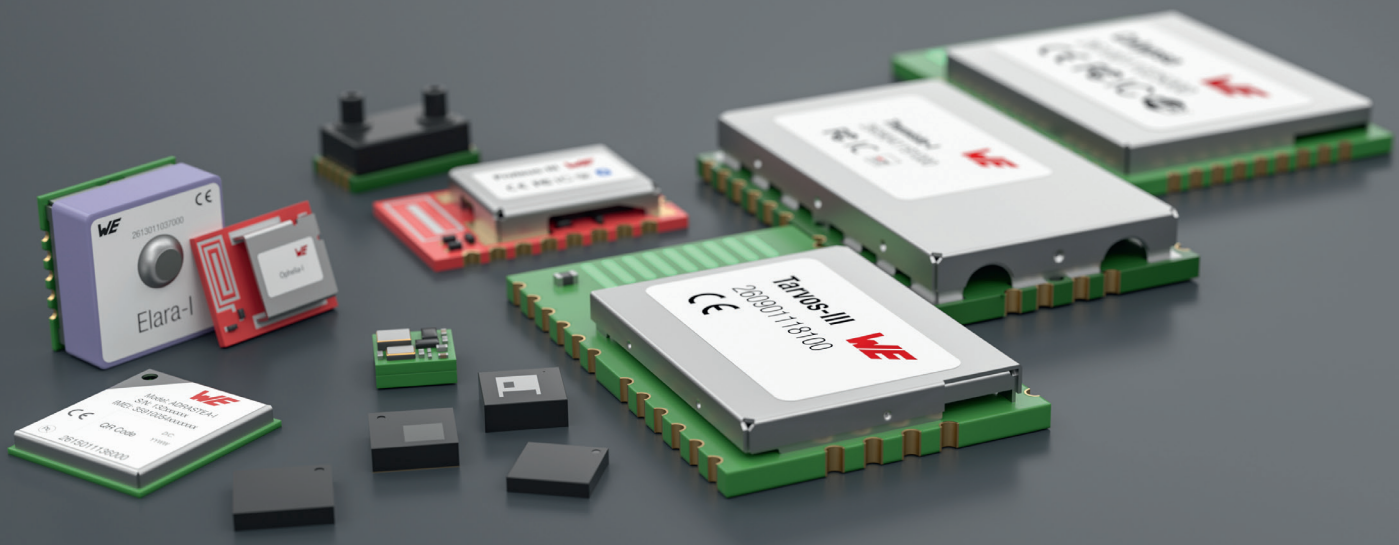


User manual

Telesto-II

AMB9626 / 2607021191010

Version 2.6

November 10, 2026

WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

****

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 including the possibility of a firmware update in the customer system design.

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Overview of helpful application notes

Application note ANR008 - Wireless Connectivity Software Development Kit
http://www.we-online.com/ANR008
To ease the integration of the Würth Elektronik eiSos radio modules into an application, Würth Elektronik eiSos offers the corresponding Software Development Kit (SDK) for most commonly used host processors. This SDK contains drivers and examples in C-code to communicate with the corresponding radio module. This application note shows which SDKs are available and describes how to download and use them.

Application note ANR010 - Range estimation
http://www.we-online.com/ANR010
This application note presents the two most used mathematical range estimation models, Friis and two ray ground reflection, and its implementation in the range estimation tool of the RED-EXPERT.

Application note ANR015 - From 868 MHz To 915 MHz
http://www.we-online.com/ANR015
Due to radio regulation laws in Europe and North America different frequencies are used in the sub-GHz range for radio data transmission. Therefore Würth Elektronik eiSos offers each product operating in the European 868 MHz range an counterpart operating in the American 915 MHz range. This application note shows which modules are comparable, where they differ and what to consider when switching from 868 to 915 MHz and vice versa.

Application note ANR016 - Radio module migration guide
http://www.we-online.com/ANR016
Due to our long term availability policy Würth Elektronik eiSos offers beside radio modules with most recent technology and chipset still the predecessor modules. This application note describes what to consider when switching in between module generations.

1. Revision history

Manual version	FW version	HW version	Notes	Date
1.0 - 1.6	1.0.0 - 1.1.0	2.0	• Initial version	April 2018
2.0	1.3.0	2.2	• New corporate design and structure	November 2018
2.1	1.1.0	2.2	• Added chapter `Reference design` • Added chapter `Information for explosion protection`	February 2019
2.2	1.3.0	2.2	• Corrected examples in chapter `UART_Baudrate` • Updated label in chapter `General labeling information` • Updated address of Division Wireless Connectivity & Sensors location	October 2019
2.3	1.3.0	2.0	• Updated firmware update chapter	June 2020
2.4	1.3.0	2.2	• Removed 2607021191019 from `Ordering information` as there are no longer pre-cuts available. The modules are available in all quantities as cut tape • New corporate design	May 2023
2.5	1.3.0	2.2	• Added certificates in addition to the required compliance statements in chapter `Regulatory compliance information`.	June 2023
2.6	1.3.0	2.2	• Corrections in chapter `Firmware history`	November 2026

2. Abbreviations

Abbreviation	Name	Description
ACK	Acknowledgement	Acknowledgement pattern confirming the reception of the transmitted data packet
BDM	Business Development Engineer	Support and sales contact person responsible for limited sales area
CS	Checksum	
DC	Duty cycle	Transmission time in relation of one hour. 1 % means, channel is occupied for 36 s per hour
FHSS	Frequency Hopping Spread Spectrum	One of the radio options for 915 MHz band, according to FCC and IC regulatorys
0xhh [HEX]	Hexadecimal	All numbers beginning with 0x are stated as hexadecimal numbers. All other numbers are decimal
HIGH	High signal level	Digital voltage level that is detected as high by the module
LOW	Low signal level	Digital voltage level that is detected as low by the module
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 allows communicating with the module of a specific interface
US	User settings	Any relation to a specific entry in the user settings is marked in a special font and can be found in the respective chapter
VDD	Voltage Drain Drain	Supply voltage

3. Introduction

3.1. Operational description

The Telesto-II was designed as a radio sub module for wireless communication between devices such as control systems, remote controls, sensors etc. It offers several addressing modes and relieves the host system of radio-specific tasks such as

- checksum calculation,
- address resolution, and
- repetition of unacknowledged telegrams.

They can be deployed wherever the comparatively rare wireless exchange of small data packets between two or more parties is required. The asynchronous Frequency Hopping (FHSS) used in Telesto-II has some specific requirements that needs to be taken into account when setting up a network by adopting the module's configuration parameters.

A serial interface (UART) whose data rate and format can be adjusted flexibly is available for communicating with the host system.

3.2. Block diagram

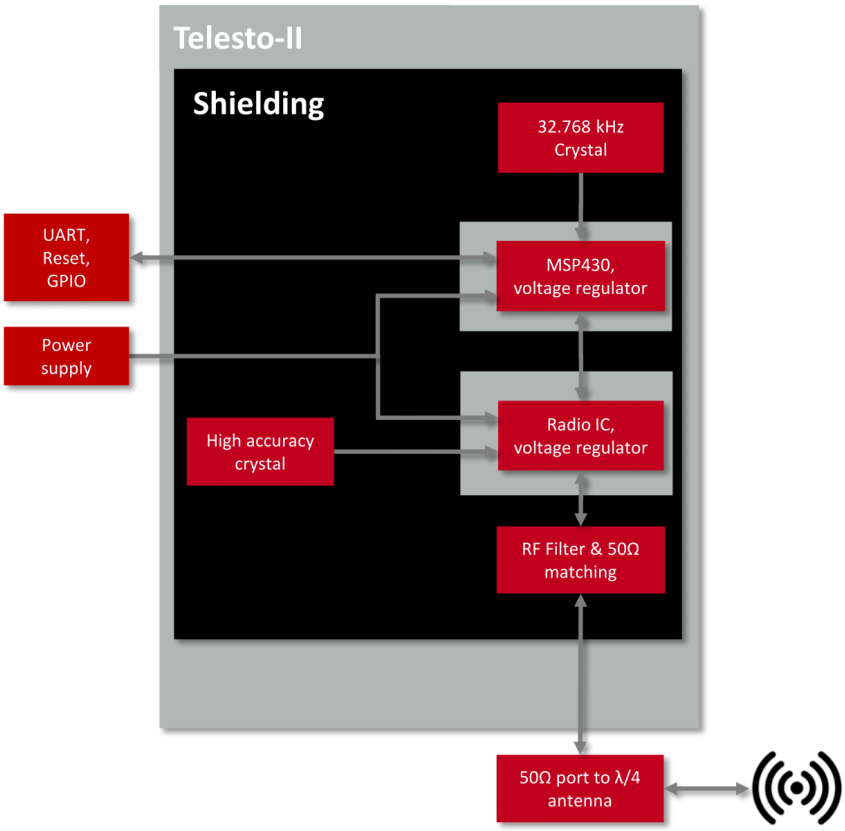


Figure 1: Block diagram

3.3. Ordering information

WE order code	Former order code	Description
2607021191010	AMB9626	Radio module 915 MHz, FHSS
2607029291011	AMB9626-EV	EV-Kit including EV-Board and USB dongle

Table 3: Ordering information

4. Electrical specifications

As not otherwise stated measured on the EV-Board for Telesto-II with T = 25℃, VCC = 3.3 V, internal DC-DC converter active and 50 Ω conducted.

4.1. Operating conditions

Description	Min.	Typ.	Max.	Unit
Ambient temperature	-40	25	85	℃
Supply voltage (VDDS)	2.0	3.0	3.6	V

Table 4: Operating conditions

4.2. Absolute maximum ratings

Description	Min.	Typ.	Max.	Unit
VCC	-0.3		3.9	V
Level at any module I/O pin	-0.3		VCC+0.3, max 3.9	V
Output RF level		14		dBm
Input RF level			10	dBm

Table 5: Absolute maximum ratings

4.3. Power consumption

As a voltage regulator is integrated, the current consumption is strongly depending on the supplied voltage level and stability.

The transmit and receive currents are depending on the impedance matching, and therefore may vary depending on antenna selection and matching.

A stable power supply is indispensable to ensure valid operating conditions for the module. Releasing the */RESET* pin before the VCC is stable may damage the module permanently.

A stable power supply and proper antenna design and matching is indispensable to achieve the stated radio characteristics.

4.3.1. Static

The stated current consumption is the sum of the CPU current and the radio current, depending on the active radio mode.
Conditions: Telesto-II-EV with T = 25 °C, VCC = 3.3 V, terminated unused module pads and 50 Ω conducted.

Description	Min	Typ.	Max	Unit
TX current consumption at max output power		53		mA
RX current consumption		30		mA
Low power (LPM3), radio off, UART via ACLK		3		µA

Table 6: Power consumption

4.4. Radio characteristics

Conditions: Telesto-II-EV, T = 25 °C, VCC = 3.0 V, terminated unused module pads, 50 Ω conducted.
The user configurable `PHY_RSSIThreshold` value (default = 10 dB) must be taken into account for any range consideration as it reduces the link budged by the configured value.

Description	Min	Typ.	Max	Unit
Max output power		14	14	dBm
Best input sensitivity		-99		dBm
Frequencies	902.5		927.5	GHz

Table 7: Radio characteristics

4.5. Pin characteristics

Property	Min	Typ.	Max	Unit
GPIO maximum current per pin		2		mA
GPIO maximum current over all		48		mA
Internal pull-up resistor	20	35	50	kΩ
Internal Pull-down resistor	20	35	50	kΩ

Table 8: Pin characteristics

4.6. Integrated flash characteristics

The integrated flash memory has only a limited number cycles. This number of flash cycles has a guaranteed min. value of 10000 and a typical value of 100000.
Hosts shall implement methods to prevent their applications from excessively using flash cycles. This can be achieved by always performing a `CMD_GET_REQ` before any `CMD_SET_REQ` and other command that uses flash cycles.

5. Pinout

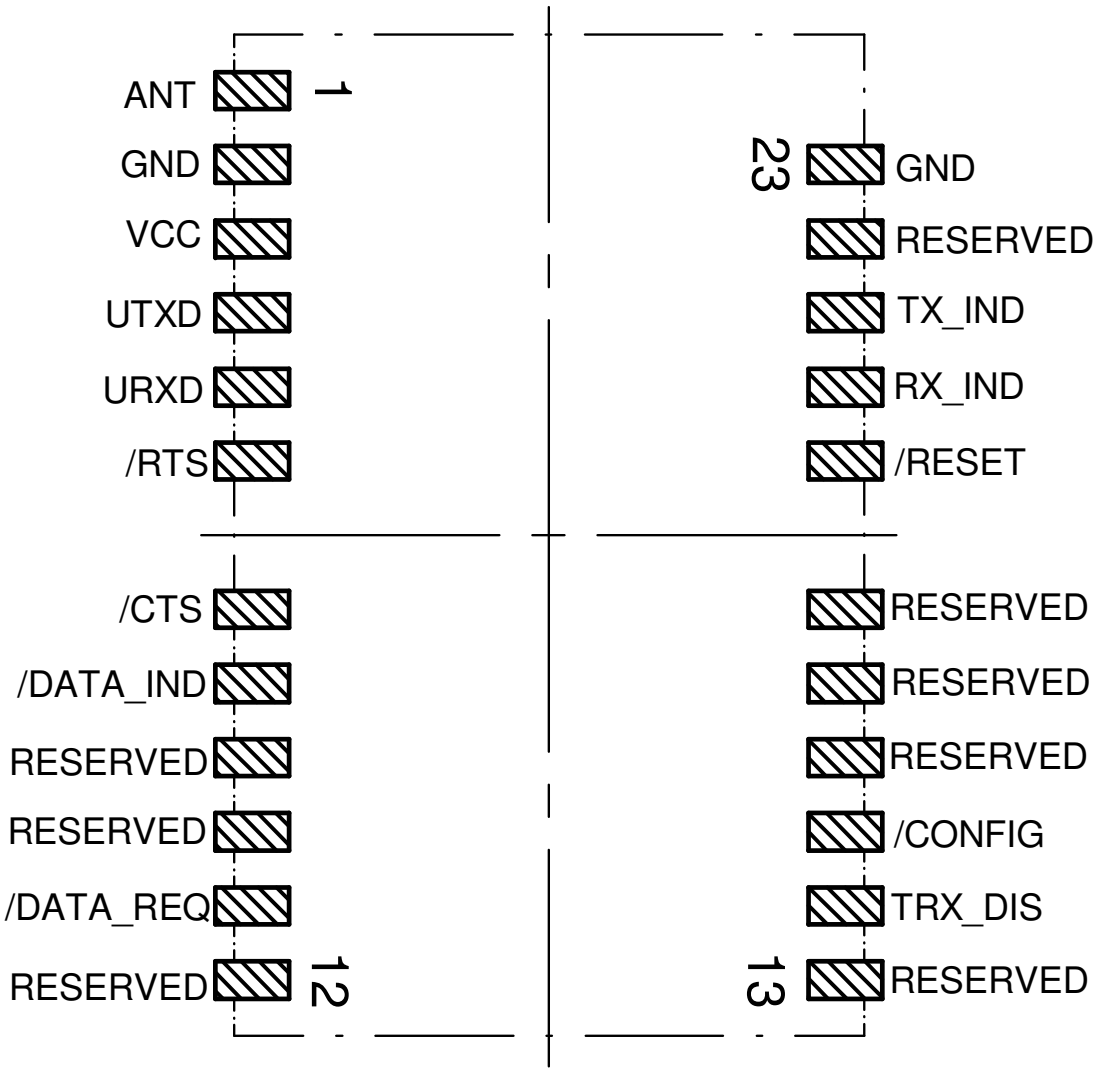


Figure 2: Pinout

No	Designation	I/O	Description
1	*ANT*	I/O	Antenna connection, 50 Ω
2	*GND*	Supply	Ground
3	*VCC*	Supply	Supply voltage
4	*UTXD*	Output	UART TX (module transmission)
5	*URXD*	Input	UART RX (module reception)
6	*/RTS*	Output	UART ready to send. HIGH level signalizes a busy module UART buffer. While HIGH, all received UART bytes will be discarded.

