R9A06G062GNP

Guidelines for wireless evaluation

Introduction

This application note introduces the measurement procedure and precautions of radio evaluation and example of field test.

Note: The contents of this document are provided as an example for reference and do not guarantee the signal quality in systems. When measuring by yourself, please use within the testing facility such as anechoic chamber for strict observance of the radio wave law, or obtain the technical standard conformity certificate.

Target Device

R9A06G062GNP

Contents

1. Overview

This application note introduces the measurement procedure and precautions of radio evaluation and example of the field test. The communication distance varies depending on the installation condition of the antenna and various environmental conditions around the surroundings such as obstacles. Therefore, in order to obtain the original communication characteristics of the radio, it is recommended to measure according to the precautions described in this manual.

1.1 Related documents

The following document is related to the application note. Also to this document when using this application note,

・Design Guidelines for a Pattern Antenna(R01AN3776)

2. Advance preparation

2.1 Antenna matching

Before the radio evaluation, it is necessary first to match the antenna to the desired frequency band. If the antenna matching is misaligned, radio waves can not be radiated efficiently. Since the monopole antenna used in this document uses ground for one side of the dipole antenna, antenna characteristics will change depending on the size of the board. Therefore, it is necessary to adjust the antenna matching for each board to be used. To adjust the matching circuit, attach a semi-rigid cable to the feed point of the antenna end and confirm while checking the VSWR with the network analyzer. For detailed adjustment method, refer to the application note (R01AN3776).

3. Evaluation procedure

3.1 Attach an antenna

Attach antennas to both transmitter and receiver respectively. As shown in Figure 3-1, when the dipole antenna stands vertically, the horizontal plane becomes omnidirectional, so connect the antenna so that it is horizontal with the ground plane of the evaluation board and use it vertically. If the directivity of the antenna changes, the optimum gain can not be obtained.

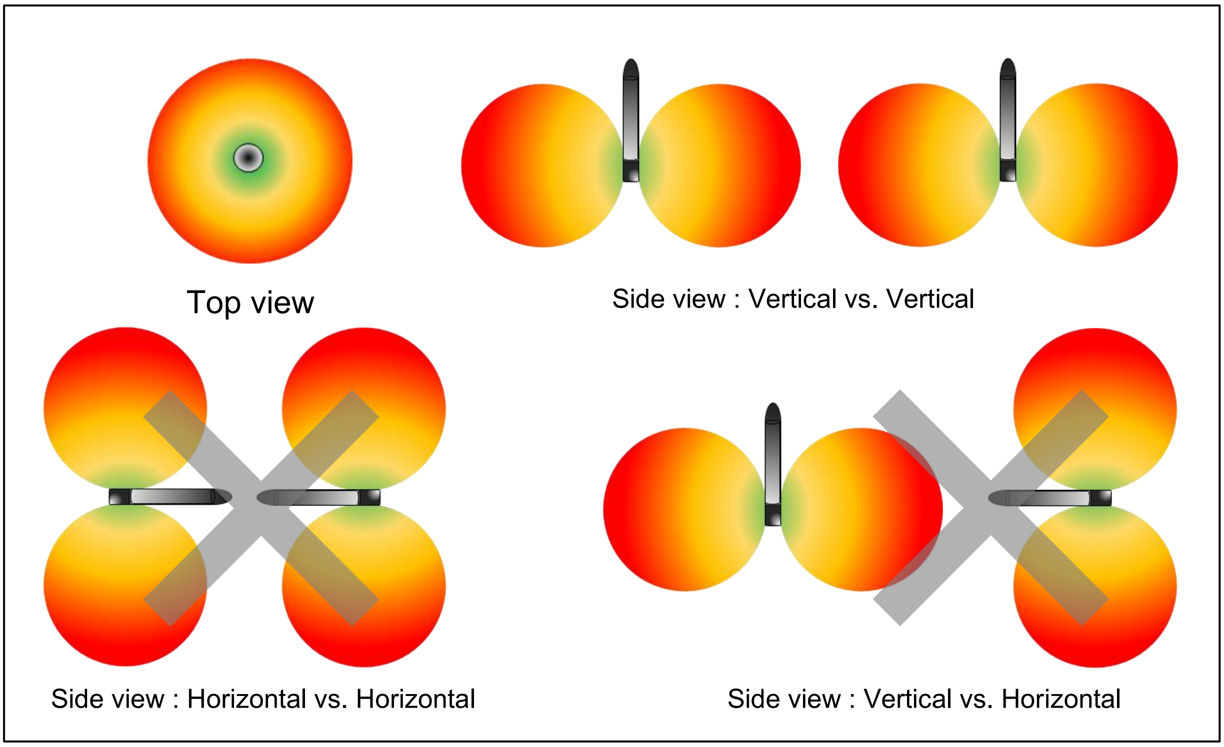

Figure 3-1 Radio field intensity and directivity of antenna

3.2 Installation of an evaluation board

3.2.1 Direction of an antenna

When installing the evaluation board, it is necessary to match the polarization plane of the antenna of both transmitter and receiver. Since the radio waves have a vibration direction, the communication distance will not lengthen because loss will increase if polarization planes are not matched.

