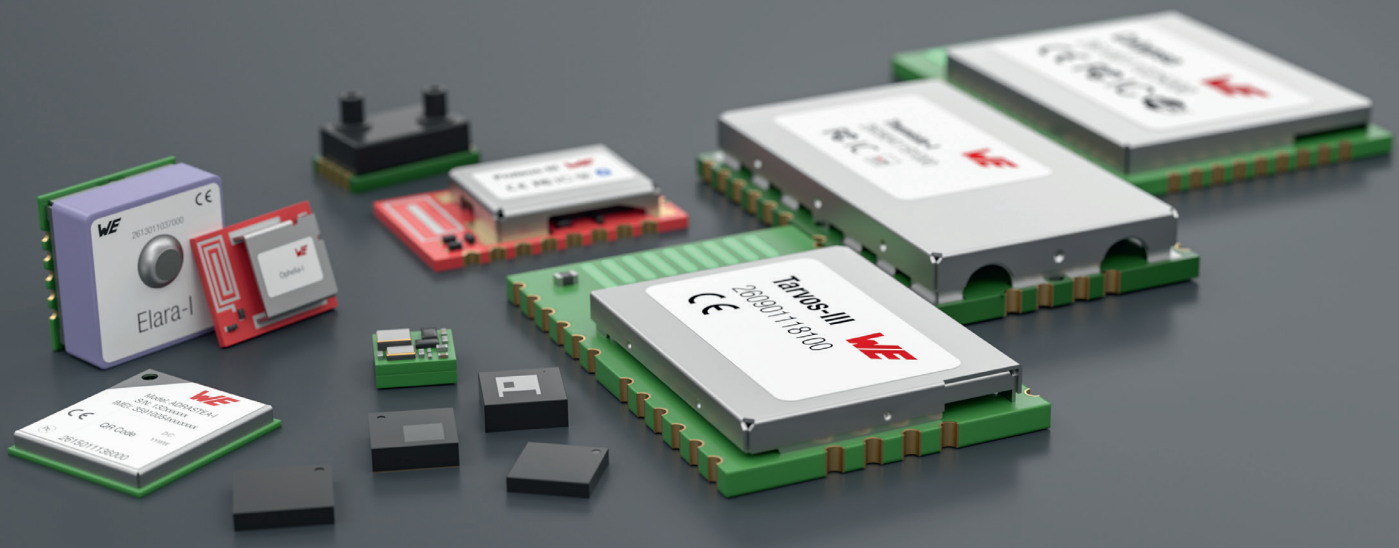


User manual

Ophelia-III

2611011022000

Version 1.0

March 20, 2024

WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

Revision history

Manual version	HW version	Notes	Date
1.0	1.2	• Initial release	March 2024

Abbreviations

Abbreviation	Name	Description
BTMAC		Bluetooth® conform MAC address of the module used on the RF-interface.
CS	Checksum	Byte wise XOR combination of the preceding fields.
DSSS	Direct sequence spread spectrum	Technique to spread a message on the radio
DTM	Direct test mode	Mode to test Bluetooth® specific RF settings.
EV (Board)	Evaluation (Board)	Ophelia-III populated on motherboard with USB interface for test and evaluation purpose.
FEC	Forward error correction	Technique to correct received erroneous radio messages
I/O	Input/output	Pinout description.
LPM	Low power mode	Mode for efficient power consumption.
LRM	Long range mode	Radio mode with higher range and lower throughput.
MAC		MAC address of the module.
MTU	Maximum transmission unit	Maximum packet size of the Bluetooth® connection.
Payload		The intended message in a frame / package.
RF	Radio frequency	Describes wireless transmission.
RSSI	Receive Signal Strength Indicator	The RSSI indicates the strength of the RF signal. Its value is always printed in two's complement notation.
SPI	Serial Peripheral Interface	Allows the serial communication with the module.
UART	Universal Asynchronous Receiver Transmitter	Allows the serial communication with the module.
[HEX] 0xhh	Hexadecimal	All numbers beginning with 0x are hexadecimal numbers. All other numbers are decimal, unless stated otherwise.

Contents

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 ANR027 - Bluetooth listing guide

http://www.we-online.com/ANR027
Every product containing Bluetooth® technology needs to be listed at the Bluetooth® SIG (special interest group). This application note explains the steps to be done to gain a Bluetooth® listing for the end product using a Würth Elektronik eiSos Bluetooth® LE radio module.

Application note ANR030 - nRF Connect

http://www.we-online.com/ANR030
This application note gives a short overview about the options to create a custom firmware for Würth Elektronik eiSos radio modules by using the hardware platform and the embedded nRF5x system on chip. It presents options on firmware development environments and accessories (like SDKs) for the use within the nRF5 ecosystem. The reader is informed on how to access to a multitude of radio standards (like Bluetooth® LE, Bluetooth® MESH, Bluetooth® LE Audio, Matter, Zigbee, Thread, Wirepas) for custom firmware developments whilst the hardware platform can stay the same.

1 Introduction

1.1 Operational description

The Ophelia-III module is a radio module/device for wireless communication between devices such as control systems, remote controls, sensors etcetera.

Be aware that the Ophelia-III module does not contain any firmware.

The user has the complete freedom to use it with proprietary firmware, Wirepas firmware or develop his own application based on the Nordic nRF Connect SDK (e.g. Matter, IEEE 802.11.4, Thread, Zigbee). To fulfill the needs and specifications of such applications, a tailored firmware can be developed, based on the Ophelia-III hardware. This includes the connection and communication to custom sensors, custom Bluetooth® LE profiles, timing configurations, security configurations as well as power consumption optimizations.
Even with it's small dimensions of 8 x 12 mm, Ophelia-III provides a strongly miniaturized integrated PCB antenna. Besides, it is possible to connect an external antenna, if high radio ranges are of interest.
The main functionality is accessible through pads with edge castellation. This offers easy prototype building, as it is suitable for hand soldering. More optional GPIOs without enlarging the size are accessible through land grid pads that can only be connected through reflow process.

The Ophelia-III shares the same hardware platform as the Proteus-III module. For this reason, Proteus-III is often referred to in this user manual.

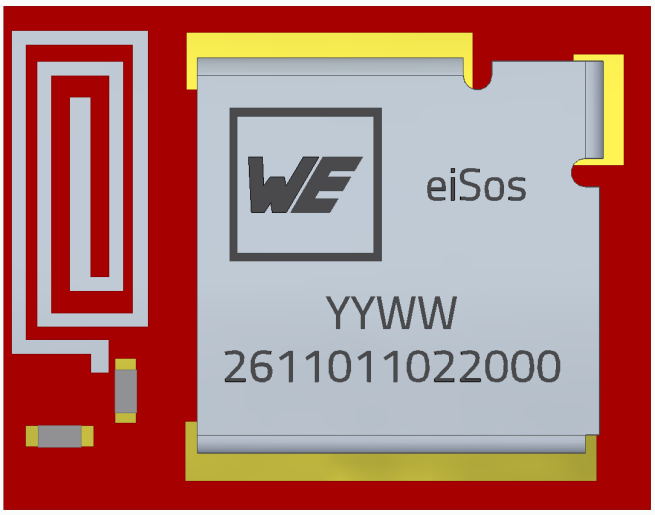


Figure 1: Ophelia-III

1.1.1 Key features

The Ophelia-III offers the following key features that are described in this manual in more detail:

nRF52 series microprocessor generation provided by Nordic Semiconductor: the heart of Ophelia-III is the Bluetooth® LE nRF52840 chip, offering high performance values combined with low power consumption. It is a 32 Bit ARM Cortex-M4F CPU with 1024 kB flash + 256 kB RAM and up to 8 dBm output power.

