

# **USER MANUAL**

**802.11b/g/n 1Tx1R + BT5.0 IOT Combo Module**

**Model Name: RIGEL**



## 1. FEATURE AND SPECIFICATIONS

### 1.1 DESCRIPTION

RTL8721CSM is a highly integrated single-chip low power single band(2.4GHz) Wireless LAN (WLAN) and Bluetooth Low Energy (BLE5.0) communication controller. It consists of a high performance MCU (ARMv8-M, Cortex-M33 instruction set compatible) called Real-M300 (or KM4 thereafter) and a low power MCU (ARMv8-M, Cortex-M23 instruction set compatible) called Real-M200 (or KM0 thereafter), WLAN(802.11 b/g/n) MAC, an 1T1R capable WLAN baseband, RF, Bluetooth and peripherals.

### 1.2 PRODUCT FEATURES

**RTL8721CSM device contains dual processors:**

#### ■ **KM4 CPU**

- Cortex-M33 instruction set compatible
  - Floating Point Unit (FPU)
  - DSP
  - TrustZone-M
- Running at a frequency of up to 200MHZ (configurable)
- Memory Protection (MPU)
- Built-in Nested Vectored Interrupt Controller (NVIC)
- Non-maskable Interrupt (NMI) with a selection of sources
- 32KB I-Cache and 4KB D-Cache
- Up to 512KB contiguous main SRAM@200MHz
- Optional 4MB PSRAM@50MHz

#### ■ **KM0 CPU**

- Cortex-M33 instruction set compatible
- Running at a frequency of up to 20MHZ
- Built-in Nested Vectored Interrupt Controller (NVIC)
- Non-maskable Interrupt (NMI) with a selection of sources
- 16KB I-Cache and 4KB D-Cache
- Up to 64KB contiguous main SRAM
- Up to 1KB retention SRAM for keeping data in power saving mode

**Module feature includes:**

- Bluetooth Low Energy V5.0
- Bluetooth Class I transmission power
- Both central and peripheral modes
- Internal co-existence mechanism between Wi-Fi and BT to share the same antenna
- Operate at ISM frequency Band (2.4GHz)
- IEEE Standards Support, 802.11b, 802.11g, 802.11n
- Support for both 20 MHz, 40MHz channel width in 2.4GHz band
- Low power architecture
- Low power Tx/Rx for short range application @1.8V
- Low power beacon listen mode
- Low power RX mode
- Very low power suspends mode (DLPS)
- Built-in PA, also supports external PA and LNA
- Supports Antenna Diversity
- RoHS directive compliance

## 1.3 PRODUCT SPECIFICATIONS

### MAIN CHIPSET

Realtek RTL8721CSM

### FUNCTIONAL SPECIFICATIONS

| BT Function           |                      |
|-----------------------|----------------------|
| Standard              | Bluetooth V5.0LE     |
| Bus Interface         | UART                 |
| Data Rate             | 1 Mbps, 2Mbps        |
| Modulation Scheme     | GFSK                 |
| Frequency Range       | 2.400~2.4835 GHz     |
| Operating Channel     | 0~39                 |
| Transmit Output Power | Typical 4.5dBm       |
| Receiver Sensitivity  | < 0.1% BER at -88dBm |

| Wi-Fi Function       |   |
|----------------------|---|
| Standard             | IEEE802.11b; IEEE 802.11g; IEEE 802.11n                             |
| Bus Interface        | UART  |
| Data Rate            | <b>802.11b:</b><br>11, 5.5, 2, 1 Mbps                               |
|                      | <b>802.11g:</b><br>54, 48, 36, 24, 18, 12, 9, 6 Mbps                |
|                      | <b>802.11n:</b><br>MCS 0 to 7 for HT20MHz<br>MCS 0 to 7 for HT40MHz |
|                      |   |
| Media Access Control | CSMA/CA with ACK  |
| Modulation Technique | <b>802.11b:</b><br>CCK, DQPSK, DBPSK                                |
|                      | <b>802.11g:</b><br>64QAM, 16QAM, QPSK, BPSK                         |
|                      | <b>802.11n:</b><br>64QAM, 16QAM, QPSK, BPSK                         |
|                      |   |

