International Compliance Laboratories

FCC Part 15 Subpart C
Transmitter Certification Test Report

Direct Sequence Spread Spectrum Transmitter

ICL Report # 2122
FCC ID: 2AC46-DRE002

Test Specification: FCC Rule Part: 15.247

Manufacturer: Mesh Systems, LLC
Model Name: ActiveSense Range Extender
Model Number: RX1
Serial Number: 2122 (Defined at ICL)

Test Start Date: 10/6/2015
Test End Date: February 4, 2016

Report Issue Date: February 29, 2016

Test Result: Pass

Prepared By:

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Reviewed By:

Ronald W. Zimmerman

Ronald W. Zimmerman
ICL President and NCE

Table of Contents

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 15.207	Power Line Conducted Emissions	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

Range Extender – Theory of Operation.docx document provided by Mesh Systems, LLC.

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

Range Extender Antenna S463XX-915.pdf document provided by Mesh Systems, LLC.

4.0 Product Description

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

4.1 FCC-IDs

The FCC-ID for this product (the EUT) is 2AC46-DRE002

4.2 Product Name

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

4.3 Product Description

The Range Extender is a device that supports extended range in communication between the Hub and Sensors.

4.4 Model Number

RX1

4.5 Unit Serial Number

2122 (Defined at ICL)

4.6 Printed Circuit Board Information

A label with the text “9.1.0.44” was on the top of the RF shield. “4150891” was silkscreened on the top side of the PCB edge (see Internal Photos document).

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 NEARSON having part number S463AH-915. The connection is a reverse polarity SMA plug. See datasheet for more information.

The gain of the antenna is 2 dBi as detailed by the datasheet.

4.11 Power Source

The EUT was powered by an AC to USB adaptor which was supplied with the Range Extender. It was manufactured by HDP Power Products and had the following information printed on its housing: Model Number: HDP-QB05010U. Input: 100-240V 50/60Hz (120V 60Hz was used) 0.15A. Output: 5Vdc 1.0A. Safety and EMC standards listed UL/cUL, CE, CB, GS, SAA, C-Tick, FCC, RoHS, and REACH.

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 performed by ICL:

The Range Extender was placed in continuously transmitting and modulating by switching to the appropriate frequency:

1. Power the Range Extender.
2. After a brief flash of three LED colors: red, blue, and green, a short pause will happen.
3. The EUT will then cycle through a repeated pattern green, red, white, and blue. Each color represents one of the channels of the EUT. They are defined as follows:
   Green – Lowest Channel – 904.5 MHz
   Red – Mid Channel #1 – 910.5 MHz
   White – Mid Channel #2 – 919.5 MHz
   Blue – Highest Channel – 926.5 MHz
4. Sweep the magnet provided in the "circle" area when the desired channel color is seen. The EUT should now be continuously transmitting and modulating.
5. Remove power from the AC port or disconnect the USB when done taking measurements.
6. Repeat steps 1-5 for additional 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

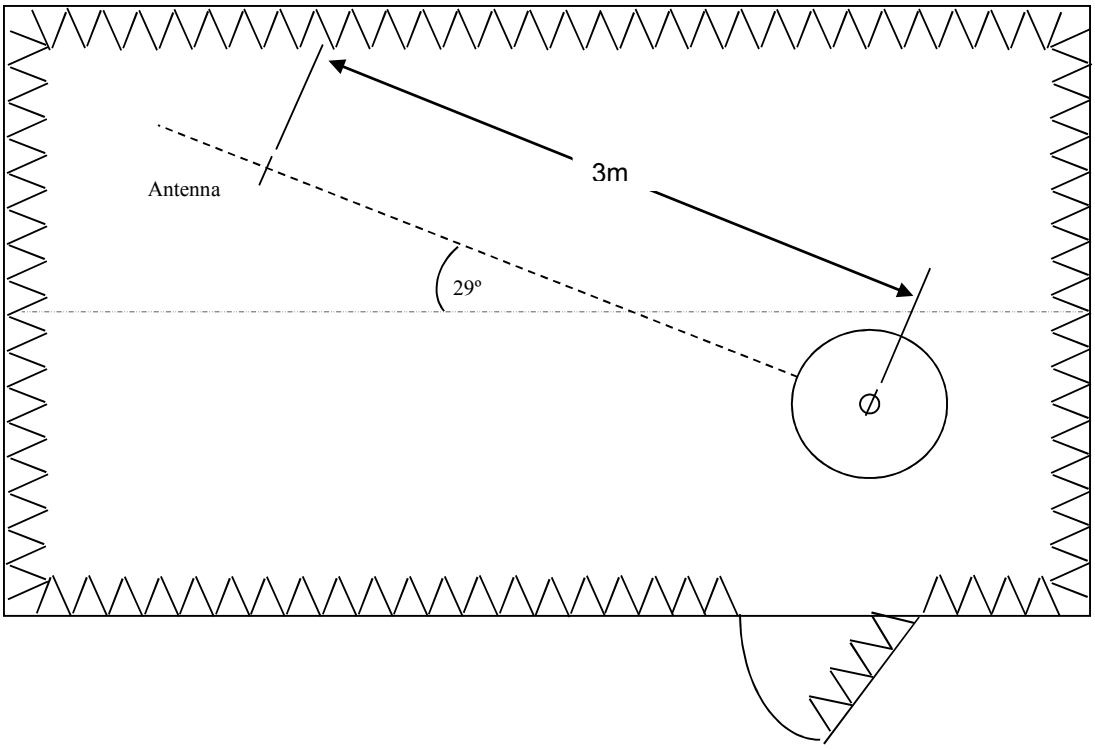
On the following products or types of products:
Light Industrial, Commercial, Residential, Heavy Industrial, Scientific, Medical, Portable Test and Measurement Equipment, Information Technology Equipment, Telecom, Automotive, and other Electrical and Electronic Equipment

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:



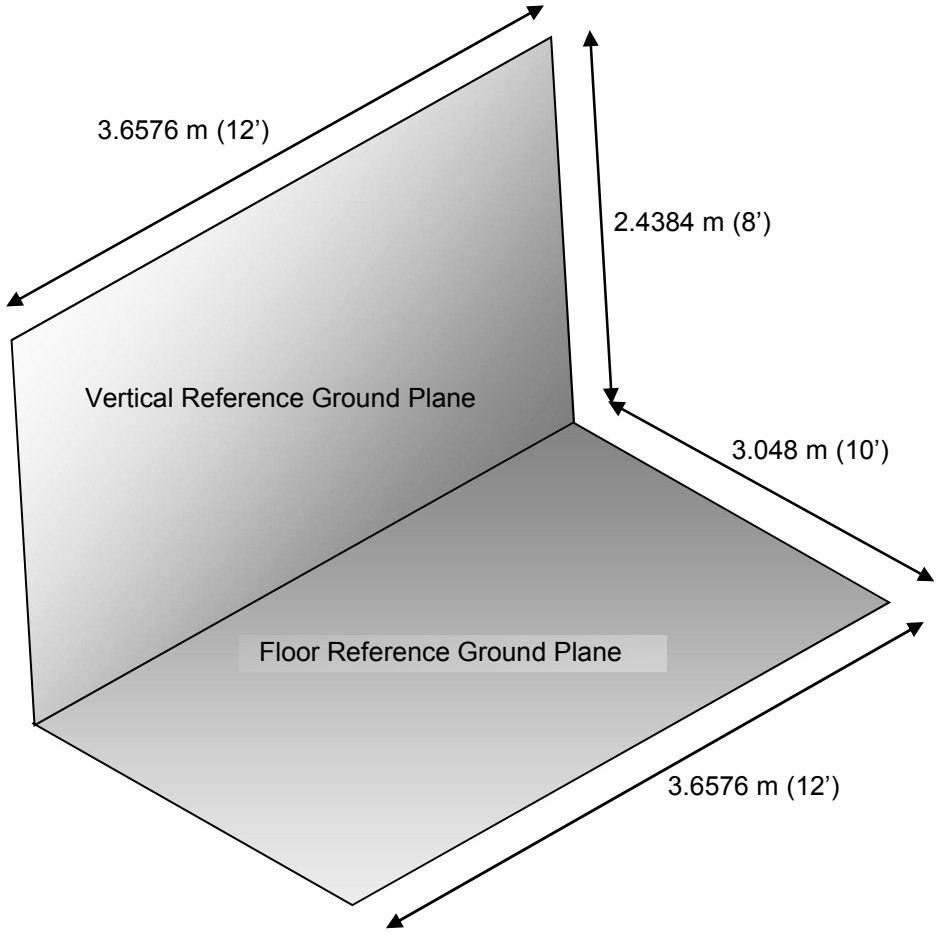
Power to the room is filtered to prevent ambient noise from coupling to the EUT and measurement equipment. Filters are models 07294/GFUL57915-1x100 (100 Amp 277/480Vac 50/60Hz) manufactured by Genisco Electronics Corporation.

