International Compliance Laboratories

# FCC Part 15 Subpart C
# Transmitter Certification Test Report

## Direct Sequence Spread Spectrum Transmitter

**ICL Report # 2119 Rev 1**
**FCC ID: 2AC46-DH001**

**Test Specification: FCC Rule Part: 15.247**

**Manufacturer: Mesh Systems, LLC**
**Model Name: ActiveSense Hub**
**Model Number: HB1**
**Serial Number: 2119A (Defined at ICL)**

**Test Start Date: October 7, 2015**
**Test End Date: February 12, 2016**

**Report Issue Date: February 23, 2016**

**Test Result: Pass**

**Prepared By:**

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**Reviewed By:**

Ronald W. Zimmerman

**Ronald W. Zimmerman**
**ICL President and NCE**

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## 1.0 Purpose

The purpose of this report is to demonstrate compliance with Part 15, Subpart C of the FCC's Code of Federal Regulations.

## 2.0 Summary of Testing

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| FCC 15.207 | Power Line Conducted Emissions | MEETs Requirement |
| FCC 15.247(a) | 6dB Bandwidth | MEETs Requirement |
| FCC 15.247(c) | Occupied Bandwidth and Band Edge Compliance | MEETs Requirements |
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| FCC 15.247(d),15.205, and 15.209 | Emissions in Restricted Bands | MEETs Requirement |
| FCC 15.247(i), 1.1307, 1.1310, 2.1091, 2.1093 | RF Exposure Limits | MEETs Requirements |

## 3.0 Reference Documents

The following standards were used:

ANSI C63.4-2009: American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 KHz to 40GHz

US Code of Federal Regulations (CFR): Title 47 - Telecommunication, Chapter I – Federal Communications Commission, Subchapter A – General, Part 1, *Practice and Procedure (Oct. 1,* 2014)

US Code of Federal Regulations (CFR) Title 47 – Telecommunication, Chapter I – Federal Communications Commission, Subchapter A – General, Part 2, *Frequency Allocations and radio Treaty Matters; General Rules and Regulations (Oct. 1, 2014)*

US Code of Federal Regulations (CFR): Title 47, Part 15, Subpart C: *Radio Frequency Devices, Intentional Radiators (October 1, 2014)*

FCC KDB Publication No. 558074 dated June 9, 2015: Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247

FCC KDB Publication No. 447498 dated October 23, 2015: RF Exposure Procedures and Equipment Authorization Policies for Mobile and Portable Devices

*Hub–Theory of Operation* document provided by Mesh Systems, LLC.

*Test Set-Up Photos.pdf* document provided by International Compliance Laboratories, LLC

# 4.0 Product Description

Details on the EUT and its general operation can be found in the *Hub – Theory of Operation.docx* provided by Mesh Systems, LLC.

## 4.1 FCC-IDs

The FCC-ID for this product (the EUT) is 2AC46-DH001

Additionally the approved module (cell phone modem) is integrated into the EUT and has an FCC-ID of MIVCNN0301.

## 4.2 Product Name

ActiveSense Hub.
Note: During testing a code name of “Gateway” was used. This may occasionally be seen in the data presented.

## 4.3 Product Description

The Hub is a telemetry device that allows remote management and control of wireless sensors.

## 4.4 Model Number

HB1

## 4.5 Unit Serial Number

2119A (Defined at ICL)

## 4.6 Printed Circuit Board Information

A label on top of the printed circuit board had the following information: “4150759”, a bar code, and “000013 P117797B” below the bar code.

## 4.7 Transmitter Frequency of Operation

Four discrete frequencies are used. They are 904.5MHz, 910.5MHz, 919.5MHz, and 926.5MHz

## 4.8 Other Internal Frequencies

Other internal frequencies for the product are 32.768kHz, 4MHz, and 40MHz

## 4.9 Antennas

The product has two antennas. One for the cell phone modem (already certified) and one for the transceiver to be certified. Both antennas are the same. They can be described as pentaband multiposition captive antennas manufactured by Embedded Antenna Desgin, LTD with part number “FPTF35313-IPX-12-5” (PTF2100 with 125mm cable and IPEX).

The antennas are mounted to the enclosure in a parallel fashion (see external photos) and are either placed at a 90 degree angle when the enclosure is placed flat or upright when the enclosure is set on end. These antenna positions were taken into account during radiated emissions investigations.

### 4.10 Gain

The EUT's transmitter was initially set at a gain of +1dBm (setting "37"). Due to intermodulation products found in the co-location investigation with the modem module's transmissions, the gain needed to be reduced to -4dBm (setting "27"). All measurement data will detail the gain setting was used at the time of its test. The manufacturer agreed to this new gain setting of -4dBM (setting "27").

### 4.11 Power Source

The EUT was powered by two power supplies from CUI Inc.:

1. P/N: EPSA050250U-P5P-EJ, Model No.:EPSA050250U, Input:100-240V~0.4A,50-60Hz, Output:+5V⎓2.5A installed with one pass through the ferrite core of a snap-on Laird P/N: 28A0392-0A2 near the EUT side (not AC plug side). **Note: This ferrite was necessary to pass radiated emissions testing with this supply and was present during power line conducted emissions testing.**
2. P/N: SWI12-5-N-P5-C1, Model: ATS012T-W051U LPS, Input:100-240V~50-60Hz 0.31A MAX, Output:5.0V⎓2.5A 12.5W MAX. A ferrite already comes installed on this power supply from the manufacturer and is inclusive in the part number.

The customer related that the 1st power supply would be initially marketed with the product and then a transition from the 1st to the 2nd power supply would occur. Both power supplies were assessed for compliance.

### 4.12 Cables

Two USB cables were used to populated ports on the product. The top port was populated with a standard USB 2.0 plug to mini-USB plug measuring approximately 77cm long. The bottom port was populated with a standard USB 2.0 plug to min-USB plug measuring approximately 150cm long. The bottom port allowed ICL to send commands to the unit for transmitter configuration.

## 5.0 Auxiliary Equipment Information

To configure the EUT's channel of transmission, turn on 100% duty/modulated output for a set duration, and transmit packets in a typical manner an auxiliary terminal was necessary.

A computer driver for the EUT was also necessary to install. Mesh Systems, LLC provided an ".inf" file entitled "MeshSystems_4150760".

A hyper-terminal was set-up for 9600 Baud, 8 Data bits, No Parity, 1 Stop bit, and No Flow Control. The ASCII settings were configured to "Send line ends with line feeds" and "Append line feeds to incoming to incoming lines" and "Wrap lines that extend terminal width"

When connected via USB cable to mini-USB on the bottom min-USB port that EUT could be given commands.

Mesh Systems, LLC provided the commands to configure channels, the cell phone modem, and transmit packets.

An ActiveSense Rodent Sensor was used as an auxiliary piece of equipment to evaluate measurements during typical communications between the Hub and the Sensor. When the Sensor was swept with a magnetic it would communicate with the Hub in a typical fashion.

# 6.0 Manufacturer Information

Mesh Systems, LLC
N1070 Quality Drive
Greenville, WI 54942

Contact: Nate Welch
Title: Engineering Technician
Phone: (920) 363-0563
FAX: (317) 661-4801
Email: nate.welch@mesh-systems.com
Website: http://mesh-systems.com/

# 7.0 Test Facilities

## 7.1 Location

The radiated and conducted emissions test sites are located at the following address:

International Compliance Laboratories, LLC
1057 Tullar Court
Neenah, WI 54904
Phone: (920) 720-5555
Fax: (920) 720-5556

## 7.2 Laboratory Accreditations/Recognitions/Certifications

The Semi-Anechoic Chamber Test Site and Conducted Emissions Site have been fully described, submitted to, and accepted by the FCC, Industry Canada. In addition, ICL is compliant to ISO 17025 as certified by the American Association for Laboratory Accreditation (A2LA) under their National Voluntary Laboratory Accreditation Program. The following certification numbers have been issued in recognition of these accreditations and certifications:

FCC Test Firm Registration Number: 918349
A2LA Certificate Number: 2599.01

# Accredited Laboratory

A2LA has accredited

## INTERNATIONAL COMPLIANCE LABORATORIES, LLC

*Neenah, WI*

for technical competence in the field of

## Electrical Testing

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005 *General requirements for the competence of testing and calibration laboratories*. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (*refer to joint ISO-ILAC-IAF Communiqué dated 8 January 2009*).

Presented this 6th day of June 2014.

President & CEO
For the Accreditation Council
Certificate Number 2599.01
Valid to April 30, 2016

*For the tests or types of tests to which this accreditation applies, please refer to the laboratory's Electrical Scope of Accreditation.*

American Association for Laboratory Accreditation

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005

INTERNATIONAL COMPLIANCE LABORATORIES, LLC
1057 Tullar Court
Neenah WI 54956
Ronald W. Zimmerman Phone: 920 720 5555

ELECTRICAL (EMC)

Valid to: April 30, 2016 Certificate Number: 2599.01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following electromagnetic compatibility and product safety tests:

| **Test Technology:** | **Test Method(s):** |
|---|---|
| *Emissions* | |
| RF (Radiated and Conducted) | CFR 47 FCC, Part 15 (using ANSI C63.4:2009) (*up to 18 GHz*);<br>CFR 47 FCC, Part 18 (using MP-5);<br>CISPR 11 (*up to 1 GHz*);<br>EN 55011 (*up to 1 GHz*);<br>CISPR 14-1 (*excluding clause 6*);<br>EN 55014-1 (*excluding clause 6*);<br>CISPR 15 (*clause 8 only*);<br>EN 55015 (*clause 8 only*);<br>CISPR 22;<br>EN 55022;<br>ICES-001; ICES-003 |
| Harmonic Current Emissions | IEC 61000-3-2; EN 61000-3-2 |
| Voltage Fluctuations and Flicker | IEC 61000-3-3; EN 61000-3-3 |
| *Immunity* | |
| Electrostatic Discharge (ESD) | IEC 61000-4-2 |
| Radiated Immunity | IEC 61000-4-3 (*up to 2.7 GHz*) |
| Electrical Fast Transients (EFT)/Burst | IEC 61000-4-4 |
| Electrical Surge | IEC 61000-4-5 |
| Conducted Immunity | IEC 61000-4-6 |

(A2LA Cert. No. 2599.01) Revised 09/30/2015 Page 1 of 3

5202 Presidents Court, Suite 220 | Frederick, MD 21703-8398 | Phone: 301 644 3248 | Fax: 240 454 9449 | www.A2LA.org

| **Test Technology:** | **Test Method(s):** |
|---|---|
| *Immunity (Cont'd)* | |
| Power Frequency and Magnetic Field | IEC 61000-4-8 (*excluding short duration mode*) |
| Voltage Dip, Interruptions, and Variations | IEC 61000-4-11 |
| *Generic and Product Specific EMC Standards* | |
| Generic Immunity Residential | IEC 61000-6-1; EN 61000-6-1 |
| Generic Immunity Industrial | IEC 61000-6-2; EN 61000-6-2 |
| Generic Emissions Residential | IEC 61000-6-3 (*up to 16A*); EN 61000-6-3 (*up to 16A*) |
| Generic Emissions Industrial | IEC 61000-6-4; EN 61000-6-4 |
| Laboratory Equipment | IEC 61326-1; EN 61326-1 |
| Medical Equipment | IEC 60601-1-2:2001; IEC 60601-1-2 |
| Information Technology Equipment | CISPR 24; EN 55024 |
| Household Appliances and Similar | CISPR 14-2; EN 55014-2 |
| Industry Canada Radio Tests | RSS-GEN; RSS-210 *(up to 18 GHz)* |
| *ETSI Radio Tests* | |
| Immunity | EN 301 489-1 *(up to 16A)*; EN 301 489-17 |
| *Automotive Component EMC* | |
| Emissions | CISPR 25; SAE J1113-41 |
| Bulk Current Injection (BCI) | SAE J1113-4; ISO 11452-4 |
| Electrostatic Discharge (ESD) | SAE J1113-13; ISO 10605 |
| Radiated RF Immunity | SAE J1113-21; ISO 11452-2 |
| Electrical Transients | SAE J1113-11; ISO 7637-2 |

| **Test Technology:** | **Test Method(s):** |
|---|---|
| *Harley Davidson Component EMC* | |
| Engineering Guideline | EG-812-22614 |
| Radiated Emissions | EG-812-22614-401 |
| Conducted Emissions | EG-812-22614-402 |
| Bulk Current Injection (BCI) | EG-812-22614-405 |
| Electrostatic Discharge (ESD) | EG-812-22614-407 |
| *United Nations UNECE* | |
| Emissions | E/ECE/324 Addendum 9: Regulation 10, Annexes 7 and 8 |
| Immunity | E/ECE/324 Addendum 9: Regulation 10, Annex 9 |

