# Test Report No. 7191148600-EEC16/03
**dated 26 Oct 2016**

PSB Singapore

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FORMAL REPORT ON TESTING IN ACCORDANCE WITH
47 CFR FCC Parts 15B & C
OF A
**RFID BOARD**
**[ Model : 03146441-01 ]**
**[ FCC ID : 2AK8D03146441 ]**

| | |
|---|---|
| **TEST FACILITY** | TÜV SÜD PSB Pte Ltd<br>Electrical & Electronics Centre (EEC), Product Services,<br>No. 1 Science Park Drive, Singapore 118221 |
| **FCC REG. NO.** | 99142 (3m and 10m Semi-Anechoic Chamber, Science Park) |
| **IND. CANADA REG. NO.** | 2932I-1 (3m and 10m Semi-Anechoic Chamber, Science Park) |
| **PREPARED FOR** | ASM Assembly Systems Singapore Pte. Ltd.<br>535 Yishun Industrial Park A<br>ASM Tech-Park Building 2<br>Singapore 768775<br><br>Tel : (65) 6877 3811 Fax : (65) 6877 3901 |
| **QUOTATION NUMBER** | 2191047601 |
| **JOB NUMBER** | 7191148600 |
| **TEST PERIOD** | 20 Oct 2016 – 24 Oct 2016 |

| **PREPARED BY** | **APPROVED BY** |
|---|---|
| Quek Keng Huat | Foo Kai Maun |
| Higher Associate Engineer | Executive Engineer |

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| LA-2007-0382-B | LA-2007-0386-C | |
| LA-2007-0383-G | LA-2010-0464-D | |

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**TEST SUMMARY**

The product was tested in accordance with the customer's specifications.

**Test Results Summary**

| Test Standard | Description | Pass / Fail |
|---|---|---|
| 47 CFR FCC Part 15 | | |
| 15.107(a), 15.207 | Conducted Emissions | Pass |
| 15.109(a), 15.205, 15.209, 15.225(d) | Radiated Emissions (Spurious Emissions inclusive Restricted Bands Requirement) | Pass |
| 15.225(a) | Radiated Emissions (Fundamental) | Pass |
| 15.225(b) | Radiated Emissions (Fundamental) | Not Applicable *See Note 1 |
| 15.225(c) | Radiated Emissions (Fundamental) | Not Applicable *See Note 1 |
| 15.225(e) | Frequency Stability Versus Temperature | Pass |
| 15.225(e) | Frequency Stability Versus Input Voltage | Pass |

**Notes**

1. The carrier frequency of the Equipment Under Test (EUT) is 13.56MHz.
2. The EUT is a Class B device when in non-transmitting state and meets the 47 CFR FCC Part15B Class B requirements.
3. All test measurement procedures are according to ANSI C63.4: 2014 and ANSI C63.10: 2013.

**Modifications**

No modifications were made.

## PRODUCT DESCRIPTION

| | | |
|---|---|---|
| Description | : | The Equipment Under Test (EUT) is a **RFID BOARD.** |
| Applicant | : | ASM Assembly Systems Singapore Pte. Ltd.<br>535 Yishun Industrial Park A<br>ASM Tech-Park Building 2<br>Singapore 768775 |
| Manufacturer | : | ASM Assembly Systems Singapore Pte. Ltd.<br>535 Yishun Industrial Park A<br>ASM Tech-Park Building 2<br>Singapore 768775 |
| Factory (ies) | : | ASM Assembly Systems Singapore Pte. Ltd.<br>535 Yishun Industrial Park A<br>ASM Tech-Park Building 2<br>Singapore 768775 |
| Model Number(s) | : | 03146441-01 |
| FCC ID | : | 2AK8D03146441 |
| Serial Number(s) | : | KL*H7-0004 |
| Microprocessor(s) | : | i. RFID transceiver: CR95HF (STMicroelectronics)<br>ii. RFID Tag: ZC-2016-530 (Leneno) |
| Operating Frequency | : | 13.56 MHz |
| Oscillator Frequency | : | 27.12MHZ |
| Modulation | : | 100% Amplitude-Shift Keying (ASK) according to ISO 15693 |
| IF Filter Bandwidth | : | 18MHz |
| Port / Connectors | : | UART (Communication Interface) |
| Rated Input Power | : | 5Vdc, 75mA max |
| Accessories | : | Nil |

