



RADIO TEST REPORT

Test Report No.: 10248551S-A

Applicant : Yokogawa Electric Corporation
Type of Equipment : Field Wireless Communication Module
Model No. : FN110
FCC ID : SGJ-WFC011
Test regulation : FCC Part15 Subpart C: 2014
Test result : Complied

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Date of test: March 24 to 25, 2014

Tested by:

M. Hosaka

Makoto Hosaka
Engineer
Consumer Technology Division

Approved by :

T. Imamura

Toyokazu Imamura
Leader
Consumer Technology Division



- ☐ The testing in which "Non-accreditation" is displayed is outside the accreditation scopes in UL Japan.
☒ There is no testing item of "Non-accreditation".

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13-EM-F0429

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SECTION 1: Customer information

Company Name : Yokogawa Electric Corporation
Address : 2-9-32 Naka-cho, Musashino-shi, Tokyo 180-8750 Japan
Telephone Number : +81-422-52-5518
Facsimile Number : +81-422-52-2102
Contact Person : Tomoyuki Kamoshita

SECTION 2: Equipment under test (E.U.T.)

2.1 Identification of E.U.T.

Type of Equipment : Field Wireless Communication Module
Model No. : FN110
Serial No. : Refer to 4.2 in this report.
Rating : DC 2.9V - 4.8V
Receipt Date of Sample : March 18, 2014
Country of Mass-production : Japan
Condition of EUT : Production model
Modification of EUT : No modification by the test lab.

2.2 Product description

Model: FN110 (referred to as the EUT in this report) is a Field Wireless Communication Module.

Clock frequency(ies) in the system : Transceiver 16MHz
CPU 14MHz (Tx)
CPU 14MHz,32MHz (Rx)
RTC 32KHz
*14MHz: Internal clock of CPU

Radio specification:

Equipment type : Transceiver
Frequency of operation : 2405-2475MHz
Bandwidth : 2MHz
Channel spacing : 5MHz
Type of modulation : O-QPSK, DSSS
Antenna type : Multilayer Chip Antenna
Antenna gain : 2.0dBi
Antenna connector type : None
ITU code : G1D
Operation temperature range : -40 to +85 deg.C

FCC 15.31 (e)

The RF Module is constantly provided voltage (DC 2.8V) through the regulator regardless of input voltage. Therefore, this EUT complies with the requirement.

FCC 15.203

The antenna is not removable from the EUT. Therefore, the equipment complies with the antenna requirement.

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SECTION 3: Test specification, procedures & results

3.1 Test specification

Test specification : FCC Part 15 Subpart C: 2014, final revised on March 6, 2014 and effective April 7, 2014
* The revision on March 6, 2014 does not affect the test specification applied to the EUT.
Title : FCC 47CFR Part15 Radio Frequency Device Subpart C Intentional Radiators
Section 15.207 Conducted limits
Section 15.209 Radiated emission limits, general requirements
Section 15.247 Operation within the bands 902-928MHz, 2400-2483.5MHz,
and 5725-5850MHz

3.2 Procedures & Results

Item	Test Procedure *1)	Specification	Remarks	Deviation	Worst Margin	Results
Conducted emission	ANSI C63.10:2009	FCC 15.207	-	N/A	22.1dB Freq.: 0.46108MHz Detector: Quasi-Peak Phase: N Mode: Tx 2405MHz	Complied
6dB bandwidth	ANSI C63.10:2009	FCC 15.247 (a)(2)	Conducted	N/A	* See data	Complied
Maximum peak conducted output power	ANSI C63.10:2009	FCC 15.247 (b)(3)	Conducted	N/A		Complied
Out of band emission & Restricted band edges	ANSI C63.10:2009	FCC 15.109, 15.247 (d) & 15.209	Conducted / Radiated	N/A	0.2dB Freq.: 4810.000MHz Polarization: Horizontal Detection: Average Mode: Tx, 2405 MHz	Complied
Power density	ANSI C63.10:2009	FCC 15.247 (e)	Conducted	N/A	* See data	Complied
Note: UL Japan's EMI Work Procedures No.13-EM-W0420 and 13-EM-W0422. *1) These tests were also referred to KDB 558074 v03 r01 (FCC), "Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247".						

3.3 Addition to standard

Item	Test Procedure	Specification	Remarks	Worst Margin	Results
Occupied bandwidth (99%)	ANSI C63.4:2009 RSS-Gen 4.6.1	-	Conducted	-	-
Note: UL Japan's Work Procedures No. 13-EM-W0420 and 13-EM-W0422					

* Other than above, no addition, exclusion nor deviation has been made from the standard.

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3.4 Uncertainty

The following uncertainties have been calculated to provide a confidence level of 95% using a coverage factor k=2.

Item	Frequency range	No.1 SAC ^{*1} /SR ^{*2} (±)	No.2 SAC/SR (±)	No.3 SAC/SR (±)
Radiated emission (Measurement distance: 3m)	9kHz-30MHz	3.7 dB	3.7 dB	3.6 dB
	30MHz-300MHz	4.8 dB	5.0 dB	4.8 dB
	300MHz-1GHz	5.0 dB	5.0 dB	4.8 dB
	1GHz-15GHz	4.9 dB	4.9 dB	4.9 dB
Radiated emission (Measurement distance: 1m)	15GHz-18GHz	5.7 dB	5.6 dB	5.6 dB
	18GHz-40GHz	5.2 dB	4.3 dB	4.3 dB

*1: SAC=Semi-Anechoic Chamber

*2: SR= Shielded Room is applied besides radiated emission

Item	Frequency range	No.5/6 SR ^{*1} (±)
Conducted emission (AC Mains) AMN/LISN	9kHz-150kHz	3.9 dB
	150kHz-30MHz	3.5 dB

*1: SR= Shielded Room

Conducted emission test

The data listed in this test report has enough margin, more than the site margin.

Radiated emission test

The data listed in this test report meets the limits unless the uncertainty is taken into consideration.

Antenna port conducted test

Power measurement uncertainty above 1GHz for this test was: (±) 1.5dB

Conducted emissions, Power Density Measurement (below 1GHz) uncertainty for this test was: (±) 1.6dB

Conducted emissions, Power Density Measurement (1G-3GHz) uncertainty for this test was: (±) 1.4dB

Conducted emissions, Power Density Measurement (3G-18GHz) uncertainty for this test was: (±) 2.8dB

Conducted emissions Measurement (18G-26.5GHz) uncertainty for this test was: (±) 2.5dB

Bandwidth measurement uncertainty for this test was: (±) 5.4%

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3.5 Test location

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Telephone number : +81 463 50 6400

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JAB Accreditation No. : RTL02610

	FCC Registration No.	IC Registration No.	Width x Depth x Height (m)	Size of reference ground plane (m) / horizontal conducting plane	Maximum measurement distance
☐ No.1 semi-anechoic chamber	697847	2973D-1	20.6 x 11.3 x 7.65	20.6 x 11.3	10m
☐ No.2 semi-anechoic chamber	697847	2973D-2	20.6 x 11.3 x 7.65	20.6 x 11.3	10m
☒ No.3 semi-anechoic chamber	697847	2973D-3	12.7 x 7.7 x 5.35	12.7 x 7.7	5m
☐ No.4 semi-anechoic chamber	-	-	8.1 x 5.1 x 3.55	8.1 x 5.1	-
☐ No.1 shielded room	-	-	6.8 x 4.1 x 2.7	6.8 x 4.1	-
☐ No.2 shielded room	-	-	6.8 x 4.1 x 2.7	6.8 x 4.1	-
☐ No.3 shielded room	-	-	6.3 x 4.7 x 2.7	6.3 x 4.7	-
☐ No.4 shielded room	-	-	4.4 x 4.7 x 2.7	4.4 x 4.7	-
☒ No.5 shielded room	-	-	7.8 x 6.4 x 2.7	7.8 x 6.4	-
☐ No.6 shielded room	-	-	7.8 x 6.4 x 2.7	7.8 x 6.4	-
☒ No.1 measurement room	-	-	2.55 x 4.1 x 2.5	-	-

3.6 Test setup, Data of test & Test instruments

Refer to APPENDIX 1 to 3.

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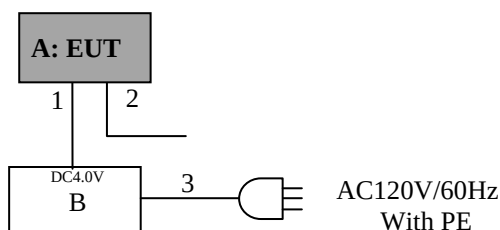
SECTION 4: Operation of E.U.T. during testing

4.1 Operating mode

Test item	Mode	Tested frequency
All items	Transmitting IEEE 802.15.4	2405MHz, 2440MHz, 2475MHz
*1) Software: IrDAApp ver 2.0.0.		
*2) Power setting: 00		

Justification: The system was configured in typical fashion (as customer would normally use it) for testing.

4.2 Configuration and peripherals



*Cabling and setup were taken into consideration and test data was taken under worse case conditions.

Description of EUT and support equipment

No.	Item	Model number	Serial number	Manufacturer	Remarks
A	Field Wireless Communication Module	FN110	9BC17D	Yokogawa Electric Corporation	EUT
B	DC Power Supply	PAN35-10A	ML002085	Kikusui CORP.	

List of cables used

No.	Cable name	Length (m)	Shield		Remarks
			Cable	Connector	
1	DC	5.9	Unshielded	Unshielded	-
2	RS485	5.0	Shielded	Shielded	-
3	AC	1.5	Unshielded	Unshielded	-

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SECTION 5: Conducted emission

5.1 Operating environment

Test place : See test data (APPENDIX 1)
Temperature : See test data (APPENDIX 1)
Humidity : See test data (APPENDIX 1)

5.2 Test configuration

EUT was placed on a platform of nominal size, 1m by 1.5m, raised 0.8m above the conducting ground plane. The table is made of Styrofoam and covered with polyvinyl chloride. That has very low permittivity. The rear of tabletop was located 40cm to the vertical conducting plane. The rear of EUT, including peripherals was aligned and was flushed with rear of tabletop. All other surfaces of tabletop were at least 80cm from any other grounded conducting surface. EUT was located 80cm from LISN. Each EUT current-carrying power lead, except the ground (safety) lead, was individually connected through a LISN to the input power source. Photographs of the set up are shown in APPENDIX 3.

