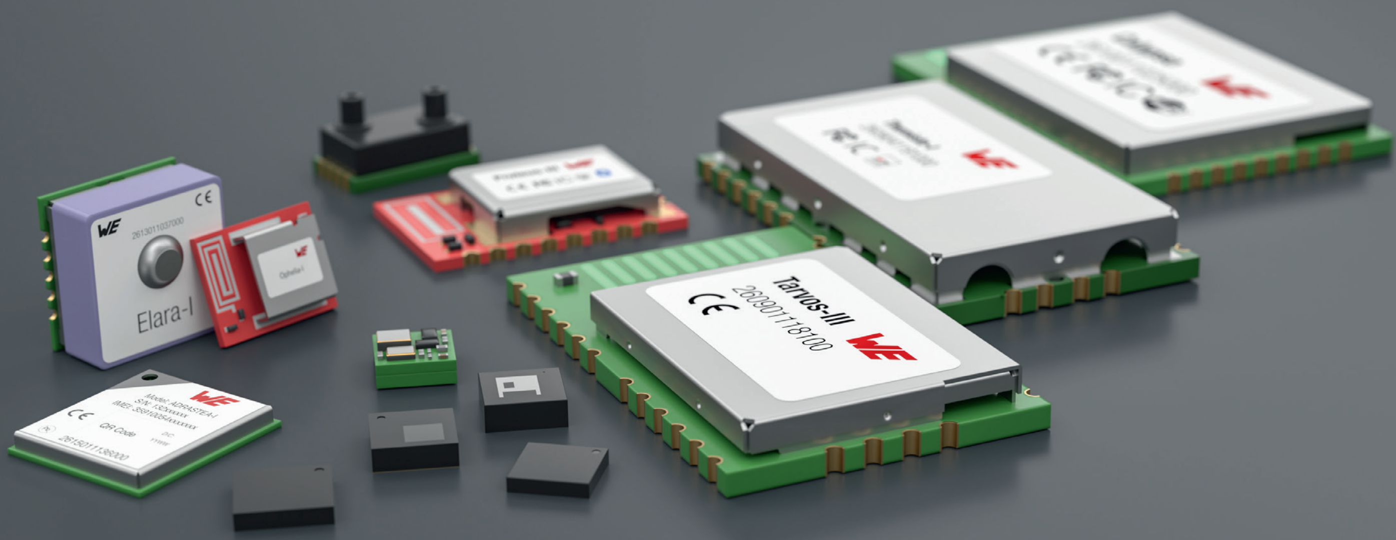


User manual

Olis-e

2609051182000

Version 1.0

June 17, 2025

WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

Revision history

Manual version	HW version	Notes	Date
1.0	2.2	• Initial release	June, 2025

Abbreviations

Abbreviation	Name	Description
BDM	Business Development Engineer	Support and sales contact person responsible for limited sales area
BYOF	Build Your Own Firmware	Product variant not containing firmware
DC	Duty cycle	Transmission time in relation of one hour. 1% means, channel is occupied for 36 seconds per hour.
GPIO	General Purpose Input Output	
0xhh [HEX]	Hexadecimal	All numbers beginning with 0x are stated as hexadecimal numbers. All other numbers are decimal.
HIGH	High signal level	
IDE	Integrated Development Environment	
LOW	Low signal level	
MCU	Micocontroller Unit	
RF	Radio frequency	Describes everything relating to the wireless transmission.
RTC	Real Time Clock	
RX	Receive	
SPI	Serial Peripheral Interface	Communication interface
TX	Transmit	
UART	Universal Asynchronous Receiver Transmitter	Communication interface
VDD	Supply voltage	

Contents

Overview of helpful application notes

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 ANR031 - Certification of custom modules

http://www.we-online.com/ANR031
This application note explains how certifications of a standard product can be used to gain the certification of a customized product. This is done for firmware, which has been adapted by Würth Elektronik eiSos, as well as for firmware written by customer.

1. Introduction

Olis-e is a low-power long-range radio module for wireless communication between devices such as control systems, remote controls, sensors etc.

To meet the specific needs and requirements of various applications, custom firmware can be developed using the Olis-e hardware. Since Olis-e is built on the CC1310 micro controller [1] from Texas Instruments (TI), users can leverage available tools, documentation, and software examples from TI.

For radio communication, Olis-e supports 6LoWPAN, IEEE 802.15.4, MIOTY, Wireless M-Bus and proprietary radio.
Combining RF with further requirements or devices, like sensors, directly on the Olis-e, eliminates the need for an additional host.

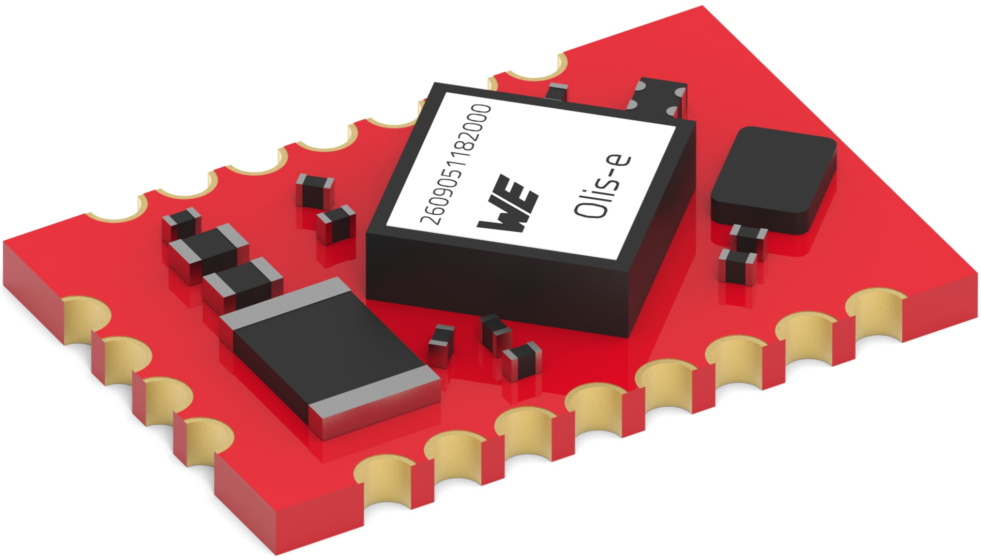


Figure 1: Olis-e

1.1. Block diagram

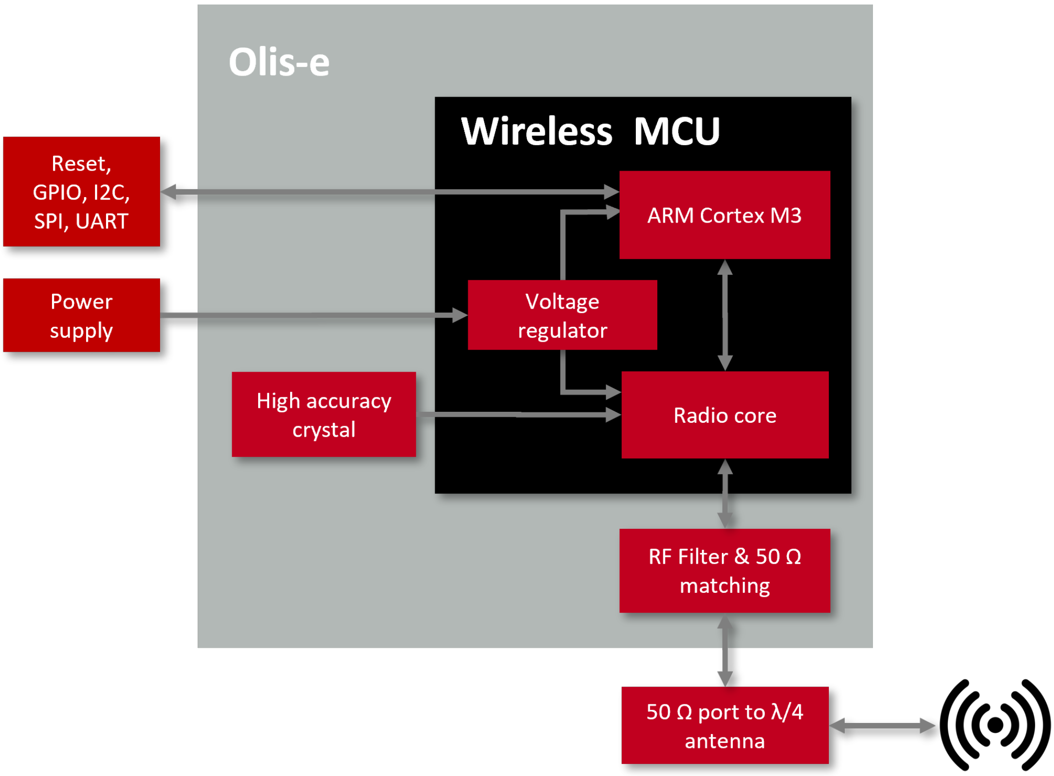


Figure 2: Block diagram

1.2. Ordering information

WE order code	Description
2609051182000	Olis-e radio module 868 MHz, T&R packaging
2609059282001	EV kit with Olis-e radio module

Table 1: Ordering information

2. Electrical specifications

Unless otherwise stated, measurements were taken on the EV-Board "Metis-e-EV" with T = 25 ℃, VDDS = 3 V and internal DC-DC converter active. Any radio transmission in the standard firmware uses boost mode independent of the chosen output power.

Some of the electrical parameters like output power or current consumption are a result of the used hardware and firmware. As the Olis-e shares the same hardware platform as the Metis-e module these values have been verified on the Metis-e-EV. Proper implementation of firmware is needed to get the same values.

2.1. Operating conditions

Description	Min.	Typ.	Max.	Unit
Ambient temperature	-40	25	85	℃
Supply voltage (VDDS)	2.2[1]	3.0	3.8	V
Rising supply voltage slew rate	0		100	mV/µs
Falling supply voltage slew rate	0		20	mV/µs
Falling supply voltage slew rate, with low power flash settings			3	mV/µs

Table 2: Operating conditions

2.2. Absolute maximum ratings

Description	Min.	Typ.	Max.	Unit
Supply voltage (VDDS)	-0.3		4.1	V
Voltage on any digital pin	-0.3		VDDS + 0.3, max 4.1	V
Input RF level			10	dBm
Output RF level, with boost mode		14		dBm

Table 3: Absolute maximum ratings

[1] When the whole temperature range is used, a minimum voltage of 2.4 V is recommended.

2.3. Power consumption

As a DC/DC voltage regulator is integrated, the current consumption strongly depends on the supplied voltage level.

Supply Voltage	Current Consumption
3.8 V	26 mA
3.6 V	28 mA
2.2 V	44 mA

Table 4: Power consumption TX 14 dBm at different supply voltages

The transmit and receive currents depend on the impedance matching. Especially the transmit current varies depending on antenna selection and matching.

Load Impedance	Current Consumption
Open	38 mA
50 Ω	28 mA
0 Ω	18 mA

Table 5: Power consumption TX 14 dBm, 3.6 V at loads with different impedances

The indicated values are the complete current consumption for radio and active MCU. Not to be confused with only radio or only CPU core currents, as sometimes stated by others.

STOP

A stable power supply is indispensable to ensure valid operating conditions for the module.

2.3.1. Static

The current consumption is the sum of the CPU current and radio TX or RX current in active modes.

