AN14466

Antenna Auto Detection

Rev. 2.0 — 16 December 2024 Application note

Document information

Information	Content
Keywords	Antenna, Wi-Fi, Bluetooth LE, 802.15.4, diversity, single antenna, dual antenna, front-end (FE), radio performance
Abstract	Describes the antenna auto detection feature.

1 Introduction

Antenna auto detection is a feature for RW61x designs with three antenna diversity to automatically determine which antenna is best suited for optimal performance. The feature automatically selects the primary antenna and secondary antenna. SDK 2.15.0 and greater supports antenna auto detection.

Antenna auto detection includes three modes:

- Normal detect mode
- Quick detect mode
- PCB detect mode

Note: *The RW61x reference design board does not support the antenna auto detection feature by default.*

1.1 Supported devices

This document applies to the following wireless devices:

- RW610 [5]
- RW612 [6]

Note: *The RW61x design must support antenna diversity. Contact your NXP representative to discuss if your hardware design supports antenna diversity.*

2 Front-end module (FEM) settings

NXP SDK release supports two FEM settings. The `design type` parameter in the calibration data file is used to set the FEM. For more information on calibration data, refer to [1].

To support antenna auto detection, the parameter `Ref_Design_Type` must be set to 0xA2 or 0xA3.

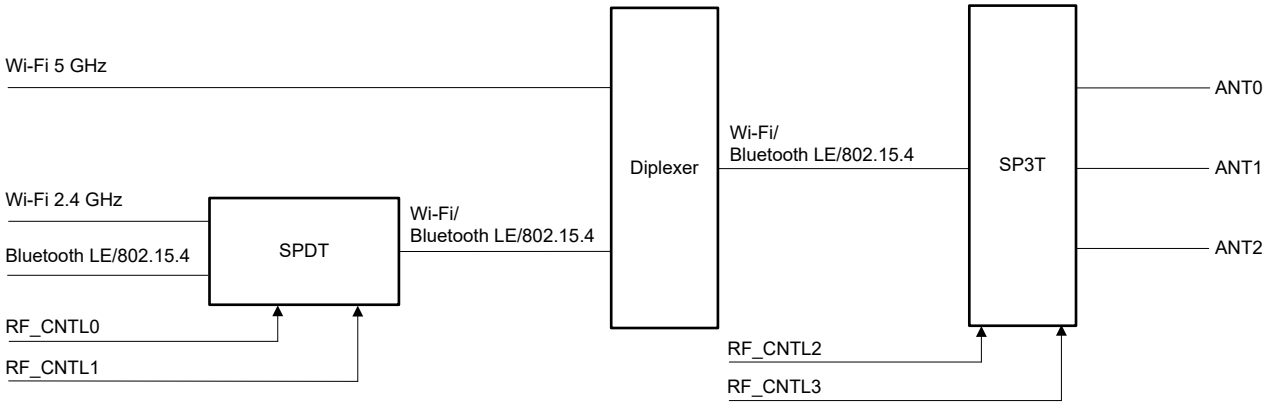
Example of calibration data file content:

```
[StructureInfo]
STRUCTURE_REV=0x0F
[Main_Table]
Ref_Design_Type=0xA3
Device_ID=0x00
SPI_Size=0x40
Ant_TX=0xFF
Ant_RX=0xFF
Soc_OR_Rev=0x00
TMP_At_Cal=0x0022
RFXTAL=0x72
Region_Code=0x00
MISC_Flag=0x00
TEST_VERSION=0x42679
MFG_VERSION=0x200003F
DLL_VERSION=0x1000012
…
```

2.1 Design type 0xA2

In design type 0xA2, RF_CNTL[0:3] signals are used to configure the RF switches in the hardware design.

The RF_CNTL[0:3] signals must be set as shown in Figure 1.