5.3 Test conditions

Frequency range : 0.15 - 30MHz
EUT position : Table top

5.4 Test procedure

The AC Mains Terminal Continuous disturbance Voltage had been measured with the EUT within a Shielded room. The EUT was connected to a Line Impedance Stabilization Network (LISN). An overview sweep with peak detection has been performed. The measurements had been performed with a quasi-peak detector and if required, a CISPR average detector. The conducted emission measurements were made with the following detection of the test receiver.

Detection Type : Quasi-Peak/ CISPR Average
IF Bandwidth : 9kHz

5.5 Results

Summary of the test results : Pass
Refer to APPENDIX 1.

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SECTION 6: Radiated emission

6.1 Operating environment

Test place : See test data (APPENDIX 1)
Temperature : See test data (APPENDIX 1)
Humidity : See test data (APPENDIX 1)

6.2 Test configuration

EUT was placed on a urethane platform of nominal size, 0.5m by 0.5m, raised 0.8m (below 15GHz) / 1m (above 15GHz) above the conducting ground plane. Photographs of the set up are shown in APPENDIX 3.

6.3 Test conditions

Frequency range : 30MHz to 25GHz
EUT position : Table top

6.4 Test procedure

The Radiated Electric Field Strength intensity has been measured on a semi-anechoic chamber with a ground plane and at a distance of 3m (below 15GHz) / 1m (above 15GHz) (Refer to Figure 1). Measurements were performed with quasi-peak, peak and average detector. The measuring antenna height was varied between 1 and 4m and EUT was rotated a full revolution in order to obtain the maximum value of the electric field intensity. The measurements were performed for both vertical and horizontal antenna polarization.

The radiated emission measurements were made with the following detection.

Frequency	30-1000MHz	1-25GHz		20dBc
Detection type	Quasi-Peak	Peak	Average *1)	Peak
IF Bandwidth	120kHz	RBW: 1MHz VBW: 3MHz	RBW: 1MHz VBW: 3MHz Detector: RMS	RBW: 100kHz VBW: 300kHz

*1) Average Power Measurement was measured based on 12.2.5 of KDB 558074 "Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247".

The carrier level and noise levels were confirmed at each position of X, Y and Z axes of EUT to see the position of maximum noise, and the test was made at the position that has the maximum noise.

Worst case:

Antenna polarization	Carrier (Band edge)	Spurious			
		Below 1GHz	Above 1GHz		
			1-15GHz	15-18GHz	18-25GHz
Horizontal	Y	X	X	Y	Y
Vertical	Y	X	Y	X	Z

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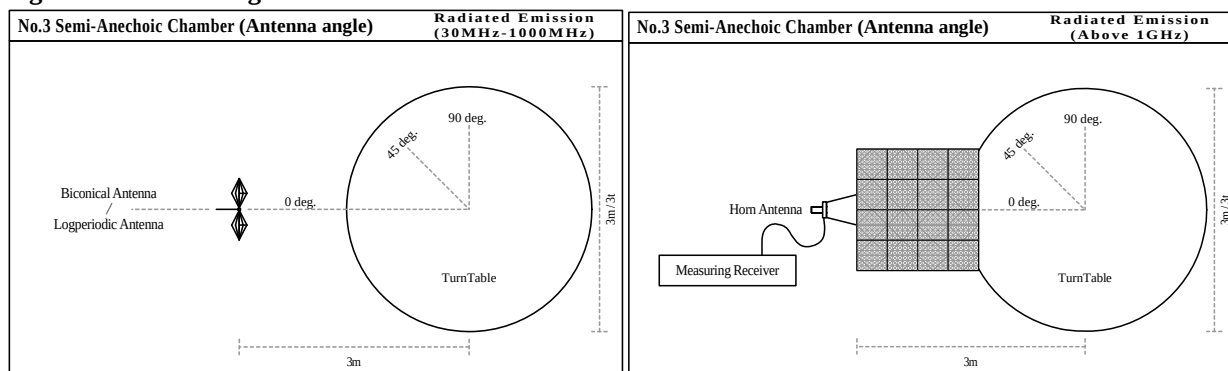
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Figure 1. Antenna angle



6.5 Band edge

Band edge level at 2390MHz and 2483.5MHz is below the limits of FCC 15.209 and band edge level at 2400MHz is below the 20dBc. Refer to the data.

6.6 Results

Summary of the test results : Pass

Refer to APPENDIX 1.

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SECTION 7: Out of band emissions (Antenna port conducted)

Test procedure

The Out of Band Emissions was measured with a spectrum analyzer connected to the antenna port. In any 100kHz bandwidth outside the frequency band in which the spread spectrum intentional radiator is operating, the radio frequency power that is produced by the intentional radiator confirmed 20dB below that in the 100kHz bandwidth within the band that contains the highest level of the desired power, based on a radiated measurement. In the frequency range below 30MHz, RBW was narrowed to separate the noise contents. Then, wide-band noise near the limit was checked separately, however the noise was not detected as shown in the chart. (9kHz-150kHz:RBW=200Hz, 150kHz-30MHz:RBW=10kHz)

Summary of the test results: Pass
Refer to APPENDIX 1.

SECTION 8: 6dB bandwidth & Occupied bandwidth (99%)

Test procedure

The bandwidth was measured with a spectrum analyzer connected to the antenna port. The test was measured based on Method 8.1 Option 1 and 8.2 Option 2 of KDB 558074 "Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247".

Summary of the test results: Pass
Refer to APPENDIX 1.

SECTION 9: Maximum peak conducted output power

Test procedure

The Maximum Peak Output Power was measured with a power meter connected to the antenna port. The test was measured based on Method 9.1.3 PKPM1 of KDB 558074 "Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247".

Summary of the test results: Pass
Refer to APPENDIX 1.

SECTION 10: Peak power density

Test procedure

The peak power density was measured with a spectrum analyzer connected to the antenna port.

Instrument used : Spectrum Analyzer
RBW / VBW : 3kHz / 9.1kHz

The test was measured based on Method 10.2 PKPSD of KDB 558074 "Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247".

Summary of the test results: Pass
Refer to APPENDIX 1.

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APPENDIX 2: Test instruments

Test instruments

APPENDIX 3: Photographs of test setup

Conducted emission
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Pre-check of the worst position

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APPENDIX 1: Data of Radio tests

DATA OF CONDUCTED EMISSION TEST

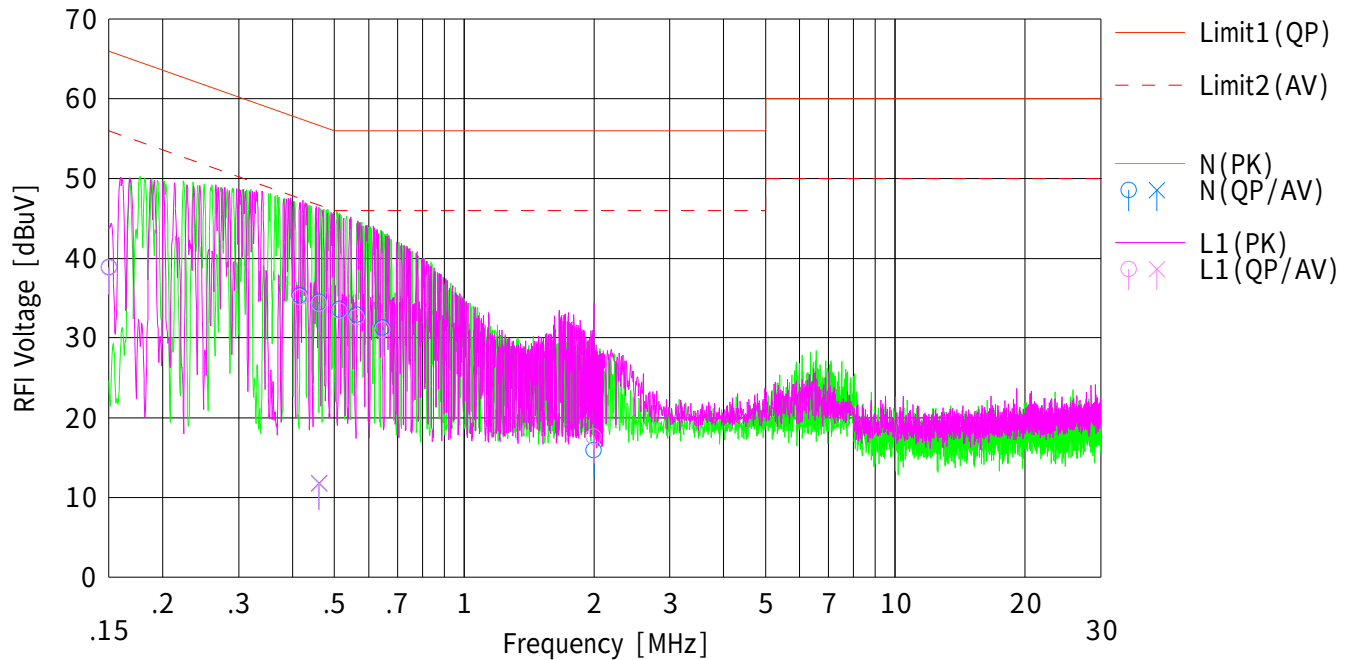
UL Japan,Inc. Shonan EMC Lab. No.5 Shielded Room
Date : 2014/03/25

Company : Yokogawa Electric Corporation
Kind of EUT : Field Wireless Communication Module
Model No. : FN110
Serial No. : 9BC17D
Remarks : -