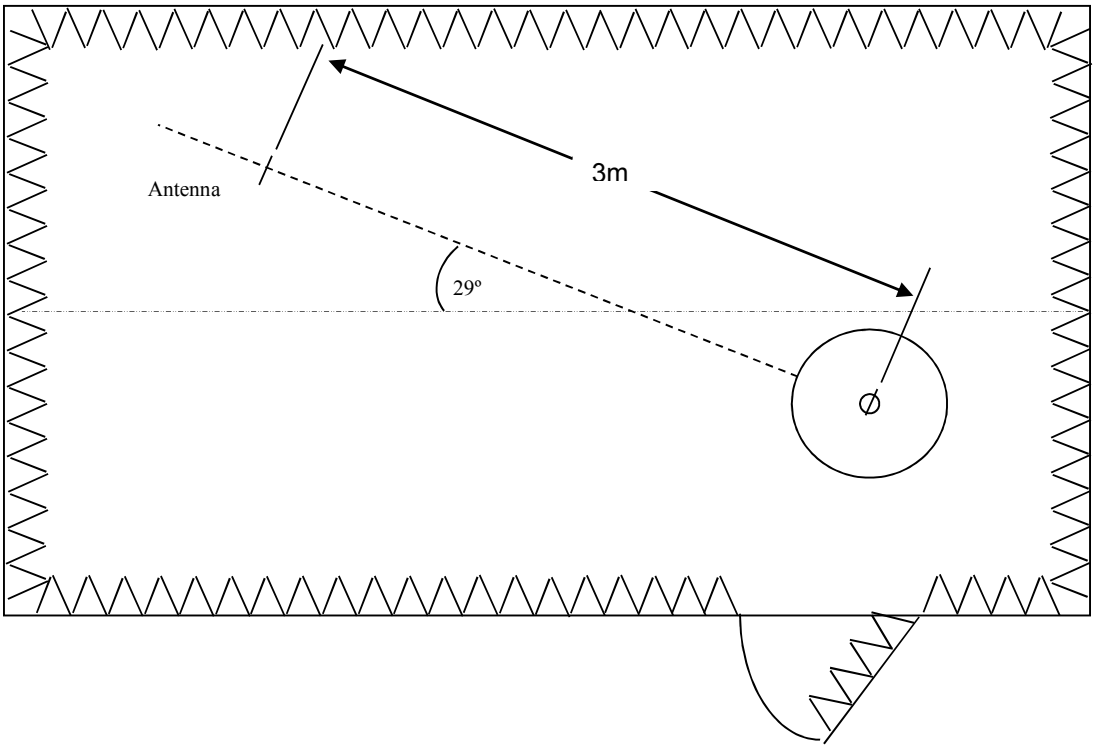
On the following products or types of products:
Light Industrial, Commercial, Residential, Heavy Industrial, Scientific, Medical, Portable Test and Measurement Equipment, Information Technology Equipment, Telecom, Automotive, and other Electrical and Electronic Equipment

# 8.0 Test Site Facility Description

## 8.1 Semi-Anechoic Chamber Test Site

The semi-anechoic chamber is a Series 81 EMC test chamber manufactured by ETS – Rayproof. This chamber was recently moved in 2006 to International Compliance Laboratories in Neenah, WI. The interior walls and ceiling are completely covered with 4" x 4" ferrite tiles and 16" absorber cones. The chamber is also equipped with a 1.2 meter flush mounted turntable. The test chamber's dimensions are 30ft. x 20ft. x 20ft. The test volume is 2.0-meter in diameter and 2 meters high and is centered on the turntable.

A diagram of the Semi-Anechoic Chamber Test Site is shown in Figure 1 below:



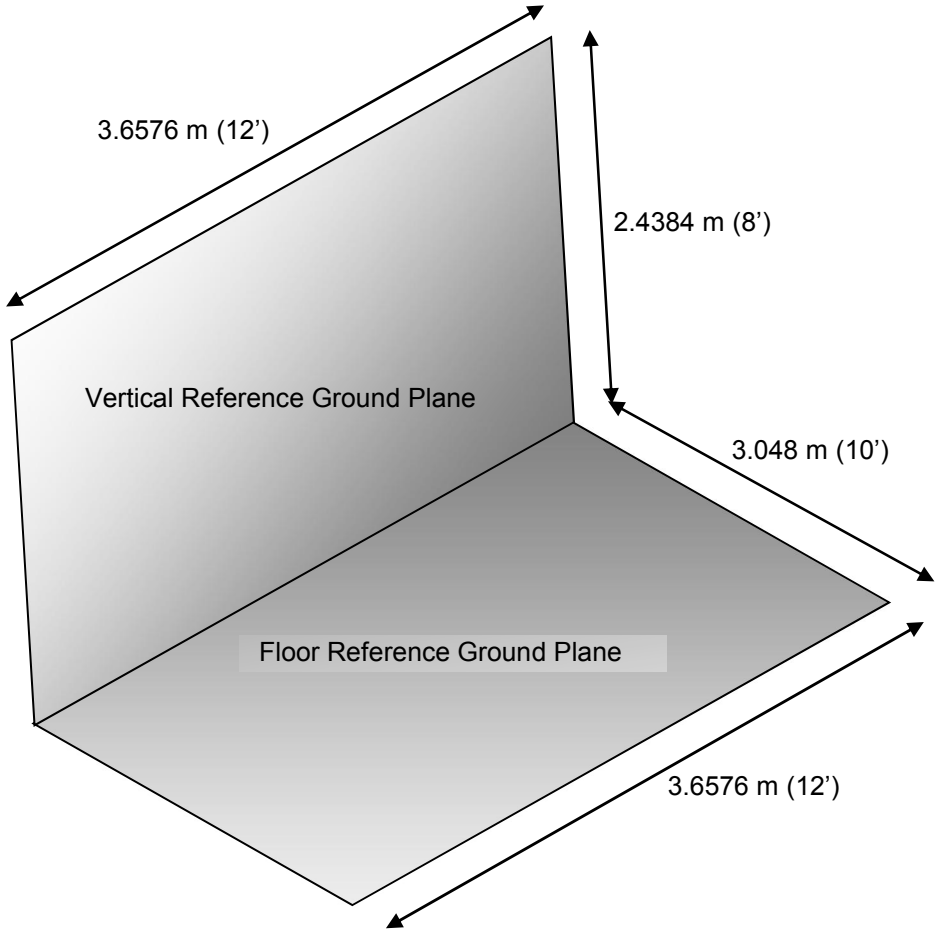

Power to the room is filtered to prevent ambient noise from coupling to the EUT and measurement equipment. Filters are models 07294/GFUL57915-1x100 (100 Amp 277/480Vac 50/60Hz) manufactured by Genisco Electronics Corporation.

The room is of sufficient size to test table top and floor standing equipment in accordance with section 6.1.4 of ANSI C63.4.

## 8.2 Conducted Emissions Test Site Description

The conducted emissions test site is an open area with two reference planes configured in the following way:

Reference Floor Plane constructed of stainless steel measuring:
Width: 3.048 meters (10')
Length: 3.6576 meters (12')
Vertical Reference Plane constructed of galvanized steel measuring:
Height: 2.4384 meters (8')
Length: 3.6576 meters (12')




The vertica ninum tape with a conductive bined.

The vertical reference plane is bonded to the building earthing system via fasteners. Additionally, these fasteners support the vertical reference plane against the wall by penetrating the building's steel construction. Electrical conduit nearby, also fastened to the same building steel construction, guaranteed a good earth connection.

# 9.0 List of Calibrated Test Equipment

| Equipment List | | | | | |
|---|---|---|---|---|---|
| **Manufacturer** | **Equipment Type** | **Model** | **Serial** | **Last Calibrated** | **Cal Interval** |
| Hewlett Packard | EMI Test Receiver | 8546A | 3746A00414 | 4/10/2015 | 1 year |
| Hewlett Packard | Filter Section | 85460A | 3704A00360 | 4/10/2015 | 1 year |
| EMCO | Biconilog Antenna | 3141 | 9706-1052 | 3/18/2015 | 3 years |
| EMCO | Horn Antenna | 3115 | 6217 | 3/31/2014 | 3 years |
| COM Power | Active Loop Antenna | AL-130 | 121016 | 4/1/2014 | 3 years |
| Hewlett Packard | Pre-Amplifier, 1.0 – 26.5 GHz | 8449B | 3008A00151 | 12/11/2015 | 1 year |
| Micro-Tronics | High–Pass Filter | HPM50108 | G251 | Verified 10/22/2015 | 2 years |
| Micro-Tronics | High–Pass Filter | HPM50111 | 041 | Verified 4/10/2015 | 2 years |
| Pasternack | Low Noise Amplifier, 2.0 -18.0 GHz | PE1524 | 0081 | 12/11/2015 | 2 years |
| ETS-Rayproof | Absorber-Lined Shielded Enclosure | Series 81 | n/a | 4/1/2014 | NSA: 2 years |
| Rohde & Schwarz | EMI Test Receiver | ESI 26 | 863342/015 | 7/22/2015 | 1 year |
| COM Power | LISN | LIN-115 | 241118 | 3/28/2014 | 2 years |

**Table 1. Calibrated Test Equipment**

# 10.0 Test Setups

The EUT was set-up in the following way during each the following tests.

## 10.1 Radiated RF Emissions Set-up

The EUT was placed as ANSI C63.4:2009 directs. On a foam table top, the EUT was placed lengthwise at the back of the table such that its LEDs and cord connections draped from the back of the table. Its power supply (power accessory), also considered part of the EUT, was placed 10cm away from the ActiveSense Hub's enclosure and at the back edge of the table. Two mini-USB ports were populated on the Hub with unterminated USB cables. Each cable and power supply cord was coiled into a 40cm bundle such that the bottom edge of the cabling hung 40cm above the ground reference plane. An AC extension cord provided power to the EUT's power supply. As ANSI C63.4 directed, the power cord dropped from the back of the table to the reference ground plane and then routed over to the filtered AC power in the chamber's turn table hole.

Radiated Emissions above 1GHz were performed with RF absorber placed on the floor between the horn antenna and the EUT periphery. Bore siting was required when taking antenna height measurements to make sure the EUT was within the beam width of the antenna. Additionally, with the exception of the fundamental and second harmonic, low noise pre-amplifiers were used to reduce the noise floor and explore the spectrum above 1GHz. A high-pass filter (suppressing the 900MHz band) was necessary to effectively measure harmonics without overloading the preamplifier. A photo of the radiated emissions set-up for frequencies below 1GHz is shown in a file named "Test Set-Up Photos.pdf" external to this test report.

Both EUT power supplies were investigated during radiated emissions, as well as 3 orthogonal positions of the EUT. This followed guidance as given in section 4.9 of this test report.

## 10.2 Antenna Port Conducted RF Measurements Set-up

Antenna port conducted RF measurements were performed on a plywood bench-top inside a semi-anechoic chamber using the Rhode & Schwarz ESI 26 Receiver, an external 20dB attenuator, and a SMA plug to U.FL jack adaptor. The 900MHz high-pass filter was also necessary to explore the spectrum above 1GHz. The EUT's antenna was removed during this test and measurements were taken directly off of the antenna port (50ohm). The hyper terminal application and cable as described in the Auxiliary Equipment section was connection and used to send transmitter configuration commands to the ActiveSense Hub. The hyper terminal cable was removed during measurements. All conducted RF benchtop measurements were performed with the power supply Model No.:EPSA050250U.

### 10.3 Power Line Conducted Emissions Set-up

The power line conducted emissions set-up was similar to the radiated emissions set-up. Cabling routed off the back of the table in a similar way with the exception of the extension cord. The excess cabling was bundle in the center of the cord (40cm) between the LISN and the EUT's power supply. Both power supplies were investigated during this test (Model No.:EPSA050250U with ferrite and Model:ATS012T-W051U LPS). A photo of the conducted emissions set-up for frequencies 150kHz to 30MHz is shown in a file named "Test Set-Up Photos.pdf" external to this test report.

# 11.0 Summary of Tests

## 11.1 Antenna Requirement – FCC Section 15.203

The EUT employs a permanently attached antenna that internally uses a unique coupling to the intentional radiator. The antenna is secured to the enclosure via hardware and then uses a U.FL type connector to mate to the main board. This satisfies the requirements of CFR 47 Part 15.203.

## 11.2 Power Line Conducted Emissions – FCC Section 15.207

Power line conducted emissions measurements were performed in accordance with FCC Part 15.207 and ANSI C63.4-2009. Measurements were taken from 150kHz to 30MHz with the EMI test receiver's resolution bandwidth set to 9kHz and the video bandwidth set to 30kHz. The calculation for the power line conducted emissions is as follows:

**Corrected Reading = Analyzer Reading + LISN Loss + Cable Loss**
**Margin (dB) = Applicable Limit – Corrected Reading**

The EUT was tested in normal operation at 120Vac 60Hz. Both power supplies were evaluated that would be marketed with the ActiveSense Hub. These were the EPSA050250U and ATS012T-W051U LPS. See section 4.11 of this test report for more information. Note that the ferrite (Laird P/N: 28A0392-0A2) necessary to pass radiated emissions testing was installed on the EPSA050250U. The ferrite on the ATS012T-W051U LPS came already installed and was considered part of the product.

Details of this test are shown in the form below along with plots and graphs.

