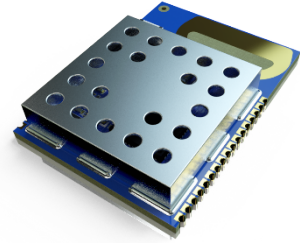


Product Overview

The DWM1001 module is based on Decawave's DW1000 Ultra Wideband (UWB) transceiver IC, which is an IEEE 802.15.4-2011 UWB implementation. It integrates UWB and Bluetooth® antenna, all RF circuitry, Nordic Semiconductor nRF52832 and a motion sensor.

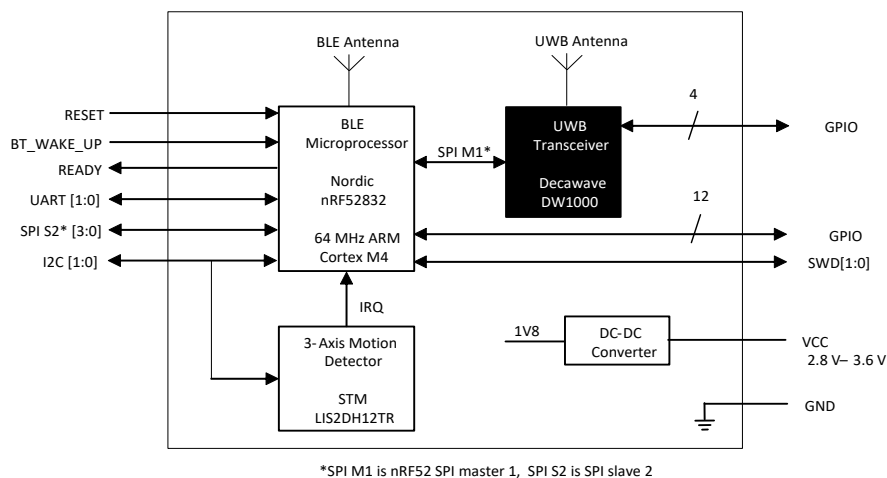


Key Features

- Ranging accuracy to within 10cm.
- UWB Channel 5 printed PCB antenna (6.5 GHz)
- 6.8 Mbps data rate IEEE 802.15.4-2011 UWB compliant
- Nordic Semiconductor nRF52832
- Bluetooth® connectivity
- Bluetooth® chip antenna
- Motion sensor: 3-axis accelerometer
- Current consumption optimised for low power sleep mode: <math><15\mu\text{A}</math>
- Supply voltage: 2.8 V to 3.6 V
- Size: 19.1 mm x 26.2 mm x 2.6 mm
- Modules marked DWM1001C are certified to ETSI, FCC and ISED regulations
 - FCC ID: 2AQ33-DWM1001, IC: 23794-DWM1001
 - See the module marking section of this datasheet

Key Benefits

- Accelerates design cycle, reduces development costs, shortens time to market
- Low-power hardware design enabling longer battery life
- SPI, UART, I2C and Bluetooth® to interface DWM1001 to host device
- Ready-to-go embedded firmware for Two Way Ranging RTLS application:
 - C API to DWM1001 firmware (available as a library) for user code customisation
 - On-board Bluetooth® SMART for connectivity to phones/tablets/PCs
 - SPI, UART and Bluetooth® APIs to access DWM1001 from an external device
 - See MDEK1001 and PANS on www.decawave.com for additional information



Block Diagram

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DOCUMENT INFORMATION**Disclaimer**

Decawave reserves the right to change product specifications without notice. As far as possible changes to functionality and specifications will be issued in product specific errata sheets or in new versions of this document. Customers are advised to check with Decawave for the most recent updates on this product.

Modules labelled "**DWM1001**" are pre-loaded with PANS firmware, please refer to the "DWM1001 Firmware User Guide" for disclaimer and license terms.

Modules labelled "**DWM1001C**" are delivered without firmware - blank -.

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LIFE SUPPORT POLICY

Decawave products are not authorized for use in safety-critical applications (such as life support) where a failure of the Decawave product would reasonably be expected to cause severe personal injury or death. Decawave customers using or selling Decawave products in such a manner do so entirely at their own risk and agree to fully indemnify Decawave and its representatives against any damages arising out of the use of Decawave products in such safety-critical applications.



Caution! ESD sensitive device. Precaution should be used when handling the device in order to prevent permanent damage.

REGULATORY APPROVALS

See Regulatory Information Page 23

1 OVERVIEW

The block diagram on page 1 of this data sheet shows the major sections of the DWM1001. An overview of these blocks is given below.

1.1 UWB Transceiver DW1000

The module has a DW1000 UWB transceiver mounted on the PCB. The DW1000 uses a 38.4 MHz reference crystal. The crystal has been trimmed in production to reduce the initial frequency error to approximately 3 ppm, using the DW1000 IC's internal on-chip crystal trimming circuit.

Always-On (AON) memory can be used to retain DW1000 configuration data during the lowest power operational states when the on-chip voltage regulators are disabled. This data is uploaded and downloaded automatically. Use of DW1000 AON memory is configurable.

The on-chip voltage and temperature monitors allow the host to read the voltage on the VDDAON pin and the internal die temperature information from the DW1000.

See the DW1000 Datasheet [2] for more detailed information on device functionality, electrical specifications and typical performance.

1.2 Bluetooth® Microprocessor Nordic nRF52832

The nRF52832 is an ultra-low power 2.4 GHz wireless system on chip (SoC) integrating the nRF52 Series 2.4 GHz transceiver and an ARM Cortex-M4 CPU with 512kB flash memory and 64kB RAM.

See the nRF52832 Datasheet[1] for more detailed information on device functionality, electrical specifications and typical performance.

1.3 Power Supply and Power management

The power management circuit consists of a switch mode regulator. It is a buck convertor or step-down convertor. The input voltage to the DWM1001 can be in the range 2.8V to 3.6V. Outputs from the convertor provides 1.8V which is required by the DW1000[2]

1.4 Three Axis Motion Detector STMicroelectronics LIS2DH12TR

The LIS2DH12 is an ultra-low-power high performance three-axis linear accelerometer with digital I2C/SPI serial interface standard output. The LIS2DH12 has user-selectable full scales of $\pm 2g/\pm 4g/\pm 8g/\pm 16g$ and is capable of measuring accelerations with output data rates from 1 Hz to 5.3 kHz. The self-test capability allows the user to check the functionality of the sensor in the final application. The device may be configured to generate interrupt signals by detecting two independent inertial wake-up/free-fall events as well as by the position of the device itself. The LIS2DH12 is guaranteed to operate over an extended temperature range from $-40\text{ }^{\circ}\text{C}$ to $+85\text{ }^{\circ}\text{C}$.

See the LIS2DH12TR Datasheet[4] for more detailed information on device functionality, electrical specifications and typical performance.

1.5 Software on board

The DWM1001C modules are delivered without firmware - blank -.

The DWM1001 modules come pre-loaded with embedded firmware which provides two-way ranging (TWR) and real time location system (RTLS) functionality. See the details in the DWM1001 Firmware User Guide [6]. The module can be configured and controlled via its API, which can be accessed through a number of different interfaces, allowing flexibility to the product designer. The details of the API are described in the DWM1001 Firmware API Guide [5]. Decawave also provides the module firmware in the form of binary libraries and some source code. A build environment is provided, so that the user can customise the operation and if required add their own functions[6].

2 DWM1001 CALIBRATION

Depending on the end-use applications and the system design, DWM1001 settings may need to be tuned. To help with this tuning several built-in functions such as continuous wave transmission and continuous packet transmission can be enabled. See the DW1000 User Manual [3] for further details.

