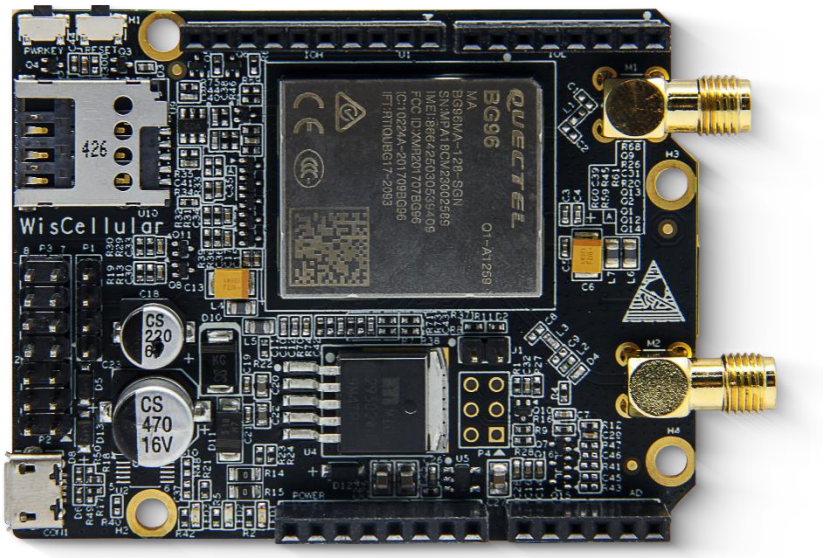
User Manual for

# WisLink Cellular BG96 Arduino Shield RAK2011

Version 2.0 | November 2018

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39 PAGES

# Table of Contents

# List of Tables



# List of Screenshots

# List of Images

# 1 Overview

## 1.1 Introduction

WisLink Cellular BG96 Arduino Shield RAK2011 is a compact cellular communications module that supports Low-Power Wide-Area (LPWA) technology for networking Internet-of-Things (IoT) devices. It can simultaneously support 2G, 4G/LTE, NB-IoT and GPS, with an additional feature of Voice-over-LTE (VoLTE) for high definition (HD) and uninterrupted voice calls.

This multitude of features allow users the flexibility of migrating from 2G to 4G/LTE without requiring any hardware change, improve power consumption, system capacity and spectrum efficiency by utilizing the Narrow Band Internet-of-Things, tracking units through GPS and location base services (LBS), stay on the 4G/LTE network even when making or receiving calls and other networking features.

The RAK2011 is based on the Quectel BG96 module and comes with drivers for Windows, Linux and Android support via AT commands. It supports networking protocols such as PPP, TCP, UDP, SSL, TLS, FTP(S), HTTP(S), NITZ, PING and MQTT. This is useful for facilitating software development and system integration into any IoT applications.

RAK2011 can be used as a development platform in tandem with external microcontrollers/microprocessors based platforms for IoT applications or it can be used as standalone device. It is in full compliance with FCC, CE, RoHS and Japan TELEC/JATE.

## 1.2 Package Content

WisLink Cellular BG96 Arduino Shield RAK2011 retail package includes:


***Image 1** | Package Content*

# 2 WisLink Cellular BG96 Arduino Shield RAK2011

## 2.1 Overview

The picture below shows part identification on top view of WisLink Cellular BG96 Arduino Shield RAK2011.

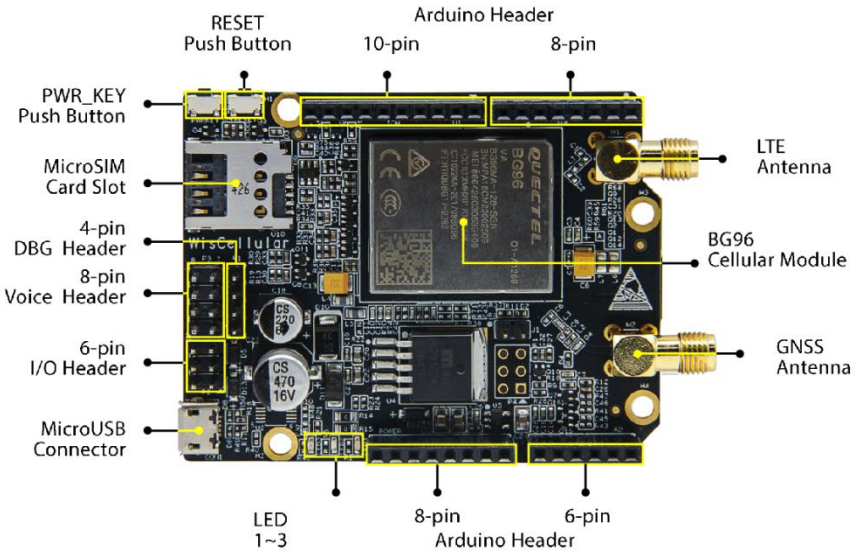



*Image 2 | Top View of Board*

The underside and dimension of the RAK2011 is shown below:

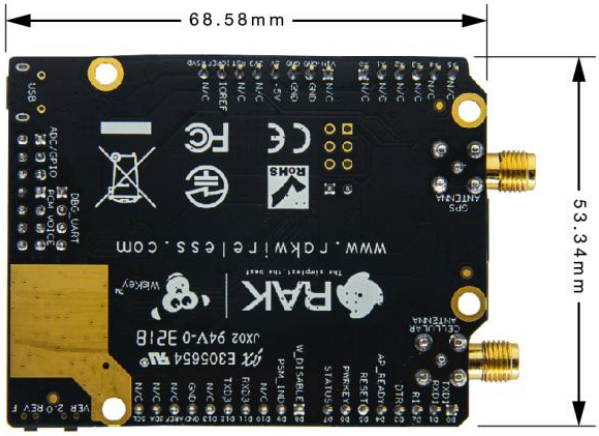



*Image 3 | Bottom View of Board*

## 2.2 Functional Diagram

The block diagram below shows internal architecture and external interfaces:

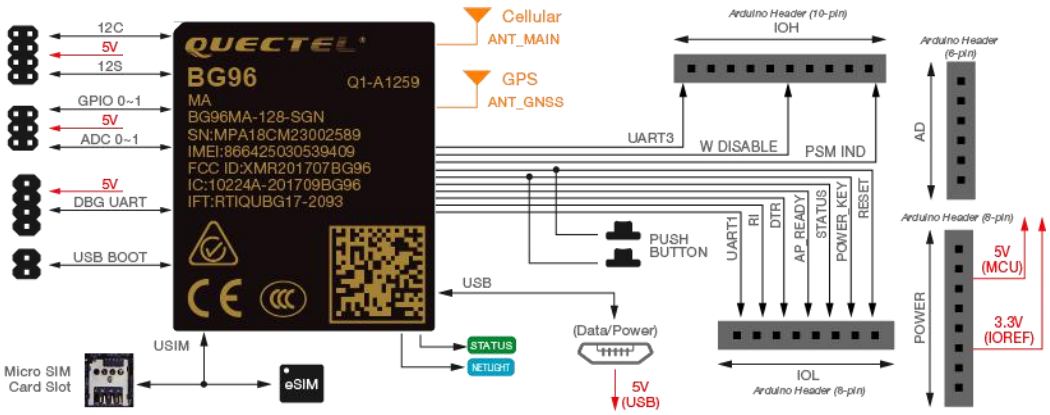



***Image 4** | Functional Diagram*

## 2.3 Interfaces

The RAK2011 is built around the Quectel BG96 LPWA IoT cellular module and provides the following interfaces, headers, jumpers, buttons and connectors:

- Micro-B USB
- Micro SIM Card Slot
- Arduino Headers (UART1, UART3, RESET, PWRKEY, STATUS, AP_READY, DTR, RI, PSM_IDC, W_DISABLE, 5V, 3.3V)
- 2x4 PCM Voice Headers (I2C, I2S)
- 2x3 Digital/Analog I/O Headers (ADC0, ADC1, GPIO0, GPIO1)
- 1x4 Debug UART Header (UART2)
- 1x2 USB BOOT Jumper

It has two push buttons to allow the user to power on/off and reset the board:

- POWER_KEY – Power on/off the BG96 module
- RESET – Reset the BG96 module

It has two SMA antenna connectors:

- Cellular (LTE/GSM) Antenna (3GPP Bands) – UART1
- GPS Antenna (1575.42±1.023 MHz) – UART3

## 2.4 Operating Modes

The WisLink Cellular BG96 Arduino Shield RAK2011 can operate in the following modes:

### 1.4.1 Normal Operation

**Idle** - Software is active. The BG96 module has registered to the network, and is ready to send and receive data.

**Talk/Data** - Network connection is ongoing; the power consumption is determined by the network settings and data transfer rate.

