



TEST REPORT

Report Number: R14400105-E1

Applicant : Zoll Mfg Corp
121 Gamma Dr
Pittsburgh, PA 15238-2919

Model : LV 5100 Medical System

Contains FCC ID : W56LV51C1BW0

EUT Description : LifeVest wearable cardioverter defibrillator.

Test Standard(s) : FCC CFR47 Part 2, Part 24, Part 27

Date Of Issue:

2022-11-14

Prepared by:

UL LLC.

12 Laboratory Dr.

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REVISION HISTORY

Rev.	Issue Date	Revisions	Revised By
V1	2022-08-30	Initial Review	Noah Bennett
V2	2022-10-17	Fixed Change in ID FCC ID where applicable	Noah Bennett
V3	2022-11-14	Added Max EIRP Section with new Antenna Gain	Noah Bennett

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1. ATTESTATION OF TEST RESULTS

Applicant Name and Address	ZOLL MFG CORP 121 GAMMA DR PITTSBURGH, PA 15238-2919
Model	LV 5100 Medical System
Contains FCC ID	W56LV51C1BW0
EUT Description	999010131
Serial Number	LifeVest wearable cardioverter defibrillator
Sample Receipt Date	2022-07-08, 2022-08-10
Date Tested	2022-08-23, 2022-08-24, 2022-11-09
Applicable Standards	FCC CFR47 Part 2, Part 24, Part 27
Test Results	See section 2
<p>UL LLC. tested the above equipment in accordance with the requirements set forth in the above standards. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.</p> <p>The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. It is the manufacturer's responsibility to assure that additional production units of this model are manufactured with identical electrical and mechanical components. All samples tested were in good operating condition throughout the entire test program. Measurement Uncertainties are published for informational purposes only and were not taken into account unless noted otherwise.</p> <p>This document may not be altered or revised in any way unless done so by UL LLC. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL LLC. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by A2LA, NIST, or any agency of the U.S. government.</p>	
Approved & Released By:	Prepared By:
	
Dan Coronio Operations Leader UL Verification Services.	Noah Bennett Electrical Engineer UL LLC.

2. SUMMARY OF TEST RESULTS

This report contains data provided by the customer which can impact the validity of results. UL LLC. is only responsible for the validity of results after the integration of the data provided by the customer.

Requirement Description	Band	Requirement Clause Number (FCC)	Result	Remarks
Effective Radiated Power	12	27.50 (c) (10)	Compliant	None.
Equivalent Isotropic Radiated	2	24.232 (c)		
	4	27.50 (d) (4)		

Requirement Description	Requirement Clause Number (FCC)	Result	Remarks
Occupied Bandwidth	2.1049	Not performed	Refer to original module test report of FCC ID: RI7ME910C1WW.
Band Edge and Emission Mask	2.1051, 22.917 (a), 24.238 (a), 27.53 (h), 27.53(g)	Not performed	Refer to original module test report of FCC ID: RI7ME910C1WW.
Out of Band Emissions	2.1051, 22.917 (a), 24.238 (a), 27.53 (h), 27.53(g)	Not performed	Refer to original module test report of FCC ID: RI7ME910C1WW.
Frequency Stability	2.1055, 22.355, 24.235, 27.54	Not performed	Refer to original module test report of FCC ID: RI7ME910C1WW.
Peak-to-Average Ratio	22.913 (d), 24.232 (d), 27.50 (d) (5)	Not performed	Refer to original module test report of FCC ID: RI7ME910C1WW.
Field Strength of Spurious Radiation	2.1053, 22.917 (a), 24.238 (a), 27.53 (h), 27.53(g)	Partially performed and complies	See Note 1.

Note 1: Previously tested. This test report covers the assessment of the original radio module installed in a new host under FCC KDB 996369 D04 Module Integration Guide v02 via Spurious radiated emissions testing and conducted output power testing to verify continued compliance. It is the responsibility of the end product manufacturer to provide the original module reports to show full compliance to the FCC requirements.

3. TEST METHODOLOGY

The tests documented in this report were performed in accordance with the following:

- ANSI C63.26:2015
- FCC CFR 47 Part 2, Part 24, Part 27
- FCC KDB 996369 D04 v02: Module Integration Guide

4. FACILITIES AND ACCREDITATION

UL LLC is accredited by A2LA, certification # 0751.06, for all testing performed within the scope of this report. Testing was performed at the locations noted below.

	Address	ISED CABID	ISED Company Number	FCC Registration
<input type="checkbox"/>	Building: 12 Laboratory Dr RTP, NC 27709, U.S.A	US0067	2180C	703469
<input checked="" type="checkbox"/>	Building: 2800 Perimeter Park Dr. Suite B Morrisville, NC 27560, U.S.A	US0067	27265	703469

5. DECISION RULES AND MEASUREMENT UNCERTAINTY

5.1. METROLOGICAL TRACEABILITY

All test and measuring equipment utilized to perform the tests documented in this report are calibrated on a regular basis, with a maximum time between calibrations of one year or the manufacturers' recommendation, whichever is less, and where applicable is traceable to recognized national standards.

5.2. DECISION RULES

The Decision Rule is based on Simple Acceptance in accordance with ISO Guide 98-4:2012 Clause 8.2. (Measurement uncertainty is not taken into account when stating conformity with a specified requirement.)

5.3. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

PARAMETER	U_{Lab}
Worst Case Radiated Disturbance, 1000 to 18000 MHz	4.73 db
RF output power, conducted	1.3 dB (PK); 0.45 dB (AV)

Uncertainty figures are valid to a confidence level of 95%.