2.1.1 Crystal Oscillator Trim

DWM1001 modules are calibrated at production to minimise initial frequency error to reduce carrier frequency offset between modules and thus improve receiver sensitivity. The calibration carried out at module production will trim the initial frequency offset to less than 3 ppm, typically.

2.1.2 Transmitter Calibration

The DWM1001C is calibrated in module production, the calibrated values are permanently stored in the DW1000 OTP. This module is calibrated to meet the regulatory power spectral density requirement of less than -41.3 dBm/MHz.

2.1.3 Antenna Delay Calibration

In order to measure range accurately, precise calculation of timestamps is required. To do this the antenna delay must be known. The DWM1001 allows this delay to be calibrated and provides the facility to compensate for delays introduced by PCB, external components, antenna and internal DWM1001 delays.

The DWM1001's antenna delay was pre-calibrated for the RF configuration used within PANS. The antenna delay is stored in OTP memory.

To calibrate the antenna delay, range is measured at a known distance using two DWM1001 systems. Antenna delay is adjusted until the known distance and reported range agree.

Antenna delay calibration must be carried out as a once off measurement for each DWM1001 design implementation. If required, for greater accuracy, antenna delay calibration should be carried out on a per DWM1001 module basis, see DW1000 User Manual [3] for full details. Further details can be found in the Antenna Delay Application Note [8].

3 DWM1001 PIN CONNECTIONS

3.1 Pin Numbering

DWM1001 module pin assignments are as follows (viewed from top): -

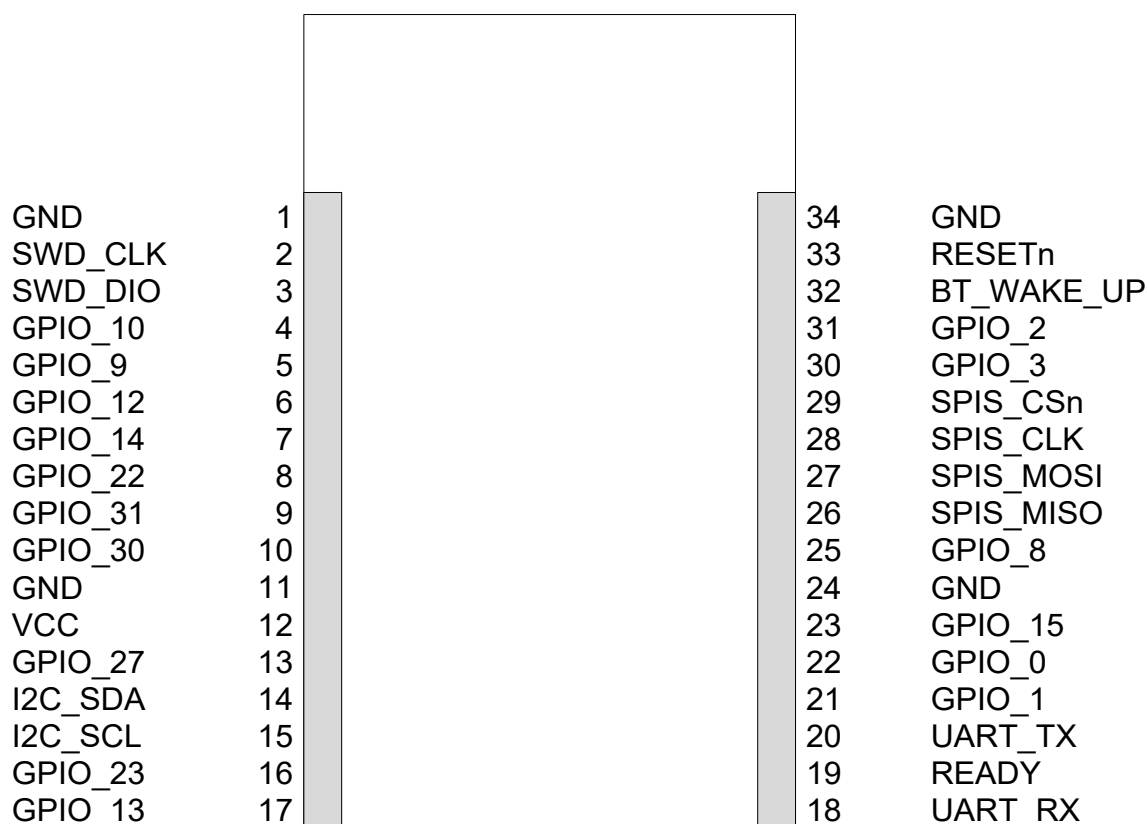


Figure 1: DWM1001 Pin Diagram

3.2 Pin Descriptions

Pin details are given in

Table 1: DWM1001 Pin functions

SIGNAL NAME	PI N	I/O (Default)	DESCRIPTION	REFERENCE (Pin designation)
Digital Interface				
SWD_CLK	2	DI	Serial wire debug clock input for debug and programming of Nordic Processor	[N] SWDCLK
SWD_DIO	3	DIO	Serial wire debug I/O for debug and programming of Nordic Processor	[N] SWDIO
GPIO_10	4	DIO	General purpose I/O pin.	[N] P0.10
GPIO_9	5	DIO	General purpose I/O pin.	[N] P0.9
GPIO_12	6	DIO	General purpose I/O pin.	[N] P0.12
GPIO_14	7	DIO	General purpose I/O pin.	[N] P0.14
GPIO_22	8	DIO	General purpose I/O pin.	[N] P0.22
GPIO_31	9	DIO	General purpose I/O pin. ADC function of nRF52	[N] P0.31
GPIO_30	10	DIO	General purpose I/O pin. ADC function of nRF52	[N] P0.30
GPIO_27	13	DIO	General purpose I/O pin.	[N] P0.27
I2C_SDA (Master)	14	DIO	Master I2C Data Line.	[N] P0.29

SIGNAL NAME	PI N	I/O (Default)	DESCRIPTION	REFERENCE (Pin designation)
I2C_SCL (Master)	15	DO	Master I2C Clock Line	[N] P0.28
GPIO_23	16	DIO	General purpose I/O pin.	[N] P0.23
GPIO_13	17	DIO	General purpose I/O pin.	[N] P0.13
UART_RX	18	DI	UART_RX	[N] P0.11
READY	19	DO	Generated interrupt from the device. Indicates events such as SPI data ready, or location data ready. See the function <code>dwm_int_cfg()</code> in the DWM1001 Firmware API Guide for details[5].	[N] P0.26
UART_TX	20	DO	UART_TX, This is also the ADC function of the nRF52	[N] P0.05
GPIO_1	21	DIO	General purpose I/O pin of the DW1000. It may be configured for use as a SFDLED driving pin that can be used to light a LED when SFD (Start Frame Delimiter) is found by the receiver. Refer to the DW1000 User Manual [1] for details of LED use.	[DW] GPIO1
GPIO_0	22	DIO	General purpose I/O pin of the DW1000. It may be configured for use as a RXOKLED driving pin that can be used to light a LED on reception of a good frame. Refer to the DW1000 User Manual [1] for details of LED use.	[DW] GPIO0
GPIO_15	23	DIO	General purpose I/O pin.	[N] P0.15
GPIO_8	25	DIO	General purpose I/O pin.	[N] P0.08
SPIS_MISO	26	DI	Configured as a SPI slave this pin is the SPI data output. Refer to Datasheet for more details [1].	[N] P0.07
SPIS_MOSI	27	DO	Configured as a SPI slave this pin is the SPI data input. Refer to Datasheet for more details [1].	[N] P0.06
SPIS_CLK	28	DI	Configured as a SPI slave this pin is the SPI clock. This is also the ADC function of the nRF52	[N] P0.04
SPIS_CSn	29	DI	Configured as a SPI slave this pin is the SPI chip select. This is an active low enable input. The high-to-low transition on SPICSn signals the start of a new SPI transaction. This is also the ADC function of the nRF52	[N] P0.03
GPIO_3	30	DO	This pin is configured for use as a TXLED driving pin that can be used to light a LED during transmit mode. Refer to the DW1000 User Manual [2] for details of LED use.	[DW] GPIO3
GPIO_2	31	DO	This pin is configured for use as a RXLED driving pin that can be used to light a LED during receive mode. Refer to the DW1000 User Manual [2] for details of LED use.	[DW] GPIO2
BT_WAKE_UP	32	DI	When this pin is asserted to its active low state the Bluetooth device will advertise its availability for 20 seconds by broadcasting advertising packets. This is also the ADC function of the nRF52.	[N] P0.02
RESETn	33	DI	Reset pin. Active Low Input.	[N] P0.21
Power Supplies				
VCC	12	P	External supply for the module. 2.8V - 3.6V	

SIGNAL NAME	PIN	I/O (Default)	DESCRIPTION	REFERENCE (Pin designation)
Ground				
GND	1, 11, 24, 34	G	Common ground.	

