RL78/G1H, RAA604S00

Electrical Characteristics of 870-MHz-Band RF Transceiver (ETSI EN 303 204)

Introduction

This document shows the measurement results with RF transceiver (RL78/G1H+front-end module+SAW) at 870MHz band. The front-end module consists of SW(switch), PA(power amplifier) and LNA(low noise amplifier).
The target regulation is “ETSI EN 303 204-1 V2.1.2 (2016-09)” and the frequency band is 870MHz to 875.6MHz in Europe.

Although this document describes the RL78/G1H, the same system configuration is possible for the RAA604S00.

Note: The contents of this document are provided as an example for reference and do not guarantee the signal quality in systems. When implementing this example into an existing system, thoroughly evaluate the product in the overall system and apply the contents of this document at your own responsibility.

Target Device for Operation Check

The data shown in this document is measured with the following microcomputer.

Microcomputer: RL78/G1H Family

Contents

1. System Configuration

Figure 1 shows the system configuration using RL78/G1H, front-end module and SAW filter. Table 1/2 shows examples of front-end module and SAW filter specifications. The evaluation described in this document uses front-end module and SAW filter.

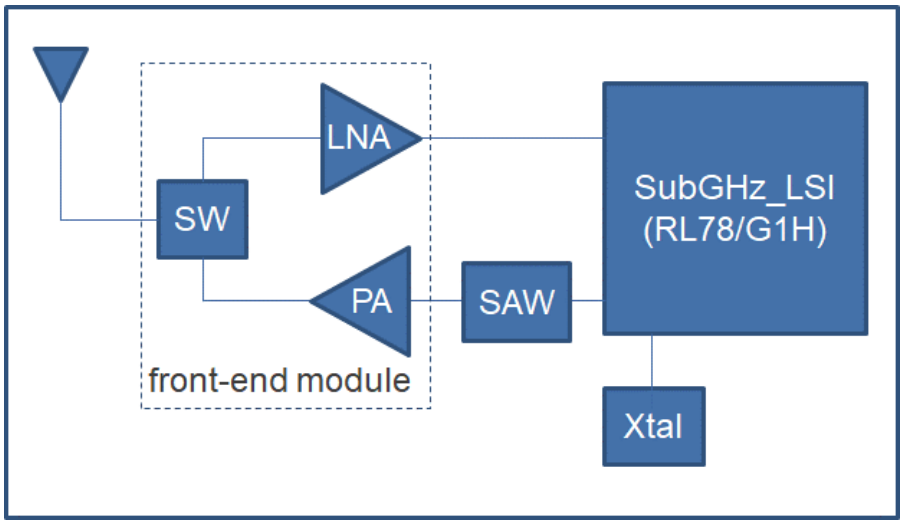

Figure 1 System Configuration

Table 1 Examples of front-end module specifications

Item	Specifications
Frequency	860 - 930 MHz
TX Output Power	+30 dBm (typ)
TX Gain	26 dB (min)
RX Gain	16 dB (typ)
RX Noise Figure	2 dB (typ)

Table 2 Examples of SAW filter specifications

Item	Specifications
Pass Band Frequency	858.92 – 877.92 MHz
Insertion Loss	4 dB (max)

2. Electrical Characteristics

2.1 Current Characteristics

Table 3 Current Characteristics (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, Temperature = Room, TX Power = +27 dBm)

Items		RF Frequency [MHz]	Gain Setting	Unit	Evaluation results	Spec
TX Mode	VDDRF (*1)	872.8	85 dec	mA	34.2	-
	VDDPA (*2)			mA	353.6	
	Total (VDDRF + VDDPA)			mA	387.7	
RX Mode	VDDRF (*1)	872.8	-	mA	5.9	-
	VDDPA (*2)			mA	6.4	
	Total (VDDRF + VDDPA)			mA	12.3	
Idle Mode	VDDRF (*1)	872.8	-	mA	1.2	-
	VDDPA (*2)			mA	6.4(*3)	
	Total (VDDRF + VDDPA)			mA	7.6(*3)	

(*1) Current of RF part in G1H. MCU part is not included, (*2) Current of the front-end module,
(*3) It depends on the control method of the front-end module.

2.2 TX Electrical Characteristics

Table 4 TX Electrical Characteristics 1 (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, Temperature = Room)

Items		RF Frequency [MHz]	Gain Setting	Unit	Evaluation results	Spec
TX Power Range	Max	872.8	102 dec	dBm	+27.7	-
	Min		0 dec	dBm	+0.5	-
	variable power range		-	dB	27.2	-
TX Power	@+27dBm	870.1	85 dec	dBm	+27.1	-
		872.8			+27.1	
		875.5			+27.1	
Harmonics	2nd	870.1	85 dec	dBm /MHz	-48.3	-30.0 (*1)
		872.8			-49.3	
		875.5			-50.0	
	3rd	870.1			-48.8	-30.0 (*1)
		872.8			-48.6	
		875.5			-48.3	

(*1) ETSI EN 303 204-1 V2.1.2 (2016-09)（Refer to Unwanted emissions in the spurious domain）

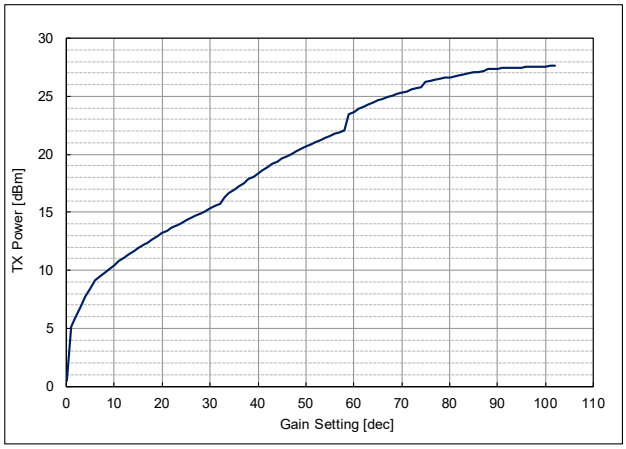

Figure 2 TX Power vs. Gain Setting (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, Temperature = Room, Frequency = 872.8 MHz)

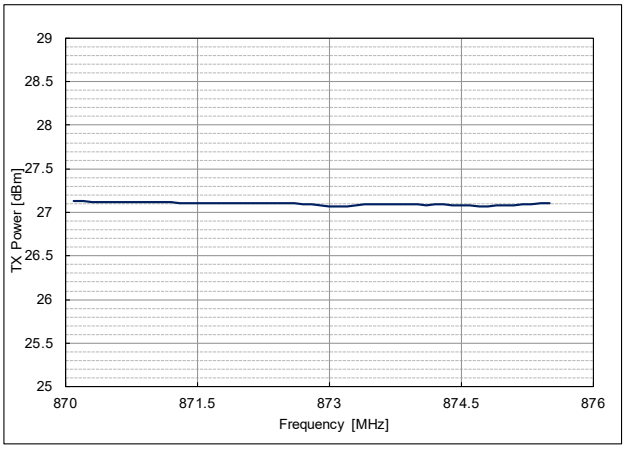

Figure 3 TX Power vs. RF Frequency (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, Temperature = Room, Gain Setting = 85)

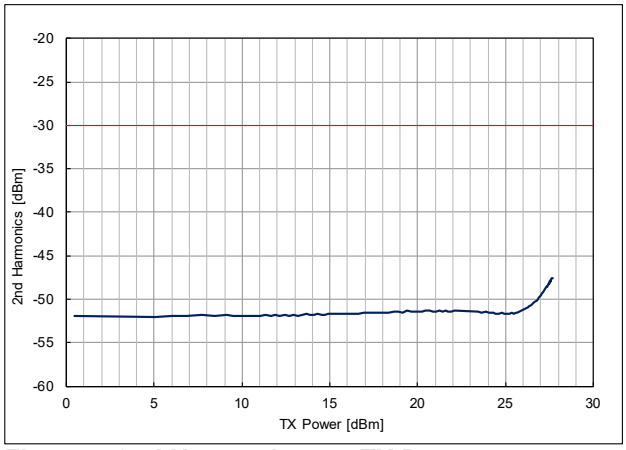

Figure 4 2nd Harmonics vs. TX Power (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, Temperature = Room, Frequency = 872.8 MHz)

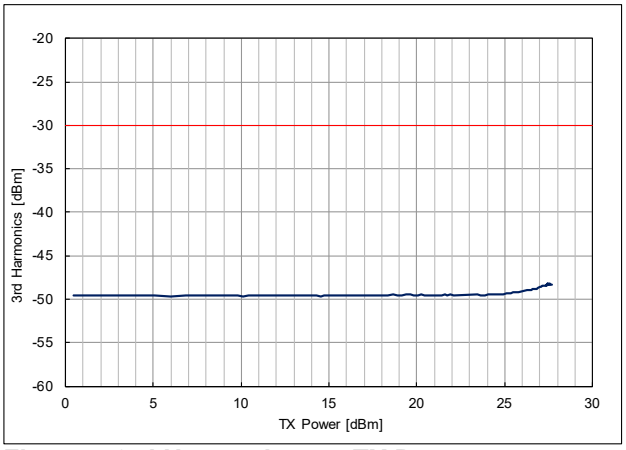

Figure 5 3rd Harmonics vs. TX Power (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, Temperature = Room, Frequency = 872.8 MHz)

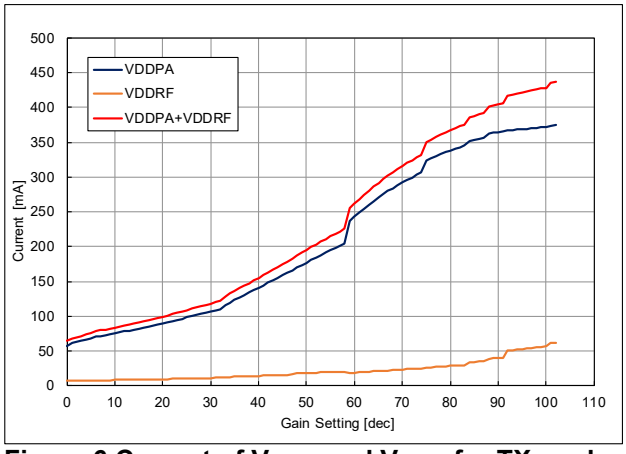

Figure 6 Current of V_{DDPA} and V_{DDRF} for TX mode vs. Gain Setting (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, Temperature = Room, Frequency = 872.8 MHz)

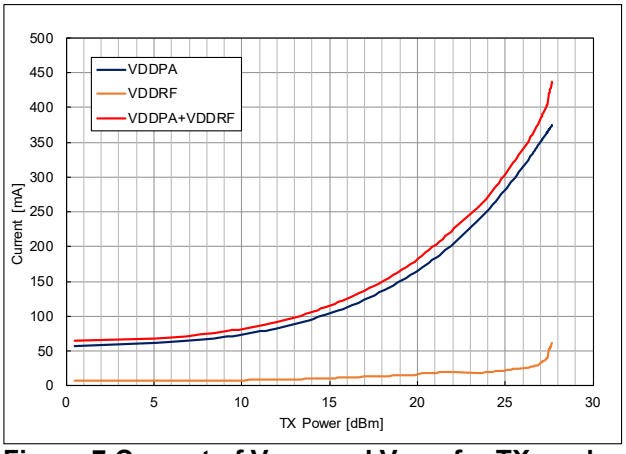

Figure 7 Current of V_{DDPA} and V_{DDRF} for TX mode vs. TX Power (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, Temperature = Room, Frequency = 872.8 MHz)

Table 5 TX Electrical Characteristics 2 (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 50kbps, modulation index = 0.5, Temperature = Room, TX Power = +27 dBm)

Items	RF Frequency [MHz]	Gain Setting	Unit	Evaluation results	Spec
Occupied Bandwidth	870.1	85 dec	kHz	52.6	100 (*1)
	872.8			52.5	
	875.5			52.5	
Adjacent Channel Power Ratio (M1_Lower, 84.375 kHz offset) (*2)	870.1	85 dec	dBc	-41.0	-20 (*3)
	872.8			-41.3	
	875.5			-41.1	
Adjacent Channel Power Ratio (M1_Upper, 84.375 kHz offset) (*2)	870.1			-42.6	-20 (*3)
	872.8			-43.5	
	875.5			-42.2	
Adjacent Channel Power Ratio (M2_Lower, 168.75 kHz offset) (*2)	870.1	85 dec	dBc	-58.3	-35 (*3)
	872.8			-59.8	
	875.5			-59.3	
Adjacent Channel Power Ratio (M2_Upper, 168.75 kHz offset) (*2)	870.1			-58.4	-35 (*3)
	872.8			-60.2	
	875.5			-59.2	
Deviation Offset	870.1	85 dec	% rms	3.40	30 (*4)
	872.8			3.39	
	875.5			3.39	
Zero Crossing Error	870.1	85 dec	% pk	2.03	±12.5 (*4)
	872.8			1.80	
	875.5			1.95	
Frequency tolerance (*5)	870.1	85 dec	ppm	1.16	±11.5 (*1)

(*1) ETSI EN 303 204-1 V2.1.2 (2016-09),
(*2) IEEE.802.15.4v
M1: 9/16*S*(h+1), M2: 9/8*S*(h+1), S(Channel spacing): 100 kHz, h(modulation index): 0.5
(*3) Wi-SUN, (*4) IEEE.802.15.4g
(*5) This characteristic depends on the temperature variation of a crystal resonator.