Description	Typ.	Unit
TX current 14 dBm output power, boost mode	28	mA
RX current	8	mA
Low power (standby) radio off, UART off, RTC running, full RAM retention	1.6	µA
Low power (shutdown) radio off, UART off, RTC off, no RAM retention	0.2	µA

Table 6: Power consumption @3.6 V

2.3.2. Voltage supply dependency

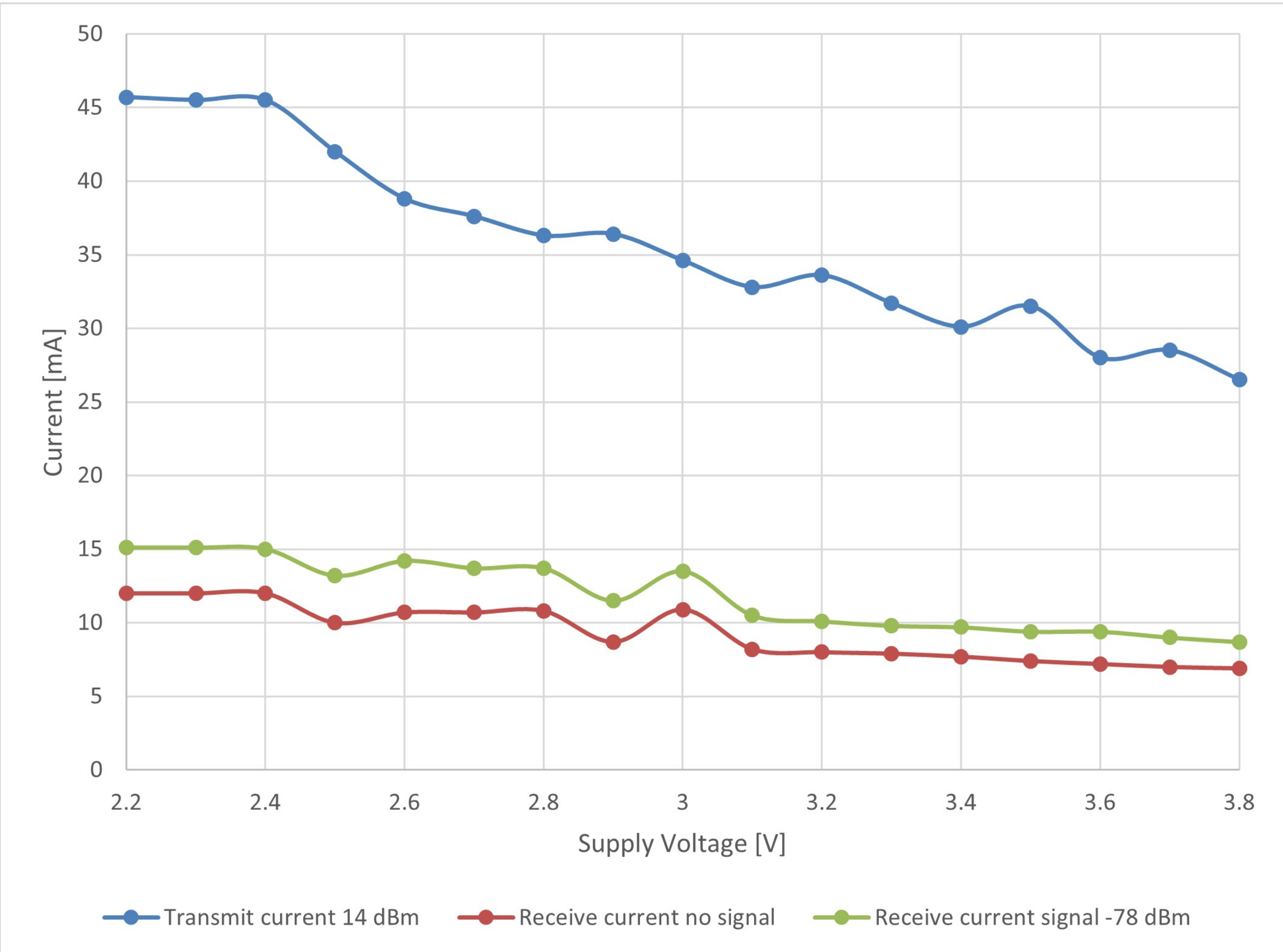


Figure 3: Typical behavior of transmit and receive current in relation to applied supply voltage

2.4. Radio characteristics

Description	Min	Max	Unit
RF frequency	863	870	MHz
RX sensitivity	-117	-105	dBm
TX power	-10	14	dBm

Table 7: Radio characteristics

Due to the miniaturization, including losses on the transition from module to mother PCB, the expected sensitivity is 3 dB below the values stated for the CC1310. Although the chipset can be configured for a broader frequency range, the impedance matching is optimized for the 868 MHz range. Within the specified frequency range and with the radio profiles as used in Metis-e and Tarvos-e, European radio conformity as per RED has been proven to be possible on this hardware platform.

Property	Conditions	Value	Unit
Frequency range		24	MHz
Frequency tolerance	at 25 +/- 3 [℃]	+/- 10	ppm
Frequency stability		15	ppm
Load capacitance		8	pF

Table 8: Crystal specification

Table 8 shows pure crystal specification, not including tolerances of CC1310's load capacitance. Including parasitic capacitance of the PCB we recommend to adapt the load capacitance as described in chapter 4.3.

2.5. Pin characteristics

Property	Value	Unit
Default GPIO maximum current	2	mA
Maximum current of *RX_IND*,*TX_IND*	4	mA
Pull-up current (T = 25 ℃, VDDS = 1.8 V)	71.7	µA
Pull-down current (T = 25 ℃, VDDS = 1.8 V)	21.1	µA
Pull-up current (T = 25 ℃, VDDS = 3.8 V)	277	µA
Pull-down current (T = 25 ℃, VDDS = 3.8 V)	113	µA

Table 9: Pin characteristics

3. Pinout

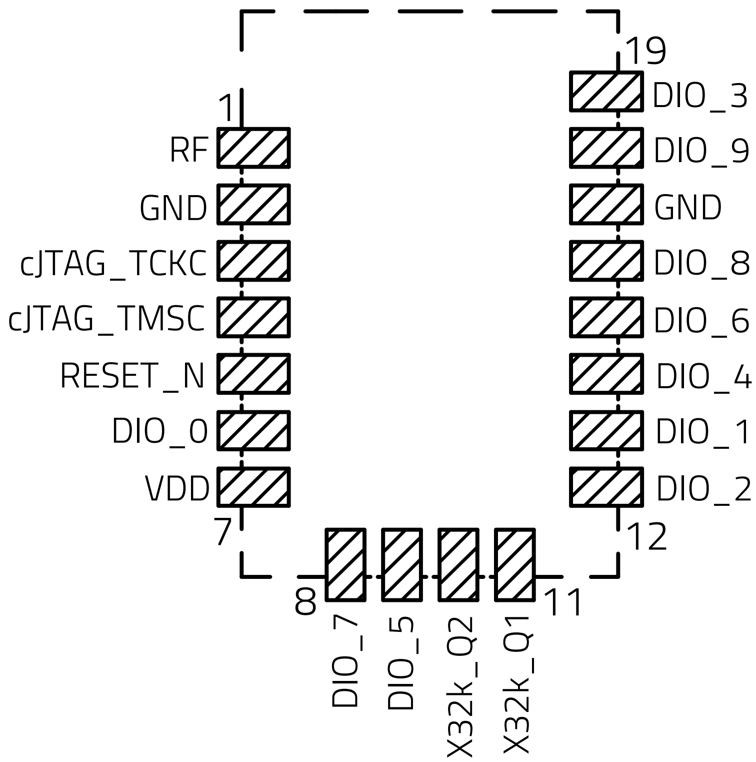


Figure 4: Pinout (top view)

No	Designation	I/O	Description
1	*RF*	I/O	50 Ω radio connection to transceiver
2, 17	*GND*	Supply	Negative supply voltage
3	*cJTAG_TCKC*	I/O	cJTAG interface. Test Clock
4	*cJTAG_TMSC*	I/O	cJTAG interface. Test Serial Data
5	*/RESET*	Input	Apply a rising edge to reset the module. Pin has internal pull-up of 100k Ω. Low level holds module in reset state.
6	*DIO_0*	GPIO	General purpose I/O
7	*VDD*	Supply	Positive supply voltage
8	*DIO_7*	GPIO	General purpose I/O
9	*DIO_5*	GPIO	General purpose I/O
10	*X32k_Q2*	Input	External 32-kHz crystal oscillator pin 1
11	*X32k_Q1*	Input	External 32-kHz crystal oscillator pin 2
12	*DIO_2*	GPIO	General purpose I/O
13	*DIO_1*	GPIO	General purpose I/O
14	*DIO_4*	GPIO	General purpose I/O
15	*DIO_6*	GPIO	General purpose I/O
16	*DIO_8*	GPIO	General purpose I/O
18	*DIO_9*	GPIO	General purpose I/O.
19	*DIO_3*	GPIO	General purpose I/O

Table 10: Pinout

4. Build your own firmware

The BYOF approach is not suited for novice and non-advanced firmware developers. In such a case, consider using one of the standard modules Tarvos-e or Metis-e from our product portfolio.

This chapter describes the steps to run one of the example projects in Code Composer Studio™ on the Olis-e hardware. It can be used as a starting point for a custom application. After the firmware has been developed, Würth Elektronik eiSos offers the service to flash the firmware at our production site. Contact your local contact person or *WCS@we-online.com* for quotes regarding these topics.

4.1. Creating an example project

Download *Code Composer Studio™* and install it.

When started for the first time, the "Get Started" page will appear. Click on "Create a new Project" on the page to start the Project Wizard and create a new project.

Figure 5: Create a new project using the link on the "Get-Started"-page.

Select "CC1310F128" as device.

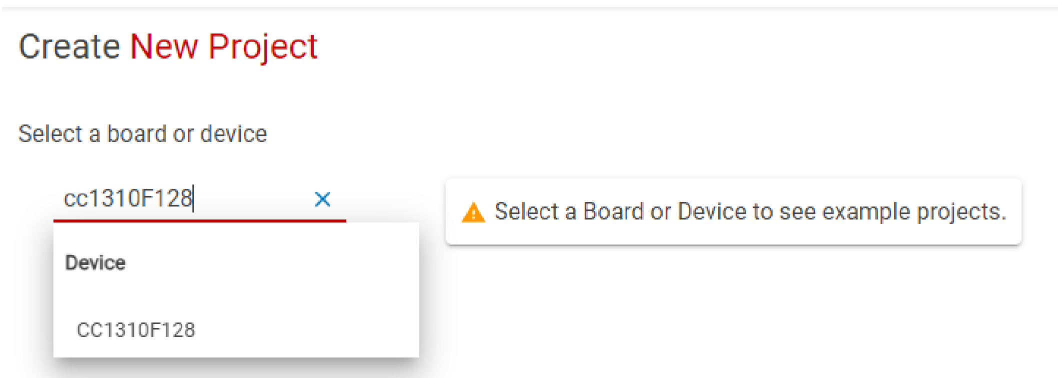


Figure 6: Select CC1310F128 as device.

For this example, the "rfPacketTx" is used with CCS TI compiler and TI-RTOS. Click on "CREATE" to start the import of the project.

Figure 7: Create the project and start the import process.

The IDE checks for requirements and dependencies of the project. Depending on the selected project, further installation of software tools is required. In this case, a prompt will appear asking to download and install. Confirm to proceed.
Once all requirements are met and the project was downloaded, the example project can be imported.