|                             |   |
|-----------------------------|---|
| <b>Network Architecture</b> | Infrastructure mode   |
|                             | <b>2.4GHz</b>   |
| <b>Operation Channel</b>    | 11: (Ch. 1-11) – United States<br>13: (Ch. 1-13) – Europe<br>14: (Ch. 1-14) – Japan |
| <b>Frequency Range</b>      | <b>802.11bg</b><br>2.400 ~ 2.4835 GHz   |
| <b>EVM</b>                  | CCK < 35%<br>OFDM < -25dB<br>MCS0(HT20/40MHz) < -5dB<br>MCS7(HT20/40MHz) < -28dB    |
| <b>Frequency Offset</b>     | <b>2.4GHz</b><br>-20ppm < Center Frequency < +20ppm                                 |

**Transmit Output Power - single chain @ant**

**Tolerance:  $\pm 1.5\text{dBm}$  @ 2.4GHz**

| <b>802.11b</b>      | <b>1Mbps</b> | <b>2Mbps</b> | <b>5.5Mbps</b> | <b>11Mbps</b> |
|---------------------|--------------|--------------|----------------|---------------|
| <b>Tgtpwr (dBm)</b> | 18           | 18           | 18             | 18            |

| <b>802.11g</b>      | <b>6~24Mbps</b> | <b>36Mbps</b> | <b>48Mbps</b> | <b>54Mbps</b> |
|---------------------|-----------------|---------------|---------------|---------------|
| <b>Tgtpwr (dBm)</b> | 18              | 18            | 16            | 16            |

| <b>802.11n HT20</b> | <b>MCS0</b> | <b>MCS1</b> | <b>MCS2</b> | <b>MCS3</b> | <b>MCS4</b> |
|---------------------|-------------|-------------|-------------|-------------|-------------|
| <b>Tgtpwr (dBm)</b> | 18          | 18          | 18          | 18          | 18          |
|                     | <b>MCS5</b> | <b>MCS6</b> | <b>MCS7</b> |             |             |
|                     | 16          | 16          | 16          |             |             |

| <b>802.11n HT40</b> | <b>MCS0</b> | <b>MCS1</b> | <b>MCS2</b> | <b>MCS3</b> | <b>MCS4</b> |
|---------------------|-------------|-------------|-------------|-------------|-------------|
| <b>Tgtpwr (dBm)</b> | 18          | 18          | 18          | 18          | 18          |
|                     | <b>MCS5</b> | <b>MCS6</b> | <b>MCS7</b> |             |             |
|                     | 16          | 16          | 16          |             |             |

**Receiver Sensitivity**

| <b>Frequency Band</b> | <b>Rate</b>  | <b>Condition</b> | <b>Typical (ISS) (dBm)</b> |
|-----------------------|--------------|------------------|----------------------------|
| <b>2.4G</b>           | 11b-1M       | PER < 8%         | -94                        |
|                       | 11b-11M      | PER < 8%         | -86                        |
|                       | 11g-6M       | PER < 10%        | -90                        |
|                       | 11g-54M      | PER < 10%        | -71                        |
|                       | 11n-HT20MCS0 | PER < 10%        | -87                        |
|                       | 11n-HT20MCS7 | PER < 10%        | -70                        |
|                       | 11n-HT40MCS0 | PER < 10%        | -84                        |
|                       | 11n-HT40MCS7 | PER < 10%        | -67                        |

|                          |                         |   |              |
|--------------------------|-------------------------|---|--------------|
| <b>Security</b>          | <b>Items</b>            | <b>Description</b>  |              |
|                          | <b>Hardware engine</b>  | AES/DES/SHA hardware engine   |              |
|                          | <b>TrustZone</b>        | TrustZone-M supported   |              |
|                          | <b>Secure boot</b>      | Secure boot supported   |              |
|                          | <b>SWD protection</b>   | Debug port access protection and prohibition modes  |              |
|                          | <b>eFuse protection</b> | Secure eFuse  |              |
|                          | <b>RSIP</b>             | Flash decryption on-the-fly   |              |
| <b>Operating Voltage</b> |                         | 3.3V $\pm$ 5% I/O supply voltage  |              |
| <b>Power Consumption</b> | <b>Mode</b>             | <b>Average</b>  | <b>Peak</b>  |
|                          | <b>TX</b>               | <i>TBDmA</i>  | <i>TBDmA</i> |
|                          | <b>RX</b>               | <i>TBDmA</i>  | <i>TBDmA</i> |
|                          | <b>Suspend Mode</b>     | <i>TBDmA</i>  | <i>TBDmA</i> |
| <b>Antenna Type</b>      |                         | 2x Printed Antenna on PCBA and 1x U.FL connector for antenna diversity<br>1x FAKRA connector reserved(optional) |              |