5.4. SAMPLE CALCULATION

RADIATED EMISSIONS

Where relevant, the following sample calculation is provided:

Field Strength (dBuV/m) = Measured Voltage (dBuV) + Antenna Factor (dB/m) + Cable Loss (dB) – Preamp Gain (dB)
 $36.5 \text{ dBuV} + 18.7 \text{ dB/m} + 0.6 \text{ dB} - 26.9 \text{ dB} = 28.9 \text{ dBuV/m}$

MAINS CONDUCTED EMISSIONS

Where relevant, the following sample calculation is provided:

Final Voltage (dBuV) = Measured Voltage (dBuV) + Cable Loss (dB) + Limiter Factor (dB) + LISN Insertion Loss.
 $36.5 \text{ dBuV} + 0 \text{ dB} + 10.1 \text{ dB} + 0 \text{ dB} = 46.6 \text{ dBuV}$

6. EQUIPMENT UNDER TEST

6.1. DESCRIPTION OF EUT

The EUT is a wearable cardioverter defibrillator (WCD) is worn by a patient at risk for sudden cardiac arrest. It is lightweight and easy to wear, allowing patients to return to their activities of daily living. The LifeVest WCD monitors the patient's heart continuously. If the patient goes into a life-threatening, rapid heart rhythm, the LifeVest WCD delivers a defibrillating treatment in an attempt to restore the patient's heart to normal rhythm. The treatment is automatic and does not require bystanders to help.

This is a verification report for EUT with certified radio module. This report only concerns the WWAN radio module. The certified module is FCC ID: W56LV51C1BW0. Radiated spurious emissions testing and conducted output power testing was performed due to the EUT using a different antenna with higher gain than originally certified with.

6.2. MAXIMUM OUTPUT POWER

EIRP/ERP TEST PROCEDURE

ANSI C63.26:2015
KDB 971168 D01 Section 5.6

$$\text{ERP/EIRP} = \text{PMeas} + \text{GT} - \text{LC}$$

where: ERP/EIRP = effective or equivalent radiated power, respectively (expressed in the same units as PMeas, typically dBW or dBm);

PMeas = measured transmitter output power or PSD, in dBm or dBW;

GT = gain of the transmitting antenna, in dBd (ERP) or dBi (EIRP);

LC = signal attenuation in the connecting cable between the transmitter and antenna, in dB.

For devices utilizing multiple antennas, KDB 662911 provides guidance for determining the effective array transmit antenna gain term to be used in the above equation.

The transmitter has a maximum average conducted and ERP / EIRP output powers as follows:

LTE BAND 2

Part 24 / RSS 133						
EIRP Limit (W)		2.00				
Antenna Gain (dBi)		4.71				
Bandwidth (MHz)	Modulation	Low Frequency (MHz)	Upper Frequency (MHz)	Conducted Average (dBm)	EIRP Average (dBm)	EIRP Average (W)
1.4	QPSK	1850.7	1909.3	22.60	27.31	0.538
	16QAM			22.40	27.11	0.514
3.0	QPSK	1851.5	1908.5	22.60	27.31	0.538
	16QAM			22.60	27.31	0.538
5.0	QPSK	1852.5	1907.5	22.50	27.21	0.526
	16QAM			23.00	27.71	0.590
10.0	QPSK	1855.0	1905.0	22.60	27.31	0.538
	16QAM			22.90	27.61	0.577
15.0	QPSK	1857.5	1902.5	22.50	27.21	0.526
	16QAM			22.80	27.51	0.564
20.0	QPSK	1860.0	1900.0	22.70	27.41	0.551
	16QAM			23.00	27.71	0.590

Tested By: 27465/44389

Test Date: 2022-08-10; 2022-11-09

LTE BAND 4

Part 27 / RSS 139						
EIRP Limit (W)		1.00				
Antenna Gain (dBi)		5.83				
Bandwidth (MHz)	Modulation	Low Frequency (MHz)	Upper Frequency (MHz)	Conducted Average (dBm)	EIRP Average (dBm)	EIRP Average (W)
1.4	QPSK	1710.7	1754.3	22.60	28.43	0.697
	16QAM			22.40	28.23	0.665
3.0	QPSK	1711.5	1753.5	22.60	28.43	0.697
	16QAM			22.20	28.03	0.635
5.0	QPSK	1712.5	1752.5	22.80	28.63	0.729
	16QAM			23.10	28.93	0.782
10.0	QPSK	1715.0	1750.0	22.80	28.63	0.729
	16QAM			23.00	28.83	0.764
15.0	QPSK	1717.5	1747.5	22.80	28.63	0.729
	16QAM			23.30	29.13	0.818
20.0	QPSK	1720.0	1745.0	23.50	29.33	0.857
	16QAM			23.20	29.03	0.800

Tested By: 84740/44389; 27465/44389

Test Date: 2022-08-09; 2022-11-09

LTE BAND 12

Part 27 / RSS 130						
ERP Limit (W)		3.00				
Antenna Gain (dBi)		1.25				
Bandwidth (MHz)	Modulation	Low Frequency (MHz)	Upper Frequency (MHz)	Conducted Average (dBm)	ERP Average (dBm)	ERP Average (W)
1.4	QPSK	699.7	715.3	23.60	22.70	0.186
	16QAM			22.90	22.00	0.158
3.0	QPSK	700.5	714.5	23.50	22.60	0.182
	16QAM			22.80	21.90	0.155
5.0	QPSK	701.5	713.5	23.00	22.10	0.162
	16QAM			23.80	22.90	0.195
10.0	QPSK	704.0	711.0	24.00	23.10	0.204
	16QAM			23.90	23.00	0.200

Tested By: 84740/44389; 27465/44389

Test Date: 2022-08-09; 2022-11-09

6.3. SOFTWARE AND FIRMWARE

The EUT Firmware installed during testing was 3.4/RC2.

6.4. MAXIMUM ANTENNA GAIN

The antenna(s) gain and type, as provided by the manufacturer' are as follows:

LTE Band Name	Frequency (MHz)	Gain (dBi)
LTE BAND 2	1850-1915	4.71
LTE BAND 4	1710-1755	5.83
LTE BAND 12	699-716	1.25

6.5. WORST-CASE CONFIGURATION AND MODE

The EUT supports LTE Bands of:
Band 2, Band 4, and Band 12.

