

# **RTL8762E RCU MP Test Sample Flow**

**Version 1.0**

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## Revision History

Date	Version	Modification	Author	Reviewer
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# 1 Introduction

This paper introduces RTL8762E remote control test flow, including typical test flow and implementation of related technology. The test flow ensures that specification of remote control meets production requirement.

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## 2 Test flow

Typical production line test flow includes downloading files to remote control, PCBA-level test and Function-level test. Basic test flow is shown in Figure 2.1.

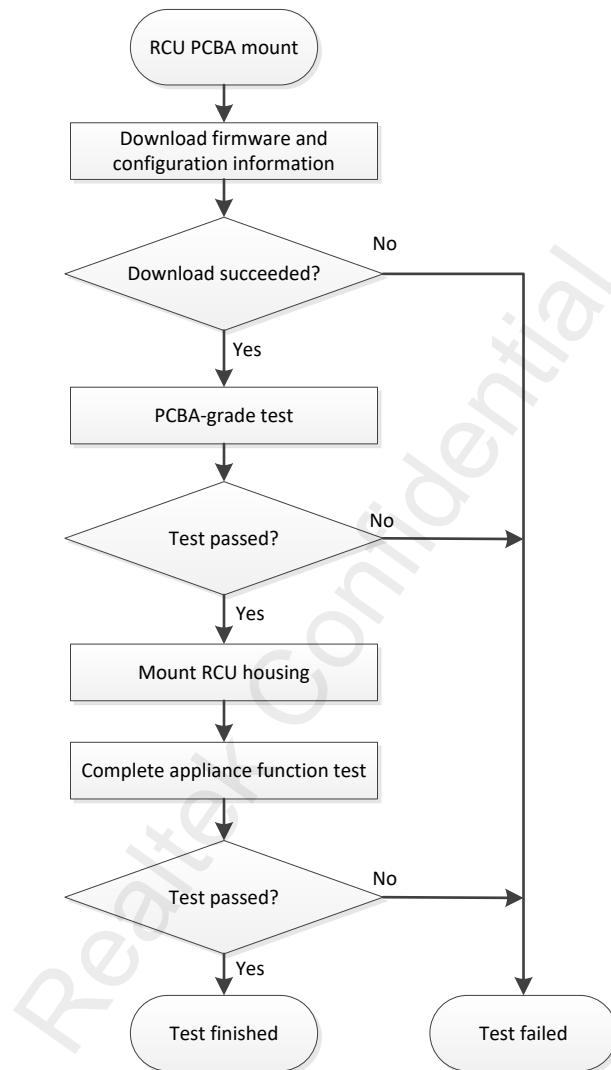


Figure 2.1 Production line test flow chart

PCBA-level test includes reading MAC address, checking version number, button test, MIC performance test, frequency drift calibration, RF performance test and current consumption test. Basic test flow is shown in Figure 2.2.

