


**SK TECH CO., LTD.**

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## TEST REPORT

|                              |   |                         |             |
|------------------------------|---|-------------------------|-------------|
| <b>Test Report No.:</b>      | SKTRFC-120620-014   |                         |             |
| <b>Applicant:</b>            | DUALi Inc.  |                         |             |
| <b>Applicant Address:</b>    | 1-309 Innoplex, 552 Woncheon-dong, Youngtong-gu, Suwon, Gyeonggi-do South Korea                 |                         |             |
| <b>Manufacturer:</b>         | DUALi Inc.  |                         |             |
| <b>Manufacturer Address:</b> | 1-309 Innoplex, 552 Woncheon-dong, Youngtong-gu, Suwon, Gyeonggi-do South Korea                 |                         |             |
| <b>Equipment Under Test:</b> | SMART CARD READER   |                         |             |
| <b>FCC ID:</b>               | SWUDRAGON   | <b>Model No.:</b>       | DRAGON      |
| <b>Brand/Trade Name:</b>     | DUALi Inc.  |                         |             |
| <b>Receipt No.:</b>          | SKTEU12-0533  | <b>Date of receipt:</b> | May 8, 2012 |
| <b>Date of Issue:</b>        | June 20, 2012   |                         |             |
| <b>Location of Testing:</b>  | SK TECH CO., LTD.<br>#820-2, Wolmoon-ri, Wabu-up, Namyangju-si, Kyunggi-do, 472-905 South Korea |                         |             |
| <b>Test Procedure:</b>       | ANSI C63.4-2003   |                         |             |
| <b>Test Specification:</b>   | 47CFR, Part 15 Rules  |                         |             |
| <b>Equipment Class:</b>      | DXT - Part 15 Low Power Transceiver, Rx Verified  |                         |             |
| <b>Test Result:</b>          | The above-mentioned device has been tested and passed.  |                         |             |

Tested &amp; Reported by: Jungtae Kim

Approved by: Jongsoo Yoon

June 20, 2012

Signature

June 20, 2012

Signature

Date

|                       |  |
|-----------------------|--|
| <b>Other Aspects:</b> | -  |
| <b>Abbreviations:</b> | · OK, Pass = passed · Fail = failed · N/A = not applicable |

- This test report is not permitted to copy partly and entirely without our permission.
- This test result is dependent on only equipment to be used.
- This test result is based on a single evaluation of submitted samples of the above mentioned.



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## 1. GENERAL

These tests were performed using the test procedure outlined in ANSI C63.4-2003 for intentional radiators, and in accordance with the limits set forth in FCC Part 15.225. The EUT (Equipment Under Test) has been shown to be capable of compliance with the applicable technical standards.

We attest to the accuracy of data. All measurements reported herein were performed by SK TECH CO., LTD. and were made under Chief Engineer's supervision.

We assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

## 2. TEST SITE

SK TECH CO., LTD.

### 2.1 Location

#820-2, Wolmoon-ri, Wabu-up, Namyangju-si, Kyunggi-do, 472-905 South Korea

(FCC Registered Test Site Number: 938639)

(OPEN AREA TEST SITE INDUSTRY CANADA NUMBER: IC 5429A-1)

This test site is in compliance with ISO/IEC 17025 for general requirements for the competence of testing and calibration laboratories.

This laboratory is recognized as a Conformity Assessment Body (CAB) for CAB's Designation Number: KR0007 by FCC.


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## 2.2 List of Test and Measurement Instruments