7	*/CTS*	Input	UART clear to send. HIGH signal indicates host busy. Disabled by default. **If the pin function is disabled, connect it to GND.**
8	*/DATA_IND*	Output	Packet receive indication. Goes LOW as soon as a valid packet with correct address is received via radio, stays LOW for and additional `UART_DIDelay` and remains LOW as long as the output via UART continues.
9	*RESERVED*	Output	Reserved. **Do not connect**.
10	*RESERVED*	Output	Reserved. **Do not connect**.
11	*/DATA_REQ*	Input	A falling edge triggers the wireless transmission of buffered data (transparent `OpMode` only). When enabled this pin uses an internal pull-up resistor. Can be disabled by `CfgFlags`. **If the pin function is disabled, connect it to GND.**
12	*RESERVED*	Output	Reserved. **Do not connect**.
13	*RESERVED*	Output	Reserved. **Do not connect**.
14	*TRX_DIS*	Input	Switches the radio receive function off when a HIGH level is applied. **The pin level must be hold LOW during the module boot up**. **Connect to GND if not needed**.
15	*/CONFIG*	Input	Switch the module's `OpMode` on a falling edge detection. Can be disabled by `CfgFlags`. **Connect to GND if function is disabled**.
16	*RESERVED*	Output	Reserved. **Do not connect**.
17	*RESERVED*	Output	Reserved. **Do not connect**.
18	*RESERVED*	Output	Reserved **Do not connect**.
19	*/RESET*	Input	Module internal pull-up, a rising edge will release module from reset, LOW will hold module in reset state.
20	*TX_IND*	Output	Shows radio activity, HIGH on radio TX. Can be enabled by `CfgFlags`.
21	*RX_IND*	Output	Shows radio activity, HIGH on radio RX. Can be enabled by `CfgFlags`.
22	*RESERVED*	Output	Reserved. **Do not connect**.
23	*GND*	Supply	Ground

Table 9: Pinout

6. Quickstart

6.1. Minimal pin configuration

In the factory state, the modules are immediately ready for operation; the following pins are required in the minimal configuration: *VCC*, *GND*, *UTXD*, and *URXD*.

If the module has to be connected to a PC, an adapter (TTL to RS-232 or TTL to USB) has to be used. The Telesto-II-EV is suited for this.

In the default configuration all module inputs (*TRX_DIS* and */CONFIG*) are activated and must be connected as shown in table 9. If the function of the */DATA_REQ* pin is enabled (see chapter 10.20), this pin has an internal pull-up resistor.

If *TRX_DIS* is used by the host it must be set to *GND* during start-up / after reset till the module's start-up is completed. The module will wait for this pin to go to *GND* level before finishing its start-up procedure. The module's UART or function pins (such as */CONFIG*) will not be available until the start-up is finished.

6.2. Power up

Condition: $\Delta t > 2$ ms.

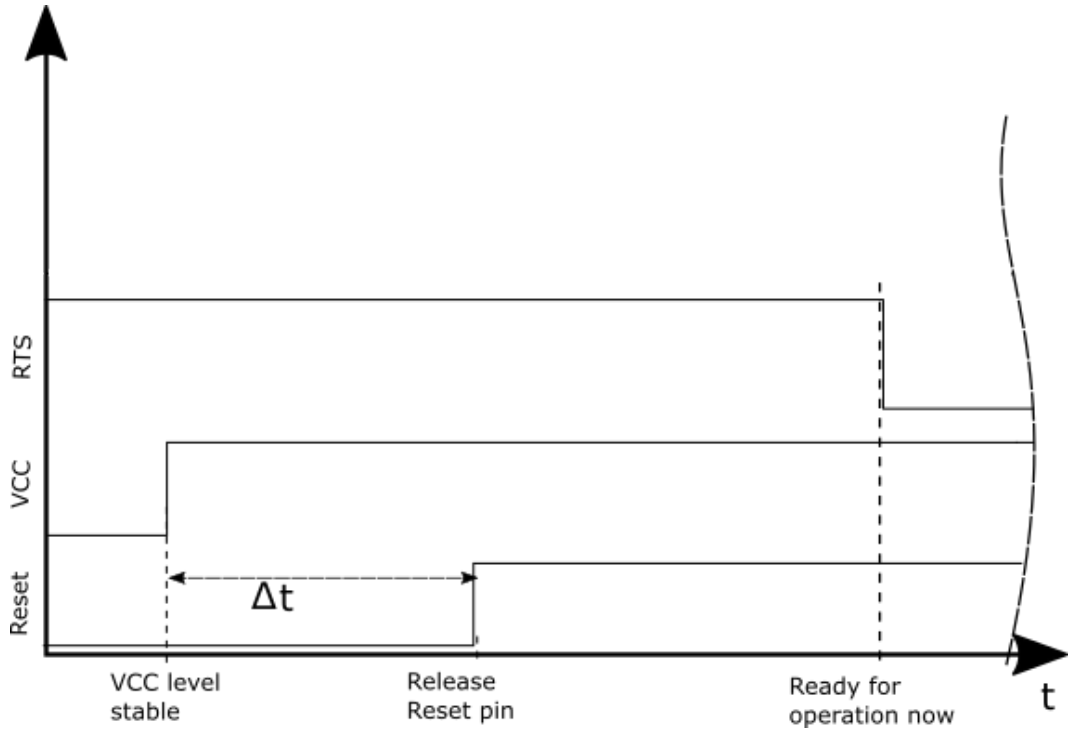


Figure 3: Power up

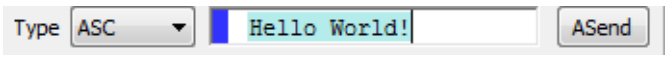
6.3. Quickstart example

Sending and receiving: Hello World
Connect your pair of modules, EV-Boards or USB-sticks with the PC as explained in chapter 6.1. Please make sure you have a minimum distance of 3 meters between the two modules or devices to avoid over modulation. The module's firmware is very sensitive to over modulation due to the active channel detection algorithm that is used due to the need for frequency hopping. When short distances are needed, you could reduce the transmission power to a minimum.

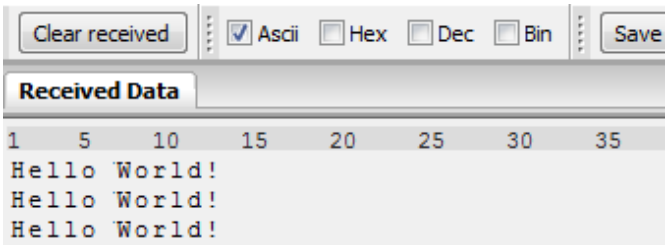
When the connection to the PC is done, please use a terminal tool of your choice. For convenience we assume you selected the tool "hterm". Select the two corresponding COM ports and open them with a configuration of 9600 Baud, 8 Data bits, 1 Stop bit and Parity set to None.



Enter the string "Hello World" into the input line of hterm and use the "ASend" button followed by pushing the "start" button to send the data once.



This data will be received by the second module and shows up as received data in the second hterm instance. You may send any string of size 1 to 120 characters from one module to the other.



You just used the so called "transparent mode" of the modules to send your data. The address mode that was used is "0". Thus all radio frames are broadcasts that can be received by anyone listening with an Telesto-II in default settings. The frame you sent was generated using the timeout method.

Due to the frequency hopping that is needed for 915 MHz FCC compliance, the amount of data that can be send and received per time is limited. A minimum delay of 100 ms between 2 frames shall be implemented.

Besides the transparent mode, that is suited for transparent data transmission, the so called "command mode" allows both, the module configuration and the data transmission, using a predefined command interface (see chapter 9).

7. Functional description

7.1. Operating modes

The Telesto-II can be used in the following operating modes:

1. Transparent mode (transparent data transmission)
2. Command mode (module configuration and data transmission using the predefined command interface)

The operating mode after power-up can be configured by means of the `OpMode` parameter. By default, the module operates in transparent mode.

Starting in the command mode, the module responds with a `CMD_SET_MODE_CNF` telegram.

7.1.1. Switching from transparent to command mode

The command mode can be entered by applying a falling edge on the */CONFIG* pin. The detection of the falling edge on the */CONFIG* pin can be disabled using the user setting `CfgFlags`.

The successful switchover is acknowledged by a `CMD_SET_MODE_CNF` (0x02 *0x44* 0x01 0x10 0x57) telegram indicating command mode.

The switchover can only occur when no data is being received by wireless transmission or UART interface (approximately 100 µs after */RTS* goes low and indicates readiness).

7.1.2. Switching from command to transparent mode

The transparent mode can be entered by applying a falling edge on the */CONFIG* pin or by using the command `CMD_SET_MODE_REQ` . The detection of the falling edge on the */CONFIG* pin can be disabled using the user setting `CfgFlags`.

The successful switchover is acknowledged by a `CMD_SET_MODE_CNF` telegram indicating transparent mode.

The switchover can only occur when no data is being received by wireless transmission or UART interface (approximately 100 µs after */RTS* goes low and indicates readiness).



Recommendation: Automatic switching to a specific mode can be realized by applying falling edges on the */CONFIG* pin as long as the needed `CMD_SET_MODE_CNF` is returned:

- 0x02 *0x44* 0x01 0x10 0x57 telegram indicating command mode
- 0x02 *0x44* 0x01 0x00 0x47 telegram indicating transparent mode

7.1.3. Transparent mode

In this mode, data is received via the serial interface and initially buffered. As soon as a specific condition is met, the RF telegram is generated with a preamble, checksum, and address information (optional). The condition of your choice can be determined by the user setting `UART_PktMode`.

To initiate a RF transmission several options are available (see table `10`).

Start Condition	Description:	Dependent user settings
Timeout	Transmission starts if no new character is detected within a configurable time period after receiving a character via UART. The timeout is reset every time a new character is received.	`UART_Timeout` `UART_PktMode`
End-Of-Text-Character	Transmission begins when the preconfigured character is transmitted via UART.	`UART_PktMode` `UART_ETXChar`

Fixed Packet Size	Transmission starts when the preconfigured number of bytes is reached in the RX buffer of the UART.	`UART_PktSize`
		`UART_RTSLimit`
		`UART_PktMode`

/Data Request Pin	The transmission starts as soon as a falling edge is detected on the */DATA_REQ* pin.	`CfgFlags`

Table 10: Communication in transparent mode

The `UART_PktMode` parameter (see chapter `10.3`) can be used to determine which of the listed combinations is to be used.

7.1.3.1. /RTS signal, busy processor

The */RTS* pin signalizes a busy UART buffer which means, when */RTS* is set, no more UART bytes will be accepted nor processed.

The */RTS* pin is set when any of the events in the prior chapter has occurred and a data packet is processed.

To avoid loss of data bytes by the UART it is absolutely essential to use the */RTS* pin for the flow control and consider it byte by byte.



If the */RTS* pin is ignored it could lead to malfunctions of the module.

7.1.4. Command mode

This operating mode primarily serves the module configuration. The module Telesto-II acts as a slave and can be fully controlled by an external host using the predefined command interface described in chapter 9.

It can also be used for wireless transmission of payload data providing a feedback dependent on the transmission success.

7.2. Adopting parameters to fit your application

The non-volatile parameters (see chapter 10) can only be changed in the command mode by using the CMD_SET_REQ command. This command will need the following parameters:

- memory position of the parameter
- the new value that shall be applied to this parameter

Furthermore, there are volatile settings that can be accessed by explicit commands for each parameter. All available commands are introduced in chapter 9.

7.3. Device addressing and wireless monitoring

To connect several modules to networks or to send data to specific devices, the module supports the so called address mode. The corresponding user setting parameter MAC_AddrMode determines whether all modules in range, or all modules in a network or a single module with a fixed address is supposed to receive a certain message.
The address resolution can be disabled ("packet sniffer") with bit 7 in the CfgFlags. A module configured in this way will receive all data packets and forward them to the serial interface, regardless of the addressing mode. In sniffer mode, the module does not send any acknowledgement.
Settings like the module address can only be modified in the command mode. Thus we recommend to permanently operate in command mode by setting the user settings parameter OpMode to the value of 0x10 (16).
To use non-broadcast transmissions you need to adopt the following non-volatile settings:

- MAC_AddrMode (mode 1 or 2 should be used depending on the number of addresses you need)
- MAC_DefaultSourceAddrLSB as the local address for each device of your network, each member of the network will need an unique address. A value of 255 is invalid.
- MAC_DefaultSourceNetID, as the local network address for each device of your network, each member of the network will need an unique address. A value of 255 is invalid.

In command mode, the command `CMD_DATAEX_REQ`, that has the destination address as an own parameter, can be used to send your data to the specified address. A broadcast message can still be achieved when using 0xFF (255) for both destination address LSB and destination net ID.

8. Host connection

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 data rate is adjusted through a configuration structure. The structure allows the configuration of the non-volatile parameters `UART_Baudrate`, `UART_Databits`, `UART_Parity` and `UART_Stoppbits`.
Since the UART speed is derived from a digitally calibrated oscillator, this may result in variations of up to $\pm$ 2 %. When the UART Clock is derived from the ACLK (i.e. 32768 Hz crystal) of the module this variation can be up to $\pm$ 47 %. Details to this behavior can be extracted from Ti's Family User's Guide for MSP430x5xx µC family.
The output of characters on the serial interface takes place with secondary priority. For this reason, short interruptions may occur between the output of individual characters.
The following data formats are supported:

- 7 or 8 bits
- None, even or odd parity
- 1 or 2 stop bits

9. The command interface

In the command mode, communication with the module occurs in the form of predefined commands. These commands must be sent in telegrams according to the format described in table 11.

Start signal	Command	Length	Payload	CS

Table 11: Telegram format in the command mode

Start signal: STX = 0x02 (1 byte)

Command: One of the predefined commands according to section 0 (1 byte)

Length: Specifies the number of data in the following field of variable length and is limited to 128 in order to prevent buffer overflow (1 byte)

Payload: Variable number of data or parameters (maximum 128 byte, LSB first)

CS: XOR (exclusive-OR, "^")-assignment of the precedent fields, inclusive start sign STX, which means: 0x02 ^Command ^Length ^Payload Byte0 ... (1 byte)



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*.

Using a specific command, data can also be sent via RF, i.e. the module can be operated entirely in the command mode. Only this way quick channel changes, can be realized If no new signal is received for UART_Timeout milliseconds (see chapter 10.7) after receiving the STX signal, the unit will wait for a new start signal.

9.1. Data transfer & reception in the command mode

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

9.1.1. CMD_DATA_REQ

This command serves the simple data transfer in the command mode. Transmission takes place on the configured channel to the previously parameterized destination address.

This command is especially suitable for transmission for a point-to-point connection. The number of payload data bytes is limited to 120.
Format:

Start signal	Command	Payload length	Payload	CS
0x02	0x00	1 Byte	Payload length Bytes	1 Byte

Response:

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

Status:

0x00: ACK received or not requested (`MAC_NumRetrys` is 0 or `MAC_AddrMode` is 0)

0x01: no ACK received

9.1.2. CMD_DATAEX_REQ

This command serves data transfer in a network with several parties. The destination address to be used (depending on the parameterized addressing mode, see also chapter `10.10`) is specified along with the command. The number of payload data bytes is limited to 120.