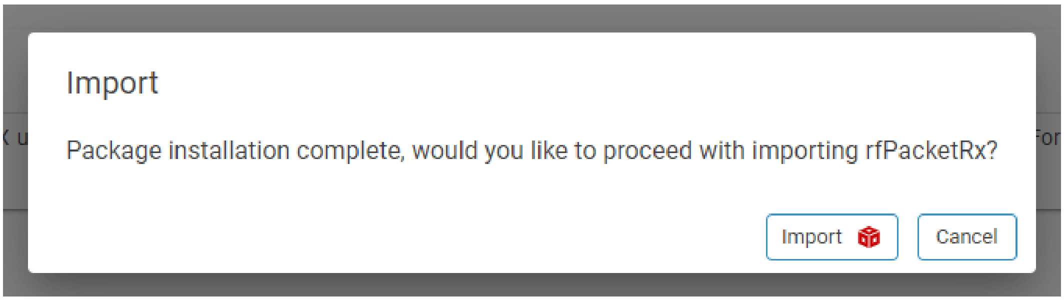


Figure 8: Import the project into the IDE to start developing.

If a compiler was installed in the previous step, it might not be detected correctly. Open the settings via File->Preferences->Code Composer Studio Settings and check if the compiler is listed. If that is not the case, referesh the discovered compilers.
If the compiler is not detected, the build process will fail due to missing compiler.

4.2. Adapt the board file

The board file defines the hardware and allows to encapsulate it from the main application. The "rfPacketTx"-example is configured to be used with the CC1310_LAUNCHXL-board from Texas Instruments. As Olis-e uses the variant with 10 GPIO pins, the example will not work without changes and the hardware specific files have to be adapted.

To adapt the example for Olis-e-EV-Board hardware, perform the following steps:

- Remove the files CC1310_LAUNCHXL.h, CC1310_LAUNCHXL.h and CC1310_LAUNCHXL_fxns.c
- Create the files Olis-e.h and Olis-e.c with content of `Minimal code example`
- Replace the content of board.h as in `Minimal code example`

Olis-e has no external low frequency crystal mounted. Use internal crystal or connect external one. Per default, the internal crystal is selected in the ccfg file. See chapter `4.3` for required and recommended settings.

4.3. Adapt the ccfg file

The ccfg configuration file allows to adapt and configure the MCU and radio of the CC1310-chip. Depending on the application, adaptions can or have to be made to this file. For details and information, refer to the CC1310 datasheet [2].

The following options are recommended for Olis-e.

4.3.1. Crytal selection

Olis-e has no external frequency crystal mounted. By default the option 0x02 (LF XOSC) is selected and therefore the internal 32.768-kHz crystal is used. This is a valid option for Olis-e and can be used in default state.

```
#ifndef SET_CCFG_MODE_CONF_SCLK_LF_OPTION
#define SET_CCFG_MODE_CONF_SCLK_LF_OPTION          0x2       // LF XOSC
#endif
```

4.3.2. Cap-array tuning

The load capacitance delta of -4 shall be applied to adhere to the Olis-e hardware.

```
#ifndef SET_CCFG_MODE_CONF_XOSC_CAP_MOD
#define SET_CCFG_MODE_CONF_XOSC_CAP_MOD            0x0      // Apply cap-array delta
#endif

#ifndef SET_CCFG_MODE_CONF_XOSC_CAPARRAY_DELTA
#define SET_CCFG_MODE_CONF_XOSC_CAPARRAY_DELTA     (int8_t)-4   // Signed 8-bit value, directly
     modifying trimmed XOSC cap-array value
#endif
```

4.4. Radio settings

The radio settings highly affect the certification and declarations of conformity. Regarding certification of custom modules, refer to the application note ANR031 "Certification of custom modules" in chapter `Overview of helpful application notes`.

In the example project, the definition of the radio settings can be found in the "smartrf_settings" folder, containing both the source and header file. Texas Instruments provides *SmartRf™ Studio*, which allows configuration of the settings using the tool and exporting the code for the software project as smartrf_settings.
Radio conformity with settings from SmartRF™ "2.5kbps, SimpleLink Long Range" have been proven and the profile "50 kbps, 2-GFSK, 25 kHz deviation" is comparable to another proven profile. We assume that all for EU proposed profiles in SmartRF™ comply to radio equipment directive.

- The radio settings have a high impact on certification. The user of Olis-e has complete freedom on the firmware and therefor the responsibility for the firmware beeing compliant to CE and RED.
- Due to the impact of the firmware and the hardware integration we recommend a radio compliance spot check (worst case).
- The manufacturer of the end device has per law the sole responsibility of the compliance for the end product.

4.5. Creating a hex file

If a hex file is required, its creation has to be enabled first.
Open the project options (right-click on the project and select "properties") and enable the option under Build->Tools->Arm Hex Utility. Now, the build operation creates a hex file.

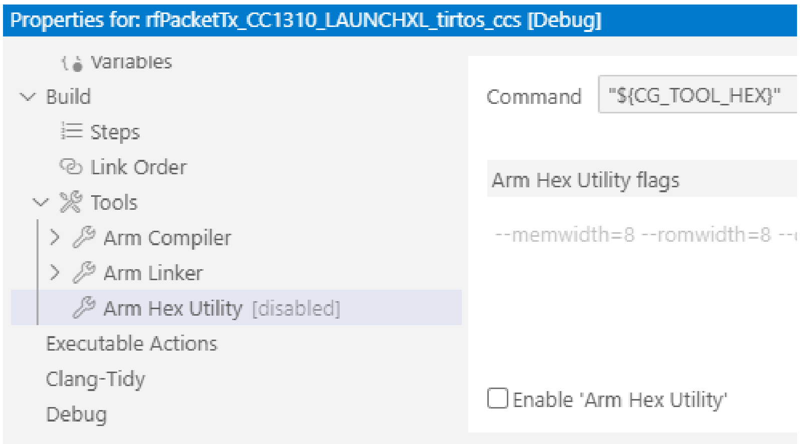


Figure 9: Hex file output is disabled by default. It can be enabled in the build options.

Under General Options, set both "Specify memory width" and "Specify ROM width" to 8.

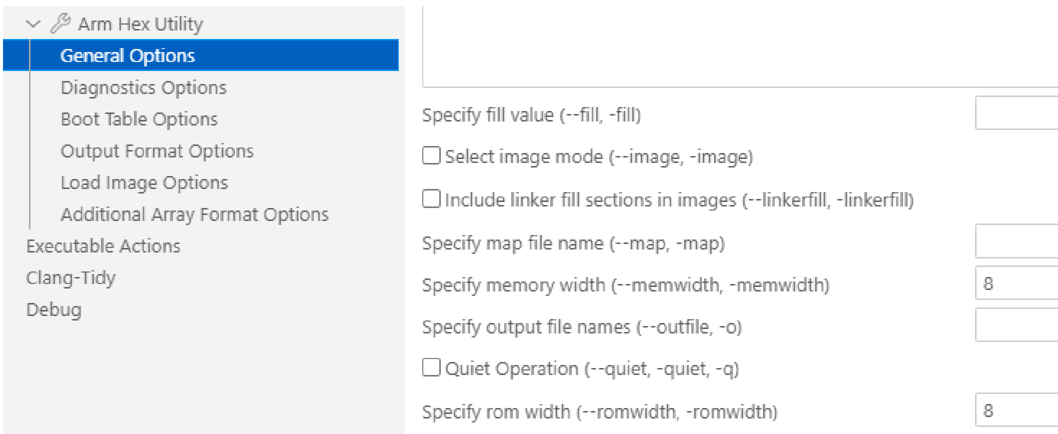


Figure 10: Configure the options to be compatible with Olis-e.

In Output Format Options, select Intel hex in the drop down.

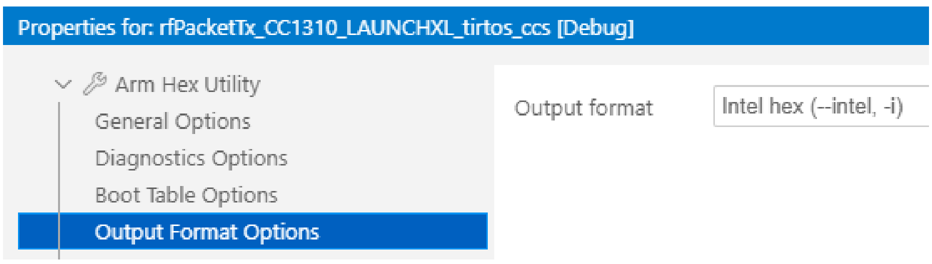


Figure 11: Select the file type of the output. Here, Intel hex is selected as output format.

5. Hardware history

Version 2.2 "Release"

- This is the initial hardware version

6. Design in guide

6.1. 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.

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

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.

- Elements for ESD protection should be placed on all pins that are accessible from the outside and should be placed close to the accessible area. For example, the RF-pin is accessible when using an external antenna and should be protected.
- ESD protection for the antenna connection must be chosen such as to have a minimum effect on the RF signal. For example, a protection diode with low capacitance such as the 8231606A or a 68 nH air-core coil connecting the RF-line to ground give good results.
- Placeholders for optional antenna matching or additional filtering are recommended.
- The antenna path should be kept as short as possible.

> **!** Again, no fixed values can be recommended, as they depend on the influencing circumstances of the application (antenna, interferences etc.).

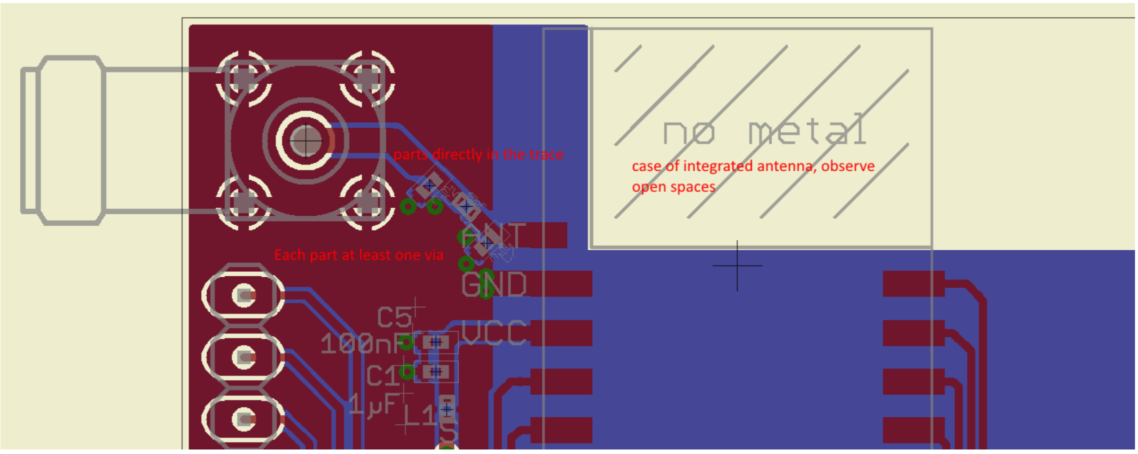


Figure 12: Layout

- To avoid the risk of short circuits and interference there should be no routing underneath the module on the top layer of the baseboard.
- On the second layer, a ground plane is recommended, to provide good grounding and shielding to any following layers and application environment.
- In case of integrated antennas it is required to have areas free from ground. This area should be copied from the 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.