Mode : Tx 2405MHz
Order No. : 10248551S
Power : AC120V/60Hz (DC4V)
Temp./Humi. : 26deg.C / 38%RH

Limit1 : FCC 15C(15.207) QP
Limit2 : FCC 15C(15.207) AV

Engineer : Makoto Hosaka



No.	Freq. [MHz]	Reading		C.Fac	Results		Limit		Margin		Phase	Comment
		<QP> [dBuV]	<AV> [dBuV]		<QP> [dBuV]	<AV> [dBuV]	<QP> [dBuV]	<AV> [dBuV]	<QP> [dB]	<AV> [dB]		
1	0.15000	25.9	---	13.0	38.9	---	66.0	56.0	27.1	---	N	
2	0.41637	22.3	---	13.0	35.3	---	57.5	47.5	22.2	---	N	
3	0.46108	21.5	-1.2	13.0	34.5	11.8	56.6	46.6	22.1	34.8	N	
4	0.51515	20.5	---	13.1	33.6	---	56.0	46.0	22.4	---	N	
5	0.56431	19.8	---	13.1	32.9	---	56.0	46.0	23.1	---	N	
6	0.64787	18.2	---	13.1	31.3	---	56.0	46.0	24.7	---	N	
7	1.99955	2.8	---	13.1	15.9	---	56.0	46.0	40.1	---	N	
8	0.15000	25.8	---	13.0	38.8	---	66.0	56.0	27.2	---	L1	
9	0.41637	22.1	---	13.0	35.1	---	57.5	47.5	22.4	---	L1	
10	0.46108	21.3	-1.3	13.0	34.3	11.7	56.6	46.6	22.3	34.9	L1	
11	0.51515	20.3	---	13.1	33.4	---	56.0	46.0	22.6	---	L1	
12	0.56431	19.5	---	13.1	32.6	---	56.0	46.0	23.4	---	L1	
13	0.64787	17.9	---	13.1	31.0	---	56.0	46.0	25.0	---	L1	
14	1.99955	4.5	---	13.1	17.6	---	56.0	46.0	38.4	---	L1	

Calculation: Result [dBuV] = Reading [dBuV] + C.Fac (LISN + Cable + Att) [dB]
LISN: SLS-06

DATA OF CONDUCTED EMISSION TEST

UL Japan,Inc. Shonan EMC Lab. No.5 Shielded Room
Date : 2014/03/25

Company : Yokogawa Electric Corporation

Kind of EUT : Field Wireless Communication Module

Model No. : FN110

Serial No. : 9BC17D

Remarks : -

Mode : Tx 2440MHz

Order No. : 10248551S

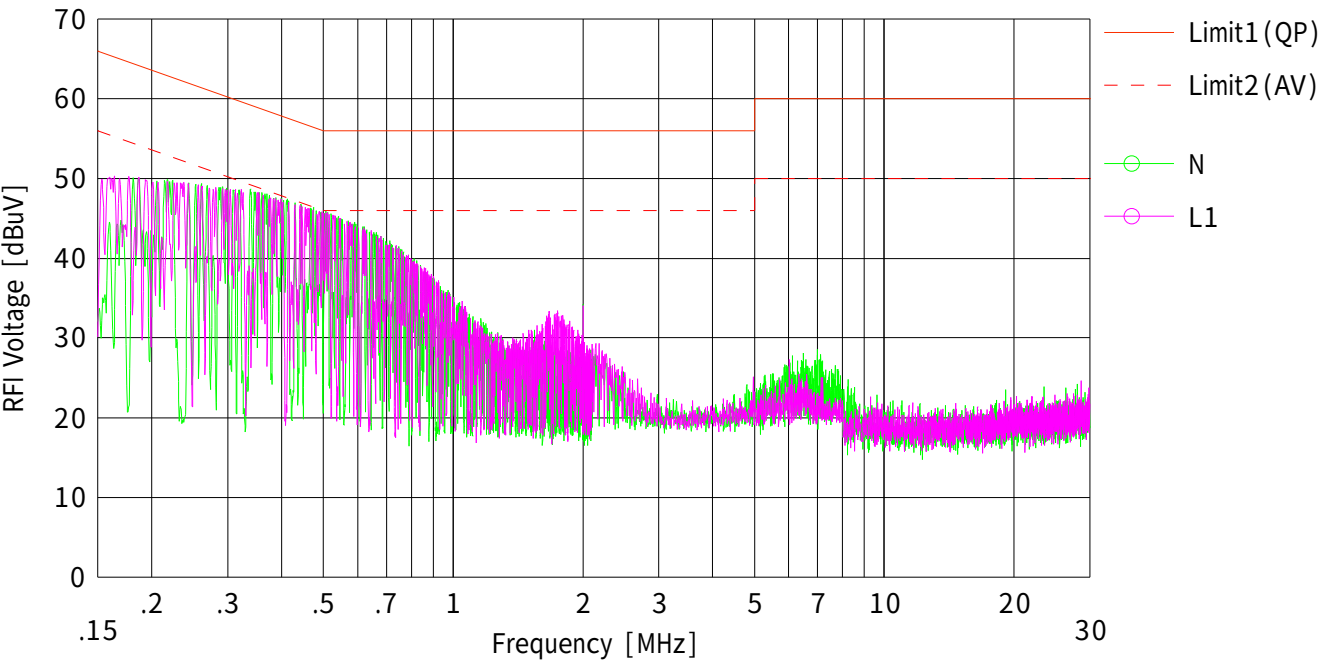
Power : AC120V/60Hz (DC4V)

Temp./Humi. : 26deg.C / 38%RH

Limit1 : FCC 15C(15.207) QP

Limit2 : FCC 15C(15.207) AV

Engineer : Makoto Hosaka



No.	Freq.	Reading	C.Fac	Results	Limit		Margin		Phase	Comment
	[MHz]	[dBuV]	[dB]	[dBuV]	<QP> [dBuV]	<AV> [dBuV]	<QP> [dB]	<AV> [dB]		

DATA OF CONDUCTED EMISSION TEST

UL Japan,Inc. Shonan EMC Lab. No.5 Shielded Room
Date : 2014/03/25

Company : Yokogawa Electric Corporation

Kind of EUT : Field Wireless Communication Module

Model No. : FN110

Serial No. : 9BC17D

Remarks : -

Mode : Tx 2475MHz

Order No. : 10248551S

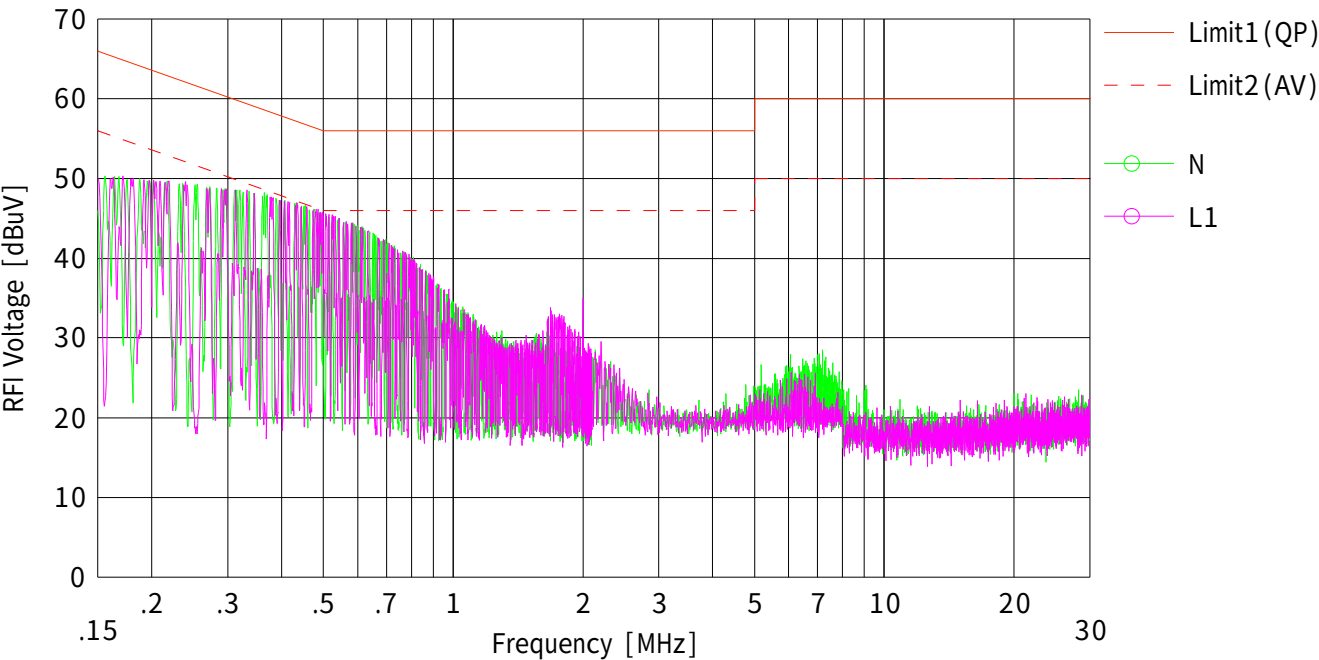
Power : AC120V/60Hz (DC4V)

