

# Hardware Manual phyNODE-KW41Z

## Preface

As a member of PHYTEC's phyWAVE® product family the phyWAVE- KW41Z is one of a series of PHYTEC wireless modules that can be populated with different controllers and, hence, offer different functions and configurations. PHYTEC supports multiple wireless modules using different protocols like IEEE 802.15.4, Bluetooth Smart and IEEE 802.11:

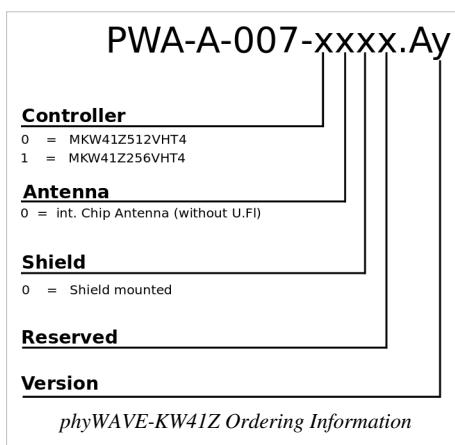
1. as the basis for Rapid Development Kits which serve as a reference and evaluation platform.
2. as insert-ready, fully functional phyWAVE® OEM modules, which can be embedded directly into the user's peripheral hardware design.

Implementation of an OEM-able module subassembly as the "core" of your embedded design allows you to focus on hardware peripherals and firmware without expending resources to "re-invent" microcontroller circuitry and RF design. Furthermore, much of the value of the phyWAVE® module lies in its layout and test.

Production-ready firmware implementations and Design Services for our hardware will further reduce your development time and risk and allow you to focus on your product expertise. Take advantage of PHYTEC products to shorten time-to-market, reduce development costs, and avoid substantial design issues and risks. With this new innovative full system solution you will be able to bring your new ideas to market in the most timely and cost-efficient manner.

## Ordering Information

The part numbering of the phyWAVE- KW41Z has the following structure:



**Product Specific Information and Technical Support** In order to receive product specific information on changes and updates in the best way also in the future, we recommend to register at <http://www.phytec.de/de/support/registrierung.html> or <http://www.phytec.eu/europe/support/registration.html>

For technical support and additional information concerning your product, please visit the support section of our web site which provides product specific information, such as errata sheets, application notes, FAQs, etc.

<http://www.phytec.de/support/knowledge-database/internet-of-things/iot/> or <http://www.phytec.eu/europe/support/faq/faq.html#IOT>

## Regulatory

PHYTEC wireless modules (henceforth products) are designed for installation in electrical appliances or as dedicated Evaluation Boards (i.e.: for use as a test and prototype platform for hardware/software development) in laboratory environments.

## CE Compliance

PHYTEC products fulfill the norms of the European Union's Directive for Electro Magnetic Conformity only in accordance to the descriptions and rules of usage indicated in this hardware manual (particularly in respect to the DSC connector, power supply, climate conditions and serial interface to a host-PC). The measurements that lead to the verified declaration of conformity are being executed by an external laboratory according to the normative regulation stated in:

- EN 300 328 – Radio spectrum conformity of radio equipment in the 2.4 GHz ISM band
- EN 301 489 – Electro Magnetic Conformity for radio equipment
- EN 60950-1 – Information technology equipment, Safety

Implementation of PHYTEC products into target devices, as well as user modifications and extensions of PHYTEC products, is subject to renewed establishment of conformity to, and certification of, Electro Magnetic Directives. Users should ensure conformance following any modifications to the products as well as implementation of the products into target systems.

## FCC Certification

Warning: changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with a minimum distance of 20cm between the radiator & your body. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

### Labeling Instruction for End User Device Integrator

Please notice that if the FCC identification number is not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display a label referring to the enclosed module. This exterior label can use wording such as the following: **“Contains FCC ID: 2AP33001”** any similar wording that expresses the same meaning may be used.

§ 15.19 Labelling requirements shall be complied on end user device. Integrator shall bear the following statement in a conspicuous location on the device:

*This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.*

*Labeling rules for special device, please refer to §2.925, § 15.19 (a)(5). For E-label, please refer to §2.935.*

### Installation Notice

The module is limited to OEM installation ONLY. The OEM integrator is responsible for ensuring that the end-user has no manual instruction to remove or install module. The module is limited to installation in mobile application, a separate approval is required for all other operating configurations, including portable configurations with respect to Part 2.1093 and difference antenna configurations.