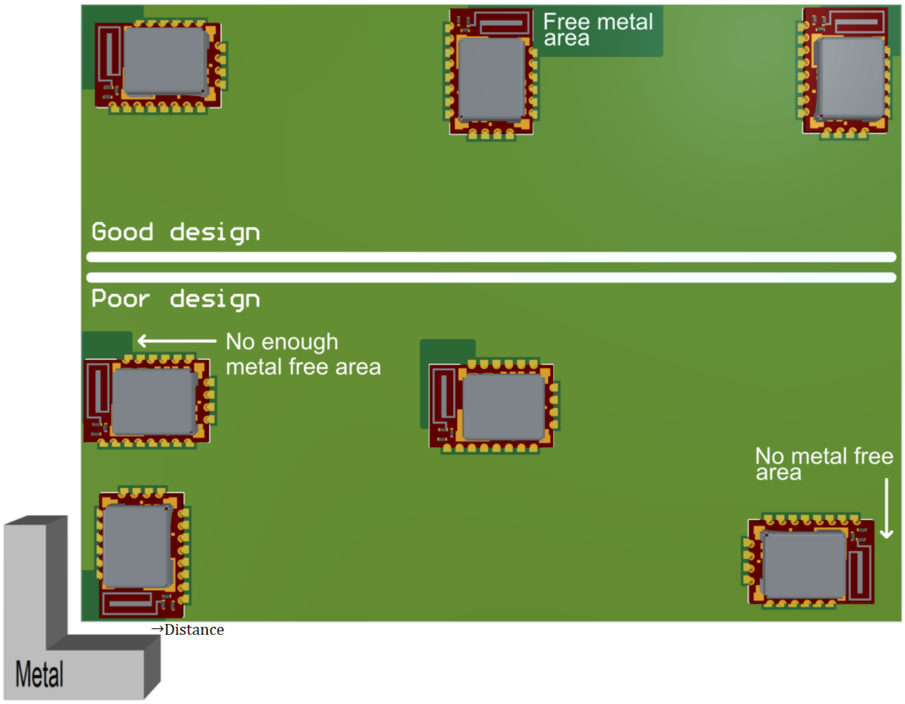


Figure 13: Placement of the module with integrated antenna

6.2. 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.

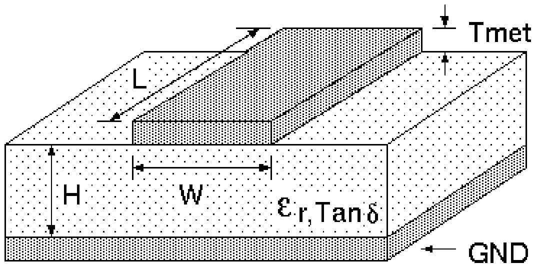


Figure 14: Dimensioning the antenna connection as micro strip

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

$$W = 1.25 \times \left(\frac{5.98 \times H}{e^{\frac{50 \times \sqrt{\epsilon_r + 1.41}}{87}}} - T_{met} \right) \quad (1)$$

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

- As rule of thumb a distance of about 3×W should be observed between the micro strip and other traces / ground.
- The micro strip refers to ground, therefore there has to be the ground plane underneath the trace.
- Keep the feeding line as short as possible.

6.3. 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 electro-magnetic field blocking.

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

6.3.1. Wire antenna

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

6.3.2. 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.

6.3.3. 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 EV 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.

6.3.4. 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*.

6.3.4.1. 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 15: 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

6.3.4.2. 2600130081 - Hyperion-I dipole antenna

Figure 16: Hyperion-I dipole antenna

Ideally suited for applications where no ground plane is available.

Specification	Value
Center frequency [MHz]	868
Frequency range [MHz]	853 – 883
Wavelength	λ /2
VSWR	$\leq$ 2.0
Impedance [Ω]	50
Connector	SMA (Male)
Dimensions (L x d) [mm]	142 x 10
Peak gain [dBi]	-2.3
Operating temp. [℃]	-30 – +80

6.3.4.3. 2600130082 - Hyperion-II magnetic base antenna

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

Figure 17: Hyperion-II magnetic base antenna with 1.5 m antenna cable

The 2600130082 is an antenna in form of $\lambda/4$ and therefore needs a ground plane at the feeding point.

Specification	Value
Frequency range [MHz]	824 – 894
VSWR	$\leq$ 2.0
Polarisation	Vertical
Impedance [Ω]	50±5
Connector	SMA (Male)
Dimensions (L x d) [mm]	89.8 x 27
Weight [g]	50±5
Operating temp. [°C]	-30 – +60

7. Reference design

7.1. Receiver Sensitivity

The module reacts with reduced receiver sensitivity if coupling between radio and *Pin4*, *Test2* occurs. The following points can be used to suppress this coupling:

- 68 pF capacitor on *Pin4*.
- 4-Layer PCB with Signal/GND - GND - Power/GND - Signal/GND layer and routing.
- Ground in between the signal lines properly connected to GND plane.