The worst-case scenario for all measurements is based on the average conducted output power measurement from previous certification reports. It was found that QPSK results were worst case. The EUT was tested in battery mode as it is the only mode of operation supported. Maximum supposed Bandwidth, with 1RB was used to represent worst case.

The EUT was investigated in three orthogonal orientations X/Y/Z for Low Band and Mid Band frequency ranges. See the below table for WC Orientations:

Antenna	Frequency Band (MHz)	Orientation
Main 1	Low Band ($F_c < 1000\text{MHz}$)	Y
Main 2	Mid Band ($1000\text{MHz} < F_c < 3000\text{MHz}$)	X

6.6. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List				
Description	Manufacturer	Model	Serial Number	FCC ID
Battery Charger	Zoll	LifeVest 5100 Charger	102000091	N/A
Battery	Zoll	LifeVest 5100 Battery	101000186	N/A
AC Adapter	Wall	EM10682P	002848	N/A
Electrode belt	Zoll	LifeVest 5100 Electrode Belt	N/A	N/A

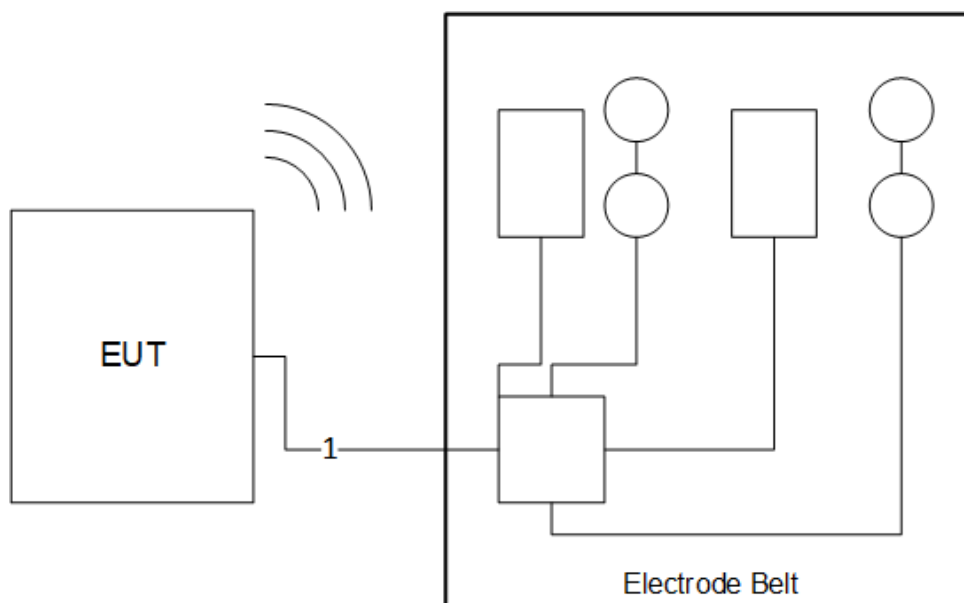
I/O CABLES

I/O Cable List						
Cable No.	Port	# of Identical Ports	Connector Type	Cable Type	Cable Length (m)	Remarks
1	10-Pin	1	Parallel	Shielded	<3m	Used to connect EUT to Electrode belt and accessories

TEST SETUP

The EUT is connected to a callbox during the tests. The EUT was left connected and transmitting during the entirety of the tests.

Setup Diagram



7. TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment was utilized for the tests documented in this report:

Test Equipment Used - Radiated Disturbance Emissions Test Equipment (Morrisville – Chamber 1)

Equip. ID	Description	Manufacturer/Brand	Model Number	Last Cal.	Next Cal.
	1-18 GHz				
AT0072	Double-Ridged Waveguide Horn Antenna, 1 to 18 GHz	ETS Lindgren	3117	2022-05-11	2023-05-11
	Gain-Loss Chains				
C1-SAC03	Gain-loss string: 1-18GHz	Various	Various	2022-05-05	2023-05-05
	Receiver & Software				
197954	Spectrum Analyzer	Rohde & Schwarz	ESW44	2022-04-14	2023-04-14
SOFTEMI	EMI Software	UL	Version 9.5 (18 Oct 2021)		
	Additional Equipment used				
200539	Environmental Meter	Fisher Scientific	15-077-963 (s/n 181474341)	2021-09-27	2022-09-27
213025	Wideband Radio Communications Tester	Rohde and Schwarz	CMW500	2021-11-18	2022-11-18
BRF008	1710-1785MHz notch filter, 2W, $F_{high} = 9\text{GHz}$	Micro-Tronics	BRM50713-01	2022-02-17	2023-02-17
HPF009	1GHz high-pass filter, 2W, $F_{high} = 10\text{GHz}$	Micro-Tronics	HPM17672	2022-02-17	2023-02-17

Test Equipment Used - Wireless Conducted Measurement Equipment

Equipment ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
	Common Equipment				
	Conducted Room 1				
213025	Callbox	R&S	CMW 500	2021-11-18	2022-11-18
HI0091	Environmental Meter	Fisher Scientific	15-077-963	2022-07-20	2023-07-20
SOFTEMI	Antenna Port Software	UL	Version 2022.08.16	NA	NA

8. RADIATED TEST RESULTS

This report contains data provided by the applicant which can impact the validity of results. UL LLC is only responsible for the validity of results after the integration of the data provided by the customer.

8.1. FIELD STRENGTH OF SPURIOUS RADIATION ABOVE 1GHz

TEST PROCEDURE

KDB 971168 D01 v03r01/D02 v02/r01

All tests above 1GHz were done with a Resolution Bandwidth of 1MHz, and a Video Bandwidth of 3MHz.