Temp./Humi. : 26deg.C / 38%RH

Limit1 : FCC 15C(15.207) QP

Limit2 : FCC 15C(15.207) AV

Engineer : Makoto Hosaka

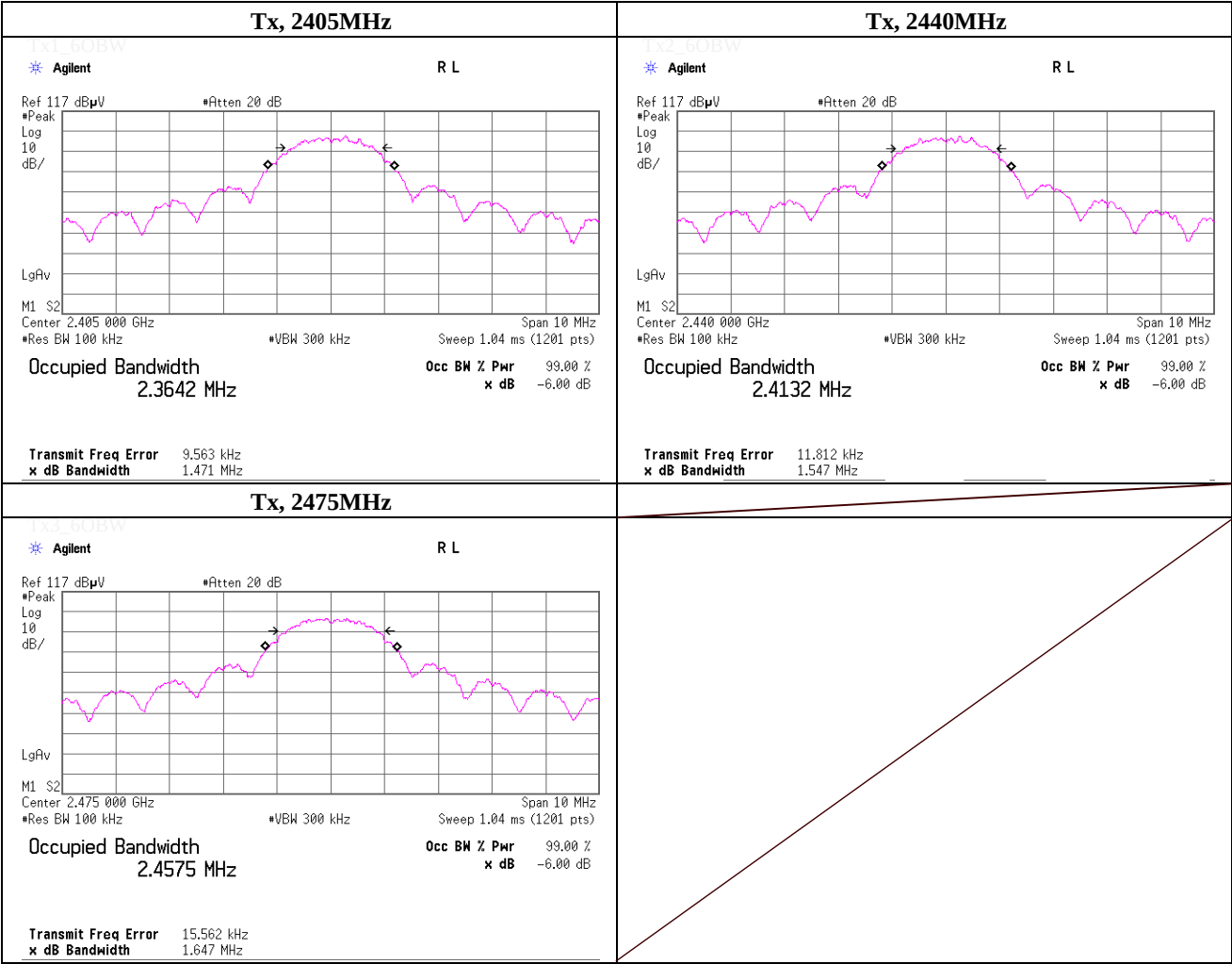


No.	Freq.	Reading	C.Fac	Results	Limit		Margin		Phase	Comment
	[MHz]	[dBuV]	[dB]	[dBuV]	<QP> [dBuV]	<AV> [dBuV]	<QP> [dB]	<AV> [dB]		

-6dB Bandwidth

Test place	UL Japan, Inc. Shonan EMC Lab.	No.1 Measurement Room
Date	March 25, 2014	
Temperature / Humidity	22deg.C , 38%RH	
Engineer	Makoto Hosaka	
Mode	Tx, IEEE 802.15.4,	

Freq. [MHz]	-6dB Bandwidth [MHz]	Limit [MHz]
2405.0000	1.471	> 0.500
2440.0000	1.547	> 0.500
2475.0000	1.647	> 0.500



Maximum Peak Conducted Output Power

(PKPM1)

Test place UL Japan, Inc. Shonan EMC Lab. No.5 Shielded Room
 Date March 24, 2014
 Temperature / Humidity 20deg.C , 30%RH
 Engineer Makoto Hosaka
 Mode Tx, IEEE 802.15.4, ,

(* P/M: Power Meter with power sensor)

Ch	Freq.	P/M (Peak) Reading	Cable Loss	Atten. Loss	Result		Limit		Margin
	[MHz]	[dBm]	[dB]	[dB]	[dBm]	[mW]	[dBm]	[mW]	[dB]
Low	2405.0	0.42	1.61	10.02	12.05	16.03	30.00	1000	17.95
Mid	2440.0	0.29	1.68	10.03	12.00	15.85	30.00	1000	18.00
High	2475.0	0.25	1.75	10.04	12.04	16.00	30.00	1000	17.96

Sample Calculation:

Result = Reading + Cable Loss (including the cable(s) customer supplied) + Atten. Loss

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Radiated Emission

Test place No.3 Semi Anechoic Chamber
 Date March 24, 2014
 Temperature / Humidity 24 deg.C, 32 %RH
 Engineer Tatsuya Arai
 Mode Tx, 2405 MHz

(* PK: Peak, AV: Average, QP: Quasi-Peak)

Polarity	Frequency [MHz]	Detector	Reading [dBuV]	Ant.Fac. [dB/m]	Loss [dB]	Gain [dB]	Result [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Height [cm]	Angle [deg]	Remark
Hori.	240.000	QP	21.5	16.9	8.2	32.0	14.6	46.0	31.4	100	0	
Hori.	2389.060	PK	50.6	26.8	14.7	38.2	53.9	73.9	20.0	100	222	
Hori.	2390.000	PK	49.7	26.8	14.7	38.2	53.0	73.9	20.9	100	222	
Hori.	4810.000	PK	69.0	31.0	7.9	37.1	70.8	73.9	3.1	111	152	
Hori.	7215.000	PK	63.7	37.1	9.1	39.4	70.5	73.9	3.4	110	199	
Hori.	9620.000	PK	50.6	38.6	10.2	37.6	61.8	73.9	12.1	100	187	
Hori.	12025.000	PK	52.8	39.6	11.2	38.5	65.1	73.9	8.8	123	358	
Hori.	16835.000	PK	47.5	39.2	3.3	38.6	51.4	73.9	22.5	100	359	
Hori.	19240.000	PK	61.7	40.8	1.9	48.4	56.0	73.9	17.9	100	358	
Hori.	21645.000	PK	53.3	40.8	2.7	47.9	48.9	73.9	25.0	100	0	
Hori.	24050.000	PK	51.3	40.5	3.4	47.5	47.7	73.9	26.2	100	350	
Hori.	2389.060	AV	42.4	26.8	14.7	38.2	45.7	53.9	8.2	100	222	
Hori.	2390.000	AV	39.8	26.8	14.7	38.2	43.1	53.9	10.8	100	222	
Vert.	240.000	QP	21.7	16.9	8.2	32.0	14.8	46.0	31.2	100	0	
Vert.	2389.060	PK	47.8	26.8	14.7	38.2	51.1	73.9	22.8	174	182	
Vert.	2390.000	PK	47.2	26.8	14.7	38.2	50.5	73.9	23.4	174	182	
Vert.	4810.000	PK	67.0	31.0	7.9	37.1	68.8	73.9	5.1	100	349	
Vert.	7215.000	PK	61.5	37.1	9.1	39.4	68.3	73.9	5.6	191	179	
Vert.	9620.000	PK	51.3	38.6	10.2	37.6	62.5	73.9	11.4	132	184	
Vert.	12025.000	PK	53.6	39.6	11.2	38.5	65.9	73.9	8.0	100	357	
Vert.	16835.000	PK	47.4	39.2	3.3	38.6	51.3	73.9	22.6	100	351	
Vert.	19240.000	PK	61.5	40.8	1.9	48.4	55.8	73.9	18.1	119	0	
Vert.	21645.000	PK	53.6	40.8	2.7	47.9	49.2	73.9	24.7	118	358	
Vert.	24050.000	PK	52.5	40.5	3.4	47.5	48.9	73.9	25.0	114	0	
Vert.	2389.060	AV	38.8	26.8	14.7	38.2	42.1	53.9	11.8	174	182	
Vert.	2390.000	AV	36.6	26.8	14.7	38.2	39.9	53.9	14.0	174	182	

Result = Reading + Ant.Fac. + Loss (Cable+(Attenuator or Filter)(below 18GHz)-Distance factor(above 15GHz)) - Gain(Amplifier)

Distance factor : 15GHz -40GHz : 20log(3.0m/1.0m)= 9.5dB

Average measurement value with duty factor

Polarity	Frequency [MHz]	Detector	Reading [dBuV]	Ant.Fac. [dB/m]	Loss [dB]	Gain [dB]	Duty Factor [dB]	Result [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Remark
Hori.	4810.000	PK	69.0	31.0	7.9	37.1	-17.1	53.7	53.9	0.2	
Hori.	7215.000	PK	63.7	37.1	9.1	39.4	-17.1	53.4	53.9	0.5	
Hori.	9620.000	PK	50.6	38.6	10.2	37.6	-17.1	44.7	53.9	9.2	
Hori.	12025.000	PK	52.8	39.6	11.2	38.5	-17.1	48.0	53.9	5.9	
Hori.	16835.000	PK	47.5	39.2	3.3	38.6	-17.1	34.3	53.9	19.6	
Hori.	19240.000	PK	61.7	40.8	1.9	48.4	-17.1	38.9	53.9	15.0	
Hori.	21645.000	PK	53.3	40.8	2.7	47.9	-17.1	31.8	53.9	22.1	
Hori.	24050.000	PK	51.3	40.5	3.4	47.5	-17.1	30.6	53.9	23.3	
Vert.	4810.000	PK	67.0	31.0	7.9	37.1	-17.1	51.7	53.9	2.2	
Vert.	7215.000	PK	61.5	37.1	9.1	39.4	-17.1	51.2	53.9	2.7	
Vert.	9620.000	PK	51.3	38.6	10.2	37.6	-17.1	45.4	53.9	8.5	
Vert.	12025.000	PK	53.6	39.6	11.2	38.5	-17.1	48.8	53.9	5.1	
Vert.	16835.000	PK	47.4	39.2	3.3	38.6	-17.1	34.2	53.9	19.7	
Vert.	19240.000	PK	61.5	40.8	1.9	48.4	-17.1	38.7	53.9	15.2	
Vert.	21645.000	PK	53.6	40.8	2.7	47.9	-17.1	32.1	53.9	21.8	
Vert.	24050.000	PK	52.5	40.5	3.4	47.5	-17.1	31.8	53.9	22.1	

