International Compliance Laboratories

FCC Part 15 Subpart C
Transmitter Certification Test Report

Direct Sequence Spread Spectrum Transmitter

ICL Report # 2032 Rev 1
FCC ID: 2AC46-DS003

Test Specification: FCC Rule Part: 15.247

Manufacturer: Mesh Systems, LLC
Model Name: ActiveSense Rodent Sensor
Model Number: RD1
Serial Number: 2032 (Defined at ICL)

Test Start Date: November 11, 2015
Test End Date: February 4, 2016

Report Issue Date: March 16, 2016

Test Result: Pass

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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

Test Section	Description	Result
FCC 15.203	Antenna Requirement	MEETs Requirement
FCC 15.247(a)	6dB Bandwidth	MEETs Requirement
FCC 15.215(c) FCC 15.247(d)	Occupied Bandwidth and Band Edge Compliance	MEETs Requirements
FCC 15.247(b)	Maximum Conducted (Average) Output Power	MEETs Requirement
FCC 15.247(d)	Emissions in Non-Restricted Bands	MEETs Requirements
FCC 15.247(e)	Power Spectral Density	MEETs Requirement
ANSI C63.4	Fundamental Radiated Measurement	Reported
FCC 15.247(d)	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

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

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

BRW915-Spec-Sheet.pdf document provided by Mesh Systems, LLC.

4.0 Product Description

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

4.1 FCC-IDs

The FCC-ID for this product (the EUT) is 2AC46-DS003

4.2 Product Name

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

4.3 Product Description

The sensor is a wireless device that monitors activity and periodically reports the data back to the Hub.

4.4 Model Number

RD1

4.5 Unit Serial Number

2032 (Defined at ICL)

4.6 Printed Circuit Board Information

A label with a coded graphic is on the back side of the board (see Internal Photos document). Under the graphic are two lines of information: “4 5.1215 K151” and “4150742-5”

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 32.768 kHz and 40 MHz.

4.9 Antennas

The product has one custom antenna supplied by Embedded Antenna Design, Ltd having part number BRW915-RS-ST. The connection is a reverse polarity SMA plug. See datasheet for more information.

The gain of the antenna is 0 dBi as detailed by the datasheet.

4.11 Power Source

The EUT was powered by an internal 3.6V 1600mAh battery. Each test performed used fresh batteries as provided by the customer.

5.0 Auxiliary Equipment Information

To configure the EUT's channel of transmission and turn on the transmitter continuously and modulated, a small magnet provided by the customer was necessary.

The following instructions were given to ICL:

Here is how to change frequencies on the sensor.
1. Hold magnet over the center of the sensor.
2. While keeping the magnet in place observe the following red LED blink sequences to select the frequency. Each sequence will repeat a few times before moving to the next.
    1 repeating fast blink - Freq 1
    2 repeating fast blinks - Freq 2
    3 repeating fast blinks - Freq 3
    4 repeating fast blinks - Freq 4
3. At the desired frequency remove the magnet and the sensor will start continuously transmitting.
4. To stop transmission swipe the magnet one more time.
5. Repeat steps 1 - 3 as needed for other frequencies.

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 54956
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*); CFR 47 FCC, Part 18 (using MP-5); CISPR 11 (*up to 1 GHz*); EN 55011 (*up to 1 GHz*); CISPR 14-1 (*excluding clause 6*); EN 55014-1 (*excluding clause 6*); CISPR 15 (*clause 8 only*); EN 55015 (*clause 8 only*); CISPR 22; EN 55022; 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

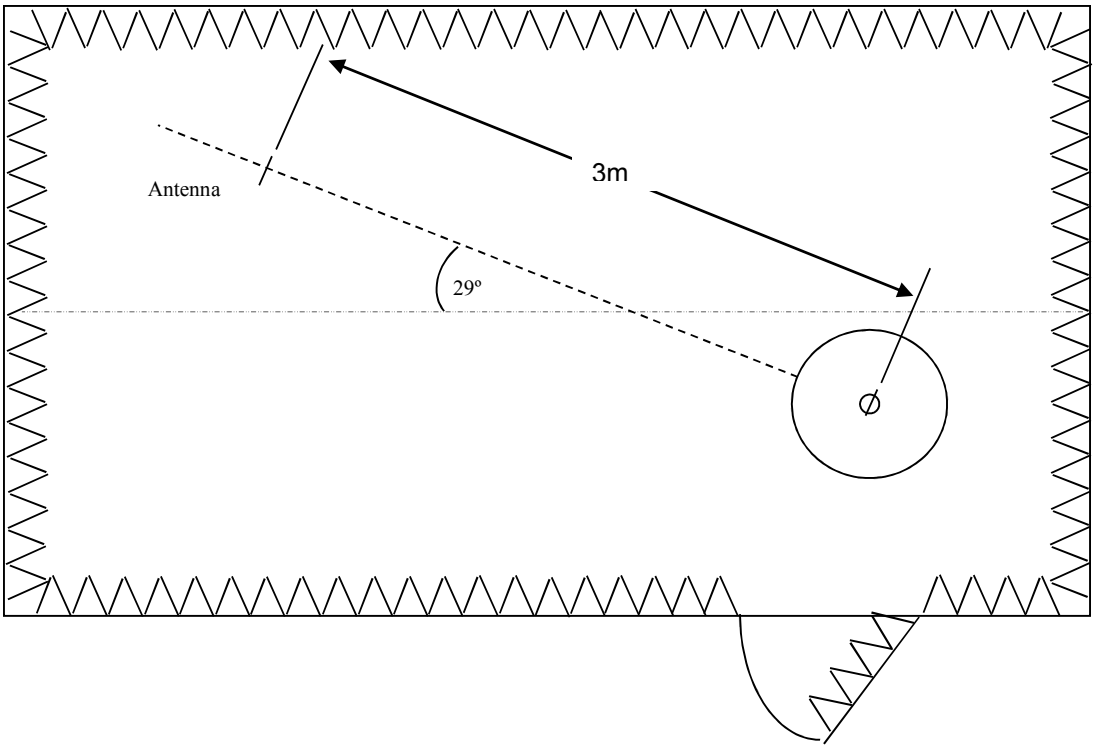
On the following products or types of products:
Light Industrial, Commercial, Residential, Heavy Industrial, Scientific, Medical, Portable Test and Measurement Equipment, Information Technology Equipment, Telecom, Automotive, and other Electrical and Electronic Equipment

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 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:



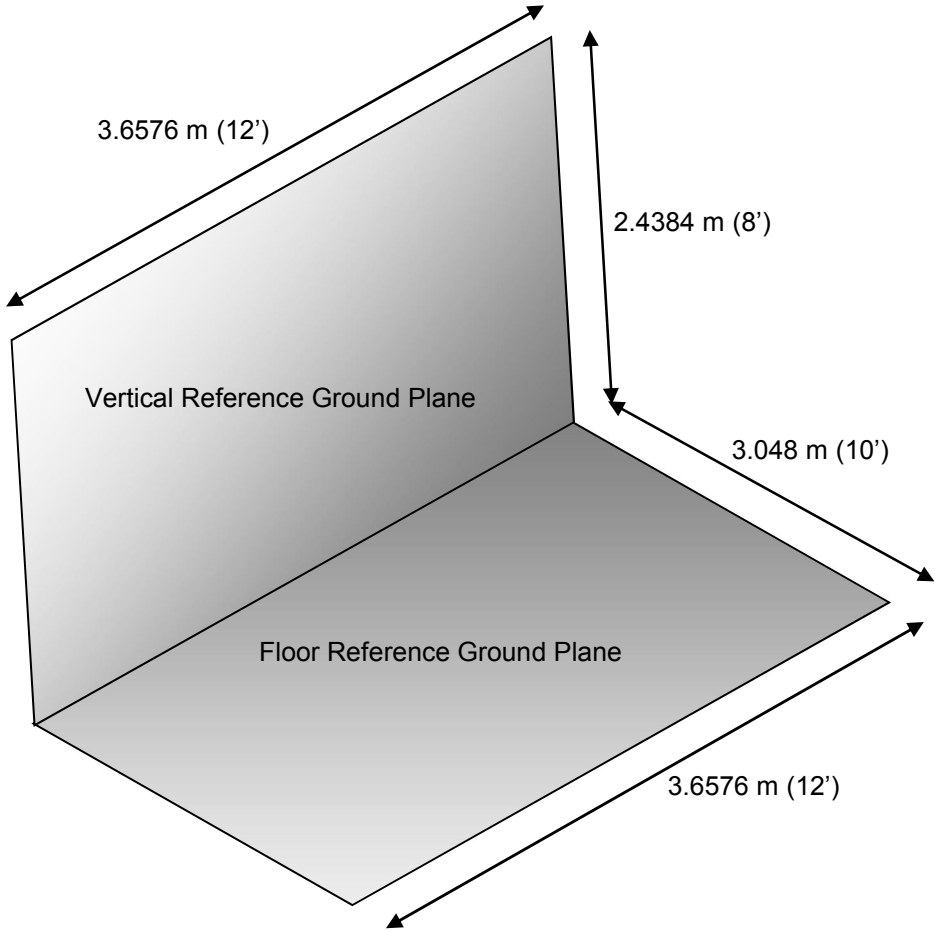
Power to the room is filtered to prevent ambient noise from coupling to the EUT and measurement equipment. Filters are models 07294/GFUL57915-1x100 (100 Amp 277/480Vac 50/60Hz) manufactured by Genisco Electronics Corporation.

The room is of sufficient size to test table top and floor standing equipment in accordance with 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
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

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 directly in the center.

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 measurements at various antenna heights 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.

Three orthogonal positions of the EUT were investigated during radiated emissions.

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 to Reverse-SMA 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).

11.0 Summary of Tests

11.1 Antenna Requirement – FCC Section 15.203

The EUT has an antenna that uses a unique coupling to the intentional radiator. The ActiveSense Rodent Sensor main board employed a reverse polarity-SMA jack connection. The antenna uniquely mated to this connection and satisfying the requirements of CFR 47 Part 15.203.

11.2 6dB Bandwidth – FCC Sect. 15.247(a)

11.2.1 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. Measurements were taken continuously transmitting and modulated

11.2.2 Test Results

Results are shown below in Table 2 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	541.1	≥500kHz	Pass
910.5	549.1	≥500kHz	Pass
919.5	549.1	≥500kHz	Pass
926.5	549.1	≥500kHz	Pass