The inserted destination network and destination address are loaded into the volatile runtime settings and thus kept until the system is reset or they are changed by the user.
Format in addressing mode 0:

Start signal	Command	Length	Reserved	Payload	CS
0x02	0x01	1 Byte	0xFF	(Length - 1) Bytes	1 Byte

Format in addressing mode 1:

Start signal	Command	Length	Reserved	Destination address	Payload	CS
0x02	0x01	1 Byte	0xFF	1 Byte	(Length - 2) Bytes	1 Byte

Format in addressing mode 2:

Start signal	Command	Length	Reserved	Destinatic network ID	Destination address	Payload	CS
0x02	0x01	1 Byte	0xFF	1 Byte	1 Byte	(Length - 2) Bytes	1 Byte

Response:

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

Status:

0x00: ACK received or not requested (MAC_NumRetrys is 0 or MAC_AddrMode is 0)

0x01: no ACK received, if requested

0x02: invalid channel selected

9.1.3. CMD_DATAEX_IND

This telegram indicates the reception of data bytes and represents the counterpart to the commands CMD_DATA_REQ and CMD_DATAEX_REQ. Apart from the RX field strength (RSSI value), this telegram also includes the sender's address (number of address bytes is depending on the parameterized addressing mode, see also chapter 10.10).
Format in addressing mode 0:

Start signal	Command	Length	Payload	Field strength	CS
0x02	0x81	1 Byte	(Length - 1) Bytes	1 Byte	1 Byte

Format in addressing mode 1:

Start signal	Command	Length	Sender address	Payload	Field strength	CS
0x02	0x81	1 Byte	1 Byte	(Length - 1) Bytes	1 Byte	1 Byte

Format in addressing mode 2:

Start signal	Command	Length	Sender network ID	Sender address	Payload	Field strength	CS
0x02	0x81	1 Byte	1 Byte	1 Byte	(Length - 1) Bytes	1 Byte	1 Byte

9.2. Requesting parameters and actions

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

9.2.1. CMD_FWRELEASE_REQ

This command is used to request the firmware version of the module.
Format:

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

Response:

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

The main version number is returned first, followed by the secondary version number and the revision number.

9.2.2. CMD_SERIALNO_REQ

This command can be used to query the individual serial number of the module. Format:

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

Response:

Start signal	Command | 0x40	Length	Serial number	CS
0x02	0x4B	0x04	4 Bytes	1 Byte

For the serial number, the most significant byte (MSB), which identifies the product (product ID), is returned first.

9.2.3. CMD_RESET_REQ

This command triggers a software reset of the module. The reset is performed after the acknowledgement is transmitted.

Format:

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

Response:

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

Status:

0x00: success

9.2.4. CMD_RSSI_REQ

This command returns the RX level of the last received radio frame start indicator "SYNC" (so even for frames with bit errors in the payload the RSSI value is updated) determined by the transceiver IC in the form of a signed two's complement.

Format:

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

Response:

Start signal	Command | 0x40	Length	RX level	CS
0x02	0x4D	0x01	1 Byte	1 Byte

The value obtained in this way delivers the RX level $RSSI_{dBm}$ in dBm as follows: Conversion of the hexadecimal value to a decimal $RSSI_{dec}$ Example:

$$\begin{aligned} 0xDB_{hex} &= 10111101_{bin} \Rightarrow \\ & -128 + 0 \times 64 + 1 \times 32 + 1 \times 16 + 1 \times 8 + 1 \times 4 + 0 \times 2 + 1 \times 1 = -67dBm \end{aligned}$$

The relation between the calculated value and the physical RX level in dBm is not linear across the entire operating range but can be estimated as linear in the range from -110 to -30 dBm.

9.2.5. CMD_ERRORFLAGS_REQ

This command returns internal error states. Format:

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

Response:

Start signal	Command | 0x40	Length	Error Flags	CS
0x02	0x4E	0x02	2 Bytes	1 Byte

The value of "0" returned by the error flag implies that no error has occurred. The value is reset either after a query or by a reset.

The meaning of the error flags is not described in detail in this context.

9.3. Modification of volatile parameters

This group contains all functions that will modify runtime settings while the module is running. These settings are all volatile and will be reset to defaults on a reset of the module.

9.3.1. CMD_SET_MODE_REQ

This command is used to toggle the operating mode, e.g. to exit the command mode. The new operating mode is loaded into the volatile runtime settings. This and all other commands can be used in command mode only.

The following operating modes are defined:

- Transparent mode: 0x00
- Command mode: 0x10

Format:

Start signal	Command	Length	Desired operating mode	CS
0x02	0x04	0x01	0x00	0x07

Response `CMD_SET_MODE_CNF`:

Start signal	Command | 0x40	Length	New operating mode	CS
0x02	0x44	0x01	1 Byte	1 Byte

9.3.2. CMD_SET_PAPOWER_REQ

This command is used to set the RF TX-power (output power). Unlike the user settings parameter `PHY_PAPower`, this is a volatile runtime parameter, but it is handled in the same way. Thus see chapter `10.16` for more information.

The entered power value is entered as a complement on two. The valid range is from -10 to +14 dBm

Format:

Start signal	Command	Length	Power	CS
0x02	0x11	0x01	1 Byte	1 Byte

Response:

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

9.3.3. CMD_SET_DESTNETID_REQ

This command serves to configure the destination network ID in addressing mode 2. Unlike the user settings parameter `MAC_DefaultDestNetID`, this is a volatile runtime parameter.

Format:

Start signal	Command	Length	Destination network ID	CS
0x02	0x07	0x01	1 Byte	1 Byte

Return:

Start signal	Command | 0x40	Length	Status	CS
0x02	0x47	0x01	1 Byte	1 Byte

Status:

0x00: success

9.3.4. CMD_SET_DESTADDR_REQ

This command serves to configure the destination address in addressing modes 1 and 2. Unlike the user settings parameter `MAC_DefaultDestAddrLSB`, this is a volatile runtime parameter. Format: Mode 1 + 2:

Start signal	Command	Length	Destination address	CS
0x02	0x08	0x01	1 Byte	1 Byte

Return:

Start signal	Command | 0x40	Length	Status	CS
0x02	0x48	0x01	1 Byte	1 Byte

Status:

0x00: success

9.4. Modification of non-volatile parameters

The non-volatile parameters are also called user settings and are stored in a special flash location. This settings can also be configured using our windows PC software "ACC".

9.4.1. CMD_SET_REQ

This command enables direct manipulation of the parameters in the module's non-volatile user settings. The respective parameters are accessed by means of the corresponding SettingsIndex. Parameters with size of two or more Bytes have to be transferred with the LSB first unless otherwise specified.

The modified parameters only take effect after a restart of the module. This can be done by a CMD_RESET_REQ or using the */RESET* pin.

STOP

The validity of the specified parameters is not verified by the application. Incorrect values can result in device malfunction up to a scenario where the firmware of the module needs to be re-flashed to get it operating again!

STOP

Any use of CMD_SET_REQ will consume one flash erase/write cycle. Flash erase/write cycles are limited through hardware (guaranteed minimum 100k cycles). For frequently changing parameters use the volatile parameters "Runtime settings", see chapter 9.3 .

STOP

To store the parameters in the flash memory of the module, the particular memory segment must be buffered into RAM, then to be erased entirely and then restored from RAM.
If a reset or VCC instability occurs during this procedure (e.g. due to supply voltage fluctuations), the entire memory area may be destroyed and the module can only be resurrected by means of a JTAG or Bootloader firmware update.
Recommended procedure: First verify the configuration of the module with CMD_GET_REQ and only apply a CMD_SET_REQ if required. Make sure the VCC is stable and no reset occurs during this procedure.

Format:

Start signal	Command	Length	Memory position	Number of bytes	Parameter	CS
0x02	0x09	1 Byte	1 Byte	1 Byte	(Length -2) Bytes	1 Byte

Response:

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

Status:

0x00: Request successfully received and processed

0x01: Operation failed due to invalid parameter

9.4.2. CMD_GET_REQ

This command can be used to query individual or multiple user settings parameters. The requested number of bytes from the specified memory position are returned.

You can query individual or multiple consecutive parameters in the memory at the same time. The sum of the memory position and requested data must not be more than the total size of the user-settings (however a max. of 128 Bytes). Otherwise no data will be returned.

Parameters of 2 or more bytes will be transmitted LSB first.

Format:

Start signal	Command	Length	Memory position	Number of bytes	CS
0x02	0x0A	1 Byte	1 Byte	1 Byte	1 Byte

Response:

Start signal	Command | 0x40	Length	Memory position	Number of bytes	Parameter	CS
0x02	0x4A	1 Byte	1 Byte	1 Byte	(Length -2) Bytes	1 Byte

Read access to the memory area outside the user settings is blocked.

9.4.3. CMD_FACTORY_RESET_REQ

This command restores the default user settings of the module. If this was successful, a software reset of the module is executed additionally. The reset is automatically performed after the acknowledgement is transmitted.

Format:

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

Response:

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

Status:

0x00: Request successfully received and processed

0x01: Request not successful

10. User settings - Module configuration values

10.1. Difference between volatile and non-volatile settings

The so-called user settings are stored permanently into the internal flash of the module. At start-up, these user settings are loaded as start values into the volatile settings ("Runtime settings"). Some of the runtime settings can be modified by special commands (see chapter 9.3). These runtime settings are lost and replaced by the user settings content when the module is restarted.



See chapters 9.3 and 9.4 for methods to change volatile and/or non-volatile settings.

The non-volatile user settings 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.



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!

10.2. Modifying the user settings

The following chapters will give examples for the modification for many parameters using the commands CMD_SET_REQ and CMD_GET_REQ. The PC software ACC can also be used to change non-volatile parameters.

Designation	Summary	Permissible values	Default value	Memory position	Length
UART_PktMode	Selects the packet generation method	0, 1	0	5	1
UART_PktSize	Number of characters for transmission start with set packet size	1 - 120	120	7	1
UART_RTSLimit	Number of received characters after which */RTS* responds	1 - 120	100	8	1

UART_ETXChar	End-of-text character used to mark data packets; reception of this character triggers wireless transmission	0 - 255	10	9	1
UART_Timeout	Timeout after the last character before the data received via UART are transmitted via wireless transmission [ms]	2 - 65535	5	12	2
UART_DIDelay	Delay between signal by pin */DATA_INDICATION* and beginning of output by UART [ms]	0 - 65535	0	14	2
MAC_NumRetrys	Number of wireless retries, 0: retrys disabled	0 - 255	0	20	1
MAC_AddrMode	Wireless Addressing mode	0 - 2	0	21	1
MAC_DefaultDestNetID	Default destination network ID	0 - 255	0	24	1
MAC_ DefaultDestAddrLSB	Default destination address (LSB)	0 - 255	0	25	1
MAC_ DefaultSourceNetID	Own network ID	0 - 254	0	28	1
MAC_ DefaultSourceAddrLSB	Own address (LSB)	0 - 254	0	29	1
MAC_ACKTimeout	Waiting time for wireless acknowledgement [ms]	5 - 65535	8	32	2
PHY_PAPower	Output power [dBm]; value range depends on RF configuration Format: two's complement	-11 - 15	15	41	1
PHY_ LongPreambleTimeout	Length of the preamble used for channel hopping [ms]	5 - 65535	50	44	2

PHY_RSSIThreshold	RSSI value [dB] over noise level that determines the threshold for active channel detection	6 - 40	10	46	1
OpMode	Operating mode, transparent or command mode	0, 16	0	60	1
CfgFlags	Flags for setting various properties; see chapter 10.20	0 - 65535	512	72	2
UART_Baudrate	Symbol rate of the UART	1200 - 19200	9600	80	4
UART_Databits	Number of data bits	7, 8	8	84	1
UART_Parity	Parity	0, 1, 2	0	85	1
UART_Stoppbits	Stop bits	1, 2	1	86	1
RF_ConfigIndex	Index for predefined radio settings	0	0	92	1

Table 12: Overview of non-volatile user-settings

10.3. UART_PktMode

Designation	Summary	Permissible values	Default value	Memory position	Length
UART_PktMode	Selects the packet generation method	0, 1	0	5	1

Selects the packet mode used for generating packets for the transparent operating mode. In command mode the packet end is defined by the length information in the packet header. Only used in OpMode = transparent.

Two modes have been implemented:

Mode 0: Transmission starts when the timeout defined with UART_Timeout has been reached or the packet has reached size UART_PktSize.

Mode 1: Transmission starts when the character defined with UART_ETXChar has been detected or the packet has reached size UART_PktSize .The UART_ETXChar will be sent too.

10.3.1. Example 1:

Set the parameter UART_PktMode to 0 (which means the transmission starts when the defined packet size or timeout has been reached).

Command:

Start signal	Command	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x09	0x03	0x05	0x01	0x00	0x0C

Response:

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

Request successfully received and processed

10.3.2. Example 2:

Read the UART_PktMode from memory position 5 and length 1.

Command:

Start signal	Command	Length	Memory Position	Amount of Bytes	CS
0x02	0x0A	0x02	0x05	0x01	0x0E

Response:

Start signal	Command | 0x40	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x4A	0x03	0x05	0x01	0x00	0x4F

Successfully read the value of `UART_PktMode` as 0.

10.4. UART_PktSize

Designation	Summary	Permissible values	Default value	Memory position	Length
UART_PktSize	Number of characters for transmission start with set packet size	1 - 120	120	7	1

Maximum number of bytes after which the wireless transmission of the data received via UART starts. Used in packet mode 0 as well as in packet mode 1. Maximum is 120 due to buffer size.

Not used in command mode.

10.4.1. Example 1:

Set the parameter UART_PktSize to 120 (0x78).

Command:

Start signal	Command	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x09	0x03	0x07	0x01	0x78	0x76

Response:

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

Request successfully received and processed

10.4.2. Example 2:

Read the UART_PktSize from memory position 7 and length 1.

Command:

Start signal	Command	Length	Memory Position	Amount of Bytes	CS
0x02	0x0A	0x02	0x07	0x01	0x0C

Response:

Start signal	Command | 0x40	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x4A	0x03	0x07	0x01	0x80	0xCD

Successfully read the value of UART_ PktSize as 128 (0x80).

10.5. UART_RTSLimit

Designation	Summary	Permissible values	Default value	Memory position	Length
UART_RTSLimit	Number of received characters after which /RTS responds	1-120	100	8	1

Number of bytes after which the host system is prompted to interrupt the data transfer over */RTS*. This is necessary, because depending on the host system, an immediate response to the */RTS* signal may not take place (UART FIFO).

Not used in command mode.

10.5.1. Example 1:

Set the parameter UART_RTSLimit to 120 (0x78)
Command:

Start signal	Command	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x09	0x03	0x08	0x01	0x78	0x79

Response:

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

Request successfully received and processed

10.5.2. Example 2:

Read the UART_RTSLimit from memory position 8 and length 1.

Command:

Start signal	Command	Length	Memory Position	Amount of Bytes	CS
0x02	0x0A	0x02	0x08	0x01	0x03

Response:

Start signal	Command | 0x40	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x4A	0x03	0x08	0x01	0x70	0x32

Successfully read the value of UART_RTSLimit as 112 (0x70).

10.6. UART_ETXChar

Designation	Summary	Permissible values	Default value	Memory position	Length
UART_ETXChar	End-of-text character used to mark data packets, reception of this character triggers wireless transmission	0 - 255	10	9	1

End-of-text character that triggers the transmission of the data received via UART. Only used in packet mode 1 and in OpMode = transparent. During the wireless transmission, the ETX character is treated like a normal character.

Not used in the command mode.

10.6.1. Example 1:

Set the parameter UART_ETXChar to 13.

Command:

Start signal	Command	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x09	0x03	0x09	0x01	0x0D	0x0D

Response:

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

Request successfully received and processed

10.6.2. Example 2:

Read the UART_ETXChar from memory position 9 and length 1.