Result = Reading + Ant.Fac. + Loss (Cable+(Attenuator or Filter)(below 18GHz)-Distance factor(above 15GHz)) - Gain(Amplifier) + Duty factor

Distance factor : 15GHz -40GHz : 20log(3.0m/1.0m)= 9.5dB

20dBc Data Sheet (RBW 100kHz, VBW 300kHz)

Polarity	Frequency [MHz]	Detector	Reading [dBuV]	Ant.Fac. [dB/m]	Loss [dB]	Gain [dB]	Result [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Remark
Hori.	2405.000	PK	100.0	26.8	14.7	38.2	103.3	-	-	100k/300k
Hori.	2400.000	PK	58.3	26.8	14.7	38.2	61.6	83.3	21.7	100k/300k
Vert.	2405.000	PK	96.7	26.8	14.7	38.2	100.0	-	-	100k/300k
Vert.	2400.000	PK	54.5	26.8	14.7	38.2	57.8	80.0	22.2	100k/300k

Result = Reading + Ant.Fac. + Loss (Cable+(Attenuator or Filter)(below 18GHz)-Distance factor(above 15GHz)) - Gain(Amplifier)

Distance factor : 15GHz -40GHz : 20log(3.0m/1.0m)= 9.5dB

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Radiated Emission

Test place No.3 Semi Anechoic Chamber
 Date March 24, 2014
 Temperature / Humidity 24 deg.C, 32 %RH
 Engineer Tatsuya Arai
 Mode Tx, 2440 MHz

(* PK: Peak, AV: Average, QP: Quasi-Peak)

Polarity	Frequency [MHz]	Detector	Reading [dBuV]	Ant.Fac. [dB/m]	Loss [dB]	Gain [dB]	Result [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Height [cm]	Angle [deg]	Remark
Hori.	240.000	QP	21.6	16.9	8.2	32.0	14.7	46.0	31.3	100	0	
Hori.	4880.000	PK	68.4	31.4	7.9	37.0	70.7	73.9	3.2	100	339	
Hori.	7320.000	PK	61.1	37.2	9.1	39.4	68.0	73.9	5.9	117	205	
Hori.	9760.000	PK	50.0	38.8	10.1	37.5	61.4	73.9	12.5	100	188	
Hori.	12200.000	PK	53.3	39.6	11.3	38.4	65.8	73.9	8.1	136	1	
Hori.	17080.000	PK	46.9	40.4	3.4	38.7	52.0	73.9	21.9	100	349	
Hori.	19520.000	PK	59.1	40.8	2.0	48.1	53.8	73.9	20.1	100	353	
Hori.	21960.000	PK	55.5	40.9	2.8	48.2	51.0	73.9	22.9	100	0	
Hori.	24400.000	PK	49.9	40.5	3.5	47.6	46.3	73.9	27.6	121	350	
Vert.	240.000	QP	21.8	16.9	8.2	32.0	14.9	46.0	31.1	100	0	
Vert.	4880.000	PK	67.2	31.4	7.9	37.0	69.5	73.9	4.4	100	359	
Vert.	7320.000	PK	60.1	37.2	9.1	39.4	67.0	73.9	6.9	169	178	
Vert.	9760.000	PK	51.3	38.8	10.1	37.5	62.7	73.9	11.2	143	184	
Vert.	12200.000	PK	52.7	39.6	11.3	38.4	65.2	73.9	8.7	100	359	
Vert.	17080.000	PK	46.5	40.4	3.4	38.7	51.6	73.9	22.3	100	344	
Vert.	19520.000	PK	58.3	40.8	2.0	48.1	53.0	73.9	20.9	120	359	
Vert.	21960.000	PK	54.6	40.9	2.8	48.2	50.1	73.9	23.8	115	16	
Vert.	24400.000	PK	53.4	40.5	3.5	47.6	49.8	73.9	24.1	115	357	

Result = Reading + Ant.Fac. + Loss (Cable+(Attenuator or Filter)(below 18GHz)-Distance factor(above 15GHz)) - Gain(Amplifier)

Distance factor : 15GHz -40GHz : 20log(3.0m/1.0m)= 9.5dB

Average measurement value with duty factor

Polarity	Frequency [MHz]	Detector	Reading [dBuV]	Ant.Fac. [dB/m]	Loss [dB]	Gain [dB]	Duty Factor [dB]	Result [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Remark
Hori.	4880.000	PK	68.4	31.4	7.9	37.0	-17.1	53.6	53.9	0.3	
Hori.	7320.000	PK	61.1	37.2	9.1	39.4	-17.1	50.9	53.9	3.0	
Hori.	9760.000	PK	50.0	38.8	10.1	37.5	-17.1	44.3	53.9	9.6	
Hori.	12200.000	PK	53.3	39.6	11.3	38.4	-17.1	48.7	53.9	5.2	
Hori.	17080.000	PK	46.9	40.4	3.4	38.7	-17.1	34.9	53.9	19.0	
Hori.	19520.000	PK	59.1	40.8	2.0	48.1	-17.1	36.7	53.9	17.2	
Hori.	21960.000	PK	55.5	40.9	2.8	48.2	-17.1	33.9	53.9	20.0	
Hori.	24400.000	PK	49.9	40.5	3.5	47.6	-17.1	29.2	53.9	24.7	
Vert.	4880.000	PK	67.2	31.4	7.9	37.0	-17.1	52.4	53.9	1.5	
Vert.	7320.000	PK	60.1	37.2	9.1	39.4	-17.1	49.9	53.9	4.0	
Vert.	9760.000	PK	51.3	38.8	10.1	37.5	-17.1	45.6	53.9	8.3	
Vert.	12200.000	PK	52.7	39.6	11.3	38.4	-17.1	48.1	53.9	5.8	
Vert.	17080.000	PK	46.5	40.4	3.4	38.7	-17.1	34.5	53.9	19.4	
Vert.	19520.000	PK	58.3	40.8	2.0	48.1	-17.1	35.9	53.9	18.0	
Vert.	21960.000	PK	54.6	40.9	2.8	48.2	-17.1	33.0	53.9	20.9	
Vert.	24400.000	PK	53.4	40.5	3.5	47.6	-17.1	32.7	53.9	21.2	

Result = Reading + Ant.Fac. + Loss (Cable+(Attenuator or Filter)(below 18GHz)-Distance factor(above 15GHz)) - Gain(Amplifier) + Duty factor

Distance factor : 15GHz -40GHz : 20log(3.0m/1.0m)= 9.5dB

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Radiated Emission

Test place No.3 Semi Anechoic Chamber
 Date March 24, 2014
 Temperature / Humidity 24 deg.C, 32 %RH
 Engineer Tatsuya Arai
 Mode Tx, 2475 MHz

(* PK: Peak, AV: Average, QP: Quasi-Peak)

Polarity	Frequency [MHz]	Detector	Reading [dBuV]	Ant.Fac. [dB/m]	Loss [dB]	Gain [dB]	Result [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Height [cm]	Angle [deg]	Remark
Hori.	240.000	QP	21.6	16.9	8.2	32.0	14.7	46.0	31.3	100	0	
Hori.	2483.500	PK	56.3	26.9	14.8	38.1	59.9	73.9	14.0	100	215	
Hori.	4950.000	PK	67.9	31.7	7.8	37.0	70.4	73.9	3.5	105	338	
Hori.	7425.000	PK	58.9	37.3	9.3	39.4	66.1	73.9	7.8	100	206	
Hori.	9900.000	PK	48.9	38.9	10.1	37.5	60.4	73.9	13.5	100	188	
Hori.	12375.000	PK	48.9	39.7	11.4	38.2	61.8	73.9	12.1	159	1	
Hori.	17325.000	PK	48.3	42.2	3.6	38.9	55.2	73.9	18.7	117	346	
Hori.	19800.000	PK	58.5	40.7	2.1	48.0	53.3	73.9	20.6	100	350	
Hori.	22275.000	PK	55.2	40.9	2.9	48.3	50.7	73.9	23.2	100	359	
Hori.	24750.000	PK	49.8	40.5	3.5	47.6	46.2	73.9	27.7	116	353	
Hori.	2483.500	AV	45.8	26.9	14.8	38.1	49.4	53.9	4.5	100	215	
Vert.	240.000	QP	21.6	16.9	8.2	32.0	14.7	46.0	31.3	100	0	
Vert.	2483.500	PK	52.2	26.9	14.8	38.1	55.8	73.9	18.1	152	181	
Vert.	4950.000	PK	67.6	31.7	7.8	37.0	70.1	73.9	3.8	106	151	
Vert.	7425.000	PK	57.6	37.3	9.3	39.4	64.8	73.9	9.1	169	180	
Vert.	9900.000	PK	50.3	38.9	10.1	37.5	61.8	73.9	12.1	144	178	
Vert.	12375.000	PK	49.0	39.7	11.4	38.2	61.9	73.9	12.0	100	359	
Vert.	17325.000	PK	47.3	42.2	3.6	38.9	54.2	73.9	19.7	100	359	
Vert.	19800.000	PK	57.7	40.7	2.1	48.0	52.5	73.9	21.4	115	11	
Vert.	22275.000	PK	57.0	40.9	2.9	48.3	52.5	73.9	21.4	115	13	
Vert.	24750.000	PK	52.1	40.5	3.5	47.6	48.5	73.9	25.4	113	10	
Vert.	2483.500	AV	41.6	26.9	14.8	38.1	45.2	53.9	8.7	152	181	