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
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 directly in the center. An extension cord routed from source of power and the power adaptor. The extension cord was connected in such a manner that it took the most direct path to the power accessory (from the turn table hole to the table edge and then to the AC adaptor).

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 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 Range Extender employed a reverse polarity-SMA connection. The antenna uniquely mated to this connection and satisfied 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 as powered through its AC to USB adaptor.

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, LLC	**Date(s) of Test:**	3/2/2016
Test Engineer:	Dan Berg	**Voltage/Frequency:**	120V 60Hz
Model:	ActiveSense Range Extender (RX1)	**Serial Number:**	2122
Software Version:	n/a	**Mode of Operation:**	926.5 MHz transmit (see below)

Setup Pictures Taken	Verification Completed
☒	☒

Environmental Conditions in Lab		
	Requirement	**Actual**
Temperature	15°C - 35°C	21°C - 23°C
Humidity	10%- 90% R.H.	19% - 22% R.H.
Air Pressure	n/a	102 kPa

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, Quasi-Peak, and Average	See plots and tables below

Notes:

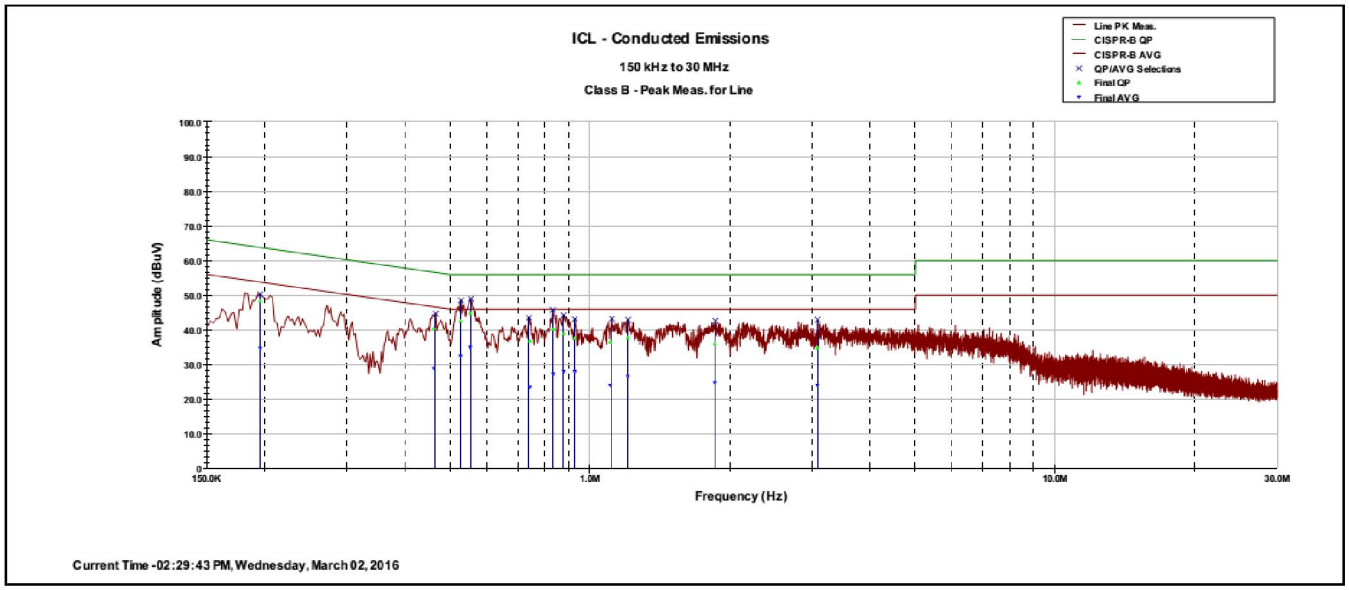
Set-up

- 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 was included in an external document called "Test Set-up Photos of Range Extender.pdf".

- Exploratory measurements were made to find the mode of operation with the highest emissions relative to the limit. Modes investigated were the following: Mode after power up (cycling Red, Green, White, and Blue LEDs), 904.5 MHz transmitting, 910.5 MHz transmitting, 919.5 MHz transmitting, and 926.5 MHz transmitting. Each channel that was transmitted continuously and modulated. The mode of 926.5 MHz transmitting continuously and modulated was found to have the highest emissions relative to the limit. Final was taken in this configuration.

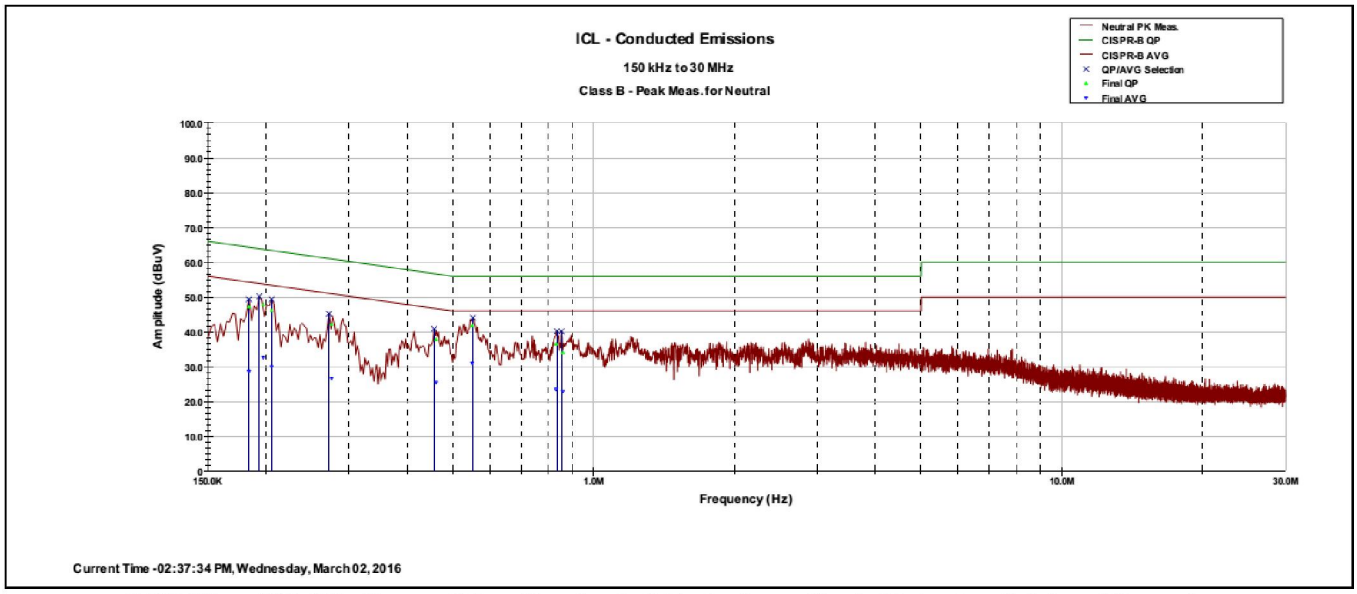
- Final quasi-peak and average measurements were taken and found to be compliant. See below for test data.



