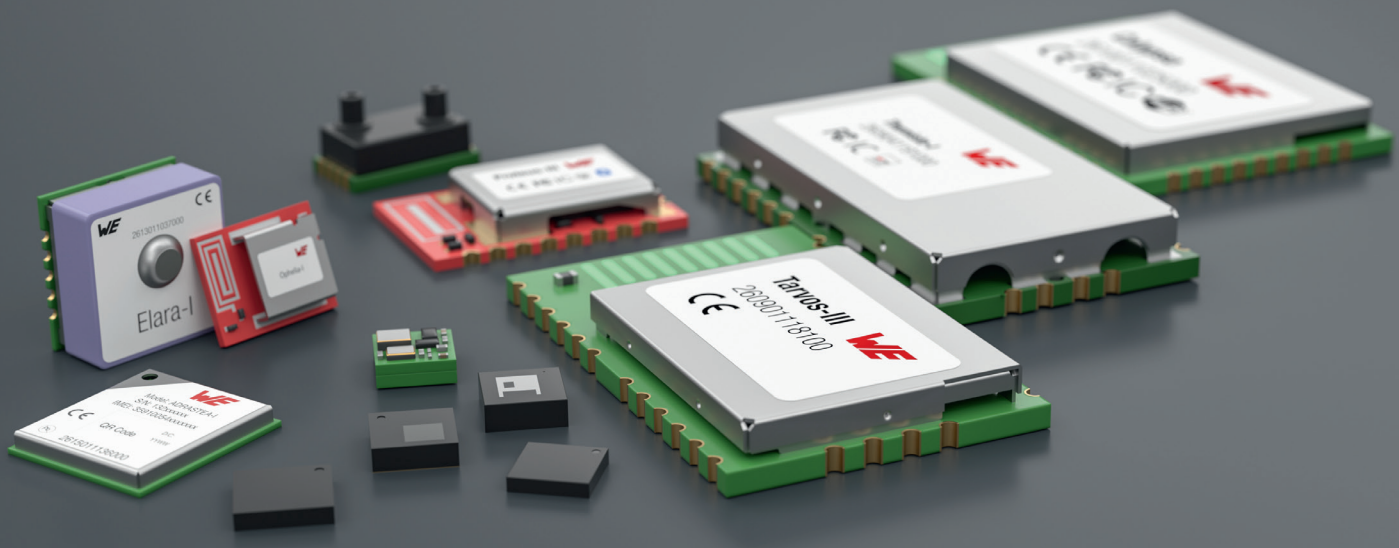

ANR036

Build your own firmware - getting started with Zephyr®

Version 1.0

February 18, 2025

WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

Revision history

Manual version	Notes	Date
1.0	• Initial version	February 2025

Abbreviations

Abbreviation	Description
BYOF	Build Your Own Firmware
EV	Evaluation Board / Kit
OS	Operating System
SDK	Software Development Kit
WE	Würth Elektronik eiSos

Contents

Overview of helpful application notes

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

Zephyr® OS [1, 2] is an operating system for micro-controllers distributed by the Linux® Foundation and used in many end devices. This operating system includes features like multi-threading and dynamic memory allocation. It also supports various radio stacks and provides many functions for using external electronic components, such as sensors, radio modules, and displays.

Besides the radio modules with integrated firmware, Würth Elektronik eiSos also offers various BYOF (build your own firmware) variants of them. These radio modules come without firmware and are therefore highly suited to develop optimized custom solutions for special applications.

Examples for custom firmwares:

- A firmware on base of the Ophelia-I BYOF module [3], whose only task is to transmit Bluetooth® LE beacons. This is the optimal solution in terms of cost and energy efficiency for applications where Bluetooth® LE beacons are needed. In that scenario, the Bluetooth® LE radio stack integrated in Zephyr® OS is combined with the Ophelia-I hardware to reach highest efficiency.
- A firmware on base of the Oceanus-I BYOF module [4], that collects sensor data from temperature and humidity sensors via I^2C and transmits them via LoRa®. This is typical example for IoT-enabled weather stations. Here the LoRa® radio stack and sensor drivers integrated in Zephyr® OS are combined with the Oceanus-I hardware to create a standalone[1] solution.
  As an alternative, the Ophelia-III BYOF module [5] and the integrated Bluetooth® LE stack can be used for that application. In this scenario data can be transmitted directly to a smart phone.

To be able to use the integrated Zephyr® stacks and features on Würth Elektronik eiSos radio module hardware, Würth Elektronik eiSos integrated the hardware description of their BYOF modules into the Zephyr® SDK[2]. With this, the BYOF hardware platform of interest can be simply selected during firmware development using the Zephyr® SDK.

[1] Standalone: No external microcontroller is needed. All functions are implemented in the chipset of the radio module.
[2] Besides of this, the drivers of various Würth Elektronik eiSos sensors are available as well.

