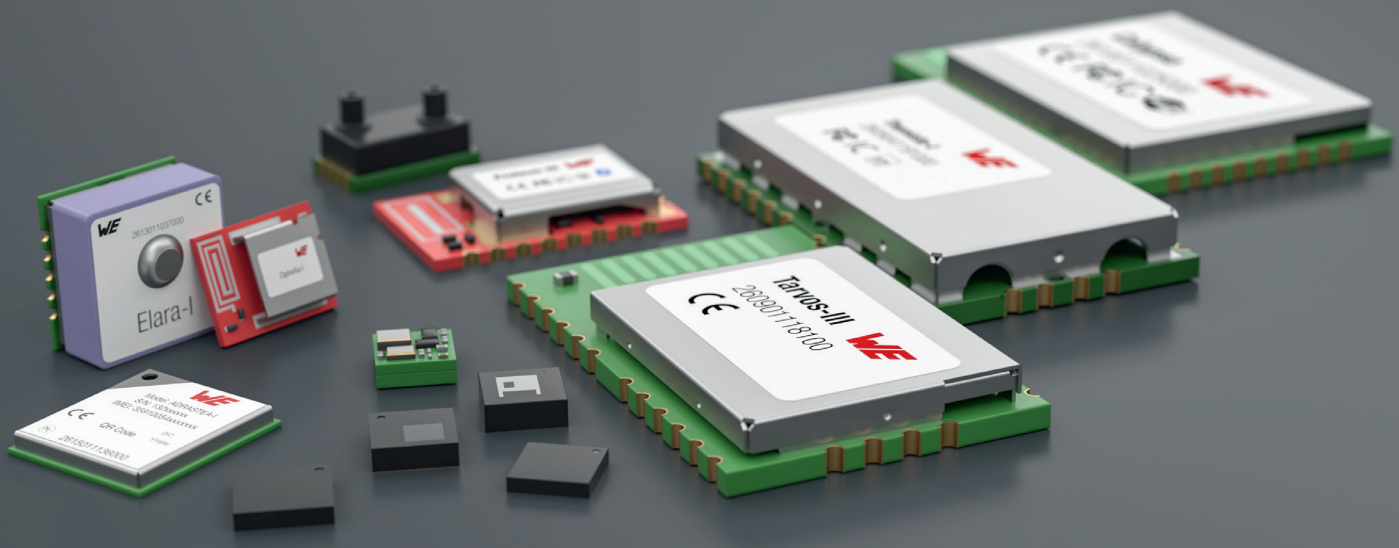

ANR016

Radio Module Migration Guide

Always be up to date: Replacing a radio module by its successor

Version 1.9

February 11, 2025

WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

Revision history

Manual version	Notes	Date
1.0	• Initial version	October 2019
1.1	• Added Proteus-III	February 2020
1.2	• Update `Tarvos-I to Tarvos-III` chapter due to Tarvos-III firmware update affecting transparent mode • Update `Tarvos-II to Tarvos-III` chapter due to Tarvos-III firmware update affecting transparent mode • Update `Thebe-I to Thebe-II` chapter due to Thebe-II firmware update affecting transparent mode • Improvements for Proteus chapters	January 2021
1.3	• Added chapters `Telesto-III to Themisto-I` and `Tarvos-III to Thebe-II`	January 2021
1.4	• Added chapter `Thadeus to Tarvos-III`	July 2021
1.5	• Added chapters `Tarvos/AMB8420 to Tarvos-III` and `References`	September 2021
1.6	• Added chapters `Proteus-II to Proteus-e` and `Proteus-III to Proteus-e`	March 2022

1.7	• Updated `Important notes`, meta data and document style	July 2023
1.8	• Added chapter `Thyone-I to Thyone-e`	August 2024
1.9	• Added chapter `Puck-I to Skoll-I`	February 2025

Abbreviations

Abbreviation	Name	Description
ACK	Acknowledgement	Radio packet sent back to the transmitter to acknowledge the reception of data.
	Blocking	The ability to receive the wanted radio signal with close radio noise.
LRM	Long range mode	Special radio profile for large transmission ranges.
	Payload	The intended message in a frame / package.
RF	Radio frequency	Describes wireless transmission.
SRD	Short Range Device	Unlicensed frequency bands.

Contents

1 Introduction

The radio frequency spectrum is regulated by designated regulatory authorities that define how specific spectrum bands can be used. As each frequency band has its strength, Würth Elektronik eiSos provides for each frequency band proprietary radio modules, which allow energy efficient and fast data transmission.

With the evolution of radio chips, new proprietary radio modules have been developed, that are more energy efficient during data transmission and reception. Furthermore new coding and modulation techniques have been added, that allow higher transmission ranges (long range mode) and/or higher data rates.

Due to this natural evolution, when redesigning a device that is already using a proprietary radio module, it is recommended to use the latest member of the corresponding radio module family.

This application note describes the key factors to be considered, when replacing a proprietary Würth Elektronik eiSos radio module with its successor from the same family.

Due to changes in hardware platform and firmware when replacing a radio module with its successor, the end device's radio certification becomes void. A new radio certification or declaration needs to be acquired by performing actions according to the local statutory requirements at the location of deployment.

If a switch from 868 MHz to 915 MHz is desired to serve also the North American market, the application note ANR015 [1] describes the necessary steps to be performed.

2 Thadeus to Tarvos-III

The Thadeus is a 434 MHz proprietary radio module. The Tarvos-III is a 868-MHz radio module of a later generation, that reduces the power consumption, improves the blocking capabilities and provides new modulation techniques to boost the transmission range.

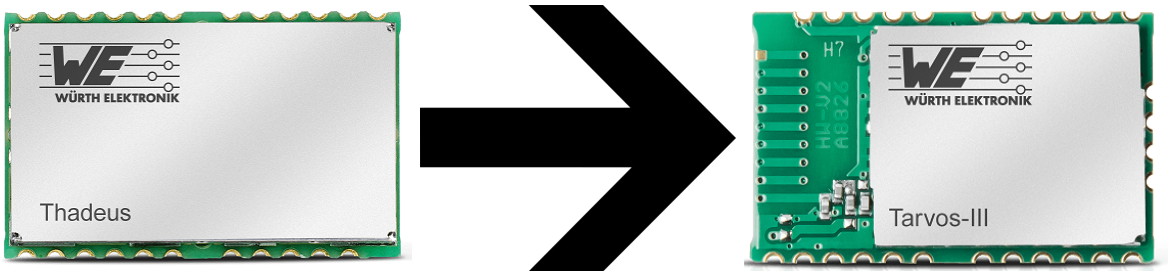

Figure 1: Thadeus to Tarvos-III

2.1 Summary

In comparison to the Thadeus, the Tarvos-III has 4 additional pins. Since the size and the remaining footprint of the two modules are the same, the Thadeus can be replaced by the Tarvos-III, if no underlying non-insulated copper area touches the 4 new pins of the Tarvos-III. Besides of this, a few pin functions changed, such that the sleep mode for example has to be triggered in a different way on the Tarvos-III. Due to this, and due to new firmware functions the host firmware must be adapted to communicate with the Tarvos-III.
Radio compatibility of both modules is not given as both operate in different frequency bands. Nevertheless, the radio features like addressing or acknowledgements remain the same.

2.2 Hardware adaption

2.2.1 Foot print

Both Thadeus and Tarvos-III have the same dimensions of 17×27×4 mm with the pins located at the same positions. The only change in the footprint is the presence of 4 additional pins (i1-i4) of the JTAG interface on the Tarvos-III.
If a design has been made for Thadeus, the footprint matches the Tarvos-III, if no underlying non-insulated copper area touches the JTAG pins i1-i4 of the Tarvos-III.

In addition to the radio signal to an external antenna on pin 1, the Tarvos-III offers an alternative option to use the on-board PCB antenna. The order code for Tarvos-III with external antenna is 260901118100x. The integrated PCB antenna with reduced efficiency is available using order code 260901108100x.

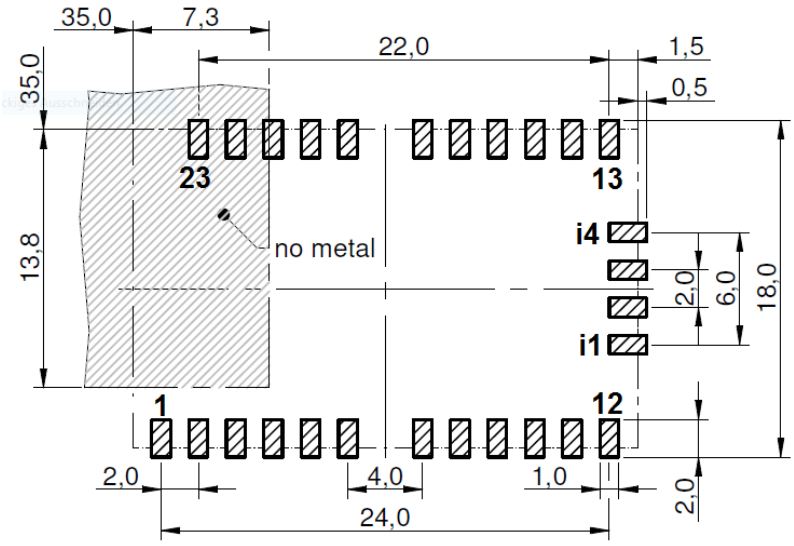

Figure 2: Universal footprint

2.2.2 Pinout

Although the Thadeus and Tarvos-III share the same footprint, some of the pin functions differ on the new hardware platform. The main pin functions such as power supply and UART use the same footprint pin on both modules:

Pin No.	Thadeus	Tarvos-III	Comment
1	*ANT*	*ANT*	Antenna pin connection
2	*GND*	*GND*	Ground
3	*VCC*	*VCC*	Supply voltage
4	*UTXD*	*UTXD*	UART TX
5	*URXD*	*URXD*	UART RX
6	*/RTS*	*/RTS*	UART */RTS*
9	*RESERVED*	*RESERVED*	
10	*RESERVED*	*RESERVED*	
16	*RESERVED*	*RESERVED*	
17	*RESERVED*	*RESERVED*	
18	*RESERVED*	*RESERVED*	
19	*/RESET*	*/RESET*	Reset pin
20	*/TX_IND*	*/TX_IND*	Pin indicating when a radio packet is transmitted
21	*/RX_IND*	*/RX_IND*	Pin indicating when a radio packet is received
22	*RESERVED*	*RESERVED*	
23	*GND*	*GND*	Ground

Table 1: Pins with same functions on both, Thadeus and Tarvos-III

But pins with special functions changed:

Pin No.	Thadeus	Tarvos-III	Comment
7	*/CTS*	*RESERVED*	*/CTS* function no longer supported.
8	*DATA_IND*	*RESERVED*	*DATA_IND* function no longer supported.
11	*DATA_REQ*	*RESERVED*	*DATA_REQ* function no longer supported.
12	*RESERVED*	*BOOT*	The *BOOT* pin is used on the Tarvos-III to set the module into boot mode, where the module's firmware can be updated using the ACC tool.
13	*SLEEP*	*RESERVED*	Sleep function by pin no longer supported, as the Tarvos-III enters the sleep modes via command.
14	*TRX_DISABLE*	*WAKE-UP*	Pin function changed. The *WAKE-UP* pin is used to wake-up the module from sleep mode.
15	*/CONFIG*	*MODE_1*	The *MODE_1* pin is used on the Tarvos-III to determine the operating mode during boot. In contrast to the Thadeus, switching between transparent mode and command mode is not possible during runtime by using the *MODE_1* pin.

Table 2: Pins of the Thadeus and Tarvos-III that have different functions

2.2.3 Antenna

The Tarvos-III is available in two hardware variants. The first variant provides the radio signal at the *ANT* pin, the same as Thadeus. Using this variant an external antenna matched to 50 Ω can be connected at this pin.
The second variant of the Tarvos-III offers an internal PCB antenna. Using this variant the *ANT* pin has no function and can be left open. No external antenna has to be connected.

2.3 Host firmware adaption

2.3.1 Command Mode

If you are not already using command mode we recommend to switch over to using command mode whenever your application can be adopted.

2.3.2 UART interface

The Thadeus uses 9600 Baud 8n1 and Tarvos-III uses 115200 Baud 8n1 by default. The Thadeus provides the command and transparent mode on the UART (transparent mode by default). The Tarvos-III provides the command mode and, using firmware version 3.0.0 or higher, the transparent mode (command mode by default).
The command interface on the UART uses of the same command structure. The UART

command numbers itself and range of parameter values for a specific command may differ. Thus the command interface must be updated in the host controller. The source codes of the command interface for host integration are available in the Wireless Connectivity SDK on GitHub [2, 3].

2.3.3 Radio interface

The radio interfaces of the Tarvos-III and Thadeus are not compatible as different radio profiles and radio channels (frequencies) are used. Nevertheless, both radio modules support radio features like addressing and acknowledgment.

2.3.4 Power saving modes

As the pins *SLEEP* and *TRX_DISABLE* of the Thadeus are no more available on the Tarvos-III, the low power modes are handled in a different way. The Tarvos-III does not enable the possibility to switch off the radio exclusively by a pin, but allows to enter into two different sleep modes via UART command. The Tarvos-III can be woken up again from any sleep mode using the *WAKE-UP* pin, which is at the location of the Thadeus *TRX_DISABLE* pin.

2.3.5 Boot mode

The Tarvos-III needs to be set to boot mode, if a firmware update is performed. To switch the boot mode on, the *BOOT* pin has to be handled by host controller. The firmware update uses the UART interface at the dedicated module UART pins. Both, Thadeus and Tarvos-III can be connected to the ACC PC tool to perform changes in user settings and a firmware update. Please refer to the product specific details for the firmware update.

2.3.6 Timings

Due to change of the underlying hardware, especially the CPU and radio IC, as well as the use of an RTOS (real time operating system) in the Tarvos-III, most of the timing parameters have slightly changed. Some were decreased, but others increased.
Due to the CPU change and the RTOS the UART RX of the module is now using a shift register of 32 bit instead of 8 bit, which will introduce (worst case) a latency of up to 3 additional byte durations (depending on the selected UART data rate) to each received UART message (command or transparent).
The host-application needs to take this changed timings into account to be able to use the Tarvos-III as replacement.