| No. | Description                          | Manufacturer  | Model No.     | Serial No.  | Calibrated until | Used                                |
|-----|--------------------------------------|---------------|---------------|-------------|------------------|-------------------------------------|
| 1   | Spectrum Analyzer                    | Agilent       | E4405B        | US40520856  | 2013.03          | <input checked="" type="checkbox"/> |
| 2   | Spectrum Analyzer                    | Agilent       | E4440A        | MY46186322  | 2013.03          | <input checked="" type="checkbox"/> |
| 3   | EMC Spectrum Analyzer                | Agilent       | E7405A        | US40240203  | 2013.03          |                                     |
| 4   | EMI Test Receiver                    | Rohde&Schwarz | ESPI7         | 101206      | 2012.07          | <input checked="" type="checkbox"/> |
| 5   | EMI Test Receiver                    | Rohde&Schwarz | ESIB40        | 100277      | 2013.03          |                                     |
| 6   | EMI Test Receiver                    | Rohde&Schwarz | ESHS10        | 862970/019  | 2012.07          | <input checked="" type="checkbox"/> |
| 7   | Artificial Mains Network             | Rohde&Schwarz | ESH3-Z5       | 836679/018  | 2012.07          | <input checked="" type="checkbox"/> |
| 8   | Pre-amplifier                        | HP            | 8447F         | 3113A05153  | 2012.07          | <input checked="" type="checkbox"/> |
| 9   | Pre-amplifier                        | MITEQ         | AFS44         | 1116321     | 2012.12          |                                     |
| 10  | Pre-amplifier                        | MITEQ         | AFS44         | 1116322     | 2012.07          |                                     |
| 11  | Power Meter                          | Agilent       | E4417A        | MY45100426  | 2012.07          |                                     |
| 12  | Power Meter                          | Agilent       | E4418B        | US39402176  | 2012.07          |                                     |
| 13  | Power Sensor                         | Agilent       | E9327A        | MY44420696  | 2012.07          |                                     |
| 14  | Power Sensor                         | Agilent       | 8482A         | MY41094094  | 2012.07          |                                     |
| 15  | Power Sensor                         | Agilent       | 8485A         | 3318A13916  | 2012.07          |                                     |
| 16  | Attenuator (10dB)                    | HP            | 8491B         | 38067       | 2012.07          |                                     |
| 17  | Attenuator (20dB)                    | Weinschel     | 44            | AH6967      | 2012.07          |                                     |
| 18  | High Pass Filter                     | Wainwright    | WHKX3.0/18G   | 8           | 2012.07          |                                     |
| 19  | VHF Precision Dipole Antenna (TX/RX) | Schwarzbeck   | VHAP          | 1014 / 1015 | 2012.11          |                                     |
| 20  | UHF Precision Dipole Antenna (TX/RX) | Schwarzbeck   | UHAP          | 989 / 990   | 2012.11          |                                     |
| 21  | Loop Antenna                         | Schwarzbeck   | HFH2-Z2       | 863048/019  | 2012.12          | <input checked="" type="checkbox"/> |
| 22  | TRILOG Broadband Antenna             | Schwarzbeck   | VULB9168      | 189         | 2013.05          | <input checked="" type="checkbox"/> |
| 23  | Horn Antenna                         | AH Systems    | SAS-200/571   | 304         | N/A              |                                     |
| 24  | Horn Antenna                         | EMCO          | 3115          | 00040723    | 2013.05          |                                     |
| 25  | Horn Antenna                         | EMCO          | 3115          | 00056768    | 2012.09          |                                     |
| 26  | Horn Antenna                         | Schwarzbeck   | BBHA9170      | BBHA9170318 | 2013.09          |                                     |
| 27  | Vector Signal Generator              | Agilent       | E4438C        | MY42080359  | 2012.07          |                                     |
| 28  | PSG analog signal generator          | Agilent       | E8257D-520    | MY45141255  | 2012.07          |                                     |
| 29  | DC Power Supply                      | HP            | 6633A         | 3325A04972  | 2012.07          |                                     |
| 30  | DC Power Supply                      | HP            | 6622A         | 3348A03223  | 2012.07          |                                     |
| 31  | Temperature/Humidity Chamber         | DAEJIN        | DJ-THC02      | 06071       | 2013.03          | <input checked="" type="checkbox"/> |
| 32  | Hygro/Thermo Graph                   | SATO          | PC-5000TRH-II | -           | 2012.07          | <input checked="" type="checkbox"/> |

## 2.3 Test Date

Date of Test: May 24, 2012 ~ June 18, 2012

## 2.4 Test Environment

See each test item's description.



### **3. DESCRIPTION OF THE EQUIPMENT UNDER TEST**

The product specification described herein was obtained from the product data sheet or user's manual.

#### **3.1 Rating and Physical Characteristics**

|                           |  |
|---------------------------|--|
| Power source              | External USB                               |
| Local Oscillator or X-Tal | X-Tal: 27.12 MHz                           |
| Tx Frequency              | 13.56 MHz                                  |
| Antenna Type              | Internal PCB antenna (83 × 53 mm, 2-turns) |
| Type of Modulation        | ASK  |

\*\*: The equipment authorization for FCC Part 15B as a digital device was made under DoC process with a separate test report number.

#### **3.2 Equipment Modifications**

None

#### **3.3 Submitted Documents**

Block diagram

Schematic diagram

Part List

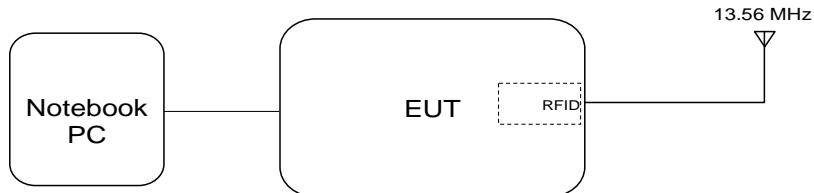
User manual



## 4. MEASUREMENT CONDITIONS

### 4.1 Description of test configuration

The measurements were taken in transmitting RF signals continuously.



[System Block Diagram of Test Configuration]

Test software used: (for Card RFID)DualCard.exe, Ver2.6

### 4.2 List of Peripherals

| Equipment Type               | Manufacturer                         | Model      | S/N                    |
|------------------------------|--------------------------------------|------------|------------------------|
| Notebook PC                  | LENOVO INFORMATION PRODUCTS CO., LTD | 20095      | WB05800041             |
| Adaptor<br>(for Notebook PC) | DELTA ELECTRONICS (JIANGSU) LTD.     | ADP-90DD B | 11S36001941ZZ30023X3CZ |

### 4.3 Type of Used Cables

| # | START       |          | END         |           | CABLE     |                         |
|---|-------------|----------|-------------|-----------|-----------|-------------------------|
|   | NAME        | I/O PORT | NAME        | I/O PORT  | LENGTH(m) | SHIELDED                |
| 1 | EUT         | USB      | Notebook PC | USB       | 0.7       | NO<br>(w/ ferrite core) |
| 2 | Notebook PC | DC Input | Adaptor     | DC Output | 1.8       | NO                      |
| 3 | Adaptor     | AC Input | AC mains    | -         | 1.2       | NO                      |

