



SHURE

ELECTROMAGNETIC COMPATIBILITY LABORATORY

TEST REPORT

TEST REPORT TITLE: Electromagnetic Compatibility Tests of the Shure ULXD2 L50A Digital Wireless Transmitter in the 657MHz to 663MHz Band

TEST ITEM DESCRIPTION:

The Shure ULXD2 is a digital wireless microphone transmitter, microprocessor controlled transmitter.

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

Project ID Number: SEL-030/ULXD2 L50A

Date Tested: July 12, 2017, November 22, 2017, January 24, 2018, February 14, 15, 26, 27, 2018, March 8, 2018

Test Personnel: Alex Mishinger, Danny Palaniswami, Juan Castrejon, Brad McCain and Craig Kozokar

Test Specification: FCC Part 15C, Section 15.236g
RSS 210 Issue 9, Annex G: Radio Apparatus Operating in the Television Bands

TEST REPORT BY:	<u>Craig Kozokar</u>	<u>Global Compliance Engineer</u>	<u>May 1, 2018</u>
APPROVED BY:	<u>Thomas E. Beaudin</u>	<u>GC Project Engineer</u>	<u>May 1, 2018</u>
	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	November 14, 2018	Updated to include RSS 210 certification information

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)
ULXD2	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 and RSS 210 Issue 9, Annex G: Radio Apparatus Operating in the Television Bands.

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 RSS 210	Radiated Spurious Emissions	30 MHz to 10 GHz	A	Pass
FCC Part 15C RSS 210	Maximum Radiated Power	657.125MHz 662.875MHz	B	Pass
FCC Part 15C RSS 210	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

RSS 210 Issue 9, Annex G: Radio Apparatus Operating in the Television Bands

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 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 L50A Digital Wireless Transmitter Sample

ULXD2 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 and RSS 210 Issue 9, Annex G for Radiated RF Spurious Emissions, Maximum Radiated Output, and Necessary Bandwidth.

8. Conclusions:

It was determined that the Shure ULXD2 L50A Digital Wireless Microphone Transmitter did fully comply with the requirements of FCC Part 15C, Section 236g and RSS 210 Issue 9, Annex G, 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 and RSS 210 Issue 9, Annex G 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 and in RSS 210 Issue 9, Annex G, 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:

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:

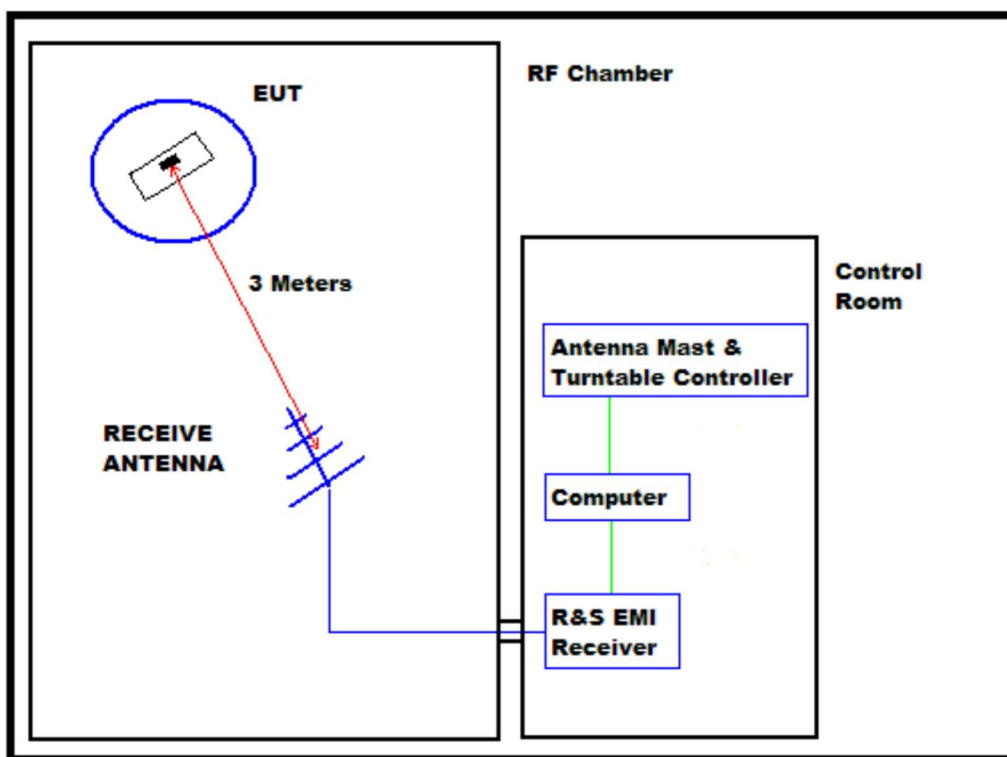
The EUT was powered up and the frequency of the transmitter was selected using the front panel controls. The EUT was checked for proper operation after it was setup on the table. For radiated spurious emissions the testing was conducted with the EUT set to the low and high frequency within the operating frequency range, and at 20mW RF output.

Appendix A

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.

Appendix A

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.

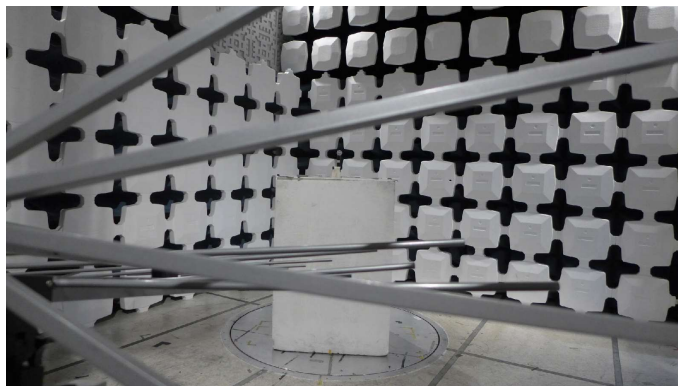


Figure 1: QLXD2 Transmitter Test Setup

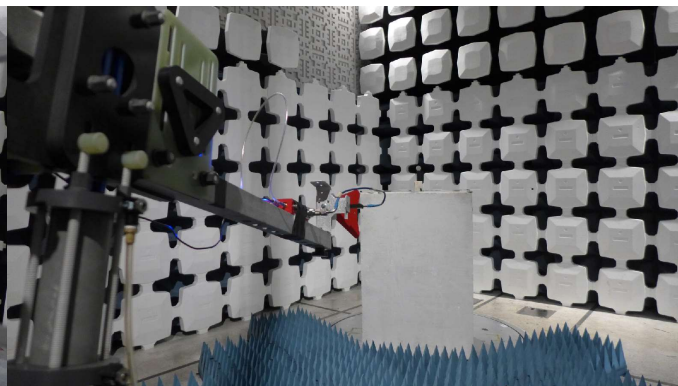


Figure 2: QLXD2 Transmitter Test Setup



SHURE Radiated RF Emissions Test Report

Common Information

Test Description: FCC15C Radiated Emissions 30MHz - 1GHz
EUT: ULXD2 L50A
Serial Number: # 1
Operating Conditions: 657.125MHz, 20mW
Testing data: Tested on January 24, 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 dB μ V/m - 120 dB μ V/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

Subrange	Step Size	Detectors	IF BW	Meas. Time	Preamp
Receiver: [ESR 26]					
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

