SHURE

ELECTROMAGNETIC COMPATIBILITY LABORATORY
TEST REPORT

TEST REPORT TITLE: Electromagnetic Compatibility Tests of the Shure ULXD1 L50A Digital Wireless Transmitter in the 657MHz to 663MHz Band

TEST ITEM DESCRIPTION:

The Shure ULXD1 is a digital wireless microphone transmitter, microprocessor controlled transmitter.

For:	Shure Incorporated 5800 West Touhy Avenue Niles, IL 60714
Project ID Number:	SEL-030/ULXD1 L50A
Date Tested:	July 12, 2017, November 22, 2017, January 24, 25, 2018, February 16, 26, 27, 2018, March 8, 2018
Test Personnel:	Alex Mishinger, Danny Palaniswami, Juan Castrejon, and Craig Kozokar
Test Specification:	FCC Part 15C, Section 15.236g

TEST REPORT BY:	Craig Kozokar	Global Compliance Engineer	MAY 1, 2018
APPROVED BY:	Thomas E Brewster	GC Project Engineer	5/1/18
	Signature	Position	Date

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LIST OF APPENDICIES

APPENDIX	TEST DESCRIPTION
A	Radiated RF Spurious Emissions Measurement, 30 MHz to 10 GHz
B	Maximum Radiated Power
C	Necessary Bandwidth

REPORT REVISION HISTORY

Revision	Date	Description
0	March 30, 2018	Initial release

1. INTRODUCTION

1.1. Scope of Tests

This report presents the results of testing per FCC Part 15C, Section 236g, Radiated RF Spurious Emissions, Maximum Radiated Output, and Necessary Bandwidth. 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 sample meet the requirements of the above standards. The equipment under test (EUT) contained a transmitter that was designed to transmit in the UHF TV frequency bands shown in Table 1.

Model	Band	Frequency (MHz)	Output Power (mW)
ULXD1	L50A	657 – 663	1, 10, and 20

Table 1. EUT Frequency Band 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 236g.

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

Test Spec	Description	Tested Frequency	Appendix	Test Results
FCC Part 15C	Radiated Spurious Emissions	30 MHz to 10 GHz	A	Pass
FCC Part 15C	Maximum Radiated Power	657.125MHz 662.875MHz	B	Pass
FCC Part 15C	Necessary Bandwidth Measurements	657.125MHz 662.875MHz	C	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 236g

EN 300 422-1 v1.4.2 (2011-08), “Wireless Microphone “Electromagnetic Compatibility and Radio spectrum Matters (ERM); Wireless microphones in the 25MHz to 3GHz frequency range; Part 1; Technical characteristics and methods of measurements”

ANSI C63.4 (2014), "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 40 GHz"

3. EUT SET-UP AND OPERATION

3.1. General Description

The test sample used was Shure ULXD1 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 ULXD1 L50A Digital Wireless Transmitter Sample

ULXD1 L50A Serial Numbers
#1

3.3 Operational Mode

All necessary bandwidth tests were performed separately in the transmit frequency and output power modes shown in Table 4.

Band	Frequency in MHz	L/H	Power Level in mW
L50A	657.125	Low	20
L50A	662.875	High	20

Table 4. EUT Frequencies and Power Levels

All radiated spurious emissions and maximum radiated power tests were performed separately in the transmit frequency and output power modes shown in Table 5.

Band	Frequency in MHz	L/H	Power Level in mW
L50A	657.125	Low	20
L50A	662.875	High	20

Table 5. EUT Frequencies and Power Levels

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 meet the requirements of FCC Part 15C, Section 236g for Radiated RF Spurious Emissions, Maximum Radiated Output, and Necessary Bandwidth.

8. Conclusions:

It was determined that the Shure ULXD1 L50A Digital Wireless Microphone Transmitter did fully comply with the requirements of FCC Part 15C, Section 236g, Radiated RF Spurious Emissions, Maximum Radiated Output, and Necessary Bandwidth.

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	8/8/2017	8/8/2018
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	6/22/2018
L23-011-44	BiConiLog Antenna	ETS Lindgren	3142C	79899	25MHz-1GHz	2/27/2017	2/27/2018
L23-011-54	EMI Test Receiver	Rohde & Schwarz	ESR26	100220	9kHz-26GHz	3/30/2017	3/30/2018
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	4/27/2017	4/27/2018
L23-011-41	Horn Antenna	ETS Lindgren	3117	123511	1GHz to 18 GHz	5/7/2017	5/7/2018
L23-011-57	High Pass Filter	K&L	11SH10-940/X10000-0/0	3	940MHz – 10GHz	3/31/2017	3/31/2018
L23-022-02	Spectrum Analyzer	Rohde & Schwarz	FSW26	103788	9kHz-26GHz	3/28/2017	3/28/2018
L23-022-01	Spectrum Analyzer	Rohde & Schwarz	FSU26	201043	9kHz-26GHz	8/23/2017	8/23/2018
L23-040-09	20dB attenuator	Mini-Circuits	BW-S20W2	N/A	20MHz to 18GHz	2/21/2017	2/21/2018
L23-040-04	20dB attenuator	Mini-Circuits	BW-S20W5	1133	20MHz to 18GHz	7/18/2017	7/18/2018
L23-034-05	Temperature Hygrometer	Extech	445703	48254-66	N/A	9/15/2016	9/15/2018
L23-034-04	Temperature Hygrometer	Extech	445703	48254-13	N/A	9/15/2016	9/15/2018
L23-023-01	RF Signal Generator	Rohde & Schwarz	SMF100A	101553	20Hz to 26.5GHz	8/23/2017	8/23/2018

Appendix A

A. RADIATED RF SPURIOUS EMISSIONS – 30 MHZ TO 10 GHZ

Purpose:
This test performed to determine if the EUT meets the radiated RF emission requirements of the FCC Part 15C section 236g over the frequency range from 30MHz to 10GHz. A Quasi-Peak and Average detectors were used for the measurements.

Requirements:
As stated in FCC 15C section 236g, spurious emissions must meet the limits specified in section 8.4 of ETSI EN 300 422-1 V1.4.2 (2011-08)

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}	U_{ETSI}
Radiated disturbance (electric field strength on an open area test site or alternative test site) (30 MHz – 1000 MHz)	4.12 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 6

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:
A Shure model WL93 was plugged into the EUT microphone socket. Photographs of the test setup are shown in Figure 1 and Figure 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 table. For radiated spurious emissions the testing was conducted with the EUT set to the low and high frequency within the operating frequency range, and at 20mW RF output.

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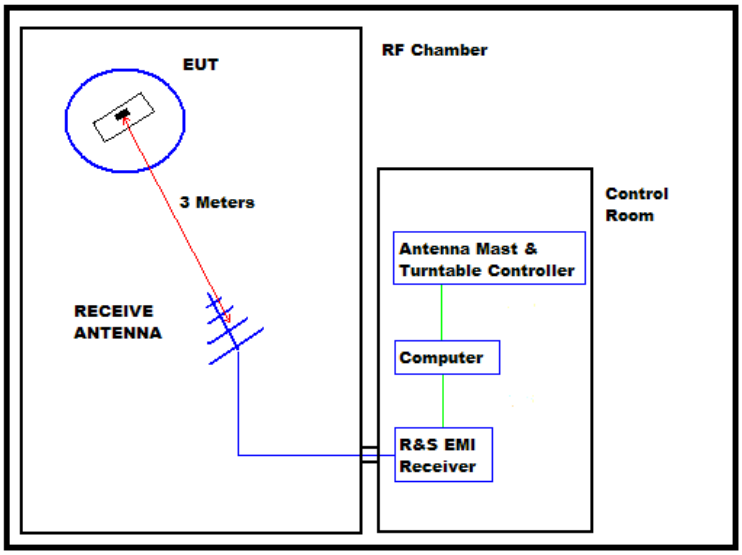
Specific Test Procedures:

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.