2 Provided BYOF platforms

For the radio module of interest, Zephyr® SDK contains the corresponding hardware description of the underlying evaluation board. The following platforms are available:

Oceanus-I EV (2618019382001)

- Radio module Oceanus-I (2618011182000) [6] using chipset STM32WLE5CCU6 [7]
- 868 MHz proprietary and LoRa® radio
- Available since Zephyr® 4.1 under *./zephyr/boards/we/oceanus1ev*

Ophelia-I EV (2612019022001)

- Radio module Ophelia-I (2612011022000) [8] using chipset nRF52805 [9]
- 2.4 GHz proprietary and Bluetooth® LE radio
- Available since Zephyr® 4.1 under *./zephyr/boards/we/ophelia1ev*

Ophelia-III Family EV (2611149022001)

- Radio module Ophelia-III (2611011022000) [10] using chipset nRF52840 [11]
- 2.4 GHz proprietary, 802.15.4 and Bluetooth® LE radio
- Available since Zephyr® 4.1 under *./zephyr/boards/we/proteus3ev*

Orthosie-I EV (2617029022001)

- Radio module Orthosie-I (2617011022000) [12] using chipset ESP32-C3 [13]
- 2.4 GHz WiFi 802.11b/g/n and Bluetooth® LE radio
- Available since Zephyr® 4.1 under *./zephyr/boards/we/orthosie1ev*

Proteus-II Family EV (2608049024011)

- Radio module using Proteus-II[2] (2608011024010) [14] using chipset nRF52832 [15]
- 2.4 GHz proprietary, 802.15.4 and Bluetooth® LE radio
- Available since Zephyr® 4.1 under *./zephyr/boards/we/proteus2ev*

[2]For this platform, there is no empty hardware. Please use Proteus-II instead and erase the firmware.

3 Getting started

This chapter describes the steps which need to be done to have an example project running on a chosen *WE* radio module platform.

3.1 Zephyr® toolchain and SDK installation

First of all, the Zephyr® build system must be installed on the PC. This includes the tools of the toolchain for building Zephyr® projects, as well as the Zephyr® SDK [1] containing the source code of the Zephyr® OS, examples, platform definitions and drivers. Please refer to the Zephyr® installation instruction available on:
https://docs.zephyrproject.org/latest/develop/getting_started/index.html

Besides of that the flasher probe (i.e. Segger j-link [16]) needs to be installed, if not already done for other projects.

3.2 Choose examples and hardware platform

Once this is done, choose a recommended example for the hardware platform of interest.

Platform	Recommended example	Location
Oceanus-I EV-Board	Repeated transmission of LoRa® frames	*./zephyr/samples/drivers/lora/send*
	Reception of LoRa® frames	*./zephyr/samples/drivers/lora/receive*
Ophelia-I EV-Board	Bluetooth® LE peripheral heart rate GATT service	*./zephyr/samples/bluetooth/peripheral_hr*
Ophelia-III Family EV-Board	Bluetooth® LE peripheral role functionality	*./zephyr/samples/bluetooth/peripheral*
Orthosie-I EV-Board	Bluetooth® LE peripheral role functionality	*./zephyr/samples/bluetooth/peripheral*
	WiFi shell module that provides a set of commands	*./zephyr/samples/net/wifi/shell*
Proteus-II Family EV-Board	Bluetooth® LE peripheral role functionality	*./zephyr/samples/bluetooth/peripheral*

Table 1: Recommended examples

3.3 Compiling the example

Once the example has been chosen, open the command line and enter the zephyr directory:

```
cd %HOMEPATH%\zephyrproject\zephyr
```

Then run the build command:

```
west build -p always -b <your-board-name> <example-directory>
```

For Oceanus-I EV-Board using the "LoRa® send" example, the build command is as follows:

```
west build -p always -b we_oceanus1ev samples/drivers/lora/send
```

For Ophelia-I EV-Board using the "Bluetooth® LE peripheral heart rate" example, the build command is as follows:

```
west build -p always -b we_opheliа1ev samples/bluetooth/peripheral_hr -DCONF_FILE=
    prj_minimal.conf
```

The minimal build configuration file is needed due to the size limitations of the flash and ram.

3.4 Prepare the hardware

Once the compilation of the example has been succeeded, the hardware needs to be prepared. Please check the product specific user manual to clarify the following points:

1. Which jumpers need to be set, which need to be removed?
2. How can I supply power to the board?
3. Where can I connect the debug probe (i.e. Segger j-link)?