### 11.2.1 Test Limits

In accordance with FCC Part 15.207(a), the equipment must meet the emissions limits as given by the table below:

| Emission Type | Frequency Range (MHz) | Quasi-Peak Limits (dBuV) | Average Limits (dBuV) |
|---|---|---|---|
| Conducted (Class B) | 0.15 to 0.5 | 66 decreasing linearly with logarithm of frequency to 56 | 56 decreasing linearly with logarithm of frequency to 46 |
| | 0.5 to 5 | 56 | 46 |
| | 5 to 30 | 60 | 50 |

**Table 2. Power Line Conducted Limits 15.207(a)**

### 11.2.2 Test Results

# Conducted Emissions Form

Test Standard: *FCC CFR 47: Part 15: 2014*

| | | | |
|---|---|---|---|
| **Manufacturer:** | Mesh Systems, LTD | **Date(s) of Test:** | 12/9/2015 |
| **Test Engineer:** | Dan Berg | **Voltage/Frequency:** | 120V 60Hz |
| **Model:** | ActiveSense Hub | **Serial Number:** | 2119A |
| **Software Version:** | n/a | **Mode of Operation:** | Typical communication |

| Setup Pictures Taken | Verification Completed |
|---|---|
| ☒ | ☒ |

| Environmental Conditions in Lab | | |
|---|---|---|
| | **Requirement** | **Actual** |
| **Temperature** | 15°C - 35°C | 20°C - 21°C |
| **Humidity** | 10%- 90% R.H. | 37% - 39% R.H. |
| **Air Pressure** | n/a | 100kPa - 101kPa |

| Test Equipment Utilized |
|---|
| TILE! 7 EMC Control Software |
| Rhode and Schwarz ESIB EMI Test Receiver |
| COM-Power LIN-115 LISN |
| |
| |
| |
| |

| Overall Test Result | Limit Required |
|---|---|
| MEETs Requirements | Class B (FCC 15.207a) |

| EUT Configuration: | | Lines Tested |
|---|---|---|
| Table Top (80 cm above Ground Plane) | | Line and Neutral |
| **Frequency Range** | **Detector Used** | **Comments** |
| 150kHz – 30MHz | Peak and Quasi-Peak | See plots and graphs |

**Notes:**

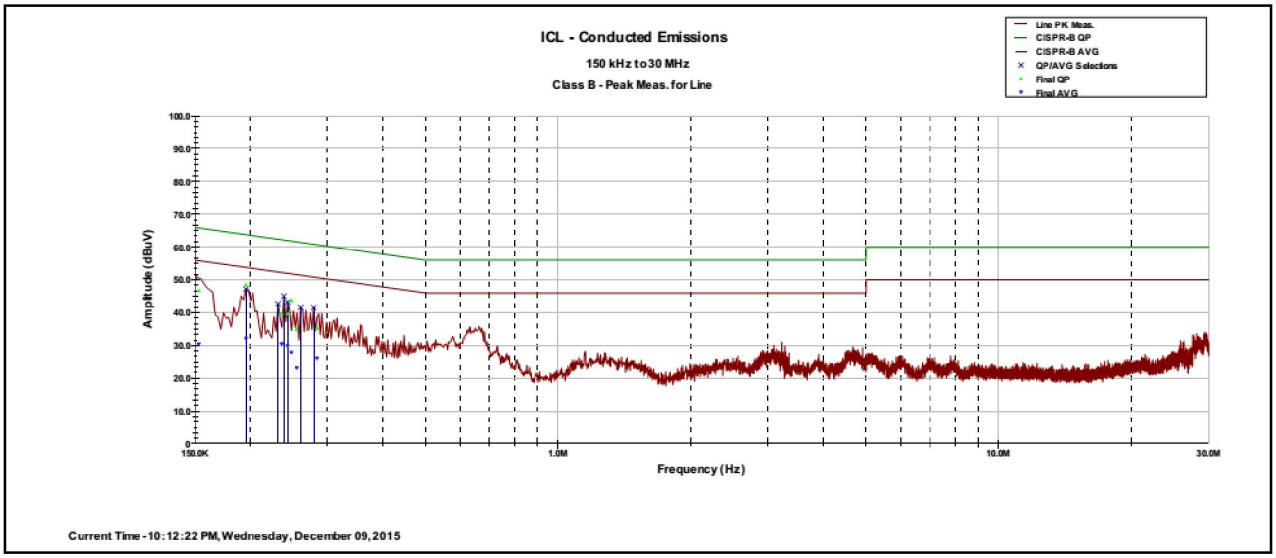
Set-up

- The EUT was set-up in accordance with ANSI C63.4 as directed by FCC Part 15.

- The test set-up was arranged as described in the Power Line Conducted Emissions Set-up section of this test report. A photo of the test set-up is included in that section.

- The EUT was tested in a typical mode of operation.

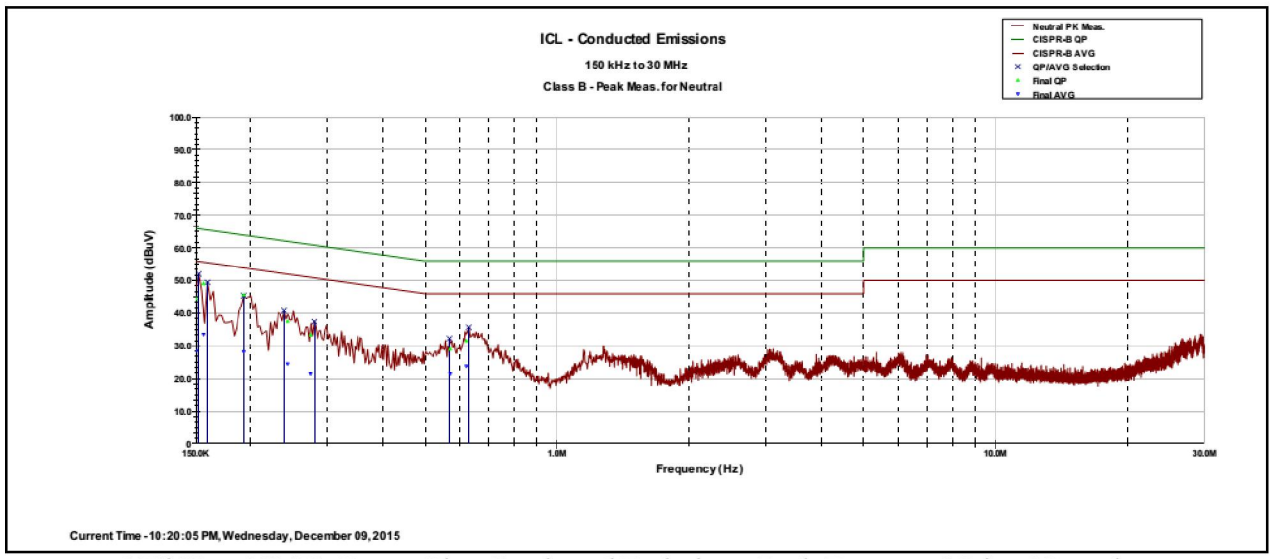
- Final quasi-peak and average measurements were taken and found to be compliant. See below for test data.




150kHz – 30MHz Power Line Conducted Emissions, Peak-Detector, Mains: Line
Power Supply: Model No. EPSA050250U with Laird ferrite PN 28A0392-0A2

| ICL - Conducted Emissions | | | | | | |
|---|---|---|---|---|---|---|
| **Frequency** | **QP Meas.** | **QP Limit** | **QP Margin** | **AVG Meas.** | **AVG Limit** | **AVG Margin** |
| | **(dBuV)** | **(dBuV)** | **(dB)** | **(dBuV)** | **(dBuV)** | **(dB)** |
| 153.00 KHz | 46.77 | 65.84 | 19.07 | 30.48 | 55.84 | 25.36 |
| 195.44 KHz | 48.44 | 63.80 | 15.37 | 32.14 | 53.80 | 21.66 |
| 235.71 KHz | 39.69 | 62.25 | 22.55 | 30.49 | 52.25 | 21.76 |
| 243.01 KHz | 39.60 | 61.99 | 22.39 | 29.93 | 51.99 | 22.07 |
| 247.79 KHz | 43.71 | 61.83 | 18.12 | 27.92 | 51.83 | 23.91 |
| 254.89 KHz | 34.90 | 61.60 | 26.69 | 23.06 | 51.60 | 28.54 |
| 283.73 KHz | 35.22 | 60.71 | 25.48 | 26.14 | 50.71 | 24.57 |
| Negative margin indicates measurements ABOVE the limit.<br>Positive margin indicates measurements BELOW the limit. | | | | | | |

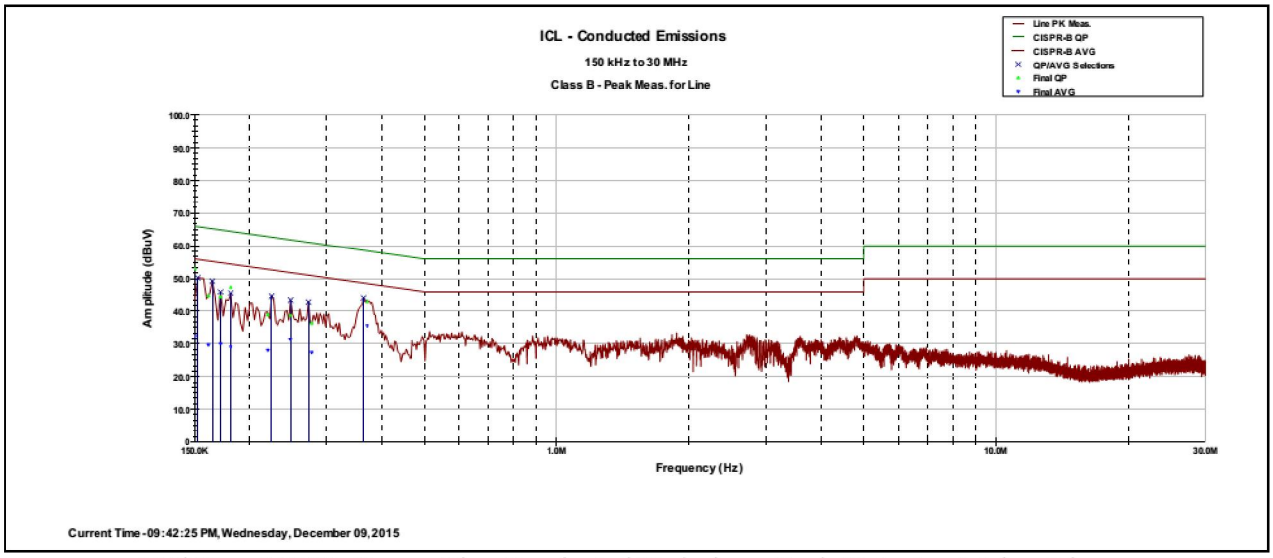
Final Quasi-Peak and Average Measurements for Mains: Line
Power Supply: Model No. EPSA050250U with Laird ferrite PN 28A0392-0A2




150kHz – 30MHz Power Line Conducted Emissions, Peak-Detector, Mains: Neutral
Power Supply: Model No. EPSA050250U with Laird ferrite PN 28A0392-0A2

| ICL - Conducted Emissions | | | | | | |
|---|---|---|---|---|---|---|
| **Frequency** | **QP Meas.** | **QP Limit** | **QP Margin** | **AVG Meas.** | **AVG Limit** | **AVG Margin** |
| | **(dBuV)** | **(dBuV)** | **(dB)** | **(dBuV)** | **(dBuV)** | **(dB)** |
| 150.00 KHz | 44.50 | 66.00 | 21.50 | 28.42 | 56.00 | 27.58 |
| 156.40 KHz | 49.13 | 65.65 | 16.53 | 33.54 | 55.65 | 22.11 |
| 193.05 KHz | 45.61 | 63.90 | 18.29 | 28.18 | 53.90 | 25.73 |
| 243.05 KHz | 37.49 | 61.99 | 24.50 | 24.45 | 51.99 | 27.54 |
| 273.65 KHz | 33.37 | 61.01 | 27.63 | 21.50 | 51.01 | 29.50 |
| 570.88 KHz | 29.04 | 56.00 | 26.96 | 21.53 | 46.00 | 24.47 |
| 620.55 KHz | 31.57 | 56.00 | 24.43 | 23.78 | 46.00 | 22.22 |
| Negative margin indicates measurements ABOVE the limit.<br>Positive margin indicates measurements BELOW the limit. | | | | | | |

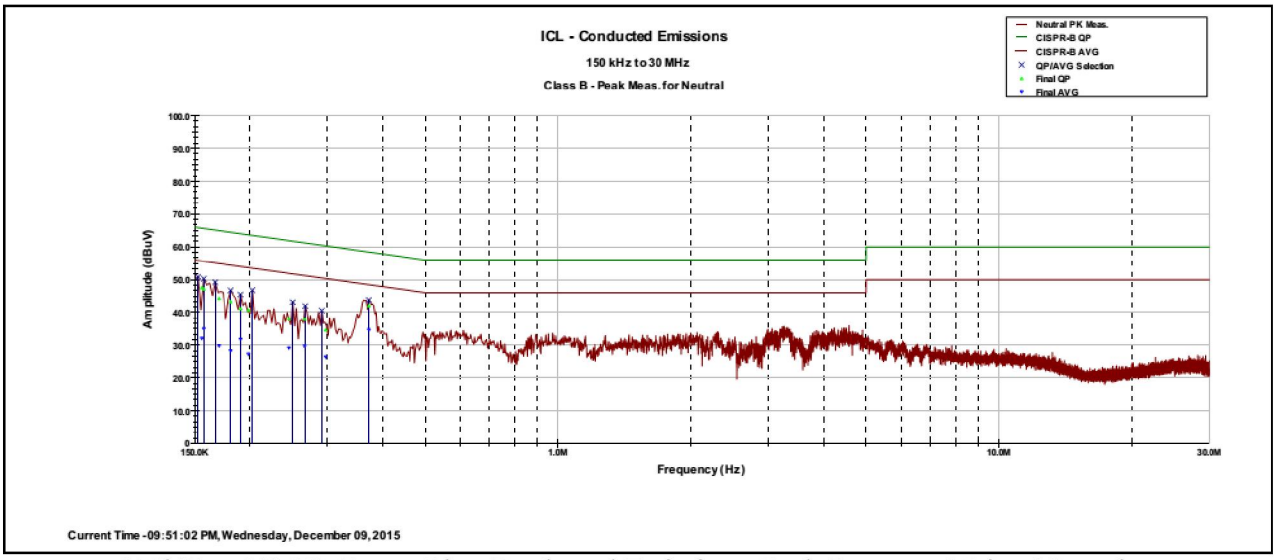
Final Quasi-Peak and Average Measurements for Mains: Neutral
Power Supply: Model No. EPSA050250U with Laird ferrite PN 28A0392-0A2




150kHz – 30MHz Power Line Conducted Emissions, Peak-Detector, Mains: Line
Power Supply: Model No. ATS012T-W051U LPS

| ICL - Conducted Emissions | | | | | | |
|---|---|---|---|---|---|---|
| **Frequency** | **QP Meas.** | **QP Limit** | **QP Margin** | **AVG Meas.** | **AVG Limit** | **AVG Margin** |
| | **(dBuV)** | **(dBuV)** | **(dB)** | **(dBuV)** | **(dBuV)** | **(dB)** |
| 150.00 KHz | 53.06 | 66.00 | 12.94 | 32.32 | 56.00 | 23.68 |
| 161.09 KHz | 44.66 | 65.41 | 20.75 | 29.68 | 55.41 | 25.73 |
| 171.52 KHz | 44.34 | 64.89 | 20.55 | 30.01 | 54.89 | 24.88 |
| 181.09 KHz | 47.38 | 64.44 | 17.06 | 28.96 | 54.44 | 25.48 |
| 219.72 KHz | 38.92 | 62.83 | 23.91 | 28.05 | 52.83 | 24.78 |
| 247.62 KHz | 38.72 | 61.84 | 23.12 | 31.39 | 51.84 | 20.45 |
| 276.55 KHz | 36.37 | 60.92 | 24.55 | 27.35 | 50.92 | 23.57 |
| 370.25 KHz | 42.89 | 58.50 | 15.61 | 35.56 | 48.50 | 12.94 |
| Negative margin indicates measurements ABOVE the limit.<br>Positive margin indicates measurements BELOW the limit. | | | | | | |

