R8C/3MQ

Electrical characteristics of RF transceiver

R01AN1545EJ0100
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Introduction

This data shows the basic characteristic of RF transceiver. Please confirm a user's manual about performance.

Target Device

Data shown in this document is applied with the following microcomputer.

Microcomputer: R8C/3MQ Family

Contents

1. Electrical characteristics

1.1 TX Electrical characteristics

Table 1 TX electrical characteristics 1 (VCC = VCCRF = 3.3 V)

Items		RF Frequency [MHz]	PA Level Setting	Unit	-20°C	room temp	85°C
TX Power	Max	2405	31 dec	dBm /2 MHz	-1.0	-1.1	-1.2
		2440			-0.3	-0.6	-1.0
		2480			-0.4	-0.8	-1.2
	Min	2405	0 dec		-40.6	-40.6	-40.9
		2440			-39.0	-39.4	-40.0
		2480			-38.4	-39.0	-39.8
	variable power range	2405	-	dB	39.6	39.5	39.7
		2440			38.7	38.8	39.0
		2480			37.9	38.2	38.6
Harmonics*	2nd	2405	31 dec	dBm /1 MHz	-56.9	-57.8	-63.3
		2440			-61.0	-61.3	-63.1
		2480			-59.1	-58.3	-58.5
	3rd	2405			-52.7	-53.4	-53.7
		2440			-54.7	-55.7	-55.5
		2480			-53.7	-54.3	-54.9
Spurious emission*	30 MHz-88 MHz	2405	31 dec	dBm /100 KHz	-77.1	-76.8	-77.5
		2440			-76.7	-76.4	-77.0
		2480			-76.5	-76.3	-76.8
	88 MHz-216 MHz	2405			-76.6	-76.1	-75.8
		2440			-75.8	-76.1	-76.4
		2480			-76.1	-75.8	-76.3
	216 MHz-960 MHz	2405			-71.2	-70.1	-72.3
		2440			-69.5	-70.0	-74.5
		2480			-69.3	-69.6	-73.0
	960 MHz-1 GHz	2405			-77.1	-76.2	-76.1
		2440			-76.3	-75.6	-76.1
		2480			-76.6	-76.1	-76.4

*It is not compensated measurement RF cable loss.

Table 2 TX electrical characteristics 2 (VCC = VCCRF = 3.3V)

Items		RF Frequency [MHz]	PA Level Setting	Unit	-20°C	room temp	85°C
Spurious emission*	1 GHz-12.75 GHz	2405	31 dec	dBm /1 MHz	-53.1	-53.8	-53.1
		2440			-54.6	-55.6	-55.3
		2480			-53.3	-54.8	-54.7
	1.8 GHz-1.9 GHz	2405			-66.7	-66.3	-65.8
		2440			-66.2	-66.4	-66.2
		2480			-66.7	-66.4	-66.2
	5.15 GHz-5.3 GHz	2405			-65.3	-65.0	-64.8
		2440			-65.3	-65.3	-65.2
		2480			-65.2	-64.7	-65.8
EVM		2405	31 dec	%rms	9.0	8.2	10.0
		2440			9.6	9.0	9.0
		2480			9.0	9.1	9.0
Absolute Limit		2405	31 dec	dBm	-38.6	-38.4	-38.8
		2440			-37.7	-37.9	-38.4
		2480			-37.5	-37.7	-38.3
Relative Limit		2405	31 dec	dB	-37.5	-37.3	-37.6
		2440			-37.4	-37.2	-37.4
		2480			-37.1	-36.9	-37.1
Frequency tolerance		2405	31 dec	ppm	-7.4	0.4	11.9
		2440			-7.4	0.5	11.9
		2480			-7.4	0.4	11.9

*It is not compensated measurement RF cable loss.

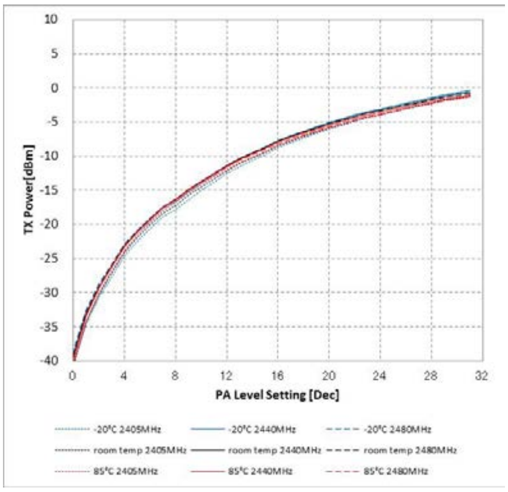

Figure 1 TX Power vs. PA Level Setting, Temperature, and RF Frequency (VCC = VCCRF = 3.3 V)