### 4.4 Uncertainty

| Measurement Item      | Combined Standard Uncertainty<br>$U_c$ | Expanded Uncertainty<br>$U = k \times U_c (k = 2)$ |
|-----------------------|--|--|
| Radiated disturbance  | $\pm 2.30$ dB                          | $\pm 4.60$ dB                                      |
| Conducted disturbance | $\pm 1.96$ dB                          | $\pm 3.92$ dB                                      |



## 5. TEST AND MEASUREMENTS

### Summary of Test Results

| Requirement   | FCC, 47CFR15           | Report Section | Test Result |
|---|------------------------|----------------|-------------|
| Antenna Requirement   | 15.203                 | 5.1            | PASS        |
| Radiated Emissions<br>Field Strength within the band<br>13.553-13.567 MHz   | 15.225(a)              | 5.2            | PASS        |
| Field Strength within the bands<br>13.410-13.553 MHz and 13.567-13.710 MHz<br>13.110-13.410 MHz and 13.710-14.010 MHz | 15.225(b) & (c)        | 5.2            | PASS        |
| Radiated Harmonics and Spurious<br>Emissions Outside of the 13.110 – 14.010 MHz                                       | 15.225(d)<br>15.209(a) | 5.2            | PASS        |
| Frequency Tolerance of Carrier Signal   | 15.225(e)              | 5.3            | PASS        |
| AC Power Line Conducted Emissions   | 15.207(a)              | 5.4            | PASS        |

### 5.1 ANTENNA REQUIREMENT

#### 5.1.1 Regulation

##### FCC 47CFR15 – 15.203

FCC section 15.203, An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of Part 15C. The manufacturer may design the unit so that the user can replace a broken antenna, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of Sections 15.211, 15.213, 15.217, 15.219, or 15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with Section 15.31 (d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this Part are not exceeded.

#### 5.1.2 Result:

**PASS**

The EUT has an integral PCB loop antenna, and meets the requirements of this section.


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## 5.2 RADIATED EMISSIONS

### 5.2.1 Regulation

#### FCC 47CFR15 – 15.225

- (a) The field strength of any emissions within the band 13.553-13.567 MHz shall not exceed 15,848 microvolts/meter at 30 meters.
- (b) Within the bands 13.410-13.553 MHz and 13.567-13.710 MHz, the field strength of any emissions shall not exceed 334 microvolts/meter at 30 meters.
- (c) Within the bands 13.110-13.410 MHz and 13.710-14.010 MHz the field strength of any emissions shall not exceed 106 microvolts/meter at 30 meters.
- (d) The field strength of any emissions appearing outside of the 13.110-14.010 MHz band shall not exceed the general radiated emission limits in § 15.209.

| Frequency (MHz) | Field strength limit ( $\mu$ V/m) @ 30 m | Field strength limit ( $\text{dB}\mu$ V/m) @ 30 m | Field strength limit ( $\text{dB}\mu$ V/m) @ 3 m |
|-----------------|--|---|--|
| 13.110 – 13.410 | 106                                      | 40.5  | 80.5   |
| 13.410 – 13.553 | 334                                      | 50.5  | 90.5   |
| 13.553 – 13.567 | 15,848                                   | 84.0  | 124.0  |
| 13.567 – 13.710 | 334                                      | 50.5  | 90.5   |
| 13.710 – 14.010 | 106                                      | 40.5  | 80.5   |

#### FCC 47CFR15 – 15.209

- (a) Except as provided elsewhere in this Subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

| Frequency (MHz) | Field strength limit ( $\mu$ V/m) | Field strength limit ( $\text{dB}\mu$ V/m) | Measurement Distance (m) |
|-----------------|-----------------------------------|--|--------------------------|
| 0.009 – 0.490   | $2400/F$ (kHz) = 266.7 – 4.9      | 48.5 – 13.8                                | 300                      |
| 0.490 – 1.705   | $24000/F$ (kHz) = 49.0 – 14.1     | 33.8 – 23.0                                | 30                       |
| 1.705 – 30.0    | 30                                | 29.5                                       | 30                       |
| 30 – 88         | 100                               | 40.0                                       | 3                        |
| 88 – 216        | 150                               | 43.5                                       | 3                        |
| 216 – 960       | 200                               | 46.0                                       | 3                        |
| Above 960       | 500                               | 54.0                                       | 3                        |

\* The emission limits shown in the above table are based on measurement instrumentation employing a CISPR quasi-peak detector. For the frequency bands 9 – 90 kHz, 110 – 490 kHz and above 1000 MHz, the radiated emission limits are based on measurements employing an average detector.

\* The lower limit shall apply at the transition frequencies.



## 5.2.2 Measurement Procedure

### Radiated Emissions Test, 9 kHz to 30 MHz (Magnetic Field Test)

1. The preliminary radiated measurements were performed to determine the frequency producing the maximum emissions at a distance of 1 meter or 3 meters according to Section 15.31(f)(2).
2. The EUT was placed on the top of the 0.8-meter height, 1 × 1.5 meter non-metallic table.
3. Emissions from the EUT are maximized by adjusting the orientation of the Loop antenna and rotating the EUT on the turntable. Manipulating the system cables also maximizes EUT emissions if applicable.
4. To obtain the final measurement data, each frequency found during preliminary measurements was re-examined and investigated. The test-receiver system was set up to average, peak, and quasi-peak detector function with specified bandwidth.