Table 2. Summary of 6dB Bandwidth Test

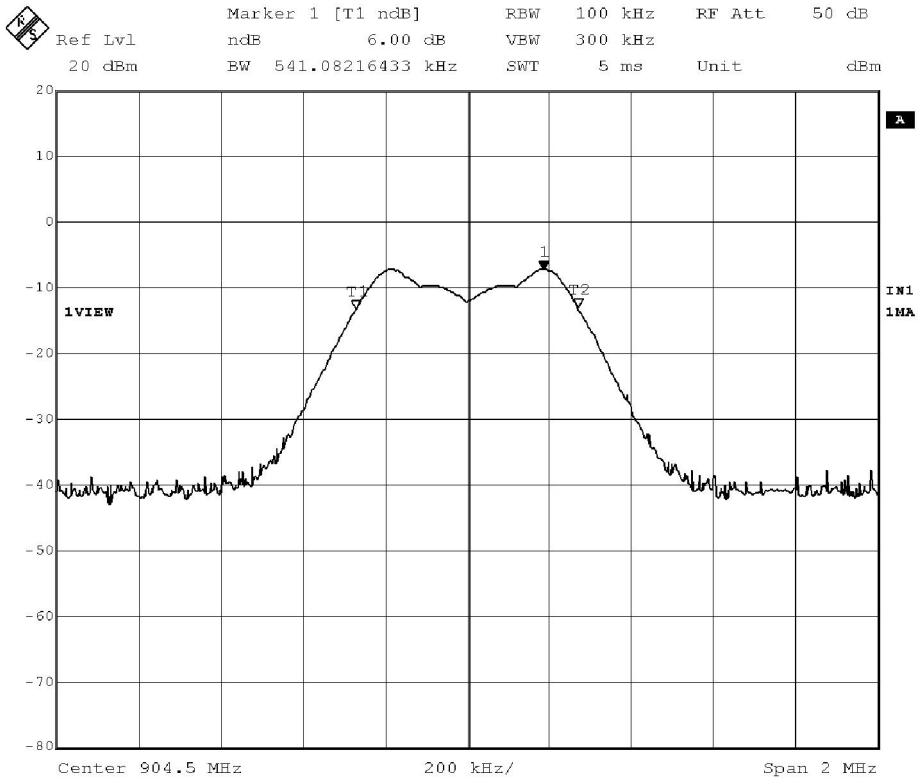


Figure 2. 6dB Bandwidth Plot - Low Channel – 904.5MHz

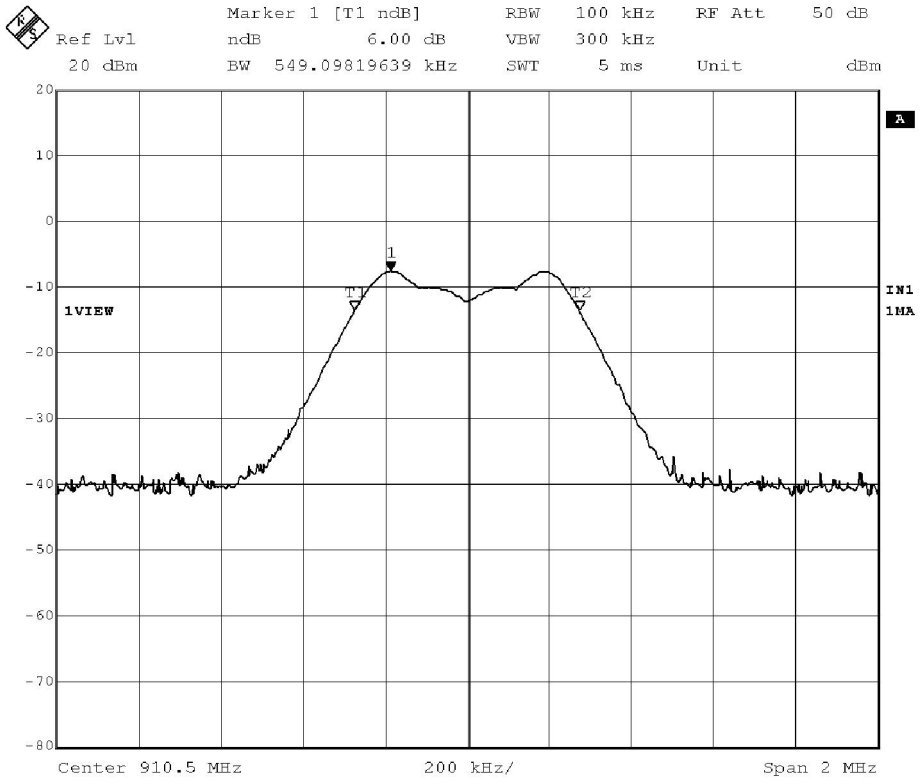


Figure 3. 6dB Bandwidth Plot - Mid Channel #1 – 910.5 MHz

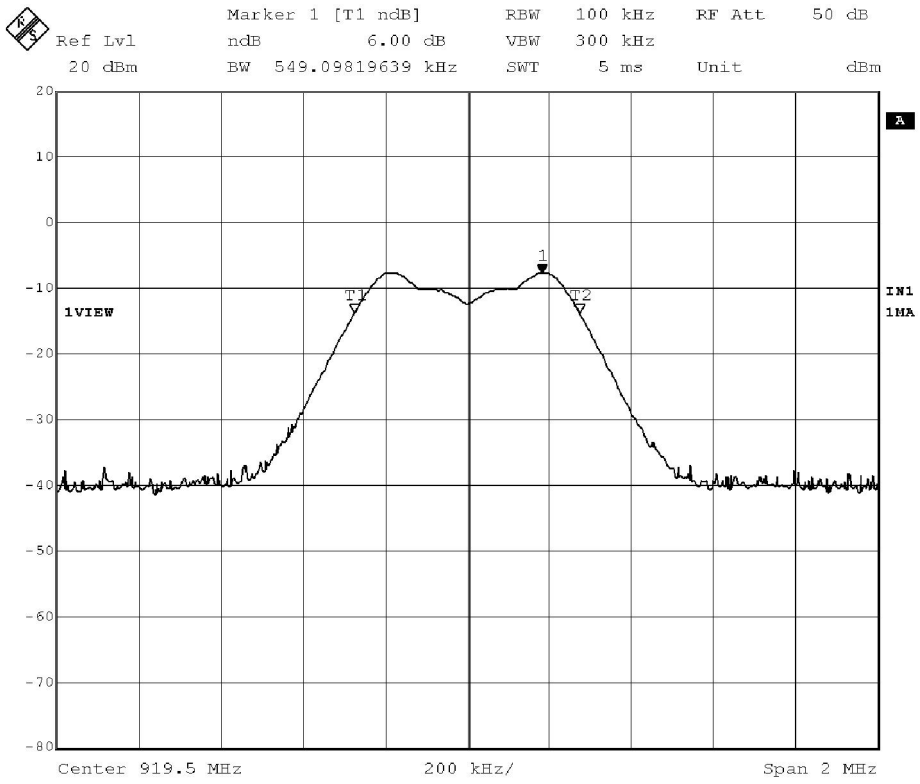


Figure 4. 6dB Bandwidth Plot - Mid Channel #2 – 919.5 MHz

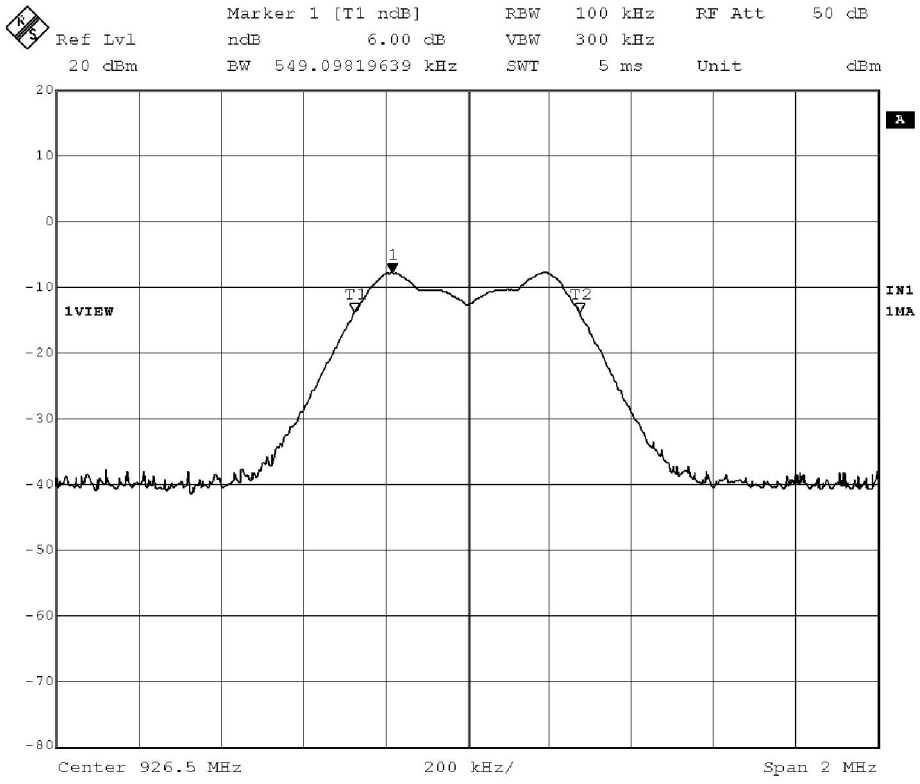


Figure 5. 6dB Bandwidth Plot - High Channel – 926.5 MHz

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

11.3.1 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 continuously transmitting and modulated. The relevant settings used are listed below:

a) The two end channels were 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 10 kHz.
e) Video bandwidth (VBW) set to 30 kHz (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.

11.3.2 Test Results

The results are shown below in Table 3 and Figure 6 through Figure 7 below.

Channel	Frequency (MHz)	Delta Marker #1 (dB down/MHz)		Delta Marker #2 (dB down/MHz)		Occupied Bandwidth (kHz)
Low	904.5	20.18	904.205	20.28	904.783	578
High	926.5	20.40	926.209	20.02	926.791	582

Table 3. Summary of Occupied Bandwidth Measurements

The results for Band Edge Compliance are shown in Figure 8 and Figure 9. As seen in the plots the peak power in any 100 kHz bandwidth outside of the authorized frequency band is attenuated by more than 30dB 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).