Final Quasi-Peak and Average Measurements for Mains: Line
Power Supply: Model No. ATS012T-W051U LPS




150kHz – 30MHz Power Line Conducted Emissions, Peak-Detector, Mains: Neutral
Power Supply: Model No. ATS012T-W051U LPS

| ICL - Conducted Emissions | | | | | | |
|---|---|---|---|---|---|---|
| **Frequency** | **QP Meas.** | **QP Limit** | **QP Margin** | **AVG Meas.** | **AVG Limit** | **AVG Margin** |
| | **(dBuV)** | **(dBuV)** | **(dB)** | **(dBuV)** | **(dBuV)** | **(dB)** |
| 155.46 KHz | 47.50 | 65.70 | 18.20 | 32.07 | 55.70 | 23.63 |
| 157.16 KHz | 47.10 | 65.61 | 18.51 | 35.01 | 55.61 | 20.60 |
| 170.10 KHz | 44.28 | 64.96 | 20.67 | 29.83 | 54.96 | 25.13 |
| 181.09 KHz | 43.25 | 64.44 | 21.19 | 28.36 | 54.44 | 26.08 |
| 190.66 KHz | 41.16 | 64.01 | 22.84 | 31.81 | 54.01 | 22.20 |
| 198.61 KHz | 40.77 | 63.67 | 22.89 | 27.33 | 53.67 | 26.34 |
| 245.51 KHz | 38.08 | 61.91 | 23.83 | 29.21 | 51.91 | 22.70 |
| 266.38 KHz | 37.93 | 61.23 | 23.30 | 29.72 | 51.23 | 21.51 |
| 297.03 KHz | 34.63 | 60.33 | 25.70 | 26.47 | 50.33 | 23.86 |
| 372.49 KHz | 42.06 | 58.45 | 16.38 | 34.65 | 48.45 | 13.80 |
| Negative margin indicates measurements ABOVE the limit.<br>Positive margin indicates measurements BELOW the limit. | | | | | | |

Final Quasi-Peak and Average Measurements for Mains: Neutral
Power Supply: Model No. ATS012T-W051U LPS

## 11.3 6dB Bandwidth – FCC Sect. 15.247(a)

### 11.3.1 Test Methodology

The 6dB bandwidth was measured in accordance with the FCC KDB Publication No. 558074 dated June 9, 2015 entitled “Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247”. The RBW of the spectrum analyzer was set to 100 kHz and VBW 300 kHz. The Span was set to 3MHz, large enough to capture the entire emissions and >> RBW. Note: Measurements were taken with a gain setting of “27”.

### 11.3.2 Test Results

Results are shown below in Table 3 and Figure 2 through Figure 5. The measurements below were relative to the peak of the waveform and required no correction.

| DTS Channel (MHz) | Bandwidth (kHz) | Limit | Result |
|---|---|---|---|
| 904.5 | 547.1 | ≥500kHz | Pass |
| 910.5 | 547.1 | ≥500kHz | Pass |
| 919.5 | 553.1 | ≥500kHz | Pass |
| 926.5 | 547.1 | ≥500kHz | Pass |

**Table 3. Summary of 6dB Bandwidth Test**

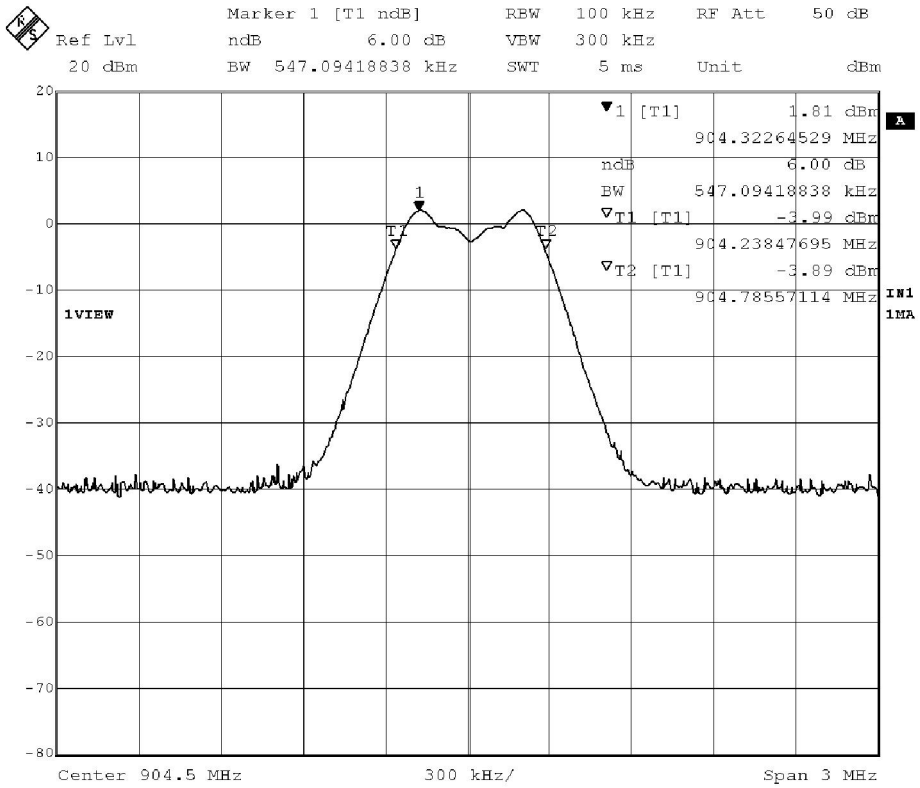



**Figure 2. 6dB Bandwidth Plot - Low Channel – 904.5MHz**

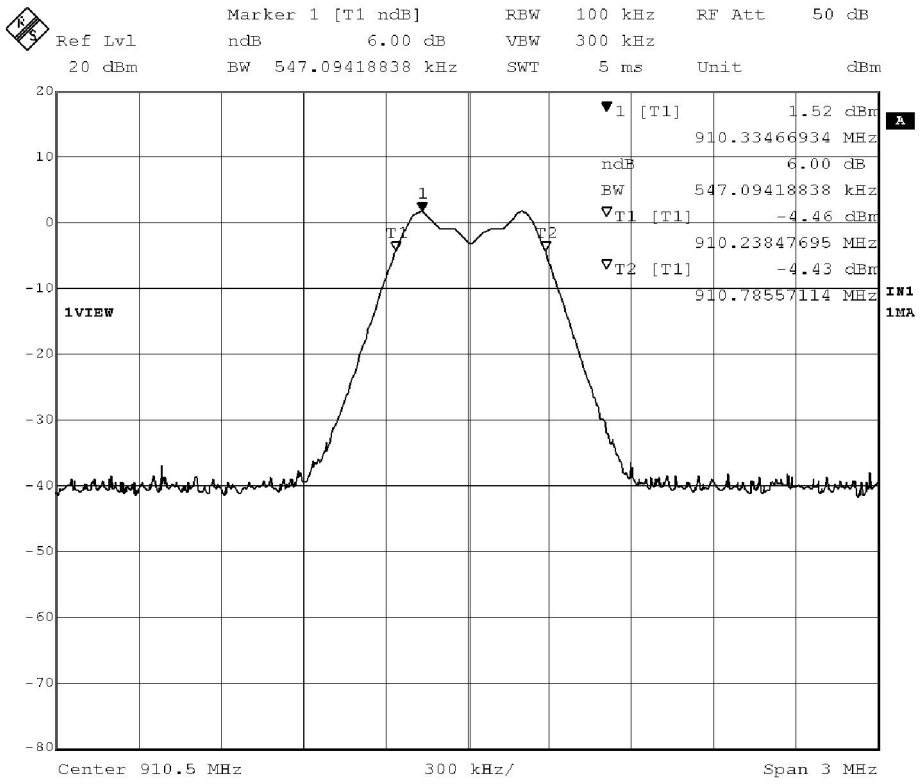



**Figure 3. 6dB Bandwidth Plot - Mid Channel #1 – 910.5 MHz**

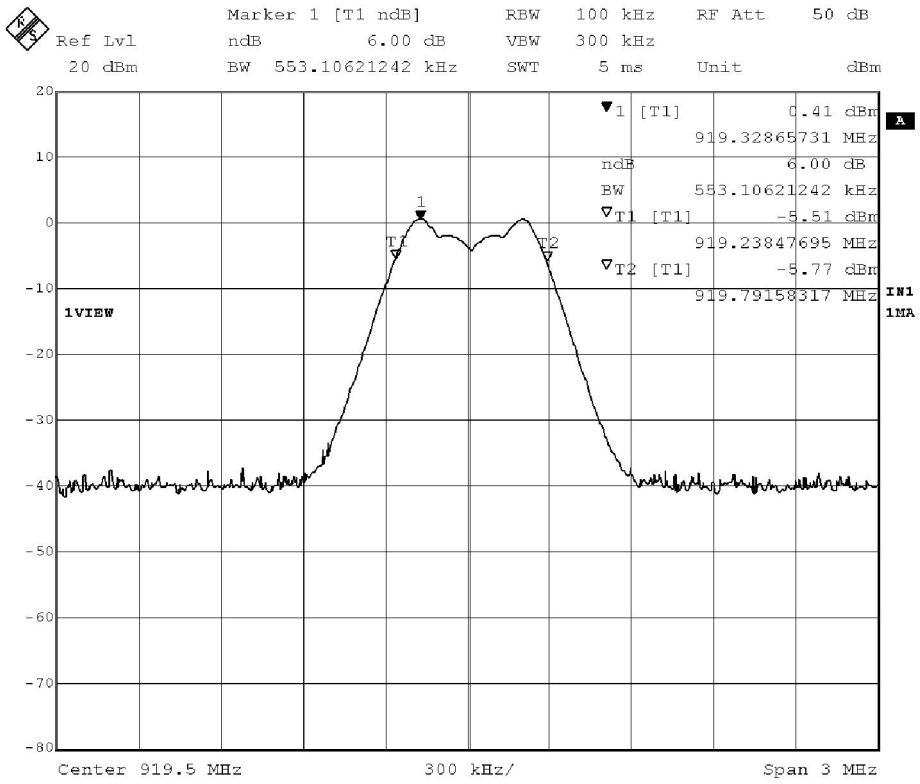



**Figure 4. 6dB Bandwidth Plot - Mid Channel #2 – 919.5 MHz**

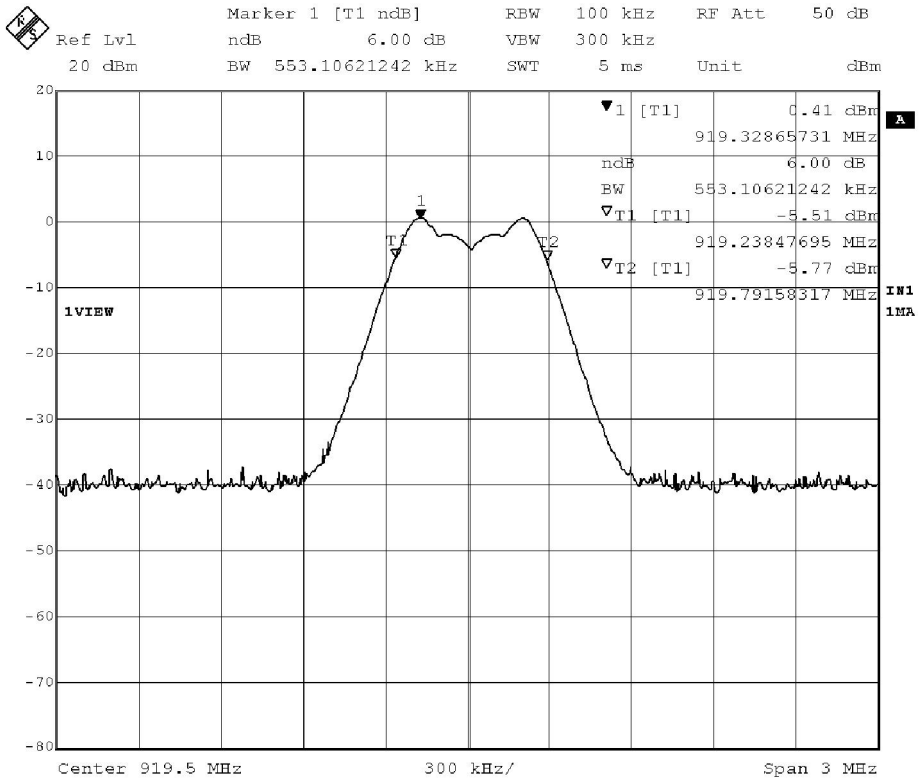



**Figure 5. 6dB Bandwidth Plot - High Channel – 926.5 MHz**

## 11.4 Occupied Bandwidth and Band-Edge Compliance– FCC Sect. 15.215(c) & 15.247(d)

### 11.4.1 Test Methodology

The occupied bandwidth was measured using the procedure found in ANSI C63.4:2009, section 13.7. A value of 20dB down from the reference level was used.
Measurements were taken with a EUT gain setting of "27", continuously transmitting modulated. The relevant settings used are listed below:

a) Each channel was investigated and centered on the spectrum analyzer.
b) The span was set to 2MHz to capture the whole modulated waveform on the spectrum analyzer's screen.
c) The Sweep time was set Auto.
d) Resolution bandwidth (RBW) set to 10kHz.
e) Video bandwidth (VBW) set to 30kHz (3xRBW).
f) The Trace Max Hold function was applied and the trace allowed to stabilize.
g) The Peak Search function was applied to find the reference level of the waveform.
h) The Delta marker function was engaged and the marker was moved until the amplitude was as close as possible to 20dB from the reference level found above.
i) An additional Delta marker was engaged and the marker was moved again but this time on the opposite side of the waveform unit the amplitude was as close as possible to 20dB from the reference level found above.
j) The two Delta marker frequencies were subtracted and the occupied bandwidth recorded.