## SUPPORTING EQUIPMENT DESCRIPTION

| Equipment Description (Including Brand Name) | Model, Serial & FCC ID Number | Cable Description (List Length, Type & Purpose) |
|---|---|---|
| ASM Control Board | P/N: 03125534-02<br>S/N: KL-47-0004<br>FCC ID: Nil | Nil |
| GW Power Supply | M/N: GPR-3030<br>S/N: 1720389<br>FCC ID: DoC | 2.00m unshielded power cable |
| Kvaser CAN Communication | M/N: USB CANIII<br>S/N: 18786<br>FCC ID: DoC | 2.00m USB cable |
| Fujitsu Laptop | M/N: Celsius #710<br>S/N: DSCF018897<br>FCC ID: DoC | Nil |
| Fujitsu Adapter | P/N: CP500601-01 FPCAC113<br>S/N: 1230107901<br>FCC ID: DoC | 2.00m unshielded power cable |

## EUT OPERATING CONDITIONS

| **47 CFR FCC Part 15** |
|---|
| **1. Conducted Emissions**<br>**2. Radiated Emissions (Spurious Emissions inclusive Restricted Bands Requirement)**<br>**3. Radiated Emissions (Fundamental)**<br>**4. Frequency Stability Versus Temperature**<br>**5. Frequency Stability Versus Input Voltage** |
| The EUT was exercised by operating in maximum continuous transmission in test mode, i.e transmitting at 13.56MHz continuously. |

**47 CFR FCC Parts 15.107(a) and 15.207 Conducted Emission Limits**

| Frequency Range (MHz) | Limit Values (dBµV) | |
|---|---|---|
| | Quasi-peak (Q-P) | Average (AV) |
| 0.15 - 0.5 | 66 – 56 * | 56 – 46 * |
| 0.5 - 5.0 | 56 | 46 |
| 5.0 - 30.0 | 60 | 50 |
| * Decreasing linearly with the logarithm of the frequency | | |

**47 CFR FCC Parts 15.107(a) and 15.207 Conducted Emission Test Instrumentation**

| Instrument | Model | S/No | Cal Due Date |
|---|---|---|---|
| Schaffner EMI Receiver | SMR4503 | 040 | 06 Mar 2017 |
| Agilent EMC Analyzer-SA7 | E7403A | US41160167 | 24 Aug 2017 |
| Schaffner LISN –LISN10 (EUT) | NNB42 | 04/10055 | 30 Oct 2017 |
| EMCO LISN (for supporting) – LISN6 | 3825/2 | 9309-2127 | 30 Oct 2017 |

**47 CFR FCC Parts 15.107(a) and 15.207 Conducted Emission Test Setup**

1. The EUT and supporting equipment were set up in accordance with the requirements of the standard on top of a 1.5m x 1m x 0.8m high, non-metallic table.
2. The power supply for the EUT was fed through a 50Ω/50μH EUT LISN, connected to filtered mains.
3. The RF OUT of the EUT LISN was connected to the EMI test receiver via a low-loss coaxial cable.
4. All other supporting equipment were powered separately from another LISN.

**47 CFR FCC Parts 15.107(a) and 15.207 Conducted Emission Test Method**

1. The EUT was switched on and allowed to warm up to its normal operating condition.
2. A scan was made on the NEUTRAL line over the required frequency range using an EMI test receiver.
3. High peaks, relative to the limit line, were then selected.
4. The EMI test receiver was then tuned to the selected frequencies and the necessary measurements made with a receiver bandwidth setting of 9kHz. Both Quasi-peak and Average measurements were made.
5. Steps 2 to 4 were then repeated for the LIVE line.