RESULTS

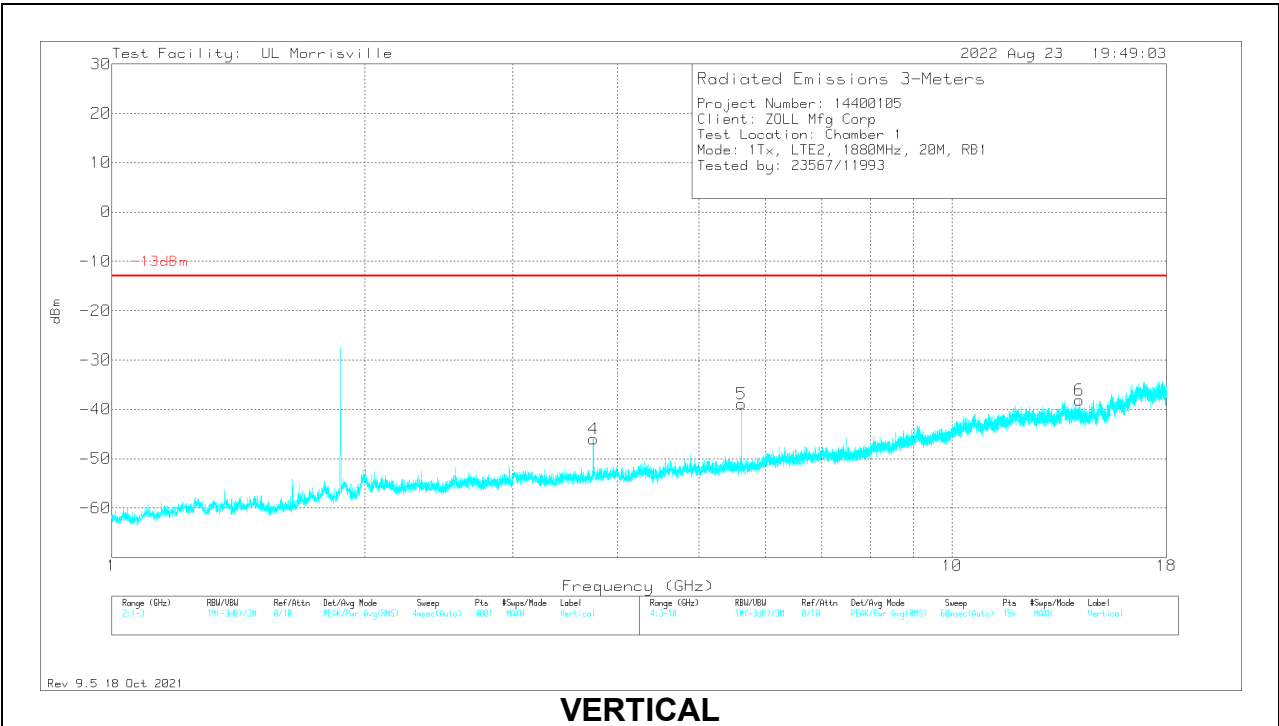
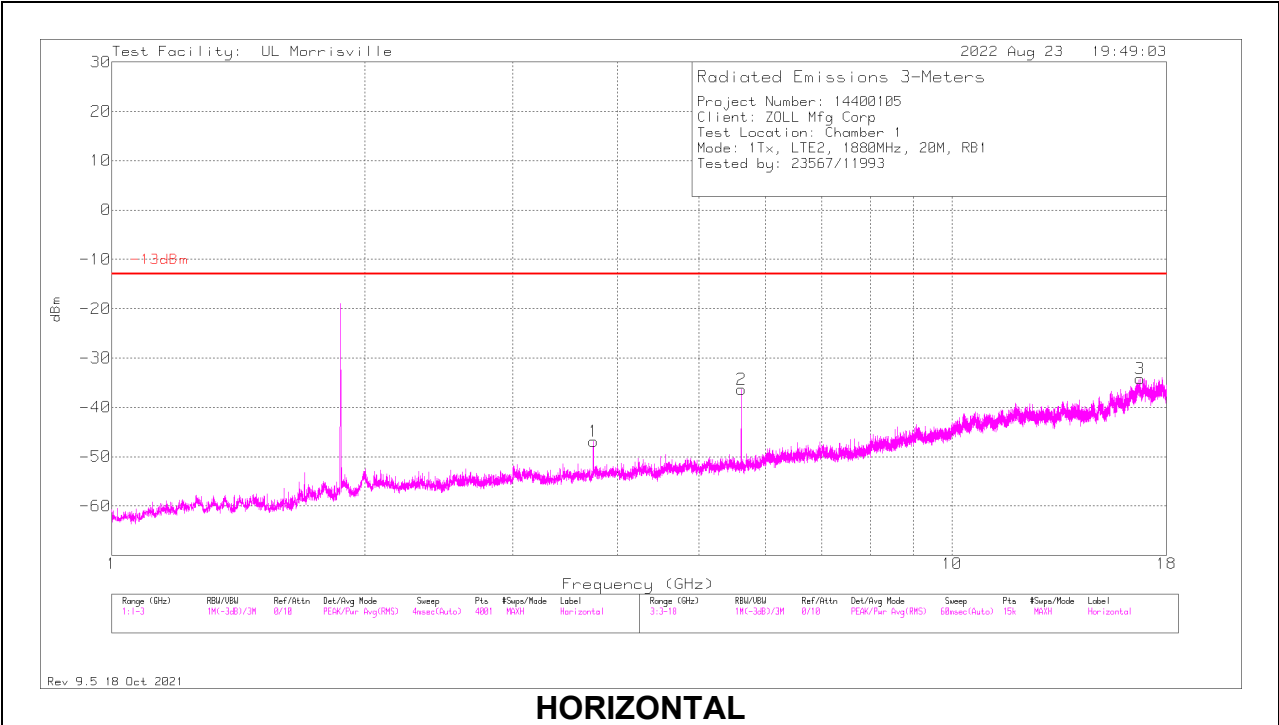
8.1.1. LTE2

LIMITS

FCC: §24.238(a)

The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least $43 + 10 \log (P)$ dB.

