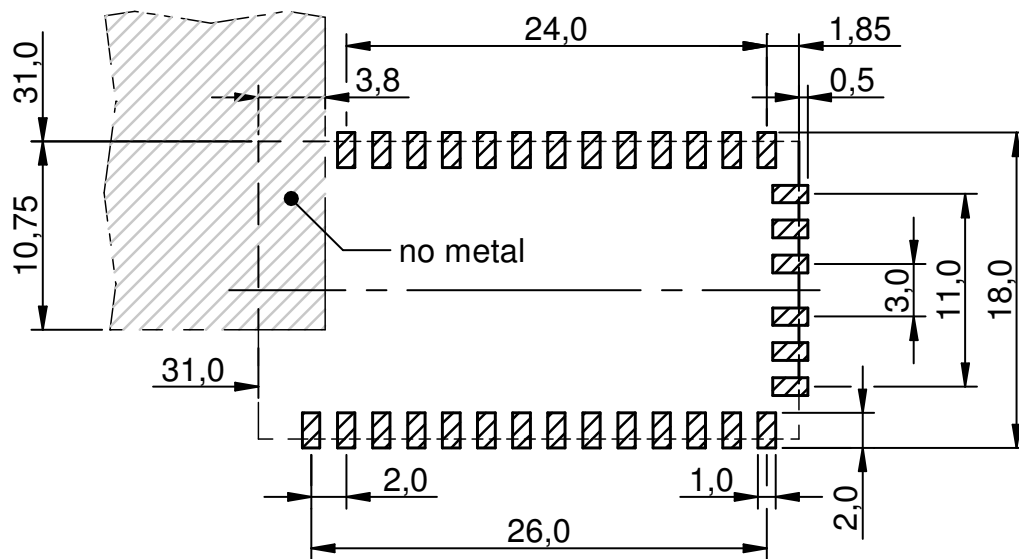Figure 13: Module drawing [mm]

18.4. Footprint

Figure 14: Footprint and dimensions [mm]

18.5. Antenna free area

To avoid influence and mismatching of the antenna the recommended free area around the antenna should be maintained. As rule of thumb a minimum distance of metal parts to the antenna of $\lambda/10$ should be kept (see figure 14). Even though metal parts would influence the characteristic of the antenna, but the direct influence and matching keep an acceptable level.

19. Marking

19.1. Lot number

The 15 digit lot number is printed in numerical digits as well as in form of a machine readable bar code. It is divided into 5 blocks as shown in the following picture and can be translated according to the following table.
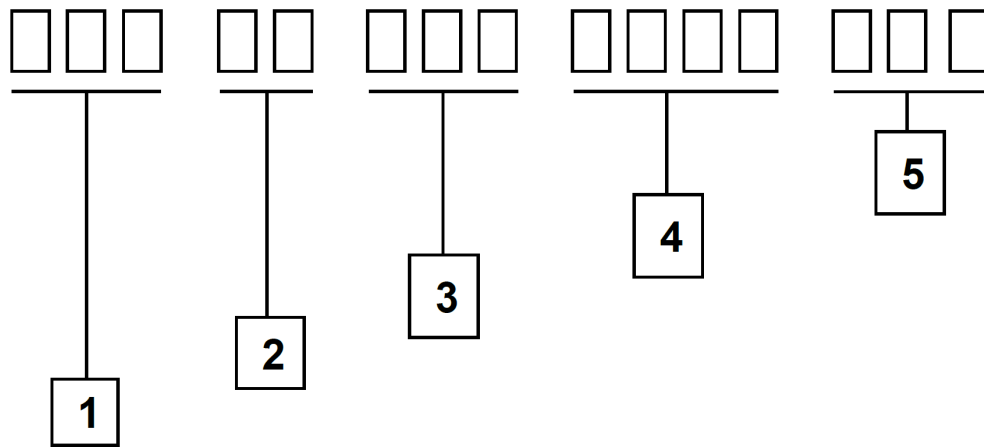

