Preliminary Data Sheet

QPK3000

Fully Integrated UWB RTLS Module

The QPK3000 is a hardware module that enables the addition of UWB RTLS Tag functionality to a wide range of products through a simple integration process with guaranteed interoperability.

The module is capable of transmitting and receiving UWB and Bluetooth® Low Energy and/or IEEE 802.15.4™-2020 at 2.4 GHz using two state-of-the-art integrated antennas.

Applications

- **High-precision Real-Time Location Systems (RTLS) and asset tracking**, implemented using Uplink TDoA techniques or Two-Way Ranging UWB.
- **Last-meter positioning, "Nearby Interaction" and "Find My Asset" use cases**, enabled by FiRa™ Two-Way Ranging UWB combined with Bluetooth Low Energy communication.
- **Location-aware wireless sensor networks**, leveraging UWB for both communication and ranging.
- **Applications based on the omlox™ standard** for interoperable industrial positioning using UWB and IEEE 802.15.4 radio.

QPK3000
Fully Integrated UWB RTLS Module

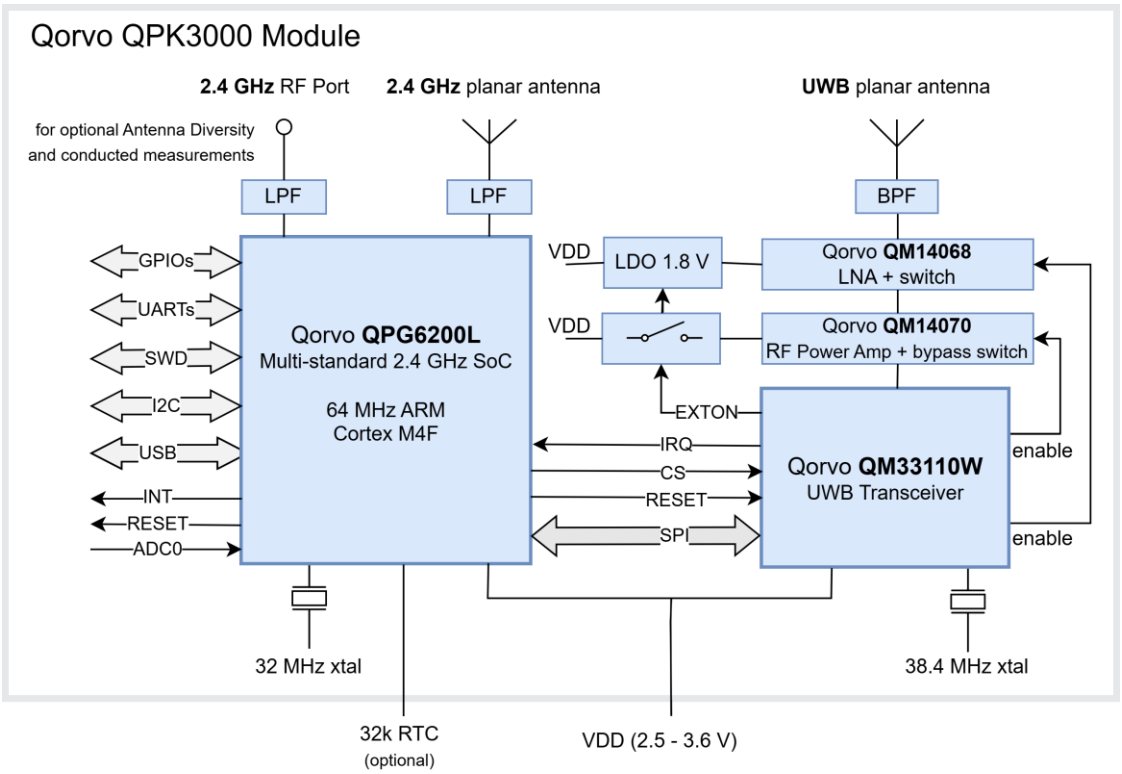
1 Product Overview

- Enable existing products, or new products, to add UWB RTLS functionality.
- Supports interoperability and compatibility with major Enterprise Access Points supporting UWB natively and enabling best-in-class ultra precise location.
- Supports building custom or proprietary RTLS solutions based on Zephyr OS.
- Fully optimized, tested, validated and calibrated RF design resulting in best-in-class wireless range.
- Low power consumption allows powering from batteries for multiple years.
- Suitable for UWB two-way ranging and TDoA applications.
- Designed to be compliant with FiRa PHY and MAC specifications enabling interoperability with other FiRa compliant devices.
- Designed to be compliant with the omlox Air- 8 World-Wide specification, enabling interoperability with other omlox compliant devices.
- FCC (USA), ISED (Canada) and ETSI (EU) radio certified (filing pending).

2 Key Features

- IEEE 802.15.4z UWB BPRF compliant.
- Fully aligned with FiRa and omlox PHY requirements, enabling FiRa or omlox MAC or proprietary stack protocols development.
- UWB channels 5 (6.5 GHz) and 9 (8 GHz).
- Narrow-Band Multi-standard 2.4 GHz support both Bluetooth LE and IEEE 802.15.4.
- Best-in-class RF link budget and RX sensitivity.
- Extended RF link budget, with +10 dB additional Tx power option for EU indoors operation per CEPT ECC/DEC/(06)04 amendment with integrated RF Power amplifier.
- Efficient planar antennas for Bluetooth LE / IEEE 802.15.4 and UWB operations.
- Optional pin for additional 2.4 GHz antenna to enable antenna diversity, effectively increasing RX sensitivity by 8–12 dB.
- SESIP Level 2 (Cybersecurity) compliant.
- Dimensions: 20 mm x 20 mm x 3.2 mm.
- Supply voltage: 2.5 V to 3.6 V.
- Temperature range: -40°C to +85°C.
- 37 pins, 1.5 mm pitch side castellation.

3 Functional Block Diagram



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4 Description

The QPK3000 module is a fully integrated low-power IR-UWB Module, compliant with IEEE 802.15.4-2015 (PHY and MAC layers) and IEEE 802.15.4z-2020. The module is 20 x 20 mm size with castellation pitch of 1.5 mm.

It integrates

- Qorvo QPG6200L multi-standard 2.4 GHz SoC with 64 MHz ARM Cortex M4F processor
- Qorvo QM33110W UWB Transceiver
- Qorvo QM14070 RF power amplifier with bypass switch
- Qorvo QM14068 LNA + switch
- Antenna's: 1x 2.4 GHz planar antenna, 1x UWB planar antenna, optional second 2.4 GHz antenna via RF port enabling leveraging unique antenna diversity feature of QPG6200L SoC
- RF Band Pass filters, 32 MHz and 38.4 MHz crystals, load switch, LDO and level shifters.

The main components are detailed in the sections below.

4.1 The QPG6200L

The QPG6200L is a multi-standard SoC with integrated **2.4 GHz transceiver.** Its Core MCU hosts application firmware to control external and internal peripherals such as the QM33110W UWB Transceiver, connected through an internal SPI interface.

The MCU clock speed can be configured for 32, 64, 96 or 192 MHz.

The Core MCU can be programmed externally through SWD.

The QPG6200L contains

- 2048 kB Non-Volatile Memory (RRAM) (of which 8 kB is One-Time Programmable)
- 336 kB Low Leakage Retention RAM.

RRAM can be used to store data such as antenna calibration data, Tx power level and crystal initial frequency error adjustment. These adjustment values can be automatically retrieved when needed.

The QPG6200L also exposes a variety of multifunction I/O's, including USB, UART, I^2C and interrupt line to connect an external sensor, e.g., accelerometer, as well as an option to connect a 32 kHz low power clock.

Also contained is an Integrated Secure Element Subsystem featuring: Secure **Boot** (rooted in ROM with Boot Keys in OTP), Secure **Storage** (PUF-based), Secure **Provisioning**, Secure **Debugging** and Secure **Device Attestation**. The QPG6200L is PSA/SESIP Level 2 compliant.

4.2 The QM33110W

The QM33110W IC is a fully integrated low-power, single chip CMOS RF **6.5 GHz-8 GHz** IR-**UWB transceiver** device compliant with the IEEE 802.15.4-2015 and IEEE 802.15.4z–2020 standard. (Note that the z version is downwards compatible for UWB enhancements.) The device can be used in TWR or TDoA systems to locate assets. They also provide precision location and data transfer simultaneously.

QM33110W consists of an analog front-end containing a receiver and a transmitter and a digital backend that interfaces to the QPG6200L host processor. Temperature and voltage monitors are provided on-chip.

The QM33110W has an on-chip One-Time Programmable (OTP) memory. This memory can be used to store calibration data such as TX power level and crystal initial frequency error adjustment. These adjustment values can be automatically retrieved when needed.

The device supports

- channels 5 (6489.6 MHz) and channel 9 (7987.2 MHz)
- data rates of 850 kbps, 6.8 Mbps
- 2-way ranging and TDoA location schemes
- enhanced Time-of-Flight security modes
- packet length from zero to 1023 bytes
- custom modes to support ultra-short frame lengths.

5 Pin Configuration and Assignments

The QPK3000 is supplied in a 37-pin side castellated package.
The pin configuration and pin assignments are given in the figure and table below.

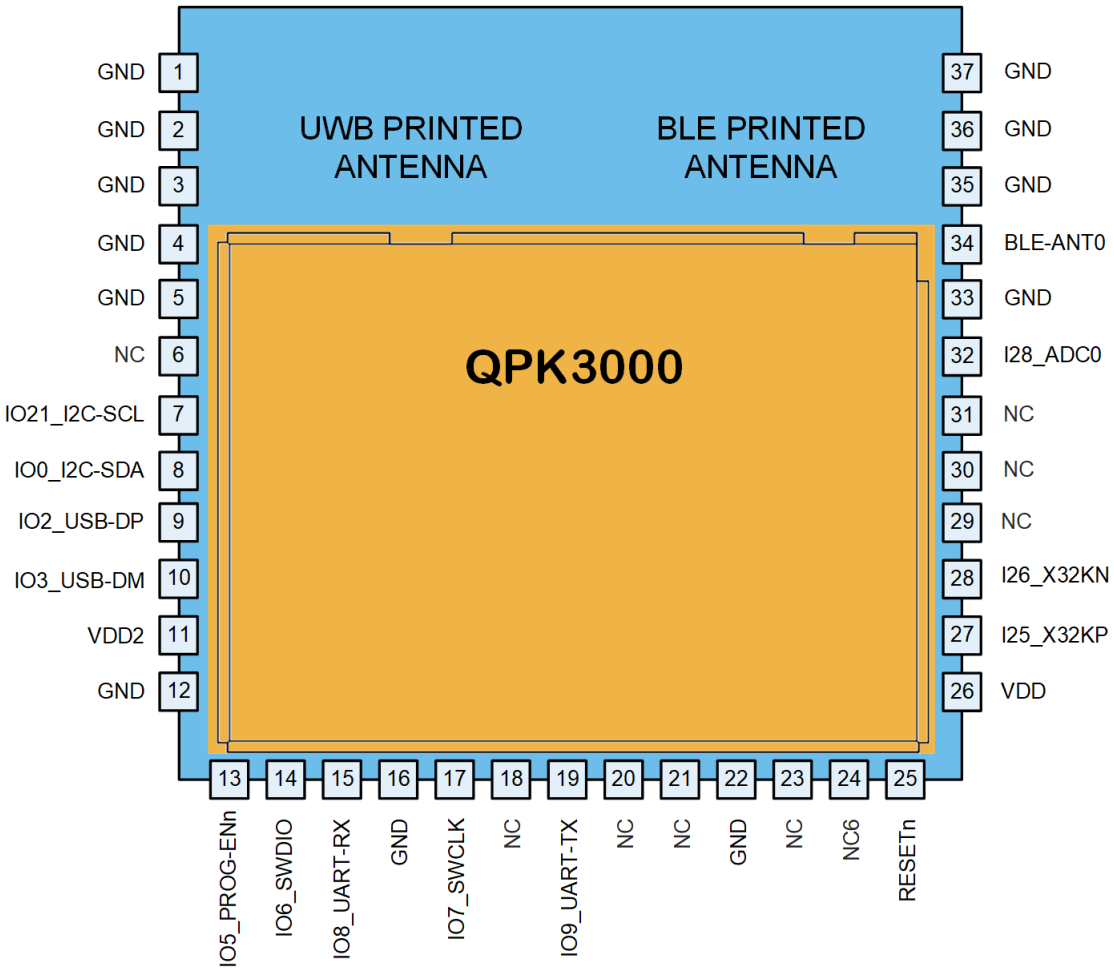


Figure 1: Pin Configuration – Top View

5.1 Pin Assignments

Table 1: Pin Functions – GPIO

(G=Ground, D=Digital, A=Analog, P=Power, I=Input, O=Output)

Pin Nr	Pin Name	I/O (default)	Description
1	GND	G	common ground
2	GND	G	common ground
3	GND	G	common ground
4	GND	G	common ground
5	GND	G	common ground
6	NC	-	not connected
7	IO21_I2C-SCL	DIO	general purpose I/O, also serves as I^2C clock signal
8	IO0_I2C-SDA	DIO	general purpose I/O, also serves as I^2C data signal
9	IO2_USB-DP	DIO	general purpose I/O, also serves as USB differential data D+ (plus)
10	IO3_USB-DM	DIO	general purpose I/O, also serves as USB differential data D- (minus)
11	VDD2	P	power supply
12	GND	G	common ground
13	IO5_PROG-ENn	DIO	general purpose I/O, also serves as programming mode at startup/reset (Low)
14	IO6_SWDIO	DIO	general purpose I/O, also serves as serial wire debug I/O for debug and programming
15	IO8_UART-RX	DIO	general purpose I/O, also serves as UART RX
16	GND	G	common ground
17	IO7_SWCLK	DIO	general purpose I/O, serial wire debug clock input for debug and programming
18	NC	-	not connected
19	IO9_UART-TX	DIO	general purpose I/O, also serves as UART TX
20	NC	-	not connected
21	NC	-	not connected
22	GND	G	common ground
23	NC	-	not connected
24	NC	-	not connected
25	RESETn	DI	general purpose I/O, active-low reset input
26	VDD	P	power supply
27	X32KP_GPI25	A/DI	general purpose I/O, optional 32 KiHz reference xtal input
28	X32KN_GPI26	A/DI	general purpose I/O, optional 32 KiHz reference xtal input
29	NC	-	not connected
30	NC	-	not connected
31	NC	-	not connected
32	I28_ADC0	AI	ADC input
33	GND	G	common ground
34	BLE-ANT0	RF	external BLE / 2.4 GHz antenna
35	GND	G	common ground
36	GND	G	common ground
37	GND	G	common ground

5.2 GPIO Mapping Table

The QPK3000 features programmable GPIO lines that can be mapped individually to functional signals, as specified in the table below.