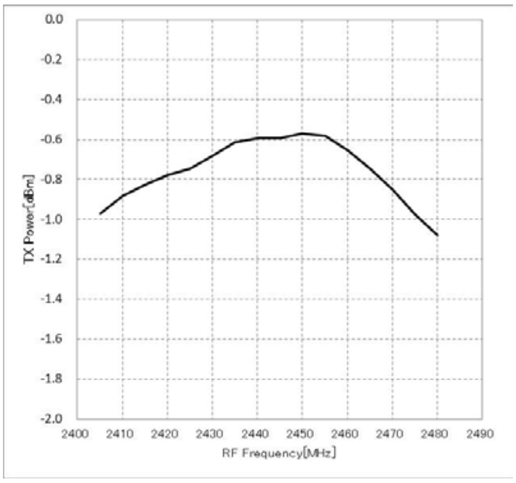

Figure 2 TX Power vs. RF Frequency (VCC = VCCRF = 3.3 V, PA Level setting = 31, room temperature)

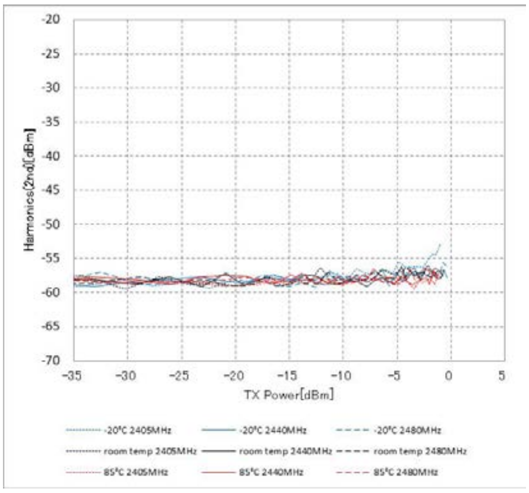

Figure 3 Harmonics 2nd vs. TX Power, Temperature, and RF Frequency (VCC = VCCRF = 3.3 V)

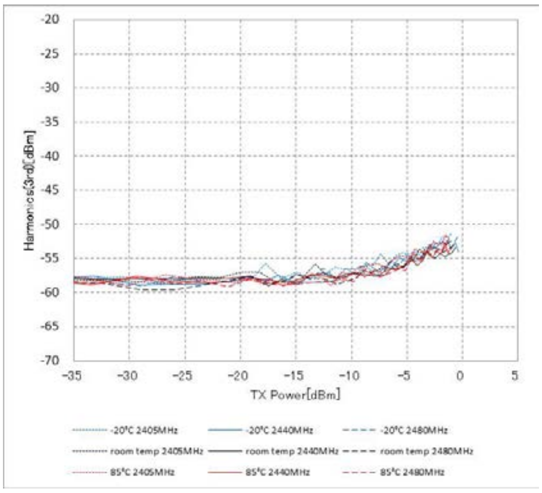

Figure 4 Harmonics 3rd vs. TX Power, Temperature, and RF Frequency (VCC = VCCRF = 3.3 V)

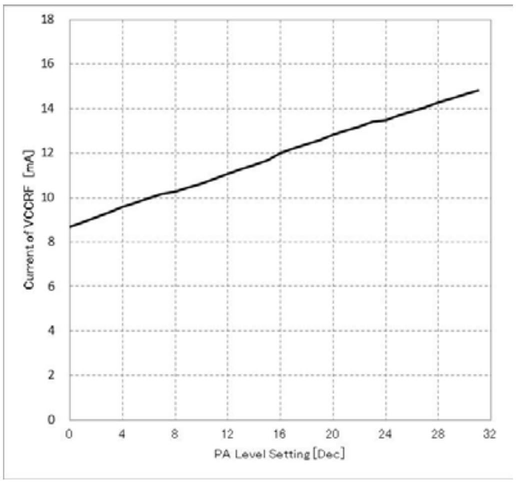

Figure 5 Current of VCCRF for TX mode vs. PA Level Setting (VCC = VCCRF = 3.3 V, RF Frequency = 2440 MHz, room temperature)

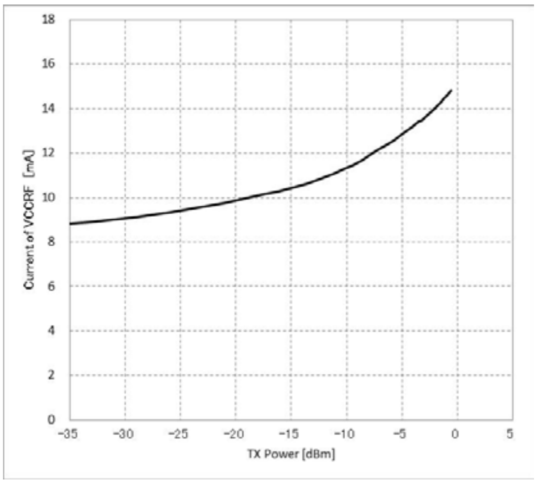

Figure 6 Current of VCCRF for TX mode vs. TX Power (VCC = VCCRF = 3.3 V, RF Frequency = 2440 MHz, room temperature)

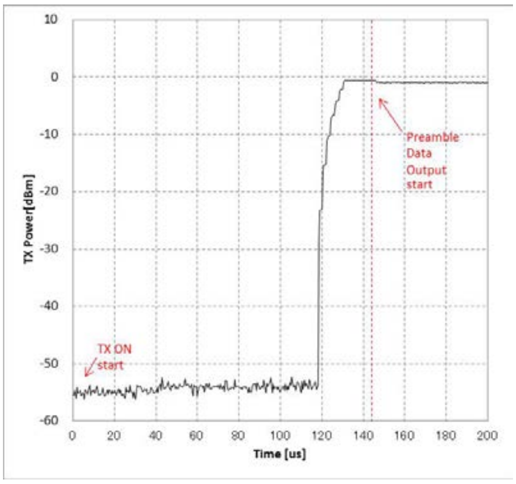

Figure 7 PA Ramp-Up (VCC = VCCRF = 3.3 V, RF Frequency = 2440 MHz, PA Level setting = 31, room temperature)