### 1.4.2 Extended Idle Mode DRX (e-I-DRX)

BG96 module may negotiate with the network, via non-access stratum signaling, the use of e-I-DRX for reducing power consumption while being available for mobile terminating data and/or network originated functions within a certain period dependent on the DRX cycle value.

### 1.4.3 Airplane Mode

`AT+CFUN` command or `W_DISABLE#` pin can set the module into airplane mode. In this case, RF functions are disabled.

### 1.4.4 Minimum Functionality Mode

`AT+CFUN` command can set the BG96 module into a minimum functionality mode without removing the power supply. In this case, both RF function and (U)SIM card will be disabled.

### 1.4.5 Sleep Mode

In this mode, the current consumption of the BG96 module will be reduced to a lower level. During this mode, the BG96 module can still receive paging message, SMS and TCP/UDP data from the network.

### 1.4.6 Power Saving Mode (PSM)

The BG96 module may enter into Power Saving Mode for reducing its power consumption. PSM is similar to power-off, except the BG96 module remains registered on the network and there is no need to reestablish PDN connections.

### 1.4.7 Power OFF Mode

In this mode, the power management unit shuts down the power supply. The software is not active, the serial interfaces are not accessible, but operating voltage remains applied.

## 2.5 Cellular (LTE/GSM) Operating Frequency

The table below lists all the supported cellular (LTE/GSM) operating frequencies:

| 3GPP Band | Transmit (MHz) | Receive (MHz) |
|---|---|---|
| B1 | 1920 ~ 1980 | 2110 ~ 2170 |
| B2 (PCS1900) | 1850 ~ 1910 | 1930 ~ 1990 |
| B3 (DCS1800) | 1710 ~ 1785 | 1805 ~ 1880 |
| B4 | 1710 ~ 1755 | 2110 ~ 2155 |
| B5 (GSM850) | 824 ~ 849 | 869 ~ 894 |
| B8 (GSM900) | 880 ~ 915 | 925 ~ 960 |
| B12 | 699 ~ 716 | 728 ~ 746 |
| B13 | 777 ~ 787 | 746 ~ 757 |
| B18 | 815 ~ 829.9 | 860 ~ 874.9 |
| B19 | 830 ~ 844.9 | 875 ~ 889.9 |
| B20 | 832 ~ 862 | 791 ~ 821 |
| B26 | 814 ~ 848.9 | 859 ~ 893.9 |
| B28 | 703 ~ 748 | 758 ~ 803 |
| B39 | 1880 ~ 1920 | 1880 ~ 1920 |

***Table 1** | Cellular Operating Frequency*

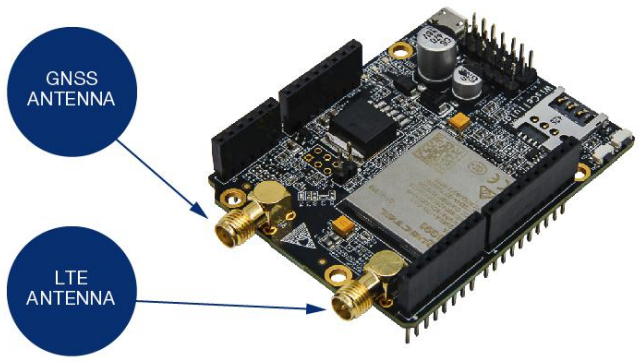



***Image 5** | LTE and GNSS Antenna*

## 2.6 Arduino Header

The mapping of Arduino headers on the WisLink Cellular BG96 Arduino Shield RAK2011 is shown below:

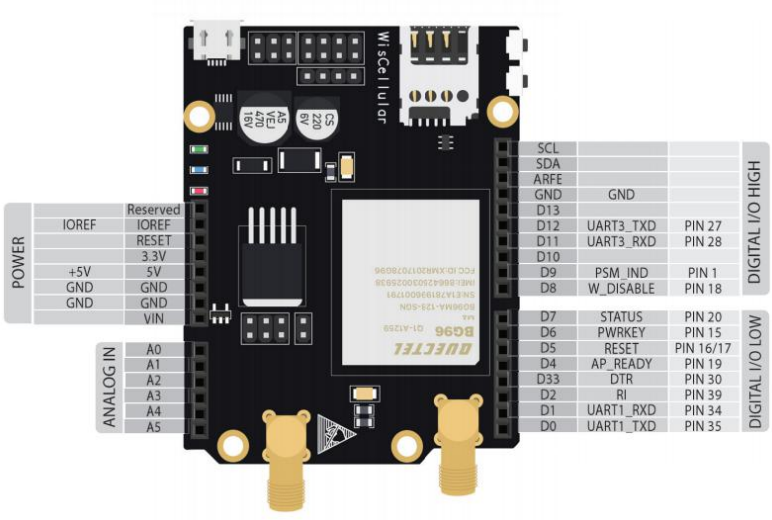



***Image 6** | Pin Configurations for Arduino headers*

The Arduino header signal definition is shown below:

| Name | Pin | I/O | Description |
|---|---|---|---|
| UART1_TXD | D0 | D0 | UART1_TXD |
| UART1_RXD | D1 | D1 | Receive cellular (LTE/GSM) data |
| R1 | D2 | D0 | Ring indicator |
| DTR | D3 | D1 | Data Terminal Ready (sleep mode control) |
| AP_READY | D4 | D1 | Application processor sleep state detection |
| RESET | D5 | D1 | Reset signal of the BG96 module |
| PWRKEY | D6 | D1 | Turn on/off the BG96 module |
| STATUS | D7 | D0 | Indicate the BG96 module's operation status |
| W_DISABLE | D8 | D1 | Airplane mode control |
| PSM_IND | D9 | D0 | Power saving mode indicator |
| UART3_RXD | D11 | D0 | Transmit GPS data |
| UART3_TXD | D12 | D1 | Receive GPS data |

***Table 2** | Pin Configurations foir Arduino Headers*

UART1 interface supports 9600, 19200, 38400, 57600, 115200, 230400, 460800 and 921600 baud rates, and the default is 115200bps. It is used for cellular (LTE/GSM) data transmission and AT command communication.

UART3 interface supports 115200bps baud rate. It is used for outputting GPS data and NEMA sentences.

## 2.7 PCM Voice Header

A standard 2x4 (2.54mm) male header is used to provide one Pulse Code Modulation (PCM) digital interface and one I2C interface to external CODEC extension board. PCM voice header pin definition is shown below:

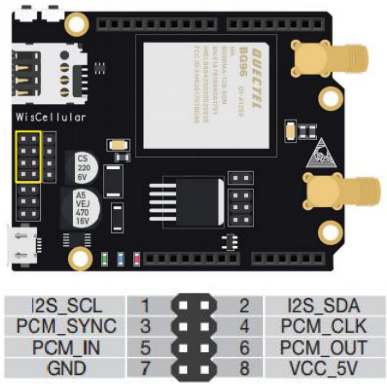



*Image 7 | PCM Voice Header*

The PCM voice header pin definition is shown below:

| Name | Pin | I/O | Description | Comments |
|---|---|---|---|---|
| I2C_SCL | 1 | OD | I2C serial clock | External pull-up resistor is required. 1.8V only. Keep this open if unused. |
| I2C_SDA | 2 | OD | I2C serial data | |
| PCM_SYNC | 3 | DO | PCM frame sync output | 1.8V power domain. Keep this open if unused. |
| PCM_CLK | 4 | DO | PCM clock output | |
| PCM_IN | 5 | DI | PCM data input | |
| PCM_OUT | 6 | DO | PCM data output | |

*Table 3 | PCM Voice Header*

The reference design for external CODEC extension board is shown below:

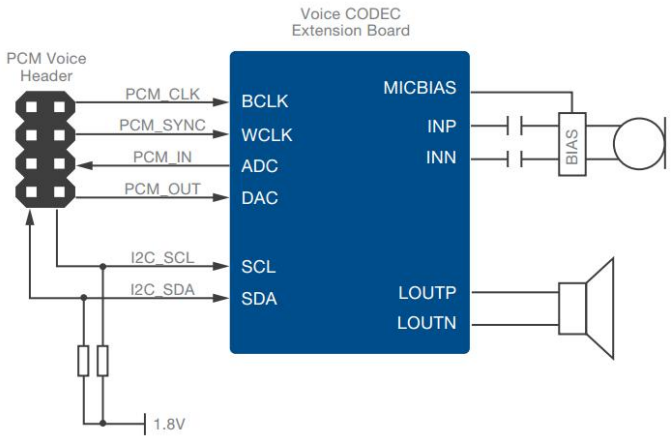



*Image 8 | External CODEC Extension Board*

## 2.8 Analog Input / Digital I/O Header

A standard 2x3 (2.54mm) male header is used to provide 2 analog input (ADC0 and ADC1) and 2 digital input and output port pins (GPIO0 and GPIO1) to an optional external extension board for additional features that may utilize these analog Input and digital I/O port pins. The analog input and digital I/O header pin layout is shown below:

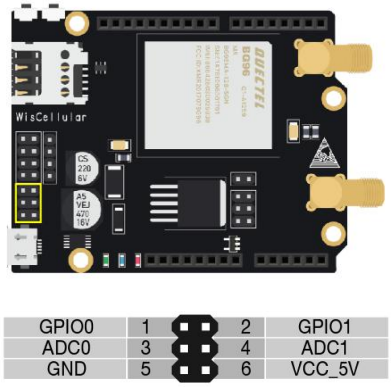



*Image 9 | Analog Input / Digital I/O Header*

The analog Input/Digital I/O header signal definition is shown below:

| Name | Pin | I/O | Description | DC Characteristics | Comments |
|---|---|---|---|---|---|
| GPIO0 | 1 | IO | General Purpose Input / Output | $V_{OL}$ max = 0.45V<br>$V_{OH}$ min = 1.35V<br>$V_{IL}$ min = 0.3V<br>$V_{IL}$ max = 0.6V<br>$V_{IH}$ min = 1.2V<br>$V_{IH}$ max = 2.0V | 1.8V power domain. Keep this open if unused. |
| GPIO1 | 2 | | | | |
| ADC0 | 3 | AI | General Purpose Analog to Digital Converter | Voltage range: 0.3V to 1.8V<br>15-bit resolution | Keep this open when unused. |
| ADC1 | 4 | | | | |

*Table 4 | Analog Input / Digital I/O Header*

## 2.9 Debug Header

A standard 1x4 (2.54mm) male header is used to provide a serial port (UART2) interface for debug and log output at 115200bps baud rate. The debug header pin definition is shown below:

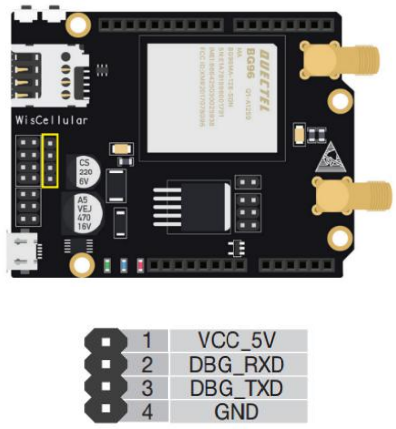



*Image 10 | Debug Header*

The analog Input/Digital I/O header signal definition is shown below:

| Name | Pin | I/O | Description | DC Characteristics | Comments |
|---|---|---|---|---|---|
| DB_G_RXD | 2 | DI | Receive data | $V_{IL}$ min = 0.3V<br>$V_{IL}$ max = 0.6V<br>$V_{IH}$ max = 1.2V<br>$V_{IH}$ max = 2.0V | 1.8V power domain.<br>Keep this open if unused. |
| DBG_TXD | 3 | DO | Transmit data | $V_{OL}$ min = 0V<br>$V_{OL}$ max = 0.45V<br>$V_{OH}$ min = 1.35V<br>$V_{OH}$ max = 1.8V | 1.8V power domain.<br>Keep this open if unused. |

*Table 5 | Debug Header*

## 2.10 Micro-B USB Interface

A Standard Micro-B USB compliant with the USB 2.0 standard specification is used to provide an interface to connect to a PC for control of  BG96 cellular modem and firmware upgrade.

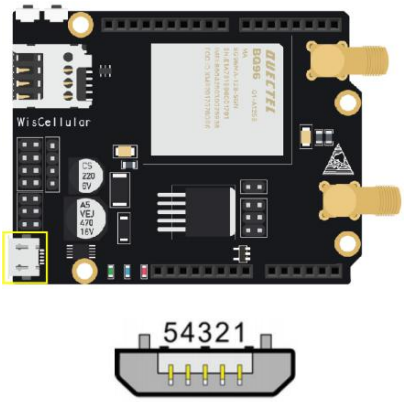



*Image 11 | Micro-USB Interface*

The Micro-B USB pin definition is shown below:

| Pin | Description |
|---|---|
| 1 | USB_VBUS (+5V) |
| 2 | USB_DM |
| 3 | USB_DP |
| 4 | N/C |
| 5 | GND |

*Table 6 | Micro-USB Interface*

## 2.11 USB Boot Jumper

A Standard 2 pin USB Boot header (when closed) is used to force the RAK2011 to boot from USB port for performing a firmware upgrade.

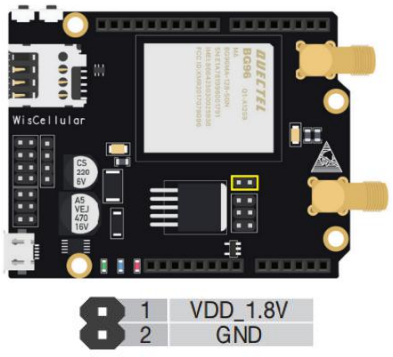



*Image 12 | USB Boot Jumper*

## 2.12 PWRKEY Push Button

PWRKEY push button is used to turn on/off the BG96 module. To turn on the BG96 module, push PWRKEY button for at least 100ms. The STATUS pin from Arduino header will output HIGH.

To turn off the BG96 module, push PWRKEY button for at least 650ms. STATUS pin from Arduino header will output LOW.

## 2.13 RESET Push Button

The RESET push button is used to reset the BG96 module. To reset the BG96 module, push the RESET button between 150ms and 460ms.

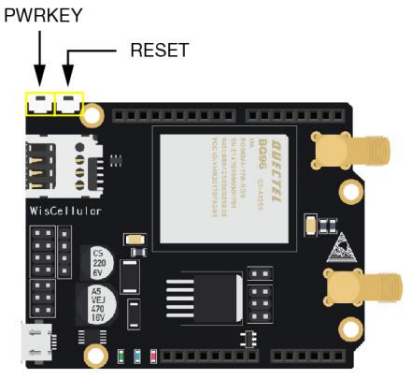



*Image 13 | PWRKEY and RESET Push Button*

## 2.14 LED Indicators

Here is the list of functions for LEDs indicators:

### 1.14.1 Green

- **STATUS** - indicates module operation status.

### 1.14.2 Blue

- **NETLIGHT** - indicates network activity status.

### 1.14.3 Red

- **Power ON** - indicates power status.

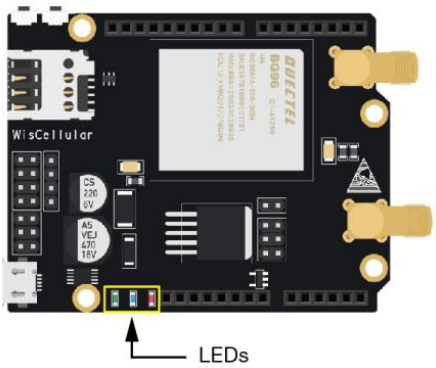



*Image 14 | LEDs*

## 2.15 Power Requirements

The RAK2011 can be powered by +5V from a MCU baseboard via Arduino header (POWER) if used as an Arduino Shield.

It can also be powered by +5V out of Micro-B USB if used as a standalone modem.

| Parameter | Min. | Max. |
|---|---|---|
| Power Supply Voltage | 3.7V | 5.5V |
| Current Consumption | | 500mA |
| Digital Input Voltage | 0V | IOREF |
| Digital Output Voltage | 0V | IOREF |

*Table 7 | Power Requirements*

## 2.16 Environmental Requirements

The table below lists the operation and storage temperature requirements:

| Parameter | Min. | Typical | Max. |
|---|---|---|---|
| Operation Temp. Range | -35˚C | +25 ˚C | +75 ˚C |
| Extended Temp. Range | -40 ˚C | | +85 ˚C |
| Storage Temp. Range | -40 ˚C | | +90 ˚C |

*Table 8 | Environmental Requirements*

## 2.17 Mechanical Dimensions

The mechanical dimension of the WisLink Cellular BG96 Arduino Shield RAK2011 can be found here:

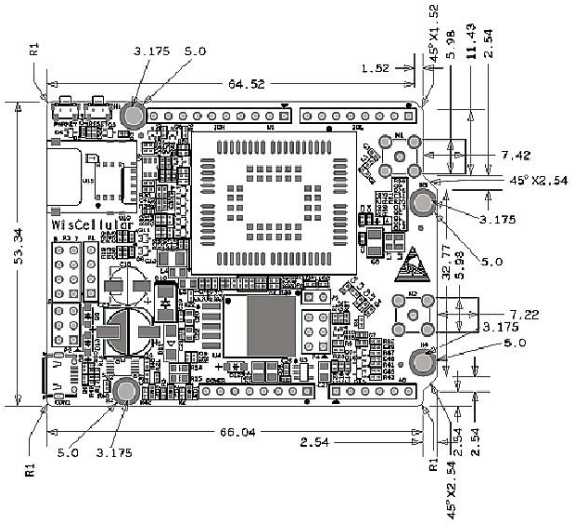



*Image 15 | Mechanical Dimensions*

# 3 Antenna

## 3.1 Cellular (LTE/GSM) Antenna

### 3.1.1 Overview

The cellular (LTE/GSM) antenna for the RAK2011 covers working frequency band from 824MHz to 2690MHz.