## 1.4 Operation Conditions

**Table 3-2 Recommended Operation Conditions**

| Symbol         | Rating                        | Min   | Typ | Max   | Units |
|----------------|-------------------------------|-------|-----|-------|-------|
| 3.3V_In        | 3.3V Supply Voltage           | 3.135 | 3.3 | 3.465 | V     |
| T <sub>A</sub> | Ambient operating temperature | -20   | 25  | 85    | °C    |
| T <sub>S</sub> | Storage temperature           | -40   | 25  | 85    | °C    |

**Table 3-3 DC Characteristics**

| Symbol          | Parameter           | Min | Typ | Max | Units |
|-----------------|---------------------|-----|-----|-----|-------|
| V <sub>IL</sub> | Input Low Voltage   | -   | -   | 0.8 | V     |
| V <sub>IH</sub> | Input High Voltage  | 2.0 | -   | -   | V     |
| V <sub>OL</sub> | Output Low Voltage  | -   | -   | 0.4 | V     |
| V <sub>OH</sub> | Output High Voltage | 2.4 | -   | -   | V     |

## WARNINGS

### FCC Statement

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

Reorient or relocate the receiving antenna.

Increase the separation between the equipment and receiver.

Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

Consult the dealer or an experienced radio/TV technician for help.

**FCC Caution:** Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.

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

This device and its antenna(s) must not be co-located or operating in conjunction with any other antenna or transmitter.

For product available in the USA/Canada market, only channel 1~11 can be operated. Selection of other channels is not possible.

### FCC Radiation Exposure Statement

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance **20cm** between the radiator & your body.

### ISED Statement

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:

1. This device may not cause interference.

2. This device must accept any interference, including interference that may cause undesired operation of the device.

L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

1. L'appareil ne doit pas produire de brouillage;

2. L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

### ISED Radiation Exposure Statement:

This equipment complies with IC RSS-102 radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance **20cm** between the radiator & your body.

Cet équipement est conforme aux limites d'exposition aux rayonnements IC établies pour un environnement non contrôlé.

Cet équipement doit être installé et utilisé avec un minimum de **20cm** de distance entre la source de rayonnement et votre corps.

The transmitter module may not be co-located with any other transmitter or antenna.

Le module émetteur peut ne pas être coimplanté avec un autre émetteur ou antenne.

For product available in the USA/Canada market, only channel 1~11 can be operated. Selection of other channels is not possible.

Pour les produits disponibles aux États-Unis / Canada du marché, seul le canal 1 à 11 peuvent être exploités. Sélection d'autres canaux n'est pas possible.



This module is intended for OEM integrators under the following conditions:

1. Ensure that the end-user has no manual instructions to remove or install module.
2. This module is certified pursuant to Part 15 rules section 15.247 and RSS-247.
3. This module has been approved to operate with the antenna types listed below, with the maximum permissible gain indicated.