Note 1: Wakeup is available for all pins.

Note 2: All pins support Pull-Up and Pull-Down except pins 27 and 28.

Table 2: GPIO Mapping Table

Pin Nr	Pin Name	Analog	QPG6200L GPIO Name	Prog	CSSYS	CSSYS	UART_0/1	SPI_M	I²C_M_0/1	USB	LED	PWMXL
9	IO2_USB-DP	-	GPIO2	-	SWCLK_TCK	TRACE_DATA_1	TX / RX	SSN	SDA / -	DP	LED_2	PWMXL_2
10	IO3_USB-DM	-	GPIO3	-	TDI	TRACE_DATA_2	RX / TX	SCLK	SCL / -	DM	LED_3	PWMXL_3
13	IO5_PROG-ENn	-	GPIO5	ENN	-	TRACE_CLK	-	MISO	- / -	-	-	PWMXL_7
14	IO6_SWDIO	-	GPIO6	SSN	SWDIO_TMS	-	-	SSN	- / -	-	-	PWMXL_0
17	IO7_SWCLK	-	GPIO7	SCLK	SWCLK_TCK	-	-	SCLK	- / -	-	-	PWMXL_1
15	IO8_UART-RX	-	GPIO8	MOSI	TDI	-	TX / RX	MOSI	- / -	-	-	PWMXL_2
19	IO9_UART-TX	-	GPIO9	MISO	SWV_TDO	-	RX / TX	MISO	- / -	-	LED_3	PWMXL_3
27	X32KP_GPI25	-	GPI25	-	-	-	RX / -	MISO	- / -	-	-	-
28	X32KN_GPI26	-	GPI26	`	-	-	- / -	-	- / -	-	-	-
32	ANIO0_GPI28	ANIO0	GPI28	-	-	-	-	-	- / -	-	-	-
7	IO21_I2C-SCL	MICBIAS	GPIO21	-	-	TRACE_DATA_0	RX / TX	SCLK	SCL / -	-	LED_3	PWMXL_7
8	IO0_I2C-SDA	IRLED	GPIO0	-	-	TRACE_CLK	TX / RX	MOSI	SDA / -	-	LED_0	PWMXL_0

6 Characteristics and Ratings

6.1 Absolute Maximum Ratings

Table 3: Absolute Maximum Ratings

Parameter	Min.	Max.	Units	Note
Supply voltage VDD and VDD2	2.5	3.6	V	
Max. input power on pin for ext. RF port (BLE / 2.4 GHz)	-	10	dBm	
Max. input voltage on pin for ext. RF port (BLE / 2.4 GHz)	-	1.8	V	ESD clamp diodes may limit applied voltage
Storage temperature	-40	+125	˚C	
Operating temperature	-40	+85		
MSL (Moisture Sensitivity Level)	3	3	level	
Tsol (Reflow soldering temperature)		+250	˚C	see also: Figure 2
ESD HBM (Human Body Model) IEC 61000-4-2	all pins: 2000 V			
ESD CDM (Charged Device Model) ANSI/ESDA/JEDEC JS-002 2025	all pins: 1000 V (class C3)			

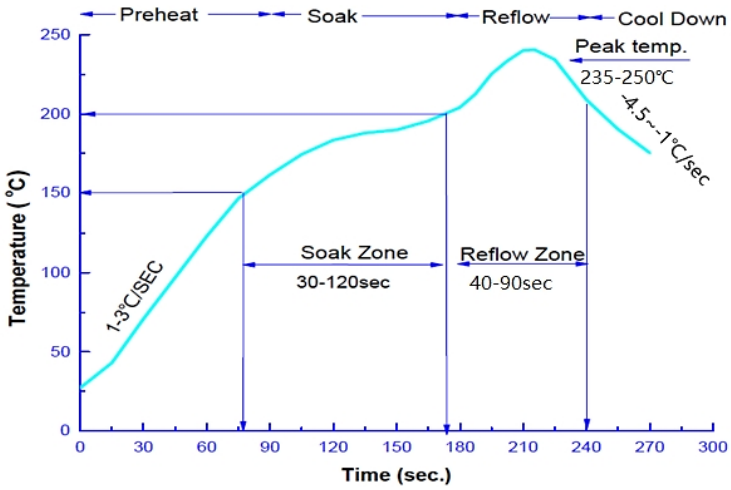


Figure 2: Module Solder Profile

6.2 Nominal Operating Conditions

Table 4: Nominal Operating Conditions

Parameter	Min.	Typ.	Max.	Units
Operating temperature	-40	-	+85	˚C
Supply voltage VDD and VDD2	2.5	3	3.6	V

Note 1: Operation is guaranteed by design when operating within these ranges.

Note 2: Sufficient headroom for any power supply voltage ripple should be considered in system designs.

6.3 DC Characteristics – Current Consumption

Conditions: T_{amb} = 25 ˚C, MCU clock speed is 96 MHz, DCDC ON.

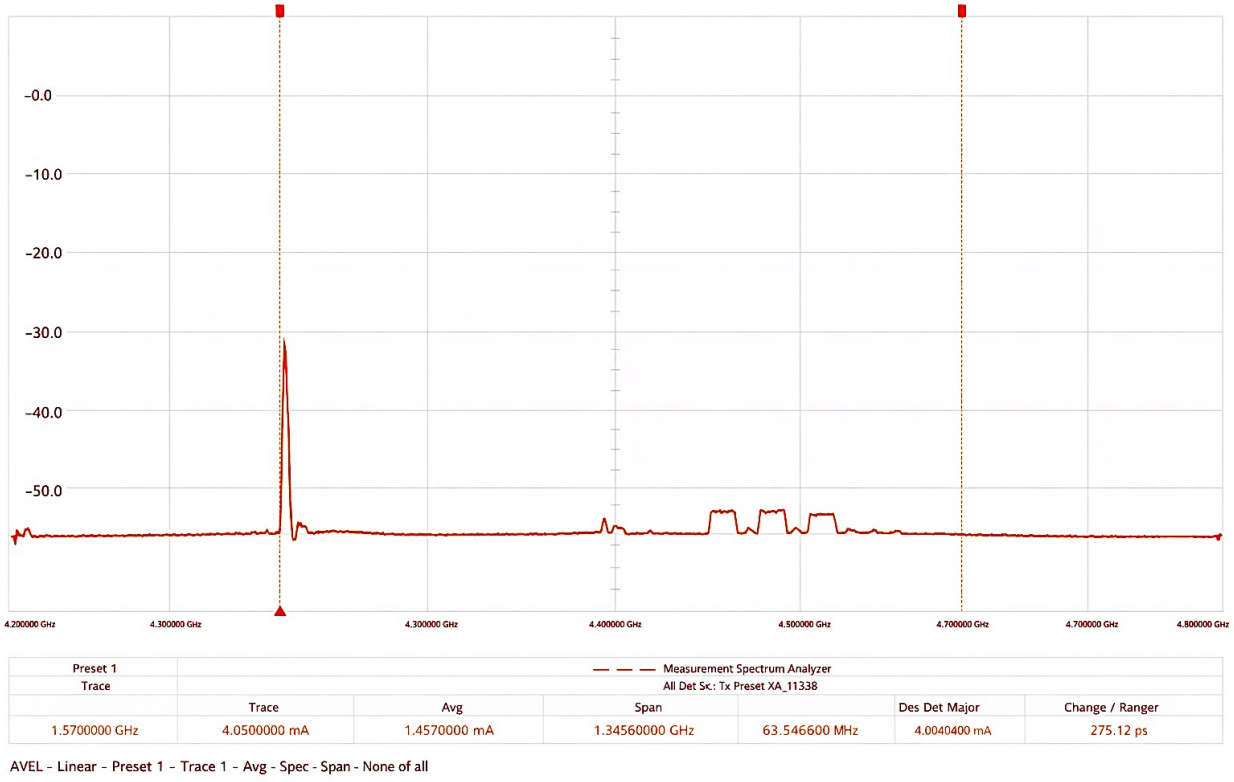
Table 5: DC Characteristics - Current Consumption

Parameter	Min.	Typ.	Max.	Units	Condition / Note
Supply current in sleep state		5.1		µA	QPG6200 in sleep system state, full RAM retained, QM33110W sleep
Supply current while transmitting UWB frame with PA bypassed		43.3		mA	Channel 5, FiRa BPRF Set #3, 24 Bytes, continuous frame transmission at typ. output power
Supply current while transmitting UWB frame with PA bypassed		57.5		mA	Channel 9, FiRa BPRF Set #3, 24 Bytes, continuous frame transmission at typ. output power
Supply current while transmitting UWB frame with PA enabled		166.6		mA	Channel 5, FiRa BPRF Set #3, 24 Bytes, continuous frame transmission at typ. output power
Supply current while transmitting UWB frame with PA enabled		182.1		mA	Channel 9, FiRa BPRF Set #3, 24 Bytes, continuous frame transmission at typ. output power
Supply current while transmitting BLE ADV frame		8.7		mA	TX power = 4 dBm
Supply current while transmitting BLE ADV frame		20		mA	TX power = 10 dBm
Supply current while receiving UWB frame, LNA: enabled		65		mA	Channel 5
Supply current while receiving UWB frame, LNA: enabled		80		mA	Channel 9
Digital Output Drive Current SPIMISO	8	10		mA	
Digital Output Drive Current EXTON	3	4		mA	

Current consumption profiles (current vs time) for both Bluetooth LE and UWB are depicted on the next pages for various operating scenarios. All plots except the BLE connection event have a Y-axis of 50 mA per square, and the BLE connection event has 10 mA per square.

Note 1: For Bluetooth LE advertising and connection events the 1st current spike is due to charging the DCDC decoupling capacitor.

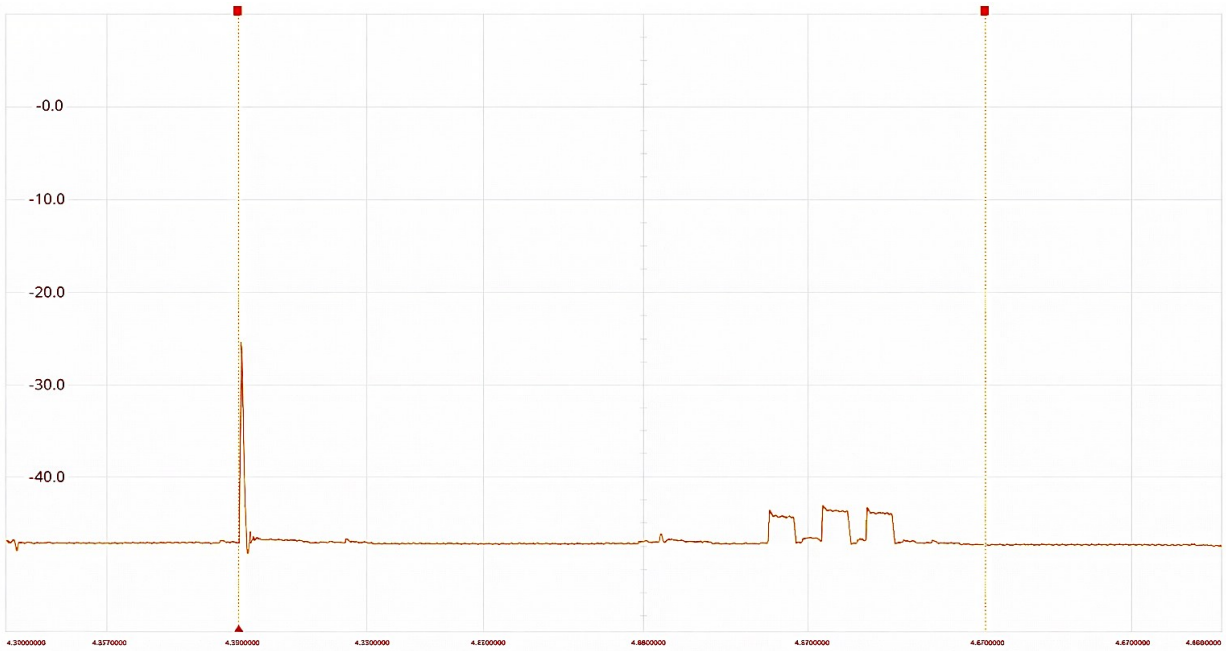
Note 2: For UWB Tx the 1st current spike is due to enabling the internal LDO.



