



RADIO TEST REPORT

Test Report No. : 10392826H-A-R1

Applicant : UNION TOOL CO.
Type of Equipment : Heart rate Sensor
Model No. : WHS-2
FCC ID : 2ACS48600043
Test regulation : FCC Part 15 Subpart C: 2014
Test Result : Complied

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2. The results in this report apply only to the sample tested.
3. This sample tested is in compliance with the above regulation.
4. The test results in this report are traceable to the national or international standards.
5. This test report must not be used by the customer to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the Federal Government.
6. This report is a revised version of 10392826H-A. 10392826H-A is replaced with this report.

Date of test: August 6 to 19, 2014

Representative test engineer:

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Engineer
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NVLAP LAB CODE: 200572-0

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SECTION 1: Customer information

Company Name	:	UNION TOOL CO.
Address	:	6-17-1 Minami-Ohi, Shinagawa-ku, Tokyo 140-0013 JAPAN
Telephone Number	:	+81-3-5493-1023
Facsimile Number	:	+81-3-5493-1019
Contact Person	:	Suego Kobayashi

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

2.1 Identification of E.U.T.

Type of Equipment	:	Heart rate Sensor
Model No.	:	WHS-2
Serial No.	:	Refer to Section 4, Clause 4.2
Rating	:	DC 3.7V
Receipt Date of Sample	:	July 24, 2014
Country of Mass-production	:	Japan
Condition of EUT	:	Production model
Modification of EUT	:	No Modification by the test lab

2.2 Product Description

General Specification

Clock frequency(ies) in the system	:	32.768kHz, 16MHz
------------------------------------	---	------------------

Radio Specification

Bluetooth 4.0

Radio Type	:	Transceiver
Frequency of Operation	:	2402-2480MHz
Modulation	:	GFSK
Bandwidth & Channel Spacing	:	2MHz
Power Supply (radio part input)	:	DC 3.0V
Antenna type	:	$\lambda/4$ monopole antenna
Antenna Gain	:	-11.52dBi

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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 May 1, 2014 and effective June 2, 2014

Title : FCC 47CFR Part15 Radio Frequency Device Subpart C Intentional Radiators
Section 15.207 Conducted limits
Section 15.247 Operation within the bands 902-928MHz,
2400-2483.5MHz, and 5725-5850MHz

* The EUT complies with FCC Part 15 Subpart B: 2014, final revised on May 1, 2014 and effective June 2, 2014.

3.2 Procedures and results

Item	Test Procedure	Specification	Worst margin	Results	Remarks
Conducted Emission	FCC: ANSI C63.4:2003 7. AC powerline Conducted Emission measurements IC: RSS-Gen 7.2.4	FCC: Section 15.207 IC: RSS-Gen 7.2.4	N/A *1)	N/A	-
6dB Bandwidth	FCC: "Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247(issued on June 5, 2014)" IC: RSS-Gen 4.6.2	FCC: Section 15.247(a)(2) IC: RSS-210 A8.2(a)	See data.	Complied	Conducted
Maximum Peak Output Power	FCC: "Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247(issued on June 5, 2014)" IC: RSS-Gen 4.8	FCC: Section 15.247(b)(3) IC: RSS-210 A8.4(4)		Complied	Conducted
Power Density	FCC: "Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247(issued on June 5, 2014)" IC: -	FCC: Section 15.247 (e) IC: RSS-210 A8.2(b)		Complied	Conducted
Spurious Emission Restricted Band Edges	FCC: "Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247(issued on June 5, 2014)" IC: RSS-Gen 4.9	FCC: Section15.247(d) IC: RSS-210 A8.5 RSS-Gen 7.2.3	4.9dB 7206.00MHz, AV, Vertical	Complied	Conducted/ Radiated

*1) The test is not applicable since the EUT is not the device that is designed to be connected to the public utility (AC) power line, and radio communication is OFF when micro USB is connected to EUT.

Note: UL Japan, Inc.'s EMI Work Procedures No. 13-EM-W0420 and 13-EM-W0422.

* In case any questions arise about test procedure, ANSI C63.4: 2003 is also referred.

FCC Part 15.31 (e)

The EUT provides stable voltage (DC3.0V) constantly to the wireless transmitter regardless of input voltage. Instead of a new battery, DC power supply was used for the test. That does not affect the test result, therefore the EUT complies with the requirement.

FCC Part 15.203 Antenna requirement

It is impossible for end users to replace the antenna, because the antenna is mounted inside of the EUT. Therefore, the equipment complies with the antenna requirement of Section 15.203.

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3.3 Addition to standard

Item	Test Procedure	Specification	Worst margin	Results	Remarks
99% Occupied Bandwidth	IC: RSS-Gen 4.6.1	IC: RSS-Gen 4.6.1	N/A	-	Conducted

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

3.4 Uncertainty

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

Test room (semi-anechoic chamber)	Radiated emission						
	(3m*)(+dB)				(1m*)(+dB)		(0.5m*)(+dB)
	9kHz -30MHz	30MHz -300MHz	300MHz -1GHz	1GHz -10GHz	10GHz -18GHz	18GHz -26.5GHz	26.5GHz -40GHz
No.1	4.0dB	5.1dB	5.0dB	5.1dB	6.0dB	4.9dB	4.3dB
No.2	3.9dB	5.2dB	5.0dB	4.9dB	5.9dB	4.7dB	4.2dB
No.3	4.3dB	5.1dB	5.2dB	5.2dB	6.0dB	4.8dB	4.2dB
No.4	4.6dB	5.2dB	5.0dB	5.2dB	6.0dB	5.7dB	4.2dB

*3m/1m/0.5m = Measurement distance

Power meter (+dB)	
Below 1GHz	Above 1GHz
0.7dB	1.5dB

Antenna terminal conducted emission and Power density (+dB)			Antenna terminal conducted emission (+dB)		Channel power (+dB)
Below 1GHz	1GHz-3GHz	3GHz-18GHz	18GHz-26.5GHz	26.5GHz-40GHz	
1.5dB	1.7dB	2.8dB	2.8dB	2.9dB	2.6dB

Radiated emission test(3m)

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

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3.5 Test Location

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	IC Registration Number	Width x Depth x Height (m)	Size of reference ground plane (m) / horizontal conducting plane	Other rooms
No.1 semi-anechoic chamber	2973C-1	19.2 x 11.2 x 7.7m	7.0 x 6.0m	No.1 Power source room
No.2 semi-anechoic chamber	2973C-2	7.5 x 5.8 x 5.2m	4.0 x 4.0m	-
No.3 semi-anechoic chamber	2973C-3	12.0 x 8.5 x 5.9m	6.8 x 5.75m	No.3 Preparation room
No.3 shielded room	-	4.0 x 6.0 x 2.7m	N/A	-
No.4 semi-anechoic chamber	2973C-4	12.0 x 8.5 x 5.9m	6.8 x 5.75m	No.4 Preparation room
No.4 shielded room	-	4.0 x 6.0 x 2.7m	N/A	-
No.5 semi-anechoic chamber	-	6.0 x 6.0 x 3.9m	6.0 x 6.0m	-
No.6 shielded room	-	4.0 x 4.5 x 2.7m	4.0 x 4.5 m	-
No.6 measurement room	-	4.75 x 5.4 x 3.0m	4.75 x 4.15 m	-
No.7 shielded room	-	4.7 x 7.5 x 2.7m	4.7 x 7.5m	-
No.8 measurement room	-	3.1 x 5.0 x 2.7m	N/A	-
No.9 measurement room	-	8.0 x 4.6 x 2.8m	2.4 x 2.4m	-
No.11 measurement room	-	6.2 x 4.7 x 3.0m	4.8 x 4.6m	-

* Size of vertical conducting plane (for Conducted Emission test) : 2.0 x 2.0m for No.1, No.2, No.3, and No.4 semi-anechoic chambers and No.3 and No.4 shielded rooms.