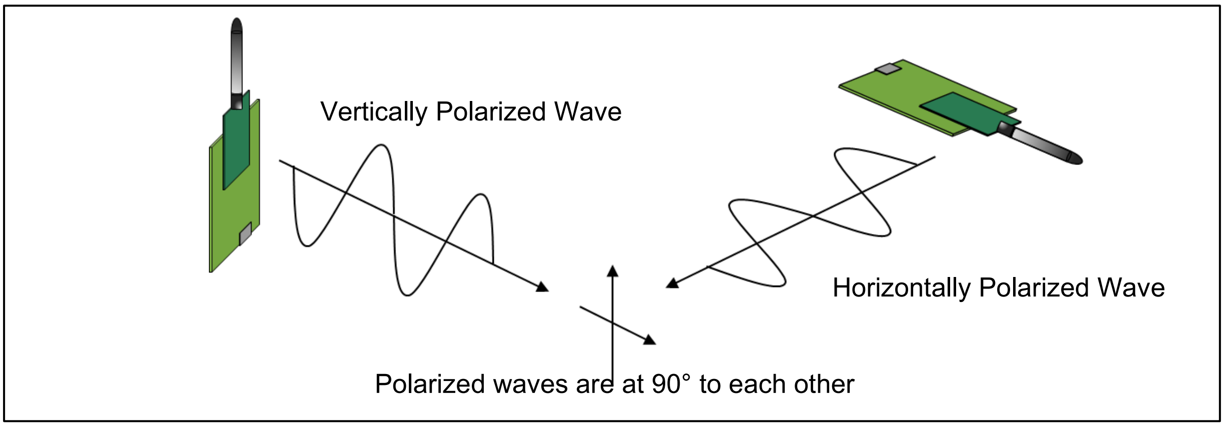

Figure 3-2 Antenna polarization

3.2.2 Height of an antenna

Use a tripod or the like to eliminate the influence of obstacles and install the evaluation board as high as possible. Also, please install so that both transmitter and receiver are at the same height.

3.2.3 Around the antenna

Please do not install anything within one wavelength from the antenna. Keep it away from the metal as much as possible in order to remarkably degrade characteristics in particular. When installing the evaluation board, in order to prevent the resonance frequency from shifting to the low frequency side due to the wavelength shortening effect of the dielectric, please fix with curing tape to wood stick or foamed styrol. Also, since the human body likewise affects the frequency, measure it away from the evaluation board as much as possible, for example by using a long cable.

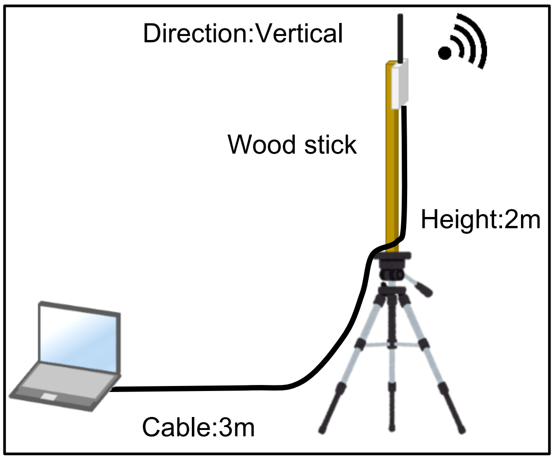

Figure 3-3 Transmitting side

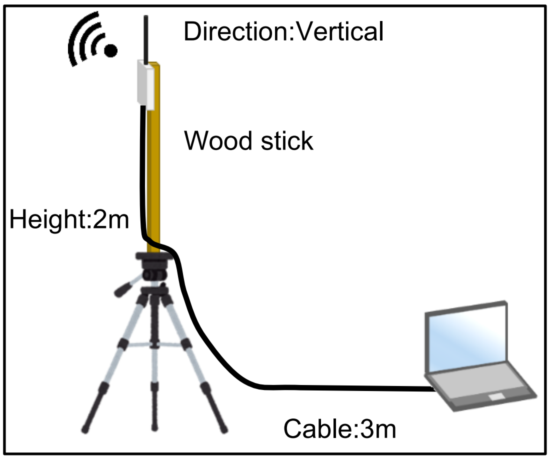

Figure 3-4 Receiving side

3.3 Connect the evaluation boat and the laptop with a USB cable

Connect the laptop and the evaluation board with a USB cable and execute each function by command from the laptop. At this time there is a possibility that reception sensitivity may deteriorate due to USB radiation noise, so wire the USB cable vertically to the antenna. In addition, as shown in Figure 3-5, it is necessary to suppress the emission of noise by using a ferrite core, an EMI filter or the like as necessary. When connecting to a laptop with a serial conversion (FTDI) cable without using the USB port of the evaluation board, please take measures against shielding and separate the distance between the evaluation board and the laptop sufficiently.