Preset 1	Measurement Spectrum Analyzer					
Trace	All Det Sc.: Tx Preset XA_11338					
	Trace	Avg	Span		Des Det Major	Change / Ranger
1.5700000 GHz	4.0500000 mA	1.4570000 mA	1.34560000 GHz	63.546600 MHz	4.0040400 mA	275.12 ps

AVEL - Linear - Preset 1 - Trace 1 - Avg - Spec - Span - None of all

Figure 3: Typical Current Consumption Profile during BLE Advertising Events – Tx = 4 dBm



Preset 1	Measurement Spectrum				
Trace	All Det Sr. 1x: Preset /X. 11338				
	Trace	Avg	Span	Des Det Major	Change / Ranger
4.3570000 GHz	1.4377200 mA	1.5437200 mA	1.34560000 GHz	63.5466000 mA	275.12 ps

AVEL - Linear - Preset 1 - Trace 1 - Avg - Spec - Span - None of all

Figure 4: Typical Current Consumption Profile during BLE Advertising Events – Tx = 10 dBm

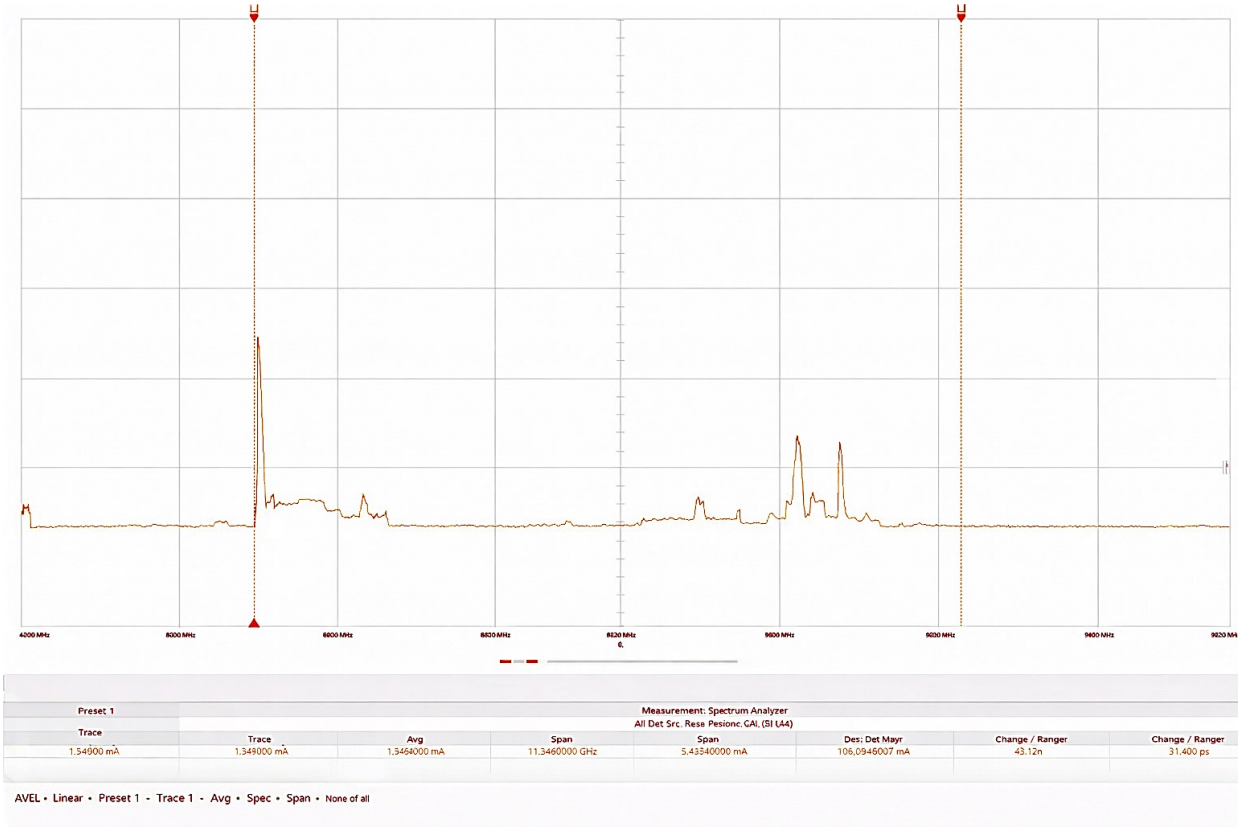


Figure 5: Typical Current Consumption Profile during Single BLE Connection Event - Tx = 4 dBm

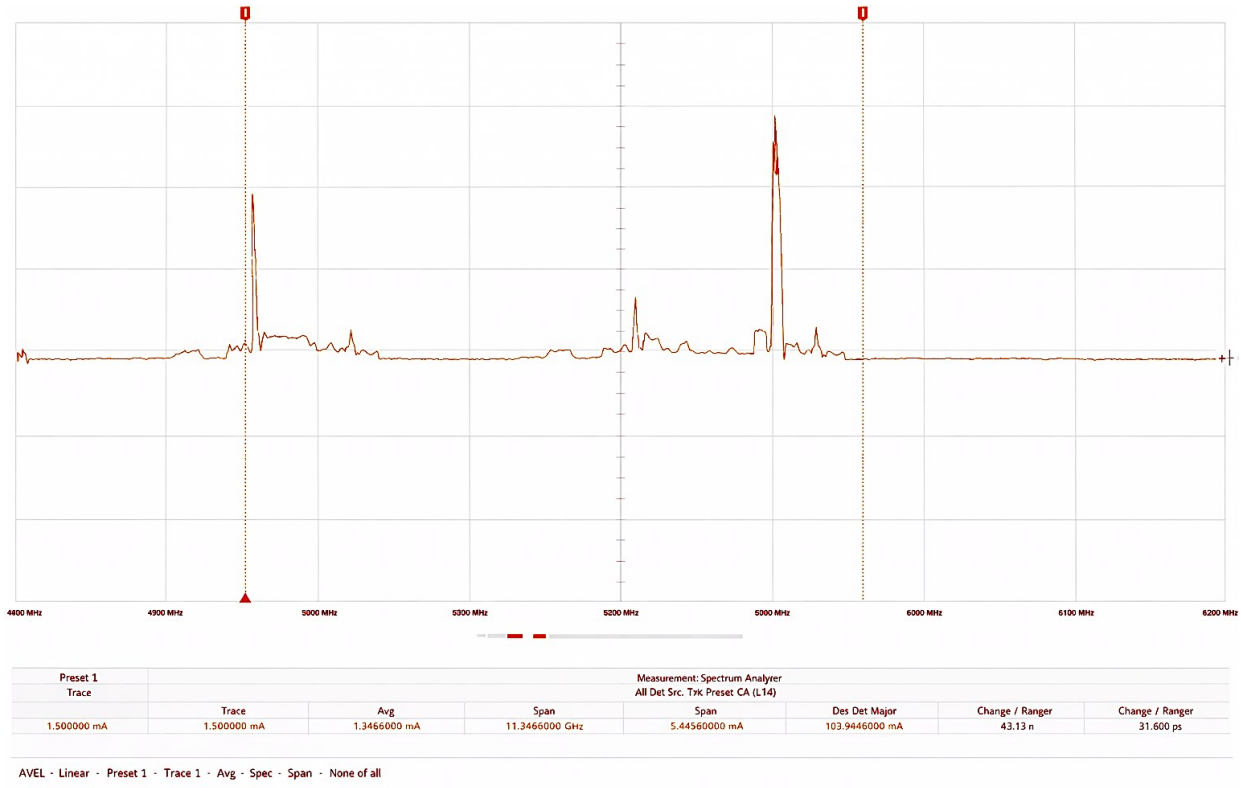


Figure 6: Typical Current Consumption Profile during Single BLE Connection Event - Tx = 10 dBm

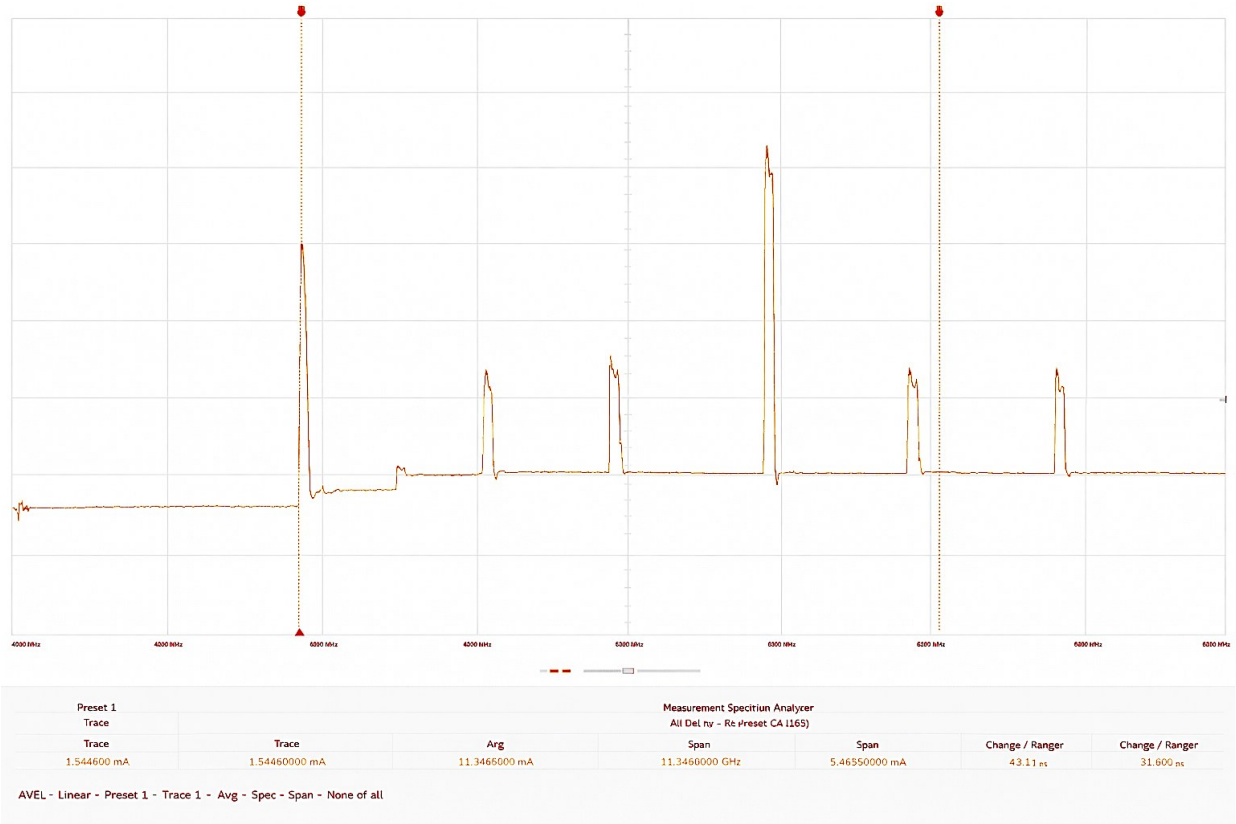


Figure 7: Typical Current Consumption Profile – FiRa DS-TWR – Ch 5 - PA enabled – LNA enabled

