phyWAVE®-KW2xD

Hardware Manual

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Conventions, Abbreviations and Acronyms

This hardware manual describes the phyWAVE-KW2xD wireless module. The manual specifies the phyWAVE-KW2xD's design and function. Precise specifications for the NXP Semiconductor Kinetis KW2x microcontrollers can be found in the microcontroller data sheet/reference manual.

Note: We refrain from providing detailed part specific information within this manual, which can be subject to continuous changes, due to part maintenance for our products. Please read the paragraph "**Product Change Management and information in this manual on parts populated on the SOM"** within the *Preface*.

Conventions

The conventions used in this manual are as follows:

- Signals that are preceded by an "n", "/", or "#"character (e.g.: nRD, /RD, or #RD), or that have a dash on top of the signal name (e.g.: $\overline{\text{RD}}$) are designated as active low signals. That is, their active state is when they are driven low, or are driving low.
- A "0" indicates a logic zero or low-level signal, while a "1" represents a logic one or high-level signal.
- Tables which describe jumper settings show the default position in **bold, blue text.**
- Text in *blue italic* indicates a hyperlink within, or external to the document. Click these links to quickly jump to the applicable URL, part, chapter, table, or figure.

Types of Signals

Different types of signals are brought out at the phyWAVE DSC-Connector. The following table lists the abbreviations used to specify the type of a signal.

Signal Type	Description	Abbr.
Power	Supply voltage input	PWR_I
Ref-Voltage	Reference voltage output	REF_O
Input	Digital input	I
Output	Digital output	O
Input / Output	Bidirectional input/output	I/O
5V Input PD	5 V tolerant input with pull down	5V_PD
USB IO	Differential line pairs 90 Ohm USB level bidirectional input/output	USB_I/O

Table 1: Signal Types used in this Manual

Abbreviations and Acronyms

Many acronyms and abbreviations are used throughout this manual. Use the table below to navigate unfamiliar terms used in this document.

Abbreviation	Definition
DSC	Direct Solder Connection; a phyWAVE wireless module can be populated on any base board via DSC without the need of dedicated expensive connectors.
EMI	Electromagnetic Interference.
GPI	General purpose input.
GPIO	General purpose input and output.
GPO	General purpose output.
J	Solder jumper; these types of jumpers require solder equipment to remove and place.
JP	Solderless jumper; these types of jumpers can be removed and placed by hand with no special tools.
PCB	Printed circuit board.
PEB	PHYTEC Extension Board
POR	Power-on reset
RTC	Real-time clock.
SOC	System on Chip
Sx	User button Sx (e.g. S1, S2, etc.) used in reference to the available user buttons, or DIP-Switches on the carrier board.

Table 2: Abbreviations and Acronyms used in this Manual

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Preface

As a member of PHYTEC's phyWAVE® product family the phyWAVE-KW2xD 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.

For more information go to:

http://www.phytec.de/de/leistungen/entwicklungsunterstuetzung.html or
http://www.phytec.eu/europe/oem-integration/evaluation-start-up.html

Ordering Information[1]

The part numbering of the phyWAVE-KW2xD has the following structure:

PWA-A-002-*xxxx.Ay*

Product number

Assembly options:
Controller

0 – KW21D256VHA5
1 – KW21D512VHA5
2 – KW22D512VHA5 (includes Device USB)
3 – KW24D512VHA5 (includes Device USB)

Antenna

0 – int. PCB Antenna
1 – ext. Antenna via U.FL

Shielding

0 – Shield not mounted
1 – Shield mounted (essential if product is targeted for US market)

Reserved

Version number

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

[1]: The structure shows the ordering options available as of the printing of this manual. Additional ordering options may have been added. Please contact our sales team to ´get an update on the ordering options available.

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Declaration of Electro Magnetic Conformity of the PHYTEC phyWAVE-KW2xD

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.

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.

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 have been 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.

Product Change Management and information in this manual on parts populated on the wireless module

When buying a PHYTEC wireless module, you will, in addition to our HW and SW offerings, receive a free obsolescence maintenance service for the HW we provide.

Our PCM (Product Change Management) Team of developers, is continuously processing, all incoming PCN's (Product Change Notifications) from vendors and distributors concerning parts which are being used in our products.

Possible impacts to the functionality of our products, due to changes of functionality or obsolesce of a certain part, are being evaluated in order to take the right masseurs in purchasing or within our HW/SW design.

Our general philosophy here is: **We never discontinue a product as long as there is demand for it.**

Therefore we have established a set of methods to fulfill our philosophy:

Avoiding strategies

- Avoid changes by evaluating long-livety of parts during design in phase.
- Ensure availability of equivalent second source parts.
- Stay in close contact with part vendors to be aware of roadmap strategies.

Change management in rare event of an obsolete and non replaceable part

- Ensure long term availability by stocking parts through last time buy management according to product forecasts.
- Offer long term frame contract to customers.

Change management in case of functional changes

- Avoid impacts on product functionality by choosing equivalent replacement parts.
- Avoid impacts on product functionality by compensating changes through HW redesign or backward compatible SW maintenance.
- Provide early change notifications concerning functional relevant changes of our products.

Therefore we refrain from providing detailed part specific information within this manual, which can be subject to continuous changes, due to part maintenance for our products.

In order to receive reliable, up to date and detailed information concerning parts used for our product, please contact our support team through the contact information given within this manual.

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1 Introduction

The phyWAVE-KW2xD is a subminiature (19 mm x 29 mm) insert-ready wireless module populated with the NXP Semiconductor Kinetis KW2x microcontroller. The low power architecture and an integrated IEEE 802.15.4 transceiver enable its insertion in a wide range of wireless applications using one of the offered network stacks, i.e. Thread, 6LoWPAN/IPv6, or ZigBee.

The phyWAVE-KW2xD 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-KW2xD 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 M4 microprocessor will be used as application processor which runs the network stack and the user application to interface the sensors.

The phyWAVE-KW2xD 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-KW2xD. 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.