Appendix A

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

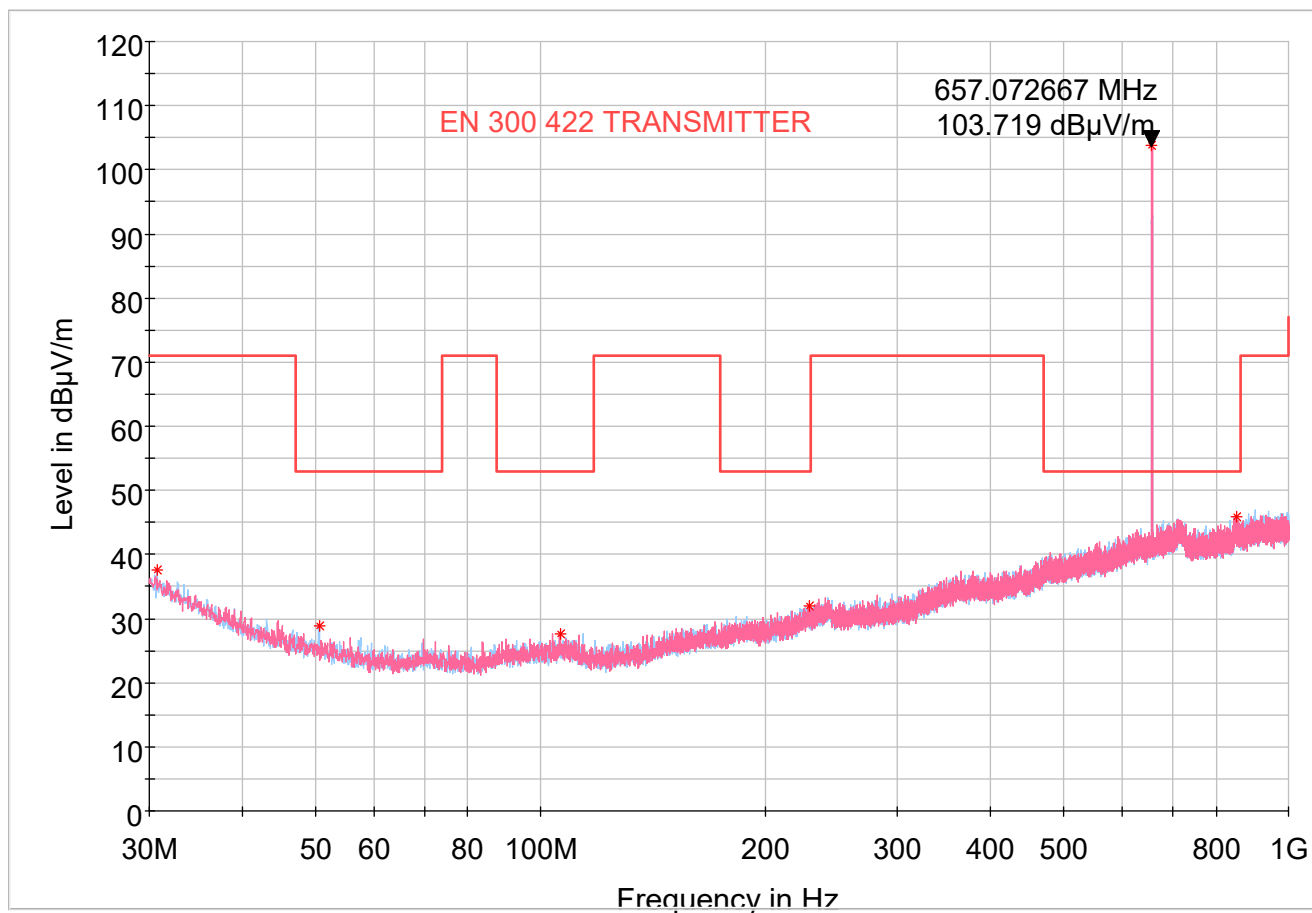
Subrange 1

Frequency Range: 25 MHz - 1 GHz

Receiver: ESR 26 [ESR 26]
@ GPIB0 (ADR 20), SN 1316.3003K26/101347, FW 2.26, CAL
5/28/2016Signal Path: Receiver-EMI to 1 GHz
FW 1.0
Correction Table: Receiver-EMI Antenna 18GHz L23_041_38 8mAntenna: 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 27Antenna Tower: Tower [EMCO 2090 Antenna Tower]
@ GPIB0 (ADR 8), FW REV 3.21Turntable: 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)
30.776000	37.55	71.00	33.45	---	---	100.0	H	0.0	---	5:10:20 PM - 1/24/2018	---
50.596333	28.92	53.00	24.08	---	---	300.0	H	225.0	---	5:10:20 PM - 1/24/2018	---
851.137333	45.81	53.00	7.19	---	---	400.0	H	356.0	---	5:10:20 PM - 1/24/2018	---
106.177333	27.66	53.00	25.34	---	---	100.0	V	232.0	---	5:10:20 PM - 1/24/2018	---
657.072667	103.72	53.00	-50.72	---	---	350.0	V	180.0	---	5:10:20 PM - 1/24/2018	---
229.011667	32.03	53.00	20.97	---	---	350.0	V	308.0	---	5:10:20 PM - 1/24/2018	---

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
---	---	---	---	---	---	---		---	---	



SHURE Radiated RF Emissions Test Report

Common Information

Test Description: FCC15C Radiated Emissions 1GHz - 10GHz
EUT: ULXD2 L50A
Serial Number: # 1
Operating Frequency: 657.125MHz
Power Level / Mod Mode: 20mW
Name: Brad McClain
Comments: Tested on February 14, 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 dB μ V/m - 120 dB μ V/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

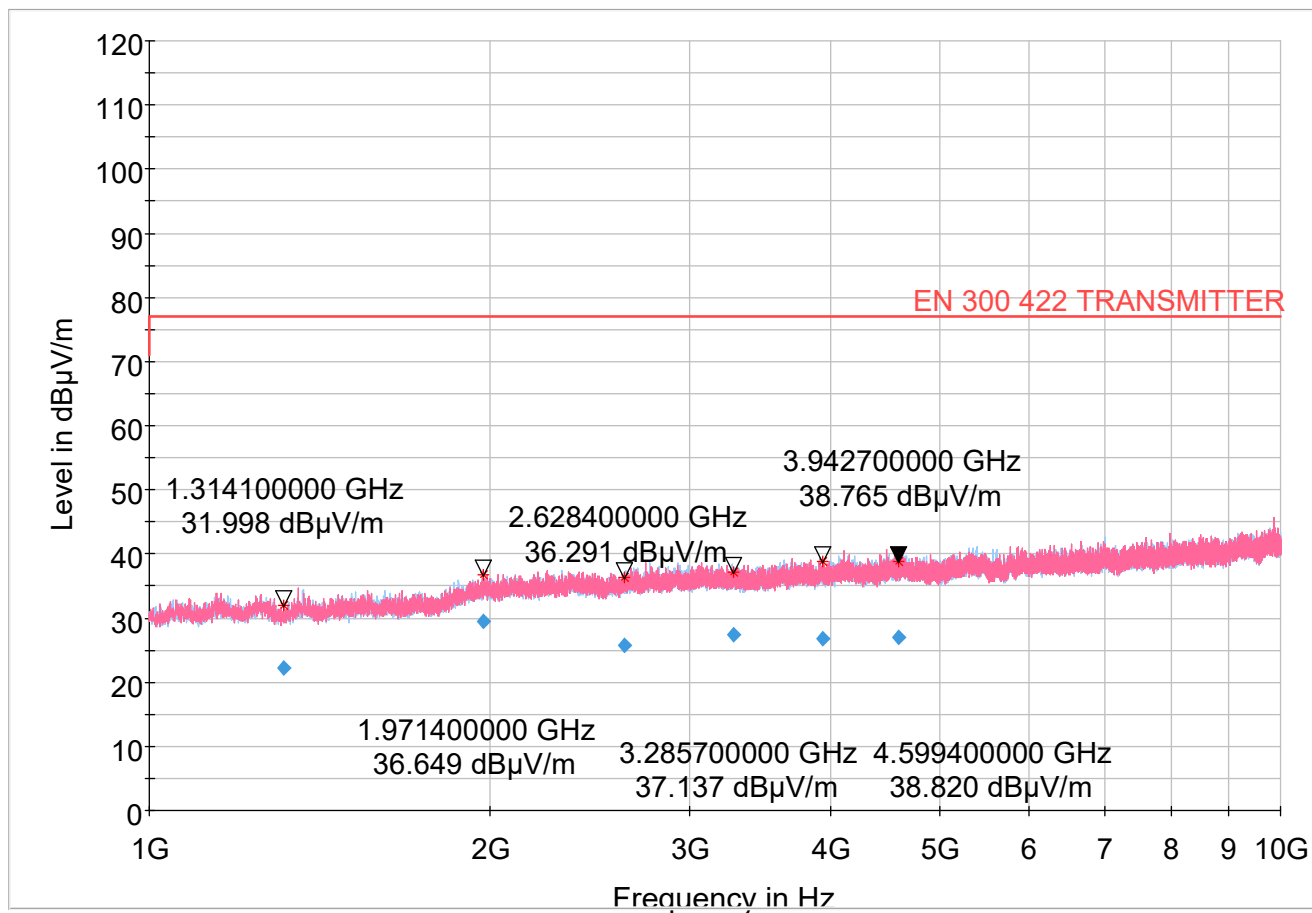
Signal Path: Receiver-EMI to 18 GHz
FW 1.0

