WÜRTH ELEKTRONIK

PROTEUS-E/OPHELIA-I EVALUATION BOARD USER MANUAL

FOR RADIO MODULES

EV Order Code	Module order code	Product Name
2612019024001	2612011024000	Proteus-e
2612019022001	2612011022000	Ophelia-I

VERSION 1.0

JANUARY 27, 2022

****

MUST READ

Check for firmware updates

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

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

Revision history

Manual version	HW version	Notes	Date
1.0	1.0	• Initial version	October 2021

Abbreviations

Abbreviation	Name	Description
COM port	Communication port	
EV (Board)	Evaluation (Board)	
ESD	Electro Static Discharge	
FCC	Federal Communications Commission	
FSE	Field Sales Engineer	Support and sales contact person responsible for limited sales area
FTDI	Future Technology Devices International	USB to serial converter chip
GND	Ground	
GPIO	General Purpose Input/Output	
HIGH	High signal level	
JTAG	Joint Test Action Group	Flash und debug interface
Bluetooth LE	Bluetooth Low Energy	
LDO	Low Dropout	Low dropout voltage regulator
LED	Light Emitting Diode	
LFCLK	Low frequency clock	
LFXO	Low frequency crystal oscillator	
LOW	Low signal level	
PC	Personal Computer	
PCB	Printed Circuit Board	
RF	Radio frequency	Describes everything relating to the wireless transmission.
SMA	Sub Miniature version A	
SWD	Serial Wire Debug	Flash und debug interface
UART	Universal Asynchronous Receiver Transmitter	Seriel communication with the radio module.
USB	Universal Serial Bus	
VDD	Voltage Drain Drain	Supply voltage

Contents

1 Supported radio modules

The evaluation board described in this manual can be used to evaluate the following products:

Order code	Product Name	Description
2612011024000	Proteus-e	Bluetooth® LE 5.1 radio module with smart antenna configuration
2612011022000	Ophelia-I	Ophelia-I radio module with smart antenna configuration

Order code	Product Name
261201902x001	Proteus-e/Ophelia-I evaluation board

Table 1: Compatibility

> For both order codes 2612019024001 (Proteus-e evaluation board) and 2612019022001 (Ophelia-I evaluation board), the board is equipped with the Proteus-e Bluetooth 5.1 radio module. These modules have the same hardware platform, based on Nordic nRF52805 chipset.

> No micro-USB connection cable is delivered with the evaluation board.

2 Functional description

The evaluation board offers the user the possibility to develop hard- and software for the mounted radio module. It can be connected to an USB port of a PC.

For the connection to a micro controller system the development board is equipped with a multi-pin connector that makes all pins of the radio module accessible. Jumpers allow the module to be disconnected from components such as the USB interface which are not required.

Feel free to check our youtube channel:
www.youtube.com/user/WuerthElektronik/videos for video tutorials, hands-ons and webinars relating to our products.

2.1 Taking into operation

First of all, the corresponding FTDI driver package (*www.ftdichip.com/Drivers/VCP.htm*) has to be installed on your PC to communicate with the USB interface of the evaluation board.

Then place the jumpers of the evaluation board on their default location as shown in Figure 2.

The next step is to connect the evaluation board to the PC using a USB-cable. In that way a COM port can be detected and installed on your PC. Check the device manager to acquire the COM port name of the evaluation board. A typical name is "COM12" in Windows systems or "/dev/ttyUSB0" in Linux systems.

The *WE-SmartCommander* or any other serial terminal program (like *Hterm* for Windows) has to be run and the corresponding COM port has to be opened using the default settings of the mounted radio module. After the module is powered through the USB jack or an alternative power supply, the reset button should be pressed to ensure a clean start-up of the module.

> The evaluation board is equipped with the Proteus-e radio module (flashed with Bluetooth® LE firmware). To turn it into an Ophelia-I module, the firmware needs to be erased from the module using the programming interface (see Chapter 3.5.6). To do that, please refer to Nordic instructions and resources [1].

> A module without firmware (Ophelia-I) or with firmware other than Proteus-e cannot be taken into operation using the Smart Commander tool [4].

Please refer to the module reference manual to get the detailed module specific quick start instructions [3] [2].