**Sample Calculation Example**

| | |
|---|---|
| At 20 MHz | Q-P limit = 60.0 dBμV |
| Transducer factor of LISN, pulse limiter & cable loss at 20 MHz = 11.2 dB | |
| Q-P reading obtained directly from EMI Receiver = 40.0 dBμV (Calibrated for system losses) | |
| Therefore, Q-P margin = 60.0 - 40.0 = 20.0 | i.e. 20.0 dB below Q-P limit |

**47 CFR FCC Parts 15.107(a) and 15.207 Conducted Emission Results**

| | | | |
|---|---|---|---|
| Test Input Power | 415Vac (3 Phase) | Temperature | 24ºC |
| Line Under Test | AC Mains | Relative Humidity | 60% |
| | | Atmospheric Pressure | 1030mbar |
| | | Tested By | Chang Wai Kit |

| Frequency (MHz) | Q-P Value (dBµV) | Q-P Limit (dBµV) | Q-P Margin (dB) | AV Value (dBµV) | AV Limit (dBµV) | AV Margin (dB) | Line |
|---|---|---|---|---|---|---|---|
| 0.4201 | 41.6 | 57.4 | 15.8 | 35.3 | 47.4 | 12.1 | L1 |
| 0.4895 | 49.6 | 56.2 | 6.6 | 36.3 | 46.2 | 9.9 | L1 |
| 0.4946 | 50.8 | 56.1 | 5.3 | 37.1 | 46.1 | 9.0 | L3 |
| 0.5013 | 48.7 | 56.0 | 7.3 | 34.5 | 46.0 | 11.5 | L2 |
| 0.5404 | 43.4 | 56.0 | 12.6 | 34.6 | 46.0 | 11.4 | L2 |
| 0.5477 | 41.5 | 56.0 | 14.5 | 33.9 | 46.0 | 12.1 | L1 |

Notes

1. All possible modes of operation were investigated from 150kHz to 30MHz. Only the worst case emissions measured, using the correct CISPR detectors, are reported. All other emissions were relatively insignificant.
2. A "positive" margin indicates a PASS as it refers to the margin present below the limit line at the particular frequency. Conversely, a “negative” margin indicates a FAIL.
3. EMI receiver Resolution Bandwidth (RBW) and Video Bandwidth (VBW) settings:
   9kHz - 30MHz
   RBW: 9kHz VBW: 30kHz
4. Conducted Emissions Measurement Uncertainty
   All test measurements carried out are traceable to national standards. The uncertainty of the measurement at a confidence level of approximately 95%, with a coverage factor of 2, in the range 9kHz – 30MHz is ±2.2dB.

**47 CFR FCC Part 15.205 Restricted Bands**

| MHz | | | MHz | | | MHz | | | GHz | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.090 | - | 0.110 | 16.42 | - | 16.423 | 399.9 | - | 410 | 4.5 | - | 5.15 |
| 0.495 | - | 0.505 | 16.69475 | - | 16.69525 | 608 | - | 614 | 5.35 | - | 5.46 |
| 2.1735 | - | 2.1905 | 16.80425 | - | 16.80475 | 960 | - | 1240 | 7.25 | - | 7.75 |
| 4.125 | - | 4.128 | 25.5 | - | 25.67 | 1300 | - | 1427 | 8.025 | - | 8.5 |
| 4.17725 | - | 4.17775 | 37.5 | - | 38.25 | 1435 | - | 1626.5 | 9.0 | - | 9.2 |
| 4.20725 | - | 4.20775 | 73 | - | 74.6 | 1645.5 | - | 1646.5 | 9.3 | - | 9.5 |
| 6.215 | - | 6.218 | 74.8 | - | 75.2 | 1660 | - | 1710 | 10.6 | - | 12.7 |
| 6.26775 | - | 6.26825 | 108 | - | 121.94 | 1718.8 | - | 1722.2 | 13.25 | - | 13.4 |
| 6.31175 | - | 6.31225 | 123 | - | 138 | 2200 | - | 2300 | 14.47 | - | 14.5 |
| 8.291 | - | 8.294 | 149.9 | - | 150.05 | 2310 | - | 2390 | 15.35 | - | 16.2 |
| 8.362 | - | 8.366 | 156.52475 | - | 156.52525 | 2483.5 | - | 2500 | 17.7 | - | 21.4 |
| 8.37625 | - | 8.38675 | 156.7 | - | 156.9 | 2690 | - | 2900 | 22.01 | - | 23.12 |
| 8.41425 | - | 8.41475 | 162.0125 | - | 167.17 | 3260 | - | 3267 | 23.6 | - | 24.0 |
| 12.29 | - | 12.293 | 167.72 | - | 173.2 | 3332 | - | 3339 | 31.2 | - | 31.8 |
| 12.51975 | - | 12.52025 | 240 | - | 285 | 3345.8 | - | 3358 | 36.43 | - | 36.5 |
| 12.57675 | - | 12.57725 | 322 | - | 335.4 | 3600 | - | 4400 | Above 38.6 | | |
| 13.36 | - | 13.41 | | | | | | | | | |