Antenna: Correction Table: Receiver-EMI Antenna TEMP 2016 11 23
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)
1314.100000	32.00	77.00	45.00	---	---	379.0	V	248.0	---	4:47:55 PM - 2/14/2018	---
1971.400000	36.65	77.00	40.35	---	---	306.0	V	8.0	---	4:45:28 PM - 2/14/2018	---
2628.400000	36.29	77.00	40.71	---	---	239.0	H	61.0	---	4:41:54 PM - 2/14/2018	---
3285.700000	37.14	77.00	39.86	---	---	249.0	V	42.0	---	4:44:15 PM - 2/14/2018	---
3942.700000	38.76	77.00	38.24	---	---	385.0	H	46.0	---	4:43:00 PM - 2/14/2018	---
4599.400000	38.82	77.00	38.18	---	---	365.0	V	127.0	---	4:46:44 PM - 2/14/2018	---

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)
1314.100000	22.25	77.00	54.75	1000.0	1000.000	379.0	V	248.0	-16.1	4:48:03 PM - 2/14/2018	---
1971.400000	29.56	77.00	47.45	1000.0	1000.000	306.0	V	8.0	-13.3	4:45:36 PM - 2/14/2018	---
2628.400000	25.75	77.00	51.25	1000.0	1000.000	239.0	H	61.0	-12.1	4:42:04 PM - 2/14/2018	---
3285.700000	27.47	77.00	49.53	1000.0	1000.000	249.0	V	42.0	-11.0	4:44:24 PM - 2/14/2018	---
3942.700000	26.70	77.00	50.30	1000.0	1000.000	385.0	H	46.0	-9.0	4:43:08 PM - 2/14/2018	---
4599.400000	27.07	77.00	49.93	1000.0	1000.000	365.0	V	127.0	-7.2	4:46:52 PM - 2/14/2018	---



SHURE Radiated RF Emissions Test Report

Common Information

Test Description: FCC15C Radiated Emissions 30MHz - 1GHz
EUT: ULXD2 L50A
Serial Number: # 1
Operating Conditions: 662.875MHz, 20mW
Testing Data: 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

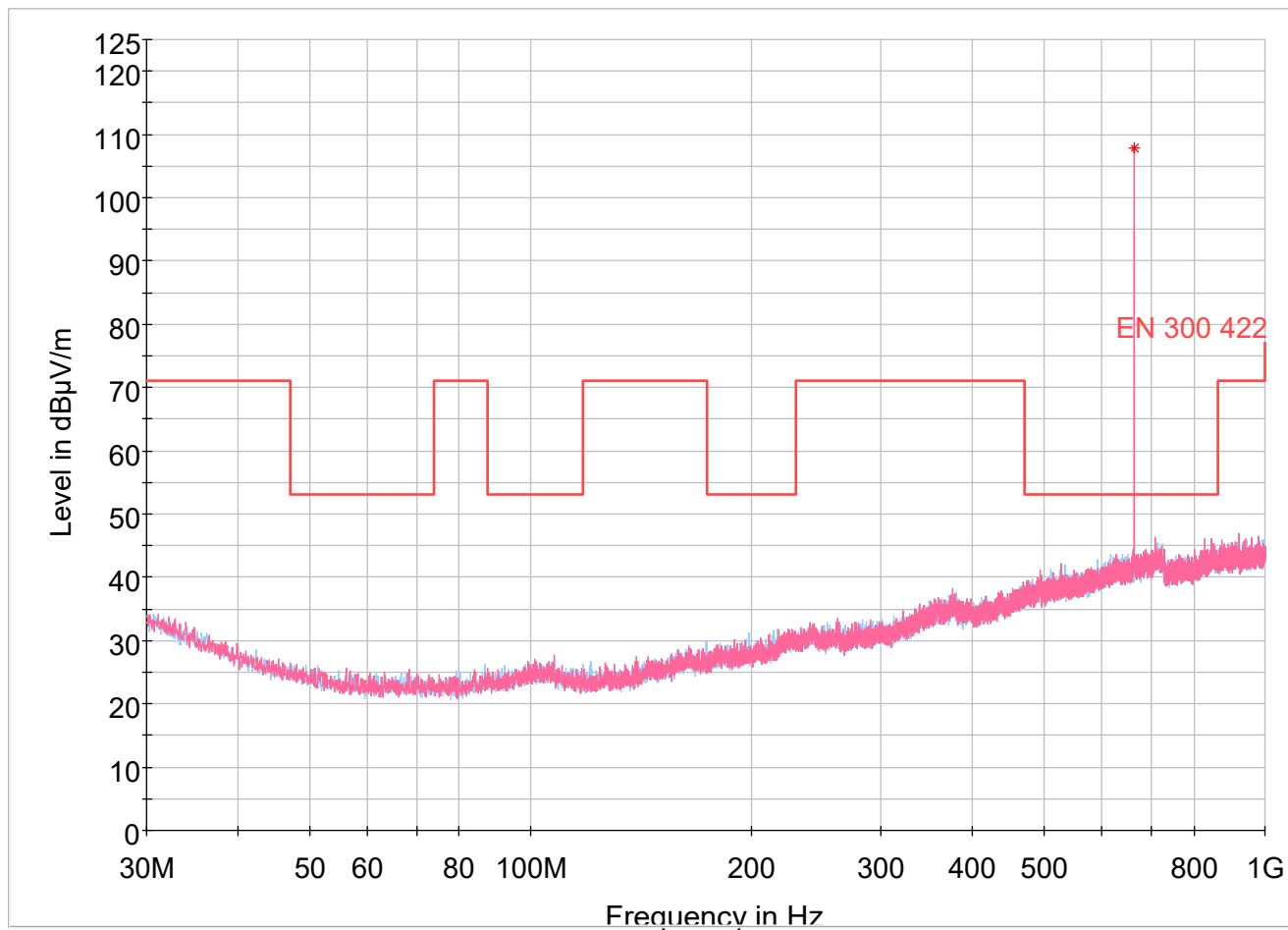
Signal Path: Receiver-EMI to 1 GHz
FW 1.0
Correction Table: Receiver-EMI Antenna 18GHz L23_041_38 8m