3.6 Data of EMI, Test instruments, and Test set up

Refer to APPENDIX.

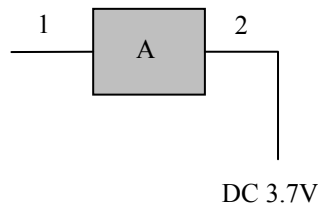
SECTION 4: Operation of E.U.T. during testing

4.1 Operating Mode(s)

Bluetooth Low Energy (BT LE): Transmitting (Tx), Payload: PRBS9

Test Item	Operating Mode	Tested frequency
6dB Bandwidth Spurious Emission Restricted Band Edges Power Density 99% Occupied Bandwidth Maximum Peak Output Power	BT LE	2402MHz 2440MHz 2480MHz
*Transmitting duty was not 100% on all tests. *Power of the EUT was set by the software as follows; Power settings: 0dBm Software: 20140220_RF_v015 version: v0015 *This setting of software is the worst case. Any conditions under the normal use do not exceed the condition of setting. In addition, end users cannot change the settings of the output power of the product.		

4.2 Configuration and peripherals



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

Description of EUT

No.	Item	Model number	Serial number	Manufacturer	Remarks
A	Heart rate Sensor	WHS-2	0050000049	UNION TOOL CO.	EUT

List of cables used

No.	Name	Length (m)	Shield		Remarks
			Cable	Connector	
1	Signal Cable	0.1	Unshielded	Unshielded	*1)
2	DC Cable	2.0	Unshielded	Unshielded	-

*1) The cable was used as test jig and will not be included in the package of production model.
There was no influence on Spurious emission test.

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SECTION 5: Radiated Spurious Emission

Test Procedure

It was measured based on "11.0 Emissions in non-restricted frequency bands" of "558074 D01 DTS Meas Guidance v03r02 (Issued on June 5, 2014)".

EUT was placed on a urethane platform of nominal size, 0.5m by 1.0m, raised 0.8m above the conducting ground plane.

The Radiated Electric Field Strength has been measured in a Semi Anechoic Chamber with a ground plane.

The height of the measuring antenna varied between 1 and 4m and EUT was rotated a full revolution in order to obtain the maximum value of the electric field strength.

The measurements were performed for both vertical and horizontal antenna polarization with the Test Receiver, or the Spectrum Analyzer.

The measurements were made with the following detector function of the test receiver and the Spectrum analyzer (in linear mode).

The test was made with the detector (RBW/VBW) in the following table.

When using Spectrum analyzer, the test was made with adjusting span to zero by using peak hold.

Test Antennas are used as below;

Frequency	Below 30MHz	30MHz to 300MHz	300MHz to 1GHz	Above 1GHz
Antenna Type	Loop	Biconical	Logperiodic	Horn

In any 100kHz bandwidth outside the restricted 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.

20dBc was applied to the frequency over the limit of FCC 15.209 / Table 5 of RSS-Gen 7.2.5(IC) and outside the restricted band of FCC15.205 / Table 3 of RSS-Gen 7.2.2 (IC).

Frequency	Below 1GHz	Above 1GHz		20dBc
Instrument used	Test Receiver	Spectrum Analyzer		Spectrum Analyzer
Detector	QP	PK	AV *1)	PK
IF Bandwidth	BW 120kHz	RBW: 1MHz VBW: 3MHz	Average Power Method: 12.2.5.2 RBW: 1MHz VBW: 3MHz Trace: Free Run Detector: Power Averaging (RMS) Duty factor and Dwell factor was added to the results.	RBW: 100kHz VBW: 300kHz
Test Distance	3m	3m (below 10GHz), 1m *2) (above 10GHz)		3m (below 10GHz), 1m *2) (above 10GHz)

*1) Average Power Measurement was performed based on 6.0 & 12.2.5 of "558074 D01 DTS Meas Guidance v03r02 (Issued on June 5, 2014) (Issued on June 5, 2014)"

*2) Distance Factor: $20 \times \log(3.0\text{m}/1.0\text{m}) = 9.5\text{dB}$

- 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.

The test results and limit are rounded off to one decimal place, so some differences might be observed.

Measurement range : 30M-26.5GHz
Test data : APPENDIX
Test result : Pass

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SECTION 6: Antenna Terminal Conducted Tests

Test Procedure

The tests were made with below setting connected to the antenna port.

Test	Span	RBW	VBW	Sweep time	Detector	Trace	Instrument used
6dB Bandwidth	5MHz	100kHz	300kHz	Auto	Peak	Max Hold	Spectrum Analyzer
99% Occupied Bandwidth	Enough width to display 20dB Bandwidth	1 to 3% of Span	Three times of RBW	Auto	Peak	Max Hold*1)	Spectrum Analyzer
Maximum Peak Output Power	-	-	-	Auto	Peak	-	Power Meter (Sensor: 50MHz BW)
Peak Power Density	1.5 times the 6dB Bandwidth	3kHz	10kHz	Auto	Peak	Max Hold	Spectrum Analyzer *2)
Conducted Spurious Emission *3)	9kHz to 150kHz	200Hz	620Hz	Auto	Peak	Max Hold	Spectrum Analyzer
	150kHz to 30MHz	9.1kHz	27kHz				
*1) The measurement was performed with Max Hold since the duty cycle was not 100%.							
*2) Section 10.2 Method PKPSD (peak PSD) of "558074 D01 DTS Meas Guidance v03r02 (Issued on June 5, 2014)".							
*3) 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=9.1kHz)							

The test results and limit are rounded off to two decimals place, so some differences might be observed.