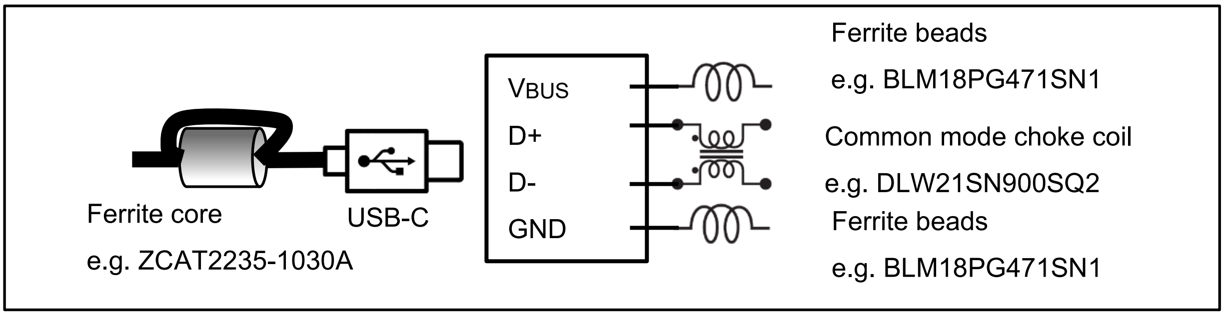

Figure 3-5 Example of USB noise suppression

3.4 Run terminal software

Activate terminal software (Tera Term etc.) and configure the serial port. When the RF characteristics evaluation program starts up, it becomes possible to enter commands.

3.5 Enter commands on the laptop (FSK)

3.5.1 Executing the command of the receiver

Enter the command in Table 3-1 to the receiver and put it in the packet reception state.

Table 3-1 measurement commands of receiver

```
? >rst                      - Hardware reset
? >tboot 9                  - Boot mode setting(e.g. 9)
? >tope FSK JP f 2b 22      - Operation mode setting(e.g. JP band / FSK 100kbps_m=1)
? >tch 0                    - Channel setting(e.g. 920.9MHz)
? >tberlen 250              - BER measurement setting(e.g. 250byte)
? >tberpn9 1                - PN code setting(e.g. PN9)
? >tffcs 4                  - FCS length setting(e.g. FSK 4byte)
? >tdw 1                    - Data whitening setting(e.g. ON)
? >trxgain -20              - RF front-end loss setting(e.g. -2.5dB / RFSW=-0.5dB/SAW=-2.0dB)
? >tfrx 0x11                - RX start(e.g. FSK RX start / BER measurement)
```

3.5.2 Execute the command of the transmitter

Enter the commands in Table 3-2 on the transmitter and transmit 300 packets.

Table 3-2 measurement commands of transmitter

```
? >rst                      - Hardware reset
? >tboot 9                  - Boot mode setting(e.g. 9)
? >tope FSK JP f 2b 22      - Operation mode setting(e.g. JP band / FSK 100kbps_m=1)
? >tch 0                    - Channel setting(e.g. 920.9MHz)
? >ttxpowd -8.0             - TX power setting(e.g. -8dBm@R9A06G062GNP output)
? >tpl 8                    - Preamble length setting(e.g. 8byte)
? >tfrlen 250               - Data length setting(e.g. 250byte / include FCS)
? >tberpn9 1                - PN code setting(e.g. PN9)
? >tffcs 4                  - FCS length setting(e.g. FSK 4byte)
? >tdw 1                    - Data whitening setting(e.g. ON)
? >ti 0                     - TX interval setting(e.g. min setting / Controlled by “tttl JP” command)
? >tfccavt 0xFF5A           - CCA threshold setting(e.g. FSK -83dBm)
? >ttxopt 1                 - CCA setting(e.g. CCA=ON)
? >tttl JP                  - Transmission time control setting(e.g. ARIB STD-T108 compliant)
? >tftx 300                 - TX start(e.g. FSK TX start / 300 packets)
```

3.5.3 Confirm the result displayed on the receiver

After confirming that the transmission has finished 300 packets, when the receiving side terminates the packet reception state with the return key, the result shown in Table 3-3 is displayed.