Figure 15: Lot number structure

Block	Information	Example(s)
1	eiSos internal, 3 digits	439
2	eiSos internal, 2 digits	01
3	Hardware version, 3 digits	V2.4 = 024, V12.2 = 122
4	Date code, 4 digits	1703 = week 03 in year 2017, 1816 = week 16 in year 2018
5	Firmware version, 3 digits	V3.2 = 302, V5.13 = 513

Table 19: Lot number details

As the user can perform a firmware update the printed lot number only shows the factory delivery state. The currently installed firmware can be requested from the module using the corresponding product specific command. The firmware version as well as the hardware version are restricted to show only major and minor version not the patch identifier.

19.2. General labeling information

The module labels may include the following fields:

- Manufacturer identification WE, Würth Elektronik or Würth Elektronik eiSos

- WE Order Code and/or article alias

- Serial number or MAC address

- Certification identifiers (CE, FCC ID, IC, ARIB,...)

- Bar code or 2D code containing the serial number or MAC address

If the module is using a Serial Number, this serial number includes the product ID (PID) and an 6 digit number. The 6 rightmost digits represent the 6 digit number, followed by the product ID (2 or 3 digits). Some labels indicate the product ID with a "." as marker in-between the 2 fields. The PID and the 6 digit number form together a unique serial number for any wireless connectivity product.

In case of small labels, the 3 byte manufacturer identifier (0x0018DA) of the MAC address is not printed on the labels. The 3 byte counter printed on the label can be used with this 0018DA to produce the full MAC address by appending the counter after the manufacturer identifier.
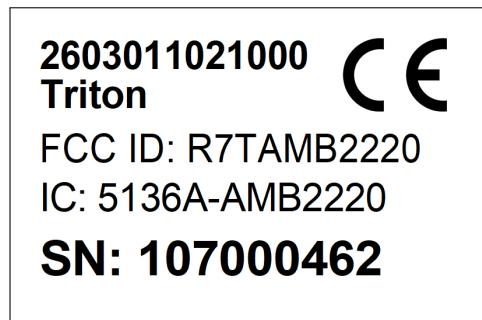
```
┌─────────────────────────────────┐
│ 2603011021000    C E            │
│ Triton                          │
│ FCC ID: R7TAMB2220              │
│ IC: 5136A-AMB2220               │
│ SN: 107000462                   │
└─────────────────────────────────┘
```

Figure 16: Label of the Triton

20. Information for explosion protection

In case the end product should be used in explosion protection areas the following information can be used:

- The module itself is unfused.

- The maximum output power of the module is 10dBm for external antenna and 7.5dBm for internal antenna.

- The total amount of capacitance of all capacitors is 14.4μF.

- The total amount of inductance of all inductors is 62.6nH for external antenna and 5.8nH for internal antenna variant.

21. Regulatory compliance information

21.1. Important notice EU

The use of RF frequencies is limited by national regulations. The Triton has been designed to comply with the R&TTE directive 1999/5/EC and the RED directive 2014/53/EU of the European Union (EU).
The Triton can be operated without notification and free of charge in the area of the European Union. However, according to the R&TTE / RED directive, restrictions (e.g. in terms of duty cycle or maximum allowed RF power) may apply.

21.2. Important notice FCC

The use of RF frequencies is limited by national regulations. The Triton has been designed to comply with the FCC Part 15.
The Triton can be operated without notification and free of charge in the area of the United States of America. However, according to the FCC Part 15, restrictions (e.g. in terms of maximum allowed RF power and antenna) may apply.

21.3. Conformity assessment of the final product

The Triton is a subassembly. It is designed to be embedded into other products (products incorporating the Triton are henceforward referred to as "final products").
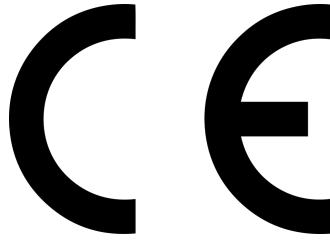It is the responsibility of the manufacturer of the final product to ensure that the final product is in compliance with the essential requirements of the underlying national radio regulations. The conformity assessment of the subassembly Triton carried out by Würth Elektronik eiSos does not replace the required conformity assessment of the final product.

