YCHIOT

# MAX2001®

**[This module has passed ROHS certification]**

# DATASHEET

## Compatible with Decawave DWM1000

## Long Range UWB RF Module

## Version V1.9

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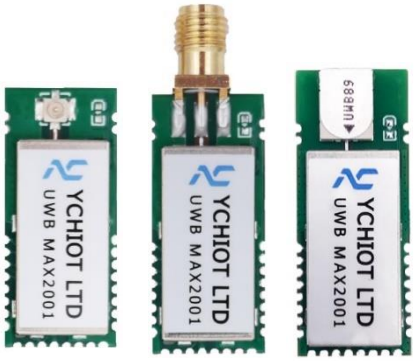
## YCHIOT MAX2001 / MAX2001C UWB Module Features Overview

The MAX2001 and MAX2001C module is an ultra-wideband transceiver module based on the DW1000 chip design of decaWave, which is self-developed by YCHIOT. The module integrates the antenna and all radio frequency circuits, power management and clock circuits. This module can be used in TWR or TDOA positioning systems to locate targets with an accuracy of less than 10cm; and the module supports data transmission rates up to 6.8Mbps.




### KEY FEATURES

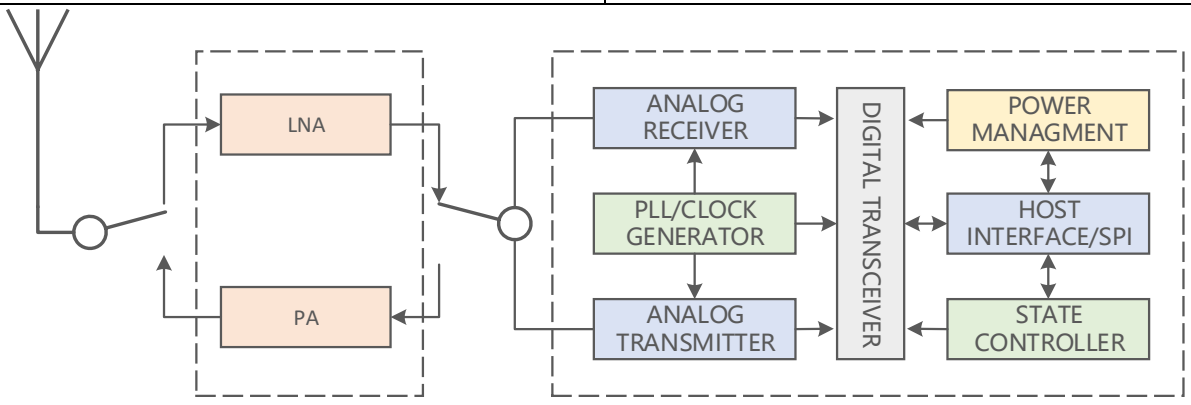
- Comply with IEEE802.15.4-2011 ultra-wideband standard;
- Support the radio frequency band from 3.5GHz to 4.2GHz;
- The output power of transmitter can be programmed and controlled; Tyically, the output power of transmitter is over-22dbm/Mhz;
- Fully coherent receiver, maximum use distance, high accuracy;
- The design complies with FCC&ETSI UWB spectrum standards;
- The power supply is 2.8V~3.6V;
- The data transmission rate is 110kbps, 850kbps, and 6.8Mbps in three modes;
- The maximum data packet length is 1023 bytes, which meets the application requirements of high data volume exchange;
- Integrated MAC support function
- Support TWR and TDOA positioning;
- The host interface is SPI;

### KEY BENEFITS

- Used for object positioning in real-time positioning system with an accuracy of up to 10 cm
- **Communication and Ranging distance over 400 meters**
- It has a larger communication range, reducing the additional infrastructure required in RTLS (Real Time Location System);
- High multipath fading immunity;
- Enable high-density label distribution in RTLS (Real-time Location System);
- The package interface is compatible with the original DWM1000.
- **The MAX2001C Module support 0.5ppm 38.4M TCXO.**

### APPLICATIONS

- Precision real time location systems (RTLS) using TWR or TDOA schemes in a variety of markets.
- Location-aware wireless sensor networks (WSNs)




**HIGH LEVEL BLOCK DIAGRAM**

# Content

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

**REGULATORY APPROVALS**

All products developed by the user incorporating the DWM1000 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 MAX2001 Series Module OVERVIEW

The MAX2001 module is an IEEE 802.15.4-2011 UWB implementation, including Decawave DW1000 UWB transceiver, and other components reside on-module. MAX2001 enables cost effective and reduced complexity integration of UWB communications and ranging features, greatly accelerating design implementation.

## *1.1 MAX2001 Functional Description*

The DW1000 on board the MAX2001 is a fully integrated low-power, single chip CMOS RF transceiver IC compliant with the IEEE 802.15.4-2011 [1] UWB standard. The MAX2001 module requires no RF design as the antenna and associated analog and RF components are on the module.

The module contains an on-board 38.4 MHz reference crystal. The crystal has been trimmed in production to reduce the initial frequency error to approximately 2 ppm, using the DW1000 IC's internal on-chip crystal trimming circuit, see section 2.1.1.

Always-On (AON) memory can be used to retain MAX2001 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 MAX2001 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 MAX2001.

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

## *1.2 MAX2001 Power Up*

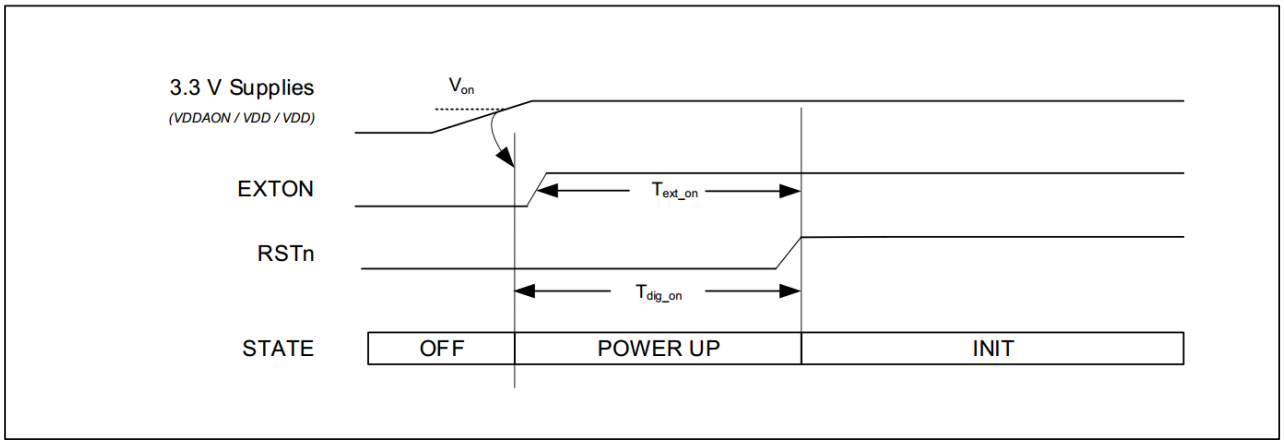



**Figure 1.2 MAX2001 Power-up Sequence**

When power is applied to the MAX2001, RSTn is driven low by internal circuitry as part of its power up sequence. See Figure 1.2 above. RSTn remains low until the on-module crystal oscillator has powered up and its output is suitable for use by the rest of the device, at which time RSTn is deasserted high.

**Table 1: DW1000 Power-up Timings**

| Parameter | Description | Nominal Value | Units |
|---|---|---|---|

| | | | |
|---|---|---|---|
| $V_{ON}$ | Voltage threshold to enable power up | 2.0 | V |
| $T_{EXT\_ON}$ | Time at which EXTON goes high before RSTn is released | 3 | ms |
| $T_{DIG\_ON}$ | RSTn held low by internal reset circuit / driven low by external reset circuit | 3 | ms |

RSTn may be used as an output to reset external circuitry as part of system bring-up as power is applied.

An external circuit can reset the DWM1000 by asserting RSTn for a minimum of 10 ns. RSTn is an asynchronous input. MAX2001 initialization will proceed when the pin is released to high impedance. **RSTn should never be driven high by an external source**. Please see DW1000 Datasheet [2] for more details of DW1000 power up.

### *1.3 SPI Host Interface*

The DW1000 host communications interface is a slave-only SPI. Both clock polarities (SPIPOL=0/1) and phases (SPIPHA=0/1) are supported. The data transfer protocol supports single and multiple byte read/writes accesses.All bytes are transferred MSB first and LSB last. A transfer is initiated by asserting SPICSn low and terminated when SPICSn is deasserted high.

See the DW1000 Datasheet [2] for full details of the SPI interface operation and mode configuration for clock phase and polarity.