Table 6 TX Electrical Characteristics 3 (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 50kbps, modulation index = 0.5, Temperature = Room, TX Power = +27 dBm)

Items		RF Frequency [MHz]	Gain Setting	Unit	Evaluation results	Spec
Unwanted emissions	9 kHz- 47 MHz	870.1	85 dec	dBm /100 kHz	-49.6	-36 (*1)
		872.8			-51.7	
		875.5			-49.2	
	47 MHz- 74 MHz	870.1		dBm /100 kHz	-60.2	-54 (*1)
		872.8			-60.2	
		875.5			-60.2	
	74 MHz- 87.5 MHz	870.1		dBm /100 kHz	-65.7	-36 (*1)
		872.8			-66.2	
		875.5			-65.4	
	87.5 MHz- 118 MHz	870.1		dBm /100 kHz	-66.6	-54 (*1)
		872.8			-66.0	
		875.5			-66.3	
	118 MHz- 174 MHz	870.1		dBm /100 kHz	-65.9	-36 (*1)
		872.8			-66.7	
		875.5			-66.3	
	174 MHz- 230 MHz	870.1		dBm /100 kHz	-66.4	-54 (*1)
		872.8			-66.4	
		875.5			-66.6	
	230 MHz- 470 MHz	870.1		dBm /100 kHz	-64.8	-36 (*1)
		872.8			-64.6	
		875.5			-64.6	
	470 MHz- 790 MHz	870.1		dBm /100 kHz	-60.4	-54 (*1)
		872.8			-59.6	
		875.5			-60.3	
	790 MHz- fc-m MHz (*2)	870.1		dBm /100 kHz	-41.7	-36 (*1)
		872.8			-40.4	
		875.5			-37.3	
	fc-m MHz- fc-n MHz (*2)	870.1		dBm /10 kHz	-39.5	-36 (*1)
		872.8			-41.2	
		875.5			-42.5	
	fc-n MHz- fc-p MHz (*2)	870.1		dBm /1 kHz	-47.3	-36 (*1)
		872.8			-46.8	
		875.5			-45.7	
	fc+p MHz- fc+n MHz (*2)	870.1		dBm /1 kHz	-46.5	-36 (*1)
		872.8			-47.2	
		875.5			-47.2	

(*1) ETSI EN 303 204-1 V2.1.2 (2016-09)

(*2) fc: Operating frequency m: 1 MHz n: 0.4 MHz p: 0.25 MHz
m/n/p are in the case of operating channel width: 100 kHz

Table 7 TX Electrical Characteristics 4 (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 50kbps, modulation index = 0.5, Temperature = Room, TX Power = +27 dBm)

Items		RF Frequency [MHz]	Gain Setting	Unit	Evaluation results	Spec
Unwanted emissions	fc+n MHz-fc+m MHz (*2)	870.1	85 dec	dBm /10 kHz	-41.2	-36 (*1)
		872.8			-42.0	
		875.5			-41.4	
	fc+m MHz-1 GHz (*2)	870.1		dBm /100 kHz	-42.0	-36 (*1)
		872.8			-40.5	
		875.5			-38.1	
	1 GHz-6 GHz	870.1		dBm /1 MHz	-36.9	-30 (*1)
		872.8			-37.2	
		875.5			-36.8	
Transient power	-OCW (*3)	870.1	85 dec	dBm /1 kHz	-11.4	0 (*1)
		872.8			-16.3	
		875.5			-19.3	
	OCW (*3)	870.1		dBm /1 kHz	-16.7	0 (*1)
		872.8			-17.3	
		875.5			-12.9	
	-0.5*OCW -400 kHz (*3)	870.1		dBm /1 kHz	-30.6	-27 (*1)
		872.8			-30.2	
		875.5			-32.0	
	0.5*OCW +400 kHz (*3)	870.1		dBm /1 kHz	-32.0	-27 (*1)
		872.8			-32.2	
		875.5			-30.6	
	-0.5*OCW -1200 kHz (*3)	870.1		dBm /1 kHz	-44.4	-27 (*1)
		872.8			-44.7	
		875.5			-45.1	
	0.5*OCW +1200 kHz (*3)	870.1		dBm /1 kHz	-42.9	-27 (*1)
		872.8			-42.7	
		875.5			-42.4	

(*1) ETSI EN 303 204-1 V2.1.2 (2016-09)
(*2) fc: Operating frequency m: 1 MHz n: 0.4 MHz p: 0.25 MHz
m/n/p are in the case of operating channel width: 100 kHz
(*3) OCW: 100 kHz

Table 8 TX Electrical Characteristics 5 (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 50kbps, modulation index = 0.5, Temperature = Room, TX Power = +27 dBm)

Items		RF Frequency [MHz]	Gain Setting	Unit	Evaluation results	Spec
Tx out of band emission (around)	Absolute Lower Power (Margin)	870.1	85 dec	dB	PASS (Refer to figure 8)	0 (*1)
		872.8			PASS (Refer to figure 9)	
		875.5			PASS (Refer to figure 10)	
	Absolute Upper Power (Margin)	870.1		dB	PASS (Refer to figure 8)	0 (*1)
		872.8			PASS (Refer to figure 9)	
		875.5			PASS (Refer to figure 10)	
Tx out of band emission (Band edge)	f_{low} -0.4 MHz- f_{low} -0.2 MHz (*2)	870.1	85 dec	dBm /1 kHz	PASS (Refer to figure 11)	-36 (*1)
		872.8			PASS (Refer to figure 12)	
		875.5			PASS (Refer to figure 13)	
	f_{low} -0.2 MHz- f_{low} (Margin) (*2)	870.1		dB	PASS (Refer to figure 11)	0 (*1)
		872.8			PASS (Refer to figure 12)	
		875.5			PASS (Refer to figure 13)	
	f_{high} - f_{high} +0.2 MHz (Margin) (*2)	870.1		dB	PASS (Refer to figure 11)	0 (*1)
		872.8			PASS (Refer to figure 12)	
		875.5			PASS (Refer to figure 13)	
	f_{high} +0.2 MHz- f_{high} +0.4 MHz (*2)	870.1		dBm /1 kHz	PASS (Refer to figure 11)	-36 (*1)
		872.8			PASS (Refer to figure 12)	
		875.5			PASS (Refer to figure 13)	

(*1) ETSI EN 303 204-1 V2.1.2 (2016-09)
(*2) f_{low}: 870.0 MHz f_{high}: 875.6 MHz

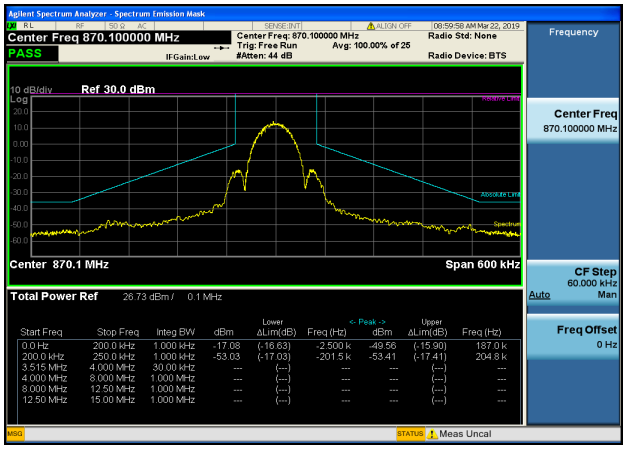

Figure 8 TX Out Of Band Emissions for Operating Channel (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 50kbps, mod index = 0.5, Frequency = 870.1 MHz, Gain Setting = 85, Temperature = Room)

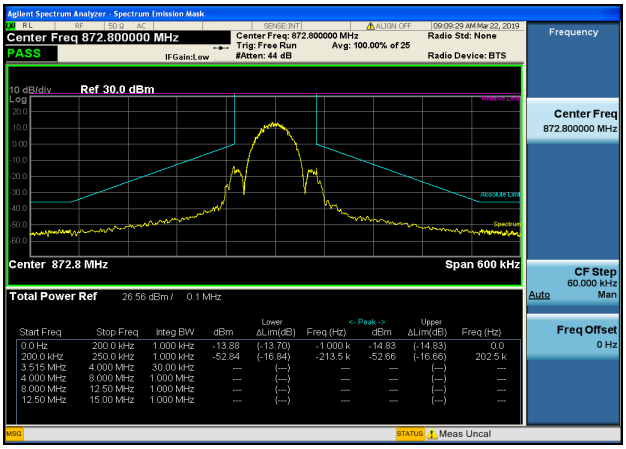

Figure 9 TX Out Of Band Emissions for Operating Channel (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 50kbps, mod index = 0.5, Frequency = 872.8 MHz, Gain Setting = 85, Temperature = Room)

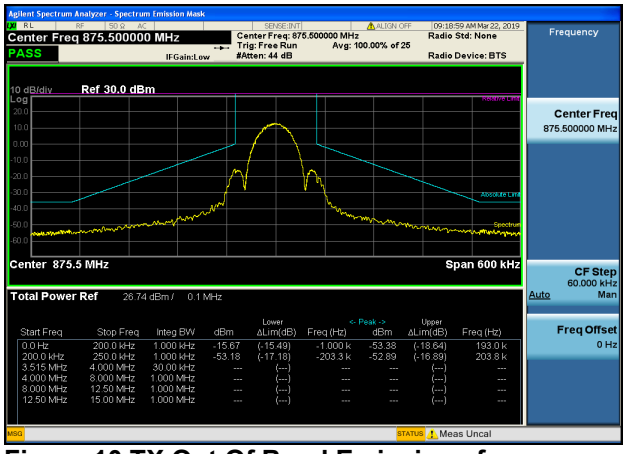

Figure 10 TX Out Of Band Emissions for Operating Channel (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 50kbps, mod index = 0.5, Frequency = 875.5 MHz, Gain Setting = 85, Temperature = Room)