Table 2: Explanation of Abbreviations

ABBREVIATION	EXPLANATION
DI	Digital Input
DIO	Digital Input / Output
DO	Digital Output
G	Ground
P	Power Supply
N	nRF52832
DW	DW1000

Note: Any signal with the suffix 'n' indicates an active low signal.

Table 3: Internal nRF52832 pins used and their function

nRF52832 Pin	Function
PO.19	DW_IRQ
PO.16	DW_SCK
PO.20	DW_MOSI
PO.18	DW_MISO
PO.17	DW_SPI_CS
PO.24	DW_RST
PO.25	ACC_IRQ
PO.29	I2C_SDA
PO.28	I2C_SCL

DW1000's GPIOs 5,6 control the DW1000 SPI mode configuration. Within the DWM1001 module, those GPIOs are unconnected and will be internally pulled down. Consequently, SPI will be set to mode 0. For more details, please refer to DW1000 data sheet [2].

Table 4: I2C slave devices address I2C

I2C slave device	Address
LIS2DH12	0X19

4 ELECTRICAL SPECIFICATIONS

The following tables give detailed specifications for the DWM1001 module. $T_{amb} = 25\text{ }^{\circ}\text{C}$ for all specifications given.

4.1 Nominal Operating Conditions

Table 5: DWM1001 Operating Conditions

Parameter	Min.	Typ.	Max.	Units	Condition/Note
Operating temperature	-40		+85	$^{\circ}\text{C}$	
Supply voltage VCC	2.8	3.3	3.6	V	Normal operation
Voltage on VDDIO for programming OTP	3.7	3.8	3.9	V	Note that for programming the OTP in the DWM1001 this supply is connected to the VDDIO test point which is on the back side of the PCB. (See Figure 6)

4.2 DC Characteristics

Table 6: DWM1001 DC Characteristics

Parameter	Min.	Typ.	Max.	Units	Condition/Note
Supply current in DEEP SLEEP mode		4		μA	All peripherals in lowest power consumption mode Achievable where RTC and accelerometer are disabled with custom firmware.
Supply current in DEEP SLEEP mode		12		μA	RTC and accelerometer operational, all other peripherals in lowest power consumption mode*
Supply current in IDLE mode		13		mA	MCU and DW1000 awake
TX peak current		111		mA	
TX mean current		82		mA	
RX peak current		154		mA	
RX mean current		134		mA	
Current in Bluetooth® discovery mode		6		mA	
Digital input voltage high	$0.7 \times \text{VCC}$		VCC	V	
Digital input voltage low	GND		$0.3 \times \text{VCC}$	V	
Digital output voltage high	$0.7 \times \text{VCC}$		VCC	V	
Digital output voltage low	GND		$0.3 \times \text{VCC}$	V	

* Using a ranging update rate of 1 Hz

4.3 Receiver AC Characteristics

Table 7: DWM1001 Receiver AC Characteristics

Parameter	Min.	Typ.	Max.	Units	Condition/Note
Frequency range	6240		6739.2	MHz	Centre Frequency 6489.6 MHz

4.4 Receiver Sensitivity Characteristics

$T_{amb} = 25\text{ }^{\circ}\text{C}$, 20 byte payload. These sensitivity figures assume an antenna gain of 0 dBi and should be modified by the antenna characteristics, depending on the orientation of the DWM1001.

Table 8: DWM1001 Typical Receiver Sensitivity Characteristics

Packet Error Rate	Data Rate	Receiver Sensitivity	Units	Condition/Note		
1%	6.8 Mbps	-98*(-92)	dBm/500 MHz	Preamble 128	Carrier frequency offset ± 10 ppm	All measurements performed on Channel 5, PRF 64 MHz
10%	6.8 Mbps	-99*(-93)	dBm/500 MHz	Preamble 128		

*equivalent sensitivity with Smart TX Power enabled. This is enabled in the onboard firmware.

4.5 Transmitter AC Characteristics

Table 9: DWM1001 Transmitter AC Characteristics

Parameter	Min.	Typ.	Max.	Units	Condition/Note
Frequency range	6240		6739.2	MHz	
Output power spectral density			-41.3*	dBm/MHz	See DW1000 Datasheet [1]
Output Channel Power		-17		dBm/500MHz	
Output power variation with temperature*	-1		+1	dB	Using on board compensation.

* When using the Decawave supplied embedded firmware for the DWM1001 module

4.5.1 Absolute Maximum Ratings

Table 10: DWM1001 Absolute Maximum Ratings

Parameter	Min.	Max.	Units
Supply voltage	2.8	3.9	V
Receiver power		0	dBm
Temperature - Storage temperature	-40	+85	°C
Temperature – Operating temperature	-40	+85	°C
ESD (Human Body Model)		2000	V
DWM1001 pins other than VCC, VDDIO and GND		3.6	Note that 3.6 V is the max voltage that may be applied to these pins

Stresses beyond those listed in this table may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions beyond those indicated in the operating conditions of the specification is not implied. Exposure to the absolute maximum rating conditions for extended periods may affect device reliability.