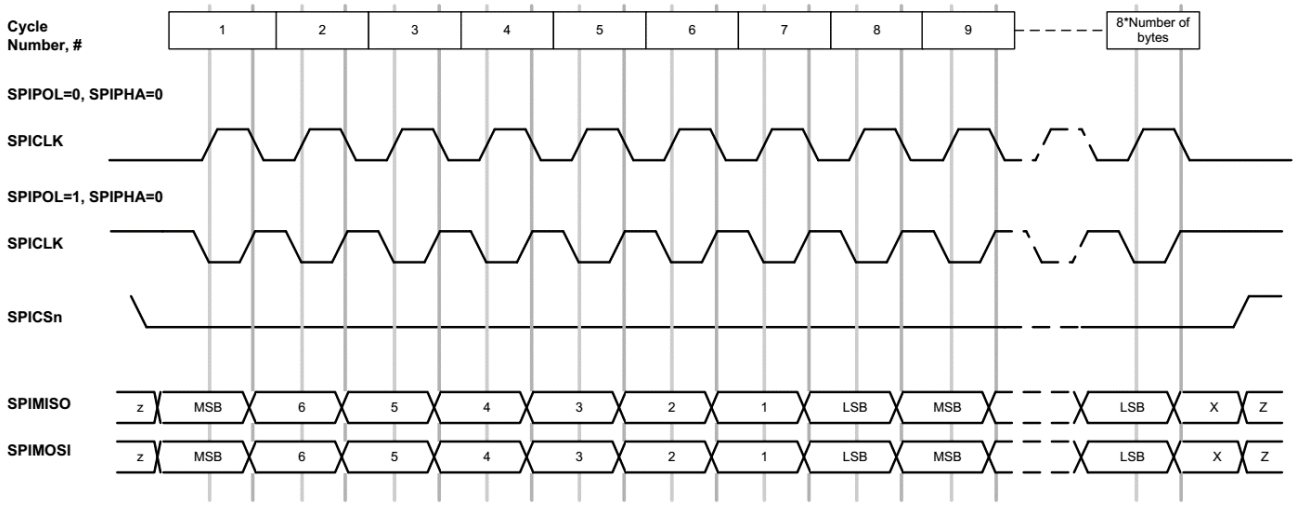



**Figure 1.3.1 DW1000 SPIPHA=0 Transfer Protocol**

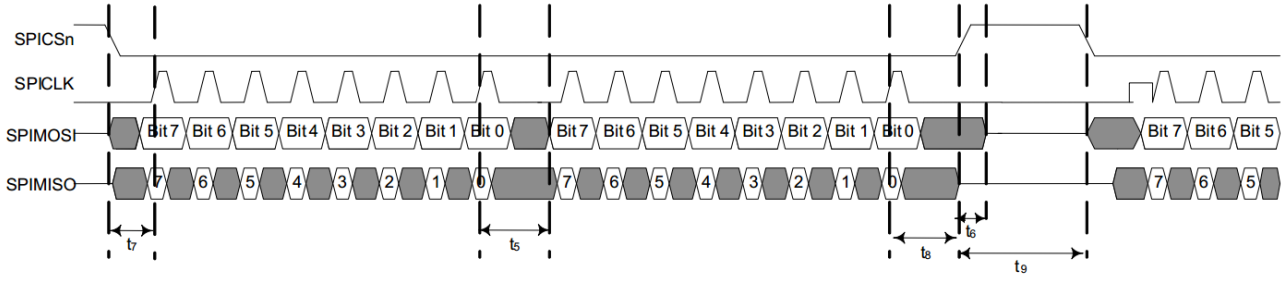



**Figure 1.3.2 DW1000 SPI Timing Diagram**

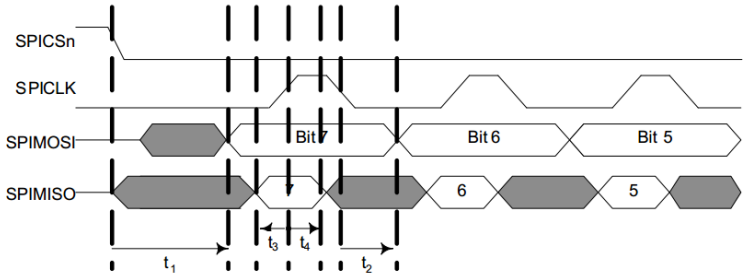



**Figure 1.3.3 DW1000 SPI Detailed Timing Diagram**

**Table 1.3 MAX2001 SPI Timing Parameters**

| Parameter | Min. | Typ. | Max | Unit | Description |
|---|---|---|---|---|---|
| SPICLK Period | 50 | | | ns | The maximum SPI frequency is 20 MHz when the CLKPLL is locked,<br>otherwise the maximum SPI frequency is 3 MHz. |
| $t_1$ | | | 38 | ns | SPICSn select asserted low to valid slave output data |
| $t_2$ | 12 | | | ns | SPICLK low to valid slave output data |
| $t_3$ | 10 | | | ns | Master data setup time |
| $t_4$ | 10 | | | ns | Master data hold time |
| $t_5$ | 32 | | | ns | LSB last byte to MSB next byte |
| $t_6$ | | | 10 | ns | SPICSn de-asserted high to SPIMISO tri-state |
| $t_7$ | 16 | | | ns | Start time; time from select asserted to first SPICLK |
| $t_8$ | 40 | | | ns | Idle time between consecutive accesses |
| $t_9$ | 40 | | | ns | Last SPICLK to SPICSn de-asserted |

### *1.4 General Purpose Input Output (GPIO)*

TheMAX2001 provides 8 configurable pins.

On reset, all GPIO pins default to input. GPIO inputs, when appropriately configured, are capable of generating interrupts to the host processor via the IRQ signal.

GPIO0, 1, 2, & 3, as one of their optional functions, can drive LEDs to indicate the status of various chip operations. Any GPIO line being used to drive an LED in this way should be connected as shown. GPIO5 & 6 are used to configure the operating mode of the SPI as described in the DW1000 Datasheet [2]. See DW1000 Datasheet [2] and DW1000 User Manual [3] provide full details of the configuration and use of the GPIO lines.

### *1.5 AON Memory*

Configuration retention in lowest power states is enabled in MAX2001 by provision of an Always-On (AON) memory array with a separate power supply, VDDAON. The MAX2001 may be configured to upload its configuration to AON before entering a low-power state and to download the configuration when waking up from the low –power state.

### *1.6 One-Time Programmable (OTP) Memory*

The MAX2001 contains a 56x32 -bit user programmable OTP memory on the DW1000 device that is used to store per chip calibration information.

### *1.7 Interrupts and Device Status*

DWM1000 has a number of interrupt events that can be configured to drive the IRQ output pin. The default IRQ pin polarity is active high. A number of status registers are provided in the system to monitor and report data of interest. See DW1000 User Manual [3] for a full description of system interrupts and their configuration and of status registers.

### *1.8 MAC*

A number of MAC features are implemented including CRC generation, CRC checking and receive frame filtering. See the DW1000 Datasheet [2] and DW1000 User Manual [3] for full details.

# 2 MAX2001 CALIBRATION

## *2.1 MAX2001 CALIBRATION*

Depending on the end-use application s and the system design, MAX2001 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 MAX2001 Crystal Oscillator Trim*

MAX2001 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 2 ppm, typically.

### *2.1.2 Transmitter Calibration*

In order to maximise range, MAX2001 transmit power spectral density (PSD) should be set to the maximum allowable for the geographic region in which it will be used. For most regions this is -41.3 dBm/MHz.

As the module contains an integrated antenna, the transmit power can only be measured over the air. The Effective Isotropic Radiated Power (EIRP) must be measured and the power level adjusted to ensure compliance with applicable regulations.

The MAX2001 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 regulatory spectral mask.

If required, transmit calibration should be carried out on a per DWM1000 module basis, see DW1000 User Manual [3] for full details.1

### *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 MAX2001 allows this delay to be calibrated and provides the facility to compensate for delays introduced by PCB, external components, antenna and internal MAX2001 delays.

To calibrate the antenna delay, range is measured at a known distance using two MAX2001 systems. Antenna delay is adjusted until the known distance and reported range agree. The antenna delay can be stored in OTP memory.

Antenna delay calibration must be carried out as a once off measurement for each MAX2001 design implementation. If required, for greater accuracy, antenna delay calibration should be carried out on a per MAX2001 module basis, see DW1000 User Manual [3] for full details.

# 3 MAX2001 SERIES MODULE PIN CONNECTIONS

## *3.1 Pin Numbering*

MAX2001-SMA / CA / IPEX module pin assignments are as follows (viewed from top):

