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TEST REPORT

Report Number: **102859212LEX-001**
Project Number: **G102859212**

Report Issue Date: **2/23/2017**

Product Name: **Cat M1 Module**

FCC Standards: **Title 47 CFR Part 27**

Industry Canada Standards: **RSS-130 Issue 1**

Tested by:
Intertek Testing Services NA, Inc.
731 Enterprise Drive
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Client:
Sequans Communications
19 Le Parvis de La Defense
Paris France

Report prepared by

Brian Daffin,
Engineer

Report reviewed by

Bryan Taylor,
Team Leader

TABLE OF CONTENTS

1 Introduction and Conclusion

The tests indicated in Section 2 were performed on the product constructed as described in Section 3. The remaining test sections are the verbatim text from the actual data sheets used during the investigation. These test sections include the test name, the specified test method, a list of the actual test equipment used, documentation photos, results and raw data. No additions, deviations, or exclusions have been made from the standard(s) unless specifically noted.

Based on the results of our investigation, we have concluded the product tested complied with the requirements of the standard(s) indicated. The results obtained in this test report pertain only to the item(s) tested.

The INTERTEK-Lexington laboratory is located at 731 Enterprise Drive, Lexington Kentucky, 40510. The radiated emission test site is a 10-meter semi-anechoic chamber. The chamber meets the characteristics of CISPR 16-1 and ANSI C63.4. For measurements, a remotely controlled flush-mount metal-top turntable is used to rotate the EUT a full 360 degrees. A remote controlled non-conductive antenna mast is used to scan the antenna height from one to four meters. The test site is listed with the FCC under Registration Number 485103.

2 Test Summary

Page	Test full name	FCC Reference	Industry Canada	Result
6	Conducted Output Power	§ 27.50(b)	RSS-130 (4.4)	Pass
8	Occupied Bandwidth	§2.1049	RSS-GEN (4.6.1)	Pass
11	Conducted Spurious Emissions	§27.53(c)	RSS-130 (4.6)	Pass
12	Radiated Output Power	§ 27.50(b)	RSS-130 (4.4)	Pass
14	Radiated Spurious Emissions (Transmitter)	§27.53(c)	RSS-130 (4.6)	Pass
16	Frequency Stability	§27.54	RSS-130 (4.3)	Pass

3 Description of Equipment Under Test

Equipment Under Test	
Manufacturer	Sequans Communications
Model Number	NL-SW-LTE-SVZM21
Serial Number	VMG1610200024002
Receive Date	12/21/2016
Test Start Date	1/12/2017
Test End Date	1/19/2017
Device Received Condition	Good
Test Sample Type	Production
Frequency Band	777-787 MHz (LTE Band 13)
Modulation Type	QPSK
Transmission Control	Base Station Simulator
Maximum Output Power (Conducted)	23.69 dBm (LTE Band 13)
Antenna Type	External
Operating Voltage	5 VDC

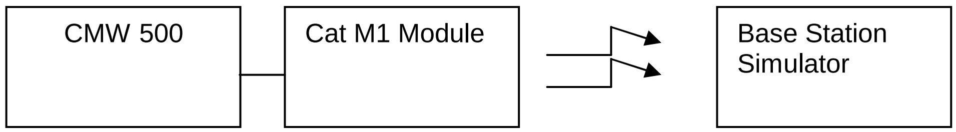
Description of Equipment Under Test
The NL-SW-LTE-SVZM21 is a Cat-M1 LTE Module that operates on Band 13.

Operating modes of the EUT:

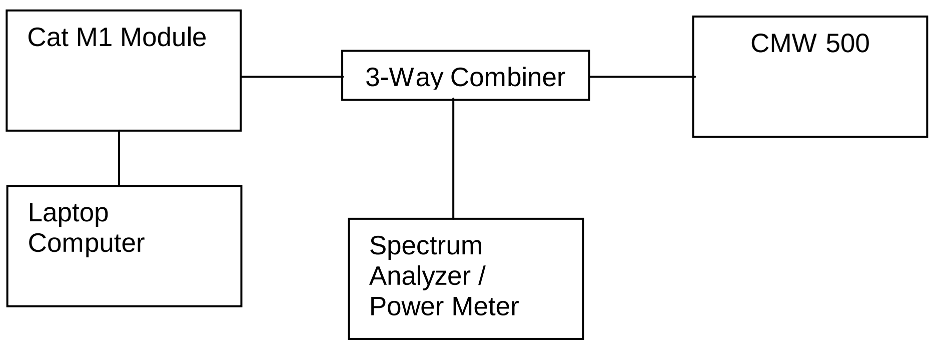
No.	Descriptions of EUT Exercising
1	Transmitting an LTE signal
2	Receive / idle mode

3.1 System setup including cable interconnection details, support equipment and simplified block diagram

3.2 EUT Block Diagram:



Block Diagram for Radiated Tests



Block Diagram for Conducted Tests at the Antenna Port

3.3 Cables:

Cables					
Description	Length	Shielding	Ferrites	Connection	
				From	To
Power	1m	No	No	AC/DC Adapter	DC Plug

4 Conducted Output Power

4.1 Test Limits

§ 27.50

(c)(10) Portable stations (hand-held devices) in the 600 MHz uplink band and the 698-746 MHz band, and fixed and mobile stations in the 600 MHz uplink band are limited to 3 watts ERP.