150kHz – 30MHz Power Line Conducted Emissions, Peak-Detector, Mains: Line
Mode: 926 MHz Transmitting and Modulated

ICL - Conducted Emissions						
Frequency	**QP Meas.**	**QP Limit**	**QP Margin**	**AVG Meas.**	**AVG Limit**	**AVG Margin**
	(dBuV)	**(dBuV)**	**(dB)**	**(dBuV)**	**(dBuV)**	**(dB)**
195.44 KHz	48.37	63.80	15.43	34.68	53.80	19.12
461.08 KHz	40.43	56.67	16.25	28.88	46.67	17.79
526.51 KHz	42.57	56.00	13.43	32.48	46.00	13.52
552.3 KHz	44.77	56.00	11.23	34.99	46.00	11.01
741.84 KHz	36.82	56.00	19.18	23.55	46.00	22.45
833.3 KHz	40.18	56.00	15.82	27.28	46.00	18.72
877.86 KHz	38.95	56.00	17.05	28.02	46.00	17.98
927.11 KHz	37.57	56.00	18.43	27.96	46.00	18.04
1.1055 MHz	36.54	56.00	19.46	24.01	46.00	21.99
1.206 MHz	37.82	56.00	18.18	26.56	46.00	19.44
1.8552 MHz	36.05	56.00	19.95	24.76	46.00	21.24
3.0827 MHz	34.84	56.00	21.16	23.96	46.00	22.04
Negative margin indicates measurements ABOVE the limit. Positive margin indicates measurements BELOW the limit.						

Final Quasi-Peak and Average Measurements for Mains: Line
Mode: 926 MHz Transmitting and Modulated



150kHz – 30MHz Power Line Conducted Emissions, Peak-Detector, Mains: Neutral
Mode: 926 MHz Transmitting and Modulated

ICL - Conducted Emissions						
Frequency	**QP Meas.**	**QP Limit**	**QP Margin**	**AVG Meas.**	**AVG Limit**	**AVG Margin**
	(dBuV)	**(dBuV)**	**(dB)**	**(dBuV)**	**(dBuV)**	**(dB)**
183.48 KHz	47.20	64.33	17.13	28.70	54.33	25.62
196.95 KHz	47.85	63.74	15.89	32.60	53.74	21.14
205.01 KHz	46.13	63.40	17.27	30.04	53.40	23.36
275.57 KHz	42.16	60.95	18.78	26.61	50.95	24.34
460.61 KHz	37.93	56.68	18.76	25.48	46.68	21.20
549.96 KHz	41.78	56.00	14.22	31.00	46.00	15.00
831.19 KHz	36.54	56.00	19.46	23.54	46.00	22.46
858.90 KHz	34.07	56.00	21.93	22.91	46.00	23.09
Negative margin indicates measurements ABOVE the limit. Positive margin indicates measurements BELOW the limit.						

Final Quasi-Peak and Average Measurements for Mains: Neutral
Mode: 926 MHz Transmitting and Modulated

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. Measurements were taken continuously transmitting and modulated

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	553.1	≥500kHz	Pass
910.5	553.1	≥500kHz	Pass
919.5	557.7	≥500kHz	Pass
926.5	557.1	≥500kHz	Pass

