



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:

T. Nakagawa

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Approved by:

Takayuki Shimada

Takayuki Shimada
Engineer
Consumer Technology Division



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.

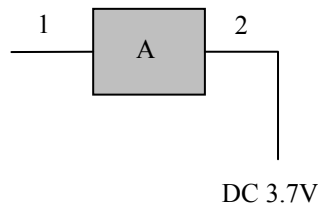
SECTION 4: Operation of E.U.T. during testing

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.

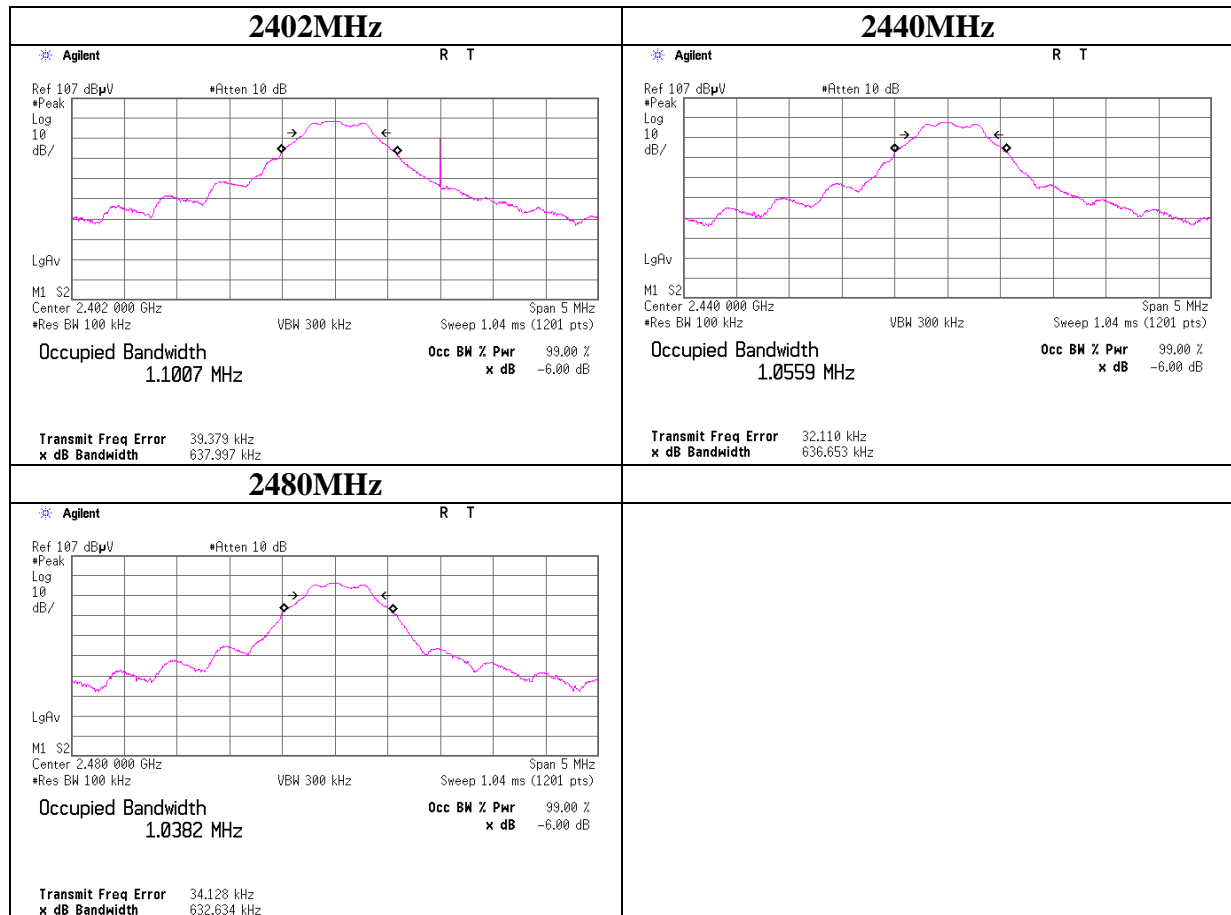
Test data : APPENDIX
Test result : Pass