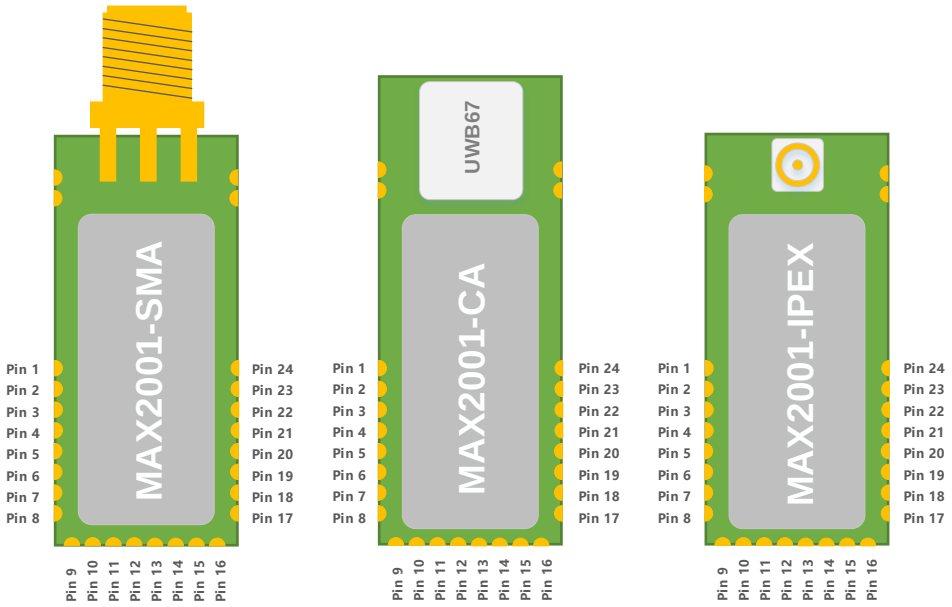



**Figure 3.1.1 MAX2001-SMA / CA / IPEX Pin Diagram**

## *3.2 Pin Descriptions*

**Table 3.2.1 MAX2001 Pin functions**

| SIGNAL NAME | PIN | I/O (Default) | DESCRIPTION |
|---|---|---|---|
| **Digital Interface** | | | |
| SPICLK | 20 | DI | SPI clock |
| SPIMISO | 19 | DO (O-L) | SPI data output. Refer to DW1000 Datasheet for more details [2]. |
| SPIMOSI | 18 | DI | SPI data input. Refer to DW1000 Datasheet for more details [2]. |
| SPICSn | 17 | DI | 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. SPICSn can also act as a wake-up signal to bring DW1000 out of either SLEEP or DEEPSLEEP states Refer to DW1000 Datasheet for more details [2]. |
| WAKEUP | 2 | DIO | When asserted into its active high state, the WAKEUP pin brings the DW1000 out of SLEEP or DEEPSLEEP states into operational mode. If unused, this pin can be tied to ground. |
| EXTON | 1 | DO (O-L) | External device enable. Asserted during wake up process and |

| | | | |
|---|---|---|---|
| | | | held active until device enters sleep mode. Can be used to control external DC-DC converters or other circuits that are not required when the device is in sleep mode so as to minimize power consumption. Refer to DW1000 Datasheet for more details [2]. |
| IRQ / GPIO8 | 22 | DIO (O-L) | Interrupt Request output from the DW1000 to the host processor. By default IRQ is an active-high output but may be configured to be active low if required. For correct operation in SLEEP and DEEPSLEEP modes it should be configured for active high operation. This pin will float in SLEEP and DEEPSLEEP states and may cause spurious interrupts unless pulled low.<br>When the IRQ functionality is not being used the pin may be reconfigured as a general purpose I/O line, GPIO8. |
| GPIO7 | 4 | DIO(I) | Defaults to operate as a SYNC input – refer [2]. THIS FUNCTIONALITY IS NOT APPLICABLE TO THE DW1000. This pin may be reconfigured as a general purpose I/O pin, GPIO7 under software control. |
| GPIO6 / SPIPHA | 9 | DIO(I) | General purpose I/O pin.<br>On power-up it acts as the SPIPHA (SPI phase selection) pin for configuring the SPI mode of operation. Refer to Section 5.2.2 and the DW1000 Datasheet for more details [2].<br>After power-up, the pin will default to a General Purpose I/O pin. |
| GPIO5/SPIPOL | 10 | DIO(I) | General purpose I/O pin.<br>On power-up it acts as the SPIPOL (SPI polarity selection) pin for configuring the SPI operation mode. Refer to Section 5.2.2 and the DW1000 Datasheet for more details [2].<br>After power-up, the pin will default to a General Purpose I/O pin. |
| GPIO4 | 11 | DIO(I) | General purpose I/O pin. |
| GPIO3 / TXLED | 12 | DIO(I) | General purpose I/O pin.<br>It may be configured for use as a TXLED driving pin that can be used to light a LED following a transmission. Refer to the DW1000 User Manual [2] for details of LED use. |
| GPIO2/RXLED | 13 | DIO(I) | General purpose I/O pin.<br>It may be 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. |
| GPIO1 /SFDLED | 14 | DIO(I) | General purpose I/O pin.<br>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 [2] for details of LED use. |
| GPIO0 / RXOKLED | 15 | DIO(I) | General purpose I/O pin.<br>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 [2] for details of LED use. |
| RSTn | 3 | DIO(O-H) | Reset pin. Active Low Output.<br>May be pulled low by external open drain driver to reset the DW1000. Refer to DW1000 Datasheet for more details [2]. |
| **Power Supplies** | | | |
| VDDAON | 5 | P | External supply for the Always-On (AON) portion of the chip. |
| VDD3V3 | 6.7 | P | 3.3 V supply pins. Note that for programming the OTP in the DWM1000 module this voltage may be increased to a nominal value of 3.8 V for short periods. |
| **Ground** | | | |
| GND | 8,21<br>,23,24 | G | Common ground. |
| XTAL | 16 | | Common ground (MAX2001 series Module)<br>External XTAL Signal (MAX2001C series Module) |

**Table 3.2.2 Explanation of Abbreviations**

| ABBREVIATION | EXPLANATION |
|---|---|
| I | Input |
| IO | Input / Output |
| O | Output |
| G | Ground |
| P | Power Supply |
| PD | Power Decoupling |
| O-L | Defaults to output, low level after reset |
| O-H | Defaults to output, high level after reset |
| I | Defaults to input. |
| Note: Any signal with the suffix ‘n’ indicates an active low signal. | |

# 4 ELECTRICAL SPECIFICATIONS

## *4.1 Nominal Operating Conditions*

**Table 4.1 MAX2001 Operating Conditions**

| Parameter | Min. | Typ. | Max. | Units | Condition/Note |
|---|---|---|---|---|---|
| Operating temperature | -40 | | +85 | ℃ | |
| Supply voltage VDDAON, VDD3V3 | 2.2 | 3.3 | 3.6 | V | Normal operation |
| Supply voltage VDD3V3 for programming OTP | 3.7 | 3.8 | 3.9 | V | Note that for programming the OTP in theMAX2001 the VDD3V3 voltage must be increased to 3.8 V nominal for short periods. |
| GPIO[0 – 7]<br>WAKEUP<br>RSTn<br>SPICSn<br>SPIMOSI<br>SPICLK | | | 3.6 | | Note that 3.6 V is the max voltage that may be applied to these pins |

Note: Unit operation is guaranteed by design when operating within these ranges

## *4.2 DC Characteristics*

Tamb = 25 ˚C, all supplies centred on typical values

**Table 4.2 MAX2001 DC Characteristics**

| Parameter | Min. | Typ. | Max. | Units | Condition/Note |
|---|---|---|---|---|---|
| Supply current DEEP SLEEP mode | | 200 | | nA | Total current drawn from all supplies. |
| Supply current SLEEP mode | | 550 | | nA | |
| Supply current IDLE mode | | 13.4 | | mA | |
| Supply current INIT mode | | 3.5 | | mA | |
| TX3.3 V supplies<br>(VDDAON, VDD) | | | 140 | mA | |
| RX3.3 V supplies<br>(VDDAON, VDD) | | | 160 | mA | Channel 2 |
| Digital input voltage high | 0.7*VDD | | | V | |
| Digital input voltage low | | | 0.3VDD | V | |
| Digital output voltage high | 0.7*VDD | | | V | Assumes 500 Ω load |
| Digital output voltage low | | | 0.3VDD | V | Assumes 500 Ω load |

| | | | | | |
|---|---|---|---|---|---|
| GPIO,IRQ,<br>SPIMOSI<br>,EXTON<br>Digital Output Drive Current | 4<br>8<br>3 | 6<br>10<br>4 | | mA | |

### *4.3 Receiver AC Characteristics*

$T_{amb}$ = 25 ˚C, all supplies centred on nominal values

**Table 4.3 MAX2001 Receiver AC Characteristics**

| Parameter | Min. | Typ. | Max. | Units | Condition/Note |
|---|---|---|---|---|---|
| Frequency range | 3244 | | 20000 | MHz | |
| Channel bandwidth | | 499 | | MHz | |
| In-band blocking level | | 30 | | dBc | Continuous wave interferer |
| Out-of-band blocking level | | 55 | | dBc | Continuous wave interferer |

### *4.4 Receiver Sensitivity Characteristics*

Tamb = 25 ˚C, all supplies centred on typical values. 20 byte payload. These sensitivity figures assume an antenna gain of 0 dBi and should be modified by the antenna characteristics quoted in Table 4.4 depending on the orientation of the MAX2001.

**Table 4.4 MAX2001 Typical Receiver Sensitivity Characteristics**

| Packet Error Rate | Data Rate | Receiver Sensitivity | Units | Condition/Note | | |
|---|---|---|---|---|---|---|
| 1% | 110kbps | -102 | dBm/500 MHz | Preamble 2048 | Carrier frequency offset ： ± 10ppm | All measurements performed on Channel 2,16MHz |
| | 850kpbs | -101 | dBm/500 MHz | Preamble 1024 | | |
| | 6.8Mbps | -93 | dBm/500 MHz | Preamble 256 | | |
| 10% | 110kbps | -106 | dBm/500 MHz | Preamble 2048 | | |
| | 850kpbs | -102 | dBm/500 MHz | Preamble 1024 | | |
| | 6.8Mbps | -94 | dBm/500 MHz | Preamble 256 | | |

### *4.5 Reference Clock AC Characteristics*

25℃， all supplies centred on typical values

**Table 4.5 MAX2001 Reference Clock AC Characteristics**

| Parameter | Min. | Typ. | Max. | Units | Condition/Note |
|---|---|---|---|---|---|
| On-board crystal oscillator reference frequency | | 38.4 | | MHz | |
| On-board crystal trimming range | | ±25 | | ppm | Internally trimmed to +/- 2 ppm under typical conditions. |
| On-board crystal frequency stability with temperature | | | ±30* | ppm | -40°C to +85° |
| On-board crystal aging | | | ±3 | ppm/3year | @25°C ±2°C |
| Low Power RC Oscillator | 5 | 12 | 15 | KHz | |

*By using the temperature monitoring capability of the DW1000 chip on the MAX2001 module it is possible to dynamically trim the crystal during run time to maintain the +/- 2ppm specification over the full temperature range of operation.