Flexible wired interfacing: Ophelia-III is equipped with extra pins suited for custom device/sensor connection. With help of these, a tailored firmware can be developed, which is optimized to the customer's needs. The pins can be configured to various functions such as UART, SPI, I^2C, ADC, PWM, NFC and GPIO.

High design flexibility: Ophelia-III offers the user a high grade of freedom when developing an application.

1.2 Block diagram

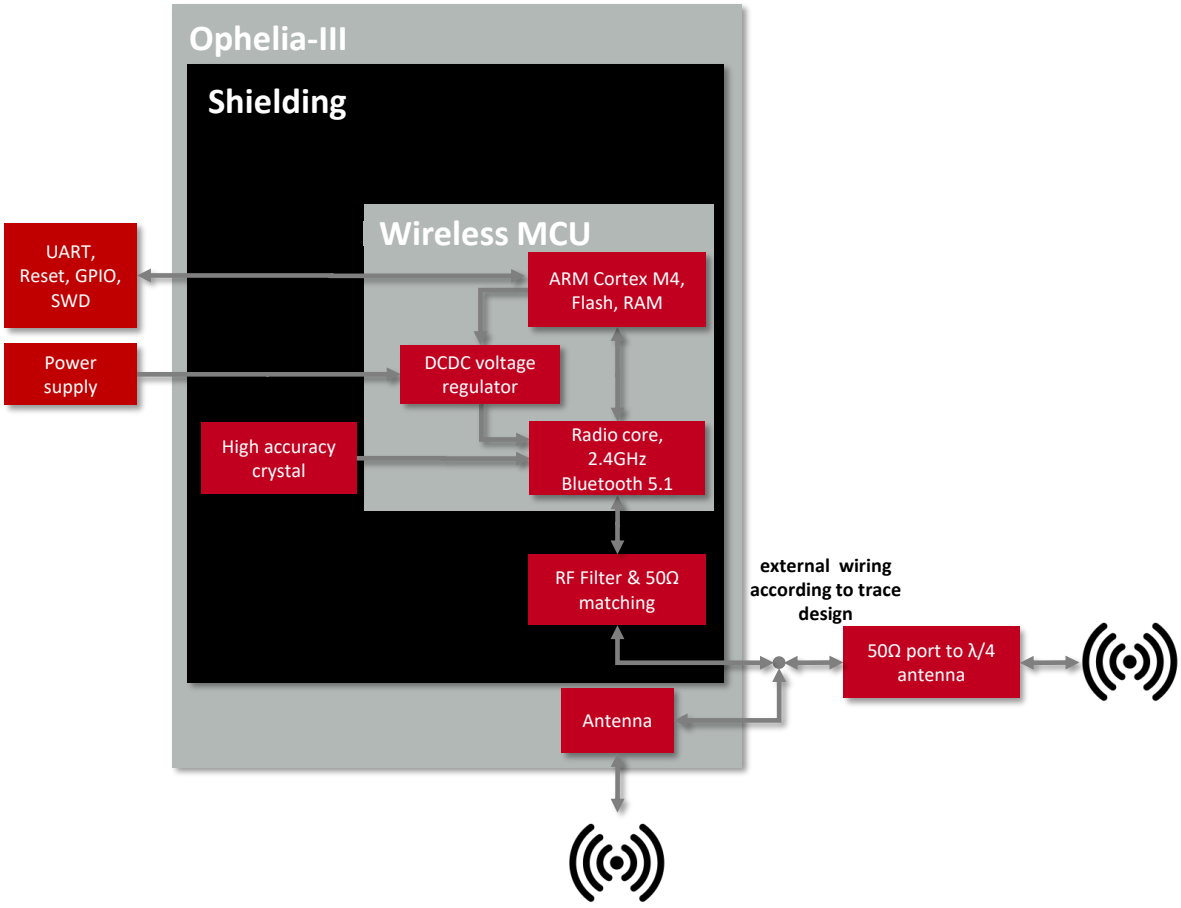


Figure 2: Block diagram of the module

1.3 Ordering information

WE order code	Description
2611011022000	Ophelia-III Module, Tape & Reel

Table 1: Ordering information

2 Electrical specifications

If not otherwise stated, the following values have been measured on an evaluation board Proteus-III EV with T = 25 ℃, VDDS =3 V, f = 2.44 GHz, internal DC-DC converter in use.

The Ophelia-III shares the same hardware platform as the Proteus-III module. For this reason, the following values have been measured on a Proteus-III-EV and the electrical specifications are based on the Proteus-III module.

2.1 Recommended operating conditions

Description	Min.	Typ.	Max.	Unit
Ambient temperature	-40	25	85	℃
Supply voltage (VDDS)	1.8[1]	3	3.6	V
Supply rise time (0V to $\geq$ 1.7V)			60	ms

Table 2: Recommended operating conditions

The on-chip power-on reset circuitry may not function properly for rise times longer than the specified maximum.

An instable supply voltage may significantly decrease the radio performance and stability.

2.2 Absolute maximum ratings

[1] Power fail comparator can be activated and configured. Since Ophelia-III does not have any firmware, this function is not automatically active. To avoid flash fail due to voltage drop, the comparator can be set to 1.8 V.

Description	Min.	Typ.	Max.	Unit
Supply voltage (VDD)	-0.3		+3.9	V
Voltage on any digital pin, VDD<3.6 V	-0.3		VDD+0.3	V
Voltage on any digital pin, VDD≥3.6 V	-0.3		3.9	V
Input RF level			10	dBm
Flash endurance	10 000			Write/erase cycles

Table 3: Absolute maximum ratings

2.3 Power consumption

2.3.1 Static

Parameter	Power	Test conditions	Value	Unit
TX current consumption	Maximum output power	Transmitter only, DC/DC converter enabled, 1 Mbps Bluetooth® LE, CPU current not included, nRF52840 *product specification*	16.4	mA
		Full module current consumption DC/DC converter enabled, (Bluetooth® LE firmware)	18.9	mA

Table 4: Current consumption - transmitting

Parameter	Test conditions	Value	Unit
RX current consumption	Receiver only, DC/DC converter enabled, 1 Mbps Bluetooth® LE, CPU current not included, nRF52 data sheet	6.25	mA
	Full module current consumption DC/DC converter enabled, (Bluetooth® LE firmware)	7.7	mA

Table 5: Current consumption - receiving

Parameter	Test conditions	Value	Unit
Current consumption	Sleep (system off mode)	0.4	µA

Table 6: Current consumption - low power

[1] For ease of use, our current measurements include all active components and options of the SoC that are active in an operation state in the stated value (e.g. CPU, radio, UART, timers, flash, RAM...).

2.4 Radio characteristics

Parameter	Min.	Max.	Unit
Frequency	2360	2500	MHz

Table 7: Frequency range

Parameter	Min.	Max.	Unit
RSSI accuracy valid range (±2dB)	-90	-20	dBm

Table 8: RSSI accuracy

Parameter	Test conditions	Value	Unit
Output power	Conducted	+6	dBm
	Radiated	+4	dBm
Input sensitivity	Conducted, BER = 1E-3, 1 Mbps, Bluetooth® LE	-92	dBm
	Radiated, BER = 1E-3, 1 Mbps, Bluetooth® LE	-90	dBm

Table 9: Transmit and receive power

All transmit and receive power levels are measured on the evaluation board. The values already include losses of transitions from module to motherboard to SMA or modules PCB antenna. They are realistic values for the end application.