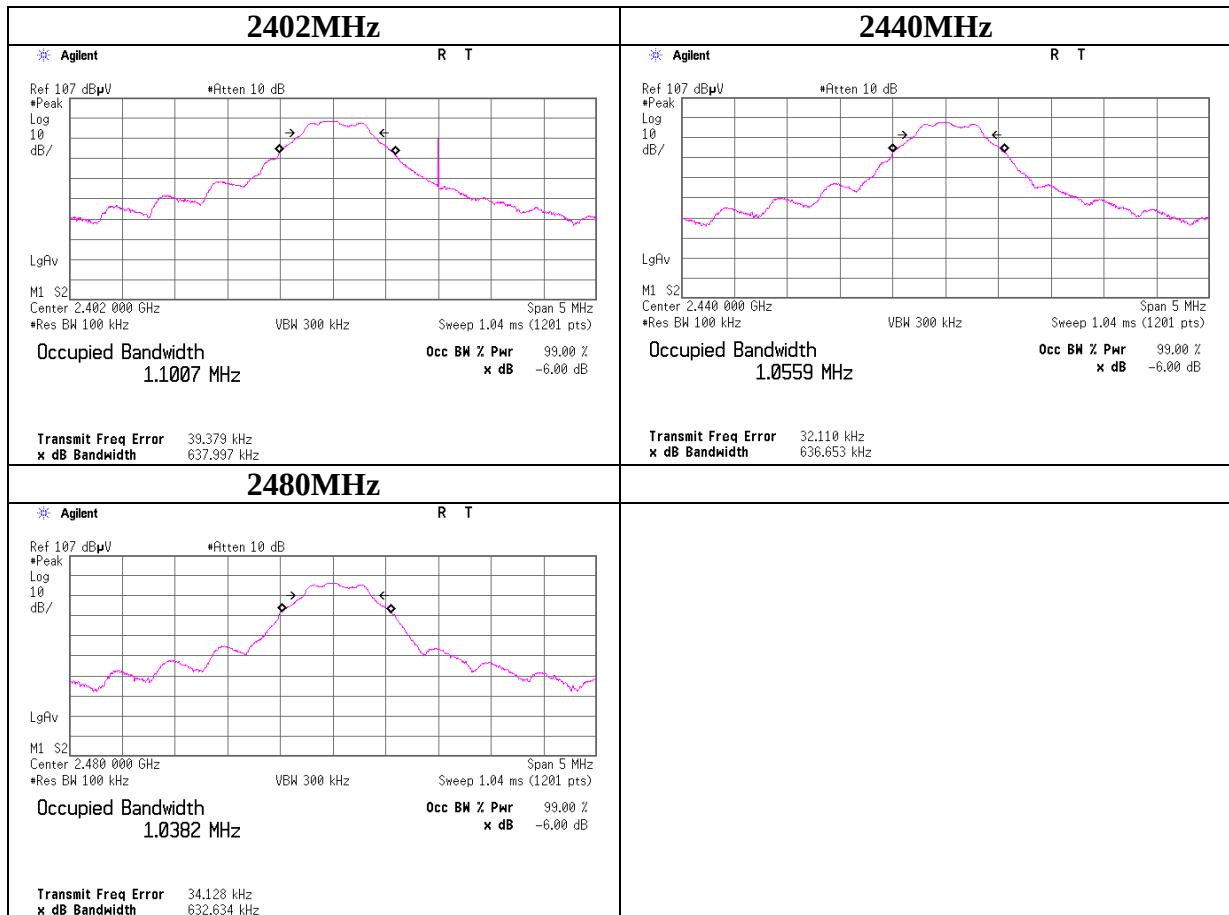
Test data : APPENDIX
Test result : Pass

APPENDIX 1: Data of EMI test

6dB Bandwidth

Test place	Ise EMC Lab. No.3 Measurement Room
Report No.	10392826H
Date	08/06/2014
Temperature/ Humidity	24 deg.C / 49% RH
Engineer	Tomohisa Nakagawa
Mode	BT LE Tx

Frequency [MHz]	6dB Bandwidth [kHz]	Limit [kHz]
2402	637.997	>500
2440	636.653	>500
2480	632.634	>500



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Maximum Peak Output Power

Test place : Ise EMC Lab. No.3 Measurement Room
Report No. : 10392826H
Date : 08/06/2014
Temperature/ Humidity : 24 deg.C / 49% RH
Engineer : Tomohisa Nakagawa
Mode : BT LE Tx

Freq. [MHz]	Reading [dBm]	Cable Loss [dB]	Atten. [dB]	Result		Limit		Margin [dB]
				[dBm]	[mW]	[dBm]	[mW]	
2402	-11.21	1.31	10.00	0.10	1.02	30.00	1000	29.90
2440	-12.09	1.32	10.00	-0.77	0.84	30.00	1000	30.77
2480	-13.18	1.33	10.00	-1.85	0.65	30.00	1000	31.85

Sample Calculation:
Result = Reading + Cable Loss + Attenuator

Reference data (Average)

Freq. [MHz]	Reading [dBm]	Cable Loss [dB]	Atten. [dB]	Result		Limit		Margin [dB]
				[dBm]	[mW]	[dBm]	[mW]	
2402	-11.95	0.00	10.00	-1.95	0.64	30.00	1000	31.95
2440	-12.99	0.00	10.00	-2.99	0.50	30.00	1000	32.99
2480	-14.14	0.00	10.00	-4.14	0.39	30.00	1000	34.14

Sample Calculation:
Result = Reading + Cable Loss + Attenuator

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Radiated Spurious Emission

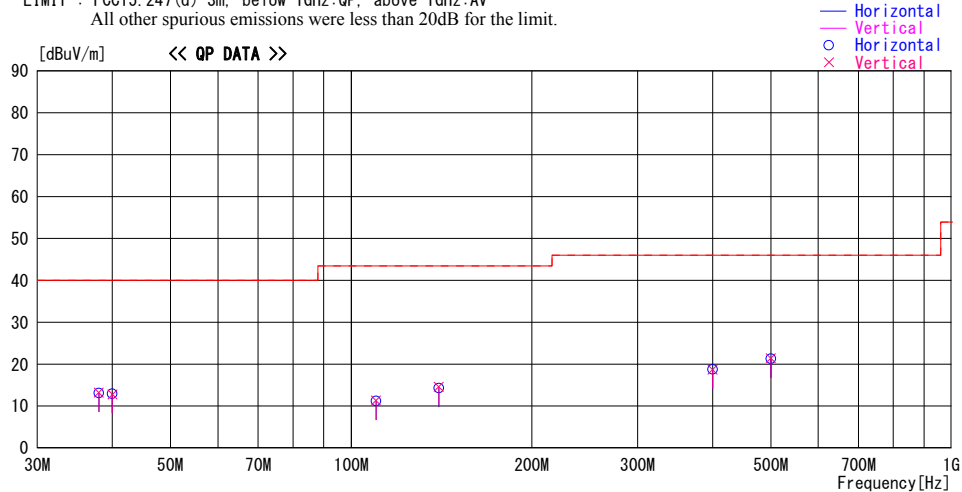
DATA OF RADIATED EMISSION TEST

UL Japan, Inc. Ise EMC Lab. No. 4 Semi Anechoic Chamber
Date : 2014/08/19

Report No. : 10392826H
Power : DC 3.7V
Temp./Humi. : 24deg. C / 58% RH
Engineer : Tomohisa Nakagawa

Mode / Remarks : BT LE Tx 2402MHz Worst-axis (Hori X, Vert X)

LIMIT : FCC15.247(d) 3m, below 1GHz:QP, above 1GHz:AV
All other spurious emissions were less than 20dB for the limit.