QPSK LTE2 (20MHz)



RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBm)	Det	AT0072 (dB/m)	Gain/Loss (dB)	CF (dB)	Filter (dB)	Corrected Reading dBm	-13dBm	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	3.743	-59.07	Pk	33.3	-32.9	11.8	0	-46.87	-13	-33.87	0-360	101	H
4	3.743	-58.17	Pk	33.3	-32.9	11.8	0	-45.97	-13	-32.97	0-360	101	V
2	5.614	-50.31	Pk	34.7	-32.5	11.8	0	-36.31	-13	-23.31	0-360	101	H
5	5.614	-52.92	Pk	34.7	-32.5	11.8	0	-38.92	-13	-25.92	0-360	101	V
6	14.167	-62.57	Pk	38.9	-26.3	11.8	0	-38.17	-13	-25.17	0-360	300	V
3	16.747	-63.64	Pk	41.9	-24.2	11.8	0	-34.14	-13	-21.14	0-360	200	H

Pk - Peak detector

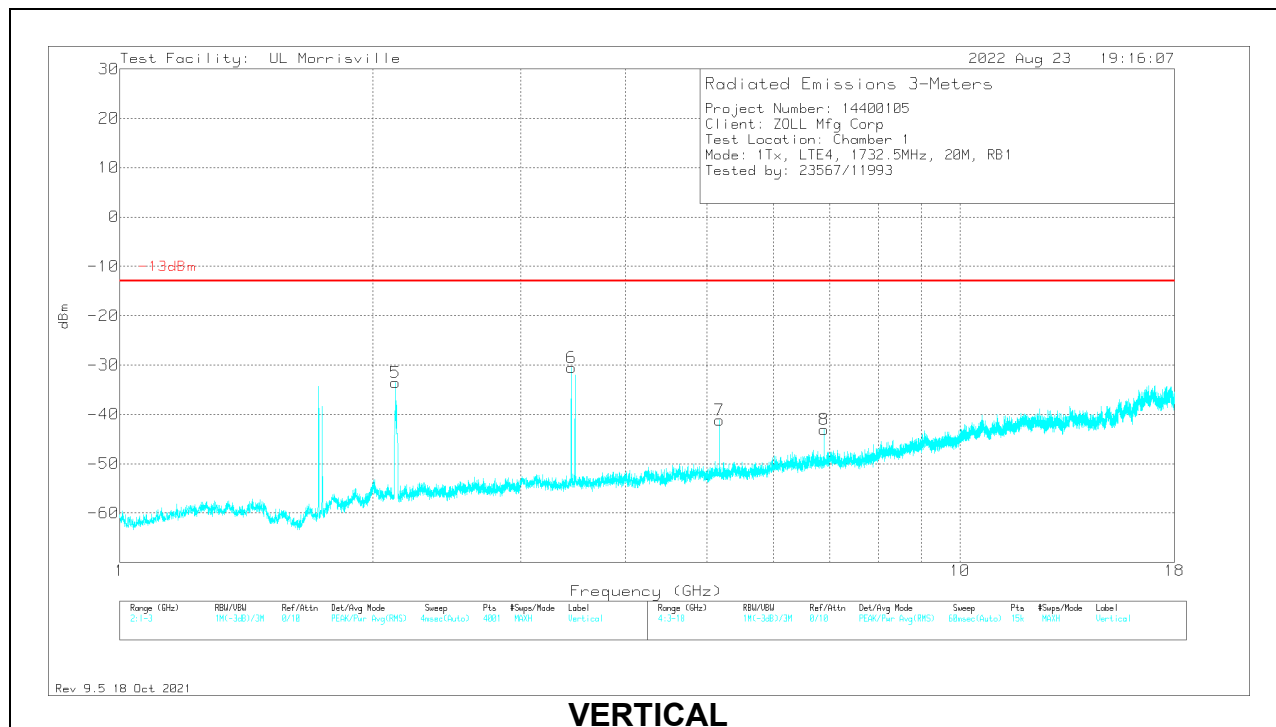
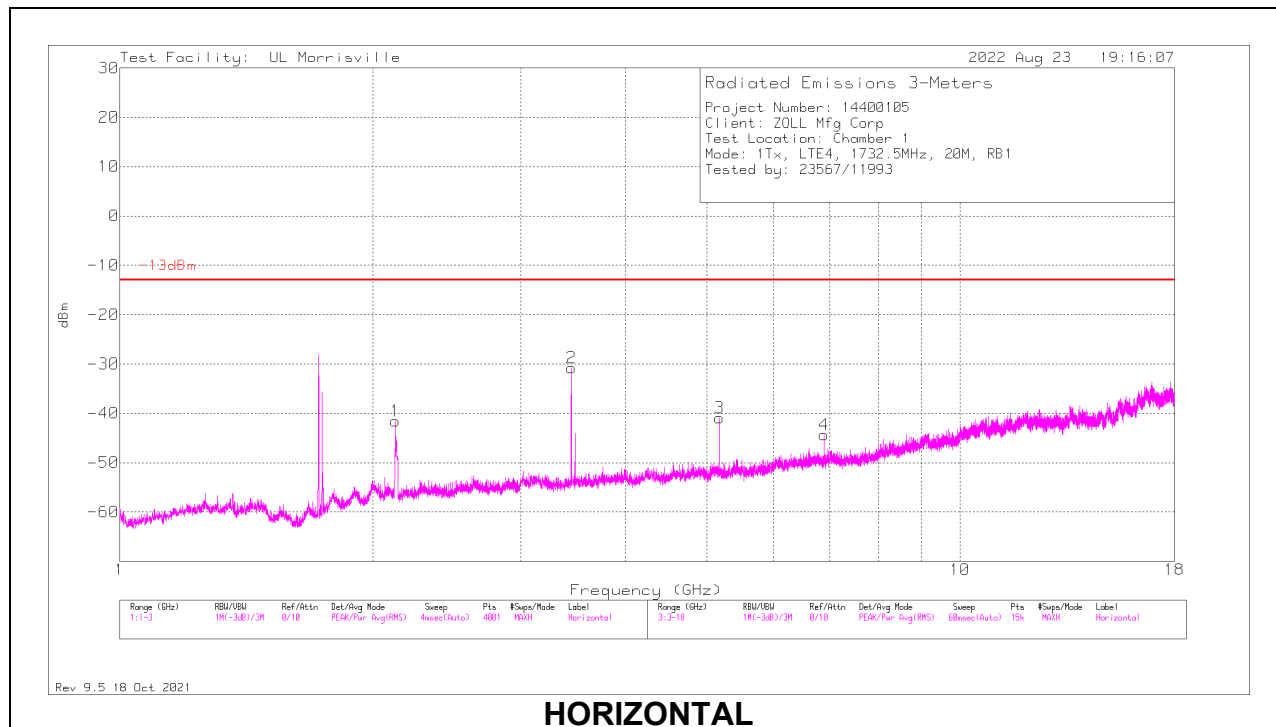
8.1.2. LTE4

