SHURE

ELECTROMAGNETIC COMPATIBILITY LABORATORY
TEST REPORT

TEST REPORT TITLE: Electromagnetic Compatibility Tests of the Shure ULXD2 Digital Wireless Transmitter in the X52 Band (902MHz to 928MHz)

TEST ITEM DESCRIPTION:

The Shure ULXD2 is a digital wireless microphone transmitter.

For: Shure Incorporated
5800 West Touhy Avenue
Niles, IL 60714

Project ID Number: SEL-043/ULXD2 X52 FCC15C

Date Tested: May 8th thru May 16th, 2019 and August 21, 2019

Test Personnel: Jamal Qureshi, Frank Salmeron, and Juan Castrejon

Test Specification:

IC RSS-GEN – General Requirements and Information for the Certification of Radio Apparatus
RSS-247 - Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
FCC Title 47, Part 2.1051
FCC Part 15C, Section 15.247(a)(2)
FCC Part 15C, Section 15.247(b)(3)
FCC Part 15C, Section 15.247(b)(4)
FCC Part 15C, Section 15.247(d)
FCC Part 15C, Section 15.247(e)
FCC Part 15C, Section 15.249(a)

TEST REPORT BY:	Craig Kohler	Global Compliance Engineer	August 28, 2019
APPROVED BY:	Signature	Position	Date
		Global Compliance Engineer	August 28, 2019

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LIST OF APPENDICIES

APPENDIX	TEST DESCRIPTION
A	Minimum Bandwidth
B	Maximum Peak Conducted and Radiated Output Power
C	Unwanted Emissions
D	Power Spectral Density
E	Spurious Emissions on Antenna Port

REPORT REVISION HISTORY

Revision	Date	Description
0	June 27, 2019	Initial release
1	August 28, 2019	Updated Conducted RF Power Output test

1. INTRODUCTION

1.1. Scope of Tests

This report presents the results of testing per FCC Part 15C, Section 15.247(a)(2), Section 15.247(b)(3), Section 15.247(b)(4), Section 15.247(d), Section 15.247(e), Section 15.249(a), FCC Part 2.1051, RSS-Gen, and RSS-247. The following data was taken following the measurement method as described in the document section(s) listed on page 1 of this document. Provided is the data for the test sample. Also included is a summary of the measurements made and a description of the measurement setup. The test samples meet the requirements of the above standards. The equipment under test (EUT) contained a transmitter that was designed to transmit in the frequency bands shown in Table 1.

Model	Band	Frequency (MHz)	Output Power (mW)
ULXD2	X52	902 to 928	0.25, 10, 20

Table 1. EUT Frequencies and Power Levels

1.2. Purpose

This series of testing was performed to determine if the test item would meet the requirements of FCC Part 15C, Section 15.247(a)(2), Section 15.247(b)(3), Section 15.247(b)(4), Section 15.247(d), Section 15.247(e), Section 15.249(a), FCC Part 2.1051 RSS-Gen, and RSS-247.

1.3 Deviations, Additions and Exclusions

None

1.4 EMC Laboratory Identification

The electromagnetic compatibility tests were performed at the Shure Electromagnetic Laboratory, Shure Incorporated, 5800 West Touhy Ave, Niles, Illinois 60714-4608. This laboratory is registered with Industry Canada as Site # 616A-1. The Shure Electromagnetic Laboratory is accredited by the National Institute of Standards and Technology (NIST) under the National Voluntary Laboratory Accreditation Program (NVLAP).
The NVLAP Lab Code is: 200946-0.

1.5 Summary of Tests Performed

The following electromagnetic compatibility tests (Table 2) were performed on the test item in accordance with ETSI specifications.

Table 2. Summary of tests performed

FCC Part 15C and IC Test Spec	Description	EUT Firmware	Tested Frequency in MHz	High Density Mode	Appendix	Test Results
15.247(a)(2), RSS-247 5.2(a)	Minimum Bandwidth	2.3.32.0	902.400, 915.000, 927.600	Off	A	Pass
15.247(b)(3) RSS-247 5.4(d)	Maximum Peak Conducted Output Power	2.3.32.0	902.400, 915.000, 927.600	Off	B	Pass
RSS-247 5.4(d)	Maximum E.I.R.P.	2.3.32.0	902.400, 915.000, 927.600	Off	B	Pass
15.249(a)	Field Strength Fundamental	2.3.32.0	902.400, 915.000, 927.600	On	B	Pass
15.247(b)(4)	ULXD2 Antenna Gain less than 6dBi	N/A	N/A	N/A	B	N/A
15.247(d) RSS-247 5.5	Unwanted Emissions	2.3.32.0	902.400, 915.000, 927.600	Off and On	C	Pass
15.247(e) RSS-247 5.2(b)	Power Spectral Density	2.3.32.0	902.400, 915.000, 927.600	Off	D	Pass
2.1051	Spurious Emissions on Antenna Port	2.3.32.0	902.400, 915.000, 927.600	Off	E	Pass

2 APPLICABLE DOCUMENTS

The following documents of the exact issue designated form part of this document to the extent specified herein:

FCC Part 15C, Section 15.247(a)(2)

FCC Part 15C, Section 15.247(b)(3)

FCC Part 15C, Section 15.247(b)(4)

FCC Part 15C, Section 15.247(d)

FCC Part 15C, Section 15.247(e)

FCC Part 15C, Section 15.249(a)

FCC Title 47, Chapter I, Subchapter A, Part 2 – Frequency Allocations and Radio Treaty Matters, General Rules and Regulations, Subpart J – Equipment Authorization Procedures

RSS-247 Issue 2, February 2017 “digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices”

ANSI C63.10 (2013), "American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices"

RSS-Gen Issue 5, “General Requirements for Compliance of Radio Apparatus”

3 EUT SET-UP AND OPERATION

3.1. General Description

The test sample used was Shure ULXD2 digital wireless microphone transmitter. The EUT was arranged and tested per individual Appendices.

3.2 Test Sample

The following product sample was tested:

Table 3: Shure ULXD2 Digital Wireless Transmitter Sample

Band	Serial Numbers
X52	4190734885 4190734884

3.3 Operational Mode

The transmit frequency and output power modes shown in the individual appendixes.

4. Test Instrumentation

A list of the test equipment used can be found in Table 10-1. All equipment used was within calibration during and throughout the duration of the tests. All calibrations are traceable to the National Institute of Standards and Technology (NIST).

5. Procedure

The specific test procedures are presented in the individual appendices.

6. Other Test Conditions:

6.1. Test Personnel

All EMC tests were performed by qualified personnel from the Shure EMC Laboratory.

6.2. Disposition of the EUT

The EUTs and all associated equipment were returned to Shure Incorporated upon completion of the tests.

7. Results of Tests:

The results are presented in Appendices. It was found that the EUT meets the requirements of FCC Part 15C, Section 247(a)(2), Section 15.247(b)(3), Section 15.247(b)(4), Section 15.247(d), Section 15.247(e), Section 15.249(a), FCC 2.1051, RSS-Gen, and.RSS-247.

8. Conclusions:

It was determined that the Shure ULXD2 Digital Wireless Microphone Transmitter did fully comply with the requirements of FCC Part 15C, Section 247(a)(2), Section 15.247(b)(3), Section 15.247(b)(4), Section 15.247(d), Section 15.247(e), Section 15.249(a), and FCC 2.1051, RSS-Gen, RSS-247.

9. **Certification**:

Shure EMC Laboratory certifies that the information contained in this report was obtained under conditions which meet or exceed those specified in the test specifications.

The data presented in this test report pertains to the EUTs at the test date. Any electrical or mechanical modification made to the EUTs subsequent to the specified test date will serve to invalidate the data and void this certification.

This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the U.S. Government.

10. Equipment List

Table 10-1 Test Equipment

L# or ID	Description	Manufacturer	Model #	Serial #	Frequency Range	Cal Date	Due Date
L23-011-01	3 meter RF Chamber	ETS Lindgren	FACT-3	AJ640	25MHz - 18GHz	8/8/2016	8/8/2019
L23-011-02	Electric Powered Turntable	ETS Lindgren	2088	N/A	N/A	N/A	N/A
L23-011-08	Controller	EMCO	2090	29799	N/A	N/A	N/A
L23-011-09	Antenna Positioner	ETS Lindgren	2071-2	35500	N/A	N/A	N/A
L23-011-15	BiConiLog Antenna	ETS Lindgren	3142C	34790	25MHz-1GHz	6/22/2017	6/22/2019
L23-011-54	EMI Test Receiver	Rohde & Schwarz	ESR26	100220	9kHz-26GHz	11/28/2017	11/28/2019
L23-011-31	EMI/EMS Test Software	Rohde & Schwarz	EMC32	V 9.21.00	N/A	N/A	N/A
L23-011-55	Horn antenna with pre-amplifier	ETS Lindgren	3117-PA	206583	1GHz to 18 GHz	4/10/2018	4/10/2020
L23-011-41	Horn Antenna	ETS Lindgren	3117	123511	1GHz to 18 GHz	1/23/2019	1/23/2021
L23-011-56	High Pass Filter	K&L	11SH10-940/X10000-0/0	2	940MHz – 10GHz	5/31/2018	5/31/2020
L23-022-02	Spectrum Analyzer	Rohde & Schwarz	FSW26	103788	9kHz-26GHz	4-24-2018	4-24-2020
L23-022-01	Spectrum Analyzer	Rohde & Schwarz	FSU26	201043	9kHz-26GHz	8/23/2017	8/23/2019
L23-034-02	Temperature Hygrometer	Extech	445703	48254-65	N/A	5/2/2018	5/2/2020
L23-034-04	Temperature Hygrometer	Extech	445703	48254-13	N/A	5/2/2018	5/2/2020
L23-023-01	RF Signal Generator	Rohde & Schwarz	SMF100A	101553	20Hz to 26.5GHz	8/23/2017	8/23/2019
L23-045-36	EMPower RF Power Meter	ETS-Lindgren	7002-006	151071	10MHz to 6GHz	1/31/2018	1/31/2020
L23-040-04	20dB Attenuator	Mini-Circuits	BW-N20W5	1133	DC-18GHz	5/31/2018	5/31/2020

Appendix A

MINIMUM BANDWIDTH

PURPOSE

This test was performed to determine if the EUT meets the minimum bandwidth requirements of FCC 15C, section 15.247(a)(2), and RSS-247 5.2(a), with the EUT operating at 902.400MHz, 915.000MHz, and 927.600MHz.

This testing results show the EUT meets FCC 15C 15.247(a)(2) and RSS-247 5.2(a), a minimum 6dB bandwidth of at least 500kHz.

REQUIREMENTS

As stated in 15.247(a)(2) and RSS-247 5.2(a), the minimum 6dB bandwidth shall be at least 500kHz.