Frequency [MHz]	Reading [dBuV]	DET	Antenna	Loss&	Level [dBuV/m]	Angle [Deg]	Height [cm]	Polar.	Limit [dBuV/m]	Margin [dB]	Comment
			Factor [dB/m]	Gain [dB]							
38.000	22.8	QP	15.3	-24.9	13.2	249	100	Vert.	40.0	26.8	NS
38.000	22.7	QP	15.3	-24.9	13.1	13	300	Hori.	40.0	26.9	NS
40.000	23.2	QP	14.5	-24.8	12.9	16	300	Hori.	40.0	27.1	NS
40.000	23.1	QP	14.5	-24.8	12.8	264	100	Vert.	40.0	27.2	NS
110.000	23.4	QP	11.7	-23.9	11.2	352	300	Hori.	43.5	32.3	NS
110.000	23.5	QP	11.7	-23.9	11.3	314	100	Vert.	43.5	32.2	NS
140.000	23.2	QP	14.5	-23.4	14.3	334	300	Hori.	43.5	29.2	NS
140.000	23.5	QP	14.5	-23.4	14.6	176	100	Vert.	43.5	28.9	NS
400.000	22.5	QP	17.5	-21.3	18.7	316	300	Hori.	46.0	27.3	NS
400.000	22.5	QP	17.5	-21.3	18.7	128	100	Vert.	46.0	27.3	NS
500.000	23.0	QP	19.2	-20.8	21.4	98	100	Vert.	46.0	24.6	NS
500.000	22.9	QP	19.2	-20.8	21.3	345	100	Hori.	46.0	24.7	NS

CHART: WITH FACTOR ANT TYPE: -30MHz: LOOP, 30-300MHz: BICONICAL, 300MHz-1000MHz: LOGPERIODIC, 1000MHz-: HORN
CALCULATION: RESULT = READING + ANT FACTOR + LOSS (CABLE + ATTEN. - GAIN (AMP))

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Radiated Spurious Emission

Test place : Ise EMC Lab. No.4 Semi Anechoic Chamber
Report No. : 10392826H
Date : 08/08/2014 08/19/2014
Temperature/ Humidity : 23 deg.C / 68% RH 24 deg.C / 58% RH
Engineer : Yuta Moriya Tomohisa Nakagawa
(1-10GHz) (10-26.5GHz)
Mode : BT LE Tx 2402MHz

Polarity	Frequency [MHz]	Detector	Reading [dBuV]	Ant.Fac. [dB/m]	Loss [dB]	Gain [dB]	Duty Factor [dB]	Averaging Factor [dB]	Result [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Remark
Hori	2390.000	PK	43.5	28.3	3.1	32.8	-	-	42.1	73.9	31.8	
Hori	2400.000	PK	54.9	28.4	3.1	32.8	-	-	53.6	73.9	20.3	
Hori	4804.000	PK	58.0	32.2	5.3	31.9	-	-	63.6	73.9	10.3	
Hori	7206.000	PK	42.5	36.7	6.5	33.0	-	-	52.7	73.9	21.2	
Hori	9608.000	PK	41.7	38.9	7.2	33.4	-	-	54.4	73.9	19.5	
Hori	2390.000	AV	34.7	28.3	3.1	32.8	1.6	-	34.9	53.9	19.0	*1)
Hori	4804.000	AV	54.8	32.2	5.3	31.9	1.6	-34.2	27.8	53.9	26.1	
Hori	7206.000	AV	34.4	36.7	6.5	33.0	1.6	-	28.3	53.9	25.6	
Hori	9608.000	AV	34.0	38.9	7.2	33.4	1.6	-	26.3	53.9	27.6	
Vert	2390.000	PK	43.3	28.3	3.1	32.8	-	-	41.9	73.9	32.0	
Vert	2400.000	PK	55.8	28.4	3.1	32.8	-	-	54.5	73.9	19.4	
Vert	4804.000	PK	60.1	32.2	5.3	31.9	-	-	65.7	73.9	8.2	
Vert	7206.000	PK	41.9	36.7	6.5	33.0	-	-	52.1	73.9	21.8	
Vert	9608.000	PK	41.6	38.9	7.2	33.4	-	-	54.3	73.9	19.6	
Vert	2390.000	AV	34.4	28.3	3.1	32.8	1.6	-	34.6	53.9	19.3	*1)
Vert	4804.000	AV	56.8	32.2	5.3	31.9	1.6	-34.2	29.8	53.9	24.1	
Vert	7206.000	AV	37.2	36.7	6.5	33.0	1.6	-	49.0	53.9	4.9	
Vert	9608.000	AV	33.7	38.9	7.2	33.4	1.6	-	48.0	53.9	5.9	

Result = Reading + Ant Factor + Loss (Cable+Attenuator+Filter-Distance factor(above 10GHz)) - Gain(Amplifier) + Duty Factor + Averaging Factor

*Other frequency noises omitted in this report were not seen or had enough margin (more than 20dB).

*1) Not out of band emission (leakage power)

Distance factor: 10GHz-26.5GHz $20\log(3.0\text{m}/1.0\text{m})= 9.5\text{dB}$

26.5GHz-40GHz $20\log(3.0\text{m}/0.5\text{m})=15.6\text{dB}$

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4383-326 Asama-cho, Ise-shi, Mie-ken 516-0021 JAPAN

Telephone : +81 596 24 8999

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Radiated Spurious Emission

DATA OF RADIATED EMISSION TEST

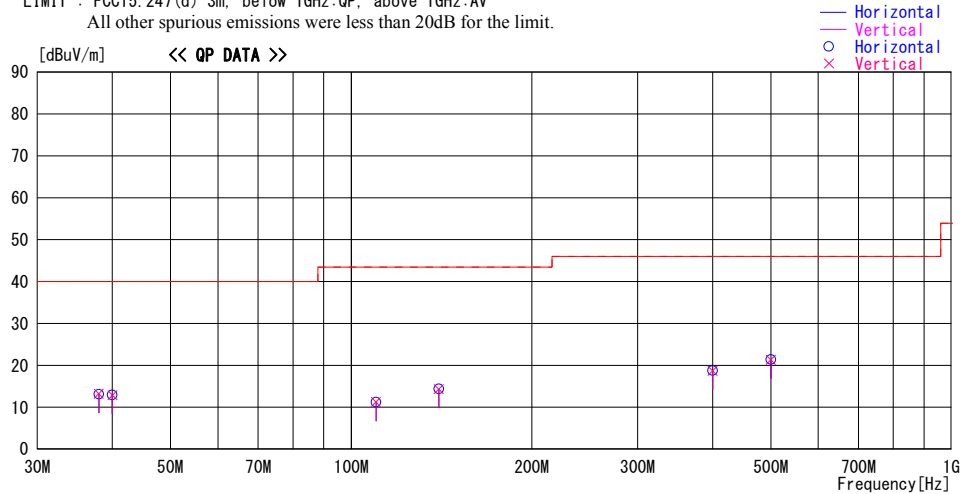
UL Japan, Inc. Ise EMC Lab. No.4 Semi Anechoic Chamber
Date : 2014/08/19

Report No. : 10392826H
Power : DC 3.7V
Temp./Humi. : 24deg. C / 58% RH
Engineer : Tomohisa Nakagawa

Mode / Remarks : BT LE Tx 2402MHz Worst-axis (Hori X, Vert X)

LIMIT : FCC15.247(d) 3m, below 1GHz:QP, above 1GHz:AV

All other spurious emissions were less than 20dB for the limit.



