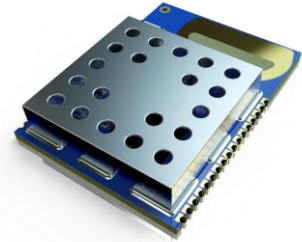




Overview

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.

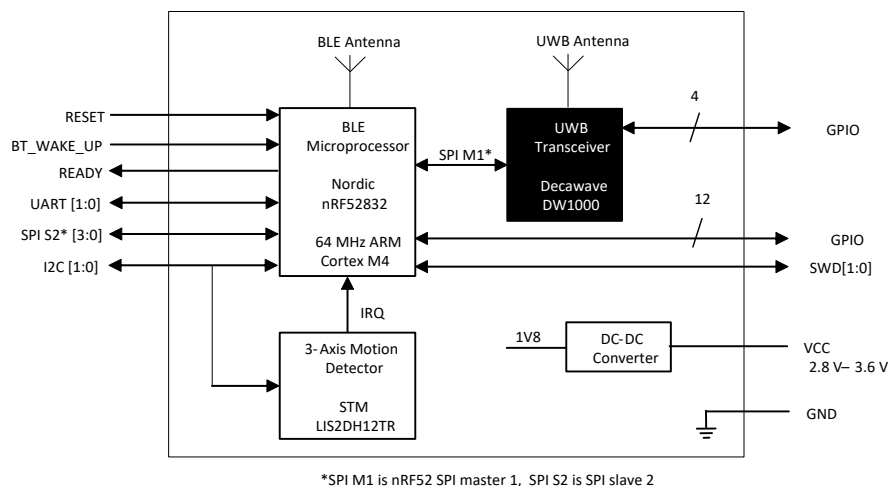


Key Features

- Ranging accuracy to within 10cm.
- UWB Channel 5 printed PCB antenna (6.5 GHz)
- 6.8 Mbps data rate
- 60 m line-of-sight range typical
- 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: <15µA
- Supply voltage: 2.8 V to 3.6 V
- Size: 19.1 mm x 26.2 mm x 2.6 mm

Key Benefits

- Enables anchors, tags & gateways to quickly get an entire RTLS system up-and-running
- Accelerates product designs for faster Time-to-Market & reduced development costs
- Ready-to-go embedded firmware to minimise software development
- Over-the-air updates
- User 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 firmware from an external device
- Low-power hardware design and software architecture for longer battery life



High Level 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.

The DWM1001 is pre-loaded with firmware, please refer to the "DWM1001 Firmware User Guide" for disclaimer and license terms.

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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

The DWM1001, as supplied from Decawave, has not been certified for use in any particular geographic region by the appropriate regulatory body governing radio emissions in that region although it is capable of such certification depending on the region and the manner in which it is used.

All products developed by the user incorporating the DWM1001 must be approved by the relevant authority governing radio emissions in any given jurisdiction prior to the marketing or sale of such products in that jurisdiction and user bears all responsibility for obtaining such approval as needed from the appropriate authorities.

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 4 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 °C to +85 °C.

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

1.5 Software on board

The DWM1001 module comes 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 a number of built in functions such as continuous wave TX 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 DWM1001 is calibrated in module production for the on board firmware application. This is calibrated to meet the power spectral density requirement of less than -41.3 dBm/MHz.

Should the user wish to do his own calibration, the DWM1001 provides the facility to adjust the transmit power in coarse and fine steps; 3 dB and 0.5 dB nominally. It also provides the ability to adjust the spectral bandwidth. These adjustments can be used to maximise transmit power whilst meeting the regulatory spectral mask.

If required, transmit calibration should be carried out on a per DWM1001 module basis, see DW1000 User Manual [3] for full details.

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.

If using the pre-loaded embedded firmware of the DWM1001 module, the Antenna Delay has been pre calibrated for this configuration. The antenna delay is stored in OTP memory.