1.1 Features of the phyWAVE-KW2xD

The phyWAVE-KW2xD offers the following features:

- Insert-ready, sub-miniature (19 mm x 29 mm) wireless module subassembly in low EMI design, achieved through advanced SMD technology
- Populated with the NXP Semiconductor Kinetis KW2xD microcontroller (LGA63 packaging)
- ARM Cortex M4 application processor providing
    - 256 kB - 512 kB Flash[2]
    - 32 kB - 64 kB SRAM[2]
    - Integrated RF-Section
        - 2.5 GHz ISM band, IEEE 802.15.4
- PCB antenna and a U.FL connector to connect an external antenna
- Controller signals and ports extend to the modules' Direct Solder Connection (DSC), enabling the phyWAVE-KW2xD to be soldered to the target application like a "big chip"
- Three Universal Asynchronous Serial Interface (UART-TTL)
- One Full-Speed Device USB interface[3]
- Two I^2C interfaces
- SPI interface
- PWM output
- 16 bit ADC and Analog Comparator with 6 bit DAC
- Hardware encryption support, Tamper detect
- JTAG and SWD interface
- RTC with populated 32 kHz quartz crystal
- Nearly all GPIOs[4] available at the DSC connector
- Wide supply voltage range of 1.8 V - 3.6 V
- Industrial temperature grade of -40°C to +85° C (*section 4.2*)

[2]: Depends on the version of the KW2xD SoC populated on the module, refer to the ordering information in the Preface.

[3]: The USB device functionality is only available in specific versions of the KW2xD SOC. Please consult the Ordering Information in the *Preface* to get to know which version of the phyWAVE supports USB.

[4]: Almost every controller port which connects directly to the DSC connector may be used as GPIO by using the NXP Semiconductor Kinetis KW2xD pin muxing options.

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1.2 Block Diagram

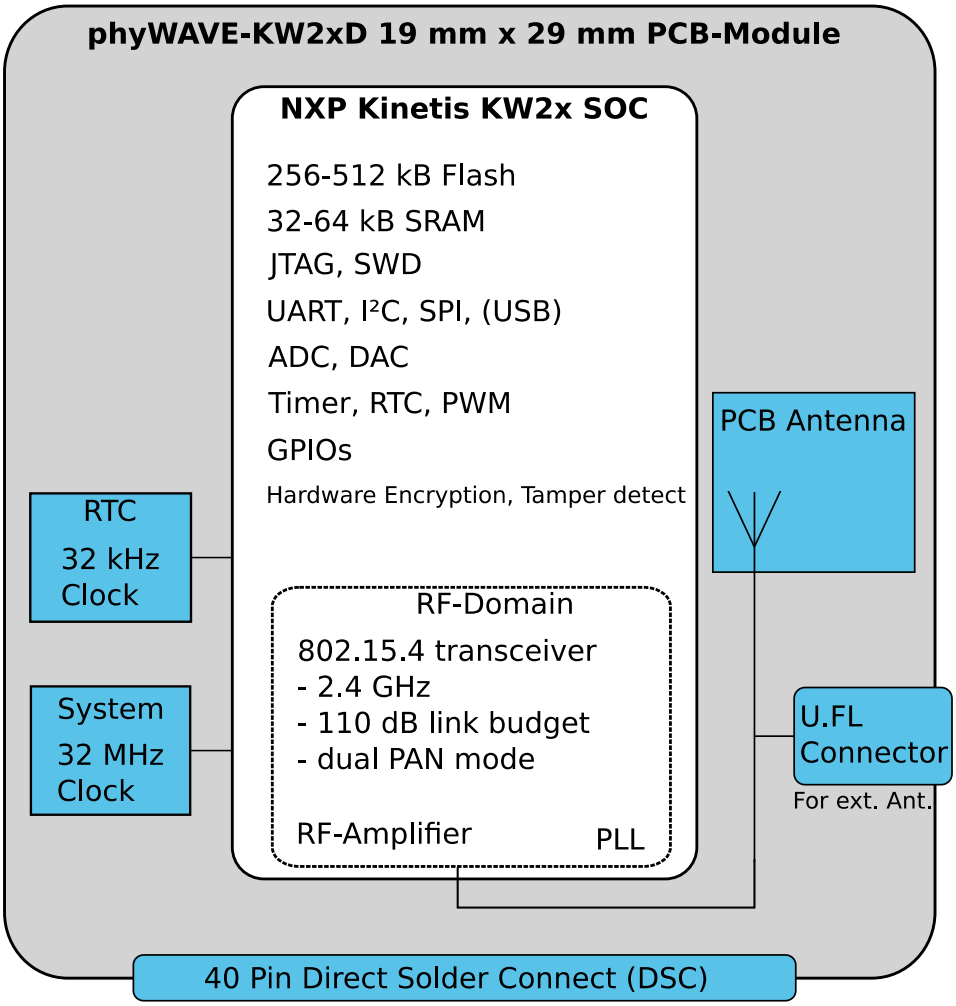

Figure 1: Block diagram of the phyWAVE-KW2xD[3]