Table 3-3 measurement results of receiver

```
FSK TotalPckt= 300   OKPckt= 300   NGPckt= 0 (NowNG= 0)

FSK TotalBit= 00090240h OKBit= 00090240h NGBit= 00000000h (NowNG=  00000000h) BER = 0.00%

FSK RSSI(dBm)=  -50.00 (Ave),  -50.00 (Max),  -50.00 (Min), 0.00 (Var), 300 (Count)

FSK LQI          =   192.0 (Ave),      192 (Max),      192 (Min), 0.00 (Var), 300 (Count)

ANT0   = 300       , ANT1   = 0        , ANT2   = 0        , ANT3   = 0
```

3.6 Enter commands on the laptop (OFDM)

3.6.1 Executing the command of the receiver

Enter the command in Table 3-4 to the receiver and put it in the packet reception state.

Table 3-4 measurement commands of receiver

```
? >rst                          - Hardware reset
? >tboot 9                      - Boot mode setting(e.g. 9)
? >tope OFDM JP op3 m6 22       - Operation mode setting(e.g. JP band / OFDM option3-MCS6)
? >tch 0                        - Channel setting(e.g. 920.9MHz)
? >tberlen 250                  - BER measurement setting(e.g. 250byte)
? >tberpn9 1                    - PN code setting(e.g. PN9)
? >tofcs 4                      - FCS length setting(e.g. OFDM 4byte)
? >trxgain -20                  - RF front-end loss setting(e.g. -2.5dB / RFSW=-0.5dB/SAW=-2.0dB)
? >torx 0x11                    - RX start(e.g. OFDM RX start / BER measurement)
```

3.6.2 Execute the command of the transmitter

Enter the commands in Table 3-5 on the transmitter and transmit 300 packets.

Table 3-5 measurement commands of transmitter

```
? >rst                          - Hardware reset
? >tboot 9                      - Boot mode setting(e.g. 9)
? >tope OFDM JP op3 m6 22       - Operation mode setting(e.g. JP band / OFDM option3-MCS6)
? >tch 0                        - Channel setting(e.g. 920.9MHz)
? >ttxpowd -6.0                 - TX power setting(e.g. -6dBm@R9A06G062GNP output)
? >tfrlen 250                   - Data length setting(e.g. 250byte / include FCS)
? >tberpn9 1                    - PN code setting(e.g. PN9)
? >tofcs 4                      - FCS length setting(e.g. OFDM 4byte)
? >ti 0                         - TX interval setting(e.g. min setting /Controlled by “tttl JP” command)
? >toccavt 0xFF5A               - CCA threshold setting(e.g. OFDM -83dBm)
? >ttxopt 1                     - CCA setting(e.g. CCA=ON)
? >tttl JP                      - Transmission time control setting(e.g. ARIB STD-T108 compliant)
? >totx 300                     - TX start(e.g. OFDM TX start / 300 packets)
```

3.6.3 Confirm the result displayed on the receiver

After confirming that the transmission has finished 300 packets, when the receiving side terminates the packet reception state with the return key, the result shown in Table 3-6 is displayed.

Table 3-6 measurement results of receiver

```
OFDM TotalPckt= 300   OKPckt= 300   NGPckt= 0 (NowNG= 0)
OFDM TotalBit= 00090240h OKBit= 00090240h NGBit= 00000000h (NowNG=00000000h) BER = 0.00%
OFDM RSSI(dBm)=  -50.00 (Ave),  -50.00 (Max),  -50.00 (Min), 0.00 (Var), 300 (Count)
OFDM LQI        =   196.0 (Ave),      196 (Max),      196 (Min), 0.00 (Var), 300 (Count)
ANT0   = 300      , ANT1   = 0        , ANT2   = 0        , ANT3   = 0
```

4. Reference case

4.1 Field test

4.1.1 Measurement environment

We measured the communication distance on a cycling road where better prospects and long straight line continues along the Tone River. At this time, both the transmitter and the receiver are fixed with a tripod at a height of 2m from the ground, and the orientation of the antenna is set perpendicular to the ground (vertically polarized wave). Connected the wireless device and the laptop with a 3m USB cable, operated the laptop at a distance. The position of the RX_DUT was fixed, and the TX_DUT was moved to a specified position, and the communication distance (PER/RSSI) was measured.