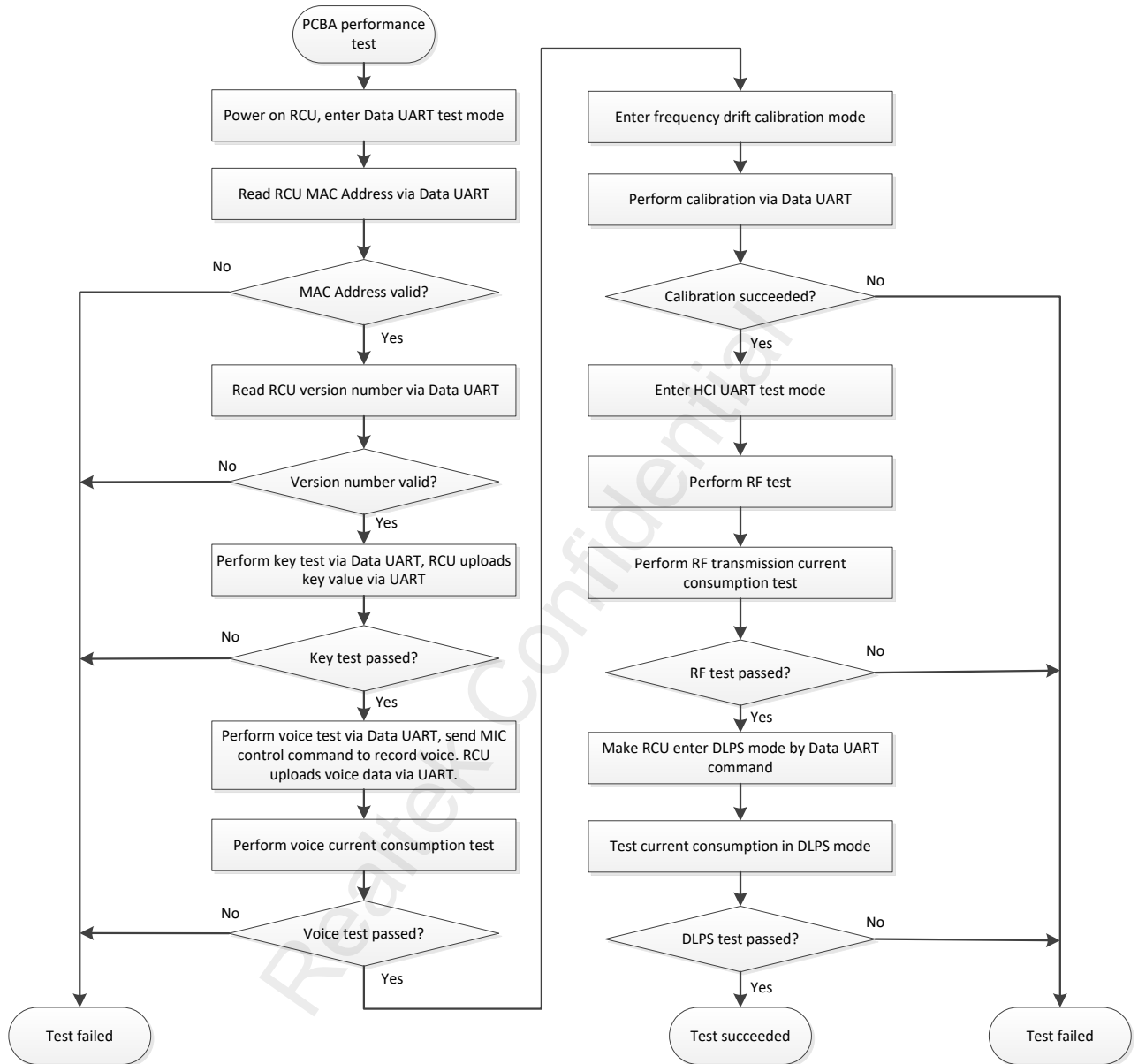


Figure 2.2 PCBA-grade test flow chart

Function-level includes Single Tone test, Bluetooth Low Energy (BLE) connection and pairing, reading MAC address, checking version number, button function test, voice function test and clearing RCU information. Basic test Flow is shown in Figure 2.3.

