RAK5010 WisTrio NB-IoT Tracker Pro Datasheet

Overview

Description

The **RAK5010 WisTrio NB-IoT Tracker Pro** is an advanced, highly flexible eMTC/NB-IoT/EGPRS tracker based on Quectel BG96 LTE Cat M1&NB1, integrated with GPS, BLE, and a variety of sensors. The MCU running the board is a Nordic nRF52840 controller.

With the GPS and BLE features, the device can be used in a wide range of applications from outdoor to indoor scenarios where location-based services are necessary.

The board is equipped with four sensors onboard: humidity and temperature sensor, pressure sensor, 3-axis motion sensor, and ambient light sensor. Additionally, the extension IOs in the module allow expandable sensor application in addition to the on-board ones.

This board is particularly suitable to be used as a quick testing and prototyping tool for applications requiring Nb-IoT connectivity. Application development supports the GCC environment.

Features

- **Quectel BG96** with LTE CAT M1, LTE NB1, EGPRS and GNSS
- **Nordic nRF52840**, with BLE 5.0 and long-range BLE
- nRF52840 integrates the ultra-low power microcontroller ARM Cortex-M4 (64 Mhz)
- Built-in humidity and temperature sensor, pressure sensor, 3-axis motion sensor, and ambient light sensor
- iPEX connectors for the LoRa and GPS antenna and an on-board ceramic antenna for the BLE
- Nano SIM and ESIM options
- Can be powered by either Micro USB, 3.7 V rechargeable battery or a 5 V Solar Panel port
- Multiple interfaces, I2C, UART, GPIO, and ADC

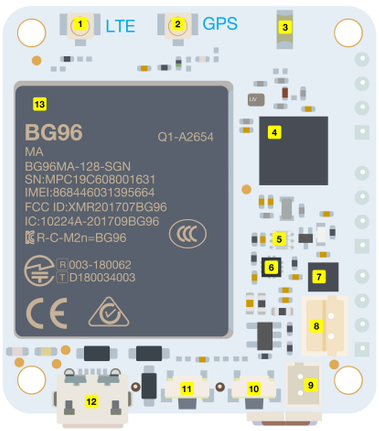
Specifications

Overview

The overview presents the RAK5010 WisTrio top view and its block diagram that shows the core of the board.

Module Overview

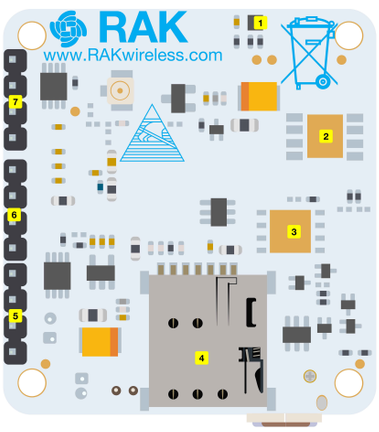
Figure 1 shows the top view and the interfaces of the RAK5010 NB-IoT tracker board.



1 LTE Antenna
2 GPS Antenna
3 BLE Antenna
4 NRF52840
5 Light Sensor/OPT3001
6 Pressure Sensor/LPS22HB
7 Motion Sensor/LIS3DH
8 Battery Connector
9 Solar Connector
10 NRF52840 RESET KEY
11 PWR KEY for BG96
12 USB for NRF52840 and charge
13 BG96 Module

Figure 1: Top View of the Board with Interfaces

Figure 2 shows the bottom of the board, where Figure 3, the dimensions of the board, and Figure 4 shows the header pin spacing.



1 Temperature Sensor/SHTC3
2 External Flash Reserved
3 ESIM Reserved
4 Nano SIM Interface
5 IO Extension (IO tolerant is set by VREF)
6 IO Extension (IO tolerant is set by VREF)
7 JLINK Interface 1.8V Tolerant

Figure 2: Bottom View of the Board with Interfaces

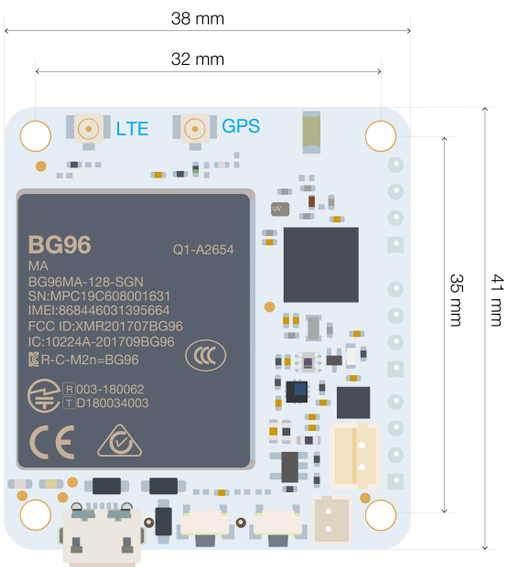


Figure 3: Board Dimensions

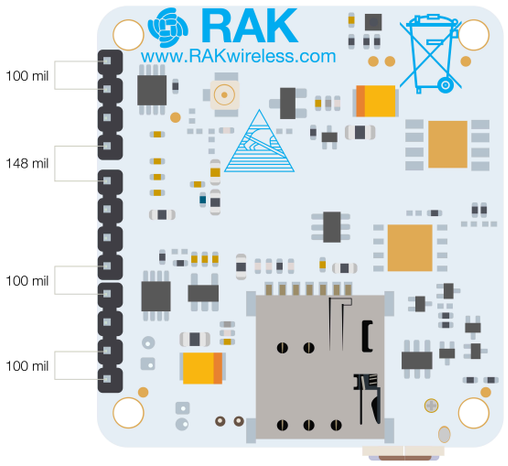


Figure 4: Header Spacing

Block Diagram

The block diagram below shows the internal architecture and external interfaces of the RAK5010 board.