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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 and maximized peak radiated voltage levels results are presented on page 12 thru page 23. The ERP measurements are shown on pages 24 thru page 25. All emissions measured from the EUT were within the ETSI EN 300 422-1 specification limits.

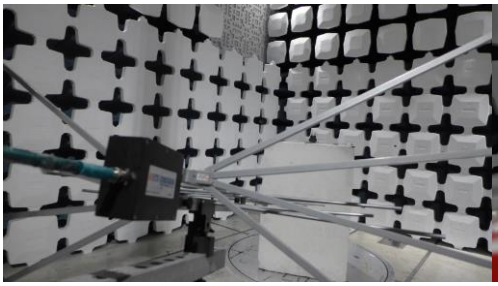

Figure 1: ULXD1 Transmitter Test Setup

Figure 2: ULXD1 Transmitter Test Setup

Appendix A

SHURE Radiated RF Emissions Test Report

Common Information

Test Description:	FCC15C Radiated Emissions 30MHz - 1GHz
EUT	ULXD1 L50A
Serial Number	# 1
Operating Conditions:	657.125MHz, 20mW Tested on January 25, 2018
Operator Name:	Alex Mishinger

EMI Auto Test Template: COMPLIANCE TEST FCC15C-EN300422 Transmitter 30MHz to 1GHz 79899 EU

Hardware Setup:	Electric Field Strength 79899 2017 02 27
Measurement Type:	Open-Area-Test-Site
Frequency Range:	30 MHz - 1 GHz
Graphics Level Range:	0 dBµV/m - 120 dBµV/m

Preview Measurements:

Antenna height:	100 - 400 cm , Step Size = 50 cm , Positioning Speed = 6
Polarization:	H + V
Turntable position:	0 - 360 deg , Continuously , Measuring Speed = 5
Graphics Display:	Show separate traces for horizontal and vertical polarization
Sweep Test Template:	Compliance Test EN300422 Transmitter 25MHz 1GHz 79899 PREVIEW

Adjustment:

Antenna height:	Range = 50 cm , Measuring Speed = 1
Turntable position:	Range = 90 deg , Measuring Speed = 5
Template for Single Meas.:	COMPLIANCE TEST EN300422 Transmitter 25 to 1000 MHz 79899 FINAL

Final Measurements:

Template for Single Meas.:	COMPLIANCE TEST EN300422 Transmitter 25 to 1000 MHz 79899 FINAL

Final Measurements:

Template for Single Meas.:	COMPLIANCE TEST EN300422 Transmitter 25 to 1000 MHz 79899 FINAL

Subrange	Step Size	Detectors	IF BW	Meas. Time	Preamp
25 MHz - 30 MHz	2.25 kHz	PK+	9 kHz	1 s	0 dB
30 MHz - 1 GHz	30 kHz	PK+	120 kHz	1 s	0 dB

Receiver: [ESR 26]

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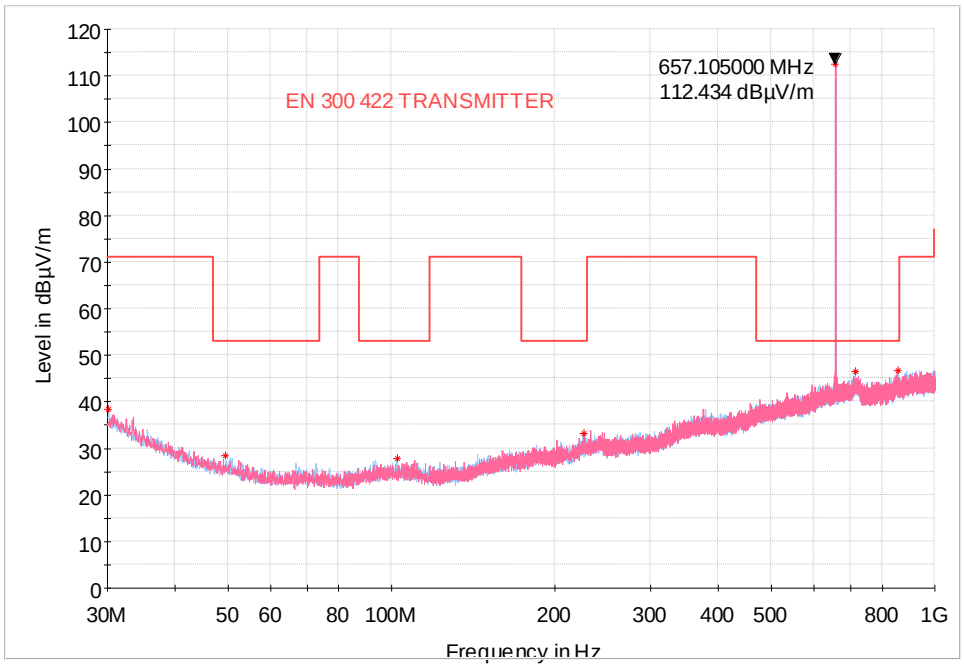
Hardware Setup: EMI radiated\Electric Field Strength 79899 2017 02 27 - [EMI radiated]

Subrange 1

Frequency Range:	25 MHz - 1 GHz
Receiver:	ESR 26 [ESR 26] @ GPIB0 (ADR 20), SN 1316.3003K26/101347, FW 2.26, CAL 5/28/2016
Signal Path:	Receiver-EMI to 1 GHz FW 1.0 Correction Table: Receiver-EMI Antenna 18GHz L23_041_38 8m
Antenna:	ETS 3142C 79899 SN 79899, CAL 12/5/2015 Correction Table (vertical): BiconiLog 3142C Hor-79899 2017 02 27 Correction Table (horizontal): BiconiLog 3142C Hor-79899 2017 02 27
Antenna Tower:	Tower [EMCO 2090 Antenna Tower] @ GPIB0 (ADR 8), FW REV 3.21
Turntable:	Turntable [EMCO Turntable] @ GPIB0 (ADR 9), SN 29799, FW REV 3.21

Appendix A

Full Spectrum



Critical Results

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment	Corr. (dB)
856.246000	46.63	53.00	6.37	---	---	100.0	H	33.0	---	1:56:18 PM - 1/25/2018	---
102.426667	27.85	53.00	25.15	---	---	150.0	H	226.0	---	1:56:18 PM - 1/25/2018	---
713.235667	46.45	53.00	6.55	---	---	250.0	H	93.0	---	1:56:18 PM - 1/25/2018	---
30.129333	38.48	71.00	32.52	---	---	250.0	H	206.0	---	1:56:18 PM - 1/25/2018	---
49.464667	28.49	53.00	24.51	---	---	400.0	H	93.0	---	1:56:18 PM - 1/25/2018	---
657.105000	112.43	53.00	-59.43	---	---	100.0	V	289.0	---	1:56:18 PM - 1/25/2018	---
225.746000	33.23	53.00	19.77	---	---	300.0	V	160.0	---	1:56:18 PM - 1/25/2018	---