*Image 16 | Cellular Antenna*

### 3.1.2 Cellular (LTE/GSM) Antenna Dimension

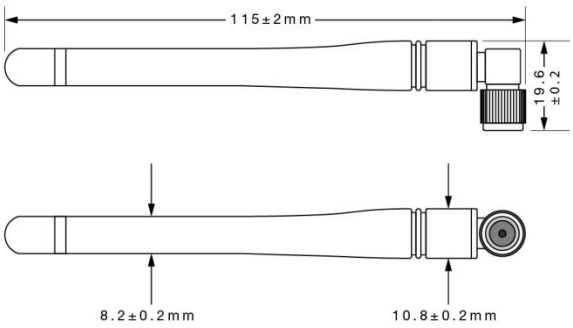
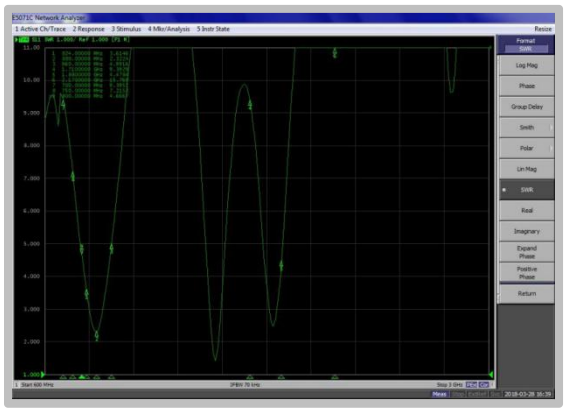



*Image 17 | Cellular Antenna Dimension*

### 3.1.3 Cellular (LTE/GSM) Antenna Parameter

The Voltage Standard Wave Radio (VSWR) plot is shown below:



***Screenshot 1*** | *Cellular (LTE/GSM) Antenna Parameter*

The VSWR data is shown in the table below:

| Freq. (MHz) | VSWR |
|---|---|
| 700 | 9.3 |
| 800 | 4.6 |
| 880 | 3.6 |
| 960 | 4.9 |
| 1710 | 9.3 |
| 1880 | 4.4 |
| 2170 | 15 |

***Table 9*** | *Cellular Antenna Parameter*

The Smith plot is shown here:

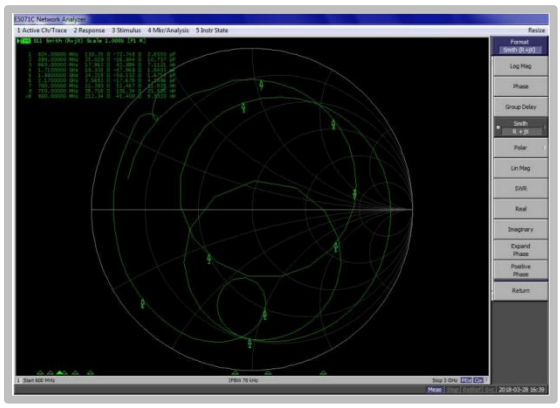


***Image 18*** | *Smith Plot*

### 3.1.4 Radiation Pattern on H-Plane

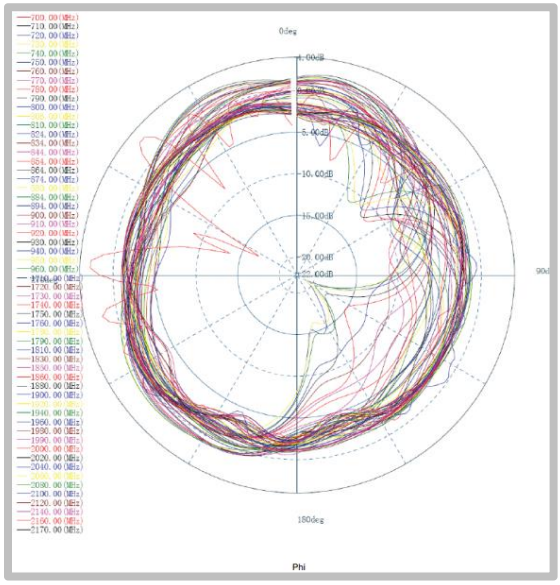



***Image 19*** | *Radiation Pattern on H-Plane*

### 3.1.5 Radiation Pattern on E1-Plane

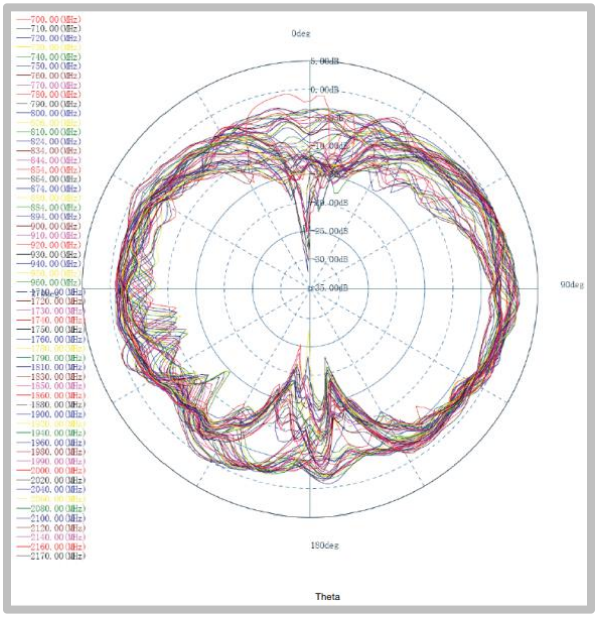



***Image 20*** | *Radiation Pattern on E1-Plane*

### 3.1.6 Radiation Pattern on E2-Plane

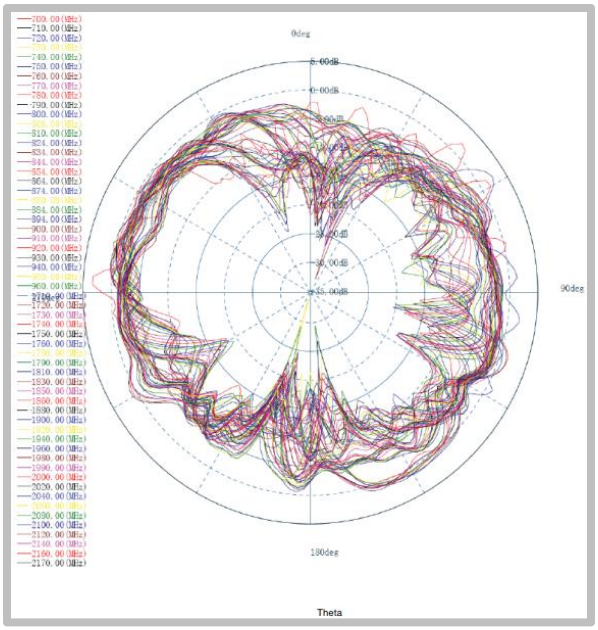



***Image 21*** | *Radiation Pattern on E2-Plane*

### 3.1.7 UGain and Efficiency Table

| Freq. (Hz) | Efficiency | Gain (dBi) | Freq. (Hz) | Efficiency | Gain (dBi) |
|---|---|---|---|---|---|
| 7.00E+08 | 49% | 1.632948 | 1.71E+09 | 35% | 0.02584 |
| 7.10E+08 | 51% | 1.826395 | 1.72E+09 | 35% | 0.0088 |
| 7.20E+08 | 49% | 1.833288 | d1.73E+09 | 36% | 0.647356 |
| 7.30E+08 | 44% | 1.600659 | 1.74E+09 | 44% | 0.806863 |
| 7.40E+08 | 46% | 1.896142 | 1.75E+09 | 35% | 0.03676 |
| 7.50E+08 | 50% | 1.936788 | 1.76E+09 | 46% | 0.549059 |
| 7.60E+08 | 50% | 1.721112 | 1.78E+09 | 34% | 0.14522 |
| 7.70E+08 | 46% | 1.406281 | 1.79E+09 | 35% | 0.41562 |
| 7.80E+08 | 45% | 1.491829 | 1.81E+09 | 36% | 0.35094 |
| 7.90E+08 | 47% | 1.8309 | 1.83E+09 | 34% | 0.30882 |
| 8.00E+08 | 45% | 1.843967 | 1.85E+09 | 38% | 0.430313 |
| 8.06E+08 | 41% | 1.714366 | 1.86E+09 | 35% | 0.33059 |
| 8.10E+08 | 45% | 2.215538 | 1.88E+09 | 37% | 0.008792 |
| 8.24E+08 | 42% | 1.97312 | 1.90E+09 | 43% | 0.479122 |
| 8.34E+08 | 44% | 1.890023 | 1.92E+09 | 40% | 0.111459 |
| 8.44E+08 | 42% | 1.407188 | 1.94E+09 | 46% | 0.407999 |
| 8.54E+08 | 42% | 1.453714 | 1.96E+09 | 44% | 0.037526 |
| 8.64E+08 | 47% | 2.111646 | 1.98E+09 | 48% | 0.405617 |
| 8.74E+08 | 46% | 1.93289 | 1.99E+09 | 48% | 0.112167 |
| 8.80E+08 | 48% | 1.960958 | 2.00E+09 | 47% | 0.144104 |
| 8.84E+08 | 46% | 1.930333 | 2.02E+09 | 46% | 0.14634 |
| 8.94E+08 | 52% | 2.347337 | 2.04E+09 | 47% | 0.033818 |
| 9.00E+08 | 50% | 2.192946 | 2.06E+09 | 45% | 0.112366 |
| 9.10E+08 | 50% | 2.265394 | 2.08E+09 | 51% | 0.672779 |
| 9.20E+08 | 49% | 2.081987 | 2.10E+09 | 48% | 0.291807 |
| 9.30E+08 | 48% | 2.005751 | 2.12E+09 | 54% | 0.939911 |
| 9.40E+08 | 49% | 2.128994 | 2.14E+09 | 54% | 1.161325 |
| 9.50E+08 | 49% | 2.305449 | 2.16E+09 | 59% | 1.631935 |
| 9.60E+08 | 48% | 2.233022 | 2.17E+09 | 59% | 1.967355 |

*Table 10 | UGain and Efficiency*

## 3.2 GPS Antenna

### 3.2.1 Overview

The GPS antenna for RAK2011 is shown below:


*Image 22 | GPS Antenna*

### 3.2.2 GPS Antenna Dimensions

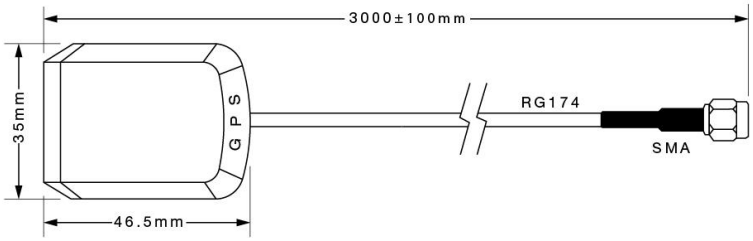



*Image 23 | GPS Antenna Dimensions*

### 3.2.3 GPS Environmental Requirements

The antenna environmental requirements are listed in the table below:

| Conditions | Temperature | Humidity |
|---|---|---|
| Working | -35ºC ~ +80ºC | 0% ~ 95% |
| Storage | -40ºC ~ +85ºC | 0% ~ 95% |

*Table 11 | GPS Environmental Requirements*

### 3.2.4 GPS Antenna Parameter

The GPS Antenna specifications and Post Environmental Tolerance (PET) are listed in the table below:

| Item | Specifications | PET |
|---|---|---|
| Range of Receiving Frequency | 1575.42±1.1 | ±2.5 |
| Center Frequency (MHz) w/ 30mm2 GND plane | 1575.42 | ±3.0 |
| Bandwidth (MHz) (Return Loss ≤ -10dB) | ≥10 | ±0.5 |
| VSWR (in Center Frequency) | ≤2.0 | ±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 | Righ-Handed Circular | - |
| Impedance (Ω) | 50 | - |
| Frequency/Temperature Coefficient (ppm/ºC) | 0±10 | - |

*Table 12 | GPS Antenna Parameter*

Amplifier Specifications are listed in the table below:

| Item | Specifications |
|---|---|
| Frequency Range | 1575.42 MHz |
| Gain | 27 dB |
| VSWR | ≤ 2.0 V |
| Noise Coefficient | ≤ 2.0 dBm |
| DC Voltage | 3 ~ 5 V |
| DC Current | 5 ± 2 mA |

*Table 13 | Amplifier Specifications*

Environmental test performance specifications are listed below:

| Item | Normal Temp. | High Temp.[1] | Low Temp.[2] |
|---|---|---|---|
| Amplifier Gain | 27dB ± 2.0 | 27dB ± 2.0 | 27dB ± 2.0 |
| VSWR | ≤ 2.0 | ≤ 2.0 | ≤ 2.0 |
| Noise Coefficient | ≤ 2.0 | ≤ 2.0 | ≤ 2.0 |

1. *High temperature test: soak in temperature (85º 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: soak in temperature (-40º C) chamber for 24-hour and return to normal temperature (at least for 1-hour) without visual shape change.*

*Table 14 | Environmental Test Performance*

# 4 Usage Model by Interface

## 4.1 Use USB Interface

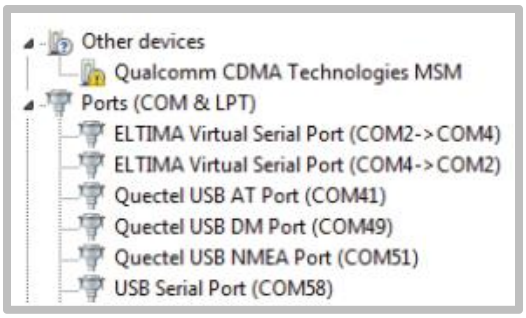
Note: Please push the PWRKEY once in order to turn on the module after connecting the USB cable.

### 4.1.1 Install USB Driver

Prior to connecting the RAK2011 to a Windows PC for the first time, the BG96 USB driver must first be installed on the PC. The driver (Quectel_BG96_Windows_USB_Driver_V1.0.rar) can be downloaded

from: https://www.rakwireless.com/en/download/Cellular/WisLink-Cellular#Tools

After the Windows USB drive installation is complete, connect RAK2011 to a PC via a Type A to Micro B USB cable. Open the Windows' Device Manager and it will show the following under Ports (COM & LPT):




***Screenshot 2** | Windows Device Manager*

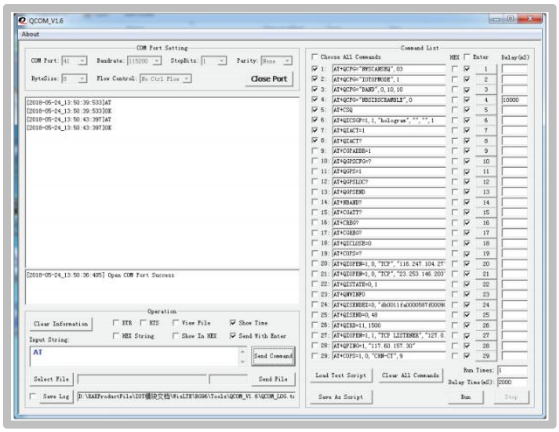
### 4.1.2 Send AT Commands

Select Quectel USB AT Port corresponding to the COM port, then open the serial port tool as shown on the screenshot. The tool (QCOM_V1.6.zip) can be downloaded at:

https://www.rakwireless.com/en/download/Cellular/WisLink-Cellular#Tools

After sending `AT\r\n`, the module will return `AT\r\nOK`, indicating the BG96 module is working normally.

You can send additional AT commands to control the module. For more AT commands, please refer to the document BG96 AT Commands Manual. It can be downloaded at:
www.quectel.com/support/downloadb/TechnicalDocuments.htm



***Screenshot 3*** | *Send AT Commands*

### 4.1.3 NB-IoT UDP Communication Test

Here are the steps for testing NB-IoT UDP Communication:

1. Plug in NB-IoT SIM card.
2. Connect WisLink Cellular RAK2011 to a Windows PC.
3. Select Quectel USB AT Port corresponding to the COM port.
4. Open the serial port tool.
5. Send the AT commands listed below to have the BG96 module find a NB-IoT network.