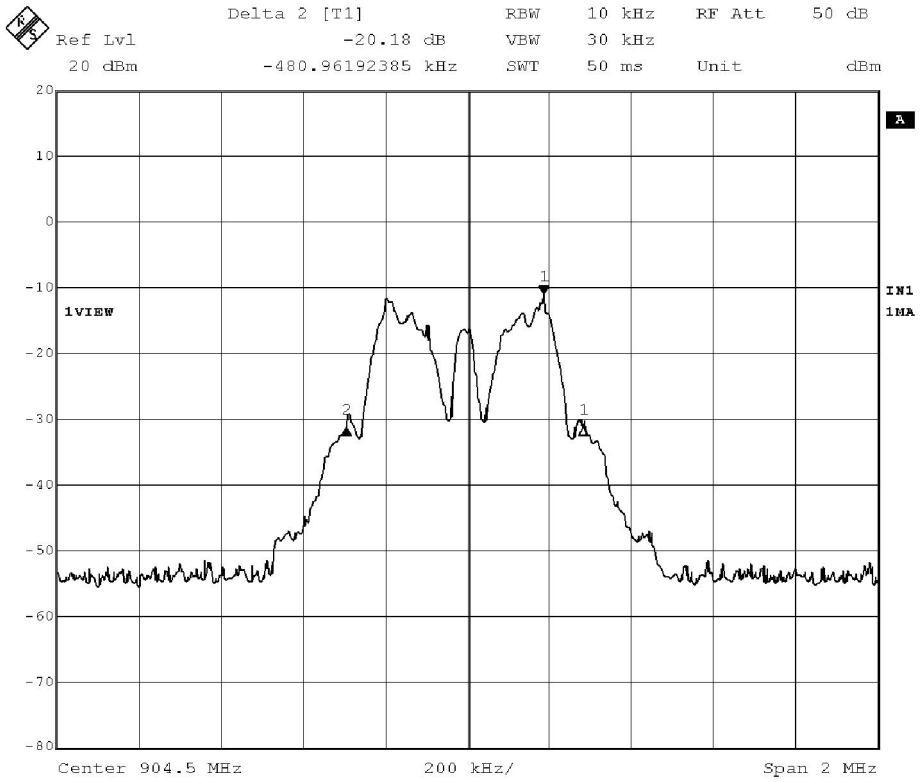


Figure 6. Occupied Bandwidth – Low Channel – 904.5MHz

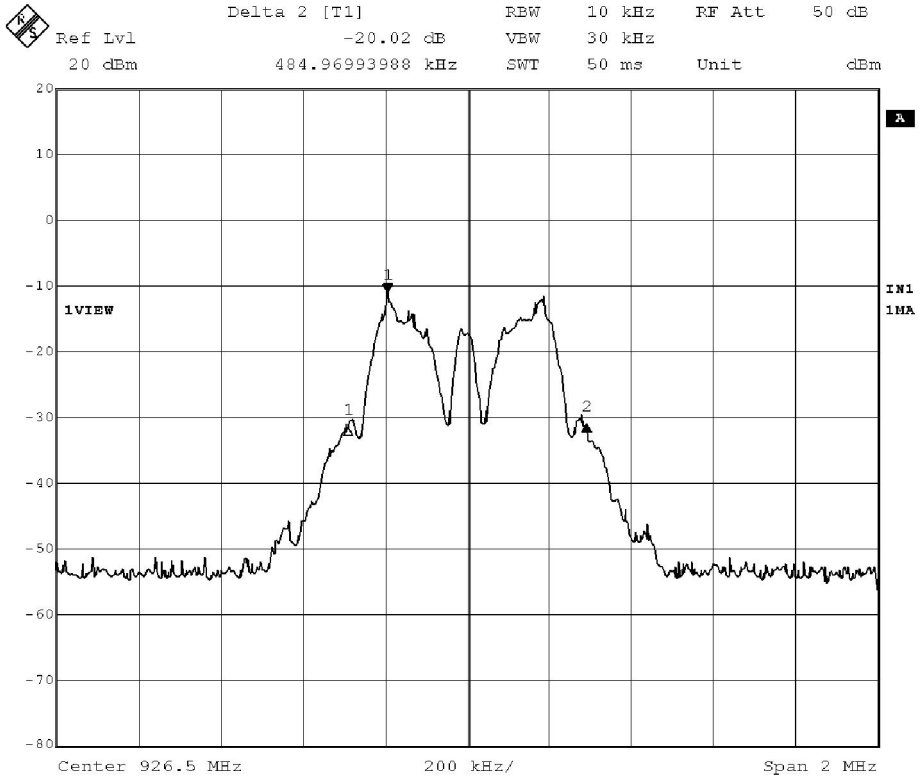


Figure 7. Occupied Bandwidth – High Channel – 926.5MHz

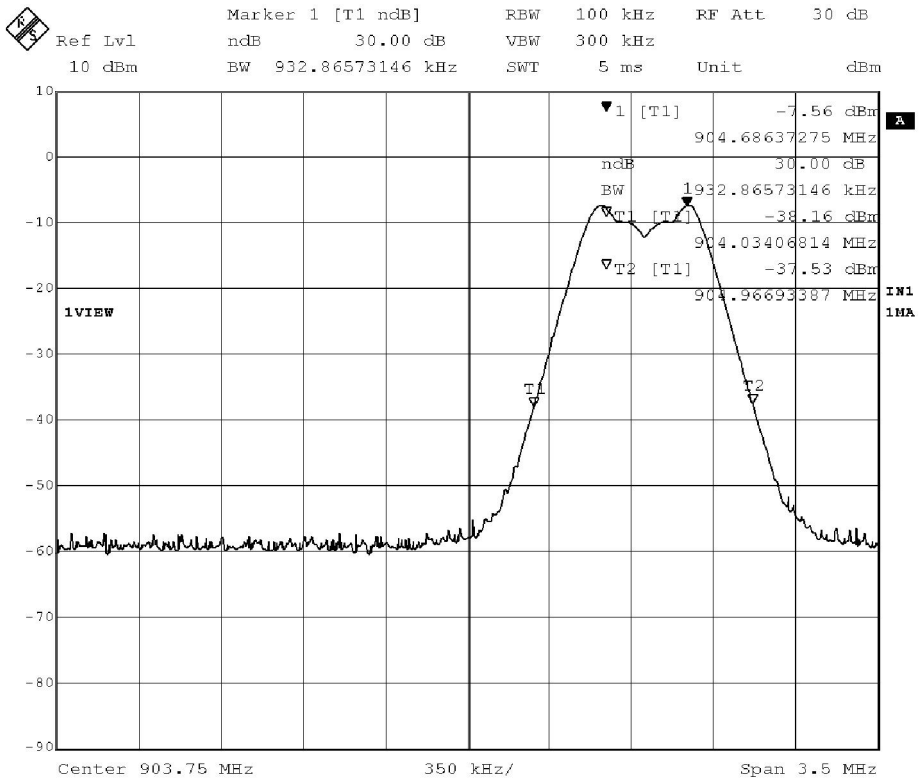


Figure 8. Band Edge Compliance at 902MHz for Low Channel – 904.5MHz.

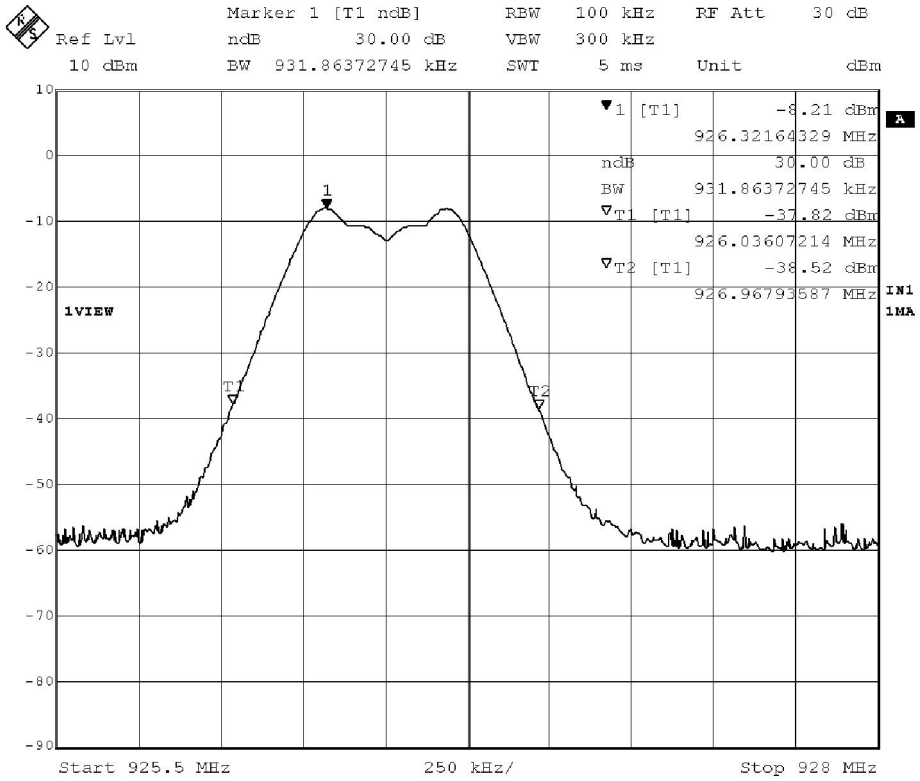


Figure 9. Band Edge Compliance at 928MHz for High Channel – 926.5MHz.