4.2 Test Procedure

The transmitter output was connected to a coaxial cable, the other end of which was connected to a Base Station Simulator. The Base Station Simulator was set to force the EUT to its maximum power setting. The EUT was placed into a call and the average power was measured. The power output at the transmitter antenna port was determined by adding the value of the cable insertion loss to the power reading. Tests were performed at three frequencies (low, middle, and high channels) and on the highest power levels, which can be setup on the transmitters.

The peak-to-average ratio (PAR) was measured using a spectrum analyzer with a RBW wider than the EBW of the measured signal. The delta between the peak and average trace was recorded.

4.3 Test Equipment Used:

Description	Serial Number	Manufacturer	Model	Cal. Date	Cal. Due
Base Station Simulator	3917	Rohde & Schwarz	CMW500	9/20/2016	9/20/2017
Spectrum Analyzer	3099	Rohde & Schwarz	FSP7	9/20/2016	9/20/2017
Power Divider	E18106	Weinschell Engineering	1506A	Time of Use	Time of Use

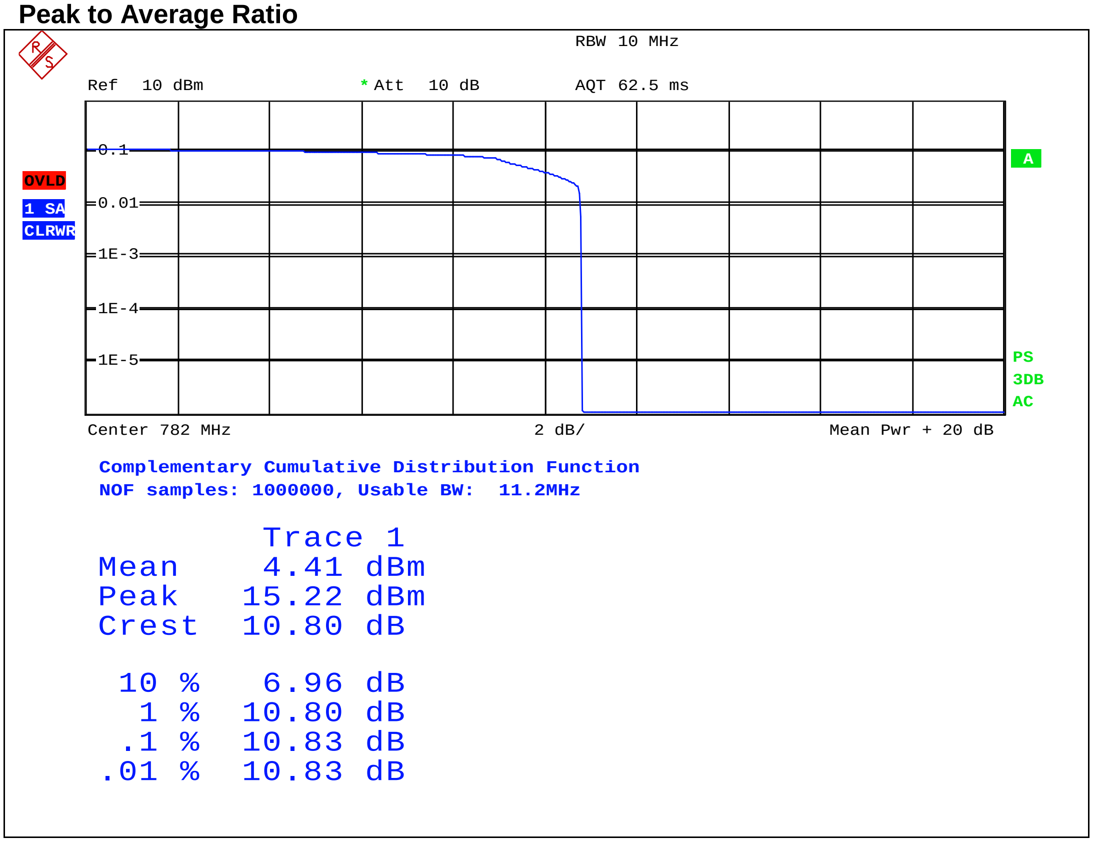
4.4 Results:

The table below shows the conducted output power delivered to the radiating antenna. Plots are also provided showing that the peak to average ratio (crest in the attached plots) is below the 13dB limit.

Conducted Output Power

Narrow Band Setting	Frequency (MHz)	RB Size	RB Offset	Max. Avg. Power (dBm)	Peak Power (dBm)
1	778	2	Low	19.85	23.69
		2	High	18.75	22.10
		6	N/A	18.40	21.69
5	782	2	Low	18.71	21.93
		2	High	18.42	21.69
		6	N/A	18.35	21.65
8	786	2	Low	18.36	21.67
		2	High	18.32	21.63
		6	N/A	18.31	21.64

Peak to Average Ratio



5 Occupied Bandwidth

5.1 Test Limits

§2.1049:

The occupied bandwidth is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission.