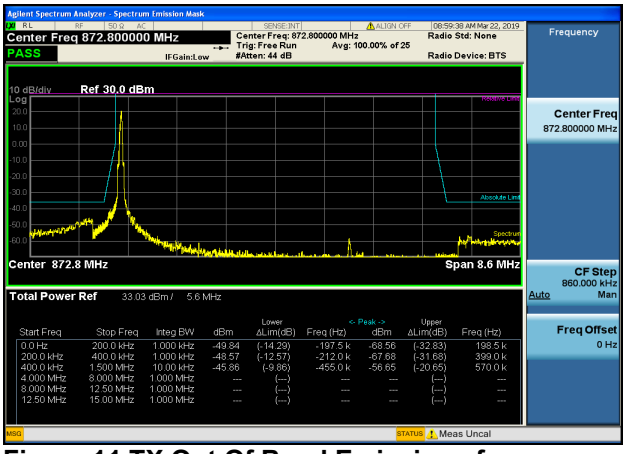

Figure 11 TX Out Of Band Emissions for Operational Frequency Band (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 50kbps, mod index = 0.5, Frequency = 870.1 MHz, Gain Setting = 85, Temperature = Room)

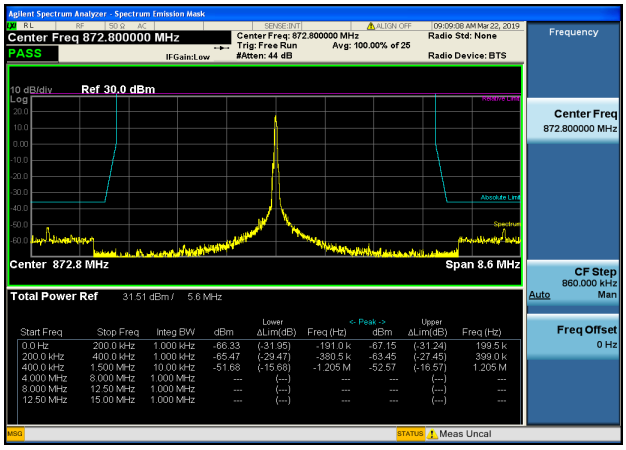

Figure 12 TX Out Of Band Emissions for Operational Frequency Band (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 50kbps, mod index = 0.5, Frequency = 872.8 MHz, Gain Setting = 85, Temperature = Room)

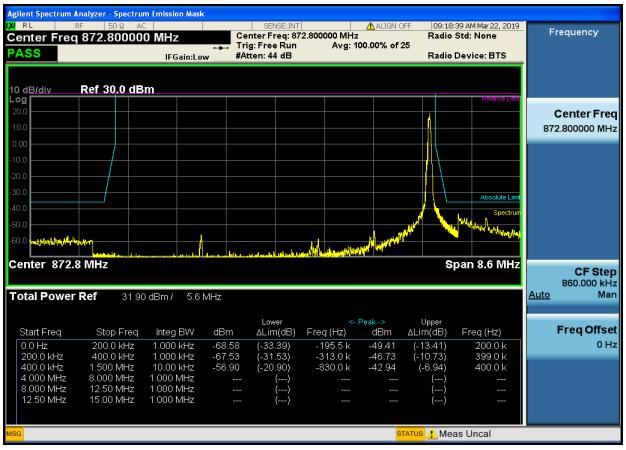

Figure 13 TX Out Of Band Emissions for Operational Frequency Band (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 50kbps, mod index = 0.5, Frequency = 875.5 MHz, Gain Setting = 85, Temperature = Room)

Table 9 TX Electrical Characteristics 6 (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 100kbps, modulation index = 0.5, Temperature = Room, TX Power = +27 dBm)

Items	RF Frequency [MHz]	Gain Setting	Unit	Evaluation results	Spec
Occupied Bandwidth	870.2	85 dec	kHz	105.3	200 (*1)
	872.8			105.0	
	875.4			105.1	
Adjacent Channel Power Ratio (M1_Lower, 225.0 kHz offset) (*2)	870.2	85 dec	dBc	-56.1	-25 (*3)
	872.8			-56.0	
	875.4			-56.1	
Adjacent Channel Power Ratio (M1_Upper, 225.0 kHz offset) (*2)	870.2			-56.2	-25 (*3)
	872.8			-56.1	
	875.4			-56.1	
Adjacent Channel Power Ratio (M2_Lower, 450.0 kHz offset) (*2)	870.2	85 dec	dBc	-62.5	-35 (*3)
	872.8			-63.3	
	875.4			-63.1	
Adjacent Channel Power Ratio (M2_Upper, 450.0 kHz offset) (*2)	870.2			-62.8	-35 (*3)
	872.8			-63.2	
	875.4			-63.0	
Deviation Offset	870.2	85 dec	% rms	3.51	30 (*4)
	872.8			3.45	
	875.4			3.43	
Zero Crossing Error	870.2	85 dec	% pk	-1.59	±12.5 (*4)
	872.8			-1.65	
	875.4			1.60	
Frequency tolerance (*5)	870.2	85 dec	ppm	1.16	±20.0 (*1)

(*1) ETSI EN 303 204-1 V2.1.2 (2016-09)
(*2) IEEE.802.15.4g
M1: 1.5*R*(1+h), M2: 3*R*(1+h), R(Symbol rate) : 100kbps, h(modulation index): 0.5
(*3) Wi-SUN, (*4) IEEE.802.15.4g
(*5) This characteristic depends on the temperature variation of a crystal resonator.

Table 10 TX Electrical Characteristics 7 (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 100kbps, modulation index =0.5, Temperature = Room, TX Power = +27 dBm)

Items		RF Frequency [MHz]	Gain Setting	Unit	Evaluation results	Spec
Unwanted emissions	9 kHz-47 MHz	870.2	85 dec	dBm /100 kHz	-52.3	-36 (*1)
		872.8			-49.0	
		875.4			-51.4	
	47 MHz-74 MHz	870.2		dBm /100 kHz	-60.4	-54 (*1)
		872.8			-59.7	
		875.4			-60.0	
	74 MHz-87.5 MHz	870.2		dBm /100 kHz	-66.1	-36 (*1)
		872.8			-65.6	
		875.4			-66.0	
	87.5 MHz-118 MHz	870.2		dBm /100 kHz	-65.7	-54 (*1)
		872.8			-66.4	
		875.4			-66.3	
	118 MHz-174 MHz	870.2		dBm /100 kHz	-65.6	-36 (*1)
		872.8			-66.6	
		875.4			-66.1	
	174 MHz-230 MHz	870.2		dBm /100 kHz	-65.9	-54 (*1)
		872.8			-65.2	
		875.4			-66.5	
	230 MHz-470 MHz	870.2		dBm /100 kHz	-64.9	-36 (*1)
		872.8			-64.8	
		875.4			-65.0	
	470 MHz-790 MHz	870.2		dBm /100 kHz	-60.2	-54 (*1)
		872.8			-60.2	
		875.4			-60.6	
	790 MHz-fc-m MHz (*2)	870.2		dBm /100 kHz	-43.5	-36 (*1)
		872.8			-44.2	
		875.4			-44.1	
	fc-m MHz-fc-n MHz (*2)	870.2		dBm /10 kHz	-46.5	-36 (*1)
		872.8			-46.0	
		875.4			-46.2	
	fc-n MHz-fc-p MHz (*2)	870.2		dBm /1 kHz	-50.8	-36 (*1)
		872.8			-51.0	
		875.4			-49.1	
	fc+p MHz-fc+n MHz (*2)	870.2		dBm /1 kHz	-51.0	-36 (*1)
		872.8			-50.5	
		875.4			-46.8	

(*1) ETSI EN 303 204-1 V2.1.2 (2016-09)

(*2) fc: Operating frequency m: 2 MHz n: 0.8 MHz p: 0.5 MHz
m/n/p are in the case of operating channel width: 200 kHz

Table 11 TX Electrical Characteristics 8 (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 100kbps, modulation index =0.5, Temperature = Room, TX Power = +27 dBm)

Items		RF Frequency [MHz]	Gain Setting	Unit	Evaluation results	Spec
Unwanted emissions	fc+n MHz- fc+m MHz (*2)	870.2	85 dec	dBm /10 kHz	-48.0	-36 (*1)
		872.8			-46.2	
		875.4			-46.4	
	fc+m MHz- 1 GHz (*2)	870.2		dBm /100 kHz	-44.2	-36 (*1)
		872.8			-44.6	
		875.4			-44.0	
	1 GHz- 6 GHz	870.2		dBm /1 MHz	-37.0	-30 (*1)
		872.8			-44.6	
		875.4			-44.0	
Transient power	-OCW (*3)	870.2	85 dec	dBm /1 kHz	-19.9	0 (*1)
		872.8			-21.1	
		875.4			-25.2	
	OCW (*3)	870.2		dBm /1 kHz	-27.0	0 (*1)
		872.8			-26.6	
		875.4			-21.3	
	-0.5*OCW -400 kHz (*3)	870.2		dBm /1 kHz	-31.3	-27 (*1)
		872.8			-31.2	
		875.4			-33.0	
	0.5*OCW +400 kHz (*3)	870.2		dBm /1 kHz	-33.2	-27 (*1)
		872.8			-33.0	
		875.4			-31.5	
	-0.5*OCW -1200 kHz (*3)	870.2		dBm /1 kHz	-45.1	-27 (*1)
		872.8			-45.6	
		875.4			-45.8	
	0.5*OCW +1200 kHz (*3)	870.2		dBm /1 kHz	-43.3	-27 (*1)
		872.8			-42.8	
		875.4			-42.7	

(*1) ETSI EN 303 204-1 V2.1.2 (2016-09)
(*2) fc: Operating frequency m: 2 MHz n: 0.8 MHz p: 0.5 MHz
m/n/p are in the case of operating channel width: 200 kHz
(*3) OCW: 200 kHz

Table 12 TX Electrical Characteristics 9 (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 100kbps, modulation index = 0.5, Temperature = Room, TX Power = +27 dBm)

Items		RF Frequency [MHz]	Gain Setting	Unit	Evaluation results	Spec
Tx out of band emission (around)	Absolute Lower Power (Margin)	870.2	85 dec	dB	PASS (Refer to figure 14)	0 (*1)
		872.8			PASS (Refer to figure 15)	
		875.4			PASS (Refer to figure 16)	
	Absolute Upper Power (Margin)	870.2		dB	PASS (Refer to figure 14)	0 (*1)
		872.8			PASS (Refer to figure 15)	
		875.4			PASS (Refer to figure 16)	
Tx out of band emission (Band edge)	f_{low} -0.4 MHz- f_{low} -0.2 MHz (*2)	870.2	85 dec	dBm /1 kHz	PASS (Refer to figure 17)	-36 (*1)
		872.8			PASS (Refer to figure 18)	
		875.4			PASS (Refer to figure 19)	
	f_{low} -0.2 MHz- f_{low} (Margin) (*2)	870.2		dB	PASS (Refer to figure 17)	0 (*1)
		872.8			PASS (Refer to figure 18)	
		875.4			PASS (Refer to figure 19)	
	f_{high} - f_{high} +0.2 MHz (Margin) (*2)	870.2		dB	PASS (Refer to figure 17)	0 (*1)
		872.8			PASS (Refer to figure 18)	
		875.4			PASS (Refer to figure 19)	
	f_{high} +0.2 MHz- f_{high} +0.4 MHz (*2)	870.2		dBm /1 kHz	PASS (Refer to figure 17)	-36 (*1)
		872.8			PASS (Refer to figure 18)	
		875.4			PASS (Refer to figure 19)	

(*1) ETSI EN 303 204-1 V2.1.2 (2016-09)
(*2) f_{low}: 870.0 MHz f_{high}: 875.6 MHz