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	107.80	53.00	-54.80	---	---	150.0	V	191.0	22.2	12:50:08 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
---	---	---	---	---	---	---		---	---	



SHURE Radiated RF Emissions Test Report

Common Information

Test Description: FCC15C Radiated Emissions 1GHz - 10GHz
EUT: ULXD2 L50A
Serial Number: # 1
Operating Frequency: 662.875MHz
Power Level / Mod Mode: 20mW
Name: Brad McClain
Comments: Tested on February 15, 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 dB μ V/m - 120 dB μ V/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

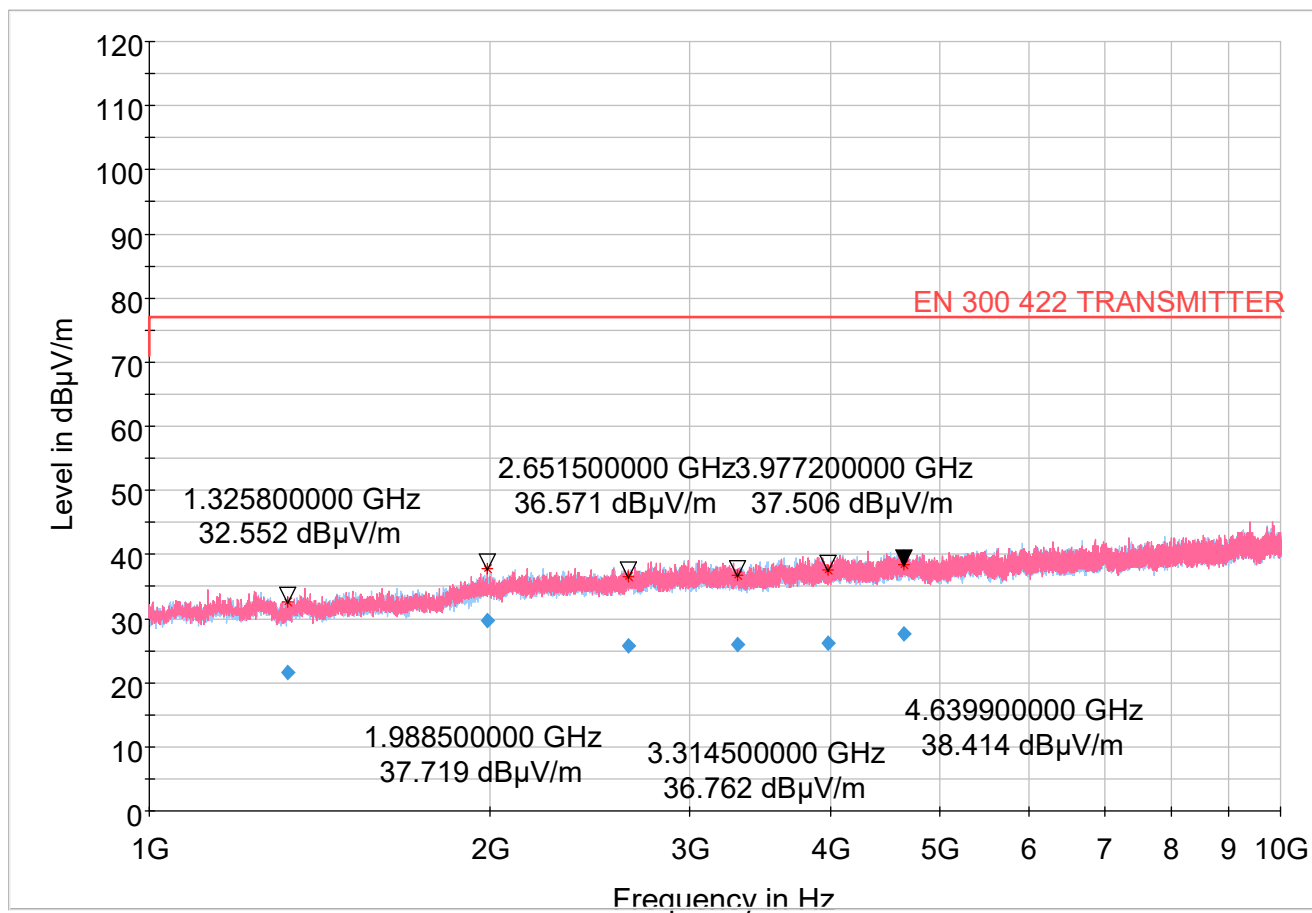
Signal Path: Receiver-EMI to 18 GHz
FW 1.0

Antenna: Correction Table: Receiver-EMI Antenna TEMP 2016 11 23
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)	DET 2 (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
1325.800000	32.55	---	77.00	44.45	---	---	310.0	V	62.0	-16.2	9:29:55 AM - 2/15/2018
1988.500000	37.72	---	77.00	39.28	---	---	297.0	V	10.0	-13.1	9:31:49 AM - 2/15/2018
2651.500000	36.57	---	77.00	40.43	---	---	325.0	V	33.0	-11.9	9:28:53 AM - 2/15/2018
3314.500000	36.76	---	77.00	40.24	---	---	120.0	H	91.0	-11.0	9:24:22 AM - 2/15/2018
3977.200000	37.51	---	77.00	39.49	---	---	332.0	H	206.0	-8.8	9:25:53 AM - 2/15/2018
4639.900000	38.41	---	77.00	38.59	---	---	182.0	V	349.0	-7.1	9:27:13 AM - 2/15/2018

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
1325.800000	21.64	77.00	55.36	1000.0	1000.000	310.0	V	62.0	-16.2	9:30:03 AM - 2/15/2018
1988.500000	29.65	77.00	47.35	1000.0	1000.000	297.0	V	10.0	-13.1	9:31:58 AM - 2/15/2018
2651.500000	25.76	77.00	51.24	1000.0	1000.000	325.0	V	33.0	-11.9	9:28:58 AM - 2/15/2018
3314.500000	25.90	77.00	51.10	1000.0	1000.000	120.0	H	94.0	-11.0	9:24:29 AM - 2/15/2018
3977.200000	26.24	77.00	50.76	1000.0	1000.000	332.0	H	206.0	-8.8	9:26:02 AM - 2/15/2018
4639.900000	27.54	77.00	49.46	1000.0	1000.000	182.0	V	349.0	-7.1	9:27:23 AM - 2/15/2018



Appendix A

Date: February 27, 2018
EUT: ULXD2
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	22.25	-79.0	4.0	4.35	-79.4	-30
1314.250	Average	V	22.25	-79.0	4.0	4.35	-79.4	-30
1971.375	Average	H	29.56	-76.0	5.0	3.66	-74.7	-30
1971.375	Average	V	29.56	-76.0	5.0	3.66	-74.7	-30
2628.500	Average	H	25.75	-78.0	6.4	4.41	-76.0	-30
2628.500	Average	V	25.75	-78.0	6.4	4.41	-76.0	-30
3285.625	Average	H	27.47	-78.0	7.6	4.66	-75.1	-30
3285.625	Average	V	27.47	-78.0	7.6	4.66	-75.1	-30
3942.750	Average	H	26.70	-78.0	8.9	5.08	-74.2	-30
3942.750	Average	V	26.70	-78.0	8.9	5.08	-74.2	-30
4599.875	Average	H	27.07	-78.0	9.4	5.66	-74.3	-30
4599.875	Average	V	27.07	-78.0	9.4	5.66	-74.3	-30

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



Appendix A

Date: February 27, 2018
EUT: ULXD2
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	21.64	-79.0	4.0	3.49	-78.5	-30
1325.750	Average	V	21.64	-79.0	4.0	3.49	-78.5	-30
1988.625	Average	H	29.65	-76.0	5.0	3.66	-74.7	-30
1988.625	Average	V	29.65	-76.0	5.0	3.66	-74.7	-30
2651.500	Average	H	25.76	-78.0	6.4	4.37	-76.0	-30
2651.500	Average	V	25.76	-78.0	6.4	4.37	-76.0	-30
3314.375	Average	H	25.90	-78.0	7.8	4.48	-74.7	-30
3314.375	Average	V	25.90	-78.0	7.8	4.48	-74.7	-30
3977.250	Average	H	26.24	-78.0	8.9	4.96	-74.1	-30
3977.250	Average	V	26.24	-78.0	8.9	4.96	-74.1	-30
4640.125	Average	H	27.54	-76.0	9.4	5.72	-72.3	-30
4640.125	Average	V	27.54	-76.0	9.4	5.72	-72.3	-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 and RSS 210 Issue 9, Annex G.