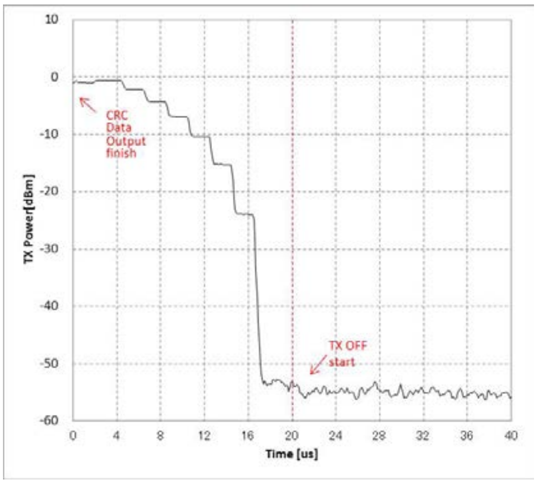

Figure 8 PA Ramp-Down (VCC = VCCRF = 3.3 V, RF Frequency = 2440 MHz, PA Level setting = 31, room temperature)

Figure 9 Transmit Spectrum (VCC = VCCRF = 3.3 V, RF Frequency = 2440 MHz, PA Level setting = 31, room temperature)

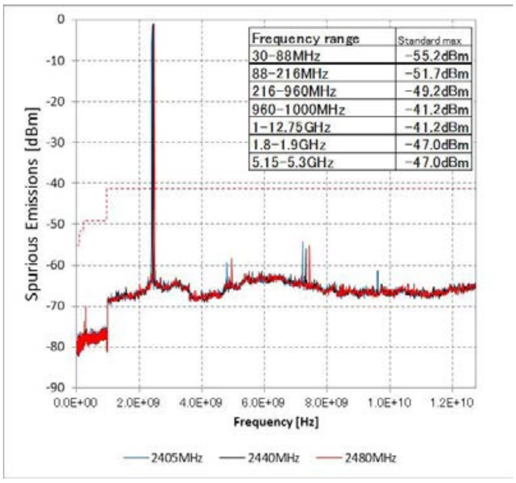

Figure 10 TX Spurious Emissions (VCC = VCCRF = 3.3 V, PA Level Setting = 31, room temperature, Resolution Bandwidth = 100 kHz when Frequency < 1 GHz, Resolution Bandwidth = 1 MHz when Frequency > 1 GHz, It is not compensated measurement RF cable loss)

1.2 RX Electrical characteristics

Table 3 RX electrical characteristics (VCC = VCCRF = 3.3 V)

Items			RF Frequency [MHz]	Unit	-20°C	room temp	85°C
Receiver sensitivity	PER = 1% PSDU Length 20 octets Interframe spacing 12 symbols		2405	dBm	-96	-94	-94
			2440		-96	-95	-93
			2480		-94	-93	-93
Maximum Input level	PER = 1% PSDU Length 20 octets Interframe spacing 12 symbols		2405	dBm	4	2	3
			2440		4	2	3
			2480		4	3	4
Adjacent channel rejection	+5 MHz		2440	dBm	27	24	27
	-5 MHz		2440	dBm	13	8	16
Alternate channel rejection	+10 MHz		2440	dBm	46	45	45
	-10 MHz		2440	dBm	44	42	46
Co-channel rejection	Band Width of AWGN = 5 MHz		2440	dB	2	2	2
Spurious emission*	30 MHz-1000 MHz		2405	dBm /100 kHz	-65.5	-65.1	-66.5
			2440		-64.2	-67.2	-68.0
			2480		-63.0	-65.3	-65.8
	1 GHz-12.75 GHz		2405	dBm /1 MHz	-56.2	-57.8	-58.2
			2440		-56.2	-57.2	-57.8
			2480		-56.1	-57.4	-57.5
RSSI range	Prf (min) = -75 dBm		2440	dB	> 75	> 75	> 75
RSSI accuracy	Prf = -75 dBm to -35 dBm (1 dB steps)	Max	2440	dB	2.0	1.3	0.1
		Min	2440		0.0	-1.1	-2.9

*It is not compensated measurement RF cable loss.