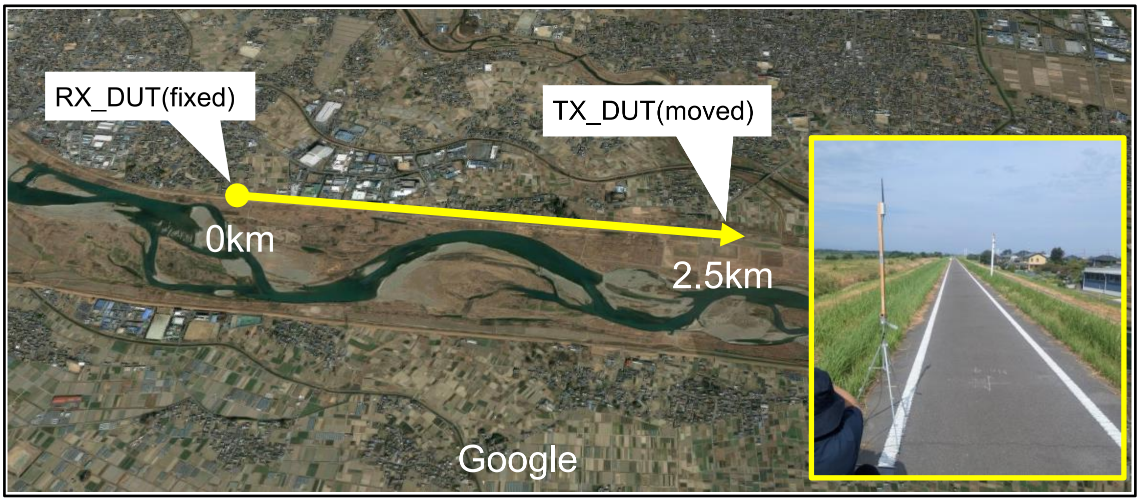

Figure 4-1 measurement environment

4.1.2 Signal / DUT conditions

(FSK)

CH=920.9MHz, Output Power=+13dBm(20mW)
Data Rate=100kbps, Modulation=2GFSK, Modulation Index=1
Preamble=8byte, FCS=4byte, Payload=250byte, FEC disabled

(OFDM)

CH=920.9MHz, Output Power=+13dBm(20mW)
Data Rate=25kbps, Option3 - MCS0
Data Rate=300kbps, Option3 - MCS4
Data Rate=400kbps, Option3 - MCS5
Data Rate=600kbps, Option3 - MCS6
STF=4symble, FCS=4byte, Payload=250byte

(RX_DUT)

Daughter board : #0010(RTK0EE0015D11001BJ), Technical Conformity No, 001YYJA3006801
Mother board : #040(RTK0EE0013D12002BJ_V3)
Antenna : Tagolas TI.92.2113 λ/2

(TX_DUT)

Daughter board : #0009(RTK0EE0015D11001BJ), Technical Conformity No, 001YYJA3006800
Mother board : #015(RTK0EE0013D12002BJ_V3)
Antenna : Tagolas TI.92.2113 λ/2

4.1.3 Test results

Table 4-1 and Figure 4-2 show the measurement results.

The communication distances of FSK (100kbps) and OFDM (300kbps) are almost the same.
Therefore, using OFDM can improve data transmission efficiency even over the same distance.

Table 4-1 Communication distance (PER＝10% or less)

	FSK 100kbps	OFDM Opt3 - MCS0 25kbps	OFDM Opt3 - MCS4 300kbps	OFDM Opt3 - MCS5 400kbps	OFDM Opt3 - MCS6 600kbps
Distance [m]	2000	over 2500	2000	2000	1600

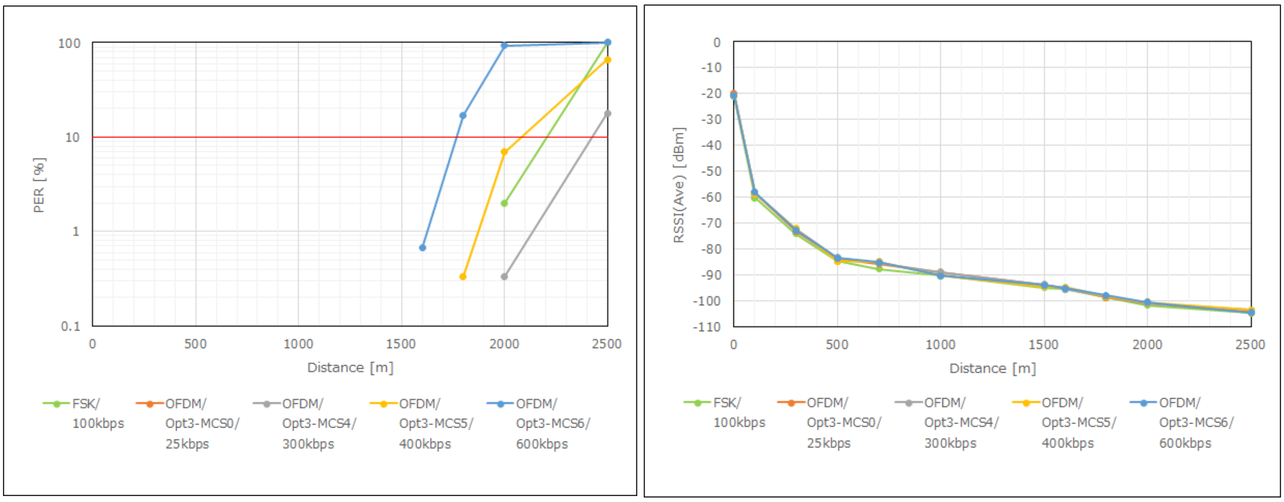

Figure 4-2 PER/RSSI in each measurement point

4.2 Notice of field test

4.2.1 Survey of field environment

Before the field test, it is necessary to check the radio wave environment in the field.