For band edge compliance the spectrum analyzer was set-up as shown in section 11.6.1 of this Test Report with exception of Span. The span was set such that the complete channel could be seen and the band edge could be positioned at the Start or Stop Frequency. The Peak reference level was obtained and the spectrum analyzer's 30dB down function was used to determine the frequencies where power decreased to this level.

### 11.4.2 Test Results

The result for Occupied Bandwidth are shown below in Table 4 and Figure 6 through Figure 9 below.

| Channel | Frequency (MHz) | Delta Marker #1 (dB down/MHz) | | Delta Marker #2 (dB down/MHz) | | Occupied Bandwidth (kHz) |
|---|---|---|---|---|---|---|
| Low | 904.5 | 20.27 | 904.7946 | 20.77 | 904.2014 | 593.2 |
| Mid #1 | 910.5 | 20.53 | 910.7946 | 20.55 | 910.2054 | 589.2 |
| Mid #2 | 919.5 | 21.73 | 919.8026 | 20.47 | 919.2054 | 597.2 |
| High | 926.5 | 21.20 | 926.7986 | 20.23 | 926.2094 | 589.2 |

**Table 4. Summary of Occupied Bandwidth Measurements**

The results for Band Edge Compliance are shown in Figure 10 and Figure 11. As seen in the plots the peak power in any 100 kHz bandwidth outside of the authorized frequency band is attenuated by more than 30 dB relative to the maximum in-band peak PSD level in 100 kHz.

This meets the requirements of FCC Part 15.215(c) and 15.247(d).