Frequency [MHz]	Reading [dBuV]	DET	Antenna	Loss&	Level [dBuV/m]	Angle [Deg]	Height [cm]	Polar.	Limit [dBuV/m]	Margin [dB]	Comment
			Factor [dB/m]	Gain [dB]							
38.000	22.8	QP	15.3	-24.9	13.2	249	100	Vert.	40.0	26.8	NS
38.000	22.7	QP	15.3	-24.9	13.1	13	300	Hori.	40.0	26.9	NS
40.000	23.2	QP	14.5	-24.8	12.9	16	300	Hori.	40.0	27.1	NS
40.000	23.2	QP	14.5	-24.8	12.9	264	100	Vert.	40.0	27.1	NS
110.000	23.4	QP	11.7	-23.9	11.2	352	300	Hori.	43.5	32.3	NS
110.000	23.4	QP	11.7	-23.9	11.2	314	100	Vert.	43.5	32.3	NS
140.000	23.3	QP	14.5	-23.4	14.4	334	300	Hori.	43.5	29.1	NS
140.000	23.2	QP	14.5	-23.4	14.3	176	100	Vert.	43.5	29.2	NS
400.000	22.5	QP	17.5	-21.3	18.7	316	300	Hori.	46.0	27.3	NS
400.000	22.5	QP	17.5	-21.3	18.7	128	100	Vert.	46.0	27.3	NS
500.000	22.9	QP	19.2	-20.8	21.3	98	100	Vert.	46.0	24.7	NS
500.000	23.0	QP	19.2	-20.8	21.4	345	100	Hori.	46.0	24.6	NS

CHART:WITH FACTOR ANT TYPE: -30MHz:LOOP, 30-300MHz:BICONICAL, 300MHz-1000MHz:LOGPERIODIC, 1000MHz-:HORN
CALCULATION:RESULT = READING + ANT FACTOR + LOSS(CABLE + ATTEN. - GAIN(AMP))

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Radiated Spurious Emission

Test place : Ise EMC Lab. No.4 Semi Anechoic Chamber
Report No. : 10392826H
Date : 08/08/2014 08/19/2014
Temperature/ Humidity : 23 deg.C / 68% RH 24 deg.C / 58% RH
Engineer : Yuta Moriya Tomohisa Nakagawa
(1-10GHz) (10-26.5GHz)
Mode : BT LE Tx 2440MHz

Polarity	Frequency [MHz]	Detector	Reading [dBuV]	Ant.Fac. [dB/m]	Loss [dB]	Gain [dB]	Duty Factor [dB]	Averaging Factor [dB]	Result [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Remark
Hori	4880.000	PK	54.3	32.5	5.4	31.9	-	-	60.3	73.9	13.6	
Hori	7320.000	PK	42.2	36.6	6.5	33.0	-	-	52.3	73.9	21.6	
Hori	9760.000	PK	40.5	38.6	7.3	33.4	-	-	53.0	73.9	20.9	
Hori	4880.000	AV	49.8	32.5	5.4	31.9	1.6	-34.2	23.2	53.9	30.7	
Hori	7320.000	AV	34.4	36.6	6.5	33.0	1.6	-	46.1	53.9	7.8	
Hori	9760.000	AV	33.7	38.6	7.3	33.4	1.6	-	47.8	53.9	6.1	
Vert	4880.000	PK	56.7	32.5	5.4	31.9	-	-	62.7	73.9	11.2	
Vert	7320.000	PK	41.5	36.6	6.5	33.0	-	-	51.6	73.9	22.3	
Vert	9760.000	PK	41.6	38.6	7.3	33.4	-	-	54.1	73.9	19.8	
Vert	4880.000	AV	53.0	32.5	5.4	31.9	1.6	-34.2	26.4	53.9	27.5	
Vert	7320.000	AV	34.8	36.6	6.5	33.0	1.6	-	46.5	53.9	7.4	
Vert	9760.000	AV	34.2	38.6	7.3	33.4	1.6	-	48.3	53.9	5.6	

Result = Reading + Ant Factor + Loss (Cable+Attenuator+Filter-Distance factor(above 10GHz)) - Gain(Amplifier) + Duty Factor + Averaging Factor

*Other frequency noises omitted in this report were not seen or had enough margin (more than 20dB).

Distance factor: 10GHz-26.5GHz $20\log(3.0\text{m}/1.0\text{m})= 9.5\text{dB}$
26.5GHz-40GHz $20\log(3.0\text{m}/0.5\text{m})=15.6\text{dB}$

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Radiated Spurious Emission

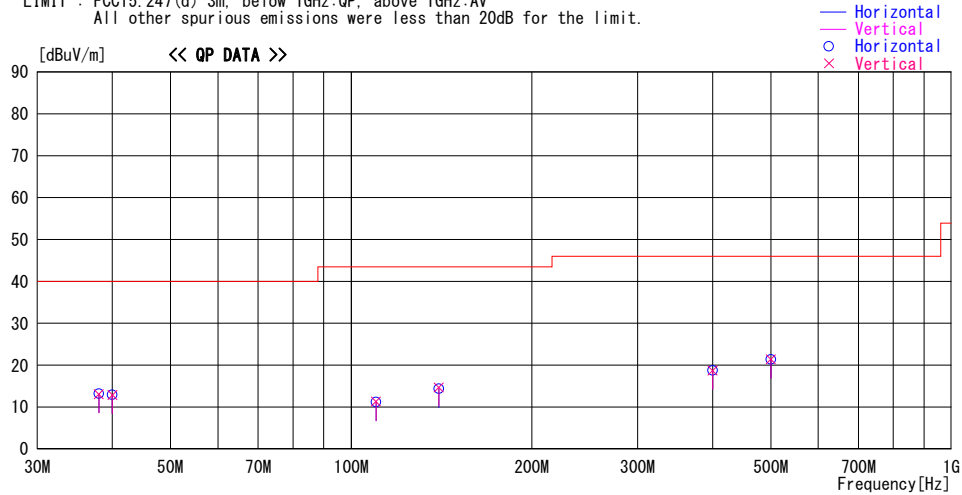
DATA OF RADIATED EMISSION TEST

UL Japan, Inc. Ise EMC Lab. No.4 Semi Anechoic Chamber
Date : 2014/08/19

Report No. : 10392826H
Power : DC 3.7V
Temp./Humi. : 24deg. C / 58% RH
Engineer : Tomohisa Nakagawa

Mode / Remarks : BT LE Tx 2402MHz Worst-axis (Hori X, Vert X)

LIMIT : FCC15.247(d) 3m, below 1GHz:QP, above 1GHz:AV
All other spurious emissions were less than 20dB for the limit.