Table 3. Summary of 6dB Bandwidth Test

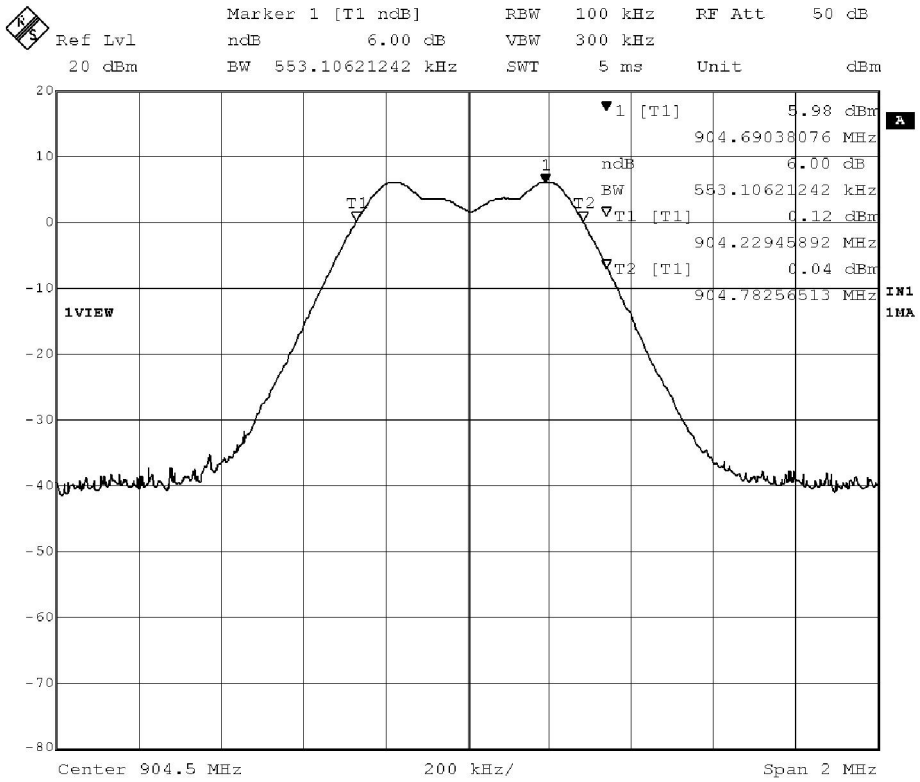


Figure 2. 6dB Bandwidth Plot - Low Channel – 904.5MHz

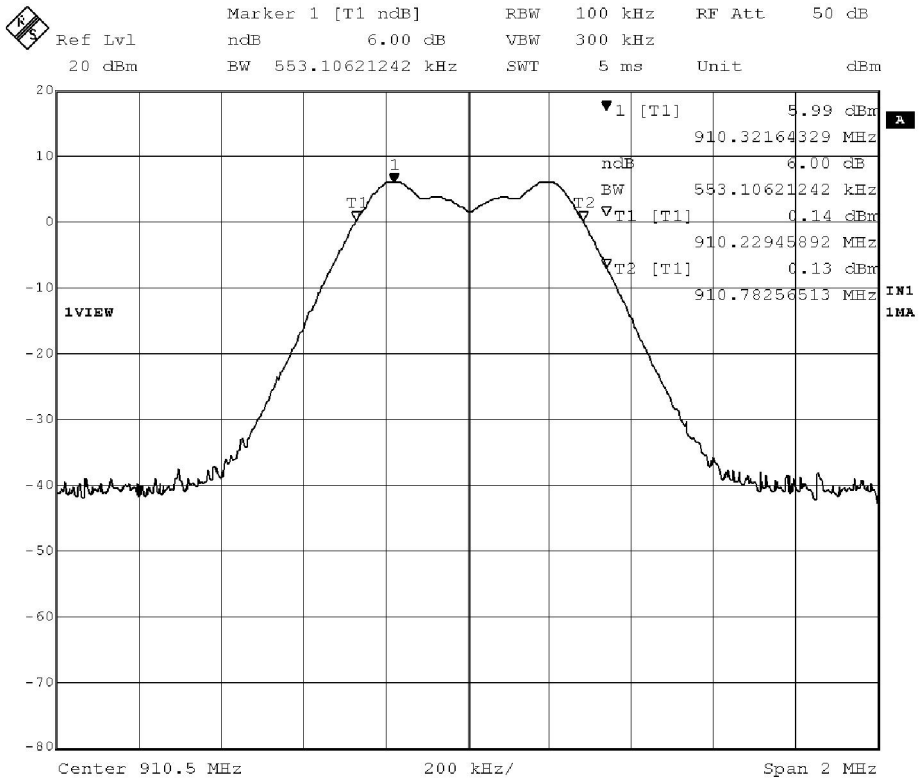


Figure 3. 6dB Bandwidth Plot - Mid Channel #1 – 910.5 MHz

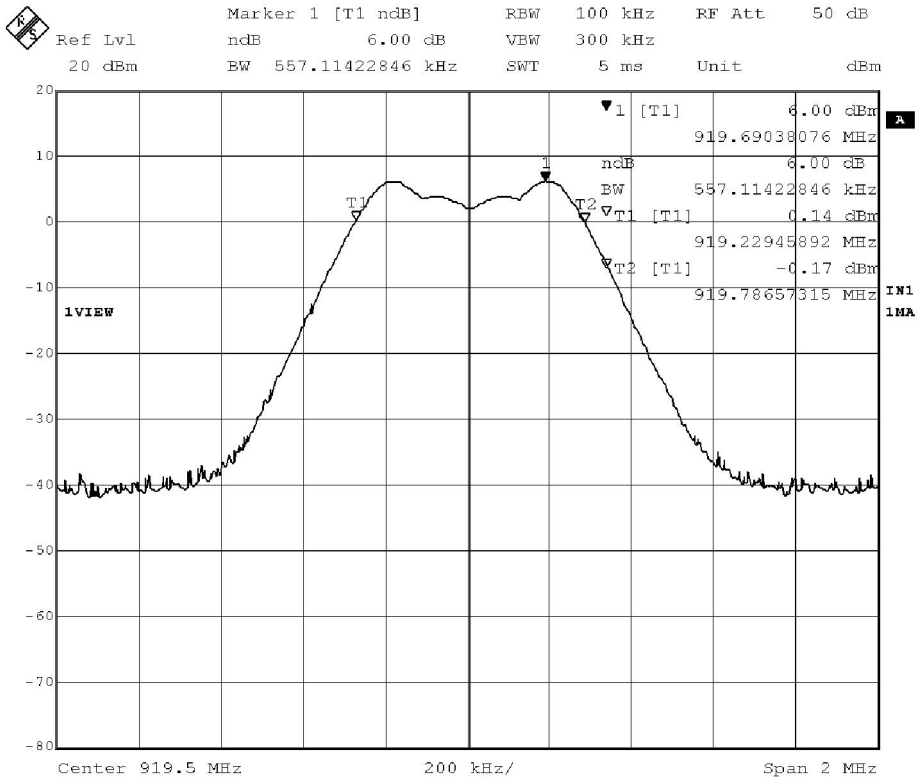


Figure 4. 6dB Bandwidth Plot - Mid Channel #2 – 919.5 MHz

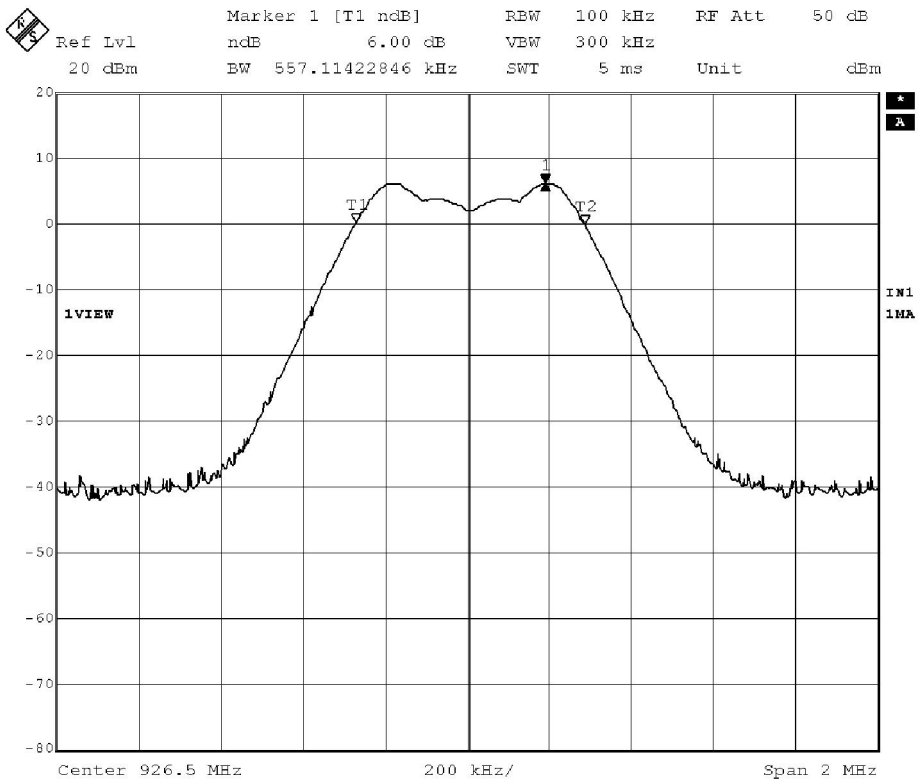


Figure 5. 6dB Bandwidth Plot - High Channel – 926.5 MHz

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 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. Test Results
The results 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	20.91	904.201	20.03	904.799	598
Mid #1	910.5	20.24	910.201	21.91	910.803	602
Mid #2	919.5	21.20	919.197	20.12	919.803	606
High	926.5	20.09	926.201	20.60	926.803	602

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 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).