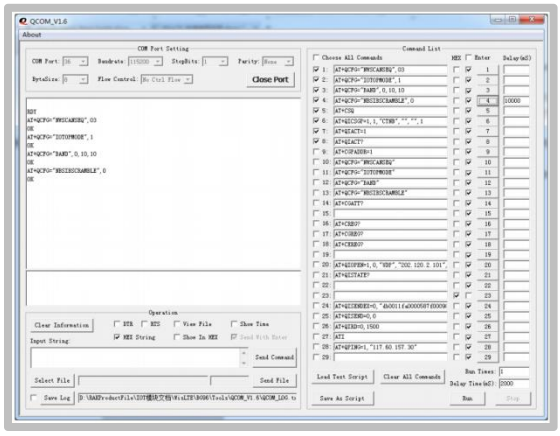
   (China Telecom's NB-IoT SIM card is used in this example. Please modify the AT commands as required according to the NBIoT network being used to provide your service. For more information on AT commands, please refer to: Quectel BG96 Network Searching Scheme Introduction.)

```
AT+QCFG="NWSCANSEQ",03  // Set the scanning network to NB-IoT network
AT+QCFG="IOTOPMODE",1
AT+QCFG="BAND",0,10,10  // Set the scan channel to BAND5
AT+QCFG="NBSIBSCRAMBLE",0
```

   You can also manually search the current network to connect. Use the following commands to do manual search and connection:

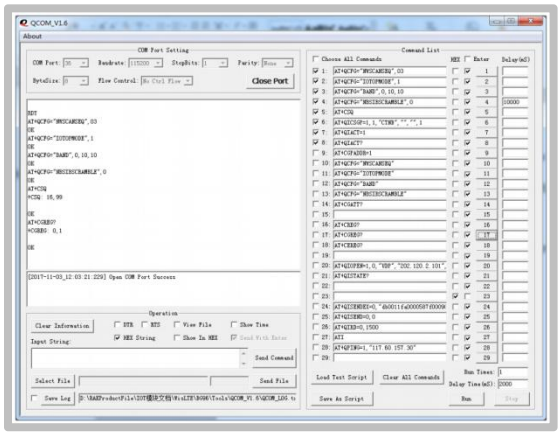
```
AT+COPS=?                       // Manually search the current network
AT+COPS=1,0,"CHN-CT",9          // Manually connect NB-IoT network
```

*These commands can be found in the: Quectel BG96 AT Commands Manual.*



***Screenshot 4*** *| NB-IoT UDP Communication Test*

6. After setting the configuration, send `AT + CSQ` to check network signal strength. If there is a signal strength value, it indicates the module has connected to NB-IoT network. You can also send `AT + CGREG?` to check the connection status of the network to determine whether or not to connect to the network:

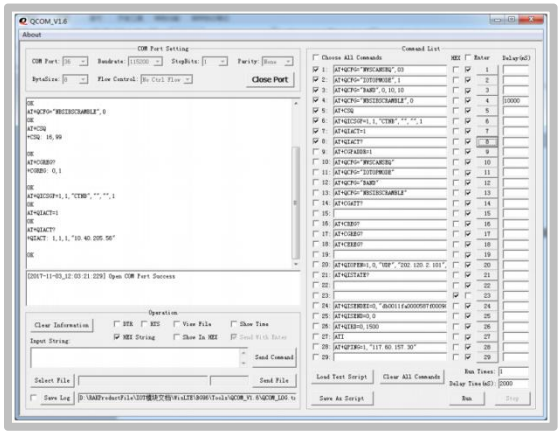


***Screenshot 5*** *| Check Network Signal Strength*

7. After connecting to the network, you need to set up the APN and activate the APN network. You can set the APN by sending the following commands:

```
AT+QICSGP=1,1,"CTNB","","",1          // Set APN parameters
AT+QIACT=1                        // Activate APN
AT+QIACT?                  // Query the APN assigned IP address
```

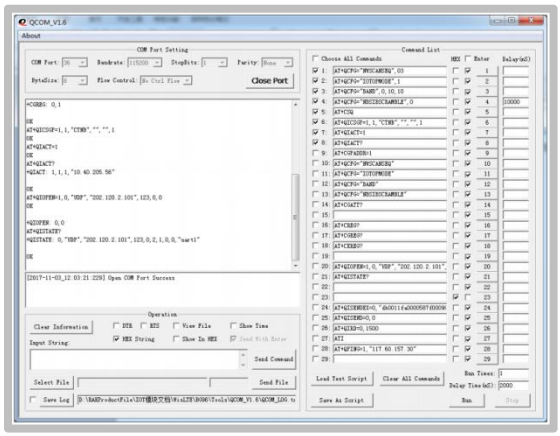
*For command details, please refer to Quectel BG96 TCP (IP) AT Commands Manual.*



***Screenshot 6** | Setup and Activate APN*

8. After activating the APN, you can establish a UDP connection; (In China Telecom's NB-IoT network, you must first inform the operator of your server's IP address. The operator will make binding before the connection is successful. The behavior of other networks might be different).

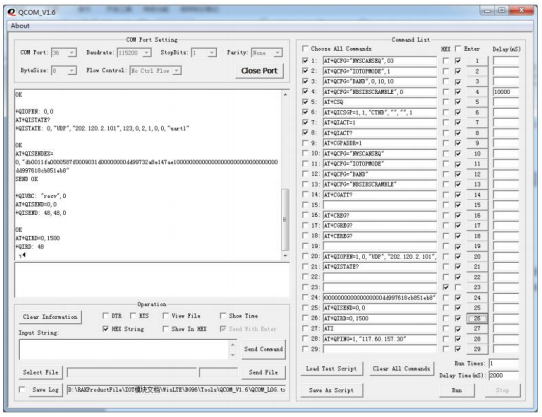
```
AT+QIOPEN=1,0,"UDP","202.120.2.101",123,0,0 //Establish UDP connection
AT+QISTATE?          // Query connection is successful
```



***Screenshot 7** | Establish UDP Connection*

9. If sending data to the server, there will be a prompt to receive data "recv". If there is no prompt, you can send the following commands to check if there is data reception.

```
AT+QISENDEX=0,"db0011fa0000587f0009031d00000000dd99732a8e147ae10000000
00000000000000000000000000dd997618cb851eb8" // send data
AT+QISEND=0,0   // Query data is sent successfully
AT+QIRD=0,1500 // Check if there is data received, if there is,
print it out directly
```



*Screenshot 8 | Check Data Reception*

### 4.1.4 GPS Function Test

Follow these steps in order to test GPS Function:

1. Plug in the module GPS antenna.
2. Select Quectel USB AT Port corresponding to the COM port.
3. Open the serial port tool.
4. Send the commands listed below to control the module's GPS capabilities:

```
AT+QGPS=1              // Turn on GNSS
AT+QGPSLOC?            // Acquire Positioning Information
AT+QGPSEND             // Turn off GNSS
```

*For detailed GPS command description, please refer to: Quectel BG96 GNSS AT Commands Manual.*

5. GPS Function Test complete!

## 4.2 Use Arduino Header Interface

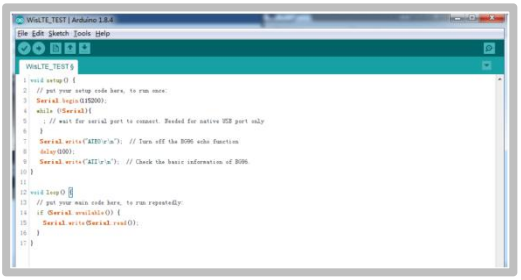
The RAK2011 also supports Arduino headers as defined by Arduino UNO R3. Please refer to the RAK2011 Arduino Header pin definition in the previous section.

Here is a test communication program to verify communication between an Arduino MCU base board and RAK2011.