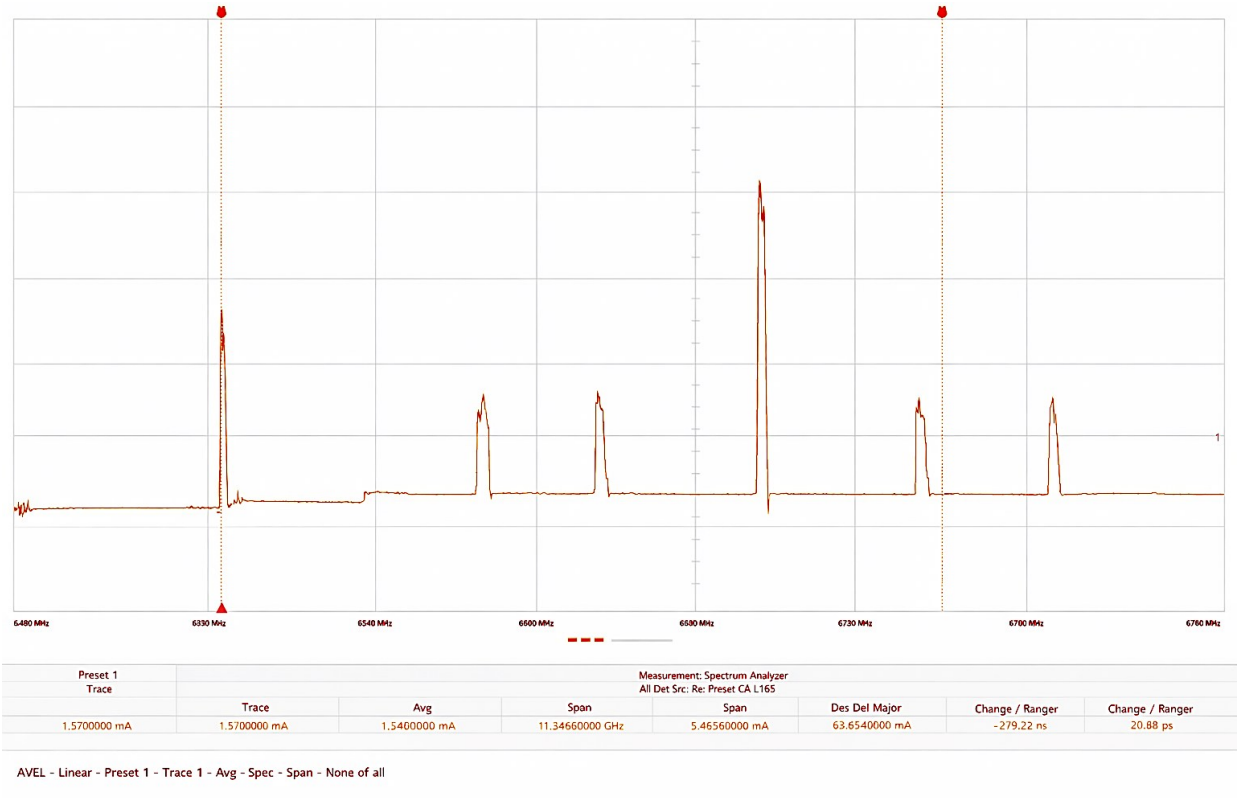


Figure 8: Typical Current Consumption Profile – FiRa DS-TWR – Ch 9 - PA enabled – LNA enabled

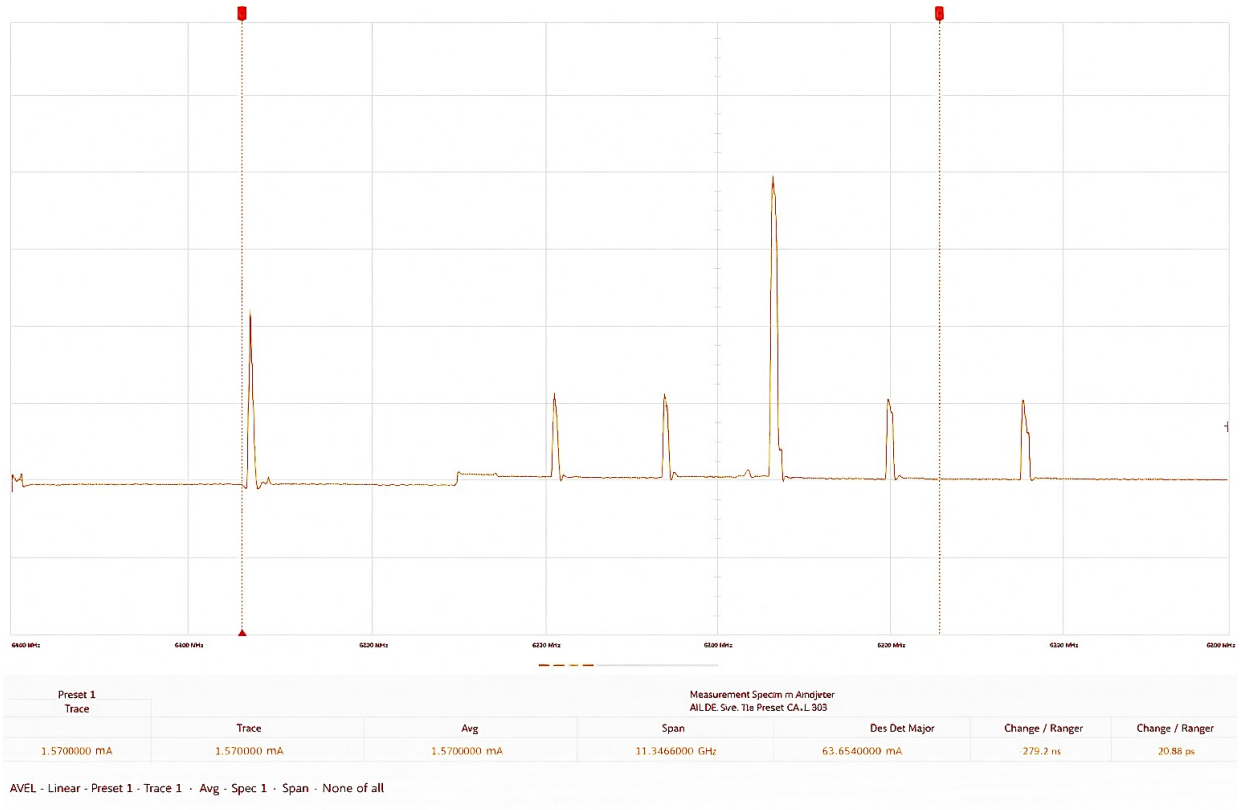


Figure 9: Typical Current Consumption Profile – FiRa DS-TWR – Ch 5 - PA bypassed – LNA enabled

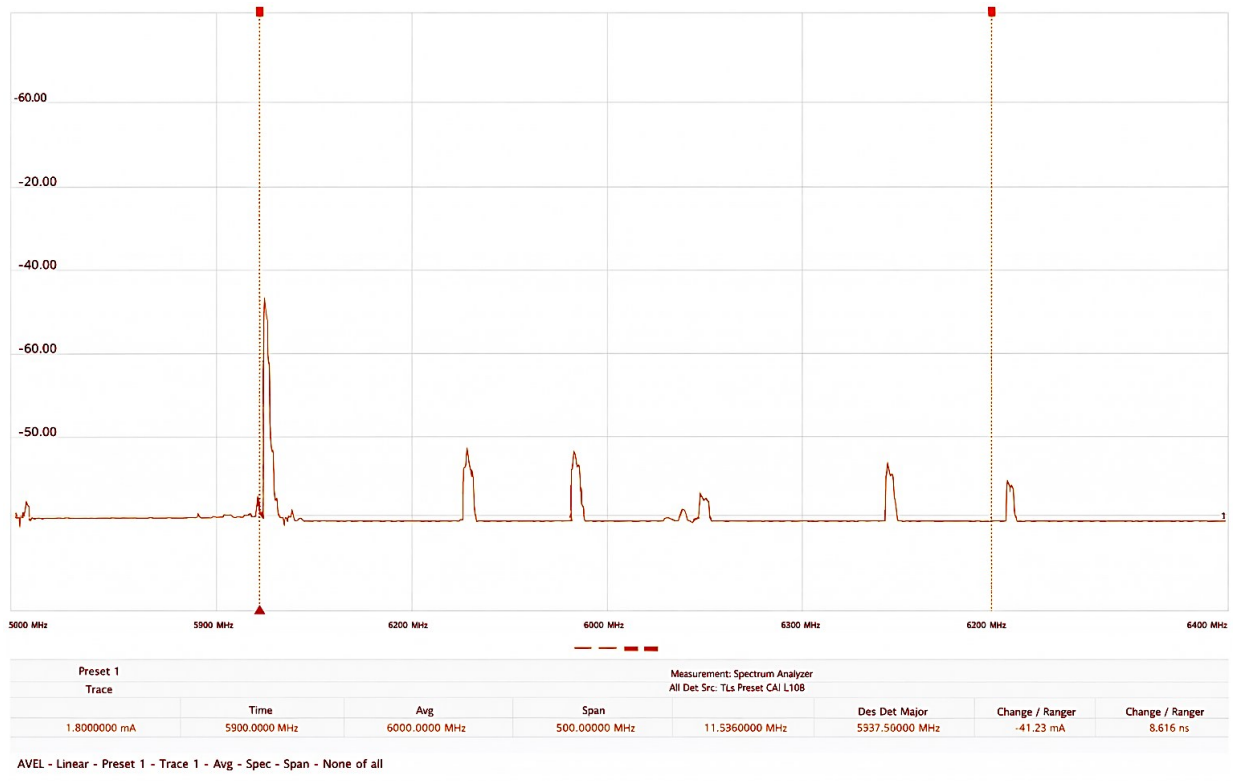


Figure 10: Typical Current Consumption Profile – FiRa DS-TWR – Ch 9 - PA bypassed – LNA enabled