### *4.6 Temperature and Voltage Monitor Characteristics*

**Table 4.6 MAX2001 Temperature and Voltage Monitor Characteristics**

| Parameter | Min. | Typ. | Max. | Units | Condition/Note |
|---|---|---|---|---|---|
| Voltage Monitor Range | 2.4 | | 3.75 | V | |
| Voltage Monitor Precision | | 20 | | mV | |
| Voltage Monitor Accuracy | | 140 | | mV | |
| Temperature Monitor Range | -40 | | +100 | ℃ | |
| Temperature Monitor Precision | | 0.9 | | ℃ | |

### *4.7 Transmitter AC Characteristics*

**Table 4.7 MAX2001 Transmitter AC Characteristics (Tamb = 25 ℃, all supplies centred on typical values)**

| Parameter | Min. | Typ. | Max. | Units | Condition/Note |
|---|---|---|---|---|---|
| Frequency range | 3244 | | 4500 | MHz | |
| Channel Bandwidths | | 500 | | MHz | Channel 1, 2 |
| Output power spectral density (programmable) | | -23.1 | | dBm/MHz | |
| Power level range | | 37 | | dB | |
| Coarse Power level step | | 3 | | dB | |

| | | | | | |
|---|---|---|---|---|---|
| Fine Power level step | | 0.5 | | dB | |
| Output power variation with temperature | | 0.05 | | dB/°C | |
| Output power variation with voltage | | 2.73 | | dB/V | Channel 2 |

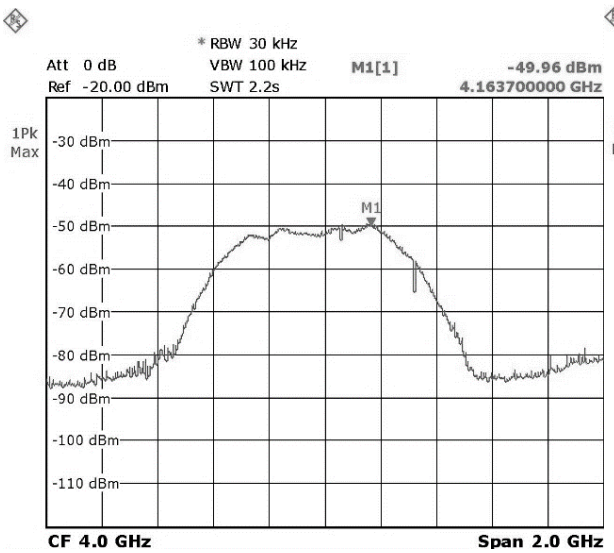



Table 4.6.1 DWM1000 Transmit power

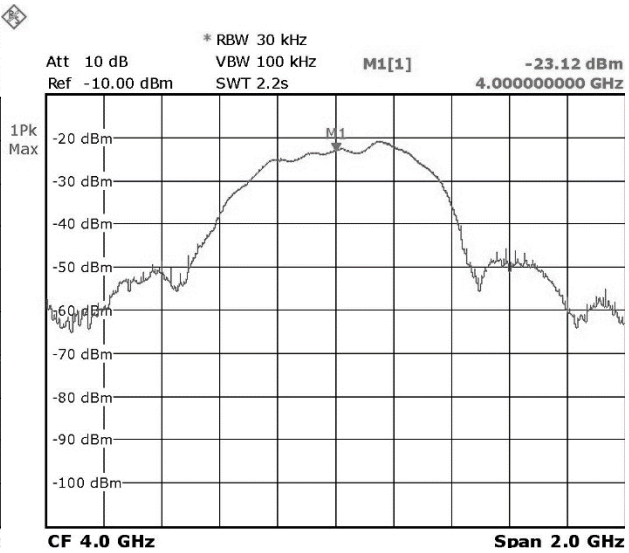



Table 4.6.2 MAX2001-SMA Transmit power

Test equipment: spectrum analyzer FSL6- ROHDESCHWARZ

### *4.8 Antenna Performance*

MAX2001-SMA use external antenna, MAX2001-CA use built-in ceramic antenna ACS5200HFAUWB (Partron).The parameter comparison is shown in the figure below. For more antenna selection, please refer to ***ap07-YCHIOT UWB Antenna and Cable Product Specification V1.3.***

**Table 4.8 Comparison of external antenna and built-in ceramic antenna**

| Parameter | External antenna | Built-in ceramic antenna |
|---|---|---|
| Frequency band | 3.1 ~ 6 GHz | 3.1 ~ 8GHz |
| Gain | 3.0dBi | 2.1 ~ 2.6dBi@ (3.168GHz ~ 4.753GHz) |
| Input resistance | 50Ω | 50Ω |
| VSWR | ≤2.2 | ≤2.0 |
| Polarization mode | Vertical | Vertical |
| Radiation direction | Omnidirectional | Omnidirectional |
| Size | Total length 80mm | Length 8mm*Width 6mm*Height1mm |

### *4.9 Absolute Maximum Ratings*

**Table 4.9 MAX2001 Absolute Maximum Ratings**

| Parameter | Min. | Max. | Units |
|---|---|---|---|
| Voltage VDD3V3 / VDDAON | -0.3 | 4.0 | V |
| Receiver Power | | 0 | dBm |
| Temperature - Storage temperature | -40 | +85 | ℃ |
| Temperature – Operating temperature | -40 | +85 | ℃ |
| ESD (Human Body Model) | | 2000 | V |

# 5 APPLICATION INFORMATION

## *5.1 MAX2001 Peripheral circuit design*

A simple application circuit integrating MAX2001 needs to provide 3.3V power supply to VDD3V3, and the 10uF and 0.1uF decoupling capacitors should be as close as possible to the module power supply, and the SPI interface (MISO / MOSI / CS / CLK) is connected to the microcontroller, and the IRQ pin is passed 10K is pulled low, RSTn is connected to the ordinary IO port of the microcontroller, WAKEUP, EXTON and SYNC can be disconnected. Refer to Figure 5.1

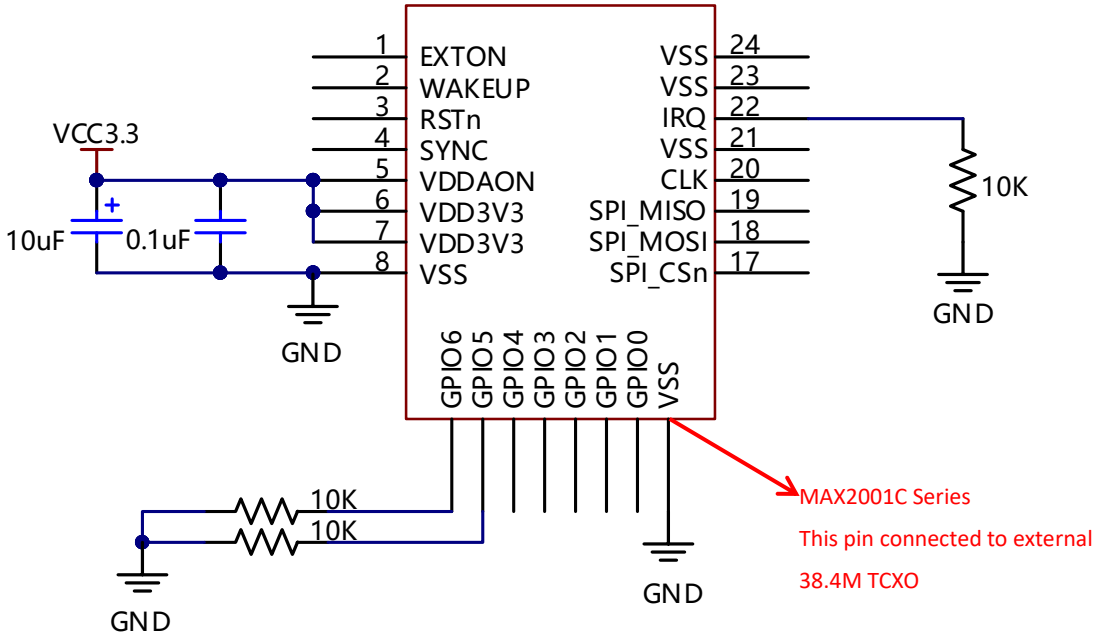



**Figure 5.1 YCHIOT MAX2001 Interface and peripheral components**

### *5.1.1 SPI Bus*

The SPI signal bus and mode configuration pins may need to be treated carefully if it is desirable to connect additional SPI devices to the SPI bus, or to configure the SPI for a non-default clock polarity of phase behaviour. Please see the DW1000 Datasheet [2] for a description of all SPI clock polarity and phase configurations, referred to as SPI modes.

The SPI MISO line may be connected to multiple slave SPI devices each of which is required to go open-drain when their respective SPICSn lines are de-asserted.