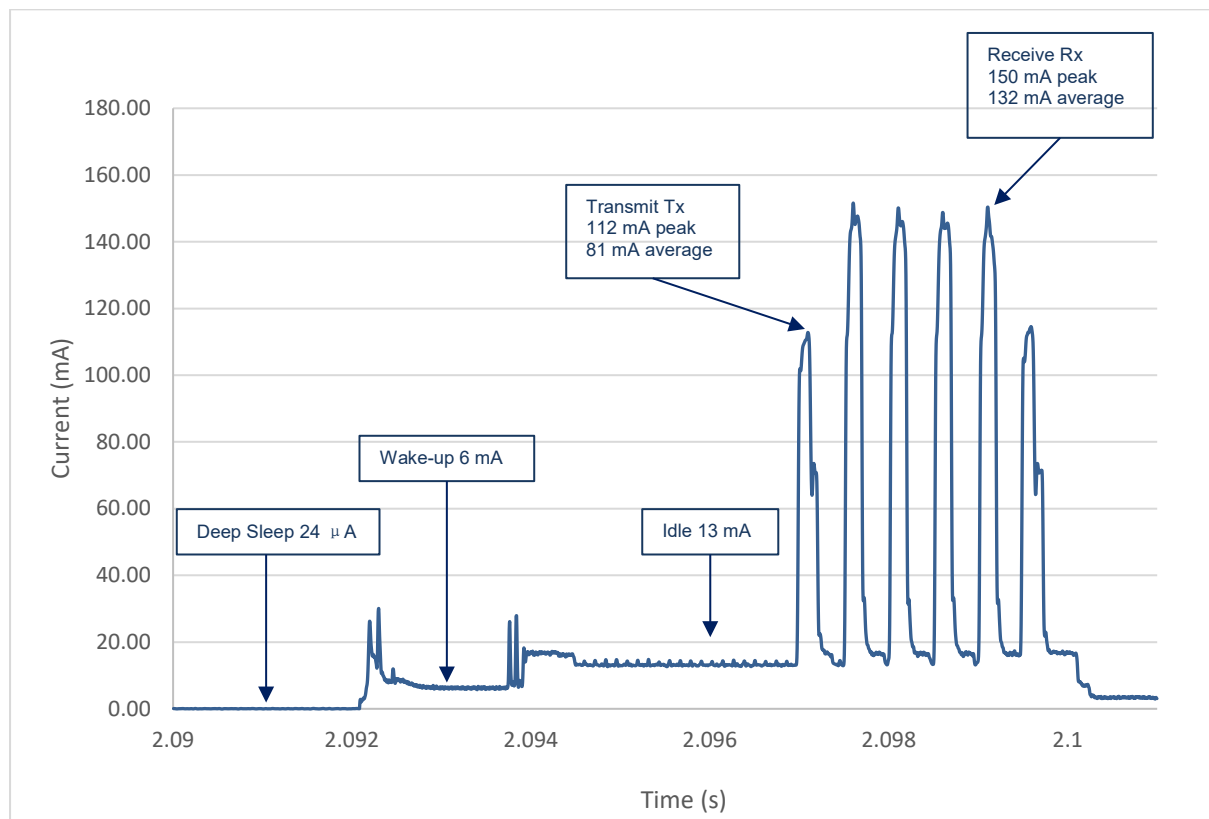
5 TRANSMIT AND RECEIVE POWER CONSUMPTION

Figure 2 shows DWM1001's power profile when running a typical Two-Way ranging communication scheme. In this specific case, the PANS R2 tag application is running on the DWM1001.

The tag is in low-power mode, and two-way ranging with 4 anchors. The deep-sleep current occurs while the tag is sleeping with only the RTC and accelerometer active.

Once awake, the tag transmits at its allocated time in the TDMA-slotting and awaits the anchors responses. This can be observed as 1 transmission followed by 4 receives and a final transmit. After this is completed, the tag spends some time computing its location, before returning to sleep. The total time awake is dependent on the number of anchors within range of the tag. For more details on the system operation, see the DWM1001 System Overview document[9].

Please note that the best achievable deep sleep current is around 12-15 μA , when limiting peripheral use to the RTC clock and keeping the microcontroller in deep sleep.



**Figure 2: Power consumption running PANS R2 tag application
Single Sided Two-Way Ranging scheme**

6 ANTENNA PERFORMANCE

This section details antenna radiation patterns for the DWM1001-Dev board. Figure 3 presents a view of the measurement planes considered in this document.

Table 11 shows antenna radiation patterns for the DWM1001 module mounted on the DWM1001-Dev board. Three planes in the spherical space about the centre of the board are measured, with theta and phi plots representing perpendicular polarisations.

The DWM1001 antenna is vertically polarised, meaning that the module is intended to be positioned vertically upright when used in an RTLS system. An omnidirectional radiation pattern is seen in the XZ plane when observed by another antenna which is also vertically polarised. This is shown in the XZ plane antenna patterns, where the vertically polarised plot, phi, has a circular, or omnidirectional shape.

If the antennas are oriented perpendicular relative to each other, then the polarisation changes. In this case, the horizontally polarised pattern, theta, applies and there are nulls at certain angles which can limit range and introduce location inaccuracy.

Table 12 presents the key characteristics of the DWM1001's antenna.