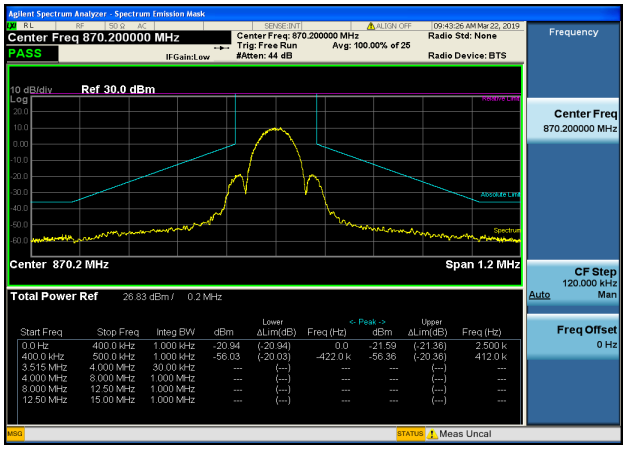

Figure 14 TX Out Of Band Emissions for Operating Channel (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 100kbps, mod index = 0.5, Frequency = 870.2 MHz, Gain Setting = 85, Temperature = Room)

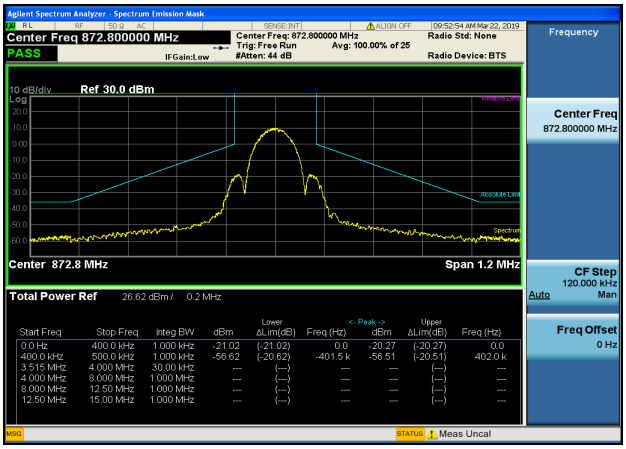

Figure 15 TX Out Of Band Emissions for Operating Channel (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 100kbps, mod index = 0.5, Frequency = 872.8 MHz, Gain Setting = 85, Temperature = Room)

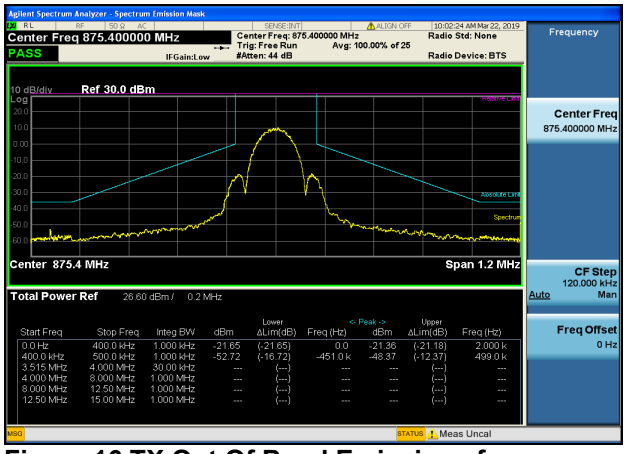

Figure 16 TX Out Of Band Emissions for Operating Channel (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 100kbps, mod index = 0.5, Frequency = 875.4 MHz, Gain Setting = 85, Temperature = Room)

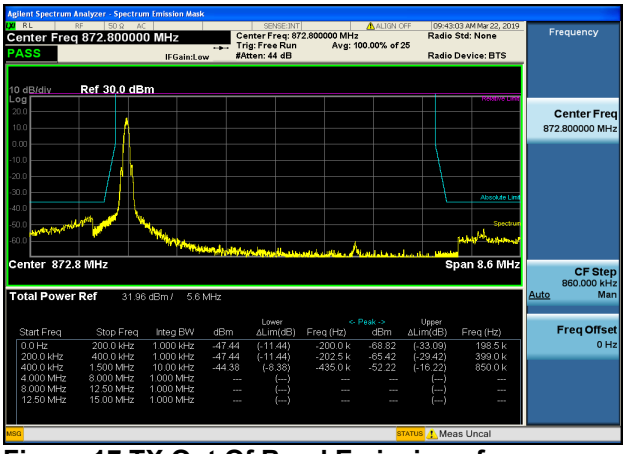

Figure 17 TX Out Of Band Emissions for Operational Frequency Band (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 100kbps, mod index = 0.5, Frequency = 870.2 MHz, Gain Setting = 85, Temperature = Room)

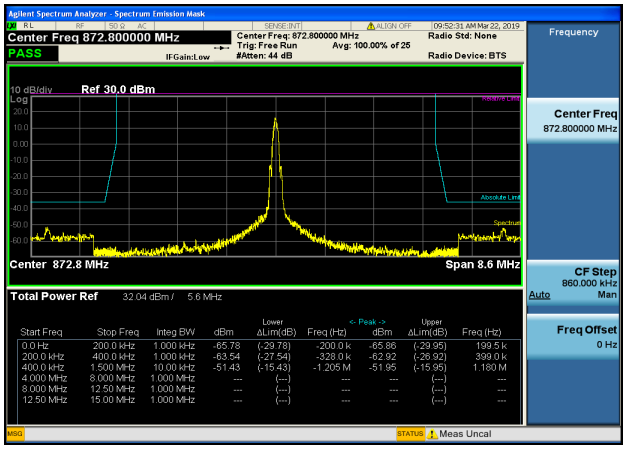

Figure 18 TX Out Of Band Emissions for Operational Frequency Band (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 100kbps, mod index = 0.5, Frequency = 872.8 MHz, Gain Setting = 85, Temperature = Room)

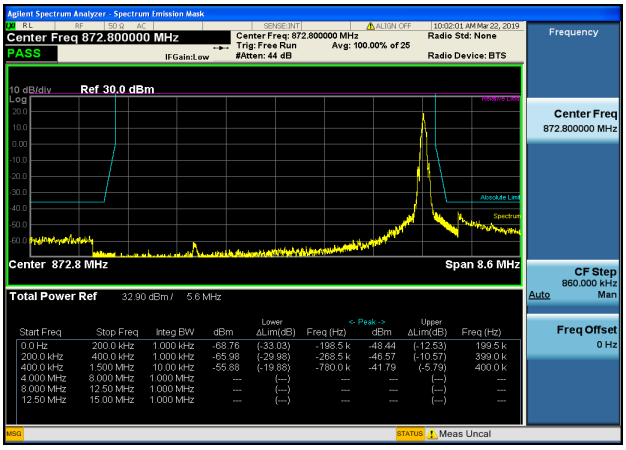

Figure 19 TX Out Of Band Emissions for Operational Frequency Band (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 100kbps, mod index = 0.5, Frequency = 875.4 MHz, Gain Setting = 85, Temperature = Room)

Table 13 TX Electrical Characteristics 10 (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V,150kbps, modulation index =0.5, Temperature = Room, TX Power = +27 dBm)

Items	RF Frequency [MHz]	Gain Setting	Unit	Evaluation results	Spec
Occupied Bandwidth	870.2	85 dec	kHz	157.8	200 (*1)
	872.8			157.8	
	875.4			157.6	
Adjacent Channel Power Ratio (M1_Lower, 168.75 kHz offset) (*2)	870.2	85 dec	dBc	-32.0	-20 (*3)
	872.8			-32.0	
	875.4			-32.1	
Adjacent Channel Power Ratio (M1_Upper, 168.75 kHz offset) (*2)	870.2			-32.1	-20 (*3)
	872.8			-32.1	
	875.4			-32.1	
Adjacent Channel Power Ratio (M2_Lower, 337.5 kHz offset) (*2)	870.2	85 dec	dBc	-58.7	-35 (*3)
	872.8			-58.7	
	875.4			-58.4	
Adjacent Channel Power Ratio (M2_Upper, 337.5 kHz offset) (*2)	870.2			-58.3	-35 (*3)
	872.8			-58.5	
	875.4			-58.7	
Deviation Offset	870.2	85 dec	% rms	3.77	30 (*4)
	872.8			3.62	
	875.4			3.61	
Zero Crossing Error	870.2	85 dec	% pk	1.81	±12.5 (*4)
	872.8			-2.20	
	875.4			-1.87	
Frequency tolerance (*5)	872.8	85 dec	ppm	1.16	±20.0 (*1)

(*1) ETSI EN 303 204-1 V2.1.2 (2016-09)
(*2) IEEE.802.15.4v
M1: 9/16*S*(h+1), M2: 9/8*S*(h+1), S(Channel spacing) : 200 kHz, h(modulation index): 0.5
(*3) Wi-SUN, (*4) IEEE.802.15.4g
(*5) This characteristic depends on the temperature variation of a crystal resonator.

Table 14 TX Electrical Characteristics 11 (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V,150kbps, modulation index = 0.5, Temperature = Room, TX Power = +27 dBm)

Items		RF Frequency [MHz]	Gain Setting	Unit	Evaluation results	Spec
Unwanted emissions	9 kHz-47 MHz	870.2	85 dec	dBm /100 kHz	-52.1	-36 (*1)
		872.8			-50.0	
		875.4			-50.5	
	47 MHz-74 MHz	870.2		dBm /100 kHz	-60.1	-54 (*1)
		872.8			-60.2	
		875.4			-60.5	
	74 MHz-87.5 MHz	870.2		dBm /100 kHz	-65.6	-36 (*1)
		872.8			-65.9	
		875.4			-66.0	
	87.5 MHz-118 MHz	870.2		dBm /100 kHz	-65.8	-54 (*1)
		872.8			-65.6	
		875.4			-65.9	
	118 MHz-174 MHz	870.2		dBm /100 kHz	-65.6	-36 (*1)
		872.8			-65.2	
		875.4			-66.4	
	174 MHz-230 MHz	870.2		dBm /100 kHz	-66.5	-54 (*1)
		872.8			-66.6	
		875.4			-66.6	
	230 MHz-470 MHz	870.2		dBm /100 kHz	-64.6	-36 (*1)
		872.8			-64.9	
		875.4			-65.1	
	470 MHz-790 MHz	870.2		dBm /100 kHz	-59.2	-54 (*1)
		872.8			-59.9	
		875.4			-59.3	
	790 MHz-fc-m MHz (*2)	870.2		dBm /100 kHz	-39.5	-36 (*1)
		872.8			-40.8	
		875.4			-41.5	
	fc-m MHz-fc-n MHz (*2)	870.2		dBm /10 kHz	-42.9	-36 (*1)
		872.8			-43.2	
		875.4			-43.6	
	fc-n MHz-fc-p MHz (*2)	870.2		dBm /1 kHz	-47.8	-36 (*1)
		872.8			-47.5	
		875.4			-45.9	
	fc+p MHz-fc+n MHz (*2)	870.2		dBm /1 kHz	-46.2	-36 (*1)
		872.8			-47.4	
		875.4			-42.8	
	fc+n MHz-fc+m MHz (*2)	870.2		dBm /10 kHz	-43.5	-36 (*1)
		872.8			-44.3	
		875.4			-42.7	

(*1) ETSI EN 303 204-1 V2.1.2 (2016-09)

(*2) fc: Operating frequency m: 2 MHz n: 0.8 MHz p: 0.5 MHz
m/n/p are in the case of operating channel width: 200 kHz

Table 15 TX Electrical Characteristics 12 (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V,150kbps, modulation index = 0.5, Temperature = Room, TX Power = +27 dBm)

Items		RF Frequency [MHz]	Gain Setting	Unit	Evaluation results	Spec
Unwanted emissions	fc+m MHz- 1 GHz(*2)	870.2	85 dec	dBm /100 kHz	-42.1	-36 (*1)
		872.8			-41.7	
		875.4			-41.2	
	1 GHz- 6 GHz	870.2		dBm /1 MHz	-37.2	-30 (*1)
		872.8			-37.3	
		875.4			-37.3	
Transient power	-OCW (*3)	870.2	85 dec	dBm /1 kHz	-21.1	0 (*1)
		872.8			-22.2	
		875.4			-24.6	
	OCW (*3)	870.2		dBm /1 kHz	-26.0	0 (*1)
		872.8			-24.7	
		875.4			-22.0	
	-0.5*OCW -400 kHz (*3)	870.2		dBm /1 kHz	-31.0	-27 (*1)
		872.8			-30.7	
		875.4			-32.9	
	0.5*OCW +400 kHz (*3)	870.2		dBm /1 kHz	-33.4	-27 (*1)
		872.8			-33.4	
		875.4			-31.2	
	-0.5*OCW -1200 kHz (*3)	870.2		dBm /1 kHz	-45.0	-27 (*1)
		872.8			-45.4	
		875.4			-45.8	
	0.5*OCW +1200 kHz (*3)	870.2		dBm /1 kHz	-43.3	-27 (*1)
		872.8			-42.7	
		875.4			-42.6	