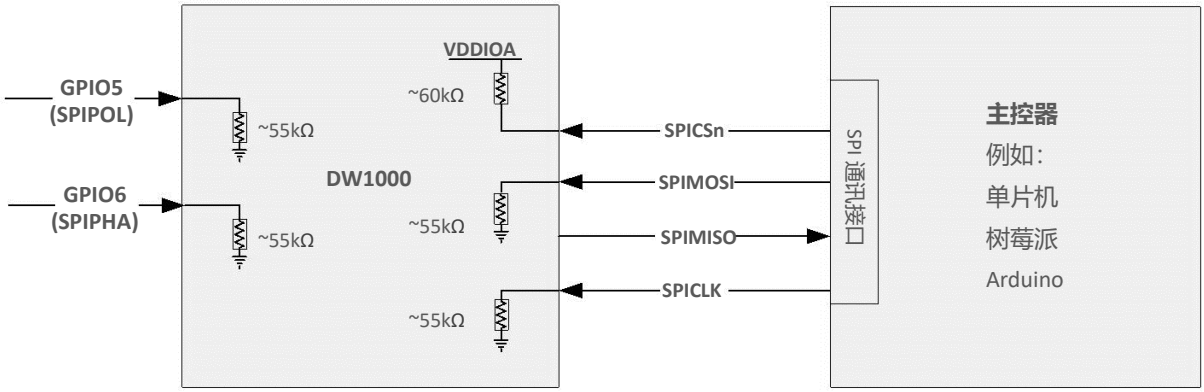



**Figure 5.1.1 SPI Bus Connections**

### *5.1.2 Configuring the SPI Mode*

The SPI interface supports a number of different clock polarity and clock / data phase modes of operation. These modes are selected using GPIO5 & 6 as follows:

**Table 5.1.1 DW1000 SPI Mode Configuration**

| GPIO 5 (SPIPOL) | GPIO 6 (SPIPHA) | SPI Mode | Description (from the master / host point of view) |
|---|---|---|---|
| 0 | 0 | 0 | Data is sampled on the rising (first) edge of the clock and launched on the falling (second) edge. |
| 0 | 1 | 1 | Data is sampled on the falling (second) edge of the clock and launched on the rising (first) edge. |
| 1 | 0 | 2 | Data is sampled on the falling (first) edge of the clock and launched on the rising (second) edge. |
| 1 | 1 | 3 | Data is sampled on the rising (first) edge of the clock and launched on the falling (first) edge. |
| Note: The 0 on the GPIO pins can either be open circuit or a pull down to ground. The 1 on the GPIO pins is a pull up to VDDIO. | | | |

GPIO 5 / 6 are sampled / latched on the rising edge of the RSTn pin to determine the SPI mode. They are internally pulled low to configure a default SPI mode 0 without the use of external components. If a mode other than 0 is required then they should be pulled up using an external resistor of value no greater than 10 kΩ to the VDDIO output supply. MAX2001 uses GPIO5/6 to control the external PA and LNA, and requires pull-down GPIO 5/6 to connect to a 10K resistor to be pulled down to ground.

## *5.2 Schematic diagram of MAX2001 Application*

Figure 5.2.1 and Figure 5.2.2 provide the connection method of MAX2001 based on STM32F103T8U6/NRF52832 MCU for reference only.

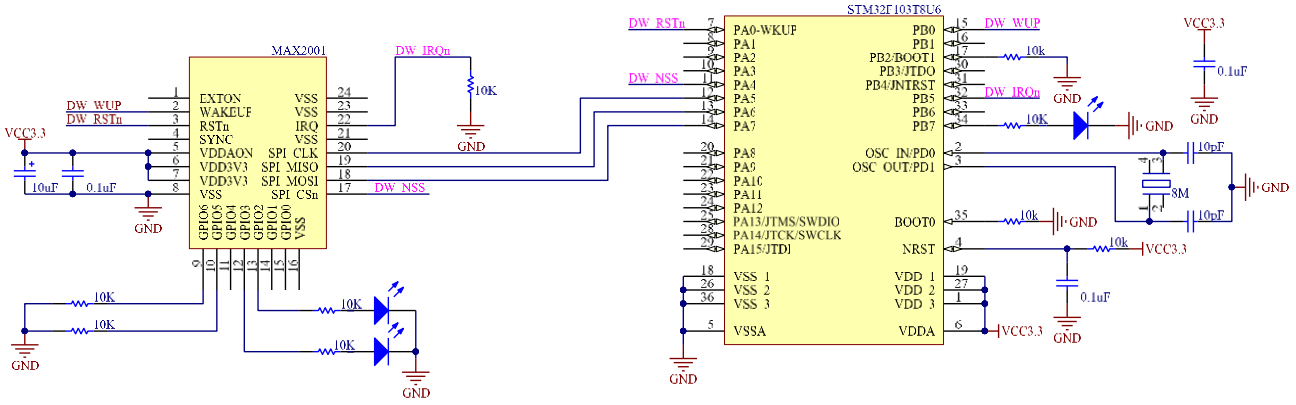



**Figure 5.2.1 MAX2001 and STM32F103T8U6wiring diagram**

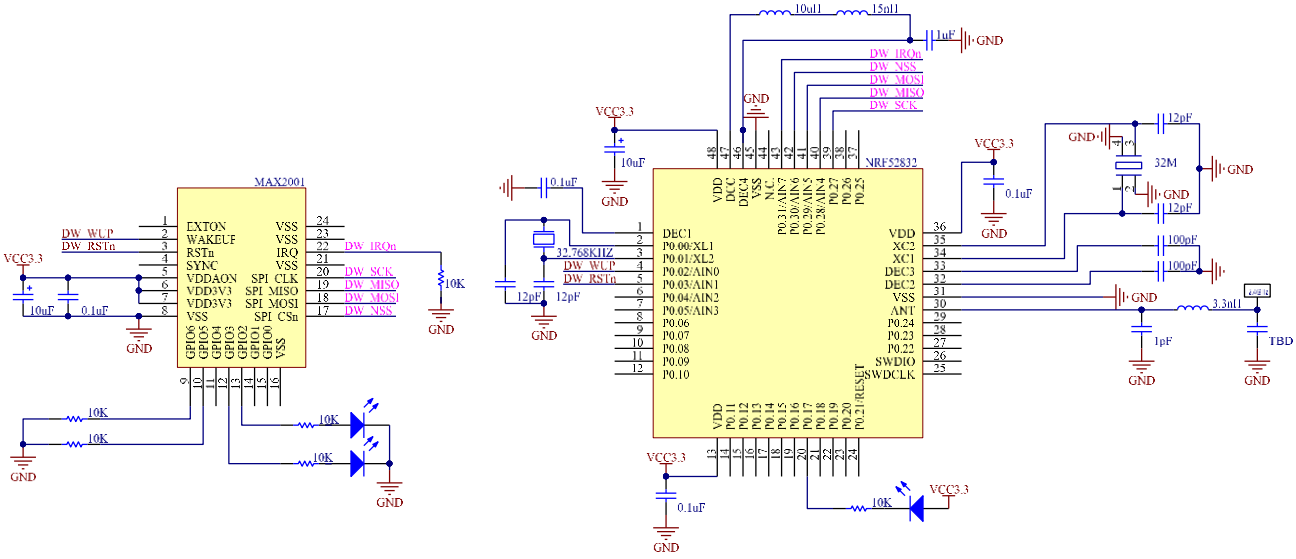



**Figure 5.2.1 MAX2001 and NRF52832 wiring diagram**

### *5.3 MAX2001 Wiring Descriptions*

When designing the bottom board PCB of MAX2001, the power amplifier part and antenna part on the MAX2001 board should be kept away from metal and any materials that will affect the RF signal to clear the PCB under the module. The EMC/EMI design of the radio frequency module needs to be fully considered. YCHIOT provides the MAX2001 development evaluation kit Mini4sPlus development board, as shown in Figure 5.3.1, and provides DEMO positioning for a fee.