If you are creating your own embedded firmware, with a different configuration for the DW1000, then you will have to calibrate antenna delay. 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): -

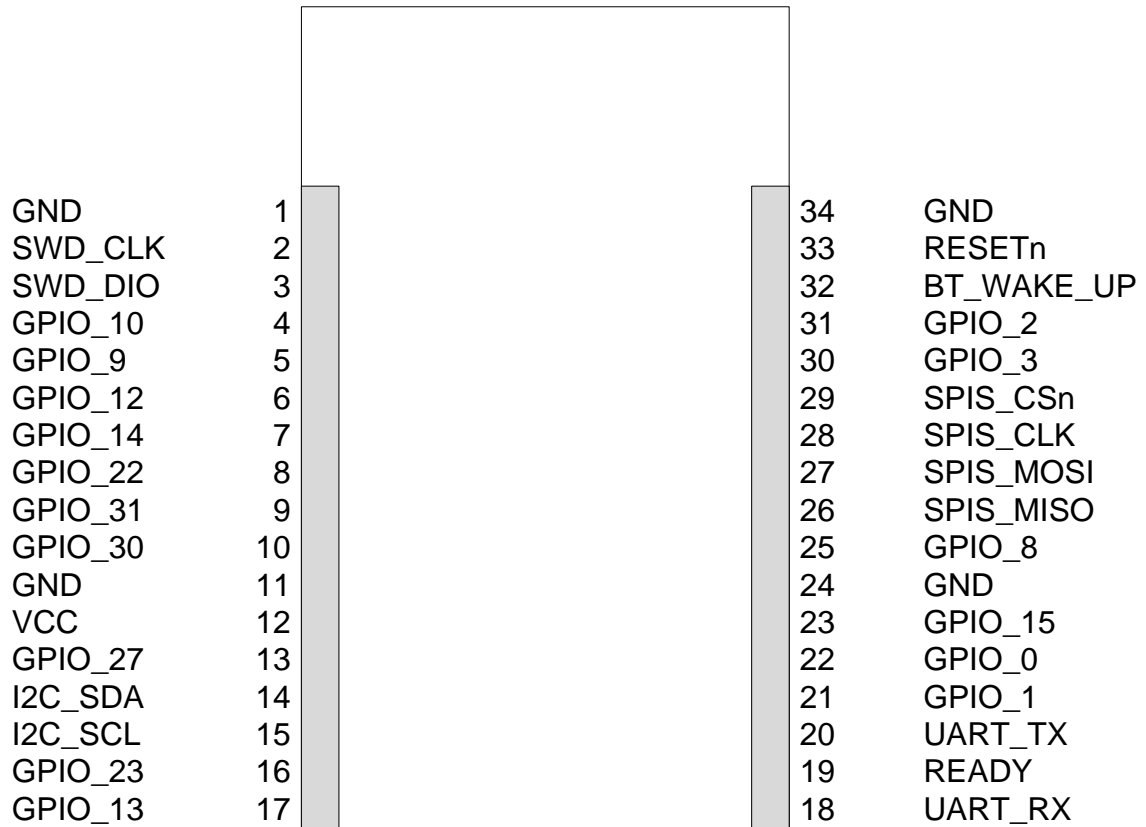


Figure 1: DWM1001 Pin Diagram

3.2 Pin Descriptions

Table 1: DWM1001 Pin functions

SIGNAL NAME	PIN	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	PIN	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	
Ground				

SIGNAL NAME	PIN	I/O (Default)	DESCRIPTION	REFERENCE (Pin designation)
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
<i>Note: Any signal with the suffix 'n' indicates an active low signal.</i>	

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 3: 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 underneath the PCB.