### Radiated Emissions Test, above 30 MHz

1. The preliminary radiated measurements were performed to determine the frequency producing the maximum emissions in an anechoic chamber at a distance of 3 meters.
2. The EUT was placed on the top of the 0.8-meter height, 1 × 1.5 meter non-metallic table. To find the maximum emission levels, the height of a measuring antenna was changed and the turntable was rotated 360°.
3. The antenna polarization was also changed from vertical to horizontal. The spectrum was scanned from 30 to 1000 MHz using the TRILOG broadband antenna
4. To obtain the final measurement data, the EUT was arranged on a turntable situated on a 4 × 4 meter at the Open Area Test Site. The EUT was tested at a distance 3 meters.
5. Each frequency found during preliminary measurements was re-examined and investigated. The test-receiver system was set up to average, peak, and quasi-peak detector function with specified bandwidth.
6. The EUT is situated in three orthogonal planes (if appropriate)
7. The presence of ambient signals was verified by turning the EUT off. In case an ambient signal was detected, the measurement bandwidth was reduced temporarily and verification was made that an additional adjacent peak did not exist. This ensures that the ambient signal does not hide any emissions from the EUT.

**5.2.3 Calculation of the field strength limits below 30 MHz**

1. No special calculation for obtaining the field strength in dB $\mu$ V/m is necessary, because the EMI receiver and the active loop antenna operate as a system, where the reading gives directly the field strength result (dB $\mu$ V/m). The antenna factors and cable losses are already taken into consideration.
2. For test distance other than what is specified, but fulfilling the requirements of section 15.31 (f) (2) the field strength is calculated by adding additionally an extrapolation factor of 40dB/decade (inverse linear distance for field strength measurements).
3. All following emission measurements were performed using the test receiver's average, peak, and quasi-peak detector function with specified bandwidth.
4. The basic equation is as follows;

$$FS = RA + DF$$

Where

FS = Field strength in dB $\mu$ V/m

RA = Receiver Amplitude in dB $\mu$ V/m

DF = Distance Extrapolation Factor in dB

Where  $DF = 40\log(D_{TEST} / D_{SPEC})$  where  $D_{TEST}$  = Test Distance and  $D_{SPEC}$  = Specified Distance

$DF = 40\log(3m/300m) = -80$ dB, for frequency band: 0.009 to 0.490MHz

$DF = 40\log(3m/30m) = -40$ dB, for frequency band: 0.490 to 30MHz


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**5.2.4 Test Results:**
**PASS**
**Table 1: Field strength below 30 MHz**

| Frequency<br>[MHz]  | RBW<br>[kHz] | Reading<br>[dB( $\mu$ V/m)] | Cable Loss<br>[dB] | Actual<br>[dB( $\mu$ V/m)] | Limit (at 3m)<br>[dB( $\mu$ V/m)] | Margin<br>[dB] |
|---|--------------|-----------------------------|--------------------|----------------------------|-----------------------------------|----------------|
| <b>Emissions Quasi-peak DATA under 15.225(a), (b)&amp;(c)</b> |              |                             |                    |                            |                                   |                |
| 13.560 0  | 9            | 68.11                       | 0.3                | 68.41                      | 124.0                             | 55.59          |
|   |              |                             |                    |                            |                                   |                |
|   |              |                             |                    |                            |                                   |                |
| <b>Emissions Quasi-peak DATA under 15.225(d), 15.209</b>      |              |                             |                    |                            |                                   |                |
| 27.13   | 9            | ---                         | 0.3                | ---                        | 69.5                              | ---            |
|   |              |                             |                    |                            |                                   |                |

**Actual ( $\text{dB}\mu\text{V}/\text{m}$ ) = Reading + Cable Loss**
**Margin (dB) = Limit – Actual**

Remark: "---" means the emission level was too low to be measured or in the noise floor.

**Table 2: Measured values of the Field strength (above 30 MHz)**

| Frequency<br>[MHz] | RBW<br>[kHz] | POL<br>[V/H] | ANT<br>[m] | Reading<br>[dB $\mu$ V] | AMP<br>[dB] | AF<br>[dB/m] | CL<br>[dB] | Actual<br>[dB $\mu$ V/m] | Limit<br>[dB $\mu$ V/m] | Margin<br>[dB] |
|--------------------|--------------|--------------|------------|-------------------------|-------------|--------------|------------|--------------------------|-------------------------|----------------|
| 487.74             | 100          | H            | 1.68       | 47.12                   | 28.96       | 17.43        | 2.76       | 38.35                    | 46.00                   | 7.65           |
| 487.74             | 100          | V            | 1.86       | 45.33                   | 28.96       | 17.43        | 2.76       | 36.56                    | 46.00                   | 9.44           |
| 786.60             | 100          | H            | 1.34       | 42.11                   | 28.83       | 21.99        | 3.54       | 38.81                    | 46.00                   | 7.19           |
| 786.60             | 100          | V            | 1.64       | 43.26                   | 28.83       | 21.99        | 3.54       | 39.96                    | 46.00                   | 6.04           |
| 840.92             | 100          | H            | 1.44       | 41.79                   | 28.70       | 22.46        | 3.68       | 39.23                    | 46.00                   | 6.77           |
| 840.92             | 100          | V            | 1.52       | 42.75                   | 28.70       | 22.46        | 3.68       | 40.19                    | 46.00                   | 5.81           |
| 868.08             | 100          | H            | 1.45       | 42.19                   | 28.64       | 22.62        | 3.74       | 39.91                    | 46.00                   | 6.09           |
| 868.08             | 100          | V            | 1.69       | 42.59                   | 28.64       | 22.62        | 3.74       | 40.31                    | 46.00                   | 5.69           |
| 895.24             | 100          | H            | 1.46       | 43.32                   | 28.57       | 22.78        | 3.79       | 41.32                    | 46.00                   | 4.68           |
| 892.24             | 100          | V            | 1.54       | 41.68                   | 28.58       | 22.76        | 3.78       | 39.64                    | 46.00                   | 6.36           |
| 922.40             | 100          | H            | 1.37       | 43.80                   | 28.51       | 23.31        | 3.85       | 42.45                    | 46.00                   | 3.55**         |
| 922.40             | 100          | V            | 1.56       | 42.58                   | 28.51       | 23.31        | 3.85       | 41.23                    | 46.00                   | 4.77           |
| 949.56             | 100          | H            | 1.36       | 43.01                   | 28.45       | 23.91        | 3.91       | 42.38                    | 46.00                   | 3.62**         |
| 949.56             | 100          | V            | 1.48       | 43.19                   | 28.45       | 23.91        | 3.91       | 42.56                    | 46.00                   | 3.44**         |