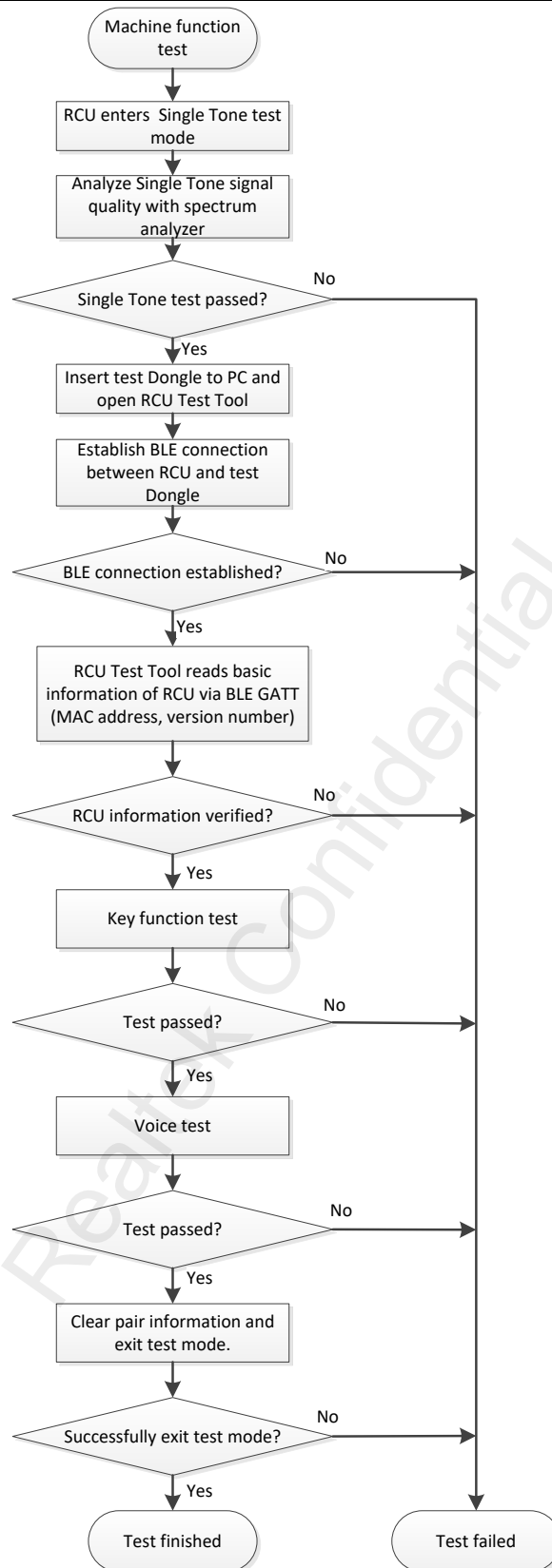


Figure 2.3 Complete appliance function test flow chart



## 2.1 Download program

RTL8762E chip supports 2 download methods: SWD offline download and MP Tool online download.

### 2.1.1 SWD Offline Download

SWD offline download method aims at applying third-party downloader to program RTL8762E chip before mounting. 2 SWD offline download methods are supplied at present:

1. J-Link Flash Algorithm. For detailed implementation please refer to “***RTL8762E Flash Programming with J-Flash or J-Link Commander***”<sup>[1]</sup>.
2. RTL8762E FW Loader. For detailed implementation please refer to “***RTL8762E FW Loader Programming Flow***”<sup>[2]</sup>.

### 2.1.2 MP Tool Download

Realtek Bluetooth MP Tool is applied as mass production download software.

MP Tool supports both UART interface and SWD interface to program RTL8762E chip:

1. Port P3\_0 and P3\_1 are selected to perform UART download.
2. Port P1\_0 and P1\_1 are selected to perform SWD download.

For detailed usage of MP Tool please refer to “***RTL8762E MP User Guide***”<sup>[3]</sup>.

### 2.1.3 Download Files

Mandatory files to be downloaded in mass production:

- Patch image: Realtek patch image.
- APP Image: Client Application Image.
- Config file: Chip configuration file.
- OTA Header: Chip running environment control field image.
- Secure Boot: Secure boot loader image.
- Upperstack image: Upper stack image.

Client should download desired User data to products in mass production User data:

- User data file: Customer private data file.

## 2.2 PCBA-level Test

PCBA-level test makes RCU enter either HCI UART test mode or Data UART test mode by external trigger. Tester will send UART command to RCU to control it to perform corresponding operation and return response. For detailed design and implementation please refer to “*RTL8762E RCU MP Test Mode Design Spec*” [4]. Diagram of PCBA-level test system is shown in Figure 2-4.