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

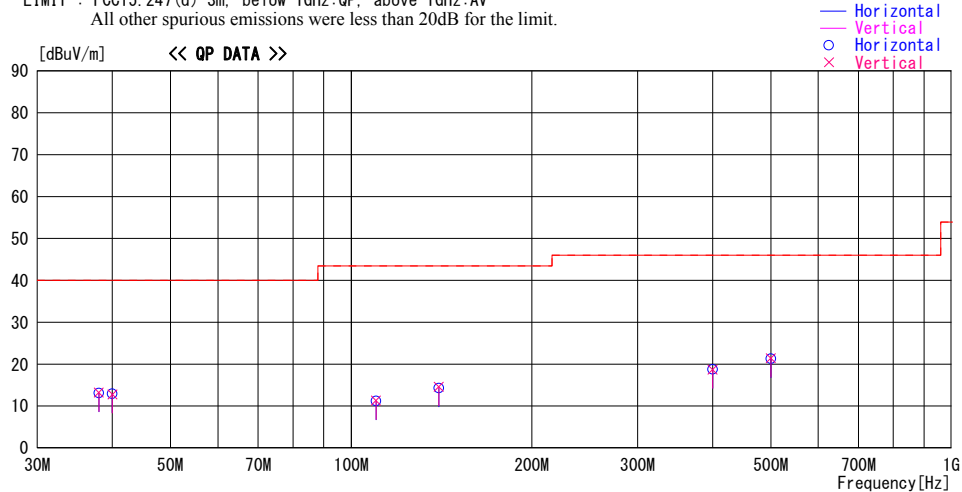
DATA OF RADIATED EMISSION TEST

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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Radiated Spurious Emission

DATA OF RADIATED EMISSION TEST

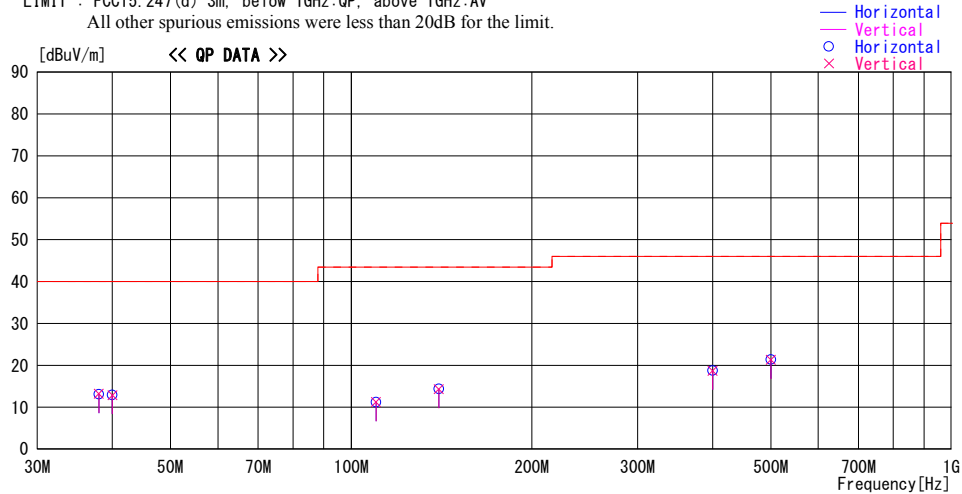
UL Japan, Inc. Ise EMC Lab. No.4 Semi Anechoic Chamber
Date : 2014/08/19

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 | 22.8 | 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