2.5 Pin characteristics

The following specifications are from the nRF52 datasheet.

Description	Min.	Typ.	Max.	Unit
Input high voltage	0.7 ×VCC		VCC	V
Input low voltage	VSS		0.3 ×VCC	V
Current at VSS+0.4 V, output set low, standard drive, VDD ≥1.7V	1	2	4	mA
Current at VSS+0.4 V, output set low, high drive, VDD ≥ 2.7 V	6	10	15	mA
Current at VSS+0.4 V, output set low, high drive, VDD ≥ 1.7 V	3			mA
Current at VDD-0.4 V, output set high, standard drive, VCC ≥1.7V	1	2	4	mA
Current at VDD-0.4 V, output set high, high drive, VDD ≥ 2.7 V	6	9	14	mA
Current at VDD-0.4 V, output set high, high drive, VDD ≥ 1.7 V	3			mA
Internal pull-up resistance	11	13	16	kΩ
Internal pull-down resistance	11	13	16	kΩ

Table 10: Pin characteristics

3 Pinout

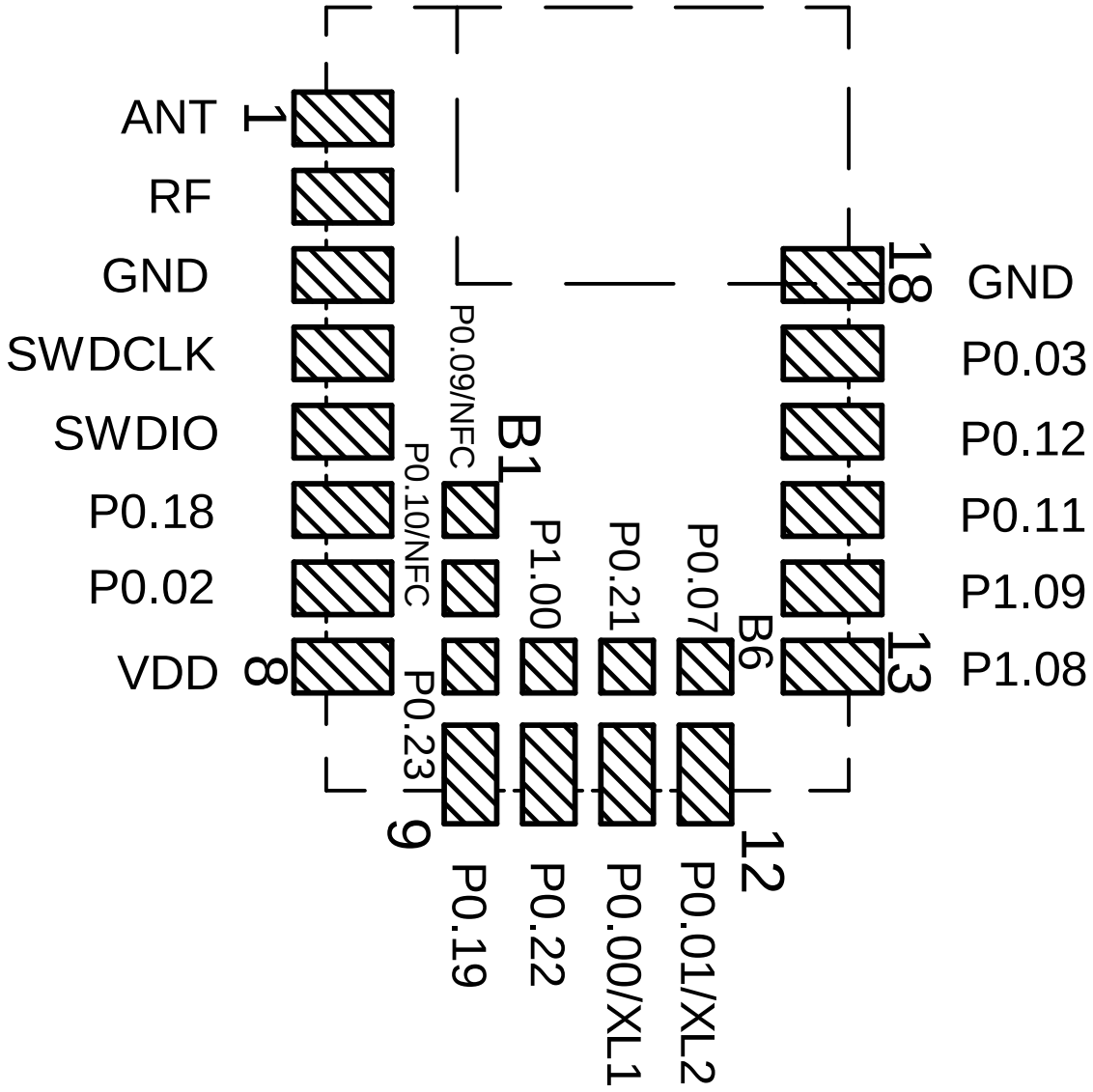


Figure 3: Pinout (top view)

No	µC Pin	I/O	Description
1	*ANT*	I/O	RF connection to PCB antenna. (see section 4)
2	*RF*	I/O	50 Ω RF connection through radio front end to transceiver part of chipset. (see section 4)
3	*GND*	Supply	Ground
4	*SWDCLK*	I/O	Serial wire clock (SWD Interface). Uses internal pull down resistor. Do not connect if not needed.
5	*SWDIO*	I/O	Serial wire input/output (SWD Interface). Uses internal pull up resistor. Do not connect if not needed.
6	P0.18	I/O	General purpose I/O
7	P0.02	I/O	General purpose I/O
8	*VDD*	Supply	Supply voltage
9	P0.19	I/O	General purpose I/O
10	P0.22	I/O	General purpose I/O
11	P0.00/XL1[1]	I/O	General purpose I/O
12	P0.01/XL2[1]	I/O	General purpose I/O
13	P1.08	I/O	General purpose I/O
14	P1.09	I/O	General purpose I/O
15	P0.11	I/O	General purpose I/O
16	P0.12	I/O	General purpose I/O
17	P0.03	I/O	General purpose I/O
18	*GND*	Supply	Ground
B1	P0.09/NFC1[2]	I/O	General purpose I/O
B2	P0.10/NFC2[2]	I/O	General purpose I/O
B3	P0.23	I/O	General purpose I/O
B4	P1.00	I/O	General purpose I/O
B5	P0.21	I/O	General purpose I/O
B6	P0.07	I/O	General purpose I/O

Table 11: Pinout

The main functionality is accessible through pad 1 - 18 with edge castellation. This offers easy prototype building as it is suitable for hand soldering. More optional GPIOs without enlarging the size are accessible through the land grid pads B1 - B6 that can only be connected through reflow process.

[1]Pins available to connect an external crystal in custom firmware. The standard firmware of Ophelia-III does not implement this function.
[2]NFC pins available for NFC function in custom firmware. The standard firmware of Ophelia-III does not implement this function.

4 Antenna connection

Ophelia-III's smart antenna configuration enables the user to choose between two antenna options:

4.1 On-board PCB antenna

The Ophelia-III has an on-board PCB antenna optimized for strong miniaturization operating in the 2.4 GHz frequency band. A simple short between the pins *RF* and *ANT* feeds the RF output of the module to the on-board antenna of the Ophelia-III. In this configuration, the module does not require any additional RF circuitry.