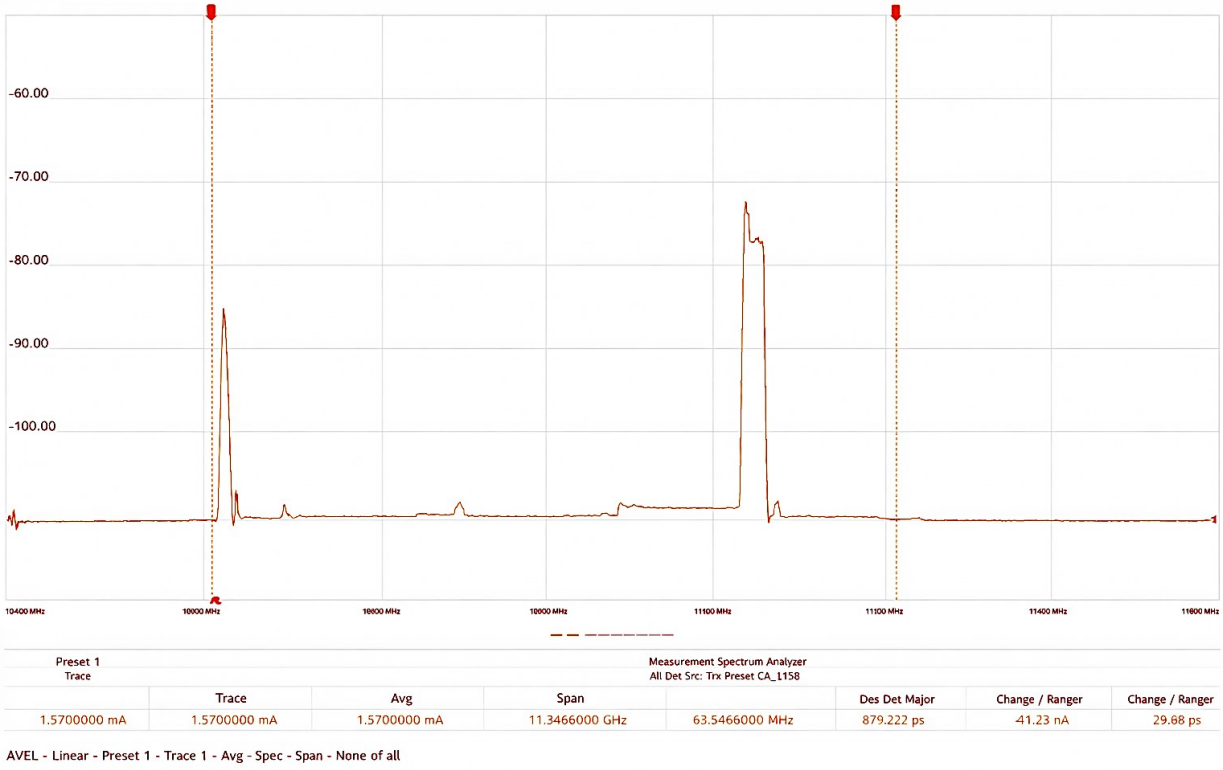


Figure 11: Typical Current Consumption Profile - UWB UL-TDOA – Ch 5 - PA enabled

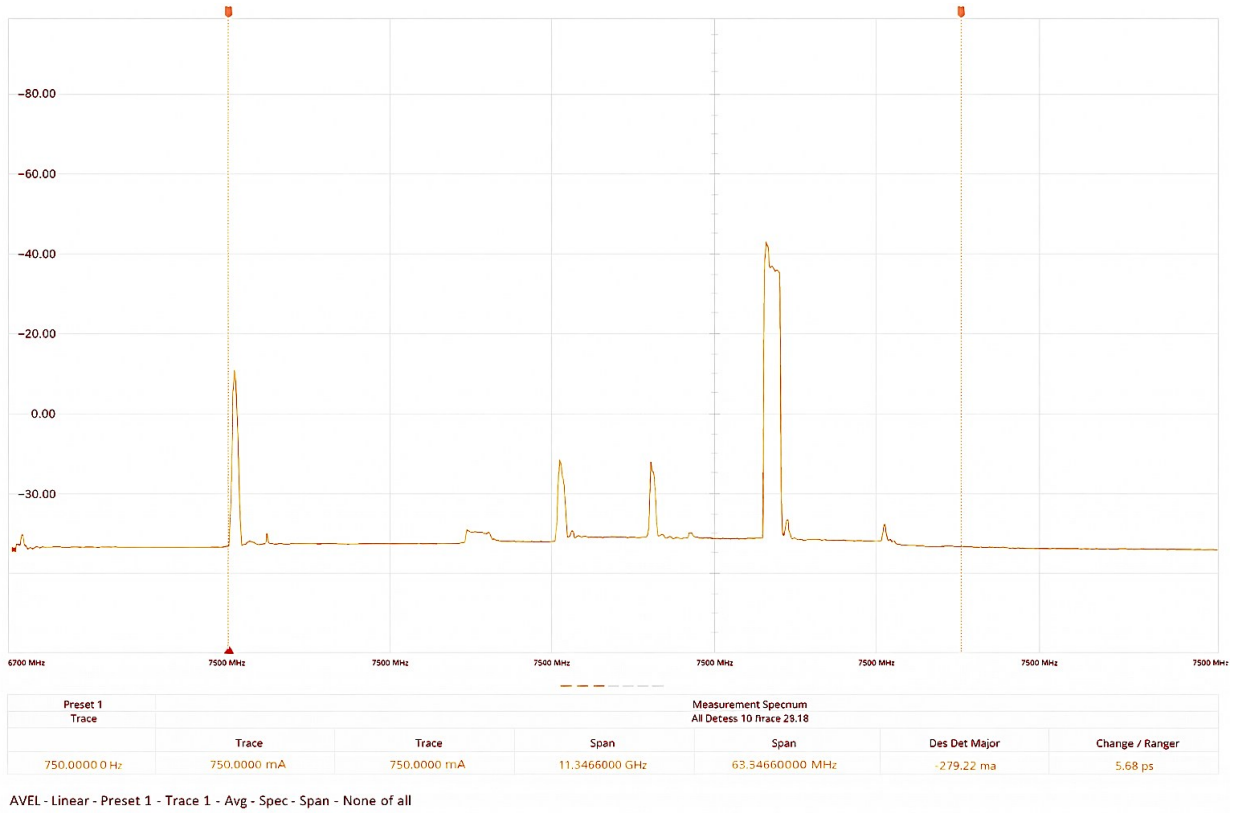


Figure 12: Typical Current Consumption Profile - UWB UL-TDOA – Ch 9 - PA enabled

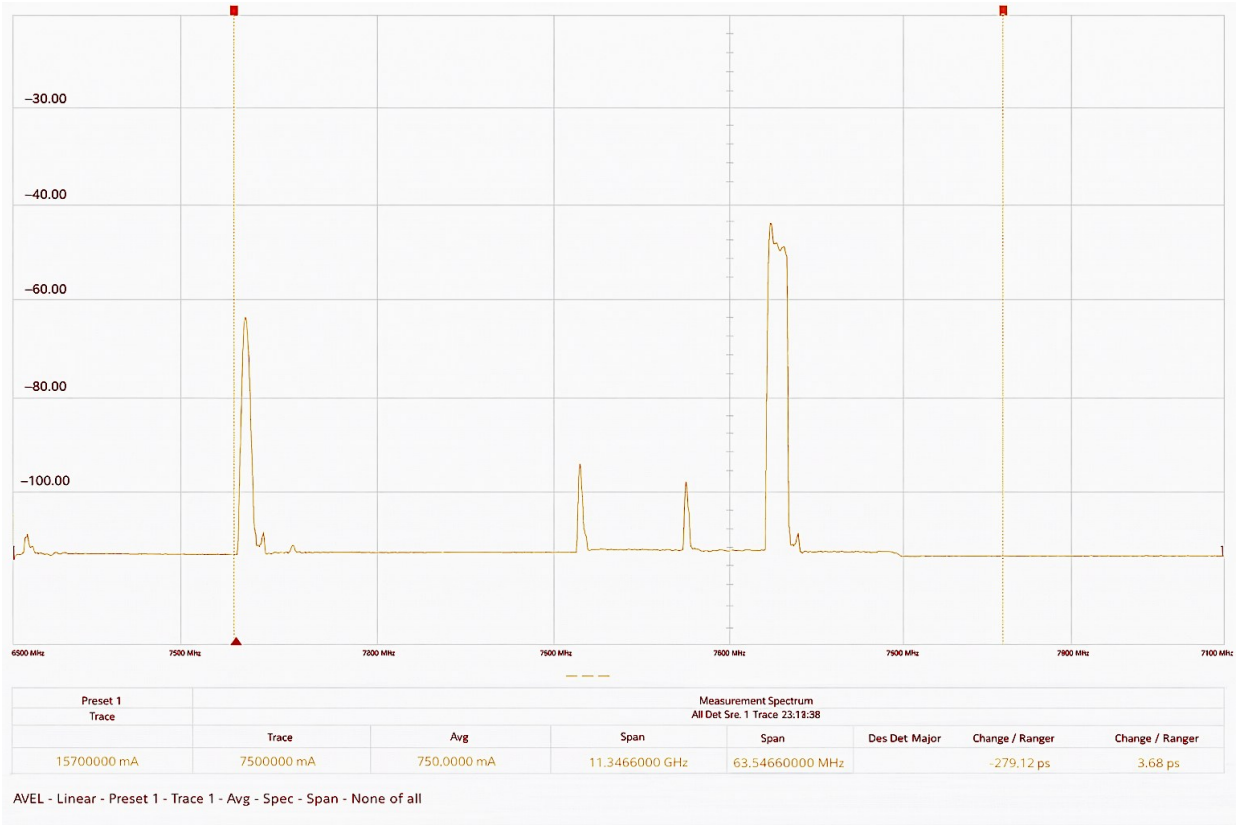


Figure 13: Typical Current Consumption Profile - UWB TX – Ch 5 - PA bypassed

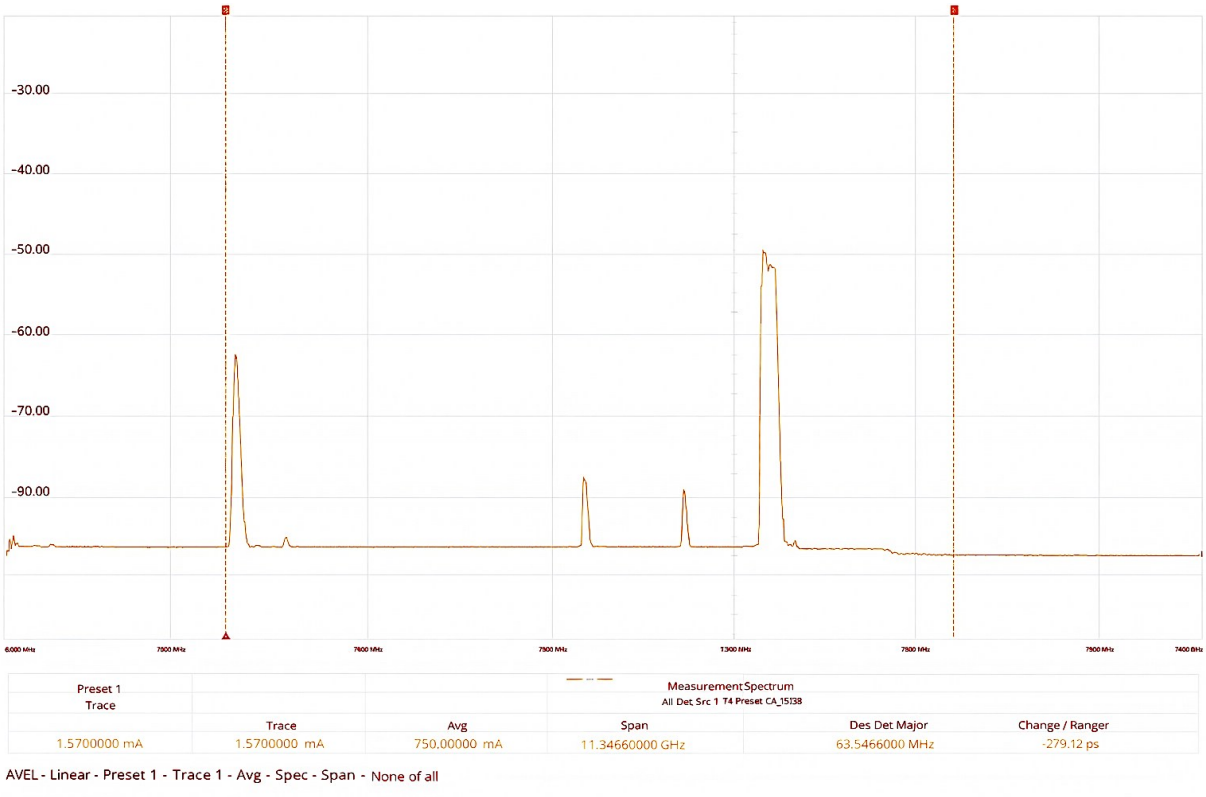


Figure 14: Typical Current Consumption Profile - UWB TX – Ch 9 – PA bypassed

6.4 UWB Characteristics

The UWB Characteristics are stated in the sections below.

For detailed information about the frame formats, PHY specifications and PHY frame-modes of IEEE 802.15.4-2015 and IEEE 802.15.4z-2020 please refer to [1] and [3] respectively.

6.4.1 Receiver Characteristics - UWB

Conditions: T_{amb} = 25 ˚C, VDD = VDD2 = 3 V unless stated otherwise.

6.4.1.1 Supported Channels and Bandwidths - UWB

The QPK3000 supports the following IEEE 802.15.4 UWB channels:

Table 6: Supported Channels and Bandwidth

UWB Channel Nr	Center Frequency [MHz]	Bandwidth [MHz]	Note
5	6489.6	499.2	
9	7987.2	499.2	programmable

6.4.2 Supported Bit Rates and Pulse Repetition Frequencies (PRF) - UWB

The QPK3000 supports the IEEE 802.15.4z-2020 UWB bit rates.
A full list is shown on the table below.

Table 7: Supported Bit Rates

Bit Rate	PRF [MHz]	Mode	Preamble Code	Remark
850 kbps	16	BPRF	9,10,11,12	all BPRF Preamble codes
850 kbps	64	BPRF	9,10,11,12	
6.8 Mbps	16	BPRF	9,10,11,12	K=3 Viterbi and RS for ECC
6.8 Mbps	64	BPRF	9,10,11,12	K=3 Viterbi and RS for ECC

Note 1: In general, lower data rates give; increased receiver sensitivity, increased link margin and longer range but due to longer frame lengths they result in increased air occupancy per frame and a reduction in the number of individual transmissions that can take place per unit time.

Note 2: A PRF of 16 MHz gives a marginal reduction in transmitter power consumption over 64 MHz PRF (BPRF).

6.4.2.1 Receiver Sensitivity Characteristics - UWB

Conditions: T_{amb} = 25 ˚C, VDD = VDD2 = 3.0 V. LNA ON. 20-byte payload. Carrier frequency offset = ±10 ppm. Reference Frequency = 38.4 MHz. Sensitivity is measured at the 1% Packet Error Rate (PER).

Table 8: Reference RF Sensitivity Level (BPRF) – Conductive Measurement

Channel	IEEE Subset / LNA State / RX Mode	Typical Receiver Sensitivity Level [dBm / 500 MHz]
CH5	Set#03 (FiRa TC) Single RX mode	-100.0
	Set#04 (FiRa TC) Single RX mode	-104.5
CH9	Set#03 (FiRa TC) Single RX mode	-100.0
	Set#04 (FiRa TC) Single RX mode	-104.5

For BPRF mode operating set #4; sensitivity is improved by 4.5 dB due to absence of PHY header and payload.

Rx Sensitivity variation over temperature: 0.025 dB/°C (LNA ON), 0.03 dB/°C (LNA bypassed).

6.4.3 Transmitter Characteristics - UWB

Conditions: T_{amb} = 25 ˚C, VDD = VDD1 = 3.0 V, Transmission period = 1 ms

Table 9: Transmitter AC Characteristics - UWB

Parameter	Condition / Note	Min.	Typ.	Max.	Units
Center Frequency	channel 5		6489.6		MHz
	channel 9		7987.2		MHz
Channel Bandwidth			499.2		MHz
Maximum Radiated Mean Power Spectral Density	channel 5, PA on for BPRF-3 (Fira TC)		-23.6		dBm / MHz
	channel 9, PA on for BPRF-3 (Fira TC)		-22.3		
Maximum Radiated Output Channel Power (payload length = 20 bytes)	channel 5, PA on for BPRF-3 (Fira TC)		1.5		dBm / 500 MHz
	channel 9, PA on for BPRF-3 (Fira TC)		2.6		
Power Level Range			45		dB
Output Power Variation with temperature			0	0.008	dB / °C
Output Power Variation with voltage	internally regulated		0		dB / V

6.4.4 UWB Transmit Power Adjustment - UWB

The QPK3000 has a coarse TX power adjustment and a fine TX power adjustment.
Please refer to the QM33110W Datasheet [5] for details.

6.4.5 Antenna Radiation Patterns

This section details UWB antenna radiation patterns for the QPK3000 with V and H plots representing perpendicular vertical and horizontal components.

The radiation patterns of the BLE antenna of the QPK3000 module are shown in Figure 18. During measurement the radio board with the module was mounted on a QPG6200L IoT carrier board with 138 mm x 68 mm size.