LIMITS

FCC: §27.53(h)

The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least $43 + 10 \log (P)$ dB.

QPSK LTE4 (20MHz)



RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBm)	Det	AT0072 (dB/m)	Gain/Loss (dB)	CF (dB)	Filter (dB)	Corrected Reading dBm	-13dBm	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1 (DL)	2.129	-50.95	Pk	31.4	-34.8	11.8	1	-41.55			0-360	101	H
5 (DL)	2.129	-42.99	Pk	31.4	-34.8	11.8	1	-33.59			0-360	101	V
6	3.447	-42.26	Pk	32.8	-32.9	11.8	0	-30.56	-13	-17.56	0-360	201	V
2	3.448	-42.47	Pk	32.8	-32.9	11.8	0	-30.77	-13	-17.77	0-360	101	H
7	5.171	-54.84	Pk	34.3	-32.4	11.8	0	-41.14	-13	-28.14	0-360	300	V
3	5.172	-54.61	Pk	34.3	-32.4	11.8	0	-40.91	-13	-27.91	0-360	300	H
8	6.895	-59.94	Pk	35.5	-30.4	11.8	0	-43.04	-13	-30.04	0-360	201	V
4	6.896	-61.18	Pk	35.5	-30.5	11.8	0	-44.38	-13	-31.38	0-360	199	H

Pk - Peak detector

DL - Downlink

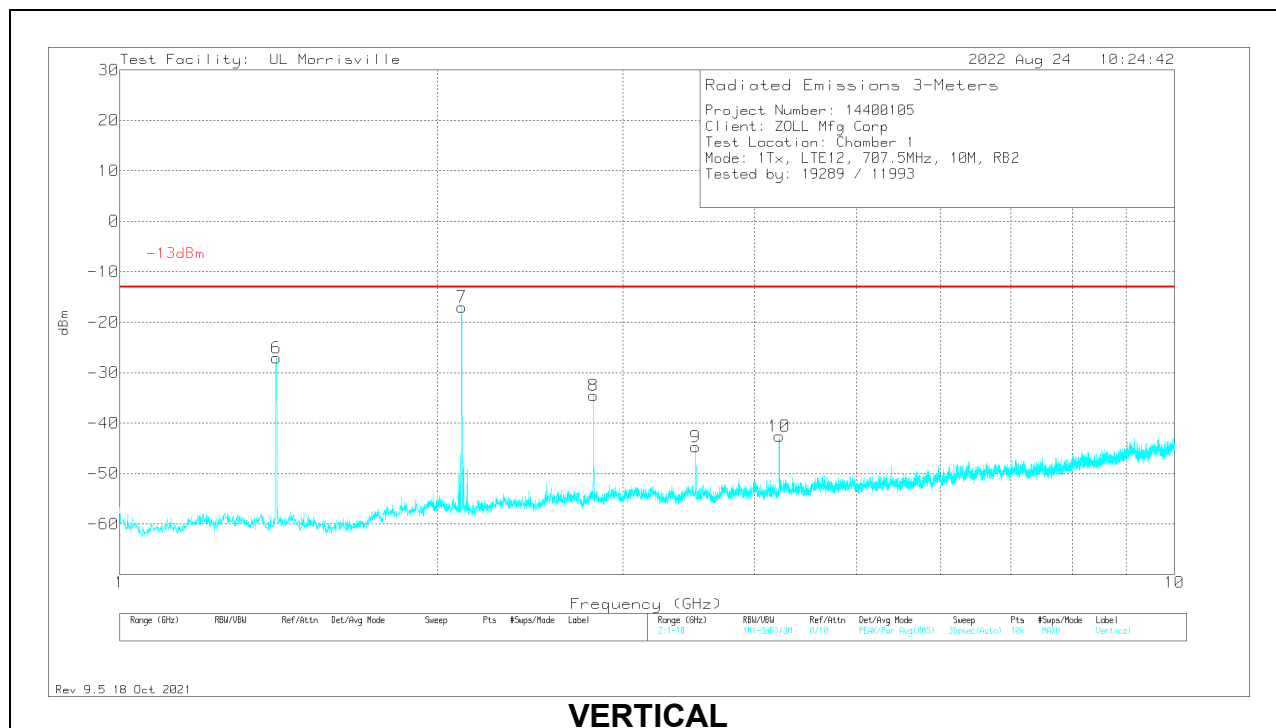
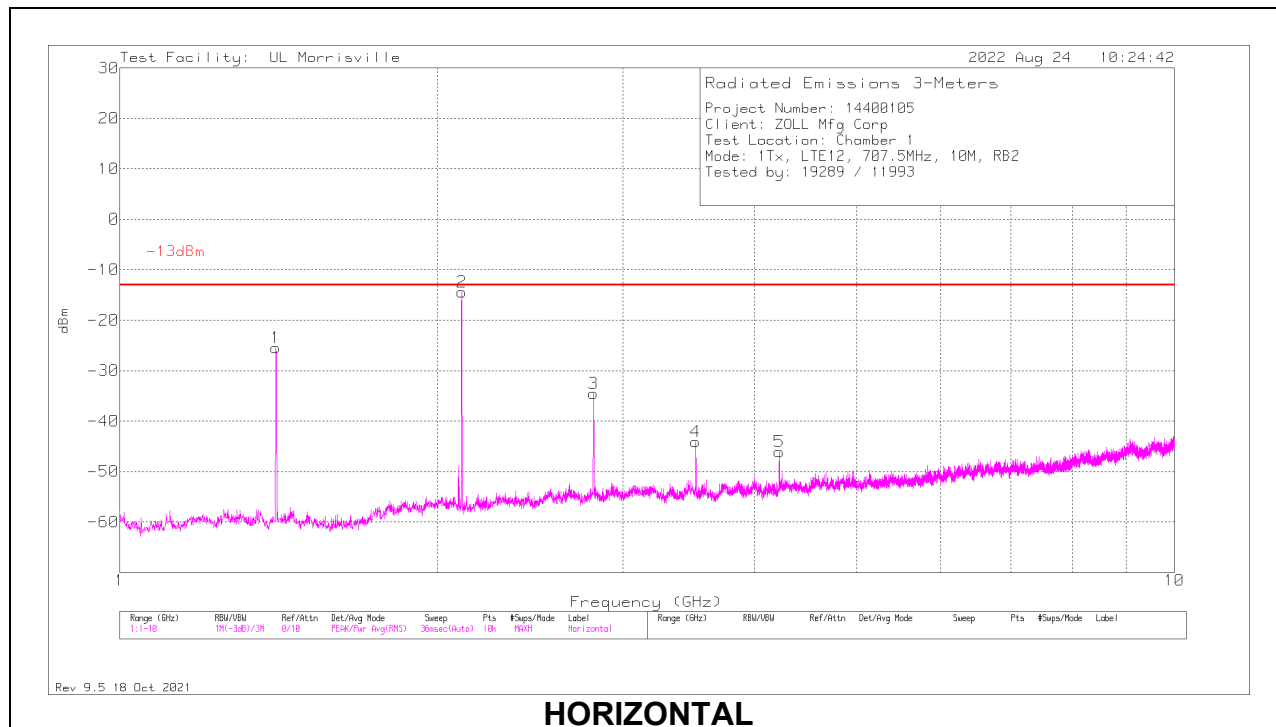
8.1.3. LTE12