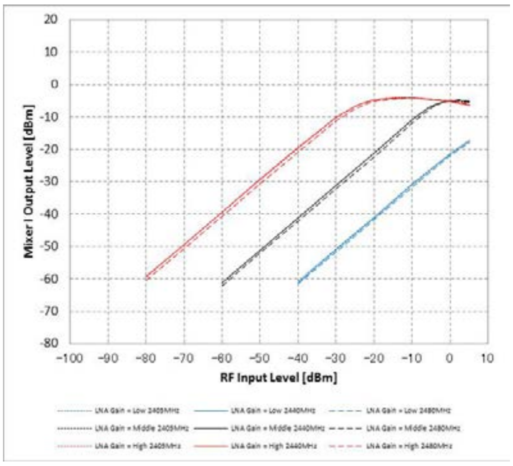

Figure 11 Mixer I Output Level vs. RF Input Level (VCC = VCCRF = 3.3 V, room temperature, IF Frequency = 2 MHz)

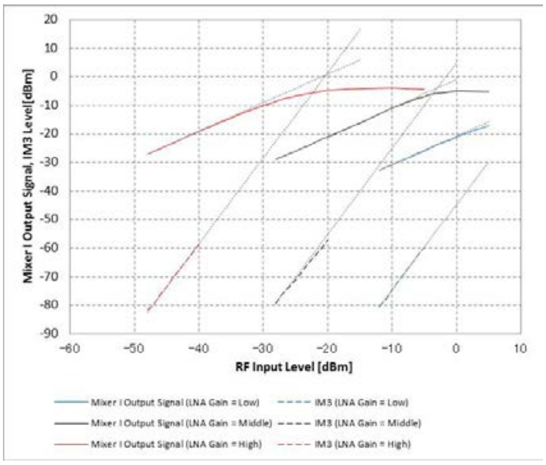

Figure 12 LNA/Mixer IIP3 vs. LNA Gain (VCC = VCCRF = 3.3 V, RF Frequency1 = 2441 MHz, RF Frequency2 = 2442 MHz, Lo Frequency = 2438 MHz, room temperature)

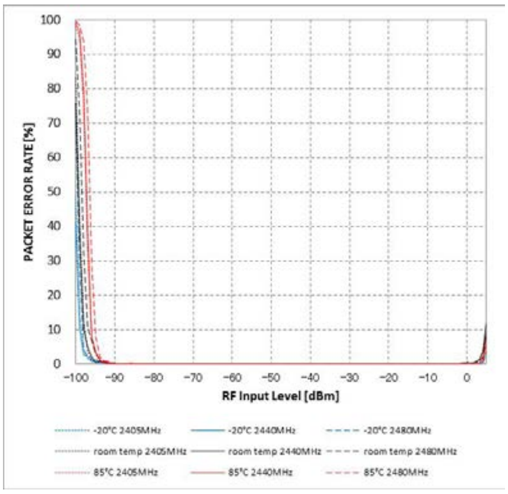

Figure 13 Packet Error Rate vs. RF Input Level (VCC = VCCRF = 3.3 V, RF Input Level = -100 dBm to +5 dBm, Data Length = 20 B)

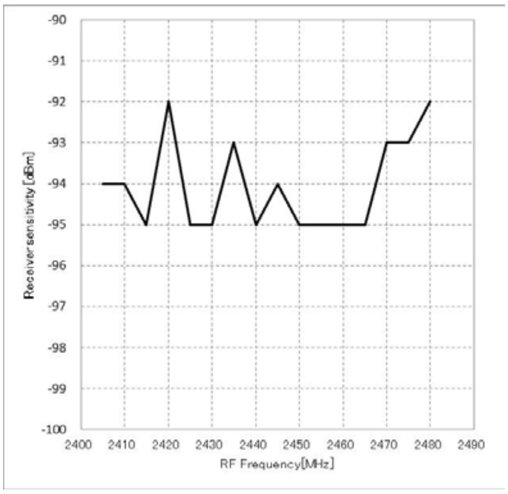

Figure 14 Receiver sensitivity vs. RF Frequency (VCC = VCCRF = 3.3 V, room temperature, Data Length = 20 B)

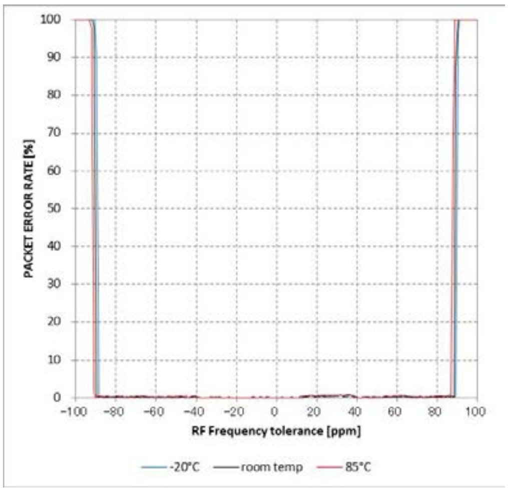

Figure 15 Packet Error Rate vs. RF Frequency tolerance (VCC = VCCRF = 3.3 V, RF Frequency = 2440 MHz, RF Input Level = -85 dBm, Data Length = 20 B)

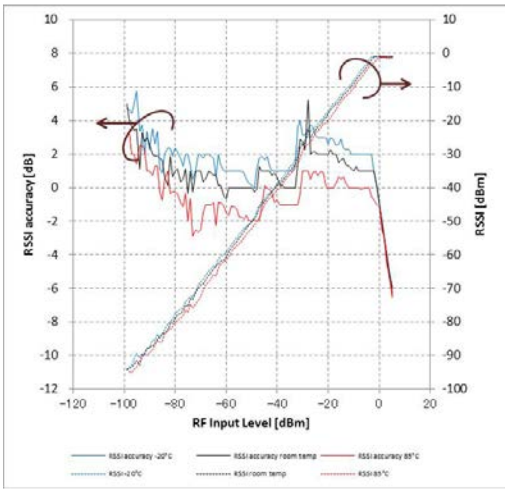

Figure 16 RSSI accuracy vs. RF Input Level (VCC = VCCRF = 3.3 V, RF Frequency = 2440 MHz, RF Input Level = -100 dBm to +5 dBm for 1 dB steps)