1.3 phyWAVE-KW2xD Component Placement

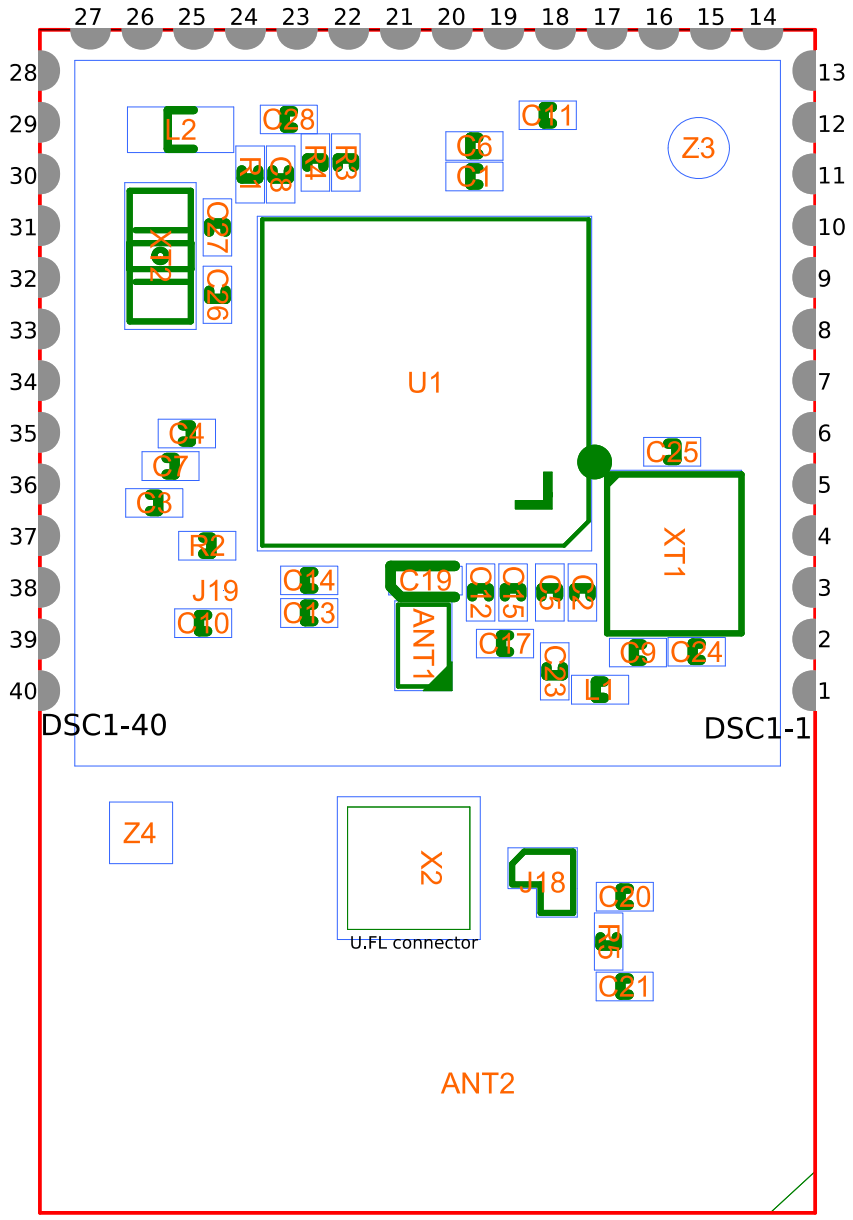

Figure 2: phyWAVE_KW2xD Component Placement (top view)

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2 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-KW2xD 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-KW2xD. 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 KW2x is a 1.8 V to 3.6 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 KW2x 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 6* gives an overview of available firmware solutions. Please also refer to the *Kinetis KW2x 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-KW2x specification. However, the availability of some interfaces is specific to the variant of the Kinetis KW2x SOC populated. Thus, some signals might not be available on your module.

Pin #	Signal	ST	SL	Description
1	GND	PWR_O	GND	Ground 0 V
2	N.C.	-	-	
3	N.C.	-	-	
4	PTC4	I/O	3.3 V	GPIO
5	PTC5	I/O	3.3 V	GPIO
6	PTC6	I/O	3.3 V	GPIO
7	PTC7	I/O	3.3 V	GPIO
8	PTD1	I/O	3.3 V	GPIO
9	PTD2	I/O	3.3 V	GPIO
10	PTD3	I/O	3.3 V	GPIO
11	PTD4	I/O	3.3 V	GPIO
12	PTD5	I/O	3.3 V	GPIO
13	PTD6	I/O	3.3 V	GPIO
14	GND	PWR_O	GND	Ground 0 V
15	PTD7	I/O	3.3 V	GPIO
16	PTE0	I/O	3.3 V	GPIO
17	PTE1	I/O	3.3 V	GPIO
18	PTE2	I/O	3.3 V	GPIO
19	PTA3	I/O	3.3 V	GPIO, JTAG_TMS, SWD_DIO
20	PTA0	I/O	3.3 V	GPIO, JTAG_TCLK, SWD_CLK
21	PTE3	I/O	3.3 V	GPIO
22	PTE4	I/O	3.3 V	GPIO
23	PTE16	I/O	3.3 V	GPIO/USB0_DP[5]
24	PTE17	I/O	3.3 V	GPIO/USB0_DM[5]
25	PTE18	I/O	3.3 V	GPIO/VOUT33[5]
26	PTE19	I/O	3.3 V	GPIO/VREGIN[5]
27	GND	PWR_O	GND	Ground 0 V
28	TAMPER, RTC_WAKEUP	I	3.3 V	TAMPER0, RTC_WAKEUP_B
29	GND	PWR_O	GND	Ground 0 V
30	Vcc	PWR_O	3.3 V	VCC 3.3 V
31	nRESET	I	3.3 V	Reset input (low active)
32	N.C.	-	-	
33	PTA1	I/O	3.3 V	GPIO, JTAG_TDI
34	PTA2	I/O	3.3 V	GPIO, JTAG_TDO

Table 3: Pinout of the phyWAVE DSC Connector DSC1

[5]: The USB device functionality is only available in specific versions of the KW2xD SOC. If the USB device feature is available, the pins are reserved for USB functionality and can not be used as regular GPIO pin. If the USB feature is not available, the pins can be used as regular GPIO. Please consult the Ordering Information in the *Preface* to get to know which version of the phyWAVE supports USB.

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Pin #	Signal	ST	SL	Description
35	N.C.	-	-	
36	PTA4	I/O	3.3 V	GPIO
37	PTA18	I/O	3.3 V	GPIO
38	PTA19	I/O	3.3 V	GPIO
39	N.C.	-	-	
40	GND	PWR_O	GND	Ground 0 V

Table 3: Pinout of the phyWAVE DSC Connector DSC1 (continued)

3 Jumpers

For configuration purposes, the phyWAVE-KW2xD has one solder jumper, that is configured prior to delivery. *Table 4* below provides a functional summary of the solder jumper which can be changed to select the internal PCB antenna, or an external antenna via U.FL connector. It shows its default position, and possible alternative positions and functions.

If manual jumper modification is required 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.