TEST SETUP AND INSTRUMENTATION

A photograph of the test setup is shown in Figure A-1. The test instrumentation can be determined from Table 10-1.

MEASUREMENT UNCERTAINTY

All measurements are an estimate of their true value. The measurement uncertainty characterizes, with a specified confidence level, the spread of values which may be possible for a given measurement system. Values of Expanded Measurement Uncertainty (95% Confidence):

Measurement Type	U_{LAB}
Necessary Bandwidth	**±0.130 %**

U_{lab} = Determined for Shure EMC Laboratory

Since U_{LAB} is less than or equal to U_{ETSI}:

- Compliance is deemed to occur if no measured disturbance exceeds the disturbance limit;
- Non-compliance is deemed to occur if any measured disturbance exceeds the disturbance limit.

EUT OPERATION

The EUT was powered up and the transmit frequency and power output of the EUT were selected. The EUT was checked for proper operation after it was setup for the test. Testing was conducted with the EUT set to transmit at 902.400MHz, 915.000MHz, and 927.600MHz, at an output power level of 20mW.

Appendix A

TEST PROCEDURE

The EUT antenna output connector was connected thru an attenuator to a spectrum analyzer.

RESULTS

The measurements show the EUT met the minimum bandwidth of 500 kHz.

At 902.400 MHz, bandwidth measured 560.4 kHz.
At 915.000 MHz, bandwidth measured 557.4 kHz.
At 927.600 MHz, bandwidth measured 559.9 kHz.

The temperature during the testing was 73 degrees F, with relative humidity of 24%.

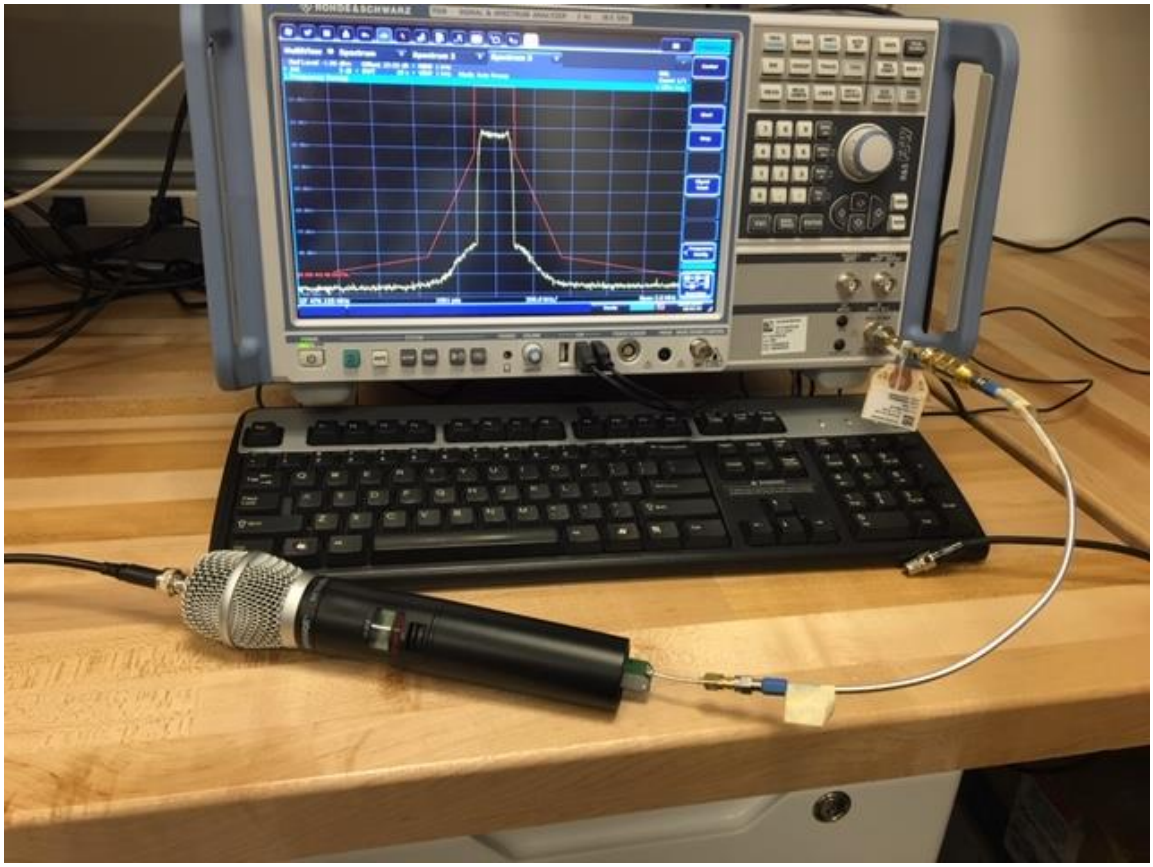
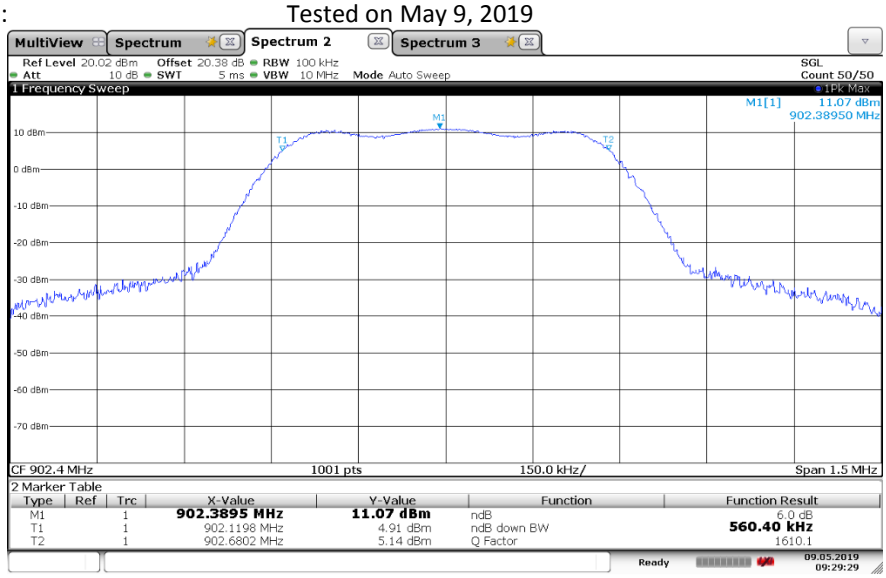


Figure A-1 - Test Setup for Minimum Bandwidth

Appendix A

Test Information

EUT Name:	ULXD2 X52
Serial Number:	4190734884
Test Description:	FCC 15C, Section 15.247(a)(2) Minimum Bandwidth
Operating Conditions:	Low Frequency, 902.400MHz, 20mW
Operator Name:	Jamal Qureshi
Date Tested:	Tested on May 9, 2019



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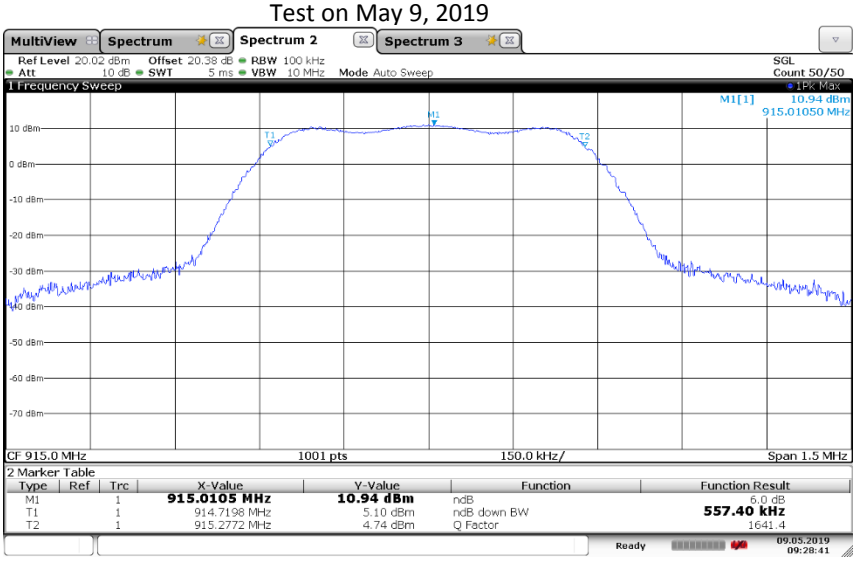
Test Information

EUT Name:	ULXD2 X52
Serial Number:	4190734884
Test Description:	FCC 15C, Section 15.247(a)(2) Minimum Bandwidth
Operating Conditions:	Middle Frequency, 915.000MHz, 20mW
Operator Name:	Jamal Qureshi
Date Tested:	Test on May 9, 2019



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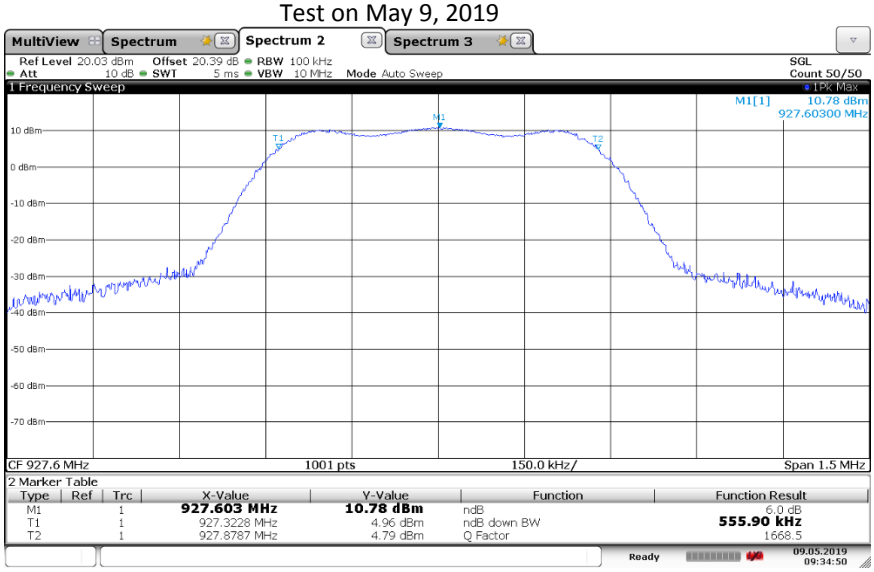
Controlled Documents\Forms and Templates\SEL-F-11 Main Body Test Form.docx

Appendix A

Test Information

EUT Name:	ULXD2 X52
Serial Number:	4190734884
Test Description:	FCC 15C, Section 15.247(a)(2) Minimum Bandwidth
Operating Conditions:	High Frequency, 927.600MHz, 20mW
Operator Name:	Jamal Qureshi
Date Tested:	Test on May 9, 2019



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Appendix B

MAXIMUM PEAK CONDUCTED OUTPUT POWER
MAXIMUM E.I.R.P.
FIELD STRENGTH OF FUNDAMENTAL

Purpose:
This test performed to determine if the EUT meets the maximum peak conducted output FCC Part15C, Section 15.247(b)(3), and RSS-247 Section 5.4(d). Also this test performed to determine if the EUT meets the RSS-247 Section 5.4(d), the e.i.r.p. shall not exceed 4W. This test was performed to determine if the EUT meets the FCC 15C, Section 15.249(a), the Field Strength of Fundamental.

