



## **BL-WN650BT**

**802.11ac 433Mbps WiFi + Bluetooth 4.2  
USB Combo Dongle Specification**

**SHENZHEN BILIAN ELECTRONIC CO., LTD**

Add: 10~11/F, Building 1A, Huaqiang idea park, Guangming district, Shenzhen. Guangdong, China  
Web: [www.b-link.net.cn](http://www.b-link.net.cn)



Top View

|                                                                                  |       |
|----------------------------------------------------------------------------------|-------|
| Dongle Name: BL-WN650BT                                                          |       |
| Module Type: 802.11a/b/g/n/ac 433Mbps 1T1R WiFi + Bluetooth 4.2 USB Combo Dongle |       |
| Revision: V0.1                                                                   |       |
| Customer Approval:                                                               |       |
| Company:                                                                         |       |
| Title:                                                                           |       |
| Signature:                                                                       | Date: |
| BL-link Approval:                                                                |       |
| Title:                                                                           |       |
| Signature:                                                                       | Date: |

## Revision History

| Revision | Summary          | Release Date |
|----------|------------------|--------------|
| 0.1      | Internal release | 2020-05-29   |
|          | Official release |              |
|          |                  |              |
|          |                  |              |

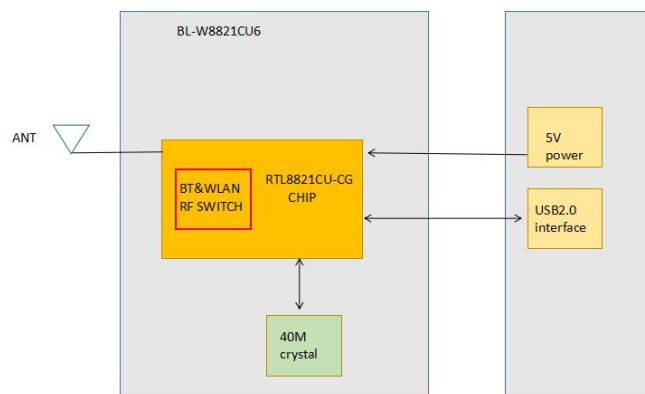
## 1. Introduction

The BL-WN650BT is a highly integrated 1T1R 802.11a/b/g/n/ac Wireless LAN (WLAN) network and bluetooth combo dongle. The dongle's interface is USB 1.0/1.1/2.0. It combines a WLAN MAC, a 1T1R capable WLAN base band. Bluetooth support 4.2 performance. The BL-WN650BT dongle provides a complete solution for a high throughput performance integrated wireless LAN and BT device.

### 1.1 Features

- Operating Frequencies: 2.4~2.4835GHz and 5.15~5.85GHz
- Host Interface is USB2.0
- IEEE Standards: IEEE 802.11a/b/g/n/ac
- Wireless data rate can reach up to 433Mbps
- Bluetooth 3.1/3.0/4.1/4.2LE
- Internal steel PIFA antenna
- Power Supply: VDD5 5V±0.3V main power supply

## 1.2 Block Diagram



## 1.3 General Specifications

|                       |                                                             |
|-----------------------|-------------------------------------------------------------|
| Dongle Name           | BL-WN650BT , WiFi + BT Combo Dongle                         |
| Chipset               | RTL8821CU-CG                                                |
| WiFi Standards        | IEEE802.11a/b/g/n/ac , 1T1R SISO , 2.4G/5GHz , 433Mbps(Max) |
| Bluetooth Standards   | Bluetooth v2.1+EDR , Bluetooth4.2LE , 3Mbps(Max)            |
| Host Interface        | USB2.0 for WiFi and Bluetooth                               |
| Antenna               | Internal steel PIFA antenna                                 |
| Dimension             | 20.4*14.6*6.28mm (L*W*H) , Tolerance: +/-0.2mm              |
| Power Supply          | DC 5V±0.3V @ 350 mA (Max)                                   |
| Operation Temperature | -0°C to +40°C                                               |
| Operation Humidity    | 10% to 95% RH (Non-Condensing)                              |