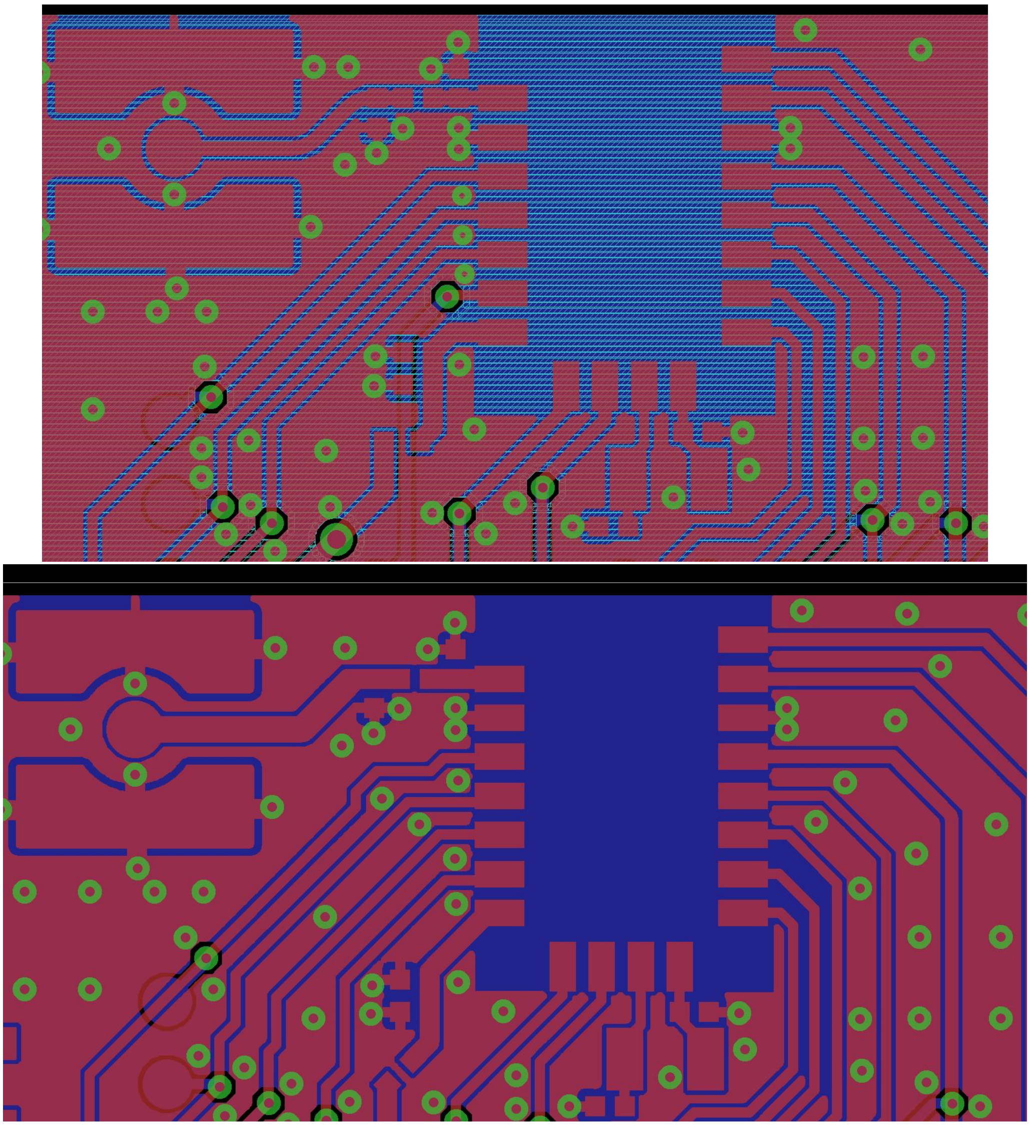


Figure 18: Examples for good decoupling

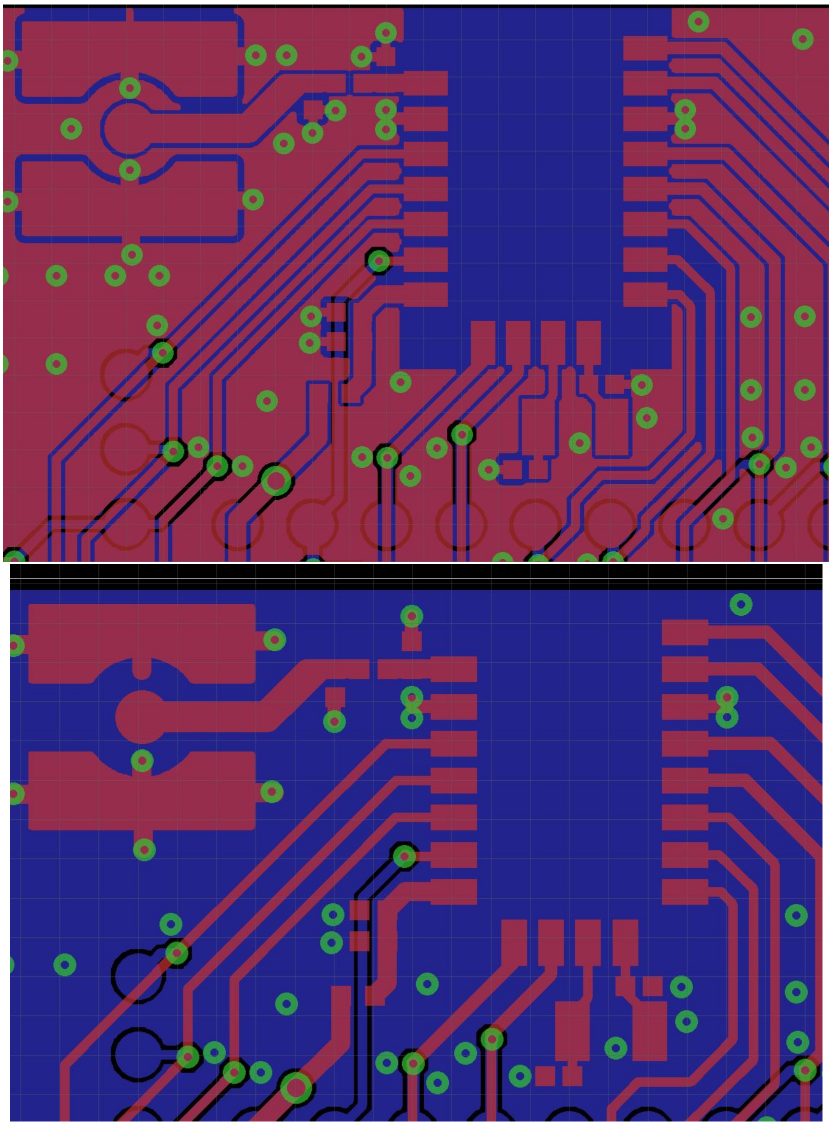
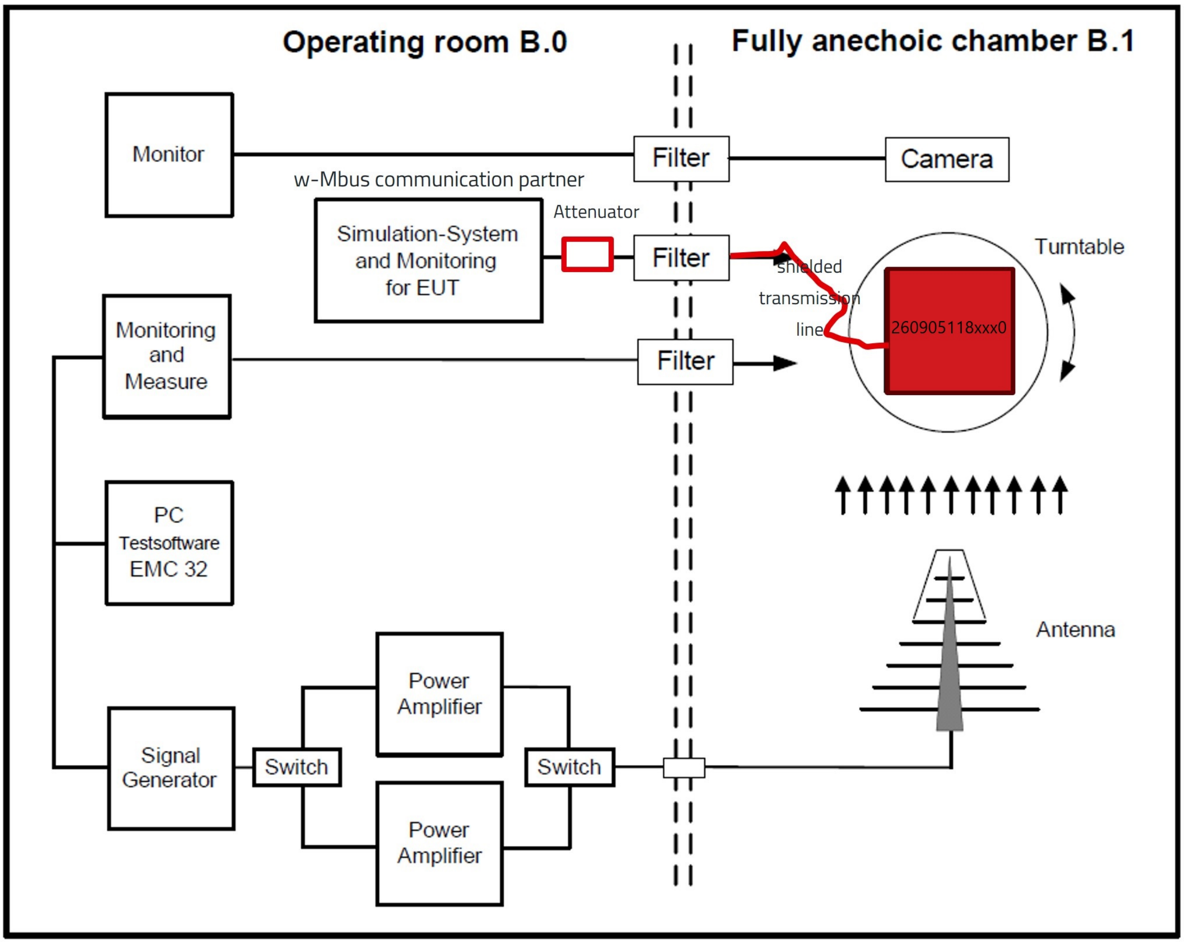


Figure 19: Examples for poor decoupling

7.2. EMC immunity behavior

For a radio device following the "Radio Equipment Directive", the multi-part EMC standard EN 301 489 is applicable, referencing the EMC basic standards of the EN 6100-* series.
Part of the EMC test is the radio immunity. The goal of this test is to verify the device's proper functioning within a radio frequency electromagnetic field, which could be present in any environment.
Everything connected to *PIN1* of Olis-e itself is within the scope of the test for the spectrum aspects. In case of Olis-e, an 868 MHz product, the EN 300 220 is applied for the spectrum aspects.
Therefore the EMC test for the Olis-e, as a stand alone radio module, and according to standard EN 301 489, shall include everything but exclude these spectrum aspects.
In the standard this is described in the specification of the arrangements of test signals:
"For transmitters with an antenna connector, the wanted RF output signal to establish a communication link shall be delivered from the antenna connector to the monitoring equipment (AE) by a shielded transmission line, such as a coaxial cable."



As the Olis-e has no integrated antenna but a connector, the compliance test were performed this way.

Furthermore, tests that are not mandatory have been performed including an attached antenna. Depending on the antenna and its ability to absorb energy of specific frequencies of the RF electromagnetic field, the RSSI value is influenced and loss of packets can occur. The phenomenon of lost packets is observed with both tested antennas, the Hermippe-III and Hyperion-I.
This means that special care has to be taken and if:

- The antenna is integrated and the communication link is not delivered by a shielded transmission line.
- The loss of packets is critical.
- The device is used in an environment where EMC disturbances are most likely present.

The evaluation board includes the reference design for an optional filter path. Using narrow band SAW filters eliminates this phenomenon completely. Tests might be needed to decide whether, filtering is needed or not, as the behavior on an antenna outside the used frequency range is usually not specified.
Table 11 give guidance about the implementation depending on the ability of the antenna to absorb energy of the specific frequencies of the RF electomagnetic field, the requirements on packet errors and the probability of EMC disturbance.

Application and environmental conditions	**Integrated** narrow band **antenna**	**Integrated** wide band **antenna**	Radio **connector**
Packet loss uncritical (PER < 10 %) Or High risk of EMC disturbance	SAW filter small likely needed	SAW filter likely needed	SAW filter small likely needed Hermippe-III suitable
Packet loss critical (PER > 10 %) Or Low risk of EMC disturbance	SAW filter unlikely needed	SAW filter small likely needed	SAW filter unlikely needed Hermippe-III or Hyperion-I suitable

Table 11: Implementation

For the EMC test the acceptable PER (packet error rate) for the end device has to be defined

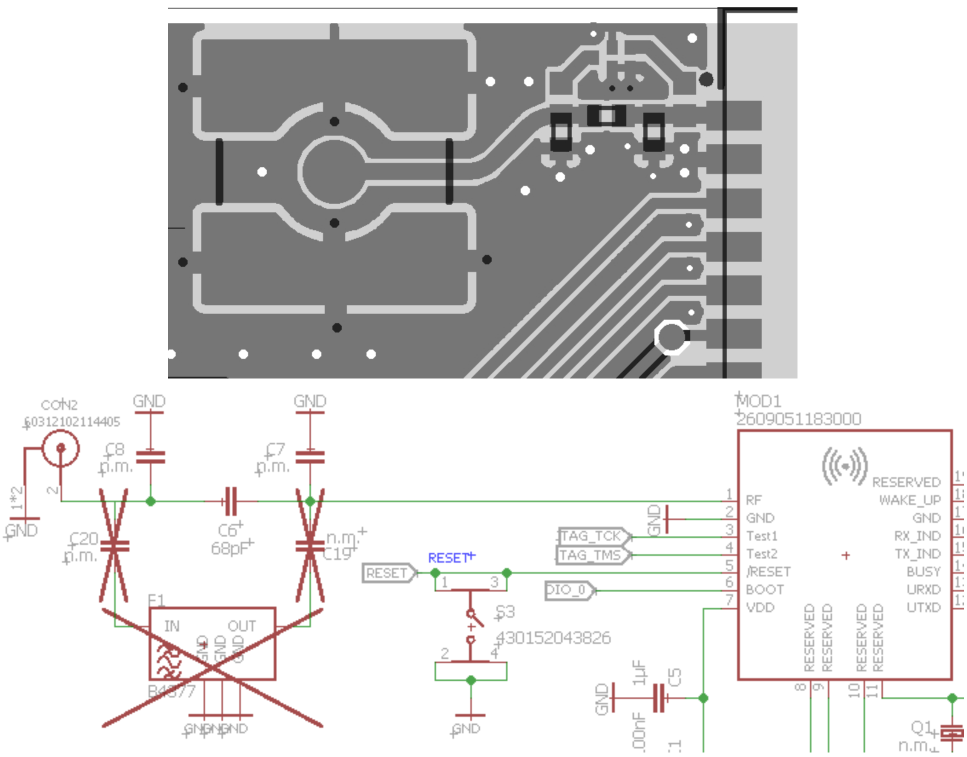


Figure 20: Example without filter

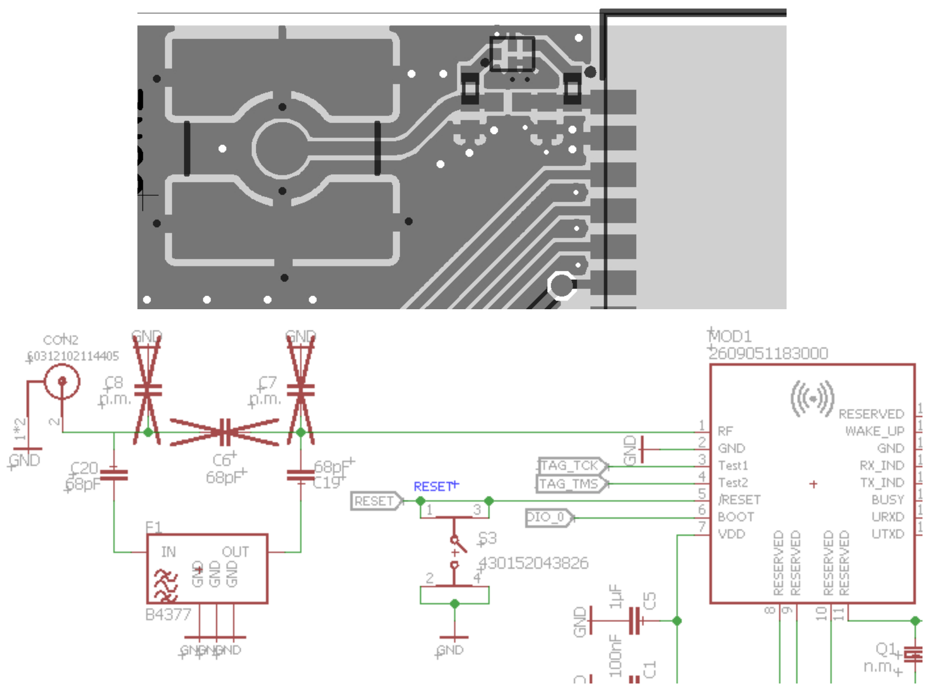
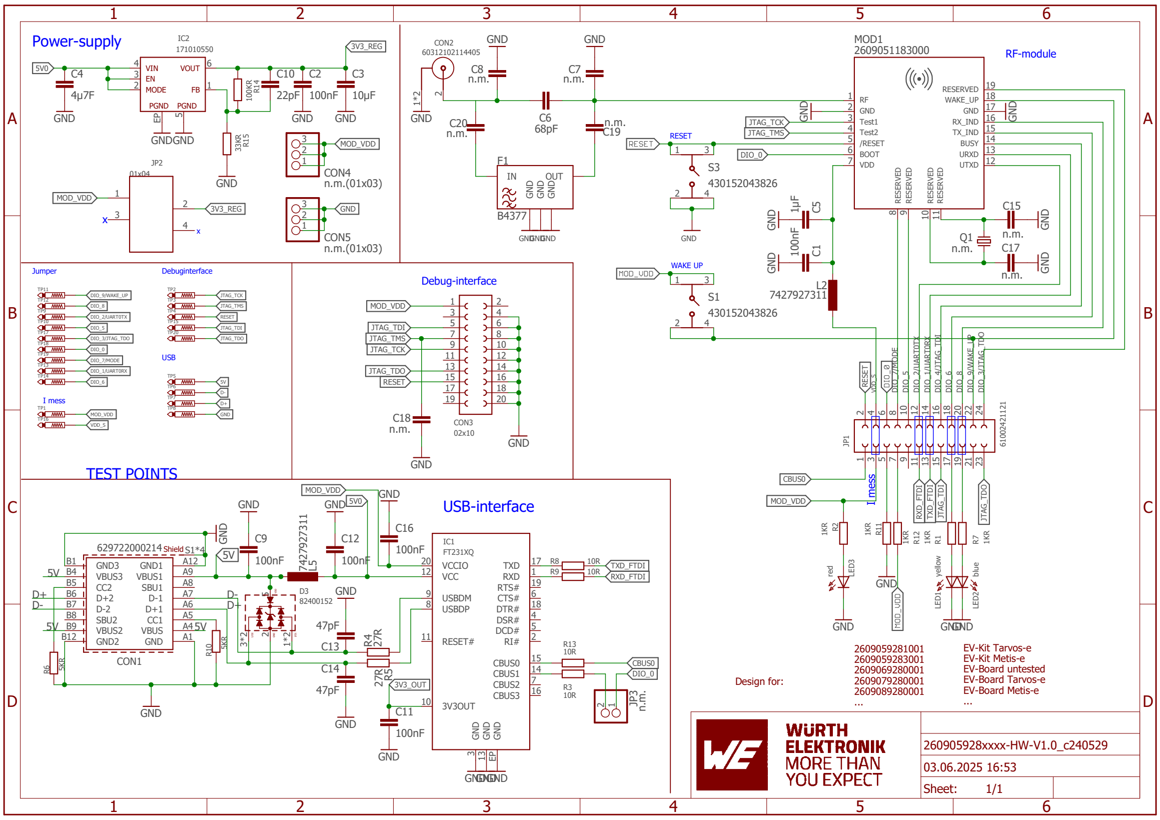