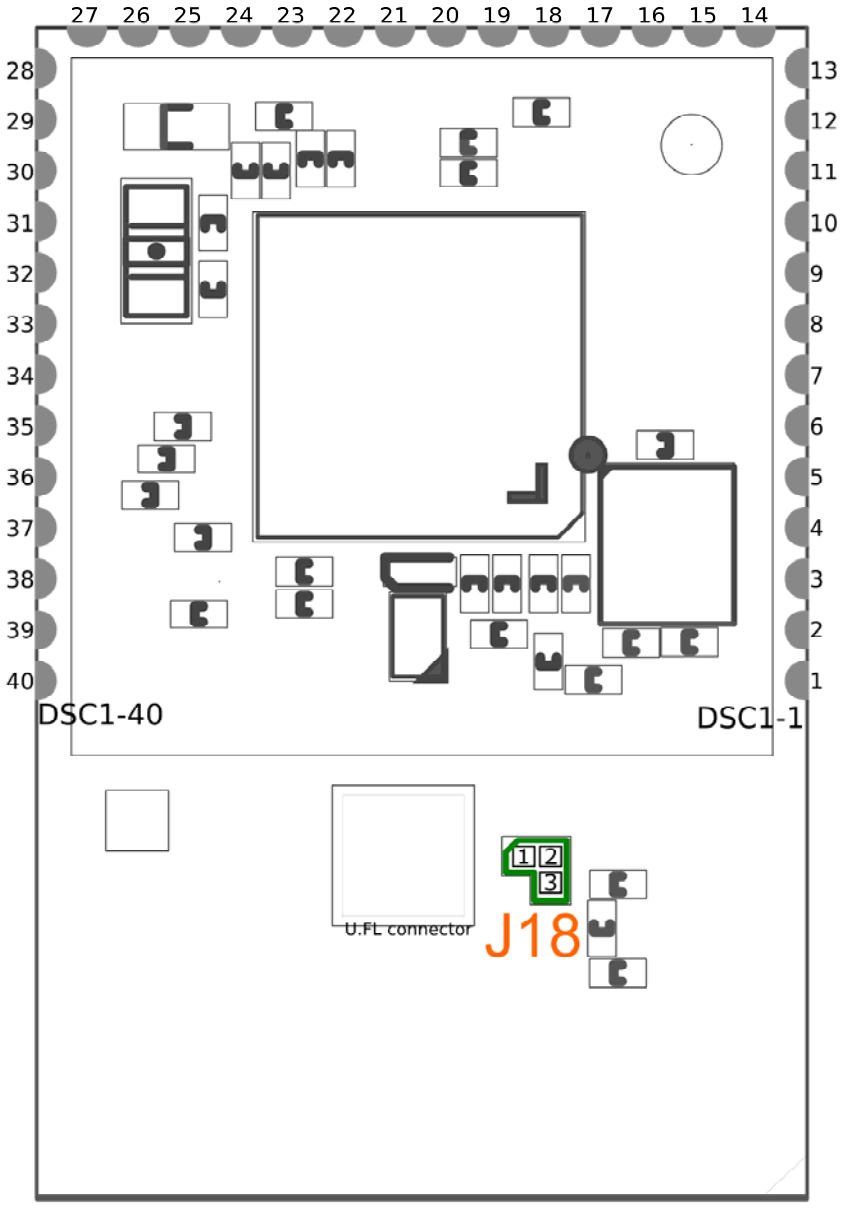

Figure 3: Jumper Locations (top view)

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Please pay special attention to the “TYPE” column to ensure you are using the correct type of jumper (0 Ohms, 10k Ohms, etc...).

The jumper (J = solder jumper) has the following function:

Jumper	Description	Type	Chapter
J18	J18 defines which antenna is used. You can specify the default setting in your order, see Ordering Information in *Preface*.	10 pF (0402)	*4.3*
1+2	phyWAVE-KW2xD configured for external antenna, connected via U.Fl. connector X2		
2+3	phyWAVE-KW2xD configured for internal PCB antenna		

Table 4: Jumper Settings

4 Technical Specification

The phyWAVE-KW2xD operates off of a single power supply voltage.

The following sections of this chapter discuss mechanical electrical, and RF specifications of the phyWAVE-KW2xD wireless module.

4.1 Physical Dimensions

The physical dimensions of the phyWAVE-KW2xD are represented in *Figure 4*. The module's profile is max. 4.8 mm thick (2.6 without shielding). The board itself is 1 mm thick.

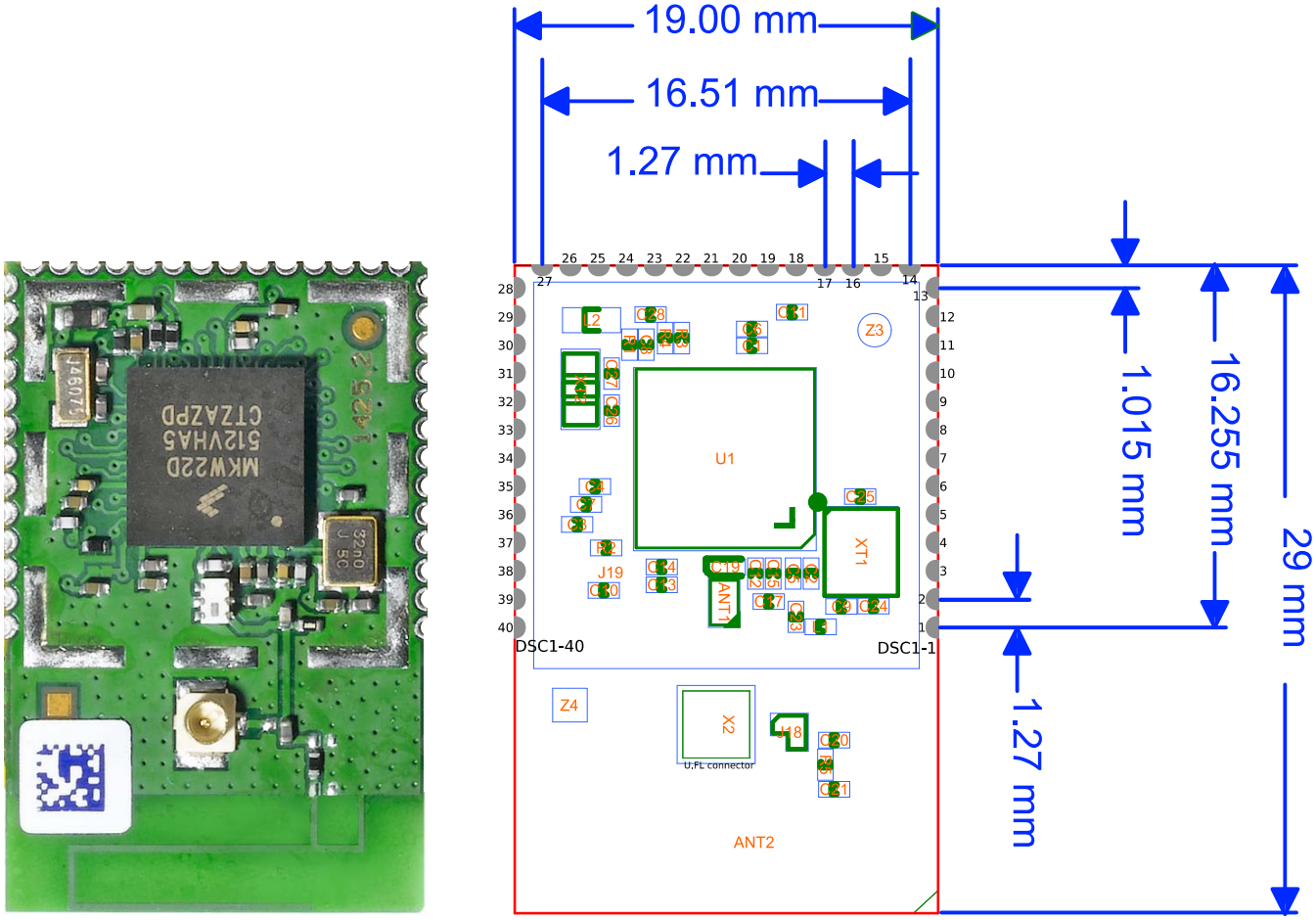

Figure 4: Dimensions of the phyWAVE-KW2xD Wireless Module (top view)

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4.2 Electrical Characteristics

Table 5 provides general specifications of the module. *Table 6* gives an overview of the most important power modes of MCU and transceiver inside the KW2x SOC and their corresponding current flow.