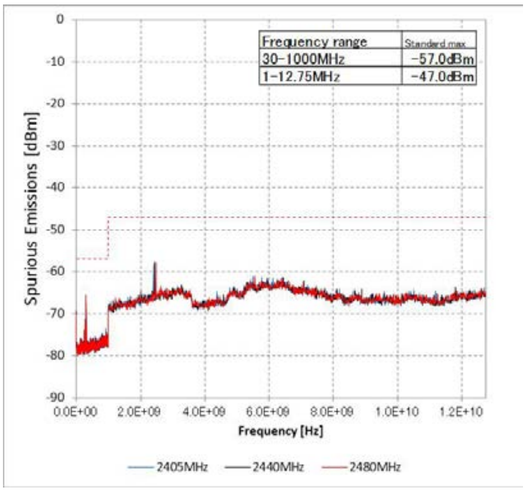

Figure 17 RX Spurious Emissions (VCC = VCCRF = 3.3 V, LNA Gain = High, room temperature, Resolution Bandwidth = 100 kHz when Frequency < 1 GHz, Resolution Bandwidth = 1 MHz when Frequency > 1 GHz, It is not compensated measurement RF cable loss)

1.3 RFIOP/RFION Port Impedance

Table 4 RFIOP/RFION Impedance (VCC = VCCRF = 3.3 V, room temperature)

Mode	Condition	RFIOP Impedance (Ω)			RFION Impedance (Ω)		
		2405 MHz	2440 MHz	2480 MHz	2405 MHz	2440 MHz	2480 MHz
TX	PA Level setting = 31	3.4 -j19.3	3.5 -j18.5	3.7 -j17.4	3.3 -j16.1	3.4 -j15.0	3.5 -j14.0
	PA Level setting = 0	3.2 -j20.6	3.2 -j19.9	3.3 -j18.8	3.3 -j17.1	3.3 -j16.1	3.3 -j15.1
RX	LNA Gain = High	2.7 -j19.7	2.7 -j18.9	2.9 -j17.7	3.5 -j16.1	3.4 -j15.2	3.5 -j14.3
	LNA Gain = Middle	3.1 -j19.7	3.1 -j19.0	3.2 -j17.9	3.3 -j16.2	3.3 -j15.2	3.3 -j14.3
	LNA Gain = Low	5.5 -j19.0	5.5 -j18.3	5.5 -j17.3	5.7 -j15.5	5.6 -j14.5	5.6 -j13.6

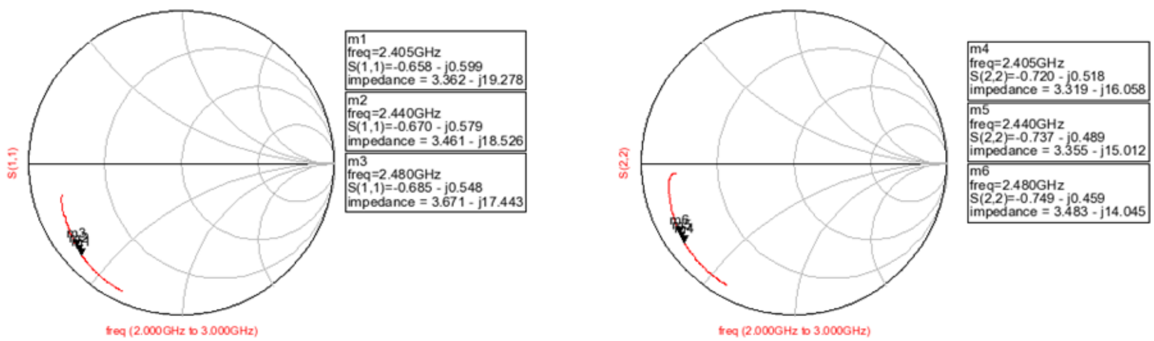

Figure 18 S11 at RFIOP and RFION for TX mode (VCC = VCCRF = 3.3 V, PA Level Setting = 31, room temperature, Z0 = 50 Ω, Left figure is RFIOP, Right figure is RFION)