4.2 DC Characteristics

Table 4: 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 5: DWM1001 Receiver AC Characteristics

Parameter	Min.	Typ.	Max.	Units	Condition/Note
Frequency range	6240		6739.2	MHz	Centre Frequency 6489.6 MHz
Channel bandwidth		500		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 6: 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 7: DWM1001 Transmitter AC Characteristics

Parameter	Min.	Typ.	Max.	Units	Condition/Note
Frequency range	6240		6739.2	MHz	
Channel bandwidths		500		MHz	Channel 5
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.

* If using the pre-loaded embedded firmware of the DWM1001 module, otherwise see the DW1000 datasheet

4.5.1 Absolute Maximum Ratings

Table 8: 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

The following Figures give power profiles for the DWM1001 on a DWM1001-DEV PCB when used for Two Way Ranging, see Figure 2. Peak values are given.

Figure 2 shows an example of the power consumption of a DWM1001 tag running the factory loaded firmware.

The tag is in low-power mode, and two-way ranging with 3 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 3 receives, repeated once. 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].

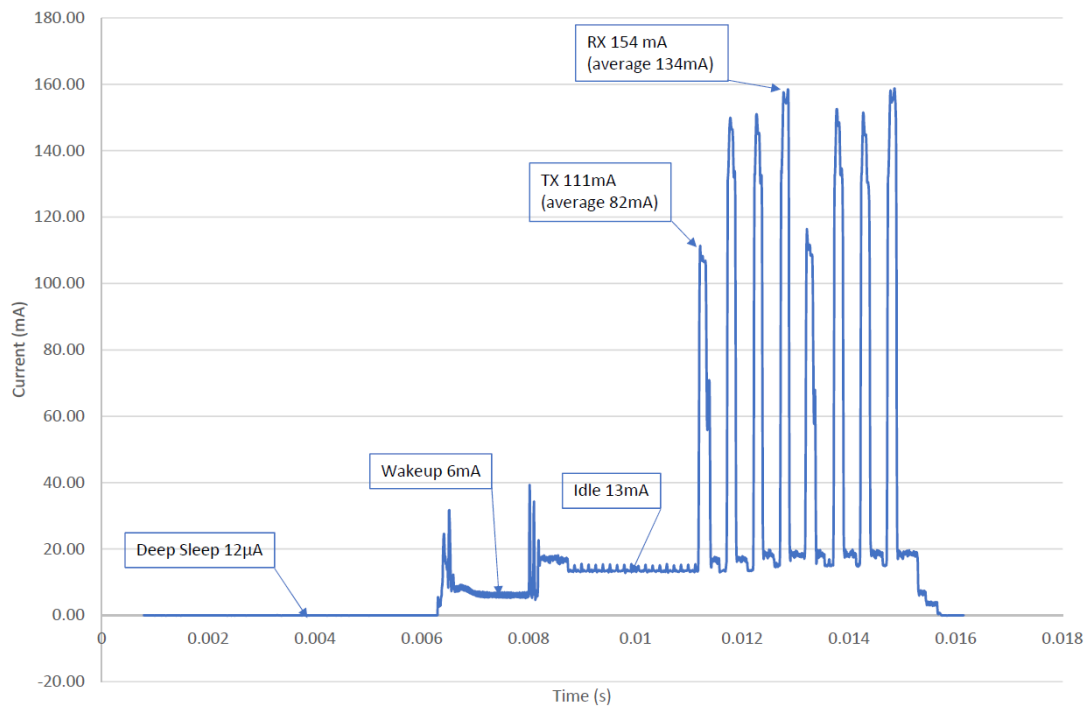


Figure 2: power consumption during Two Way Ranging

6 ANTENNA PERFORMANCE

Radiation pattern to follow.

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 3 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.