Parameter	Value
Storage temperature:	-55 °C - +125 °C
Operating temperature:	-40 °C - +85 °C
Frequency stability of 32 MHz clock source (25 °C)	10 ppm
Frequency stability: of 32 MHz clock source (-40 - +85 °C)	15 ppm
Max. MCU frequency:	50 MHz
Operating voltage:	1.8 V – 3.6 V
Humidity:	95 % r.F. not condensed

Table 5: General Electrical Specifications of the phyWAVE-KW2xD

Electrical load	Current consumption (typical current at 2.7 V, T = 25 °C)
MCU at 32 MHz[6]	12.9 mA
MCU at 16 MHz[6]	6.5 mA
MCU at 2 MHz[6]	1.1 mA
MCU in low power mode[7, 8]	1 mA down to <1 µA (depending on the power mode)
Modem RX, CCA, ED[9]	19 mA
Modem TX at 0dBm [9]	17 mA
Modem Idle (Fast transition to RX, TX, CCA) [9]	700 µA
Modem Hibernate (Register data retention) [9]	<1 µA

Table 6: Current Consumption of the MCU and Transceiver inside the NXP KW2x SoC

[6]: KW2x Reference Manual - 4.8.5.2 MCU Active Current
[7]: KW2x Data Sheet - 8.3.5 Power consumption operating behaviors
[8]: KW2x Reference Manual – 14.2 Power Modes Description
[9]: KW2x Reference Manual – 4.8.2.1 Modem Active Currents

4.3 RF Characteristics

Table 7 lists the key facts for the internal IEEE 802.15.4 transceiver.

Parameter	Value
Frequency band	2.4 GHz ISM band (2.4 GHz - 2.48 GHz)
Wireless standard	IEEE 802.15.4 PHY, upper layer e.g. Thread, 6LoWPAN, ZigBee
IEEE 802.15.4 channels	11-26
Bandwidth/channel	5 MHz
Modulation	DSSS, O-QPSK, 250 kbps
TX output power	-35 dBm - +8 dBm (programmable)
RX sensitivity	-102 dBm
Antenna	PCB or external via U.FL connector
RF Operating range indoor[10]	~20 m
RF Operating range outdoor[10]	~150 m

Table 7: RF Characteristics of the phyWAVE-KW2xD Module

[10]: 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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4.3.1 On-board PCB Antenna

The on-board PCB antenna has been exclusively designed for the phyWAVE-KW2xD wireless module. The key parameters of the RF measurement that has been executed during the CE certification process in a certified lab are listed in *Table 8*. The on-board PCB antenna has a slight directivity. The directivity pattern has been measured and is visualized in *Figure 5*. The orientation of the phyWAVE during measurements is depicted in *Figure 6*. *Figure 6* shows the phyWAVE module on the phyNODE evaluation board in the same direction as in *Figure 5 A*.

Parameter	Value
Type	PCB, unsymmetrical
Impedance	50 Ohm
Bandwidth	2.4 GHz – 2.483 GHz
Antenna gain, channel 11 [11]	0.7 dBi
Antenna gain, channel 18 [11]	1.5 dBi
Antenna gain, channel 26 [11]	2.1 dBi

Table 8: Internal PCB Antenna Characteristics of the phyWAVE-KW2xD Module

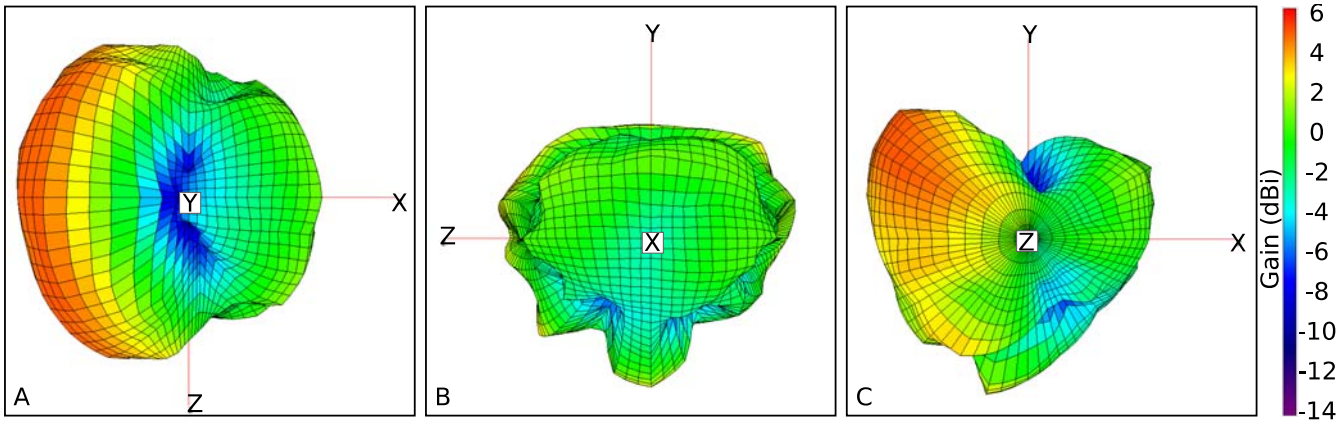

Figure 5: Measured PCB Antenna Gain with a phyWAVE-KW2xD mounted on a phyNODE Board

[11]: The antenna gain has been measured on a phyWAVE-KW2xD populated on a phyNODE board. Measurement has been executed in a shielded fully anechoic chamber to avoid interference and reflection.