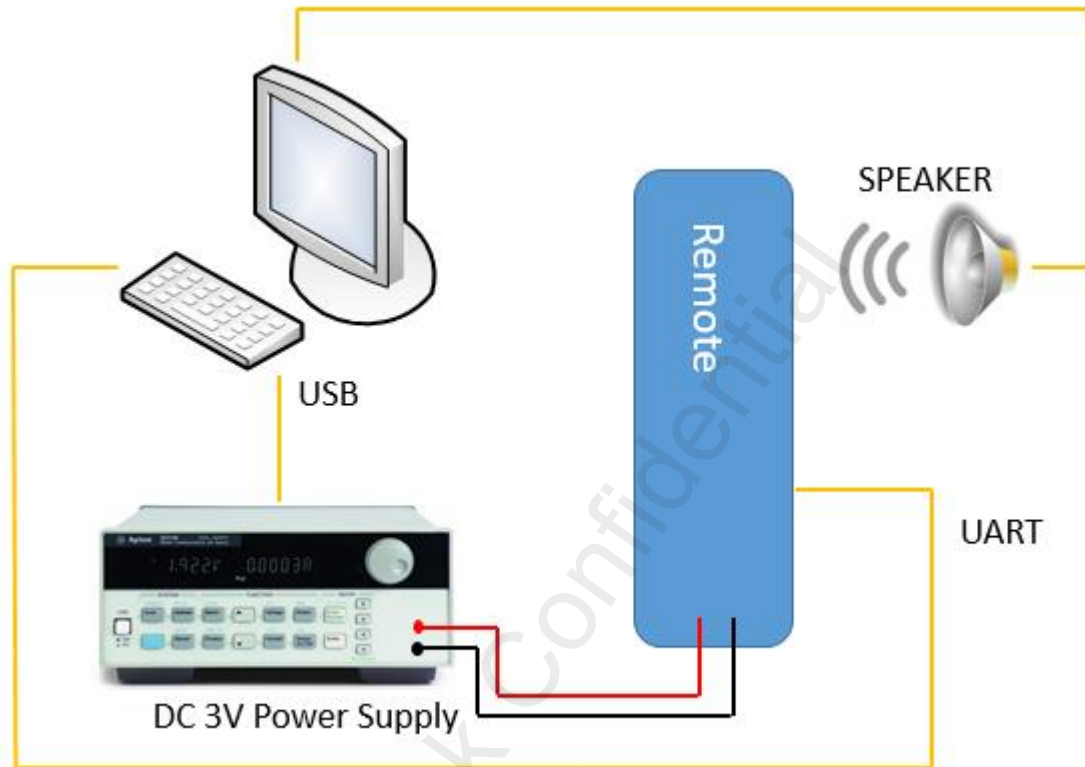


Figure 2.4 System Diagram of PCBA-level Test

### 2.2.1 Read RCU MAC Address

Upper device reads MAC Address of RCU by Data UART command to perform verification of validity and record results.

Test procedure:

1. Power on RCU and enter Data UART test mode.
2. Send READ\_MAC\_ADDR serial port command to read MAC address of RCU.
3. Verify MAC address.

### 2.2.2 Read RCU Version Information

Upper device reads version information of RCU by Data UART command to perform verification of validity and

record results.

Test procedure:

1. Power on RCU and enter Data UART test mode.
2. Send READ\_PATCH\_VERSION serial port command to read patch version information.
3. Send READ\_APP\_VERSION serial port command to read application version information.
4. Verify version information.

### 2.2.3 PCBA Matrix Keyboard Test

Upper device makes RCU enter key press test mode by Data UART command. Any key press operation will be detected and the key assignments and their information of row and column will be returned to upper device through Data UART. Upper device will perform verification of key press validity and record results.

Test procedure:

1. Power on RCU and enter Data UART test mode.
2. Send ENTER\_KEYSCAN\_TEST\_MODE serial port command to make RCU enter key press test mode.
3. Press keys of RCU in turn, RCU will return detected key press information to upper device through UART.
4. Upper device verifies validity of key press.
5. Send EXIT\_KEYSCAN\_TEST\_MODE serial port command to make RCU exit from key press test mode.

### 2.2.4 PCBA Voice Test

Upper device requires RCU to start recording voice by Data UART command. After RCU starts recording, voice data will be returned to upper device through Data UART. Upper device will analyze received data, including signal-to-noise ratio (SNR) and harmonic distortion. Meanwhile, operating current of RCU voice recording will also be measured and analyzed.

Test procedure:

1. Power on RCU and make it enter Data UART test mode.
2. Send VOICE\_TEST\_BEGIN serial port command to make RCU enter voice test mode.
3. RCU initializes voice module and starts to record voice. Record voice data will be uploaded to upper device through Data UART.
4. Meanwhile, measure RCU operating current to confirm it meets the specification.
5. Send VOICE\_TEST\_END serial port command to make RCU exit from voice test mode.
6. Upper device will analyze voice data, including SNR and harmonic distortion.