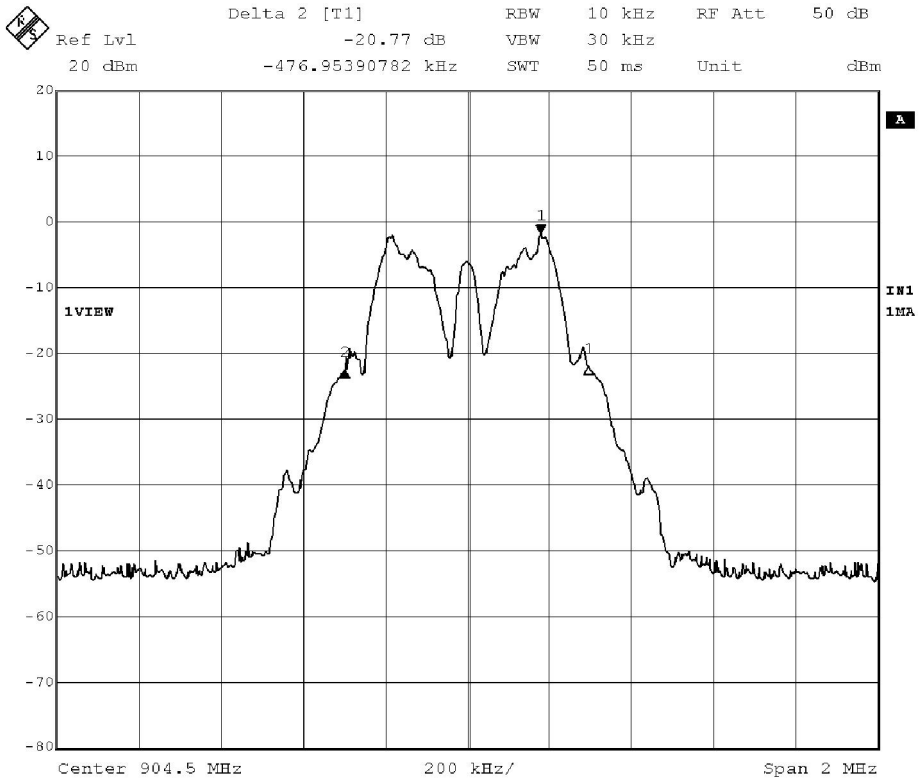



**Figure 6. Occupied Bandwidth – Low Channel – 904.5MHz**

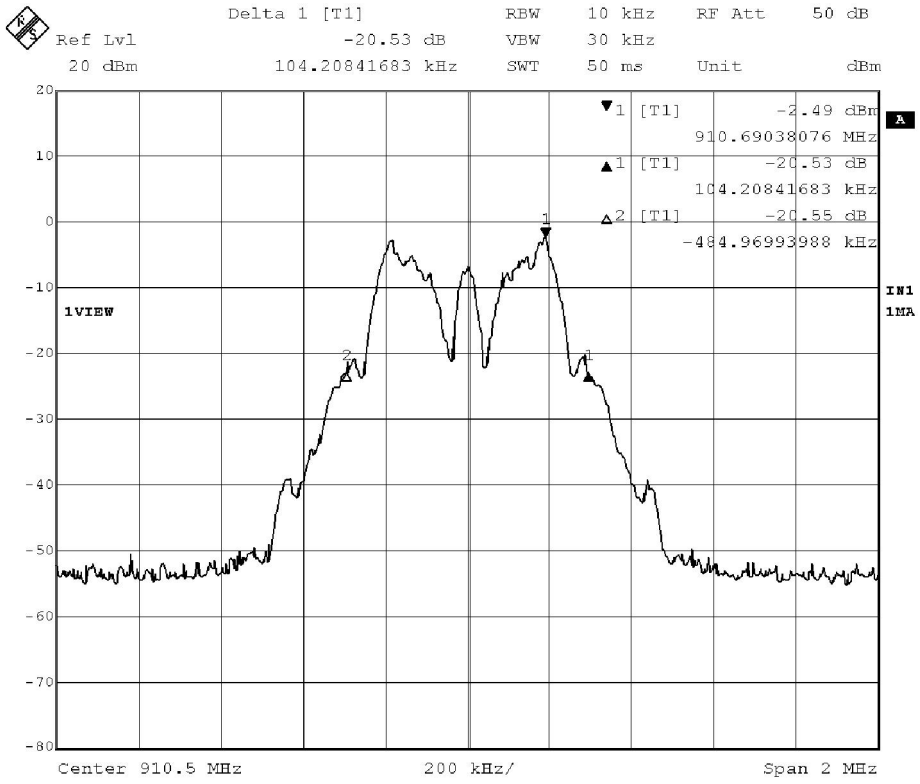



**Figure 7. Occupied Bandwidth – Low Channel #1– 910.5MHz**

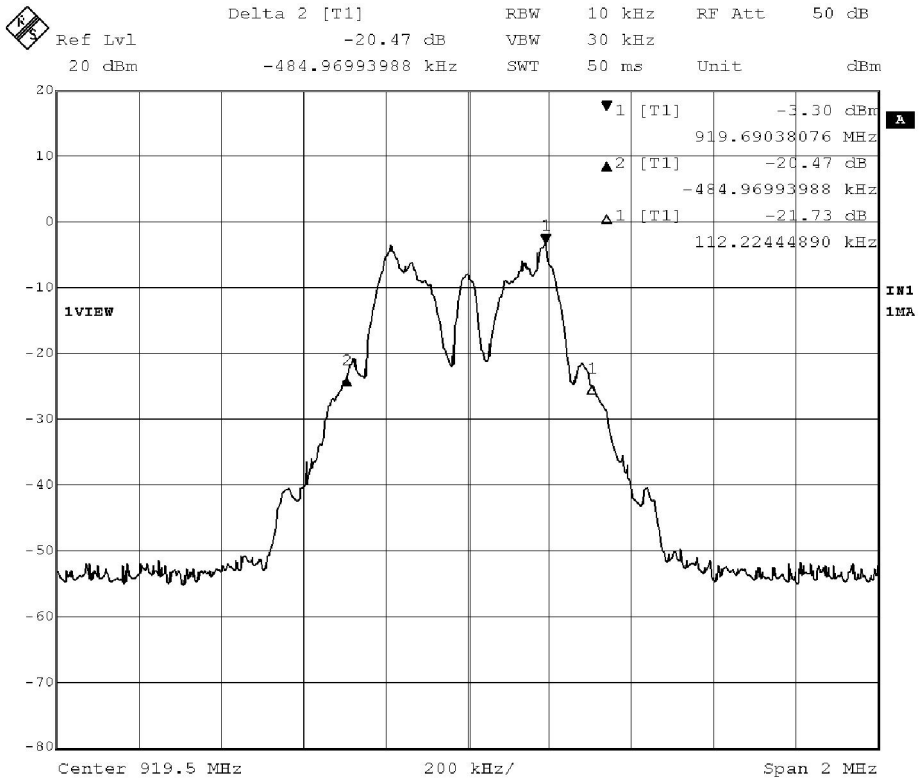



**Figure 8. Occupied Bandwidth – Low Channel #2– 919.5MHz**

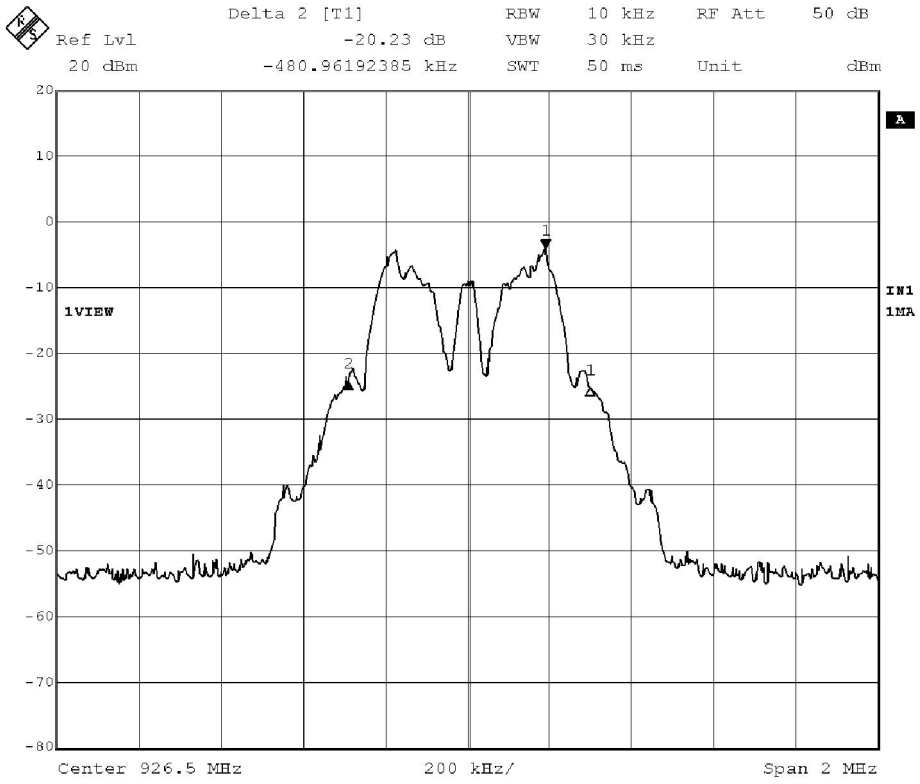



**Figure 9. Occupied Bandwidth – High Channel – 926.5MHz**

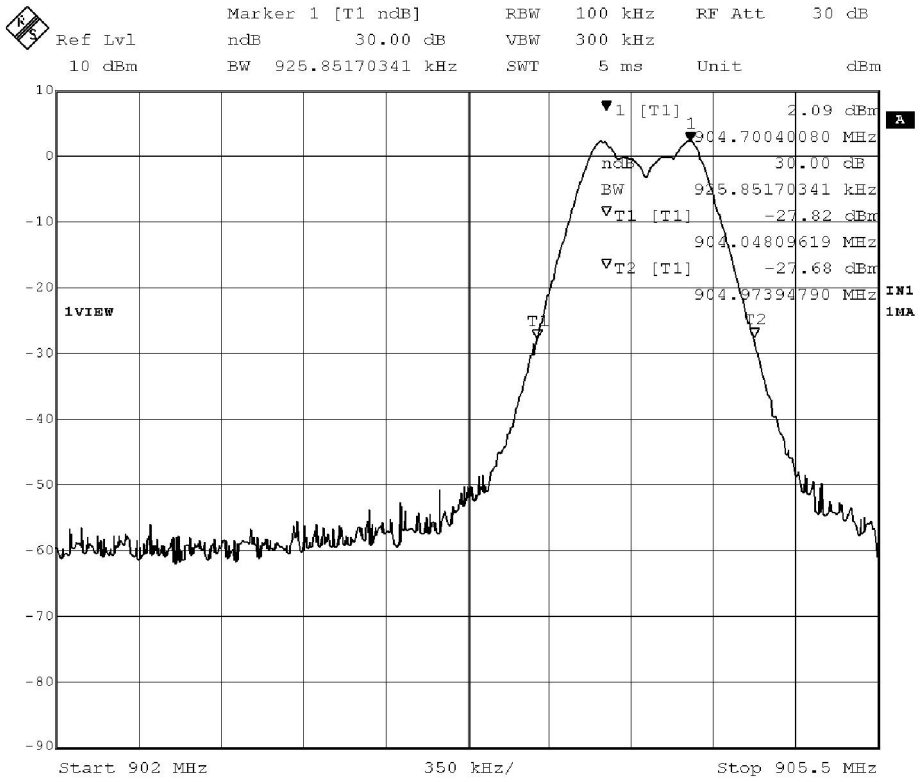



**Figure 10. Band Edge Compliance at 902MHz for Low Channel – 904.5MHz.**

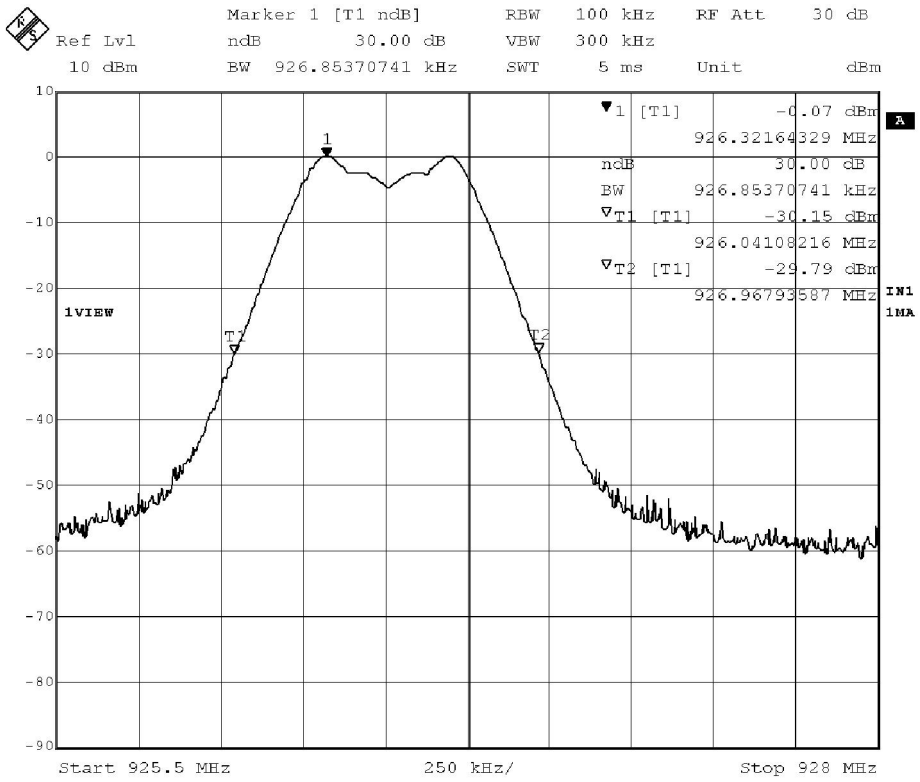



**Figure 11. Band Edge Compliance at 928MHz for High Channel – 926.5MHz.**

## 11.5 Maximum Conducted (Average) Output Power Requirement – FCC Sect. 15.247(b)

### 11.5.1 Test Methodology

The maximum conducted (average) output power was measured as an alternative to the maximum peak conducted output power as permitted by FCC Part 15.247. The measurement procedure followed the steps as described in section 9.2.2.2 of FCC Publication No. 558074, entitled "Method AVGSA01 (trace averaging with the EUT transmitting at full power throughout each sweep)". The RF output of the equipment under test was connected to a 20dB attenuator and then into the input of the spectrum analyzer. Measurements were taken with a EUT gain setting of "27", continuously transmitting modulated. The relevant settings used are listed below:

a) Span set to 1 MHz, which is greater than 1.5 x OBW, typically 1.5 x (~589kHz to ~ 597kHz) = ~883.8kHz to ~895.8kHz.
b) Resolution bandwidth (RBW) set to 10 kHz which is within 1%-5% of the OBW (~589kHz to ~597kHz).
c) Video bandwidth (VBW) set to 30kHz which is 3xRBW.
d) No special triggering was necessary to capture only full ON cycles. The product was able to continuously transmit at maximum power while modulating.
e) Sweep time was set to Auto.
f) Detector was set to RMS.
g) The trace was averaged over 100 traces.
h) A channel power function was used to integrate the spectrum for each channel's evaluation. The function integrated the spectrum as required over the OBW.

The antenna gain as reported from the Embedded Antenna Design, LTD data sheet for the PTF2100 was 1.5dBi. Since this was less than 6dBi, no special requirements needed to be considered as specified in 15.247(b)(4).

### 11.5.2 Test Results

Results are shown below in Table 5 and Figure 12 through Figure 15. The measurements below needed correction. A sample calculation for Output Power follows:

**Corrected Reading = Analyzer Reading + 20dB Attenuator Loss + Cable Loss**

| Channel | Frequency (MHz) | Output Power (dBm) | Limit | Result |
|---|---|---|---|---|
| Low | 904.5 | 20.163 | ≤1 Watt (30dBm) | Pass |
| Mid #1 | 910.5 | 20.127 | ≤1 Watt (30dBm) | Pass |
| Mid #2 | 919.5 | 19.268 | ≤1 Watt (30dBm) | Pass |
| High | 926.5 | 17.921 | ≤1 Watt (30dBm) | Pass |

**Table 5. Summary of Maximum Conducted (Average) Output Power**

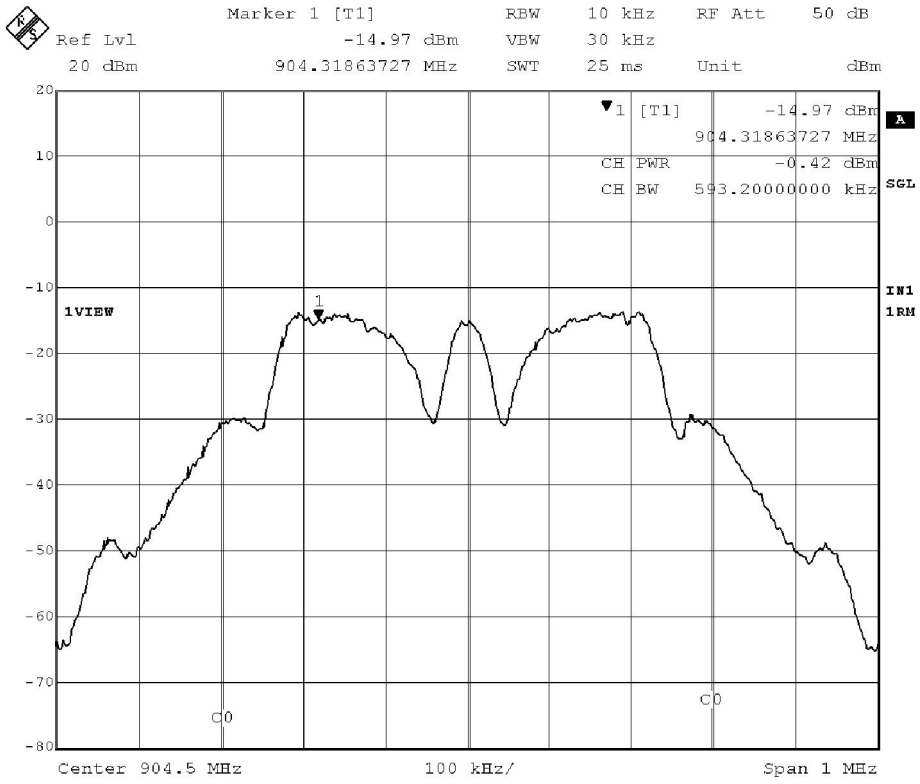



**Figure 12. Maximum (Average) Output Power Plot – Low Channel – 904.5MHz**

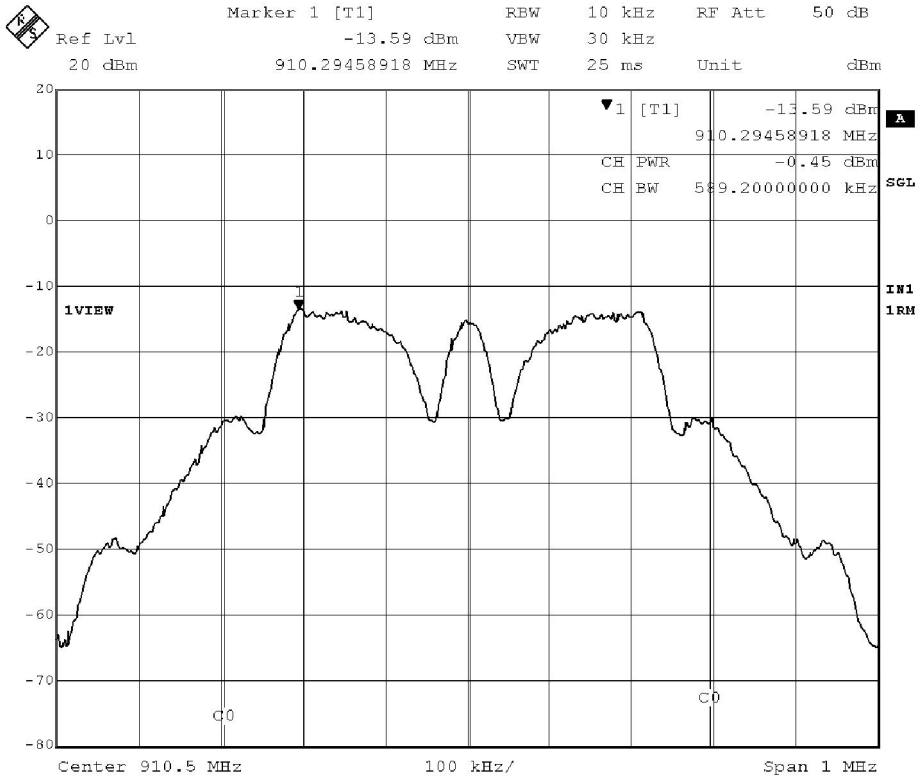



**Figure 13. Maximum (Average) Output Power Plot – Mid Channel #1 – 910.5MHz**

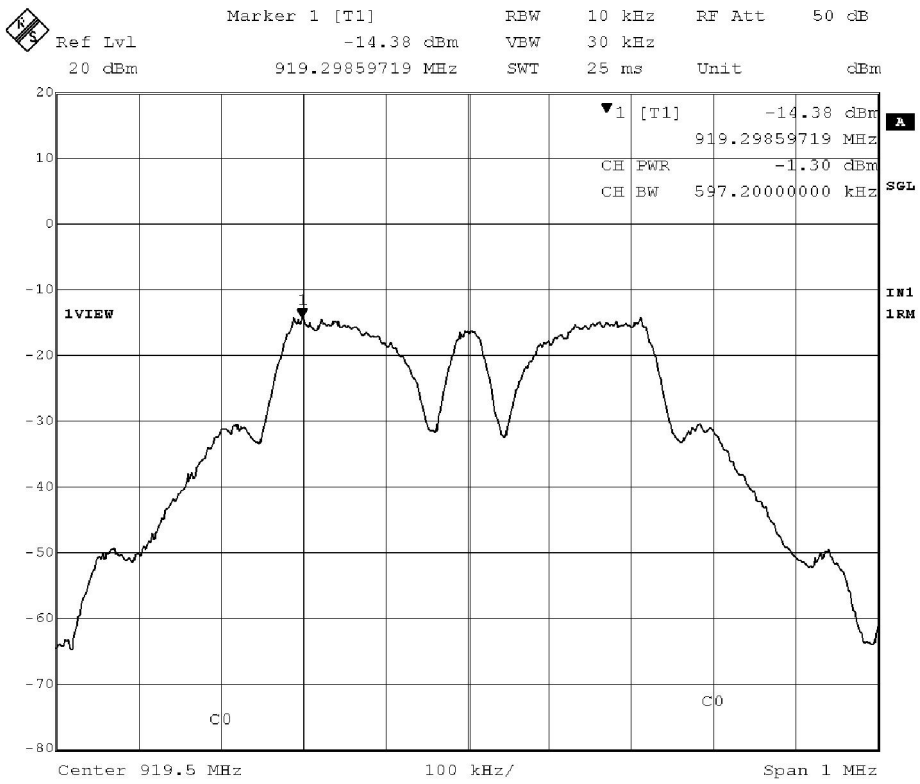



**Figure 14. Maximum (Average) Output Power Plot – Mid Channel #2 – 919.5MHz**

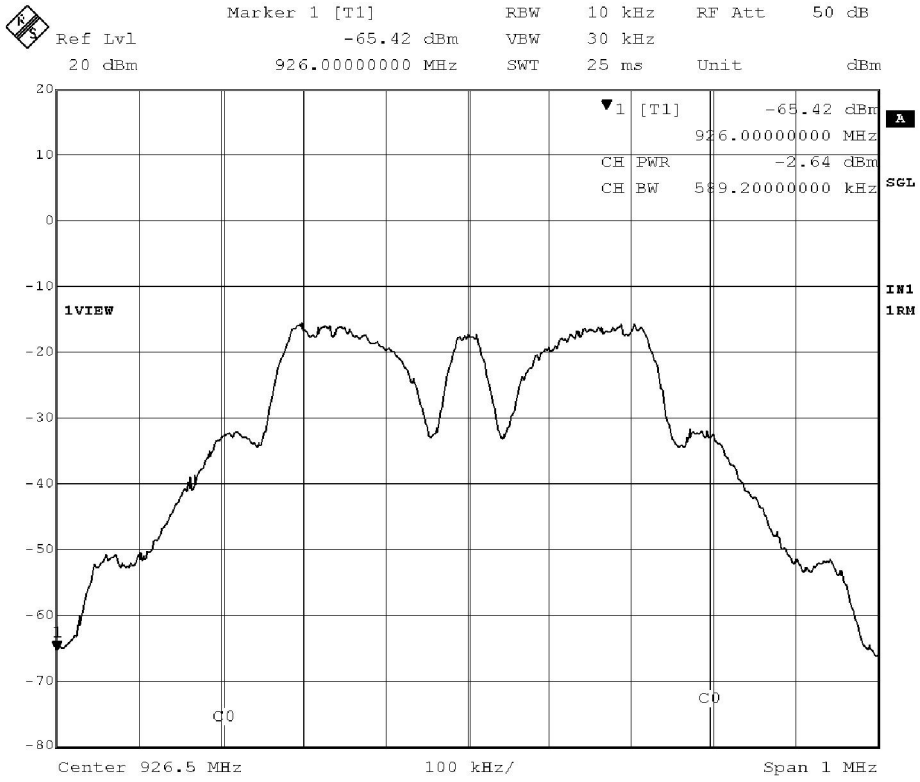



**Figure 15. Maximum (Average) Output Power Plot – High Channel – 926.5MHz**

## 11.6 Emissions in Non-Restricted Bands – FCC Sect. 15.247(d)

### 11.6.1 Test Methodology

KDB 558074 D01 Section 11.1 states:

> *The DTS rules specify that in any 100 kHz bandwidth outside of the authorized frequency band, the power shall be attenuated according to the following conditions:*
>
> *a) If the maximum peak conducted output power procedure was used to demonstrate compliance as described in 9.1, then the peak output power measured in any 100 kHz bandwidth outside of the authorized frequency band shall be attenuated by at least 20 dB relative to the maximum in-band peak PSD level in 100 kHz (i.e., 20 dBc).*
>
> *b) If maximum conducted (average) output power was used to demonstrate compliance as described in 9.2, then the peak power in any 100 kHz bandwidth outside of the authorized frequency band shall be attenuated by at least 30 dB relative to the maximum in-band peak PSD level in 100 kHz (i.e., 30 dBc).*
>
> *c) In either case, attenuation to levels below the 15.209 general radiated emissions limits is not required.*

The measurement procedure followed the steps as described in sections 11.2 and 11.3 of FCC Publication No. 558074, entitled “Reference level measurement” and “Emission level measurement”. At times it was necessary to insert a 20dB attenuator or 900MHz high-pass filter into the path between the equipment under test and the spectrum analyzer. The measurements were performed in a semi-anechoic chamber to prevent ambient intrusion. Measurements were taken with a EUT gain setting of “27”, continuously transmitting modulated. The relevant settings used are listed below:

**Reference Level Measurement**

a) The spectrum analyzer was centered on each channel of interest to find the maximum PSD level.
b) Span set to 1MHz which was greater than 1.5 x DTS Bandwidth or ~820.5kHz to ~829.5kHz.
c) Resolution bandwidth (RBW) set to 100kHz.
d) Video bandwidth (VBW) set to 300kHz.
e) Detector was set to Peak.
f) Sweep time was set to Auto.
g) Trace was set to Max Hold.
h) Enough time was given to fully stabilize the trace (in this case ~10-~20 seconds).
i) A max peak marker was used to record the measurement.