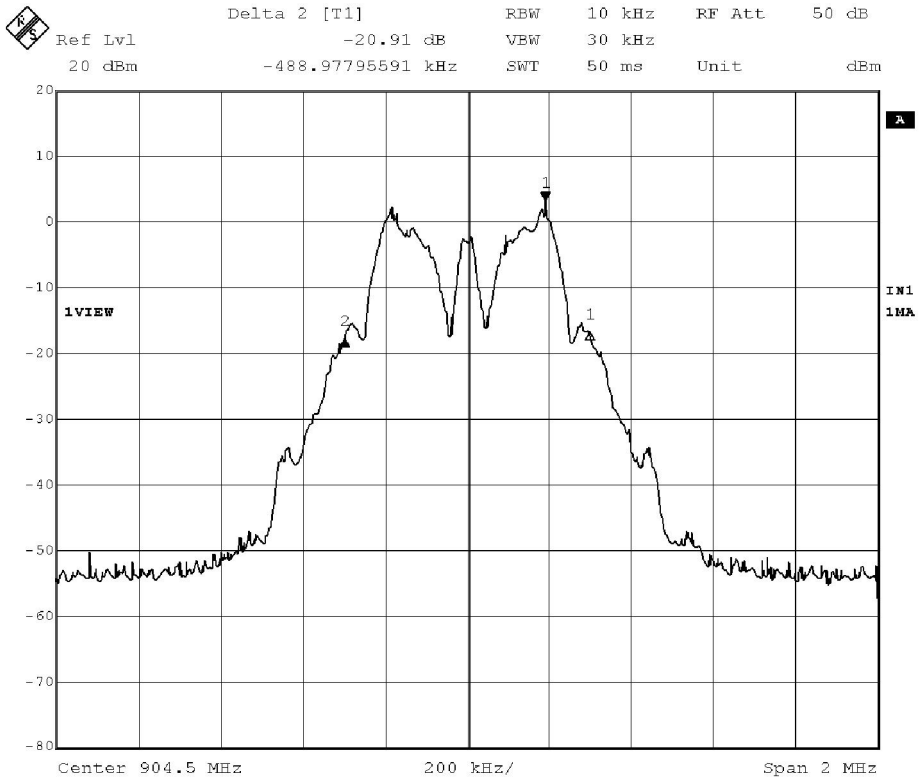


Figure 6. Occupied Bandwidth – Low Channel – 904.5MHz

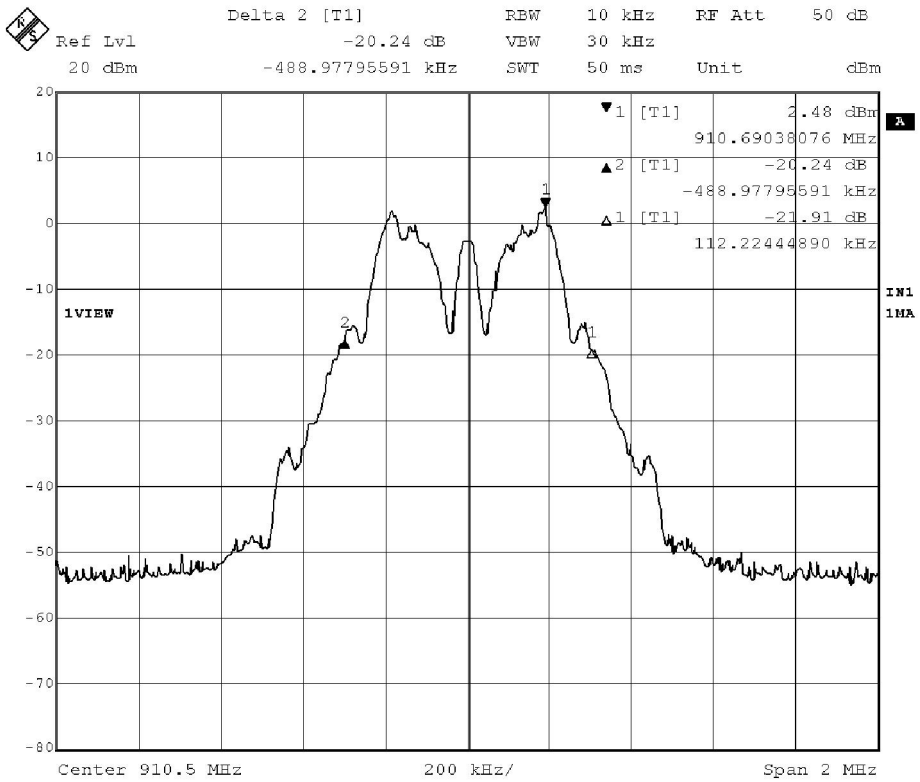


Figure 7. Occupied Bandwidth – Low Channel – 910.5MHz

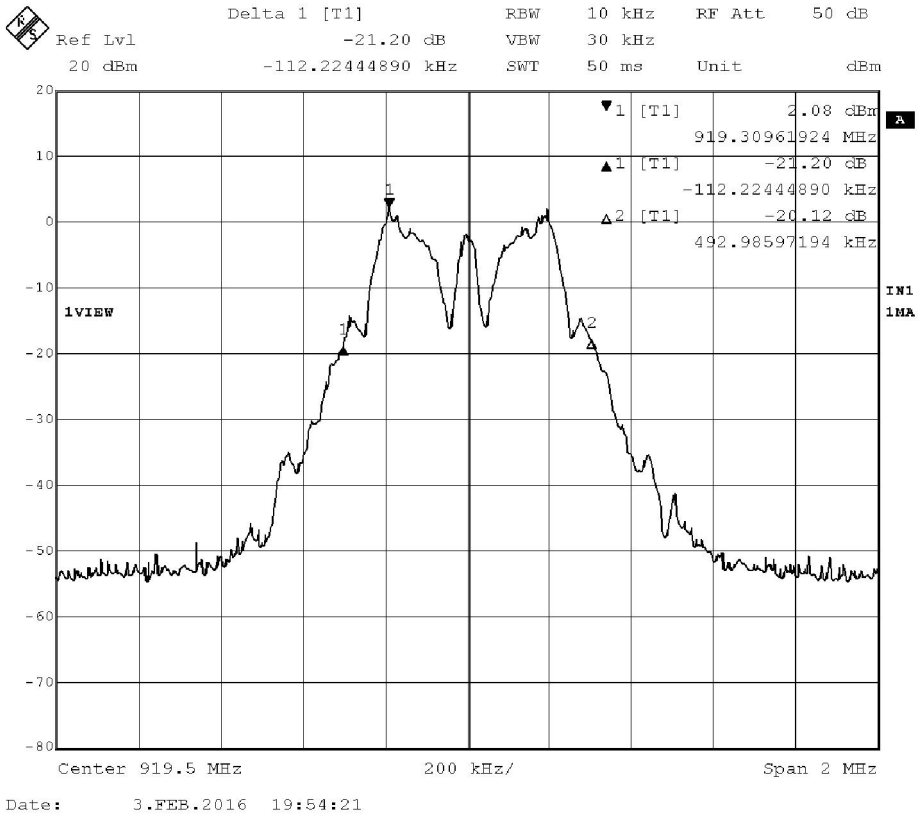


Figure 8. Occupied Bandwidth – Low Channel – 919.5MHz

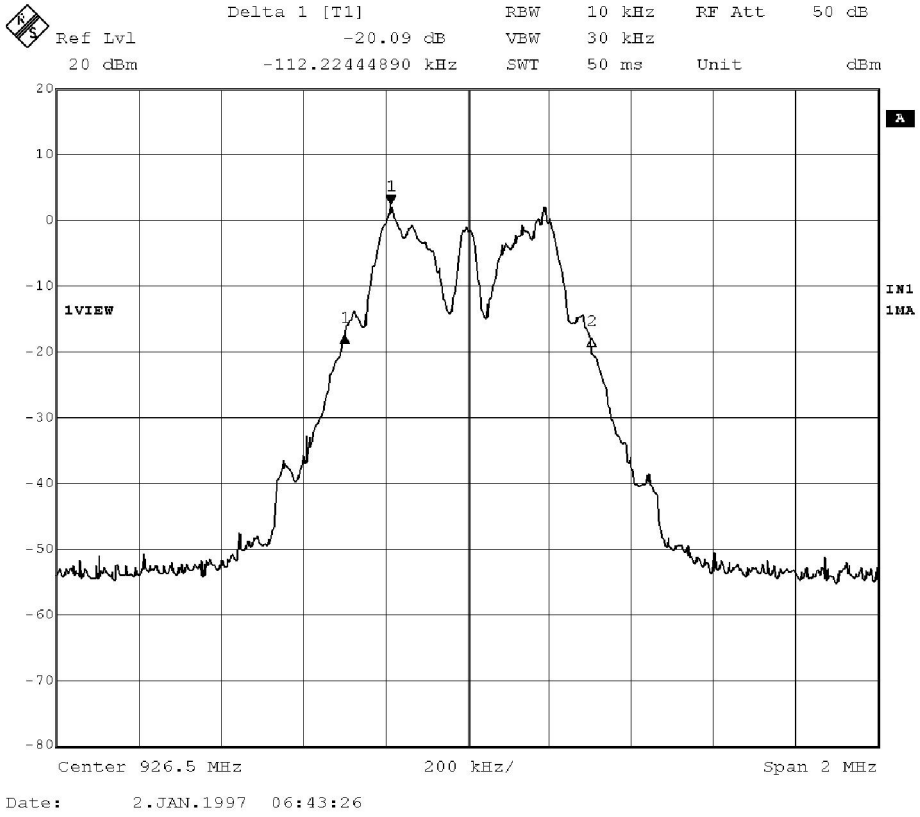


Figure 9. Occupied Bandwidth – High Channel – 926.5MHz

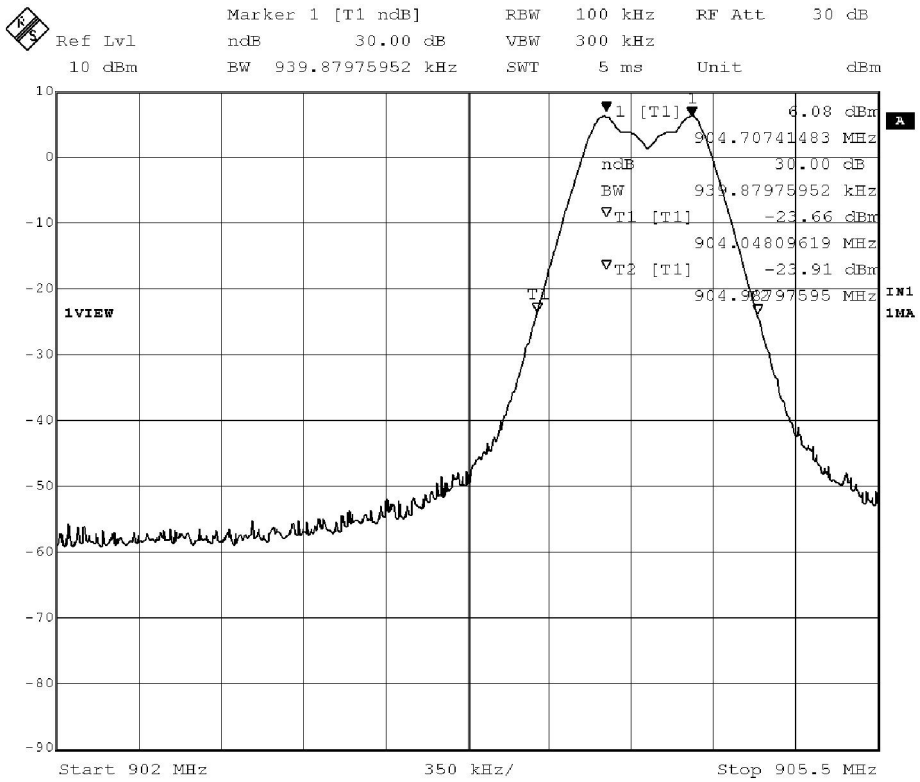


Figure 10. Band Edge Compliance at 902MHz for Low Channel – 904.5MHz.