### FCC Part 15B Compliance Requirements for End User Device

The OEM integrator is responsible for ensuring that the host product which is installed and operating with the module is in compliant with Part 15B requirements, please note that For a Class B digital device or peripheral, the instructions furnished the user manual of the end-user product shall include the following or similar statement,

placed in a prominent location in the text of the manual:

*Note:* This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

## Device Handling

**Caution!** PHYTEC products lacking protective enclosures are subject to damage by ESD and, hence, may only be unpacked, handled or operated in environments in which sufficient precautionary measures have been taken in respect to ESD-dangers. It is also necessary that only appropriately trained personnel (such as electricians, technicians and engineers) handle and/or operate these products. Moreover, PHYTEC products should not be operated without protection circuitry if connections to the product's pin header rows are longer than 3 m.

## Introduction

The phyWAVE-KW41Z is a subminiature (15 mm x 19 mm) insert-ready wireless module populated with the NXP Semiconductor Kinetis KW41Z microcontroller. The low power architecture and an integrated IEEE 802.15.4/Bletooth Low Energy hybrid transceiver enable its insertion in a wide range of wireless applications using one of the offered network stacks, i.e. Thread, IEEE802.15.4 MAC layer, ZigBee, Bluetooth Low Energy. With the Kinetis KW41Z SoC Thread and Bluetooth Low Energy can be used simultaneous due to fast switching times of the integrated radio transceiver.

The phyWAVE-KW41Z belongs to Phytec's wireless module family. The phyWAVE boards integrate all core elements of a wireless microcontroller system on a subminiature board and are designed in a manner that ensures their easy expansion and embedding in peripheral hardware developments.

A typical application of the phyWAVE-KW41Z is the usage in battery powered wireless sensor nodes, which perceive environmental data. In this scenario, no other components beside sensors, battery or accumulator and optionally energy harvesting components need to be used. The integrated ARM Cortex M0+ microprocessor will be used as application processor which runs the network stack and the user application to interface the sensors.

The phyWAVE-KW41Z wireless module can also be used as network interface in higher performance hardware, such as a gateway. A gateway may consist of a Linux driven Phytec SOM in combination with a phyWAVE-KW41Z. The SOM offers computation power while the phyWAVE module provides wireless connectivity to the system. Please contact our sales team for further information.

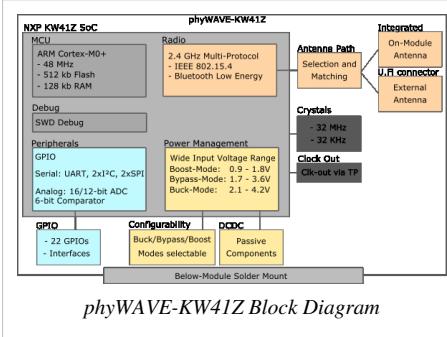
phyWAVE modules achieve their small size through modern SMD technology and multi-layer design. In accordance with the complexity of the module, 0402-packaged SMD components and laser-drilled microvias are used on the boards, providing phyWAVE users with access to this cutting edge miniaturization technology for integration into their own design. At the same time phyWAVE modules can be integrated to a carrier board by using an easy-to-solder DSC connector.

## Features of the phyWAVE-KW41Z

The phyWAVE-KW41Z offers the following features:

- Insert-ready, sub-miniature (15 mm x 19 mm) wireless module subassembly in low EMI design, achieved through advanced SMD technology
- Populated with the NXP Semiconductor Kinetis KW41Z microcontroller (QFN 48 packaging)
- ARM Cortex M4 application processor providing
  - 256 kB - 512 kB Flash
  - 64 kB – 128 kB SRAM
  - Integrated 2.5 GHz RF-Section with IEEE802.15.4 and Bluetooth Low Energy 4.2
- PCB antenna
- Controller signals and ports extend to the modules' Direct Solder Connection (DSC), enabling the phyWAVE-KW41Z to be soldered to the target application like a "big chip"
- Low Power Universal Asynchronous Serial Interface (UART-TTL)
- Two I2C interfaces
- Three SPI interfaces
- PWM output
- 16 bit ADC and Analog Comparator with 6 bit analog comparator
- Hardware encryption support, Tamper detect
- JTAG and SWD interface
- RTC with populated 32 kHz quartz crystal
- Nearly all GPIOs available at the DSC connector
- Wide supply voltage range of 0.9 V - 4.2 V
- Industrial temperature grade of -40°C to +85° C (section 4.2)