**Emissions Level Measurement**

a) A sweep was performed using automated software (TILE 7.0) across 900MHz to 10GHz.
b) RBW, VBW, Sweep time, Detector, and Trace state were set to the same parameters as in the **Reference Level Measurement** paragraph above in the software. Sweep rate and data sampling were all considered when programming the software. Multiple sweeps were ran on each frequency range to allow for trace stabilization under a trace max hold.
c) The automated software (TILE 7.0) was used to mark all peaks of interest and an analysis was done to determine which emissions were in the Non-Restricted bands. Additionally a reference line 30dB down from the Reference Level was plotted to quickly gauge if any emission was higher than the requirement.

### 11.6.2 Test Results

Results are shown below in Table 6 and Table 7. The measurements below were corrected so valid comparisons could be performed. A 20dB attenuator and 900MHz high-pass filter were inserted at times to protect the spectrum analyzer's preamp from being overdriven. A sample calculation is provided below:

When the 20dB Attenuator was inserted into the measurement chain:
**Corrected Reading = Analyzer Reading + 20dB Attenuator Loss + Cable Loss**

When the 900MHz high-pass filter was inserted into the measurement chain:
**Corrected Reading = Analyzer Reading + RF Filter Loss + Cable Loss**

| Channel | Frequency (GHz) | PSD Level Raw (dBm) | PSD Level Corrected (dBm) | 30dB Attenuated From PSD Limit (dBm) | Result |
|---|---|---|---|---|---|
| Low | 904.5 | 1.46 | 22.04 | -7.96 | Low channel found to have highest PSD Level. |
| Mid #1 | 910.5 | 1.30 | The raw PSD Levels for these channels were not corrected since they were not the highest. | | |
| Mid #2 | 919.5 | 0.73 | | | |
| High | 926.5 | -0.35 | | | |

**Table 6. Summary of Reference Level PSD Evaluation**

| Emission Frequency (GHz) | Corrected Measurement (dBm) | Attenuated 30dB under PSD Reference Level above? |
|---|---|---|
| 1.809 | -23.328 | Yes |
| 2.426 | -91.118 | Yes |
| 6.618 | -93.201 | Yes |

**Table 7. Non-Restricted Band Highest Emissions**

As shown by the measurement data, the measurements found in the non-restricted bands were attenuated by at least 30dB down as required by the FCC Part 15.247(d)

## 11.7 Power Spectral Density – FCC Sect. 15.247(e)

### 11.7.1 Test Methodology

FCC Part 15.247(e) specifies the following:

> The power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission….
>
> …The same method of determining the conducted output power shall be used to determine the power spectral density.

The measurement procedure followed the steps as described in section 10.3 of FCC Publication No. 558074, entitled "Method AVGPSD-1 (trace averaging with EUT transmitting at full power throughout each sweep)". The RF output of the equipment under test was connected to a 20dB attenuator and then into the input of the spectrum analyzer. The measurements were performed in a semi-anechoic chamber to prevent ambient intrusion. Measurements were taken with a EUT gain setting of "27", continuously transmitting modulated. The relevant settings used are listed below:

**Method AVGPSD-1**

a) Each DTS channel was investigated and was centered on the spectrum analyzer.
b) The span was set to greater than 1.5 x the OBW, which was 1.5 x (~883.8kHz to ~895.8kHz). 1MHz was used.
c) Resolution bandwidth (RBW) set to 3kHz (this falls within 3kHz ≤ RBW ≤ 100kHz specified).
d) Video bandwidth (VBW) set to 30kHz (3xRBW).
e) Detector was set to RMS.
f) Sweep Time was set to Auto
g) The trace was averaged over 100 traces.
h) The Peak Search function was applied to find the maximum amplitude level.

## 11.7.2 Test Results

Results are shown below in Table 8 and Figure 16 through Figure 19. The measurements below needed correction. A sample calculation for Power Spectral Density follows:

**Corrected Reading = Analyzer Reading + 20dB Attenuator Loss + Cable Loss**

| Channel | Frequency (MHz) | Power Spectral Density (dBm) | Limit (dBm) | Result |
|---|---|---|---|---|
| Low | 904.5 | 3.703 | 8 | Pass |
| Mid #1 | 910.5 | 3.357 | 8 | Pass |
| Mid #2 | 919.5 | 1.828 | 8 | Pass |
| High | 926.5 | 1.091 | 8 | Pass |

**Table 8. Summary of Power Spectral Density.**

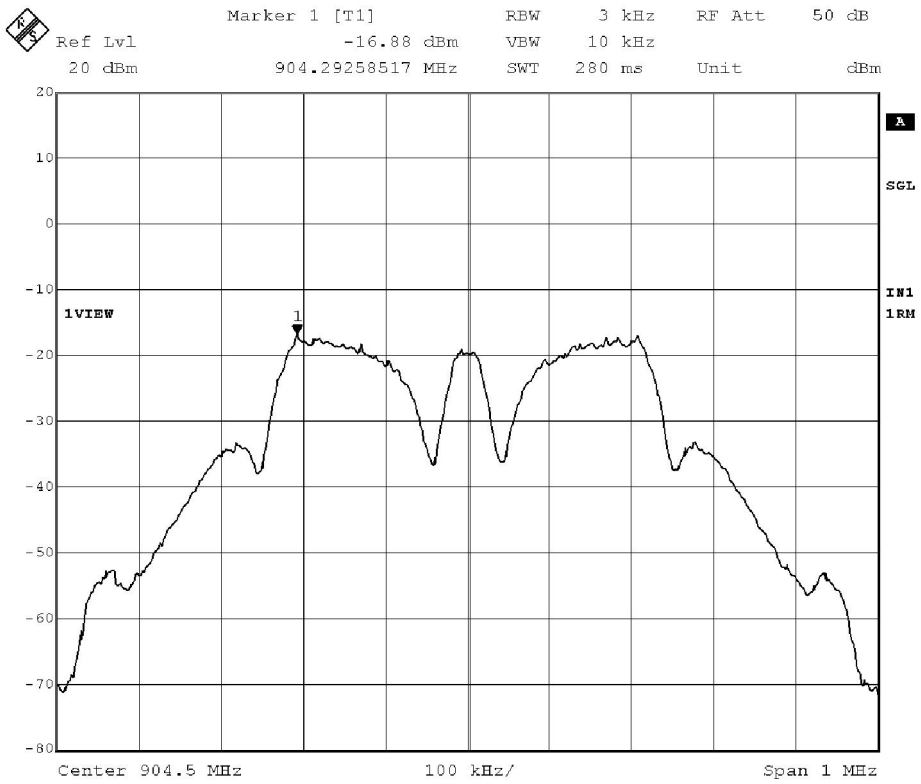



**Figure 16. Maximum Power Spectral Density – Low Channel – 904.5MHz**

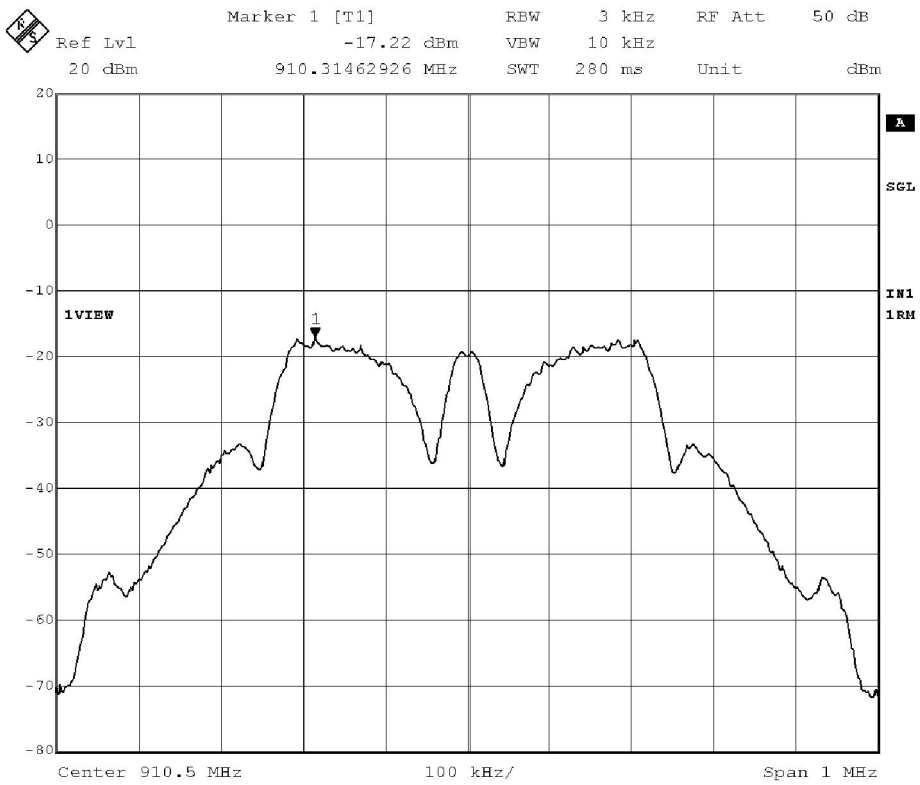



**Figure 17. Maximum Power Spectral Density – Mid Channel #1 – 910.5MHz**

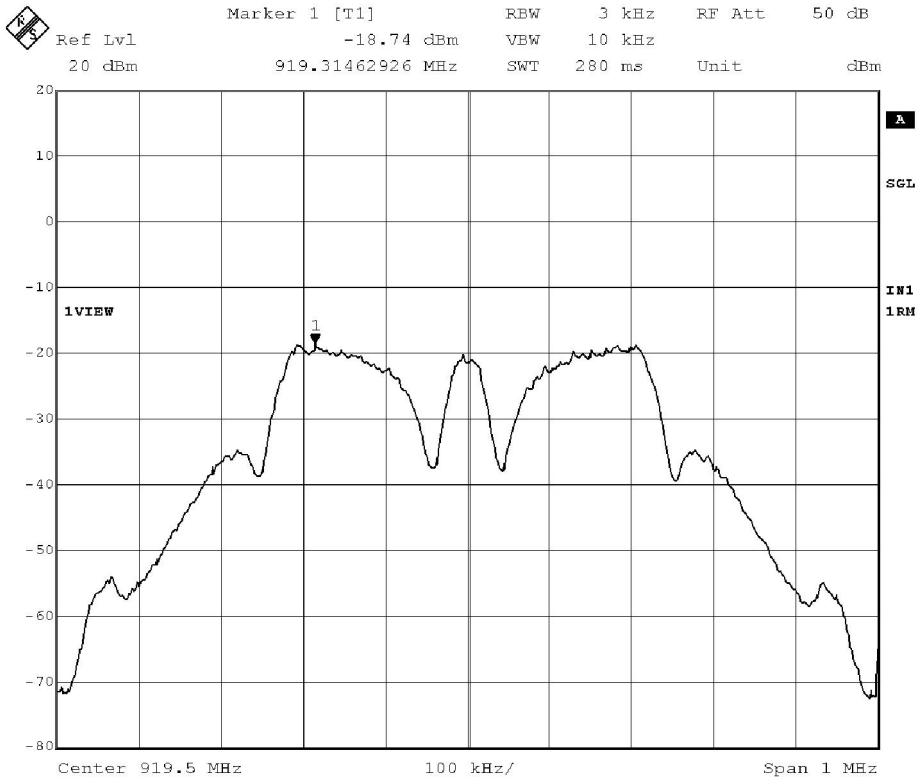



**Figure 18. Maximum Power Spectral Density – Mid Channel #2 – 919.5MHz**

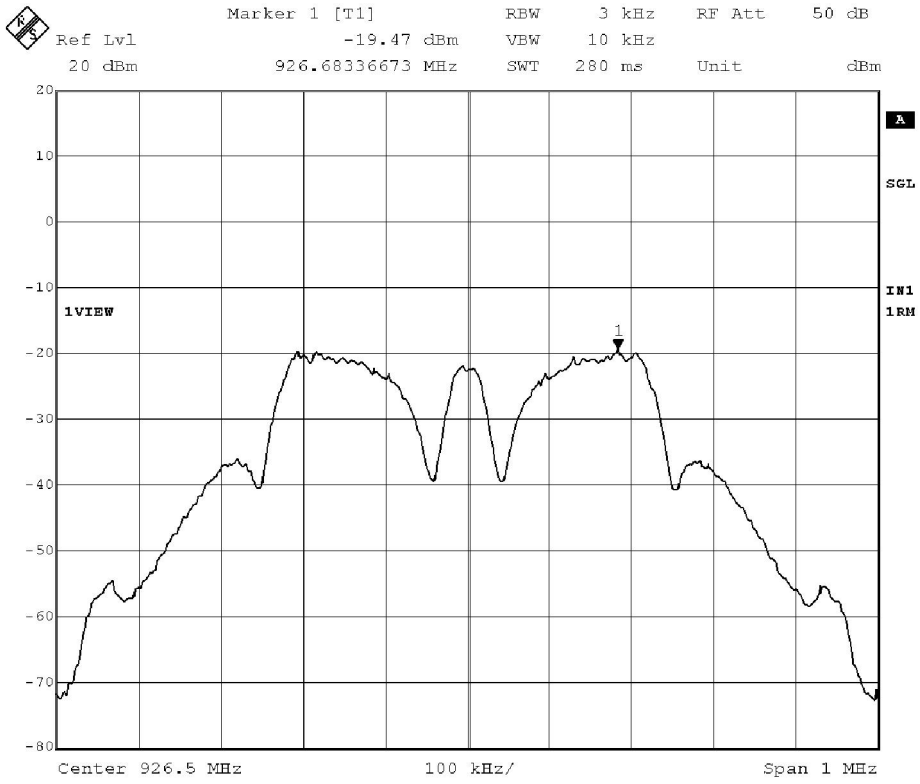



**Figure 19. Maximum Power Spectral Density – High Channel – 926.5MHz**

## 11.8 Fundamental Radiated Measurements

ANSI C63.4: 2009, section 13.4.2, directs that the radiated fundamental emissions measurement shall be recorded. See also the maximum conducted (average) power measurements of section 11.5 of this test report.