Requirements:
As stated in FCC 15C Section 15.247(b)(3). For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the *maximum conducted output power* is the highest total transmit power occurring in any mode.

FCC 15C Section 15.247(b)(4) deals with antennas with gain greater the 6dBi. The Shure ULXD2 antenna gain is not directional and has gain less than 6dBi.

As stated in RSS-247 Section 5.4(d), for DTSs employing digital modulation techniques operating in the bands 902-928 MHz and 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1W. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e).

As stated in FCC 15C Section 15.249(a), Except as provided in paragraph (b) of this section, the field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following:

Fundamental Frequency	Field Strength of Fundamental (millivolts/meter)
902-928 MHz	50

The FCC 15C Section 15.249(a) testing is done with the EUT high density mode turned on.

Appendix B

Measurement Uncertainty, Conducted:

All measurements are an estimate of their true value. The measurement uncertainty characterizes, with a specified confidence level, the spread of values which may be possible for a given measurement system.

Values of Expanded Measurement Uncertainty (95% Confidence)

Measurement Type	U_{lab}
Conducted measurements (30 MHz – 1000 MHz)	1.24 dB

U_{lab} = Determined for Shure EMC Laboratory

Since U_{lab} is less than or equal to U_{ETSI}:

- Compliance is deemed to occur if no measured disturbance exceeds the disturbance limit; Non-compliance is deemed to occur if any measured disturbance exceeds the disturbance limit.

Measurement Uncertainty, Radiated:

All measurements are an estimate of their true value. The measurement uncertainty characterizes, with a specified confidence level, the spread of values which may be possible for a given measurement system.

Values of Expanded Measurement Uncertainty (95% Confidence)

Measurement Type	U_{lab}	U_{ETSI}
Radiated disturbance (electric field strength on an open area test site or alternative test site) (30 MHz – 1000 MHz)	4.24 dB	6.00 dB

U_{lab} = Determined for Shure EMC Laboratory

U_{ETSI} = From ETSI EN 300 422-1 Table 10

Since U_{lab} is less than or equal to U_{ETSI}:

- Compliance is deemed to occur if no measured disturbance exceeds the disturbance limit; Non-compliance is deemed to occur if any measured disturbance exceeds the disturbance limit.

Test Setup and Instrumentation:

Photographs of the test setup are shown in Figure B 1. The test instrumentation can be determined from Table 10-1.

EUT Operation:

The EUT was powered up and the frequency of the transmitter was selected using the front panel controls. For rated output power, the testing was performed with the EUT set to the low, middle, and high frequency within the operating frequency range, and at 20mW RF output.

Appendix B

Maximum Peak Conducted Output Power Specific Test Procedures:

The output of the EUT was connected to the input of an ETS-Lindgren EMPower RF Power Meter.

The EUT was set to transmit on the low, middle, and high frequencies, and power levels of 20mW.

Maximum E.I.R.P. Specific Test Procedures

The radiated measurements were taken from the Unwanted Emissions, Appendix C.

Results:

The maximum peak conducted output for all frequencies measured meets the FCC15C 15.247(b)(3) requirements, and RSS-247 5.4(d). The results are shown on page 17.

The e.i.r.p. measurement did not exceed 4 W. The results are shown on page 18.

The temperature during the test was 69 degrees F, with relative humidity of 20%.

Figure B 1: Test setup for maximum peak conducted output

Appendix B

Test Information

EUT Name: ULXD2 X52
Serial Number: 4190734884
Test Description: maximum peak conducted output
Operating Low Frequency, 902.400MHz, 20mW
Operator Name: Juan Castrejon
Date Tested: Tested on August 21, 2019

Power Meter Measurement in dBm	Power Meter Measured in mW	Limit in dBm	Limit in mW	Margin In mW
12.82	19.14	30.0	1000.0	980.9

Test Information

EUT Name: ULXD2 X52
Serial Number: 4190734884
Test Description: maximum peak conducted output
Operating Middle Frequency, 915.000MHz, 20mW
Operator Name: Juan Castrejon
Date Tested: Tested on August 21, 2019

Power Meter Measurement in dBm	Power Meter Measured in mW	Limit in dBm	Limit in mW	Margin In mW
12.51	17.82	30.0	1000.0	982.2

EUT Name: ULXD2 X52
Serial Number: 4190734884
Test Description: maximum peak conducted output
Operating High Frequency, 927.600MHz, 20mW
Operator Name: Juan Castrejon
Date Tested: Tested on August 21, 2019

Power Meter Measurement in dBm	Power Meter Measured in mW	Limit in dBm	Limit in mW	Margin In mW
12.66	18.45	30.0	1000.0	981.6

Appendix B

Test Information

EUT Name: ULXD2 X52
Serial Number: 4190734885
Test Description: Maximum Radiated Output
Operating Low Frequency, 902.400MHz, 20mW
Operator Name: Frank Salmeron
Comment: RSS-247 5.4(d)
Date Tested: Tested on May 16, 2019

Measurement In dBuV/m	Substitution Measurement in dBm	Cable Loss in dB	ERP in dBm	Isotropic Antenna Gain in dB	EIRP In dBm	EIRP In Watts	EIRP Limit in Watts	Margin In Watts
103.76	13.61	2.95	10.66	2.15	12.81	0.01910	4.0	3.98

EIRP (dBm) = Measurement (dBm) - Cable Loss (dB) + Isotropic Antenna Gain (dB)

Test Information

EUT Name: ULXD2 X52
Serial Number: 4190734885
Test Description: Maximum Radiated Output
Operating Middle Frequency, 915.000MHz, 20mW
Operator Name: Frank Salmeron
Comment: RSS-247 5.4(d)
Date Tested: Tested on May 16, 2019

Measurement In dBuV/m	Substitution Measurement in dBm	Cable Loss in dB	ERP in dBm	Isotropic Antenna Gain in dB	EIRP In dBm	EIRP In Watts	EIRP Limit in Watts	Margin In Watts
104.03	12.71	3.06	9.65	2.15	11.80	0.01514	4.0	3.99

EIRP (dBm) = Measurement (dBm) - Cable Loss (dB) + Isotropic Antenna Gain (dB)

Test Information

EUT Name: ULXD2 X52
Serial Number: 4190734885
Test Description: Maximum Radiated Output
Operating Middle Frequency, 915.000MHz, 20mW
Operator Name: Frank Salmeron
Comment: RSS-247 5.4(d)
Date Tested: Tested on May 16, 2019

Measurement In dBuV/m	Substitution Measurement in dBm	Cable Loss in dB	ERP in dBm	Isotropic Antenna Gain in dB	EIRP In dBm	EIRP In Watts	EIRP Limit in Watts	Margin In Watts
103.93	14.46	2.89	11.57	2.15	13.72	0.02355	4.0	3.98

EIRP (dBm) = Measurement (dBm) - Cable Loss (dB) + Isotropic Antenna Gain (dB)

Appendix B

Test Information

EUT Name: ULXD2 X52
Serial Number: 4190734885
Test Description: Field Strength of Fundamental
Operating Low Frequency, 902.400MHz, 0.25mW
Operator Name: Frank Salmeron
Comment: FCC 15C Section 15.249(a), Data taken from Appendix C
Date Tested: Tested on May 13, 2019

Measurement in dBuV/m	Measurement in millivolts/m	Required millivolts/m
92.28	41.1	50

EUT Name: ULXD2 X52
Serial Number: 4190734885
Test Description: Field Strength of Fundamental
Operating Middle Frequency, 915.000MHz, 0.25mW
Operator Name: Frank Salmeron
Comment: FCC 15C Section 15.249(a), Data taken from Appendix C
Date Tested: Tested on May 13, 2019

Measurement in dBuV/m	Measurement in millivolts/m	Required millivolts/m
93.13	45.3	50

EUT Name: ULXD2 X52
Serial Number: 4190734885
Test Description: Field Strength of Fundamental
Operating High Frequency, 927.600MHz, 0.25mW
Operator Name: Frank Salmeron
Comment: FCC 15C Section 15.249(a), Data taken from Appendix C
Date Tested: Tested on May 13, 2019

Measurement in dBuV/m	Measurement in millivolts/m	Required millivolts/m
93.02	44.8	50

Appendix C

Unwanted Emissions

Purpose:

This test performed to determine if the EUT meets the radiated RF emission requirements of the FCC Part 15C section 15.247(d) and RSS-247 Section 5.5 over the frequency range from 30MHz to 11GHz. A Quasi-Peak and Average detectors were used for the measurements. Both FCC Part 15C and IC RSS-Gen require measurements to the 10th harmonic of the carrier.

Requirements:

As stated in FCC 15C section 247(d), In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

As stated in RSS-247 Section 5.5, In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

Appendix C

Measurement Uncertainty, Radiated:

All measurements are an estimate of their true value. The measurement uncertainty characterizes, with a specified confidence level, the spread of values which may be possible for a given measurement system.

Values of Expanded Measurement Uncertainty (95% Confidence)

Measurement Type	U_{lab}	U_{ETSI}
Radiated disturbance (electric field strength on an open area test site or alternative test site) (30 MHz – 1000 MHz)	4.24 dB	6.00 dB
Radiated disturbance (electric field strength on an open area test site or alternative test site) (1 GHz – 13 GHz)	4.56 dB	6.00 dB

U_{lab} = Determined for Shure EMC Laboratory

U_{ETSI} = From ETSI EN 300 422-1 Table 10

Since U_{lab} is less than or equal to U_{ETSI}:

- Compliance is deemed to occur if no measured disturbance exceeds the disturbance limit; Non-compliance is deemed to occur if any measured disturbance exceeds the disturbance limit.

Measurement Uncertainty, Conducted:

All measurements are an estimate of their true value. The measurement uncertainty characterizes, with a specified confidence level, the spread of values which may be possible for a given measurement system.
Values of Expanded Measurement Uncertainty (95% Confidence):

Measurement Type	U_{lab}
Conducted measurements (30 MHz – 1000 MHz)	1.24 dB

U_{lab} = Determined for Shure EMC Laboratory

Since U_{lab} is less than or equal to U_{ETSI}:

- Compliance is deemed to occur if no measured disturbance exceeds the disturbance limit; Non-compliance is deemed to occur if any measured disturbance exceeds the disturbance limit.