4.2 External antenna

For applications that use an external antenna, the Ophelia-III provides a 50 Ω RF signal on pin *RF* of the module. In this configuration, pin *ANT* of the module has to be connected to ground and pin *RF* to the external antenna via 50 Ω feed line. Refer to chapter 8 for further information.

The use cases for the integrated antenna are miniaturization and re-use of module certifications for the end-application. The use cases for the external antenna are optimization of radio range spending more space for the antenna and differentiated antenna for example when metal housings are used.

5 Custom firmware

5.1 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.
WÃ¼rth Elektronik offers its customers the possibility to flash the customers firmware (e.g. in form of an Intel hex file) on the module at our production site. This would result in a customer exclusive module with a unique ordering number. However, the customers firmware can also be flashed on the module at customers EMS.
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) of the standard module cannot be applied to this customer firmware solution without a review and verification.

5.2 Contact for firmware requests

Please contact your local Business Development Manager (BDM) or wcs@we-online.com for quotes regarding this topic.

6 Firmware flashing using the production interface

The Ophelia-III offers a serial wire debug and programming interface (SWD) for module flash access. This interface can be used by customers to install their own firmware.

Customers flashing their own firmware are fully responsible for certification, declaration, listing and qualification.

7 Design in guide

7.1 Advice for schematic and layout

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

- A clean, stable power supply is strongly recommended. Interference, especially oscillation can severely restrain range and conformity.
- Variations in voltage level should be avoided.
- LDOs, properly designed in, usually deliver a proper regulated voltage.
- Blocking capacitors and a ferrite bead in the power supply line can be included to filter and smoothen the supply voltage when necessary.

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

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.).

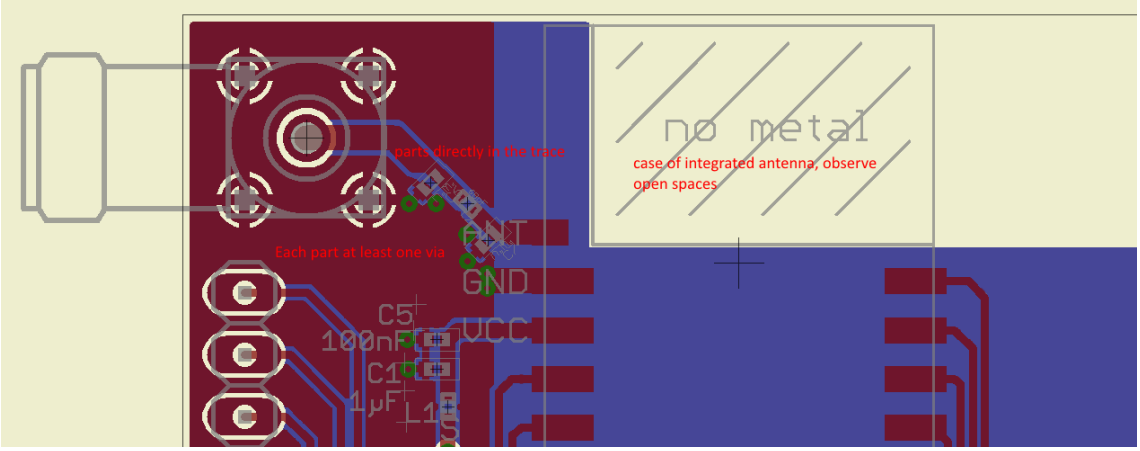


Figure 4: Layout

- To avoid the risk of short circuits and interference there should be no routing underneath the module on the top layer of the baseboard.
- On the second layer, a ground plane is recommended, to provide good grounding and shielding to any following layers and application environment.
- In case of integrated antennas it is required to have areas free from ground. This area should be copied from the evaluation board.
- The area with the integrated antenna must overlap with the carrier board and should not protrude, as it is matched to sitting directly on top of a PCB.
- Modules with integrated antennas should be placed with the antenna at the edge of the main board. It should not be placed in the middle of the main board or far away from the edge. This is to avoid tracks beside the antenna.

- Filter and blocking capacitors should be placed directly in the tracks without stubs, to achieve the best effect.
- Antenna matching elements should be placed close to the antenna / connector, blocking capacitors close to the module.
- Ground connections for the module and the capacitors should be kept as short as possible and with at least one separate through hole connection to the ground layer.
- ESD protection elements should be placed as close as possible to the exposed areas.

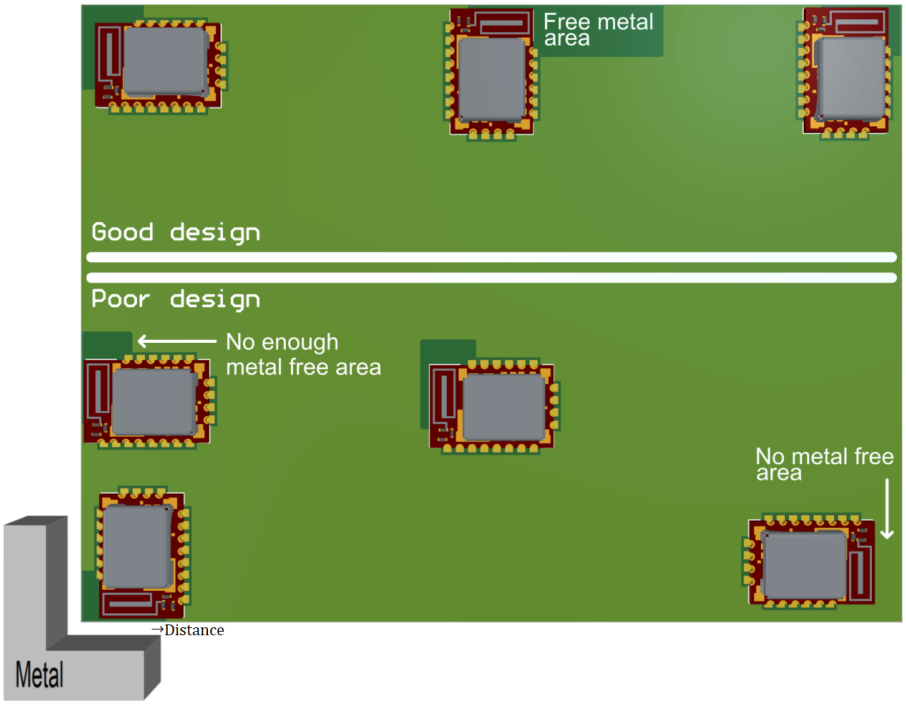


Figure 5: Placement of the module with integrated antenna

7.2 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.

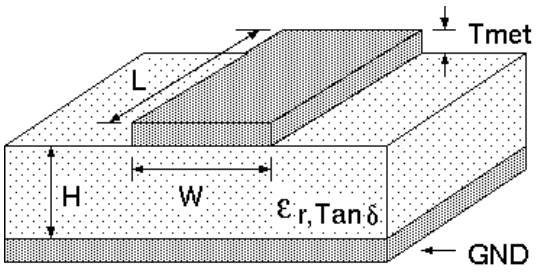


Figure 6: Dimensioning the antenna connection as micro strip

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.

7.3 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.

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

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

7.3.1 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.

7.3.2 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.

7.3.3 PCB antenna

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

7.3.4 Antennas provided by Würth Elektronik eiSos

7.3.4.1 2600130021 - Himalia - 2.4 GHz dipole antenna

Figure 7: 2.4 GHz dipole-antenna

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

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

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

8 Reference design

The Ophelia-III() with a special firmware based on Proteus-III was tested and certified on the corresponding EV-Board. This serves as a proved reference design. For the European Conformity, the EV-board serves as reference design; for the FCC, it is mandatory to follow at least the trace design.