Figure 21: Example with filter

7.3. Schematic



7.4. Layout

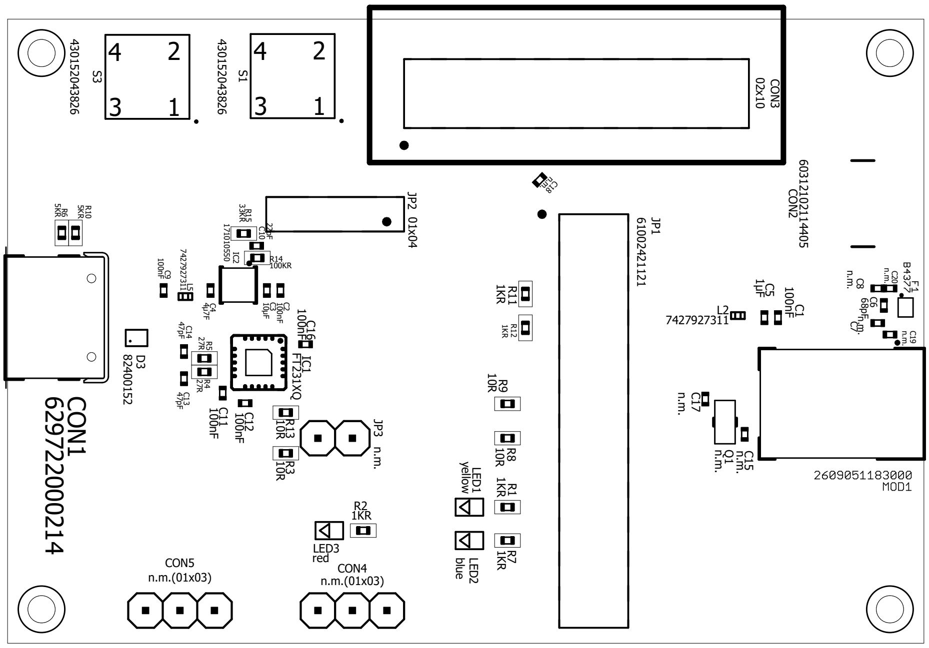


Figure 22: Assembly diagram

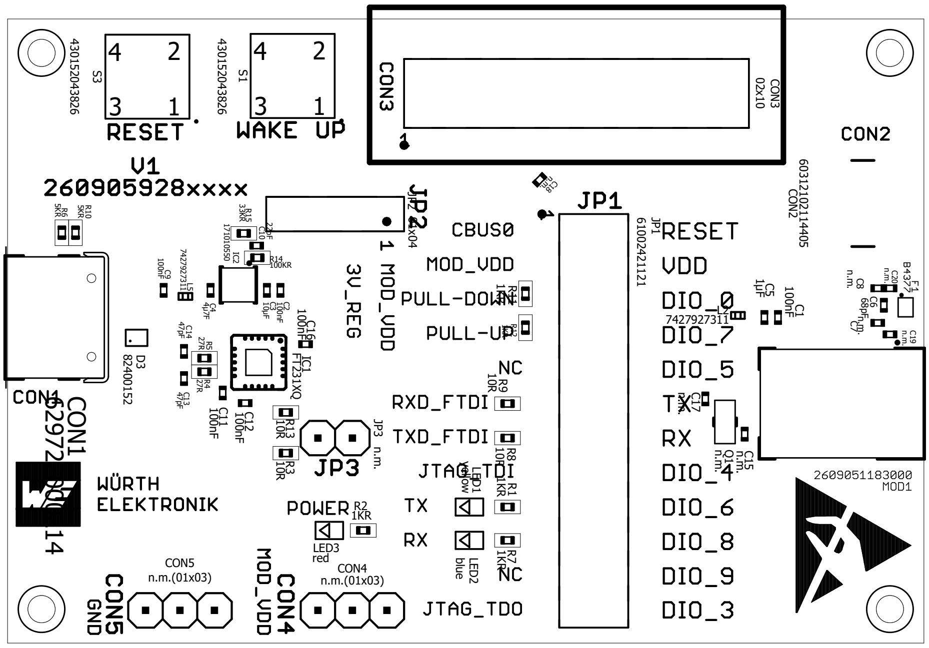


Figure 23: Silkscreen and assembly

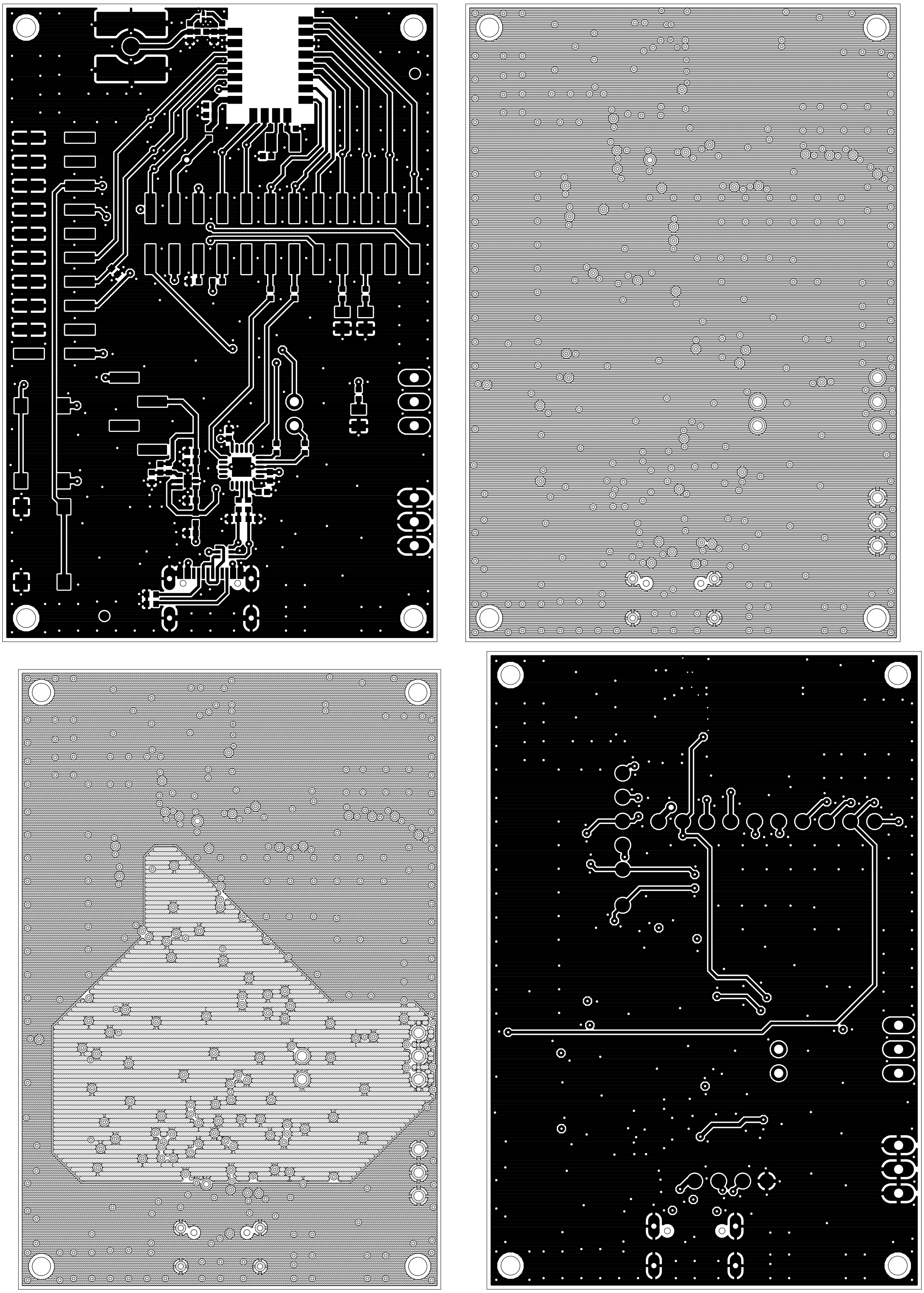


Figure 24: Top, Layer 2, Layer 3 and Bottom Layer

8. Manufacturing information

8.1. 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*.

8.2. Soldering

8.2.1. Reflow soldering

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

Profile feature		Value
Preheat temperature Min	$T_{S\,Min}$	150 °C
Preheat temperature Max	$T_{S\,Max}$	200 °C
Preheat time from $T_{S\,Min}$ to $T_{S\,Max}$	t_S	60 - 120 seconds
Ramp-up rate (T_L to T_P)		3 °C / second max.
Liquidous temperature	T_L	217 °C
Time t_L maintained above T_L	t_L	60 - 150 seconds
Peak package body temperature	T_P	260 °C
Time within 5 °C of actual peak temperature	t_P	20 - 30 seconds
Ramp-down Rate (T_P to T_L)		6 °C / second max.
Time 20 °C to T_P		8 minutes max.

Table 12: 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.