Test Setup and Instrumentation:

Photographs of the test setup are shown in Figure B 1 and Figure B 2. The test instrumentation can be determined from Table 10-1.

EUT Operation:

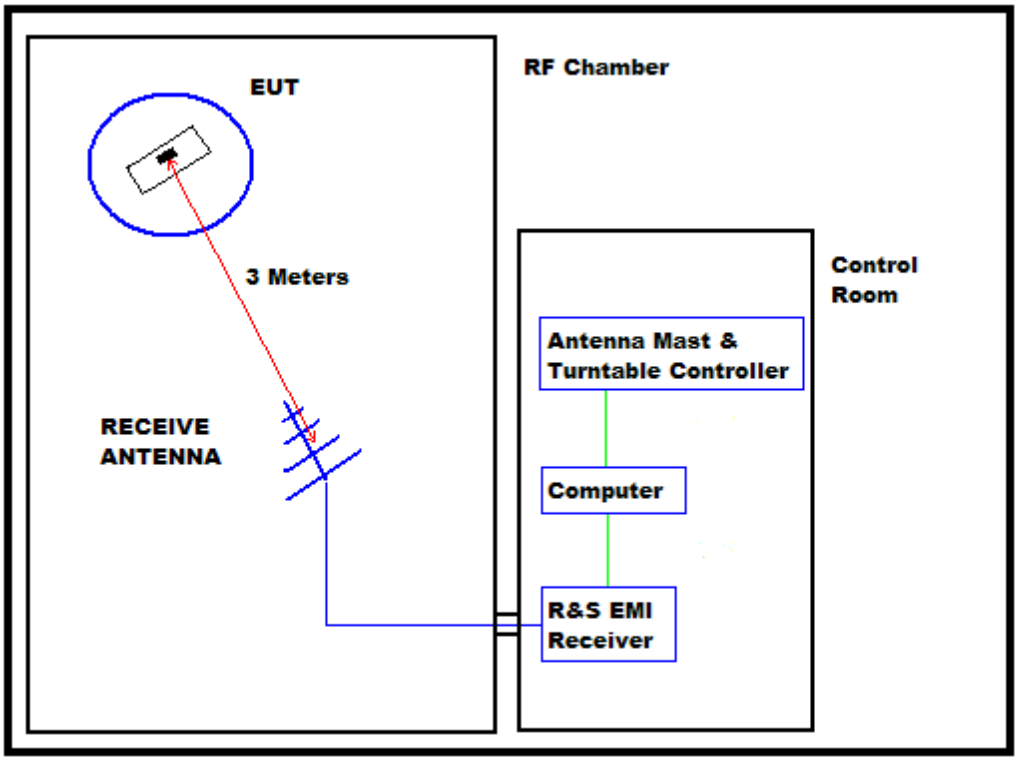
The EUT was powered up and the frequency of the transmitter was selected using the front panel controls. The EUT was checked for proper operation after it was setup on the test table. For radiated spurious emissions the testing was performed with the EUT set to the low, middle, and high frequencies with RF power output of 0.25mW and 20mW.

Appendix C

Specific Test Procedures:

All tests were performed in a 28ft. x 20ft. x 18.5ft. 3m semi-anechoic test chamber. The walls and ceiling of the shielded chamber are lined with ferrite tiles. Anechoic absorber material is installed over the ferrite tile. The floor of the chamber is used as the ground plane. The chamber complies with ANSI C63.4-2003 for site attenuation.

The shielded enclosure prevents emissions from other sources, such as radio and TV stations from interfering with the measurements. All power lines and signal lines entering the enclosure pass through filters on the enclosure wall. The power line filters prevent extraneous signals from entering the enclosure on these leads.



BLOCK DIAGRAM OF SHIELDED ENCLOSURE

Preliminary radiated measurements were performed to determine the frequencies where the significant emissions might be found. With the EUT at one set position and the measurement antenna at a set height (i.e. without maximizing), the radiated emissions were measured using a peak detector and automatically plotted. The BiConiLog measuring antenna was positioned at a 3 meter distance from the EUT for below 1GHz testing, and a double ridged waveguide antenna above 1GHz testing.

Appendix C

All significant broadband and narrowband signals found in the preliminary sweeps were then measured using a peak detector at a test distance of 3 meters. The measurements were made with a BiConiLog antenna over the frequency range of 30 MHz to 1 GHz, and a double ridged waveguide antenna over the frequency range of 1 GHz to 10 GHz.

To ensure that maximum emission levels were measured, the following steps were taken:

i. The EUT was rotated so that all of its sides were exposed to the receiving antenna.
ii. Since the measuring antennas are linearly polarized, both horizontal and vertical field components were measured.
iii. The measuring antenna was raised and lowered from 1 to 4 meters for each antenna polarization to maximize the readings.

The equivalent power was determined from the field intensity levels measured at 3 meters using the substitution method. To determine the emission power, another antenna was set in place of the EUT and connected to a calibrated signal generator. (A tuned dipole was used for all measurements below 1GHz and a double ridged waveguide antenna was used for all measurements above 1GHz.) The output of the signal generator was adjusted to match the received level at the EMI receiver. The signal level was recorded. The reading was corrected to compensate for cable loss and antenna gain.

Results:

The plots of the peak preliminary radiated voltage levels in the graphs on page 23 thru page 28. The ERP measurements were not done since all of the harmonics were in the noise floor. All emissions measured from the EUT were within the FCC 15C 15.247(d) and RSS-247 Section 5.5 specification limits.

The temperature during the testing in the RF Chamber was 73 degrees F, with relative humidity of 25%.

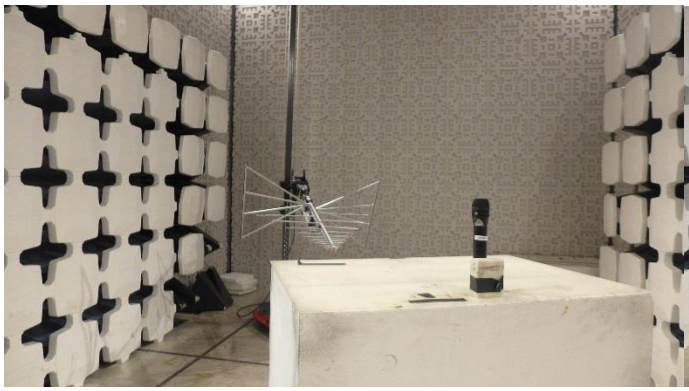


Figure B 1: ULXD2 Transmitter Test Setup

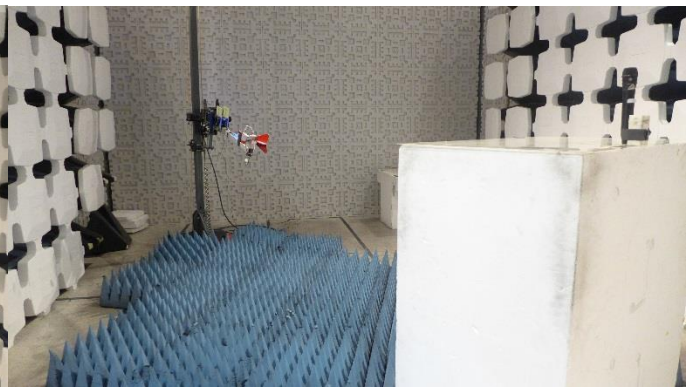


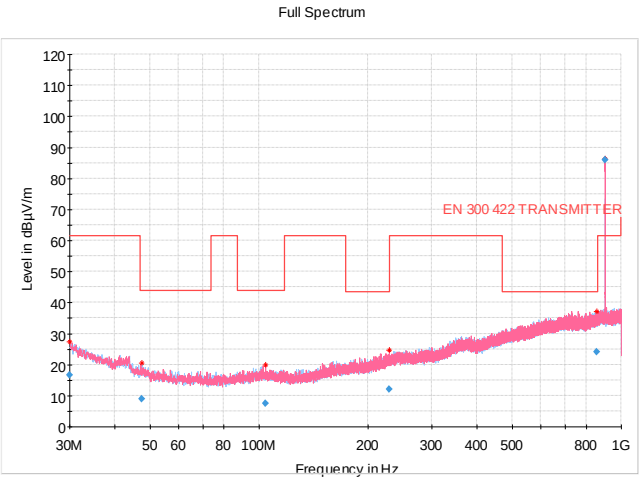
Figure B 2: ULXD2 Transmitter Test Setup

Appendix C

SHURE Radiated RF Emissions Test Report

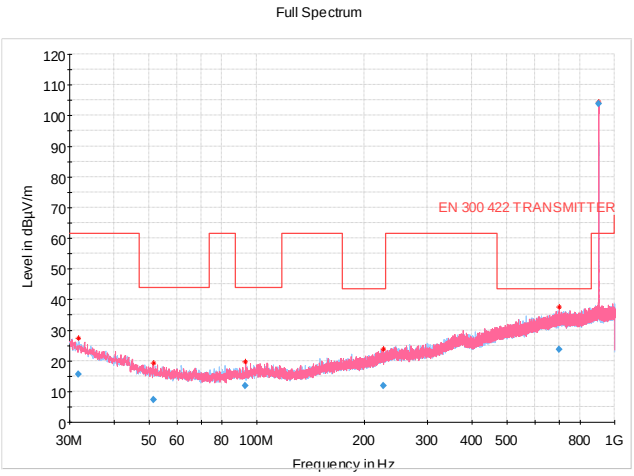
Common Information

Test Description:	FCC 15C Radiated Emissions 30MHz - 1GHz
EUT:	ULXD2 X52, with KSM8 Mic Head, High Density Mode Off
Serial Number:	4190734885
Operating Frequency:	Low Frequency 902.400MHz
RF Power Level	0.25mW
Tester Name:	Frank Salmeron
Date Tested	Tested on May 9, 2019



Common Information

Test Description:	FCC 15C Radiated Emissions 30MHz - 1GHz
EUT:	ULXD2 X52, with KSM8 Mic Head, High Density Mode Off
Serial Number:	4190734885
Operating Frequency:	Low Frequency 902.400MHz
RF Power Level	20mW
Tester Name:	Frank Salmeron
Date Tested	Tested on May 9, 2019