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.

The RF output power requirements for RSS 210 Issue 9, Annex G are listed in table G1 below.

Table G1 — Specification for Low-Power Radio Apparatus

Frequency Bands (MHz)	Transmit e.i.r.p. (mW)	Authorized Bandwidth (kHz)	Frequency Stability (ppm)
54-72 76-88 174-216	50	200	± 50
470-608 614-698 ^{Note}	250	200	± 50

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 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.



Appendix B

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, middle, and high frequencies in the low band and low and high frequencies in the high band. 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 low and high frequencies meets the FCC15C 15.236 requirements as well as those stated in RSS 210.9 Annex G.

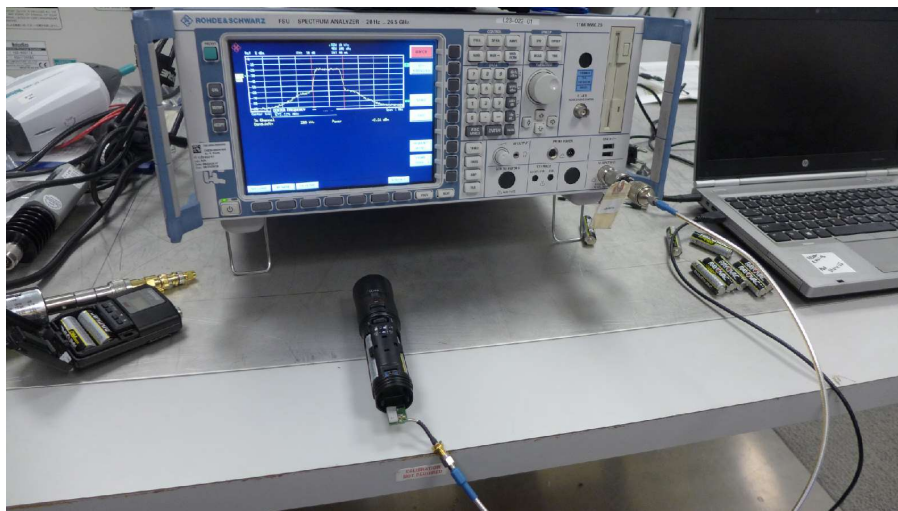


Figure 1: Test setup for Maximum Radiated Output

Appendix B

Test Information

EUT Name: ULXD2 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, RSS 210.9
 Date Tested: Tested on March 8, 2018

Power Meter Measurement in dBm	Measured Antenna Gain in dBi	Cable Loss in dB	EIRP in dBm	EIRP Limit in dBm	Margin In dB
+11.23	-0.60	0.40	11.03	13.00	1.97

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

Measured ULXD2 L50A antenna gain is -0.60dBi

Test Information

EUT Name: ULXD2 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, RSS 210.9
 Date Tested: Tested on March 8, 2018

Power Meter Measurement in dBm	Measured Antenna Gain in dBi	Cable Loss in dB	EIRP in dBm	EIRP Limit in dBm	Margin In dB
+11.13	-0.60	0.40	10.93	13.00	2.07

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

Measured ULXD2 L50A antenna gain is -0.60dBi

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	$\pm 0.130 \%$

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.