Table 10: Antenna Characteristics

Antenna Model	QPK3000 UWB Antenna	QPK3000 BLE Antenna
Antenna Type	PCB Trace Antenna	PCB Trace Antenna
Peak Gain (on 40 x 65mm radio board)	Ch5: 3.3 dBi Ch9: 3.3 dBi	2450 MHz: 0 dBi
Frequency Range	6000 – 9000 MHz	2400 – 2480 MHz

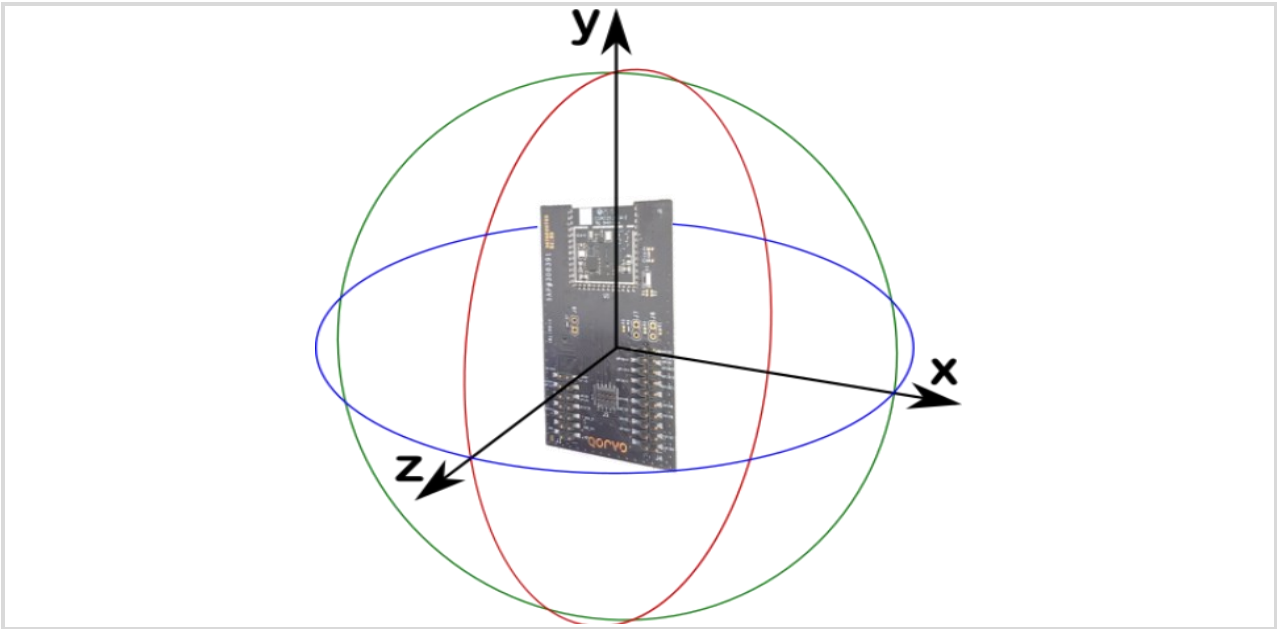


Figure 15: General Antenna Radiation Pattern Planes

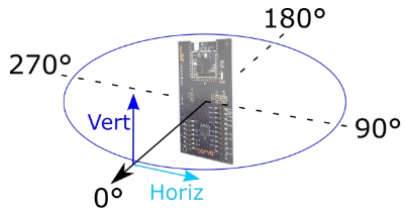
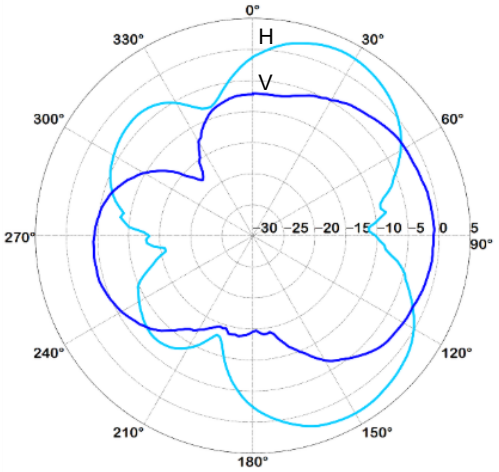
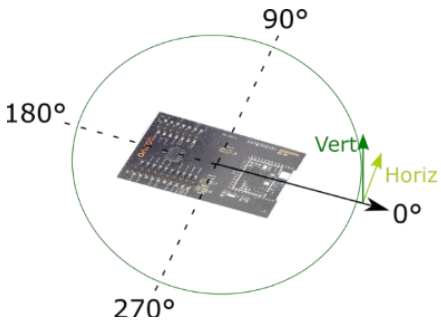
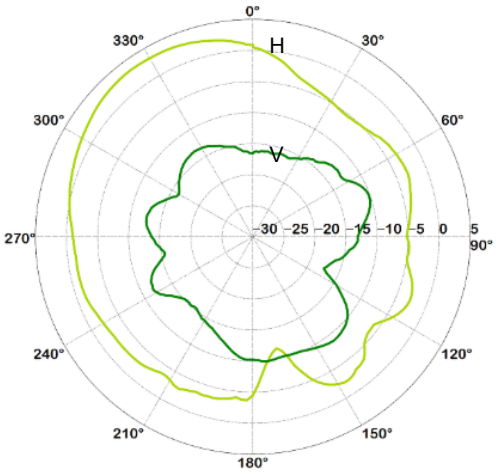
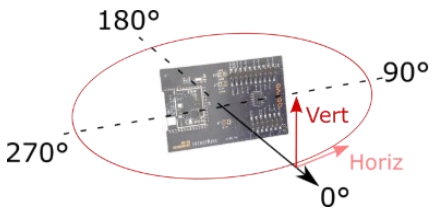
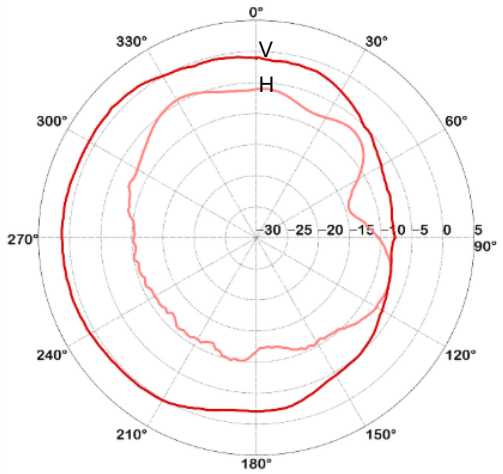
Radiation Planes - UWB Channel 5	Antenna Gain (dBi) vs. Angle (°)
XZ Plane 	
XY Plane 	
YZ Plane 	

Figure 16: UWB Channel 5 Radiation Patterns

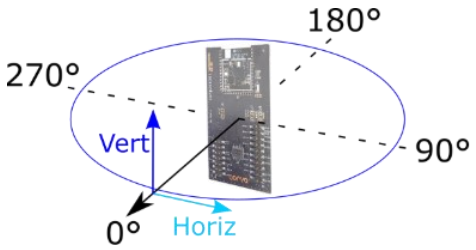
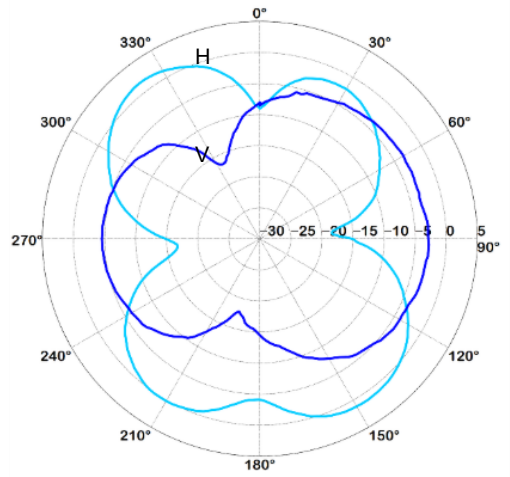
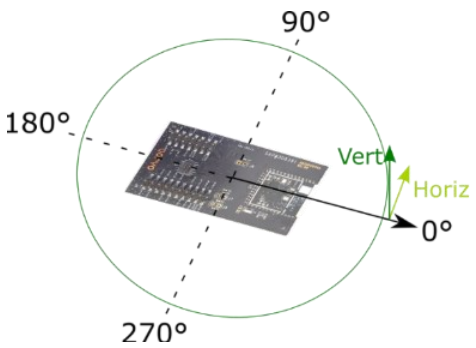
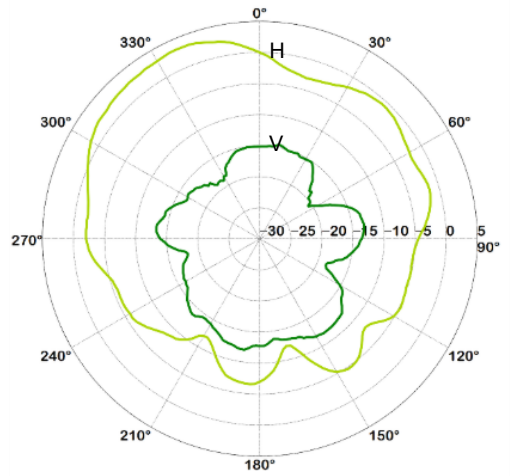
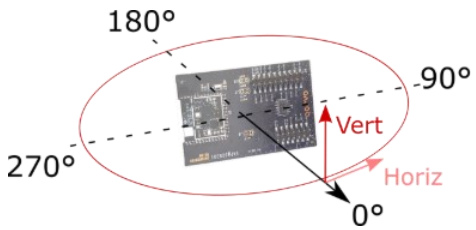
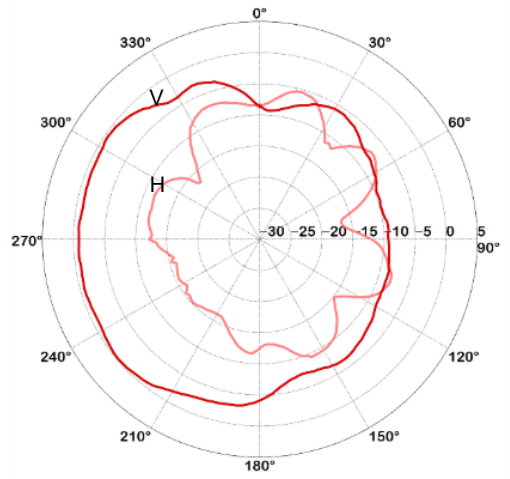
Radiation Planes - UWB Channel 9	Antenna Gain (dBi) vs. Angle (°)
XZ Plane 	
XY Plane 	
YZ Plane 	

Figure 17: UWB Channel 9 Radiation Patterns

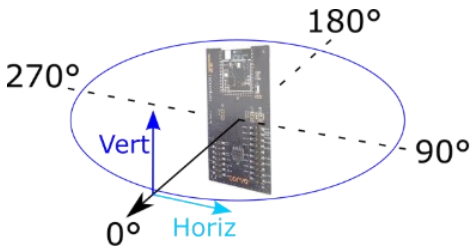
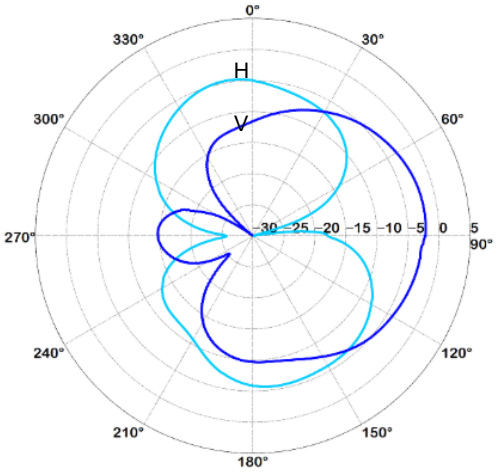
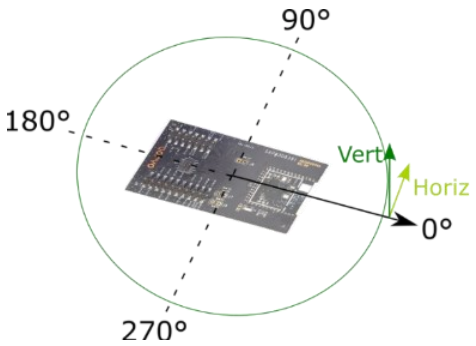
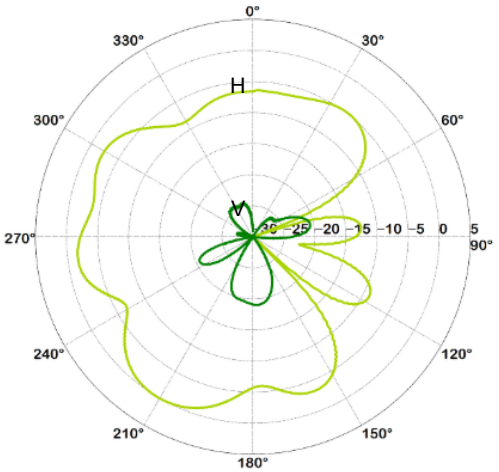
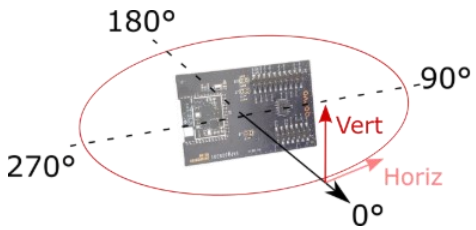
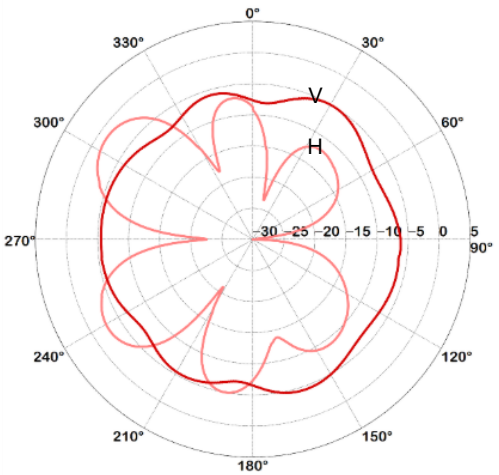
Radiation Planes - BLE 2450 MHz	Antenna Gain (dBi) vs. Angle (°)
XZ Plane 	
XY Plane 	
YZ Plane 	

Figure 18: BLE 2450 MHz Radiation Patterns

6.5 Bluetooth Low Energy / 2.4 GHz Characteristics

For the Bluetooth Low Energy / 2.4 GHz transmitter and receiver characteristics please refer to the QPG6200L Data Sheet [4]

6.6 ADC Characteristics

For the ADC Characteristics please refer to the QPG6200L Data Sheet [4].