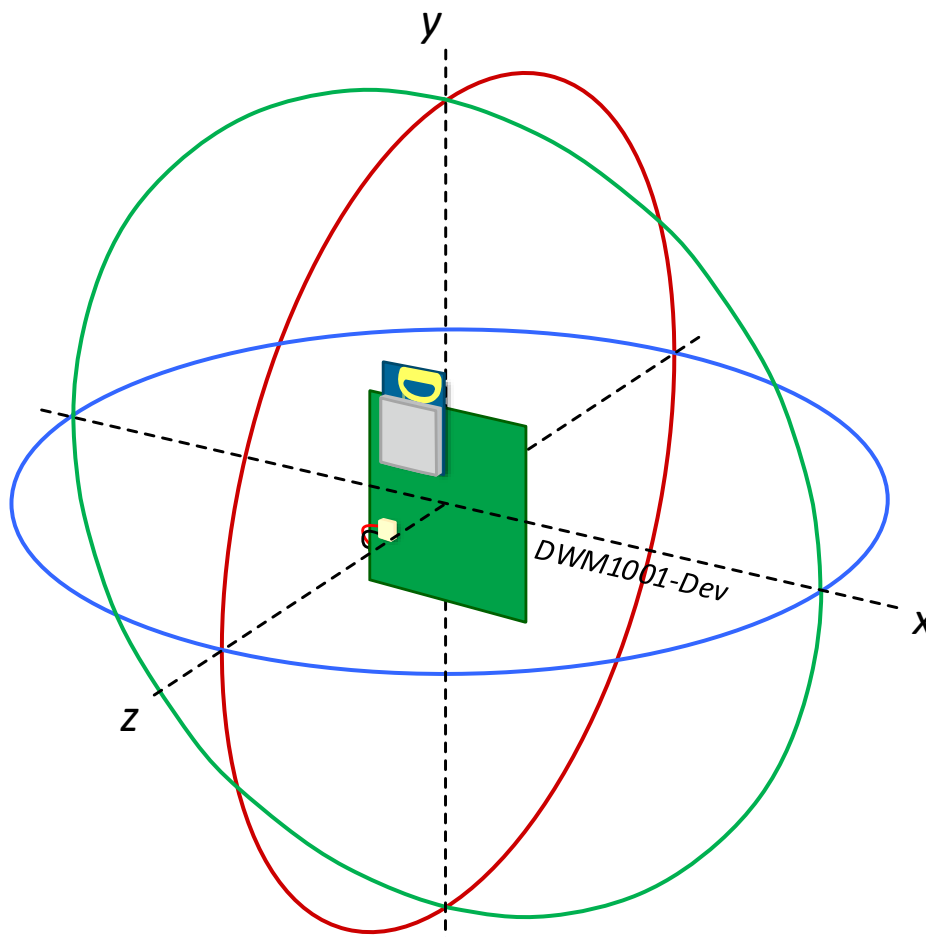


Figure 3. Antenna Radiation Pattern Planes

Table 11. Antenna Radiation Patterns

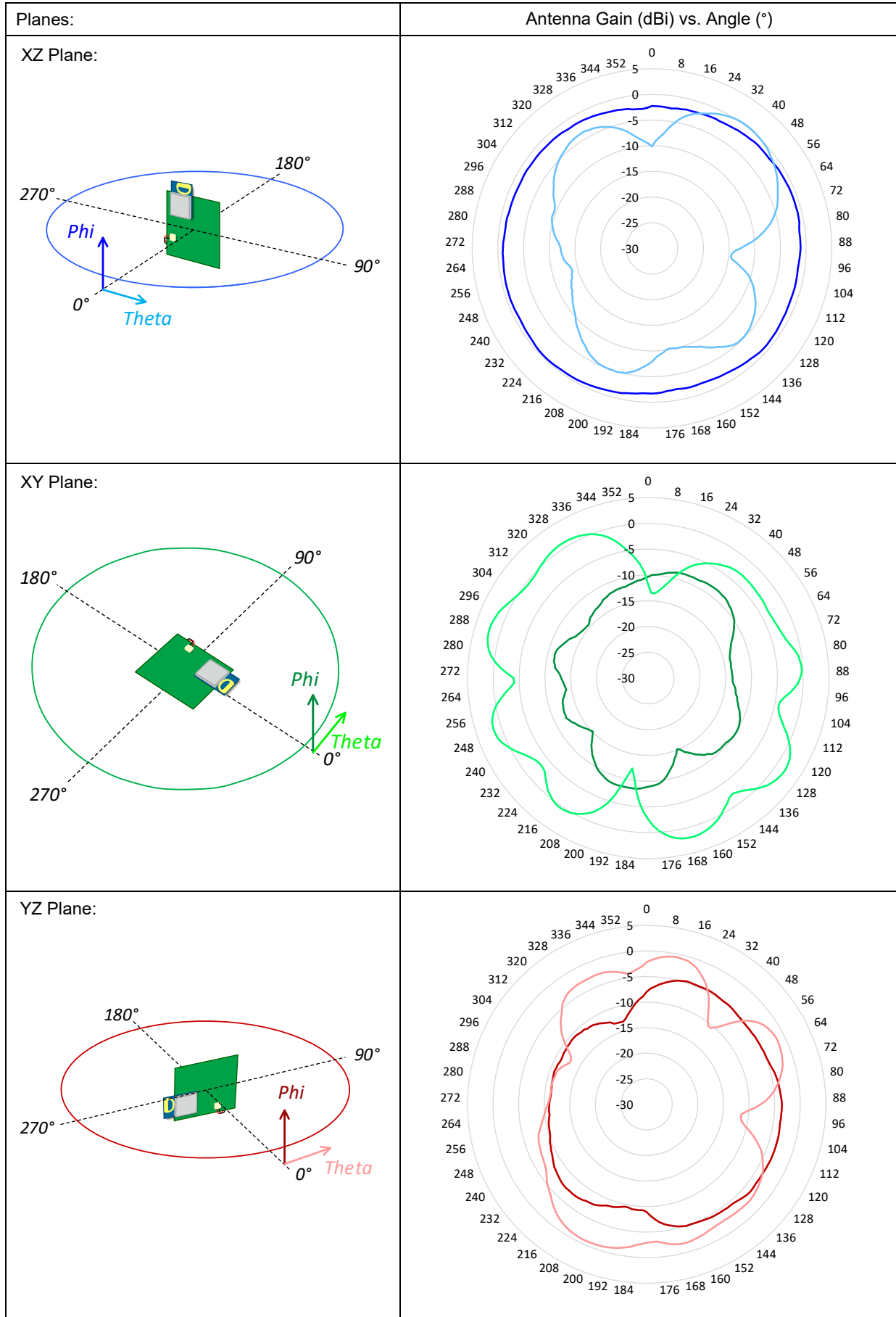


Table 12 : WB003 antenna characteristics

Antenna Model	Decawave WB003 – MiniHoe
Antenna Type	PCB Trace Monopole Antenna
Peak gain (Measured on DWM1001-DEV)	2.5 dBi
Frequency range	5500 ~ 7500 MHz

Please note the “Peak gain” and overall antenna performance are dependent on the carrier PCB geometry. When integrating the DWM1001 module to custom PCB, a variation in antenna performance may be observed.

7 APPLICATION INFORMATION

7.1 Application Board Layout Guidelines

When designing the PCB onto which the DWM1001 will be soldered, the proximity of the DWM1001 on-board antenna to metal and other non-RF transparent materials needs to be considered carefully. Two suggested placement schemes are shown below.

For best RF performance, ground copper should be flooded in all areas of the application board, except in the areas marked “Keep-Out Area”, where there should be no metal either side, above or below (e.g. do not place battery under antenna).

The two placement schemes in Figure 4 show an application board with no metallic material in the keep-out area. The diagram on the right is an application board with the antenna projecting off of the board so that the keep out area is in free-space. The diagram on the left shows an application board which does not have the module in free space but has the PCB copper removed on either side (and behind) the module antenna.

(Note: the rectangular area above the shield on the module is the antenna area)

It is also important to note that the ground plane on the application board affects the DWM1001 antenna radiation pattern. There must be a minimum spacing of 10 mm (d) without metal either side of the module antenna.

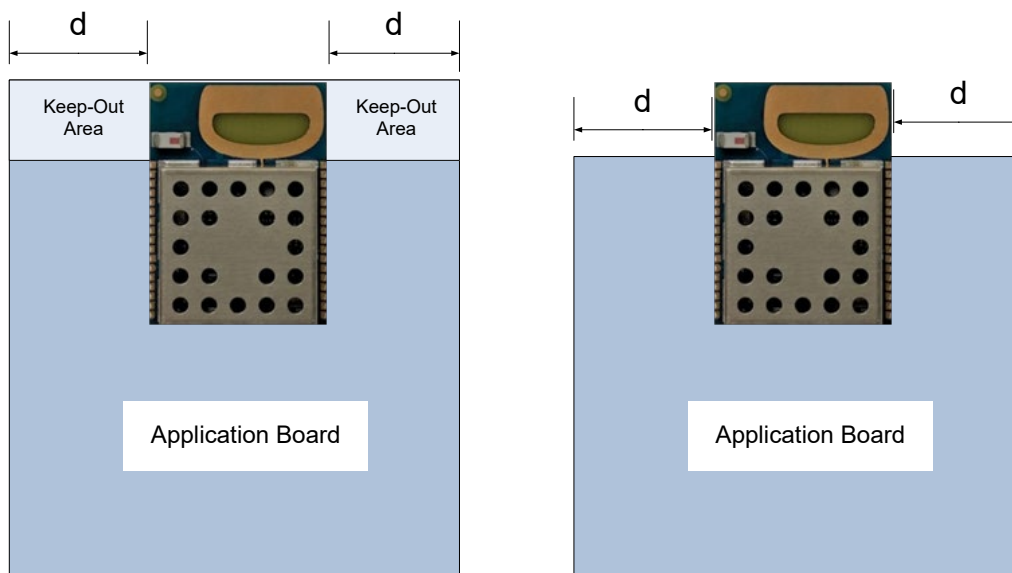


Figure 4: DWM1001 Application Board Keep-Out Areas

8 PACKAGE INFORMATION

8.1 Module Drawings

All measurements are given in millimetres.