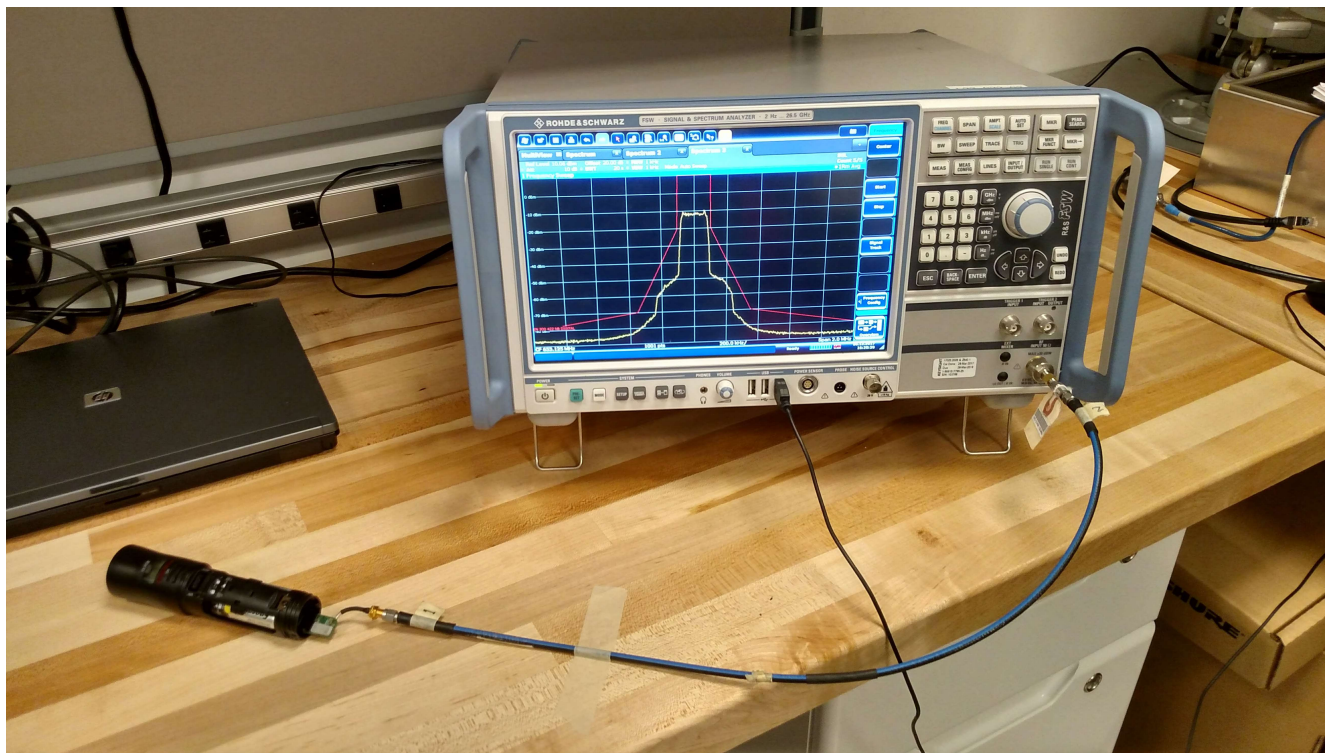


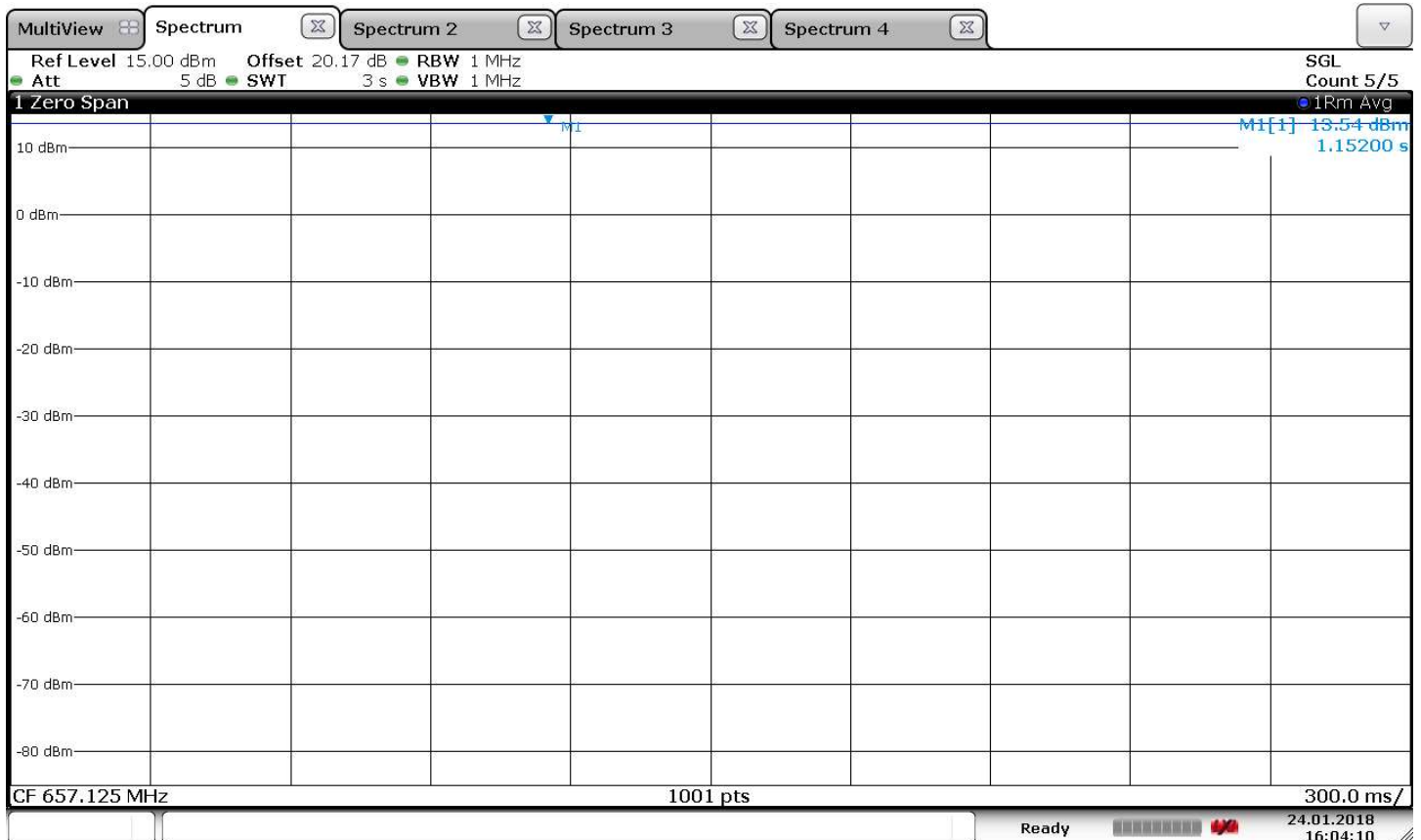
Figure B-1 - Test Setup for Necessary Bandwidth



Appendix C

Test Information

EUT Name: ULXD2 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

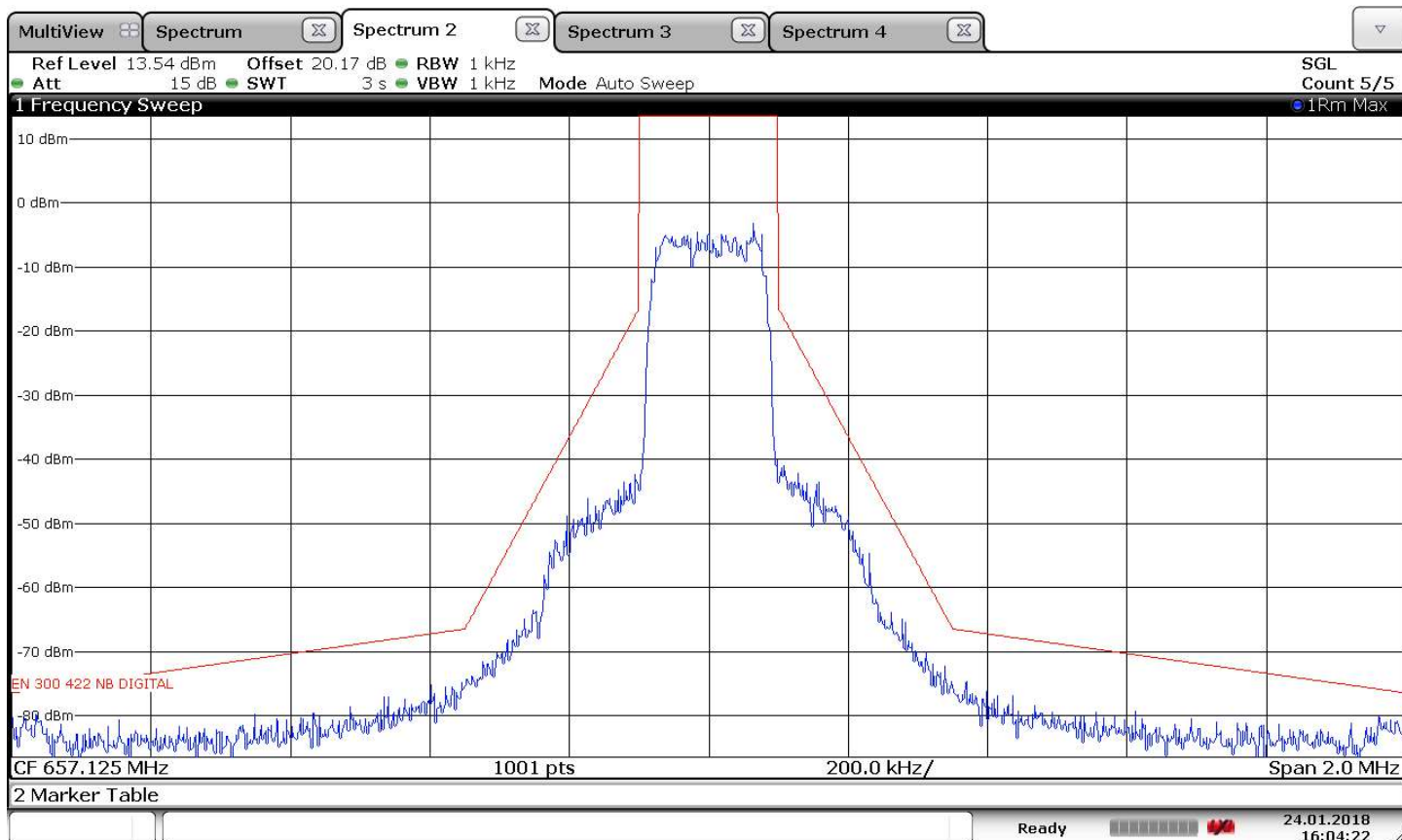


16:04:11 24.01.2018

Appendix C

Test Information

EUT Name:	ULXD2 L50A
Serial Number:	4171860328
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