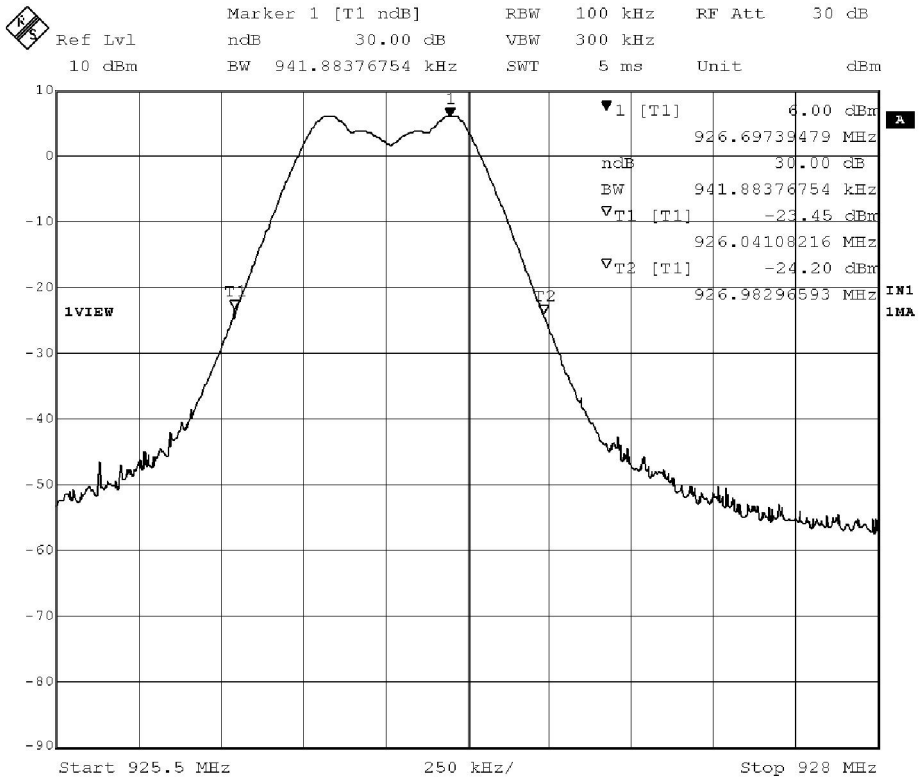


Figure 11. Band Edge Compliance at 928MHz for High Channel – 926.5MHz.

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 the EUT continuously transmitting and 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 (~598 kHz to ~ 606 kHz) = ~ 897 kHz to ~ 909kHz.
b) Resolution bandwidth (RBW) set to 10 kHz which is within 1%-5% of the OBW (~598k Hz to ~606 kHz).
c) Video bandwidth (VBW) set to 30kHz which is 3xRBW.
d) No special triggering was necessary to capture 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 NEARSON manufacturer data sheet for the S463AH-915 was 2.0 dBi. 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	24.25	≤1 Watt (30dBm)	Pass
Mid #1	910.5	24.29	≤1 Watt (30dBm)	Pass
Mid #2	919.5	24.19	≤1 Watt (30dBm)	Pass
High	926.5	24.22	≤1 Watt (30dBm)	Pass