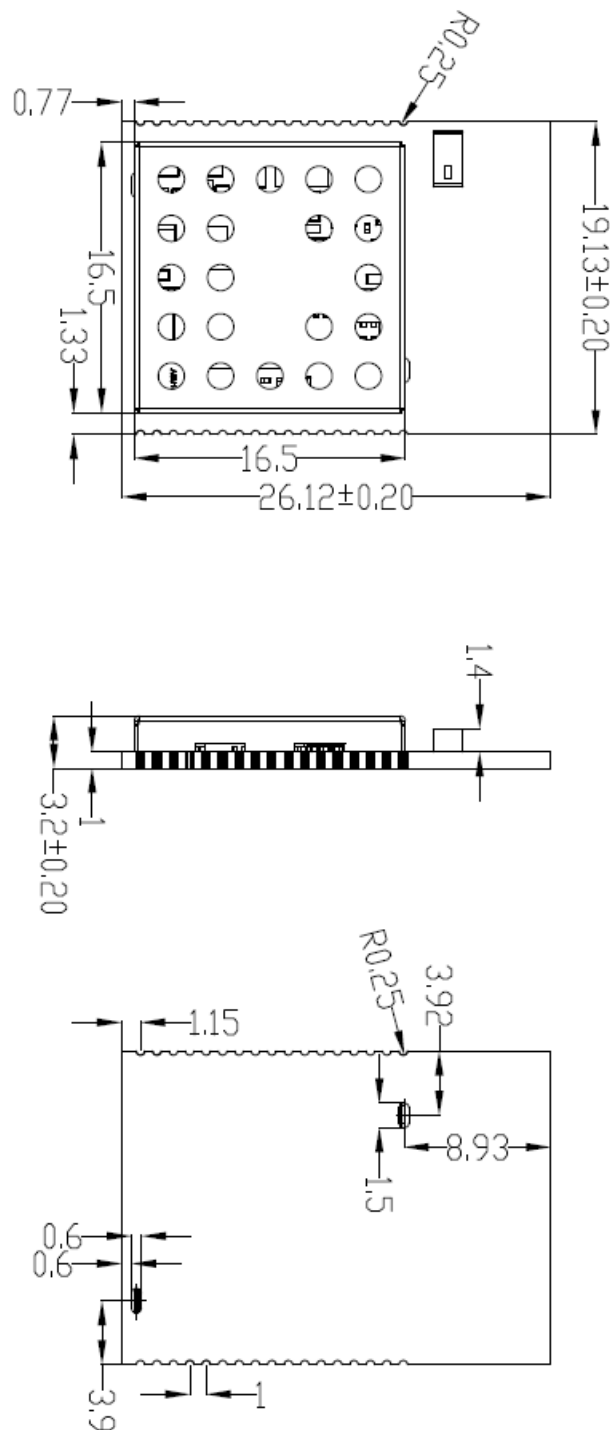


Figure 5: Module Package Size (units: mm)

8.2 Module Land Pattern

The diagram below shows the DWM1001 module land pattern.

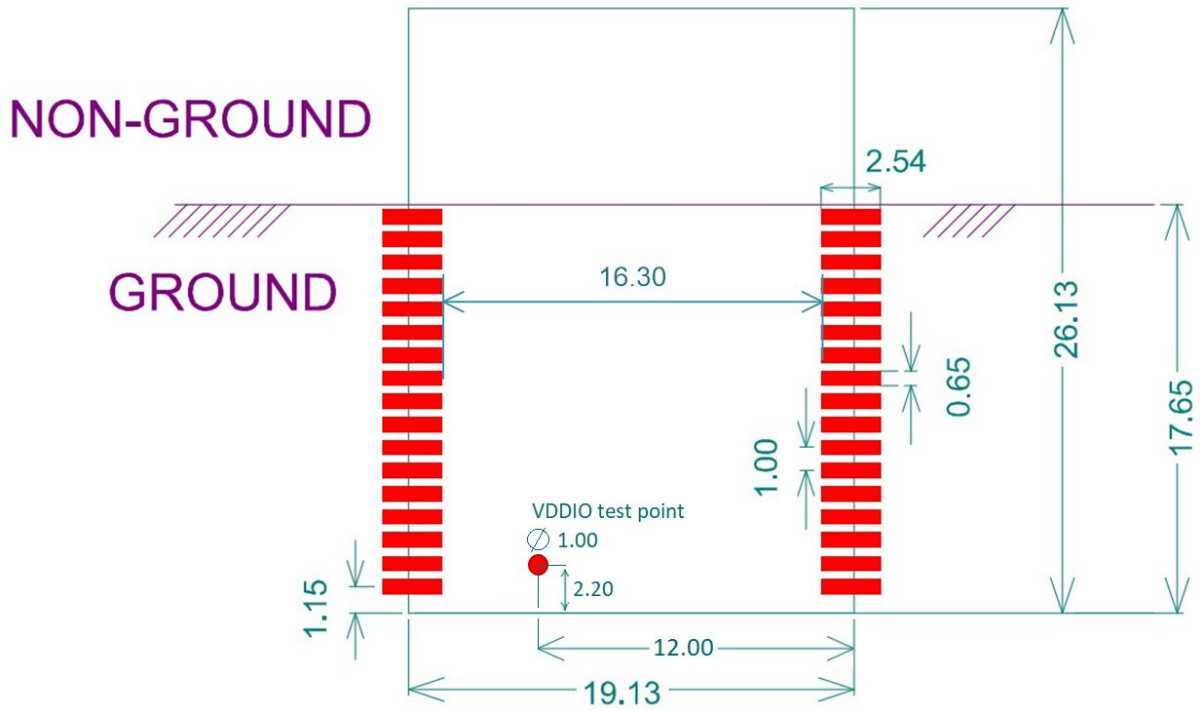


Figure 6: DWM1001 Module Land Pattern (units: mm)

8.3 Module Marking Information

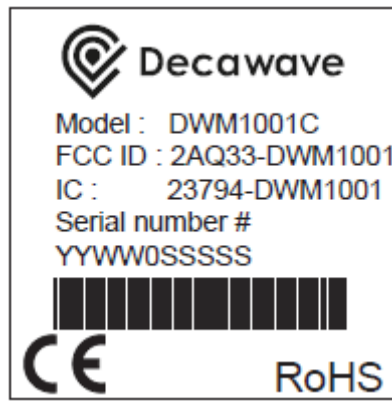
Each module has a label on the shield with a serial number in the following format:

YY WW 0 SSSSS

Where:

YY	indicates the year
WW	indicates the week of the year
0	indicates the DWM1001 module
SSSSS	indicates the module manufacturing number

Modules marked with DWM1001C are the certified version of the DWM1001.