## 2.2.5 RF Frequency Drift Calibration Test

RTL8762E realized the function that adjusting BLE frequency drift slightly by adjusting internal “**Frequency Offset**” Register. At present, 2 frequency drift calibration schemes are provided:

1. Apply fixed calibration value and RCU will not be calibrated alone. Non-conforming produces will be filtered out in follow-up RF performance test. To apply this scheme, the best “**Frequency Offset**” will be determined by testing a small quantity of samples before mass production. During mass production, fine adjustment can still be performed by using MP Tool to change value of “**Frequency Offset**” in config [3]. The precondition of such scheme is that the scenario doesn’t have strict constraints on BLE RF frequency drift (e.g. within  $\pm 30\text{kHz}$ ). Besides, optimum value of “**Frequency Offset**” will be affected by external components, especially bypass capacitors of 40MHz crystal. If there’s any modification on external components, optimum value of “**Frequency Offset**” needs to be adjusted again.

2. Self-calibration scheme. Under the circumstance that BLE RF frequency drift is strictly constrained, online self-calibration scheme should be applied. This scheme consists of upper device, Golden Sample calibration source and device under test, and its system diagram is shown in Figure 2.5. Golden Sample calibration source transmit Single Tone signal at fixed frequency. After RCU is triggered into self-calibration mode, it receives signal at fixed frequency to obtain Register configuration that minimizes frequency drift, and value of frequency drift by internal algorithm. Finally, compare the minimized value of frequency drift with threshold of upper device, return the results of tests.

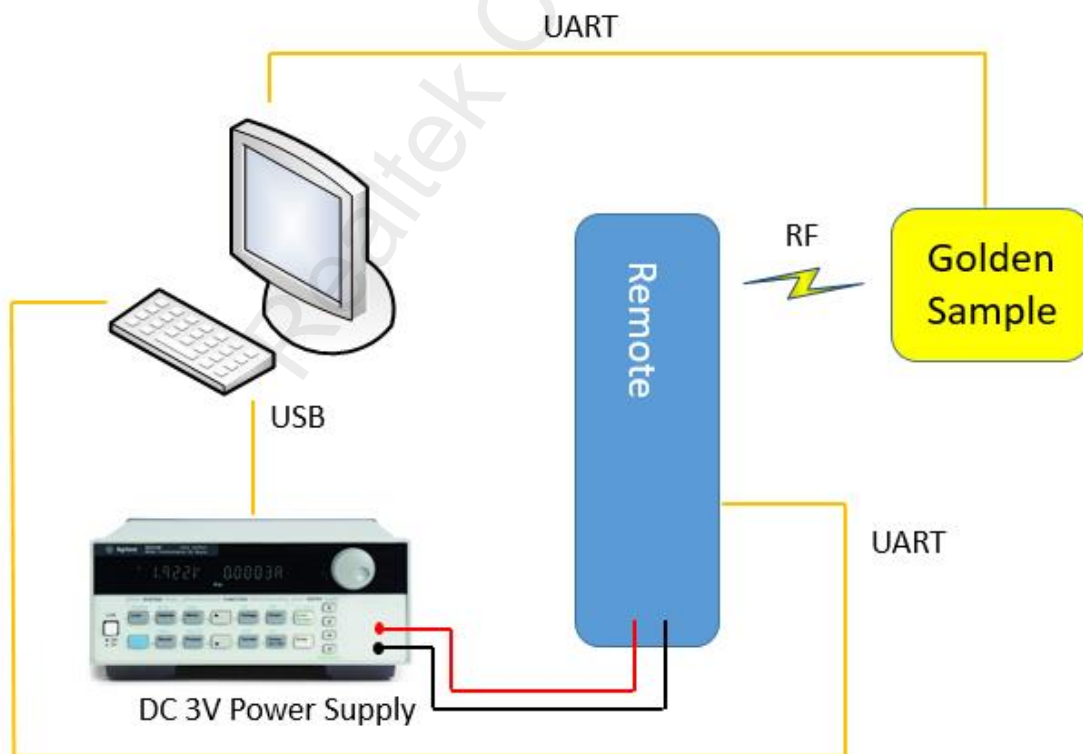


Figure 2.5 System Diagram of Frequency Drift Self-calibration

Test procedure:

1. Power on Golden Sample calibration source, upper device sends UART commands to make calibration source transmit single carrier.
2. Golden Sample calibration source transmits Single Tone signal at fixed frequency.
3. Power on RCU, upper device sends UART commands to make RCU enter self-calibration mode.
4. After RCU enters self-calibration mode, obtain Register configuration that minimizes frequency drift, and value of frequency drift by internal algorithm.
5. After RCU finishes calibration, compare the minimized value of frequency drift with threshold of upper device, return the results of tests.