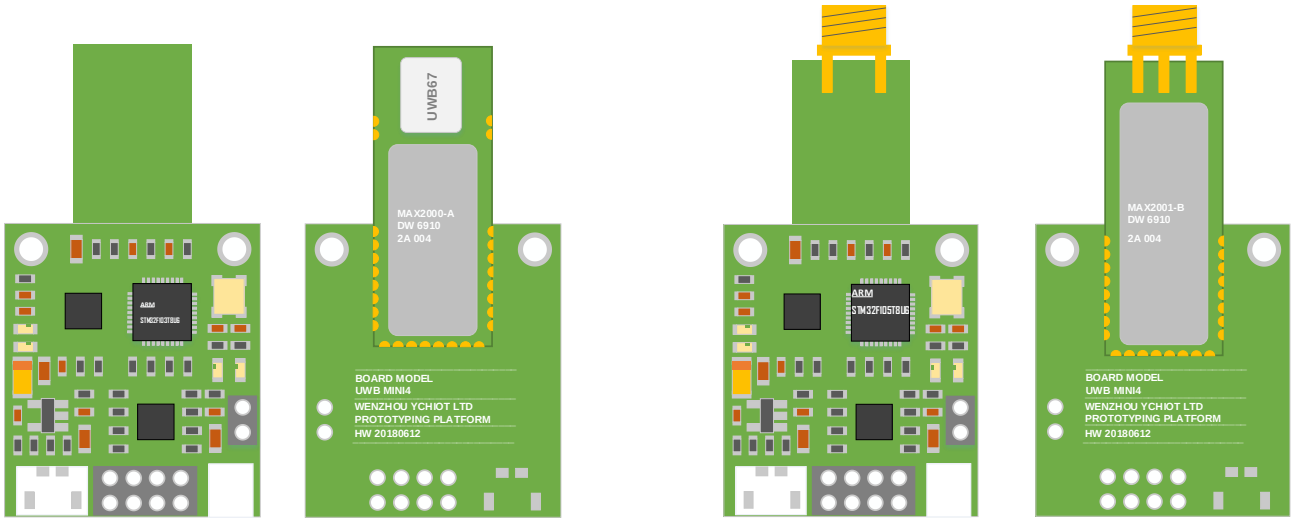



**Figure 5.3.1 YCHIOT MAX2001-SMA development board Mini4sPlus**

## *5.4 Precautions for drive control of MAX2001*

### *5.4.1 Key control signals*

**Table 5.3.1 Explanation of three key control signals**

| Signal Name | Pin | I/O (Default) | Description |
|---|---|---|---|
| GPIO6 / EXTRXE / SPIPHA | 9 | DIO(I) | Genaral IO port<br>After power-on, it is used as the SPIPHA (SPI phase selection) pin to configure the working mode of SPI, refer to chapter 5.2.2 or DW1000 data manual. After power on, this pin can be configured as a general IO port<br>It can also be configured as EXTRXE (External Receiver Enable) external receiver enable terminal. When configured in this mode, when DW1000 is receiving, this pin is high. |
| GPIO5 / EXTTXE / SPIPOL | 10 | DIO(I) | Genaral IO port<br>After power-on, it is used as the SPIPOL (SPI polarity selection) pin to configure the working mode of SPI. Refer to chapter 5.2.2 or DW1000 data manual. After power on, this pin can be configured as a general IO port<br>It can also be configured as EXTTXE (External Transmit Enable) external transmit enable terminal. When configured in this mode, when DW1000 is transmitting, this pin is high. |
| GPIO4 / EXTPA | 11 | DIO(I) | Genaral IO port<br>It can also be configured as EXTPA (External Power Amplifier) external power amplifier enable terminal. |

Note: GPIO4 / GPIO5 / GPIO6 have been configured as EXTPA, EXTTXE and EXTRXE

### *5.4.2 Schematic diagram of PA and LNA working principle*

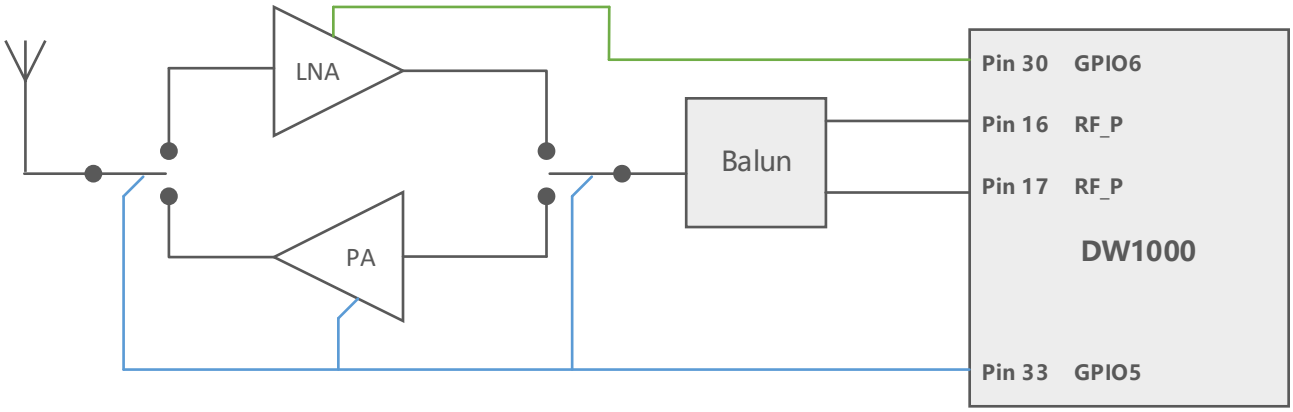



**Figure 5.3 Schematic diagram of PA and LNA working principle**

**Table 5.3.2 GPIO5/6 Truth Table**

| GPIO5 | GPIO 6 | Mode | Status |
|---|---|---|---|
| 0 | 0 | PA Disable，LNA Disable | Idle |
| 0 | 1 | PA Disable，LNA open | Receive |
| 1 | 0 | PA open，LNA Disable | Transmit |
| 1 | 1 | Error | / |

### *5.4.3 Code modification*

Only need to turn on and off the PA and LNA at the right time to achieve the predetermined power amplifier effect. Users who use the official decaWave API functions only need make a few lines of code to changes to the program. The following code needs to be added to the last few lines under the dwt_initialise() function in the deca_device.c file (line 253~263). For detailed register information, please refer to page 10 of the document "aps009_dw1000_under_laes_v1.3".

```
{
    uint32 reg;
    // Set up MFIO
    reg = dwt_read32bitreg(GPIO_CTRL_ID);
    reg |= 0x00014000 ; //7 and 8 to mode - to be used with PA
    reg |= 0x00050000 ; //8 and 9 to mode - RX/TX testing
    dwt_write32bitreg(GPIO_CTRL_ID,reg);
    //disable fine grain sequencing - this is needed when using PA on the TX
    dwt_write16bitoffsetreg(PMSC_ID,PMSC_TXFINESEQ_OFFSET,PMSC_TXFINESEQ_DIS_MASK);
}
```

### *5.4.4 Case Analysis*

Hardware development platform: Mini4sPlus label

Program ranging algorithm: DS-TWR

Test object: GPIO5 and GPIO6 of MAX2001 module

Test instrument: ordinary oscilloscope

As shown in the figure, using our Mini4sPlus label, under the oscilloscope, T1 (yellow) represents the waveform of GPIO5, and T2 (blue) represents the waveform of GPIO6. Combining the truth table of GPIO5/6 in Table 5.3.2, it can be seen that in a TWR ranging cycle, the PA is turned on twice, respectively when the Poll command and the Final command are sent. After the tag sends the Poll, it immediately enters the receiving state, that is, GPIO6 is pulled high and the LNA is turned on.

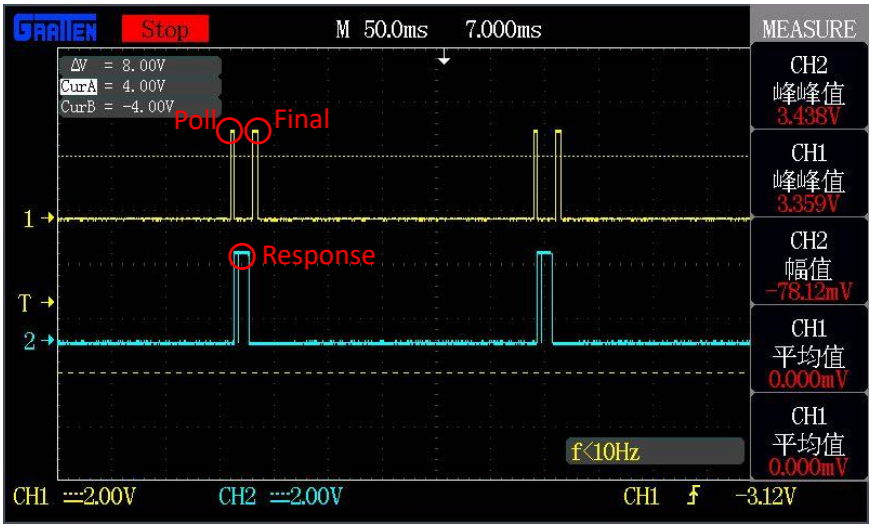
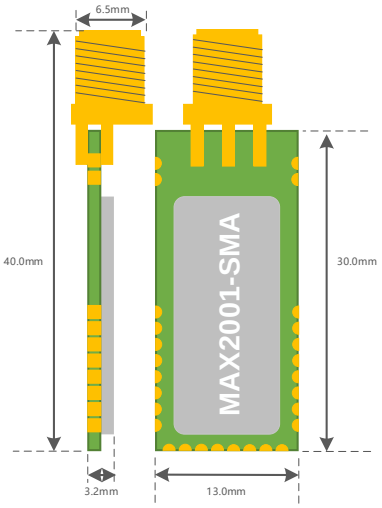
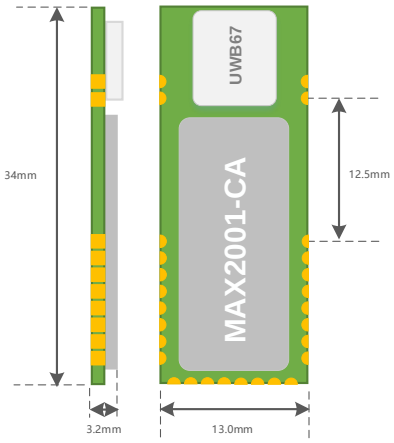
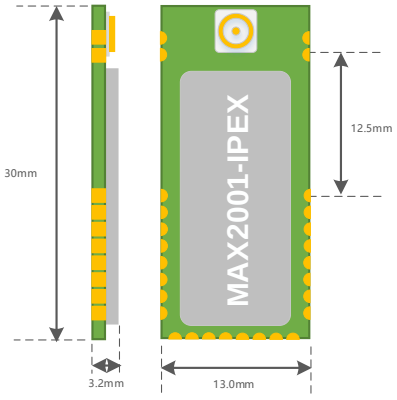