2.3.7 Transparent mode

Tarvos-III firmware 3.0.0 or newer is required for transparent mode support.

3 Tarvos/AMB8420 to Tarvos-III

The Tarvos series is a family of 868 MHz proprietary radio modules. The Tarvos (formerly known as AMB8420) has been succeeded by the Tarvos-III, that reduces the power consumption and provides a cleaner frequency spectrum, improved blocking capabilities and new modulation techniques to boost the transmission range.

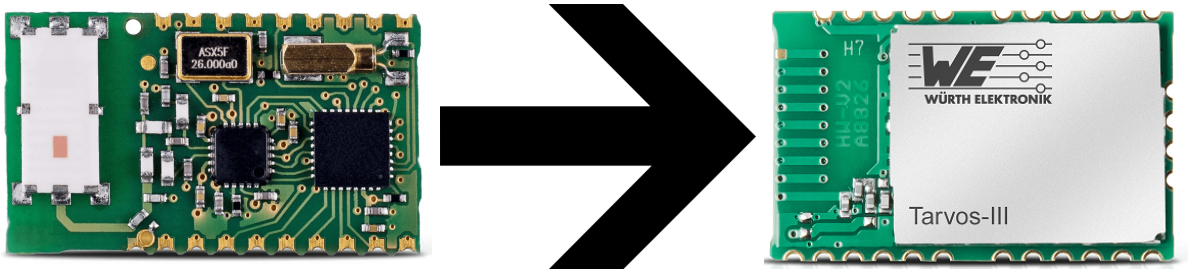

Figure 3: Tarvos to Tarvos-III

3.1 Summary

In comparison to the Tarvos, the Tarvos-III has a slightly different size and footprint. Both radio modules are available with internal antenna and as a variant with the radio signal on the module pad for external antenna connection.
A few pin and software functions changed, such that the host firmware must be adapted to communicate with the Tarvos-III.
Radio compatibility of both modules is given under certain conditions.

If the host cannot be adopted it may not be possible to perform migration to a more recent product.

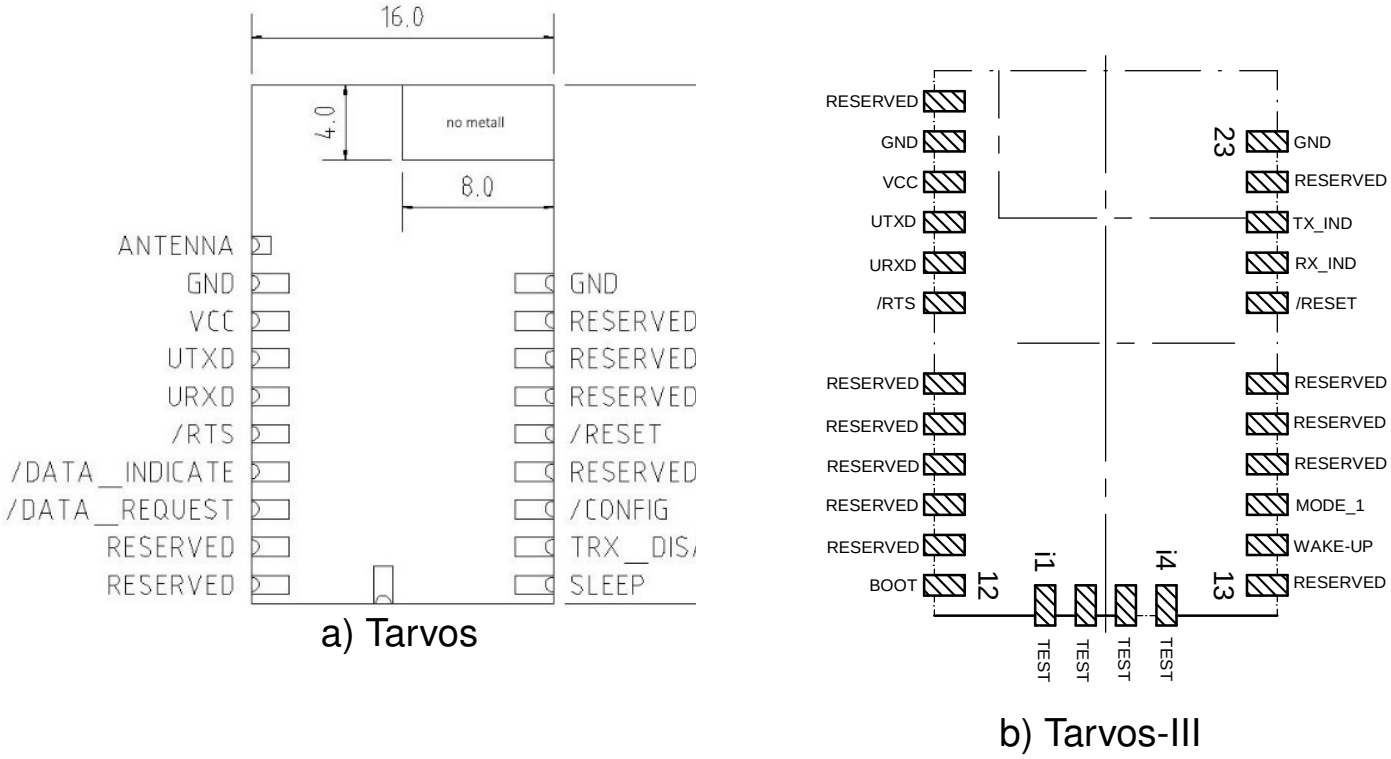

Figure 4: Pinout

3.2 Hardware adaption

3.2.1 Foot print

Both Tarvos and Tarvos-III have similar but not identical dimensions. Where the Tarvos has the size of 16×27.5 mm, the Tarvos-III is 17×27 mm. In addition to that Tarvos-III has additional pins and new pad locations.

3.2.2 Pinout

The pinout of both modules is very similar. The main functions such as power supply, reset and UART share the same pins, but special pin functions have been updated.
In detail, the *DATA_REQUEST*, *DATA_INDICATION*, *TRX_DISABLE* and *SLEEP* pins have been replaced by the *WAKE_UP*, *TX_IND* and *RX_IND* pins. This has the effect that it's not longer possible to trigger the radio transmission and sleep mode via pin. Both, the data transmission as well as the sleep mode have to be triggered by UART commands. The wake-up from sleep mode is still possible via the *WAKE_UP* pin.
The switch between transparent and command mode is now done via the *MODE_1* pin, that replaces the *CONFIG* pin and defines the operation mode right after the start-up of the module.
Last but not least a *BOOT* pin has been added, that allows the Tarvos-III to enter the boot mode for firmware updates via the UART.

3.2.3 Antenna

The Tarvos and the Tarvos-III are available in two hardware variants. The first variant provides the radio signal at the *ANT* pin. Using this variant an external antenna matched to 50 Ω can be connected at this pin.
The second variant offers an internal PCB antenna. Using this variant the *ANT* pin has no function and can be left open. No external antenna has to be connected.

3.3 Host firmware adaption

3.3.1 Command Mode

If you are not already using command mode, we recommend to switch over to using command mode whenever your application can be adopted.

3.3.2 UART interface

The Tarvos uses 9600 Baud 8n1 and Tarvos-III uses 115200 Baud 8n1 by default. The Tarvos provides the command and transparent mode on the UART (transparent mode by default). The Tarvos-III provides the command mode and, using firmware version 3.0.0 or higher, the transparent mode (command mode by default).
The command interface on the UART uses of the same command structure. The UART command numbers itself and range of parameter values for a specific command may differ. Thus the command interface must be updated in the host controller. The source codes of the command interface for host integration are available in the Wireless Connectivity SDK on GitHub [2, 3].

3.3.3 Radio interface

The Tarvos-III is supporting more radio channels and radio profiles than available on Tarvos.
Both radio modules support the 38.4 kbps and 100 kbps radio profile as well as radio channels 102 - 110. If one of these radio channels and radio profiles is used, the Tarvos and Tarvos-III are radio compatible provided that acknowledgements are disabled. The radio timing behavior must be adapted using the respective user settings to allow the communication between Tarvos and Tarvos-III, in case acknowlegdements are enabled.
Using these radio settings, a higher radio range can be achieved compared to Tarvos owing to the higher default transmission power of Tarvos-III.
The new radio profiles of the Tarvos-III are incompatible to the previous Tarvos generations, but offer various advantages. The radio profiles 3 and 4 allow a higher transmission range, where radio profile 5 provides a fast data transmission due to the increased data-rate.

Radio profile	Data rate (gross) [kbps]	Max payload size [Byte]	Radio channels
-	4.8	128[2]	102 - 110
-	10	128[2]	102 - 110
-	38.4	128[2]	103 - 109
-	76.8	128[2]	104 - 108
-	100	128[2]	105 - 107

Table 3: Radio profiles of the Tarvos

Radio profile	Data rate (gross) [kbps]	Max payload size [Byte]	Radio channels
0	38.4	128	1 - 139
2	100	128	1 - 139
3 (LRM)	10 (=0.625 kbps net)	48	1 - 139
4 (LRM)	20 (=2.5 kbps net)	64	1 - 139
5	400	224	1 - 139

Table 4: Radio profiles of the Tarvos-III

3.3.4 Power saving modes

As the pins *SLEEP* and *TRX_DISABLE* of the Tarvos are no more available on the Tarvos-III, the low power modes are handled in a different way. The Tarvos-III does not enable the possibility to switch off the radio exclusively via pin, but allows to enter into two different sleep modes via UART command. The Tarvos-III can be woken from any sleep mode using the *WAKE-UP* pin, which is at the location of the Tarvos *TRX_DISABLE* pin.

3.3.5 Boot mode

The Tarvos-III needs to be set to boot mode, if a firmware update is performed. To switch the boot mode on, the *BOOT* pin has to be handled by host controller. The firmware update uses the UART interface at the dedicated module UART pins. Both, Tarvos and Tarvos-III can be connected to the ACC PC tool to perform changes in user settings and a firmware update. Please refer to the product specific details for the firmware update.

3.3.6 Timings

Due to change of the underlying hardware, especially the CPU and radio IC, as well as the use of an RTOS (real time operating system) in the Tarvos-III, most of the timing parameters have slightly changed. Some were decreased, but others increased.

[2]The maximum payload size depends on the selected address mode.

Due to the CPU change and the RTOS the UART RX of the module is now using a shift register of 32 bit instead of 8 bit, which will introduce (worst case) a latency of up to 3 additional byte durations (depending on the selected UART data rate) to each received UART message (command or transparent).
The host-application needs to take this changed timings into account to be able to use the Tarvos-III as replacement.

3.3.7 Switch between transparent and command mode

Tarvos-III firmware 3.0.0 or newer is required for transparent mode support.

The *CONFIG* pin has been replaced by the *MODE_1* pin, that defines the operation mode after module start-up by the pin level. During operation the mode can be switched by UART commands.

4 Tarvos-I to Tarvos-III

The Tarvos series is a family of 868 MHz proprietary radio modules. The Tarvos-I has been succeeded by the Tarvos-II (chapter 5), that scores with lower sleep, transmission and receptions currents, as well with a cleaner frequency spectrum. The Tarvos-II itself has been succeeded by the Tarvos-III, that further reduces the power consumption and provides new modulation techniques to boost the transmission range. Each generation also includes improvements in the blocking capabilities.

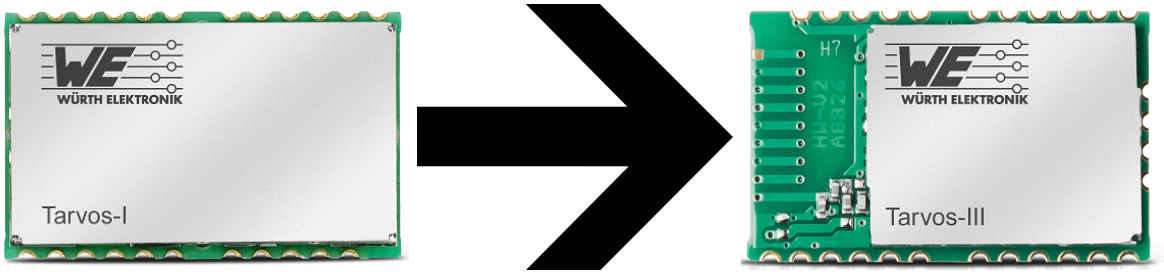

Figure 5: Tarvos-I to Tarvos-III

4.1 Summary

In comparison to the Tarvos-I, the Tarvos-III has 4 additional pins. Since the size and the remaining footprint of the two modules are the same, the Tarvos-I can be replaced by the Tarvos-III, if no underlying non-insulated copper area touches the 4 new pins of the Tarvos-III. Besides of this, a few pin functions changed, such that the sleep mode for example has to be triggered in a different way on the Tarvos-III. Due to this, and due to new firmware functions the host firmware must be adapted to communicate with the Tarvos-III.
Radio compatibility of both modules is given in most operation modes.

If the host cannot be adopted it may not be possible to perform migration to a more recent product.

4.2 Hardware adaption

4.2.1 Foot print

Both Tarvos-I and Tarvos-III have the same dimensions of 17×27×4 mm with the pins located at the same positions. The only change in the footprint is the presence of 4 additional pins (i1-i4) of the JTAG interface on the Tarvos-III.
If a design has been made for Tarvos-I, the footprint matches the Tarvos-III, if no underlying non-insulated copper area touches the JTAG pins i1-i4 of the Tarvos-III.

In addition to the radio signal to an external antenna on pin 1, the Tarvos-III offers an alternative option to use the on-board PCB antenna. In order to ensure a comparable radio performance to Tarvos-I, it is recommended to use the variant with antenna pin to connect to an external antenna. The order code for Tarvos-III with external antenna is 260901118100x. The integrated PCB antenna with reduced efficiency is available using order code 260901108100x.