RF_CNTL1_SW	RF_CNTL0_SW	Subsystem
1	0	Bluetooth LE/802.15.4
0	1	Wi-Fi

RF_CNTL3_SW	RF_CNTL2_SW	Antenna
1	0	Antenna 0
0	1	Antenna 1
1	1	Antenna 2

Figure 1. RF front-end diagram of design type 0XA2

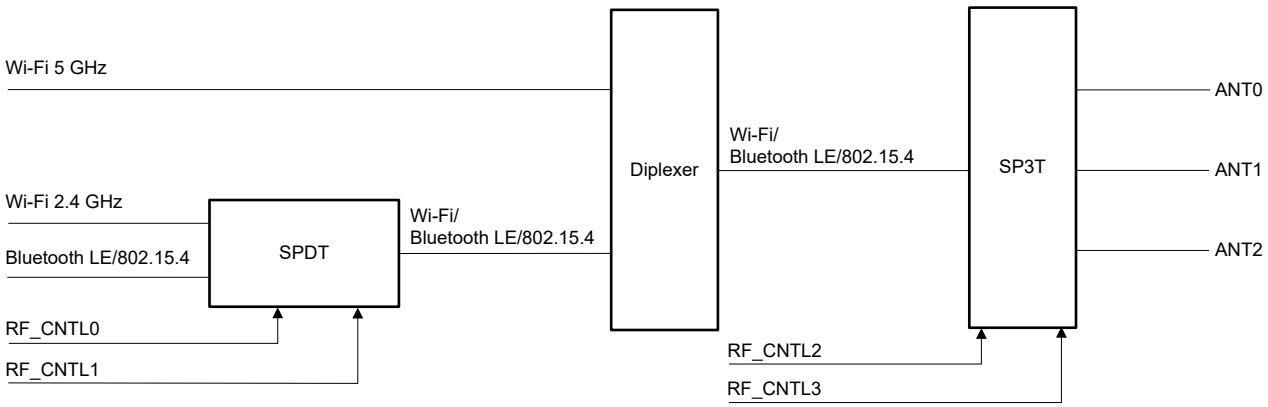
Table 1 shows the recommended FEM setting of design type 0xA2

Table 1. Recommended FEM setting of design type 0xA2

Selected antenna	Wi-Fi	Bluetooth LE/802.15.4
Antenna 0	0x09	0x0A
Antenna 1	0x05	0x06
Antenna 2	0x0D	0x0E

2.2 Design type 0xA3

In design type 0xA3, RF_CNTL[0:3] signals are used to configure the RF switches in the hardware design. The RF_CNTL[0:3] signals must be set as shown in Figure 2.



RF_CNTL1_SW	RF_CNTL0_SW	Subsystem
1	0	Bluetooth LE/802.15.4
0	1	Wi-Fi

RF_CNTL3_SW	RF_CNTL2_SW	Antenna
0	0	Antenna 0
0	1	Antenna 1
1	1	Antenna 2

Figure 2. RF front-end diagram of design type 0XA3

Table 2 shows the recommended FEM setting of design type 0xA3

Table 2. Recommended FEM setting of design type 0xA3

Selected antenna	Wi-Fi	Bluetooth LE/802.15.4
Antenna 0	0x01	0x02
Antenna 1	0x05	0x06
Antenna 2	0x0D	0x0E

3 Feature modes

This section describes the three antenna auto detection modes.

3.1 Normal detect mode

In normal detect mode, the RW61x board scans for access points (AP) antenna by antenna, across the channel list. The command `wlan-detect-ant` is used to set the channel list (Section 4).

Each antenna scans and lists the names of the five APs with the RSSI value closest to the antenna RSSI value. The names of the access points are compared to find a common AP that all the antennas can scan.

The RSSI value of the common AP on each antenna is compared to find the best two antennas. If there is no common AP, the average RSSI value of the top five APs on each antenna is compared to find the best two antennas.

Figure 3 illustrates the normal detect mode.