Complete layout and schematic information can be found in the manual of the Ophelia-III EV-board.

8.1 EV-Board

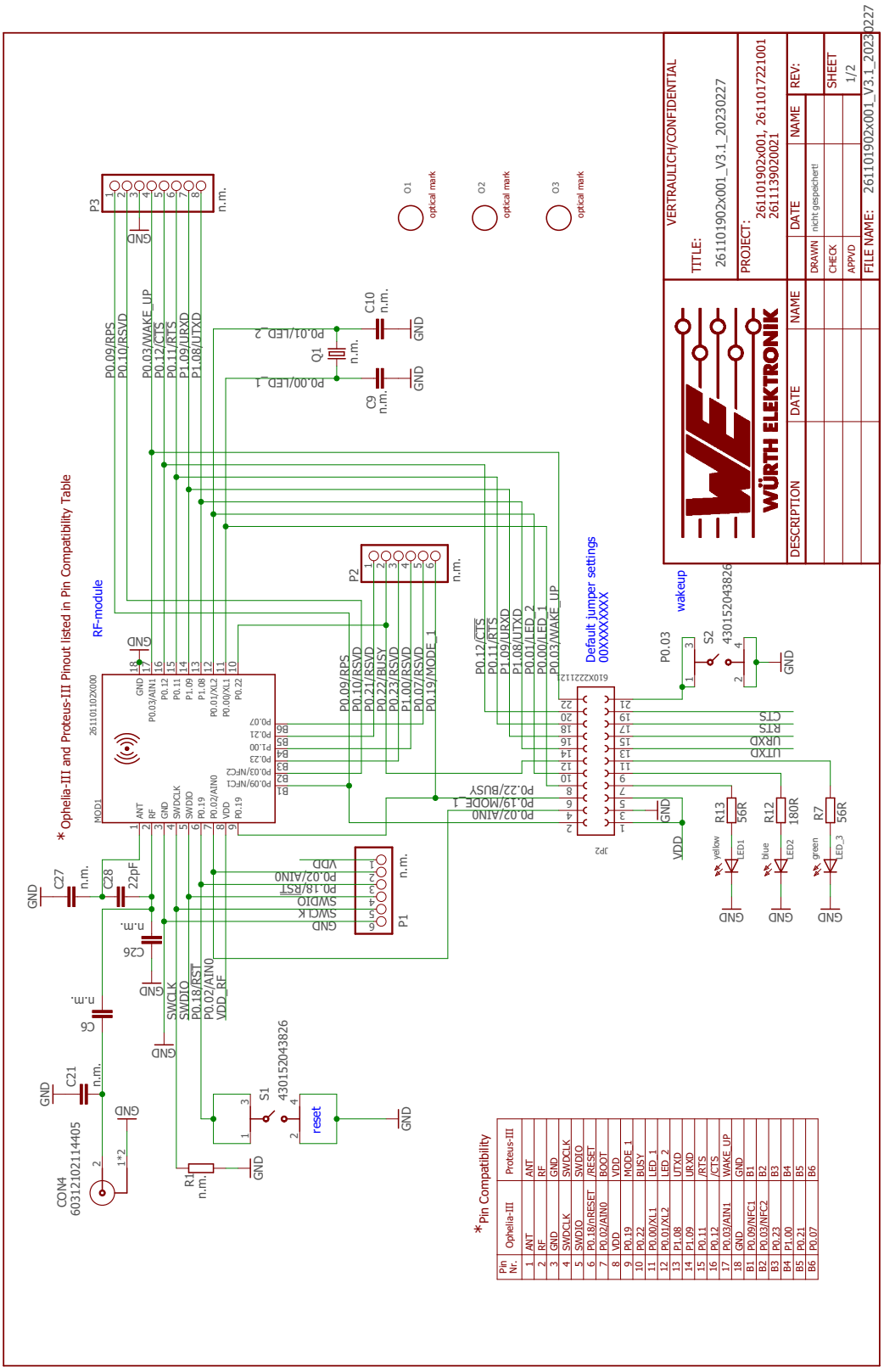


Figure 8: Reference design: Schematic page 1

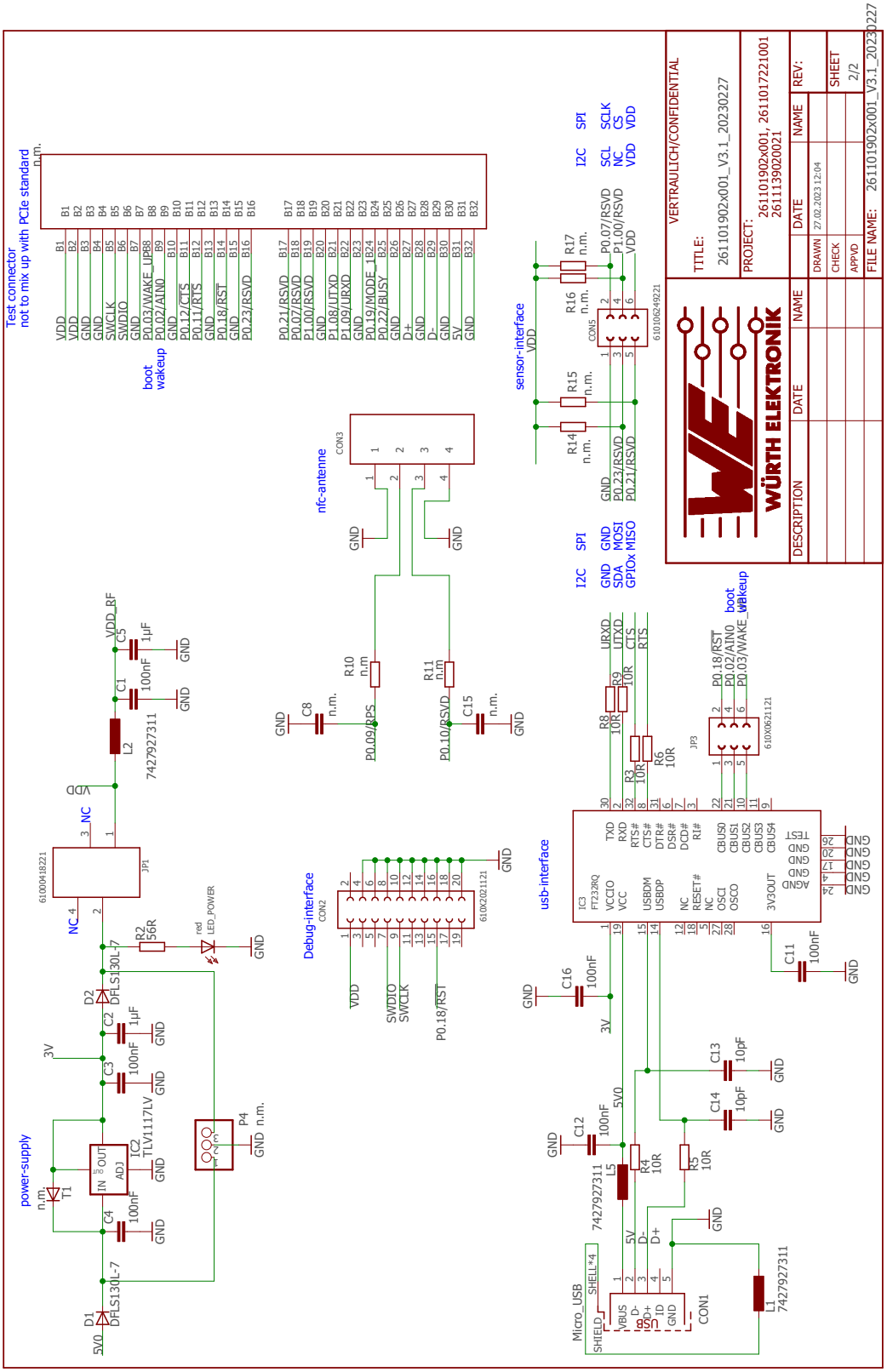