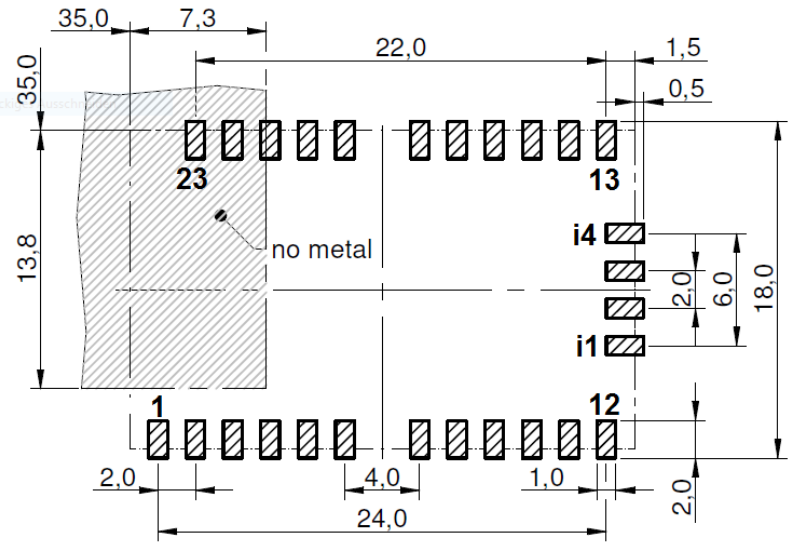

Figure 6: Universal footprint

4.2.2 Pinout

Although the Tarvos-I and Tarvos-III share the same footprint, some of the pin functions differ on the new hardware platform. The main pin functions such as power supply and UART use the same footprint pin on both modules:

Pin No.	Tarvos-I	Tarvos-III	Comment
1	*ANT*	*ANT*	Antenna pin connection
2	*GND*	*GND*	Ground
3	*VCC*	*VCC*	Supply voltage
4	*UTXD*	*UTXD*	UART TX
5	*URXD*	*URXD*	UART RX
6	*/RTS*	*/RTS*	UART */RTS*
9	*RESERVED*	*RESERVED*	
10	*RESERVED*	*RESERVED*	
16	*RESERVED*	*RESERVED*	
17	*RESERVED*	*RESERVED*	
18	*RESERVED*	*RESERVED*	
19	*/RESET*	*/RESET*	Reset pin
20	*/TX_IND*	*/TX_IND*	Pin indicating when a radio packet is transmitted
21	*/RX_IND*	*/RX_IND*	Pin indicating when a radio packet is received
22	*RESERVED*	*RESERVED*	
23	*GND*	*GND*	Ground

Table 5: Pins with same functions on both, Tarvos-I and Tarvos-III

But pins with special functions changed:

Pin No.	Tarvos-I	Tarvos-III	Comment
7	*/CTS*	*RESERVED*	*/CTS* function no longer supported.
8	*DATA_IND*	*RESERVED*	*DATA_IND* function no longer supported.
11	*DATA_REQ*	*RESERVED*	*DATA_REQ* function no longer supported.
12	*RESERVED*	*BOOT*	The *BOOT* pin is used on the Tarvos-III to set the module into boot mode, where the module's firmware can be updated using the ACC tool.
13	*SLEEP*	*RESERVED*	Sleep function by pin no longer supported, as the Tarvos-III enters the sleep modes via command.
14	*TRX_DISABLE*	*WAKE-UP*	Pin function changed. The *WAKE-UP* pin is used to wake-up the module from sleep mode.
15	*/CONFIG*	*MODE_1*	The *MODE_1* pin is used on the Tarvos-III to determine the operating mode during boot. In contrast to the Tarvos-I, switching between transparent mode and command mode is not possible during runtime by using the *MODE_1* pin.

Table 6: Pins of the Tarvos-I and Tarvos-III that have different functions

4.2.3 Antenna

The Tarvos-III is available in two hardware variants. The first variant provides the radio signal at the *ANT* pin, the same as Tarvos-I. Using this variant an external antenna matched to 50 Ω can be connected at this pin.
The second variant of the Tarvos-III offers an internal PCB antenna. Using this variant the *ANT* pin has no function and can be left open. No external antenna has to be connected.

4.3 Host firmware adaption

4.3.1 Command Mode

If you are not already using command mode we recommend to switch over to using command mode whenever your application can be adopted.

4.3.2 UART interface

The Tarvos-I uses 9600 Baud 8n1 and Tarvos-III uses 115200 Baud 8n1 by default. The Tarvos-I provides the command and transparent mode on the UART (transparent mode by default). The Tarvos-III provides the command mode and, using firmware version 3.0.0 or higher, the transparent mode (command mode by default).
The command interface on the UART uses of the same command structure. The UART

command numbers itself and range of parameter values for a specific command may differ. Thus the command interface must be updated in the host controller. The source codes of the command interface for host integration are available in the Wireless Connectivity SDK on GitHub [2, 3].

4.3.3 Radio interface

The radio interface of the Tarvos-III is compatible to that of Tarvos-I provided that the Tarvos-III is configured to use the 38.4 kbps or the 100 kbps profile with the radio settings as described in section 4.3.3.1. Using these radio settings, a higher radio range can be achieved compared to Tarvos-I owing to the higher default transmission power of Tarvos-III. The new radio profiles of the Tarvos-III are incompatible to the previous Tarvos generations, but offer various advantages. The radio profiles 3 and 4 allow a higher transmission range, where radio profile 5 provides a fast data transmission due to the increased data-rate.
Furthermore, all the radio channels, that are used by the Tarvos-I, are also supported by the Tarvos-III.

Radio profile	Data rate (gross) [kbps]	Max payload size [Byte]	Radio channels
-	4.8	128[2]	101 - 111
-	10	128[2]	101 - 111
-	38.4	128[2]	101 - 111
-	76.8	128[2]	101 - 111
-	100	128[2]	101 - 111

Table 7: Radio profiles of the Tarvos-I

Radio profile	Data rate (gross) [kbps]	Max payload size [Byte]	Radio channels
0	38.4	128	1 - 139
2	100	128	1 - 139
3 (LRM)	10 (=0.625 kbps net)	48	1 - 139
4 (LRM)	20 (=2.5 kbps net)	64	1 - 139
5	400	224	1 - 139

Table 8: Radio profiles of the Tarvos-III

4.3.3.1 Radio compatibility settings

General: Tarvos-I firmware must be of version 2.1.0 or later.

[2]The maximum payload size depends on the selected address mode.

Address mode: Tarvos-I supports only address mode 0 and 1.

Addresses: The Tarvos-III uses broadcast addresses by default, where as the Tarvos-I uses 0 as default destination address and network ID.

Timings: The ACK timeouts must be adjusted to ensure interoperability between Tarvos-III and Tarvos-I, when using acknowledgements.

4.3.4 Power saving modes

As the pins *SLEEP* and *TRX_DISABLE* of the Tarvos-I are no more available on the Tarvos-III, the low power modes are handled in a different way. The Tarvos-III does not enable the possibility to switch off the radio exclusively by a pin, but allows to enter into two different sleep modes via UART command. The Tarvos-III can be woken up again from any sleep mode using the *WAKE-UP* pin, which is at the location of the Tarvos-I *TRX_DISABLE* pin.

4.3.5 Boot mode

The Tarvos-III needs to be set to boot mode, if a firmware update is performed. To switch the boot mode on, the *BOOT* pin has to be handled by host controller. The firmware update uses the UART interface at the dedicated module UART pins. Both, Tarvos-I and Tarvos-III can be connected to the ACC PC tool to perform changes in user settings and a firmware update. Please refer to the product specific details for the firmware update.

4.3.6 Timings

Due to change of the underlying hardware, especially the CPU and radio IC, as well as the use of an RTOS (real time operating system) in the Tarvos-III, most of the timing parameters have slightly changed. Some were decreased, but others increased.
Due to the CPU change and the RTOS the UART RX of the module is now using a shift register of 32 bit instead of 8 bit, which will introduce (worst case) a latency of up to 3 additional byte durations (depending on the selected UART data rate) to each received UART message (command or transparent).
The host-application needs to take this changed timings into account to be able to use the Tarvos-III as replacement.

4.3.7 Transparent mode

Tarvos-III firmware 3.0.0 or newer is required for transparent mode support.

5 Tarvos-II to Tarvos-III

The Tarvos series is a family of 868 MHz proprietary radio modules. The Tarvos-II has been succeeded by the Tarvos-III, that reduces the power consumption, improves the blocking capabilities and provides new modulation techniques to boost the transmission range.

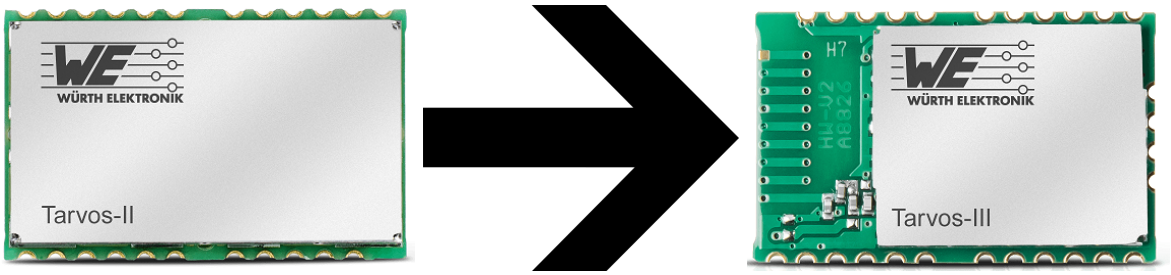

Figure 7: Tarvos-II to Tarvos-III

5.1 Summary

In comparison to the Tarvos-II, the Tarvos-III has 4 additional pins. Since the size and the remaining footprint of the two modules are the same, the Tarvos-II can be replaced by the Tarvos-III, if no underlying non-insulated copper area touches the 4 new pins of the Tarvos-III. Besides of this, a few pin functions changed, such that the sleep mode for example has to be triggered in a different way on the Tarvos-III. Due to this, and due to new firmware functions the host firmware must be adapted to communicate with the Tarvos-III.
Radio compatibility of both modules is given in most operation modes.

If the host cannot be adopted it may not be possible to perform migration to a more recent product.

5.2 Hardware adaption

5.2.1 Foot print

Both Tarvos-II and Tarvos-III have the same dimensions of 17×27×4 mm with the pins located at the same positions. The only change in the footprint is the presence of 4 additional pins (i1-i4) of the JTAG interface on the Tarvos-III.
If a design has been made for Tarvos-II, the footprint matches the Tarvos-III, if no underlying non-insulated copper area touches the JTAG pins i1-i4 of the Tarvos-III.

In addition to the radio signal to an external antenna on pin 1, the Tarvos-III offers an alternative option to use the on-board PCB antenna. In order to ensure a comparable radio performance to Tarvos-I, it is recommended to use the variant with antenna pin to connect to an external antenna. The order code for Tarvos-III with external antenna is 260901118100x. The integrated PCB antenna with reduced efficiency is available using order code 260901108100x.

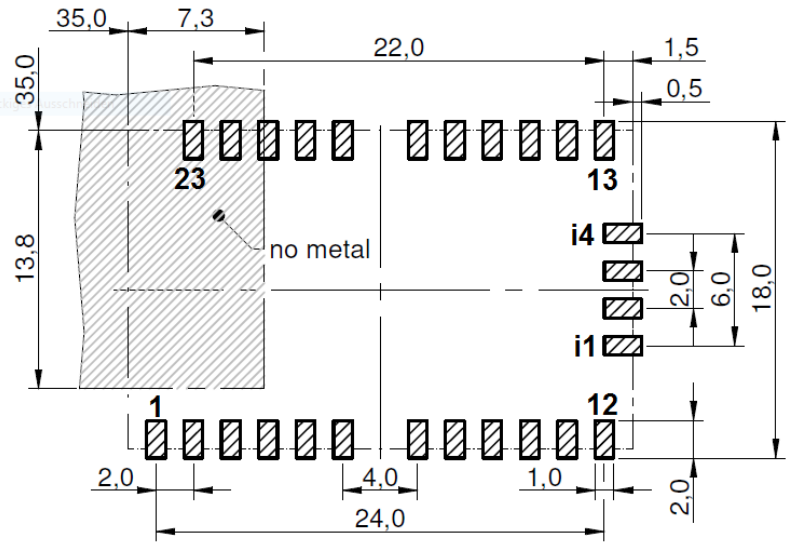

Figure 8: Universal footprint

5.2.2 Pinout

Although the Tarvos-II and Tarvos-III share the same footprint, some of the pin functions differ on the new hardware platform. The main pin functions such as power supply and UART use the same footprint pin on both modules:

Pin No.	Tarvos-II	Tarvos-III	Comment
1	*ANT*	*ANT*	Antenna pin connection
2	*GND*	*GND*	Ground
3	*VCC*	*VCC*	Supply voltage
4	*UTXD*	*UTXD*	UART TX
5	*URXD*	*URXD*	UART RX
6	*/RTS*	*/RTS*	UART */RTS*
9	*RESERVED*	*RESERVED*	
10	*RESERVED*	*RESERVED*	
13	*RESERVED*	*RESERVED*	
16	*RESERVED*	*RESERVED*	
17	*RESERVED*	*RESERVED*	
18	*RESERVED*	*RESERVED*	
19	*/RESET*	*/RESET*	Reset pin
20	*/TX_IND*	*/TX_IND*	Pin indicating when a radio packet is transmitted
21	*/RX_IND*	*/RX_IND*	Pin indicating when a radio packet is received
22	*RESERVED*	*RESERVED*	
23	*GND*	*GND*	Ground

Table 9: Pins with same functions on both, Tarvos-II and Tarvos-III

But pins with special functions changed:

Pin No.	Tarvos-II	Tarvos-III	Comment
7	*/CTS*	*RESERVED*	*/CTS* function no longer supported.
8	*DATA_IND*	*RESERVED*	*DATA_IND* function no longer supported.
11	*DATA_REQ*	*RESERVED*	*DATA_REQ* function no longer supported.
12	*RESERVED*	*BOOT*	The *BOOT* pin is used on the Tarvos-III to set the module into boot mode, where the module's firmware can be updated using the ACC tool.
14	*TRX_DISABLE*	*WAKE-UP*	Pin function changed. The *WAKE-UP* pin is used to wake-up the module from sleep mode.
15	*/CONFIG*	*MODE_1*	The *MODE_1* pin is used on the Tarvos-III to determine the operating mode during boot. In contrast to the Tarvos-II, switching between transparent mode and command mode is not possible during runtime by using the *MODE_1* pin.