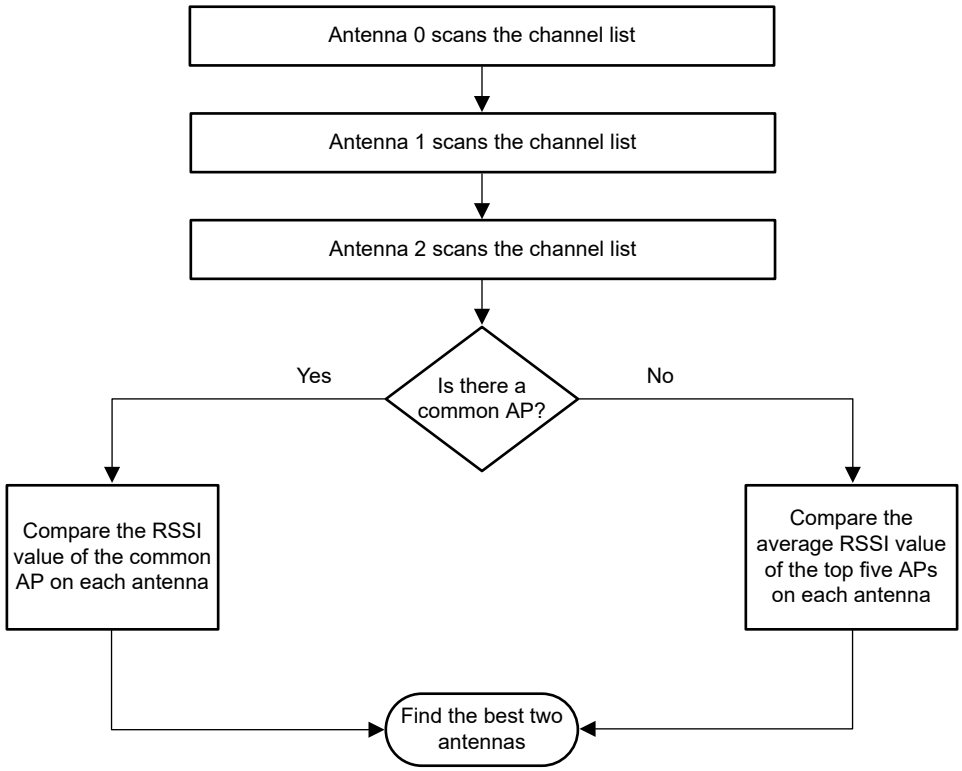


Figure 3. Flowchart for the normal detect mode

Note: *The common AP is the AP that all three antennas can scan.*

3.2 Quick detect mode

In quick detect mode, the RW61x board scans for access points antenna by antenna, for the first channel in the list. The command `wlan-detect-ant` is used to set the channel list (Section 4).

Each antenna scans and lists the top five AP names. The AP names are compared to find a common AP.

The RSSI value of the common AP on each antenna is compared to find the best two antennas. If there is no common AP, the average RSSI value of the top five APs on each antenna is compared to find the best two antennas.

If the best two antennas are not found, the RW61x board scans for access points for the second channel.

Figure 4 illustrates the quick detect mode (the channel number (n) increments every time at the start of every new flow).