Result = Reading + Ant.Fac. + Loss (Cable+(Attenuator or Filter)(below 18GHz)-Distance factor(above 15GHz)) - Gain(Amplifier)

Distance factor : 15GHz -40GHz : 20log(3.0m/1.0m)= 9.5dB

Average measurement value with duty factor

Polarity	Frequency [MHz]	Detector	Reading [dBuV]	Ant.Fac. [dB/m]	Loss [dB]	Gain [dB]	Duty Factor [dB]	Result [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Remark
Hori.	4950.000	PK	67.9	31.7	7.8	37.0	-17.1	53.3	53.9	0.6	
Hori.	7425.000	PK	58.9	37.3	9.3	39.4	-17.1	49.0	53.9	4.9	
Hori.	9900.000	PK	48.9	38.9	10.1	37.5	-17.1	43.3	53.9	10.6	
Hori.	12375.000	PK	48.9	39.7	11.4	38.2	-17.1	44.7	53.9	9.2	
Hori.	17325.000	PK	48.3	42.2	3.6	38.9	-17.1	38.1	53.9	15.8	
Hori.	19800.000	PK	58.5	40.7	2.1	48.0	-17.1	36.2	53.9	17.7	
Hori.	22275.000	PK	55.2	40.9	2.9	48.3	-17.1	33.6	53.9	20.3	
Hori.	24750.000	PK	49.8	40.5	3.5	47.6	-17.1	29.1	53.9	24.8	
Vert.	4950.000	PK	67.6	31.7	7.8	37.0	-17.1	53.0	53.9	0.9	
Vert.	7425.000	PK	57.6	37.3	9.3	39.4	-17.1	47.7	53.9	6.2	
Vert.	9900.000	PK	50.3	38.9	10.1	37.5	-17.1	44.7	53.9	9.2	
Vert.	12375.000	PK	49.0	39.7	11.4	38.2	-17.1	44.8	53.9	9.1	
Vert.	17325.000	PK	47.3	42.2	3.6	38.9	-17.1	37.1	53.9	16.8	
Vert.	19800.000	PK	57.7	40.7	2.1	48.0	-17.1	35.4	53.9	18.5	
Vert.	22275.000	PK	57.0	40.9	2.9	48.3	-17.1	35.4	53.9	18.5	
Vert.	24750.000	PK	52.1	40.5	3.5	47.6	-17.1	31.4	53.9	22.5	

Result = Reading + Ant.Fac. + Loss (Cable+(Attenuator or Filter)(below 18GHz)-Distance factor(above 15GHz)) - Gain(Amplifier) + Duty factor

Distance factor : 15GHz -40GHz : 20log(3.0m/1.0m)= 9.5dB

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Test place UL Japan, Inc. Shonan EMC Lab. No.5 Shielded Room
Date March 24, 2014
Temperature / Humidity 20deg.C , 30%RH
Engineer Makoto Hosaka

Burst rate confirmation

Tx, IEEE 802.15.4,

Configuration during the test	
Tx2_duty1 Agilent R L Mkr1 31.08 ms -0.12 dBm Ref 10 dBm Atten 20 dB Peak Log 10 dB/ LgAv S1 S2 W3 FS AR Σ(f): FTun Center 2.405 000 GHz Res BW 1 MHz VBW 3 MHz Sweep 100.3 ms (8001 pts) Span 0 Hz	Tx2_duty2

Duty Factor Calculation

Tx, IEEE 802.15.4,

Worst duty cycle specification	
Duty factor =20log(13.976/100)=-17.1dB	
Tx2_duty1 Maximum transmission “ON” time per timeslot in FN110: Data frame length :32 us/byte×133 bytes=4.256 ms Ack frame length : 0.604 ms Total maximum “ON” time over 100ms in our system: Transmission without Ack :3 times Receiving with Ack transmission :2 times 4.256 ms×3+0.604 ms×2=13.976 ms	Tx2_duty2

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Test place

UL Japan, Inc. Shonan EMC Lab. No.1 Measurement Room

Date

March 25, 2014

Temperature / Humidity

22deg.C , 38%RH

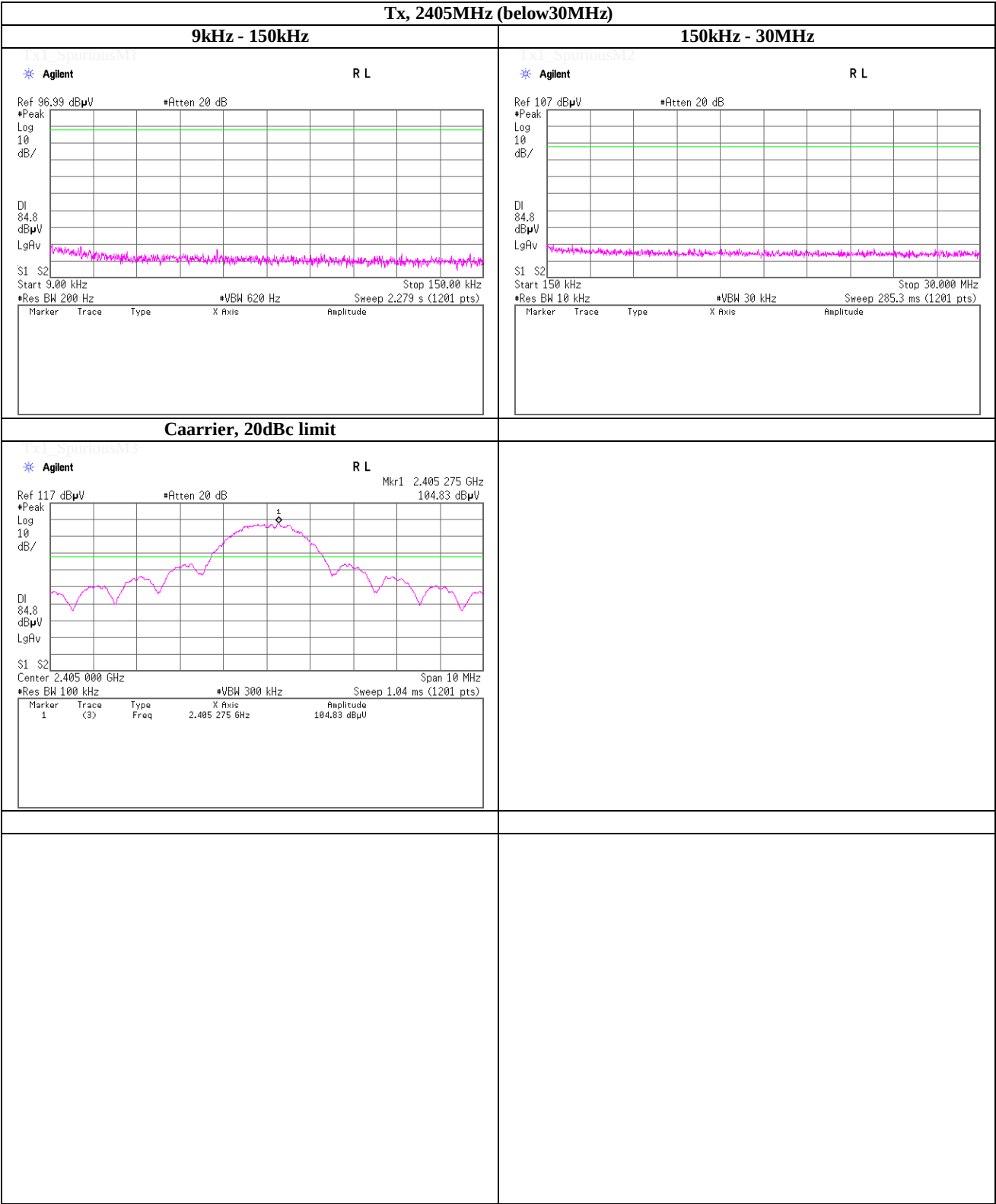
Engineer

Makoto Hosaka

(Reference chart) Spurious emission (Conducted)

Tx, IEEE 802.15.4,

Tx, 2405MHz (below30MHz)



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Test place

UL Japan, Inc. Shonan EMC Lab.