Table 10: Pins of the Tarvos-II and Tarvos-III that have different functions

5.2.3 Antenna

The Tarvos-III is available in two hardware variants. The first variant provides the radio signal at the *ANT* pin, the same as Tarvos-II. Using this variant an external antenna matched to 50 Ω can be connected at this pin.
The second variant of the Tarvos-III offers an internal PCB antenna. Using this variant the *ANT* pin has no function and can be left open. No external antenna has to be connected.

5.3 Host firmware adaption

5.3.1 Command Mode

If you are not already using command mode we recommend to switch over to using command mode whenever your application can be adopted.

5.3.2 UART interface

The Tarvos-II uses 9600 Baud 8n1 and Tarvos-III uses 115200 Baud 8n1 by default. The Tarvos-II provides the command and transparent mode on the UART (transparent mode by default). The Tarvos-III provides the command mode and, using firmware version 3.0.0 or higher, the transparent mode (command mode by default).
The command interface on the UART uses of the same command structure. The UART command numbers itself and range of parameter values for a specific command may differ. Thus the command interface of the Tarvos-III must be updated in the host controller. The source

codes of the command interface for host integration are available in the Wireless Connectivity SDK on GitHub [2, 3].

5.3.3 Radio interface

The radio interface of the Tarvos-III is compatible to that of Tarvos-II provided that the Tarvos-III is configured to use the 38.4 kbps or the 100 kbps profile with the radio settings as described in section 5.3.3.1. Using these radio settings, a higher radio range can be achieved compared to Tarvos-I owing to the higher default transmission power of Tarvos-III. The new radio profiles of the Tarvos-III are incompatible to the previous Tarvos generations, but offer various advantages. The radio profiles 3 and 4 allow a higher transmission range, where radio profile 5 provides a fast data transmission due to the increased data-rate.
All radio channels, that can be used by the Tarvos-II, are supported by the Tarvos-III, too.

Radio profile	Data rate (gross) [kbps]	Max payload size [Byte]	Radio channels
0	38.4	128	101 - 139
1	2.4	128	101 - 139
2	100	128	101 - 139

Table 11: Radio profiles of the Tarvos-II

Radio profile	Data rate (gross) [kbps]	Max payload size [Byte]	Radio channels
0	38.4	128	1 - 139
2	100	128	1 - 139
3 (LRM)	10 (=0.625 kbps net)	48	1 - 139
4 (LRM)	20 (=2.5 kbps net)	64	1 - 139
5	400	224	1 - 139

Table 12: Radio profiles of the Tarvos-III

5.3.3.1 Radio compatibility settings

General: Tarvos-II firmware must be of version 3.5.0 or later.

Address mode: Tarvos-II supports only address mode 0, 1 and 2.

Addresses: The Tarvos-III uses broadcast addresses by default, where as the Tarvos-II uses 0 as default destination address and network ID.

Timings: The ACK timeouts must be adjusted to ensure interoperability between Tarvos-III and Tarvos-II, when using acknowledgements.

5.3.4 Power saving modes

As the pin *TRX_DISABLE* of the Tarvos-II is no more available on the Tarvos-III, the low power modes are handled in a different way. The Tarvos-III does not enable the possibility to switch off the radio exclusively by a pin, but allows to enter into two different sleep modes via UART command. The Tarvos-III can be woken up again from any sleep mode using the *WAKE-UP* pin, which is at the location of the Tarvos-II *TRX_DISABLE* pin.

5.3.5 Boot mode

The Tarvos-III needs to be set to boot mode, if a firmware update is performed. To switch the boot mode on, the *BOOT* pin has to be handled by host controller. The firmware update uses the UART interface at the dedicated module UART pins. Both, Tarvos-II and Tarvos-III can be connected to the ACC PC tool to perform changes in user settings and a firmware update. Please refer to the product specific details for the firmware update.

5.3.6 Timings

Due to change of the underlying hardware, especially the CPU and radio IC, as well as the use of an RTOS (real time operating system) in the Tarvos-III, most of the timing parameters have slightly changed. Some were decreased, but others increased.
Due to the CPU change and the RTOS the UART RX of the module is now using a shift register of 32 bit instead of 8 bit, which will introduce (worst case) a latency of up to 3 additional byte durations (depending on the selected UART data rate) to each received UART message (command or transparent).
The host-application needs to take this changed timings into account to be able to use the Tarvos-III as replacement.

5.3.7 Transparent mode

Tarvos-III firmware 3.0.0 or newer is required for transparent mode support.

6 Tarvos-III to Thebe-II

The Tarvos-III is a 868 MHz proprietary radio module with 14 dBm output power. For some applications the transmission range of it may not be suffient. Therefore the 500 mW variant of it, the so called Thebe-II radio module, provides a high transmission range caused by its increased output power.

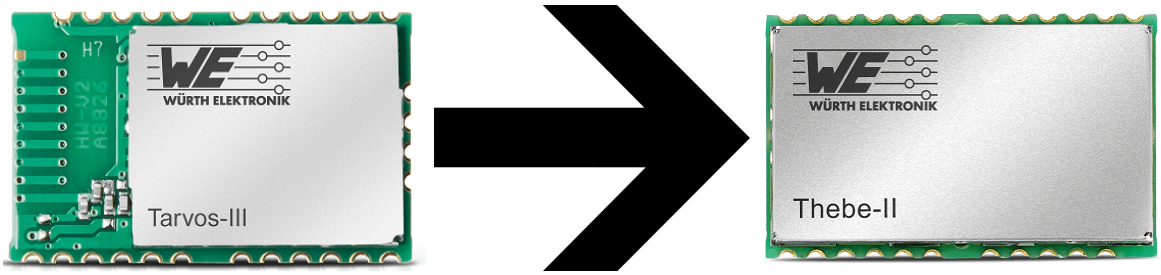

Figure 9: Tarvos-III to Thebe-II

6.1 Summary

Only the hardware variant of the Tarvos-III with external antenna pad can be replaced by the Thebe-II without any layout modification of the underlying PCB. However the power supply used on the PCB must be suited for the peaks in current during transmission caused by Thebe-II.
The radio settings (radio power, channel and profile) differ in both radio modules. Thus, if backward compatibility is required, matching radio settings must be configured by the host controller to allow radio compatible replacement of the Tarvos-III with an Thebe-II.

6.2 Hardware adaption

6.2.1 Foot print

The Tarvos-III and Thebe-II have the same footprint and size. Only the height increases from 3.2 to 3.8mm.

6.2.2 Pinout

There are two hardware variants of the Tarvos-III radio module available. One with an antenna pad *ANT* providing the radio signal for 50 Ω matched external antenna connection, and one with integrated PCB antenna. The antenna pad of the variant with integrated PCB antenna does not have any function.
The Thebe-II radio module itself has only one hardware variant, the one with the antenna pad *ANT*.
Thus only the hardware variant of the Tarvos-III using an external antenna can be replaced by an Thebe-II without any redesign of the layout.
In case a Tarvos-III with integrated PCB antenna has been used, the RF path on the underlying

PCB must be created first to solder an Thebe-II on it.

6.2.3 Power supply

As the Thebe-II has a higher power demand than Tarvos-III, please check how much power the power supply circuit can provide. Thebe-II needs up to 500 mA at 3.3 V when transmitting data with maximum transmission power.

6.3 Host firmware adaption

Both, the Tarvos-III and Thebe-II provide the same functions. Both use the same command set to control the radio module. Solely, the provided radio profiles, allowed radio channels and output powers differ.

6.3.1 Radio interface

The following points must be only considered, if backward compatibility of the radio is required.

The radio profiles and allowed radio channels differ in some points.

Radio profile	Data rate (gross) [kcps]	Max payload size [Byte]	Radio channels
0	38.4	128	1 - 139
2	100	128	2 - 138
3 (LRM)	10 (=0.625 kbps net)	48	1 - 139
4 (LRM)	20 (=2.5 kbps net)	64	1 - 139
5	400	224	46 - 94, 106

Table 13: Radio profiles of the Tarvos-III

Radio profile	Data rate (gross) [kbps]	Max payload size [Byte]	Radio channels
0	38.4	128	129 - 132
2	100	128	131
3 (LRM)	10 (= 0.625 kbps net)	48	129 - 132
4 (LRM)	20 (= 2.5 kbps net)	64	129 - 132
7	50	128	131

Table 14: Radio profiles of the Thebe-II

Caused by the high output power, the Thebe-II provides only a few radio channels in the so called "band P". To be radio compatible after a replacement of a Tarvos-III by an Thebe-II, the user's application must use a radio profile (i.e. 0, 2, 3 or 4) and radio channel (i.e. in the range of 129 to 132, with further restrictions by the radio profile itself) that is provided by both radio modules.
For example, if radio profile 0 with radio channel 129 are used, the Thebe-II and Tarvos-III are radio compatible.

Besides of that, the Thebe-II allows to use 12-26 dBm output power, where the Tarvos-III allows 0-14 dBm. Both are set to their maximum by default.

Due to EU laws (radio equipment directive, EN300220-2 annex B) the application must ensure to maintain the duty cycle for devices in band P (500 mW, around 869 MHz) at under 10 %.

7 Thebe-I to Thebe-II

The Thebe series is a family of 868 MHz proprietary radio modules with 500 mW output power to achieve high transmission ranges. The Thebe-I has been succeeded by the Thebe-II, that is significantly smaller in size and provides new modulation techniques to boost the transmission range.

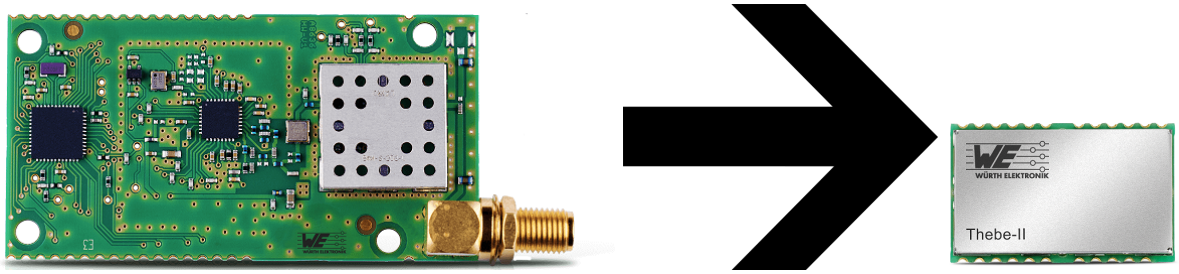

Figure 10: Thebe-I to Thebe-II

7.1 Summary

The Thebe-I and Thebe-II have different sizes and footprints. Thus, when replacing the Thebe-I by a Thebe-II, a redesign of the hardware is needed. Due to new firmware functions the host firmware must be adapted to communicate with the Thebe-II.
The radio compatibility in between both modules is not given.

7.2 Hardware adaption

7.2.1 Foot print

The Thebe-I and Thebe-II have different footprints. Besides the number of pins, the size has been reduced significantly. The Thebe-I has dimensions of 33.5×76×14.5mm where as the Thebe-II has a significantly smaller form factor of 17×27×3.8 mm.

7.2.2 Pinout

Although the Thebe-I and Thebe-II have different footprints, the main pin functions such as power supply, reset and UART are retained. Only the following pin functions have changed. On Thebe-II

- the pins */CTS*, *DATA_IND*, *DATA_REQ*, *TRX_DISABLE* and */CONFIG* are no longer supported.
- the pin *BOOT* has been added, that can be used to set the Thebe-II into boot mode.
- the pin *WAKE-UP* has been added to wake-up the module from sleep mode.
- the pin *ANT* has been added to attach an external 50 Ω antenna.

7.2.3 Antenna

The Thebe-I has a SMA antenna connector integrated on the module to attach an external antenna. The Thebe-II on the other hand provides a module pin to connect any 50 Ω matched external antenna on the customer PCB.

7.3 Host firmware adaption

7.3.1 UART interface

The Thebe-I uses 9600 Baud 8n1 and Thebe-II uses 115200 Baud 8n1 by default. The Thebe-I provides the command and transparent mode on the UART (transparent mode by default). The Thebe-II provides the command mode and, using firmware version 3.0.0 or higher, the transparent mode (command mode by default).
The command interface on the UART uses of the same command structure. The UART command numbers itself and range of parameter values for a specific command may differ. Thus the command interface must be updated in the host controller. The source codes of the command interface for host integration are available in the Wireless Connectivity SDK on GitHub [2, 3].

7.3.2 Radio interface

The radio profiles of the Thebe-I and Thebe-II are not compatible. Therefore it is not possible to have a communication from a Thebe-I to a Thebe-II or vice versa.

The radio profiles and channel frequencies differ. The new radio profiles of the Thebe-II offer various advantages. The radio profiles 3 and 4 allow a higher transmission range, where radio profile 2 provides a fast data transmission due to the increased data-rate.

Radio profile	Data rate (gross) [kbps]	Max payload size [Byte]	Radio channels
0	4.8	128	0 - 18
1	4.8	128	9
2	9.6	128	9
7	50	128	9

Table 15: Radio profiles of the Thebe-I

Radio profile	Data rate (gross) [kbps]	Max payload size [Byte]	Radio channels
0	38.4	128	129 - 132
2	100	128	131
3 (LRM)	10 (= 0.625 kbps net)	48	129 - 132
4 (LRM)	20 (= 2.5 kbps net)	64	129 - 132
7	50	128	131

Table 16: Radio profiles of the Thebe-II

7.3.3 Power saving modes

As the pin *TRX_DISABLE* of the Thebe-I is no more available on the Thebe-II, the low power modes are handled in a different way. The Thebe-II does not enable the possibility to switch off the radio exclusively by a pin, but offers the possibility to enter into two different sleep modes via UART command. The Thebe-II can be woken up again from any sleep mode using the *WAKE-UP* pin.

7.3.4 Boot mode

The Thebe-II needs to be set to boot mode, if a firmware update is performed. To switch the boot mode on, the *BOOT* pin has to be handled by host controller. The firmware update uses the UART interface at the dedicated module UART pins. Both, Thebe-I and Thebe-II can be connected to the ACC PC tool to perform changes in user settings and a firmware update. Please refer to the product specific details for the firmware update.

7.3.5 Transparent mode

Thebe-II firmware 3.0.0 or newer is required for transparent mode support.