(*1) ETSI EN 303 204-1 V2.1.2 (2016-09)
(*2) fc: Operating frequency m: 2 MHz n: 0.8 MHz p: 0.5 MHz
m/n/p are in the case of operating channel width: 200 kHz
(*3) OCW: 200 kHz

Table 16 TX Electrical Characteristics 13 (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V,150kbps, modulation index = 0.5, Temperature = Room, TX Power = +27 dBm)

Items		RF Frequency [MHz]	Gain Setting	Unit	Evaluation results	Spec
Tx out of band emission (around)	Absolute Lower Power (Margin)	870.2	85 dec	dB	PASS (Refer to figure 20)	0 (*1)
		872.8			PASS (Refer to figure 21)	
		875.4			PASS (Refer to figure 22)	
	Absolute Upper Power (Margin)	870.2		dB	PASS (Refer to figure 20)	0 (*1)
		872.8			PASS (Refer to figure 21)	
		875.4			PASS (Refer to figure 22)	
Tx out of band emission (Band edge)	f_{low} -0.4 MHz- f_{low} -0.2 MHz (*2)	870.2	85 dec	dBm /1 kHz	PASS (Refer to figure 23)	-36 (*1)
		872.8			PASS (Refer to figure 24)	
		875.4			PASS (Refer to figure 25)	
	f_{low} -0.2 MHz- f_{low} (Margin) (*2)	870.2		dB	PASS (Refer to figure 23)	0 (*1)
		872.8			PASS (Refer to figure 24)	
		875.4			PASS (Refer to figure 25)	
	f_{high} - f_{high} +0.2 MHz (Margin) (*2)	870.2		dB	PASS (Refer to figure 23)	0 (*1)
		872.8			PASS (Refer to figure 24)	
		875.4			PASS (Refer to figure 25)	
	f_{high} +0.2 MHz- f_{high} +0.4 MHz (*2)	870.2		dBm /1 kHz	PASS (Refer to figure 23)	-36 (*1)
		872.8			PASS (Refer to figure 24)	
		875.4			PASS (Refer to figure 25)	

(*1) ETSI EN 303 204-1 V2.1.2 (2016-09)
(*2) f_{low}: 870.0 MHz f_{high}: 875.6 MHz

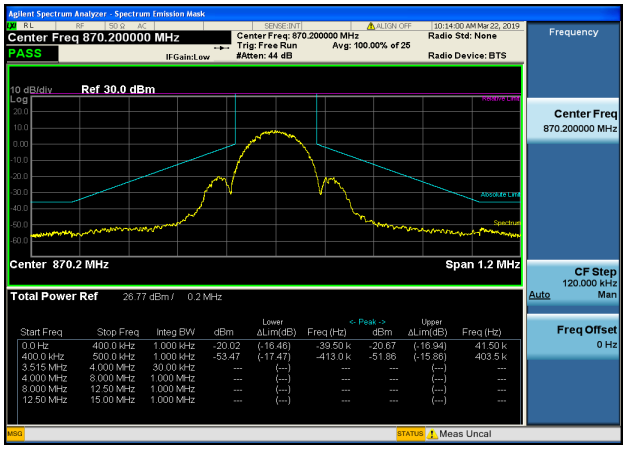

Figure 20 TX Out Of Band Emissions for Operating Channel (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 150kbps, mod index = 0.5, Frequency = 870.2 MHz, Gain Setting = 85, Temperature = Room)

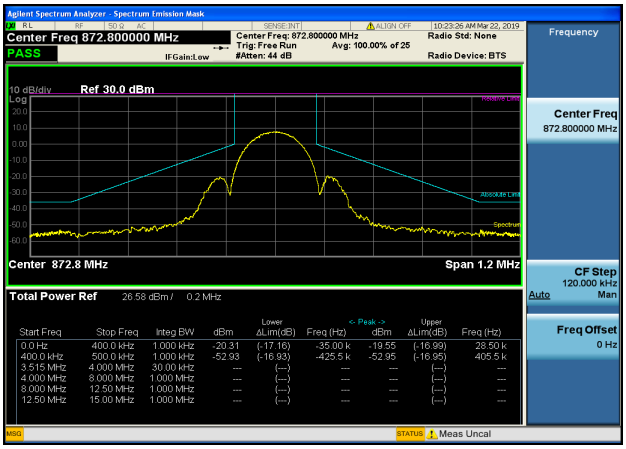

Figure 21 TX Out Of Band Emissions for Operating Channel (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 150kbps, mod index = 0.5, Frequency = 872.8 MHz, Gain Setting = 85, Temperature = Room)

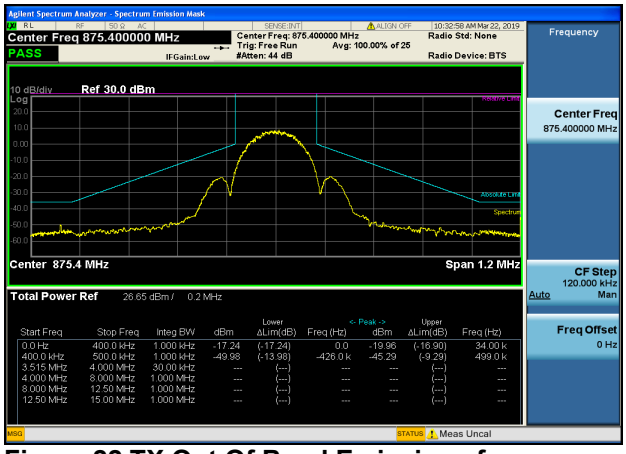

Figure 22 TX Out Of Band Emissions for Operating Channel (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 150kbps, mod index = 0.5, Frequency = 875.4 MHz, Gain Setting = 85, Temperature = Room)

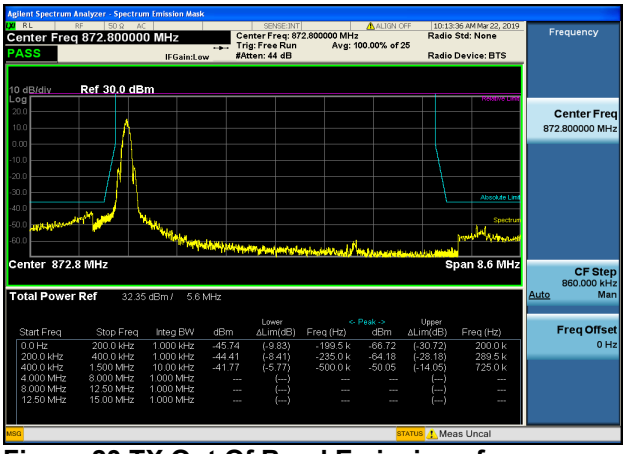

Figure 23 TX Out Of Band Emissions for Operational Frequency Band (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 150kbps, mod index = 0.5, Frequency = 870.2 MHz, Gain Setting = 85, Temperature = Room)

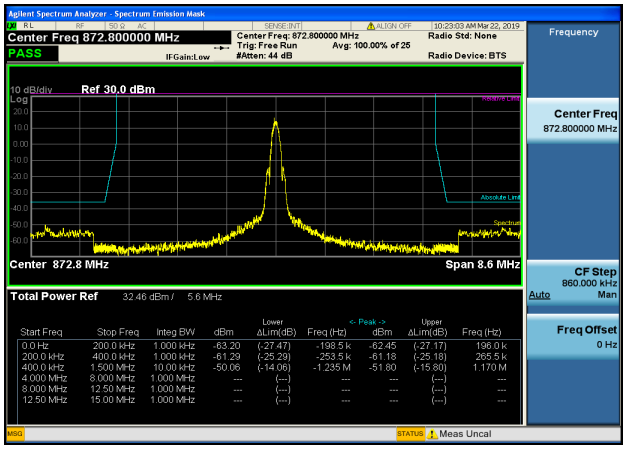

Figure 24 TX Out Of Band Emissions for Operational Frequency Band (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 150kbps, mod index = 0.5, Frequency = 872.8 MHz, Gain Setting = 85, Temperature = Room)

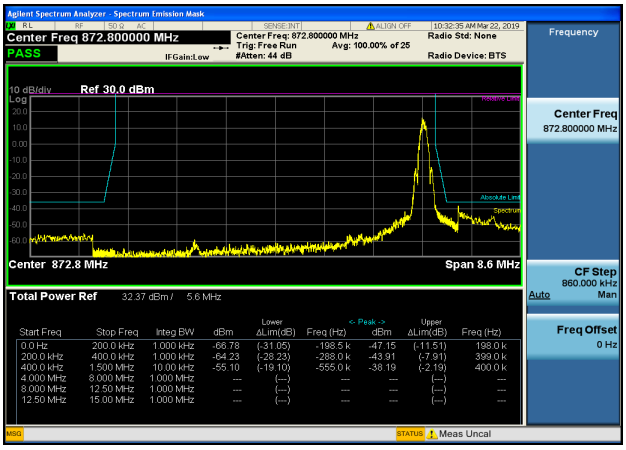

Figure 25 TX Out Of Band Emissions for Operational Frequency Band (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 150kbps, mod index = 0.5, Frequency = 875.4 MHz, Gain Setting = 85, Temperature = Room)

2.3 RX Electrical Characteristics

Table 17 RX Electrical Characteristics (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 50kbps, modulation index = 0.5, Temperature = Room)

Items			RF Frequency [MHz]	Unit	Evaluation results	Spec
Receiver sensitivity	PER < 1 % PSDU Length 20 octets		870.1	dBm	-109	-91 (*1)
			872.8		-109	
			875.5		-109	
	BER < 0.1 %		870.1	dBm	-111	-91 (*3)
			872.8		-111	
			875.5		-111	
Maximum Input level	PER < 1 % PSDU Length 20 octets		870.1	dBm	> -10	-
			872.8		> -10	
			875.5		> -10	
	BER < 0.1 %		870.1	dBm	> -10	-
			872.8		> -10	
			875.5		> -10	
Frequency tolerance	PER < 1 % PSDU Length 20 octets	Max	872.8	ppm	+46	-
		Min			-48	
Adjacent channel rejection	-100 kHz	BER < 0.1 % (*4)	872.8	dB	35	27 (*3)
	+100 kHz				34	
	-100 kHz	PER < 10 % (*5) Length 250 octets			31	10 (*2)
	+100 kHz				31	
Alternate channel rejection	-200 kHz	PER < 10 % (*5) Length 250 octets	872.8	dB	39	30 (*2)
	+200 kHz				35	
Blocking	-1 MHz	BER < 0.1 % (*4)	872.8	dB	62	32 (*3)
	+1 MHz				54	
	-2 MHz				59	37 (*3)
	+2 MHz				59	
	-5 MHz				63	47 (*3)
	+5 MHz				63	
	-10 MHz				63	52 (*3)
	+10 MHz				62	
	-60 MHz				66	-
	+60 MHz				67	
Image rejection	-1.1 MHz		872.8	dB	40	-
Spurious emission	9 kHz - 1 GHz		870.1	dBm /100 kHz	-82.1	-57 (*3)
			872.8		-83.7	
			875.5		-82.8	
	1 GHz - 6 GHz		870.1	dBm /1 MHz	-70.9	-47 (*3)
			872.8		-71.0	
			875.5		-71.1	