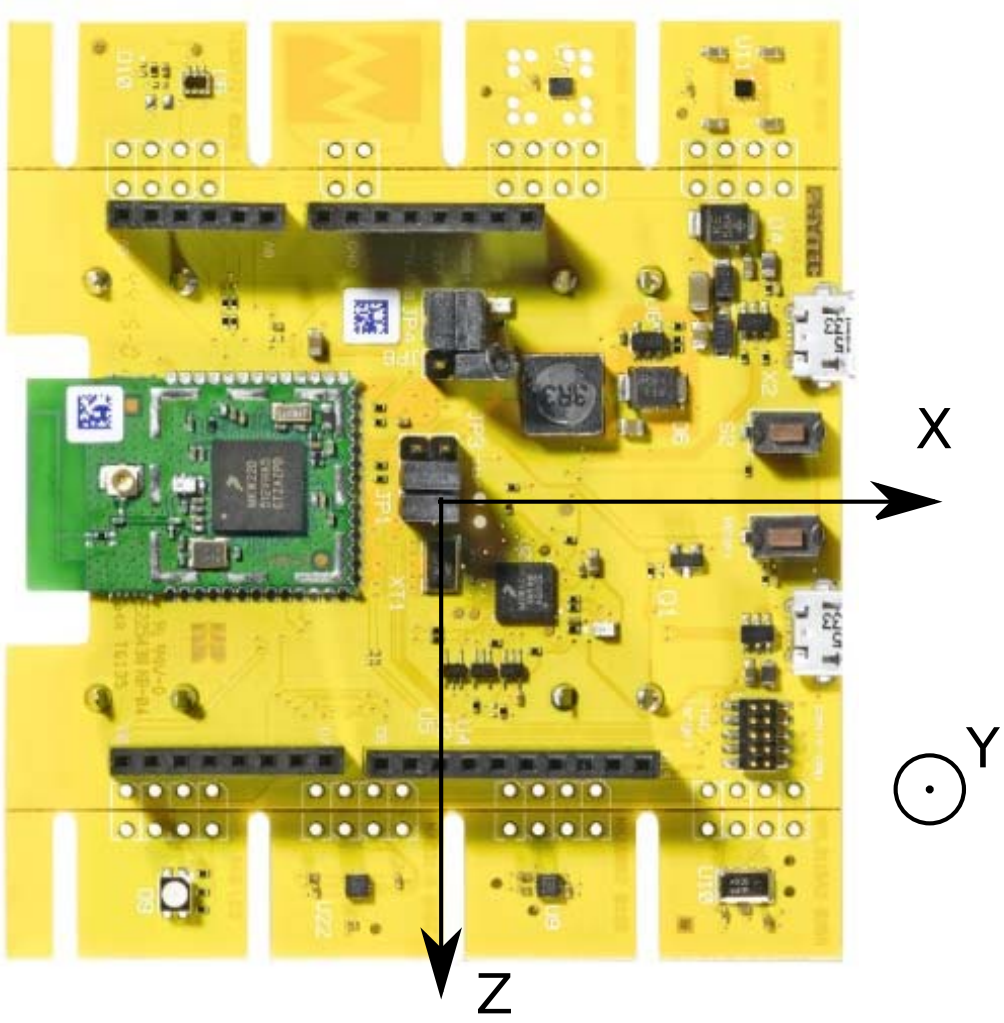

Figure 6: Orientation of the phyWAVE-KW2xD during RF Antenna Gain Measurements

Please find more information about the phyNODE in *chapter 5* or *at* http://www.phytec.de/produkte/internet-of-things/phynode.

Note: The directivity pattern in *Figure 5* is only valid for a phyNODE with a populated phyWAVE in the measurement setup depicted in *Figure 6*. If you use the phyWAVE-KW2xD module standalone or mounted on your own hardware, antenna characteristics and directivity might change. *Chapter 5* gives guidelines how you can achieve similar results when integrating the module to your application.

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4.3.2 External Antenna

In general, all external antennas in the 2.4 GHz frequency band with an impedance of 50 Ohm can be used with the phyWAVE-KW2x. However, the module may exceed regulated maximum output power when using antennas with a strong directivity. Therefore, we selected a one-quarter wave rod antenna that can be used with the module. The proposed external antenna as well as the internal PCB antenna has been measured for CE compliance. You can safely use it in your application[12]. *Table 9* shows the measured characteristics of the Pulse W1010 rod antenna. The antenna gain in the datasheet of the antenna - available at the *Pulse* website - is reported to be 2 dBm. The measured antenna characteristics in *Table 9* show a slightly higher gain, which is regulatory compliant. The Pulse datasheet also provides a 360° radiation pattern. The radiation pattern of the external rod antenna is donut-shaped.

Parameter	Value
Manufacturer	Pulse
Manufacturer Part Number	W1010
Type	unsymmetrical
Impedance	50 Ohm
Bandwidth	2.4 GHz – 2.483 GHz
Antenna gain, channel 11	2.6 dBi
Antenna gain, channel 18	2.8 dBi
Antenna gain, channel 26	2.1 dBi

Table 9: Characteristics of the Pulse W1010 external Rod Antenna (measured in Combination with the phyWAVE-KW2xD)

Phytec item number of the verified external antenna:

- External rod antenna: *xx19*
- Adapter cable that converts from U.FL to SMA connector: *WK130*

Fitting solutions with other external antennas are also available in case you need to place the phyWAVE module along with an antenna in a custom housing. Please contact our sales team for more information.

[12]: Nevertheless, the final end product must be validated for being CE conformant.

5 Integrating and Handling of the Module

5.1 Footprint Recommendation for a Custom PCB

Figure 7 shows the recommended footprint for the host PCB.