Command:

Start signal	Command	Length	Memory Position	Amount of Bytes	CS
0x02	0x0A	0x02	0x09	0x01	0x02

Response:

Start signal	Command | 0x40	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x4A	0x03	0x09	0x01	0x0A	0x49

Successfully read the value of UART_ETXChar as 10.

10.7. UART_Timeout

Designation	Summary	Permissible values	Default value	Memory position	Length
UART_Timeout	Timeout for radio send data trigger (after the last received UART character) [ms]	2 - 65535	5	12	2

The timeout defines the delay in milliseconds in transparent mode after the last character has been received by the UART before the wireless transmission starts. Only used in packet mode 0. The value should be chosen appropriate to the UART data rate. Only used in OpMode = transparent.

10.7.1. Example 1:

Set the parameter UART_Timeout to 10.

Command:

Start signal	Command	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x09	0x04	0x0C	0x02	0x0A 0x00	0x0B

Response:

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

Request successfully received and processed

10.7.2. Example 2:

Read the UART_Timeout from memory position 12 and length 2.

Command:

Start signal	Command	Length	Memory Position	Amount of Bytes	CS
0x02	0x0A	0x02	0x0C	0x02	0x04

Response:

Start signal	Command | 0x40	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x4A	0x04	0x0C	0x02	0x05 0x00	0x47

Successfully read the value of UART_Timeout as 5 ms. 5

10.8. UART_DIDelay

Designation	Summary	Permissible values	Default value	Memory position	Length
UART_DIDelay	Delay between signal by pin */DATA_INDICATION* and beginning of UART transmission to host [ms]	0 - 65535	0	14	2

This parameter determines the delay in milliseconds between the indication of incoming RF data by the */DATA_INDICATION* pin and the output of the data on UART. This delay can be used to alert a sleeping host system to prepare for the reception of data.

10.8.1. Example 1:

Set the parameter UART_DIDelay to 5.

Command:

Start signal	Command	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x09	0x04	0x0E	0x02	0x05 0x00	0x06

Response:

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

Request successfully received and processed

10.8.2. Example 2:

Read the UART_DIDelay from memory position 14 and length 2.

Command:

Start signal	Command	Length	Memory Position	Amount of Bytes	CS
0x02	0x0A	0x02	0x0E	0x02	0x06

Response:

Start signal	Command | 0x40	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x4A	0x04	0x0E	0x02	0x00 0x00	0x40

Successfully read the value of UART_DIDelay as 0 ms.

10.9. MAC_NumRetrys

Designation	Summary	Permissible values	Default value	Memory position	Length
MAC_NumRetrys	Number of wireless retries	0 - 255	0	20	1

Determines the maximum number of wireless transmission retries. If this parameter is set to a value other than 0, the receiver module will automatically be prompted to send a wireless acknowledgement ("ACK"). Please note that sending acknowledgements additionally increases the traffic.

According to *ESTI EN 301 391*, the value for MAC_NumRetrys should be 5 at most.

10.9.1. Example 1:

Setting the number of wireless retries to 5 (parameter MAC_NumRetrys).

Command:

Start signal	Command	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x09	0x03	0x14	0x01	0x05	0x18

Response:

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

Request successfully received and processed

10.9.2. Example 2:

Read the MAC_NumRetrys from memory position 20 and length 1.

Command:

Start signal	Command	Length	Memory Position	Amount of Bytes	CS
0x02	0x0A	0x02	0x14	0x01	0x1F

Response:

Start signal	Command | 0x40	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x4A	0x03	0x14	0x01	0x00	0x5E

Successfully read the value of MAC_NumRetrys as 0.

10.10. MAC_AddrMode

Designation	Summary	Permissible values	Default value	Memory position	Length
MAC_AddrMode	Addressing mode to use	0 - 2	0	21	1

Addressing mode selection. The following modes have been implemented:

- No addressing (mode 0): Each module receives the transmitted RF telegram and delivers the received data to the host system via UART. No address information is transmitted in the radio telegram.
- 1-byte address (mode 1): The receiving module only delivers the data to the host system via UART if the destination address configured at the sender (MAC_DefaultDestAddrLSB) corresponds to the source address (MAC_DefaultSourceAddrLSB) or the destination address 255 (broadcast) was specified. Both the destination address and the source address are transmitted in the wireless telegram (total = 2 bytes).
- 2-bytes address (mode 2): The receiving module only delivers the data to the host system via UART if both the destination network ID and the destination address correspond to the source addresses (MAC_DefaultSourceNetID and MAC_DefaultSourceAddrLSB) or the destination address 255 (broadcast) was specified. A total of 4 bytes of address information are transmitted in the wireless telegram.

Caution: In addressing mode 0, the use of wireless acknowledgement may cause problems if several wireless modules are addressed simultaneously. Therefore no ACK is requested when using addressing mode 0.

The receiver and transmitter modules must operate in the same addressing mode! Otherwise the receiver cannot decrypt the data packet sent and thus the packet is discarded!

10.10.1. Example 1:

Setting the MAC_AddrMode to 1.

Command:

Start signal	Command	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x09	0x03	0x15	0x01	0x01	0x1D

Response:

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

Request successfully received and processed

10.10.2. Example 2:

Read the `MAC_AddrMode` from memory position 21 and length 1.

Command:

Start signal	Command	Length	Memory Position	Amount of Bytes	CS
0x02	0x0A	0x02	0x15	0x01	0x1E

Response:

Start signal	Command | 0x40	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x4A	0x03	0x15	0x01	0x01	0x5E

Successfully read the value of `MAC_AddrMode` as 1.

10.11. MAC_DefaultDestNetID

Designation	Summary	Permissible values	Default value	Memory position	Length
MAC_DefaultDestNetID	Default destination network ID	0 - 255	0	24	1

Destination network address which is used in addressing mode 2. Can be modified with the command CMD_SET_DESTNETID_REQ at runtime (volatile). If the special broadcast ID and the broadcast address are set to 255, the packets will be received by all network participants.

10.11.1. Example 1:

Set the parameter MAC_DefaultDestNetID to 1.

Command:

Start signal	Command	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x09	0x03	0x18	0x01	0x01	0x10

Response:

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

Request successfully received and processed

10.11.2. Example 2:

Read MAC_DefaultDestNetID from memory position 24, length 1.

Command:

Start signal	Command	Length	Memory Position	Amount of Bytes	CS
0x02	0x0A	0x02	0x18	0x01	0x13

Response:

Start signal	Command | 0x40	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x4A	0x03	0x18	0x01	0x00	0x52

Successfully read the value of MAC_DefaultDestNetID as 0.

10.12. MAC_DefaultDestAddrLSB

Designation	Summary	Permissible values	Default value	Memory position	Length
MAC_DefaultDestAddrLSB	Default destination address (LSB)	0 - 255	0	25	1

Least significant byte of the destination address which is used in addressing modes 1 and 2. Can be modified with the command CMD_SET_DESTADDR_REQ at runtime (volatile). If the special broadcast address 255 is used (in the case of addressing mode 2, broadcast ID is also 255), the packets will be received by all network participants.

10.12.1. Example 1:

Set the parameter MAC_DefaultDestAddrLSB to 1.

Command:

Start signal	Command	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x09	0x03	0x19	0x01	0x01	0x11

Response:

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

Request successfully received and processed

10.12.2. Example 2:

Read the MAC_DefaultDestNetID from memory position 24 and length 1.

Command:

Start signal	Command	Length	Memory Position	Amount of Bytes	CS
0x02	0x0A	0x02	0x18	0x01	0x13

Response:

Start signal	Command | 0x40	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x4A	0x03	0x18	0x01	0x00	0x52

Successfully read the value of MAC_DefaultDestNetID as 0.

10.13. MAC_DefaultSourceNetID

Designation	Summary	Permissible values	Default value	Memory position	Length
MAC_DefaultSourceNetID	Own/Local network ID	0 - 254	0	28	1

Source network ID to be used in addressing mode 2.

10.13.1. Example 1:

Set the parameter MAC_DefaultDestNetID to 1.

Command:

Start signal	Command	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x09	0x03	0x1C	0x01	0x01	0x14

Response:

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

Request successfully received and processed

10.13.2. Example 2:

Read the MAC_DefaultSourceNetID from memory position 28, length 1.

Command:

Start signal	Command	Length	Memory Position	Amount of Bytes	CS
0x02	0x0A	0x02	0x1C	0x01	0x17

Response:

Start signal	Command | 0x40	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x4A	0x03	0x1C	0x01	0x00	0x56

Successfully read the value of MAC_DefaultSourceNetID as 0.

10.14. MAC_DefaultSourceAddrLSB

Designation	Summary	Permissible values	Default value	Memory position	Length
MAC_DefaultSourceAddrLSB	Own/Local address (LSB)	0 - 254	0	29	1

Source device address to be used in addressing modes 1 and 2.

10.14.1. Example 1:

Set the parameter MAC_DefaultSourceAddrLSB to 1.

Command:

Start signal	Command	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x09	0x03	0x1D	0x01	0x01	0x15

Response:

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

Request successfully received and processed

10.14.2. Example 2:

Read MAC_DefaultSourceAddrLSB from memory position 29, length 1.

Command:

Start signal	Command	Length	Memory Position	Amount of Bytes	CS
0x02	0x0A	0x02	0x1D	0x01	0x16

Response:

Start signal	Command | 0x40	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x4A	0x03	0x1D	0x01	0x00	0x57

Successfully read the value of MAC_DefaultSourceAddrLSB as 0.

10.15. MAC_ACKTimeout

Designation	Summary	Permissible values	Default value	Memory position	Length
MAC_ACKTimeout	Waiting time for wireless acknowledgement [ms]	5 - 65535	8	32	2

Time to wait for a RF acknowledgement before a RF retry is triggered.

10.15.1. Example 1:

Set the parameter MAC_ACKTimeout to 15.

Command:

Start signal	Command	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x09	0x04	0x20	0x02	0x0F 0x00	0x22

Response:

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

Request successfully received and processed.

10.15.2. Example 2:

Read the MAC_ACKTimeout from memory position 32 and length 2.

Command:

Start signal	Command	Length	Memory Position	Amount of Bytes	CS
0x02	0x0A	0x02	0x20	0x02	0x28

Response:

Start signal	Command | 0x40	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x4A	0x04	0x20	0x02	0x0A 0x00	0x64

Successfully read the value of MAC_ACKTimeout as 10 ms.

10.16. PHY_PAPower

Designation	Summary	Permissible values	Default value	Memory position	Length
PHY_PAPower	Output power [dBm], value range depends on RF configuration complement on two	-11 - 15	15	41	1

Parameter for the RF output power of the module. The maximum permissible output depends on the used RF configurations.

The RF chip only supports discrete values. Mapping to the next possible PHY_PAPower value is done by the module. The next smaller PHY_PAPower value is always chosen when the transferred value is not possible. The step distance equals 1 dB.

The user settings PHY_PAPower is entered as a complement on two.



The statutory regulations for the maximum power output have to be adhered to.

10.16.1. Example 1:

Using the value 15 dBm with parameter PHY_PAPower.

Command:

Start signal	Command	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x09	0x03	0x29	0x01	0x0F	0x2F

Response:

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

Request successfully received and processed

10.16.2. Example 2:

Read the PHY_PAPower from memory position 41 and length 1.

Command:

Start signal	Command	Length	Memory Position	Amount of Bytes	CS
0x02	0x0A	0x02	0x29	0x01	0x22

Response:

Start signal	Command | 0x40	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x4A	0x03	0x29	0x01	0x0F	0x6C

Successfully read the value of `PHY_PAPower` as 15 dBm.

10.17. PHY_LongPreambleTimeout

Designation	Summary	Permissible values	Default value	Memory position	Length
PHY_LongPreambleTimeout	Length of the preamble used for channel hopping [ms]	5 - 65535	50	44	2

This value specifies the length of the preamble sent in advance to the payload data packet. This preamble is used to detect the right channel for data transmission.

RF_ConfigIndex	Preamble timeout recommended
0	50 ms



For optimal data transmission quality, all communicating modules shall use the same preamble timeout value.

10.17.1. Example 1:

Set the PHY_LongPreambleTimeout to 100 ms. Take decimal 100, convert it to MSB first hex notation 0x0064 and then apply the LSB first byte order: 0x6400.

Command:

Start signal	Command	Length + 2	Memory position	Length	Parameter	CS
0x02	0x09	0x04	0x2C	0x02	0x64 0x00	0x45

Response:

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

Request successfully received and processed.

10.17.2. Example 2:

Read the PHY_LongPreambleTimeout from memory position 44 and length 2.

Command:

Start signal	Command	Length	Memory Position	Amount of Bytes	CS
0x02	0x0A	0x02	0x2C	0x02	0x24

Response:

Start signal	Command | 0x40	Length + 2	Memory position	Length	Parameter	CS
0x02	0x4A	0x04	0x2C	0x02	0x32 0x00	0x50

Successfully read the value of `PHY_LongPreambleTimeout` as 50 ms.

10.18. PHY_RSSIThreshold

Designation	Summary	Permissible values	Default value	Memory position	Length
PHY_RSSIThreshold	RSSI value [dB] over noise level that determines the threshold for active channel detection	6 - 40	10	46	1

This value determines the dynamic threshold that is used to detect an active channel. The threshold for channel active detection is selected as PHY_RSSIThreshold added to the averaged noise level of the respective channel.



The minimum applicable value is 6 dB.



The configured value is to be taken into account for any range estimation as it will reduce the link budget by the configured value.

Best practice for network setup is a minimum distance in between sending nodes of at least 5m.



To make the firmware more robust against false channel detections and packet loss, the value of PHY_RSSIThreshold has to be increased to match the environment of the radio network. In this case, the operating range decreases since all signals lower than the current noise level plus PHY_RSSIThreshold are classified as noise and hence ignored.

10.18.1. Example 1:

Set the parameter PHY_RSSIThreshold to 6dB.

Command:

Start signal	Command	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x09	0x03	0x2E	0x01	0x06	0x21

Response:

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

Request successfully received and processed

10.18.2. Example 2:

Read the `PHY_RSSIThreshold` from memory position 46 and length 1.

Command:

Start signal	Command	Length	Memory Position	Amount of Bytes	CS
0x02	0x0A	0x02	0x2E	0x01	0x25

Response:

Start signal	Command | 0x40	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x4A	0x03	0x2E	0x01	0x0A	0x6E

Successfully read the value of `PHY_RSSIThreshold` as 10 dB.

10.19. OpMode

Designation	Summary	Permissible values	Default value	Memory position	Length
OpMode	Operating mode	0, 16	0	60	1

Choose between operating modes. Can be selected between mode 0 (transparent data transfer) and mode 16 (command mode).

10.19.1. Example 1:

Set the parameter OpMode to 16 (command mode).

Command:

Start signal	Command	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x09	0x03	0x3C	0x01	0x10	0x25

Response:

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

Request successfully received and processed

10.19.2. Example 2:

Read the OpMode from memory position 60 and length 1.

Command:

Start signal	Command	Length	Memory Position	Amount of Bytes	CS
0x02	0x0A	0x02	0x3C	0x01	0x37

Response:

Start signal	Command | 0x40	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x4A	0x03	0x3C	0x01	0x00	0x76

Successfully read the value of OpMode as 0 (transparent mode).

10.20. CfgFlags

Designation	Summary	Permissible values	Default value	Memory position	Length
CfgFlags	Flags for setting various properties see chapter 10.20	0 - 65535	512	72	2

16-bit field in which the use of individual pins or signals can be disabled. Table 13 represents a description of the respective flags.

To use multiple settings, add the bit numbers and choose the result as value for CfgFlags.