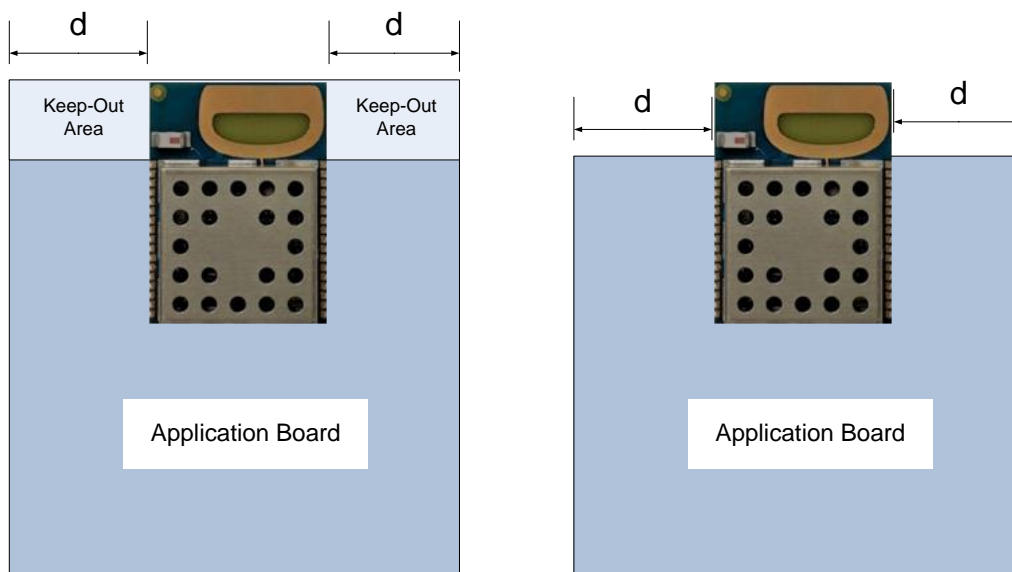


Figure 3: DWM1001 Application Board Keep-Out Areas

8 PACKAGE INFORMATION

8.1 Module Drawings

All measurements are given in millimetres.