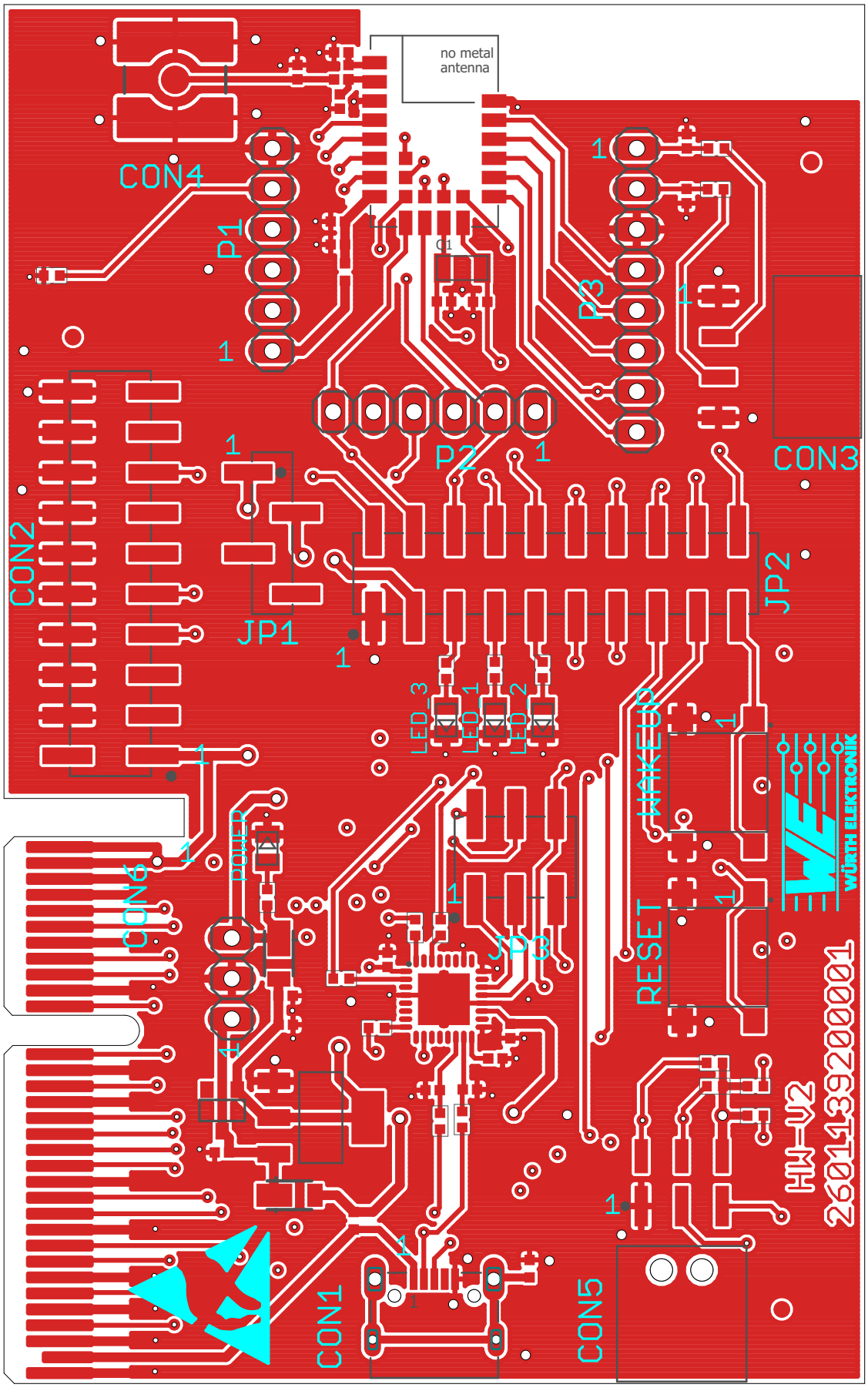


Figure 9: Reference design: Schematic page 2


no metal
antenna
CON4
P1
P3
P2
CON3
CON2
JP1
JP2
LED_3
LED_1
LED_2
WAKEUP
RESET
JP3
CON6
POWER
CON1
CON5
HW-U2
2601139200001