(*1) IEEE.802.15.4g, (*2) Wi-SUN
(*3) ETSI EN 303 204-1 V2.1.2 (2016-09)
(*4) The level of the desired signal: DUT sensitivity +3 dB
(*5) The level of the desired signal: -88 dBm

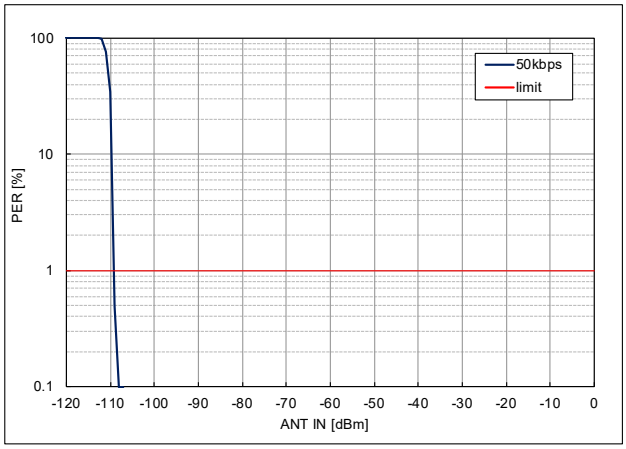

Figure 26 Packet Error Rate vs. RF Input Level (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 50kbps, RF Frequency = 872.8 MHz, RF Input Level = -120 dBm to -3 dBm, Data Length = 20 B, mod index = 0.5, Temperature = Room)

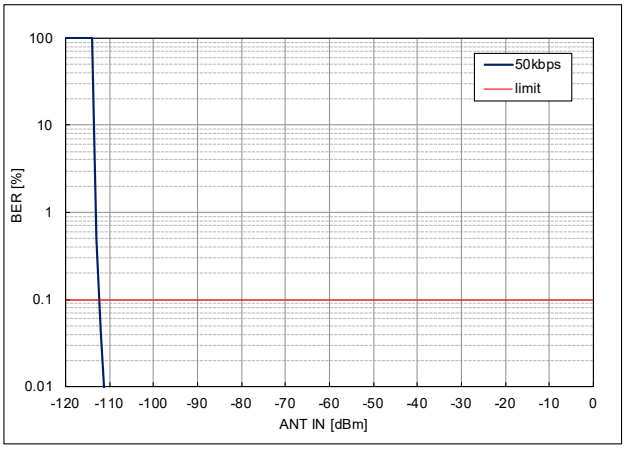

Figure 27 Bit Error Rate vs. RF Input Level (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 50kbps, RF Frequency = 872.8 MHz, RF Input Level = -120 dBm to -3 dBm, mod index = 0.5, Temperature = Room)

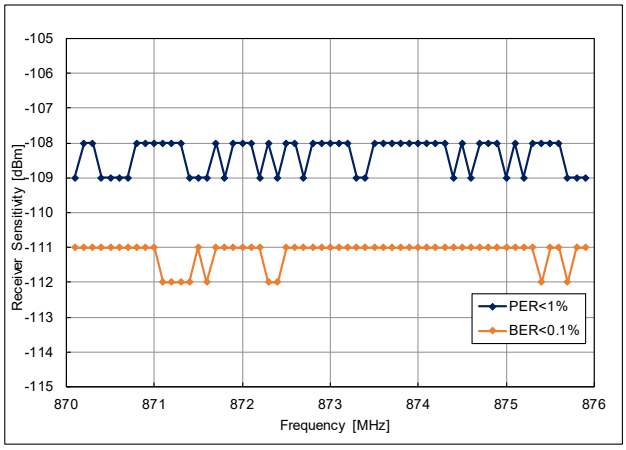

Figure 28 Receiver Sensitivity vs. RF Frequency (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 50kbps, Data Length = 20 B, mod index = 0.5, Temperature = Room)

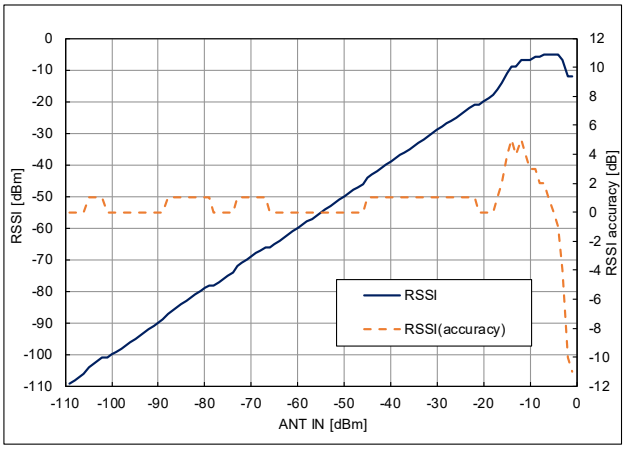

Figure 29 RSSI Accuracy vs. RF Input Level (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 50kbps, RF Frequency = 872.8 MHz, mod index = 0.5, Temperature = Room)

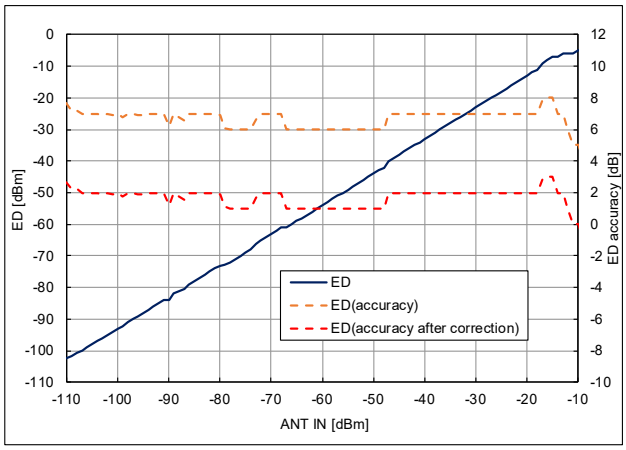

Figure 30 ED Accuracy vs. RF Input Level (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 50kbps, RF Frequency = 872.8 MHz, mod index = 0.5, Temperature = Room)

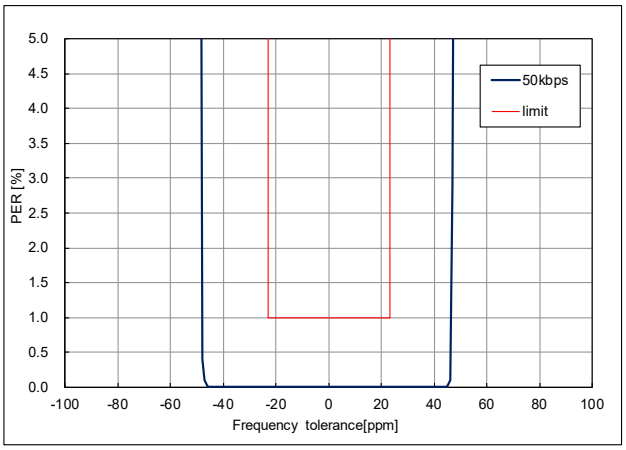

Figure 31 Packet Error Rate vs. RF Frequency tolerance (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 50kbps, RF Frequency = 872.8 MHz, RF Input Level = DUT sensitivity +3 dB, Data Length = 20 B, mod index = 0.5, Temperature = Room)

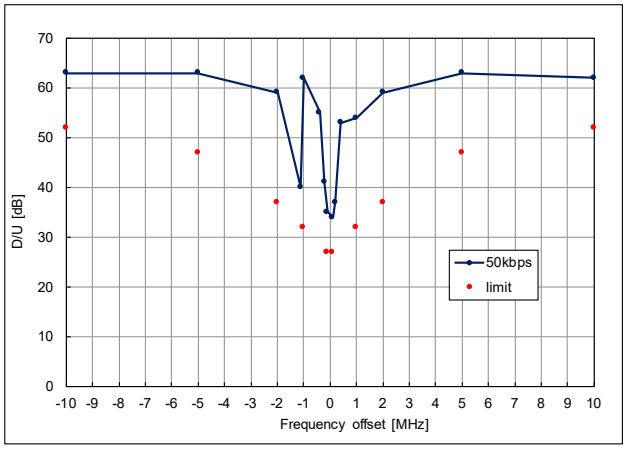

Figure 32 Desire/Unwanted Signal Ratio vs. RF Frequency offset (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 50kbps, RF Frequency = 872.8 MHz, RF Input Level = DUT sensitivity +3 dB, mod index = 0.5, Temperature = Room)

Table 18 RX Electrical Characteristics (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 100kbps, modulation index = 0.5, Temperature = Room)

Items			RF Frequency [MHz]	Unit	Evaluation results	Spec
Receiver sensitivity	PER < 1 % PSDU Length 20 octets		870.2	dBm	-106	-88 (*1)
			872.8		-106	
			875.4		-106	
	BER < 0.1 %		870.2	dBm	-108	-88 (*3)
			872.8		-108	
			875.4		-108	
Maximum Input level	PER < 1 % PSDU Length 20 octets		870.2	dBm	> -10	-
			872.8		> -10	
			875.4		> -10	
	BER < 0.1 %		870.2	dBm	> -10	-
			872.8		> -10	
			875.4		> -10	
Frequency tolerance	PER < 1 % PSDU Length 20 octets	Min	872.8	ppm	+126	-
		Max			-128	
Adjacent channel rejection	-200 kHz	BER < 0.1 % (*4)	872.8	dB	34	24 (*3)
	+200 kHz				34	
	-200 kHz	PER < 10 % (*5) Length 250 octets	872.8		31	10 (*2)
	+200 kHz				32	
Alternate channel rejection	-400 kHz	PER < 10 % (*5) Length 250 octets	872.8	dB	45	30 (*2)
	+400 kHz				46	
Blocking	-1 MHz	BER < 0.1 % (*4)	872.8	dB	37	29 (*3)
	+1 MHz				62	
	-2 MHz				65	34 (*3)
	+2 MHz				61	
	-5 MHz				61	44 (*3)
	+5 MHz				59	
	-10 MHz				59	49 (*3)
	+10 MHz				58	
	-60 MHz				61	-
	+60 MHz				62	
Image rejection	-1.1 MHz		872.8	dB	40	-
Spurious emission	9 kHz - 1 GHz		870.2	dBm /100 kHz	-83.5	-57 (*3)
			872.8		-83.1	
			875.4		-84.0	
	1 GHz - 6 GHz		870.2	dBm /1 MHz	-71.3	-47 (*3)
			872.8		-70.6	
			875.4		-71.3	

(*1) IEEE.802.15.4g, (*2) Wi-SUN
(*3) ETSI EN 303 204-1 V2.1.2 (2016-09)
(*4) The level of the desired signal: DUT sensitivity +3 dB
(*5) The level of the desired signal: -85 dBm

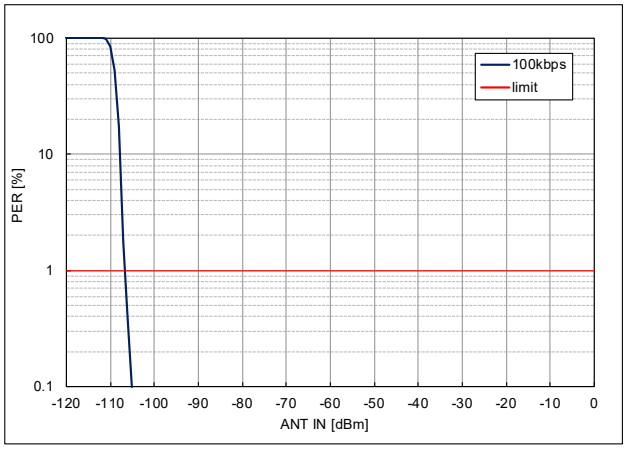

Figure 33 Packet Error Rate vs. RF Input Level (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 100kbps, RF Frequency = 872.8 MHz, RF Input Level = -120 dBm to -3 dBm, Data Length = 20 B, mod index = 0.5, Temperature = Room)