Final Results

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)	Comment
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Appendix A

SHURE Radiated RF Emissions Test Report

Common Information

Test Description:	FCC15C Radiated Emissions 1GHz - 10GHz
EUT:	ULXD1 L50A
Serial Number	# 1
Operating Frequency:	657.125MHz
Power Level / Mod Mode:	20mW
Name:	Alex Mishinger
Comments:	Tested on February 16, 2018

EMI Auto Test Template: COMPLIANCE TEST FCC15C-EN300422 Transmitter 1GHz to 10GHz 3117-PA 200363

Hardware Setup:	Electric Field Strength 3117-PA 200363 2017 10 17
Measurement Type:	Open-Area-Test-Site
Frequency Range:	1 GHz - 10 GHz
Graphics Level Range:	0 dBµV/m - 120 dBµV/m

Preview Measurements:

Antenna height:	100 - 400 cm , Step Size = 50 cm , Positioning Speed = 6
Polarization:	H + V
Turntable position:	0 - 360 deg , Continuously , Measuring Speed = 5
Graphics Display:	Show separate traces for horizontal and vertical polarization
Sweep Test Template:	COMPLIANCE TEST EN300422 Transmitter 1-18 GHz 3117-PA 200363 PREVIEW

Adjustment:

Antenna height:	Range = 50 cm , Measuring Speed = 1
Turntable position:	Range = 90 deg , Measuring Speed = 5
Template for Single Meas.:	COMPLIANCE TEST EN300422 Transmitter 1 to 18 GHz 3117-PA 200363 MAX

Final Measurements:

Template for Single Meas.:	COMPLIANCE TEST EN300422 Transmitter 1 to 18 GHz 3117-PA 200363 FINAL

Subrange	Step Size	Detectors	IF BW	Meas. Time	Preamp
Receiver: [ESR 26]					
1 GHz - 18 GHz	250 kHz	AVG	1 MHz	1 s	0 dB

Appendix A

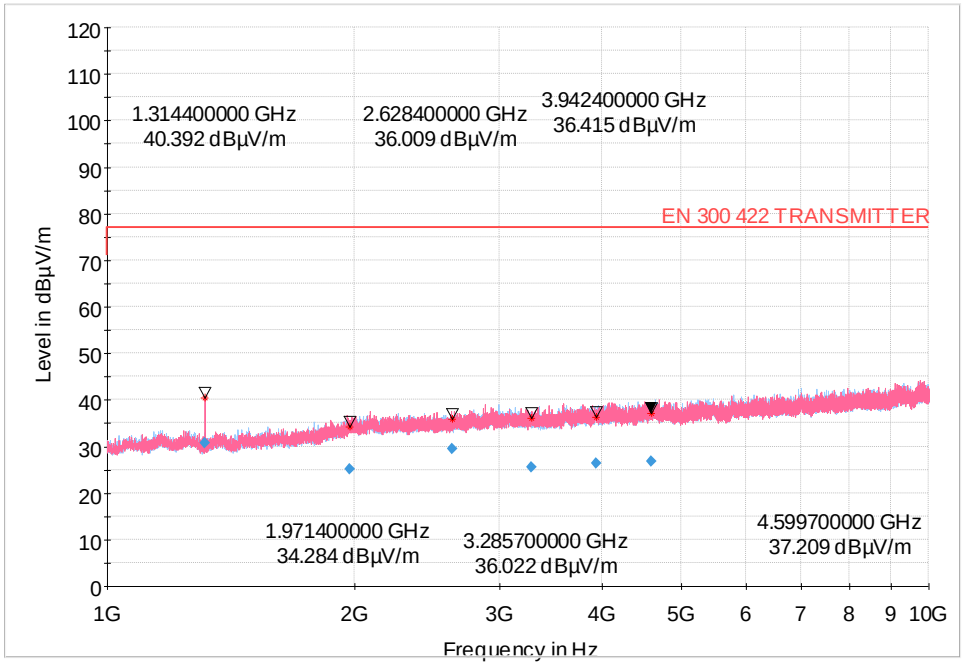
Hardware Setup: EMI radiated\Electric Field Strength 3117-PA 200363 2017 10 17 - [EMI radiated]

Subrange 1

Frequency Range:	1 GHz - 18 GHz
Receiver:	ESR 26 [ESR 26] @ GPIB0 (ADR 20), SN 1316.3003K26/101347, FW 2.26, CAL 5/28/2016
Signal Path:	Receiver-EMI to 18 GHz FW 1.0 Correction Table: Receiver-EMI Antenna TEMP 2016 11 23
Antenna:	EMI3117-PA 200385 SN 200385, CAL 10/16/2018 Correction Table (vertical): Horn ETS 3117-PA 200363 2017 10 16 Correction Table (horizontal): Horn ETS 3117-PA 200363 2017 10 16 Correction Table (vertical): L23_041_47 Cable Correction Table (horizontal): L23_041_47 Cable
Antenna Tower:	Tower [EMCO 2090 Antenna Tower] @ GPIB0 (ADR 8), FW REV 3.21
Turntable:	Turntable [EMCO Turntable] @ GPIB0 (ADR 9), SN 29799, FW REV 3.21

Appendix A

Full Spectrum



Critical Frequencies

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment	Corr. (dB)
1314.400000	40.39	77.00	36.61	---	---	292.0	V	212.0	---	12:08:40 PM - 2/16/2018	---
1971.400000	34.28	77.00	42.72	---	---	109.0	V	42.0	---	12:02:07 PM - 2/16/2018	---
2628.400000	36.01	77.00	40.99	---	---	104.0	V	10.0	---	12:03:55 PM - 2/16/2018	---
3285.700000	36.02	77.00	40.98	---	---	185.0	V	193.0	---	12:05:54 PM - 2/16/2018	---
3942.400000	36.41	77.00	40.59	---	---	325.0	V	54.0	---	12:07:23 PM - 2/16/2018	---
4599.700000	37.21	77.00	39.79	---	---	215.0	V	92.0	---	12:04:57 PM - 2/16/2018	---

Final Result

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment	Corr. (dB)
1314.400000	30.78	77.00	46.22	1000.0	1000.000	292.0	V	212.0	-16.1	12:08:49 PM - 2/16/2018	---
1971.400000	25.15	77.00	51.85	1000.0	1000.000	109.0	V	42.0	-13.3	12:02:16 PM - 2/16/2018	---
2628.400000	29.45	77.00	47.55	1000.0	1000.000	104.0	V	10.0	-12.1	12:04:03 PM - 2/16/2018	---
3285.700000	25.58	77.00	51.42	1000.0	1000.000	185.0	V	194.0	-11.0	12:06:03 PM - 2/16/2018	---
3942.400000	26.40	77.00	50.60	1000.0	1000.000	325.0	V	54.0	-9.0	12:07:28 PM - 2/16/2018	---
4599.700000	26.71	77.00	50.29	1000.0	1000.000	215.0	V	93.0	-7.2	12:05:05 PM - 2/16/2018	---

Appendix A

SHURE Radiated RF Emissions Test Report

Common Information

Test Description:	FCC15C Radiated Emissions 30MHz - 1GHz EU
EUT	ULXD1 L50A
Serial Number	# 1
Operating Conditions:	662.875MHz, 20mW
	Tested on November 22, 2017
Operator Name:	Alex Mishinger