## 2. Electrical and Thermal Specifications

### 2.1 Recommended Operating Conditions

| Parameters                                   |      | Min | Typ | Max | Units |
|----------------------------------------------|------|-----|-----|-----|-------|
| Ambient Operating Temperature                |      | 0   | 25  | 40  | °C    |
| Internal Antenna Voltage Standing Wave Ratio |      | 1.5 | 2   | 3   | /     |
| Supply Voltage                               | VDD5 | 4.7 | 5.0 | 5.3 | V     |

## 2.2 Digital I/O DC Specifications

| Symbol | Parameter           | Min  | Typ | Max  | Units |
|--------|---------------------|------|-----|------|-------|
| VIH    | Input High Voltage  | 2.0  | 3.3 | 3.6  | V     |
| VIL    | Input Low Voltage   | --   | 0   | 0.9  | V     |
| VOH    | Output High Voltage | 2.97 | --  | 3.3  | V     |
| VOL    | Output Low Voltage  | 0    | --  | 0.33 | V     |

## 2.3 Current Consumption

| Conditions : VDD5=5V ; Ta:25°C               |                        |     |       |
|----------------------------------------------|------------------------|-----|-------|
| Use Case                                     | VBAT Current (average) |     |       |
|                                              | Typ                    | Max | Units |
| WiFi Radio Off (Linux Driver)                | 60                     | 80  | mA    |
| WiFi Unassociated (Linux Driver, BT_Disable) | 70                     | 100 | mA    |
| 2.4G 1Mbps TX (RF-Test)                      | 270                    | 290 | mA    |
| 2.4G 1Mbps RX (RF-Test)                      | 70                     | 80  | mA    |
| 2.4G 11Mbps TX (RF-Test)                     | 190                    | 210 | mA    |
| 2.4G 11Mbps RX (RF-Test)                     | 71                     | 82  | mA    |
| 2.4G 6Mbps TX (RF-Test )                     | 170                    | 190 | mA    |
| 2.4G 6Mbps RX (RF-Test)                      | 72                     | 85  | mA    |
| 2.4G 54Mbps TX (RF-Test)                     | 120                    | 150 | mA    |
| 2.4G 54Mbps RX (RF-Test)                     | 72                     | 82  | mA    |
| 2.4G MCS0(HT20) TX (RF-Test)                 | 170                    | 190 | mA    |
| 2.4G MCS0(HT20) RX (RF-Test)                 | 72                     | 80  | mA    |
| 2.4G MCS7(HT20) TX (RF-Test)                 | 110                    | 130 | mA    |
| 2.4G MCS7(HT20) RX (RF-Test)                 | 72                     | 82  | mA    |

|                                                     |     |     |    |
|-----------------------------------------------------|-----|-----|----|
| 2.4G MCS7(HT40) TX (RF-Test)                        | 110 | 130 | mA |
| 2.4G MCS7(HT40) RX (RF-Test)                        | 72  | 83  | mA |
| 5.8G 6Mbps TX (RF-Test )                            | 210 | 230 | mA |
| 5.8G 6Mbps RX (RF-Test)                             | 78  | 89  | mA |
| 5.8G 54Mbps TX (RF-Test)                            | 130 | 150 | mA |
| 5.8G 54Mbps RX (RF-Test)                            | 75  | 88  | mA |
| 5.8G MCS0(HT20) TX (RF-Test)                        | 210 | 230 | mA |
| 5.8G MCS0(HT20) RX (RF-Test)                        | 73  | 90  | mA |
| 5.8G MCS7(HT40) TX (RF-Test)                        | 120 | 140 | mA |
| 5.8G MCS7(HT40) RX (RF-Test)                        | 75  | 87  | mA |
| 5.8G MCS0(HT80) TX (RF-Test)                        | 140 | 160 | mA |
| 5.8G MCS0(HT80) RX (RF-Test)                        | 85  | 95  | mA |
| 5.8G MCS9(HT80) TX (RF-Test)                        | 110 | 130 | mA |
| 5.8G MCS9(HT80) RX (RF-Test)                        | 85  | 97  | mA |
|                                                     |     |     |    |
| Bluetooth Unassociated (Linux Driver, WiFi_Disable) | 50  | 70  | mA |
| BT BR_1M DH5 TX@6dBm(MPTools, WiFi_Disable)         | 97  | 110 | mA |
| BT EDR_3M DH5 TX@6dBm(MPTools, WiFi_Disable)        | 100 | 110 | mA |
| BT LE_1M TX@6dBm(MPTools, WiFi_Disable)             | 95  | 110 | mA |
| BT BR_1M DH5 RX Active(MPTools, WiFi_Disable)       | 72  | 82  | mA |
| BT EDR_3M DH5 RX Active(MPTools, WiFi_Disable)      | 71  | 83  | mA |
| BT LE_1M RX Active(MPTools, WiFi_Disable)           | 72  | 83  | mA |