**Margin (dB) = Limit – Actual**
**[Actual = Reading + AF + CL]**

1. H = Horizontal, V = Vertical Polarization

2. AF/CL = Antenna Factor and Cable Loss

NOTE: 1. All emissions not reported were more than 20 dB below the specified limit or in the noise floor.

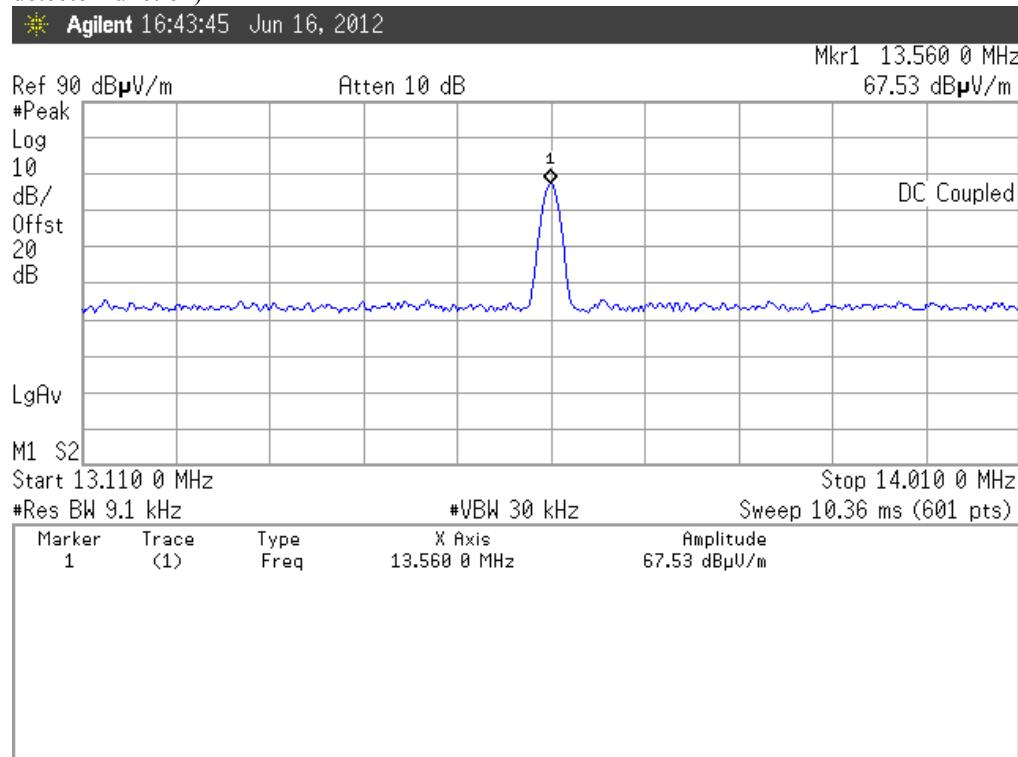
2. These test results of Table 1 and Table 2 were measured at the 3 m distance.

**\*\* The measured result is within the test standard limit by a margin less than the measurement uncertainty; it is therefore not possible to state compliance based on the 95 % level of confidence. However, the result indicates that compliance is more probable than non-compliance.**