8 Telesto-III to Themisto-I

The Telesto-III is a 915 MHz proprietary radio module with 14 dBm output power. For some applications the transmission range of it may not be sufficient. Therefore the 25 dBm variant of it, the so called Themisto-I radio module, provides a high transmission range caused by its increased output power.

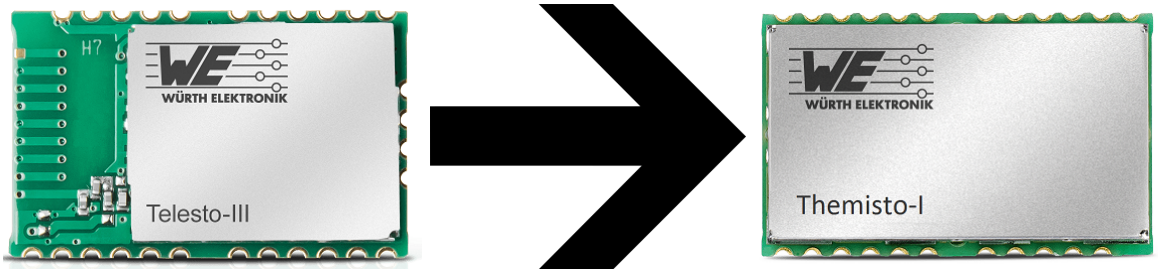

Figure 11: Telesto-III to Themisto-I

8.1 Summary

Only the hardware variant of the Telesto-III with external antenna pad can be replaced by the Themisto-I without any layout modification of the underlying PCB. However the power supply used on the PCB must be suited for the peaks in current during transmission caused by Themisto-I.
The radio settings (radio power and profile) differ in both radio modules. Thus, if backward compatibility is required, matching radio settings must be configured by the host controller to allow radio compatible replacement of the Telesto-III with a Themisto-I.

8.2 Hardware adaption

8.2.1 Foot print

The Telesto-III and Themisto-I have the same footprint and size. Only the height increases from 3.2 to 3.8mm.

8.2.2 Pinout

There are two hardware variants of the Telesto-III radio module available. One with an antenna pad *ANT* providing the radio signal for 50 Ω matched external antenna connection, and one with integrated PCB antenna. The antenna pad of the variant with integrated PCB antenna does not have any function.
The Themisto-I radio module itself has only one hardware variant, the one with the antenna pad *ANT*.
Thus only the hardware variant of the Telesto-III using an external antenna can be replaced by

a Themisto-I without any redesign of the layout.
In case a Telesto-III with integrated PCB antenna has been used, the RF path on the underlying PCB must be created first to solder a Themisto-I on it.

8.2.3 Power supply

As the Themisto-I has a higher power demand than Telesto-III, please check how much power the power supply circuit can provide. Themisto-I needs up to 400 mA at 3.3 V when transmitting data with maximum transmission power.

8.3 Host firmware adaption

Both, the Telesto-III and Themisto-I provide the same functions. Both use the same command set to control the radio module. Solely, the provided radio profiles and output powers differ.

8.3.1 Radio interface

The following points must be only considered, if backward compatibility of the radio is required.

Telesto-III does not provide radio profile 8 and 9, so far. Thus if radio profile 6 is used, both, Telesto-III and Themisto-I are radio compatible.
The profiles 8 and 9 are long range profiles that provide much higher range at the cost of throughput.

Radio profile	Data rate (gross) [kcps]	Max payload size [Byte]	Radio channels
6	400	224	201-251

Table 17: Radio profiles of the Telesto-III

Radio profile	Data rate (gross) [kbps]	Max payload size [Byte]	Radio channels
6	400	224	201-251
8 (LRM)	480 (= 240 kbps net)	224	201-251
9 (LRM)	480 (= 30 kbps net)	224	201-251

Table 18: Radio profiles of the Themisto-I

Besides of that, the Themisto-I allows to use 12-25 dBm output power, where the Telesto-III allows 0-14 dBm. Both are set to their maximum by default.

9 Metis-I to Metis-II

The Metis series is a family of 868 MHz wireless M-BUS radio modules. The Metis-I has been succeeded by the Metis-II, that scores with lower sleep, transmission and receptions currents, as well with a cleaner frequency spectrum and better blocking capabilities.

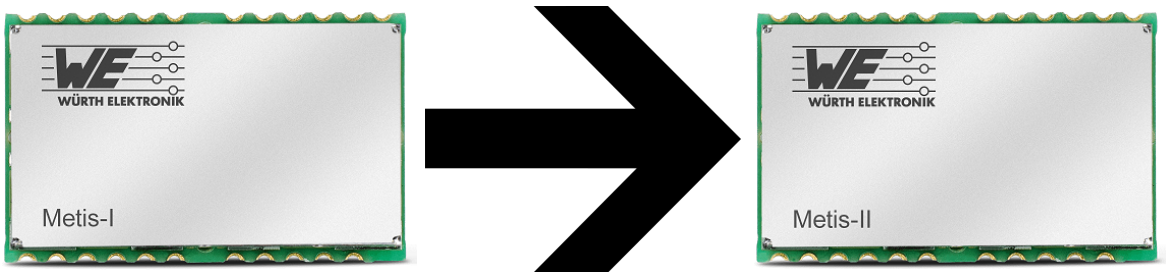

Figure 12: Metis-I to Metis-II

9.1 Summary

As the footprint, pinout and firmware functions coincide, the Metis-I can be replaced by Metis-II without any modification to the hardware design or the host controller firmware.

10 Proteus-I to Proteus-II

The Proteus series is a family of Bluetooth® LE radio modules. The Proteus-I has been succeeded by the Proteus-II, that scores with additional Bluetooth® 5.0 related features.

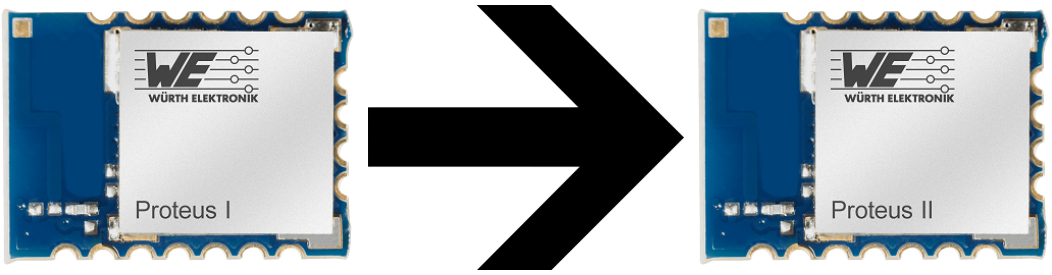

Figure 13: Proteus-I to Proteus-II

10.1 Summary

As the footprints and pinouts coincide and the Proteus-II includes all features of Proteus-I, the Proteus-I can be replaced by Proteus-II without any change in the hardware design. If needed, the host controller firmware can be extended by including the following new Bluetooth® 5.0 functions of the Proteus-II:

- Option to enable the high throughput mode with 4 times the original throughput and data packets of 964 bytes.
- New commands to set up the radio to 2 Mbit data rate mode.

Both, the Proteus-I and Proteus-II are available with integrated PCB-antenna or antenna pin to connect an external antenna. Depending on the Proteus-I variant, the right Proteus-II variant shall be chosen to achieve same ranges.

As the Bluetooth® module is replaced, a new Bluetooth® listing is mandatory.

11 Proteus-II to Proteus-III

The Proteus series is a family of Bluetooth® LE radio modules. The Proteus-I has been succeeded by the Proteus-II, that scores with additional Bluetooth® 5.0 related features. Both are succeeded by the Bluetooth® 5.1 radio module Proteus-III.

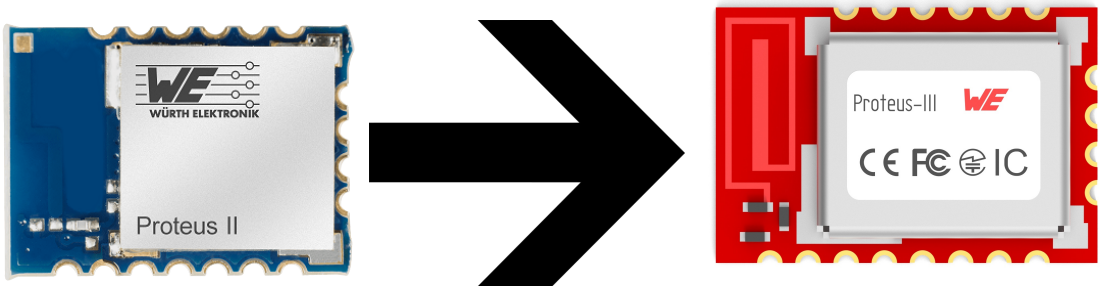

Figure 14: Proteus-II to Proteus-III

11.1 Summary

The Proteus-III has been designed in a way that the footprint and pinout matches the one of the Proteus-II. Under certain conditions the Proteus-II can be replaced by the Proteus-III without hardware modification of the base PCB.
The firmware of the Proteus-III includes additional features and improvement of existing features. Therefore, the host firmware shall be updated if new or improved functions of the Proteus-III shall be used.
Some default parameters have been adjusted. Further some timings may change due to the chipset and Bluetooth® stack update.

As the Bluetooth® module is replaced, a new Bluetooth® listing is mandatory.

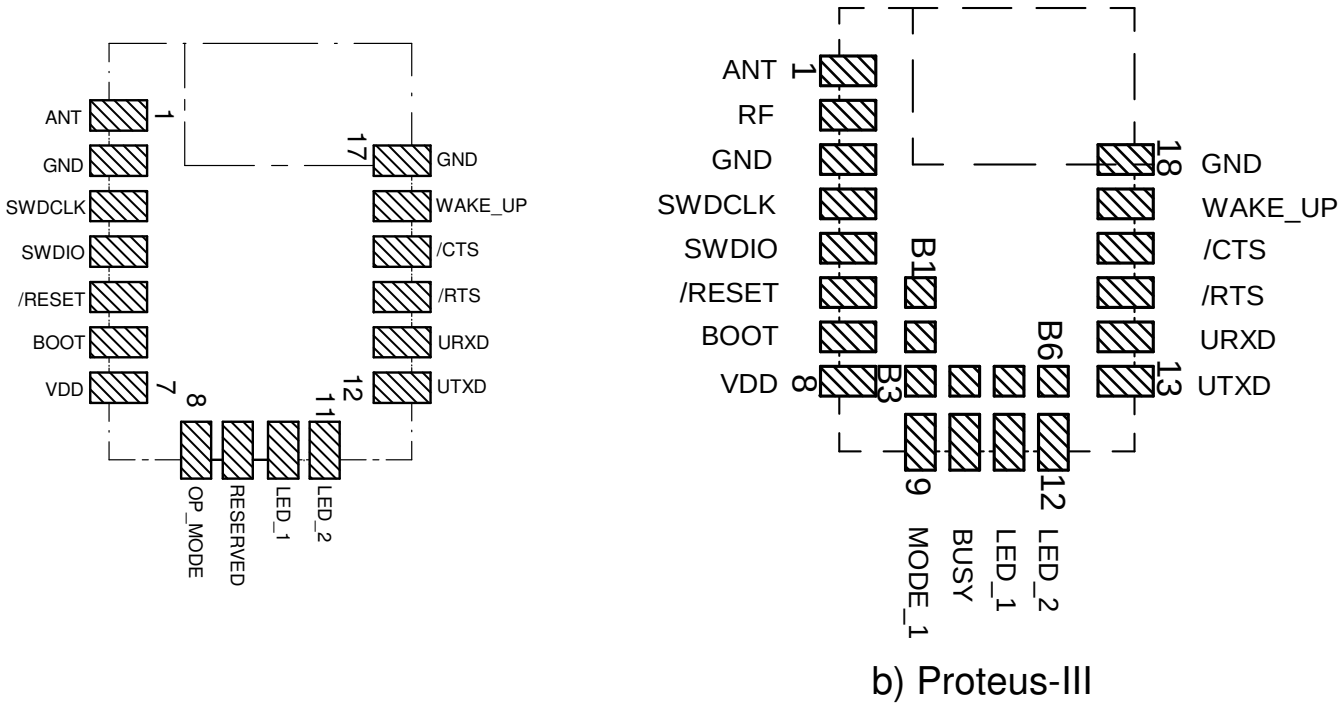

Figure 15: Pinout

11.2 Hardware adaption

11.2.1 Foot print

In comparison to the Proteus-II, the Proteus-III has one additional pin on the left edge, which increases the length to 12×8×2 mm. Six more additional pins have been added on the bottom side of the Proteus-III.
If a design has been made for Proteus-II, the footprint matches the Proteus-III, if no underlying non-insulated copper area touches the new *B1-B6* and *ANT* pins of the Proteus-III. Further this match is only positive for the Proteus-I/-II with external antenna.
Due to the increase size of the Proteus-III by 1 mm, the base PCB must be large enough to solder the new module.

11.2.2 Pinout

Although the Proteus-II and Proteus-III share the same footprint, some of the pin functions differ on the new hardware platform.

Pin No	Proteus-II	Pin No	Proteus-III	Comment
2	*GND*	3	*GND*	Ground
3	*SWDCLK*	4	*SWDCLK*	Serial wire clock (SWD Interface).
4	*SWDIO*	5	*SWDIO*	Serial wire input/output (SWD Interface).
5	*/RESET*	6	*/RESET*	Reset pin.
6	*BOOT*	7	*BOOT*	Boot pin.
7	*VDD*	8	*VDD*	Supply voltage
8	*OP_MODE*	9	*MODE_1*	Operation mode pin to switch between Command Mode and Peripheral only Mode.
10	*LED_1*	11	*LED_1*	Indicates the module state.
11	*LED_2*	12	*LED_2*	Indicates the module state.
12	*UTXD*	13	*UTXD*	UART Transmission.
13	*URXD*	14	*URXD*	UART Reception.
14	*/RTS*	15	*/RTS*	UART /RTS signal.
15	*/CTS*	16	*/CTS*	UART /CTS signal.
16	*WAKE_UP*	17	*WAKE_UP*	Wake-up will allow leaving the system-off mode or re-enabling the UART.
17	*GND*	18	*GND*	Ground

Table 19: Pins with same functions on both, Proteus-II and Proteus-III

Pin No	Proteus-II	Pin No	Proteus-III	Comment
-	-	1	*ANT*	Connection to the internal PCB antenna.
1	*ANT*	2	*RF*	Pin providing the radio signal.
9	RESERVED	10	*BUSY*	Indicates on the Proteus-III if module is busy with data transmission when using Peripheral only Mode.
-	-	B1	RESERVED	Pin for remote GPIO access.
-	-	B2	RESERVED	Pin for remote GPIO access.
-	-	B3	RESERVED	Pin for remote GPIO access.
-	-	B4	RESERVED	Pin for remote GPIO access.
-	-	B5	RESERVED	Pin for remote GPIO access.
-	-	B6	RESERVED	Pin for remote GPIO access.