Figure 4-3 shows an example of the radio wave environment in Japan.

Japan's Wi-SUN band is 920MHz, but large LTE signals are observed in the 860-890MHz and 945-960MHz bands.

When the large LTE signals are present, the RFIC's(R9A06G062GNP) RX LNA will saturate, causing intermodulation distortion in the Wi-SUN CH (920 MHz). As a result, RX sensitivity will be degraded.

In such environments, be sure to use a SAW filter in the RX path to attenuate the LTE signals.

without SAW : Large LTE signals are observed in the 860-890MHz/945-960MHz bands.

with SAW : The LTE signals are attenuated by using SAW (920MHz band).

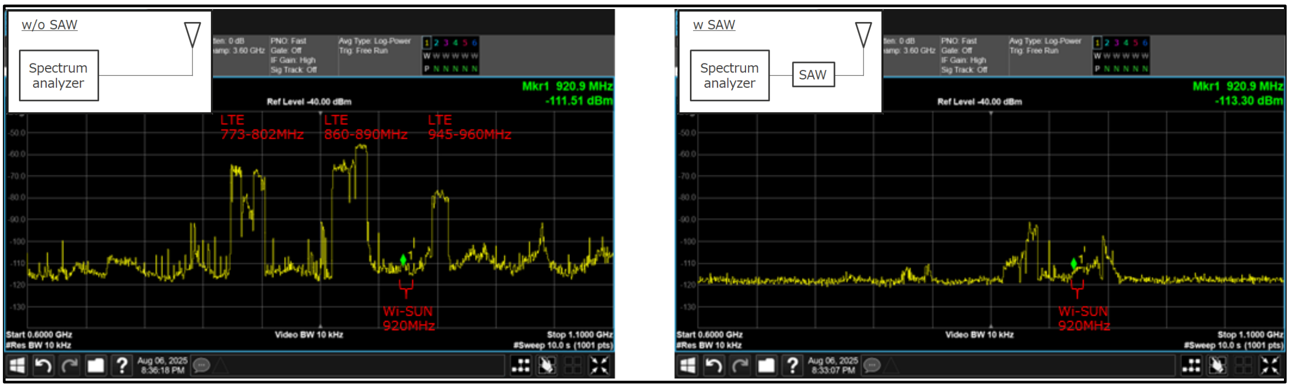

Figure 4-3 Radio wave environment in Japan

Table 4-2 shows an example of calculation of intermodulation distortion caused by Japanese LTE signals. When there are LTE signals in the 860 to 890 MHz range, intermodulation distortion occurs in the 830 to 920 MHz range.

Since 920MHz is a Wi-SUN band, RX characteristics may be degraded, so it is necessary to attenuate the LTE signal using a SAW filter.

Table 4-2 Intermodulation distortion calculation example

Interference 1(f_{u1}) = 860MHz

Interference 2(f_{u2}) = 890MHz

Intermodulation 1 = $2f_{u1} - f_{u2}$ = 830MHz

Intermodulation 2 = $2f_{u2} - f_{u1}$ = 920MHz

4.2.2 Check the ED value

Before the field test, check the ED value (Energy detect) of the RX_DUT.

There is no issue if the ED value is -110dBm or less.

If a high ED value is observed, it is possible that another system is using the same CH, so change the CH and search for a CH with a lower ED value.

Table 4-3 shows the procedure for performing ED, and Table 4-4 shows an example of the ED results.

Table 4-3 measurement commands of receiver for ED

```
? >rst                          - Hardware reset
? >tboot 9                      - Boot mode setting(e.g. 9)
? >tope tope OFDM JP op3 m6 22  - Operation mode setting(e.g. Japan band / OFDM option3-MCS6)
? >tch 0                        - Channel setting(e.g. 920.9MHz)
? >tberlen 250                  - BER measurement setting(e.g. 250byte)
? >tberpn9 1                    - PN code setting(e.g. PN9)
? >tofcs 4                      - FCS length setting(e.g. OFDM 4byte)
? >trxgain -20                  - RF front-end loss setting(e.g. -2.5dB / RFSW=-0.5dB/SAW=-2.0dB)
? >te 1 300                     - ED start(e.g. OFDM ED start / 300 times)
```

Table 4-4 ED measurement results

```
APL ---> STACK  ED (OFDM)
        Now ED...     Freq = 920900000 [Hz]
        ...
        ED Completed
        ed  :       0.0 (Ave),         0 (Max),         0 (Min), 0.00 (Var), 300 (Count)
        rssi: -111.93 (Ave), -110.50 (Max), -113.50 (Min), 0.30 (Var), 300 (Count) (dBm)
```

4.2.3 Check the number of completed TX packets

Check the number of completed TX packets on the TX_DUT. CCA is performed before TX, so if the power above the CCA threshold is detected, TX will stop. Therefore, even if the number of TX packets is set to 300, it is possible that not all packets will be transmission.