**47 CFR FCC Parts 15.109(a), 15.209 and 15.225(d) Radiated Emission Limits**

| Frequency Range (MHz) | Quasi-Peak Limit Values (dBµV/m) |
|---|---|
| 0.009 - 0.490 | 20 log [2400 / F (kHz)] @ 300m |
| 0.490 - 1.705 | 20 log [24000 / F (kHz)] @ 30m |
| 1.705 - 30.0 | 30.0 @ 30m |
| 30 - 88 | 40.0 @ 3m |
| 88 - 216 | 43.5 @ 3m |
| 216 - 960 | 46.0 @ 3m |
| Above 960 | 54.0* @ 3m |
| * For frequency bands 9kHz – 90kHz, 110kHz – 490kHz and above 1GHz, average detector was used. A peak limit of 20dB above the average limit does apply. | |

**47 CFR FCC Parts 15.109(a), 15.209 and 15.225(d) Radiated Emission Test Instrumentation**

| Instrument | Model | S/No | Cal Due Date |
|---|---|---|---|
| R&S Test Receiver (20Hz –26.5GHz) – ESMI1(Ref) | ESMI | 849182/003<br>848926/007 | 22 Apr 2017 |
| Schaffner Bilog Antenna –(30MHz-2GHz) BL4 | CBL6112B | 2593 | 15 Dec 2016 |
| R&S Preamplifier (1GHz -18GHz) | SCU18 | 102191 | 11 Mar 2017 |
| EMCO Loop Ant (ext) | 6502 | 9108-2673 | 16 Feb 2017 |

**47 CFR FCC Parts 15.109(a), 15.209 and 15.225(d) Radiated Emission Test Setup**

1. The EUT and supporting equipment were set up in accordance with the requirements of the standard on top of a 1.5m X 1.0m X 0.8m high, non-metallic table for measurement up to 1GHz. For measurement above 1GHz, 1.5m height table was used.
2. The filtered power supply for the EUT and supporting equipment were tapped from the appropriate power sockets located on the turntable.
3. The relevant broadband antenna was set at the required test distance away from the EUT and supporting equipment boundary.

**47 CFR FCC Parts 15.109(a), 15.209 and 5.225(d) Radiated Emission Test Method**

1. The EUT was switched on and allowed to warm up to its normal operating condition.
2. A prescan was carried out to pick the worst emission frequencies from the EUT. For EUT which is a portable device, the prescan was carried out by rotating the EUT through three orthogonal axes to determine which altitude and equipment arrangement produces such emissions.
3. The test was carried out at the selected frequency points obtained from the prescan in step 2. Maximization of the emissions, was carried out by rotating the EUT, changing the antenna polarization, and adjusting the antenna height in the following manner:
   a. Vertical or horizontal polarisation (whichever gave the higher emission level over a full rotation of the EUT) was chosen.
   b. The EUT was then rotated to the direction that gave the maximum emission.
   c. Finally, the antenna height was adjusted to the height that gave the maximum emission.
4. A Quasi-peak measurement was made for that frequency point if it was less than or equal to 1GHz. For frequency point in the range of 9kHz – 90kHz, 110kHz – 490kHz and above 1GHz, both Peak and Average measurements were carried out.
5. Steps 3 and 4 were repeated for the next frequency point, until all selected frequency points were measured.
6. The frequency range covered was from the lowest radio frequency signal generated from the EUT, without going below 9kHz to 10$^{th}$ harmonics of the EUT fundamental frequency, using the loop antenna for frequency below 30MHz, Bi-log antenna for frequencies from 30MHz up to 1GHz, and the Horn antenna above 1GHz.