**Figure 5.4 GPIO 5 and GPIO6 electrical level analysis of MAX2001 module**

# 6 PACKAGE INFORMATION

## *6.1 Module Drawings*

MAX2001 and MAX2001C are both a 24-pin stamp package, and the pin definition is fully compatible with DWM1000. All measurements below are in millimeters.

| Type | Image | Size |
|---|---|---|
| MAX2001-SMA / MAX2001C-SMA |   |   |
| MAX2001-CA / MAX2001C-CA |   |   |
| MAX2001-IPEX / MAX2001C-IPEX |   |   |

### *6.2 Recommended Module Package*

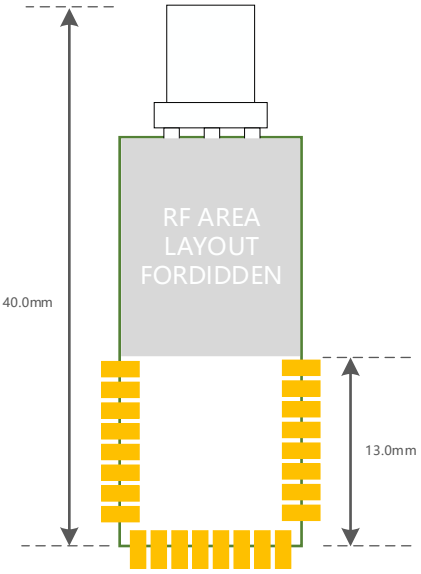
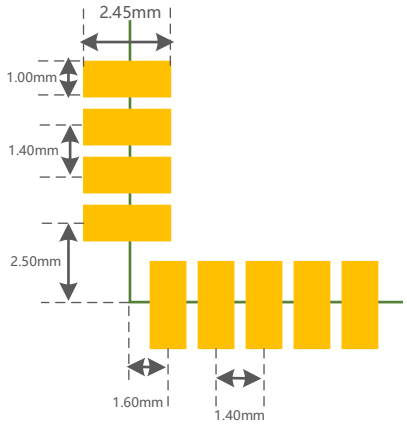
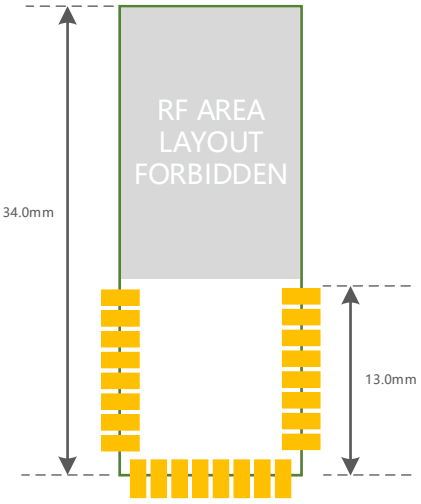
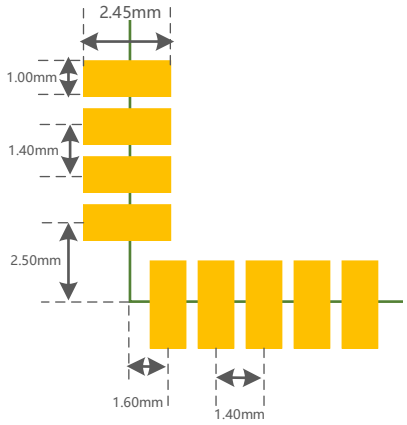
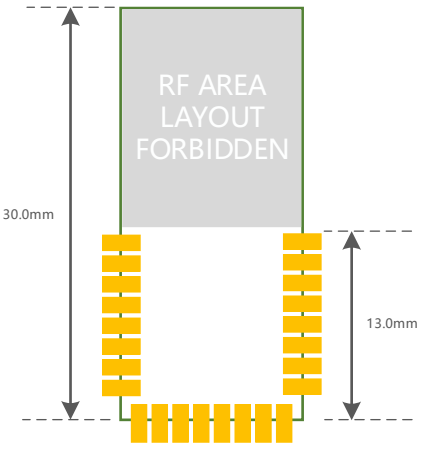
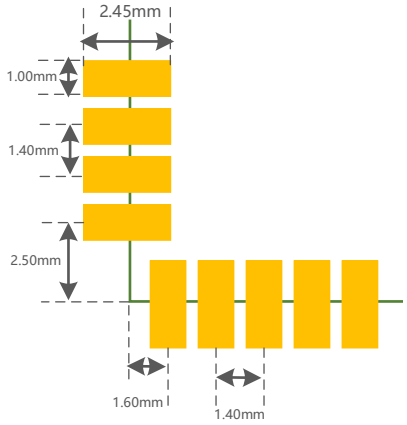
| Product | PCB 1 | PCB 2 |
|---|---|---|
|  |  |  |
|  |  |  |
|  |  |  |

**Figure 6.2 MAX2001 Module Land Pattern（Unit：mm）**

**Table 6.2 Module Weight**

| Parameter | Min | Typ | Max | Units |
|---|---|---|---|---|
| Unit weight | | 3.2 | | g |

### *6.3 Module welding curve*

Manual welding is recommended for UWB module welding to avoid the internal device movement of UWB module caused by secondary reflow welding, which will affect the product performance.

If reflow soldering is necessary, it is recommended to use low-temperature solder paste for reflow soldering and add inert gas for protection. The reference temperature curve is as follows:

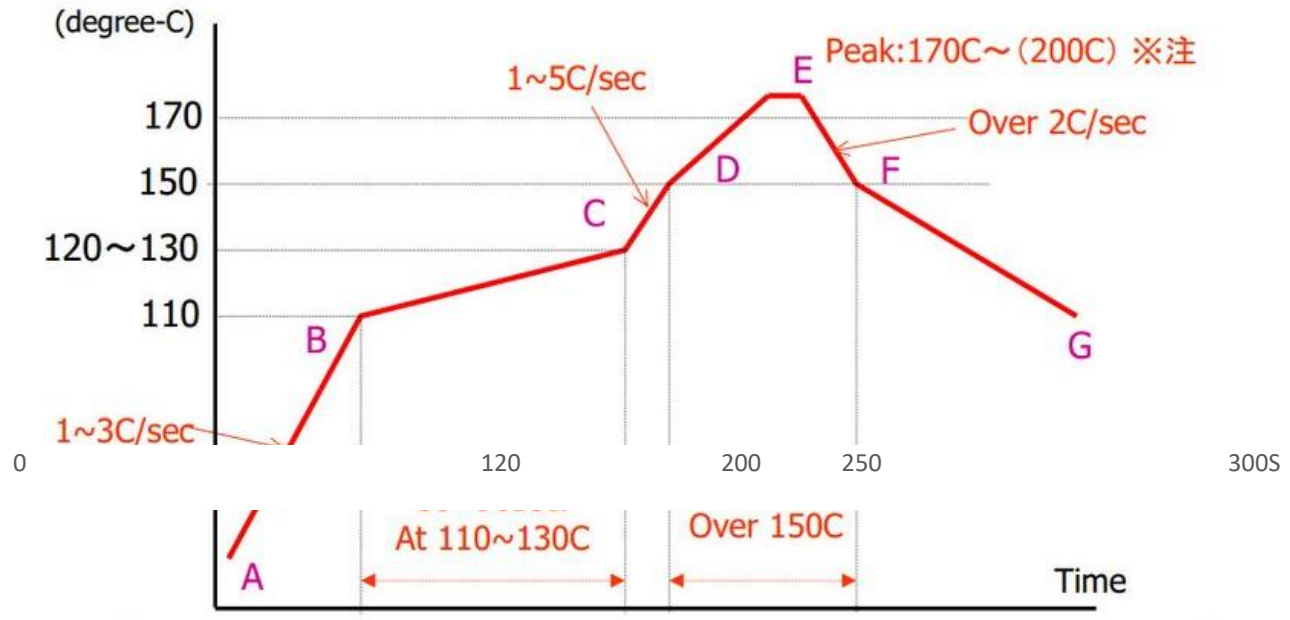



**Figure 6.3 MAX2001 Module Solder Profile**

# 7 ORDERING INFORMATION

| Product | Demo | Model | Crystal | Antenna interface | Status |
|---|---|---|---|---|---|
| UWB RF module |  | MAX2001-CA | 10ppm TCXO | Ceramic antenna | In-stock |
| | | MAX2001C-CA | External TCXO | Ceramic antenna | Coming Soon |
| UWB RF module |  | MAX2001-SMA | 10ppm TCXO | SMA outer screw inner hole | In-stock |
| | | MAX2001C-SMA | External TCXO | SMA outer screw inner hole | Coming Soon |
| UWB RF module |  | MAX2001-IPEX | 10ppm TCXO | IPEX interface | In-stock |
| | | ***MAX2001C-IPEX*** | ***External TCXO*** | ***IPEX interface*** | ***In-stock*** |

For technical question, retail and bulk purchase of MAX2001 and MAX2001 evaluation board, please contact:

Mr. Lin 15606880772 (BD)

Mr. Wu 13296707815 (After sales)

QQ： 171932915

WeChat: 15606880772

Purchase Link: https://ychiot.taobao.com/

Official Website: http://www.ychiot.com/

# 8 GLOSSARY

| 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 [1] 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 | Defined in the context of the IEEE 802.15.4-2011 [1] standard. |

| | | |
|---|---|---|
| | Delimiter | |
| 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 | 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 |