8.2 Radiation characteristic of the module's internal antenna

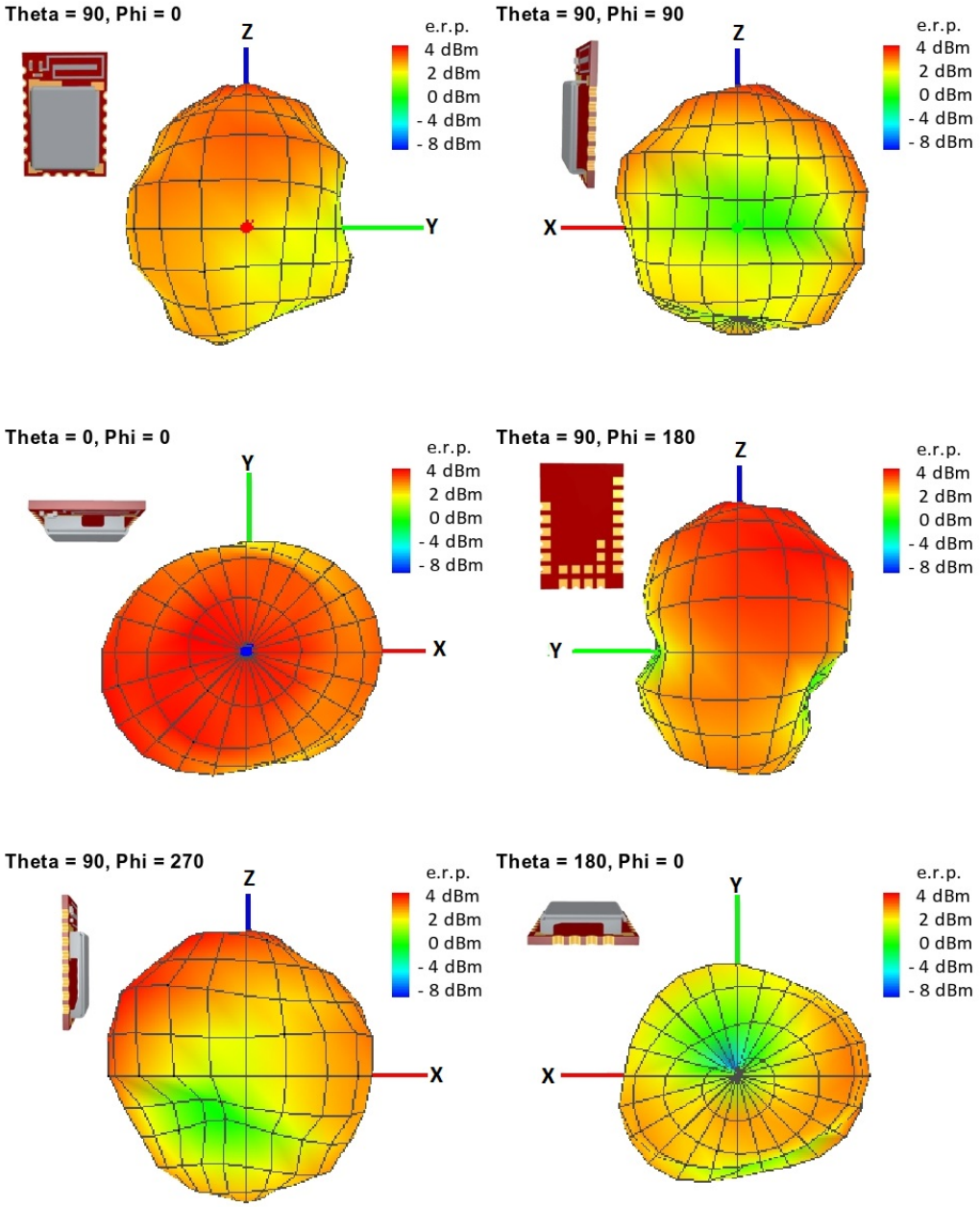


Figure 11: Antenna characteristic of the module with its integrated antenna measured on the official evaluation board

It is important to be aware that size and shape of the ground plane as well as the placement of module has influence on the radiation pattern.

9 Manufacturing information

9.1 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*.

9.2 Soldering

9.2.1 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.

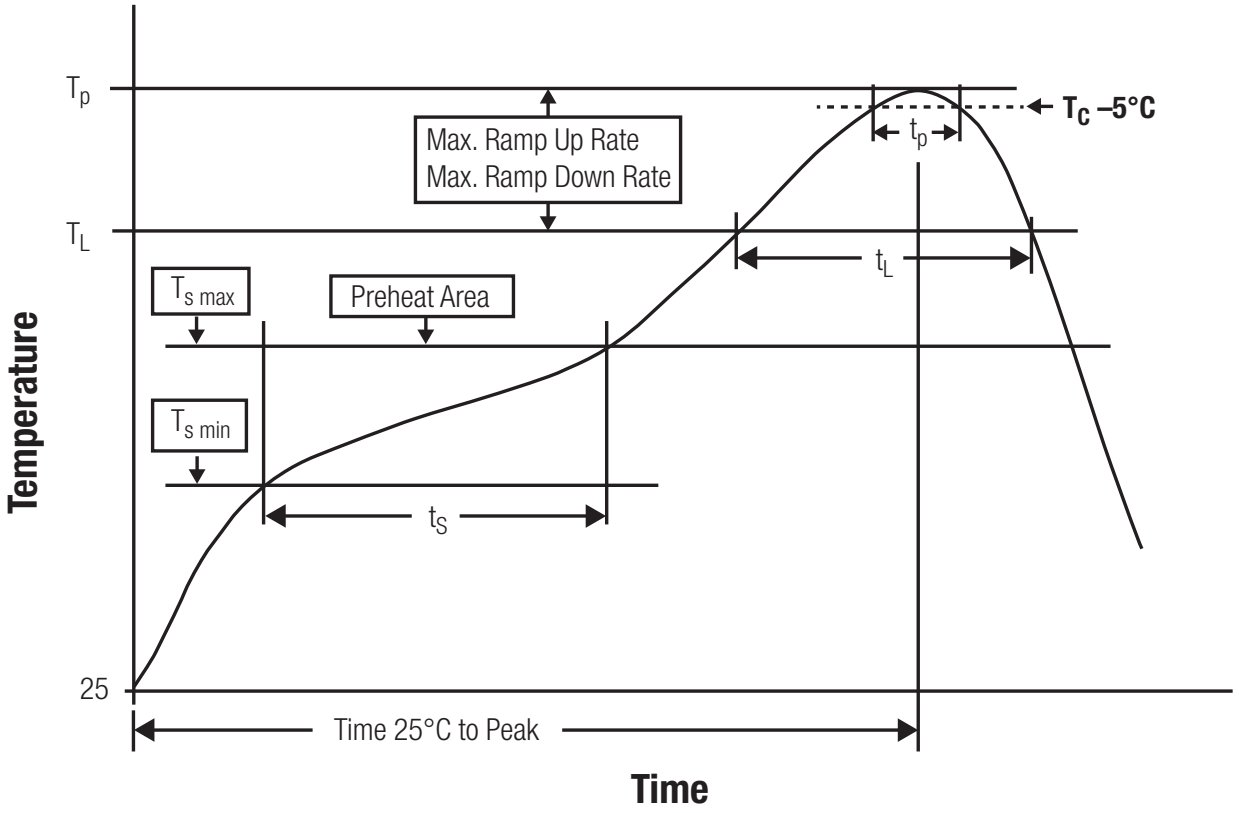


Figure 12: Reflow soldering profile

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

9.2.2 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.

9.2.3 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.

9.2.4 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.

9.3 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.

9.4 Safety recommendations

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

- Use in areas with risk of explosion (for example oil refineries, gas stations).
- Use in areas such as airports, aircraft, hospitals, etc., where the product may interfere with other electronic components.

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

- Compliance with the instructions in the product manual is recommended for correct product set-up.
- The product must be provided with a consolidated voltage source. The wiring must meet all applicable fire and security prevention standards.
- Handle with care. Avoid touching the pins as there could be ESD damage.