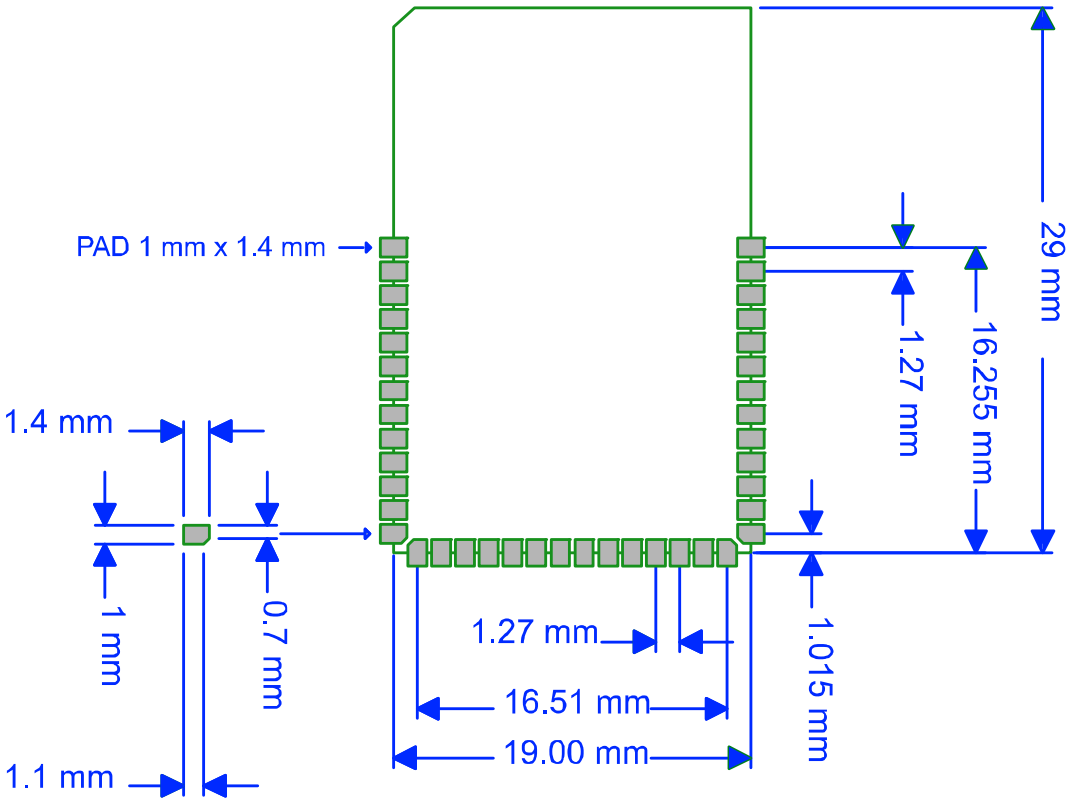

Figure 7: Footprint of the phyWAVE-KW2xD

The footprint, as shown in *Figure 7*, is available in *.dxf* file format at ftp://ftp.phytec.de/pub/Products/phyWAVE-KW2xD/Layout/Dimension. Use of this data allows integrating the phyWAVE-KW2xD wireless module as a single component into your design.

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5.2 Module Placement into Custom Application PCB

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. *Figure 8* 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 27 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, we recommend placing the module on the edge of your custom PCB. It is very important that there is no copper material (e.g. GND plane, or any other tracks) directly below the PCB antenna. As shown in *Figure 8* the uppermost 5.3 mm of the module must be clear of any material. This ensures that the characteristics of the PCB antenna are as specified in *section 4.3.1*.

If phyWAVE wireless modules shall be placed inside a housing with very limited space and where the above stated conditions can not be met you should consider using an external antenna. For more information regarding the antenna configuration and characteristics refer *section 4.3*.

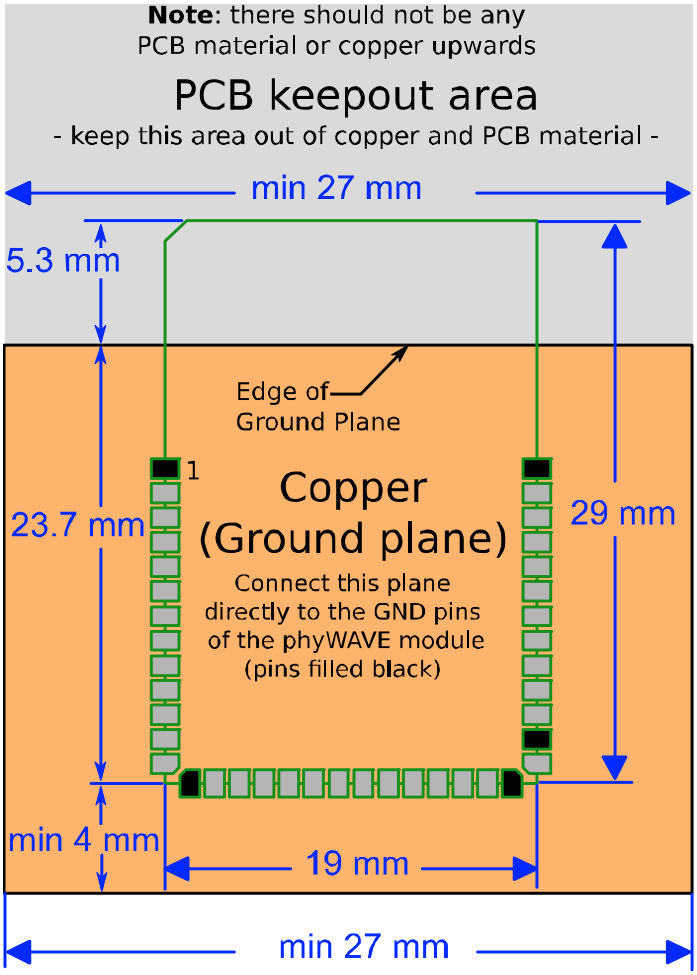

Figure 8: Recommended integration of the phyWAVE-KW2xD

5.3 Soldering Recommendations

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

1. Use no-clean flux solder paste.
2. Use adhesive when placing the module to the host PCB to avoid a displacement of the module during the soldering process.
3. Do not wash the PCB after soldering the module; moisture could be trapped between module and host PCB.
4. Use only one soldering phase. If the host PCB requires multiple flows, apply the module on the final flow.

5.4 Application Schematic

Figure 9 shows a typical application schematic that includes functionality such as JTAG debug interface, reset button, power-on LED, two user LEDs, power and optionally device USB connectivity.

If you want to use the device USB functionality, the power supply will look slightly different, compared to an integration without USB functionality. Make sure to get a correct version of the Kinetis KW2x SoC, with the included device USB functionality, on the phyWAVE. Variants with a KW22 and KW24 have USB functionality while phyWAVE modules with the KW21 mounted do not have USB functionality. Refer to the Ordering Information in the *Preface* to get to know about the phyWAVE-KW2xD versioning scheme.

The USB subsystem inside KW22 and KW24 is powered from +5 V USB supply voltage. An internal linear voltage regulator provides a 3.3 V supply voltage, generated from the 5 V USB supply voltage. This internal voltage regulator powers the USB subsystem and optionally the complete SOC with a current of up to 120 mA. In *Figure 9* – Variant 1, USB – the whole system is powered via the internal voltage regulator. The 5 V power supply from the USB connector (Signal '*P5V_USB*') is connected to the LDO input pin. The 3.3 V system supply voltage is generated inside the KW22/24 and connected to the signal VCC3V3 that supplies the MCU of the KW22/24 SOC.

For debugging purposes UART2 can be used via TP1 and TP2.

With the phyNODE board, a more advanced application schematic is available on request. The phyNODE board is equipped with different sensors to perceive environmental data such as temperature and humidity. Furthermore it integrates a CMSIS-dap debugger which allows programming and debugging of the populated phyWAVE wireless module. The phyNODE board serves as platform for different wireless communication modules.