Frequency [MHz]	Reading [dBuV]	DET	Antenna	Loss&	Level [dBuV/m]	Angle [Deg]	Height [cm]	Polar.	Limit	Margin	Comment
			Factor [dB/m]	Gain [dB]					[dBuV/m]	[dB]	
38.000	22.7	QP	15.3	-24.9	13.1	249	100	Vert.	40.0	26.9	NS
38.000	22.8	QP	15.3	-24.9	13.2	13	300	Hori.	40.0	26.8	NS
40.000	23.2	QP	14.5	-24.8	12.9	16	300	Hori.	40.0	27.1	NS
40.000	23.2	QP	14.5	-24.8	12.9	264	100	Vert.	40.0	27.1	NS
110.000	23.4	QP	11.7	-23.9	11.2	352	300	Hori.	43.5	32.3	NS
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140.000	23.3	QP	14.5	-23.4	14.4	334	300	Hori.	43.5	29.1	NS
140.000	23.6	QP	14.5	-23.4	14.7	176	100	Vert.	43.5	28.8	NS
400.000	22.5	QP	17.5	-21.3	18.7	316	300	Hori.	46.0	27.3	NS
400.000	22.5	QP	17.5	-21.3	18.7	128	100	Vert.	46.0	27.3	NS
500.000	23.0	QP	19.2	-20.8	21.4	98	100	Vert.	46.0	24.6	NS
500.000	23.0	QP	19.2	-20.8	21.4	345	100	Hori.	46.0	24.6	NS

CHART:WITH FACTOR ANT TYPE: -30MHz:LOOP, 30-300MHz:BICONICAL, 300MHz-1000MHz:LOGPERIODIC, 1000MHz-:HORN
CALCULATION:RESULT = READING + ANT FACTOR + LOSS(CABLE + ATTEN. - GAIN(AMP))

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Radiated Spurious Emission

Test place : Ise EMC Lab. No.4 Semi Anechoic Chamber
Report No. : 10392826H
Date : 08/08/2014 08/19/2014
Temperature/ Humidity : 23 deg.C / 68% RH 24 deg.C / 58% RH
Engineer : Yuta Moriya Tomohisa Nakagawa
(1-10GHz) (10-26.5GHz)
Mode : BT LE Tx 2480MHz

Polarity	Frequency [MHz]	Detector	Reading [dBuV]	Ant.Fac. [dB/m]	Loss [dB]	Gain [dB]	Duty Factor [dB]	Averaging Factor [dB]	Result [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Remark
Hori	2483.500	PK	53.7	28.7	3.2	32.7	-	-	52.9	73.9	21.0	
Hori	4960.000	PK	51.1	32.7	5.4	31.9	-	-	57.3	73.9	16.6	
Hori	7440.000	PK	42.7	36.5	6.6	33.1	-	-	52.7	73.9	21.2	
Hori	9920.000	PK	41.5	38.3	7.3	33.5	-	-	53.6	73.9	20.3	
Hori	2483.500	AV	41.6	28.7	3.2	32.7	1.6	-	40.8	53.9	13.1	*1)
Hori	4960.000	AV	47.1	32.7	5.4	31.9	1.6	-34.1	19.2	53.9	34.7	
Hori	7440.000	AV	34.7	36.5	6.6	33.1	1.6	-	44.7	53.9	9.2	
Hori	9920.000	AV	34.2	38.3	7.3	33.5	1.6	-	46.3	53.9	7.6	
Vert	2483.500	PK	52.7	28.7	3.2	32.7	-	-	51.9	73.9	22.0	
Vert	4960.000	PK	54.0	32.7	5.4	31.9	-	-	60.2	73.9	13.7	
Vert	7440.000	PK	42.7	36.5	6.6	33.1	-	-	52.7	73.9	21.2	
Vert	9920.000	PK	41.8	38.3	7.3	33.5	-	-	53.9	73.9	20.0	
Vert	2483.500	AV	40.9	28.7	3.2	32.7	1.6	-	38.5	53.9	15.4	*1)
Vert	4960.000	AV	50.0	32.7	5.4	31.9	1.6	-34.1	20.5	53.9	33.4	
Vert	7440.000	AV	34.1	36.5	6.6	33.1	1.6	-	44.1	53.9	9.8	
Vert	9920.000	AV	34.0	38.3	7.3	33.5	1.6	-	46.1	53.9	7.8	

Result = Reading + Ant Factor + Loss (Cable+Attenuator+Filter-Distance factor(above 10GHz)) - Gain(Amplifier) + Duty Factor + Averaging Factor

*Other frequency noises omitted in this report were not seen or had enough margin (more than 20dB).

*1) Not out of band emission (leakage power)

Distance factor: 10GHz-26.5GHz $20\log(3.0\text{m}/1.0\text{m})= 9.5\text{dB}$
26.5GHz-40GHz $20\log(3.0\text{m}/0.5\text{m})=15.6\text{dB}$

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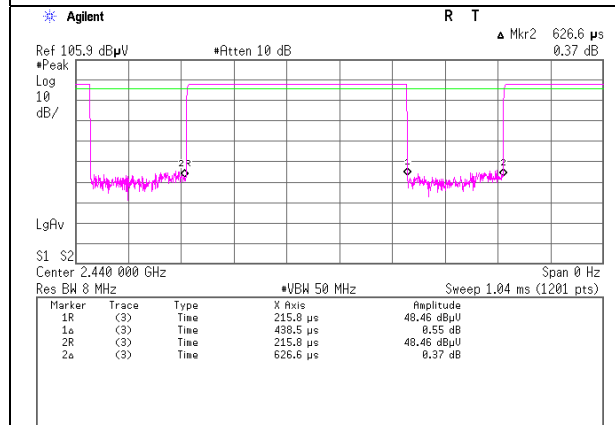
Telephone : +81 596 24 8999

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Burst rate confirmation

Test place Ise EMC Lab. No.3 Measurement Room
Report No. 10392826H
Date 08/06/2014
Temperature/ Humidity 24 deg.C / 49% RH
Engineer Tomohisa Nakagawa
Mode BT LE Tx 2440MHz

Tx on / (Tx on + Tx off) = 0.699
Tx on / (Tx on + Tx off) * 100 = 69.9
Duty factor = 10 * log (0.6266 / 0.438) = 1.56



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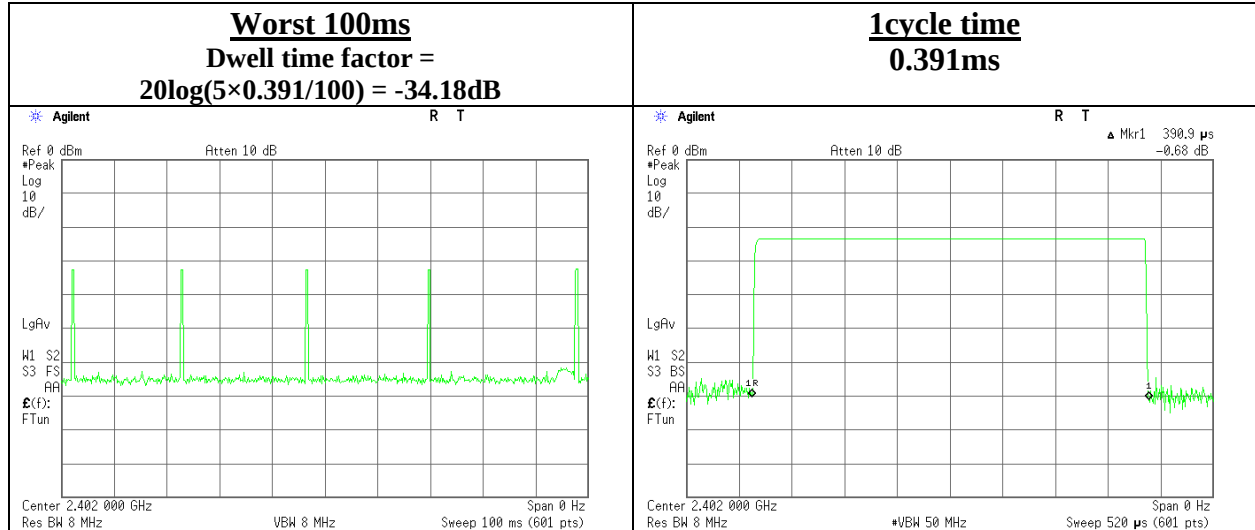
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Averaging factor