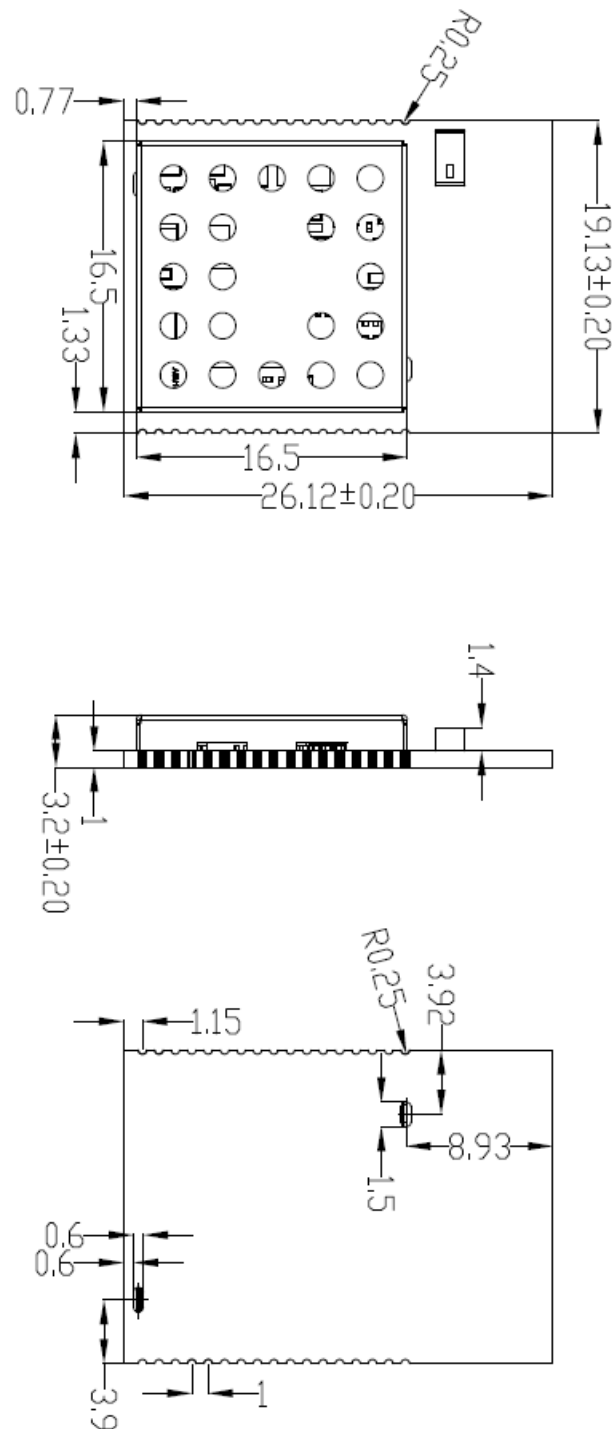


Figure 4: Module Package Size (units: mm)

8.2 Module Land Pattern

The diagram below shows the DWM1001 module land pattern.

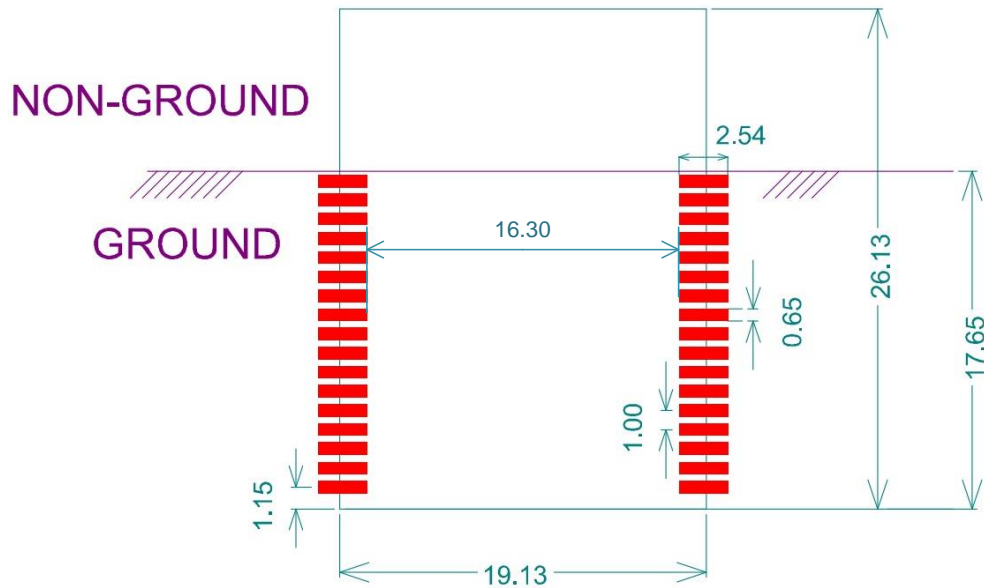


Figure 5: DWM1001 Module Land Pattern (units: mm)