## 2.2.6 RF Performance Test

HCI UART test mode allows BLE RCU device in normal APP mode to momentarily expose its HCI layer through UART by external trigger (e.g. Pull down some GPIO pin during reboot process). When test is requested on production line, exposing HCI layer enables RCU to connect with Bluetooth test instrument through UART under the circumstance that final product firmware has been downloaded. RCU runs Direct Test Mode (DTM) command to perform production line test and ensures this UART port can be used for other purposes in normal mode<sup>[4]</sup>.

Same with standard BLE DTM test mode, RCU supports series of standard HCI commands in HCI UART test mode. BLE RCU RF performance, including output power, modulation characteristic, carrier frequency drift and sensitivity, can be verified with Bluetooth test instruments (e.g. Anritsu MT8852B). Detailed test commands can be found in related chapters in Bluetooth Core Specification.

System diagram of RF Performance test is shown in Figure 2.6 System Diagram of RF Performance.

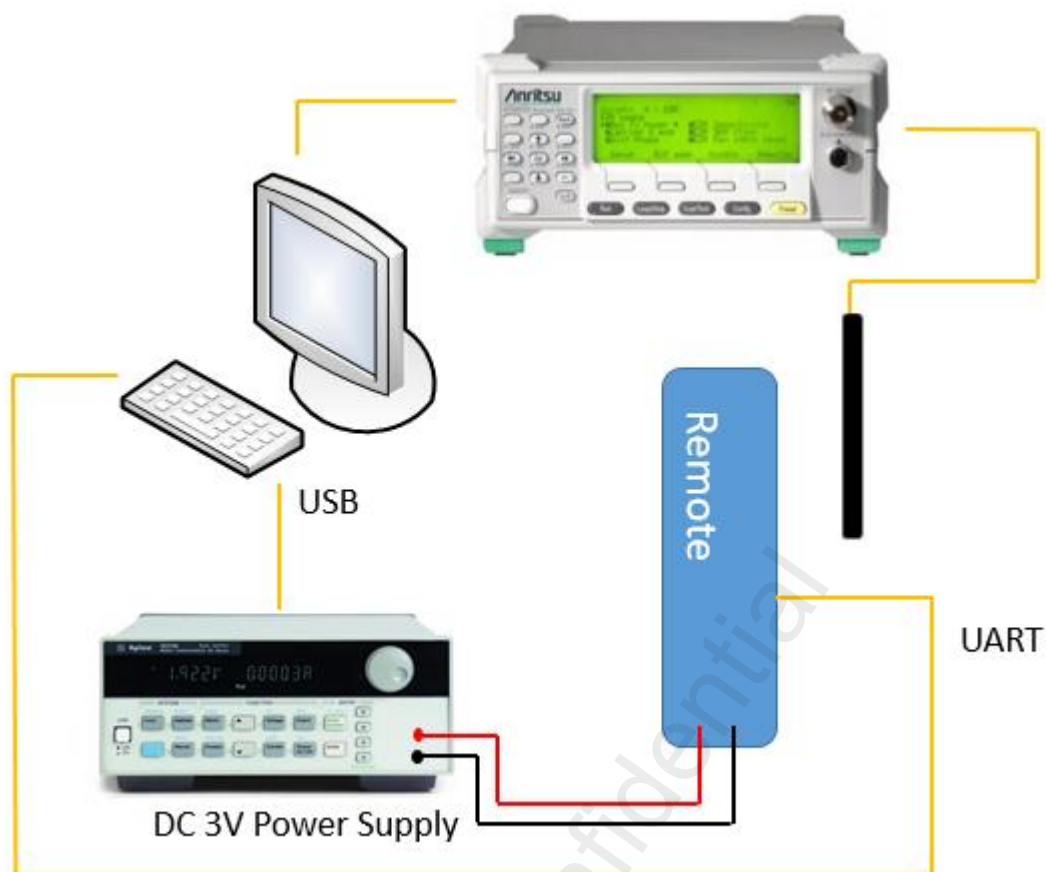


Figure 2.6 System Diagram of RF Performance Test

Test procedure:

1. Power on RCU and make it enter HCI UART test mode.
2. Use Bluetooth test instruments (e.g. Anritsu MT8852B) to verify BLE RCU RF performance, including output power, modulation characteristic, carrier frequency drift and sensitivity.