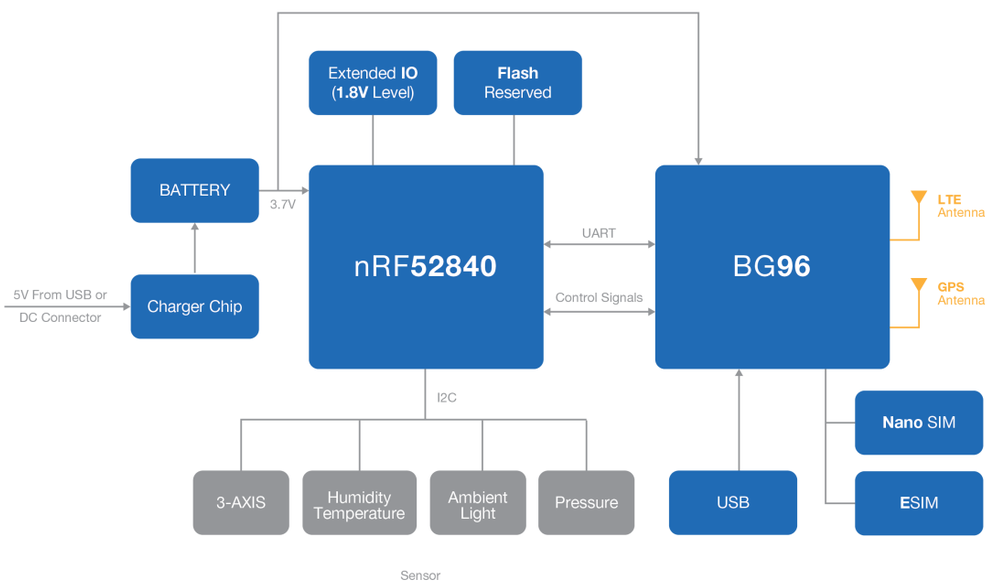


Figure 5: RAK5010 Block Diagram

Hardware

The hardware specification is categorized into seven parts. It discusses the interfacing, pinouts, and its corresponding functions and diagrams. It also covers the standard parameters of the board in terms of Electrical, Mechanical and Environmental of which the tabular data of the functionalities and the standard values are presented. Moreover, a thorough discussion of the RAK5010 specification is included in this section.

Interfaces

The node is built around the BG96 module and the nRF52840 BLE chip. It provides the following interfaces, headers, jumpers, buttons, and connectors:

- Micro USB
- 2 sets of 4-pin 2.54 mm Headers (UART, GPIOS, I2C, power)

- 4-pin Jlink header
- 2-pin battery female interface
- 2-pin Solar Panel female interface
- LEDs
- Reset Button
- PWR Button for the BG96

There are two antenna connectors:

- LTE Antenna with iPEX connector
- GPS Antenna with iPEX connector

Micro-B USB Interface

A standard Micro-B USB is compliant with USB 2.0 standard specification. This USB interface is connected to the USB port of NRF52840 for default. It also can connect to BG96 by reworking some resistors on the board. If this USB port is connected to the BG96, BG96 AT command port, GNSS port, and debug port can be accessed through this USB. It is also used as a charge input port for the battery. The Micro-B USB pin definition is shown in Figure 6:

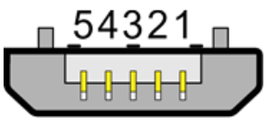


Figure 6: USB Connector Pinout

Pin	Description
1	USB_VBUS (+5 V)
2	USB_DM
3	USB_DP
4	NC
5	GND

This USB port is also used as port for charging the battery.

LEDs

Three LEDs are used to indicate operating status. Listed in the table are their functions:

Color	Connection	Function
Green LED	connected to the nRF52840	Defined by the user
🔵 Blue LED	connect to the BG96	Indicates the status of the BG96
🔴 Red LED	connect to the BG96	Indicates the network status of the BG96

RESET Push Button

Reset Push Button is used to reset the nRF52840. You can control the BG96 reset with by the firmware of the nRF52840.

PWRKEY Push Button

When the BG96 is in power off mode, it can be turned back on to normal mode by holding the PWRKEY button for at least 100 ms. Holding the PWRKEY button for at least 650 ms, the module will execute the power-down procedure after the PWRKEY is released.

IO Connections between the BG96 and the nRF52840

The nRF52840 communicates with the BG96 primarily though the UART interface. There is, however, additional signaling between the two modules. This is for the purpose of auto monitoring of status indicators and control. The pin mapping is shown below:

Function of BG96	PIN definition on nRF52840
TX of UART	P0.08 (RX for the nRF52840)
RX of UART	P0.06 (TX for the nRF52840)
BG96_CTS	P0.11
BG96_RTS	P0.07
BG96_RI	P0.27
BG96_STATUS	P0.31
BG96_RESET	P0.28
BG96_PWRKEY	P0.02
BG96_WDISABLE	P0.29
BG96_DTR	P0.26
BG96_AP READY	P0.30
BG96_PSM	P0.03

If BG96_RESET, BG96_PWRKEY, and BG96_WDISABLE are not set correctly, the BG96 module will not boot up normally. When powering up, the BG96 RESET should be retained at a low-level voltage, the BG96_WDISABLE should be retained at low-level voltage, and the BG96_PWRKEY should be given a pulse with a high level and at least 100 ms width to turn the BG96 normally.

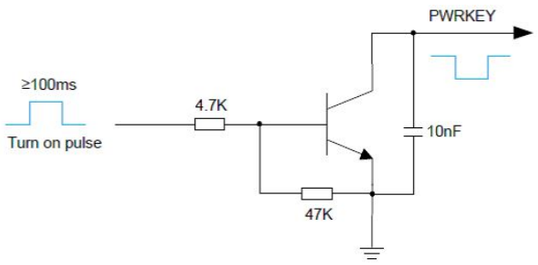


Figure 7: Turning on the BG96 via the PWRKEY

Antenna Connector

The connectors for both the GPS and LTE antennas are iPEX. Make sure that the LTE antenna is tuned to work at the operational frequency of your LTE provider, corresponding to your region.

Pin Definition

There are two connectors on the board:

P1

Solar panel interface

Pin	Pin Name	Description
1	C0NN_5V	Positive of Solar Panel
2	GND	GND

> 📝 **NOTE**
>
> The output of the solar panel cannot exceed 5.5 V. Otherwise, it may cause permanent damage to the board.

P2

Li-ion battery connector

Pin	Pin Name	Description
1	GND	GND
2	VBAT	Positive of the Battery

J9

J9 is J-LINK connector, with J-LINK debugger, you can program and debug nRF52840.

Pin	Pin Name	Description
1	VDD	1.8 V default. Reference voltage for J-LINK, note 1

Pin	Pin Name	Description
2	SWDIO	SWD data signal (1.8 V tolerant)
3	SWDCLK	SWD clock signal (1.8 V tolerant)
4	GND	GND

> 📝 **NOTE**
>
> VDD of J9 should connect to the PIN1 of SEGGER J-LINK (see Figure 8) debugger for SWDIO/SWDCLK reference voltage. If this pin is not connected correctly, the J-LINK logic level may not set to VDD of nrf52840, and it may damage the nrf52840.

Figure 8 shows the definition of 20-Pin segger J-LINK connector.

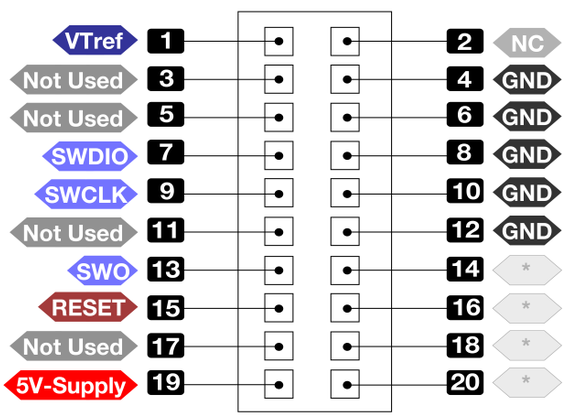


Figure 8: J-LINK Pinout

Pin	Signal	Type	Description
1	VTref	Input	This is the target reference voltage. It is used to check if the target has power, to create the logic-level reference for the input comparators, and to control the output logic levels to the target. It is normally fed from the VDD of the target board and must not have a series resistor.