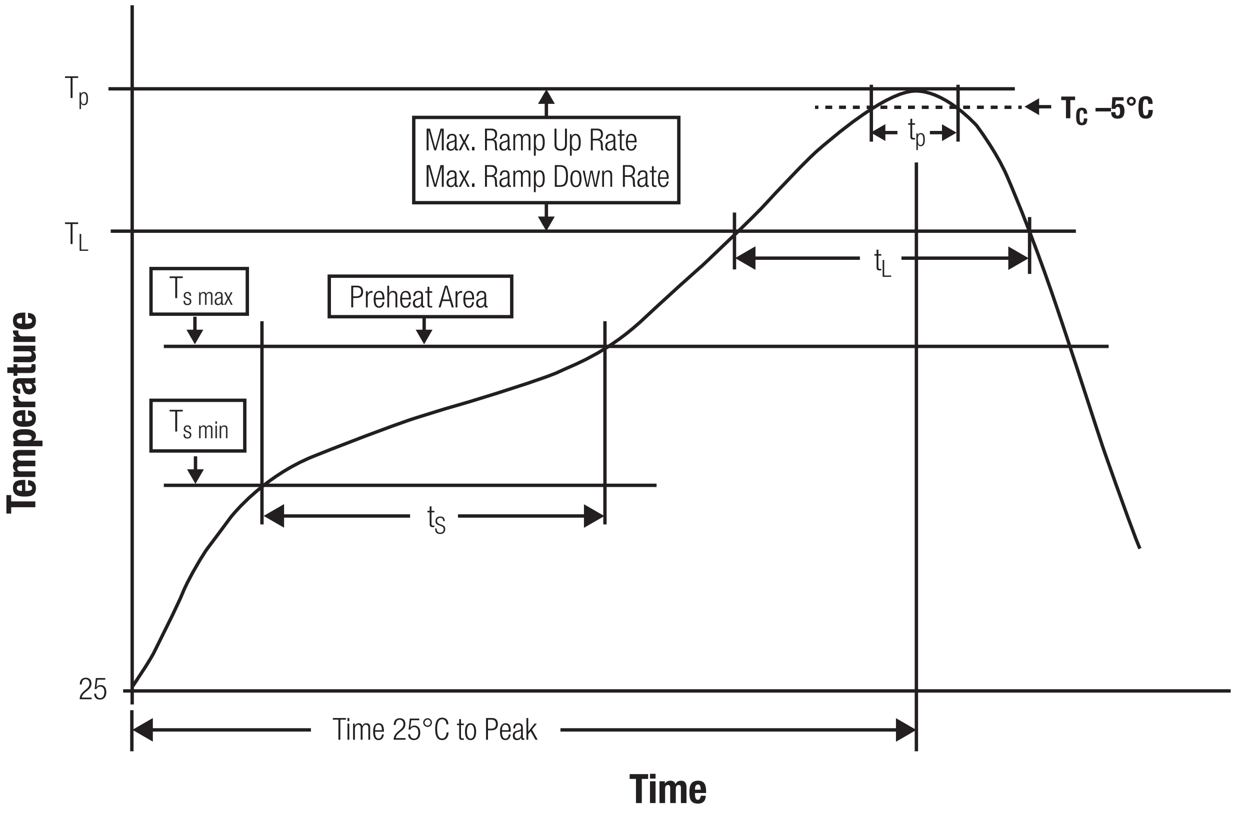


Figure 25: Reflow soldering profile

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

8.2.2. 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.

8.2.3. 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 behaviour of the device. This might be critical for components with high power.

8.2.4. 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.

8.3. ESD handling

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

- the first contact point when handling the PCB is always between the local GND and the host PCB GND, unless there is a galvanic coupling between the local GND (for example work table) and the host PCB GND.
- Before assembling an antenna patch, connect the grounds.
- While handling the RF pin, avoid contact with any charged capacitors and be careful when contacting any materials that can develop charges (for example coaxial cable with around 50-80 pF/m, patch antenna with around 10 pF, soldering iron etc.)
- Do not touch any exposed area of the antenna to avoid electrostatic discharge. Do not let the antenna area be touched in a non ESD-safe manner.
- When soldering, use an ESD-safe soldering iron.

8.4. 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.

9. Product testing

9.1. 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.

9.2. 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.

10. Physical specifications

10.1. Dimensions

Dimensions
12 mm x 8 mm x 2 mm

Table 13: Dimensions

10.2. Weight

Weight
< 1 g

Table 14: Weight

10.3. Module drawing

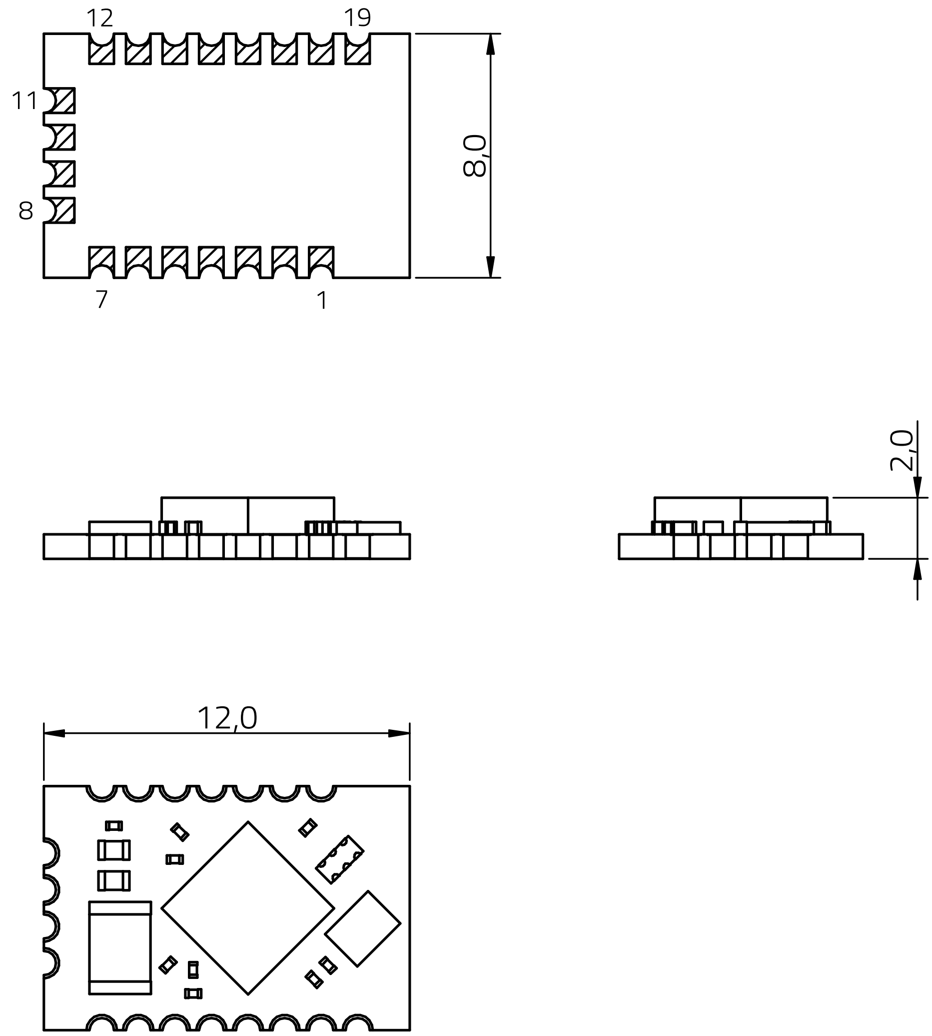


Figure 26: Dimensions [mm]

10.4. Footprint

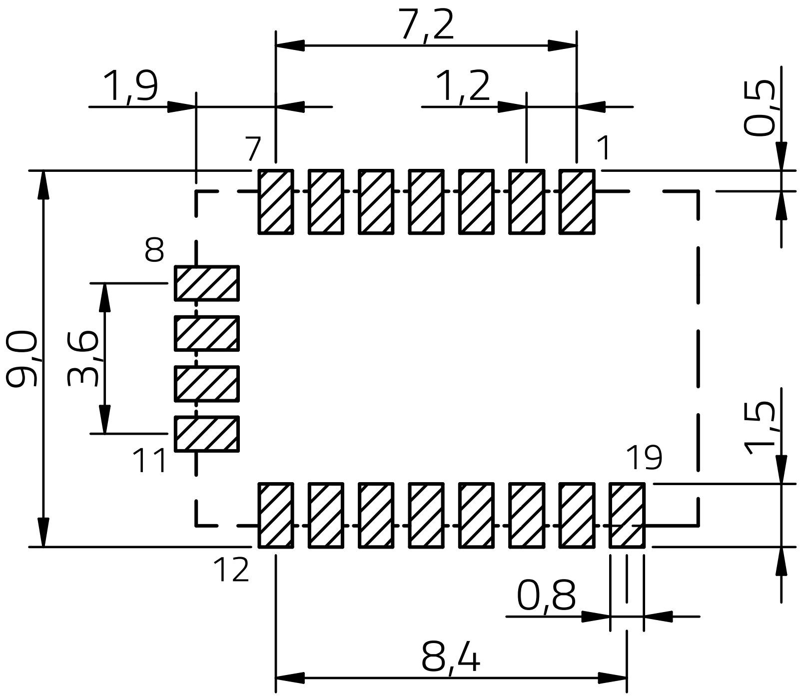


Figure 27: Footprint [mm]

10.5. Antenna free area

To avoid influence and mismatching of the antenna the recommended free area around the antenna should be maintained. As rule of thumb a minimum distance of metal parts to the antenna of $\lambda/10$ should be kept (see figure 27). Even though metal parts would influence the characteristic of the antenna, but the direct influence and matching keep an acceptable level.

11. Marking

11.1. 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.

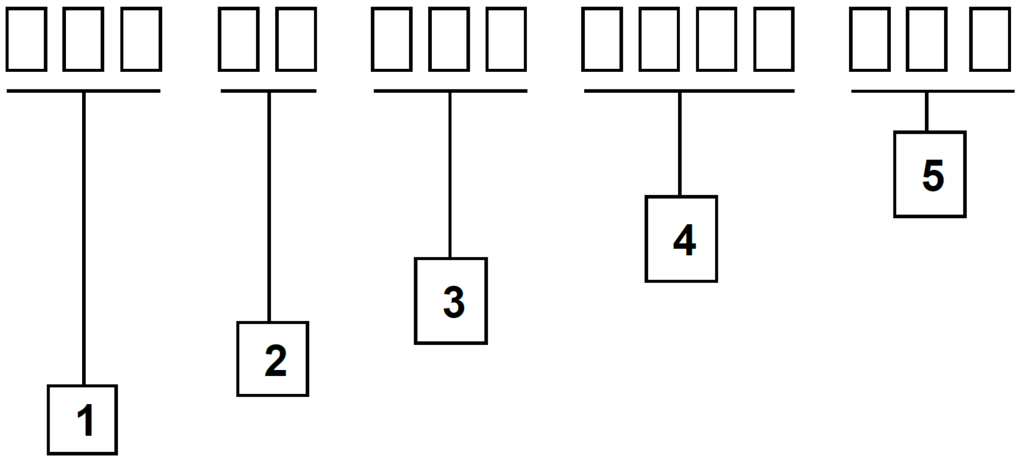


Figure 28: Lot number structure

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 15: 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.