Table 20: Pins of the Proteus-II and Proteus-III, that have different functions

Besides the differences in the antenna configuration that is addressed in the following chapter, the only function change is the presence of the *BUSY* pin on the Proteus-III. This pin indicates,

when the module is ready for radio transmission. If the pin level is high, the radio module is busy.
In Proteus-II the pin number of the *BUSY* pin has been marked as "reserved, do not connect". Thus, it's possible to replace a Proteus-II by Proteus-III without forcing an increased current consumption at this pin.

11.2.3 Antenna

The Proteus-II has been available in two variants. Variant one is providing the radio signal on the *ANT* pin to connect an external antenna. Variant two uses the internal PCB antenna, where the *ANT* pin has no function. In contrast, the Proteus-III combines both variants. The *RF* pin provides the radio signal, where the *ANT* pin can be used to access the internal PCB antenna. This means, that either an external antenna can be connected to the *RF* pin, or a shortcut between the *RF* and *ANT* pin must be created on the base PCB to use the internal PCB antenna.

For using the Proteus-III integrated PCB antenna, please refer to the reference design in the Proteus-III user manual.

11.3 Host firmware adaption

In comparison to the firmware of the Proteus-II, the Proteus-III contains new Bluetooth® features as well as improved features, that already existed on Proteus-II.
New features are:

- Commands to switch Proteus-III GPIOs via remote access.
- Option to enable connection setup and data transmission in long range mode (LE Coded).
- Option to receive beacons (iBeacon, Eddystone beacon) from other devices than Proteus radio modules.
- Option to choose between different contents of the advertising packet.
- Additional security modes for pairing: LescPasskey mode (enter a secure generated pass key) and LescNumComp mode (compare two secure generated pass keys).

The following features changed:

- Extended user setting `RF_ConnectionTiming` to allow finer selection of the timing behavior.
- Extended user setting `RF_ScanTiming` to allow finer selection of the timing behavior.
- Replaced the user settings `UART_Flags` and `UART_BaudrateIndex` by `UART_ConfigIndex`.

In case one of the above features is used in host controller firmware, it must be updated. Please refer to the Wireless Connectivity SDK [2, 3] for radio module drivers and examples in C-code.

12 Proteus-II to Proteus-e

The Proteus series is a family of Bluetooth® LE radio modules. Proteus-I has been the first Bluetooth® LE radio module of Würth Elektronik eiSos that has been followed by Proteus-II and Proteus-III, which introduced new Bluetooth® LE features.
Proteus-e is the first Bluetooth® LE radio module of the so called "eco-line" characterized by reduced size, features and cost.

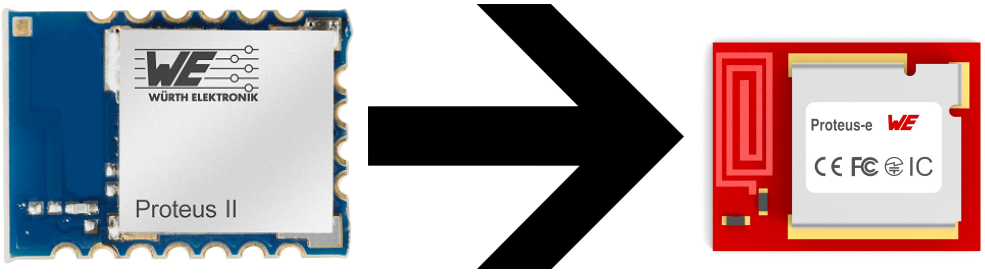

Figure 16: Proteus-II to Proteus-e

12.1 Summary

In comparison to the Proteus-II, the Proteus-e provides a reduced size and a smaller footprint without edge castellation. In case the Proteus-II is replaced by a Proteus-e, a new hardware design must be done, but due to the reduced size, it fits into the previously used space on the PCB.
A few basic functions, like FOTA or central functions, have been removed in the Proteus-e firmware. In case these are not needed by the application, the Proteus-e can be controlled by the same UART commands. Only a few adaptions must be done to the host controller firmware to support the updated feature set.

As the Bluetooth® module is replaced, a new Bluetooth® listing is mandatory.

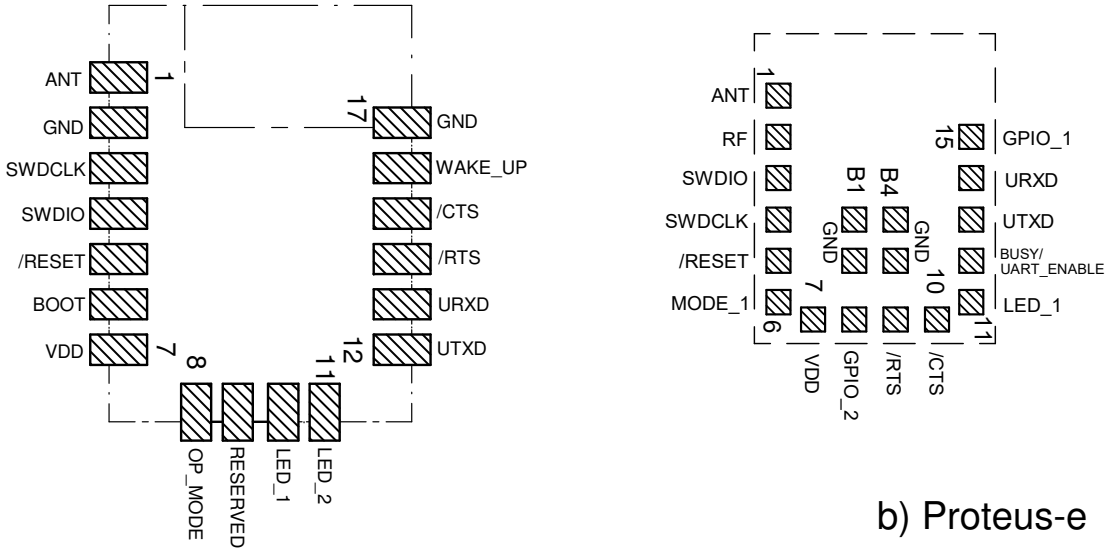

Figure 17: Pinout

12.2 Hardware adaption

12.2.1 Foot print

In comparison to the Proteus-II, the Proteus-e has a similar but different footprint. Due to the reduced size of the Proteus-e (9×7×2 mm), the Proteus-e matches the space reserved for a Proteus-II (11×8×2 mm) design-in.

12.2.2 Pinout

Although the Proteus-II and Proteus-e have a different footprint, most of the pin functions are the same on the new hardware platform.

Pin No	Proteus-II	Pin No	Proteus-e	Comment
3	*SWDCLK*	4	*SWDCLK*	Serial wire clock (SWD Interface).
4	*SWDIO*	3	*SWDIO*	Serial wire input/output (SWD Interface).
5	*/RESET*	5	*/RESET*	Reset pin.
7	*VDD*	7	*VDD*	Supply voltage.
8	*OP_MODE*	6	*MODE_1*	Operation mode pin to switch between Command Mode and Peripheral only Mode (Transparent mode).
10	*LED_1*	11	*LED_1*	Indicates the module state.
12	*UTXD*	13	*UTXD*	UART Transmission.
13	*URXD*	14	*URXD*	UART Reception.
14	*/RTS*	9	*/RTS*	UART /RTS signal.
15	*/CTS*	10	*/CTS*	UART /CTS signal.
17	*GND*	B1-B4	*GND*	Ground.

Table 21: Pins with same functions on both, Proteus-II and Proteus-e

Pin No	Proteus-II	Pin No	Proteus-e	Comment
-	-	1	*ANT*	Connection to the internal PCB antenna.
1	*ANT*	2	*RF*	Pin providing the radio signal.
16	*WAKE-UP*	10	*BUSY/ UART_ENABLE*	This pin is shared on the Proteus-e serving several functions.
-	-	15	*GPIO_1*	Pin for remote GPIO access.
-	-	8	*GPIO_2*	Pin for remote GPIO access.
6	*BOOT*	-	-	FOTA has been removed.
11	*LED_2*	-	-	*LED_2* has been removed.

Table 22: Pins of the Proteus-II and Proteus-e, that have different functions

Besides the differences in the antenna configuration that is addressed in the following chapter, there are two major changes in the usage of the module pins:

1. The state indication of the module is done only by one LED on Proteus-e.
2. The new pin *BUSY/UART_ENABLE* is a shared pin. In Transparent Mode it indicates when the module is busy with data transmission. In Command Mode it can be used to wake-up the module and enable the UART.

12.2.3 Antenna

The Proteus-II has been available in two variants. Variant one is providing the radio signal on the *ANT* pin to connect an external antenna. Variant two uses the internal PCB antenna, where the *ANT* pin has no function. In contrast, the Proteus-e combines both variants. The *RF* pin provides the radio signal, where the *ANT* pin can be used to access the internal PCB antenna. This means, that either an external antenna can be connected to the *RF* pin, or a short cut between the *RF* and *ANT* pin must be created on the base PCB to use the internal PCB antenna.

For using the Proteus-e integrated PCB antenna, please refer to the reference design in the Proteus-e user manual. It's mandatory to respect the trace designs suggested in the user manual to keep the FCC and IC compliance.

12.3 Host firmware adaption

In comparison to the firmware of the Proteus-II, the Proteus-e has an updated function set. Most functions on Proteus-e and Proteus-II are the same and can be controlled by the same set of UART commands. The differences are as follows:

Removed features are:

- Firmware update over the air (FOTA) is not supported on Proteus-e.
- Central functions (like scanning, connection setup initiation) are not supported on Proteus-e.
- The so called "High throughput mode" is not supported on Proteus-e.
- Bluetooth® LE feature data length extension (DLE) that allows a higher throughput on Proteus-II.

In case one of these features is needed by the application, a replacement of Proteus-II by Proteus-e cannot be done.

Changed features are:

- Number of bonded devices reduced to 8 on Proteus-e (Proteus-II supports 32).
- User setting `RF_SecFlagsPerOnly` has been removed. Both, the Command and Transparent Mode, use the user setting `RF_SecFlags` now. Thus, in factory state the Proteus-e provides an open Bluetooth® LE connection in Transparent Mode (Proteus-III uses static pass key encryption in Transparent Mode in factory state).
- State indication is done only on *LED_1* on Proteus-e (Proteus-II uses *LED_1* and *LED_2*).
- Beacon functions replaced by more advanced functions on Proteus-e.
- User setting `RF_ScanTiming` replaced by `RF_AdvertisingInterval` on Proteus-e.

- User setting `RF_ConnectionTiming` replaced by `RF_ConnectionInterval` on Proteus-e.
- Replaced the user settings `UART_Flags` and `UART_BaudrateIndex` by `UART_ConfigIndex` on Proteus-e.
- Content of advertising and scan response packet changed on Proteus-e. Central device must run active scan to detect UUID of the Proteus-e. Device name of up to 26 bytes can be placed in the advertising packet on Proteus-e.

In case one of the above features is used in host controller firmware, it must be updated. Please refer to the Wireless Connectivity SDK [2, 3] for radio module drivers and examples in C-code.

13 Proteus-III to Proteus-e

The Proteus series is a family of Bluetooth® LE radio modules. Proteus-I has been the first Bluetooth® LE radio module of Würth Elektronik eiSos that has been followed by Proteus-II and Proteus-III, which introduced new Bluetooth® LE features.
Proteus-e is the first Bluetooth® LE radio module of the so called "eco-line" characterized by reduced size, features and cost.

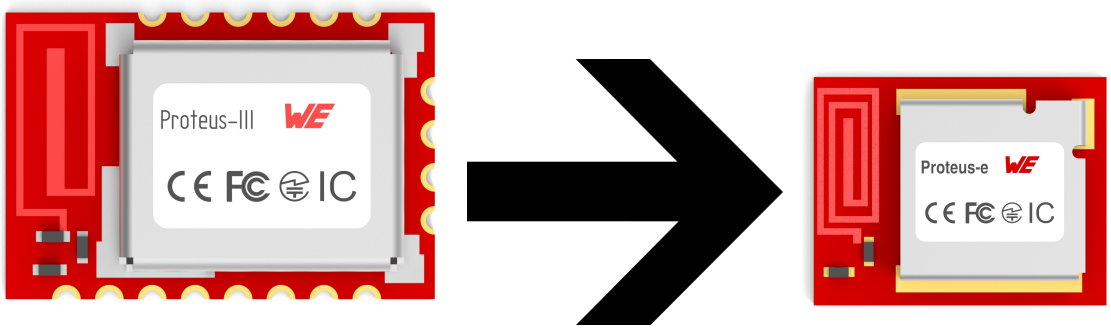

Figure 18: Proteus-III to Proteus-e

13.1 Summary

In comparison to the Proteus-III, the Proteus-e provides a reduced size and a smaller footprint without edge castellation. In case the Proteus-III is replaced by a Proteus-e, a new hardware design must be done, but due to the reduced size, it fits into the previously used space on the PCB.
Various basic functions, like FOTA or central functions, have been removed in the Proteus-e firmware. In case these are not needed by the application, the Proteus-e can be controlled by the same UART commands. Only a few adaptions must be done to the host controller firmware to support the updated feature set.

As the Bluetooth® module is replaced, a new Bluetooth® listing is mandatory.