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

8.4 Module Solder Profile

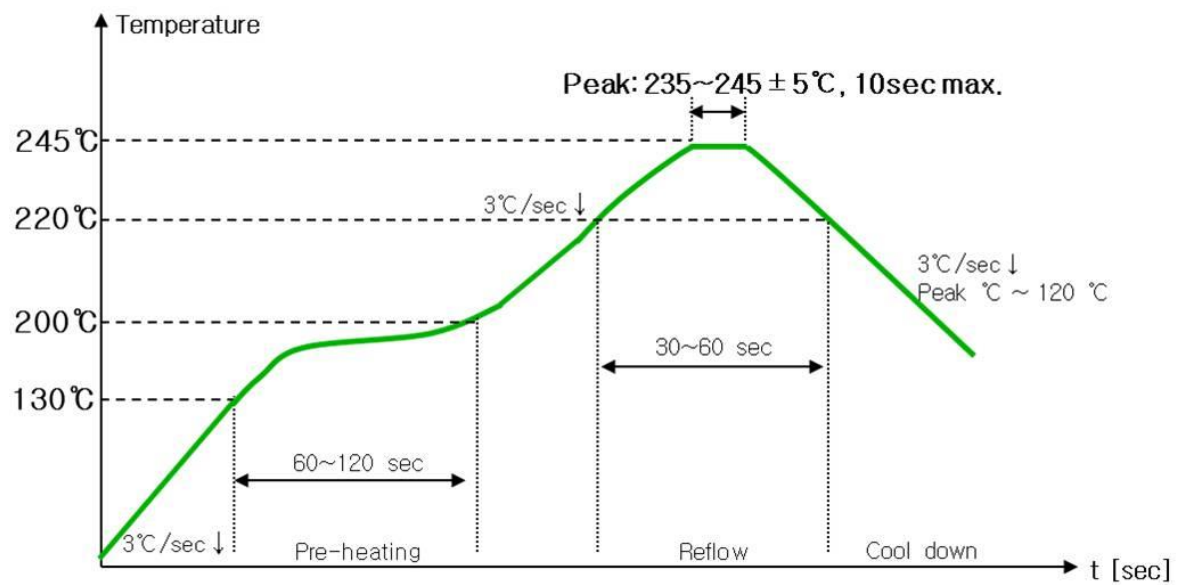


Figure 6: DWM1001 Module Solder Profile

9 ORDERING INFORMATION

9.1 Tape and Reel Information

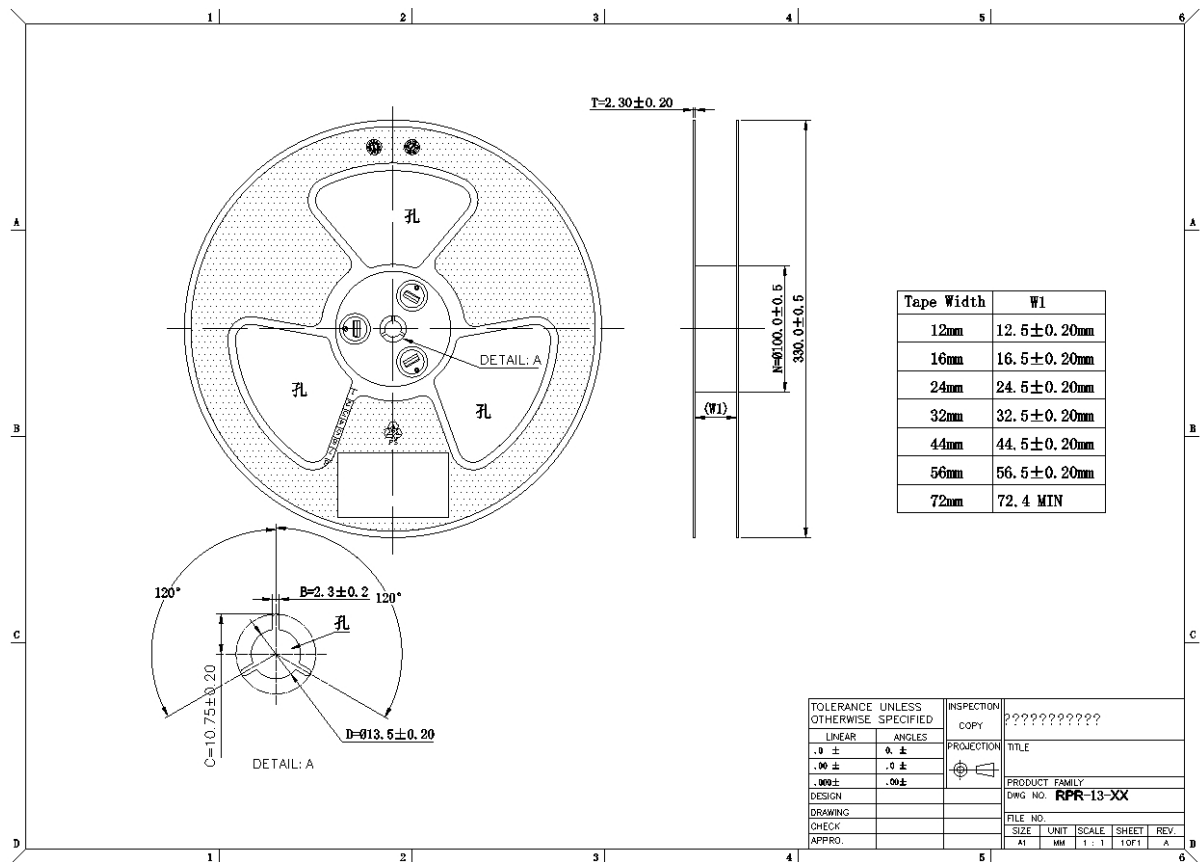


Figure 7: DWM1001 Tape and Reel Dimensions

10 GLOSSARY

Table 9: Glossary of Terms

Abbreviation	Full Title	Explanation
EIRP	Equivalent Isotropically Radiated Power	The amount of power that a theoretical isotropic antenna (which evenly distributes power in all directions) would emit to produce the peak power density observed in the direction of maximum gain of the antenna being used
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	Is 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
LIFS	Long Inter-Frame Spacing	Defined in the context of the IEEE 802.15.4-2011 [7] standard
LNA	Low Noise Amplifier	Circuit normally found at the front-end of a radio receiver designed to amplify very low level signals while keeping any added noise to as low a level as possible
LOS	Line of Sight	Physical radio channel configuration in which there is a direct line of sight between the transmitter and the receiver
NLOS	Non Line of Sight	Physical radio channel configuration in which there is no direct line of sight between the transmitter and the receiver
PGA	Programmable Gain Amplifier	Amplifier whose gain can be set / changed via a control mechanism usually by changing register values
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
TCXO	Temperature Controlled Crystal Oscillator	A crystal oscillator whose output frequency is very accurately maintained at its specified value over its specified temperature range of operation.
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