If the set number of packets has not been transmission, measure again or calculate the PER using the number of completed TX packets as the parameter.

Table 4-5 shows the transmission results of TX_DUT. In this example, all 300 packets were transmitted.

Table 4-5 measurement results of transmitter

```
command (and SetData[Dec])? >totx 300
   APL ---> STACK  OFDM TX
        Now Sending...     Freq = 920900000 [Hz]
        ...
        Stop Sending
   send success            = 300
   send err busy           = 0
   send err time overflow = 0
   send err underflow      = 0
   send err etc            = 0
   Data Send Done
```

4.3 Test circuit (Daughter board)

Figure 4-4 and Table 4-6 show the circuit diagram and bill of materials for the daughter board used in the field test.

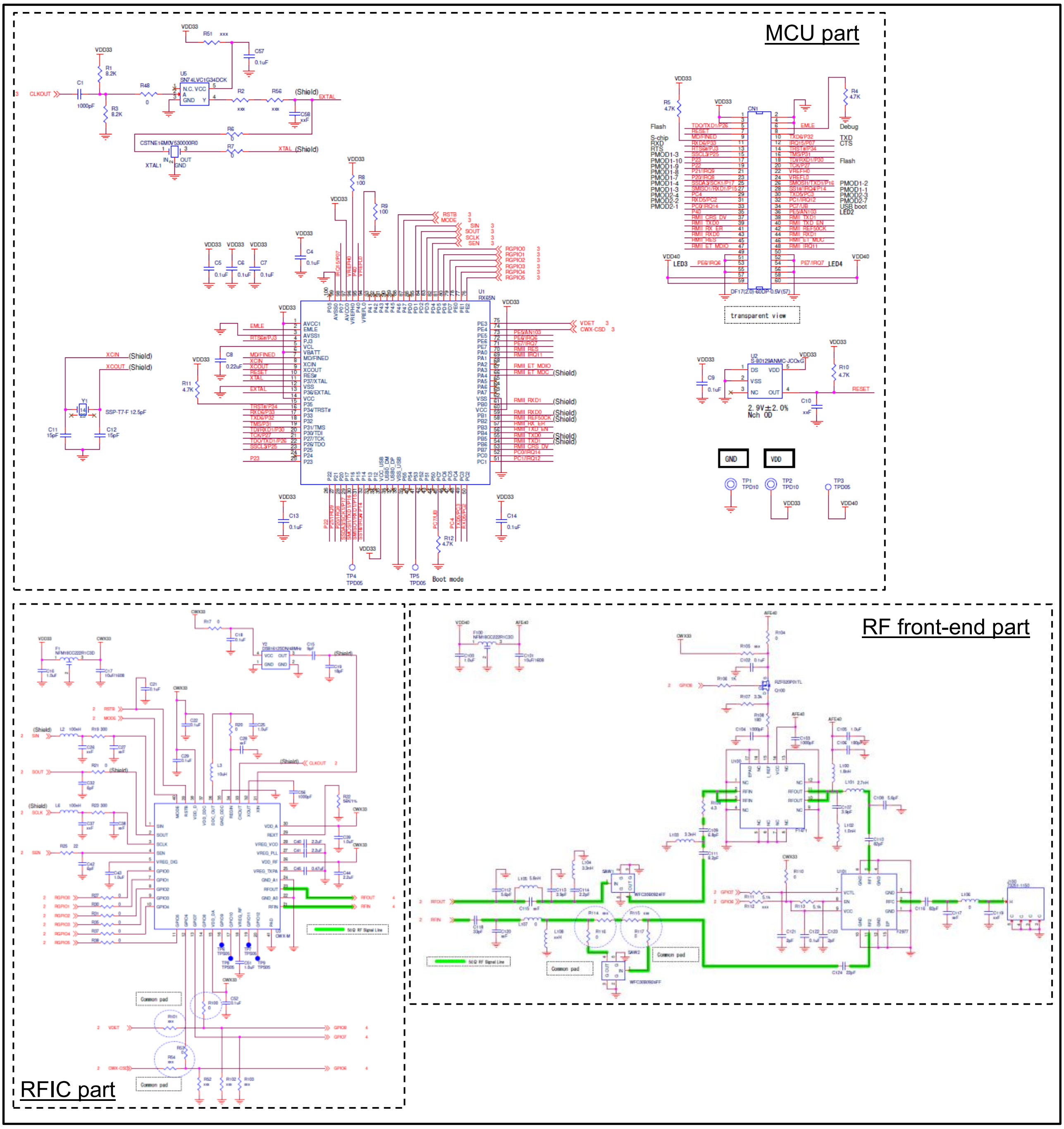

Figure 4-4 Circuit diagram

Table 4-6 Bill of materials

Parts ID	Description	Parts Number
CN1	DF17(2.0)-60DP-0.5V(57)	DF17(2.0)-60DP-0.5V(57)
C1,C56,C103,C104	1000pF	CL05B102KB5NNNC
C4,C5,C6,C7,C9,C13,C14,C18,C21,C22,C29,C52,C57,C102,C122	0.1uF	CL05A104KA5NNNC
C8	0.22uF	CL05A224KO5NNNC
C10,C26,C27,C28,C37,C38,C58,C115,C117,C119,C120	Not mounted	
C11,C12	15pF	CL05C150JB5NNNC
C15	9pF	GJM1555C1H9R0C
C16,C25,C39,C43,C51,C100,C105	1.0uF	CL05A105KO5NNNC
C17,C101	10uF/1608	GRM188R61A106M
C19	18pF	CL05C180JB5NNNC
C32,C42	6pF	GJM1555C1H6R0C
C40,C41,C44	2.2uF	EMK105ABJ225KV-F
C45	0.47uF	CL05A474KP5NNNC
C106	180pF	GRM1555C1H181JA01D
C107	3.9pF	GRM1555C1H3R9CA01D
C108,C112	5.6pF	GJM1555C1H5R6CB01
C109	6.8pF	GRM1555C1H6R8CA01D
C110,C116	82pF	GRM1555C1H820JA01D
C111	8.2pF	GRM1555C1H8R2CA01D
C113	3.9pF	GJM1555C1H3R9BB01
C114	2.2pF	GJM1555C1H2R2BB01
C118	33pF	CL05C330JB5NNNC
C121,C123	2pF	GRM1555C1H2R0CA01D
C124	22pF	CL05C220JB5NNNC
F1,F100	NFM18CC222R1C3D	NFM18CC222R1C3D
J100	73251-1150	73251-1150
L2,L6	100nH	LQG15HNR10J02D
L3	10uH	MLZ1608M100WT000