J10 and J12

J10 and J12 are IO extension headers. They bridged from the nRF52840 IOs, through logical level shift circuits. Thus, the IOs level is set by the VREF pin. The function of these IOs is configurable. They can work as UART, I2C，general GPIO, or ADC.

- Definition of J10:

Pin	Pin Name	Description
1	GND	GND
2	VBAT	Connected to the Battery

Pin	Pin Name	Description
3	AIN	Configurable IO, connected to AIN3 (P0.05) on nRF52840. If used as ADC, the input range is configurable. Refer to the manual of nrf52840. If used as general IO, the logic level is 1.8 V, and there is no level shift on it.
4	NRF_IO1	Configurable IO, connected to P0.19 on the nRF52840. There is a level shift circuit between this pin and the nRF52840.

- Definition of J12:

Pin	Pin Name	Description
1	EXT_VREF	Reference level for the IO extensions.
2	NRF_IO2	Configurable IO, connect to P0.20 on the nRF52840. There is a level shift circuit between this pin and the nRF52840.
3	NRF_IO3	Configurable IO, connect to P1.02 on the nRF52840. There is a level shift circuit between this pin and the nRF52840.
4	NRF_IO4	Configurable IO, connect to P1.01 on the nRF52840. There is a level shift circuit between this pin and the nRF52840.

The logic level shift circuit on the RAK5010 board connects EXT_VREF to your extension board's power and equalizes it to the logical level of the IO on your extension board.

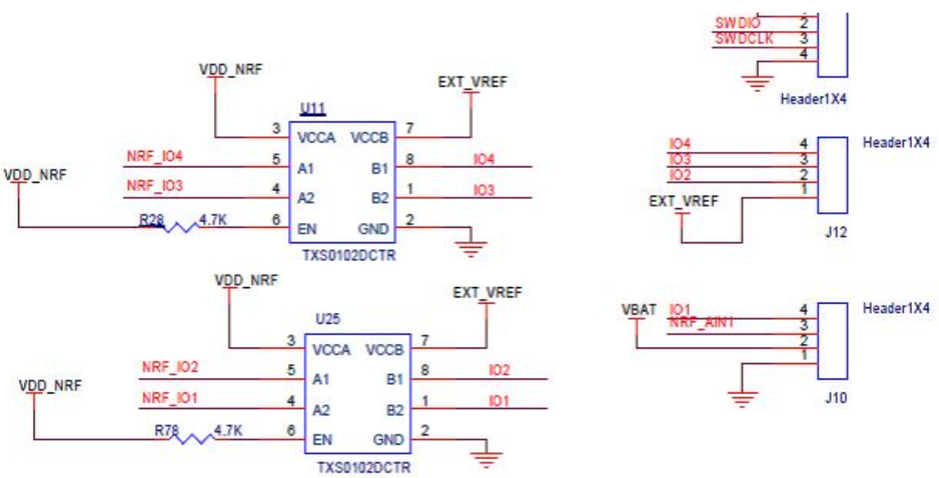


Figure 9: Typical Converter Circuitry

System on a Chip (SoCs) and Sensors

This section provides detailed specifications about the different modules present in the RAK5010 device.

1. BG96

1.1 Frequency Bands

LTE Bands	GSM	Rx-Diversity	GNSS
Cat M1 & NB1:	-	-	-

LTE Bands	GSM	Rx-Diversity	GNSS
LTE-FDD: B1/B2/B3/B4/ B5/B8/B12/B13/B18/ B19/B20/B26/B28	GSM850/GSM900	Not Supported	GPS, GLONASS, BeiDou/ Compass, Galileo, QZSS

1.2 Key Feature of BG96 Module

Feature	Details
Power Supply	- Supply Voltage: 3.3 V – 4.3 V - Typical supply voltage: 3.8 V
Transmitting Power	- Class: 3 (23 dBm ± 2 dB) for LTE-FDD bands - Class: 3 (23 dBm ± 2 dB) for LTE-TDD bands - Class: 4 (33 dBm ± 2 dB) for GSM850 - Class: 4 (33 dBm ± 2 dB) for GSM900 - Class: 1 (30 dBm ± 2 dB) for DCS1800 - Class: 1 (30 dBm ± 2 dB) for PCS1900 - Class: E2 (27 dBm ± 3 dB) for GSM850 8-PSK - Class: E2 (27 dBm ± 3 dB) for GSM900 8-PSK - Class: E2 (26 dBm ± 3 dB) for DCS1800 8-PSK -Class: E2 (26 dBm ±3 dB) for PCS1900 8-PSK
LTE Features	- Supports LTE Cat M1 and LTE Cat NB1 - Supports 1.4 MHz RF bandwidth for LTE Cat M1 - Supports 200 kHz RF bandwidth for LTE Cat NB1 - Supports SISO in the DL direction Cat M1: Max. 300 Kbps (DL)/375 Kbps (UL); Cat NB1: Max. 32 Kbps (DL)/70 Kbps (UL)
GSM Features	**GPRS**: - Supports GPRS multi-slot Class 33 (by default) - Coding scheme: CS-1, CS-2, CS-3, and CS-4 Max. 107 Kbps (DL), Max. 85.6 Kbps (UL) **EDGE**: - Supports Edge multi-slot Class 33 (by default) - Supports GMSK and 8-PSK for different MCS Downlink - Coding Schemes: CS 1-4 and MCS 1-9 Uplink Coding Schemes: CS 1-4 and MCS 1-9 Max. 296 Kbps (DL), 236.8 Kbps (UL)

2. nRF52840 Module

Parameter	Detail
CPU	ARM® Cortex®-M4 32-bit processor with FPU, 64 MHz
Flash	1 MB
RAM	256 KB
BLE Protocol	BLE 5.0
BLE Tx Power	8 dBm max
BLE Rx Sensitivity	95 dBm @ 1 Mbps BLE mode

Parameter	Detail
BLE Data Rate	2 Mbps, 1 Mbps, 500 Kbps, 125 Kbps
Current Consumption	4.8 mA in Tx, 4.6 mA in Rx, and 1.5 uA in Sleep Mode

3. Humidity and Temperature Sensors

The Temperature and Humidity Sensors are an SHTC3 from Sensirion.