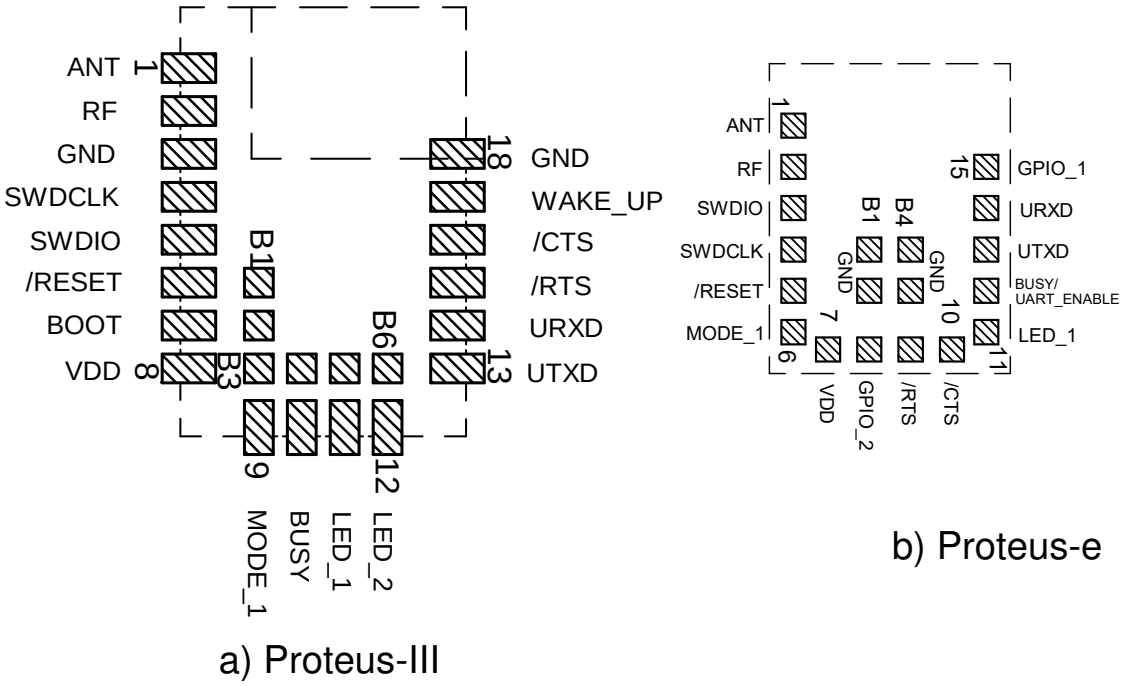

Figure 19: Pinout

13.2 Hardware adaption

13.2.1 Foot print

In comparison to the Proteus-III, the Proteus-e has a similar but different footprint. Due to the reduced size of the Proteus-e (9×7×2 mm), the Proteus-e matches the space reserved for a Proteus-III (12×8×2 mm) design-in.

13.2.2 Pinout

Although the Proteus-III and Proteus-e have a different footprint, most of the pin functions are the same on the new hardware platform.

Pin No	Proteus-III	Pin No	Proteus-e	Comment
1	*ANT*	1	*ANT*	Connection to the internal PCB antenna.
2	*RF*	2	*RF*	Pin providing the radio signal.
4	*SWDCLK*	4	*SWDCLK*	Serial wire clock (SWD Interface).
5	*SWDIO*	3	*SWDIO*	Serial wire input/output (SWD Interface).
6	*/RESET*	5	*/RESET*	Reset pin.
8	*VDD*	7	*VDD*	Supply voltage.
9	*MODE_1*	6	*MODE_1*	Operation mode pin to switch between Command Mode and Peripheral only Mode (Transparent mode).
11	*LED_1*	11	*LED_1*	Indicates the module state.
13	*UTXD*	13	*UTXD*	UART Transmission.
14	*URXD*	14	*URXD*	UART Reception.
15	*/RTS*	9	*/RTS*	UART /RTS signal.
16	*/CTS*	10	*/CTS*	UART /CTS signal.
18	*GND*	B1-B4	*GND*	Ground.

Table 23: Pins with same functions on both, Proteus-III and Proteus-e

Pin No	Proteus-III	Pin No	Proteus-e	Comment
10	*BUSY*	12	*BUSY/ UART_ENABLE*	This pin is shared on the Proteus-e serving several functions.
17	*WAKE-UP*	12	*BUSY/ UART_ENABLE*	This pin is shared on the Proteus-e serving several functions.
B1	*B1*	15	*GPIO_1*	Pin for remote GPIO access.
B2	*B2*	8	*GPIO_2*	Pin for remote GPIO access.
B3-B4	*B3-B4*	-	-	Remote GPIO function removed.
B5-B6	*B5-B6*	-	-	Pins removed.
7	*BOOT*	-	-	FOTA has been removed.
12	*LED_2*	-	-	*LED_2* has been removed.

Table 24: Pins of the Proteus-III and Proteus-e, that have different functions

There are three major changes in the usage of the module pins:

1. The state indication of the module is done only by one LED on Proteus-e.
2. The new pin *BUSY/UART_ENABLE* is a shared pin. In Transparent Mode it indicates

when the module is busy with data transmission. In Command Mode it can be used to wake-up the module and enable the UART. It replaces the pin *BUSY* and *WAKE-UP* on Proteus-III.

3. The remote GPIO function is no longer available on the B-pins, but on the *GPIO_1* and *GPIO_2* pins.

13.3 Host firmware adaption

In comparison to the firmware of the Proteus-III, the Proteus-e has an updated function set. Most functions on Proteus-e and Proteus-III are the same and can be controlled by the same set of UART commands. The differences are as follows:

Removed features are:

- The LE coded phy (long range mode) is not supported on the Proteus-e.
- Firmware update over the air (FOTA) is not supported on Proteus-e.
- Central functions (like scanning, connection setup initiation) are not supported on Proteus-e.
- LESC (Low energy secure connections) are not supported on the Proteus-e.
- Remote GPIO pins cannot be used as PWM pins on Proteus-e.
- The so called "High throughput mode" is not supported on Proteus-e.
- Bluetooth® LE feature data length extension (DLE) that allows a higher throughput on Proteus-III.

In case one of these features is needed by the application, a replacement of Proteus-III by Proteus-e cannot be done.

Changed features are:

- Number of bonded devices reduced to 8 on Proteus-e (Proteus-III supports 32).
- User setting `RF_SecFlagsPerOnly` has been removed. Both, the Command and Transparent Mode, use the user setting `RF_SecFlags` now. Thus, in factory state the Proteus-e provides an open Bluetooth® LE connection in Transparent Mode (Proteus-III uses static pass key encryption in Transparent Mode in factory state).
- The number of pins, that can be used as remote GPIOs, is reduced to 2 (Proteus-III supports 6).
- State indication is done only on *LED_1* on Proteus-e (Proteus-III uses *LED_1* and *LED_2*).
- Beacon functions replaced by more advanced functions to allow highest flexibility in the Beacon's contents on Proteus-e.
- User setting `RF_ScanTiming` replaced by `RF_AdvertisingInterval` on Proteus-e.

- User setting `RF_ConnectionTiming` replaced by `RF_ConnectionInterval` on Proteus-e.
- Content of advertising and scan response packet changed on Proteus-e. Central device must run active scan to detect UUID of the Proteus-e. Device name of up to 26 bytes can be placed in the advertising packet on Proteus-e.
- User setting `RF_AdvertisingFlags` replaced by `RF_AdvertisingData` and `RF_ScanResponseData`.

In case one of the above features is used in host controller firmware, it must be updated. Please refer to the Wireless Connectivity SDK [2, 3] for radio module drivers and examples in C-code.

14 AMB2520 to Thalassa

The AMB2520 is a 2.4 GHz proprietary radio module. It has been replaced by the Thalassa, that is still conform with the current radio regulations.

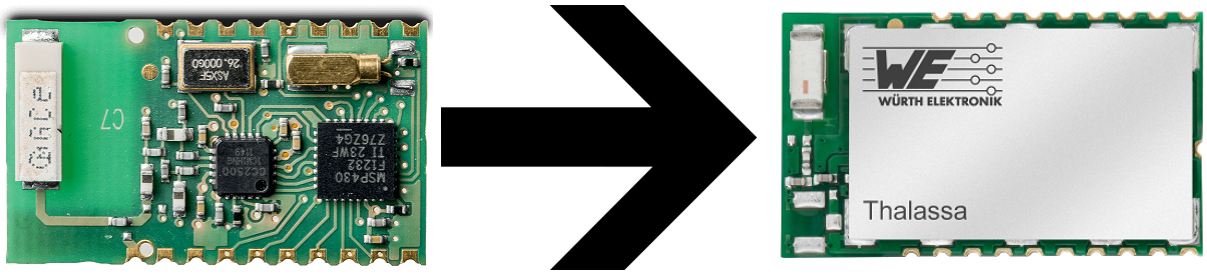

Figure 20: AMB2520 to Thalassa

14.1 Summary

In comparison to the AMB2520, the Thalassa contains one additional pin i1. If this pin does not touch any underlying non-insulated copper area, the AMB2520 can be exchanged by the Thalassa without any modification.

14.2 Hardware adaption

14.2.1 Foot print

Both, the AMB2520 and Thalassa have the same dimensions of 16×27.5×3.2 mm with the pins located at the same positions. The only change in the footprint is the presence of one additional pin (i1) of the JTAG interface on the Thalassa.
If a design has been made for AMB2520, the footprint matches the Thalassa, if no underlying non-insulated copper area touches the JTAG pin i1 of the Thalassa.

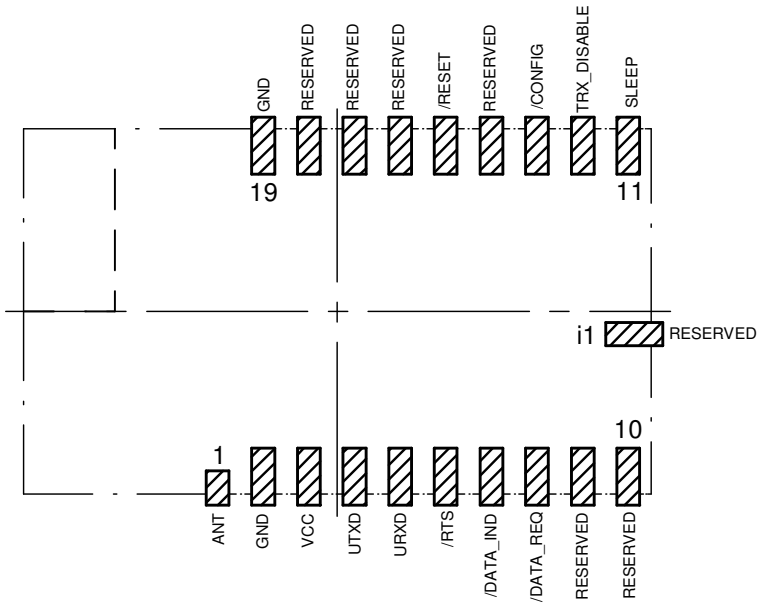

Figure 21: Universal footprint

14.2.2 Pinout

The pinout of both, the AMB2520 and Thalassa is the same.

14.2.3 Antenna

The Thalassa is available in two hardware variants. The first variant provides the radio signal at the *ANT* pin, the same as the AMB2520. Using this variant an external antenna matched to 50 Ω can be connected at this pin.
The second variant of the Thalassa offers an internal PCB antenna. Using this variant the *ANT* pin has no function and can be left open. No external antenna has to be connected.

14.3 Host firmware adaption

The firmware of both, the AMB2520 and Thalassa is the same. Thus there is no need to update the host controller's firmware.

15 Thyone-I to Thyone-e

The Thyone series is a family of 2.4 GHz proprietary radio modules.
Thyone-e is the first radio module of the so called "eco-line" variant characterized by reduced size, features and cost.

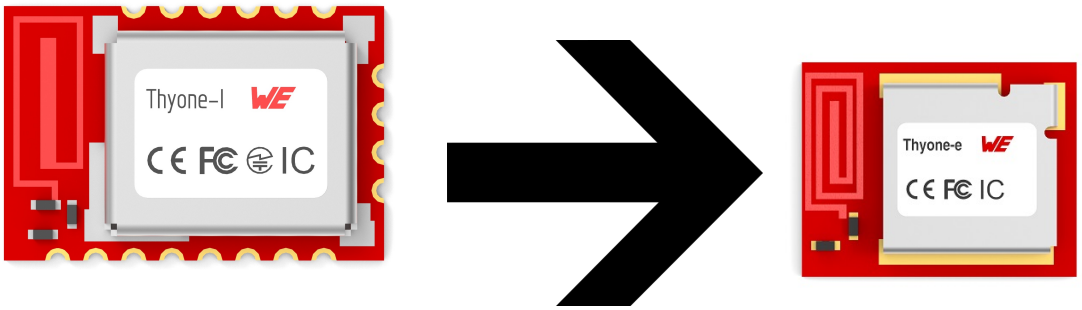

Figure 22: Thyone-I to Thyone-e

15.1 Summary

In comparison to the Thyone-I, the Thyone-e provides a reduced size and a smaller footprint without edge castellation. In case the Thyone-I is replaced by a Thyone-e, a new hardware design must be done, but due to the reduced size it fits into the previously used space on the PCB.
A few functions, like firmware update or long range radio, have been removed in the Thyone-e firmware. In case these are not needed by the application, the Thyone-e can be controlled by the same UART commands. Only a few adaptions must be done to the host controller firmware to support the updated feature set.