### 3. WiFi & Bluetooth RF Specifications

#### 3.1 2.4G WiFi RF Specification

| Conditions : VDD5=5V ; Ta:25°C  |                                                                                                                                                                                                         |                      |        |
|---------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|--------|
| Features                        | Description                                                                                                                                                                                             |                      |        |
| WLAN Standard                   | IEEE 802.11b/g/n CSMA/CA                                                                                                                                                                                |                      |        |
| Frequency Range                 | 2.4~2.4835GHz (2.4GHz ISM Band)                                                                                                                                                                         |                      |        |
| Channels                        | Ch1~Ch13 (For 20MHz Channels)                                                                                                                                                                           |                      |        |
| Modulation                      | 802.11b (DSSS) : DBPSK , DQPSK , CCK ;<br>802.11g (OFDM) : BPSK , QPSK , 16QAM , 64QAM ;<br>802.11n (OFDM) : BPSK , QPSK , 16QAM , 64QAM ;                                                              |                      |        |
| Date Rate                       | 802.11b : 1 , 2 , 5.5 , 11Mbps ;<br>802.11g : 6 , 9 , 12 , 18 , 24 , 36 , 48 , 54Mbps ;<br>802.11n (HT20) : MCS0~MCS7(1T1R_SISO) 6.5~72.2Mbps ;<br>802.11n (HT40) : MCS0~MCS7(1T1R_SISO) 13.5~150Mbps ; |                      |        |
| Frequency Tolerance             | ≤ ±15ppm                                                                                                                                                                                                |                      |        |
| 2.4G Transmitter Specifications |                                                                                                                                                                                                         |                      |        |
| TX Rate                         | TX Power                                                                                                                                                                                                | TX Power Tolerance   | EVM    |
| 802.11b@1~11Mbps                | 17dBm                                                                                                                                                                                                   | ±1.5dBm              | ≤-10dB |
| 802.11g@6Mbps                   | 17dBm                                                                                                                                                                                                   | ±1.5dBm              | ≤-10dB |
| 802.11g@54Mbps                  | 14dBm                                                                                                                                                                                                   | ±1.5dBm              | ≤-25dB |
| 802.11n@HT20_MCS0               | 17dBm                                                                                                                                                                                                   | ±1.5dBm              | ≤-10dB |
| 802.11n@HT20_MCS7               | 14dBm                                                                                                                                                                                                   | ±1.5dBm              | ≤-28dB |
| 802.11n@HT40_MCS0               | 17dBm                                                                                                                                                                                                   | ±1.5dBm              | ≤-10dB |
| 802.11n@HT40_MCS7               | 14dBm                                                                                                                                                                                                   | ±1.5dBm              | ≤-28dB |
| 2.4G Receiver Specifications    |                                                                                                                                                                                                         |                      |        |
| RX Rate                         | Min Input Level(Typ)                                                                                                                                                                                    | Max Input Level(Typ) | PER    |
| 802.11b@1Mbps                   | -94dBm                                                                                                                                                                                                  | -10dBm               | < 8%   |
| 802.11b@11Mbps                  | -86dBm                                                                                                                                                                                                  | -10dBm               | < 8%   |
| 802.11g@6Mbps                   | -90dBm                                                                                                                                                                                                  | -15dBm               | < 10%  |
| 802.11g@54Mbps                  | -74dBm                                                                                                                                                                                                  | -15dBm               | < 10%  |
| 802.11n@HT20_MCS0               | -88dBm                                                                                                                                                                                                  | -15dBm               | < 10%  |
| 802.11n@HT20_MCS7               | -70dBm                                                                                                                                                                                                  | -15dBm               | < 10%  |
| 802.11n@HT40_MCS0               | -86dBm                                                                                                                                                                                                  | -15dBm               | < 10%  |