**Sample Calculation Example**

| | |
|---|---|
| At 300 MHz | Q-P limit = 46.0 dBµV/m |
| Log-periodic antenna factor & cable loss at 300 MHz = 18.5 dB | |
| Q-P reading obtained directly from EMI Receiver = 40.0 dBµV/m (Calibrated level including antenna factors & cable losses) | |
| Therefore, Q-P margin = 46.0 - 40.0 = 6.0 | i.e. 6.0 dB below Q-P limit |

**47 CFR FCC Parts 15.109(a), 15.205, 15.209 and 15.225(d) Radiated Emission Results**

| | | | |
|---|---|---|---|
| Test Input Power | 5Vdc | Temperature | 24ºC |
| Test Distance | 3m (<30MHz)<br>3m (≥30MHz – 1GHz) | Relative Humidity | 60% |
| | | Atmospheric Pressure | 1030mbar |
| | | Tested By | Chang Wai Kit |

Spurious Emissions ranging from 9kHz – 30MHz (for 9kHz – 90kHz, 110kHz – 490kHz) *See Note 4

| Freq (GHz) | Peak Value (dBµV/m) | Peak Limit (dBµV/m) | Peak Margin (dB) | AV Value (dBµV/m) | AV Limit (dBµV/m) | AV Margin (dB) | Height (cm) | Azimuth (Degrees) | Pol (H/V) |
|---|---|---|---|---|---|---|---|---|---|
| -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

Spurious Emissions ranging from 9kHz – 30MHz *See Note 4

| Frequency (MHz) | Q-P Value (dBµV/m) | Q-P Limit (dBµV/m) | Q-P Margin (dB) | Height (cm) | Azimuth (Degrees) |
|---|---|---|---|---|---|
| 1.9920 | 4.7 | 30.0 | 25.3 | 120 | 252 |
| 2.7630 | -3.1 | 30.0 | 33.1 | 120 | 289 |
| 4.0690 | -3.5 | 30.0 | 33.5 | 120 | 156 |
| 4.4380 | -7.9 | 30.0 | 37.9 | 120 | 131 |
| 5.2080 | -6.9 | 30.0 | 36.9 | 120 | 350 |
| 6.1130 | -11.1 | 30.0 | 41.1 | 120 | 69 |

Spurious Emissions ranging from 30MHz – 1GHz

| Frequency (MHz) | Q-P Value (dBµV/m) | Q-P Limit (dBµV/m) | Q-P Margin (dB) | Height (cm) | Azimuth (Degrees) | Pol (H/V) |
|---|---|---|---|---|---|---|
| 166.3140 | 38.8 | 43.5 | 4.7 | 100 | 310 | V |
| 207.5230 | 35.7 | 43.5 | 7.8 | 100 | 77 | V |
| 232.3510 | 44.7 | 46.0 | 1.3 | 100 | 263 | V |
| 257.6320 | 37.1 | 46.0 | 8.9 | 198 | 360 | V |
| 276.0090 | 42.5 | 46.0 | 3.5 | 100 | 143 | V |
| 875.8960 | 34.5 | 46.0 | 11.5 | 106 | 310 | V |

Notes

1. All possible modes of operation were investigated. Only the worst case emissions measured, using the correct CISPR detectors, are reported. All other emissions were relatively insignificant.
2. A closer test distance of 3m was used for the measurement instead of 30m as the fundamental (carrier) electric field strength of the EUT at the 10m distance shows compliance to the limit of 30m test distance.
3. "--" indicates no emissions were found and shows compliance to the limits.
4. The measurement was done at 3m. The measured results were extrapolated to the specified test limits as specified in § 15.209 (a) based on 40dB/decade.
5. Quasi-peak measurement was used for frequency measurement up to 1GHz. Average and peak measurements were used for emissions above 1GHz. The average measurement was done by averaging over a complete cycle of the pulse train, including the blanking interval as the pulse train duration does not exceed 0.1 second.
6. A "positive" margin indicates a PASS as it refers to the margin present below the limit line at the particular frequency. Conversely, a "negative" margin indicates a FAIL.
7. EMI receiver Resolution Bandwidth (RBW) and Video Bandwidth (VBW) settings:
   9kHz - 150kHz
   RBW: 100Hz VBW: 300Hz
   150kHz - 30MHz
   RBW: 10kHz VBW: 30kHz
   30MHz - 1GHz
   RBW: 120kHz VBW: 1MHz
   >1GHz
   RBW: 1MHz VBW: 3MHz
8. The upper frequency of radiated emission investigations was according to requirements stated in Section 15.33(a) for intentional radiators & Section 15.33(b) for unintentional radiators.
9. The channel in the table refers to the transmit channel of the EUT.
10. Radiated Emissions Measurement Uncertainty
    All test measurements carried out are traceable to national standards. The uncertainty of the measurement at a confidence level of approximately 95%, with a coverage factor of 2, in the range 30MHz – 25GHz is ±4.0dB.