Older modules marked as DWM1001 are a non-certified version of the DWM1001



8.4 Module Solder Profile

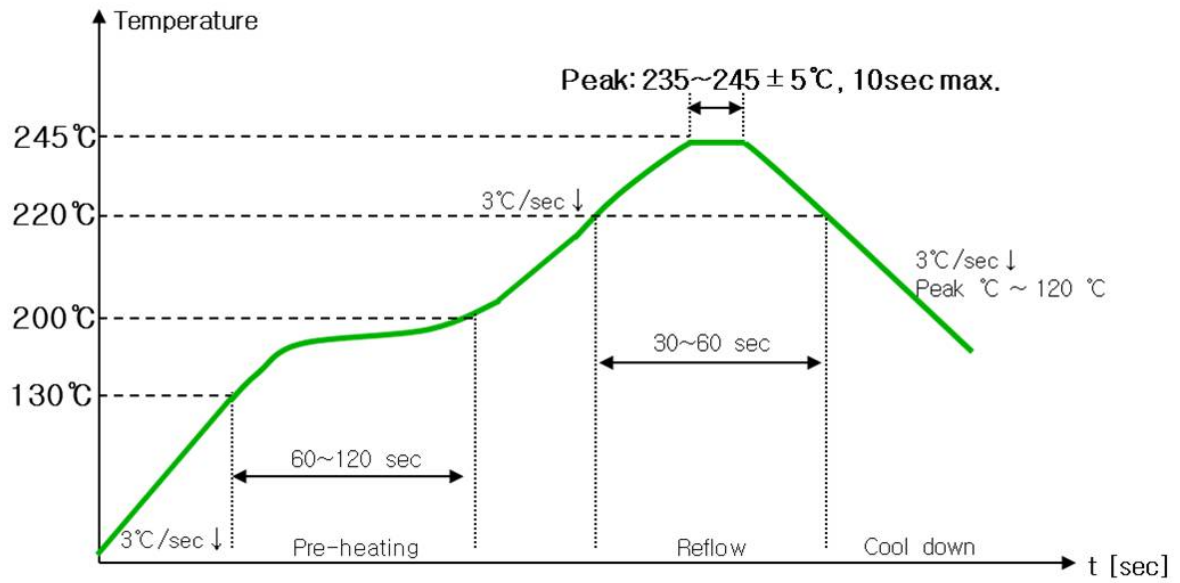


Figure 7: DWM1001 Module Solder Profile

9 ORDERING INFORMATION

9.1 Tape and Reel Information

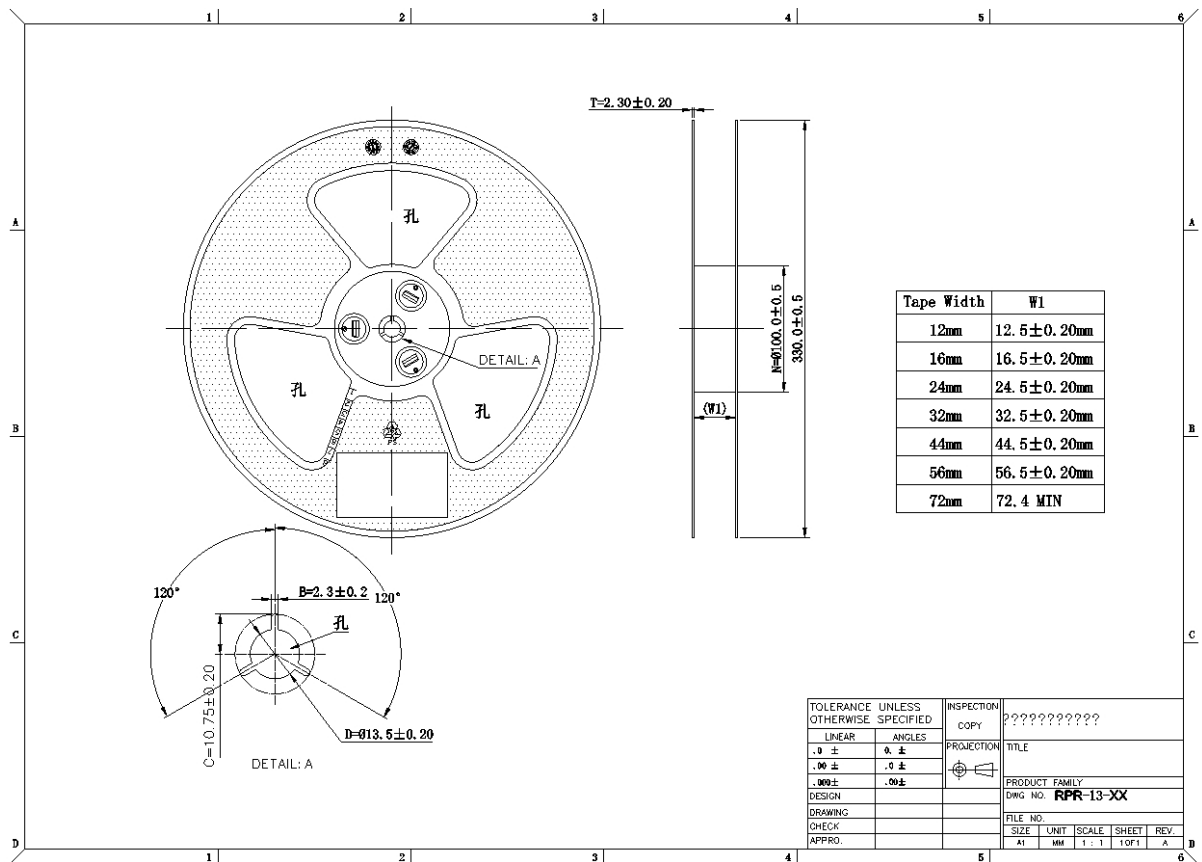


Figure 8: DWM1001 Tape and Reel Dimensions

10 REGULATORY INFORMATION

The information below is valid for the DWM1001C module only.

US FCC ID: 2AQ33-DWM1001, Canada ISED/IC: 23794-DWM1001

FCC and ETSI Test reports are available to download at: <https://www.decawave.com/product/dwm1001-module>

10.1 European Union requirements

10.1.1 Radio Equipment Directive

The DWM1001C Module has been certified for use in European Union countries. A copy of the EU Declaration of Conformity is available for download on our website.

If these modules are incorporated into a product, the manufacturer must ensure continuing compliance of the final product to the Radio Equipment Directive 2014/53/EU. The manufacturer must then draw up a new written EU Declaration of Conformity as per RED Article 18.

Furthermore, the manufacturer must ensure the final product does not exceed the specified power ratings, antenna specifications, and/or installation requirements as specified in this document. If any of these specifications are exceeded in the final product, the manufacturer must assess whether additional compliance testing is required.

IMPORTANT: The “CE” marking must be in compliance with the RED Article 19. It must be affixed to a visible location on the OEM product. The CE mark shall have a height of at least 5mm except where this is not possible on account of the nature of the apparatus. The CE marking must be affixed visibly, legibly, and indelibly.



10.1.2 ETSI harmonised standards

The DWM1001C module conforms with the requirements of the following ETSI standards:

RED reference	Standard No	Title	Edition / Date	Test Report
Article 3.1b	EN 301 489-1	Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements; Harmonised Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU	2017-02 V2.1.1	408-18
Article 3.1b (for BLE)	EN 301 489-17	Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 17: Specific conditions for Broadband Data Transmission Systems; Harmonised Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU	2017-02 V3.1.1	408-18
Article 3.1b (for UWB)	EN 301 489-33	Electromagnetic compatibility (EMC) standard for radio equipment and services; Part 33: Specific conditions for Ultra-WideBand (UWB) communications devices; Harmonised Standard covering the essential requirements of article 3.1(b) of Directive 2014/53/EU	2017-02 V2.1.1	408-18
Article 3.2 (for BLE)	EN 300 328	Wideband transmission systems; Data transmission equipment operating in the 2.4GHz band; Harmonised Standard for access to radio spectrum	2016-11 V2.1.1	407-18
Article 3.2 (for UWB)	EN 302 065-2	Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Part 2: Requirements for UWB location tracking; Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU	2016-11 V2.1.1	240-18

Please refer to Decawave's website for DWM1001C ETSI tests reports:
<https://www.decawave.com/product/dwm1001-module>

10.2 United States (FCC)

This device complies with Part 15 of the FCC Rules:

Operation is subject to the following 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

Changes and Modifications not expressly approved by Decawave Ltd. can void your authority to operate this equipment under Federal Communications Commission rules.

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

To fulfil FCC Certification requirements, an OEM manufacturer must comply with the following regulations:

1. The DWM1001C modular transmitter must be labelled with its own FCC ID number, and, if the FCC ID 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:

IMPORTANT: Contains FCC ID: 2AQ33-DWM1001. This equipment 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 (FCC 15.19).

*Please refer to Decawave's website for DWM1001C FCC tests reports:
<https://www.decawave.com/product/dwm1001-module>*

10.2.1 Radio and Television Interference

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 the 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.

You may also find helpful the following booklet, prepared by the FCC: "How to Identify and Resolve Radio-TV Interference Problems." This booklet is available from the U.S. Government Printing Office, Washington D.C. 20402.

10.3 Innovation, Science and Economic Development Canada (ISED), formerly Industry Canada (IC), Compliance Statements

This device complies with ISED licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'ISDE applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

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

The OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed (for example, digital device emissions, PC peripheral requirements, etc.). This Module is labelled with its own IC ID. If the IC ID Certification Number is not visible while installed inside another device then the final end product should display a label on it referring to the enclosed module in a visible area with the following:

"Contains Transmitter Module IC: 23794-DWM1001" OR "Contains IC: 23794-DWM1001"

Ce module est étiqueté avec son propre ID IC. Si le numéro de certification IC ID n'est pas visible lorsqu'il est installé à l'intérieur d'un autre appareil, l'appareil doit afficher l'étiquette sur le module de référence ci-joint. Dans ce cas, le produit final doit être étiqueté dans un endroit visible par le texte suivant :

"Contains Transmitter Module IC: 23794-DWM1001" OR "Contains IC: 23794-DWM1001"

10.4 Regulatory Module Integration Instructions

This module has been granted modular approval for portable applications. OEM integrators for host products may use the module in their final products without additional FCC / ISED certification if they meet the following conditions. Otherwise, additional FCC / ISED approvals must be obtained.