|                   |        |        |       |
|-------------------|--------|--------|-------|
| 802.11n@HT40_MCS7 | -68dBm | -15dBm | < 10% |
|-------------------|--------|--------|-------|

### 3.2 5G WiFi RF Specification

| Conditions : VDD5=5V ; Ta:25°C           |                                                                                                                                                                                                                                                                                                                                                  |                    |        |
|------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|--------|
| Features                                 | Description                                                                                                                                                                                                                                                                                                                                      |                    |        |
| WLAN Standard                            | IEEE 802.11a/n/ac CSMA/CA                                                                                                                                                                                                                                                                                                                        |                    |        |
| Frequency Range                          | 5.15~5.25GHz ; 5.25~5.35GHz ; 5.47~5.73GHz ;<br>5.735~5.835GHz (5GHz ISM Band) ;                                                                                                                                                                                                                                                                 |                    |        |
| Channels                                 | Ch36 , Ch40 , Ch44 , Ch48 ; Ch52~Ch64 ; Ch100~Ch140 ; Ch149~Ch165 (For 20MHz Channels)                                                                                                                                                                                                                                                           |                    |        |
| Modulation                               | 802.11a (OFDM) : BPSK , QPSK , 16QAM , 64QAM ;<br>802.11n (OFDM) : BPSK , QPSK , 16QAM , 64QAM ;<br>802.11ac (OFDM) : BPSK , QPSK , 16QAM , 64QAM , 256QAM ;                                                                                                                                                                                     |                    |        |
| Date Rate                                | 802.11a: 6 , 9 , 12 , 18 , 24 , 36 , 48 , 54Mbps ;<br>802.11n (HT20) : MCS0~MCS7(1T1R_SISO) 6.5~72.2Mbps ;<br>802.11n (HT40) : MCS0~MCS7(1T1R_SISO) 13.5~150Mbps ;<br>802.11ac (VHT20) : MCS0~MCS8(1T1R_SISO) 6.5~86.7Mbps ;<br>802.11ac (VHT40) : MCS0~MCS9(1T1R_SISO)13.5~200Mbps ;<br>802.11ac (VHT80) : MCS0~MCS9(1T1R_SISO)29.3~433.3Mbps ; |                    |        |
| Frequency Tolerance                      | ≤ ±15ppm                                                                                                                                                                                                                                                                                                                                         |                    |        |
| 5G Transmitter Specifications            |                                                                                                                                                                                                                                                                                                                                                  |                    |        |
| TX Rate                                  | TX Power                                                                                                                                                                                                                                                                                                                                         | TX Power Tolerance | EVM    |
| 802.11a@6Mbps                            | 16dBm                                                                                                                                                                                                                                                                                                                                            | ±1.5dBm            | ≤-10dB |
| 802.11a@54Mbps                           | 13dBm                                                                                                                                                                                                                                                                                                                                            | ±1.5dBm            | ≤-25dB |
| 802.11n@HT20_MCS0<br>802.11ac@VHT20_MCS0 | 16dBm                                                                                                                                                                                                                                                                                                                                            | ±1.5dBm            | ≤-10dB |
| 802.11n@HT20_MCS7<br>802.11ac@VHT20_MCS7 | 13dBm                                                                                                                                                                                                                                                                                                                                            | ±1.5dBm            | ≤-28dB |
| 802.11n@HT40_MCS0<br>802.11ac@VHT40_MCS0 | 16dBm                                                                                                                                                                                                                                                                                                                                            | ±1.5dBm            | ≤-10dB |