LIMITS

FCC: §27.53 (g)

The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least $43 + 10 \log (P)$ dB.

QPSK LTE12 (10MHz)



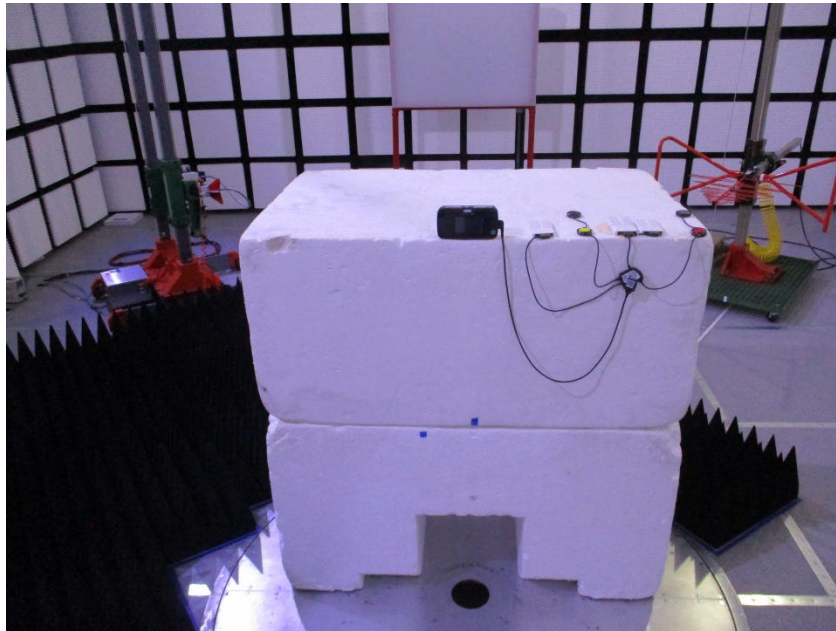
RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBm)	Det	AT0072 (dB/m)	Gain/Loss (dB)	Filter (dB)	CF (dB)	Corrected Reading dBm	-13dBm	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	1.4059	-31.31	Pk	28.7	-35.5	.9	11.8	-25.41	-13	-12.41	0-360	101	H
6	1.4068	-32.95	Pk	28.7	-35.5	.9	11.8	-27.05	-13	-14.05	0-360	101	V
2	2.11018	-21.68	Pk	31.3	-35.2	.4	11.8	-13.38	-13	-.38	101	157	H
7	2.11012	-21.62	Pk	31.3	-35.2	.4	11.8	-13.32	-13	-.32	248	153	V
3	2.8126	-45.5	Pk	32.6	-34	.6	11.8	-34.5	-13	-21.5	0-360	300	H
8	2.8135	-45.45	Pk	32.6	-34.1	.6	11.8	-34.55	-13	-21.55	0-360	300	V
4	3.5164	-56.17	Pk	33	-33	.3	11.8	-44.07	-13	-31.07	0-360	101	H
9	3.5164	-56.76	Pk	33	-33	.3	11.8	-44.66	-13	-31.66	0-360	300	V
5	4.2202	-59.22	Pk	33.5	-32.4	.3	11.8	-46.02	-13	-33.02	0-360	101	H
10	4.2202	-55.75	Pk	33.5	-32.4	.3	11.8	-42.55	-13	-29.55	0-360	101	V