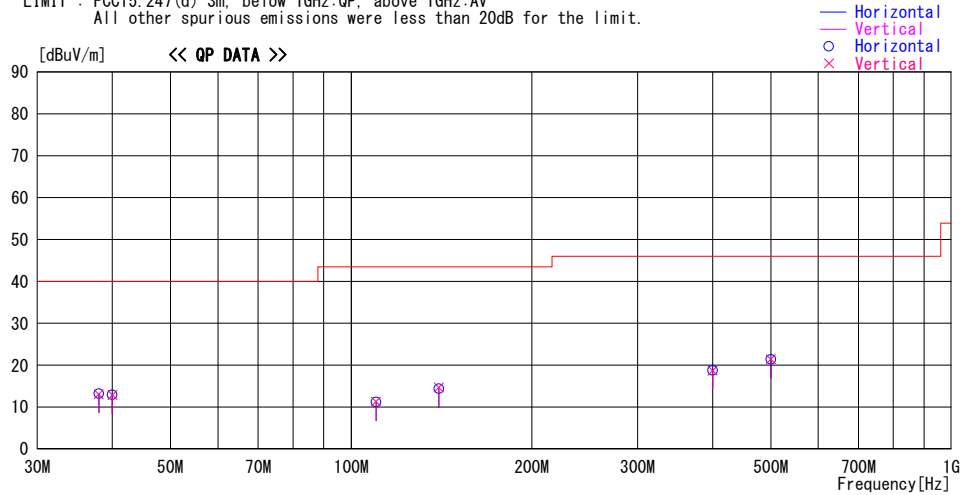
DATA OF RADIATED EMISSION TEST

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 | Reading | DET | Antenna Factor | Loss& Gain | Level | Angle | Height | Polar. | Limit | Margin | Comment |
|-----------|---------|-----|----------------|------------|----------|-------|--------|--------|----------|--------|---------|
| [MHz] | [dBuV] | | [dB/m] | [dB] | [dBuV/m] | [Deg] | [cm] | | [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 |
| 110.000 | 23.5 | QP | 11.7 | -23.9 | 11.3 | 314 | 100 | Vert. | 43.5 | 32.2 | NS |
| 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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Facsimile : +81 596 24 8124

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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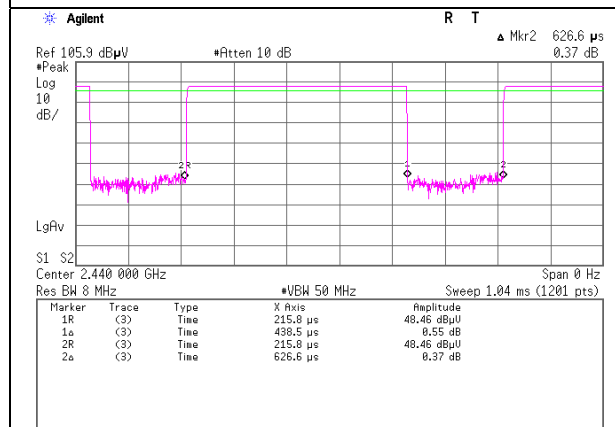
Telephone : +81 596 24 8999

Facsimile : +81 596 24 8124

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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Ise EMC Lab.

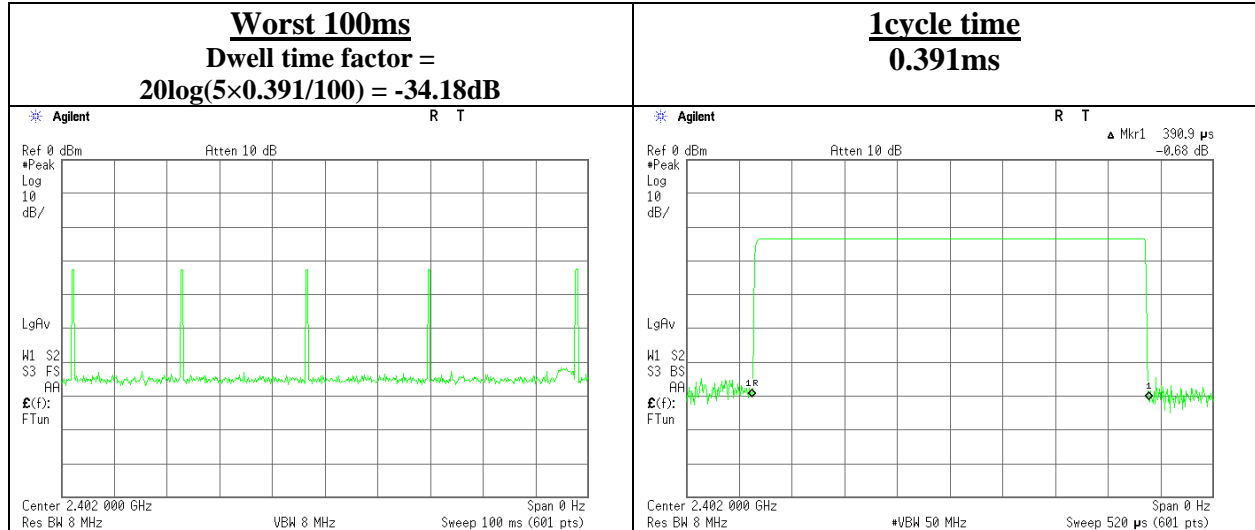
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Telephone : +81 596 24 8999