No.1 Measurement Room

Date

March 25, 2014

Temperature / Humidity

22deg.C , 38%RH

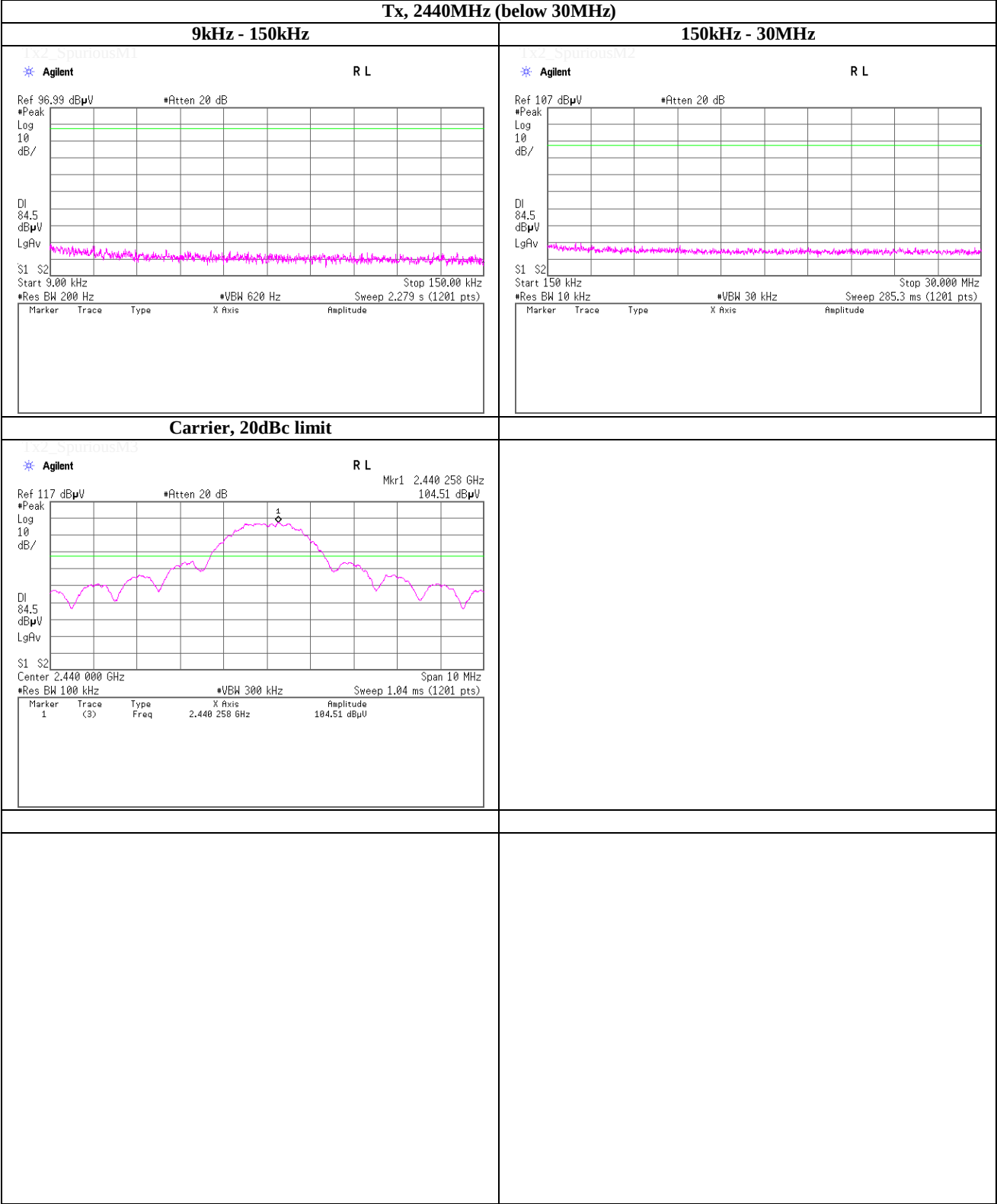
Engineer

Makoto Hosaka

(Reference chart) Spurious emission (Conducted)

Tx, IEEE 802.15.4,

Tx, 2440MHz (below 30MHz)



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Test place

UL Japan, Inc. Shonan EMC Lab. No.1 Measurement Room

Date

March 25, 2014

Temperature / Humidity

22deg.C , 38%RH

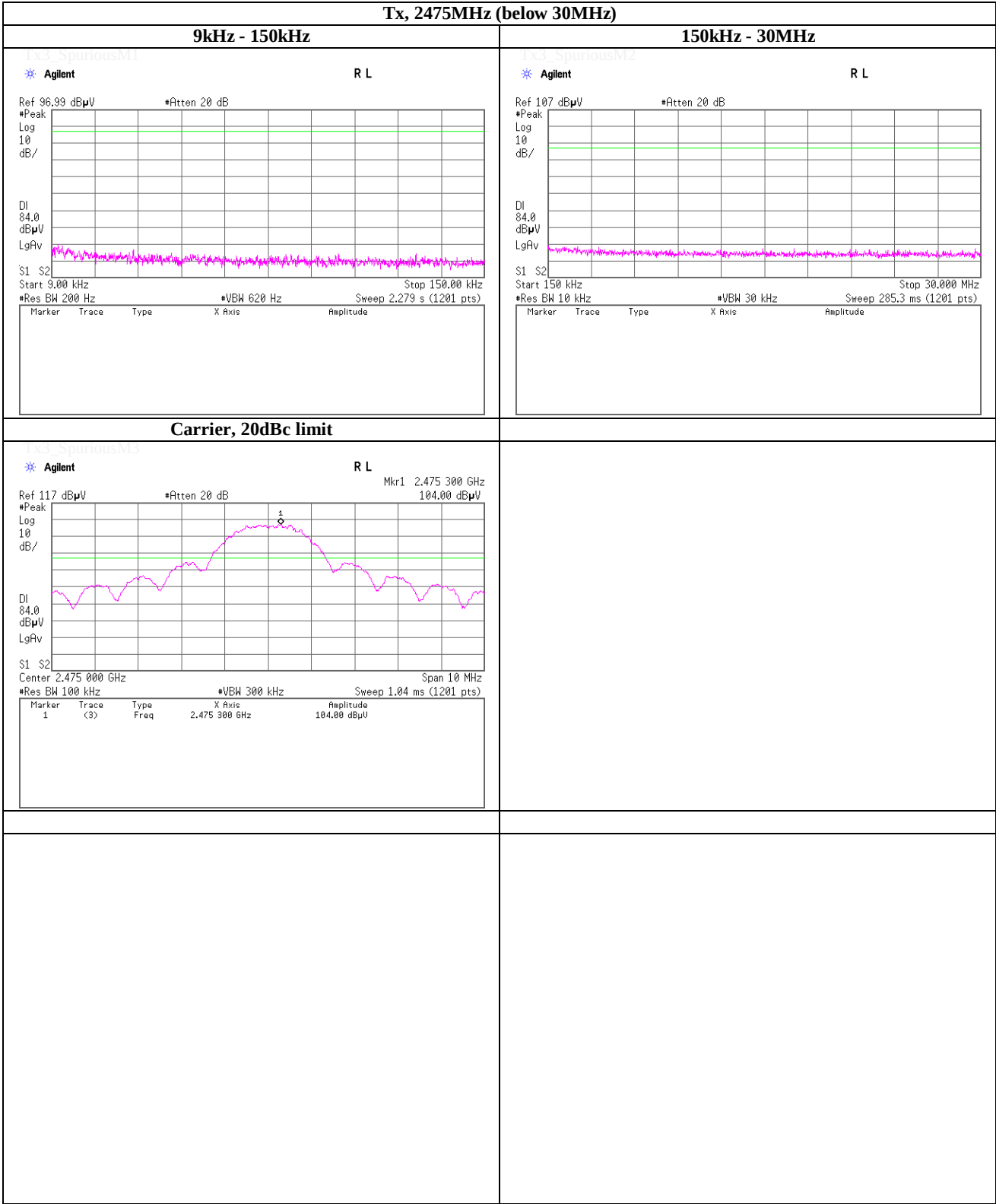
Engineer

Makoto Hosaka

(Reference chart) Spurious emission (Conducted)

Tx, IEEE 802.15.4,

Tx, 2475MHz (below 30MHz)



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Maximum Power Spectral Density
(PKPSD)

Test place

UL Japan, Inc. Shonan EMC Lab.

No.1 Measurement Room

Date

March 25, 2014

Temperature / Humidity

22deg.C , 38%RH

Engineer

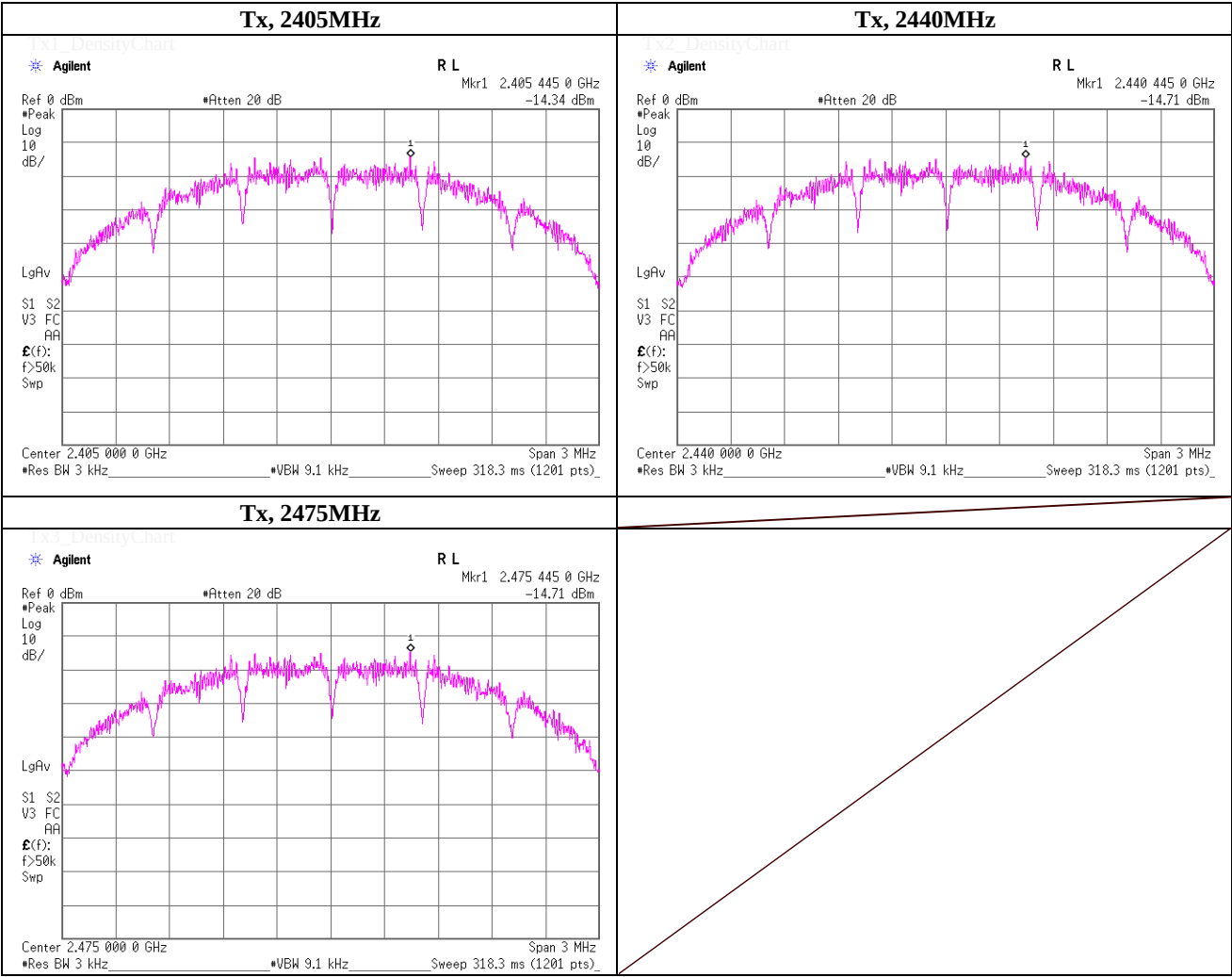
Makoto Hosaka

Mode

Tx, IEEE 802.15.4,

Ch. Freq.	Freq. Reading	Reading	Cable Loss	Atten.	Result	Limit	Margin
[MHz]	[MHz]	[dBm]	[dB]	[dB]	[dBm]	[dBm]	[dB]
2405.0000	2405.45	-14.34	1.61	10.02	-2.71	8.00	10.71
2440.0000	2440.45	-14.71	1.68	10.03	-3.00	8.00	11.00
2475.0000	2475.45	-14.71	1.75	10.04	-2.92	8.00	10.92