# 9 Appendix

## *9.1 MAX2001 ROHS Report*

CPST

**Test Report** No. C190220031001 Date: Feb 27, 2019 Page 1 of 9

| | |
|---|---|
| Applicant: | WENZHOU YCHIOT LTD |
| Applicant Address: | Room 307, YanChuang Building, ChaShan Street, Ouhai, Wenzhou, Zhejiang Province, China |

The following samples were submitted and identified on behalf of the clients as

| | |
|---|---|
| Sample Name: | UWB RF module |
| Model of test equipment: | MAX2001 |
| Trade mark: | YCHIOT |
| CPST Internal Reference No.: | C190220031 |
| Sample Received Date: | Feb 20, 2019 |
| Number of Sample Received: | 08 pcs |
| Test Period: | Feb 20, 2019 to Feb 27, 2019 |
| Test Method: | Please refer to next pages |
| Test Result: | Please refer to next pages |

Signed for and on behalf of
Eurones Consumer Products Testing Service Co., Ltd

| TESTED BY : | REVIEWED BY: | APPROVED BY: |
|---|---|---|
| Andy Wang | Sunshine Liu | Will Pan |
| Wang Guang Yu, Andy<br>Project Leader | Liu Xiao Fang, Sunshine<br>Report Reviewer | Pan Jian Ding, Will<br>Technical Supervisor |



400 111 6218
Eurones (Dongguan) Consumer Products Testing Service Co., Ltd. t (86-769) 38937858 f (86-769) 38937859 Http://www.cpstlab.com
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CPST

**Test Report** No. C190220031001 Date: Feb 27, 2019 Page 2 of 9

**********

CONCLUSION :

| TESTED SAMPLES | TEST ITEM | RESULT |
|---|---|---|
| UWB RF module | 1. RoHS Directive 2011/65/EU Annex II amending Annex (EU)2015/863 and amending Annex (EU)2017/2102<br>— Lead, Cadmium, Mercury, Hexavalent Chromium, PBBs and PBDEs Content | PASS |
| | —Di-(2-ethylhexyl) phthalate(DEHP), Benzylbutyl phthalate(BBP), Dibutyl phthalate (DBP), Diisobutyl phthalate(DIBP) Content | PASS |

**********



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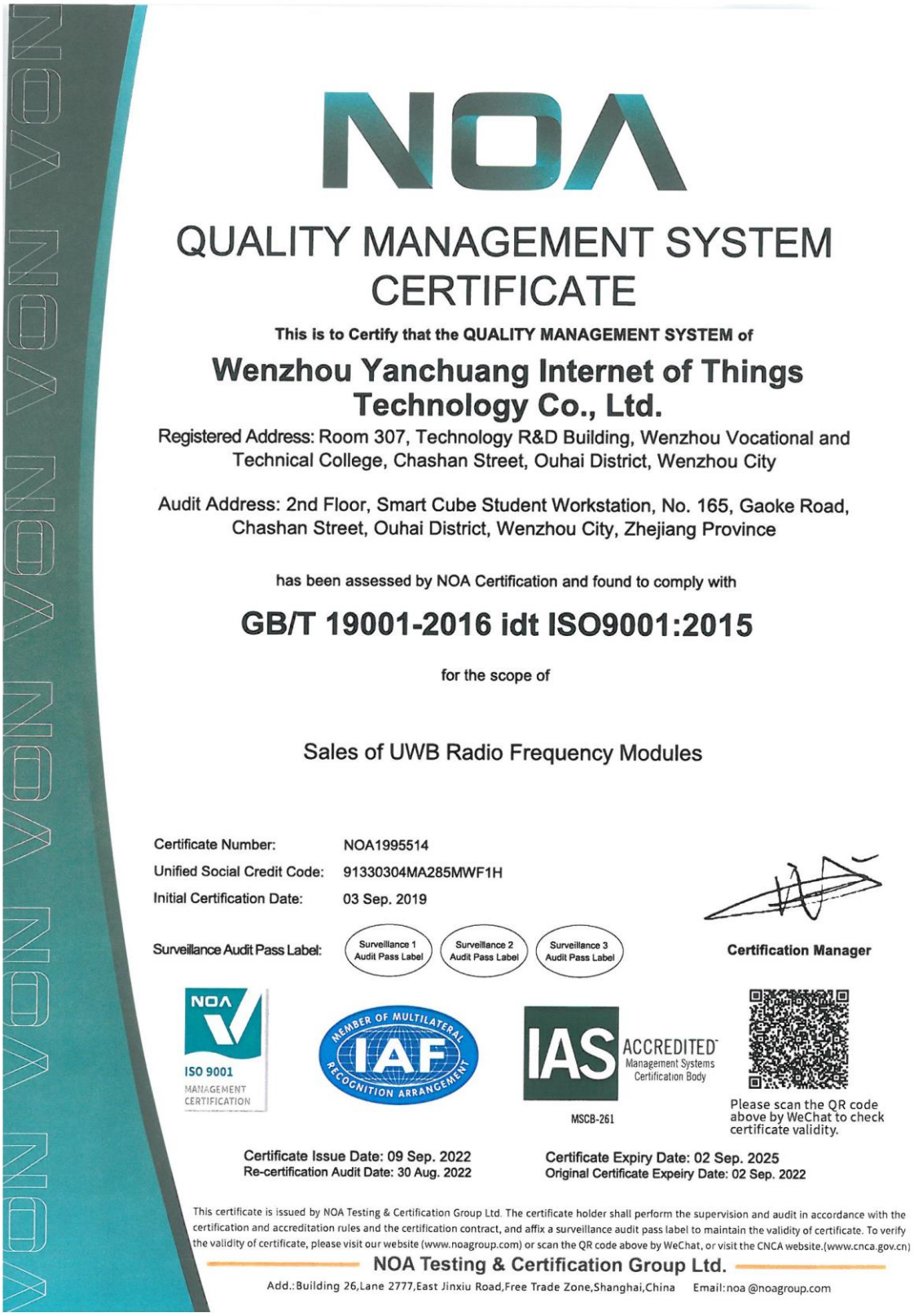
Eurones (Dongguan) Consumer Products Testing Service Co., Ltd. t (86-769) 38937858 f (86-769) 38937859 Http://www.cpstlab.com
3/F., Huafeng Building, No.77, Hetian Avenue, Houjie, Dongguan, Guangdong, China. Postcode: 523945 E-mail: service@cpstlab.com

### *9.2 ISO9001 Certification documents*



NOA

# QUALITY MANAGEMENT SYSTEM CERTIFICATE

This is to Certify that the QUALITY MANAGEMENT SYSTEM of

**Wenzhou Yanchuang Internet of Things Technology Co., Ltd.**

Registered Address: Room 307, Technology R&D Building, Wenzhou Vocational and Technical College, Chashan Street, Ouhai District, Wenzhou City

Audit Address: 2nd Floor, Smart Cube Student Workstation, No. 165, Gaoke Road, Chashan Street, Ouhai District, Wenzhou City, Zhejiang Province

has been assessed by NOA Certification and found to comply with

**GB/T 19001-2016 idt ISO9001:2015**

for the scope of

Sales of UWB Radio Frequency Modules

Certificate Number: NOA1995514

Unified Social Credit Code: 91330304MA285MWF1H

Initial Certification Date: 03 Sep. 2019

Surveillance Audit Pass Label: Surveillance 1 Audit Pass Label | Surveillance 2 Audit Pass Label | Surveillance 3 Audit Pass Label

Certification Manager

ISO 9001 MANAGEMENT CERTIFICATION

MEMBER OF MULTILATERAL RECOGNITION ARRANGEMENT IAF

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Re-certification Audit Date: 30 Aug. 2022

Certificate Expiry Date: 02 Sep. 2025
Original Certificate Expeiry Date: 02 Sep. 2022

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**NOA Testing & Certification Group Ltd.**

Add.:Building 26,Lane 2777,East Jinxiu Road,Free Trade Zone,Shanghai,China Email:noa @noagroup.com

# 10 Documentation

| Topic | MAX2001 DATASHEET |
|---|---|
| Version | MAX2001-datasheet-v1.9 |
| Created Time | 2020/11/20 |
| Reference | [1] 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 (LRWPANs). IEEE Computer Society Sponsored by the LAN/MAN Standards Committee. Available from http://standards.ieee.org/<br>[2] Decawave DW1000 Datasheet www.decawave.com<br>[3] Decawave DW1000 User Manual www.decawave.com<br>[4] Partron(Now manufactured by Abracon) Dielectric Chip Antenna, P/N ACS5200HFAUWB(Now ACA-107-T), www.digikey.com also see www.abracon.com |
| Last Updated | 2023/01/01 |

| Change person | Date | Document change record |
|---|---|---|
| Vanky Wang | 2020-11-20 | *V1.0 Release* |
| Lynn | 2022-02-08 | ***V1.7***<br>Update module reflow temperature curve<br>Update ISO9001 certification documents |
| Lynn | 2022-05-01 | ***V1.8***<br>Add the description and specification of MAX2001C Module<br>Update ISO9001 certification documents |
| Lynn | 2023-01-01 | ***V1.9***<br>Update ISO9001 certification documents<br>Update the diagrams in chapter 6.2 |