By default, CfgFlags for modules are 0x0200 (LED's enabled). For the USB-Sticks the default CfgFlags are 0x021F (LED's enabled, *Config*, *Data_Request* & *TRX_DIS* pins disabled).

Bit no.	Description
0 (0x0001)	Setting this bit disables the */CONFIG* pin. Thus the unit can no longer be switched to the command mode via this pin.
1 (0x0002)	Setting this bit disables the */DATA_REQ* pin.
2 (0x0004)	Reserved
3 (0x0008)	Setting this bit, disables handling of the status of the *TRX_DIS* pin. Hence, the module can no longer be set to the various power-saving modes via this pin.
4 (0x0010)	Setting this bit, enables a different behavior of the *TRX_DIS* pin. If this bit is set and the *TRX_DIS* pin is set, then additionally to the RF-chip, the UART is powered down. In this case, furthermore the chip is powered down to LPM3 and the *CONFIG* pin is disabled. The needed wakeup time after releasing the *TRX_DIS* pin is < 1 ms.
5 (0x0020)	Any character will be accepted as valid checksum in the command mode if this bit is set.
6 (0x0040)	Setting this bit, disables the pull down of the pin *TRX_DIS*.
7 (0x0080)	The address will not be resolved if this bit is set. The particular module can be used as packet sniffer to monitor a wireless link. No ACK is sent.
8 (0x0100)	Setting this bit enables the */CTS* flow control pin.
9 (0x0200)	Setting this bit enables the outputs for RF activity, (e.g. for LEDs).
10 to 15	Reserved

Table 13: Configuration flags

Warning: If both bit 0 and bit 2 are set, the module can no longer be set to the command mode.

This parameter set consisting of two bytes has to be transferred LSB first. That means, first the byte with bits 0 ... 7, then the byte with bits 8 ... 15.

10.20.1. Example 1:

Set the `CfgFlags` to 0.

Command:

Start signal	Command	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x09	0x04	0x48	0x02	0x00 0x00	0x45

Response:

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

Request successfully received and processed

10.20.2. Example 2:

Read the `CfgFlags` from memory position 72 and length 2.

Command:

Start signal	Command	Length	Memory Position	Amount of Bytes	CS
0x02	0x0A	0x02	0x48	0x02	0x40

Response:

Start signal	Command | 0x40	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x4A	0x04	0x48	0x02	0x00 0x02	0x04

Successfully read the value of `CfgFlags` as 512 (LEDs are enabled).

10.21. UART_Baudrate

Designation	Summary	Permissible values	Default value	Memory position	Length
UART_Baudrate	Symbol rate of the UART	1200 - 19200	9600	80	4

A 32 bit field, that contains the symbol rate for the communication interface (in LSB first notation). Symbol rates up to 115200 Baud are supported. Default symbol rate is 9600 Baud. Please note that for baud rates higher than 9600 Baud the LPM has a higher energy consumption.



The maximum usable UART baudrate on Telesto-II is, due to timing requirements of the FHSS, 19200 Baud.

10.21.1. Example 1:

Set the UART_Baudrate to 19200 Baud. Take decimal 19200, convert it to MSB first hex notation 0x00004B00 and then apply the LSB first byte order: 0x004B0000.

Command:

Start signal	Command	Length + 2	Memory position	Length	Parameter	CS
0x02	0x09	0x06	0x50	0x04	0x00 0x4B 0x00 0x00	0x12

Response:

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

Request successfully received and processed.

10.21.2. Example 2:

Read the UART_Baudrate from memory position 80 and length 4.

Command:

Start signal	Command	Length	Memory Position	Amount of Bytes	CS
0x02	0x0A	0x02	0x50	0x04	0x5E

Response:

Start signal	Command | 0x40	Length + 2	Memory position	Length	Parameter	CS
0x02	0x4A	0x06	0x50	0x04	0x80 0x25 0x00 0x00	0xD9

Successfully read the value of `UART_Baudrate` as 9600 Baud (0x00002580).

10.22. UART_Databits

Designation	Summary	Permissible values	Default value	Memory position	Length
UART_Databits	Number of data bits	7, 8	8	84	1

An 8 bit field that contains the number of data bits on the communication interface. Supported values are 7 and 8.



It is highly recommended to use 8 databits.

10.22.1. Example 1:

Set the parameter UART_Databits to 8.

Command:

Start signal	Command	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x09	0x03	0x54	0x01	0x08	0x55

Response:

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

Request successfully received and processed

10.22.2. Example 2:

Read the UART_Databits from memory position 84 and length 1.

Command:

Start signal	Command	Length	Memory Position	Amount of Bytes	CS
0x02	0x0A	0x02	0x54	0x01	0x5F

Response:

Start signal	Command | 0x40	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x4A	0x03	0x54	0x01	0x08	0x16

Successfully read the value of UART_Databits as 8.

10.23. UART_Parity

Designation	Summary	Permissible values	Default value	Memory position	Length
UART_Parity	Parity	0, 1, 2	0	85	1

Parity mode	UART_Parity value
'n' no parity	0
'e' even parity	1
'o' odd parity	2

An 8 bit field that contains the parity mode for the communication interface.

10.23.1. Example 1:

Set the parameter UART_Parity to 0 (no parity).

Command:

Start signal	Command	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x09	0x03	0x55	0x01	0x00	0x5C

Response:

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

Request successfully received and processed

10.23.2. Example 2:

Read the UART_Parity from memory position 85 and length 1.

Command:

Start signal	Command	Length	Memory Position	Amount of Bytes	CS
0x02	0x0A	0x02	0x55	0x01	0x5E

Response:

Start signal	Command | 0x40	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x4A	0x03	0x55	0x01	0x00	0x1F

Successfully read the value of `UART_Parity` as 0 (’n’ no parity).

10.24. UART_Stoppbits

Designation	Summary	Permissible values	Default value	Memory position	Length
UART_Stoppbits	Stop bits	1, 2	1	86	1

An 8 bit field that contains the number of stop bits for the communication interface. Supported are 1 and 2 stop bits.



It is highly recommended to use 1 stop bit.

10.24.1. Example 1:

Set the parameter UART_Stoppbits to 1.

Command:

Start signal	Command	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x09	0x03	0x56	0x01	0x01	0x5E

Response:

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

Request successfully received and processed

10.24.2. Example 2:

Read the UART_Stoppbits from memory position 86 and length 1.

Command:

Start signal	Command	Length	Memory Position	Amount of Bytes	CS
0x02	0x0A	0x02	0x56	0x01	0x5D

Response:

Start signal	Command | 0x40	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x4A	0x03	0x56	0x01	0x01	0x1D

Successfully read the value of UART_Stoppbits as 1.

10.25. RF_ConfigIndex

Designation	Summary	Permissible values	Default value	Memory position	Length
RF_ConfigIndex	Index for predefined radio settings	0	0	92	1

An 8 bit field that addresses the applied RF configuration.

RF_ConfigIndex	Data rate (gross) [kcps]	Modulation
0	38.4	GFSK

Table 14: RF profiles

10.25.1. Example 1:

Set the RF_ConfigIndex to 1.

Command:

Start signal	Command	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x09	0x03	0x5C	0x01	0x01	0x54

Response:

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

Request successfully received and processed

10.25.2. Example 2:

Read the RF_ConfigIndex from memory position 92 and length 1.

Command:

Start signal	Command	Length	Memory Position	Amount of Bytes	CS
0x02	0x0A	0x02	0x5C	0x01	0x57

Response:

Start signal	Command | 0x40	Length + 2	Memory Position	Length	Parameter	CS
0x02	0x4A	0x03	0x5C	0x01	0x01	0x17

Successfully read the value of RF_ConfigIndex as 1.

11. Timing parameters

11.1. Reset behavior

Following a reset, a low on the */RTS* pin signals that the module is ready for operation.

This level is however only valid, after the delay required for the internal initialization of the processor (a few µs).

11.1.1. Power-on reset

After switching the supply voltage and releasing the */RESET* pin (if wired), the time until the module is ready for operation can last up to 1 s. During this time, the processor clock-rate will be calibrated, which takes anyway between 2 and 20 ms depending on the supply voltage and temperature.

Furthermore all channels are precalibrated to allow fast channel switching and the noise level of all channels is determined to detect the active channels without fault.

11.1.2. Reset via /RESET pin

To force a module restart by means of the */RESET* pin, it must first be drawn to low for at least 10 ms. After the pin is released, */RTS* will switch to high after 100 µs at the latest and the start-up procedure begins. newline
Recommended procedure: After the */RESET* pin is released, wait for additional 100 µs after the */RTS* pin is low to be sure that the system is ready.

11.1.3. Reset as result of a serious error condition

If the module runs in a serious error condition, a software reset is executed. In this case, the module starts up automatically and can be used again. The volatile runtime settings are reset to default.

11.2. Latencies when leaving the LPM

The module enters a LPM as soon as no data-transmission request is received via serial and RF interface.

If the device returns from such a mode, all internal settings like the channel calibration values and noise levels have been retained, such that the module is ready after a few µs. Also here a low signal at the */RTS* indicates that the module is ready for operation.

11.3. 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 (flow control with /RTS signal), and the payload data is passed to the internal memory of the wireless transceiver

(FIFO).

The wireless transmission starts as soon as the first data is available in the transceiver memory. During the continuous wireless transmission the remaining payload data is transmitted byte by byte.

On the receiver side, the FIFO is read as soon as an incoming packet is detected.

If the module detects a packet that requires an ACK, the ACK is sent immediately after the packet reception.

In combination with a suitable packet generation method, this procedure enables the minimization of the latencies resulting from buffering.

12. Radio parameters

The 915 MHz frequency band is split into the channels of Table 15, where the band limit channels 200 and 252 are not to be used for any RF activity. They are chosen with equal distances of 500 kHz so that the neighbor channels should not disturb each other at the default RF data rate (38400 Baud) in a normal network setup (i.e. distances in between any nodes > 5m).

Channel	Frequency	Channel	Frequency	Channel	Frequency
200	902	218	911	236	920
201	902,5	219	911,5	237	920,5
202	903	220	912	238	921
203	903,5	221	912,5	239	921,5
204	904	222	913	240	922
205	904,5	223	913,5	241	922,5
206	905	224	914	242	923
207	905,5	225	914,5	243	923,5
208	906	226	915	244	924
209	906,5	227	915,5	245	924,5
210	907	228	916	246	925
211	907,5	229	916,5	247	925,5
212	908	230	917	248	926
213	908,5	231	917,5	249	926,5
214	909	232	918	250	927
215	909,5	233	918,5	251	927,5
216	910	234	919	252	928
217	910,5	235	919,5		

Table 15: Overview of the 51 active channels according to FCC.

To operate in this band the radio-norm FCC $15.247 prescribes to use all channels equally for data transmission. Thus the AMB9626 implements the so called "asynchronous channel hopping technique" using a new channel for each packet sent. Figure 4 illustrates exemplary the underlying idea for a frequency band consisting of 10 channels.
Thereby the device in RX mode jumps quickly through the channels to listen for some RF activity. If an active channel was detected, the receiving device listens to the data packet that will follow afterwards. To find out whether a channel is active or not, the noise level of each channel is determined permanently. A channel is classified as active if its signal power is at least `PHY_RSSIThreshold` dB above the current noise level of the channel. Otherwise the measured value is used to update the corresponding noise level.
On the TX side, the transmitting device first sends a long preamble to signalize RF activity on the chosen channel. This preamble has to be sufficiently long, that the receiver can detect the chosen channel (see the user setting `PHY_LongPreambleTimeout`). After this preamble was sent, the transmission of the data packet follows. For each transmission (preamble plus payload data) a new channel is chosen.

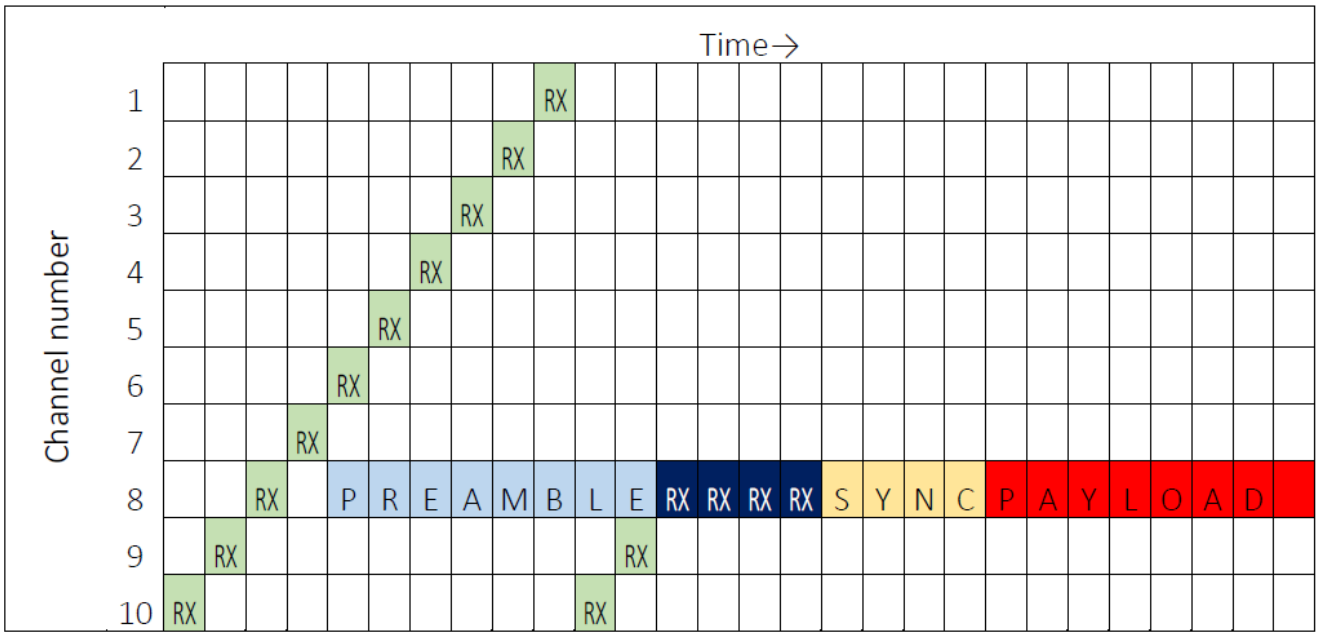


Figure 4: Channel hopping for a 10 channel system

13. Battery powered operation

The *TRX_DIS* pin can set the module to one of two different modes of operation.

13.1. Active mode

When *TRX_DIS* is low, the module is permanently ready to receive and forward data via UART or wireless transmission. The module will switch to one of the internal LPM after having processed any pending data transmission, i.e. */RTS* must be low.

13.2. Stand-by mode

When *TRX_DIS* is high, the operation of the module's transceiver is disabled. Wireless reception is not possible, but transmission of data is possible. The module will switch to one of the internal LPM as long as no data will be transmitted. A UART data rate of more than 9600 Baud will result in a higher current consumption.



The `CfgFlags` Bit 4 can modify this behavior (see chapter `10.20`).

14. Custom firmware and configuration



Any kind of configuration and firmware, which is provided as Intel hex file, can be programmed on the radio module at Würth Elektronik eiSos production sites.

In case of interest, please contact your Business Development Manager (BDM) or *WCS@we-online.com*.

14.1. Custom configuration of standard firmware

The configuration of the standard firmware includes adoption of the non-volatile settings to customer requirements and creating a customized product based on 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.

14.2. 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^2C 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 as 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.

14.3. 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 an Intel hex file) will be implemented into the module's production process at our production sites.

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.



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

15. 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.

15.1. 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.



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, WiFi, etc.) communication interface of the module to allow updating the product's firmware. Details are described in the next sections.