11.4 Maximum Peak Conducted Output Power Requirement – FCC Sect. 15.247(b)

11.4.1 Test Methodology

The maximum peak conducted output power was measured as directed by FCC Part 15.247 (b). The measurement procedure followed the steps as described in section 9.1.1 of FCC Publication No. 558074, entitled "RBW ≥ DTS bandwidth". 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 continuously transmitting and modulated. The relevant settings used are listed below:

a) Resolution bandwidth (RBW) set to 1MHz which was greater than the DTS bandwidth (~578kHz to ~582kHz)
b) Video bandwidth (VBW) set to 3MHz which is 3xRBW.
c) Span set to 3MHz which is 3xRBW.
d) Sweep time was set to Auto.
e) Detector was set to Peak.
f) The trace was set to Max Hold.
g) The trace was allowed to fully stabilize.
h) A Peak Search function was used to determine the highest amplitude of the waveform.

The antenna gain as reported from the Embedded Antenna Design, LTD data sheet for the BRW-915 was 0dBi. Since this was less than 6 dBi, no special requirements needed to be considered as specified in 15.247(b)(4).

11.4.2 Test Results

Results are shown below in Table 4 and Figure 10 through Figure 13. 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	12.751	≤1 Watt (30dBm)	Pass
Mid #1	910.5	12.658	≤1 Watt (30dBm)	Pass
Mid #2	919.5	12.343	≤1 Watt (30dBm)	Pass
High	926.5	12.250	≤1 Watt (30dBm)	Pass