21.4. Exemption clause

Relevant regulation requirements are subject to change. Würth Elektronik eiSos does not guarantee the accuracy of the before mentioned information. Directives, technical standards, procedural descriptions and the like may be interpreted differently by the national authorities. Equally, the national laws and restrictions may vary with the country. In case of doubt or uncertainty, we recommend that you consult with the authorities or official certification organizations of the relevant countries. Würth Elektronik eiSos is exempt from any responsibilities or liabilities related to regulatory compliance.

Notwithstanding the above, Würth Elektronik eiSos makes no representations and warranties of any kind related to their accuracy, correctness, completeness and/or usability for customer applications. No responsibility is assumed for inaccuracies or incompleteness.

21.5. EU Declaration of conformity

$$C \in$$

EU DECLARATION OF CONFORMITY

Radio equipment: **2603011021000 & 2603011121000**

The manufacturer: Würth Elektronik eiSos GmbH & Co. KG
                                    Max-Eyth-Straße 1
                                    74638 Waldenburg

This declaration of conformity is issued under the sole responsibility of the manufacturer.

Object of the declaration: 2603011021000 & 2603011121000

The object of the declaration described above is in conformity with the relevant Union harmonization legislation: Directive 2014/53/EU and 2011/65/EU.
Following harmonized norms or technical specifications have been applied:

    EN 300 440 V2.1.1 (2017-03)
    EN 301 489-1 V2.2.0 (Draft)
    EN 301 489-3 V2.1.1 (Final draft)
    EN 62479 : 2010
    EN 60950-1: 2006 + A11: 2009 + A1: 2010 + A12: 2011 + AC: 2011 + A2: 2013

i.A. G. Eberhardt

Trier, 31th of March 2021
Place and date of issue

21.6. FCC Compliance Statement

FCC ID: R7TAMB2220

This device complies with Part 15 of the FCC Rules.
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.
(FCC 15.19)

Modifications (FCC 15.21)
Changes or modifications for this equipment not expressly approved by Würth Elektronik eiSos may void the FCC authorization to operate this equipment.

21.7. IC Declaration of conformity

Certification Number: 5136A-AMB2220
This device complies with Industry Canada licence-exempt RSS standard(s). 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.
Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

21.8. FCC and IC requirements to OEM integrators

This module has been granted modular approval. OEM integrators for host products may use the module in their final products without additional FCC/IC (Industry Canada) certification if they meet the following conditions. Otherwise, additional FCC/IC approvals must be obtained.
The host product with the module installed must be evaluated for simultaneous transmission requirements.

- The users manual for the host product must clearly indicate the operating requirements and conditions that must be observed to ensure compliance with current FCC/IC RF exposure guidelines.

- To comply with FCC/IC regulations limiting both maximum RF output power and human exposure to RF radiation, the maximum antenna gain including cable loss in a mobile-only exposure condition must not exceed 2dBi.

- A label must be affixed to the outside of the host product with the following statements:
  This device contains FCCID: R7TAMB2220
  This equipment contains equipment certified under ICID: 5136A-AMB2220

- The final host / module combination may also need to be evaluated against the FCC Part 15B criteria for unintentional radiators in order to be properly authorized for operation as a Part 15 digital device.

- If the final host / module combination is intended for use as a portable device (see classifications below) the host manufacturer is responsible for separate approvals for the SAR requirements from FCC Part 2.1093 and RSS-102.

OEM requirements:

The OEM must ensure that the following conditions are met.

- End users of products, which contain the module, must not have the ability to alter the firmware that governs the operation of the module. The agency grant is valid only when the module is incorporated into a final product by OEM integrators.

- The end-user must not be provided with instructions to remove, adjust or install the module.