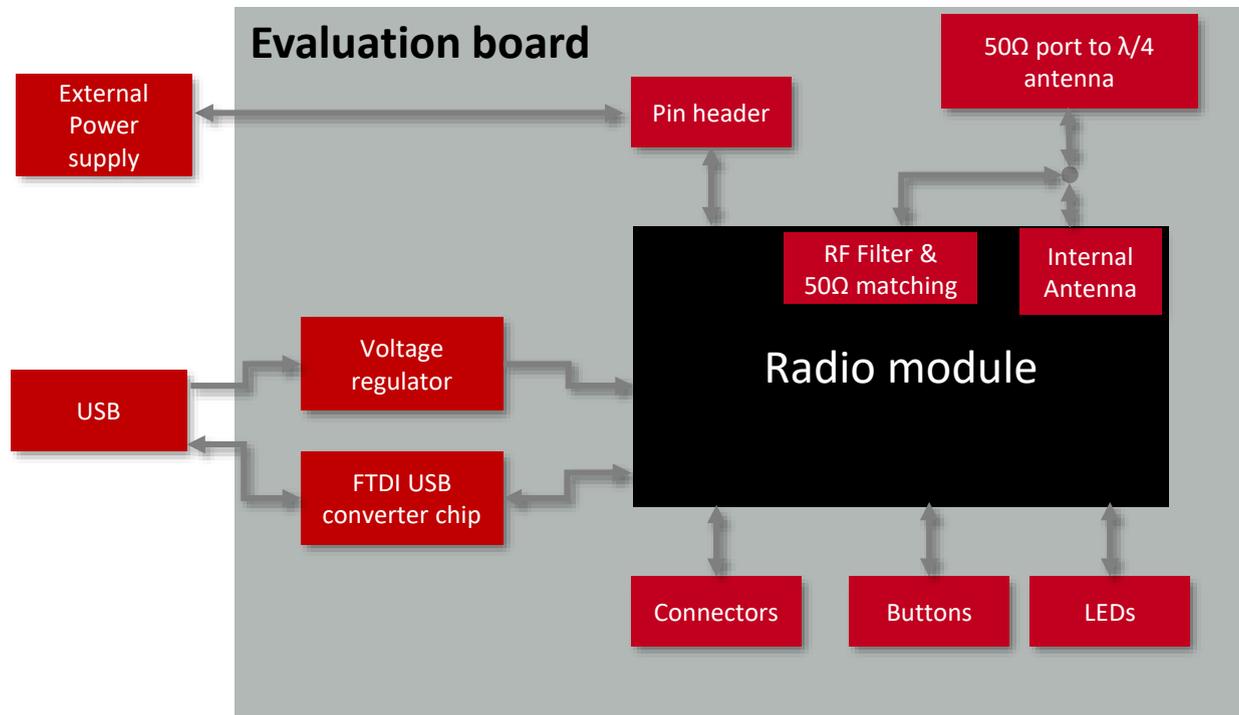# 3 Development board

3.1 Block diagram

Figure 1: Block diagram

By default, the internal PCB antenna is used on the evaluation board. For details on connection of an external antenna, please refer to chapter 3.3.2.
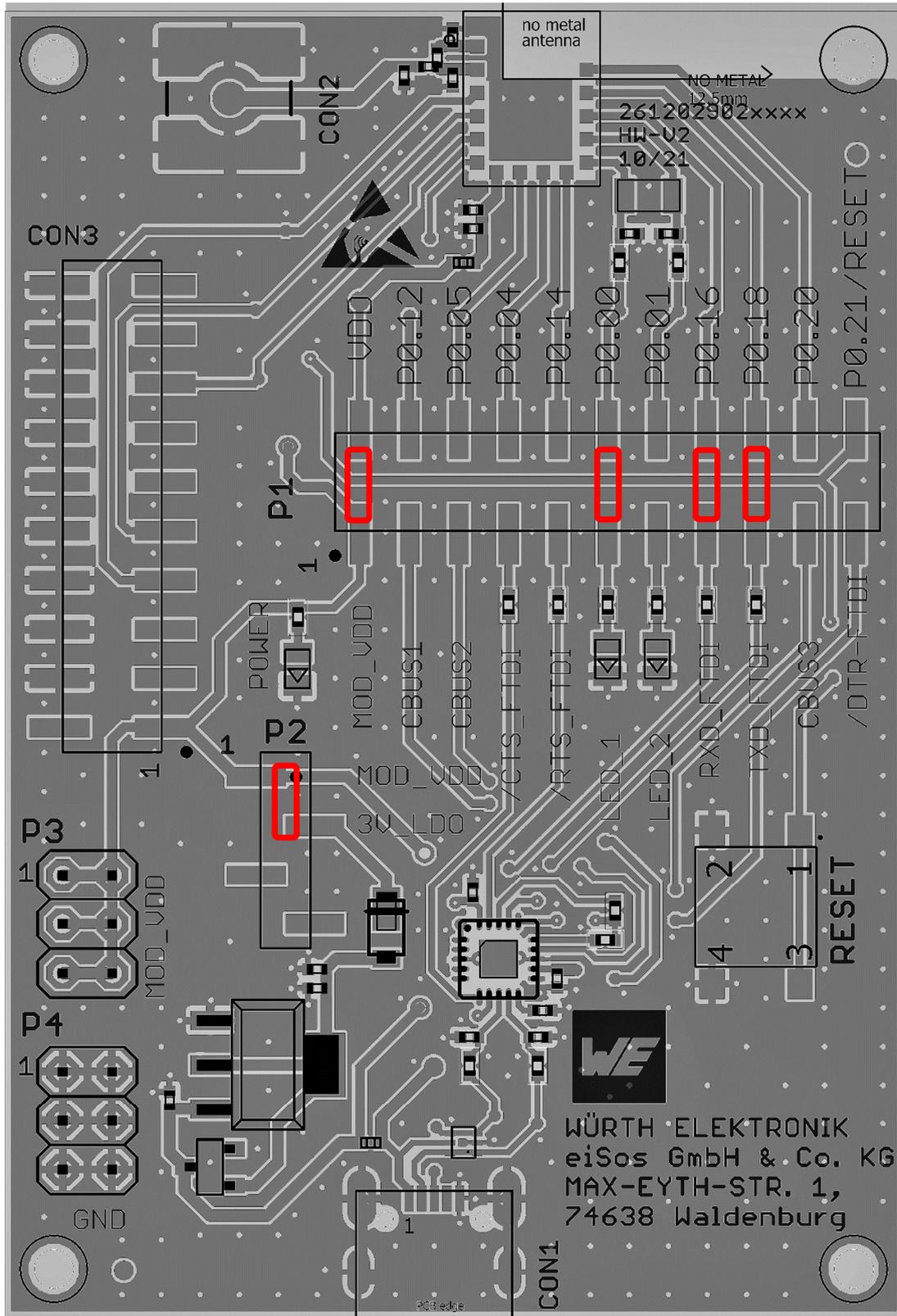
3.2 Jumpers