Pk - Peak detector

9. SETUP PHOTOS

RADIATED RF MEASUREMENT SETUP

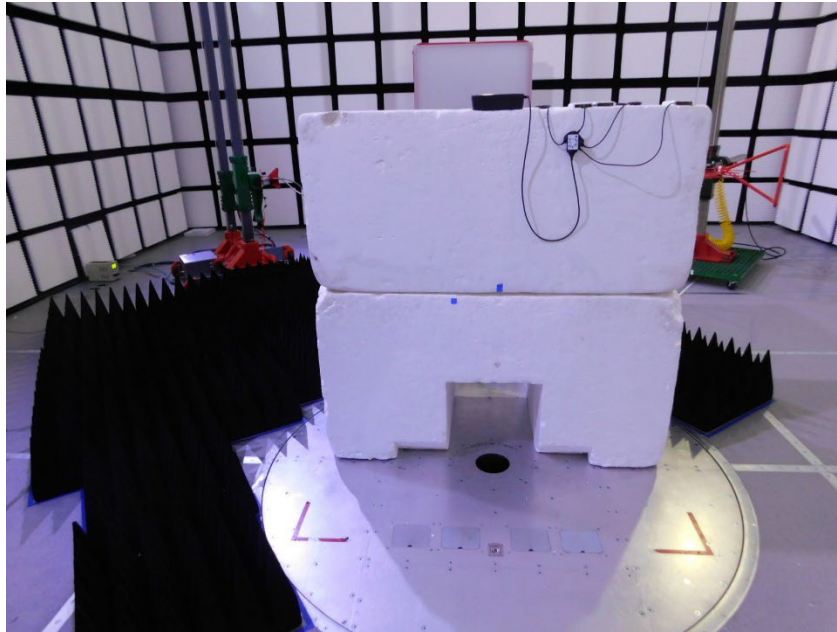


A1G FRONT PHOTO – LOW BAND



A1G BACK PHOTO – LOW BAND

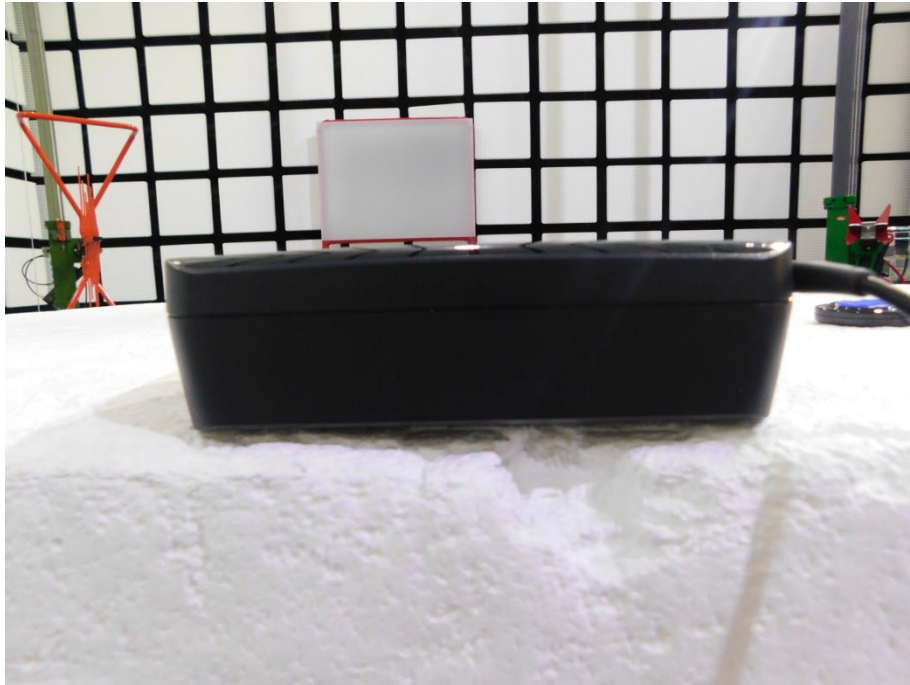
RADIATED RF MEASUREMENT SETUP



A1G FRONT PHOTO – MID BAND



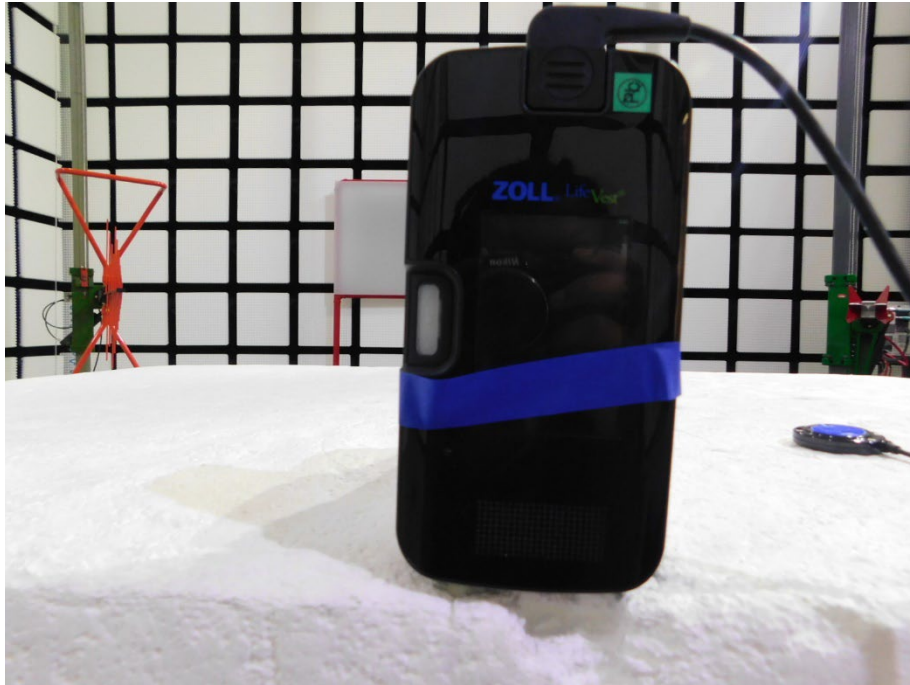
A1G BACK PHOTO – MID BAND



X-AXIS FRONT PHOTO



Y-AXIS FRONT PHOTO



Z-AXIS FRONT PHOTO

END OF REPORT