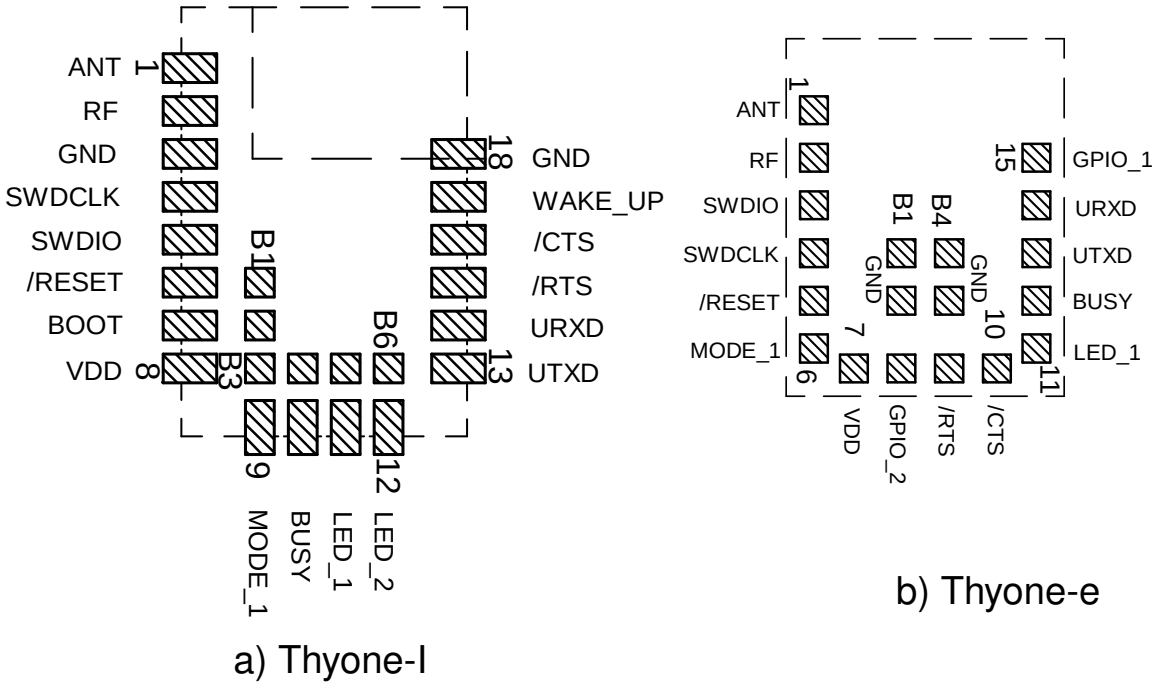

Figure 23: Pinout

15.2 Hardware adaption

15.2.1 Foot print

In comparison to the Thyone-I, the Thyone-e has a similar but different footprint. Due to the reduced size of the Thyone-e (9×7×2 mm), the Thyone-e matches the space reserved for a Thyone-I (12×8×2 mm) design-in.

15.2.2 Pinout

Although the Thyone-I and Thyone-e have a different footprint, most of the pin functions are the same on the new hardware platform.

Pin No	Thyone-I	Pin No	Thyone-e	Comment
1	*ANT*	1	*ANT*	Connection to the internal PCB antenna.
2	*RF*	2	*RF*	Pin providing the radio signal.
4	*SWDCLK*	4	*SWDCLK*	Serial wire clock (SWD Interface).
5	*SWDIO*	3	*SWDIO*	Serial wire input/output (SWD Interface).
6	*/RESET*	5	*/RESET*	Reset pin.
8	*VDD*	7	*VDD*	Supply voltage.
9	*MODE_1*	6	*MODE_1*	Operation mode pin to switch between command mode and transparent mode.
10	*BUSY*	12	*BUSY*	This pin indicates when the module is busy with data transmission.
13	*UTXD*	13	*UTXD*	UART Transmission.
14	*URXD*	14	*URXD*	UART Reception.
15	*/RTS*	9	*/RTS*	UART /RTS signal.
16	*/CTS*	10	*/CTS*	UART /CTS signal.
18	*GND*	B1-B4	*GND*	Ground.

Table 25: Pins with same functions on both, Thyone-I and Thyone-e

Pin No	Thyone-I	Pin No	Thyone-e	Comment
11	*LED_1*	11	*LED_1*	Thyone-I (TX), Thyone-e (RX and TX).
B1	*B1*	15	*GPIO_1*	Pin for remote GPIO access.
B2	*B2*	8	*GPIO_2*	Pin for remote GPIO access.
B3-B4	*B3-B4*	-	-	Remote GPIO function removed.
B5-B6	*B5-B6*	-	-	Pins removed.
7	*BOOT*	-	-	FOTA has been removed.
12	*LED_2*	-	-	*LED_2* has been removed.
17	*WAKE-UP*	-	-	Pin removed. Wake-up can be done by */RESET* pin.

Table 26: Pins of the Thyone-I and Thyone-e, that have different functions

There are two major changes in the usage of the module pins:

1. The state indication of the module is done only by one LED on Thyone-e.
2. The remote GPIO function is no longer available on the B-pins, but on the *GPIO_1* and *GPIO_2* pins.

15.3 Host firmware adaption

In comparison to the firmware of the Thyone-I, the Thyone-e has a reduced function set. Most functions on Thyone-e and Thyone-I are the same and can be controlled by the same set of UART commands. The differences are as follows:

Removed features are:

- The LE coded phy (radio profile 125 kbps and 500 kbps) is not supported on the Thyone-e.
- Firmware update is not supported on Thyone-e.
- Remote GPIO pins cannot be used as PWM pins on Thyone-e.
- The CCA (clear channel assessment) is not supported on Thyone-e.

In case one of these features is needed by the application, a replacement of Thyone-I by Thyone-e cannot be done.

Changed features are:

- State indication is done only on *LED_1* on Thyone-e (Thyone-I uses *LED_1* and *LED_2*).
- The Thyone-e can be woken up from sleep mode only by the */RESET* pin.
- Thyone-e uses different radio channels and a reduced number of radio profiles w.r.t. Thyone-I. Thus they are not radio compatible to each other.

In case one of the above features is used in host controller firmware, it must be updated. Please refer to the Wireless Connectivity SDK [2, 3] for radio module drivers and examples in C-code.

16 Puck-I to Skoll-I

The radio module Puck-I is a Bluetooth® Classic 2.1 radio module coming with the well-proven serial port profile (SPP) for wireless serial communication. As this Bluetooth® specification is no longer recommended for new designs, Würth Elektronik eiSos released the Skoll-I radio module enabling Bluetooth® Classic and Bluetooth® LE connectivity using the modern Bluetooth® 5.4 radio standard.
On the Bluetooth® Classic interface Skoll-I provides the serial port profile (SPP). Thus it's a perfect replacement of the Puck-I, adding the opportunity on top to communicate with Bluetooth® LE devices as well. This makes the Skoll-I an ideal product for possible future markets.

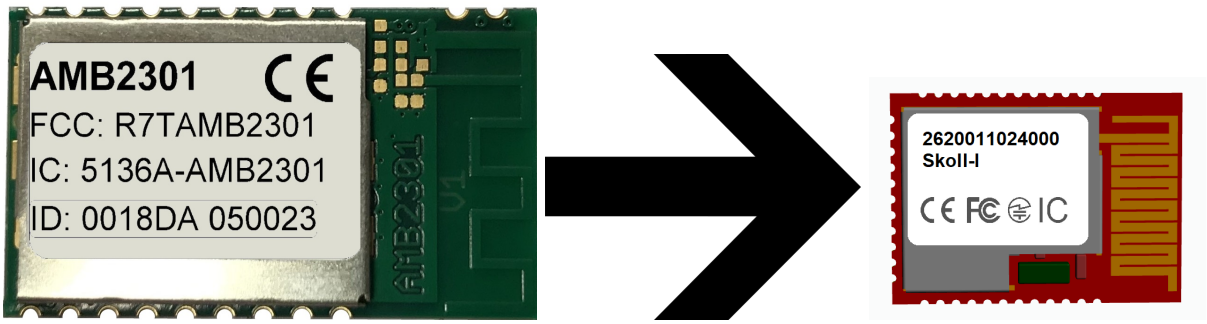

Figure 24: Puck-I to Skoll-I

16.1 Summary

In comparison to the Puck-I, the Skoll-I provides a broader function set. In case the Puck-I is replaced by a Skoll-I, a new hardware design must be done, but due to the reduced size, it fits into the previously used space on the PCB.
As the firmware of Skoll-I uses a new UART protocol, the firmware integration has to be updated as well. Nevertheless, there are two options of smooth firmware integration.
When interchanging the Puck-I by a Skoll-I module, a new Bluetooth® qualification is mandatory.

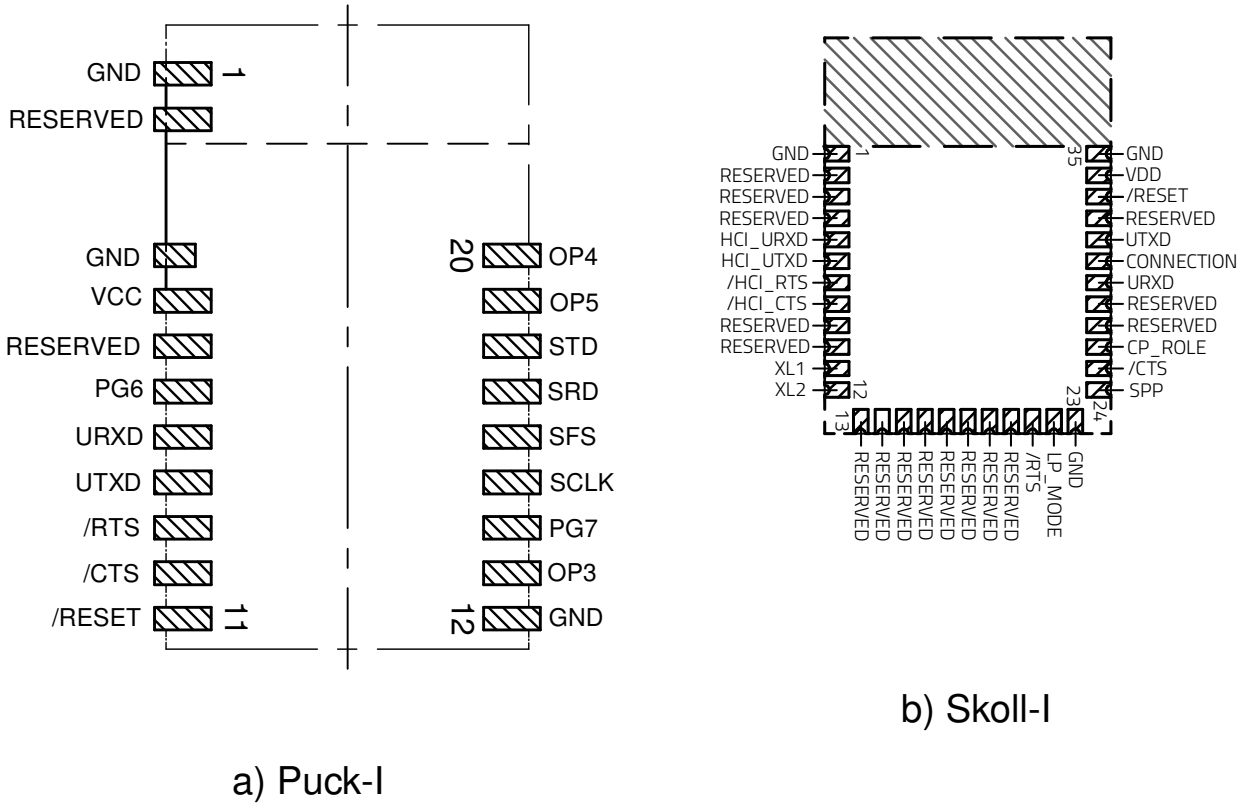

Figure 25: Pinout

16.2 Hardware adaption

16.2.1 Foot print

In comparison to the Puck-I, the Skoll-I has a smaller footprint. Due to the reduced size of the Skoll-I (16.61×12×1.7 mm), the Skoll-I fits into the space reserved for a Puck-I (27.5×16×2 mm).

16.2.2 Pinout

Besides the footprint the Puck-I and Skoll-I differ also in the pinout. Both share VCC, GND and UART lines, but the Skoll-I brings new pins that are used for mode configuration.

Pin No	Puck-I	Pin No	Skoll-I	Comment
1,3,12	*GND*	1,23,35	*GND*	Ground.
4	*VCC*	34	*VDD*	Supply voltage.
7	*URXD*	29	*URXD*	UART Reception.

8	*UTXD*	31	*UTXD*	UART Transmission.
9	*/RTS*	21	*/RTS*	UART /RTS signal.
10	*/CTS*	25	*/CTS*	UART /CTS signal.
11	*/RESET*	33	*/RESET*	Reset pin.

Table 27: Pins with same functions on both, Puck-I and Skoll-I

Pin No	Puck-I	Pin No	Skoll-I	Comment
OP3-OP5	13,19,20	-	-	Baud rate selection pin function removed.
-	-	5-8	*HCI_UART*	HCI_UART to run test modes for certification
-	-	22	*LP_MODE*	Determine low power behaviour
-	-	24	*SPP*	Pin for managing the Bluetooth® connection
-	-	26	*CP_ROLE*	Pin for managing the Bluetooth® role
-	-	30	*CONNECTION*	Pin indicating the connection state

Table 28: Pins of the Puck-I and Skoll-I, that have different functions

Besides the new HCI UART interface for running test modes, the Skoll-I brings 4 new pins for improved management of the module state.

16.3 Host firmware adaption

In comparison to the Puck-I, the Skoll-I brings the same Bluetooth® Classic SPP-features and adds Bluetooth® LE features as well as firmware over the air update (FOTA) on top. Thus it can act as Bluetooth® Classic master and slave with SPP connectivity, as well as Bluetooth® LE peripheral or central device.
It has two UART protocols running simultaneously, one text-based which is optimized for evaluation tasks. The other one is binary-based which is optimized in terms of performance.
However, there are two options to switch from Puck-I to Skoll-I:

1. Use the Skoll-I C-driver available in the Wireless Connectivity SDK [2, 3]. It brings all functions the Skoll-I provides, and comes with examples, on how to use the driver for Skoll-I.

2. Connect the *CP_ROLE* and *SPP* pin in a way, that the Skoll-I runs in data mode. In that scenario the module waits for incoming Bluetooth® connections and switches the *CONNECTION* pin, as soon as a connection has been setup. Then UART payload data can be sent/received to/from the Skoll-I without the need of using UART commands. Please refer to the Skoll-I user manual [4] for more information on that.

17 References

[1] Würth Elektronik. Application note 15 - From 868 to 915 MHz. http://www.we-online.com/ANR015.

[2] Würth Elektronik. Application note 8 - Wireless connectivity SDK. http://www.we-online.com/ANR008.

[3] Würth Elektronik. Wireless Connectivity SDK for STM32 - Radio module drivers in C-code. https://github.com/WurthElektronik/WirelessConnectivity-SDK_STM32.

[4] Würth Elektronik. Skoll-I user manual. https://www.we-online.de/katalog/de/manual/2620011024000.

18 Important notes

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