**47 CFR FCC Parts 15.225(a), 15.225(b) and 15.225(c) Radiated Emission (Fundamental) Limits**

| Fundamental Frequency (MHz) | Field Strength of Fundamental Limit Values @ 30m (dBµV/m) |
|---|---|
| 13.553 - 13.567 | 84.0 |
| 13.410 -13.553 | 50.5 |
| 13.567 -13.710 | 50.5 |
| 13.110 -13.410 | 40.5 |
| 13.710 -14.010 | 40.5 |

**47 CFR FCC Parts 15.225(a), 15.225(b) and 15.225(c) Radiated Emission (Fundamental) Test Instrumentation**

| Instrument | Model | S/No | Cal Due Date |
|---|---|---|---|
| R&S Test Receiver (20Hz –26.5GHz) – ESMI1(Ref) | ESMI | 849182/003<br>848926/007 | 22 Apr 2017 |
| EMCO Loop Ant (ext) | 6502 | 9108-2673 | 16 Feb 2017 |

**47 CFR FCC Parts 15.225(a), 15.225(b) and 15.225(c) Radiated Emission (Fundamental) Test Setup**

1. The EUT and supporting equipment were set up in accordance with the requirements of the standard on top of a 1.5m X 1.0m X 0.8m high, non-metallic table for measurement up to 1GHz. For measurement above 1GHz, 1.5m height table was used.
2. The filtered power supply for the EUT and supporting equipment were tapped from the appropriate power sockets located on the turntable.
3. The relevant broadband antenna was set at the required test distance away from the EUT and supporting equipment boundary.

**47 CFR FCC Parts 15.225(a), 15.225(b) and 15.225(c) Radiated Emission (Fundamental) Test Method**

1. The EUT was switched on and allowed to warm up to its normal operating condition.
2. A prescan was carried out to pick the fundamental frequency from the EUT. For EUT which is a portable device, the prescan was carried out by rotating the EUT through three orthogonal axes to determine which altitude and equipment arrangement produces such emissions.
3. The test was carried out at the selected frequency points obtained from the prescan in step 2. Maximization of the emissions, was carried out by rotating the EUT, changing the antenna polarization, and adjusting the antenna height in the following manner:
   a. Vertical or horizontal polarisation (whichever gave the higher emission level over a full rotation of the EUT) was chosen.
   b. The EUT was then rotated to the direction that gave the maximum emission.
   c. Finally, the antenna height was adjusted to the height that gave the maximum emission.
4. A Quasi-peak measurement was made for that frequency point if it was less than or equal to 1GHz. For frequency point that above 1GHz, both Peak and Average measurements were carried out.
5. Steps 3 and 4 were repeated for the next frequency point, until all selected frequency points were measured.

**Sample Calculation Example**

| | |
|---|---|
| At 300 MHz | Q-P limit = 46.0 dBμV/m |
| Log-periodic antenna factor & cable loss at 300 MHz = 18.5 dB | |
| Q-P reading obtained directly from EMI Receiver = 40.0 dBμV/m (Calibrated level including antenna factors & cable losses) | |
| Therefore, Q-P margin = 46.0 - 40.0 = 6.0 | i.e. 6.0 dB below Q-P limit |

**47 CFR FCC Part 15.225(a / b / c) Radiated Emission (Fundamental) Results**

| | | | |
|---|---|---|---|
| Test Input Power | 5Vdc | Temperature | 24ºC |
| Test Distance | 3m *See Note 2 | Relative Humidity | 60% |
| | | Atmospheric Pressure | 1030mbar |
| | | Tested By | Chang Wai Kit |

| Frequency (MHz) | Peak Value (dBµV/m) *see Note 3 | Q-P Limit (dBµV/m) | Q-P Margin (dB) | Height (cm) | Azimuth (Degrees) |
|---|---|---|---|---|---|
| 13.561 | 48.7 | 84.0 | 35.3 | 120 | 165 |