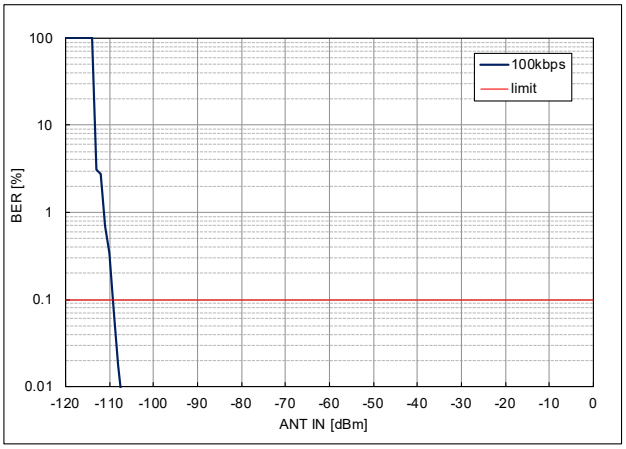

Figure 34 Bit Error Rate vs. RF Input Level (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 100kbps, RF Frequency = 872.8 MHz, RF Input Level = -120 dBm to -3 dBm, mod index = 0.5, Temperature = Room)

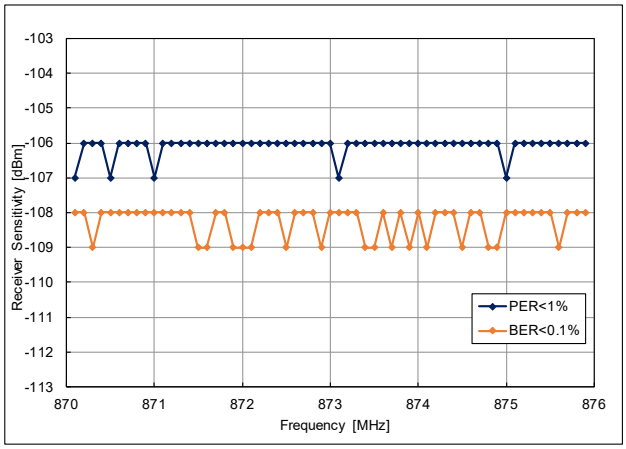

Figure 35 Receiver Sensitivity vs. RF Frequency (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 100kbps, Data Length = 20 B, mod index = 0.5, Temperature = Room)

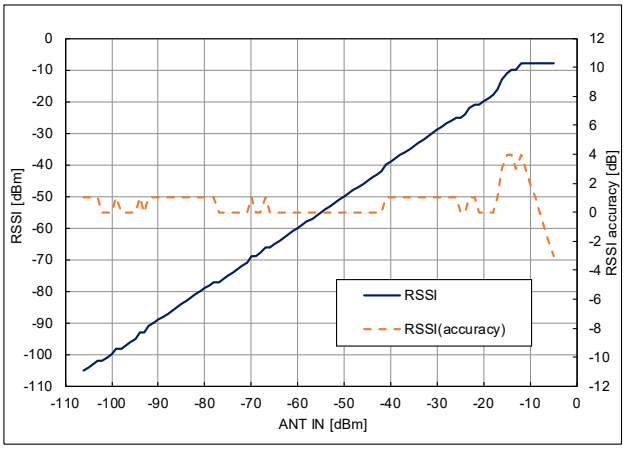

Figure 36 RSSI Accuracy vs. RF Input Level, (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 100kbps, RF Frequency = 872.8 MHz, mod index = 0.5, Temperature = Room)

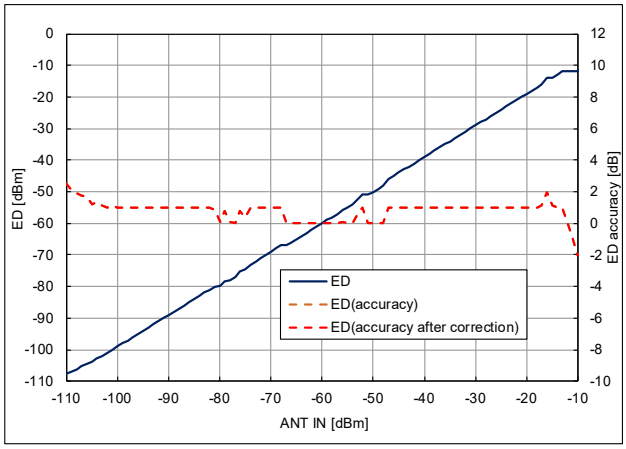

Figure 37 ED Accuracy vs. RF Input Level (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 100kbps, RF Frequency = 872.8 MHz, mod index = 0.5, Temperature = Room)

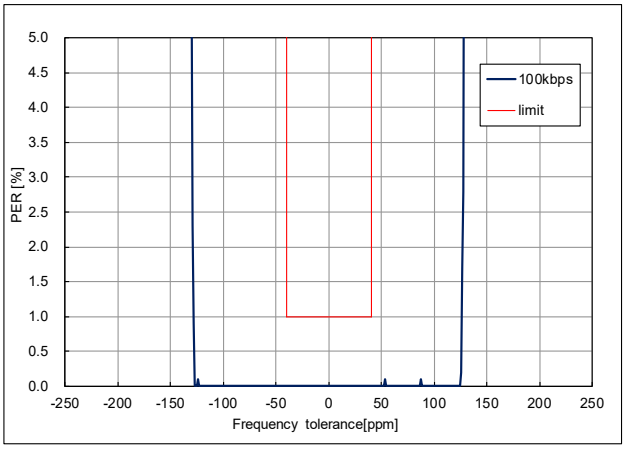

Figure 38 Packet Error Rate vs. RF Frequency tolerance (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 100kbps, RF Frequency = 872.8MHz, RF Input Level = DUT sensitivity +3 dB, Data Length = 20 B, mod index = 0.5, Temperature = Room)

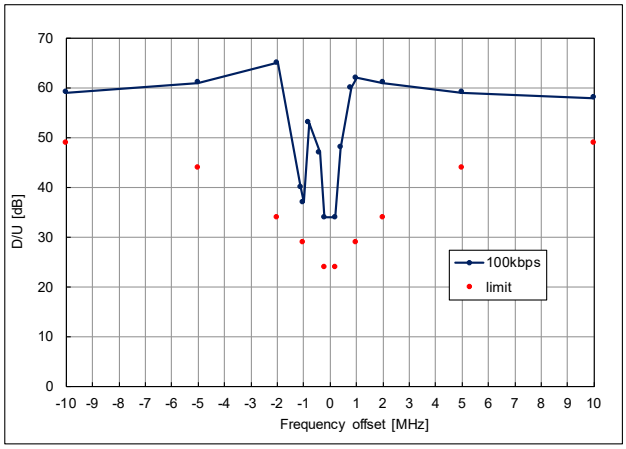

Figure 39 Desire/Unwanted Signal Ratio vs. RF Frequency offset (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 100kbps, RF Frequency = 872.8 MHz, RF Input Level = DUT sensitivity +3 dB, mod index = 0.5, Temperature = Room)

Table 19 RX Electrical Characteristics (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 150kbps modulation index = 0.5, Temperature = Room)

Items			RF Frequency [MHz]	Unit	Evaluation results	Spec
Receiver sensitivity	PER < 1 % PSDU Length 20 octets		870.2	dBm	-104	-86 (*1)
			872.8		-104	
			875.4		-104	
	BER < 0.1 %		870.2	dBm	-107	-86 (*3)
			872.8		-107	
			875.4		-107	
Maximum Input level	PER < 1 % PSDU Length 20 octets		870.2	dBm	> -10	-
			872.8		> -10	
			875.4		> -10	
	BER < 0.1 %		870.2	dBm	> -10	-
			872.8		> -10	
			875.4		> -10	
Frequency tolerance	PER < 1 % PSDU Length 20 octets	Max	872.8	ppm	+121	-
		Min			-126	
Adjacent channel rejection	-200 kHz	BER < 0.1 % (*4)	872.8	dB	32	24 (*3)
	+200 kHz				31	
	-200 kHz	PER < 10 % (*5) Length 250 octets	872.8		15	10 (*2)
	+200 kHz				16	
Alternate channel rejection	-400 kHz	PER < 10 % (*5) Length 250 octets	872.8	dB	43	30 (*2)
	+400 kHz				43	
Blocking	-1 MHz	BER < 0.1 % (*4)	872.8	dB	41	29 (*3)
	+1 MHz				55	
	-2 MHz				56	34 (*3)
	+2 MHz				57	
	-5 MHz				59	44 (*3)
	+5 MHz				59	
	-10 MHz				59	49 (*3)
	+10 MHz				58	
	-60 MHz				61	-
	+60 MHz				62	
Image rejection	-1.1 MHz		872.8	dB	43	-
Spurious emission	9 kHz - 1 GHz		870.2	dBm /100 kHz	-82.8	-57 (*3)
			872.8		-83.7	
			875.4		-83.7	
	1 GHz - 6 GHz		870.2	dBm /1 MHz	-71.0	-47 (*3)
			872.8		-70.7	
			875.4		-71.4	

(*1) IEEE.802.15.4g, (*2) Wi-SUN
(*3) ETSI EN 303 204-1 V2.1.2 (2016-09)
(*4) The level of the desired signal: DUT sensitivity +3 dB
(*5) The level of the desired signal: -83 dBm

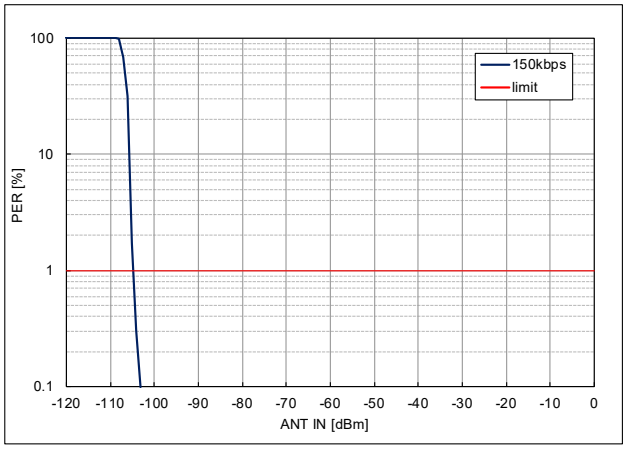

Figure 40 Packet Error Rate vs. RF Input Level (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 150kbps, RF Frequency = 872.8 MHz, RF Input Level = -120 dBm to -3 dBm, Data Length = 20 B, mod index = 0.5, Temperature = Room)

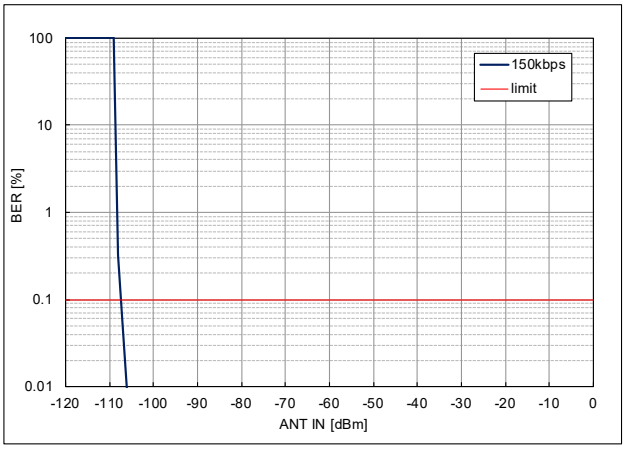

Figure 41 Bit Error Rate vs. RF Input Level (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 150kbps, RF Frequency = 872.8 MHz, RF Input Level = -120 dBm to -3 dBm, mod index = 0.5, Temperature = Room)