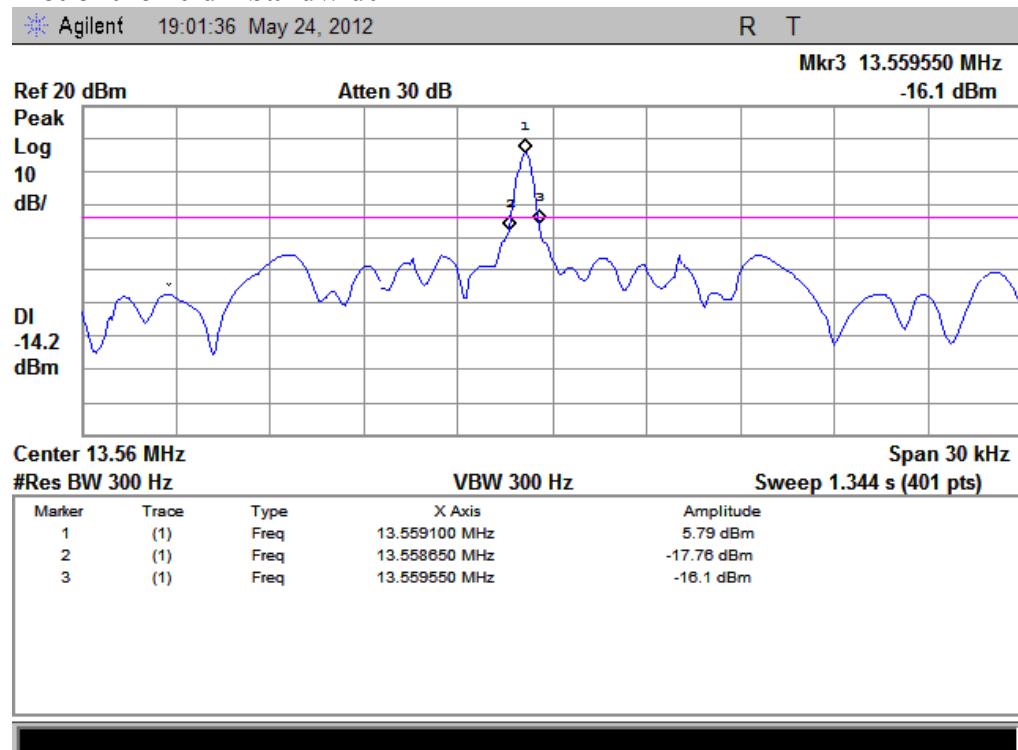

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**Figure 1. Plot of the Band edge** (Preliminary measurement in the anechoic chamber at 3 m distance to find out the frequencies, at which the spurious emissions occur, with the peak detector function)



**Figure 2. Plot of the 20 dB bandwidth**





## 5.3 FREQUENCY TOLERANCE OF CARRIER SIGNAL

### 5.3.1 Regulation

#### FCC 47CFR15 – 15.225(e)

The frequency tolerance of the carrier signal shall be maintained within +/- 0.01% of the operating frequency over a temperature variation of -20 degrees to +50 degrees C at normal supply voltage, and for a variation in the primary supply voltage from 85% to 115% of the rated supply voltage at a temperature of 20 degrees C. For battery-operated equipment, the equipment tests shall be performed using a new battery.

### 5.3.2 Measurement Procedure

#### Frequency stability versus environmental temperature

1. Supply the EUT with nominal AC voltage.
2. Turn the EUT off, and place it inside an environmental temperature chamber. For devices that are normally operated continuously, the EUT may be energized while inside the test chamber. For devices that have oscillator heaters, energize only the heater circuit while the EUT is inside the chamber.
3. RF output was connected to a frequency counter or other frequency-measuring instrument via feed through attenuators.
4. Set the temperature control on the chamber to the highest specified EUT operating temperature, and allow the temperature inside the chamber to stabilize at the set temperature before starting frequency measurements.
5. While maintaining a constant temperature inside the environmental chamber, turn the EUT on and record the operating frequency at startup and two, five, and ten minutes after the EUT is energized.
6. After all measurements have been made at the highest specified temperature turn the EUT off.
7. Repeat the above measurement process for the EUT with the test chamber set at the appropriate temperature.

#### Frequency Stability versus Input Voltage

1. At room temperature ( $20 \pm 5$ ) °C supply the EUT with nominal AC voltage.
2. Couple RF output to a frequency counter or other frequency-measuring instrument.
3. Turn the EUT on, and measure the EUT operating frequency at startup and two, five, and ten minutes after startup.
4. Supply it with 85 % of the nominal AC voltage and repeat the above procedure.
5. Supply it with 115 % of the nominal AC voltage and repeat the above procedure.


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**5.3.3 Test Results:**
**PASS**
**Table 3: Frequency Tolerance**
**Reference Frequency: 13.5600MHz, LIMIT: within  $\pm 1$  356 Hz**

| Environment Temperature<br>[°C] | Power Supplied<br>[V <sub>AC</sub> ] | Carrier Frequency Measured with Time Elapsed |          |           |          |           |          |            |          |
|---------------------------------|--------------------------------------|--|----------|-----------|----------|-----------|----------|------------|----------|
|                                 |                                      | STARUP                                       |          | 2 minutes |          | 5 minutes |          | 10 minutes |          |
|                                 |                                      | [MHZ]  | Err [Hz] | [MHZ]     | Err [Hz] | [MHZ]     | Err [Hz] | [MHZ]      | Err [Hz] |
| +50                             | 120                                  | 13.559125                                    | -875     | 13.559125 | -875     | 13.559127 | -873     | 13.559132  | -868     |
| +40                             | 120                                  | 13.559141                                    | -859     | 13.559135 | -865     | 13.559131 | -869     | 13.559129  | -871     |
| +30                             | 120                                  | 13.559164                                    | -836     | 13.559159 | -841     | 13.559152 | -848     | 13.559147  | -853     |
| +20                             | 120                                  | 13.559166                                    | -834     | 13.559166 | -834     | 13.559167 | -833     | 13.559169  | -831     |
| +10                             | 120                                  | 13.559165                                    | -835     | 13.559177 | -823     | 13.559189 | -811     | 13.559197  | -803     |
| 0                               | 120                                  | 13.559212                                    | -788     | 13.559218 | -782     | 13.559225 | -775     | 13.559232  | -768     |
| -10                             | 120                                  | 13.559239                                    | -761     | 13.559243 | -757     | 13.559248 | -752     | 13.559251  | -749     |
| -20                             | 120                                  | 13.559253                                    | -747     | 13.559256 | -744     | 13.559256 | -744     | 13.559255  | -745     |