- The Original Equipment Manufacturer (OEM) must ensure that FCC labeling requirements are met. This includes a clearly visible label on the outside of the final product. Attaching a label to a removable portion of the final product, such as a battery cover, is not permitted.

- The label must include the following text:
  Contains FCC ID: R7TAMB2220
  The enclosed device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:
  (i.) this device may not cause harmful interference and
  (ii.) this device must accept any interference received, including interference that may cause undesired operation.

  When the device is so small or for such use that it is not practicable to place the statement above on it, the information required by this paragraph shall be placed in a prominent location in the instruction manual or pamphlet supplied to the user or, alternatively, shall be placed on the container in which the device is marketed. However, the FCC identifier or the unique identifier, as appropriate, must be displayed on the device.

- The user manual for the end product must also contain the text given above.
  - Changes or modifications not expressly approved could void the user's authority to operate the equipment.
  - The OEM must ensure that timing requirements according to 47 CFR 15.231(a-c) are met.
  - The OEM must sign the OEM Modular Approval Agreement.
  - The module must be used with only the following approved antenna(s).

21.8.1. Pre-certified antennas

The Triton is pre-certified with the following antennas and maximum output power level.

Product	Certified antenna	Max. value of setting `RF_Power_Level`
Triton (260301102100x, AMB2220)	Chip antenna included in the Triton module	6
Triton (260301112100x, AMB2220-1)	λ/4 wire antenna as specified in chapter `15.3.1`	-1

22. Important notes

The following conditions apply to all goods within the wireless connectivity product range of Würth Elektronik eiSos GmbH & Co. KG:

22.1. General customer responsibility

Some goods within the product range of Würth Elektronik eiSos GmbH & Co. KG contain statements regarding general suitability for certain application areas. These statements about suitability are based on our knowledge and experience of typical requirements concerning the areas, serve as general guidance and cannot be estimated as binding statements about the suitability for a customer application. The responsibility for the applicability and use in a particular customer design is always solely within the authority of the customer. Due to this fact, it is up to the customer to evaluate, where appropriate to investigate and to decide whether the device with the specific product characteristics described in the product specification is valid and suitable for the respective customer application or not. Accordingly, the customer is cautioned to verify that the documentation is current before placing orders.

22.2. Customer responsibility related to specific, in particular safety-relevant applications

It has to be clearly pointed out that the possibility of a malfunction of electronic components or failure before the end of the usual lifetime cannot be completely eliminated in the current state of the art, even if the products are operated within the range of the specifications. The same statement is valid for all software sourcecode and firmware parts contained in or used with or for products in the wireless connectivity and sensor product range of Würth Elektronik eiSos GmbH & Co. KG. In certain customer applications requiring a high level of safety and especially in customer applications in which the malfunction or failure of an electronic component could endanger human life or health, it must be ensured by most advanced technological aid of suitable design of the customer application that no injury or damage is caused to third parties in the event of malfunction or failure of an electronic component.

22.3. Best care and attention

Any product-specific data sheets, manuals, application notes, PCN's, warnings and cautions must be strictly observed in the most recent versions and matching to the products firmware revisions. This documents can be downloaded from the product specific sections on the wireless connectivity homepage.

22.4. Customer support for product specifications

Some products within the product range may contain substances, which are subject to restrictions in certain jurisdictions in order to serve specific technical requirements. Necessary information is available on request. In this case, the field sales engineer or the internal sales person in charge should be contacted who will be happy to support in this matter.

22.5. Product improvements

Due to constant product improvement, product specifications may change from time to time. As a standard reporting procedure of the Product Change Notification (PCN) according to the JEDEC-Standard, we inform about major changes. In case of further queries regarding the PCN, the field sales engineer, the internal sales person or the technical support team in charge should be contacted. The basic responsibility of the customer as per section 22.1 and 22.2 remains unaffected. All wireless connectivity module driver software ¨wireless connectivity SDK¨ and it's source codes as well as all PC software tools are not subject to the Product Change Notification information process.