3.1 Temperature

Parameter	Conditions	Value	Units
Accuracy	Typ	±2.0	°C
Tolerance	Max	See ***Figure 2***	°C
Repeatability	-	0.1	°C
Resolution	-	0.01	°C
Specified Range	-	-40 to +125	°C
Response Time	τ 63%	<5 to 30	s
Long-term Drift	Typ.	<0.2	°C/y

3.2 Humidity

Parameter	Conditions	Value	Units
Accuracy	Typ	±2.0	%RH
Tolerance	Max	See ***Figure 2***	%RH
Repeatability	-	0.1	%RH
Resolution	-	0.01	%RH
Hysteresis	-	±1	%RH
Specified Range	Extended	0 to 100	%RH
Response Time	τ 63%	8	s
Long-term Drift	Typ.	<0.25	%RH/y

4. Pressure Sensor

The Pressure Sensor is an LPS22HB from ST:

Symbol	Parameter	Test Condition	Min	Typ	Max	Unit
PTop	Operating Temperature Range	-	-40	-	+85	°C
PTfull	Full Accuracy Temperature Range	-	0	-	+65	°C
Pop	Operating Pressure Range	-	260	-	1260	hPa
Pbits	Pressure Output Data	-	-	24	-	bitsbits
Psens	Pressure Sensitivity	-	-	4096	-	LSB/hPa
PAccRel	Relative Accuracy over Pressure	• P=800–1100 hPa • T = 25 °C	-	±0.1	-	hPa
PAccT	Absolute Accuracy	• **After OPC**: Pop=0 to 65 °C • **No OPC**: Pop=0 to 65 °C	-	±0.1 ±1	-	hPa
Pnoise	RMS Pressure Sensing Noise	With embedded filtering	-	0.0075	-	hPa RMS
ODRPres	Pressure Output Data Rate	-	-	1/10/25/50/75	-	Hz

5. 3-Axis Motion Sensor

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
FS	Measurement Range	FS bit set to 00		±2.0		g
		FS bit set to 01		±4.0		g
		FS bit set to 10		±8.0		g
		FS bit set to 11		±16.0		g
So	Sensitivity	FS bit set to 00; High-resolution mode		1		mg/digit
		FS bit set to 00; Normal mode		4		mg/digit
		FS bit set to 00; Low Power mode		16		mg/digit
		FS bit set to 01; High-resolution mode		2		mg/digit

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
		FS bit set to 01; Normal mode		8		mg/digit
		FS bit set to 01; Low-power mode		32		mg/digit
		FS bit set to 10; High-resolution mode		4		mg/digit
		FS bit set to 10; Normal mode		16		mg/digit
		FS bit set to 10; Low-power mode		64		mg/digit
		FS bit set to 11; High-resolution mode		12		mg/digit
		FS bit set to 11; Normal mode		48		mg/digit
		FS bit set to 11; Low-power mode		192		mg/digit

6. Ambient Light Sensor

The Ambient Light Sensor is an OPT3001 from TI:

Parameter	Test Condition	Min.	Typ.	Max.	Unit
Peak Irradiance Spectral Responsibility	-	-	550	-	nm
Resolution (LSB)	Lowest full-scale range, RN[3:0] = 0000b	-	0.01	-	lux
Full-scale Illuminance	-	-	83865.6	-	-
Measurement Output Result	0.64 lux per ADC code, 2620.90 lux full-scale (RN[3:0] = 0110) , 2000 lux input	2812 1800	3125 2000	3437 2200	ADC lux
Relative Accuracy Between Gain Ranges	-	-	0.2%	-	-
Infrared Response (850 nm)	-	-	0.2%	-	-
Light Source Variation (Incandescent, Halogen, Fluorescent)	Bare device, no cover glass	-	4%	-	-
Linearity	Input luminance > 40 lux Input luminance < 40 lux	-	2%	-	-
Measured Drift Across Temperature	Input luminance = 2000 lux	-	5%	-	%/ °C

Parameter	Test Condition	Min.	Typ.	Max.	Unit
Dark Condition, ADC Output	0.01 lux per ADC code	-	0 0	3 0.03	lux
Half-power Angle	50% of full-power reading	-	47	-	degrees

Antennas

1. LTE Antenna

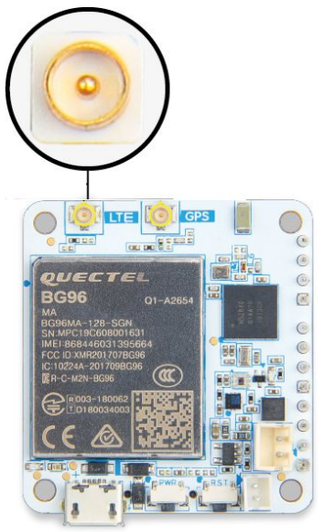


Figure 10: iPEX onboard connector for the LTE antenna

A PCB antenna (Figure 11) is included with the board. In case you want to use another antenna, keep in mind that you need to have the proper connector (iPEX) and have it tuned to the frequency band of operation in your region.

Figure 11: PCB LTE Antenna with Pigtail

Antenna Specifications

Item	Specifications
Range of Frequency	806-960/1710-2700 MHz
VSWR	≤1.5
Gain	1.0
Polarization	Linear
Impedance (Ω)	50
Antenna Type	PCB

Environmental Requirements

The antenna environmental requirements are listed in the table below:

Conditions	Temperature	Humidity
Working	-40 ºC ~ +75 ºC	0% ~ 95%
Storage	40 ºC ~ +85 ºC	0% ~ 95%

2. GPS Antenna

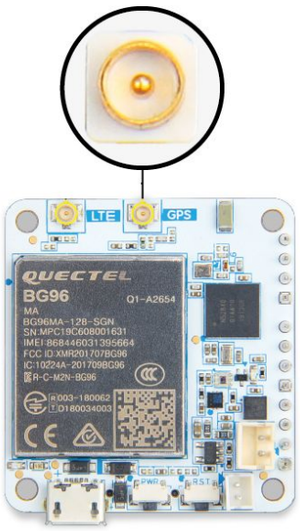


Figure 12: iPEX onboard connector for the GPS antenna

GPS Antenna Power Supply Control

To support low power and long battery life, the active GPS antenna power supply should be shut down when the system doesn't access the data from the GPS module. The GPS power supply is controlled by nRF52840 with MOSFET. The pin map of GPS_EN on Nrf52840 is P1.09, and the circuit is shown in Figures 13 and 14.