Figure 2: Jumpers, default placement

P1	Pin (Module Function)	Jumper set (default)
1,2	Current comsumption measurement bridge	Yes
3,4	P0.12 (MODE_1) to CBUS1-FTDI	No
5,6	P0.05 (GPIO_2) to CBUS2-FTDI	No
7,8	P0.04 (/RTS) to /CTS-FTDI	No
9,10	P0.14 (/CTS) to /RTS-FTDI	No
11,12	P0.00 (LED_1) to LED_1	Yes
13,14	P0.01 (BUSY/UART-ENABLE) to LED_2	No
15,16	P0.16 (UTXD) to RXD-FTDI	Yes
17,18	P0.18 (URXD) to TXD-FTDI	Yes
19,20	P0.20 (GPIO_1) to CBUS3-FTDI	No
21,22	P0.21 (/RESET) to /DTR-FTDI	No

Table 2: Jumper P1

P2	Function	Jumper set (default)
1,2	LDO power supply	Yes
1,2	External power supply	No
3	Not connected	
4	Not connected	

Table 3: Jumper P2

> By default, Jumper P2 Pin 1-2 is connected for internal LDO power supply. To use external power supply Jumper P2 Pin 1-2 shall be removed. Pin headers P3 and P4 shall be used to source the evaluation board.
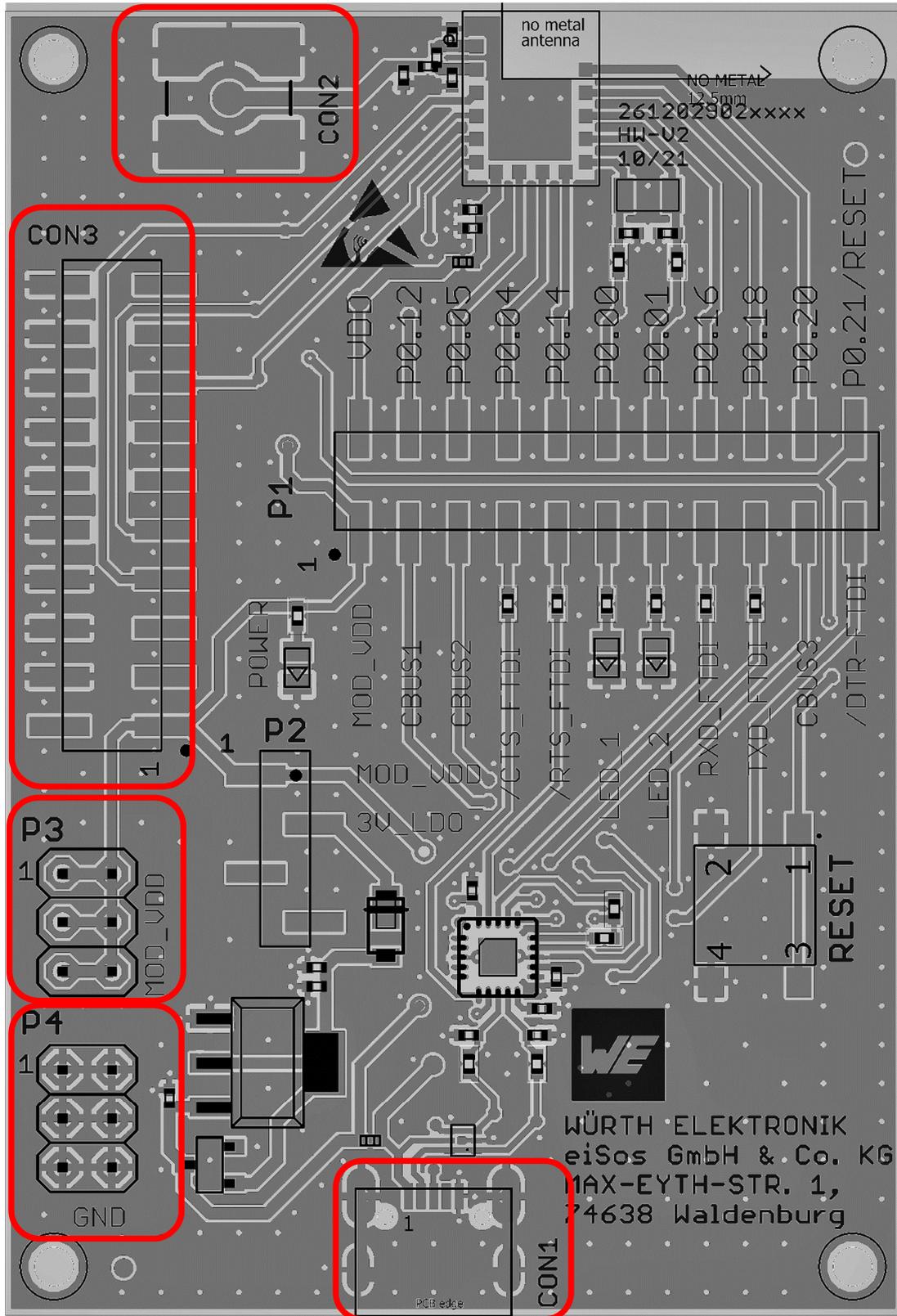
3.3 Connectors and pin headers

Figure 3: Connectors

Connector	Function
CON1	Micro-USB connector for host connection and VDD bus supply
CON2	SMA connector for external antenna
CON3	2×10 JTAG/SWD connector
P3	External power supply VDD (not mounted)
P4	External power supply GND (not mounted)

Table 4: Connector overview

> **!** To use external power supply Jumper P2 Pin 1-2 shall be removed. Pin headers P3 and P4 shall be used to source the evaluation board.

> **STOP** By default, P3 and P4 are not mounted.

3.3.1 CON1

Connector CON1 is a micro-USB connector that enables connection to PC via standard micro-USB cable.