EMI Auto Test Template: Bandsaw COMPLIANCE TEST FCC 15C 30MHz to 1GHz 34790 FCC

Hardware Setup:	Electric Field Strength 34790
Measurement Type:	Open-Area-Test-Site
Frequency Range:	30 MHz - 1 GHz
Graphics Level Range:	0 dBµV/m - 125 dBµV/m

Preview Measurements:

Graphics Display:	Show separate traces for horizontal and vertical polarization
Sweep Test Template:	Compliance Test FCC15C 30MHz 1GHz 34790 PREVIEW

Final Measurements:

Template for Single Meas.:	COMPLIANCE TEST FCC15C 30to 1000 MHz 34790 FINAL

Adjustment:

Template for Single Meas.:	COMPLIANCE TEST FCC15C 30 to 1000 MHz 34790 MAX

Final Measurements:

Template for Single Meas.:	COMPLIANCE TEST FCC15C 30 to 1000 MHz 34790 FINAL

Subrange	Step Size	Detectors	IF BW	Meas. Time	Preamp
30 MHz - 1 GHz	30 kHz	PK+	120 kHz	1 s	0 dB

Receiver: [ESR 26]

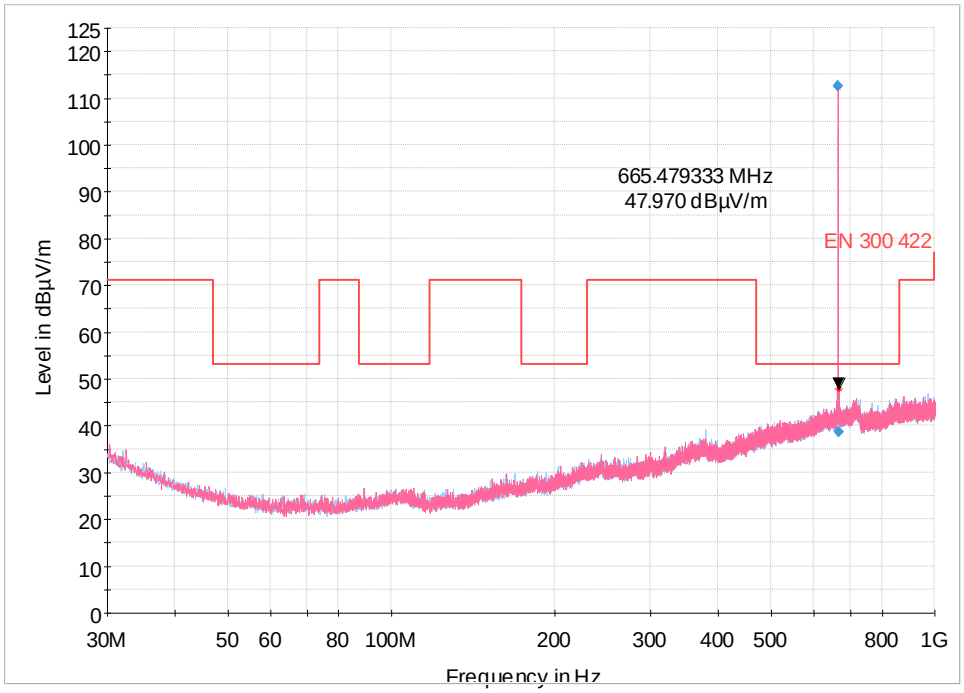
Appendix A

Hardware Setup: EMI radiated\Electric Field Strength 34790 - [EMI radiated]

Subrange 1

Frequency Range:	30 MHz - 1 GHz
Receiver:	ESR 26 [ESR 26] @ GPIB0 (ADR 20), SN 1316.3003K26/101347, FW 2.26, CAL 5/28/2017
Signal Path:	Receiver-EMI to 1 GHz FW 1.0 Correction Table: Receiver-EMI Antenna 18GHz L23_041_38 8m
Antenna:	ETS 3142C 34790 SN 34790, CAL 6/3/2017 Correction Table (vertical): BiconiLog 3142C Hor-34790 2017 06 17 Correction Table (horizontal): BiconiLog 3142C Hor-34790 2017 06 17
Antenna Tower:	Tower [EMCO 2090 Antenna Tower] @ GPIB0 (ADR 8), FW REV 3.21
Turntable:	Turntable [EMCO Turntable] @ GPIB0 (ADR 9), SN 29799, FW REV 3.21

Appendix A



Critical Frequencies

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)	Comment
662.860333	112.39	53.00	-59.39	---	---	181.0	V	151.0	22.2	2:27:17 PM - 11/22/2017
665.479333	47.97	53.00	5.03	---	---	205.0	V	40.0	22.3	2:29:09 PM - 11/22/2017

Final Frequencies

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)	Comment
662.860333	112.61	53.00	-59.61	1000.0	120.000	181.0	V	151.0	22.2	2:27:32 PM - 11/22/2017
665.479333	38.67	53.00	14.33	1000.0	120.000	205.0	V	40.0	22.3	2:29:22 PM - 11/22/2017

Appendix A

SHURE Radiated RF Emissions Test Report

Common Information

Test Description:	FCC15C Radiated Emissions 1GHz - 10GHz
EUT:	ULXD1 L50A
Serial Number	# 1
Operating Frequency:	662.875MHz
Power Level / Mod Mode:	20mW
Name:	Alex Mishinger
Comments:	Tested on February 16, 2018

EMI Auto Test Template: COMPLIANCE TEST FCC15C-EN300422 Transmitter 1GHz to 10GHz 3117-PA 200363

Hardware Setup:	Electric Field Strength 3117-PA 200363 2017 10 17
Measurement Type:	Open-Area-Test-Site
Frequency Range:	1 GHz - 10 GHz
Graphics Level Range:	0 dBµV/m - 120 dBµV/m

Preview Measurements:

Antenna height:	100 - 400 cm , Step Size = 50 cm , Positioning Speed = 6
Polarization:	H + V
Turntable position:	0 - 360 deg , Continuously , Measuring Speed = 5
Graphics Display:	Show separate traces for horizontal and vertical polarization
Sweep Test Template:	COMPLIANCE TEST EN300422 Transmitter 1-18 GHz 3117-PA 200363 PREVIEW

Adjustment:

Antenna height:	Range = 50 cm , Measuring Speed = 1
Turntable position:	Range = 90 deg , Measuring Speed = 5
Template for Single Meas.:	COMPLIANCE TEST EN300422 Transmitter 1 to 18 GHz 3117-PA 200363 MAX

Final Measurements:

Template for Single Meas.:	COMPLIANCE TEST EN300422 Transmitter 1 to 18 GHz 3117-PA 200363 FINAL

Subrange	Step Size	Detectors	IF BW	Meas. Time	Preamp
Receiver: [ESR 26]					
1 GHz - 18 GHz	250 kHz	AVG	1 MHz	1 s	0 dB