## Block Diagram



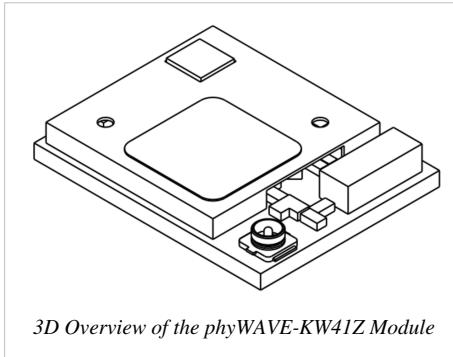
## Block Diagram Description

The NXP KW41Z SoC is used as main component on the module. For detailed documentation of the SoC please head to the manufacturer datasheet (NXP Kinetis KW41z).

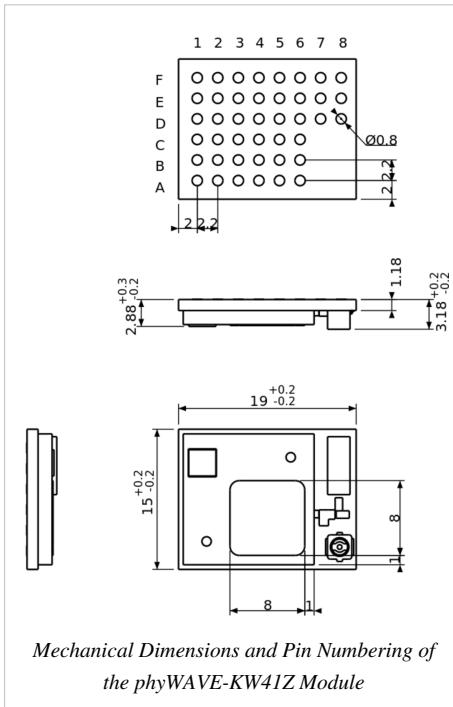
The KW41Z SoC integrates a ARM Cortex-M0+ application processor, Flash, RAM, 2.4 GHz multi-protocol Transceiver (IEEE 802.15.4 and BLE). The multi-protocol transceiver can be operating in IEEE 802.15.4 mode (DSSS, O-QPSK, 250 kb/s, 2405 MHz - 2480 MHz) or in Bluetooth Low Energy Mode (GFSK, 1 Mbit/s, 2402 MHz - 2480 MHz). Additionally common interfaces such as SPI, UART, I2C, ADC, DAC and PWM are integrated. An on-SoC DC-DC Converter can be configured to Buck or Boost mode to allow for operation from 0.9 to 4.2 V. Depending on the voltage range, Buck, Boost or Direct Mode needs to be configured via external configuration pins and in firmware. Furthermore two crystals are populated on the phyWAVE module, 32 MHz will be used for normal

operation and 32 KHz will be used during sleep-modes. The antenna mode can be configured via configuration resistor on the module (Make sure you will order the correct module variant described under Ordering Information). For detailed description about RF-Characteristics (operating frequency, antenna characteristics) please head to chapter "*RF Characteristics*".

## Mechanical Dimensions and Pin Numbering



*3D Overview of the phyWAVE-KW41Z Module*



*Mechanical Dimensions and Pin Numbering of the phyWAVE-KW41Z Module*

## Pin Description

Please note that all module connections are not to exceed their expressed maximum voltage or current. Maximum signal input values are indicated in the corresponding controller manuals/data sheets. As damage from improper connections varies according to use and application, it is the user's responsibility to take appropriate safety measures to ensure that the module connections are protected from overloading through connected peripherals.

All controller signals selected extend to the 40 pin DSC connector. This allows the phyWAVE- KW41Z to be soldered to any target application like a "big chip".

Table 3 provides an overview of the pinout of the DSC connector DSC1 with signal names and descriptions specific to the phyWAVE-KW41Z. It also provides the appropriate voltage domain, signal type (ST) and a functional grouping of the signals. The signal type includes also information about the signal direction. A description of the signal types can be found in Table 1.