CON1	Function
	Micro-USB connector for host connection and VDD bus supply

3.3.2 CON2

Connector CON2 (SMA receptacle) is used to connect an external antenna. For example, the 2.4 GHz antenna Himalia- *2600130021* can be used.

CON2	Function
Inner	RF signal
Outer	GND

The board supports 50 Ω connection by just soldering/unsoldering one component to use either module's internal PCB antenna or to connect an external antenna.

> **!** In default state, the internal PCB antenna is used on the evaluation board.
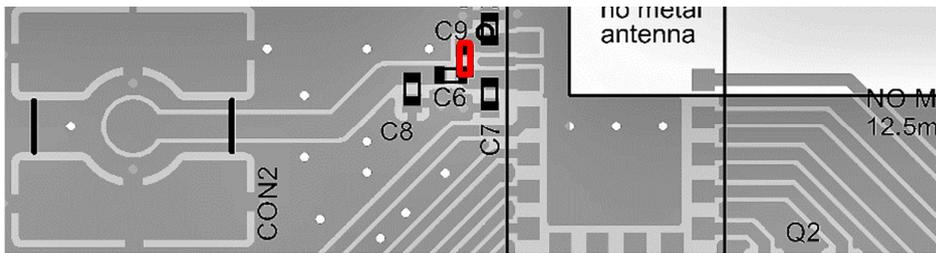
Figure 4: Capacitor connection to internal antenna

In the evaluation board default state, for usage of internal PCB antenna, C9 is populated with a 22 pF capacitor *885012005027*, and C6 is left unpopulated.
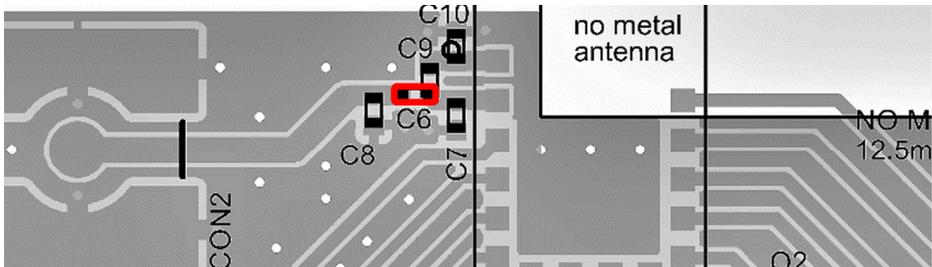
Figure 5: Capacitor connection to external antenna

In order to use the external antenna for long range tests, capacitor C6 has to be populated with a 22 pF capacitor *885012005027* and C9 shall be removed.

3.3.3 CON3

Connector CON3 is the JTAG debugging interface.

CON3	nRF52805	Function
1		*VDD*
7	*SWDIO*	*SWDIO*
9	*SWCLK*	*SWCLK*
15	P0.18	*RESET*
4,6,8,10,12,14,16,18,20		*GND*
2,3,5,11,13,17,19		Not connected

Table 5: Connector CON3

3.3.4 P3

Pin header P3 is a 3x2 pin header with *MOD_VDD* connection. P3 shall be used for external power supply.

3.3.5 P4

Pin header P4 is a 3x2 pin header with *GND* connection. P3 shall be used for external power supply.

3.4 Buttons

Figure 6: Buttons

3.4.1 RESET button

Internally the active low reset input of the micro processor is connected via a RC combination with the power supply to 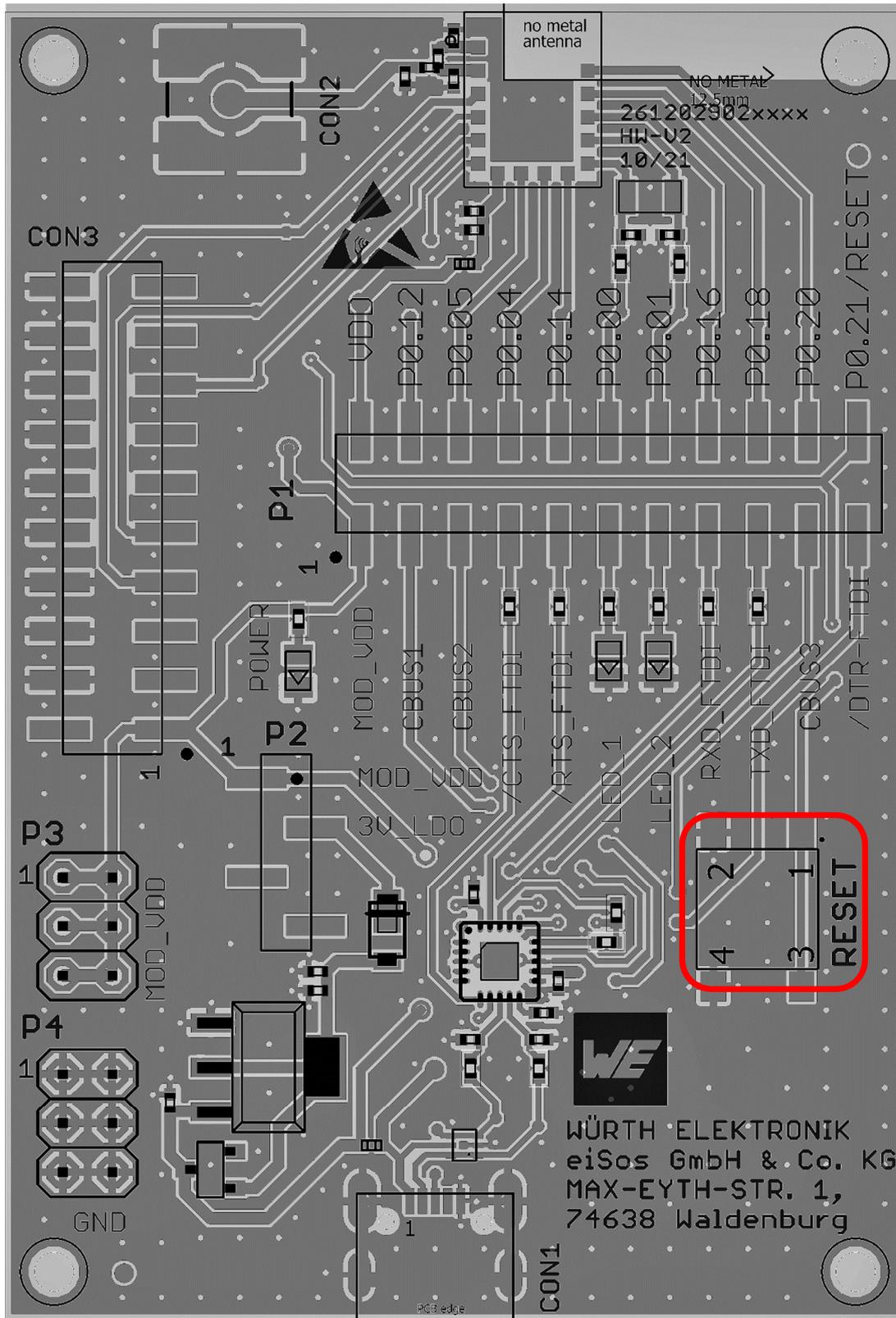ensure a proper startup of the module. The module provides a /RESET pin that is connected to this button so that the module can be restarted properly. The module provides an internal pull-up resistor. Please refer to the module specific manual for detailed information [3] [2].