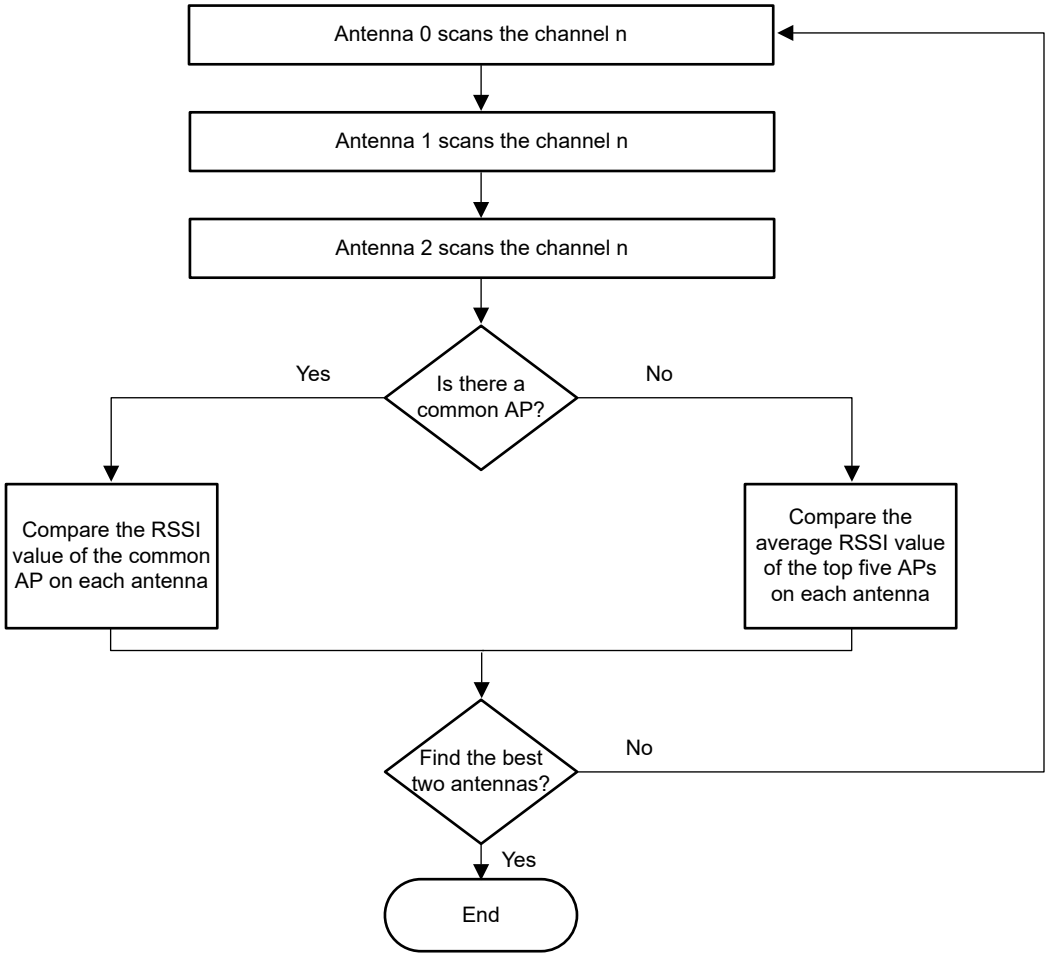


Figure 4. Flowchart for the quick detect mode

3.3 PCB detect mode

In PCB detect mode, the first antenna (Antenna0) on RW61x board scans for access points across the full channel list and lists the top two APs. The other two antennas scan for access points across the full channel list. The average RSSI value of the top two APs for the each of the three antennas is compared to find the best two antennas.

Note: *The first antenna (Antenna0) must be connected.*

Figure 5 illustrates the PCB detect mode.

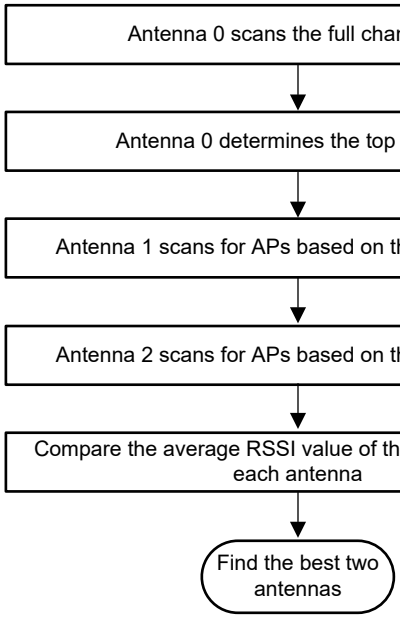


Figure 5. Flowchart for PCB detect mode

3.4 Comparison of the feature modes

Table 3 compares the antenna auto configuration modes.