L100	1.8nH	LQW18AS1N8J00D
L101	2.7nH	LQG15HS2N7S02D
L102	1.0nH	LQG15HS1N0S02D
L103	3.3nH	LQG15HS3N3S02D
L104	3.3nH	LQW15AN3N3C80
L105	5.8nH	LQW15AN5N8C00
L106,L107	0	RK73Z1ETTP
L108	Not mounted	
Q100	RZF020P01TL	RZF020P01TL
R1,R3	8.2K	RK73B1ETTP822J
R2,R51,R52,R54,R56,R101,R102,R103,R105,R112,R114,R115	Not mounted	
R4,R5,R10,R11,R12	4.7K	RK73B1ETTP472J
R6,R7,R17,R20,R21,R27,R30,R31,R35,R37,R38,R48,R53,R100,R104,R110,R116,R117	0	RK73Z1ETTP
R8,R9	100	RK73B1ETTP101J
R19,R23	300	RK73B1ETTP301J
R22	56K/1%	RK73H1ETTP5602F
R25	22	RK73B1ETTP220J
R106	1K	RK73B1ETTP102J
R107	3.3k	RK73B1ETTP332J
R108	180	RK73B1ETTP181J
R109	4.3	RK73B1ETTP4R3J
R111,R113	5.1k	RK73B1ETTP512J
SAW1,SAW2	WFC30B0924FF	WFC30B0924FF
TP1,TP2	Test pad	
TP3,TP4,TP5	Test pad	
TP6,TP7,TP8,TP9	Test pad	
U1	RX65N	R5F565NEDDFP
U2	S-80129ANMC-JCOxG	S-80129ANMC-JCOxG
U3	CWX-M	R9A06G062GNP
U5	SN74LVC1G34DCK	SN74LVC1G34DCK
U100	F1471	F1471
U101	F2977	F2977
XTAL1	CSTNE16M0V530000R0	CSTNE16M0V530000R0
Y1	SSP-T7-F 12.5pF	SSP-T7-F 12.5pF
Y2	DSB1612SDN/48MHz	DSB1612SDN

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Aug.29.2025	-	First edition issued

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)

   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.
2. Processing at power-on

   The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.
3. Input of signal during power-off state

   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.
4. Handling of unused pins

   Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.
5. Clock signals

   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.
6. Voltage application waveform at input pin

   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).
7. Prohibition of access to reserved addresses

   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.
8. Differences between products

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