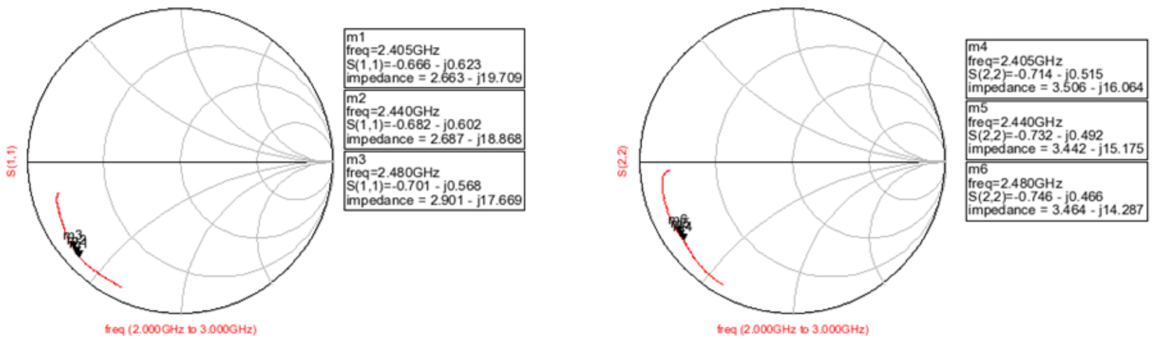

Figure 19 S11 at RFIOP and RFION for RX mode (VCC = VCCRF = 3.3 V, LNA Gain = High, room temperature, Z0 = 50 Ω, Left figure is RFIOP, Right figure is RFION)

Table 5 RFIO differential Impedance (VCC = VCCRF = 3.3 V, room temperature)

Mode	Condition	RFIO differential Impedance (Ω)		
		2405 MHz	2440 MHz	2480 MHz
TX	PA Level setting = 31	3.9 -j49.9	3.8 -j48.5	4.0 -j46.8
	PA Level setting = 0	3.5 -j50.7	3.3 -j49.2	3.4 -j47.5
RX	LNA Gain = High	3.4 -j48.4	3.3 -j47.0	3.5 -j45.3
	LNA Gain = Middle	3.7 -j48.8	3.6 -j47.3	3.6 -j45.7
	LNA Gain = Low	7.8 -j47.5	7.5 -j46.1	7.6 -j44.6

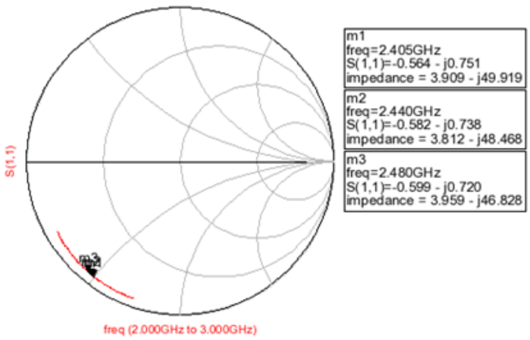

Figure 20 S11 at differential Port RFIOP and RFION for TX mode (VCC = VCCRF = 3.3 V, PA Level Setting = 31, room temperature, Z0 = 100 Ω)

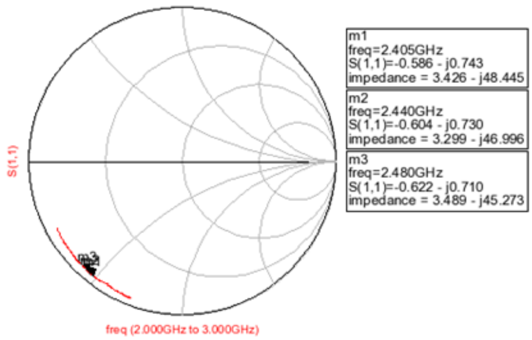

Figure 21 S11 at differential Port RFIOP and RFION for RX mode (VCC = VCCRF = 3.3 V, LNA Gain = High, room temperature, Z0 = 100 Ω)

1.4 Current of VCC and VCCRF

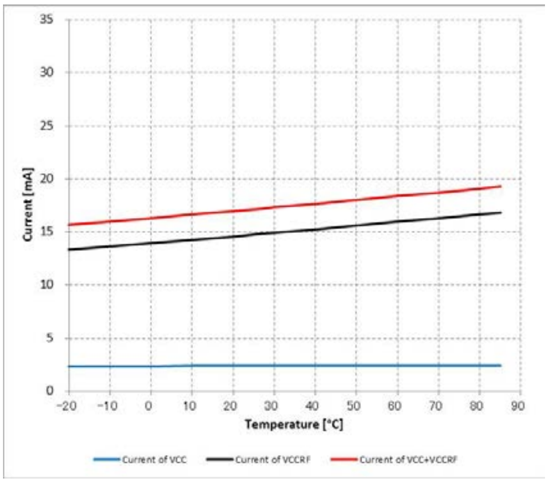

Figure 22 Current of VCC and VCCRF for TX mode vs. temperature (VCC = VCCRF = 3.3 V, PA Level Setting = 31, RF Frequency = 2440 MHz, CPU clock = Divide-by-4)

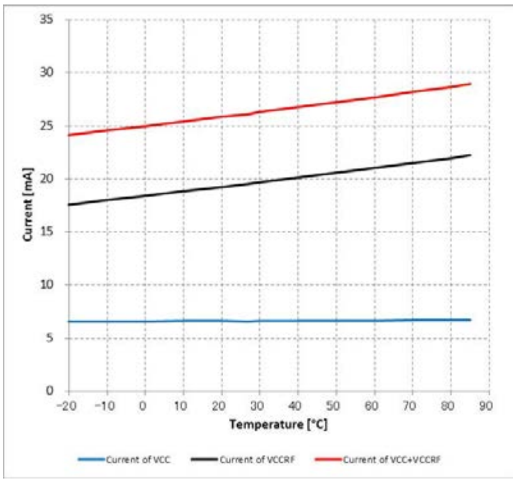

Figure 23 Current of VCC and VCCRF for RX mode vs. temperature (VCC = VCCRF = 3.3 V, LNA Gain = High, RF Frequency = 2440 MHz, CPU clock = Divide-by-4)