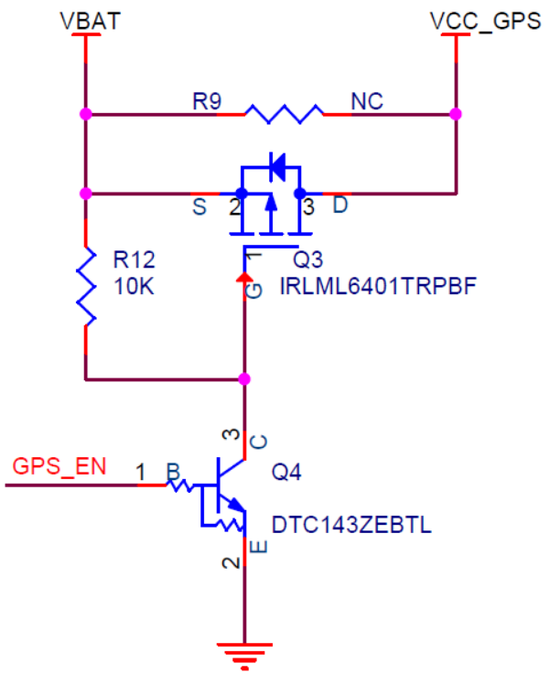


Figure 13: iPEX onboard connector for the GPS antenna

Figure 14: iPEX onboard connector for the GPS antenna

- **Set P1.07=1, GPS antenna power is on.**
- **Set P1.07=0, GPS antenna power is off.**

Antenna Specifications

Figure 15: GPS Antenna

Item	Specifications	PET
Range of Receiving Frequency	1575.42±1.1	±2.5
Center Frequency (MHz) w/ 30mm2 (2 GND plane	1575.42	±3.0
Bandwidth (MHz) (Return Loss ≤ -10dB)	≥10	±0.5
VSWR (in Center Frequency)	≤1.5	±0.5
Gain (Zenith) (dBi Typ.) w/ 70mm2 GND Plane	4.5	±0.5
Axial Ratio (dB) w/ 70mm2 GND Plane	3.0	±0.2
Polarization	Right-Handed Circular	
Impedance (Ω)	50	
Frequency Temperature Coefficient (ppm/ºC)	0±10	

Amplifier Specifications

Item	Specifications
Frequency Range	1575.42 MHz
Gain	27 dB
VSWR	≤ 2.0 V
Noise Coefficient	≤ 2.0 dB
DC Voltage	3 V ~ 5 V
DC Current	10 mA

Environmental Test Performance Specifications

Item	Normal Temp.	High Temp.	Low Temp.

Item	Normal Temp.	High Temp.	Low Temp.
Amplifier Gain	27 dB ± 2.0	27 dB ± 2.0	27 dB ± 2.0
VSWR	≤ 2.0	≤ 2.0	≤ 2.0
Noise Coefficient	≤ 2.0	≤ 2.0	≤ 2.0

> 📝 **NOTE**
>
> **1. High Temperature Test**: Soap in temperature (85 °C) and humidity (95%) chamber for 24-hour and return to normal temperature (at least for 1-hour) without visual shape change.
> **2. Low Temperature Test**: Soap in temperature (-40 °C) chamber for 24-hour and return to normal temperature (at least for 1-hour) without visual shape change.

Environmental Requirements

Conditions	Temperature	Humidity
Working	-35 ºC ~ +80 ºC	0% ~ 95%
Storage	-35 ºC ~ +80 ºC	0% ~ 95%