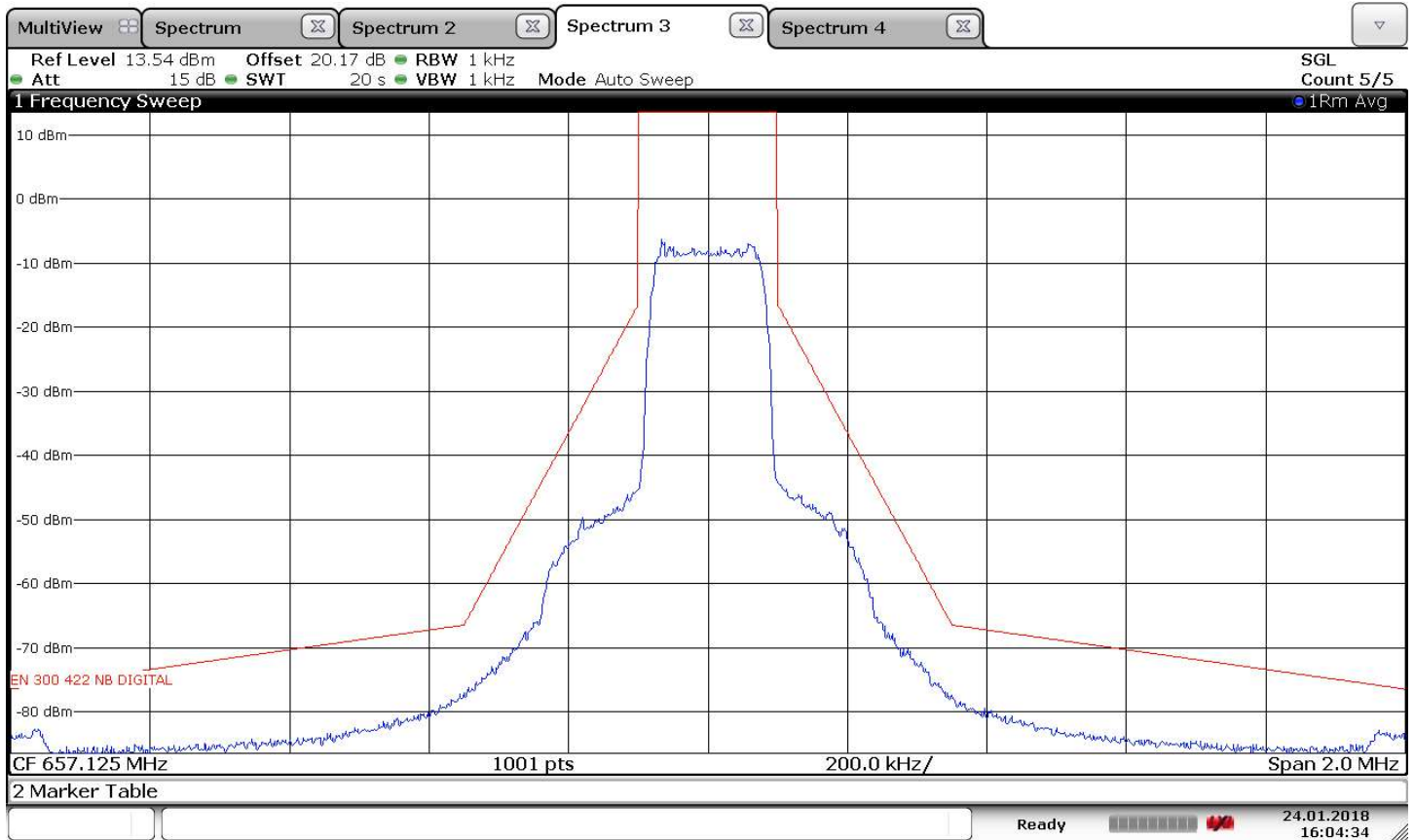


16:04:23 24.01.2018

Appendix C

Test Information

EUT Name: ULXD2 L50A
 Serial Number: 4171860328
 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