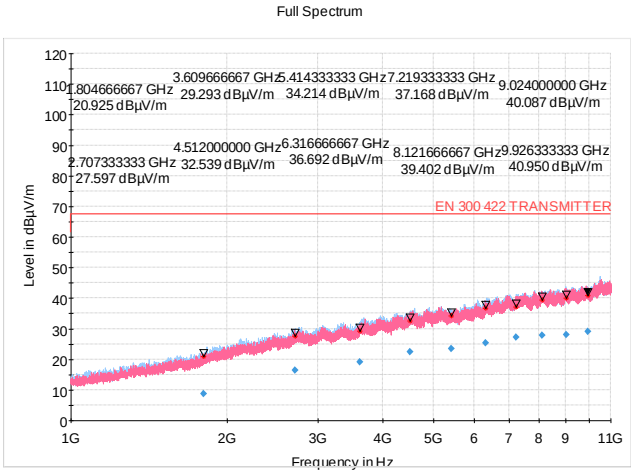


Appendix C

SHURE Radiated RF Emissions Test Report

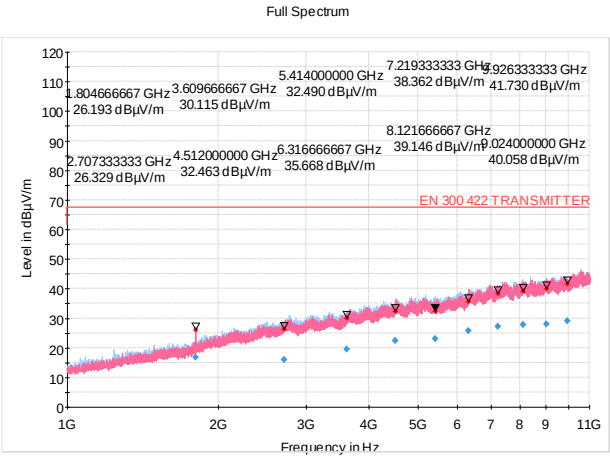
Common Information

Test Description:	FCC 15C Radiated Emissions 1GHz - 11GHz
EUT:	ULXD2 X52, with KSM8 Mic Head, High Density Mode Off
Serial Number:	4190734885
Operating Frequency:	Low Frequency 902.400MHz
RF Power Level	0.25mW
Tester Name:	Frank Salmeron
Date Tested	Tested on May 9, 2019



Common Information

Test Description:	FCC 15C Radiated Emissions 1GHz - 11GHz
EUT:	ULXD2 X52, with KSM8 Mic Head, High Density Mode Off
Serial Number:	4190734885
Operating Frequency:	Low Frequency 902.400MHz
RF Power Level	20mW
Tester Name:	Frank Salmeron
Date Tested	Tested on May 13, 2019

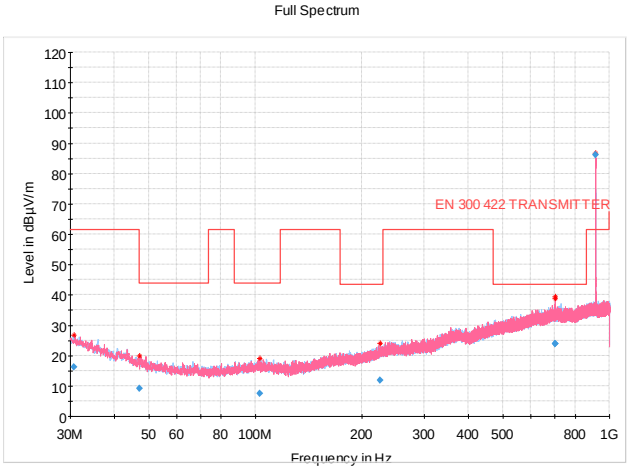


Appendix C

SHURE Radiated RF Emissions Test Report

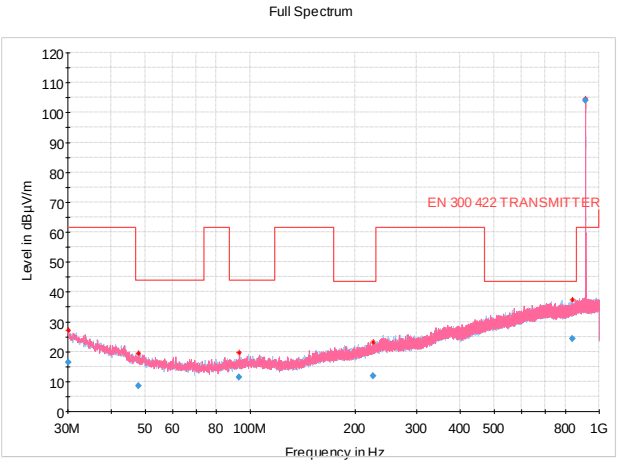
Common Information

Test Description:	FCC 15C Radiated Emissions 30MHz - 1GHz
EUT:	ULXD2 X52, with KSM8 Mic Head, High Density Mode Off
Serial Number:	4190734885
Operating Frequency:	Middle Frequency 915.000MHz
RF Power Level	0.25mW
Tester Name:	Frank Salmeron
Date Tested	Tested on May 10, 2019



Common Information

Test Description:	FCC 15C Radiated Emissions 30MHz - 1GHz
EUT:	ULXD2 X52, with KSM8 Mic Head, High Density Mode Off
Serial Number:	4190734885
Operating Frequency:	Middle Frequency 915.000MHz
RF Power Level	20mW
Tester Name:	Frank Salmeron
Date Tested	Tested on May 10, 2019

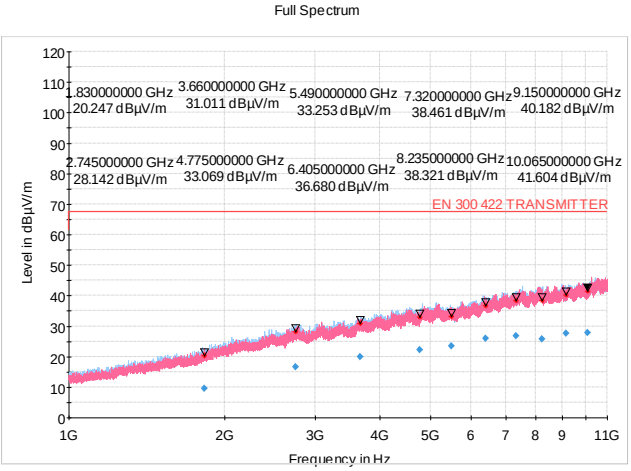


Appendix C

SHURE Radiated RF Emissions Test Report

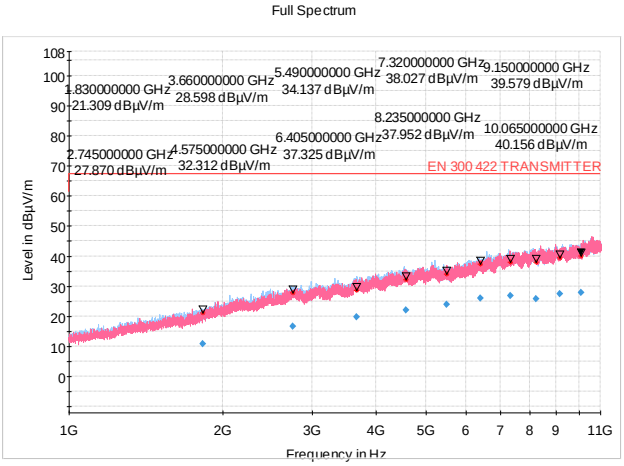
Common Information

Test Description:	FCC 15C Radiated Emissions 1GHz - 11GHz
EUT:	ULXD2 X52, with KSM8 Mic Head, High Density Mode Off
Serial Number:	4190734885
Operating Frequency:	Middle Frequency 915.000MHz
RF Power Level	0.25mW
Tester Name:	Frank Salmeron
Date Tested	Tested on May 13, 2019



Common Information

Test Description:	FCC 15C Radiated Emissions 1GHz - 11GHz
EUT:	ULXD2 X52, with KSM8 Mic Head, High Density Mode Off
Serial Number:	4190734885
Operating Frequency:	Middle Frequency 915.000MHz
RF Power Level	20mW
Tester Name:	Frank Salmeron
Date Tested	Tested on May 13, 2019

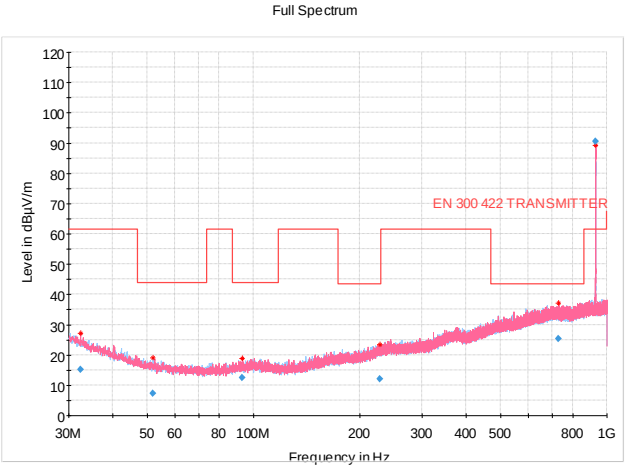


Appendix C

SHURE Radiated RF Emissions Test Report

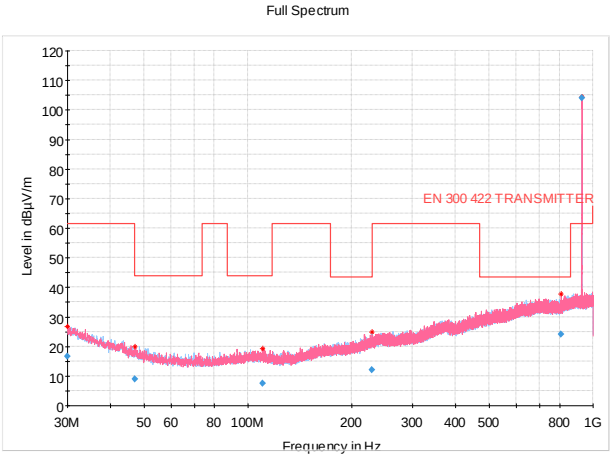
Common Information

Test Description:	FCC 15C Radiated Emissions 30MHz - 1GHz
EUT	ULXD2 X52, with KSM8 Mic Head, High Density Mode Off
Serial Number	4190734885
Operating Frequency:	High Frequency 927.600MHz
RF Power Level	0.25mW
Tester Name	Frank Salmeron
Date Tested	Tested on May 10, 2019



Common Information

Test Description:	FCC 15C Radiated Emissions 30MHz - 1GHz
EUT	ULXD2 X52, with KSM8 Mic Head, High Density Mode Off
Serial Number	4190734885
Operating Frequency:	High Frequency 927.600MHz
RF Power Level	20mW
Tester Name	Frank Salmeron
Date Tested	Tested on May 10, 2019