Table 3. Comparison of the antenna auto configuration modes

Mode	Advantage	Disadvantage
Normal detect mode	High accuracy	Time consuming
Quick detect mode	High time-efficiency	Low accuracy
PCB detect mode	Average time-efficiency Average accuracy	The first antenna is always ON. No channel hopping for the top two APs

Note:

- *Antenna auto detection time depends on the configured scan period.*
- *When the channel list is large, the quick detect mode is faster.*
- *When the device is in an open environment, the scan time of PCB detect mode is consistent.*
- *When the device is placed in a corner, the normal detect mode is more accurate.*

4 Feature configuration

The command `wlan-detect-ant` is used to enable the antenna auto detection feature. Both *wifi_cli* and *wpa_supplicant* applications in the SDK package support the feature.

Command syntax:

```
wlan-detect-ant <detect_mode> <ant_port_count> channel <channel>
```

Table 4. Command parameters

Parameter	Description
`detect_mode`	Antenna detection mode. 0 = normal detect mode 1 = quick detect mode 2 = PCB detect mode
`ant_port_count`	Total count of antenna ports Range = 0 to 3
`channel`	Defines the channel list to scan. More than one channel can be specified with a separating comma (“,”) If channel number is specified, all the channels are scanned.

Note: *For the list of supported 2.4 GHz and 5 GHz Wi-Fi channels, refer to [2] and [3].*

5 Examples

This section shows how to configure the antenna auto detection modes. For the three examples, the RW61x board is flashed with the *wifi-cli* application. For more information, refer to [4].

5.1 Example for normal detect mode

The example configures normal detect mode on channels 1 and 6.

Command example:

```
wlan-detect-ant 0 3 channel 1,6
```

Example of command output:

```
172197: Start to detect ant
Start to evaluate antenna 1
Scan on 2 channels scheduled...
11 networks found
List top 5 best scanned AP's info:
3C:51:0E:6F:F3:60  "NXP"
        channel: 1
        rssi: -52 dBm
…
5 valid scan entry found
avg_rssi: -56 dBm
Start to evaluate antenna 2
Scan on 2 channels scheduled...
2 networks found
List top 5 best scanned AP's info:
3C:51:0E:6F:F3:60  "NXP"
        channel: 1
        rssi: -90 dBm
…
2 valid scan entry found
avg_rssi: -86 dBm
Start to evaluate antenna 3
Scan on 2 channels scheduled...
3 networks found
List top 5 best scanned AP's info:
3C:51:0E:6F:F3:61  "NXPOPEN"
        channel: 1
        rssi: -88 dBm
…
Find one common device
List the info on every antenna for this common device
Antenna 1:
60:A4:4C:A1:50:50  "asus-2g-ch-1"
        rssi[0]: -48 dBm
Antenna 2:
60:A4:4C:A1:50:50  "asus-2g-ch-1"
        rssi[1]: -83 dBm
Antenna 3:
60:A4:4C:A1:50:50  "asus-2g-ch-1"
        rssi[2]: -86 dBm
Currently, best antenna is 1, next best antenna is 2
Enable Antenna diversity with evaluate mode 0 successful
172676: End of detect ant
It cost 479ms to detect ant
```

5.2 Example for quick detect mode

This example configures quick detect mode on channel 1.