Electrical Characteristics

Schematic Diagram

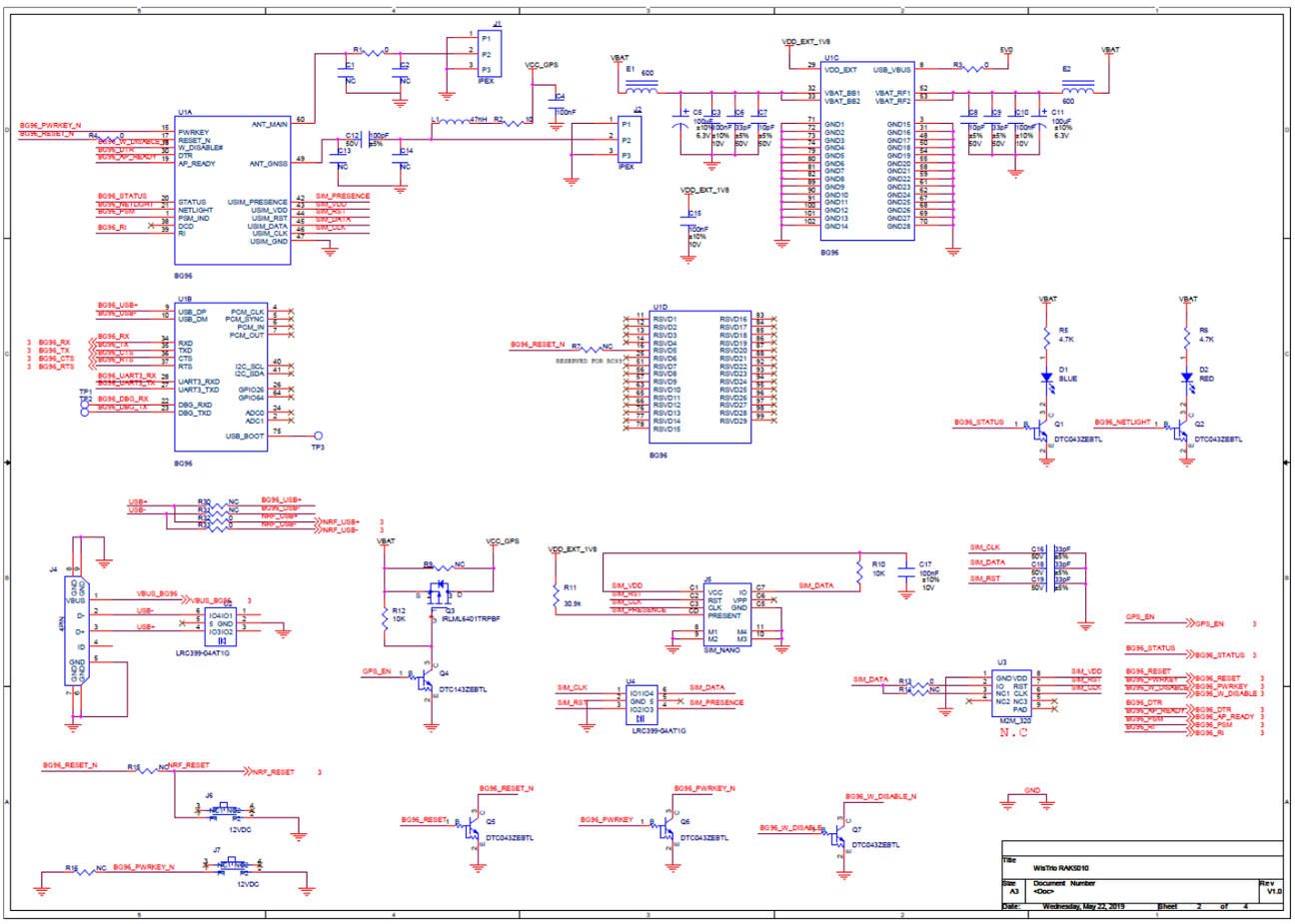


Figure 16: Schematic Diagram Part 1

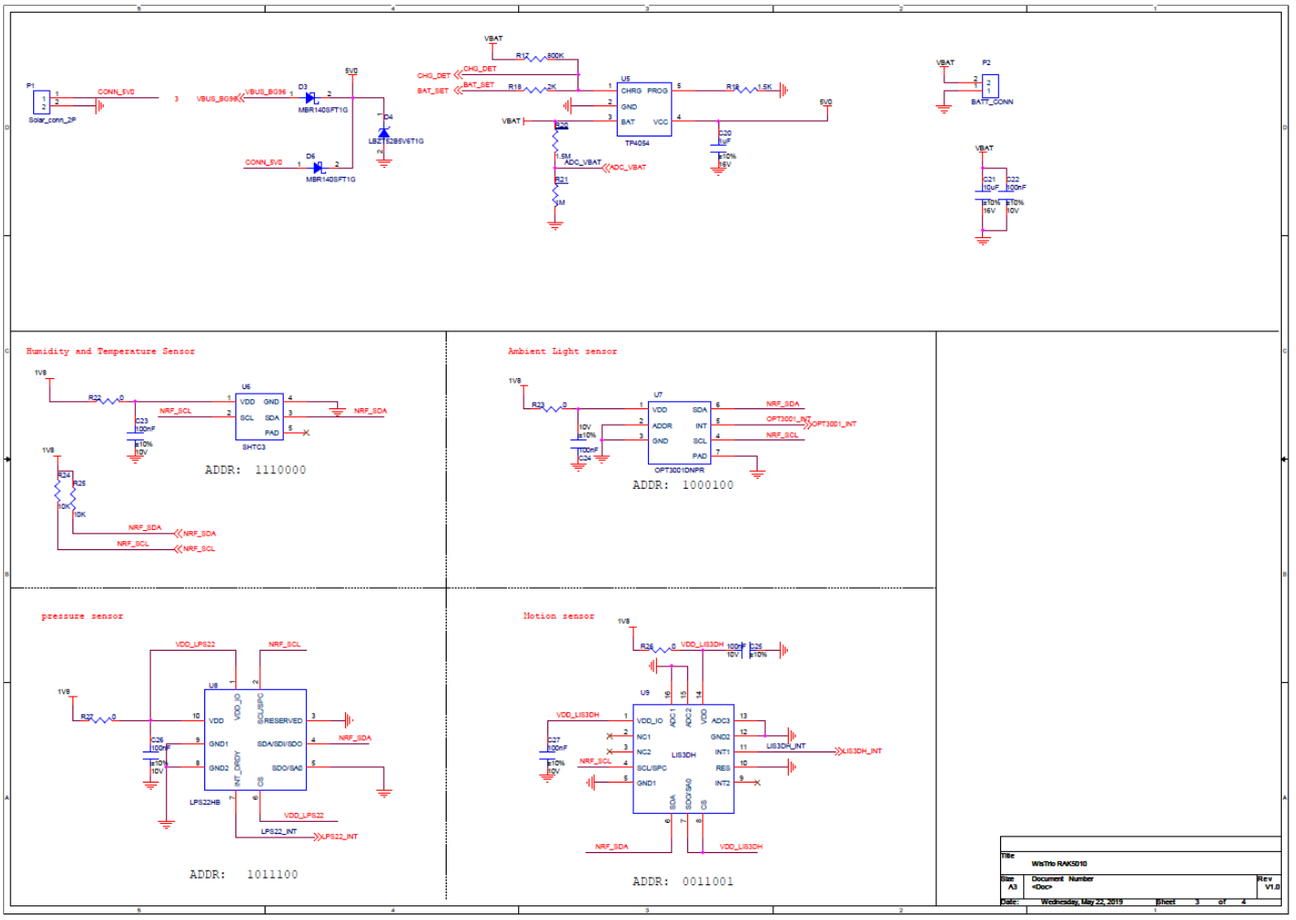


Figure 17: Schematic Diagram Part 2

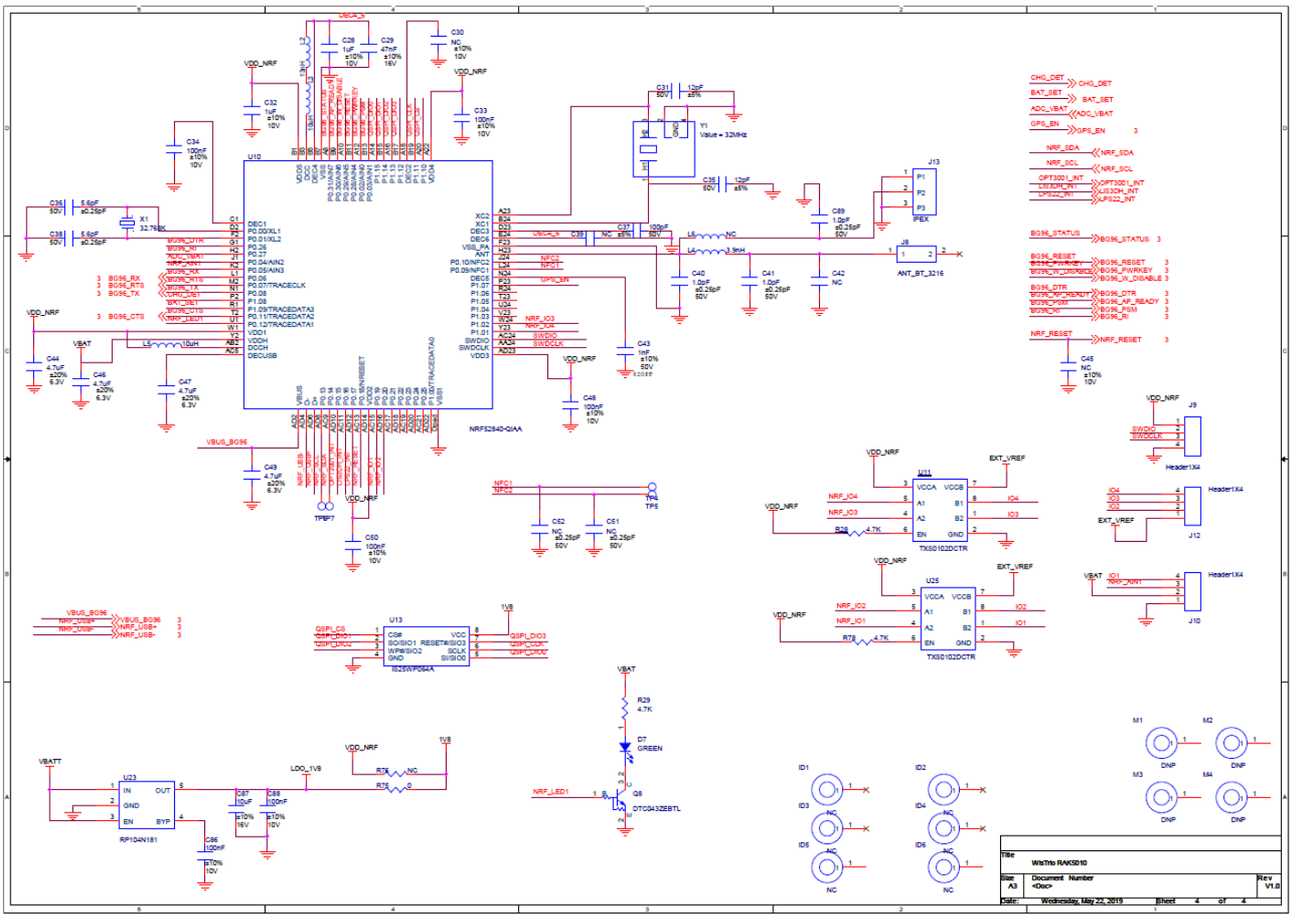


Figure 18: Schematic Diagram Part 3

Absolute Maximum Ratings

Functional operation of the device under the conditions listed is not advised. Hence, exposure to maximum rating conditions may affect device reliability.