|                                            |                             |                             |            |
|--------------------------------------------|-----------------------------|-----------------------------|------------|
| 802.11n@HT40_MCS7<br>802.11ac@VHT40_MCS7   | 13dBm                       | ±1.5dBm                     | ≤-28dB     |
| 802.11ac@VHT20_MCS8                        | 13dBm                       | ±1.5dBm                     | ≤-30dB     |
| 802.11ac@VHT40_MCS8<br>802.11ac@VHT40_MCS9 | 11dBm                       | ±1.5dBm                     | ≤-32dB     |
| 802.11ac@VHT80_MCS0                        | 15dBm                       | ±1.5dBm                     | ≤-10dB     |
| 802.11ac@VHT80_MCS9                        | 11dBm                       | ±1.5dBm                     | ≤-32dB     |
| <b>5G Receiver Specifications</b>          |                             |                             |            |
| <b>RX Rate</b>                             | <b>Min Input Level(Typ)</b> | <b>Max Input Level(Typ)</b> | <b>PER</b> |
| 802.11a@6Mbps                              | -90dBm                      | -20dBm                      | < 10%      |
| 802.11a@54Mbps                             | -73dBm                      | -20dBm                      | < 10%      |
| 802.11n@HT20_MCS0                          | -88dBm                      | -20dBm                      | < 10%      |
| 802.11n@HT20_MCS7                          | -70dBm                      | -20dBm                      | < 10%      |
| 802.11n@HT40_MCS0                          | -86dBm                      | -20dBm                      | < 10%      |
| 802.11n@HT40_MCS7                          | -68dBm                      | -20dBm                      | < 10%      |
| 802.11ac@VHT20_MCS8                        | -71dBm                      | -20dBm                      | < 10%      |
| 802.11ac@VHT40_MCS9                        | -65dBm                      | -20dBm                      | < 10%      |
| 802.11ac@VHT80_MCS0                        | -84dBm                      | -20dBm                      | < 10%      |
| 802.11ac@VHT80_MCS9                        | -57dBm                      | -20dBm                      | < 10%      |

### 3.3 Bluetooth RF Specifications

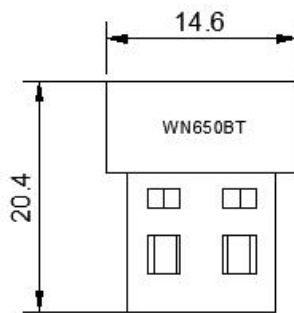
| <b>Conditions : VDD5=5V ; Ta:25°C</b> |                                                                                                                 |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------------|
| <b>Features</b>                       | <b>Description</b>                                                                                              |
| Bluetooth Specification               | Bluetooth v2.1+EDR/3.0+HS (Bluetooth Classic _ BT BR/EDR) ,<br>Bluetooth 4.2(Bluetooth Low Energy _ BT_LE) FHSS |
| Frequency Range                       | 2.4~2.4835GHz (2.4GHz ISM Band)                                                                                 |
| Channels                              | Bluetooth Classic : Ch0~Ch78 (For 1MHz Channels);<br>Bluetooth Low Energy : Ch0~Ch39 (For 2MHz Channels);       |
| Power Classes                         | Bluetooth Classic : Class1 ;<br>Bluetooth Low Energy : Class1.5 ;                                               |