Test place	Ise EMC Lab. No.3 Measurement Room
Report No.	10392826H
Date	08/06/2014
Temperature/ Humidity	24 deg.C / 49% RH
Engineer	Tomohisa Nakagawa
Mode	BT LE Tx (Hopping on)



* Worst TX Duty cycle on BLE is Advertising mode which max on time is 0.32msec and Min interval is 20msec (Refer to “Worst TX Duty sheet”).
The actual measurement value was applied as Averaging factor.

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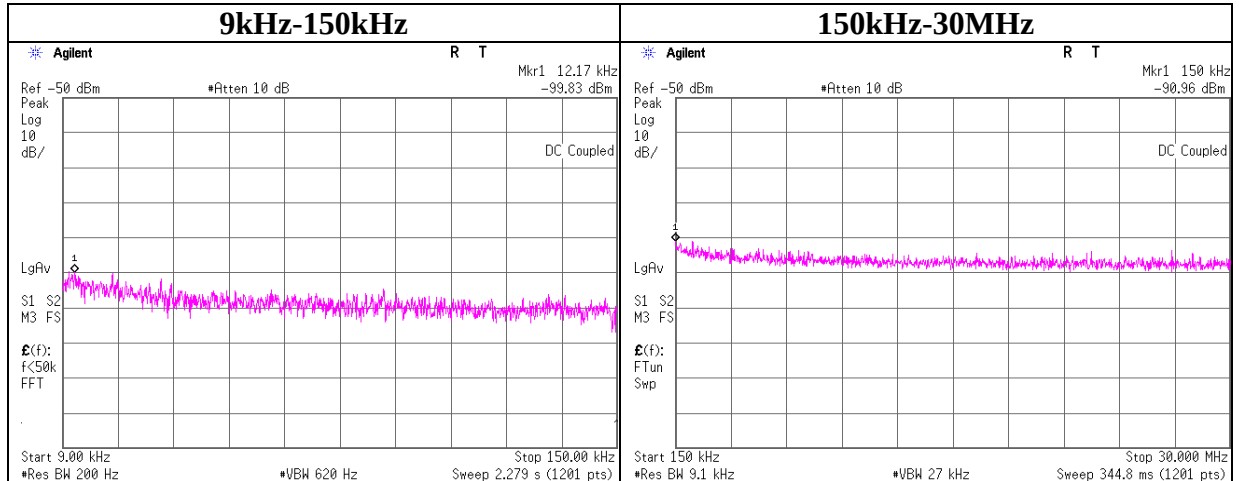
Telephone : +81 596 24 8999

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Conducted Spurious Emission

Test place : Ise EMC Lab. No.3 Measurement Room
Report No. : 10392826H
Date : 08/06/2014
Temperature/ Humidity : 24 deg.C / 49% RH
Engineer : Tomohisa Nakagawa
Mode : BT LE Tx 2402MHz

Tx 2402MHz



Frequency [kHz]	Reading [dBm]	Cable Loss [dB]	Attenuator [dB]	Antenna Gain [dBi]	EIRP [dBm]	Distance [m]	Ground bounce [dB]	E (field strength) [dBuV/m]	Limit [dBuV/m]
12.17	-99.8	0.01	10.0	2.0	-87.8	300.0	6.0	-26.6	45.8
150	-91.0	0.01	10.0	2.0	-79.0	300.0	6.0	-17.7	24.0

$E = \text{EIRP} - 20 \log(D) + \text{Ground bounce} + 104.8 [\text{dBuV/m}]$

$\text{EIRP} = \text{Reading} + \text{Cable Loss} + \text{Attenuator} + \text{Antenna Gain}$

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Power Density

Test place Ise EMC Lab. No.3 Measurement Room
Report No. 10392826H
Date 08/06/2014
Temperature/ Humidity 24 deg.C / 49% RH
Engineer Tomohisa Nakagawa
Mode BT LE Tx

Freq.	Reading	Cable Loss	Atten.	Result	Limit	Margin
[MHz]	[dBm]	[dB]	[dB]	[dBm]	[dBm]	[dB]
2402.00	-24.18	1.31	10.00	-12.87	8.00	20.87
2440.00	-25.75	1.32	10.00	-14.43	8.00	22.43
2480.00	-26.51	1.33	10.00	-15.18	8.00	23.18

Sample Calculation:

Result = Reading + Cable Loss + Attenuator

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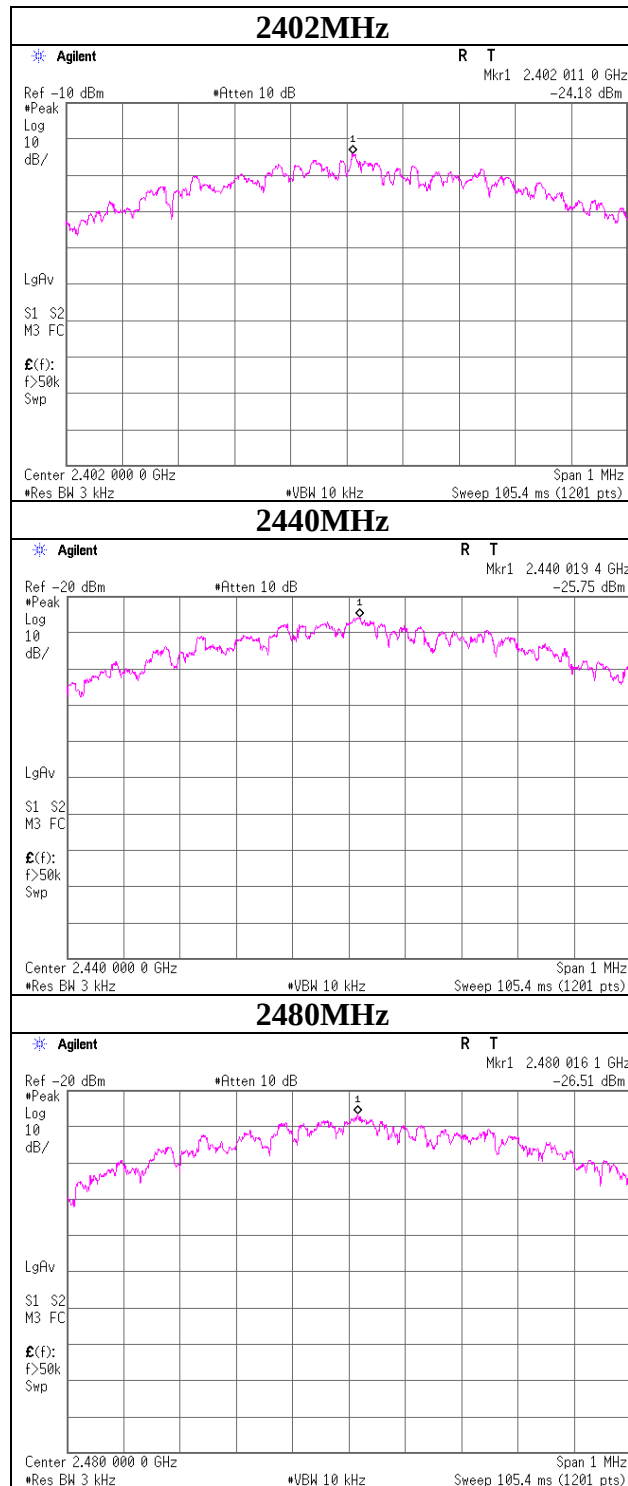
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Power Density