Ratings	Maximum Value (V)
Vbus, power supply on UBS port	-0.3 - 5.5
Vbat, battery voltage	-0.3 - 4.3
Vconn solar panel voltage	-0.3 - 5.5
IOs of J-link (J9)	-0.3 - 1.9
IOs of BG96, nRF52840 - J10 and J12	-0.3 -VREF
ESD	2000

> ⚠️ **WARNING**
>
> The RAK5010, as any electronic equipment, is sensitive to electrostatic discharge (ESD). Improper handling can cause permanent damage to module.

Current Consumption

Conditions	Current
The nRF52840 is running, the BG96 transmits data @ NB1, 23 dBm	200 mA
BLE transmits @ 0 dBm, the BG96 is in power saving mode	7 mA
The nRF52840 is in sleep mode, the BG96 is in power saving mode	13 µA

> 📝 **NOTE**
>
> For the above results to be reached, the nRF52840 regulator has to be in DC-DC mode, and all the sensors have to be in sleep mode.

Power Requirements

The RAK5010 tracker board can be powered by a battery, connected to the P2. The nominal operational voltage of the battery should be within the range in the table:

Min	Type	Max	Unit
3.3	3.7	4.3	V

If a rechargeable battery is used, the USB connector is used as a charging port. The voltage and current fed to the battery through the port should not exceed the ones in the table below.

Parameter	Value

Parameter	Value
Charging Voltage	4.5 V ~ 5.5 V
Charging Current	500 mA

A suitable Li-Ion battery should have the following parameters:

Parameter	Value
Standard Voltage	3.7 V
Charging Voltage	4.2 V
Capacity	As required
Discharge Current	2 A

A 5 V solar panel can be connected to the board via the P1 connector to serve for the purpose of charging the battery.

> ⚠️ **WARNING**
>
> To avoid damage both to the battery and board:
>
> 1. Do not power the USB port if a non-rechargeable battery is connected to the RAK5010-M
> 2. Do not attach the solar panel if the non-rechargeable battery is used.

Figure 19: Battery Charging via Solar Panel

Laboratory Testings

Figures 20 and 21 display the average current consumptions based on the different test cases.

Equipments:

- Oscilloscope
- RAK5010 WisTrio NB-IoT Tracker Pro

LoRa Packet Sending

The RAK5010 WisTrio NB-IoT Tracker Pro takes **489.733 ms** to send a LoRa packet which consumes **64.9 mA** of current.

- **Sending Time**: 489.733 ms
- **Current consumption**: 64.9 mA

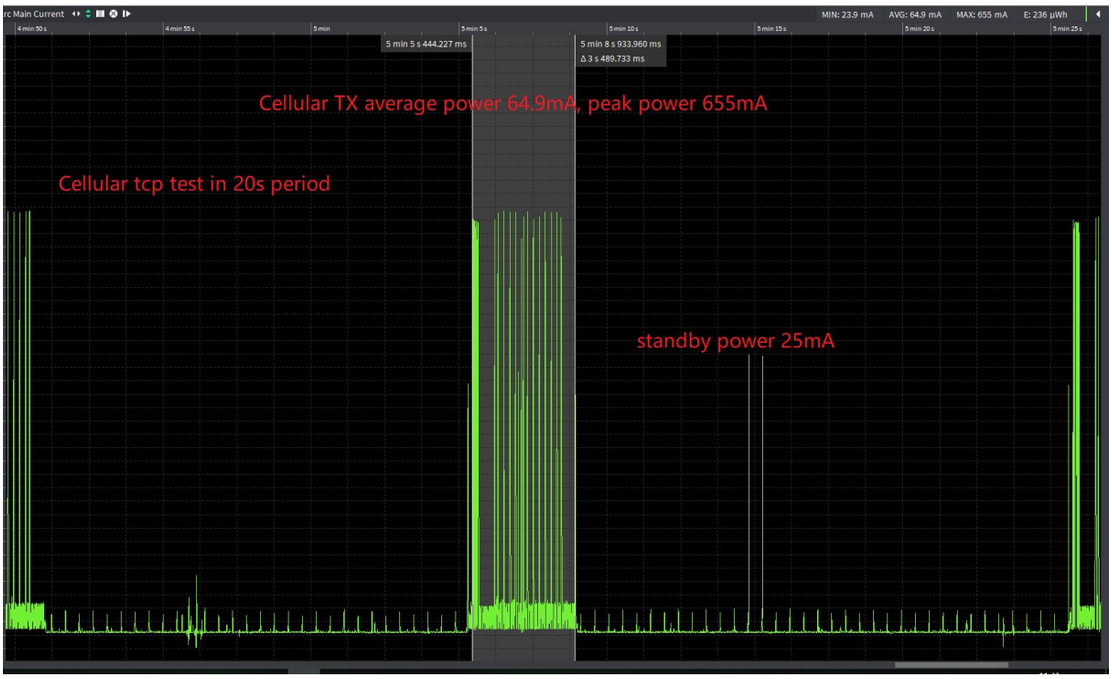


Figure 20: Oscilloscope Screen Capture of LoRa Packet Sending

Sleep Mode

When in sleep mode, the RAK5010 WisTrio NB-IoT Tracker Pro consumes **20.5 uA** of current.