15.2. Update via ACC Software and UART

Only the *UTDX*, *URXD* and *GND* signals are needed for this connection. A suitable adapter/-converter is required for a PC connection (e.g. the FTDI TTL-323R-3V3 UART to USB converter).



None of the module pins are 5 V TTL compatible. Applying overvoltage to any pin may damage the hardware permanently. Ensure your levels are in the range of the electrical specification as shown in chapter 4



Users must make sure that their host is not accessing the Telesto-II RX line (i.e. pulling it HIGH or LOW) as that will prevent ACC to access the module.

As long as our standard firmware is running on the module, it can be updated with the PC utility "ACC" via the serial interface. If the module is not directly connected to a PC, then at least the UART should be made accessible, e.g. by means of a suitable connector.
ACC can be downloaded from the Würth Elektronik eiSos homepage: *ACC*.

16. Firmware history

Version 1.0.0 "Production"

- First product release.

Version 1.1.0 "Production"

- Improved channel detection method for frequency hopping.

Version 1.2.0 "Production"

- Applied port 24 erratum

Version 1.3.0 "Production"

- Optimized sleep mode, when *TRX_DIS* pin is pulled high

17. Design in guide

17.1. Advice for schematic and layout

For users with less RF experience it is advisable to closely copy the relating EV-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.
- 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.
- 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 VDD is not stable or below the minimum operating Voltage.
  - Special care must be taken in case of battery powered systems.
- 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.

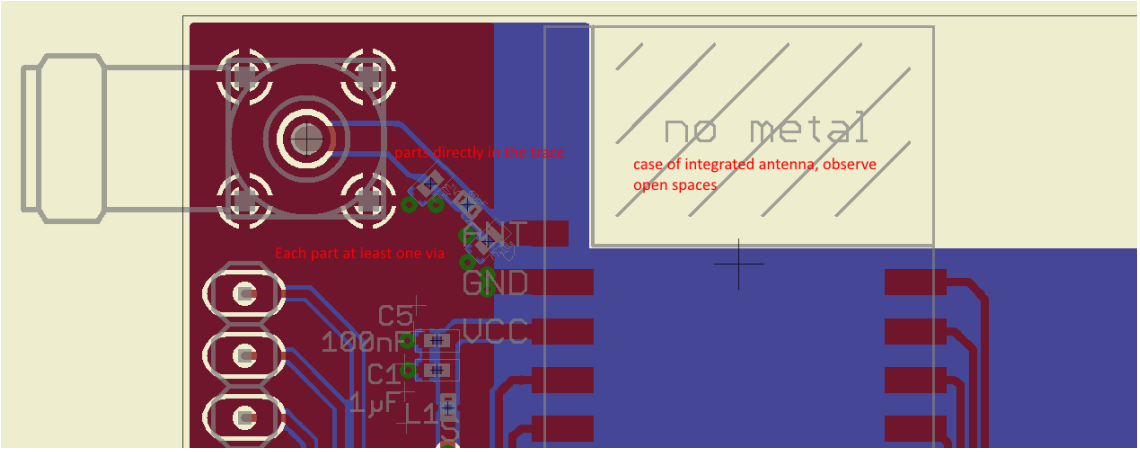


Figure 5: Layout

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

Fixed values cannot be recommended, as these depend on the circumstances of the application (main power source, interferences etc.).

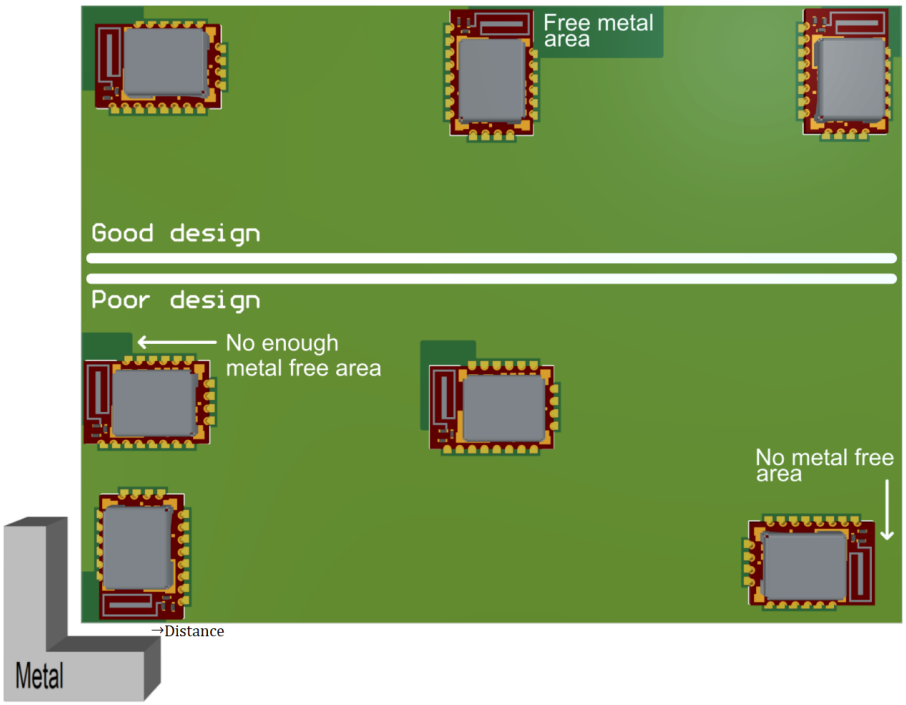


Figure 6: Placement of the module with integrated antenna

17.2. Designing the antenna connection

The antenna should be connected with a 50 Ω line. This is needed to obtain impedance matching to the module and avoids reflections. Here we show as an example how to calculate the dimensions of a 50 Ω line in form of a micro strip above ground, as this is easiest to calculate. Other connections like coplanar or strip line are more complicated to calculate but can offer more robustness to EMC. There are free calculation tools available in the internet.

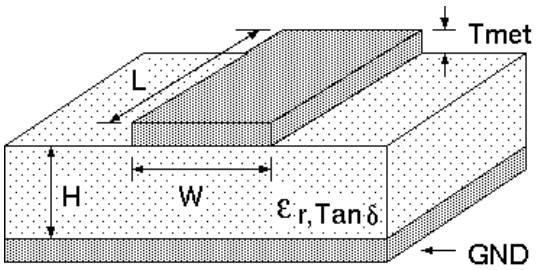


Figure 7: Dimensioning the antenna connection as micro strip

The width W for a micro strip can be calculated using the following equation:

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

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 a 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.

17.3. 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 λ /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 behavior of the antenna, but will anyway produce shadowing.



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

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

17.3.1. Wire antenna

An effective antenna is a λ /4 radiator with a suiting ground plane. The simplest realization is a piece of wire. Its 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 λ/4 radiator has approximately 40 Ω input impedance. Therefore, matching is not required.

17.3.2. 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.

17.3.3. 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 development 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.

17.3.4. Antennas provided by Würth Elektronik eiSos

Besides the radio modules Würth Elektronik eiSos provides various antennas tailored for the different frequency bands. The recommended single external antennas are shown in the subsequent chapters.



In case integrated multilayer chip antennas are needed because of space limitations, please refer to *https://www.we-online.com/en/components/products/WE-MCA*.

17.3.4.1. 2600130086 - Hermippe-III dipole antenna

Well suited for applications where the RF is lead through a metal wall that could serve as ground plane to the antenna.



Figure 8: Hermippe-III dipole antenna

Specification	Value
Frequency range [MHz]	855 – 915
VSWR (free space,without ground plane)	$\leq$ 2.0
Polarisation	Linear
Impedance [Ω]	50±5
Connector	SMA (Male)
Dimensions (L x d) [mm]	50±3 x 7.92±0.2
Weight [g]	4.5
Operating temp. [°C]	-40 – +85

17.3.4.2. 2600130083 - Hydra-I dipole antenna



Figure 9: Hydra-I dipole antenna

Ideally suited for applications where no ground plane is available.

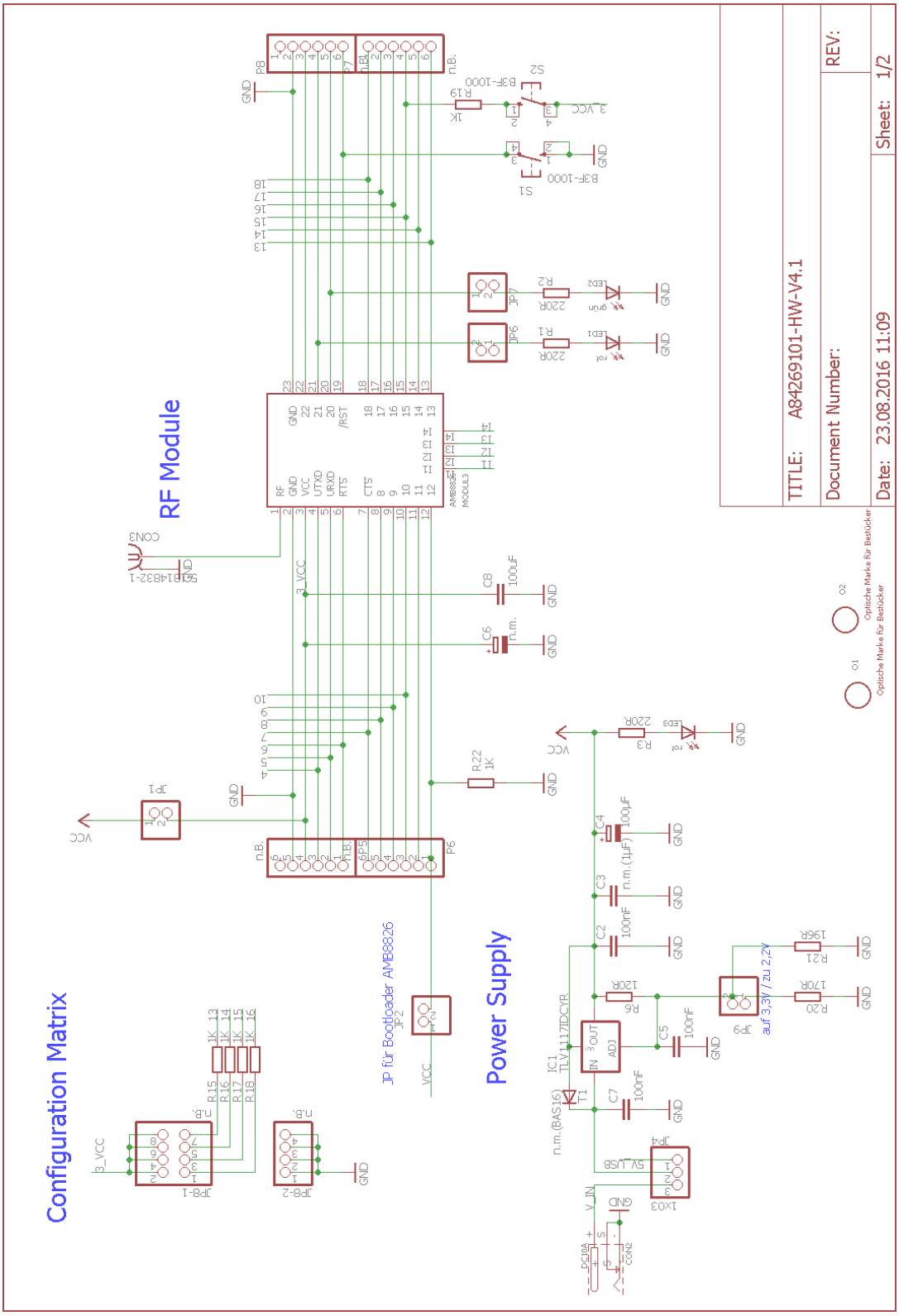
Specification	Value
Center frequency [MHz]	915
Frequency range [MHz]	868 – 928
VSWR	$\leq$ 2.5
Wavelength	λ /4
Impedance [Ω]	50
Connector	SMA (Male)
Dimensions (L x d) [mm]	179 x 10
Peak gain [dBi]	0.9
Operating temp. [℃]	-40 – +80

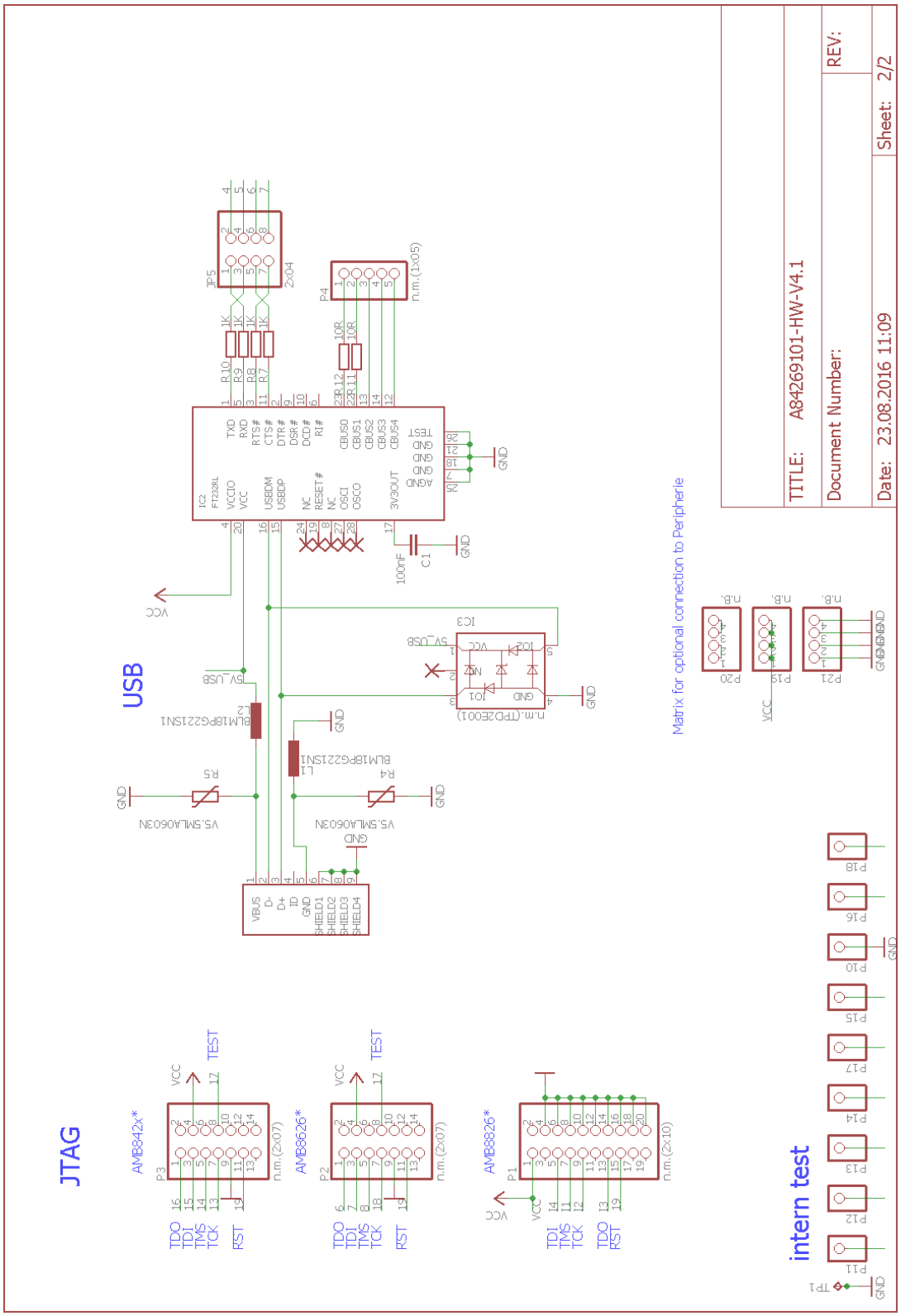
18. Reference design

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

Further information concerning the use of the EV-Board can be found in the manual of the Telesto-II EV-Board.