## 2.2.7 DLPS Current Test

DLPS current is a vital indicator of BLE RCU that affects life cycle of RCU. During production line test, performing DLPS current test can help filter out non-conforming products with higher consumption and ensure life cycle of RCU.

Test procedure:

1. Power on RCU and make it enter Data UART test mode.
2. Send ENTER\_DLPS\_TEST\_MODE serial command to RCU to make it enter DLPS mode.
3. Use current tester to test RCU current in DLPS mode.

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## 2.3 Function-level Test

Function-level test aims at testing RCU related function after assembling RCU. Firstly, verify RF performance by Single Tone mode. Secondly, use BLE Dongle to simulate user operation, inspect and verify basic functions of RCU, which includes BLE connection and paring, key function test and voice function test. Finally, clear RCU use history and test flag to ensure RCU factory settings are correct.

### 2.3.1 Function-level RF Test

RCU RF performance needs simple verification by applying RCU Single Tone test mode after it's assembled. RCU enter Single Tone by external trigger (e.g. press combination of key or pull down some GPIO pin during reboot process), and transmit single carrier signal at specified channel. RCU RF transmission power and frequency drift can be estimated by observing and measuring spectrum of single carrier on spectrum analyzer. Single Tone waveform displayed on spectrum analyzer is similar to the one in Figure 2.7.



Figure 2.7 Single Tone Signal Waveform

Test procedure:

4. Power on RCU and make it enter Single Tone test mode.
5. Use spectrum analyzer to observe and measure spectrum waveform of single carrier.
6. Verify RCU RF transmission power and frequency drift.



## 2.3.2 Function-level Fundamental Test

Use Windows RCU Tool and Windows RCU test dongle to perform fundamental function test on RCL8762E remote control in mass production. Detailed usage of Windows RCU Test Tool can be found in Realtek RCU Test Tool User Guide <sup>[5]</sup>. System diagram of basic test can be found in Figure 2.8 .

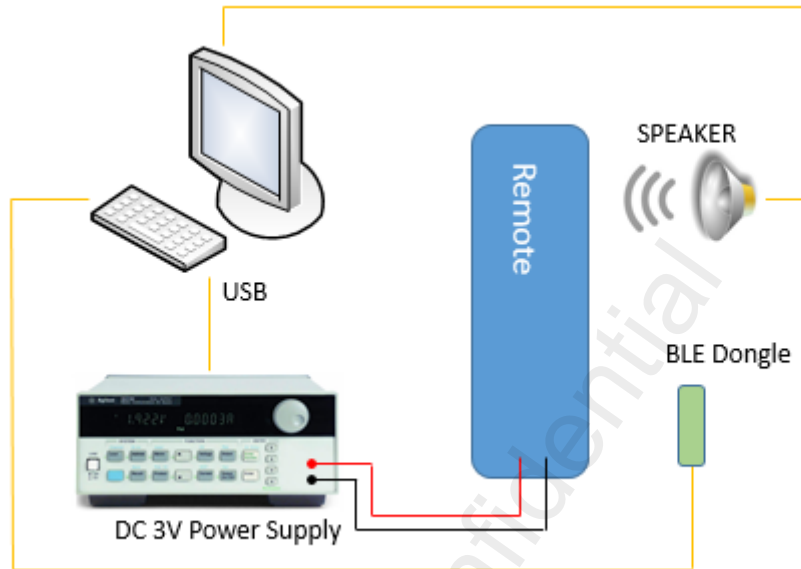


Figure 2.8 System Diagram of Function-level Fundamental Test

## 2.3.3 Connection and Pairing Test

Before performing function-level fundamental function test on RTL8762E RCU, it is required to establish connection and bonding with RCU Test Dongle. There will be multiple RCU testing at same time for efficiency. To solve this problem, there are several schemes for establishing BLE connection between RCU Test Dongle and RCU:

Scheme 1: RCU and Test Dongle in one shielding box and perform one-to-one test.