Table 4. Summary of Maximum Peak Conducted Output Power

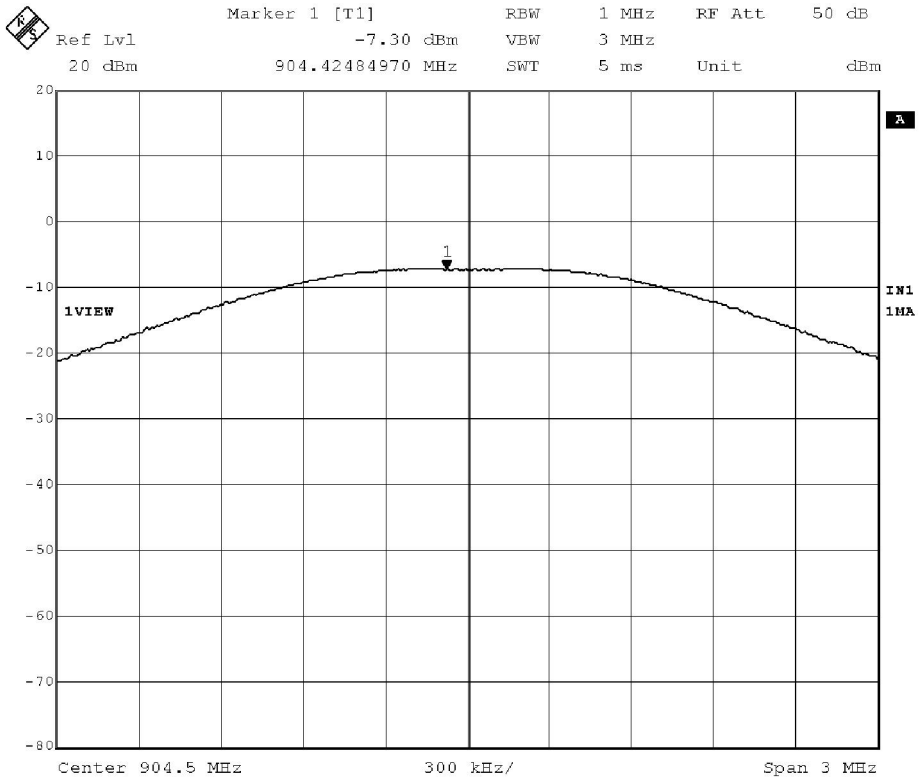


Figure 10. Maximum Peak Conducted Output Power Plot – Low Channel – 904.5MHz

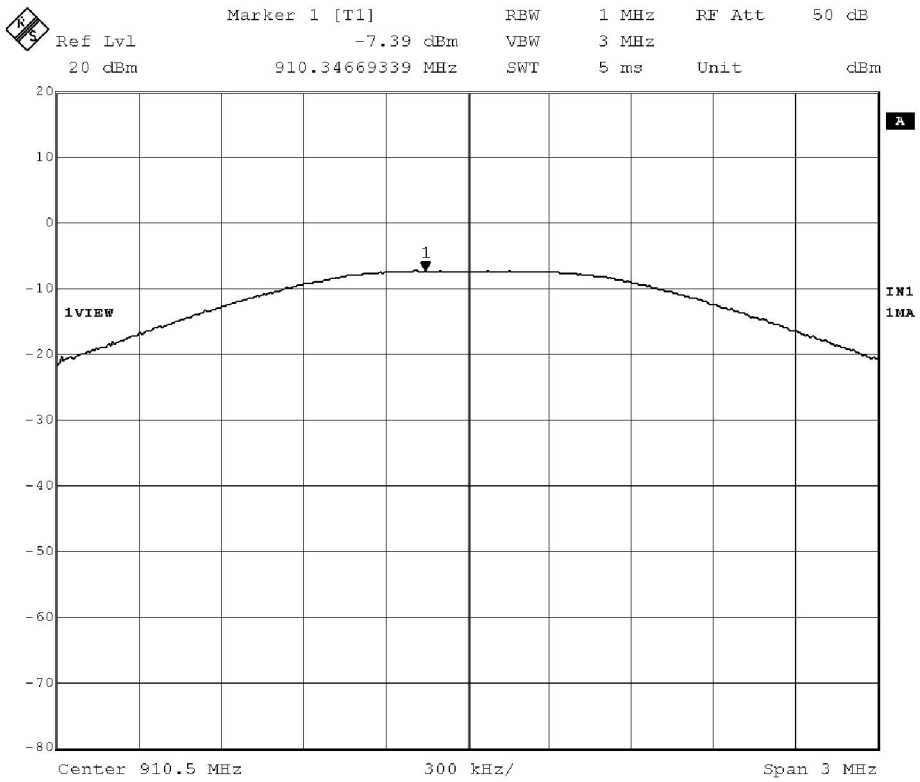


Figure 11. Maximum Peak Conducted Output Power Plot – Mid Channel #1 – 910.5MHz

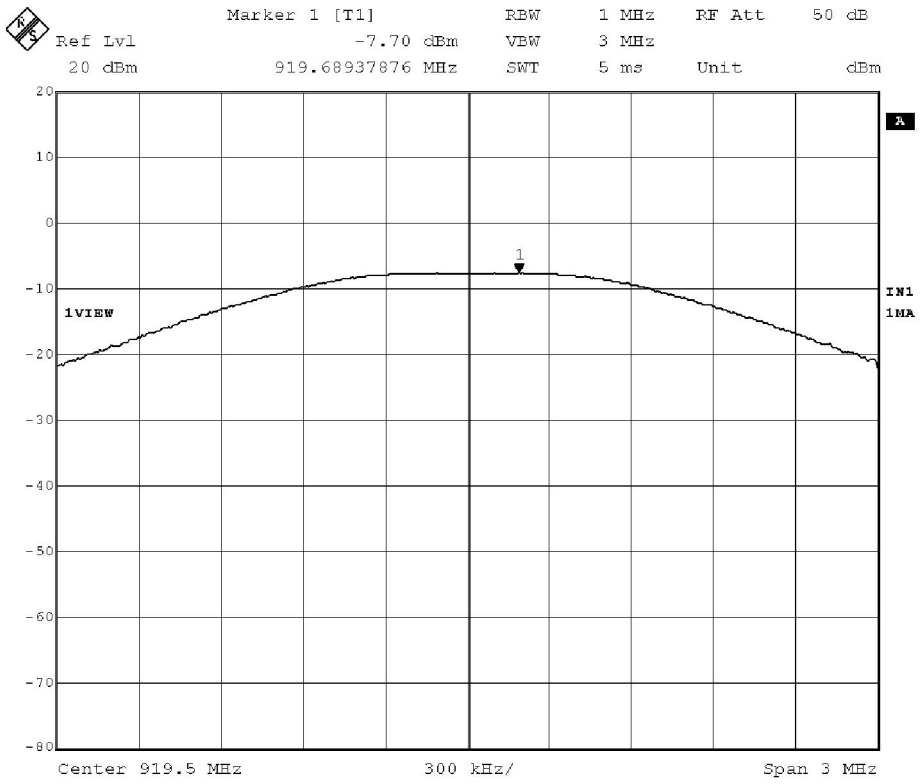


Figure 12. Maximum Peak Conducted Output Power Plot – Mid Channel #2 – 919.5MHz

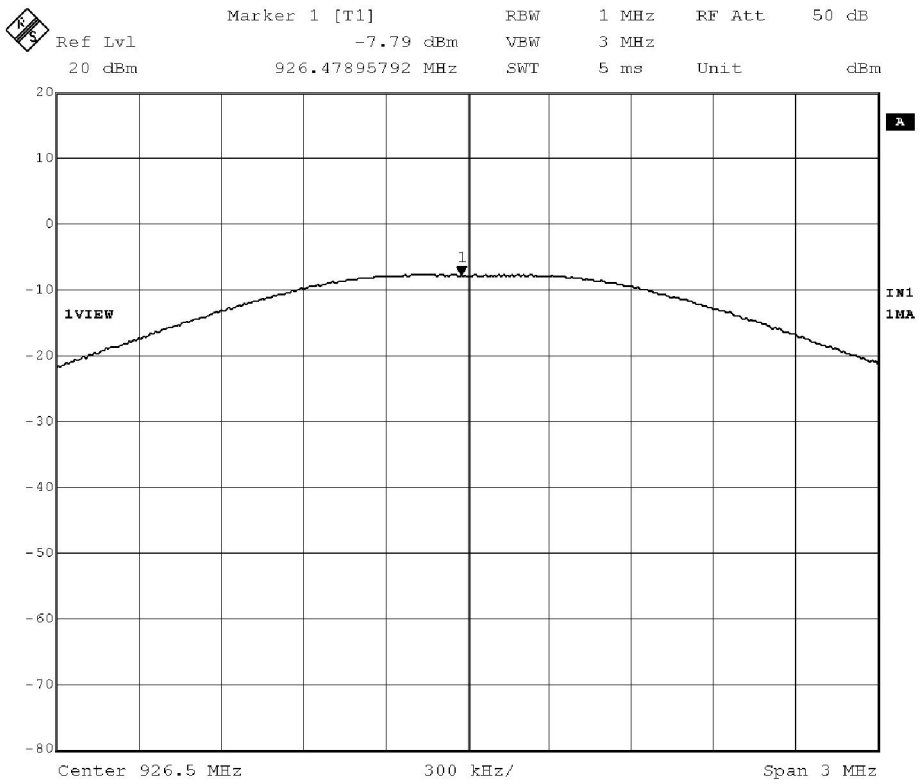


Figure 13. Maximum Peak Conducted Output Power Plot – High Channel – 926.5MHz

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

11.5.1 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 continuously transmitting and 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 ~867 kHz to ~873 kHz.
c) Resolution bandwidth (RBW) set to 100 kHz.
d) Video bandwidth (VBW) set to 300 kHz.
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 20dB down from the Reference Level was plotted to quickly gauge if any emission was higher than the requirement.

11.5.2 Test Results

Results are shown below in Table 5 and Table 6. 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)	20dB Attenuated From PSD Limit (dBm)	Result
Low	904.5	-6.81	13.60	-6.40	Low channel found to have highest PSD Level.
Mid #1	910.5	-6.99	The raw PSD Levels for these channels were not corrected since they were not the highest.		
Mid #2	919.5	-7.28			
High	926.5	-7.52			

Table 5. Summary of Reference Level PSD Evaluation

Emission Frequency (GHz)	Corrected Measurement (dBm)	Attenuated 20dB under PSD Reference Level above?
1.809	-54.478	Yes
6.330	-64.383	Yes
7.234	-66.922	Yes

Table 6. Non-Restricted Band Highest Emissions

As shown by the measurement data, the measurements found in the non-restricted bands were attenuated by at least 20dB down as required by the FCC Part 15.247(d)

11.6 Power Spectral Density – FCC Sect. 15.247(e)

11.6.1 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 10.2 of FCC Publication No. 558074, entitled "Method PKPSD (peak PSD)". 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 continuously transmitting and modulated. The relevant settings used are listed below:

Method PKPSD

a) Each DTS channel was investigated and was centered on the spectrum analyzer.
b) The span was set to 1.5 x the DTS bandwidth in each case (as the standard directs). This was 811.65 kHz, 823.65 kHz, 823.65 kHz, and 823.65 kHz for each channel (904.5 MHz to 926.5 MHz) respectively.
c) Resolution bandwidth (RBW) set to 3 kHz (this falls within 3 kHz ≤ RBW ≤ 100 kHz specified).
d) Video bandwidth (VBW) set to 30 kHz (≥ 3 x RBW).
e) Detector was set to Peak.
f) Sweep Time was set to Auto.
g) The trace was set to perform a Max Hold.
h) The Peak Search function was applied to find the maximum amplitude level.

11.6.2 Test Results

Results are shown below in Table 7 and Figure 14 through Figure 17. 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	4.211	8	Pass
Mid #1	910.5	4.628	8	Pass
Mid #2	919.5	5.213	8	Pass
High	926.5	3.880	8	Pass

Table 7. Summary of Power Spectral Density.