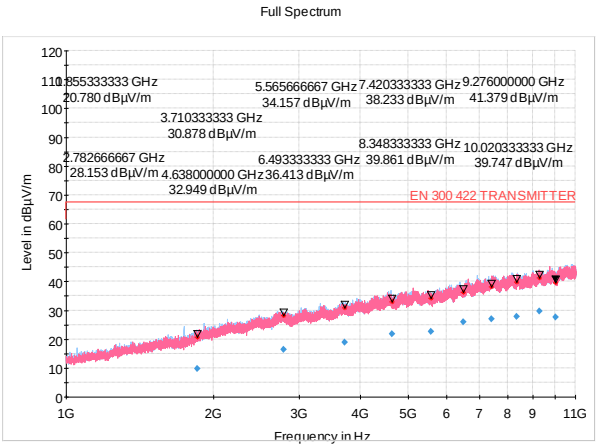


Appendix C

SHURE Radiated RF Emissions Test Report

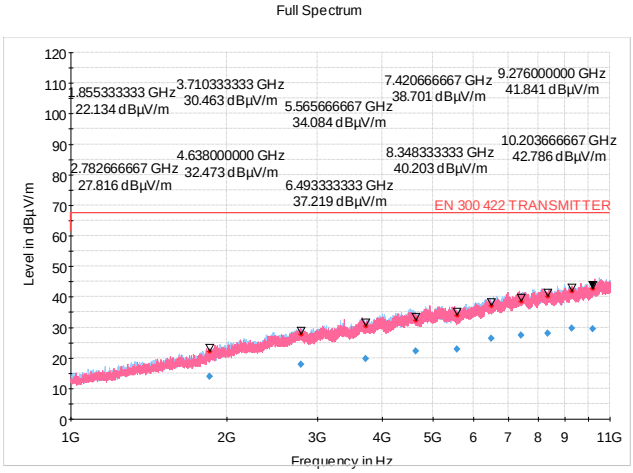
Common Information

Test Description:	FCC 15C Radiated Emissions 1GHz - 11GHz
EUT:	ULXD2 X52, with KSM8 Mic Head, High Density Mode Off
Serial Number:	4190734885
Operating Frequency:	High Frequency 927.600MHz
RF Power Level	0.25mW
Tester Name:	Frank Salmeron
Date Tested	Tested on May 08, 2019



Common Information

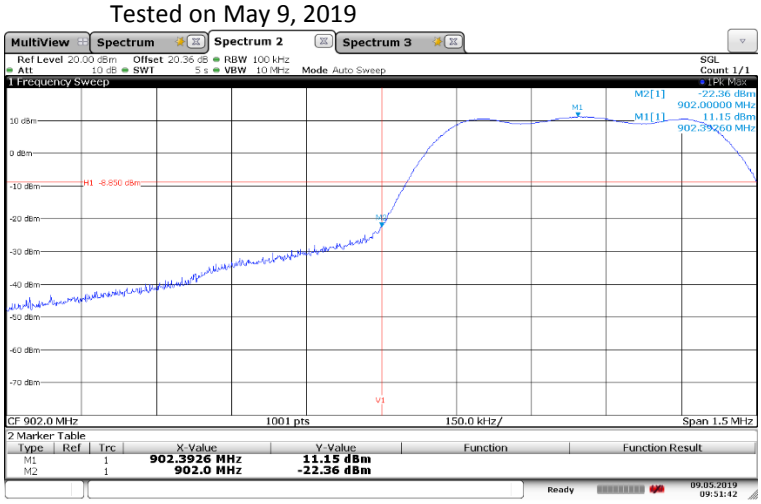
Test Description:	FCC 15C Radiated Emissions 1GHz - 11GHz
EUT:	ULXD2 X52, with KSM8 Mic Head, High Density Mode Off
Serial Number:	4190734885
Operating Frequency:	High Frequency 927.600MHz
RF Power Level	20mW
Tester Name:	Frank Salmeron
Date Tested	Tested on May 08, 2019



Appendix C

Common Information

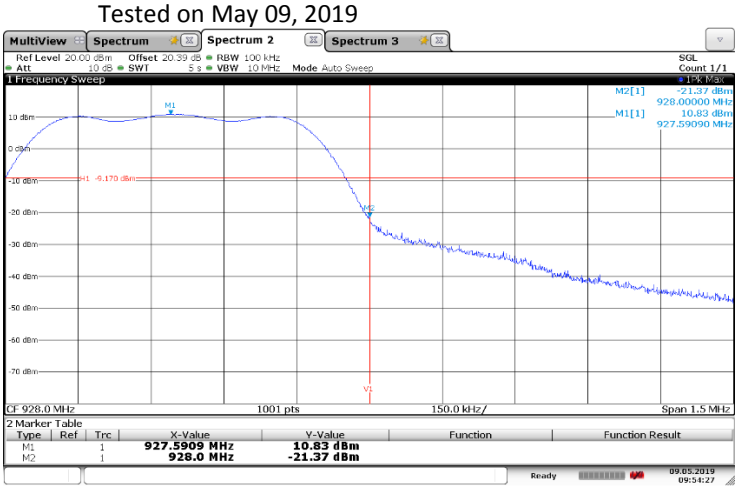
Test Description:	FCC 15C 15.247(a)(2)
EUT:	ULXD2 X52, High Density Mode Off
Serial Number:	4190734884
Operating Frequency:	Low Frequency 902.400MHz
RF Power Level	20mW
Tester Name:	Jamal Qureshi
Date Tested	Tested on May 9, 2019



09:51:42 09.05.2019

Common Information

Test Description:	FCC 15C 15.247(a)(2)
EUT:	ULXD2 X52, High Density Mode Off
Serial Number:	4190734884
Operating Frequency:	High Frequency 927.600MHz
RF Power Level	20mW
Tester Name:	Jamal Qureshi
Date Tested	Tested on May 09, 2019

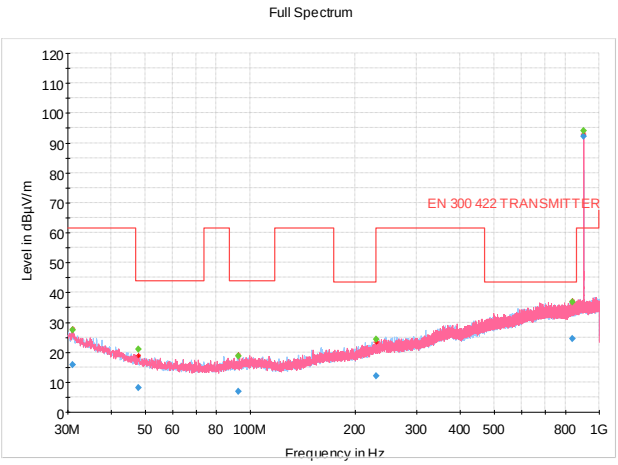


09:54:28 09.05.2019

Appendix C

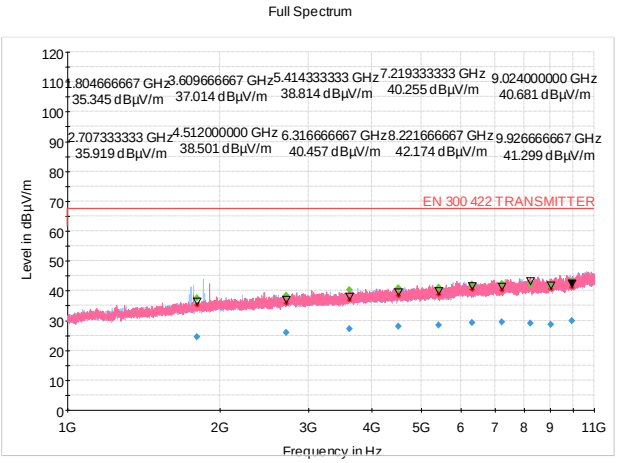
Common Information

Test Description:	FCC 15C Radiated Emissions 30MHz - 1GHz
EUT:	ULXD2 X52, High Density Mode On
Serial Number:	4190734884
Operating Frequency:	Low Frequency 902.400MHz
RF Power Level	0.25mW
Tester Name:	Frank Salmeron
Date Tested	Tested on May 14, 2019



Common Information

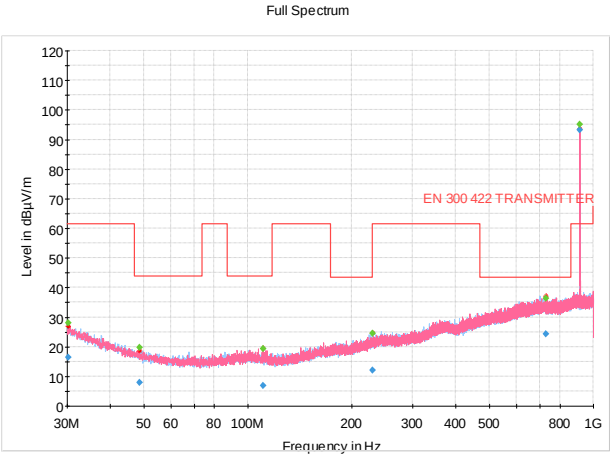
Test Description:	FCC 15C Radiated Emissions 1GHz - 11GHz
EUT:	ULXD2 X52, High Density Mode On
Serial Number:	4190734884
Operating Frequency:	Low Frequency 902.400MHz
RF Power Level	0.25mW
Tester Name:	Frank Salmeron
Date Tested	Tested on May 14, 2019



Appendix C

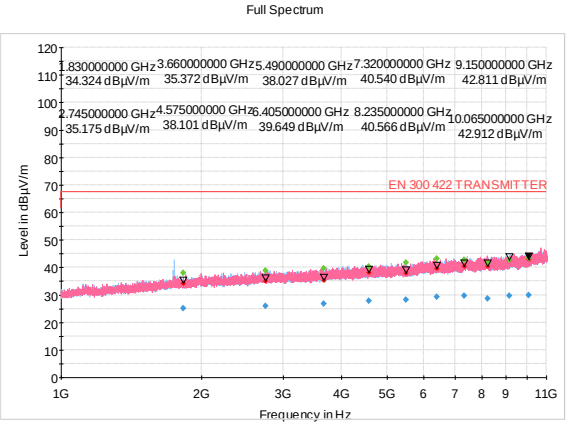
Common Information

Test Description:	FCC 15C Radiated Emissions 30MHz - 1GHz
EUT:	ULXD2 X52, High Density Mode On
Serial Number:	4190734884
Operating Frequency:	Middle Frequency 915.000MHz
RF Power Level	0.25mW
Tester Name:	Frank Salmeron
Date Tested	Tested on May 14, 2019