| Antenna Number | Brand Name | Model Name | Ant. Type   | Cable length | Connector | Support | Max Peak Gain |
|----------------|------------|------------|-------------|--------------|-----------|---------|---------------|
| Antenna 1      | LITEON     | WCBN3605L  | Printed Ant | N/A          | N/A       | 2.4G+BT | 2.06          |
| Antenna 2      | LITEON     | WCBN3605L  | Printed Ant | N/A          | N/A       | 2.4G+BT | 2.1           |
| Antenna 3      | MOLEX      | 2167990001 | PIFA        | N/A          | Fakra     | 2.4G+BT | 2.4           |
| Antenna 4      | MOLEX      | 1461530050 | PIFA        | 50 mm        | I-PEX     | 2.4G+BT | 3.2           |
| Antenna 5      | MOLEX      | 1461530100 | PIFA        | 100 mm       | I-PEX     | 2.4G+BT | 3.0           |
| Antenna 6      | MOLEX      | 1461530150 | PIFA        | 150 mm       | I-PEX     | 2.4G+BT | 2.8           |
| Antenna 7      | MOLEX      | 1461530200 | PIFA        | 200 mm       | I-PEX     | 2.4G+BT | 2.6           |
| Antenna 8      | MOLEX      | 1461530250 | PIFA        | 250 mm       | I-PEX     | 2.4G+BT | 2.4           |
| Antenna 9      | MOLEX      | 1461530300 | PIFA        | 300 mm       | I-PEX     | 2.4G+BT | 2.2           |

#### 4 Label and compliance information

Label of the end product:

FCC

The host product must be labeled in a visible area with the following " **Contains FCC ID: PPQ-WCBN3605L**".

The end product shall bear the following 15.19 statement: This device complies with part 15 of the FCC Rules.

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

ISED

This transmitter module is authorized only for use in device where the antenna may be installed such that 20 cm may be maintained between the antenna and users. The final end product must be labeled in a visible area with the following: **"Contains transmitter module IC: 4491A-WCBN3605L" or "Contains IC: 4491A-WCBN3605L"**

**Contient le module d'émission IC: 4491A-WCBN3605L**

#### 5. Information on test modes and additional testing requirements

This module has been approved under stand-alone configuration.

OEM integrator has been limited the operation channels in channel 1-11 for 2.4GHz band.

The separate approval is required for all other operating configurations, including portable configurations with respect to Part 2.1093/RSS-102 and different antenna configurations

The information on how to configure test modes for host product evaluation for different operational conditions for a stand-alone modular transmitter in a host, versus with multiple, simultaneously transmitting modules or other transmitters in a host can be found at KDB Publication 996369 D04.

OEM integrator is still responsible for testing their end product for any additional compliance requirements required with this module installed (for example, digital device emissions, PC peripheral requirements, etc.).

**IMPORTANT NOTE:** In the event that these conditions cannot be met (for example certain laptop configurations or co-location with another transmitter), then the FCC/ISED authorization is no longer considered valid and the FCC/IC No. cannot be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate FCC/ISED authorization.

**6. Additional testing, Part 15 Subpart B and ICES-003 disclaimer**

Appropriate measurements (e.g. Part 15 Subpart B compliance) and if applicable additional equipment authorizations (e.g. SDoC) of the host product to be addressed by the integrator/manufacturer.

This module is only FCC/ISED authorized for the specific rule parts 15.247, RSS-247 listed on the grant, and the host product manufacturer is responsible for compliance to any other FCC/ISED rules that apply to the host product as being Part 15 Subpart B/ICES-003 compliant.

**7. The user manual of the end product should include:**

**FCC:**

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

The antenna(s) used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons. This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

The antenna(s) used for this transmitter must not transmit simultaneously with any other antenna or transmitter.

**ISED:**

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:

1. This device may not cause interference.

2. This device must accept any interference, including interference that may cause undesired operation of the device.

L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

1. L'appareil ne doit pas produire de brouillage;

2. L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

**ISED Radiation Exposure Statement:**

This equipment complies with IC RSS-102 radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20cm between the radiator & your body.

Cet équipement est conforme aux limites d'exposition aux rayonnements IC établies pour un environnement non contrôlé. Cet équipement doit être installé et utilisé avec un minimum de 20cm de distance entre la source de rayonnement et votre corps.

The transmitter module may not be co-located with any other transmitter or antenna.

Le module émetteur peut ne pas être coïmplanté avec un autre émetteur ou antenne.

For product available in the USA/Canada market, only channel 1~11 can be operated. Selection of other channels is not possible.

Pour les produits disponibles aux États-Unis / Canada du marché, seul le canal 1 à 11 peuvent être exploités. Sélection d'autres canaux n'est pas possible.