- **Current consumption**: 20.5 uA

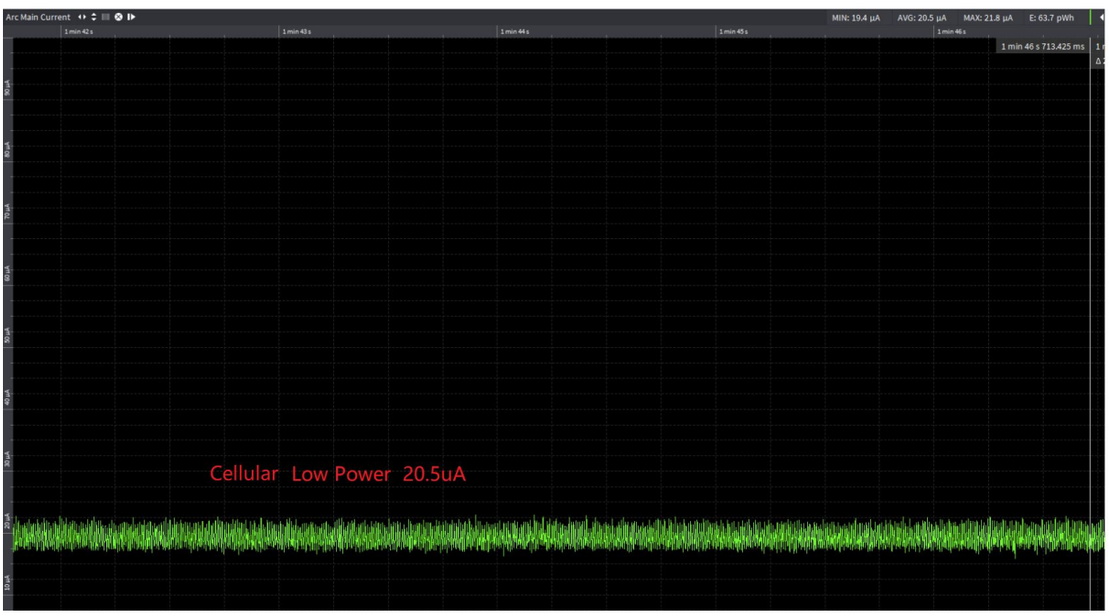


Figure 21: Oscilloscope Screen Capture of RAK4600 LoRa Module in Sleep Mode

Mechanical Characteristics

Module Dimensions

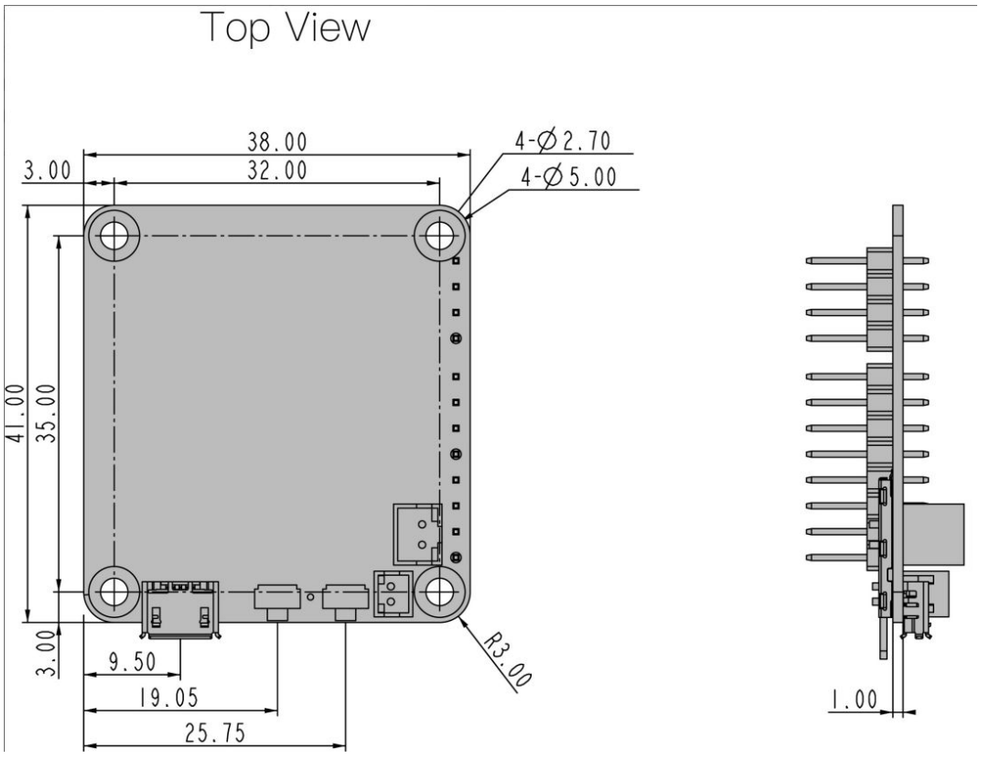


Figure 22: Top View

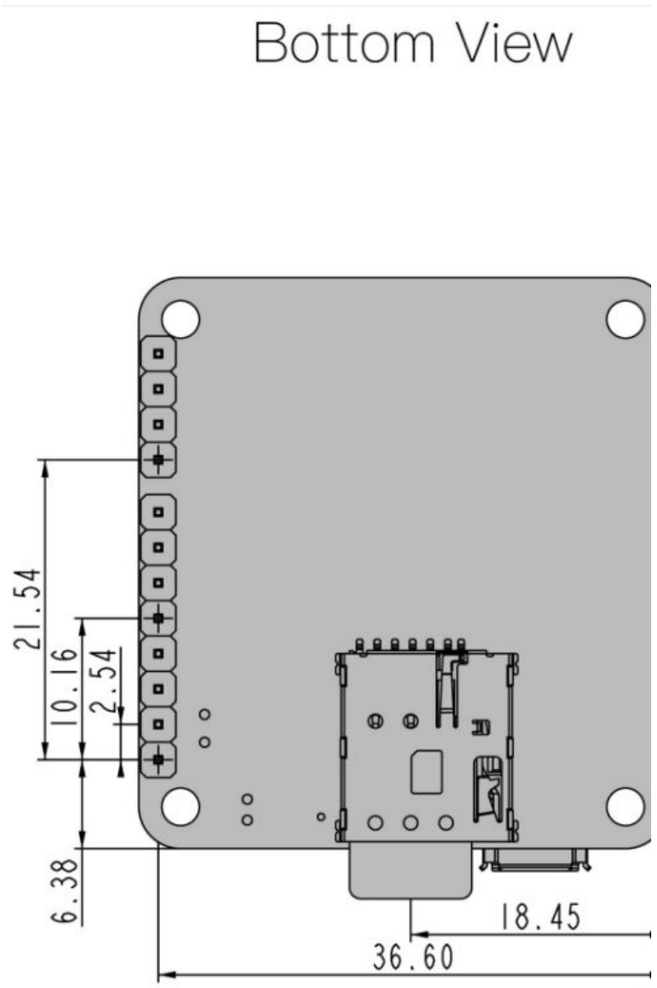


Figure 23: Bottom View

Environmental Characteristics

The table below lists the operation and storage temperature requirements:

Parameter	Min	Typical	Max
Operational Temp. Range	-35 ºC	+25 ºC	+75 ºC
Extended Temp. Range	-40 ºC	+25 ºC	+80 ºC
Storage Temp. Range	-40 ºC	+25 ºC	+80 ºC

Software

Download the latest firmware version of the RAK5010 WisTrio provided in the download link below.

> ⚠️ **WARNING**
>
> RAK5010 and RAK5010-M have the same PCB, but their firmware are different and not interchangeable.

Model	Version	Source
RAK5010	V3.0.0.15	Download

Models / Bundles

Ordering Information

Part Number	Built-in Nordic nRF52840	Built-in Nordic BG96	Built-in Temperature and Humidity Sensor	Built-in 3-axis Motion Sensor	Built-in Pressure Sensor	Built in Light Sensor
RAK5010	✓	✓	✓	✓	✓	✓
RAK5010-M	✓	✓	✓	✓		

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