Command example:

```
wlan-detect-ant 1 3 channel 1
```

Example of command output:

```
172197: Start to detect ant
Start to evaluate antenna 1
Scan on channel1 scheduled...
11 networks found
List top 5 best scanned AP's info:
3C:51:0E:6F:F3:60  "NXP"
        channel: 1
        rssi: -52 dBm
…
5 valid scan entry found
avg_rssi: -56 dBm
Start to evaluate antenna 2
Scan on channel1 scheduled...
2 networks found
List top 5 best scanned AP's info:
3C:51:0E:6F:F3:60  "NXP"
        channel: 1
        rssi: -90 dBm
…
2 valid scan entry found
avg_rssi: -86 dBm
Start to evaluate antenna 3
Scan on channel1 scheduled...
3 networks found
List top 5 best scanned AP's info:
3C:51:0E:6F:F3:61  "NXPOPEN"
        channel: 1
        rssi: -88 dBm
…
Find one common device
List the info on every antenna for this common device
Antenna 1:
60:A4:4C:A1:50:50  "asus-2g-ch-1"
        rssi[0]: -48 dBm
Antenna 2:
60:A4:4C:A1:50:50  "asus-2g-ch-1"
        rssi[1]: -83 dBm
Antenna 3:
60:A4:4C:A1:50:50  "asus-2g-ch-1"
        rssi[2]: -86 dBm
Currently, best antenna is 1, next best antenna is 2
Enable Antenna diversity with evaluate mode 1 successful
172676: End of detect ant
It cost 479ms to detect ant
```

5.3 Example for PCB detect mode

This example configures PCB detect mode.

Command example:

```
wlan-detect-ant 2 3
```

Example command output:

```
368943: Start to detect ant
Start to evaluate antenna 1
Scan on full channel scheduled...
26 networks found
List top 2 best scanned AP's info:
04:42:1A:17:22:60  "Asus_nxp"
        channel: 10
        rssi: -32 dBm
…
Start to evaluate antenna 2
Scan on channel 10 and for bssid 04:42:1A:17:22:60 scheduled...
1 network found
04:42:1A:17:22:60  "Asus_nxp"
        channel: 10
        rssi: -65 dBm
Scan on channel 6 and for bssid 6C:B0:CE:7D:44:28 scheduled...
1 network found
6C:B0:CE:7D:44:28  "R6220-ch11"
        channel: 6
        rssi: -83 dBm
Start to evaluate antenna 3
Scan on channel 10 and for bssid 04:42:1A:17:22:60 scheduled...
1 network found
04:42:1A:17:22:60  "Asus_nxp"
        channel: 10
        rssi: -66 dBm
Scan on channel 6 and for bssid 6C:B0:CE:7D:44:28 scheduled...
1 network found
6C:B0:CE:7D:44:28  "R6220-ch11"
        channel: 6
        rssi: -78 dBm
evaluate ant by specific device
Evaluate result:
              avg_rssi
Antenna 1       -36 dBm
Antenna 2       -74 dBm
Antenna 3       -72 dBm
Currently, best antenna is 1, next best antenna is 3
Enable Antenna diversity with evaluate mode 2 successful
370968: End of detect ant
It cost 2025ms to detect ant
```

6 References

[1] Application note – AN13639: Calibration Structure for RW61x
[2] Data sheet – RW610: Wireless MCU with Integrated 1x1 Wi-Fi 6, Bluetooth Low Energy (link)
[3] Data sheet – RW612: Wireless MCU with Integrated 1x1 Wi-Fi 6, Bluetooth Low Energy / 802.15.4 (link)
[4] User manual – UM11799: NXP Wi-Fi and Bluetooth Demo Applications for RW61x (link)
[5] Webpage – RW610: Wireless MCU with Integrated Radio: 1x1 Wi-Fi® 6 + Bluetooth® Low Energy Radios (link)
[6] Webpage – RW612: Wireless MCU with Integrated Tri-radio: 1x1 Wi-Fi® 6 + Bluetooth® Low Energy / 802.15.4 (link)

7 Abbreviations

Table 5. Abbreviations

Acronym	Description
Ant	Antenna
AP	Access point
FE	Front end
FEM	Front end module
PCB	Printed circuit board
RSSI	Received signal strength indicator

8 Revision history

Table 6. Revision history

Document ID	Release date	Description
AN14466 v.2.0	16 December 2024	• Section 2.1 "Design type 0xA2": replaced the value of RF_CNTL3_SW for Antenna 0 in the figure. • Section 2.2 "Design type 0xA3": replaced the value of RF_CNTL3_SW for Antenna 0 in the figure.
AN14466 v.1.0	2 December 2024	• Initial version

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