**Reference Frequency: 13.5600MHz, LIMIT: 100 PPM (within  $\pm 1$  356 Hz)**

| Power Supplied<br>[V <sub>AC</sub> ] | Carrier Frequency Measured with Time Elapsed |          |           |          |           |          |            |          |
|--------------------------------------|--|----------|-----------|----------|-----------|----------|------------|----------|
|                                      | STARUP                                       |          | 2 minutes |          | 5 minutes |          | 10 minutes |          |
|                                      | [MHZ]  | Err [Hz] | [MHZ]     | Err [Hz] | [MHZ]     | Err [Hz] | [MHZ]      | Err [Hz] |
| 85 %                                 | 13.559166                                    | -834     | 13.559166 | -834     | 13.559167 | -833     | 13.559168  | -832     |
| 100 %                                | 13.559166                                    | -834     | 13.559166 | -834     | 13.559167 | -833     | 13.559169  | -831     |
| 115 %                                | 13.559165                                    | -835     | 13.559165 | -835     | 13.559166 | -834     | 13.559168  | -832     |

**Err [Hz] = Measured carrier frequency (MHz) - Reference Frequency (13.56 MHz)**



## 5.4 AC POWER LINE CONDUCTED EMISSIONS

### 5.4.1 Regulation

#### FCC 47CFR15 – 15.207(a)

According to §15.207(a), for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a  $50\mu\text{H}/50\Omega$  line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

| Frequency of emission (MHz) | Conducted limit (dB $\mu\text{V}$ ) |            |
|-----------------------------|-------------------------------------|------------|
|                             | Quasi-peak                          | Average    |
| 0.15 – 0.5                  | 66 to 56 *                          | 56 to 46 * |
| 0.5 – 5                     | 56                                  | 46         |
| 5 – 30                      | 60                                  | 50         |

\* Decreases with the logarithm of the frequency.

### 5.4.2 Test Procedure

1. The EUT was placed on a wooden table of size, 1 m by 1.5 m, raised 80 cm in which is located 40 cm away from the vertical wall and 1.5m away from the side wall of the shielded room.
2. Each current-carrying conductor of the EUT power cord was individually connected through a  $50\Omega/50\mu\text{H}$  LISN, which is an input transducer to a Spectrum Analyzer or an EMI/Field Intensity Meter, to the input power source.
3. Exploratory measurements were made to identify the frequency of the emission that had the highest amplitude relative to the limit by operating the EUT in a range of typical modes of operation, cable position, and with a typical system equipment configuration and arrangement. Based on the exploratory tests of the EUT, the one EUT cable configuration and arrangement and mode of operation that had produced the emission with the highest amplitude relative to the limit was selected for the final measurement.
4. The final test on all current-carrying conductors of all of the power cords to the equipment that comprises the EUT (but not the cords associated with other non-EUT equipment is the system) was then performed over the frequency range of 0.15 MHz to 30 MHz.
5. The measurements were made with the detector set to PEAK amplitude within a bandwidth of 10 kHz or to QUASI-PEAK and AVERAGE within a bandwidth of 9 kHz. The EUT was in transmitting mode during the measurements.