Facsimile : +81 596 24 8124

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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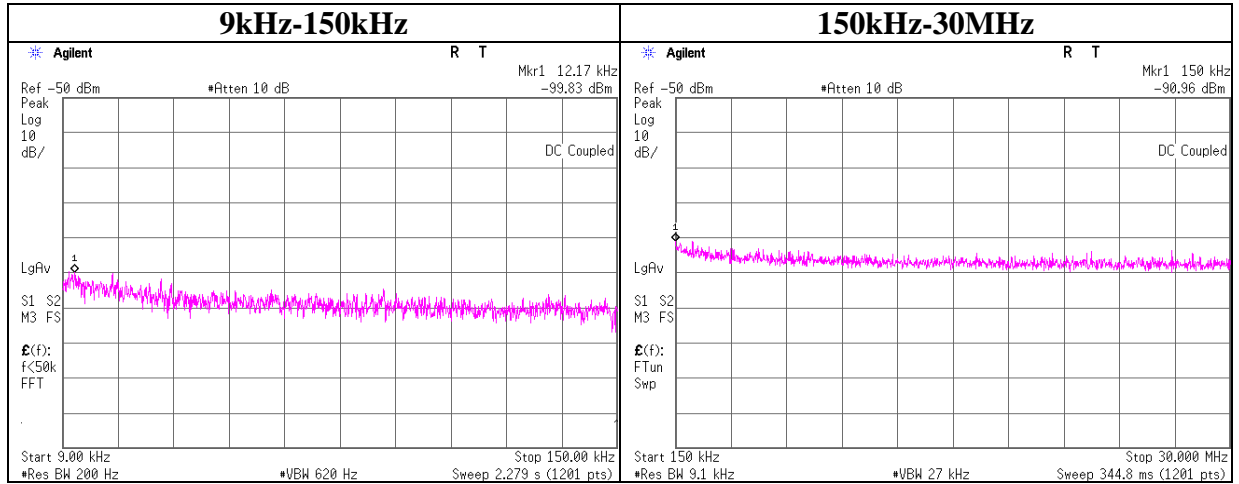
Telephone : +81 596 24 8999

Facsimile : +81 596 24 8124

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 |

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

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

UL Japan, Inc.

Ise EMC Lab.

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Telephone : +81 596 24 8999

Facsimile : +81 596 24 8124

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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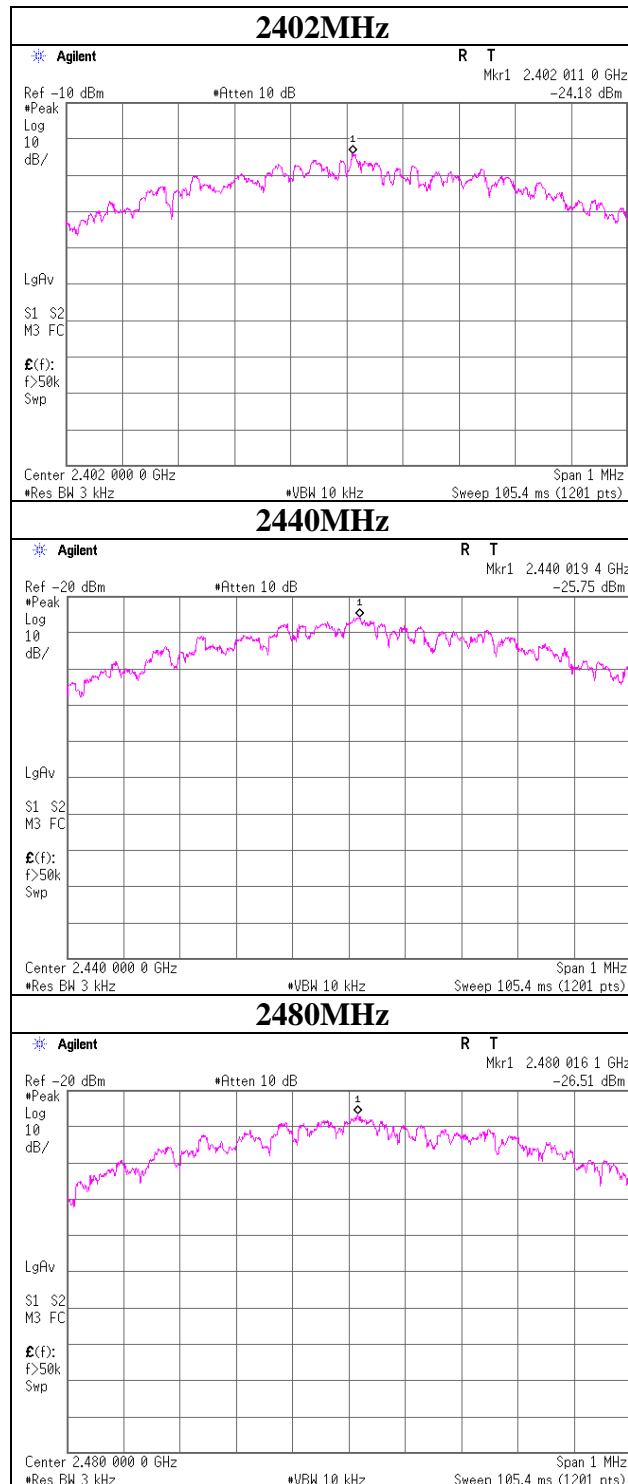
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Power Density