Scheme 2: RCU Test Tool finds that multiple RCUs are broadcasting at the same time, it will connect with the RCU that has highest RSSI automatically. This scheme is comparatively simple and suits the scenario that production line doesn't support scheme and production lines are far enough from each other. However, inappropriate configuration may cause problems that will cause failing to establish connection or connecting to inappropriate test instruments.

Scheme 3: RCU Test Tool obtain MAC address by other methods (e.g. read through serial port) and send connection request to RCU with specific MAC Address. This scheme needs MAC Address of RCU before test.

Scheme 4: Use fast pair test mode. This scheme sends direct reconnection broadcast that determined in advance and attempts to connect with corresponding test dongle. For detailed information refer to RTL8762E RCU MP Test Mode Design Spec <sup>[5]</sup>.

After establishing connection between RCU Test Tool and RCU, MAC address and version information can be read and checked via BLE.

### 2.3.4 Key and Voice Test

Key and voice test can be performed after establishing connection between RCU Test Tool and RCU, Key test is mainly used to test keys on RCU. Press all keys on RCU in turn and RCU Tool will display the corresponding key on interface. Compare the sequence that the keys are pressed with the one fixed in program to determine if the press operation is successful.

Voice test consists of manual and automatic schemes:

Manual scheme: Press and hold voice button on RCU and speak a fixed sentence. RCU transmits voice data to RCU Test Dongle via BLE. RCU Tool will save and play the voice data, so that testing personnel can determine if the voice function works normally.

Automatic scheme: Upper device controls sound source to play standard voice data and force RCU to start or terminate voice function. Sample flow chart is shown in Figure 2.9 .

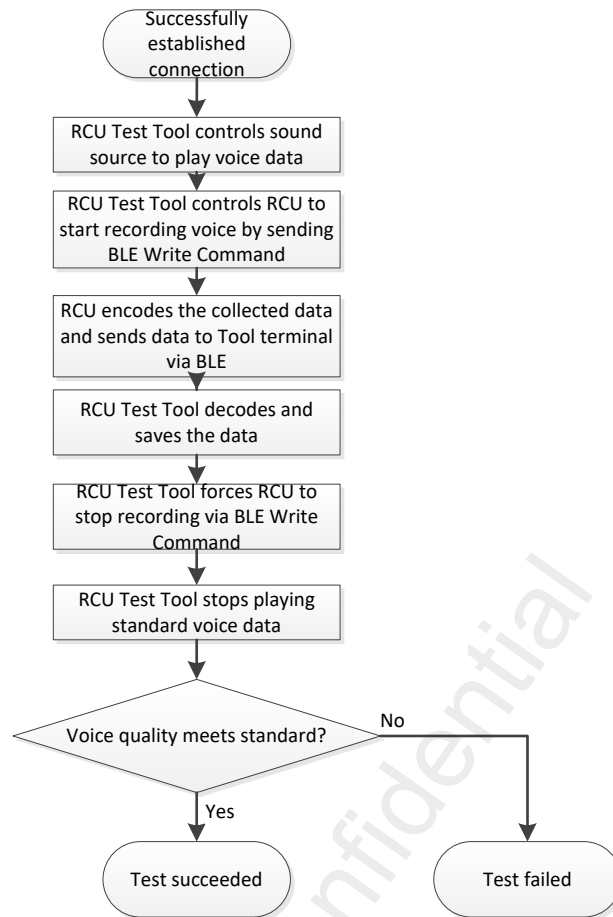


Figure 2.9 Automatic Voice Test Flow Chart

### 2.3.5 Exit from Test Mode

The last step before RCU leaves factory is to restore RCU to factory settings, including clear pair information, exit from test mode, clear test flag bit and so on. The command of exiting from test mode can be controlled via serial port or BLE command. Detailed implementation can be found in “*RTL8762E RCU MP Test Mode Design Spec*”.

## Reference

- [1] RTL8762E Flash Programming with J-Flash or J-Link Commander
- [2] RTL8762E FW Loader Programming Flow
- [3] RTL8762E MP User Guide
- [4] RTL8762E RCU MP Test Mode Design Spec
- [5] Realtek RCU Test Tool User Guide

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