Common Information

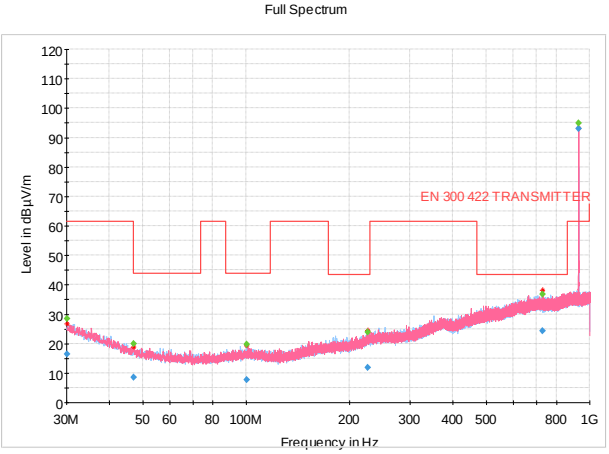
Test Description:	FCC 15C Radiated Emissions 1GHz - 11GHz
EUT:	ULXD2 X52, High Density Mode On
Serial Number:	4190734884
Operating Frequency:	Middle Frequency 915.000MHz
RF Power Level	0.25mW
Tester Name:	Frank Salmeron
Date Tested	Tested on May 15, 2019



Appendix C

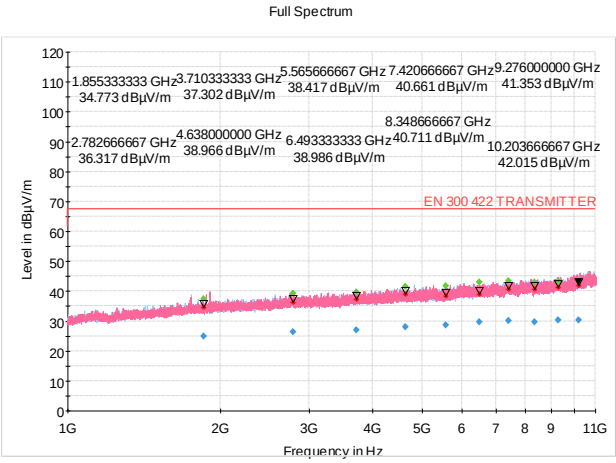
Common Information

Test Description:	FCC 15C Radiated Emissions 30MHz - 1GHz
EUT:	ULXD2 X52, High Density Mode On
Serial Number:	4190734884
Operating Frequency:	High Frequency 927.600MHz
RF Power Level	0.25mW
Tester Name:	Frank Salmeron
Date Tested	Tested on May 14, 2019



Common Information

Test Description:	FCC 15C Radiated Emissions 1GHz - 11GHz
EUT:	ULXD2 X52, High Density Mode On
Serial Number:	4190734884
Operating Frequency:	High Frequency 927.600MHz
RF Power Level	0.25mW
Tester Name:	Frank Salmeron
Date Tested	Tested on May 15, 2019



Appendix C

Test Information

EUT Name: ULXD2 X52, High Density Mode On
Serial Number: 4190734884
Test Description: Field Strength of Fundamental
Operating Low Frequency, 902.400MHz, 0.25mW
Operator Name: Frank Salmeron
Comment: FCC 15C Section 15.249(a), Data taken from Appendix C
Date Tested: Tested on May 15, 2019

Harmonic Frequency in MHz	Measurement in dBuV/m	Measurement in microvolts/m	Maximum microvolts/m	Margin in microvolts/m
1804.667	24.55	16.9	500	483.1
2707.333	25.93	19.8	500	480.2
3609.667	27.18	22.8	500	477.2
4512.000	28.09	25.4	500	474.6
5414.333	28.49	26.5	500	473.5
6316.333	29.20	29.0	500	471.0
7219.333	29.39	29.4	500	470.6
8121.667	29.05	28.4	500	471.6
9024.000	28.57	26.8	500	473.2
9926.333	29.81	30.9	500	469.1

Test Information

EUT Name: ULXD2 X52, High Density Mode On
Serial Number: 4190734884
Test Description: Field Strength of Fundamental
Operating Middle Frequency, 915.000MHz, 0.25mW
Operator Name: Frank Salmeron
Comment: FCC 15C Section 15.249(a), Data taken from Appendix C
Date Tested: Tested on May 15, 2019

Harmonic Frequency in MHz	Measurement in dBuV/m	Measurement in microvolts/m	Maximum microvolts/m	Margin in microvolts/m
1830.000	25.03	17.8	500	482.2
2745.000	26.05	20.1	500	479.9
3660.000	26.83	21.9	500	478.1
4575.000	27.72	24.3	500	475.7
5490.000	28.23	25.8	500	474.2
6405.000	29.29	29.1	500	470.9
7320.000	29.77	30.8	500	469.2
8235.000	28.74	27.4	500	472.6
9150.000	29.67	30.4	500	469.6
10065.000	29.99	31.5	500	468.5

Appendix C

Test Information

EUT Name:	ULXD2 X52, High Density Mode On
Serial Number:	4190734884
Test Description:	Field Strength of Fundamental
Operating	High Frequency, 927.600MHz, 0.25mW
Operator Name:	Frank Salmeron
Comment:	FCC 15C Section 15.249(a), Data taken from Appendix C
Date Tested:	Tested on May 15, 2019

Harmonic Frequency in MHz	Measurement in dBuV/m	Measurement in microvolts/m	Maximum microvolts/m	Margin in microvolts/m
1855.333	25.00	17.8	500	482.2
2782.667	26.43	21.0	500	479.0
3710.333	26.95	22.3	500	477.7
4638.000	28.11	25.4	500	474.6
5565.667	28.56	26.8	500	473.2
6493.333	29.66	30.4	500	469.6
7420.667	30.08	32.0	500	468.0
8348.667	29.73	30.7	500	469.3
9276.000	30.35	33.0	500	467.0
10203.667	30.38	33.1	500	466.9

Appendix D

Power Spectral Density

Purpose:

This test performed to determine if the EUT meets the Power Spectral Density requirements of the FCC Part15C, Section 15.247(e), and RSS-247 Section 5.2(b).

Requirements:

As stated in FCC 15C Section 15.247(e), for digitally modulated systems, 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. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

As stated in RSS-247 Section 5.2(b), the transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of section 5.4(d),(i.e. the power spectral density shall be determined using the same method as is used to determine the conducted output power)

Measurement Uncertainty:

All measurements are an estimate of their true value. The measurement uncertainty characterizes, with a specified confidence level, the spread of values which may be possible for a given measurement system.

Values of Expanded Measurement Uncertainty (95% Confidence)

Measurement Type	U_{lab}
Conducted measurements (30 MHz – 1000 MHz)	1.24 dB

U_{lab} = Determined for Shure EMC Laboratory

Since U_{lab} is less than or equal to U_{ETSI}:

- Compliance is deemed to occur if no measured disturbance exceeds the disturbance limit; Non-compliance is deemed to occur if any measured disturbance exceeds the disturbance limit.

Test Setup and Instrumentation:

Photographs of the test setup are shown in Figure D 1. The test instrumentation can be determined from Table 10-1.

Appendix D

EUT Operation:

The EUT was powered up and the frequency of the transmitter was selected using the front panel controls. For rated output power, the testing was performed with the EUT set to the low, middle, and high frequency within the operating frequency range, and at 20mW RF output.

Specific Test Procedures:

The Power Spectral Density test was setup as follows;

Center Frequency = Operating Frequency of EUT
Reference Level = 20 dB
Internal Attenuator = 10 dB
Offset = 20.36 dB (External attenuator)
RBW = 3 kHz
VBW = 10 MHz
Span = 1 MHz

The EUT was set to transmit on the low, middle, and high frequencies, and power level of 20mW.

Results:

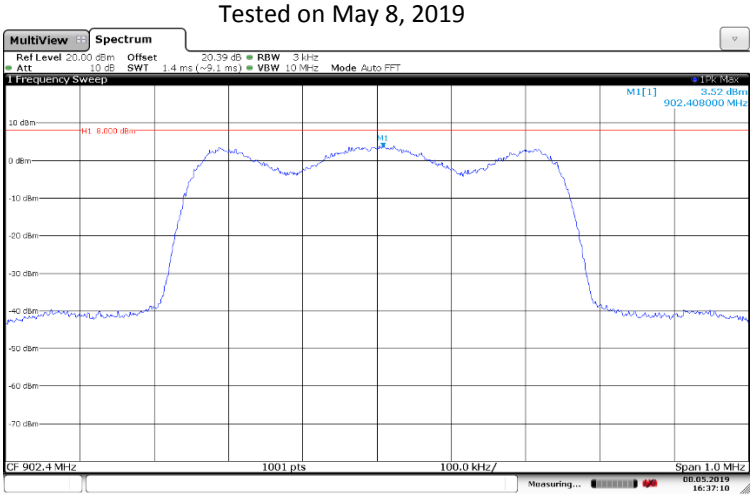
The power spectral density at low, middle and high frequencies were below 8dBm.

The results are shown on page 38 thru page 39.

Appendix D

Test Information

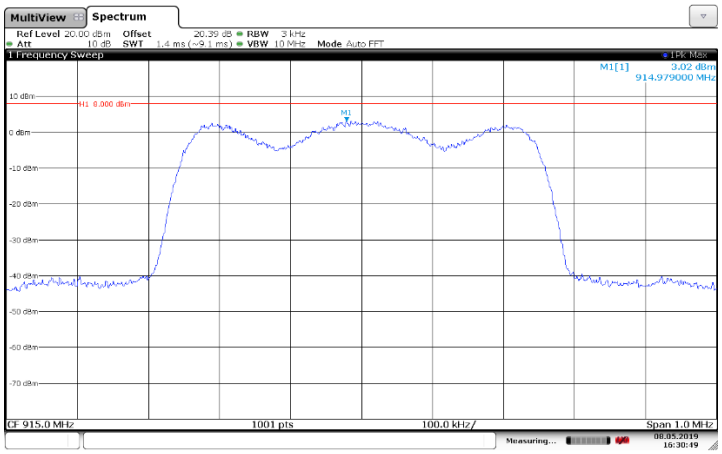
EUT Name:	ULXD2 X52
Serial Number:	4190734884
Test Description:	Power Spectral Density
Operating Conditions:	Low Frequency, 902.400MHz, 20mW
Operator Name:	Jamal Qureshi
Comment:	FCC Part15C, Section 15.247(e), RSS-247 Section 2.5(b)
Date Tested:	Tested on May 8, 2019



16:37:11 08.05.2019

Test Information

EUT Name:	ULXD2 X52
Serial Number:	4190734884
Test Description:	Power Spectral Density
Operating Conditions:	Middle Frequency, 915.000MHz, 20mW
Operator Name:	Jamal Qureshi
Comment:	FCC Part15C, Section 15.247(e), RSS-247 Section 2.5(b)
Date Tested:	Tested on May 8, 2019