|                                                                  |                                                                                               |              |            |
|------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|--------------|------------|
| Date Rate & Modulation                                           | BR_1Mbps : GFSK ;<br>EDR_2Mbps : $\pi/4$ -DQPSK ;<br>EDR_3Mbps : 8DPSK ;<br>LE_1Mbps : GFSK ; |              |            |
| Bluetooth Transmitter Specifications                             |                                                                                               |              |            |
| Items                                                            | Min                                                                                           | Typ          | Max        |
| TX Power                                                         |                                                                                               |              |            |
| BR_1M TX Power                                                   | 1                                                                                             | 5            | 9          |
| EDR_2/3M TX Power                                                | 1                                                                                             | 5            | 9          |
| LE_1M TX Power                                                   | 1                                                                                             | 5            | 9          |
| BR_1M Modulation Characteristics                                 |                                                                                               |              |            |
| $\Delta f_{1avg}$                                                | 157kHz                                                                                        | 156kHz       | 175kHz     |
| $\Delta f_{2avg}$                                                | 150kHz                                                                                        | 159kHz       | 175kHz     |
| $\Delta f_{2max}$ [For at least 99.9% of all $\Delta f_{2max}$ ] | 159kHz                                                                                        | 159kHz       | 175kHz     |
| $\Delta f_{2avg}$ / $\Delta f_{1avg}$                            | 0.95                                                                                          | 1.01         | --         |
| BR_1M Carrier Frequency Drift                                    |                                                                                               |              |            |
| 1solt(DH1)                                                       | -23kHz                                                                                        | $\pm 14$ kHz | 25kHz      |
| 3/5solt(DH3/DH5)                                                 | -40kHz                                                                                        | $\pm 13$ kHz | 40kHz      |
| Max Drift Rate                                                   | --                                                                                            | 10kHz/50uS   | 20kHz/50uS |
| EDR_2/3M Relative Transmit Power                                 |                                                                                               |              |            |
| EDR Diff Power                                                   | -4dB                                                                                          | -1.5dB       | 1dB        |
| EDR Carrier Frequency Stability                                  |                                                                                               |              |            |
| $\omega_i$                                                       | -10kHz                                                                                        | $\pm 20$ kHz | 10kHz      |
| $\omega_o$                                                       | -75kHz                                                                                        | $\pm 20$ kHz | 75kHz      |
| $\omega_i + \omega_o$                                            | -75kHz                                                                                        | $\pm 20$ kHz | 75kHz      |
| EDR Modulation Accuracy                                          |                                                                                               |              |            |
| RMS DEVM (EDR_2M)                                                | --                                                                                            | 5.3%         | 20%        |
| 99% DEVM (EDR_2M)                                                | --                                                                                            | 6%           | 30%        |

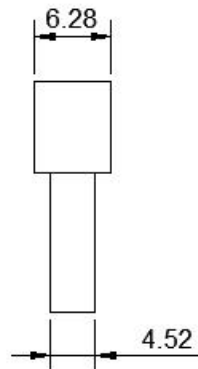
|                                                     |                  |        |                     |        |
|-----------------------------------------------------|------------------|--------|---------------------|--------|
| Peak DEVM (EDR_2M)                                  | --               | 4.9%   | 35%                 |        |
| RMS DEVM (EDR_3M)                                   | --               | 7%     | 13%                 |        |
| 99% DEVM (EDR_3M)                                   | --               | 5.9%   | 20%                 |        |
| Peak DEVM (EDR_3M)                                  | --               | 6%     | 25%                 |        |
| LE_Modulation characteristics                       |                  |        |                     |        |
| Δf1avg (LE_1M)                                      | 224kHz           | 227kHz | 275kHz              |        |
| Δf2avg (LE_1M)                                      | 190kHz           | 209kHz | 275kHz              |        |
| Δf2max[For at least 99.9% of all<br>Δf2max] (LE_1M) | 190kHz           | 210kHz | 275kHz              |        |
| Δf2avg / Δf1avg (LE_1M)                             | 0.85             | 0.92   | --                  |        |
| LE_Carrier frequency offset and drift               |                  |        |                     |        |
| Frequency offset                                    | -150kHz          | --     | 150kHz              |        |
| Frequency drift                                     | -50kHz           | --     | 50kHz               |        |
| Max drift rate                                      | -20kHz/50uS      | --     | 20kHz/50uS          |        |
| Bluetooth Receiver Specifications                   |                  |        |                     |        |
| Items                                               | Sensitivity      |        | Maximum Input Level |        |
|                                                     | Input Level(Typ) | BER    | Input Level(Typ)    | BER    |
| BR_1M                                               | -80dBm           | ≤0.1%  | -20dBm              | ≤0.1%  |
| EDR_2M                                              | -72dBm           | ≤0.01% | -20dBm              | ≤0.01% |
| EDR_3M                                              | -72dBm           | ≤0.01% | -20dBm              | ≤0.01% |
| LE_1M                                               | -75dBm           | ≤30.8% | -20dBm              | ≤30.8% |