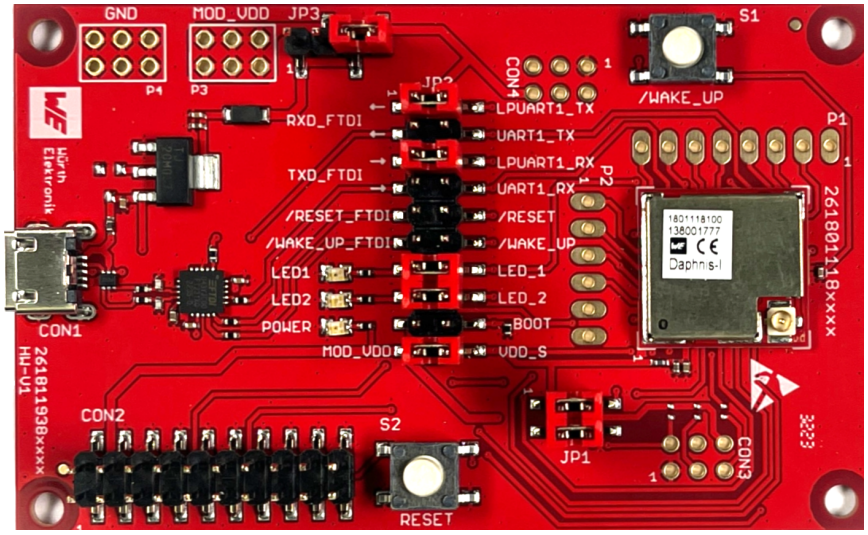

Figure 1: Oceanus-I EV-Board

On Oceanus-I EV-Board the jumpers of JP1 (1-2,3-4), JP2 (19-20) and JP3 (3-4) must be set to power the module. With this, the module is powered by the USB plug.
In case the UART shall be used for debugging, the jumpers JP2 (1-2,5-6) need to be set as well to connect the UART to the COM port of the USB plug.
For flashing and debugging the JTAG debug probe can be connected to CON2.

3.5 Flashing the example

Once the EV-Board is ready, the compiled example can be flashed using the following command:

```
west flash
```

In case the debugging option was enabled in the example, the debug messages can be seen, after opening the corresponding COM port in a terminal PC tool, like hterm [17].

4 References

[1] Zephyr OS on GitHub. https://github.com/zephyrproject-rtos/zephyr.

[2] Zephyr Organization. https://zephyrproject.org/.

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

[4] Würth Elektronik. Oceanus-I user manual. https://www.we-online.de/katalog/de/manual/2618011182000.

[5] Würth Elektronik. Ophelia-III user manual. https://www.we-online.de/katalog/de/manual/2611011022000.

[6] Würth Elektronik. Web page: Oceanus-I radio module. https://www.we-online.de/katalog/de/article/2618011182000.

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[8] Würth Elektronik. Web page: Ophelia-I radio module. https://www.we-online.de/katalog/de/article/2612011022000.

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

[10] Würth Elektronik. Web page: Ophelia-III radio module. https://www.we-online.de/katalog/de/article/2611011022000.

[11] Nordic Semiconductor. Nordic nRF52840 resources. https://www.nordicsemi.com/products/nrf52840.

[12] Würth Elektronik. Web page: Orthosie-III radio module. https://www.we-online.de/katalog/de/article/2617011022000.

[13] Espressif. Espressif ESP32C3 chipset. https://www.espressif.com/en/products/socs/esp32-c3.

[14] Würth Elektronik. Web page: Proteus-II radio module. https://www.we-online.de/katalog/de/article/2608011024010.

[15] Nordic Semiconductor. Nordic nRF52832 resources. https://www.nordicsemi.com/products/nrf52832.

[16] SEGGER J-Link debug probes. https://www.segger.com/products/debug-probes/j-link/.

[17] hterm. Terminal program. https://www.der-hammer.info/pages/terminal.html.

5 Important notes

The Application Note and its containing information ("Information") is based on Würth Elektronik eiSos GmbH & Co. KG and its subsidiaries and affiliates ("WE eiSos") knowledge and experience of typical requirements concerning these areas. It serves as general guidance and shall not be construed as a commitment for the suitability for customer applications by WE eiSos. While WE eiSos has used reasonable efforts to ensure the accuracy of the Information, WE eiSos does not guarantee that the Information is error-free, nor makes any other representation, warranty or guarantee that the Information is completely accurate or up-to-date. The Information is subject to change without notice. To the extent permitted by law, the Information shall not be reproduced or copied without WE eiSos' prior written permission. In any case, the Information, in full or in parts, may not be altered, falsified or distorted nor be used for any unauthorized purpose.

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Contact
Würth Elektronik eiSos GmbH & Co. KG
Division Wireless Connectivity & Sensors

Max-Eyth-Straße 1
74638 Waldenburg
Germany

Tel.: +49 651 99355-0
Fax.: +49 651 99355-69
www.we-online.com/wireless-connectivity