3.5 Function blocks

3.5.1 Power supply

3.5.1.1 Bus powered, power supply through USB

The development board can be run via USB. The integrated voltage regulator reduces the connected USB voltage 5 V down to 3 V and supplies the remaining parts of the circuit. If the evaluation board is power sourced the power *Power LED* lights up.

3.5.2 P1 - Current measurement

By default, the jumper P1 pin 1-2 is set for normal operation. If a current meter is connected in place of the jumper, the power consumption of the radio module can be measured.
If the meter is not attached and the bridge is not set, the module will not receive a supply voltage. However, the power *Power LED* may be active, as it is connected prior to the current measurement bridge in order not to distort the module's power consumption.

3.5.3 UART via USB

The UART of the module can be connected to the USB converter by setting the bridge P1. In this case it is available on the USB jack. With help of the installed FTDI-driver the PC will provide a virtual COM port which can be used to communicate with the module.

> ⚠️ The USB cable length must not exceed 3 meters.

3.5.4 UART direct

If a micro-controller is to be connected to the module, remove the jumpers 11-12,15-16, 17-18 on P1. The UART of the host micro controller can be attached directly on the pin header P1 (all even numbered pins). The module *RXD* line must be handled accordingly by your host (i.e. pulled up while inactive and during module boot-up). The host must obey the I/O level incompatibility values stated in the module's manual.

3.5.5 LFXO crystal

For higher LFCLK accuracy (better than ±500 ppm) a low frequency crystal oscillator of 32.768 kHz (LFXO) shall be used. A crystal, 3.2 ×1.6 mm package, for example *830009706*, can be placed on the evaluation board to position Q2. The needed load capacitance can be reached with capacitors $C31$ and $C41$, 0402 package.

> In default state, a crystal oscillator is not mounted on the evaluation board.

If the jumpers P1 pin 11-12, 13-14 are set, the radio chip nRF52805 pin P0.00 and P0.01 are connected to *LED_1* and *LED_2* on evaluation board through 0 Ω resistors R6 and R11 respectively.

If a LFXO is mounted to the evaluation board the resistors $R6$ and $R11$ shall be demounted, capacitors $C31$ and $C41$ shall be mounted.
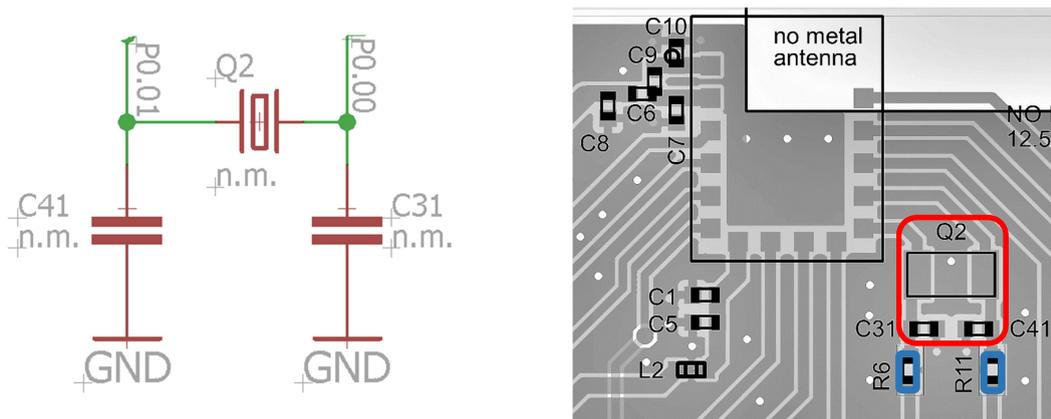
Figure 7: LFXO mounting

The input capacitance of the pin P0.00 and P0.01 are 4 pF. The values of $C31$ and $C41$ can be calculated as follows.