## 4. Mechanical Specifications

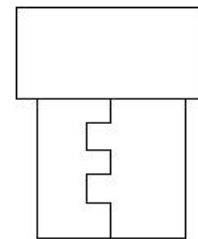
### 4.1 Module Outline Drawing



Top View



Side View

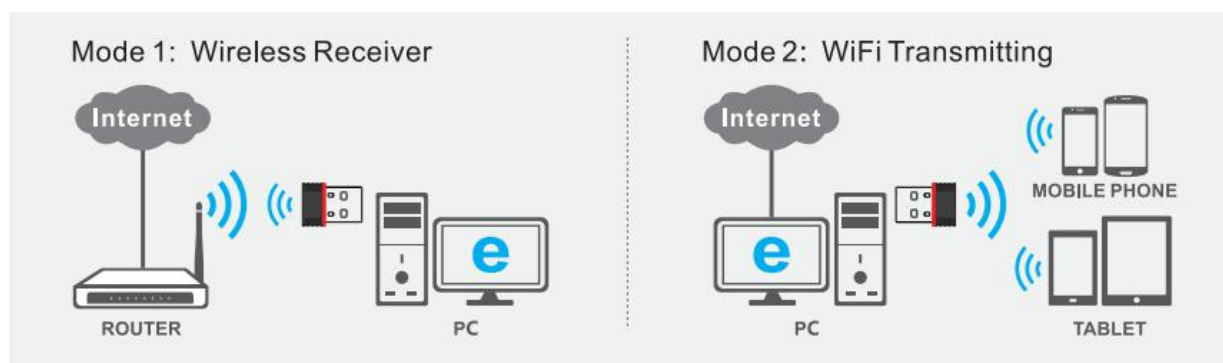


Bottom View

Module dimension: 20.4mm\*14.6mm\*6.28mm ( L\*W\*H ; Tolerance:  $\pm 0.2\text{mm}$  )

## 5. Application Information

### 5.1 Typical Application



## 6. Key Components Of Module

| No. | Parts    | Specification         | Manufacturer                                 | Note |
|-----|----------|-----------------------|----------------------------------------------|------|
| 1   | Chipset  | RTL8821CU-CG          | REALTEK                                      |      |
| 2   | PCB      | BL-W8821CU6           | Guang Dong KING SHINE Technology             |      |
|     |          |                       | MILLION SOURCE PRINTED CIRCUIT BOARD CO.,LTD |      |
|     |          |                       | Quzhou Sunlord Electronics Co.,Ltd           |      |
| 2   | Crystal  | 40MHz-10pF-10ppm-2520 | HOSONIC ELECTRONIC CO., LTD.                 |      |
|     |          |                       | HUBEI TKD ELECTRONICS TECHNOLOGY CO.,LTD.    |      |
|     |          |                       | LUCKI CM ELECTRONICS CO,LTD                  |      |
| 3   | Diplexer | DP1005-E2455FB-ACX    | ACX                                          |      |
|     |          |                       | TDK China Co., Ltd.                          |      |