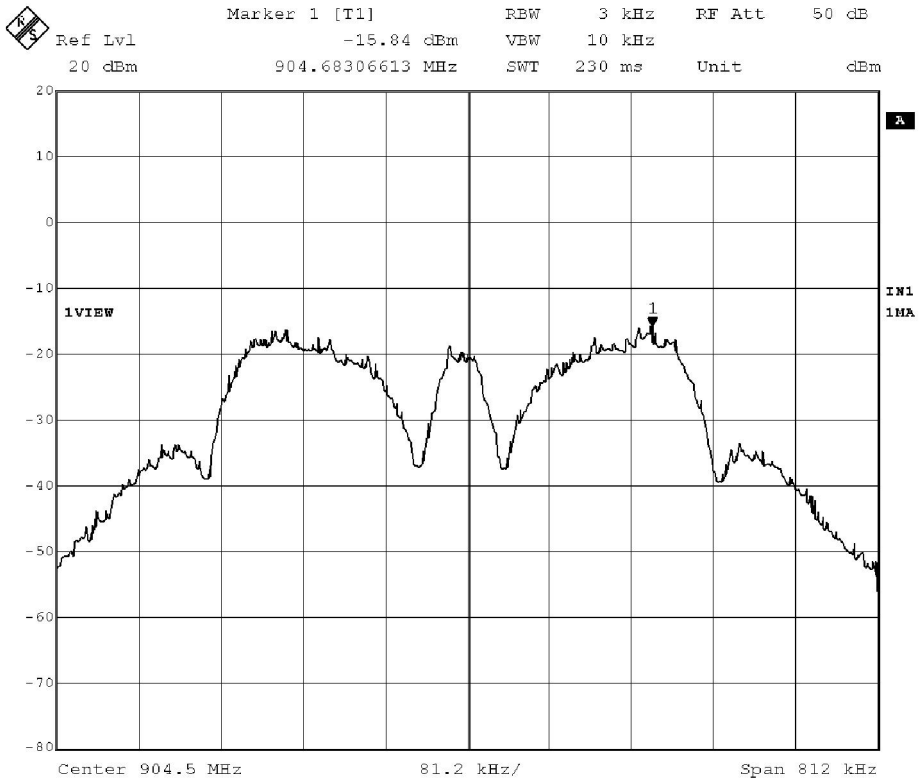


Figure 14. Maximum Power Spectral Density – Low Channel – 904.5MHz

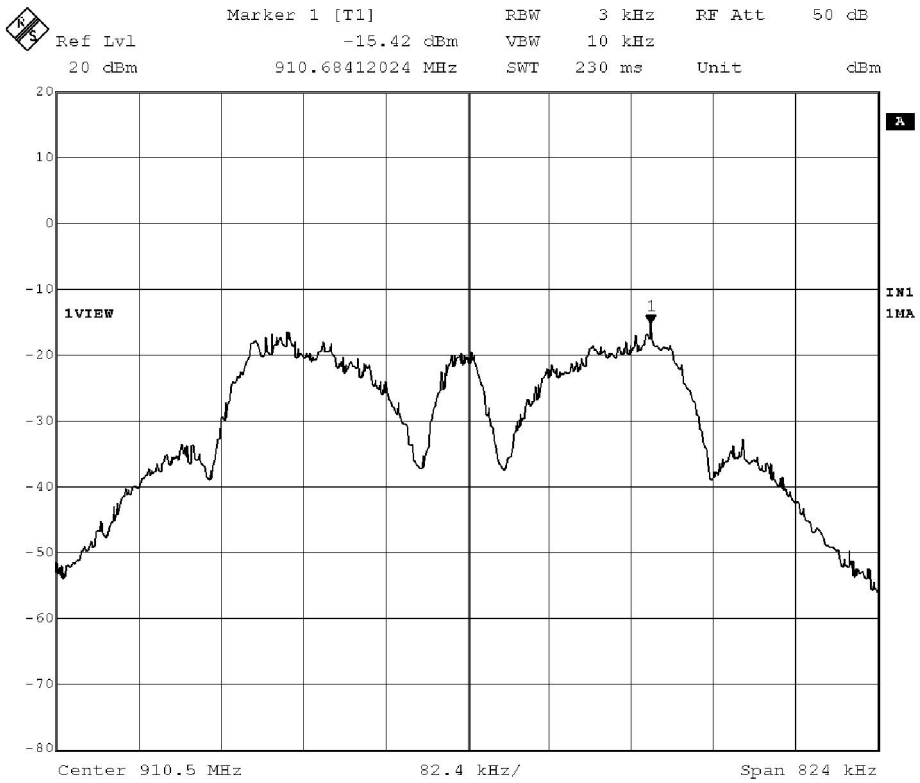


Figure 15. Maximum Power Spectral Density – Mid Channel #1 – 910.5MHz

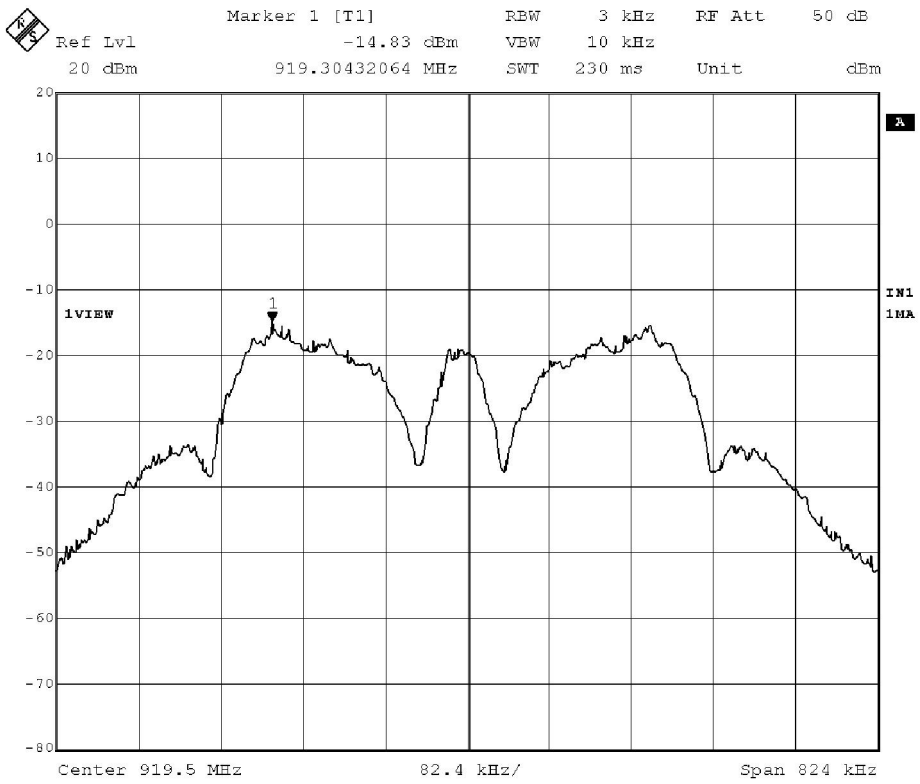


Figure 16. Maximum Power Spectral Density – Mid Channel #2 – 919.5MHz

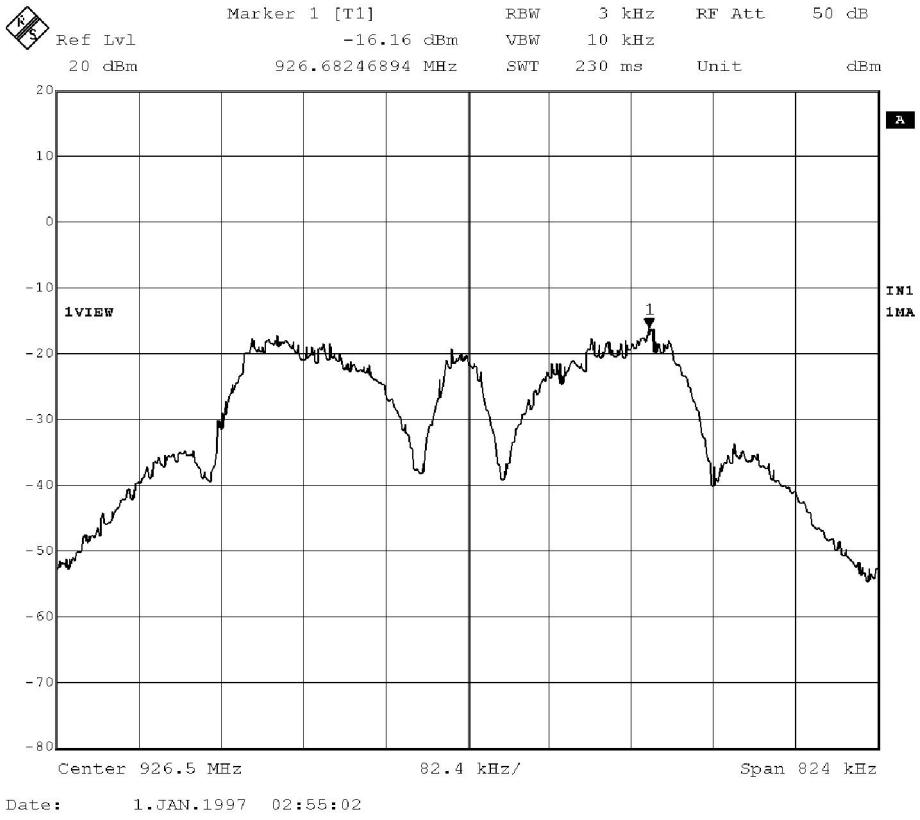


Figure 17. Maximum Power Spectral Density – High Channel – 926.5MHz

11.7 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 11.4 of this test report.

11.7.1 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 120 kHz and VBW of 300 kHz. The process followed that as detailed in ANSI C63.4: 2009. Measurements were taken continuously transmitting and modulated.