Sample Calculation:
Result = Reading + Cable Loss (including the cable(s) customer supplied) + Atten. Loss



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Test place

UL Japan, Inc. Shonan EMC Lab.

No.1 Measurement Room

Date

March 25, 2014

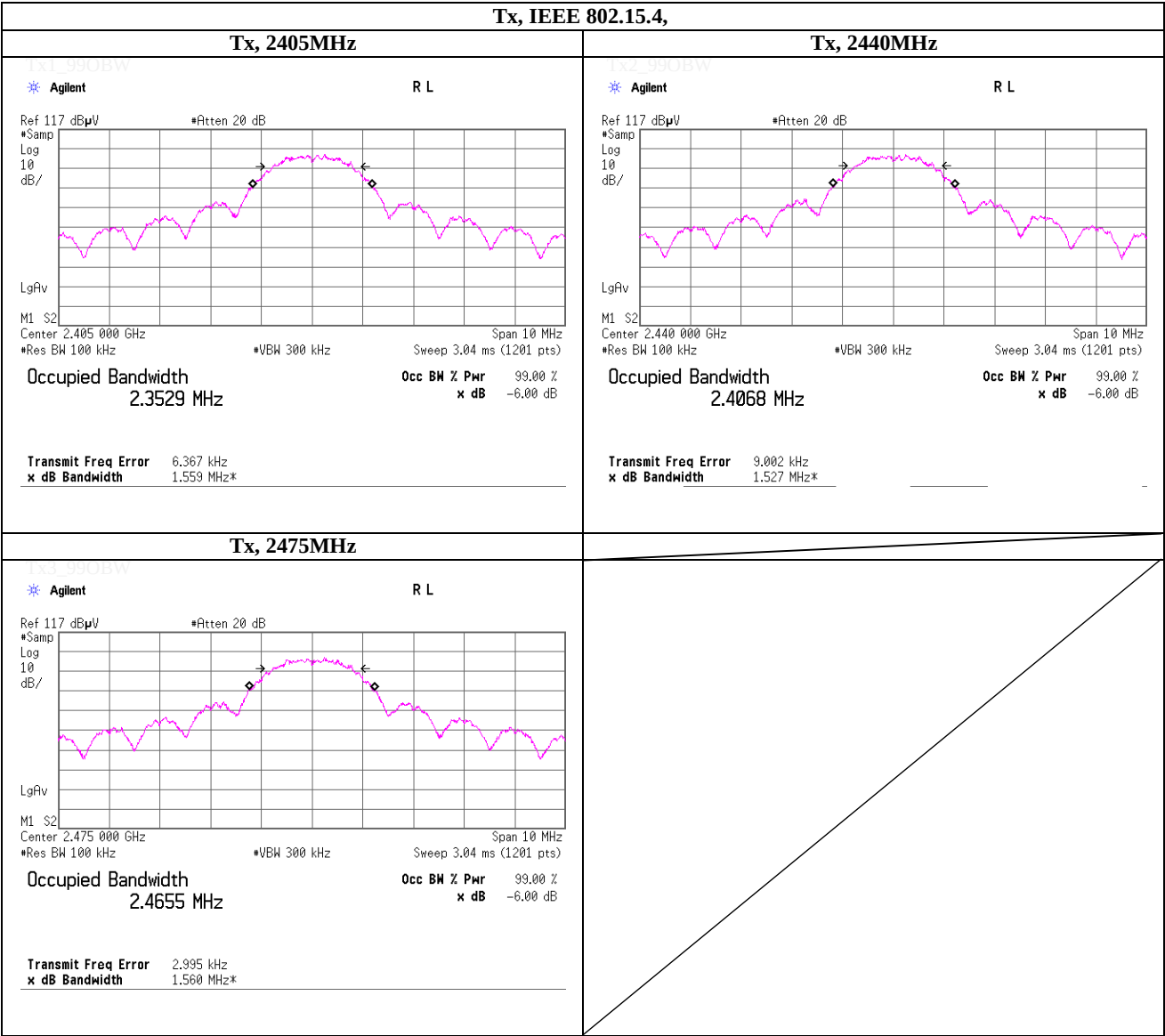
Temperature / Humidity

22deg.C , 38%RH

Engineer

Makoto Hosaka

99% Occupied Bandwidth



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APPENDIX 2

Test Instruments

EMI test equipment

Control No.	Instrument	Manufacturer	Model No	Serial No	Test Item	Calibration Date * Interval(month)
SPM-06	Power Meter	Anritsu	ML2495A	0850009	AT	2013/04/09 * 12
SPSS-03	Power sensor	Anritsu	MA2411B	0917063	AT	2013/04/09 * 12
SCC-G14	Coaxial Cable	Suhner	SUCOFLEX 102	31600/2	AT	2014/03/13 * 12
SAT10-11	Attenuator	Weinschel Corp.	54A-10	37588	AT	2013/04/09 * 12
SOS-09	Humidity Indicator	A&D	AD-5681	4061484	AT/CE	2014/03/07 * 12
KSA-08	Spectrum Analyzer	Agilent	E4446A	MY46180525	AT	2014/03/04 * 12
SOS-13	Humidity Indicator	Custom	CTH-202	Q.C.17	AT	2013/04/25 * 12
SAEC-03(NSA)	Semi-Anechoic Chamber	TDK	SAEC-03(NSA)	3	RE	2013/07/09 * 12
SAF-05	Pre Amplifier	TOYO Corporation	TPA0118-36	1440490	RE	2013/11/22 * 12
SCC-G03	Coaxial Cable	Suhner	SUCOFLEX 104A	46499/4A	RE	2013/04/11 * 12
SCC-G23	Coaxial Cable	Suhner	SUCOFLEX 104	297342/4	RE	2013/05/22 * 12
SHA-03	Horn Antenna	Schwarzbeck	BBHA9120D	9120D-739	RE	2013/08/19 * 12
SOS-05	Humidity Indicator	A&D	AD-5681	4062518	RE	2014/02/21 * 12
SSA-02	Spectrum Analyzer	Agilent	E4448A	MY48250106	RE	2014/03/17 * 12
SJM-11	Measure	PROMART	SEN1935	-	RE	-
COTS-SEMI-1	EMI Software	TSJ	TEPTO-DV(RE,CE, RFI,MF)	-	RE/CE	-
SAT10-06	Attenuator	Agilent	8493C-010	74865	RE	2013/11/22 * 12
SFL-02	Highpass Filter	MICRO-TRONICS	HPM50111	051	RE	2013/11/22 * 12
SHA-04	Horn Antenna	ETS LINDGREN	3160-09	LM3640	RE	2014/03/15 * 12
SAF-08	Pre Amplifier	TOYO Corporation	HAP18-26W	00000019	RE	2014/03/14 * 12
SCC-G15	Coaxial Cable	Suhner	SUCOFLEX 102	32703/2	RE	2014/03/13 * 12
SAF-03	Pre Amplifier	SONOMA	310N	290213	RE	2014/02/14 * 12
SAT6-06	Attenuator	JFW	50HF-006N	-	RE	2014/02/17 * 12
SBA-03	Biconical Antenna	Schwarzbeck	BBA9106	91032666	RE	2013/10/26 * 12
SCC-C1/C2/C3/C4/C5/C10/SRSE-03	Coaxial Cable&RF Selector	Fujikura/Fujikura/Suhner/Suhner/Suhner/TOYO	8D2W/12DSFA/141PE/141PE/141PE/141PE/NS4906	-/0901-271(RF Selector)	RE	2013/04/03 * 12
SLA-03	Logperiodic Antenna	Schwarzbeck	UHALP9108A	UHALP 9108-A 0901	RE	2013/10/26 * 12
STR-06	Test Receiver	Rohde & Schwarz	ESCI	101259	RE	2014/03/04 * 12
SLS-06	LISN	Schwarzbeck	NSLK8126	8126440	CE	2013/04/12 * 12
SAT13-01	Attenuator	JFW	50FP-013-H2 N	-	CE	2014/02/17 * 12
SCC-C9	Coaxial Cable	Suhner	RG223U	-	CE	2013/04/03 * 12
STR-02	Test Receiver	Rohde & Schwarz	ESCI	100575	CE	2013/09/24 * 12
SJM-05	Measure	KOMELON	KMC-36	-	CE	-

The expiration date of the calibration is the end of the expired month .

As for some calibrations performed after the tested dates , those test equipment have been controlled by means of an unbroken chains of calibrations .

All equipment is calibrated with valid calibrations . Each measurement data is traceable to the national or international standards.

Test Item :

CE: Conducted emission,

RE: Out of Band Emission (Radiated)

AT: Antenna terminal conducted test