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

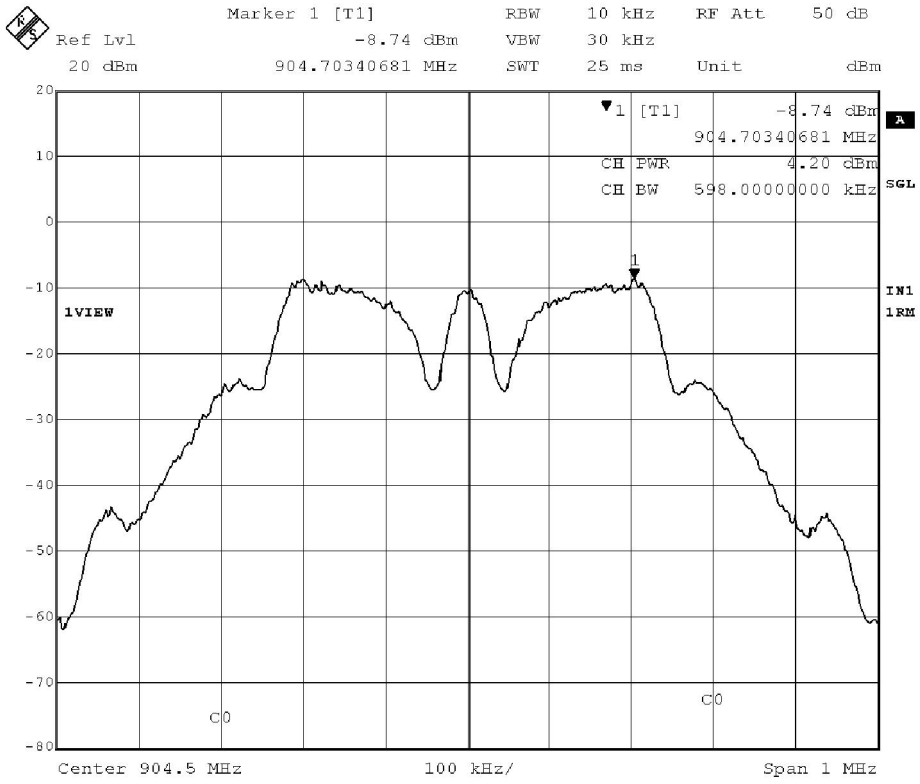


Figure 12. Maximum (Average) Output Power Plot – Low Channel – 904.5MHz

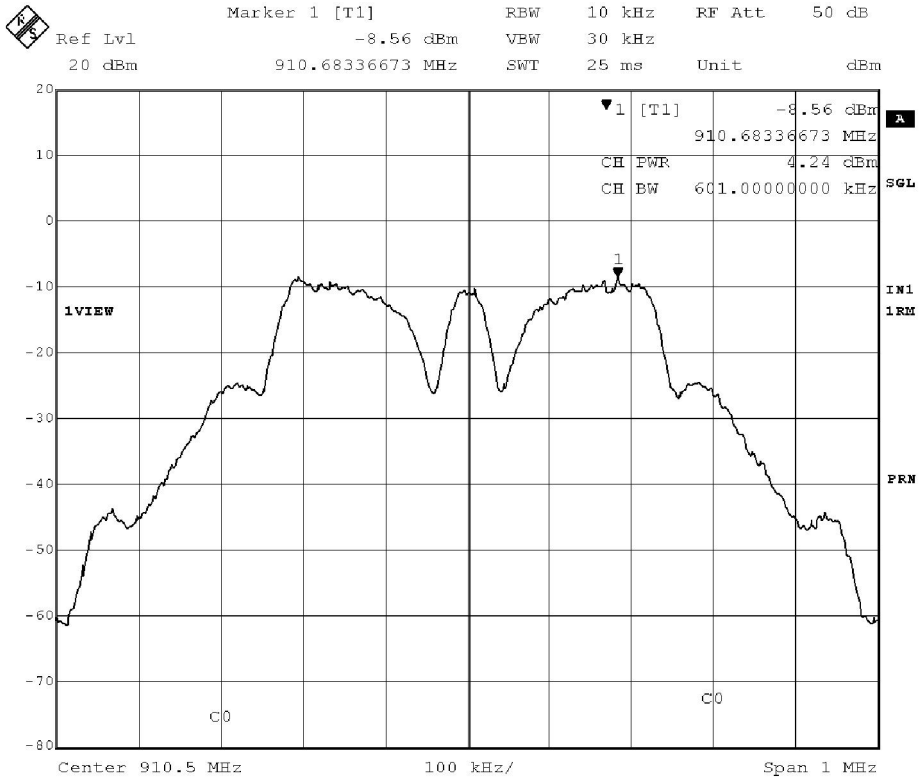


Figure 13. Maximum (Average) Output Power Plot – Mid Channel #1 – 910.5MHz

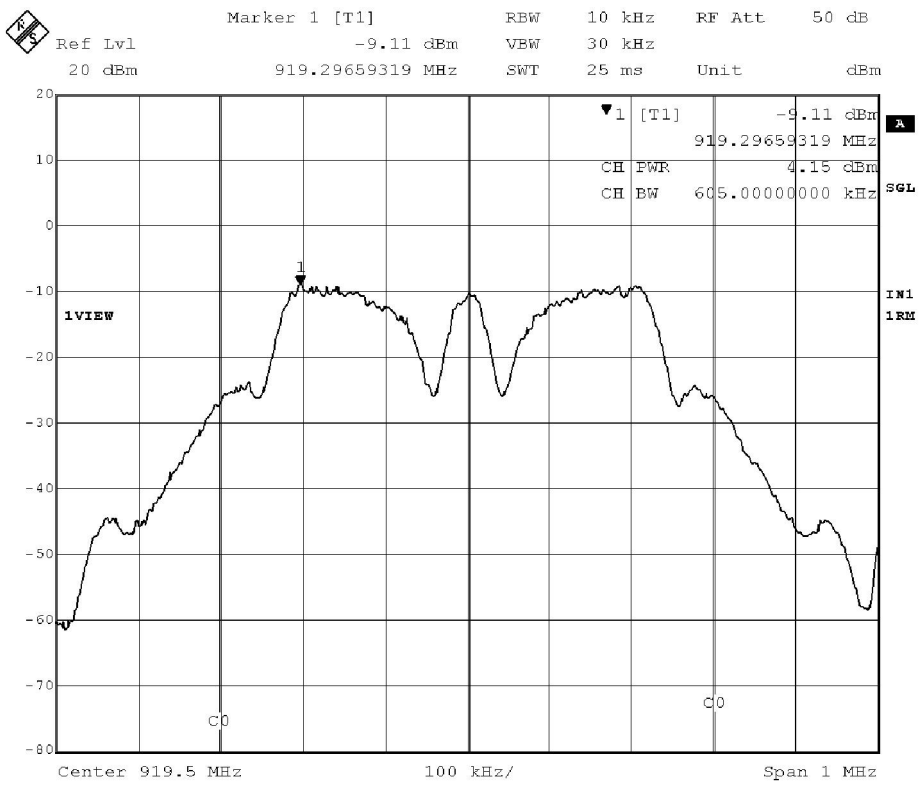


Figure 14. Maximum (Average) Output Power Plot – Mid Channel #2 – 919.5MHz

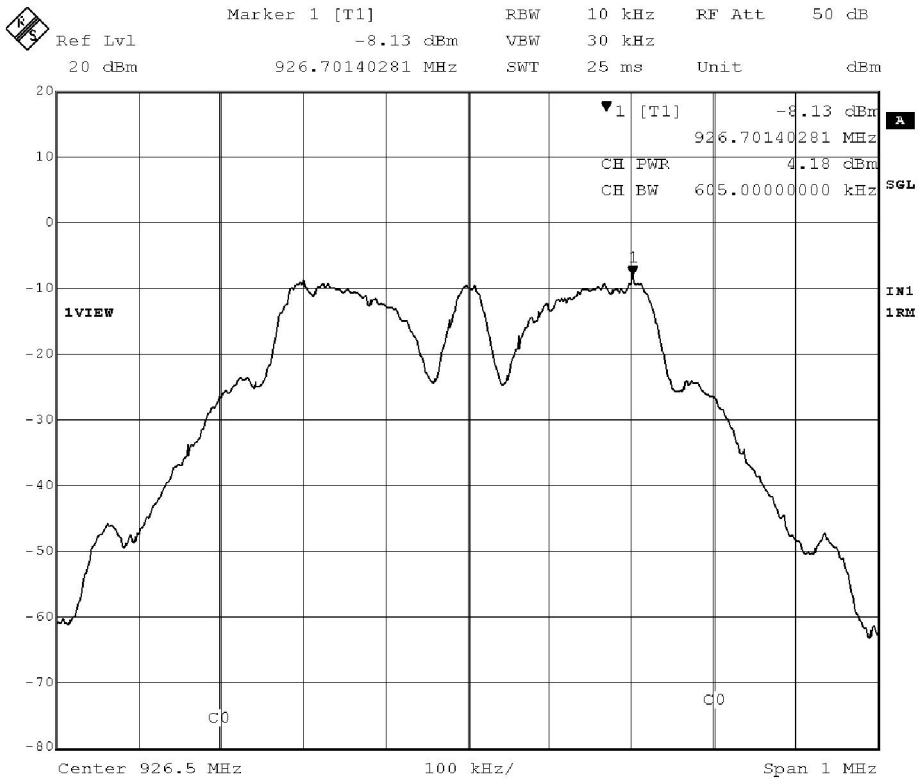


Figure 15. Maximum (Average) Output Power Plot – High Channel – 926.5MHz

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 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 ~830 kHz to ~837 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 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	**6.33**	26.38	-3.62	Low channel found to have highest PSD Level.
Mid #1	910.5	6.31	The raw PSD Levels for these channels were not corrected since they were not the highest.		
Mid #2	919.5	6.30			
High	926.5	6.21			

Table 6. Summary of Reference Level PSD Evaluation

Emission Frequency (GHz)	Corrected Measurement (dBm)	Attenuated 30dB under PSD Reference Level above?
1.809	-21.811	Yes
6.330	-74.783	Yes
7.238	-69.527	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 continuously transmitting and 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 (~897 kHz to ~909 kHz). 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	7.131	8	Pass
Mid #1	910.5	7.268	8	Pass
Mid #2	919.5	7.043	8	Pass
High	926.5	7.310	8	Pass

Table 8. Summary of Power Spectral Density.