## 5.4.3 Test Results:

PASS

Table 4: Measured values of the Conducted Emissions

| Frequency<br>[MHz]     | Reading<br>[dB $\mu$ V] | L / N | CF<br>[dB] | CL<br>[dB] | Actual<br>[dB $\mu$ V] | Limit<br>[dB $\mu$ V] | Margin<br>[dB] |
|------------------------|-------------------------|-------|------------|------------|------------------------|-----------------------|----------------|
| <b>QUASI-PEAK DATA</b> |                         |       |            |            |                        |                       |                |
| 0.3750                 | 33.52                   | L     | 0.22       | 0.02       | 33.76                  | 58.39                 | 24.63          |
| 0.4400                 | 40.19                   | L     | 0.22       | 0.03       | 40.44                  | 57.06                 | 16.62          |
| 0.4850                 | 40.03                   | N     | 0.22       | 0.04       | 40.29                  | 56.25                 | 15.96          |
| 0.5000                 | 41.96                   | L     | 0.22       | 0.04       | 42.22                  | 56.00                 | 13.78          |
| 0.5650                 | 36.92                   | L     | 0.22       | 0.04       | 37.18                  | 56.00                 | 18.82          |
| 0.5700                 | 37.91                   | N     | 0.22       | 0.04       | 38.17                  | 56.00                 | 17.83          |
| 0.5900                 | 42.45                   | L     | 0.22       | 0.04       | 42.71                  | 56.00                 | 13.29          |
| 0.5950                 | 42.57                   | N     | 0.22       | 0.04       | 42.83                  | 56.00                 | 13.17          |
| 0.6900                 | 41.11                   | N     | 0.23       | 0.04       | 41.38                  | 56.00                 | 14.62          |
| 0.7850                 | 40.40                   | L     | 0.20       | 0.05       | 40.65                  | 56.00                 | 15.35          |
| 0.8850                 | 33.07                   | L     | 0.17       | 0.06       | 33.30                  | 56.00                 | 22.70          |
| 13.5600                | 36.79                   | L     | 0.79       | 0.23       | 37.81                  | 60.00                 | 22.19          |
| <b>AVERAGE DATA</b>    |                         |       |            |            |                        |                       |                |
| 0.3750                 | 24.02                   | L     | 0.22       | 0.02       | 24.26                  | 48.39                 | 24.13          |
| 0.4400                 | 29.41                   | L     | 0.22       | 0.03       | 29.66                  | 47.06                 | 17.40          |
| 0.4850                 | 23.18                   | N     | 0.22       | 0.04       | 23.44                  | 46.25                 | 22.81          |
| 0.5000                 | 31.78                   | L     | 0.22       | 0.04       | 32.04                  | 46.00                 | 13.96          |
| 0.5650                 | 23.67                   | L     | 0.22       | 0.04       | 23.93                  | 46.00                 | 22.07          |
| 0.5700                 | 23.01                   | N     | 0.22       | 0.04       | 23.27                  | 46.00                 | 22.73          |
| 0.5900                 | 23.82                   | L     | 0.22       | 0.04       | 24.08                  | 46.00                 | 21.92          |
| 0.5950                 | 23.75                   | N     | 0.22       | 0.04       | 24.01                  | 46.00                 | 21.99          |
| 0.6900                 | 26.43                   | N     | 0.23       | 0.04       | 26.70                  | 46.00                 | 19.30          |
| 0.7850                 | 23.25                   | L     | 0.20       | 0.05       | 23.50                  | 46.00                 | 22.50          |
| 0.8850                 | 21.30                   | L     | 0.17       | 0.06       | 21.53                  | 46.00                 | 24.47          |
| 13.5600                | 35.86                   | L     | 0.79       | 0.23       | 36.88                  | 50.00                 | 13.12          |

Margin (dB) = Limit – Actual

[Actual = Reading + CF + CL]

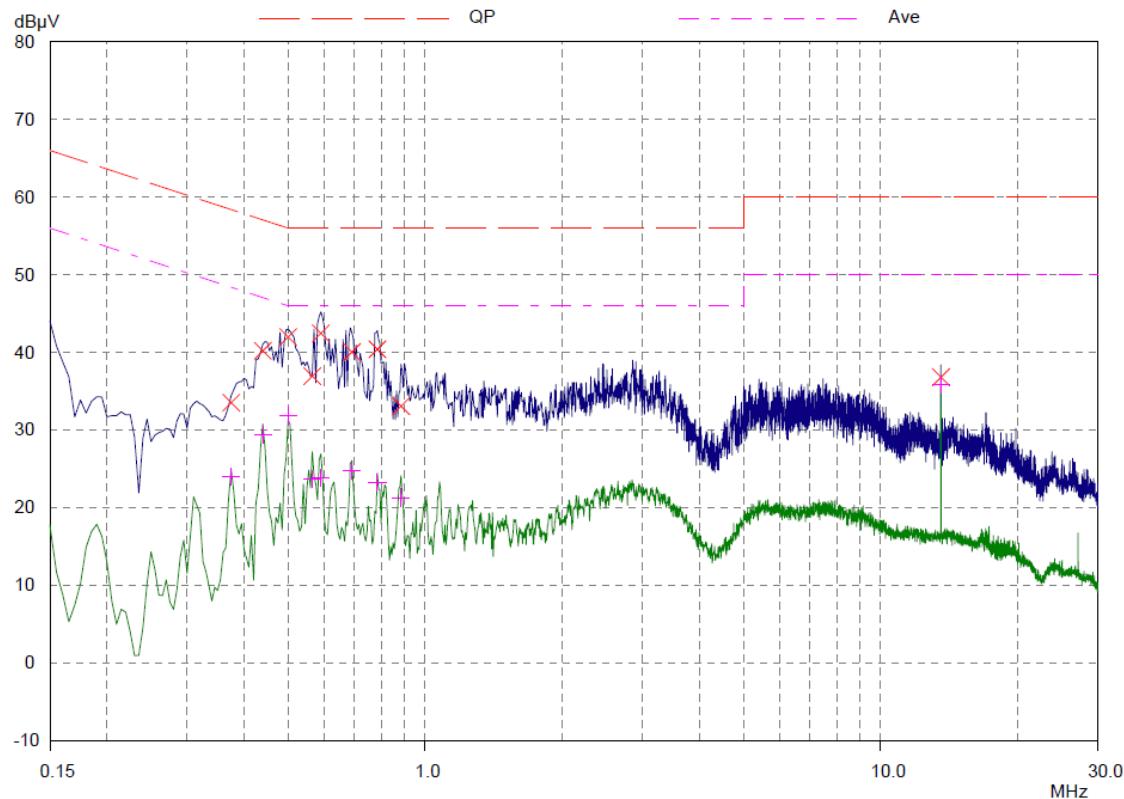
L/N = LINE / NEUTRAL

CF/CL = Correction Factor and Cable Loss

NOTE: All emissions not reported were more than 20 dB below the specified limit.

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**Figure 3. Plot of the Conducted Emissions****Line – PE (Peak and Average detector used)****Neutral – PE (Peak and Average detector used)**