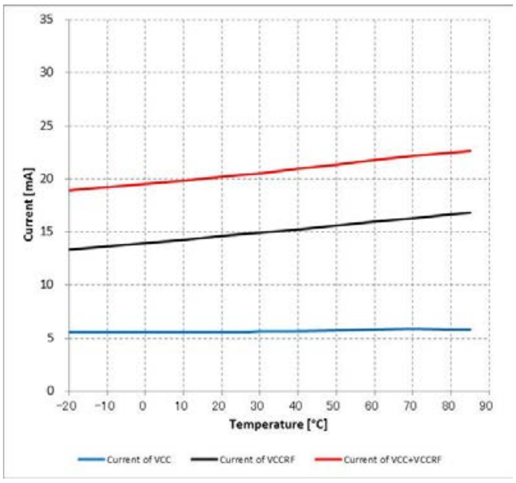

Figure 24 Current of VCC and VCCRF for TX mode vs. temperature (VCC = VCCRF = 3.3 V, PA Level Setting = 31, RF Frequency = 2440 MHz, CPU clock = No division)

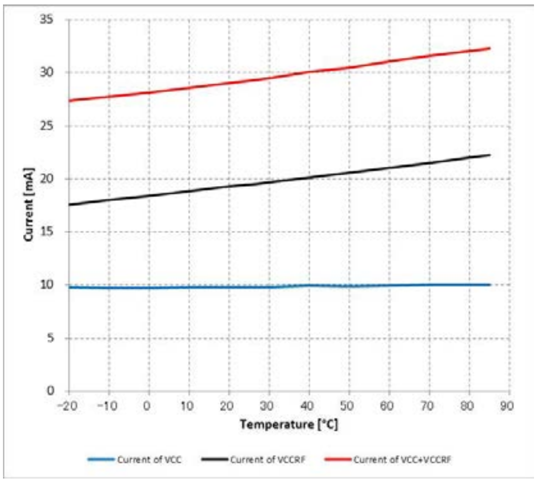

Figure 25 Current of VCC and VCCRF for RX mode vs. temperature (VCC = VCCRF = 3.3 V, LNA Gain = High, RF Frequency = 2440 MHz, CPU clock = No division)

1.5 LDO Electrical characteristics

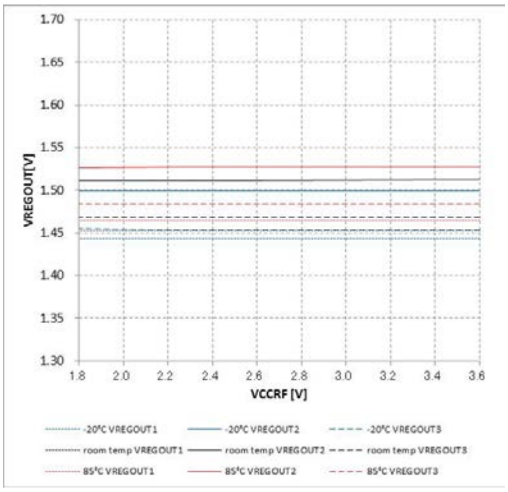

Figure 26 VREGOUT Voltage vs. VCCRF Voltage for TX mode (PA Level Setting = 31, RF Frequency = 2440 MHz, room temperature)

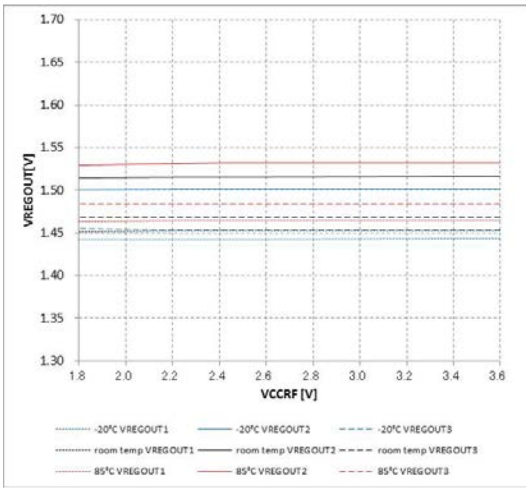

Figure 27 VREGOUT Voltage vs. VCCRF Voltage for RX mode (LNA Gain = High, VGA Gain = Max, RF Frequency = 2440 MHz, room temperature, RF input Signal = OFF)