The load capacitance C_l of LFXO calculates as

$$C_l = \frac{C31_l * C41_l}{C31_l + C41_l}$$

if we assume that $C31_l = C41_l$.

$$C_l = \frac{C31_l}{2} = \frac{C41_l}{2}$$

Whereas,

$$C31_l = C31 + C_{XL2} + C_{PCB}$$

$$C41_l = C41 + C_{XL2} + C_{PCB}$$

With this, $C31$ and $C41$ calculate as

$$
\begin{aligned}
C31 &= 2 \cdot C_l - C_{XL1} - C_{PCB} \\
C41 &= 2 \cdot C_l - C_{XL2} - C_{PCB}
\end{aligned}
$$

whereas

C_l = Load capacitance of LFXO crystal
C_{XL1} = Input capacitance of pad *LED_1* (4 pF)
C_{XL2} = Input capacitance of pad *LED_2* (4 pF)
C_{PCB} = Parasitic capacitance of PCB

Parasitic capacitance C_{PCB} can vary depending on design and track length. It can vary from 0.5 pF to 2 pF.

For the crystal *830009706* with a load capacitance C_l of 9 pF and a parasitic capacitance C_{PCB} of 2 pF, the value of $C31$ and $C41$ results in 12 pF, which was also tested on the evaluation board.

Depending on parasitic capacitance of host PCB, a capacitance of 12 pF may be a good starting value for $C31$ and $C41$.

> **(!)** Using standard firmware with Proteus-e, the external crystal is not needed. To enable use of the LFXO a custom firmware is required.

3.5.6 Programming interface

The evaluation board provides a 2×10 pin connector to connect directly to a SWD flash adapter used for development. Please take care of the correct mounting of the flash adapter. The recommended flash adapter is one of the "Segger J-Link" family.
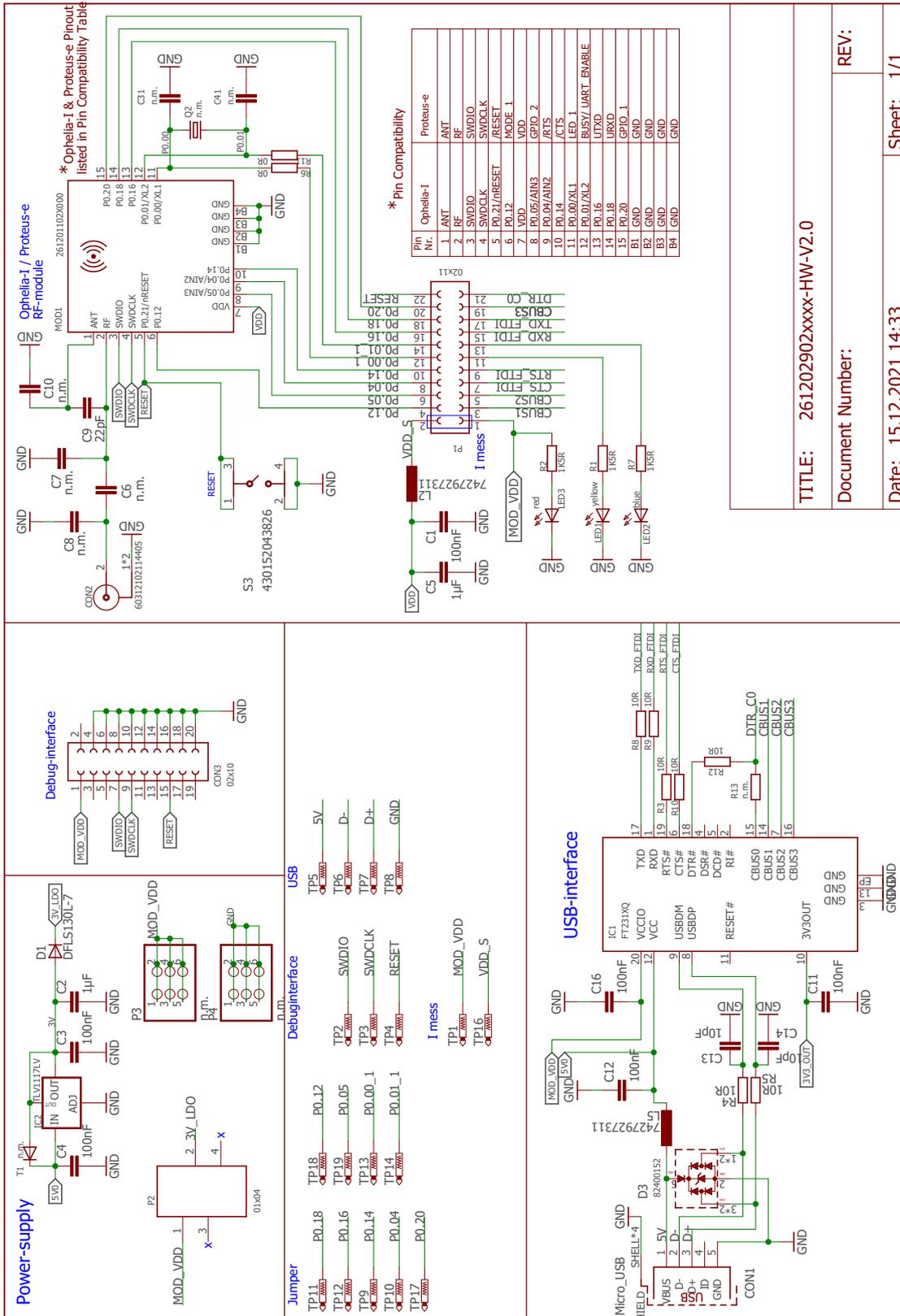
3.6 Schematic