- The host product with the module installed must be evaluated for simultaneous transmission requirements.
- The user's manual for the host product must clearly indicate the operating requirements and conditions that must be observed to ensure compliance with current FCC/ISED RF exposure guidelines.
- A label must be affixed to the outside of the host product with the following statements:

This device contains FCC ID: 2AQ33-DWM1001

This equipment contains equipment certified under IC: 23794-DWM1001

The final host / module combination may also need to be evaluated against the FCC Part 15B criteria for unintentional radiators in order to be properly authorized for operation as a Part 15 digital device.

If the final host / module combination is intended for use as a portable device (see classifications below) the host manufacturer is responsible for separate evaluations/approvals for the SAR requirements from FCC Part 2.1093 and RSS-102.

10.5 Device Classifications

Since host devices vary widely with design features and configurations module integrators shall follow the guidelines below regarding device classification and simultaneous transmission, and seek guidance from their preferred regulatory test lab to determine how regulatory guidelines will impact the device compliance. Proactive management of the regulatory process will minimize unexpected schedule delays and costs due to unplanned testing activities.

The module integrator must determine the minimum distance required between their host device and the user's body. The FCC provides device classification definitions to assist in making the correct determination. Note that these classifications are guidelines only; strict adherence to a device classification may not satisfy the regulatory requirement as near-body device design details may vary widely. Your preferred test lab will be able to assist in determining the appropriate device category for your host product and if a KDB or PBA must be submitted to the FCC.

10.6 FCC Definitions

Portable: (§2.1093) — A portable device is defined as a transmitting device designed to be used so that the radiating structure(s) of the device is / are within 20 centimetres of the body of the user.

Mobile: (§2.1091) (b) — A mobile device is defined as a transmitting device designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimetres is normally maintained between the transmitter's radiating structure(s) and the body of the user or nearby persons. Per §2.1091d(d)(4) In some cases (for example, modular or desktop transmitters), the potential conditions of use of a device may not allow easy classification of that device as either Mobile or Portable. In these cases, applicants are responsible for determining minimum distances for compliance for the intended use and installation of the device based on evaluation of either specific absorption rate (SAR), field strength, or power density, whichever is most appropriate.

10.7 Simultaneous Transmission Evaluation

This module has not been evaluated or approved for simultaneous transmission as it is impossible to determine the exact multi-transmission scenario that a host manufacturer may choose. Any simultaneous transmission condition established through module integration into a host product must be evaluated per the requirements in KDB447498D01(8) and KDB616217D01,D03 (for laptop, notebook, netbook, and tablet applications).

As mentioned above, the DWM1001C has been granted modular approval as a "Portable" device. However, end-customer Portable applications may require further RF exposure (SAR) evaluations. It is also possible that the host / module combination will need to undergo further testing for FCC Part 15 compliance regardless of the device classification. Your preferred test lab will be able to assist in determining the exact tests which are required on the host / module combination.

10.8 Operating Requirements and Conditions

The design of DWM1001 complies with U.S. Federal Communications Commission (FCC) guidelines respecting safety levels of radio frequency (RF) exposure for Portable devices.

FCC ID:

This product contains FCC ID: 2AQ33-DWM1001

10.9 Miscellaneous

Except as otherwise described above, the DWM1001C BLE and UWB transmitters meets all requirements for SAR or RF Exposure, intended or unintended, under FCC, ISED, and ETSI rules. The BLE radio falls well below the limit determined for <5mm separation (a "body-worn" device) and, for a UWB radio operating above 6GHz, there are currently no exposure limits specified.

11 GLOSSARY

Table 13: Glossary of Terms

Abbreviation	Full Title	Explanation
ETSI	European Telecommunication Standards Institute	Regulatory body in the EU charged with the management of the radio spectrum and the setting of regulations for devices that use it
FCC	Federal Communications Commission	Regulatory body in the USA charged with the management of the radio spectrum and the setting of regulations for devices that use it
GPIO	General Purpose Input / Output	Pin of an IC that can be configured as an input or output under software control and has no specifically identified function
IEEE	Institute of Electrical and Electronic Engineers	The world's largest technical professional society. It is designed to serve professionals involved in all aspects of the electrical, electronic and computing fields and related areas of science and technology
PLL	Phase Locked Loop	Circuit designed to generate a signal at a particular frequency whose phase is related to an incoming "reference" signal.
PPM	Parts Per Million	Used to quantify very small relative proportions. Just as 1% is one out of a hundred, 1 ppm is one part in a million
RF	Radio Frequency	Generally used to refer to signals in the range of 3 kHz to 300 GHz. In the context of a radio receiver, the term is generally used to refer to circuits in a receiver before down-conversion takes place and in a transmitter after up-conversion takes place
RTLS	Real Time Location System	System intended to provide information on the location of various items in real-time.
SFD	Start of Frame Delimiter	Defined in the context of the IEEE 802.15.4-2011 [7] standard.
SPI	Serial Peripheral Interface	An industry standard method for interfacing between IC's using a synchronous serial scheme first introduced by Motorola
TWR	Two Way Ranging	Method of measuring the physical distance between two radio units by exchanging messages between the units and noting the times of transmission and reception. Refer to Decawave's website for further information
UWB	Ultra Wideband	A radio scheme employing channel bandwidths of, or in excess of, 500MHz
BLE	Bluetooth Low Energy.	A low power means of data communication.

12 REFERENCES

- [1] nRF52832 Product Specification v1.3 www.nordicsemi.com
- [2] Decawave DW1000 Datasheet www.decawave.com
- [3] Decawave DW1000 User Manual www.decawave.com
- [4] STMicroelectronics LIS2DH12TR www.st.com
- [5] DWM1001 Firmware API Guide
- [6] DWM1001 Firmware User Guide
- [7] IEEE802.15.4-2011 or "IEEE Std 802.15.4™-2011" (Revision of IEEE Std 802.15.4-2006). IEEE Standard for Local and metropolitan area networks – Part 15.4: Low-Rate Wireless Personal Area Networks (LR-WPANs). IEEE Computer Society Sponsored by the LAN/MAN Standards Committee. Available from <http://standards.ieee.org/>
- [8] APS014 Antenna Delay Calibration of DW1000-based products and systems
- [9] DWM1001 System Overview

13 DOCUMENT HISTORY

Table 14: Document History

Revision	Date	Description
1.5	04/02/19	Update of regulatory information
1.4	19/12/2018	Update
1.3	22/10/2018	Update
1.2	07/08/2018	Update
1.1	27/02/18	Core update

14 MAJOR CHANGES

Revision 1.1

Page	Change Description
All	Update of version number to 1.10
9	New table detailing internal connections between nRF52 and DW1000
9	Adding I2C slave devices address
9	Specifying that nRF52 to DW1000 SPI interface mode is 0
14,15	New details on Antenna Radiation pattern
18	Adding accurate position of VDDIO test point on figure 6

Revision 1.2

Page	Change Description
All	Logo Change

Revision 1.3

Page	Change Description
1	Key benefits update

Revision 1.4

Page	Change Description
All	DWM1001C and regulation information added

Revision 1.5

Page	Change Description
All	Regulation section updated
1	Key benefits update
13	Updating power consumption profile to single sided two-way ranging

15 FURTHER INFORMATION

Decawave develops semiconductors solutions, software, modules, reference designs - that enable real-time, ultra-accurate, ultra-reliable local area micro-location services. Decawave's technology enables an entirely new class of easy to implement, highly secure, intelligent location functionality and services for IoT and smart consumer products and applications.

For further information on this or any other Decawave product, please refer to our website www.decawave.com.