Appendix A

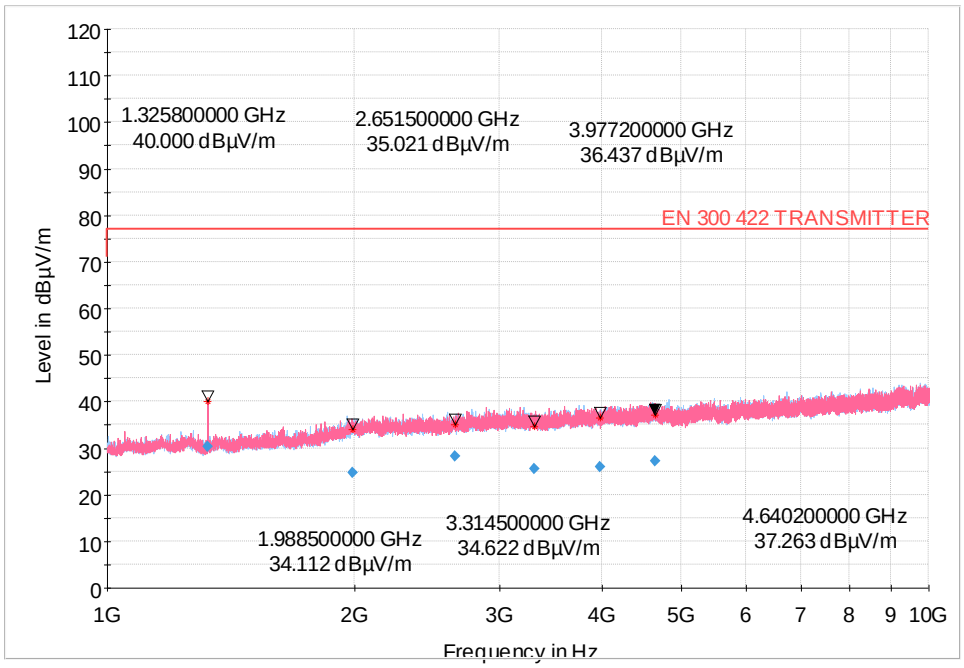
Hardware Setup: EMI radiated\Electric Field Strength 3117-PA 200363 2017 10 17 - [EMI radiated]

Subrange 1

Frequency Range:	1 GHz - 18 GHz
Receiver:	ESR 26 [ESR 26] @ GPIB0 (ADR 20), SN 1316.3003K26/101347, FW 3.36 SP2, CAL 5/28/2016
Signal Path:	Receiver-EMI to 18 GHz FW 1.0 Correction Table: Receiver-EMI Antenna TEMP 2016 11 23
Antenna:	EMI3117-PA 200385 SN 200385, CAL 10/16/2018 Correction Table (vertical): Horn ETS 3117-PA 200363 2017 10 16 Correction Table (horizontal): Horn ETS 3117-PA 200363 2017 10 16 Correction Table (vertical): L23_041_47 Cable Correction Table (horizontal): L23_041_47 Cable
Antenna Tower:	Tower [EMCO 2090 Antenna Tower] @ GPIB0 (ADR 8), FW REV 3.21
Turntable:	Turntable [EMCO Turntable] @ GPIB0 (ADR 9), SN 29799, FW REV 3.21

Appendix A

Full Spectrum



Critical Frequencies

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment	Corr. (dB)
1325.800000	40.00	77.00	37.00	---	---	275.0	V	256.0	---	12:47:19 PM - 2/16/2018	---
1988.500000	34.11	77.00	42.89	---	---	217.0	V	334.0	---	12:46:01 PM - 2/16/2018	---
2651.500000	35.02	77.00	41.98	---	---	341.0	V	16.0	---	12:48:42 PM - 2/16/2018	---
3314.500000	34.62	77.00	42.38	---	---	380.0	V	333.0	---	12:50:53 PM - 2/16/2018	---
3977.200000	36.44	77.00	40.56	---	---	390.0	V	202.0	---	12:49:51 PM - 2/16/2018	---
4640.200000	37.26	77.00	39.74	---	---	232.0	H	89.0	---	12:44:32 PM - 2/16/2018	---

Final Frequencies

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment	Corr. (dB)
1325.800000	30.24	77.00	46.76	1000.0	1000.000	275.0	V	256.0	-16.2	12:47:24 PM - 2/16/2018	---
1988.500000	24.69	77.00	52.31	1000.0	1000.000	217.0	V	334.0	-13.1	12:46:09 PM - 2/16/2018	---
2651.500000	28.13	77.00	48.87	1000.0	1000.000	341.0	V	16.0	-11.9	12:48:52 PM - 2/16/2018	---
3314.500000	25.49	77.00	51.51	1000.0	1000.000	380.0	V	333.0	-11.0	12:51:01 PM - 2/16/2018	---
3977.200000	25.93	77.00	51.07	1000.0	1000.000	390.0	V	202.0	-8.8	12:49:59 PM - 2/16/2018	---
4640.200000	27.10	77.00	49.90	1000.0	1000.000	232.0	H	89.0	-7.1	12:44:42 PM - 2/16/2018	---

Appendix A

Date: February 27, 2018
EUT: ULXD1
Band: L50A
Serial Number: # 1
Specification: EN 300 422-1, Spurious Radiated Emissions
Comments: Test Distance is 3 meters
Mode: EUT set to Low 657.125 MHz
Tested By: Alex Mishinger, February 26 & 27, 2018

Frequency in MHz	Detector Used	Antenna Polarity	Measured Level in dBuV	Matched Sig. Gen. Reading in dBm	Antenna Gain in dB	Cable Loss in dB	ERP Total in dBm	ETSI Limit in dBm
1314.250	Average	H	30.78	-71.0	4.0	4.35	-71.4	-30
1314.250	Average	V	30.78	-71.0	4.0	4.35	-71.4	-30
1971.375	Average	H	25.15	-73.0	5.0	3.66	-71.7	-30
1971.375	Average	V	25.15	-73.0	5.0	3.66	-71.7	-30
2628.500	Average	H	29.45	-70.0	6.4	4.41	-68.0	-30
2628.500	Average	V	29.45	-70.0	6.4	4.41	-68.0	-30
3285.625	Average	H	25.58	-73.0	7.6	4.66	-70.1	-30
3285.625	Average	V	25.58	-73.0	7.6	4.66	-70.1	-30
3942.750	Average	H	26.40	-71.0	8.9	5.08	-67.2	-30
3942.750	Average	V	26.40	-71.0	8.9	5.08	-67.2	-30
4599.875	Average	H	26.71	-71.0	9.4	5.66	-67.3	-30
4599.875	Average	V	26.71	-71.0	9.4	5.66	-67.3	-30

Total (dBm) = Matched Signal. Generator Reading (dBm) + Antenna Gain (dB) – Cable Loss (dB)

Appendix A

Date: February 27, 2018
EUT: ULXD1
Band: L50A
Serial Number: # 1
Specification: EN 300 422-1, Spurious Radiated Emissions
Comments: Test Distance is 3 meters
Mode: EUT set to High 662.875 MHz
Tested By: Alex Mishinger, February 26 & 27, 2018

Frequency in MHz	Detector Used	Antenna Polarity	Measured Level in dBuV	Matched Sig. Gen. Reading in dBm	Antenna Gain in dB	Cable Loss in dB	ERP Total in dBm	ETSI Limit in dBm
1325.750	Average	H	30.24	-71.0	4.0	3.49	-70.5	-30
1325.750	Average	V	30.24	-71.0	4.0	3.49	-70.5	-30
1988.625	Average	H	24.69	-73.0	5.0	3.66	-71.7	-30
1988.625	Average	V	24.69	-73.0	5.0	3.66	-71.7	-30
2651.500	Average	H	28.13	-72.0	6.4	4.37	-70.0	-30
2651.500	Average	V	28.13	-72.0	6.4	4.37	-70.0	-30
3314.375	Average	H	25.49	-73.0	7.8	4.48	-69.7	-30
3314.375	Average	V	25.49	-73.0	7.8	4.48	-69.7	-30
3977.250	Average	H	25.93	-73.0	8.9	4.96	-69.1	-30
3977.250	Average	V	25.93	-73.0	8.9	4.96	-69.1	-30
4640.125	Average	H	27.10	-72.0	9.4	5.72	-68.3	-30
4640.125	Average	V	27.10	-72.0	9.4	5.72	-68.3	-30

Total (dBm) = Matched Signal. Generator Reading (dBm) + Antenna Gain (dB) – Cable Loss (dB)

Appendix B

B. Maximum Radiated Power

Purpose:
This test performed to determine if the EUT meets the Maximum Radiated Power requirements of the FCC Part15C, Section 15.236.