**Caution!** The NXP Semiconductor KW41Z is a 0.9 V to 4.2 V operated microcontroller and as such special attention should be paid to the interface voltage levels to avoid unintentional damage to the microcontroller. Please refer to the NXP Semiconductor KW41Z Reference Manual for details on the functions and features of controller signals and port pins.

**'Note:**

- Most of the controller pins have multiple multiplexed functions. Table 3 describes only the pin type, e.g. GPIO, nRESET.., not their configurable special function. The pin multiplexing needs to be configured in the firmware of the phyWAVE module. Section 1 gives an overview of available firmware solutions. Please also refer to the Kinetis KW41Z Reference Manual to get to know about alternative pin functions.
- The following tables describe the full set of signals available at the phyWAVE DSC connector according to the phyWAVE- KW41Z specification. However, the availability of some interfaces is specific to the variant of the Kinetis KW41Z SOC populated. Thus, some signals might not be available on your module.

## Pin Table

Pin	Signal	Type	SL	Description
A1	VDCDC_IN	I	PWR	Power Supply
B1	DCDC_LP	-	PWR	DCDC Switch Inductor Input Positive
C1	DCDC_CFG	I	PWR	DCDC Switch Mode Select
D1	PSWITCH	I	PWR	DCDC Switch Enable
E1	VDD_1P8OUT	O	PWR	DCDC Pulsed 1.8V Regulated Output
F1	PTB1	I/O	3.3 V	GPIO
A2	PTC18	I/O	3.3 V	GPIO
B2	PTA19	I/O	3.3 V	GPIO
C2	PTC19	I/O	3.3 V	GPIO
D2	PTA18	I/O	3.3 V	GPIO
E2	PTB0	I/O	3.3 V	GPIO
F2	PTB2	I/O	3.3 V	GPIO
A3	PTA2 / nRESET	I/O	3.3 V	GPIO / Reset (low active)
B3	PTA0	I/O	3.3 V	GPIO / SWD_DIO
C3	PTA1	I/O	3.3 V	GPIO / SWD_CLK

D3	PTA17	I/O	3.3 V	GPIO
E3	PTB3	I/O	3.3 V	GPIO
F3	PTB18	I/O	3.3 V	GPIO
A4	PTC16	I/O	3.3 V	GPIO
B4	PTC17	I/O	3.3 V	GPIO
C4	PTC5	I/O	3.3 V	GPIO
D4	PTC4	I/O	3.3 V	GPIO
E4	PTA16	I/O	3.3 V	GPIO
F4	ADC0_DP0	I	3.3 V	ADC Channel 0 differential input positive
A5	PTC7	I/O	3.3 V	GPIO
B5	PTC6	I/O	3.3 V	GPIO
C5	PTC3	I/O	3.3 V	GPIO
D5	PTC2	I/O	3.3 V	GPIO
E5	PTC1	I/O	3.3 V	GPIO
F5	ADC0_DM0	I	3.3 V	ADC Channel 0 differential input positive
A6	GND	I	PWR	Ground 0V
B6	GND	I	PWR	Ground 0V
C6	GND	I	PWR	Ground 0V
D6	GND	I	PWR	Ground 0V
E6	XTAL_OUT	O	CLK	XTAL_OUT
F6	GND	I	PWR	Ground 0V
D7	GND	I	PWR	Ground 0V
E7	Reserved	-	-	Reserved, should remain unconnected
F7	GND	I	PWR	Ground 0V
D8	GND	I	PWR	Ground 0V
E8	GND	I	PWR	Ground 0V
F8	GND	I	PWR	Ground 0V

## Technical Specification

The phyWAVE-KW41Z operates off of a single power supply voltage.

The following sections of this chapter discuss mechanical electrical, and RF specifications of the phyWAVE-KW41Z wireless module.

## Electrical Characteristics

General electrical specifications are provided in the following table:

Parameter	Value
<b>Storage temperature</b>	-55°C + 125°C
<b>Operating temperature</b>	-40°C + 85°C
<b>Frequency stability</b> (32 MHz clock source, 25°C)	10 ppm
<b>Frequency stability</b> (32 MHz clock source, @ -40 - +85°C)	15 ppm
<b>Max. MCU frequency</b>	48 MHz
<b>Operating voltage</b>	0.9 V - 4.2 V
<b>Humidity</b>	95% r.F. not condensed

## RF Characteristics

The following table lists key facts for the internal RF transceiver in IEEE 802.15.4 mode:

Parameter	Value
<b>Frequency band (IEEE 802.15.4)</b>	2.4 GHz ISM band (2405 MHz to 2480 MHz)
<b>IEEE 802.15.4 channels</b>	11 to 26 *( <i>Note 1</i> )
<b>Bandwidth/channel</b>	5 MHz
<b>Modulation (IEEE 802.15.4)</b>	DSSS, O-QPSK, 250 kb/s
<b>RX sensitivity (IEEE 802.15.4)</b>	-100 dBm
<b>TX output power</b>	-30 dBm to +3.5 dBm (programmable)
<b>Antenna</b>	PCB Ceramic
<b>RF Operating range indoor</b> <sup>[1]</sup>	~20 m
<b>RF Operating range outdoor</b> <sup>[2]</sup>	~150 m

The following table lists key facts for the internal RF transceiver in BLE mode:

Parameter	Value
<b>Frequency band (BLE)</b>	2.4 GHz ISM band (2402 MHz to 2480 MHz)
<b>BLE channels</b>	0 to 39
<b>Bandwidth/channel</b>	2 MHz
<b>Modulation (BLE)</b>	GFSK, 1 Mbit/s
<b>RX sensitivity (BLE)</b>	-95 dBm
<b>TX output power</b>	-30 dBm to +3.5 dBm (programmable)
<b>Antenna</b>	PCB Ceramic
<b>RF Operating range indoor</b> <sup>[3]</sup>	~20 m
<b>RF Operating range outdoor</b> <sup>[4]</sup>	~150 m

## On-board Chip Antenna

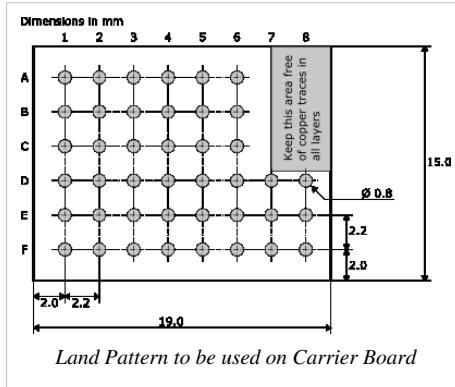
A ceramic chip antenna is populated on the module. The internal PCB antenna is measured for CE and FCC compliance. You can safely use it in your application.

The table below shows the measured characteristics of the on-module ceramic chip antenna. The antenna maximum gain has been measured to be -2 dBi. The radiation pattern of the on-module antenna is Donut shaped.

Parameter	Value
<b>Impedance</b>	50 Ohm
<b>Bandwidth</b>	2.4 GHz – 2.483 GHz
<b>Maximum Antenna gain @2440 MHz</b>	-2 dBi

## Integrating and Handling of the Module

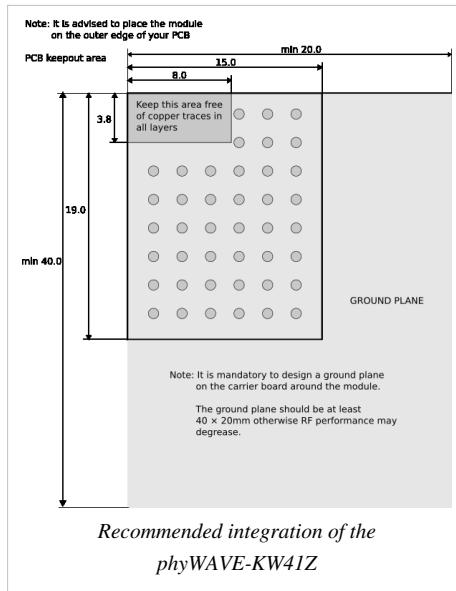
### Land Pattern Recommendation for Carrier Board



The land pattern can be provided as dxf file or other file formats on request. Please contact our sales team for more information.

### Module Placement onto Carrier Board

Successful integration in user target circuitry greatly depends on the adherence to the layout design rules for the GND connections of the phyWAVE module. For maximum EMI and RF performance we recommend as a general design rule to connect all GND pins to a solid ground plane. The figure below shows the recommended placement of the phyWAVE within your application's PCB, all GND pins are marked black. For optimal RF performance the GND area below the phyWAVE should be at least 40 mm wide. It is not critical which layer is being used for the solid GND plane. However, please make sure to connect the GND pins as short as possible, e.g. with a VIA next to each pin. Furthermore, for the selected chip antenna, it is advised to place the module at the edge of your custom PCB. It is very important that there is no copper material on any layer (e.g. GND plane, or any other tracks) in the marked area of the 8 mm x 3.8 mm below the PCB antenna. This ensures that the characteristics of the PCB antenna are as specified in this hardware manual.