Notes

1. All possible modes of operation were investigated. Only the worst case emissions measured, using the average and peak detectors, are reported. All other emissions were relatively insignificant.
2. A closer test distance of 3m was used for the measurement instead of 30m as the fundamental (carrier) electric field strength of the EUT at the 3m distance shows compliance to the limit of 30m test distance.
3. As the measured peak shows compliance to the Q-P limit, as such no Q-P measurement was required.
4. A "positive" margin indicates a PASS as it refers to the margin present below the limit line at the particular frequency. Conversely, a "negative" margin indicates a FAIL.
5. EMI receiver Resolution Bandwidth (RBW) and Video Bandwidth (VBW) settings:
   150kHz - 30MHz
   RBW: 10kHz VBW: 30kHz
   30MHz - 1GHz
   RBW: 120kHz VBW: 1MHz
   >1GHz
   RBW: 1MHz VBW: 3MHz
6. Radiated Emissions (Fundamental) Measurement Uncertainty
   All test measurements carried out are traceable to national standards. The uncertainty of the measurement at a confidence level of approximately 95%, with a coverage factor of 2, in the range 30MHz – 25GHz is ±4.0dB.

## 47 CFR FCC Part 15.225(e) Frequency Stability Versus Temperature Limits

The EUT shows compliance to the requirements of this section, which states that the frequency tolerance of the carrier frequency shall be ± 0.01% for a temperature variation of -20°C to +50°C at normal supply voltage.

## 47 CFR FCC Part 15.225(e) Frequency Stability Versus Temperature Test Instrumentation

| Instrument | Model | S/No | Cal Due Date |
|---|---|---|---|
| HP Universal Counter | 53132A | 3736A06236 | 05 Apr 2017 |
| Cincinnati Sub-Zero Products, INC. Temperature & Humidity Chamber | ZH-8-1-1-H/AC | ZF9722653 | 28 Dec 2016 |

## 47 CFR FCC Part 15.225(e) Frequency Stability Versus Temperature Test Setup

1. The EUT and supporting equipment were set up as shown in the setup photo. The EUT was placed in an environmental temperature chamber with a nominal supply voltage. For the battery operated EUT, a new battery was used.
2. The RF antenna connector of the EUT was connected to the frequency counter via a low-loss coaxial cable.

## 47 CFR FCC Part 15.225(e) Frequency Stability Versus Temperature Test Method

1. The EUT was switched off and the environmental temperature was set to the highest temperature, i.e, +50°C.
2. Upon reaching the highest set temperature with 30 minutes of stabilisation period, the EUT was switched on and configured to operate in the test mode with transmitting frequency at 13.56MHz.
3. The EUT's transmitting frequency was then measured at start up, and two, five and ten minutes after start up with the frequency counter. For each measurement, the signal capturing was continuous until no further changes were observed. Four measurements were made in total.
4. The EUT was switched off. The environmental chamber temperature was lowered by 10 °C and was allowed the temperature inside the chamber to stabilize.
5. The EUT was turned on and the step 3 was repeated.
6. The steps 3 and 4 were repeated until the lowest temperature was reached, i.e, -20 °C.

**47 CFR FCC Part 15.225(e) Frequency Stability Versus Temperature Results**

| | | | |
|---|---|---|---|
| Test Input Power | 5Vdc | Temperature | See table below |
| | | Relative Humidity | 60% |
| | | Atmospheric Pressure | 1030mbar |
| | | Tested By | Chang Wai Kit |