18.1. Schematic




TITLE: A84269101-HW-V4.1
Document Number:
REV:
Date: 23.08.2016 11:09
Sheet: 2/2
USB
JTAG
intern test
Matrix for optional connection to Peripherie
VCC
GND
TEST
TDO
TDI
TMS
TCK
RST

18.2. Layout

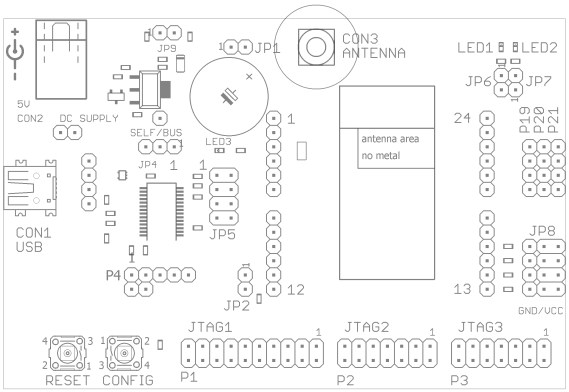


Figure 10: Assembly diagram

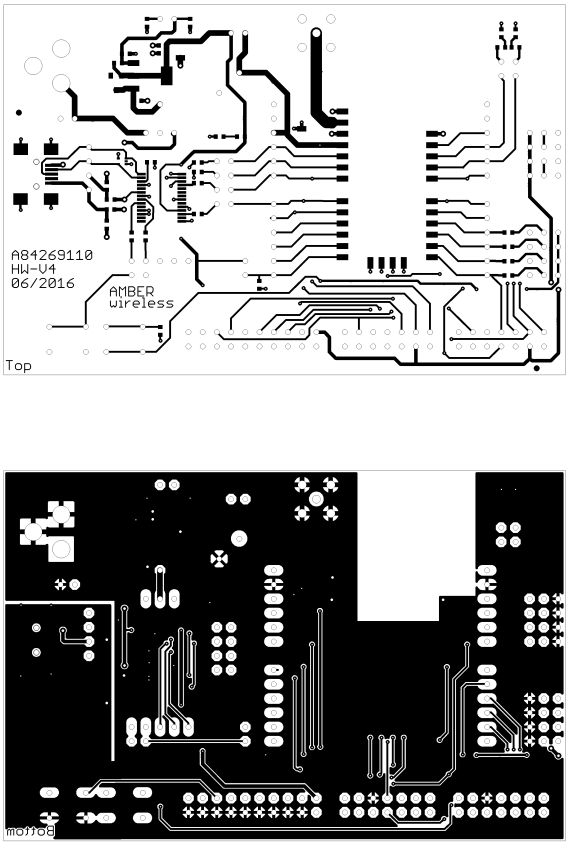


Figure 11: Top and Bottom Layer

19. Manufacturing information

19.1. 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*.

19.2. Soldering

19.2.1. 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 s
Ramp-up rate (T_L to T_P)		3 °C/s max.
Liquidous temperature	T_L	217 °C
Time t_L maintained above T_L	t_L	60 - 150 s
Peak package body temperature	T_P	245 °C
Time within 5 °C of actual peak temperature	t_P	20 - 30 s
Ramp-down rate (T_P to T_L)		6 °C/s max.
Time 20 °C to T_P		8 min max.

Table 16: Classification reflow soldering profile, 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.

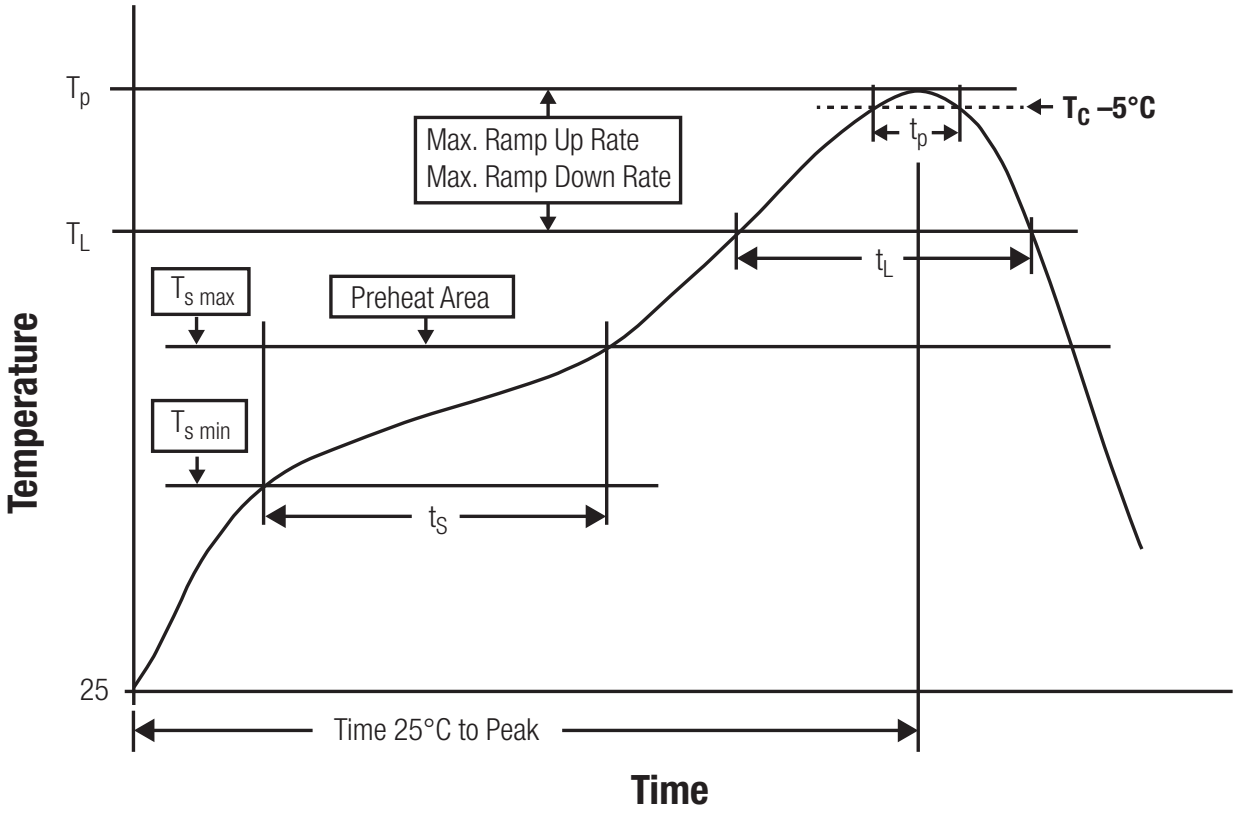


Figure 12: Reflow soldering profile

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

19.2.2. 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.

19.2.3. Potting and coating

- If the product is potted in the customer application, the potting material might shrink or expand during and after hardening. Shrinking could lead to an incomplete seal, allowing contaminants into the component. Expansion could damage components. We recommend a manual inspection after potting to avoid these effects.
- Conformal coating or potting results in loss of warranty.
- The RF shield will not protect the part from low-viscosity coatings and potting. An undefined amount of coating and potting will enter inside the shielding.
- Conformal coating and potting will influence the parts of the radio front end and consequently influence the radio performance.
- Potting will influence the temperature behavior of the device. This might be critical for components with high power.

19.2.4. Other notations

- 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.

19.3. 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 4. 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.

19.4. 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 generate a large amount of heat while transmitting. The manufacturer of the end device must take care of potentially necessary actions for his application.

20. Product testing

20.1. Würth Elektronik eiSos in-house production tests

To achieve a high quality standard, Würth Elektronik eiSos follows a philosophy of supplying fully tested radio modules. At the end of the production process, every unit undergoes an optical inspection. Here the quality of soldering, edge castellation and edge milling is monitored.

If this has been passed, the radio modules are handed over to the automatic test equipment for the electrical characterization. This includes:

- Voltage and current tests to ensure proper electrical performance
- RF characteristics (frequency, spectrum, TX power) measurement and calibration
- Radio communication tests
- Firmware and serial number programming
- Host interface communication tests

The automated testing process is logged for internal quality control. The gained measurement data of each unit is analysed to detect defective parts and investigate the corresponding root cause. Defective radio modules are discarded, in order to guarantee a 100% failure-free delivery to customers.

20.2. EMS production tests

The rigorous in-series production testing ensures that EMS don't need to duplicate firmware tests or measurements. This streamlines the process and eliminates the need for additional testing over analogue and digital interfaces during device production. When it comes to device testing, the ideal focus should be on module assembly quality:

- All module pins are soldered properly on the base PCB
- There are no short circuits
- The mounting process did not damage the module
- The communication between host and radio module is working
- The antenna is connected properly

Simple "Go/No go" tests, like checking the RSSI value, give already a hint if the power supply and antenna have been connected properly.

In addition to such standard testing procedures, radio module integrators have the flexibility to perform additional dedicated tests to thoroughly evaluate the device. Specific tests they can consider are:

- Measure module current consumption in a specified operating state. Deviations from expected results (compared to a "Golden Device") can signal potential issues.

- Perform functional tests, including communication checks with the host controller and verification of interfaces.
- Assess fundamental RF characteristics (modulation accuracy, power levels, spectrum). Verify that the device meets expected performance standards.

21. Physical specifications

21.1. Dimensions

Dimensions
17 x 27 x 3.8 mm

Table 17: Dimensions

21.2. Weight

Weight
3 g

Table 18: Weight

21.3. Module drawing

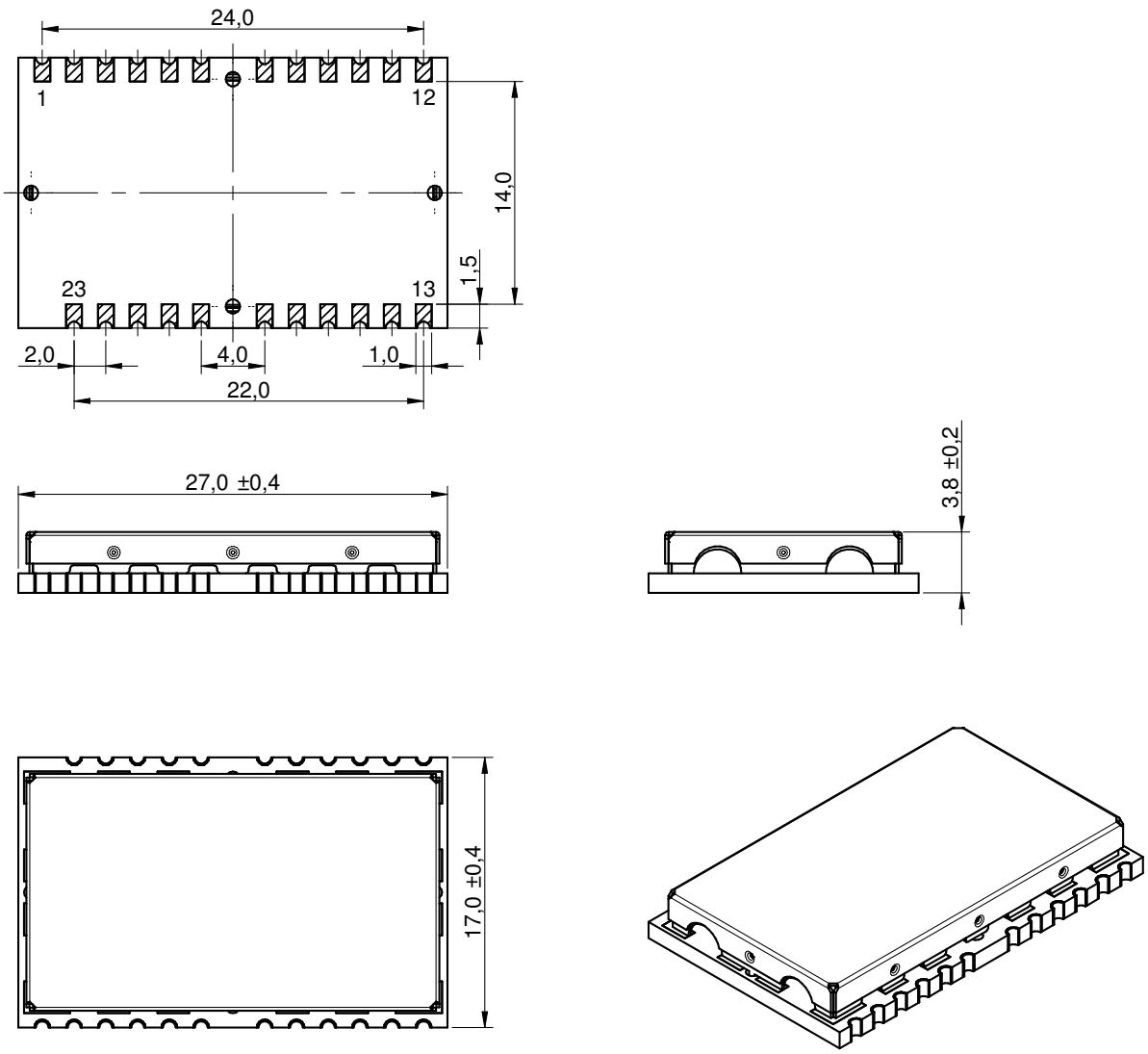


Figure 13: Module dimensions [mm]

21.4. Footprint

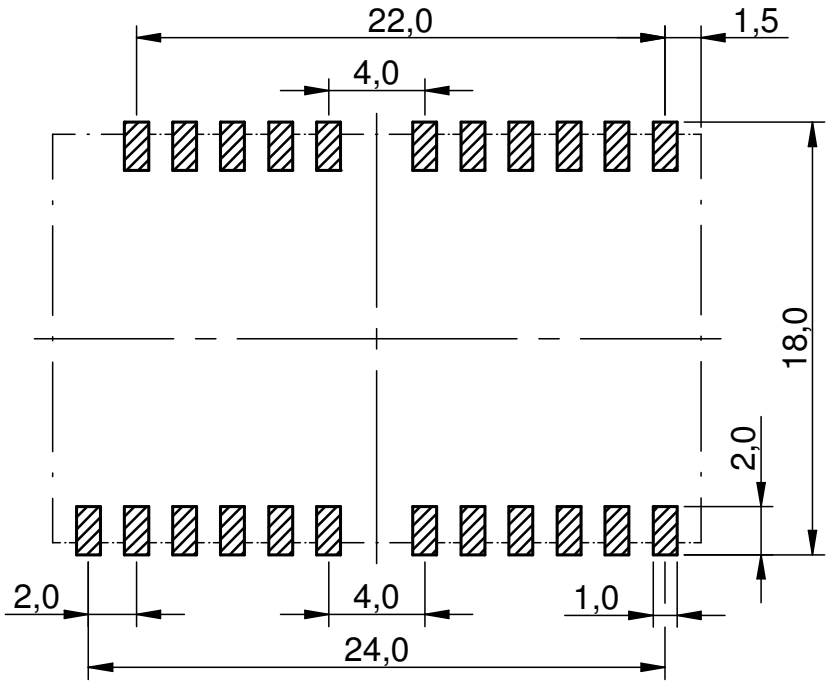


Figure 14: Footprint and dimensions [mm]

To avoid the risk of short circuits between *VCC* and *GND*, a minimum clearance of at least 14 mm between the opposing pad rows has to be maintained!

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

21.5. 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 λ/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.

22. Marking

22.1. 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.