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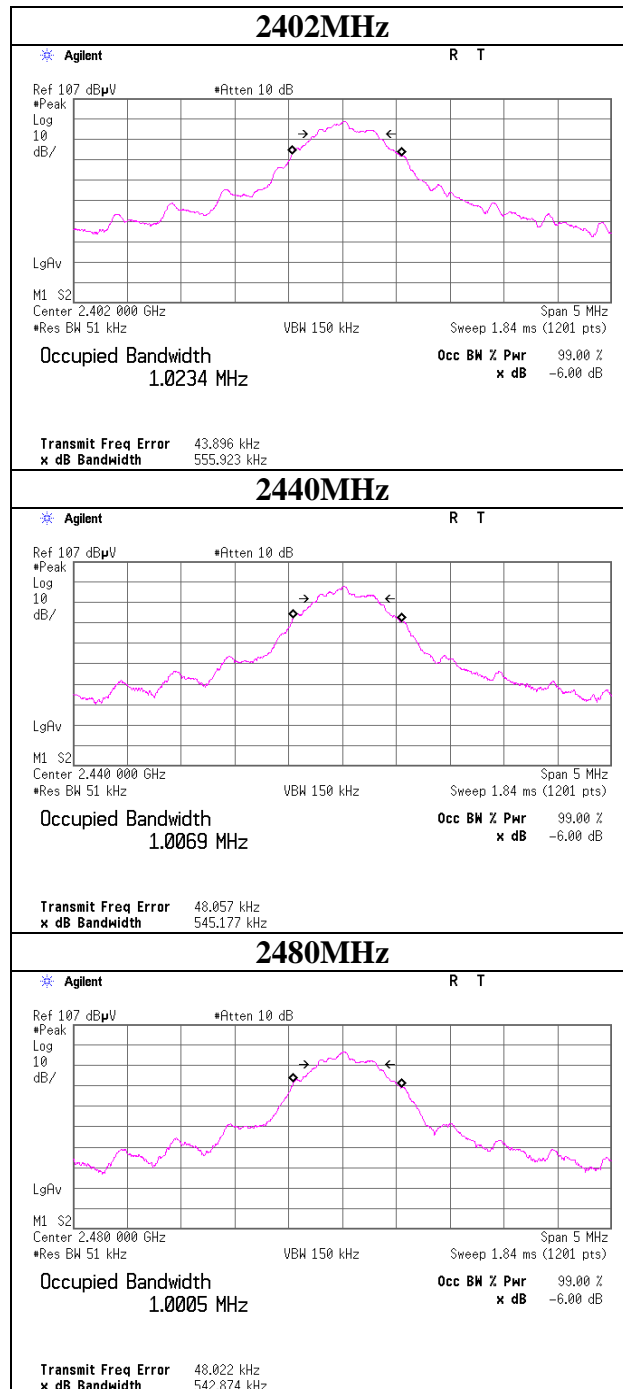
Telephone : +81 596 24 8999

Facsimile : +81 596 24 8124

99%Occupied Bandwidth

Test place
Report No.
Date
Temperature/ Humidity
Engineer
Mode

Ise EMC Lab. No.3 Measurement Room
10392826H
08/06/2014
24 deg.C / 49% RH
Tomohisa Nakagawa
BT LE Tx



UL Japan, Inc.

Ise EMC Lab.

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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

UL Japan, Inc.

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