Requirements:
As stated in FCC 15C Section 15.236 (6)(2), the maximum radiated power in the 600MHz guard band and the 600MHz duplex gap: 20mW EIRP.

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)	1.24dB

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 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 conducted with the EUT set to the low and high frequency within the operating frequency range, and at 20mW RF output.

Specific Test Procedures:

The output of the EUT was connected to a spectrum analyzer through 20dB of attenuation. The EUT was set to transmit on the low and high frequencies. The channel power was measured.

The spectrum analyzer was set to:

RBW 10kHz
VBW 100kHz
Channel BW 200kHz
Span 1MHz
Detector Average
State Average

Results:

The EIRP for the low and high frequency meets the FCC15C 15.236 requirements.

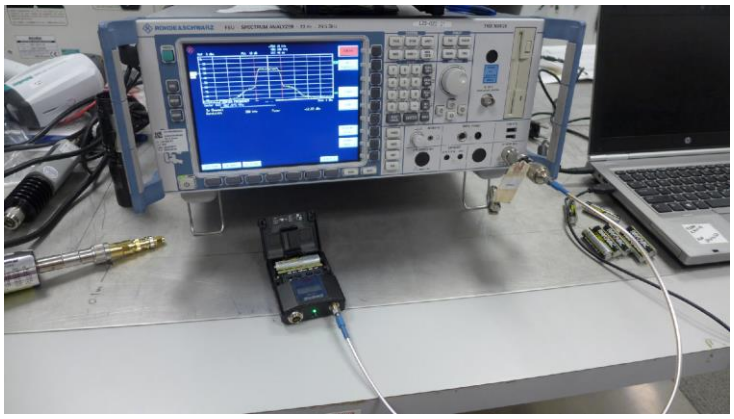


Figure 1: Test setup for Maximum Radiated Output

Appendix B

Test Information

EUT Name:	ULXD1 L50A
Serial Number:	# 1
Test Description:	Maximum Rated Output
Operating Conditions:	Low Frequency, 657.125MHz, 20mW
Operator Name:	Craig Kozokar
Comment:	FCC Part15C, Section 15.236
Date Tested:	Tested on March 8, 2018

Measurement in dBm	Measured Antenna Gain in dBi	Cable Loss in dB	EIRP in dBm	EIRP Limit in dBm	Margin In dB
+11.13	1.30	0.40	12.83	13.00	0.17

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

Measured QLXD1 L50A antenna gain is 1.30dBi

Test Information

EUT Name:	ULXD1 L50A
Serial Number:	# 1
Test Description:	Maximum Rated Output
Operating Conditions:	High Frequency, 662.875MHz, 20mW
Operator Name:	Craig Kozokar
Comment:	FCC Part15C, Section 15.236
Date Tested:	Tested on March 8, 2018

Spectrum Analyzer Measurement in dBm	Measured Antenna Gain in dBi	Cable Loss in dB	EIRP in dBm	EIRP Limit in dBm	Margin In dB
+11.03	1.30	0.40	12.73	13.00	0.27

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

Measured QLXD1 L50A antenna gain is 1.30dBi

Appendix C

NECESSARY BANDWIDTH MEASUREMENTS

B.1 PURPOSE

This test was performed to determine if the EUT meets the necessary bandwidth requirements of EN 300 422-1, section 8.3.3., with the EUT operating at 657.125MHz and 662.875MHz.

B.2 REQUIREMENTS

As stated in EN 300 422-1, section 8.3.3, the emission mask given in section 8.3.3.2 shall not be exceeded.

B.3 TEST SETUP AND INSTRUMENTATION

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

B.4 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}
Occupied 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.

B.5 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 657.125 and 662.875 MHz, at an output power level of 20mW. The transmitter was modulated per EN300422-1 V1.4.2 (2011-08), clause 7.1.2.

B.6 TEST PROCEDURE

The test procedure followed is shown in EN300422-1 V1.4.2 (2011-08), section 8.3.3.1.

Appendix C

B.7 RESULTS

The necessary bandwidth data is presented on pages 31 and 36. Data is shown on the figures for each transmitter. The figure shows the maximum relative level within the emission mask with modulation. As shown by the test data, the necessary bandwidth of the EUT meets the requirements of EN 300 422-1, section 8.3.3.

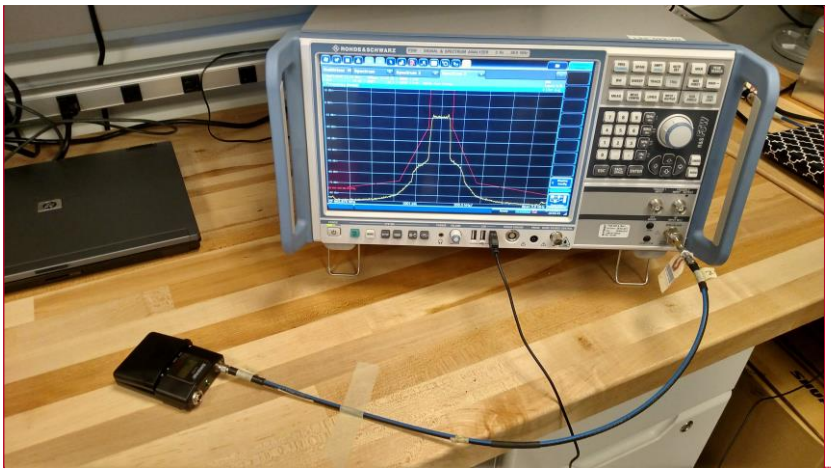


Figure B-1 - Test Setup for Necessary Bandwidth

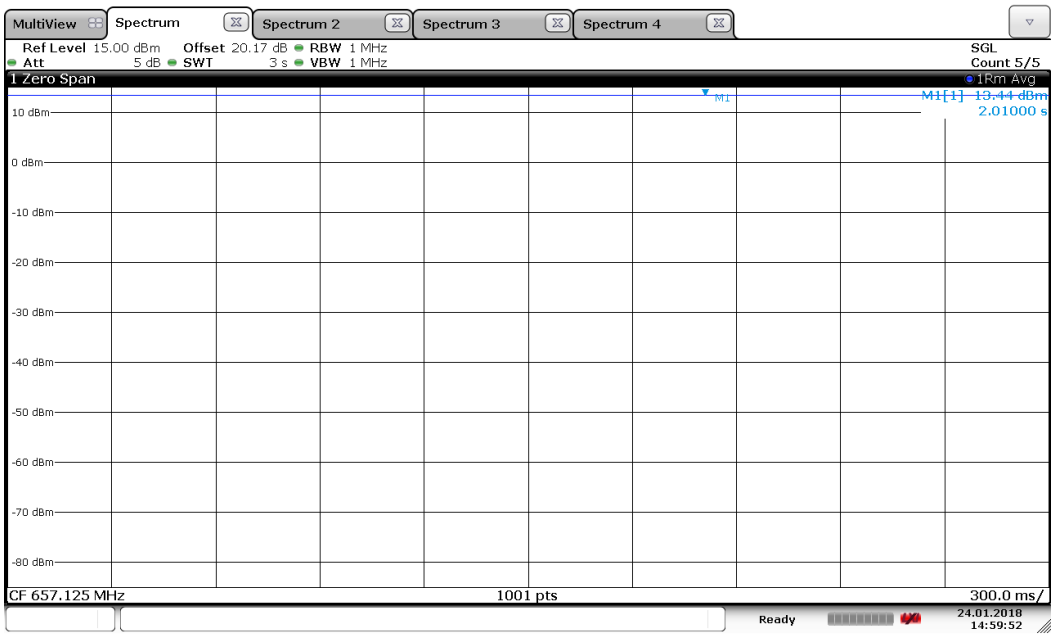
Commented [KC1]:

Commented [KC2R1]:

Appendix C

Test Information

EUT Name:	ULXD1 L50A
Serial Number:	# 1
Test Description:	EN 300 422 Digital Necessary Bandwidth
Operating Conditions:	Low Frequency, 657.125MHz, 20mW
Operator Name:	Juan Castrejon
Comment:	8.3.3.1: Step 1; Carrier Power
Date Tested:	Tested on January 24, 2018

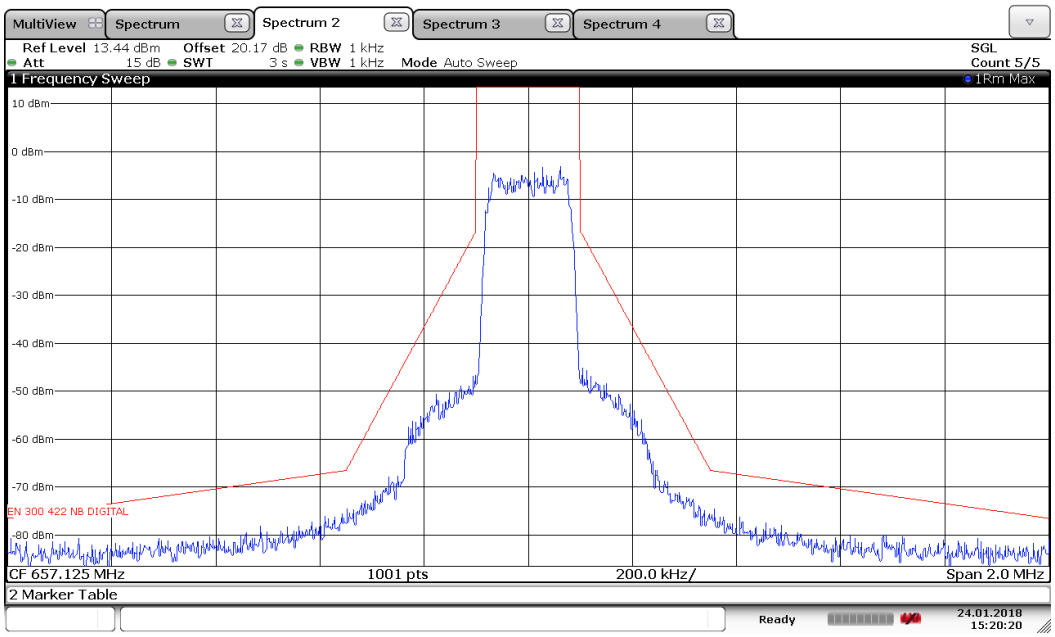


14:59:52 24.01.2018

Appendix C

Test Information

EUT Name:	ULXD1 L50A
Serial Number:	# 1
Test Description:	EN 300 422 Digital Necessary Bandwidth
Operating Conditions:	Low Frequency, 657.125MHz, 20mW
Operator Name:	Juan Castrejon
Comment:	8.3.3.1: Step 2;Maximum Relative Level
Date Tested:	Test on January 24, 2018

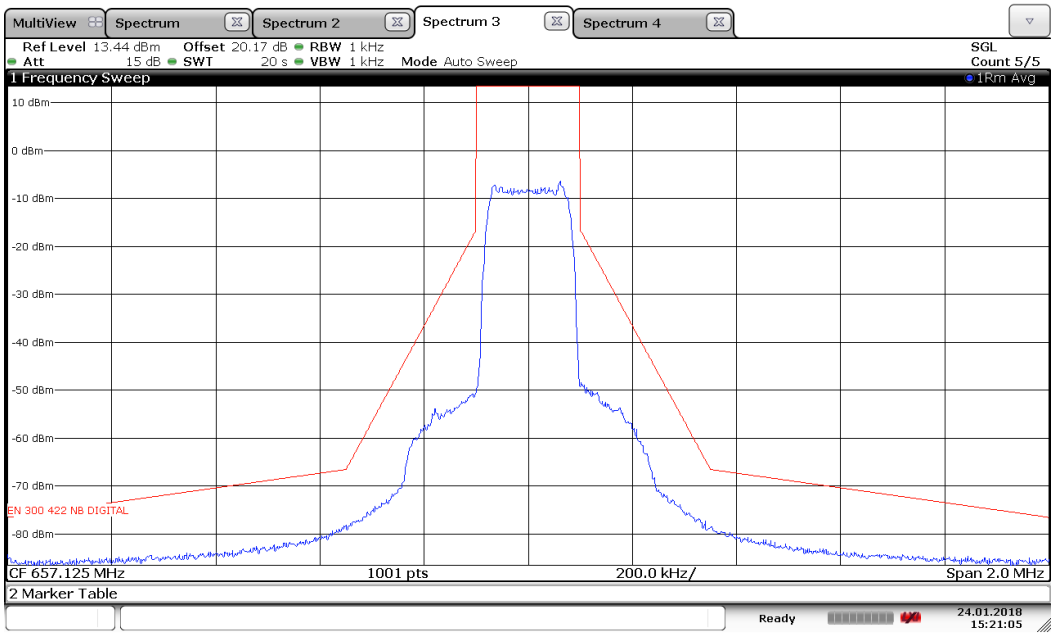


15:20:21 24.01.2018

Appendix C

Test Information

EUT Name:	ULXD1 L50A
Serial Number:	# 1
Test Description:	EN 300 422 Digital Necessary Bandwidth
Operating Conditions:	Low Frequency, 657.125MHz, 20mW
Operator Name:	Juan Castrejon
Comment:	8.3.3.1: Step 3;Lower and upper frequency transmitter Wide band noise floor
Date Tested:	Test on January 24, 2018