| Channel Frequency (MHz) | Temperature (°C) | ± 0.01% Carrier Tolerance (Hz) | Measured Tolerance (Hz) | Measurement with respects to Start Up Time (Mins) |
|---|---|---|---|---|
| 13.5600 | 50.0 | ±1356.0000 | 304.9366 | 0 |
| | | ±1356.0000 | 304.6828 | 2 |
| | | ±1356.0000 | 305.2344 | 5 |
| | | ±1356.0000 | 305.2754 | 10 |
| | 40.0 | ±1356.0000 | 298.9100 | 0 |
| | | ±1356.0000 | 299.9900 | 2 |
| | | ±1356.0000 | 300.7700 | 5 |
| | | ±1356.0000 | 301.6300 | 10 |
| | 30.0 | ±1356.0000 | 286.5317 | 0 |
| | | ±1356.0000 | 287.3672 | 2 |
| | | ±1356.0000 | 288.7759 | 5 |
| | | ±1356.0000 | 289.0077 | 10 |
| | 20.0 | ±1356.0000 | 271.7700 | 0 |
| | | ±1356.0000 | 272.7000 | 2 |
| | | ±1356.0000 | 273.9200 | 5 |
| | | ±1356.0000 | 274.2600 | 10 |
| | 10.0 | ±1356.0000 | 258.9500 | 0 |
| | | ±1356.0000 | 259.1100 | 2 |
| | | ±1356.0000 | 259.6800 | 5 |
| | | ±1356.0000 | 260.0400 | 10 |
| | 0.0 | ±1356.0000 | 254.1400 | 0 |
| | | ±1356.0000 | 253.9700 | 2 |
| | | ±1356.0000 | 253.8500 | 5 |
| | | ±1356.0000 | 253.9900 | 10 |
| | -10.0 | ±1356.0000 | 270.4100 | 0 |
| | | ±1356.0000 | 267.2000 | 2 |
| | | ±1356.0000 | 265.1700 | 5 |
| | | ±1356.0000 | 264.5400 | 10 |
| | -20.0 | ±1356.0000 | 303.0900 | 0 |
| | | ±1356.0000 | 310.0600 | 2 |
| | | ±1356.0000 | 316.3800 | 5 |
| | | ±1356.0000 | 316.8400 | 10 |

## 47 CFR FCC Part 15.225(e) Frequency Stability Versus Input Voltage Limits

The EUT shows compliance to the requirements of this section, which states that the frequency tolerance of the carrier frequency shall be ± 0.01% for variation of a primary voltage from 85% to 115% of the rated supply voltage at a temperature of 20°C. For a battery operated equipment, the equipment tests shall be performed using a new battery.

## 47 CFR FCC Part 15.225(e) Frequency Stability Versus Input Voltage Test Instrumentation

| Instrument | Model | S/No | Cal Due Date |
|---|---|---|---|
| HP Universal Counter | 53132A | 3736A06236 | 05 Apr 2017 |
| Cincinnati Sub-Zero Products, INC. Temperature & Humidity Chamber | ZH-8-1-1-H/AC | ZF9722653 | 28 Dec 2016 |

## 47 CFR FCC Part 15.225(e) Frequency Stability Versus Input Voltage Test Setup

1. The EUT and supporting equipment were set up as shown in the setup photo. The EUT was placed in an environmental temperature chamber with a nominal supply voltage. For the battery operated EUT, the EUT was supplied using a variable power supply.
2. The RF antenna connector of the EUT was connected to the frequency counter via a low-loss coaxial cable.

## 47 CFR FCC Part 15.225(e) Frequency Stability Versus Input Voltage Test Method

1. The EUT was switched off and the environmental temperature was set to 20°C.
2. Upon reaching the set temperature with 30 minutes of stabilisation period, the EUT was switched on and configured to operate in the test mode with transmitting frequency at 13.56MHz.
3. The EUT's transmitting frequency was then measured with the spectrum analyser. The signal capturing was continuous until no further changes were observed. Four measurements were made in total.

**47 CFR FCC Part 15.225(e) Frequency Stability Versus Input Voltage Results**

| | | | |
|---|---|---|---|
| Test Input Power | 5Vdc | Temperature | 20°C |
| | | Relative Humidity | 60% |
| | | Atmospheric Pressure | 1030mbar |
| | | Tested By | Chang Wai Kit |

| Channel Frequency (MHz) | Test Input Power (Vdc) | ± 1% Carrier Tolerance (Hz) | Measured Tolerance (Hz) |
|---|---|---|---|
| 13.5600 | 5.00 *(nominal voltage)* | ±1356.0000 | 273.0700 |
| | 4.25 *(85% of nominal voltage)* | ±1356.0000 | 273.3500 |
| | 5.75 *(115% of nominal voltage)* | ±1356.0000 | 273.1700 |

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