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Ise EMC Lab.

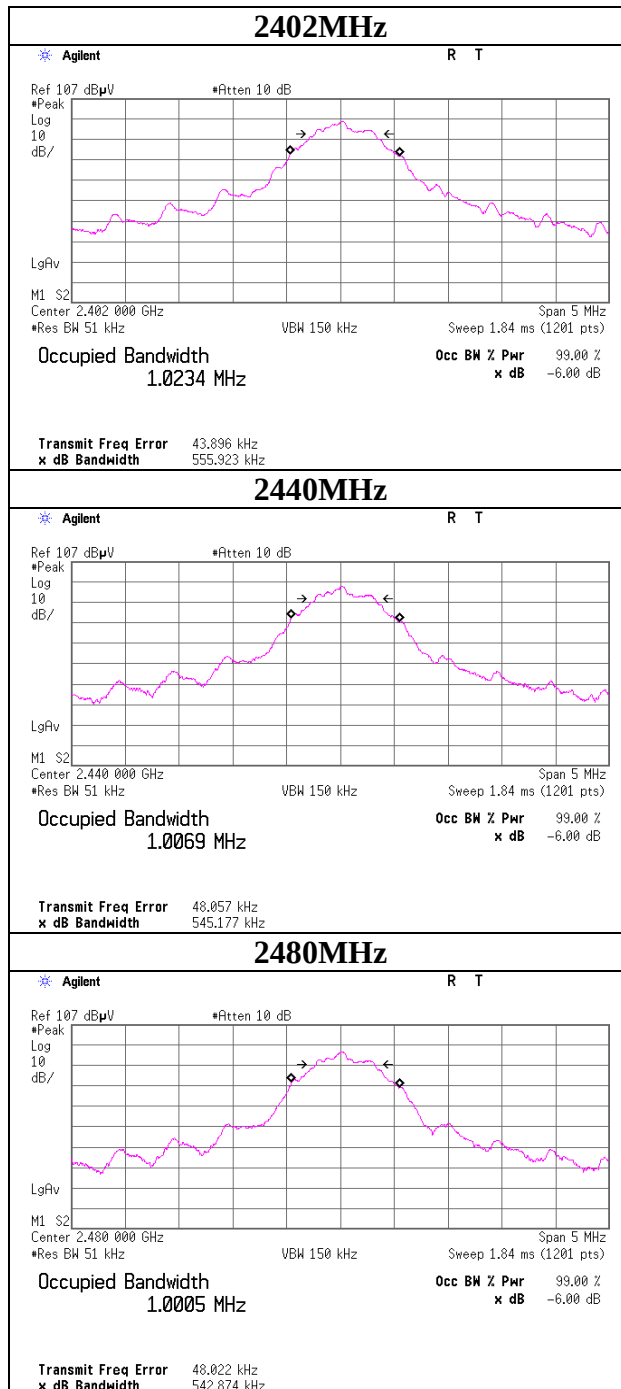
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99%Occupied Bandwidth

Test place Ise EMC Lab. No.3 Measurement Room
Report No. 10392826H
Date 08/06/2014
Temperature/ Humidity 24 deg.C / 49% RH
Engineer Tomohisa Nakagawa
Mode BT LE Tx



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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)
MRENT-115	Spectrum Analyzer	Agilent	E4440A	MY46186390	AT	2014/02/28 * 12
MPM-12	Power Meter	Anritsu	ML2495A	0825002	AT	2014/06/16 * 12
MPSE-17	Power sensor	Anritsu	MA2411B	0738285	AT	2014/06/16 * 12
MAT-22	Attenuator(10dB) 1-18GHz	Orient Microwave	BX10-0476-00	-	AT	2014/03/13 * 12
MCC-67	Microwave Cable 1G-40GHz	Suhner	SUCOFLEX102	28635/2	AT	2014/04/14 * 12
MOS-12	Thermo-Hygrometer	Custom	CTH-180	1201	AT	2014/01/14 * 12
MAEC-04	Semi Anechoic Chamber(NSA)	TDK	Semi Anechoic Chamber 3m	DA-10005	RE	2014/02/28 * 12
MOS-15	Thermo-Hygrometer	Custom	CTH-180	1501	RE	2014/02/20 * 12
MJM-22	Measure	ASKUL	-	-	RE	-
COTS-MEMI	EMI measurement program	TSJ	TEPTO-DV	-	RE	-
MRENT-112	Spectrum Analyzer	Agilent	E4440A	MY48250080	RE	2013/10/04 * 12
MHA-21	Horn Antenna 1-18GHz	Schwarzbeck	BBHA9120D	9120D-557	RE	2013/08/12 * 12
MCC-141	Microwave Cable	Junkosha	MWX221	1305S002R(1m) / 1405S146(5m)	RE	2014/06/11 * 12
MPA-12	MicroWave System Amplifier	Agilent	83017A	MY39500780	RE	2014/03/11 * 12
MHF-26	High Pass Filter 3.5-18.0GHz	UL Japan	HPF SELECTOR	002	RE	2013/09/01 * 12
MTR-01	Test Receiver	Rohde & Schwarz	ESI40	100084	RE	2013/11/12 * 12
MBA-05	Biconical Antenna	Schwarzbeck	BBA9106	1302	RE	2013/11/24 * 12
MLA-08	Logperiodic Antenna	Schwarzbeck	UKLP9140-A	N/A	RE	2013/11/24 * 12
MCC-50	Coaxial Cable	UL Japan	-	-	RE	2014/06/02 * 12
MAT-68	Attenuator	Anritsu	MP721B	6200961025	RE	2013/11/26 * 12
MPA-14	Pre Amplifier	SONOMA INSTRUMENT	310	260833	RE	2014/03/14 * 12
MHA-17	Horn Antenna 15-40GHz	Schwarzbeck	BBHA9170	BBHA9170307	RE	2014/06/11 * 12

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

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

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

Test Item: RE: Radiated Emission

AT: Antenna Terminal Conducted test

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