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

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

10 Physical specifications

10.1 Dimensions

Dimensions
12 x 8 x 2 mm

Table 13: Dimensions

10.2 Weight

Weight
<1g

Table 14: Weight

10.3 Module drawing

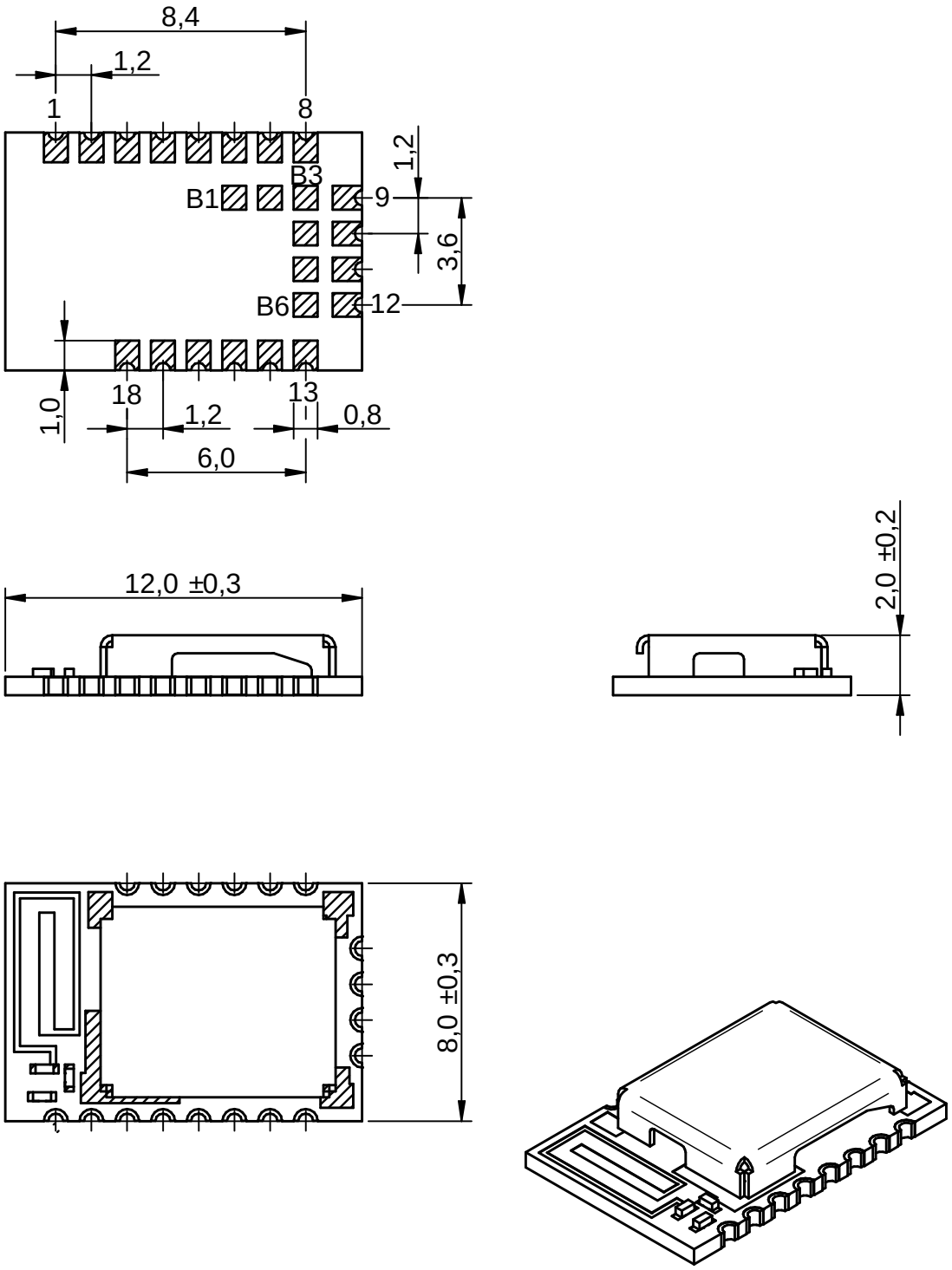


Figure 13: Module dimensions [mm]

10.4 Footprint

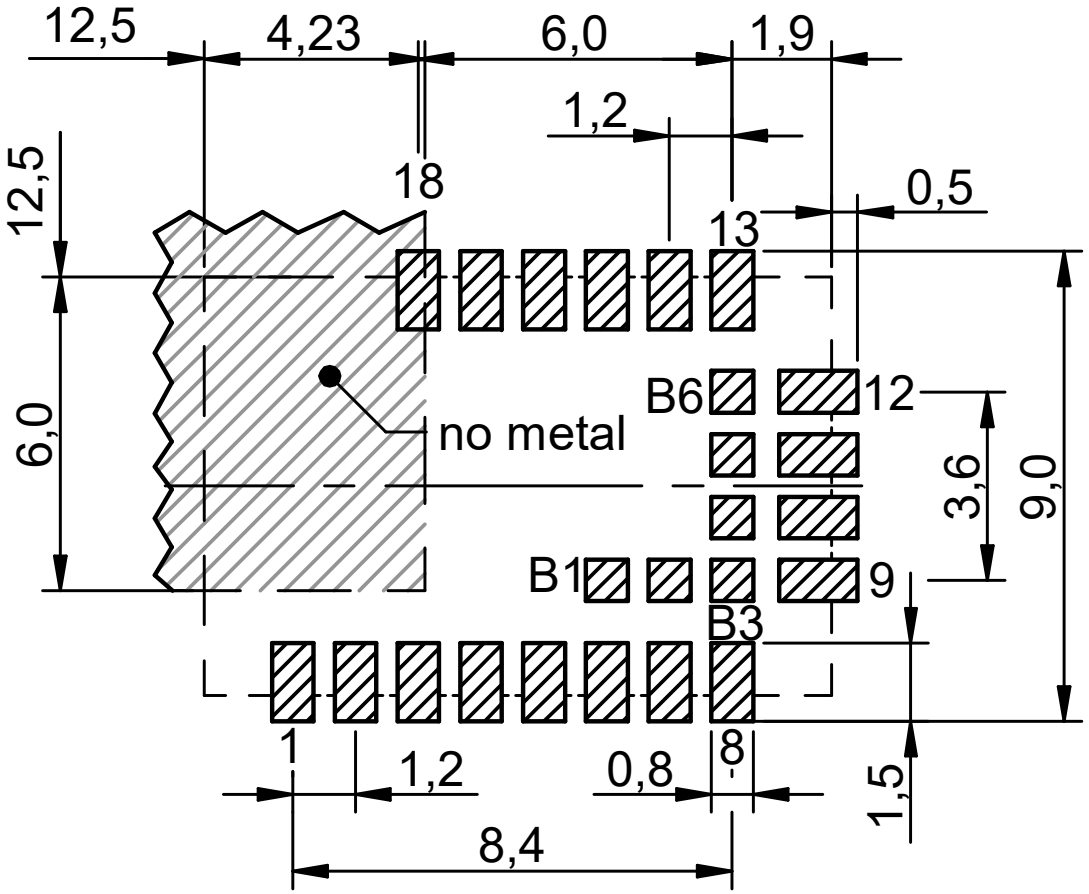


Figure 14: Footprint [mm]

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 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.

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.

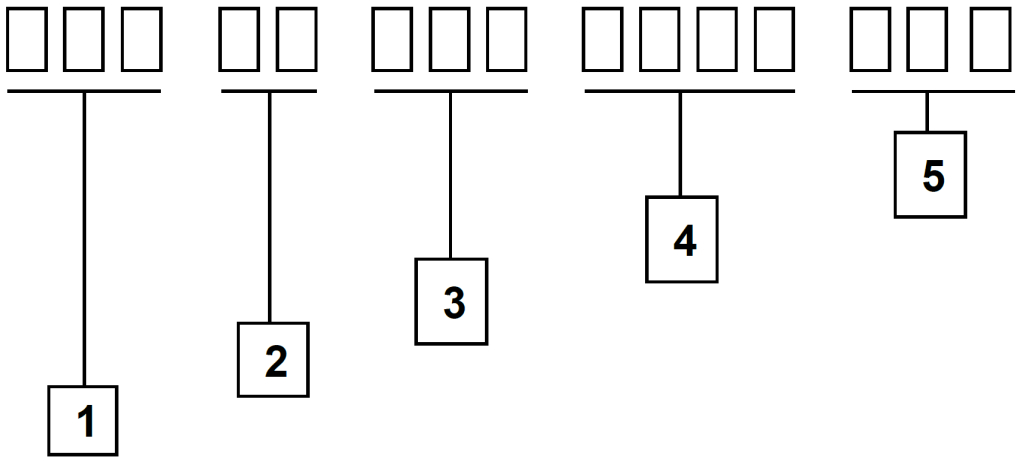


Figure 15: Lot number structure

Block	Information	Example(s)
1	eiSos internal, 3 digits	439
2	eiSos internal, 2 digits	01
3	Hardware version, 3 digits	V2.4 = 024, V12.2 = 122
4	Date code, 4 digits	2103 = week 03 in year 2021, 2216 = week 16 in year 2022
5	Firmware version, 3 digits	V3.2 = 302, V5.13 = 513

Table 15: Lot number details

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 6 dBm for external antenna and 4 dBm for internal antenna.
- The total amount of capacitance of all capacitors is 7.2 µF.
- The total amount of inductance of all inductors is 10.025 µH.
- A DC/DC regulator is included in the chip set and used to obtain low power functionality.

13 Important notes

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

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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.

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

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