22.6. Product life cycle

Due to technical progress and economical evaluation we also reserve the right to discontinue production and delivery of products. As a standard reporting procedure of the Product Termination Notification (PTN) according to the JEDEC-Standard we will inform at an early stage about inevitable product discontinuance. According to this, we cannot ensure that all products within our product range will always be available. Therefore, it needs to be verified with the field sales engineer or the internal sales person in charge about the current product availability expectancy before or when the product for application design-in disposal is considered. The approach named above does not apply in the case of individual agreements deviating from the foregoing for customer-specific products.

22.7. Property rights

All the rights for contractual products produced by Würth Elektronik eiSos GmbH & Co. KG on the basis of ideas, development contracts as well as models or templates that are subject to copyright, patent or commercial protection supplied to the customer will remain with Würth Elektronik eiSos GmbH & Co. KG. Würth Elektronik eiSos GmbH & Co. KG does not warrant or represent that any license, either expressed or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, application, or process in which Würth Elektronik eiSos GmbH & Co. KG components or services are used.

22.8. General terms and conditions

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List of Figures

List of Tables

A. Additional CRC8 Information

This Annex gives an example CRC8 implementation and test vectors.

A.1. Example CRC8 Implementation

```
#include <stdint.h>

uint8_t Get_CRC8(uint8_t * bufP, uint16_t len)
{
    uint8_t  crc = 0x00;
    for (uint16_t i = 0; i < len; i++)
    {
        crc ^= bufP[i];
    }
    return crc;
}
```

Code 1: Example CRC8 Implementation

A.2. CRC8 Test Vectors

Input data	Data length	Resulting CRC8
Null	0	0x00
0x02 0x01 0x00 0x00	4	0x03
0x02 0x87 0x01 0x00 0x16	5	0x92
0x02 0x04 0x04 0x00 0x41 0x42 0x43 0x44	8	0x06
0x02 0x88 0x07 0x00 0x00 0x55 0x00 0x00 0xDA 0x18 0x00	11	0x1A

Table 20: CRC8 Test Vectors

B. Example codes for host integration

The following code is an example implementation of a function to transmit data using a 1 Byte length field in the command frame. For demonstration reasons the Tarvos-III has been taken The full function codes of all radio modules are available in the Wireless Connectivity SDK (*www.we-online.de/wco-SDK*).

```
#define CMD_PAYLOAD_MAX 224
typedef struct {
uint8_t   Stx;
uint8_t   Cmd;
uint8_t  Length;
uint8_t   Data[CMD_PAYLOAD_MAX+1]; /* +1 for CRC8 */
}  CMD_Frame_t;
#define CMD_OFFSET_TO_DATAFIELD 3
#define CMD_OVERHEAD (CMD_OFFSET_TO_DATAFIELD+1)

bool TarvosIII_Transmit(uint8_t *PayloadP, uint8_t length)
{
/*  fill  request message with STX, command byte and length field */
CMD_Frame_t CMD_Frame;
CMD_Frame.Stx = CMD_STX; /* 0x02 */
CMD_Frame.Cmd = TarvosIII_CMD_DATA_REQ; /* 0x00 */
CMD_Frame.Length = length;

/*  fill  request message with user payload */
memcpy(CMD_Frame.Data, PayloadP, length);

/*  fill  request message with CRC8 */
CMD_Frame.Data[CMD_Frame.Length] = Get_CRC8(&CMD_Frame, CMD_Frame.Length +
    CMD_OFFSET_TO_DATAFIELD);

/* transmit  full  message via UART to radio module */
UART_SendBytes(&CMD_Frame, (CMD_Frame.Length + CMD_OVERHEAD));

/* wait  for response message from radio module */
return UART_Wait_for_Response(CMD_WAIT_TIME, TarvosIII_CMD_DATA_CNF, CMD_Status_Success,
    true);
}
```

Code 2: Example function implementation for radio modules with 1 byte length field

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