## Configuring different Power Modes for the KW41Z SoC

### Buck Mode

- V\_IN - 1.8 V to 4.2 V
- VDD\_1P8\_EXT - Generated on Module, provided by VDD\_1P8OUT Pin. Can be used to supply external sensors.
- Connecting a switch to PSWITCH pin allows to power up the module on user action. Note: A pull down on PSWITCH is available on module.

Module Pin	Module Signal Name	Carrier Board Signal Name
A1	VDCDC_IN	V_IN
B1	DCDC_LP	NC
C1	DCDC_CFG	V_IN
D1	PSWITCH	V_IN
E1	VDD_1P8OUT	NC (VDD_1P8_EXT)

### Boost Mode

- V\_IN - 0.9 V to 1.8 V
- VDD\_1P8\_EXT - Generated on Module, provided by VDD\_1P8OUT Pin. Can be used to supply external sensors.

Module Pin	Module Signal Name	Carrier Board Signal Name
A1	VDCDC_IN	V_IN
B1	DCDC_LP	V_IN
C1	DCDC_CFG	GND
D1	PSWITCH	V_IN
E1	VDD_1P8OUT	NC (VDD_1P8_EXT)

## Bypass Mode

Unsupported

## Soldering Recommendations

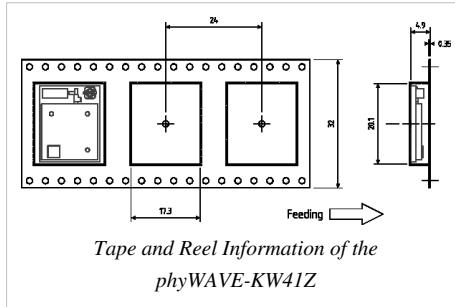
To avoid damaging the module, the following recommendations should be met:

1. Use no-clean flux solder paste.
2. Do not wash the PCB after soldering the module; moisture could be trapped between module and host PCB.
3. Use only one soldering phase. If the host PCB requires multiple flows, apply the module on the final flow.

## Tape and Reel Information

The phyWAVE-KW41Z module is available in the following configuration:

Packing Size	Order Number
400 pcs. Tape	PWA-A07-001-R400



## Integration and Support

Beside this hardware manual, more information is available to facilitate the integration of the phyWAVE-KW41Z into customer applications.

- The design of the phyNODE can be used as a reference for any customer application. More information on the phyNODE can be found at <http://www.phytec.de/produkte/internet-of-things/phynode>.
- Different support packages are available to support you in all stages of your embedded development. Please visit <http://www.phytec.de/de/support/support-pakete.html>, or <http://www.phytec.eu/europe/support/support-packages.html>, or contact our sales team for more details.

## Modifications on the phyWAVE Module

Removal of various components, such as the microcontroller and the standard quartz, is not advisable given the compact nature of the module. Should this nonetheless be necessary, please ensure that the board as well as surrounding components and sockets remain undamaged while de-soldering. Overheating the board can cause the solder pads to loosen, rendering the module inoperable. Carefully heat neighboring connections in pairs. After a few alternations, components can be removed with the solder-iron tip. Alternatively, a hot air gun can be used to heat and loosen the bonds.

**'Caution!** If any modifications to the module are performed, regardless of their nature, the manufacturer guarantee is voided.

## Document Changelog

v1.0	2017-04-19	• initial release
v1.1	2017-05-18	• added Power Modes wiring

## References

- [1] The maximum operating range depends on environmental conditions such as channel occupation, barriers and TX-power. The stated range should only be understood as a rough guideline.
- [2] The maximum operating range depends on environmental conditions such as channel occupation, barriers and TX-power. The stated range should only be understood as a rough guideline.
- [3] The maximum operating range depends on environmental conditions such as channel occupation, barriers and TX-power. The stated range should only be understood as a rough guideline.
- [4] The maximum operating range depends on environmental conditions such as channel occupation, barriers and TX-power. The stated range should only be understood as a rough guideline.

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