2. Example of Peripheral Circuit

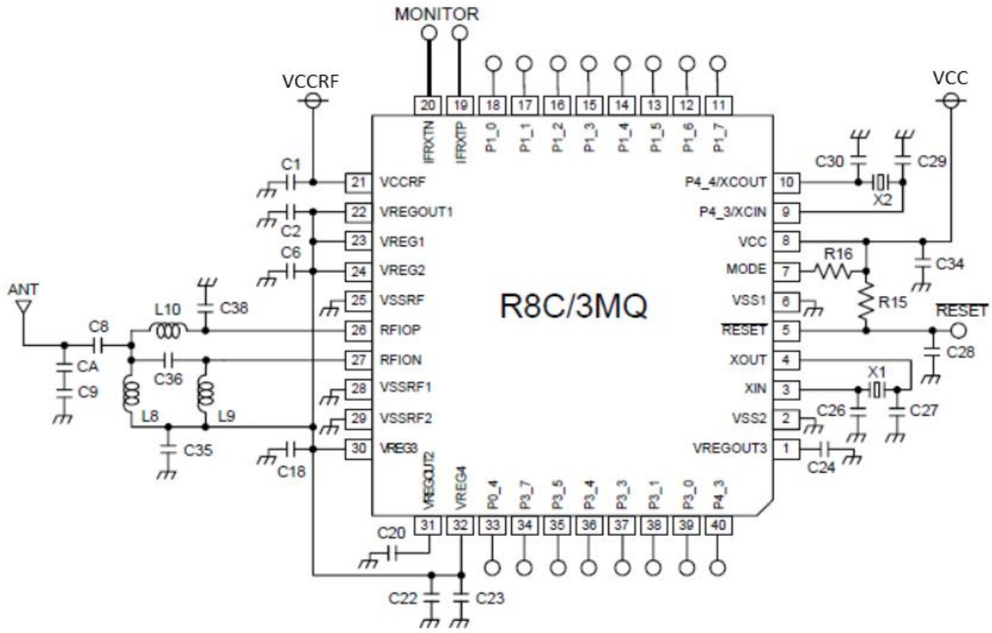

Figure 28 Example of Peripheral Circuit

Table 6 LCR Constants

Part	Value	Part	Value
C1	10 uF	C28	100 pF (*4)
C2	0.1 uF	C34	10 uF
C6	1 uF	C35	3.3 pF
C8	1.8 pF	C36	1.5 pF
C9	0.5 pF (*3)	C38	2 pF
C18	1 uF		
C20	0.47 uF	CA	6.8 pF (*3)
C22	0.1 uF	L8	33 nH
C23	100 pF	L9	1.5 nH
C24	0.1 uF	L10	1.0 nH
		R15	56 kΩ (*4)
		R16	4.7 kΩ (*5)

Table 7 X1 (16 MHz Crystal Oscillator)

Manufacturer Name	Part Number	CL	C26	C27
Nihon Dempa Kogyo Co., Ltd.	NX2520SA	12 pF	27 pF	8 pF
KYOCERA Crystal Device Corporation	CX2520DB	8 pF	27 pF	3 pF

Table 8 X2 (32.768 kHz Crystal Oscillator)

Manufacturer Name	Part Number	CL	C29	C30
Nihon Dempa Kogyo Co., Ltd.	NX3215SA	12.5 pF	18 pF	18 pF
KYOCERA Crystal Device Corporation	ST3215SB	7 pF	12 pF	12 pF

Table 9 L Marker Location

L8	VREGOUT1 side
L9	C36 side
L10	C38 side

*1 The constants are reference values for Renesas boards.
*2 Connect the bottom side DIEGND to the board GND.
*3 C9 and CA are used as notch filters for suppressing second harmonics for transmission output on Renesas boards. An inductor may be used for CA depending on the board wiring.
*4 The optimal constants of R15 and C28 to be connected to the RESET pin (pin 5) will vary depending on applications and boards. Determine the optimal constants based on your system.
*5 The recommended value of R16 to be connected to the MODE pin (pin 7) is 4.7 kΩ ±10%. Selecting a resistance other than this value may affect on-chip debugging. Careful evaluation should be performed in the user system before determining the value.
*6 The optical constants of the crystal oscillator external circuit CIN and COUT will vary depending on the board, the oscillator, and the oscillation drive capacity. Use the values recommended by the crystal oscillator manufacturer.

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Revision Record

Rev.	Date	Description	
		Page	Summary
1.00	Feb.26.13	-	First edition issued

General Precautions in the Handling of MPU/MCU Products

The following usage notes are applicable to all MPU/MCU products from Renesas. For detailed usage notes on the products covered by this manual, refer to the relevant sections of the manual. If the descriptions under General Precautions in the Handling of MPU/MCU Products and in the body of the manual differ from each other, the description in the body of the manual takes precedence.

1. Handling of Unused Pins
   Handle unused pins in accord 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 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. Unused pins should be handled as described under Handling of Unused Pins in the manual.
2. Processing at Power-on
   The state of the product is undefined at the moment 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 moment 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 moment 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 moment when power is supplied until the power reaches the level at which resetting has been specified.
3. Prohibition of Access to Reserved Addresses
   Access to reserved addresses is prohibited.
   — The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.
4. Clock Signals
   After applying a reset, only release the reset line after the operating clock signal has become stable. When switching the clock signal during program execution, wait until the target clock signal has 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. Moreover, 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.
5. Differences between Products
   Before changing from one product to another, i.e. to one with a different type number, confirm that the change will not lead to problems.
   — The characteristics of MPU/MCU in the same group but having different type numbers may differ because of the differences in internal memory capacity and layout pattern. When changing to products of different type numbers, implement a system-evaluation test for each of the products.

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