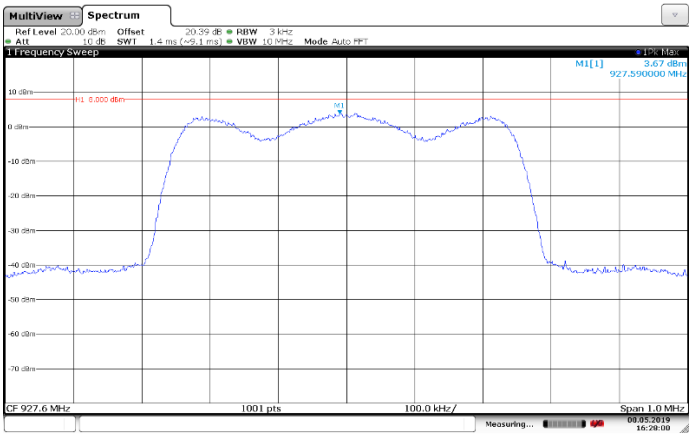


16:30:50 08.05.2019

Appendix D

Test Information

EUT Name:	ULXD2 X52
Serial Number:	4190734884
Test Description:	Power Spectral Density
Operating Conditions:	High Frequency, 927.600MHz, 20mW
Operator Name:	Jamal Qureshi
Comment:	FCC Part15C, Section 15.247(e), RSS-247 Section 2.5(b)
Date Tested:	Tested on May 8, 2019



16:28:00 08.05.2019

Appendix E

Spurious Emissions on Antenna Port

PURPOSE:
This test was performed to determine if the EUT meets the Spurious Emissions on Antenna Port requirements of the FCC Title 47, Section 2.1051 specifications over the EUT operating frequency range of 902MHz to 928MHz.

REQUIREMENTS:

As stated in paragraph Section 2.1051, the radio frequency voltage or powers generated within the equipment and appearing on a spurious frequency shall be checked at the equipment output terminals when properly loaded with a suitable artificial antenna. Curves or equivalent data shall show the magnitude of each harmonic and other spurious emission that can be detected when the equipment is operated under the conditions specified in §2.1049 as appropriate. The magnitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be specified.

MEASUREMENT UNCERTAINTY:

All measurements are an estimate of their true value. The measurement uncertainty characterizes, with a specified confidence level, the spread of values which may be possible for a given measurement system.
The expanded measurement uncertainty (95% confidence) has been determined to be ± 1.28 dB.

TEST SETUP AND INSTRUMENTATION:

Photograph of the test setup is shown in Figure E 1.The test instrumentation can be determined from Table 10-1.

EUT OPERATION:

The EUT was powered up and the frequency of the transmitter was selected using the front panel controls. For conducted spurious emissions the testing was performed with the EUT set to the low, middle, and high frequencies with RF power output of 20mW.

Appendix E

TEST PROCEDURES:

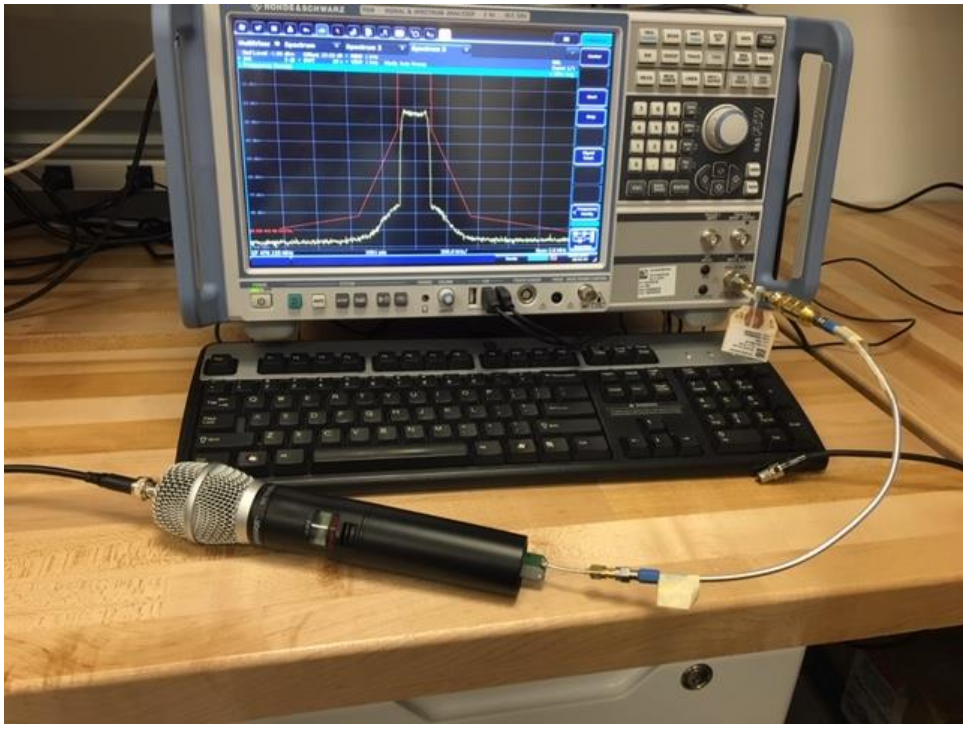
The testing was performed as states in FCC Part 2.1051.

RESULTS:

The plots of the antenna port spurious emissions are shown on page 42 thru page 43. All emissions measured from the EUT were within the FCC 15C Section 15.247(d) specification limits. The magnitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be specified.

All spurious emissions were at least 20 dB below the highest measured power of the EUT.

The temperature in the test room during the test was 73 degrees F, with relative humidity of 18%.

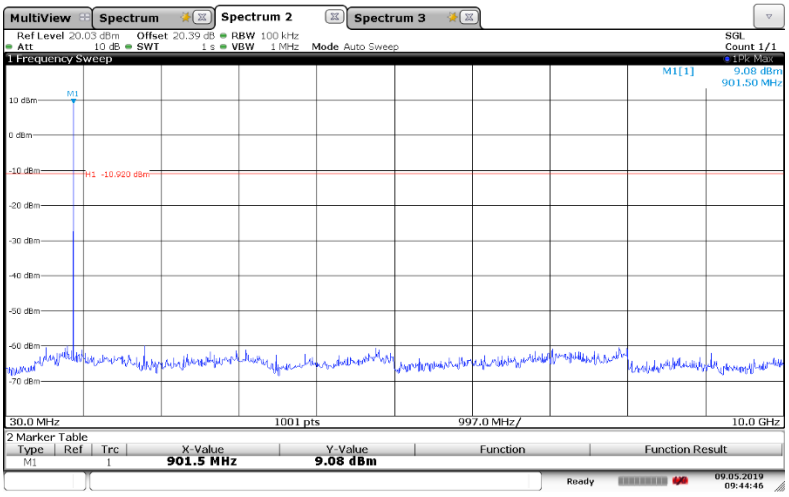


Figures E-1 - Test Setup for Spurious Emissions on Antenna Port

Appendix E

Test Information

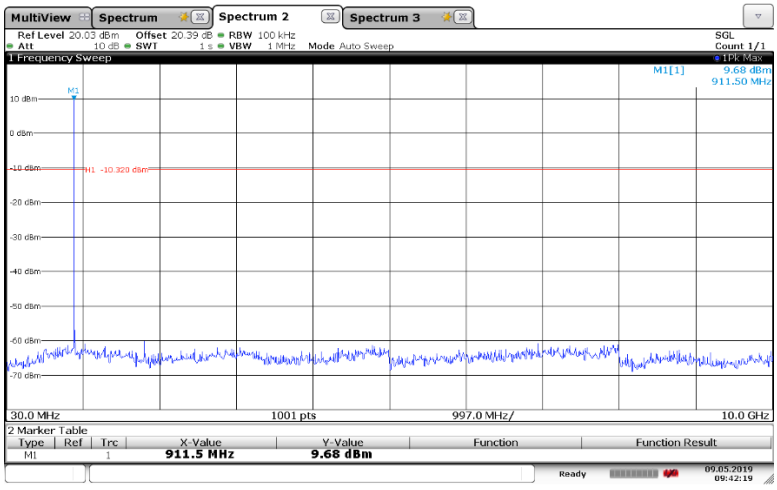
EUT Name:	ULXD2 X52
Serial Number:	4190734884
Test Description:	FCC Section 2.1051 Spurious Emissions on Antenna Port
Operating Conditions:	Low frequency 902.400MHz at 20mW
Operator Name:	Jamal Qureshi
Comment:	R & S FSU Spectrum Analyzer
Test Date	May 9, 2019



09:44:46 09.05.2019

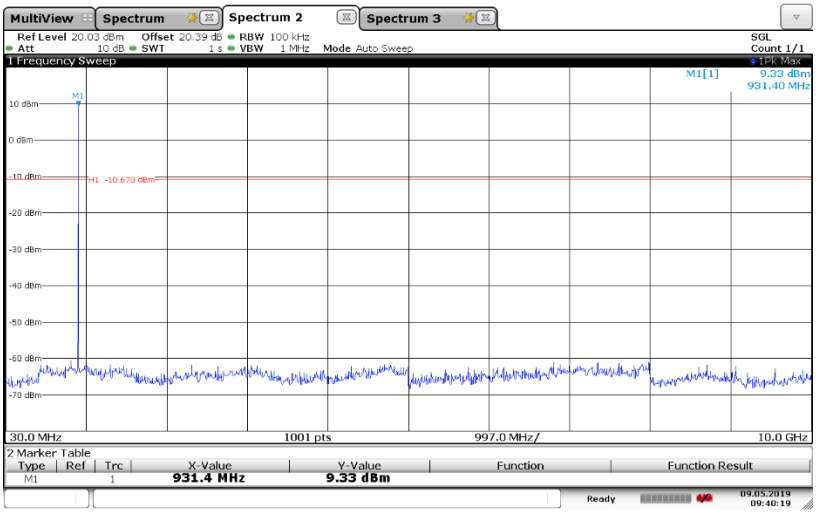
Test Information

EUT Name:	ULXD2 X52
Serial Number:	4190734884
Test Description:	FCC Section 2.1051 Spurious Emissions on Antenna Port
Operating Conditions:	Middle frequency 915.000MHz at 20mW
Operator Name:	Jamal Qureshi
Comment:	R & S FSU Spectrum Analyzer
Test Date	May 9, 2019



09:42:20 09.05.2019

Appendix E

Test Information

EUT Name:	ULXD2 X52
Serial Number:	4190734884
Test Description:	FCC Section 2.1051 Spurious Emissions on Antenna Port
Operating Conditions:	High Frequency 927.600MHz at 20mW
Operator Name:	Jamal Qureshi
Comment:	R & S FSU Spectrum Analyzer
Test Date	May 9, 2019