Figure 8: Reference design: Schematic

The reference design is the same for the Proteus-e and Ophelia-I radio modules. The module's pins on the schematic are named according to Ophelia-I module. The pin compatibility table between Ophelia-I and Proteus-e is shown in the schematic.
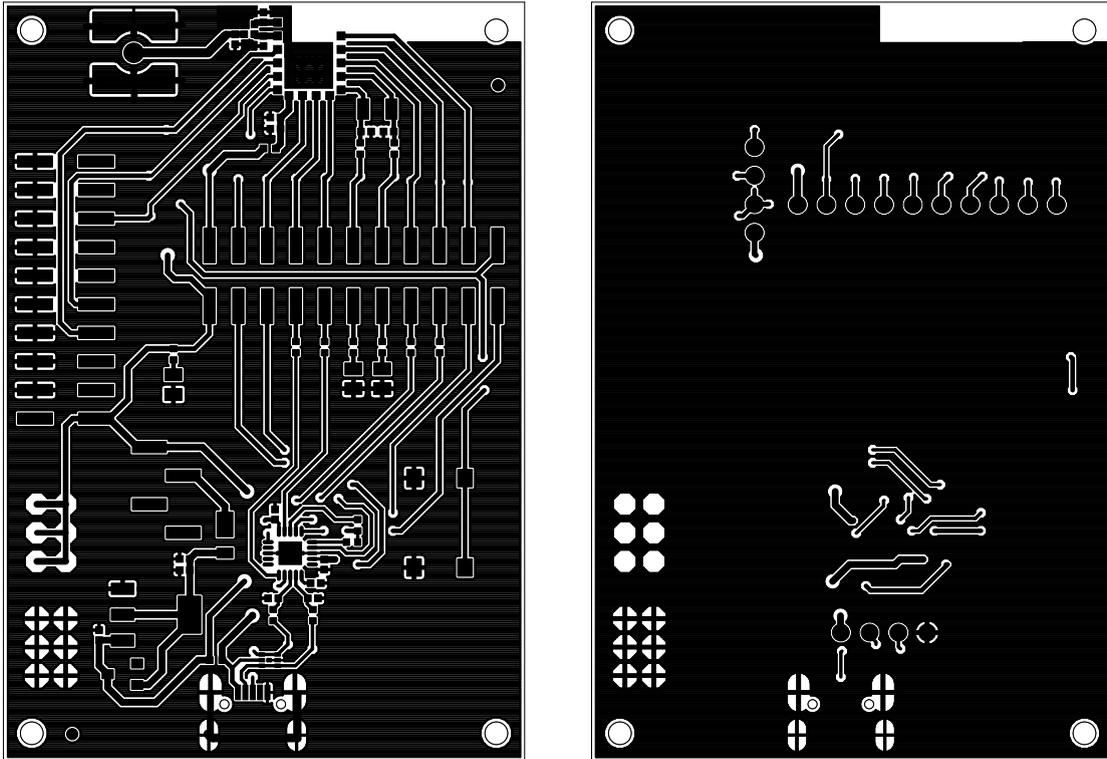
3.7 Layout

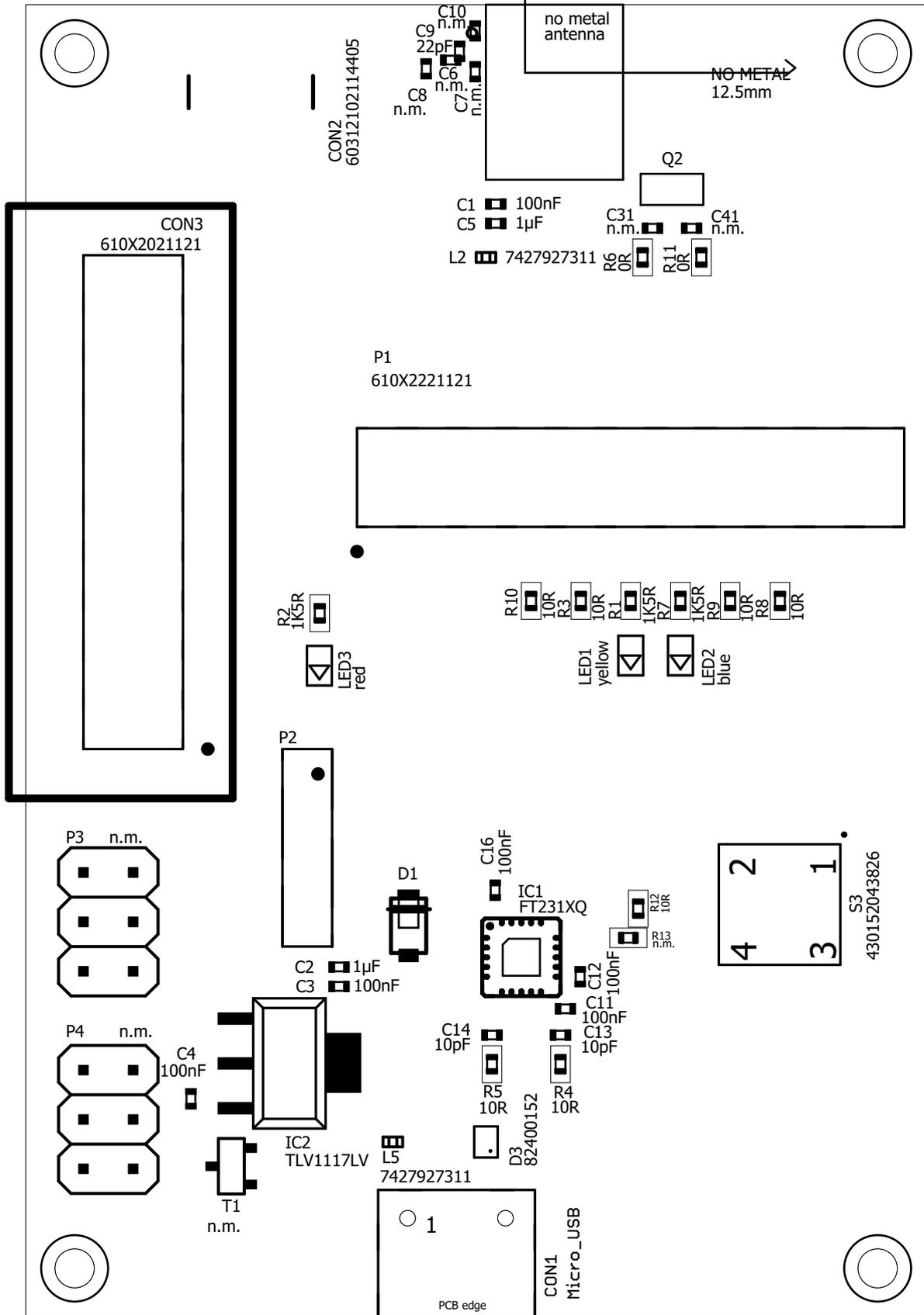Figure 9: Top layer (top), bottom layer (bottom)