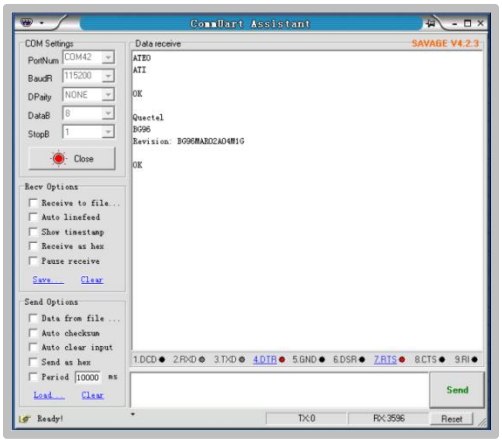
The Arduino library for RAK2011 can be downloaded from here:

https://github.com/RAKWireless/WisLTE_Arduino

```
void setup()
{
	// put your setup code here, to run once:
	Serial.begin(115200);
	while (!Serial)
	{
		; // wait for serial port to connect. For native USB port only
	}
}

void loop()
{
		// put your main code here to run repeatedly:
	if (Serial.available())
	{
		Serial.write(Serial.read());
	}
}
```



***Screenshot 9*** | *Arduino and MCU Communication Test*



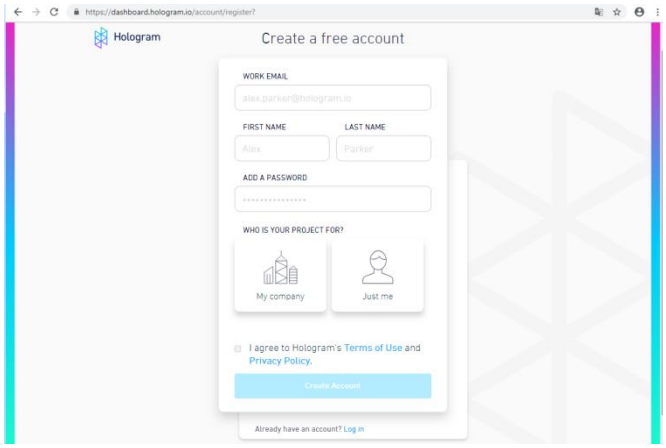

***Screenshot 10*** | *CommUART Assistant*

# 5 Hologram SIM Card

## 5.1 Creating an Hologram account

Hologram is the Connectivity Platform for the Internet of Things. You can connect devices, capture data, and manage your fleet through their complete IoT platform. Here is their official website: https://hologram.io/

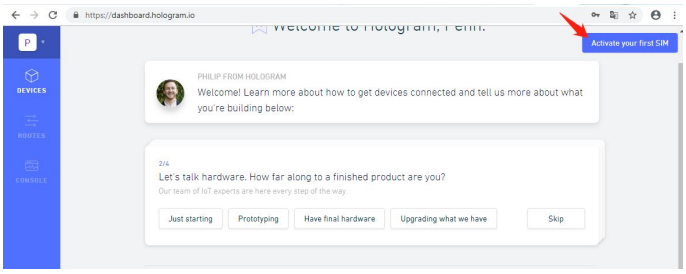
Please access this link to create an Hologram account：
https://dashboard.hologram.io/account/register?




*Screenshot 11 | Creating an Hologram account*

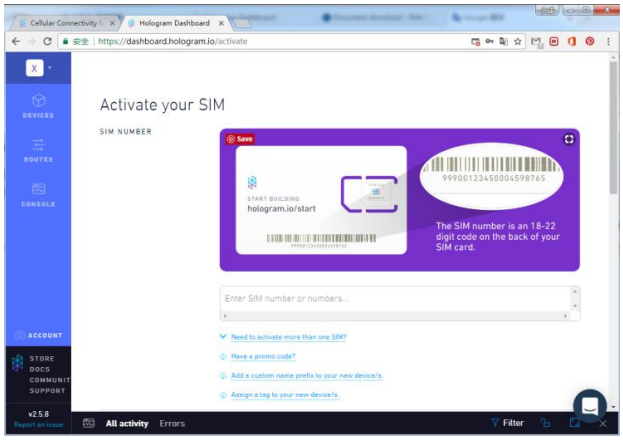
## 5.2 Activate the Hologram SIM

Log into your Hologram account and enter your Dashboard interface. Next you need to activate your purchased Hologram SIM card. Click on "Activate you first SIM" in the upper right of the page.



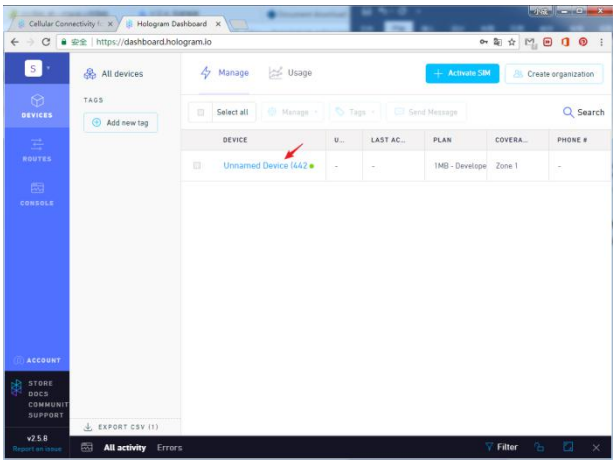

*Screenshot 12 | Activate you first SIM*

Enter the activation interface, according to the given prompts, fill in the information, you can complete the activation of the SIM card.

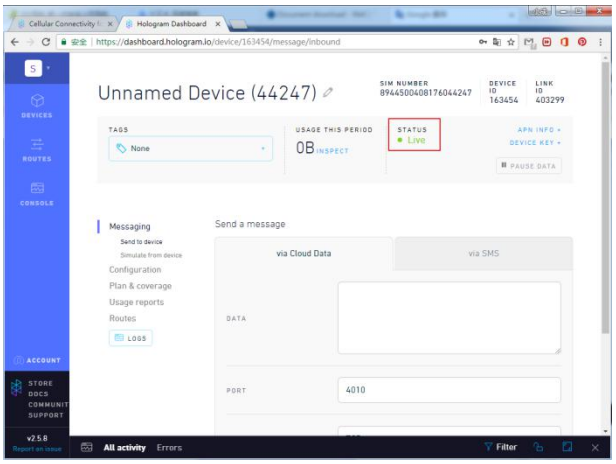



*Screenshot 13 | Input your SIM information*

Then enter the SIM card information interface. After waiting for a period of time, you will see the "Live" status, as the bellow screenshot shown.




*Screenshot 14 | Manage your SIM card*



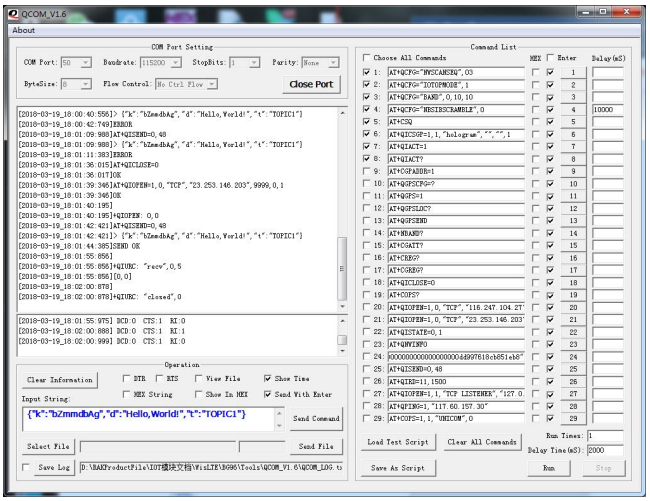

*Screenshot 15 | SIM card Status*

## 5.3 Send Data

Insert the SIM card into the board's slot, and then connect the board to the computer through the connection cable.( Please note that the LTE antenna needs to be connected)

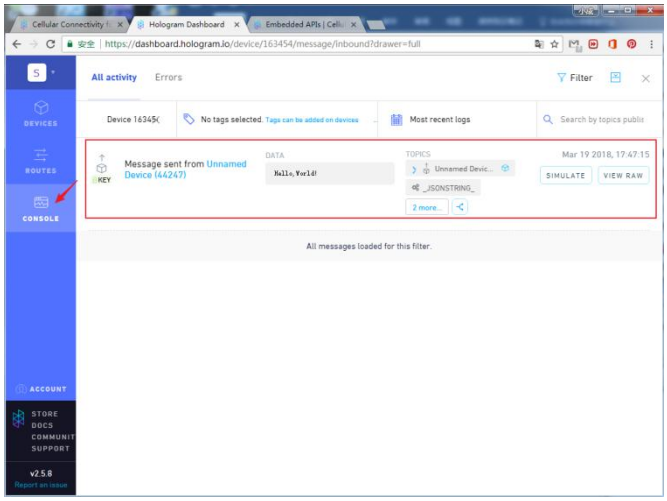
Find the port number of the AT Port and use the QCOM serial port tool to connect the board. Then send the following AT command.( For AT command details, see the AT command manual)

```
AT+COPS=?                          // Find nearby network information
AT+COPS=1,0,"CHINA MOBILE",0       // Manually set up a connected network
AT+CREG?                           // Check whether the device is registered on the
network
AT+QNWINFO                        // Query connected network information
AT+COPS?                           // Query the connected web server information
AT+QICSGP=1,1,"hologram","","",1  // Set APN network to hologram
AT+QIACT=1                         // Activate the APN network
AT+QIACT?                          // Query the APN assigned IP address
AT+QIOPEN=1,0,"TCP","23.253.146.203",9999,0,1  // Create a TCP, connection
hologram test server
AT+QISEND=0,48                     // Send data, send data length is 48
{"k":"bZmmdbAg","d":"Hello,World!","t":"TOPIC1"} //Send Packets.The data format
is a hologram-defined format.( For details, please see:
https://hologram.io/docs/reference/cloud/embedded/ )
AT+QISEND=0,0                     // Query data is sent successfully
```




*Screenshot 16 | Send data*

If the data is sent successfully, you can see the sent information on your interface of the Hologram Dashboard.