6.7 Battery and Temperature Monitor Characteristics

Table 11: Battery Monitor Characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
	Battery level range		1.71		3.6	V
	Resolution of battery level measurement			10		mV
	Accuracy of battery level measurement	max over process, voltage and temperature		25	60	mV

Table 12: Temperature Monitor Characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
	Temperature measurement range (QPG6200L)		-40		+85	°C
	Resolution of temperature measurement			0.15		
	Accuracy of temperature measurement			3		
	Temperature measurement conversion time			128		µs

6.8 Calibration

Depending on the end-use applications and the system design, QPK3000 settings may need to be tuned. To help with this tuning, a number of built-in functions such as continuous wave TX and continuous frame transmission can be enabled.

An overview of factory calibrated items is shown in the table below.

Table 13: Calibrated Items

QPK3000 Calibration Item	Calibrated on QPK3000	Condition(s) and Remarks
Crystal	✓	The 38.4 MHz xtal for the QM33110W is calibrated at production. The 32 MHz xtal for the QPG6200L does not need production calibration.
Transmit Power	✓	Both LNA and PA bypassed. Using UWB standard pulse shape.
Antenna Delay	✓	LNA ON and PA bypassed.

7 Peripherals Description

The QPK3000 features a set of peripherals and allows configuration of the mapping between the IO signals needed by the peripherals and the available IO pins.

Please note that options to use certain peripherals will be mutually exclusive due to the confined amount of user-defined GPIO pins.

7.1 UART Interface

The QPK3000 contains 2 Universal Asynchronous Receiver and Transmitters (UARTs) for interfacing with additional peripheral devices and/or for terminal logging during (software) development. The UARTs support:

- Full-duplex operation
- Baud rates from 488 Bd to 2 MBd
- Serial frames with 5, 6, 7, 8 or 9 data bits and 1 or 2 stop bits, with framing error detection
- Odd or even parity generation and checking
- Buffer overflow detection
- False start bit detection and digital low pass filter for robustness against noise
- Separate interrupts on TX Complete, TX Data Register Empty and RX Complete
- Configurable pin mappings, i.e., an RX pin and a TX pin can be made available on the QPK3000 pin-out.
- Configurable hardware flow control.

7.2 USB Device

The QPK3000 supports a USB 2.0 Device supporting Full Speed (12 Mbps) data rate.

- Support for bulk, interrupt, and isochronous transfers
- programmable double buffering for bulk and interrupt endpoints
- 1 kB data buffer
- DMA for copying data to/from the USB data buffer
- supports USB remote wake-up.

7.3 Watchdog

The QPK3000 contains a Watchdog timer that serves to detect and resolve software failures and to trigger an interrupt, an MCU reset, or a system reset when the timer reaches a certain timeout value.

Timeout values are software configurable:

- 16-bit time-out values in 16 µs resolution
- Configurable watchdog time-out (16 µs - to 1 s)
- Configurable action (interrupt / Application Microcontroller reset / Chip Soft POR)
- Protection to accidental watchdog triggering and disabling.

7.4 Generic Timers

The QPK3000 contains a number of generic timers; 6x 32-bits or 12x 16-bits (software selectable), allowing time intervals to be defined by the user. The timers can be used in a prescaled mode, where the counter is running from the main clock with a configurable divide ratio, or in count mode, where the counter is incremented on a configurable event (e.g., an external pin event).

Each timer has 4 capture/compare channels allowing generating interrupts when the count value matches the compare value, or to capture the count value on a configurable event (e.g., an external pin event).

7.5 ANIO / ADC

The QPK3000 has an integrated ADC that can be used to monitor external analog signals via the ANIO pin. The ADC can be configured for 11-bits or 16-bit resolution. For details, please refer to the QPG6200L Data Sheet [4].

7.6 I²C Interface

For details about the I²C interface please refer to the QPG6200L Data Sheet [4].

7.7 LED Generator

The QPK3000 supports up to 4 signaling LEDs, with configurable function and events.
The LED generator supports:

- 8-bit Pulse-Width Modulation (PWM)
- Fade-in/Fade-out
- Duty cycling to adjust brightness and save power.

7.8 PWM Engine

The QPK3000 contains a PWM (Pulse-Width Modulation) peripheral (PWMxL).
The PWM peripheral enables the generation of 16-bit pulse width modulated signals on an assigned GPIO. Thanks to its advanced feature set it can support a wide range of use cases, including LED driver use cases.

The main features of the PWM peripheral are:

- Programmable PWM frequency
- Up to 8 PWM channels, each with an independent phase and duty cycle
- Arbitrary waveform generation driven by RAM defined sequences
- Glitch free parameter updates.

8 Programming and Debugging the QPK3000 Module

8.1 SWD Programming

The primary programming interface for (production) programming of the NVM is the SWD interface.
For this the signals shown in the table below shall be made available for programming.

Table 14: Mapping Signals for Programming via SWD

Pin Name	Signal	Notes
GND	GND	Ground.
VDD, VDD2	VDD	The recommended supply voltage is: 3.3 V.
RESETN	RESETn	The reset signal.
IO7_SWCLK	SWD_CLK	Serial wire clock input provided by the Programmer.
IO6_SWDIO	SWD_DIO	Serial wire Data between Programmer and QPK3000 module.
IO5_PROG-ENn	PROG_ENn	Low (stable) enables programming mode at startup/reset. Should be kept low at least until the first SWD access in programming mode. The time between Reset and the first SWD access must be at least 50 ms. If no command has been received within 4 s, the chip will enter normal application mode.

The standard SWD_CLK frequency = 4 MHz.

8.2 SWD Debugging

Debugging mode is enabled by holding PROG_ENn Low for about 1 s after Reset, then High. See the image below.

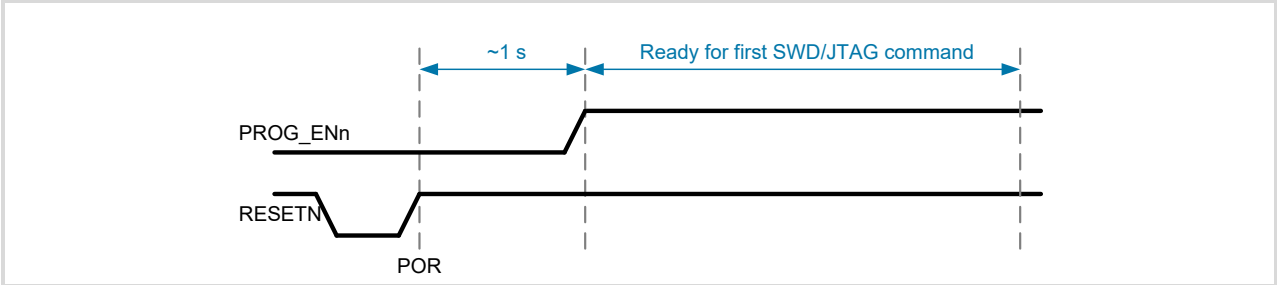


Figure 19: Entering SWD Debug Mode

While PROG_ENn is asserted low, no transaction should be started on SWD or UART (otherwise programming mode will be entered). The QPK3000 will be ready for the first SWD command for a period of 32 s. If no command has been received after that, the chip will enter normal application mode.

Note that SWD debugging is dependent on the provisioned Secure Debug configuration.

8.3 ARM Programming

For ARM Programming please refer to Cortex-M4 Devices Generic User Guide.

8.4 NVM Programming and Configuration

The NVM program and configuration memory is not programmed when the chips are shipped by Qorvo. To enable the functionality, the NVM must be programmed through a dedicated programming protocol. Please contact Qorvo Support for details of available programming solutions. If programming takes place on the target PCB, the Program Port signals need to be accessible on the PCB.

9 Packaging and Packing Information

9.1 Module Package Dimensions

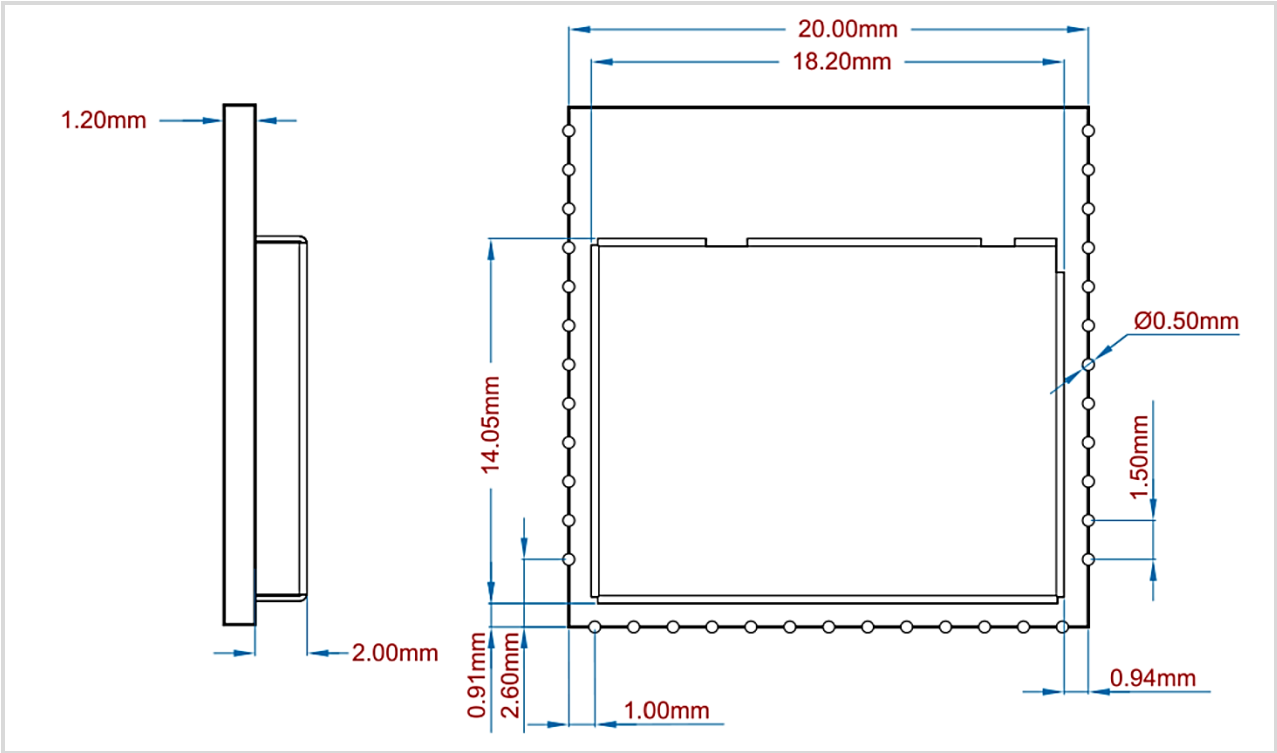


Figure 20: Package Dimensions

9.2 Module Land Pattern

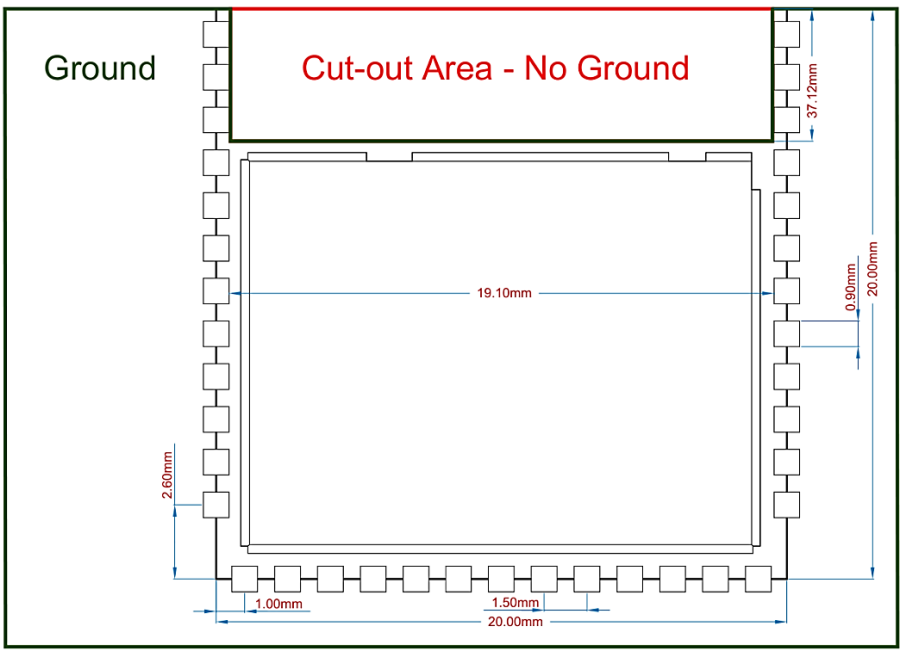


Figure 21: Module Land Pattern

9.3 Device Package Marking

The image and table below show the package markings for the QPK3000 module.