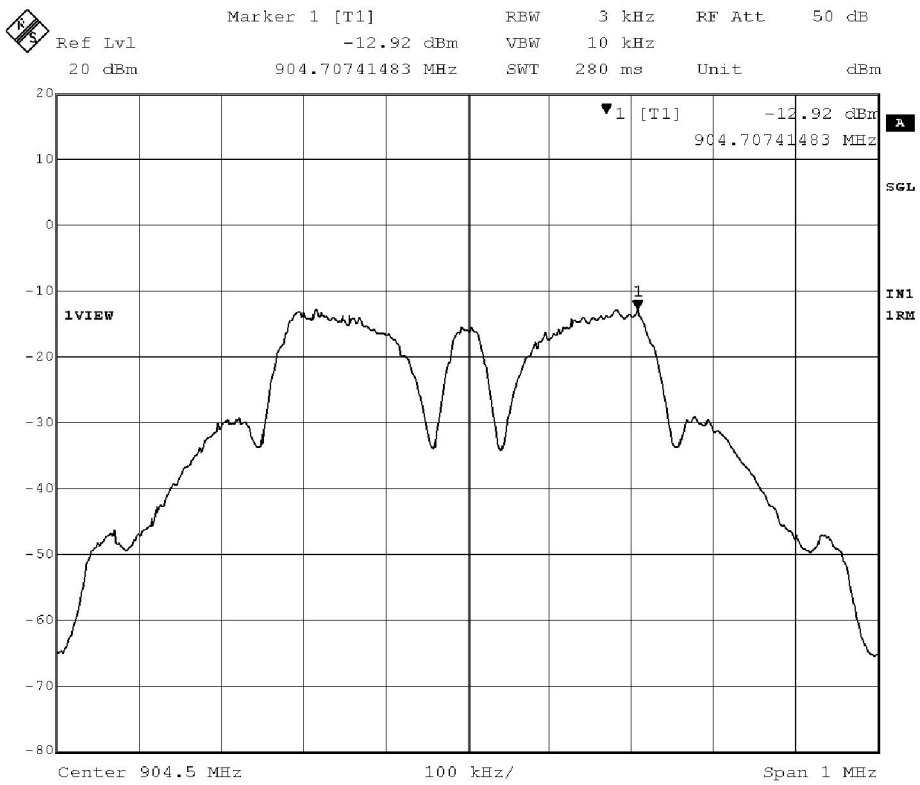


Figure 16. Maximum Power Spectral Density – Low Channel – 904.5MHz

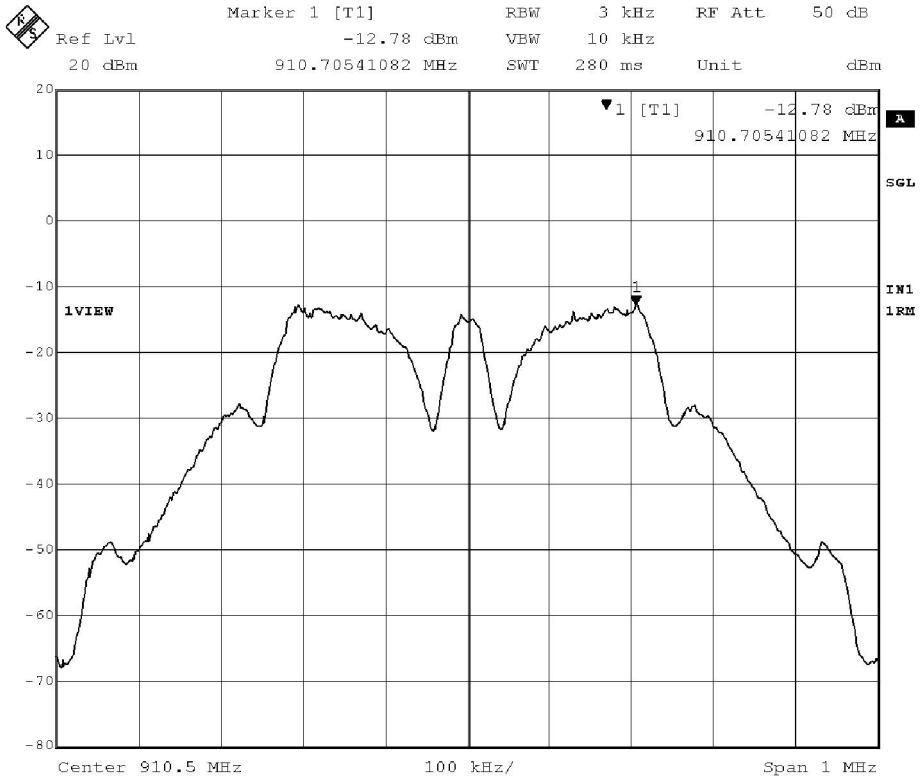


Figure 17. Maximum Power Spectral Density – Mid Channel #1 – 910.5MHz

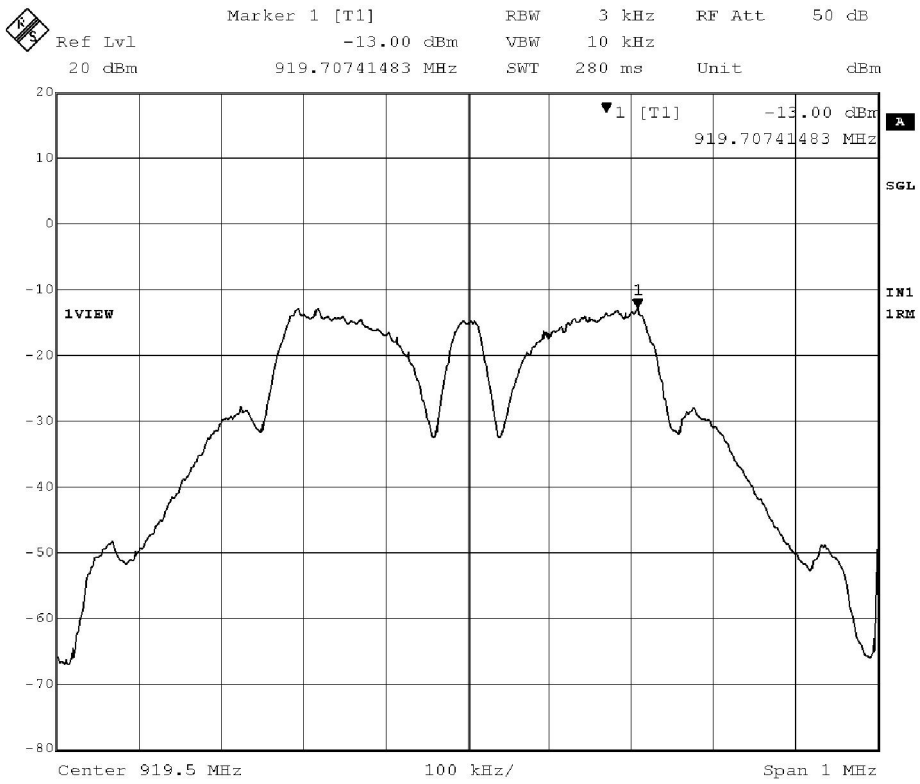


Figure 18. Maximum Power Spectral Density – Mid Channel #2 – 919.5MHz

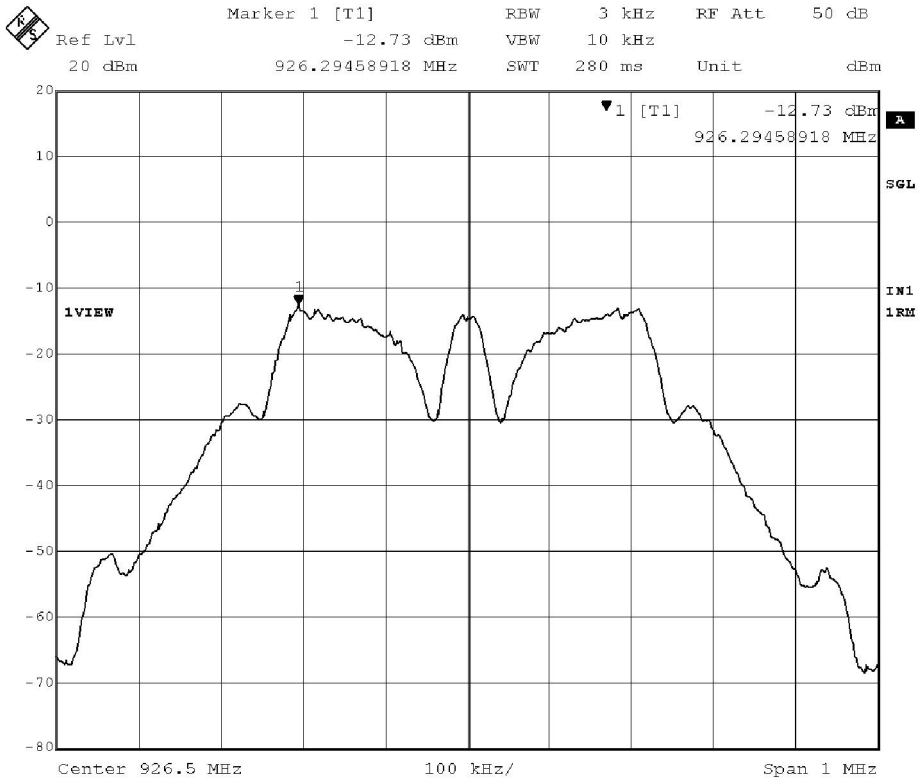


Figure 19. Maximum Power Spectral Density – High Channel – 926.5MHz

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 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.

11.8.2 Test Results

The result of the highest radiated fundamental measurement is detailed below in Table 9. Sample calculations are provided in section 11.9.1.1 of this test report for the measurement 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	V	**124.85**	293.9	105.6

Table 9. Highest Fundamental Radiated Measurements

11.9 Emissions in Restricted Bands – FCC Section 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 = 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
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.

11.9.2 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 Range Extender's antenna positioned perpendicular to the table-top and pointed upward. The channel which produced the highest harmonic or spurious emissions was 926.5 MHz.

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)
403.341	V	42.90 QP	46.02 QP	**3.12**	248.0	137.7
400.373	V	42.86 QP	46.02 QP	**3.16**	245.4	143.9
408.371	V	42.70 QP	46.02 QP	**3.32**	251.3	114.3

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. The three highest harmonic/spurious emissions relative to the limit in restricted bands are shown in the table below.

Restricted Band Emision	Antenna Polarity[2]	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)
4.6315 GHz	V	49.16	73.98	**24.82**	41.22	53.98	**12.76**	204.4	366.3
3.7059 GHz	H	46.42	73.98	**27.56**	36.42	53.98	**17.56**	166.7	148.5
2.7800 GHz	H	44.57	73.98	**29.41**	35.71	53.98	**18.27**	148.6	111.7

Table 13. Harmonic Emissions 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 = 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.

11.10.2 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.

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)	Result
910.5	2.0	1.5849	24.29	0.269	0.8482	0.08482	0.607	Pass

Table 14. Calculated Power Density for Intentional Radiator

12.0 CONCLUSION

The ActiveSense Range Extender, Model# RX1, was found to **Meet** the requirements of the CFR47, Parts 15.203, 15.207, 15.215 & 15.247 for operating within the 902-928 MHz Band. See Section 2.0 of this report for a summary of tests.