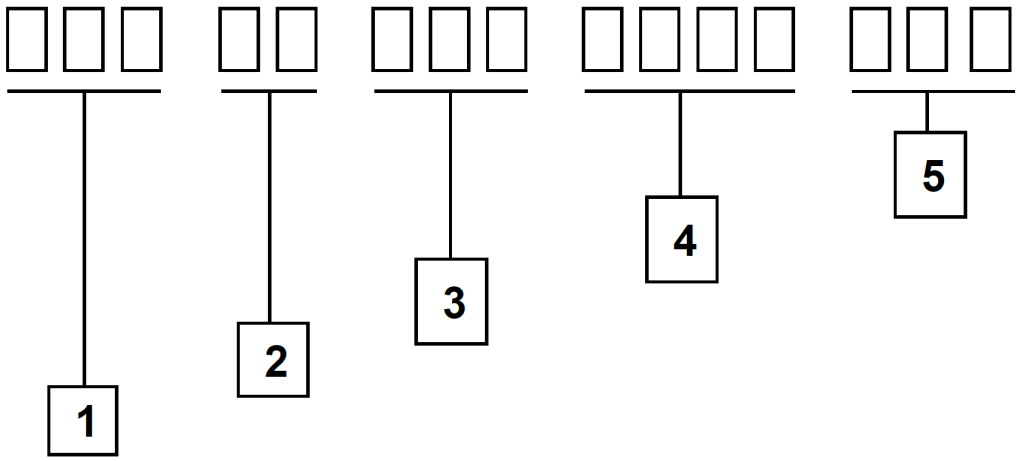


Figure 15: Lot number structure

Block	Information	Example(s)
1	eiSos internal, 3 digits	438
2	eiSos internal, 2 digits	01
3	Radio module 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	Radio module 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. Block 5 is not applicable for products without firmware.

22.2. General labeling information

Labels of Würth Elektronik eiSos radio modules include several fields. Besides the manufacturer identification, the product's *WE* order code, serial number and certification information are placed on the label. In case of small labels, additional certification marks are placed on the label of the reel.
The information on the label are fixed. Only the serial number changes with each entity of the radio module. For Telesto-II the label is as follows:



Figure 16: Label of the Telesto-II

23. 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 14 dBm.
- The total amount of capacitance of all capacitors is 335.9 nF.
- The total amount of inductance of all inductors is 62.5 nH.

24. Regulatory compliance information

24.1. Important notice FCC

The use of RF frequencies is limited by national regulations. The Telesto-II has been designed to comply with the FCC Part 15.
The Telesto-II 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.

24.2. Conformity assessment of the final product

The Telesto-II is a subassembly. It is designed to be embedded into other products (products incorporating the Telesto-II 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 Telesto-II carried out by Würth Elektronik eiSos does not replace the required conformity assessment of the final product.

24.3. 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.

24.4. FCC Compliance Statement (US)

FCC ID: R7TAMB9626

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)
Caution: Changes or modifications for this equipment not expressly approved by Würth Elektronik eiSos may void the FCC authorization to operate this equipment.
Antenna requirements
Caution: The module uses a unique coupling. The use of a permanently attached antenna with an antenna gain below 6 dBi or of an antenna that uses a unique coupling is required.

24.4.1. FCC certificate

telefication

TCB

GRANT OF EQUIPMENT AUTHORIZATION
Certification
Issued Under the Authority of the
Federal Communications Commission
By:

TCB

Telefication B.V.
Edisonstraat 12a
Zevenaar, NL-6902 PK
Netherlands

Date of Grant: 10/18/2017

Application
Dated: 10/17/2017

AMBER Wireless GmbH
Rudi-Schillings-Str. 31
Trier, 54296
Germany

Attention: Oliver Opitz , Manager

NOT TRANSFERABLE

EQUIPMENT AUTHORIZATION is hereby issued to the named GRANTEE, and is VALID ONLY for the equipment identified hereon for use under the Commission's Rules and Regulations listed below.

FCC IDENTIFIER:	R7TAMB9626
Name of Grantee:	AMBER Wireless GmbH
Equipment Class:	**Part 15 Spread Spectrum Transmitter**
Notes:	**AMB9626**
Modular Type:	**Single Modular**

Grant Notes	FCC Rule Parts	Frequency Range (MHZ)	Output Watts	Frequency Tolerance	Emission Designator
	15C	**902.5 - 927.5**	**0.024**		

Modular approval.

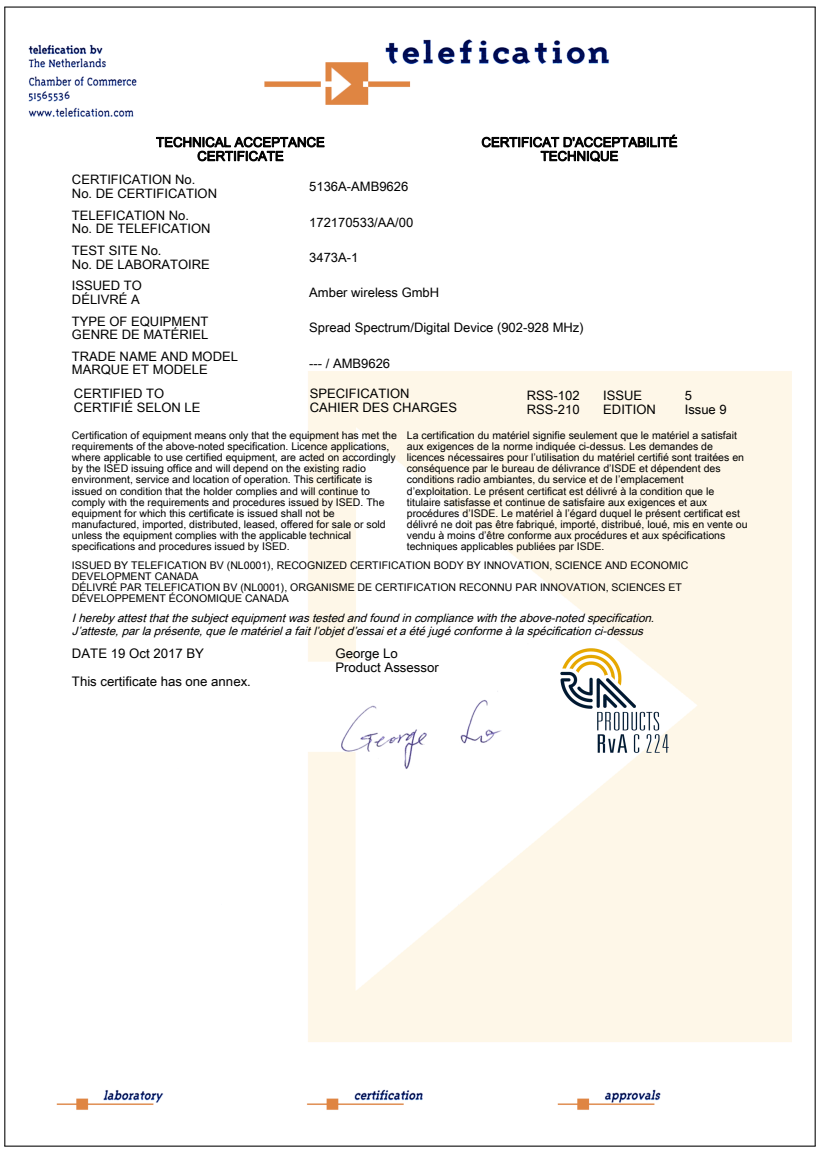
Certificate No.: 172181374/AA/00	George Lo Product Assessor	George Lo

Figure 17: FCC certificate

24.5. IC Compliance Statement (Canada)

Certification Number: 5136A-AMB9626
HVIN: AMB9626
This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(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.
Lémetteur/r'ecepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique 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.

24.5.1. IC certificate



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The Netherlands
Chamber of Commerce
51565536
www.telefication.com

telefication

TECHNICAL ACCEPTANCE CERTIFICATE | **CERTIFICAT D'ACCEPTABILITÉ TECHNIQUE**

CERTIFICATION No. No. DE CERTIFICATION	5136A-AMB9626
TELEFICATION No. No. DE TELEFICATION	172170533/AA/00
TEST SITE No. No. DE LABORATOIRE	3473A-1
ISSUED TO DÉLIVRÉ A	Amber wireless GmbH
TYPE OF EQUIPMENT GENRE DE MATÉRIEL	Spread Spectrum/Digital Device (902-928 MHz)
TRADE NAME AND MODEL MARQUE ET MODELE	--- / AMB9626
CERTIFIED TO CERTIFIÉ SELON LE	SPECIFICATION CAHIER DES CHARGES RSS-102 ISSUE 5 RSS-210 EDITION Issue 9

Certification of equipment means only that the equipment has met the requirements of the above-noted specification. Licence applications, where applicable to use certified equipment, are acted on accordingly by the ISED issuing office and will depend on the existing radio environment, service and location of operation. This certificate is issued on condition that the holder complies and will continue to comply with the requirements and procedures issued by ISED. The equipment for which this certificate is issued shall not be manufactured, imported, distributed, leased, offered for sale or sold unless the equipment complies with the applicable technical specifications and procedures issued by ISED.

La certification du matériel signifie seulement que le matériel a satisfait aux exigences de la norme indiquée ci-dessus. Les demandes de licences nécessaires pour l'utilisation du matériel certifié sont traitées en conséquence par le bureau de délivrance d'ISDE et dépendent des conditions radio ambiantes, du service et de l'emplacement d'exploitation. Le présent certificat est délivré à la condition que le titulaire satisfasse et continue de satisfaire aux exigences et aux procédures d'ISDE. Le matériel à l'égard duquel le présent certificat est délivré ne doit pas être fabriqué, importé, distribué, loué, mis en vente ou vendu à moins d'être conforme aux procédures et aux spécifications techniques applicables publiées par ISDE.

ISSUED BY TELEFICATION BV (NL0001), RECOGNIZED CERTIFICATION BODY BY INNOVATION, SCIENCE AND ECONOMIC DEVELOPMENT CANADA
DÉLIVRÉ PAR TELEFICATION BV (NL0001), ORGANISME DE CERTIFICATION RECONNU PAR INNOVATION, SCIENCES ET DÉVELOPPEMENT ÉCONOMIQUE CANADA

I hereby attest that the subject equipment was tested and found in compliance with the above-noted specification.
J'atteste, par la présente, que le matériel a fait l'objet d'essai et a été jugé conforme à la spécification ci-dessus

DATE 19 Oct 2017 BY

George Lo
Product Assessor

This certificate has one annex.

PRODUCTS
RvA C 224

laboratory certification approvals

Figure 18: IC certificate

24.6. 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.
- A label must be affixed to the outside of the host product with the following statements:
  This device contains FCC ID: R7TAMB9626
  This equipment contains equipment certified under IC ID: 5136A-AMB9626
- 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: R7TAMB9626
  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 module must be used with only the following approved antenna(s).

25. Important notes

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

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.

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 source code 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.

Best care and attention
Any product-specific data sheets, manuals, application notes, PCNs, warnings and cautions must be strictly observed in the most recent versions and matching to the products revisions. These documents can be downloaded from the product specific sections on the wireless connectivity and sensors homepage.

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 Business Development Engineer (BDM) or the internal sales person in charge should be contacted who will be happy to support in this matter.

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 Business Development Engineer (BDM), the internal sales person or the technical support team in charge should be contacted. The basic responsibility of the customer as per section "General customer responsibility" and "Customer responsibility related to specific, in particular safety-relevant applications" remains unaffected.
All software like ¨wireless connectivity SDK¨, ¨Sensor SDK¨ or other source codes as well as all PC software tools are not subject to the Product Change Notification information process.

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 Business Development Engineer (BDM) 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.

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General terms and conditions
Unless otherwise agreed in individual contracts, all orders are subject to the current version of the "General Terms and Conditions of Würth Elektronik eiSos Group", last version available at *www.we-online.com*.

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27. License terms

These License terms will take effect upon the purchase and usage of the Würth Elektronik eiSos GmbH & Co. KG wireless connectivity products. You hereby agree that these license terms are applicable to the product and the incorporated software, firmware and source codes (collectively, "Software") made available by Würth Elektronik eiSos in any form, including but not limited to binary, executable or source code form. The software included in any Würth Elektronik eiSos wireless connectivity product is purchased to you on the condition that you accept the terms and conditions of these license terms. You agree to comply with all provisions under these license terms.

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Usage and obligations
The responsibility for the applicability and use of the Würth Elektronik eiSos wireless connectivity product with the incorporated firmware in a particular customer design is always solely within the authority of the customer. Due to this fact, it is up to you to evaluate and investigate, where appropriate, and to decide whether the device with the specific product characteristics described in the product specification is valid and suitable for your respective application or not.
You are responsible for using the Würth Elektronik eiSos wireless connectivity product with the incorporated firmware in compliance with all applicable product liability and product safety laws. You acknowledge to minimize the risk of loss and harm to individuals and bear the risk for failure leading to personal injury or death due to your usage of the product.
Würth Elektronik eiSos' products with the incorporated firmware are not authorized for use in safety-critical applications, or where a failure of the product is reasonably expected to cause severe personal injury or death. Moreover, Würth Elektronik eiSos' products with the incorporated firmware are neither designed nor intended for use in areas such as military, aerospace, aviation, nuclear control, submarine, transportation (automotive control, train control, ship control), transportation signal, disaster prevention, medical, public information network etc. You shall inform Würth Elektronik eiSos about the intent of such usage before design-in stage. In certain customer applications requiring a very high level of safety and in which the malfunction or failure of an electronic component could endanger human life or health, you must ensure to have all necessary expertise in the safety and regulatory ramifications of your applications. You acknowledge and agree that you are solely responsible for all legal, regulatory and safety-related requirements concerning your products and any use of Würth Elektronik eiSos' products with the incorporated firmware in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by Würth Elektronik eiSos. YOU SHALL INDEMNIFY WÜRTH ELEKTRONIK EISOS AGAINST ANY DAMAGES ARISING OUT OF THE USE OF WÜRTH ELEKTRONIK EISOS' PRODUCTS WITH THE INCORPORATED FIRMWARE IN SUCH SAFETY-CRITICAL APPLICATIONS.

Ownership
The incorporated firmware created by Würth Elektronik eiSos is and will remain the exclusive property of Würth Elektronik eiSos.

Firmware update(s)
You have the opportunity to request the current and actual firmware for a bought wireless connectivity product within the time of warranty. However, Würth Elektronik eiSos has no obligation to update a module's firmware in their production facilities, but can offer this as a service on request. The upload of firmware updates falls within your responsibility, e.g. via ACC or another software for firmware updates. Firmware updates will not be communicated automatically. It is within your responsibility to check the current version of a firmware in the latest version of the product manual on our website. The revision table in the product manual provides all necessary information about firmware updates. There is no right to be provided with binary files, so called "firmware images", those could be flashed through JTAG, SWD, Spi-Bi-Wire, SPI or similar interfaces.

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Applicable law to these license terms shall be the laws of the Federal Republic of Germany. Any dispute, claim or controversy arising out of or relating to these license terms shall be resolved and finally settled by the court competent for the location of Würth Elektronik eiSos registered office.

Severability clause
If a provision of these license terms is or becomes invalid, unenforceable or null and void, this shall not affect the remaining provisions of the terms. The parties shall replace any such provisions with new valid provisions that most closely approximate the purpose of the terms.

Miscellaneous
Würth Elektronik eiSos reserves the right at any time to change these terms at its own discretion. It is your responsibility to check at Würth Elektronik eiSos homepage for any updates. Your continued usage of the products will be deemed as the acceptance of the change.
We recommend you to be updated about the status of new firmware and software, which is available on our website or in our data sheet and manual, and to implement new software in your device where appropriate.
By ordering a product, you accept these license terms in all terms.

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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 code 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 (*https://github.com/WurthElektronik/WirelessConnectivity-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(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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