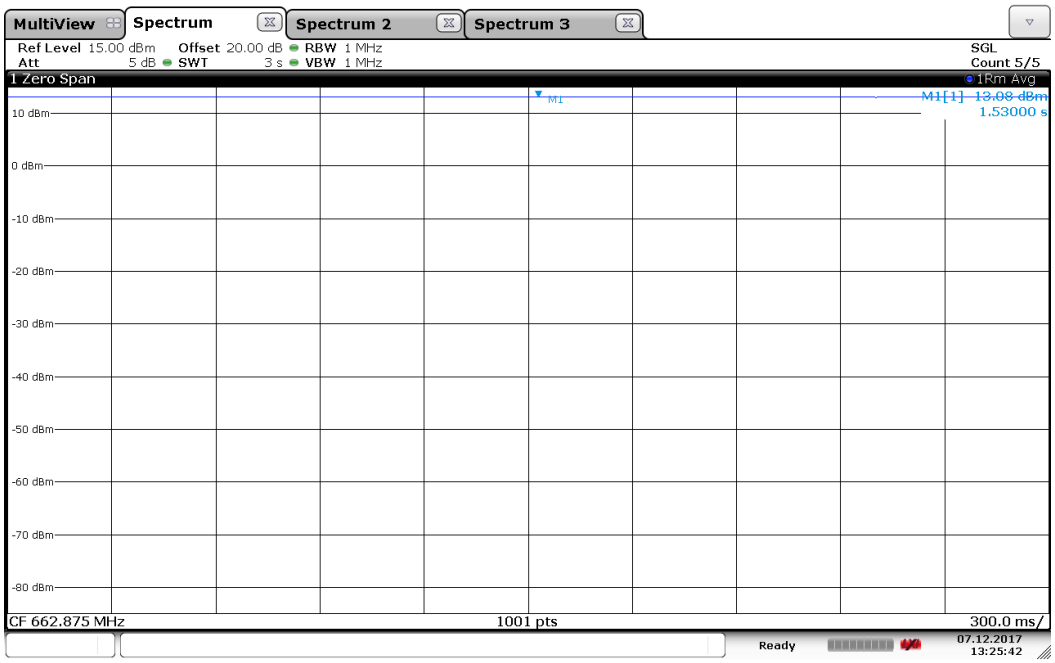


15:21:06 24.01.2018

Appendix C

Test Information

EUT Name:	ULXD1 L50A
Serial Number:	# 1
Test Description:	EN 300 422 Digital Necessary Bandwidth
Operating Conditions:	High Frequency, 662.875MHz, 20mW
Operator Name:	Danny Palaniswami
Comment:	8.3.3.1: Step 1; Carrier Power
Date Tested:	Tested on July 12, 2017

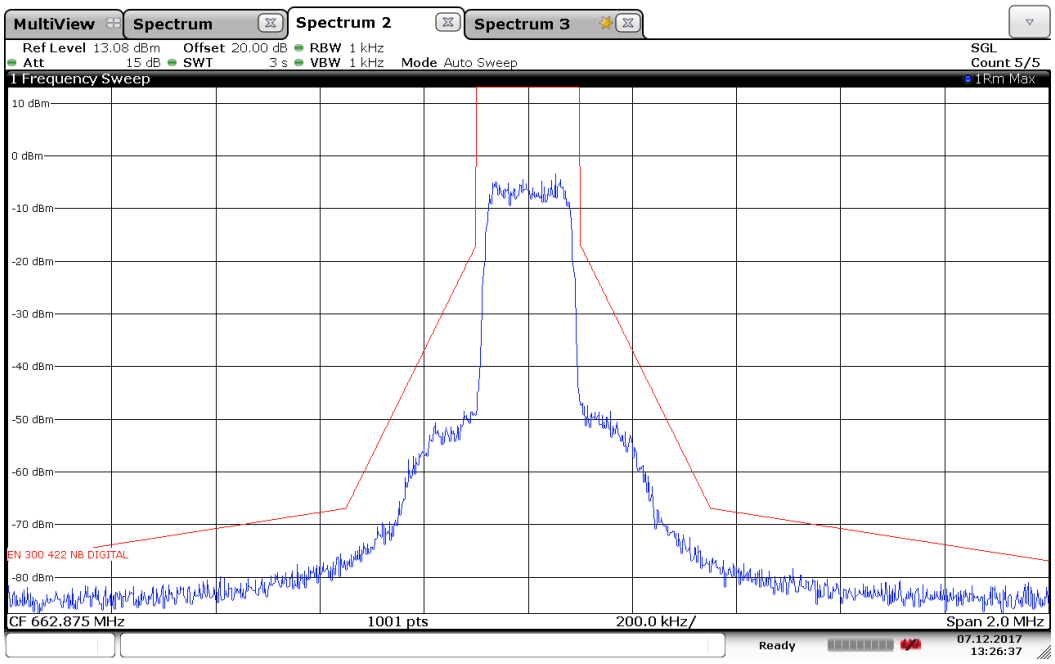


13:25:43 07.12.2017

Appendix C

Test Information

EUT Name:	ULXD1 L50A
Serial Number:	# 1
Test Description:	EN 300 422 Digital Necessary Bandwidth
Operating Conditions:	High Frequency, 662.875MHz, 20mW
Operator Name:	Danny Palaniswami
Comment:	8.3.3.1: Step 2;Maximum Relative Level
Date Tested:	Test on July 12, 2017

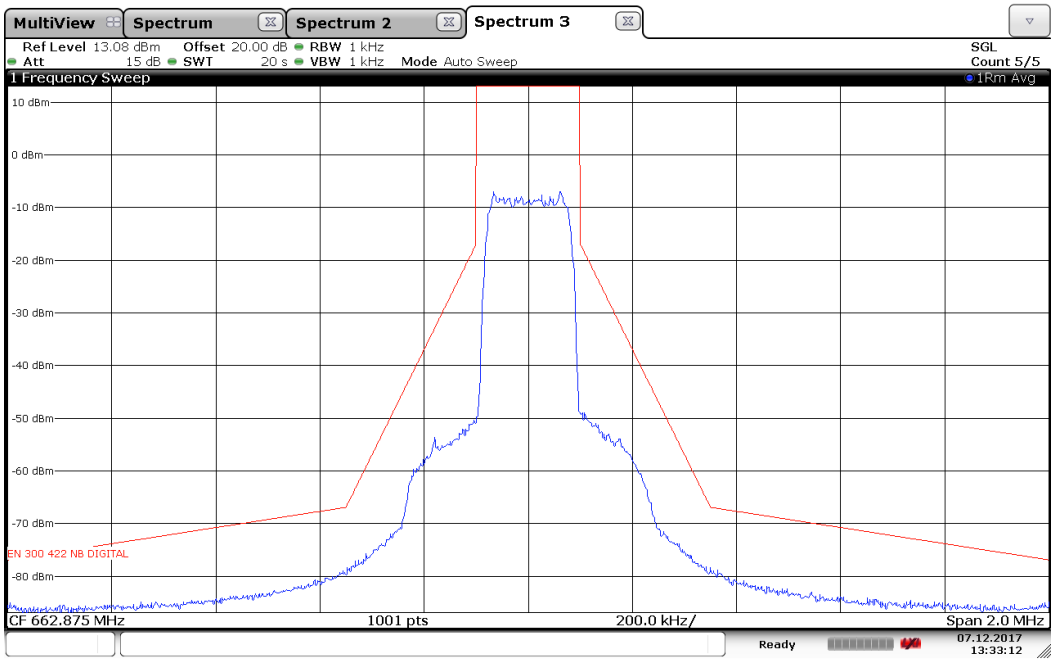


13:26:38 07.12.2017

Appendix C

Test Information

EUT Name:	ULXD1 L50A
Serial Number:	# 1
Test Description:	EN 300 422 Digital Necessary Bandwidth
Operating Conditions:	High Frequency, 662.875MHz, 20mW
Operator Name:	Danny Palaniswami
Comment:	8.3.3.1: Step 3;Lower and upper frequency transmitter Wide band noise floor
Date Tested:	Test on July 12, 2017



13:33:12 07.12.2017