11.2. 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 Olis-e the label is as follows:

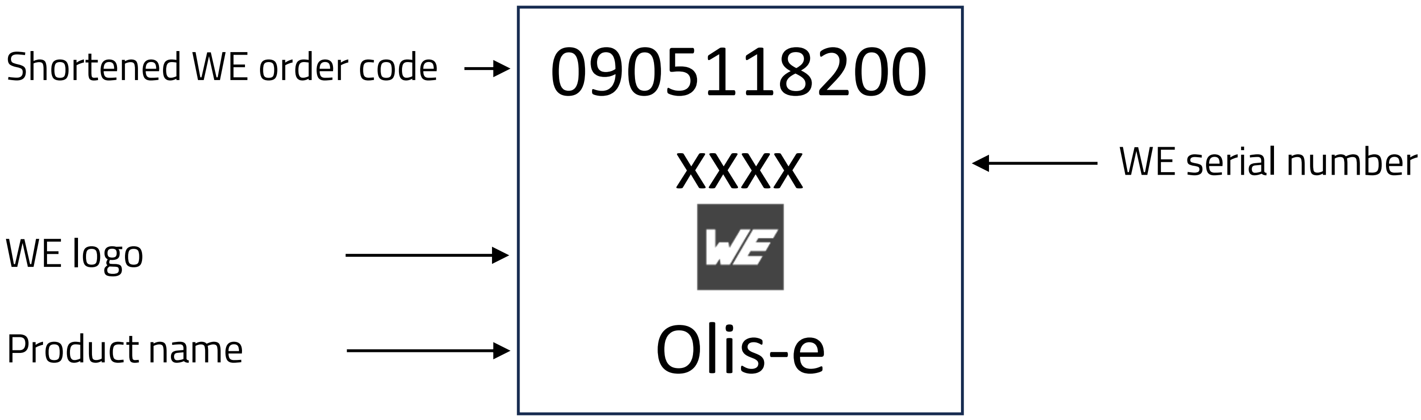


Figure 29: Label of the Olis-e

12. 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 25 mW.
- The total amount of capacitance of all discrete capacitors is 45.6 µF.
- The total amount of inductance of all discrete inductors is 6.81 µH.

13. References

[1] Texas Instruments. Texas Instruments CC130 product page. https://www.ti.com/product/CC1310/.

[2] Texas Instruments. Data sheet CC1310 Sub-1 GHz Transceiver. https://www.ti.com/lit/ds/symlink/cc1310.pdf.

[3] Würth Elektronik. Tarvos-e user manual. https://www.we-online.de/katalog/de/manual/2609051181000.

14. Regulatory compliance information

14.1. Conformity assessment of the final product

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

14.2. 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.

14.3. EU Declaration of conformity

The Olis-e is the BYOF variant of the 260905118 product family. There are product variants available that include firmware [3]. Those complete radio modules have passed the applicable tests and comply to European radio equipment directive. Implementing a suiting radio profile the Olis-e is capable to comply to:

EN 300 220-1 V3.1.1 (2017-02)
EN 300 220-2 V3.1.1 (2017-02)
EN 301 489-1 V2.2.3 (2019-11)
EN 301 489-3 V2.1.1 (2019-03)
EN 62311 : 2008
EN 62368-1: 2014/AC: 2015/A11: 2017

As the user of the Olis-e has complete freedom of the firmware Würth Elektronik eiSos GmbH & Co. KG can not declare conformity.

15. 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 15 and 15 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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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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Würth Elektronik eiSos GmbH & Co. KG products have been designed and developed for usage in general electronic equipment only. This product is not authorized for use in equipment where a higher safety standard and reliability standard is especially required or where a failure of the product is reasonably expected to cause severe personal injury or death, unless the parties have executed an agreement specifically governing such use. Moreover, Würth Elektronik eiSos GmbH & Co. KG products 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. Würth Elektronik eiSos GmbH & Co. KG must be informed about the intent of such usage before the design-in stage. In addition, sufficient reliability evaluation checks for safety must be performed on every electronic component, which is used in electrical circuits that require high safety and reliability function or performance. By using Würth Elektronik eiSos GmbH & Co. KG products, the customer agrees to these terms and conditions.

17. 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

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A. Minimal code example

A.1. Olis-e.h

```
/*  @file       OLIS_E.h
 *
 *  @brief      CC1310 LaunchPad Board Specific header file.
 *
 *  The OLIS_E header file should be included in an application as
 *  follows:
 *  @code
 *  #include "OLIS_E.h"
 *  @endcode
 *
 *  ============================================================================
 */
#ifndef __OLIS_E_BOARD_H__
#define __OLIS_E_BOARD_H__

#ifdef __cplusplus
extern "C" {
#endif

/* Includes */
#include <ti/drivers/PIN.h>
#include <ti/devices/cc13x0/driverlib/ioc.h>

/* Externs */
extern const PIN_Config BoardGpioInitTable[];

/* Defines */
/* Mapping of pins to board signals using general board aliases
 *      <board signal alias>       <pin mapping>  <comments>
 */
/* Pins */
#define OLIS_E_RESERVED_IOID_0       IOID_0 /* mandatory function to support uart fw update */
#define OLIS_E_RESERVED_IOID_1       IOID_1 /* Function for Metis-e/Tarvos-e: Bootloader UART
    RX, Application UART RX */
#define OLIS_E_RESERVED_IOID_2       IOID_2 /* Function for Metis-e/Tarvos-e: Bootloader UART
    TX, Application UART TX */
#define OLIS_E_RESERVED_IOID_3       IOID_3 /* note: IOID_3 is multiplexed with JTAG_TDO ->
    use cJTAG is mandatory */
#define OLIS_E_RESERVED_IOID_4       IOID_4 /* Function for Metis-e/Tarvos-e: Busy pin; note:
    IOID_4 is JTAG_TDI */
#define OLIS_E_RESERVED_IOID_5       IOID_5 /* Reserverd */
#define OLIS_E_LED_GREEN             IOID_6 /* Function for Metis-e/Tarvos-e: LED TX */
#define OLIS_E_RESERVED_IOID_7       IOID_7 /* Reserved */
#define OLIS_E_LED_RED               IOID_8 /* Function for Metis-e/Tarvos-e: LED RX */
#define OLIS_E_RESERVED_IOID_9       IOID_9 /* Reserved */

/*!
 *  @brief Initialize the general board specific settings
 *
 *  This function initializes the general board specific settings.
 */
void OLIS_E_initGeneral(void);
```

```
/*!
 *  @def    OLIS_E_UDMAName
 *  @brief  Enum of DMA buffers
 */
typedef enum OLIS_E_UDMAName {
    OLIS_E_UDMA0 = 0,

    OLIS_E_UDMACOUNT
} OLIS_E_UDMAName;

#ifdef __cplusplus
}
#endif

#endif /* __OLIS_E_BOARD_H__ */
```

A.2. Olis-e.c

```
/*
 *  ====================== OLIS_E.c ===================================
 *  This file is responsible for setting up the board specific items for the
 *  OLIS_E board.
 */

#include <stdbool.h>
#include <stddef.h>
#include <stdint.h>

#include <ti/devices/cc13x0/driverlib/ioc.h>
#include <ti/devices/cc13x0/driverlib/udma.h>
#include <ti/devices/cc13x0/inc/hw_ints.h>
#include <ti/devices/cc13x0/inc/hw_memmap.h>

#include "Olis-e.h"

/*
 *  =============================== PIN ===============================
 */
#include <ti/drivers/PIN.h>
#include <ti/drivers/pin/PINCC26XX.h>

const PIN_Config BoardGpioInitTable[] = {

 /* DIO_0 => boot -> skipped here! */
  OLIS_E_RESERVED_IOID_1 | PIN_PUSHPULL | PIN_INPUT_EN | PIN_PULLDOWN, /* DIO_1 */
  OLIS_E_RESERVED_IOID_2 | PIN_PUSHPULL | PIN_INPUT_EN | PIN_PULLDOWN, /* DIO_2 caution: this
      is APP_UART_TX and BL_TX parallel to JTAG_TDO */
  OLIS_E_RESERVED_IOID_3 | PIN_PUSHPULL | PIN_INPUT_EN | PIN_PULLDOWN, /* DIO_3 */
  OLIS_E_RESERVED_IOID_4 | PIN_PUSHPULL | PIN_INPUT_EN | PIN_PULLDOWN, /* DIO_4 */
  OLIS_E_RESERVED_IOID_5 | PIN_PUSHPULL | PIN_INPUT_EN | PIN_PULLDOWN, /* DIO_5 */
  OLIS_E_LED_GREEN      | PIN_PUSHPULL | PIN_INPUT_EN | PIN_PULLDOWN, /* DIO_6 */
  OLIS_E_RESERVED_IOID_7 | PIN_PUSHPULL | PIN_INPUT_EN | PIN_PULLDOWN, /* DIO_7 */
  OLIS_E_LED_RED        | PIN_PUSHPULL | PIN_INPUT_EN | PIN_PULLDOWN, /* DIO_8 */
  OLIS_E_RESERVED_IOID_9 | PIN_PUSHPULL | PIN_INPUT_EN | PIN_PULLDOWN, /* DIO_9 */
  PIN_TERMINATE                                                          /*
      Terminate list */
};

const PINCC26XX_HWAttrs PINCC26XX_hwAttrs = {
    .intPriority = ~0,
    .swiPriority = 0
};

/*
 *  =============================== Power ===============================
 */
#include <ti/drivers/Power.h>
#include <ti/drivers/power/PowerCC26XX.h>

const PowerCC26XX_Config PowerCC26XX_config = {
    .policyInitFxn     = NULL,
    .policyFxn         = &PowerCC26XX_standbyPolicy,
    .calibrateFxn      = &PowerCC26XX_calibrate,
    .enablePolicy      = true,
```

```
    .calibrateRCOSC_LF = true,
    .calibrateRCOSC_HF = true,
};

/*
 *  =============================== RF Driver ===============================
 */
#include <ti/drivers/rf/RF.h>

const RFCC26XX_HWAttrsV2 RFCC26XX_hwAttrs = {
    .hwiPriority      = ~0,       /* Lowest HWI priority */
    .swiPriority      = 0,        /* Lowest SWI priority */
    .xoscHfAlwaysNeeded = true,   /* Keep XOSC dependency while in standby */
    .globalCallback   = NULL,     /* No board specific callback */
    .globalEventMask  = 0         /* No events subscribed to */
};

/*
 *  =============================== UDMA ===============================
 */
#include <ti/drivers/dma/UDMACC26XX.h>

UDMACC26XX_Object udmaObjects[OLIS_E_UDMACOUNT];

const UDMACC26XX_HWAttrs udmaHWAttrs[OLIS_E_UDMACOUNT] = {
    {
        .baseAddr   = UDMA0_BASE,
        .powerMngrId = PowerCC26XX_PERIPH_UDMA,
        .intNum     = INT_DMA_ERR,
        .intPriority = ~0
    }
};

const UDMACC26XX_Config UDMACC26XX_config[OLIS_E_UDMACOUNT] = {
    {
         .object  = &udmaObjects[OLIS_E_UDMA0],
         .hwAttrs = &udmaHWAttrs[OLIS_E_UDMA0]
    },
};

/*
 *  ======== OLIS_E_initGeneral ========
 */
void OLIS_E_initGeneral(void)
{
    Power_init();

    if (PIN_init(BoardGpioInitTable) != PIN_SUCCESS) {
        /* Error with PIN_init */
        while (1);
    }
}

/*
 *  ======== Board_init ========
 */
void Board_init(void)
{
```

```
    OLIS_E_initGeneral();
}
```

A.3. Board.h

```
#ifndef __BOARD_H
#define __BOARD_H

//#define Board_CC1310_LAUNCHXL

#ifdef __cplusplus
extern "C" {
#endif

#include <ti/drivers/Board.h>


#include "Olis-e.h"

#define Board_PIN_LED1       OLIS_E_LED_GREEN
#define Board_PIN_LED2       OLIS_E_LED_RED

#ifdef __cplusplus
}
#endif

#endif /* __BOARD_H */
```

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