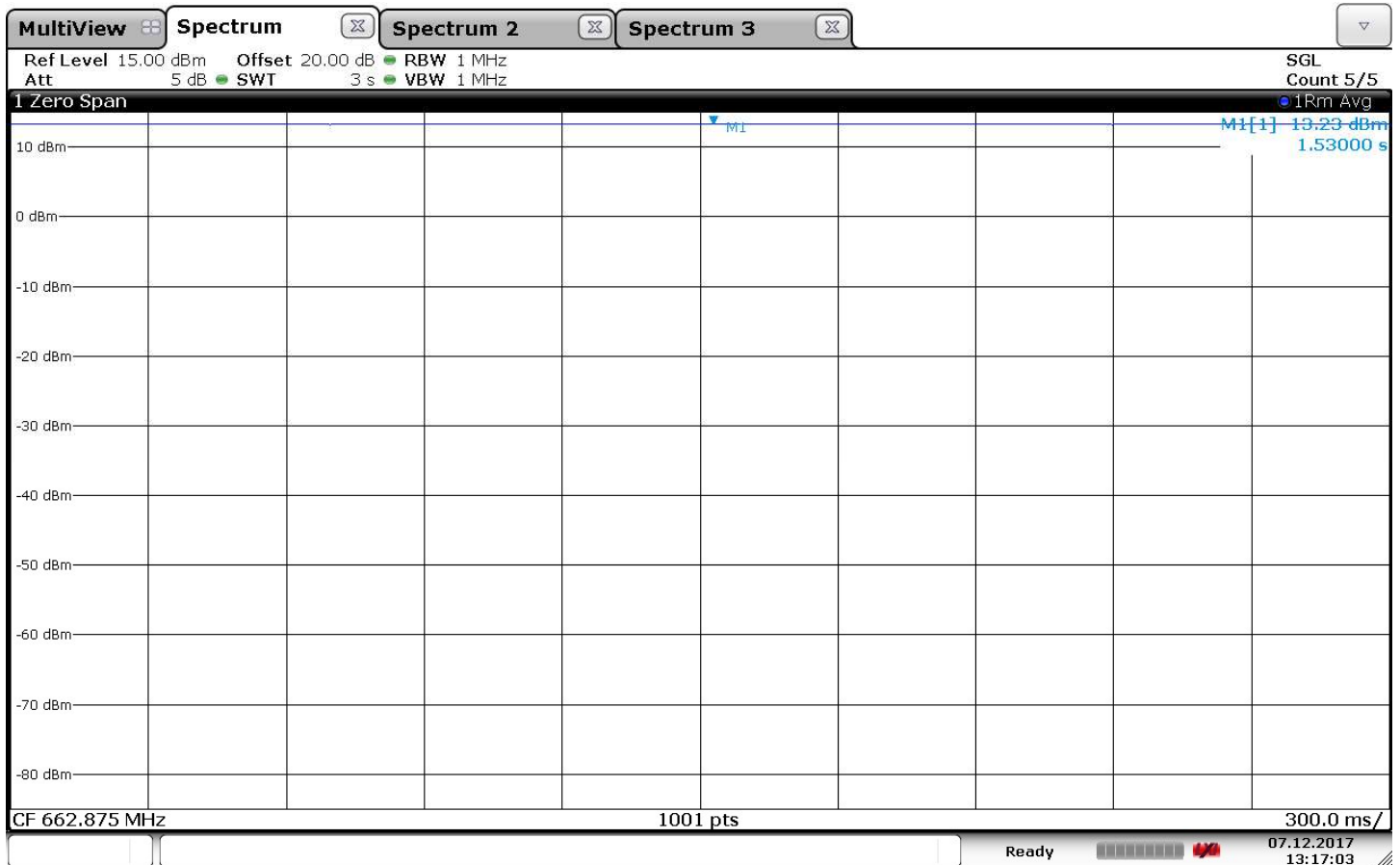
16:04:35 24.01.2018



Appendix C

Test Information

EUT Name: ULXD2 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

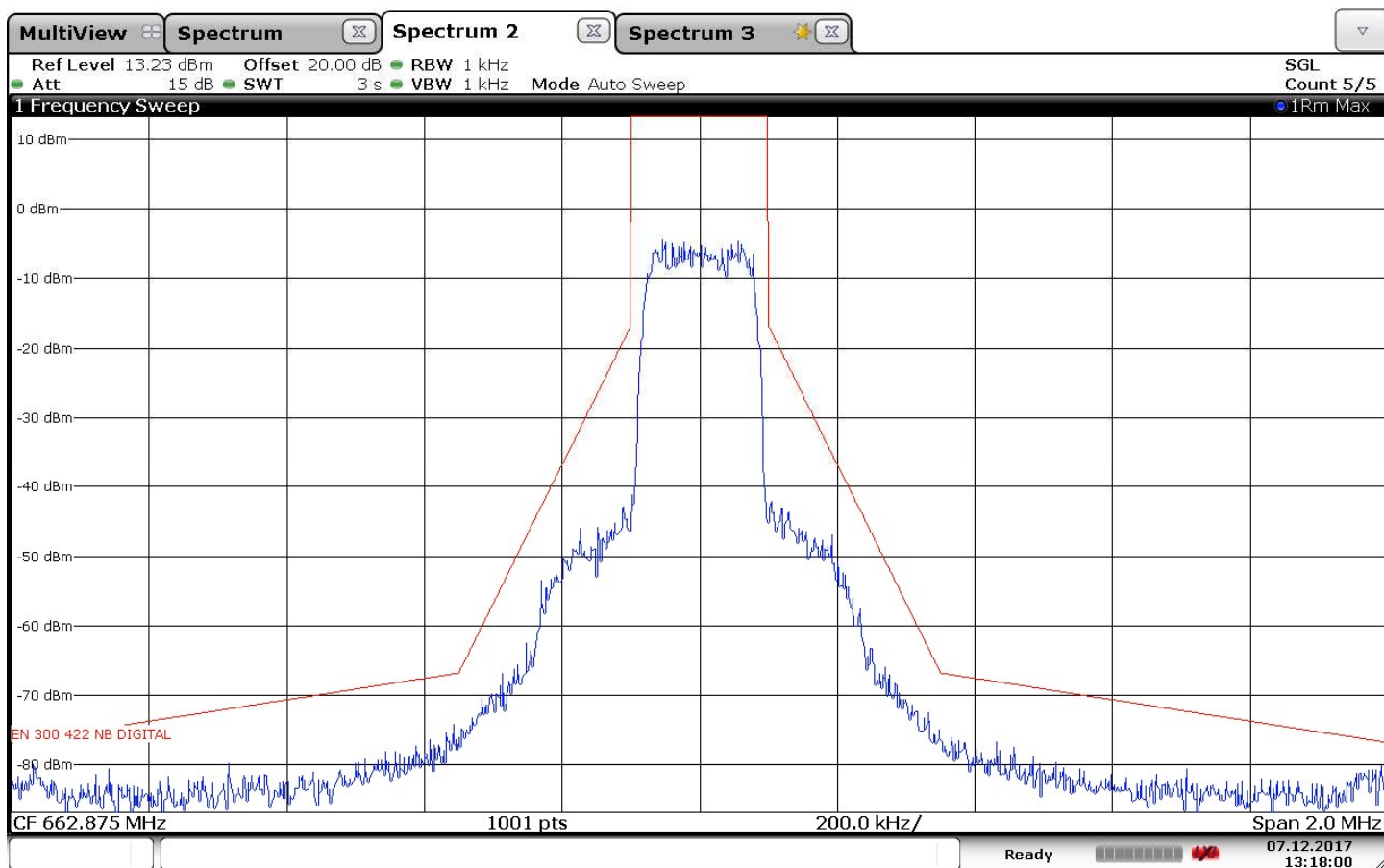


13:17:04 07.12.2017

Appendix C

Test Information

EUT Name:	ULXD2 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

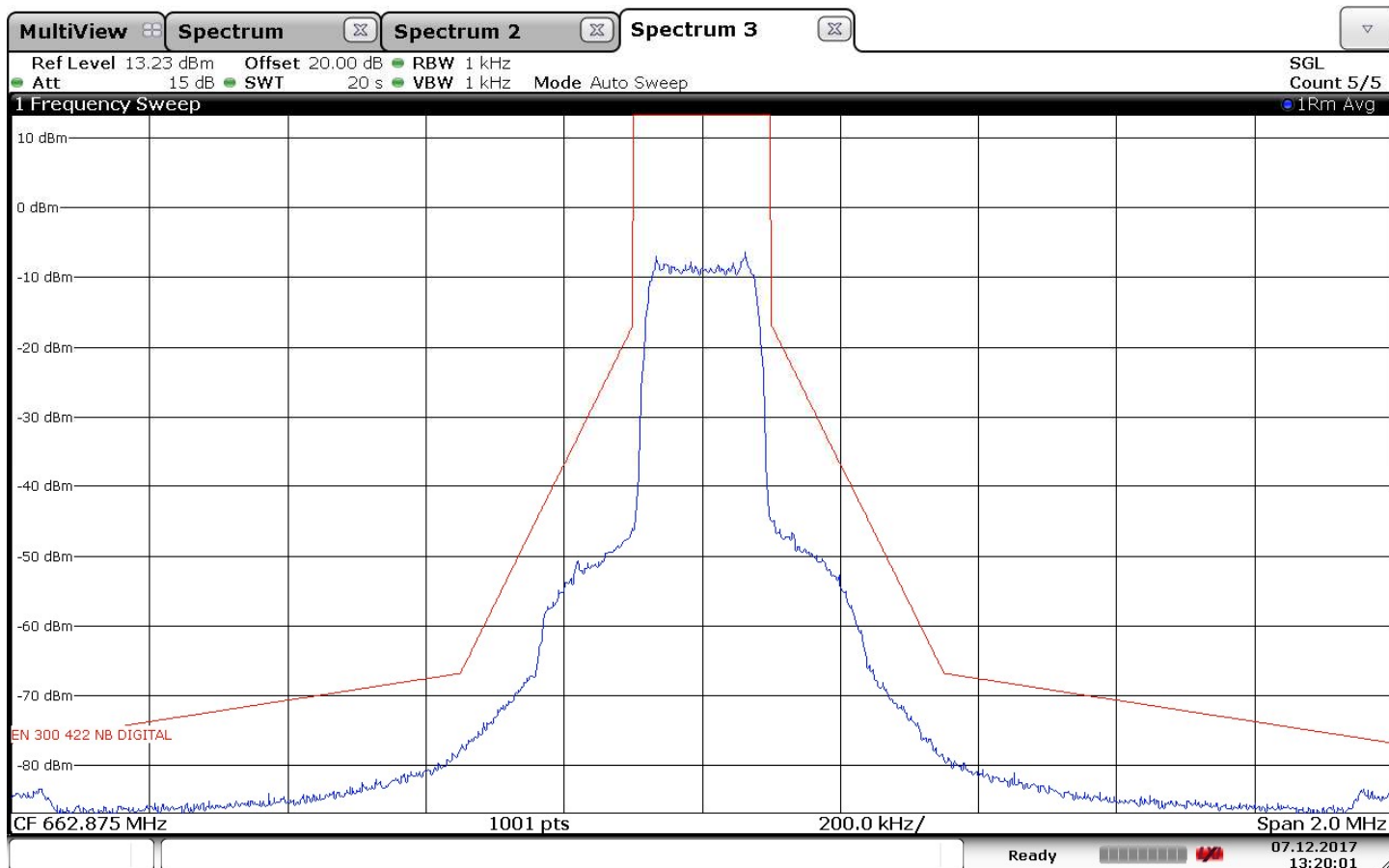


13:18:00 07.12.2017

Appendix C

Test Information

EUT Name: ULXD2 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



13:20:02 07.12.2017