TDOA	Time Difference of Arrival	Method of deriving information on the location of a transmitter. The time of arrival of a transmission at two physically different locations whose clocks are synchronized is noted and the difference in the arrival times provides information on the location of the transmitter. A number of such TDOA measurements at different locations can be used to uniquely determine the position of the transmitter. Refer to Decawave's website for further information.
UWB	Ultra Wideband	A radio scheme employing channel bandwidths of, or in excess of, 500MHz
WSN	Wireless Sensor Network	A network of wireless nodes intended to enable the monitoring and control of the physical environment
BLE	Bluetooth Low Energy.	A low power means of data communication.

11 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

12 DOCUMENT HISTORY

Table 10: Document History

Revision	Date	Description
1.0	21/12/17	First release

13 MAJOR CHANGES

To be completed on document updates.

14 ABOUT DECAWAVE

Decawave is a pioneering fabless semiconductor company whose flagship product, the DW1000, is a complete, single chip CMOS Ultra-Wideband IC based on the IEEE 802.15.4-2011 [7] UWB standard. This device is the first in a family of parts that will operate at data rates of 110 kbps, 850 kbps, 6.8 Mbps.

The resulting silicon has a wide range of standards-based applications for both Real Time Location Systems (RTLS) and Ultra Low Power Wireless Transceivers in areas as diverse as manufacturing, healthcare, lighting, security, transport, inventory & supply chain management.

Further Information

For further information on this or any other Decawave product contact a sales representative as follows: -

Decawave Ltd
Adelaide Chambers
Peter Street
Dublin
D08 T6YA
Ireland
+353 1 6975030
e: sales@decawave.com
w: www.decawave.com