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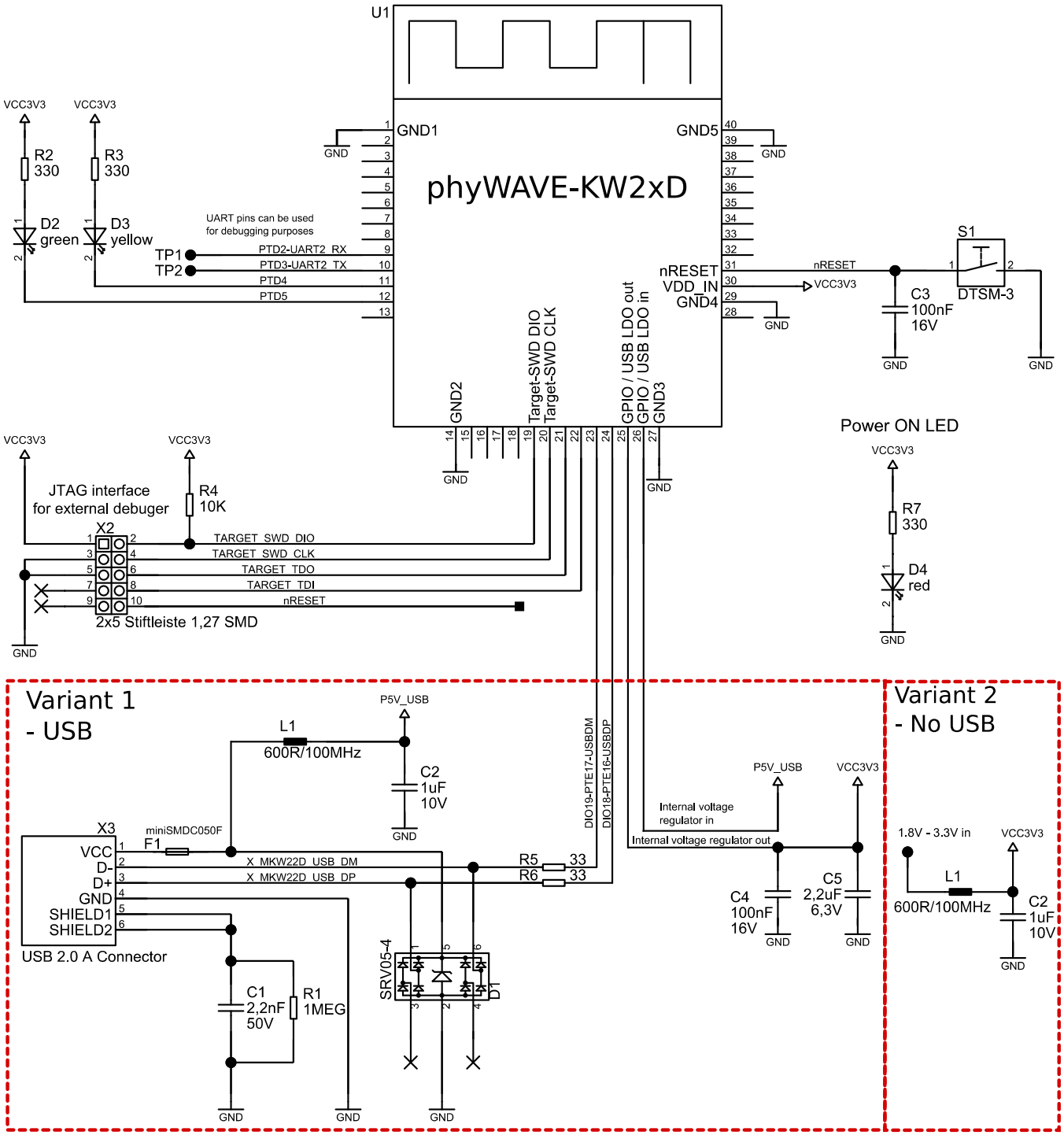

Figure 9: Minimal Application Schematic

5.5 Integration and Support

Beside this hardware manual, more information is available to facilitate the integration of the phyWAVE-KW2xD 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.

5.6 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.

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6 Firmware

There are different firmware solutions that can be used on the phyWAVE-KW2xD. For some of these solutions we provide application guides and typical use cases. Others are available through the hardware manufacturer NXP. The following sections provide a short overview.

6.1 RIOT OS

RIOT is an operating system with an integrated flexible configurable 6LoWPAN/IPv6 mesh network stack. Moreover the RIOT project includes drivers for many environmental sensors, network device driver, cryptographic libraries, a shell implementation and a makefile based build system. The RIOT project is licensed under the LGPLv 2.1 and hosted at Github. The license allows building your closed source proprietary application project on top of the open source licensed RIOT OS. The phyWAVE-KW2x and the phyNODE development platform with all of its environmental sensors is supported in RIOT. The board support for the phyWAVE-KW2xD within the RIOT-OS is done by Phytec. The project is hosted on *GitHub* at: https://github.com/RIOT-OS/RIOT.

6.2 Thread

Thread is a special interest group that defines a mesh network stack, based on open standards. The Thread defined network stack is built on 6LoWPAN and IPv6. Phytec is member of the *Thread Group* and has therefore access to the most recent specifications and software implementations.

NXP provides an implementation of the network stack according to the specifications of the Thread Group. The Thread implementation of NXP builds up on the Kinetis SDK software framework. An application manual that explains the first steps with the phyWAVE-KW2xD in combination with Thread is available at
http://www.phytec.de/produkt/internet-of-things/phywave-kw2xd-download.

6.3 Other NXP solutions

NXP itself provides some additional software stacks for the KW2xD SOC. All those stacks and examples can be used with the phyWAVE-KW2xD. However, please note that we can only give limited support for these examples. For these NXP solutions, there is no Phytec application guide available.

6.3.1 Kinetis SDK

Kinetis SDK includes drivers for peripherals such as interfaces, timers and flash for Kinetis microcontroller and provides their integration to an RTOS i.e. FreeRTOS, µC/OS II-III. The software is provided under permissive open-source licensing.

6.3.2 ZigBee

With the NXP *BeeKit Wireless Connectivity Toolkit*, a ZigBee stack is provided for Kinetis wireless microcontrollers. BeeKit also includes an IEEE 802.15.4 MAC layer implementation, called *SMAC*.

7 Revision History

Date	Version numbers	Changes in this manual
30.08.2016	Manual L-825e_1	First edition. Describes the phyWAVE-KW2xD PCB-Version 1425.2

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