Figure 10: Assembly diagram

3.8 Bill of materials

MOD1	Proteus-E/ Ophelia-I	SMD	Würth Elektronik	2612011024000/ 2612011022000
C1	100nF	C0402_IPC	Würth Elektronik	885012205037
C2	1µF	C0402_IPC	Würth Elektronik	885012105012
C3	100nF	C0402_IPC	Würth Elektronik	885012205037
C4	100nF	C0402_IPC	Würth Elektronik	885012205037
C5	1µF	C0402_IPC	Würth Elektronik	885012105012
C6	n.m.	C0402_IPC	Würth Elektronik	
C7	n.m.	C0402_IPC		
C8	n.m.	C0402_IPC		
C9	22pF	C0402_IPC	Würth Elektronik	885012005030
C10	n.m.	C0402_IPC		
C11	100nF	C0402_IPC	Würth Elektronik	885012205037
C12	100nF	C0402_IPC	Würth Elektronik	885012205037
C13	10pF	C0402_IPC	Würth Elektronik	885012005055
C14	10pF	C0402_IPC	Würth Elektronik	885012005055
C16	100nF	C0402_IPC	Würth Elektronik	885012205037
C31	n.m.	C0402_IPC		
C41	n.m.	C0402_IPC		
CON1	Micro_USB	629105150521	Würth Elektronik	629105150521
CON2	60312102114405	60312102114405	Würth Elektronik	60312102114405
CON3	02x10	610X2021121	Würth Elektronik	61002021121
D1	DFLS130L-7	SOD123_POWERDI	Diodes incorporated	DFLS130L-7
D3	82400152	WE-TVS_SOT563	Würth Elektronik	82400152
IC1	FT231XQ	QLP20	FTDI	FT231XQ-R
IC2	TLV1117LV	SOT223-4	Texas Instruments	TLV1117LV30DCYx
L2	7427927311	L0402_WE-MK	Würth Elektronik	7427927311
L5	7427927311	L0402_WE-MK	Würth Elektronik	7427927311
LED1	yellow	0805	Würth Elektronik	150080YS75000
LED2	blue	0805	Würth Elektronik	150080BS75000
LED3	red	0805	Würth Elektronik	150080RS75000
P1	02x11	61002221121	Würth Elektronik	61002221121
P2	01x04	61000418221	Würth Elektronik	61000418221
P3	n.m.	2X03		
P4	n.m.	2X03		
Q2	n.m.	3216	Würth Elektronik	830009678
R1	1K5R	R0402_IPC	Yageo	RC0402FR-071K5L
R2	1K5R	R0402_IPC	Yageo	RC0402FR-071K5L
R3	10R	R0402_IPC	Yageo	RC0402FR-0710RL
R4	10R	R0402_IPC	Yageo	RC0402FR-0710RL
R5	10R	R0402_IPC	Yageo	RC0402FR-0710RL
R6	0R	R0402_IPC	Yageo	RC0402FR-070RL
R7	1K5R	R0402_IPC	Yageo	RC0402FR-071K5L
R8	10R	R0402_IPC	Yageo	RC0402FR-0710RL
R9	10R	R0402_IPC	Yageo	RC0402FR-0710RL
R10	10R	R0402_IPC	Yageo	RC0402FR-0710RL
R11	0R	R0402_IPC	Yageo	RC0402FR-070RL
R12	10R	R0402_IPC	Yageo	RC0402FR-0710RL
R13	n.m.	R0402_IPC	Yageo	RC0402FR-0710RL
S3	430152043826	430152043826	Würth Elektronik	430152043826
T1	n.m.	SOT23		

4 Regulatory compliance information

4.1 European Conformity

Pursuant to Article 1 (2.) of the EU directive 2014/53/EU, Article 1 (2.) the directive does not apply to equipment listed in Annex I (4.): custom-built evaluation kits designed for professionals to be used solely at research and development facilities for such purposes.

4.2 FCC

Pursuant to §2.803 (c) of Title 47 Chapter I Subchapter A Part 2 Subpart I, the evaluation kit falls under the FCC exception. Therefore it is marked as "For evaluation only; not FCC approved for resale".

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5 References

[1] Nordic Semiconductor. Nordic nRF52805 resources. `https://www.nordicsemi.com/products/nrf52805`.

[2] Würth Elektronik. Ophelia-I user manual. `https://www.we-online.de/katalog/de/manual/2612011022000`.

[3] Würth Elektronik. Proteus-e user manual. `https://www.we-online.de/katalog/de/manual/2612011024000`.

[4] Würth Elektronik. Smart Commander PC tool. `https://www.we-online.com/SmartCommander`.

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8 License terms

This 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 this license terms is 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.

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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.

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

8.4 Firmware update(s)

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

8.5 Disclaimer of warranty

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

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

8.9 Miscellaneous

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

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