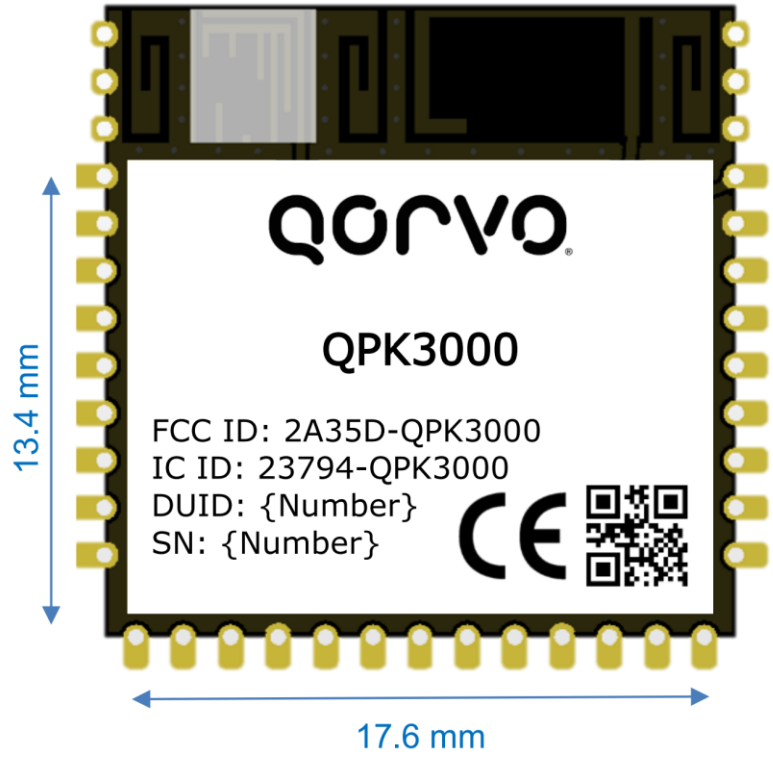


Figure 22: Device Package Marking

Elements:

- FCC ID: 2A35D-QPK3000 (filing pending)
- IC ID: 23794-QPK3000 (filing pending)
- DUID: {Number}:
  - Truncated 120 bits to 48 bits (LSB)
  - Example: 0x0000000000000000000000000004003b to 0x0004003b
- SN: {Number} = YY WW BB SSSS.
  - YY = Last two numbers of the calendar year.
  - WW = Week number.
  - BB = Batch number.
  - SSSS = Serial number.
- 2D Barcode or QR code:
  - 5x5 mm.
  - Serial number as per text.
  - YYWWBBSSSS.

9.4 Tape & Reel Packaging Information

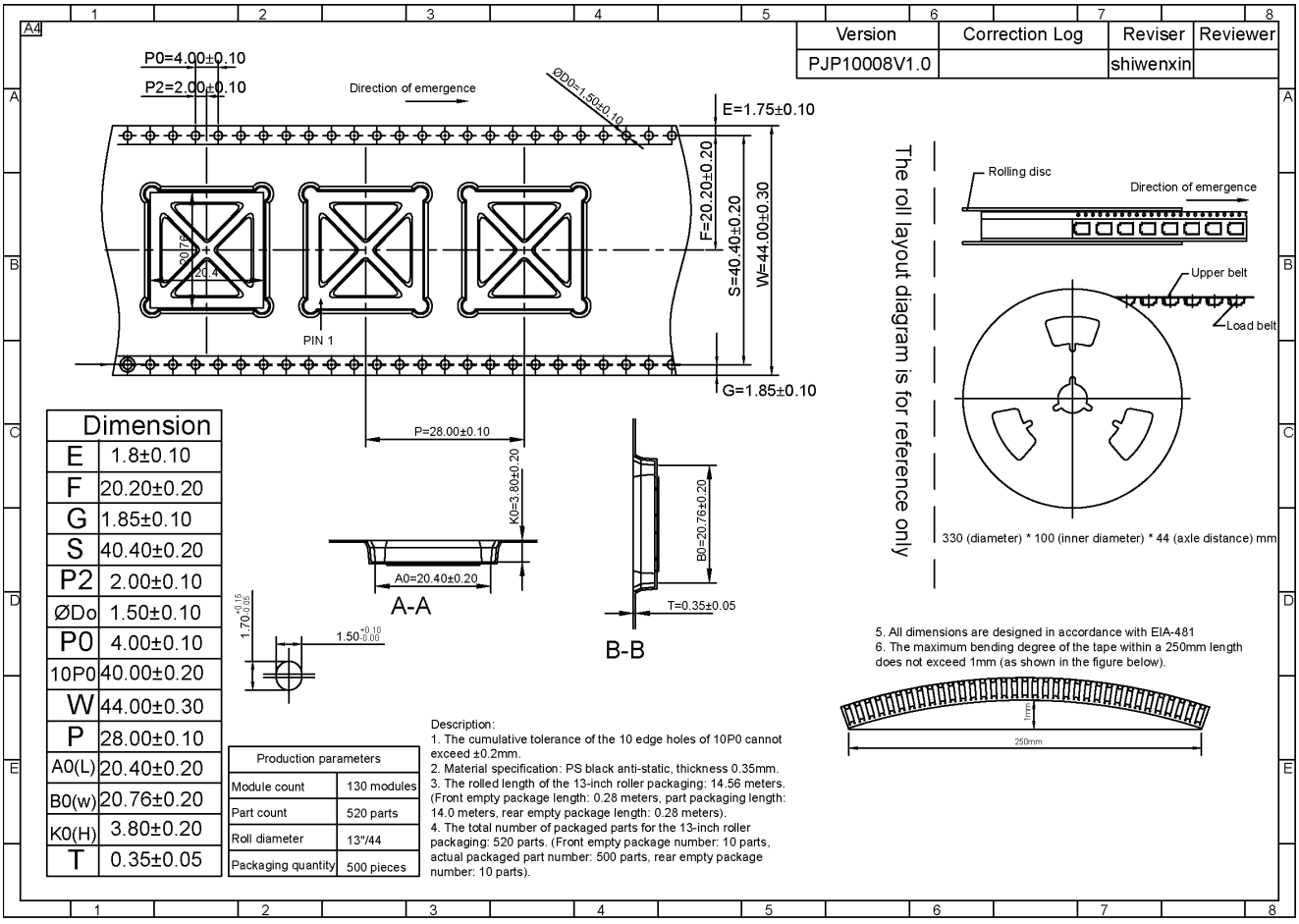


Figure 23: Tape & Reel Dimensions

10 Application Board Layout Guidelines

The sections below state guidelines for optimal RF performance and performance of the planar antennas.

10.1 RF

For best RF performance, ground copper should be flooded in all areas of the application board, except directly below the antennas.

10.2 Antennas

The QPK3000 module contains state-of-the-art planar antennas for UWB and BLE / 2.4 GHz.

The antenna polarization is mostly in the plane of the module.

Placement of the module with these antennas with respect to the application board is **non-critical**, e.g., there is no need for keep-out areas on the application board as was recommended in the past for other antenna concepts.

The only recommendations for placement of the module are:

- No material, e.g., FR4, from the application board directly below the antennas, and
- at least 1 mm separation between the rear side of the antennas and a plastic housing to prevent influence on the antennas due to dielectric permittivity loading.

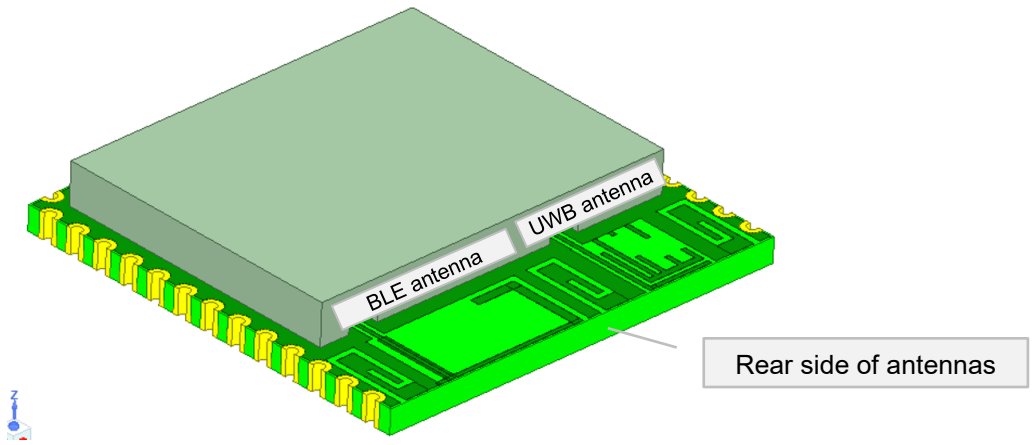


Figure 24: QPK3000 Antennas

11 Glossary of Terms

Table 15: Glossary of Terms

Abbreviation	Meaning	Explanation
EIRP	Equivalent Isotropic 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.
BPRF	Base PRF mode	64 MHz PRF Mode.
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.
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.
RTLS	Real Time Location System	System intended to provide information on the location of various items in real-time.
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. More information available here: https://www.qorvo.com/innovation/ultra-wideband/technology
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. More information available here: https://www.qorvo.com/innovation/ultra-wideband/technology
LNA	Low Noise Amplifier	An amplifier designed to amplify very low-power signals without significantly degrading their signal-to-noise ratio.

12 References

[1] IEEE 802.15.4-2015. 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 https://standards.ieee.org/.

[2] IEEE 802.15.4-2020. IEEE Standard for Low-Rate Wireless Networks. IEEE Computer Society Sponsored by the LAN/MAN Standards Committee. Available from https://standards.ieee.org/.

[3] IEEE 802.15.4z-2020 (Amendment to IEEE 802.15.4-2020). Amendment 1: Enhanced Ultra-Wideband (UWB) Physical Layers (PHYs) and Associated Ranging Techniques". IEEE Computer Society Sponsored by the LAN/MAN Standards Committee. Available from https://standards.ieee.org/.

[4] Data Sheet Qorvo QPG6200L.

[5] Data Sheet Qorvo QM33110W.

[6] T.S. Rapport, Wireless Communications – Principles & Practice, Prentice Hall, 1996.

13 Approvals and Compliance

13.1 Radio Regulatory Requirements

The QPK3000 is compliant with relevant FCC (USA), ISED (Canada) and ETSI (EU) regulatory requirements. Note: filing pending.

FCC (USA)
FCC ID: 2A35D-QPK3000

ISED (Canada)
IC: 23794-QPK3000

13.2 FCC Interference Compliance Statement - Part 15.19(a)

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

13.3 FCC Interference Statement - Part 15.105 B

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 of the following measures:

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

13.4 FCC Do not Modify Warning - Part 15 Clause 15.21

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

13.5 European Union (CE/ETSI)

The QPK3000 Module has been pre-certified for use in European Union countries. If these modules are incorporated into an (end) product, the manufacturer (entity who brings that product into the EU market) must ensure compliance of the (end) product with relevant EU Directives and Regulations and relevant EU (harmonized) standards. An EU Declaration of Conformity must be issued stating each of these standards and applicable EU Directives and Regulations.

13.6 Regulatory Approvals

All (**end)-products** developed by the manufacturer (or importer) incorporating the QPK3000 must obtain approval/certification from the relevant authority governing radio emissions, including spectrum usage, in any given jurisdiction prior to the marketing or sale of such products in that jurisdiction.

13.7 Environmental Compliance

This part is compliant with 2011/65/EU RoHS directive (Restrictions on the Use of Certain Hazardous Substances in Electrical and Electronic Equipment) as amended by Directive 2015/863/EU.

14 Ordering Information

Part No.	Description
QPK3000TR13	RTLS Module with access to programmable SDK, 500 pcs on 13” reel
QPK3000ATR13	RTLS Module with access to omlox based software, 500 pcs on 13” reel

15 Contact Information

For the latest specifications, additional product information, worldwide sales and distribution locations:

Web: www.qorvo.com **Tel:** 1-844-890-8163 **Support:** https://www.qorvo.com/support

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

Data Sheet Information Status

	Data Information Status Label	Product Life Cycle Status	Definition
	TARGET DATA SHEET	Preview	Data sheet contains early design specifications for a product under development.
►	**PRELIMINARY DATA SHEET**	Preview	Data sheet contains preliminary specifications for a product under development.
	PRODUCTION DATA SHEET	Production	Data sheet contains production product specifications.

Revision History

Revision	Date	Description
A	Mar, 2026	Released version.
B	Mar 25, 2026	Chapter 1, sections 9.3, 13.1: “filing pending” added.
		Chapter 2: size dimensions updated.
		Chapter 3: updated block diagram.
		Section 6.3: updated conditions.
		Section 6.3: updated conditions for sleep current.
		Section 6.4: product name corrected.
		Section 6.4.5: removed.
		Chapter 13: Approvals and Compliance: updated.
		All: minor text and format changes.

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