11.7.2 Test Results

The results of the radiated fundamental measurements are detailed below in Table 8. Sample calculations are provided in section 11.8.1.1 of this test report for the measurements below.

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	97.5	242.4	170.4
Low	904.5	904.3	V	**111.4**	132.8	110.5
Mid #1	910.5	910.3	H	96.6	224.5	167.8
Mid #1	910.5	910.3	V	109.6	126.2	114.5
Mid #2	919.5	919.3	H	95.3	208.1	167.2
Mid #2	919.5	919.3	V	110.5	116.8	108.5
High	926.5	926.3	H	93.4	77.50	252.8
High	926.5	926.3	V	110.7	134.7	107.1

Table 8. Fundamental Radiated Measurements

11.8 Emissions in Restricted Bands – FCC Sections 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.

11.8.1.1 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 = 1 kHz, VBW = 3 kHz) and
150kHz-30MHz Frequency Range (RBW = 9 kHz, VBW = 30 kHz):
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 = 120 kHz, VBW = 300 kHz):
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 + Filter Loss + Antenna Factor – Preamplifier gain + Duty Cycle Correction (for pulsed radiated emissions)
Margin (dB) = Applicable Limit - Corrected Reading

The EUT was investigated for radiated spurious emissions from 9 kHz 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 – 9 kHz 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.

Pulsed emissions subject to a limit requiring an average detector function were initially measured with a peak detector. The peak measurement was then corrected to a true average using the appropriate factor for emission duty cycle (per ANSI C63.4: 2009, section 13.4.2).

11.8.2 Duty Cycle Correction

For average limit comparisons in regard to pulsed radiated emissions the peak measurement was reduced by a factor of -18.7 dB to account for the duty cycle of the EUT. The duty cycle correction was determined using the formula below and methods detailed in ANSI C63.4. The video trigger on the EMI Receiver was utilized to capture the pulse train. The pulse train observed during a transmit was more than 100ms in length. Therefore, the transmitter duty cycle was maximized as much as possible during a 100ms period of normal operation. The plot on the following page (Figure 18) shows the pulses over the 100ms duration that produced the highest duty cycle. Using delta markers yields the following pulse widths:

Pulse 1 (△1) = 5.58ms

Pulse 2 (△2 minus ▽2) = 48.10ms – 42.06ms = 6.04 ms

Total On-Time = Pulse 1 + Pulse 2 = 5.58ms + 6.04ms = 11.62ms

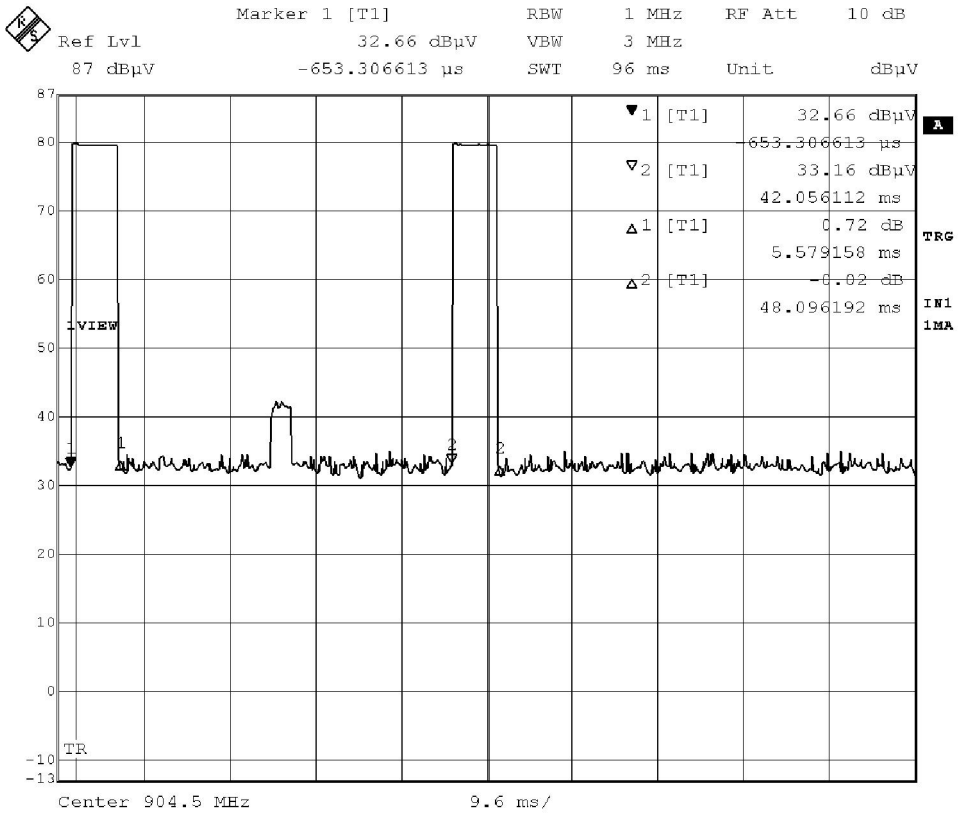


Figure 18. Capture of Maximum Duty Cycle for 904.5 MHz Channel.

The duty cycle correction formula with measured data was as follows:

$$20 \times \mathrm{Log}\left(\frac{Total\ "on\ time"\ of\ pulse\ train}{Period\ of\ pulse\ train\ (or\ 100\ ms)}\right) = 20 \times \mathrm{Log}\left(\frac{11.6\ ms}{100\ ms}\right) = \text{-18.7 dB}$$

11.8.3 Test Results

The following table details FCC 15.209 limits. All measurements were corrected to a 3-meter distance. The product orientation that produced the highest emissions relative to the limit was with the antenna and battery positioned parallel to the table-top.

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 9. 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 10. Restricted Bands of Operation (FCC Part 15.205)

Restricted Band Emision	Antenna Polarity[1]	Peak Meas. (dBuV/m)	Peak Limit (dBuV/m)	Peak Margin (dB)	Average Meas. (dBuV/m)	Average Limit (dBuV/m)	Average Margin (dB)	Turn Table (deg)	Antenna Height (cm)
3.6413 GHz	H	64.37	73.98	**9.61**	44.67	53.98	**9.31**	65.3	103.1
4.6334 GHz	H	62.38	73.98	**11.60**	43.68	53.98	**10.30**	62.0	102.8
5.4281 GHz	H	59.60	73.98	**14.38**	40.90	53.98	**13.08**	56.3	102.2

Table 11. Highest Restricted Band Emissions Relative to the Limit

All radiated peak measurements < 1GHz were evaluated against restricted band limits (as directed by FCC Part 15.247(d) and detailed in FCC Part 15.209(a)) and were found to be lower with respect to the limit than those detailed above in Table 11.

The data reported in Table 11 meets the requirements of 15.247(d) emissions in restricted bands.

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

11.9 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.

11.9.1 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 = Separation distance between radiator and human body (m)
S = Power density (W/m$^{2)}$

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.

11.9.2 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.

Freq. (MHz)	Antenna Gain (dBi)	Antenna Gain (numeric)	Peak Output Power (dBm)	Peak Output Power (W)	Power Density(S) (W/m^2)	Power Density(S) (mW/cm^2)	Limit of Power Density (S) (mW/cm^2)	Result
904.5	2.00	1.585	12.751	0.0188	0.0593	0.00593	0.603	Pass

Table 12. Calculated Power Density for Intentional Radiator

12.0 CONCLUSION

The ActiveSense Rodent Sensor, Model# RD1, was found to **Meet** the requirements of the CFR47, Parts 15.203, 15.215 & 15.247 for operating within the 902-928 MHz Band. See Section 2.0 of this report for a summary of tests.