### 11.8.1 Test Methodology

The equipment under test's intentional radiator used four channels in the 902MHz to 928MHz frequency band. Typically the high, middle, and low channels are investigated in this range. Since the channels did not lead to an even distribution, all four channels were evaluated. See the table below for results.

The EUT was rotated through 360° and the receive antenna height was varied from 1m to 4m so that the maximum radiated emissions level would be detected. A peak detector was used. Peak measurements were made with RBW of 120kHz and VBW of 300kHz. The process followed that as detailed in ANSI C63.4: 2009. Measurements were taken with a EUT gain setting of "27", continuously transmitting modulated.

### 11.8.2 Test Results

The results of the radiated fundamental measurements are detailed below in Table 9.

| Channel | Frequency Center (MHz) | Frequency (MHz) | Antenna Polarity (V or H) | Corrected Peak Level (dBuV) | Turn Table (deg) | Antenna Height (cm) |
|---|---|---|---|---|---|---|
| Low | 904.5 | 904.3 | H | 116.4 | 304.5 | 111.9 |
| Low | 904.5 | 904.3 | V | 119.4 | 232.5 | 118.0 |
| Mid #1 | 910.5 | 910.3 | H | 113.8 | 356.0 | 116.0 |
| Mid #1 | 910.5 | 910.3 | V | **122.6** | 149.1 | 112.7 |
| Mid #2 | 919.5 | 919.3 | H | 112.6 | 3.5 | 108.3 |
| Mid #2 | 919.5 | 919.7 | V | 121.2 | 162.0 | 113.4 |
| High | 926.5 | 926.7 | H | 114.4 | 294.3 | 101.4 |
| High | 926.5 | 926.7 | V | 116.7 | 350.3 | 126.3 |

**Table 9. Fundamental Radiated Measurements**

## 11.9 Emissions in Restricted Bands – FCC Secions 15.247(d)

These measurements were performed to verify that any spurious emissions or harmonics found inside restricted bands (as defined by FCC Part 15.205) met the general limits of FCC Part 15.209. Limits can be referenced in Tables below.

#### 11.9.1.1 Test Methodology

The maximum field strength was measured following procedures and practices found in ANSI C63.4:2009. An exploratory investigation was performed to find the product orientation and channel which produced the maximum harmonic and spurious emissions relative to the limit. The resolution bandwidth (RBW) and video bandwidth of the spectrum analyzer were set as indicated below. While the EUT was placed in continuous transmit and modulation, the spectrum analyzer peak detector was used to find the position (turn table azimuth and antenna height) where maximum emissions occurred. The appropriate detector was then used to take a raw measurement. The data was then corrected to give a field strength in dBuV/m. Sample calculations are given below for each frequency range.

9kHz-150kHz Frequency Range (RBW = 1kHz, VBW = 3kHz) and
150kHz-30MHz Frequency Range (RBW = 9kHz, VBW = 30kHz):
**Corrected Reading = Analyzer Reading + Cable Loss + Antenna Factor (which includes the internal gain from the amplifier) – 3m Distance Correction Factor (applicable for 300m and 30m limits – see limits table)**
**Margin (dB) = Applicable Limit - Corrected Reading**

30MHz-1000MHz Frequency Range (RBW = 120kHz, VBW = 300kHz):
**Corrected Reading = Analyzer Reading + Cable Loss + Antenna Factor**
**Margin (dB) = Applicable Limit - Corrected Reading**

1GHz-10GHz Frequency Range (RBW = 1MHz, VBW = 3MHz):
**Corrected Reading = Analyzer Reading + Cable Loss + Fiter Loss + Antenna Factor – Preamplifier gain**
**Margin (dB) = Applicable Limit - Corrected Reading**

The EUT was investigated for radiated spurious emissions from 9kHz to 10GHz, encompassing 10 times the highest fundamental frequency and containing any lower clock frequencies. Antenna polarities investigated were as follows: 1) three orthogonal planes for the loop antenna – 9kHz to 30MHz, and 2) horizontal and vertical polarities for the biconilog and horn antennas - 30MHz to 10GHz. See section 10.1 for more setup details

As a special note, since an additional intentional radiator (FCC approved radio module) was integrated into the EUT, co-location testing was necessary. With the approved module (cell phone modem) continuously transmitting at various frequencies and the other intentional radiator tuned to each of its channels (904.5 to 926.5MHz), a search for intermodulation products produced by this pairing was performed. The maximum measurements including those resulting from intermodulation products are shown in Table 12 below.

### 11.9.2 Test Results

The following table details FCC 15.209 limits. All measurements are corrected to a 3-meter distance. The product orientation that produced the highest emissions relative to the limit was with the antennas positioned upright with the enclosure set on end. The channel which produced the highest harmonic or spurious emissions was 904.5MHz.

| Frequency | Limit (uV/m) @ Distance | Limit (dBuV/m) | Distance Correction |
|---|---|---|---|
| 9kHz – 490kHz | 2400/F(kHz) @ 300m | 48.5 – 13.8 @ 300m | 300m to 3m = 80dB |
| 490kHz – 1.705MHz | 24000/F(kHz) @ 30m | 33.8 – 22.97@ 30m | 300m to 3m = 40dB |
| 1.705MHz – 30MHz | 30 @ 30m | 29.54 @ 30m | 300m to 3m = 40dB |
| 30MHz – 88MHz | 100 @ 3m | 40.0 @ 3m | n/a |
| 88MHz – 216MHz | 150 @ 3m | 43.5 @ 3m | n/a |
| 216MHz – 960MHz | 200 @ 3m | 46.0 @ 3m | n/a |
| 960MHz – 40GHz | 500 @ 3m | 54.0 @ 3m | n/a |

**Table 10. General Radiated Emission Limits of FCC 15.209**

The table below shows the restricted bands of FCC Part 15.205.

| MHz | MHz | MHz | GHz |
|---|---|---|---|
| 0.090–0.110 | 16.42–16.423 | 399.9–410 | 4.5–5.15 |
| [1] 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 |

| MHz | MHz | MHz | GHz |
|---|---|---|---|
| 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 | ([2]) |
| 13.36–13.41. | | | |

[1] Until February 1, 1999, this restricted band shall be 0.490–0.510 MHz.
[2] Above 38.6

**Table 11. Restricted Bands of Operation (FCC Part 15.205)**

| Restricted Band Emision (MHz) | Antenna Polarity[1] | QP\AVG Meas. (dBuV/m) | QP/AVG Limit (dBuV/m) | QP/AVG Margin (dB) | Turn Table (deg) | Antenna Height (cm) |
|---|---|---|---|---|---|---|
| 968.625 | V | 53.05 QP | 53.98 QP | **0.93** | 188.4 | 101.8 |
| 968.630 | H | 49.22 QP | 53.98 QP | **4.76** | 64.7 | 152.7 |
| 409.323 | H | 37.43 QP | 46.02 QP | **8.59** | 119.2 | 122.6 |
| 409.436 | V | 37.10 QP | 46.02 QP | **8.92** | 104.3 | 118.2 |

**Table 12. Highest Restricted Band Emissions Relative to the Limit**

All peak measurements >1GHz were more than 20dB below the peak limit and therefore, fell below the Average limit. Only one harmonic emission was seen above the noise floor of the measuring instrumentation within the Restricted Bands. The maximum amplitude of this harmonic emission is recorded in the table below.

| Restricted Band Emission (GHz) | Antenna Polarity[2] | Peak Meas. (dBuV/m) | Peak Limit (dBuV/m) | Peak Margin (dB) | AVG Meas. (dBuV/m) | AVG Limit (dBuV/m) | AVG Margin (dB) | Turn Table (deg) | Antenna Height (cm) |
|---|---|---|---|---|---|---|---|---|---|
| 2.7129 | V | 45.57 | 73.98 | 28.41 | 35.96 | 53.98 | 18.02 | 171.8 | 123.9 |

**Table 13. Harmonic Emission in Restricted Band.**

The data reported in Table 12 and Table 13 meets the requirements of 15.247(d) emissions in restricted bands.

[1] V = vertical antenna polarity, H = horizontal antenna polarity
[2] V = vertical antenna polarity, H = horizontal antenna polarity

## 11.10 RF Exposure Limits – FCC Sections 15.247(i), 1.1307, 1.1310, 2.1091, 2.1093

FCC Part 15.247(i) states that products under this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines.

According to the FCC's definition as given in Part 2.1093 (b), the EUT is classified as a mobile device. Additionally, since this type of mobile equipment (following Part 15.247) does not fit into any of the Parts mentioned in FCC Part 2.1093 (c), it is categorically excluded from routine environmental evaluation for RF exposure. However, it still must be evaluated against FCC Part 1.1307(c) and 1.1307(d). The published RF exposure KDB procedures contained in KDB 447498 will be adequate to do this.

### 11.10.1 MPE Calculation Method

$$E(\text{V/m}) = \frac{\sqrt{30 \times P \times G}}{d} \qquad \text{Power Density: } S(\text{W/m}^2) = \frac{E^2}{377}$$

Where the variables are defined as

$E$ = Electric field (V/m)
$P$ = Average RF output power (W)
$G$ = EUT Antenna numeric gain (numeric)
$d$ = Seperation distance between radiator and human body (m)
$S$ = Power Density

Combining equations and re-arranging the terms to express the distance as a function of the remaining variables yields:

$$S = \frac{30 \times P \times G}{377 d^2}$$

From the EUT RF output power, the minimum mobile separation distance, d=0.2m, as well as the gain of the antenna, the RF power density can be obtained.

### 11.10.2 Calculated Results and Limit (FCC Part 1.1310 – Table 1)

The Power Density Limit (mW/cm$^2$) from Table 1 of FCC Part 1.1310 was calculated from $f$(MHz)/1500 for frequencies between 300-1500MHz. The Power Density Limit (mW/cm$^2$) for frequencies 1500-100,000MHz is 1.0

| Freq. (MHz) | Antenna Gain (dBi) | Antenna Gain (numeric) | Average Output Power (dBm) | Average Output Power (W) | Power Density(S) (W/m$^2$) | Power Density(S) (mW/cm$^2$) | Limit of Power Density (S) (mW/cm$^2$) |
|---|---|---|---|---|---|---|---|
| 904.5 | 1.50 | 1.4125 | 20.163 | 0.104 | 0.292 | 0.0292 | 0.603 |

**Table 14. Calculated Power Density for Intentional Radiator**

Maximum Output Powers for the Approved Module FCC ID: MIVCNN0301
Frequencies of Maximum: 824.7 MHz and 1851.25 MHz (information from FCC Grant & Report).

| Freq. (MHz) | Antenna Gain (dBi) | Antenna Gain (numeric) | Average Output Power (dBm) | Average Output Power (mW) | Power Density(S) (W/m$^2$) | Power Density(S) (mW/cm$^2$) | Limit of Power Density (S) (mW/cm$^2$) |
|---|---|---|---|---|---|---|---|
| 824.7 | 1.50 | 1.4125 | 23.33 | 0.22 | 0.6182 | 0.06182 | 0.5498 |
| 1851.25 | 1.50 | 1.4125 | 22.90 | 0.20 | 0.5620 | 0.05620 | 1.00 |

**Table 15. Calculated Power Density for Approved FCC Module**

The Approved FCC Module can only transmit on one band at a time, either 824.7 – 848.31MHz or 1851.25 – 1908.75MHz.
The EUT's intentional radiator can transmit simultaneous with either one of these bands.

The formula for evaluating simultaneously transmitting modules is as follows:

CPD1 / LPD1 + CPD2 / LPD2 + …. etc. < 1

Where the variables are defined as

CPDx = *Calculated Power Density,* x = *each distinct transmitter*.
LPDx = *Limit of Power Density*, x = *each distinct transmitter.*

The following equations detail the permissible simultaneous transmission combinations:

1. EUT Intentional Radiator (904.5MHz) + Approved FCC Module (824.7MHz) = (0.02917 / 0.603) + 0.06182 / 0.5498 = 0.1608 which is less than 1. **Compliant.**
2. EUT Intentional Radiator (904.5MHz) + Approved FCC Module (1851.25MHz) = (0.02917 / 0.603) + 0.05620 / 1.00) = 0.1046 which is less than 1. **Compliant.**

## 12.0 CONCLUSION

It was found that the ActiveSense Hub, Model# HB1, **meets** the emission requirements (both conducted and radiated) of the CFR47, Part 15, Subpart C, Section 15.247 for operating within the 902-928 MHz Band.