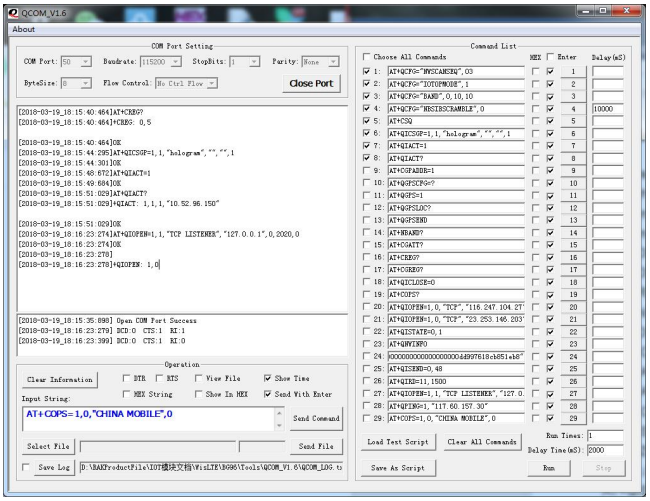



*Screenshot 17 | Send data successfully*

## 5.4 Receive Data

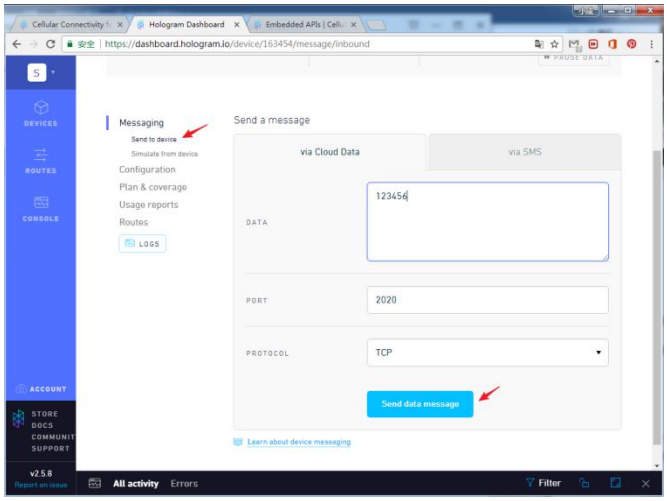
Receiving data is similar to sending data, except that the established socket is different. The receiving data is established as a TCP server. The AT commands sent are shown as below:

```
AT+COPS=?                       // Find nearby network information

AT+COPS=1,0,"CHINA MOBILE",0    // Manually set up a connected network

AT+CREG?                        // Check whether the device is registered on the
network

AT+QNWINFO                     // Query connected network information

AT+COPS?                        // Query the connected web server information

AT+QICSGP=1,1,"hologram","","",1  // Set APN network to hologram

AT+QIACT=1                      // Activate the APN network

AT+QIACT?                       // Query the APN assigned IP address

AT+QIOPEN=1,1,"TCP LISTENER","127.0.0.1",0,2020,0 // Create a TCP server, use
local IP, port 2020

AT+QIRD=11,1500                 // Read the received data, 11 is the returned
Socket identifier
```



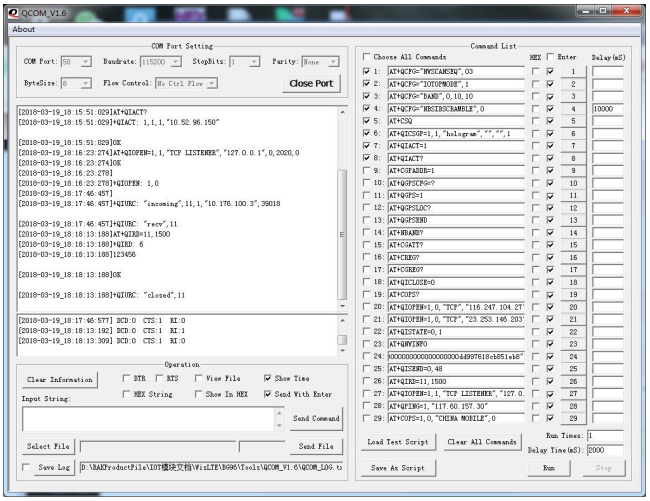

*Screenshot 18 | Create a TCP server*

After creating a successful TCP server, the user needs to return to the Hologram Dashboard interface, click on the "send to device" button, and then fill in the data to be sent. The PORT is the TCP server port of your board. Fill in and click "Send data message".




*Screenshot 19 | Send a message*

After sending the data in the Hologram Dashboard, the board will receive a message of "recv, 11" indicating that the board have already received the data. At this time, sending the "AT+QIRD=11,1500" command to obtain the received data.




*Screenshot 20 | Receive the data*

# 6 Certification

## BG96 Module Certification

| Cat-M1 | Cat-NB1 | EGPRS | GNSS | Chipset |
|---|---|---|---|---|
| LTE FDD:<br>B1/B2/B3/B4/B5<br>B8/B12/B13/B18<br>B19/B20/B26/B28<br>LTE TDD:<br>B39(For Cat-M1 Only) | LTE FDD:<br>B1/B2/B3/B4/B5/B8/B12/B<br>13/B18/B19/B20/B26/<br>B28 | 850/1900MHz<br>900/1800MHz | GPS<br>GLONASS,<br>BeiDou/Compass<br>Galileo<br>QZSS | Qualcomm<br>(MDM9206) |

*Table 15 | BG96 Module Certification*

## Regulatory Certification

## Certification Body

## WisLink Cellular BG96 Arduino Shield Pass Certification

| | | | | |
|---|---|---|---|---|
| FCC part 2/15B | EN 301 489-1/17/19/52<br>EN 55032<br>EN 55035<br>EN 301511<br>EN 301 908-1<br>EN 300328<br>EN 303 413<br>EN 62311<br>EN 60950-1 | Directive 2012/19/EU | RoHS Directive 2015/863/EU amending Annex II to 2011/65/EU<br>IEC 62321-2:2013<br>IEC 62631-1:2013<br>IEC 62631-3-1:2013<br>IEC 62631-5:2013<br>IEC 62631-4:2013<br>IEC 62631-7-1:2015<br>IEC 62631-7-2:2017<br>IEC 62631-6:2015 | Radio Equipment (R)<br>- Cellular Module: 003-180062<br>- Wi-Fi Module: 018-150012<br>Terminal Equipment (T)<br>- Cellular Module: D180034003<br>- Wi-Fi Module: D180063003 |

*Table 16 | WisLink Cellular BG96 Arduino Shield Pass Certification*

# 7 Contact Information

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# 8 Revision History

| Revision | Description | Date |
|---|---|---|
| 1.0 | Initial Release | June 23, 2017 |
| 1.1 | Improved content and layout | August 2018 |
| 1.2 | Add certification information, update some words or phases in right context | October 2018 |
| 2.0 | Add the Hologram SIM Card chapter | November 2018 |

*Table 17 | Revision History*

# 9 Document Summary

**Document Title:** WisLink Cellular BG96 Arduino Shield RAK2011 User Manual
**Product Name:** RAK2011
**Release Date:** November 2018
**Revision Number:** V2.0

| Prepared by | Checked by: | Approved by: |
|---|---|---|
| | | |

**About RAKwireless:**

Shenzhen Rakwireless Technology is a pioneer in providing innovated Lego-like IoT module solutions for the three critical elements of IoT edge devices – edge computing, cloud connectivity, and node sensing. It's patented,modularized, simplified design of combining one, two, or all the three elements to significantly help address diverse IoT applications and accelerate time-to-market.