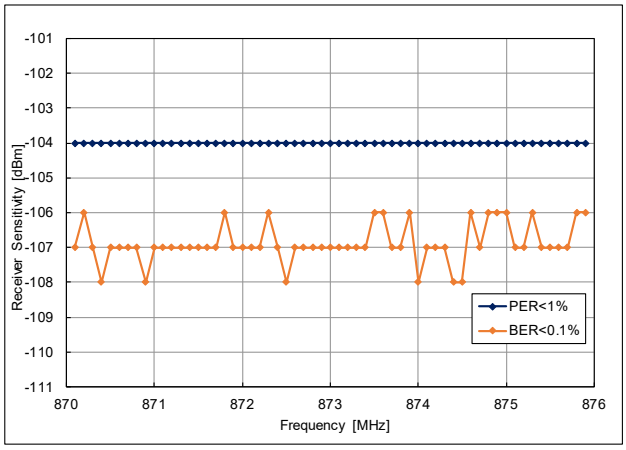

Figure 42 Receiver Sensitivity vs. RF Frequency (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 150kbps, Data Length = 20 B, mod index = 0.5, Temperature = Room)

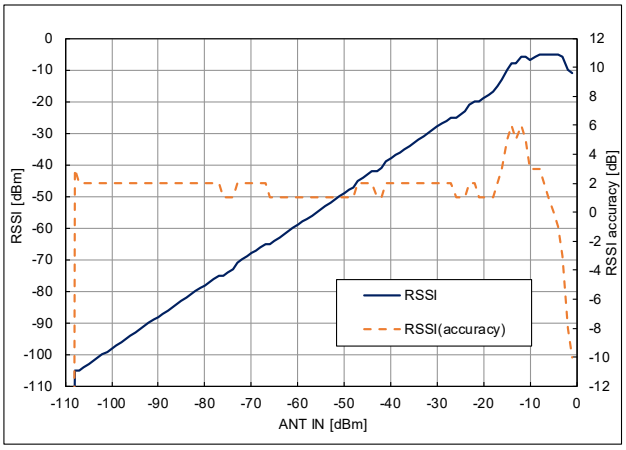

Figure 43 RSSI Accuracy vs. RF Input Level (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 150kbps, RF Frequency = 872.8 MHz, mod index = 0.5, Temperature = Room)

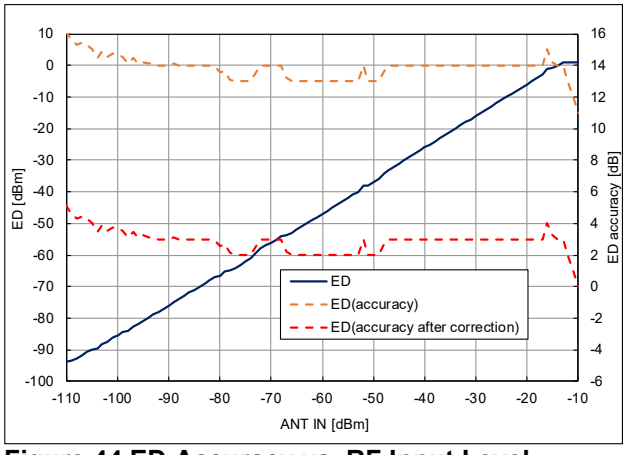

Figure 44 ED Accuracy vs. RF Input Level (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 150kbps, RF Frequency = 872.8 MHz, mod index = 0.5, Temperature = Room)

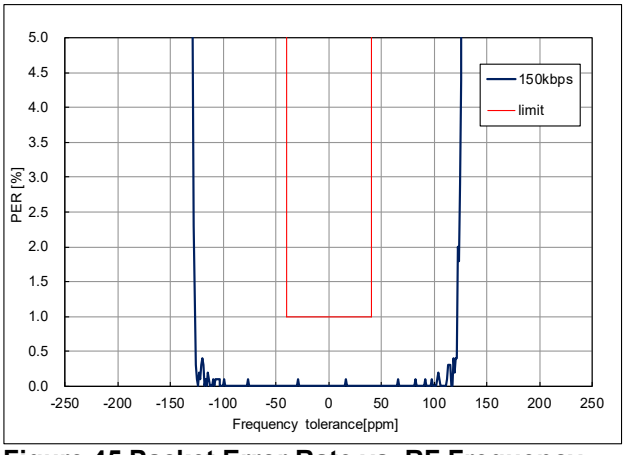

Figure 45 Packet Error Rate vs. RF Frequency tolerance (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 150kbps, RF Frequency = 872.8 MHz, RF Input Level = DUT sensitivity +3 dB, Data Length = 20 B, mod index = 0.5, Temperature = Room)

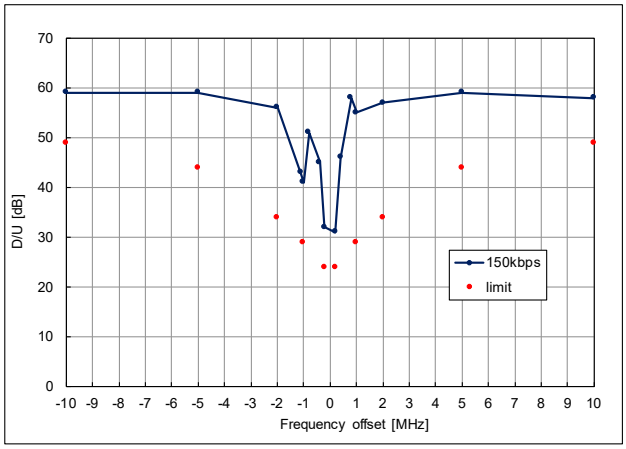

Figure 46 Desire/Unwanted Signal Ratio vs. RF Frequency offset (V_{DD} = V_{DDRF} = V_{DDPA} = 3.3 V, 150kbps, RF Frequency = 872.8 MHz, RF Input Level = DUT sensitivity +3 dB, mod index = 0.5, Temperature = Room)

3. Example of Peripheral Circuit

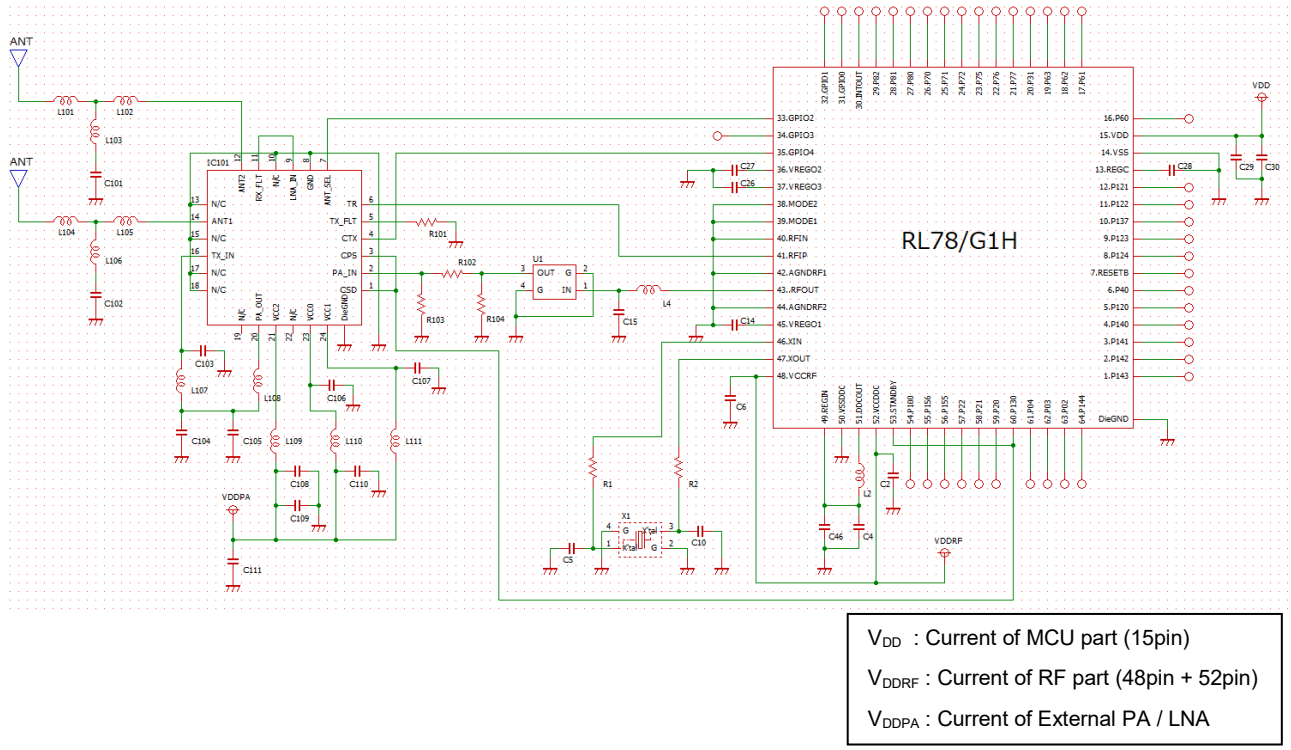

Figure 47 Example of Peripheral Circuit

Table 20 BOM Lists

Part	Description	Parts number	Part	Description	Parts number
C2	1 uF	GRM155B31C105KA12D	C109	1000 pF	GRM1552C1H102JA01
C4	1 uF	GRM155B31C105KA12D	C110	0.01 uF	GRM155B31H103KA88
C5	9 pF (*1)	GRM1552C1H9R0CA01D	C111	4.7 uF	GRM188B30J475KE18
C6	2.2 uF	GRM155R60G225ME15D			
C10	9 pF (*1)	GRM1552C1H9R0CA01D	L2	10 uH	MLZ1608M100WT
C14	1 uF	GRM155B31C105KA12D	L4	4.7 nH	LQW15AN4N7C00
C15	5.6 pF	GRM1552C1H5R6CA01D	L101	6.8 nH	MLG1005S6N8J
C26	1 uF	GRM155B31C105KA12D	L102	6.8 nH	MLG1005S6N8J
C27	1 uF	GRM155B31C105KA12D	L103	1.5 nH	MLG1005S1N5S
C28	1 uF	GRM155B31C105KA12D	L104	6.8 nH	MLG1005S6N8J
C29	1 uF	GRM155B31C105KA12D	L105	6.8 nH	MLG1005S6N8J
C30	Not mounted		L106	1.5 nH	MLG1005S1N5S
C46	47 pF	C1005CH1H470J	L107	3.0 nH	MLG1005S3N0S
C101	3.3 pF	GJM1555C1H3R3BB01	L108	1.3 nH	MLG1005S1N3S
C102	3.3 pF	GJM1555C1H3R3BB01	L109	6.8 nH	MLG1005S6N8J
C103	3.3 pF	GJM1555C1H3R3BB01	L110	4.7 nH	MLG1005S4N7S
C104	1.8 pF	GJM1555C1H1R8BB01	L111	3.3 nH	MLG1005S3N3S
C105	8.2 pF	GJM1555C1H8R2CB01			
C106	22 pF	GRM1552C1H220JZ01	R1	SHORT	
C107	47 pF	C1005CH1H470J	R2	SHORT	
C108	33 pF	GRM1552C1H330JZ01	R101	51 Ω	RK73H1ET51R0F

Part	Description	Parts number	Part	Description	Parts number
R102	51 Ω	RK73H1ET51R0F	U1	SAW Filter	SF16-0868M4UU01
R103	120 Ω	RK73H1ET1200F			
R104	120 Ω	RK73H1ET1200F	X1	Crystal resonator 48 MHz	XRCMD48M000FXQ60R0
IC101	Front-end module (SW+PA+LNA)	SE2435L			

(*1) This provides a load capacitance for the crystal resonator and its value depends on the parasitic capacitance of the combination of the crystal resonator and the board on which it is mounted.

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	May 29, 2019	–	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

   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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