5.2 Test Procedure

The EUT was connected to a spectrum analyzer using a coaxial cable and power divider. The EUT was placed into a call using base station simulator. The base station simulator was set to force the EUT to its maximum power setting. The occupied bandwidth function of the analyzer was used to automatically generate the occupied bandwidth plots. The ndB down function of the analyzer was used to automatically measure the 26dB emission bandwidth. A peak detector was used for this measurement.

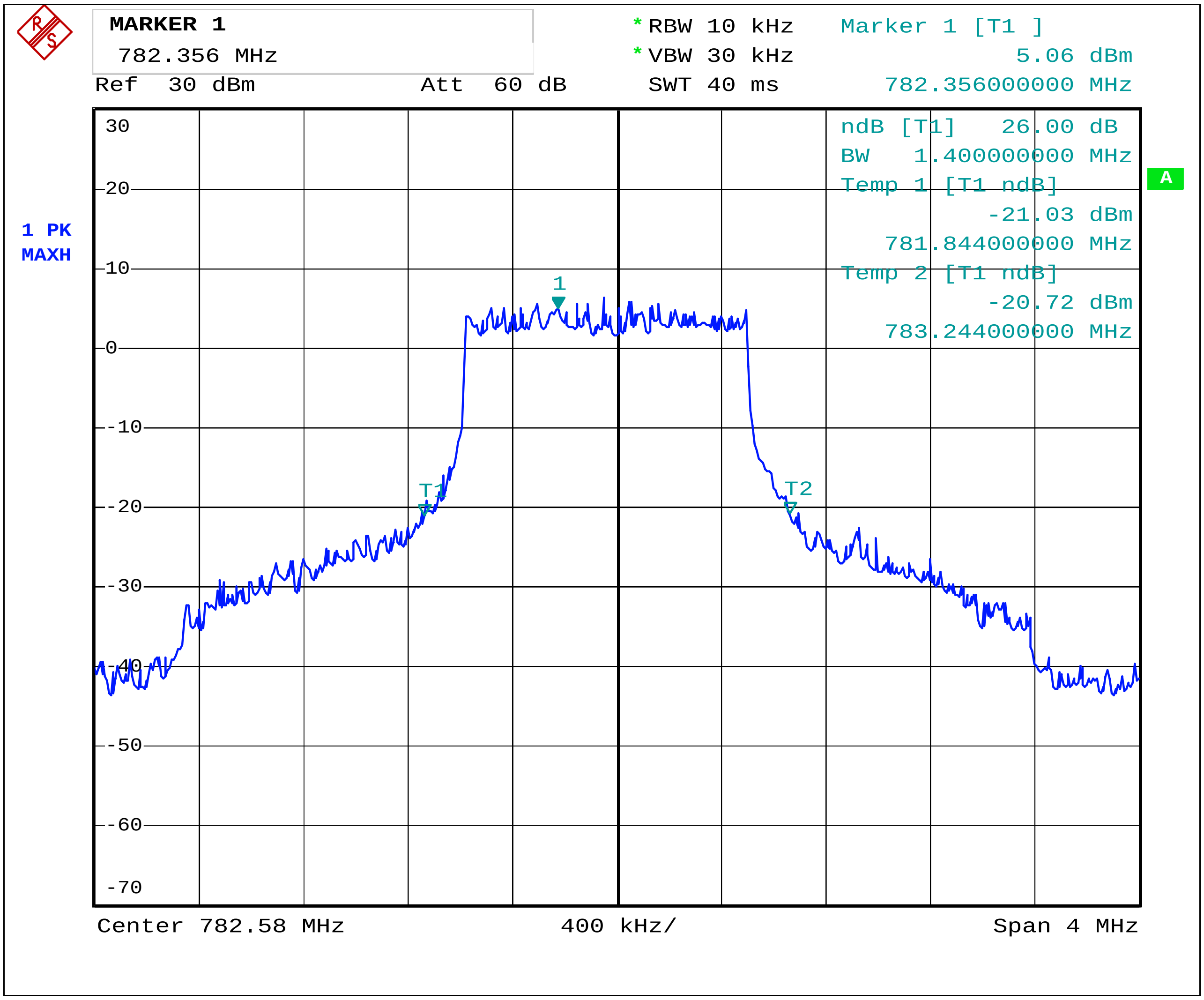
5.3 Test Equipment Used:

Description	Serial Number	Manufacturer	Model	Cal. Date	Cal. Due
Base Station Simulator	3917	Rohde & Schwarz	CMW500	9/20/2016	9/20/2017
Spectrum Analyzer	3099	Rohde & Schwarz	FSP7	9/20/2016	9/20/2017
Power Divider	E18106	Weinschell Engineering	1506A	Time of Use	Time of Use

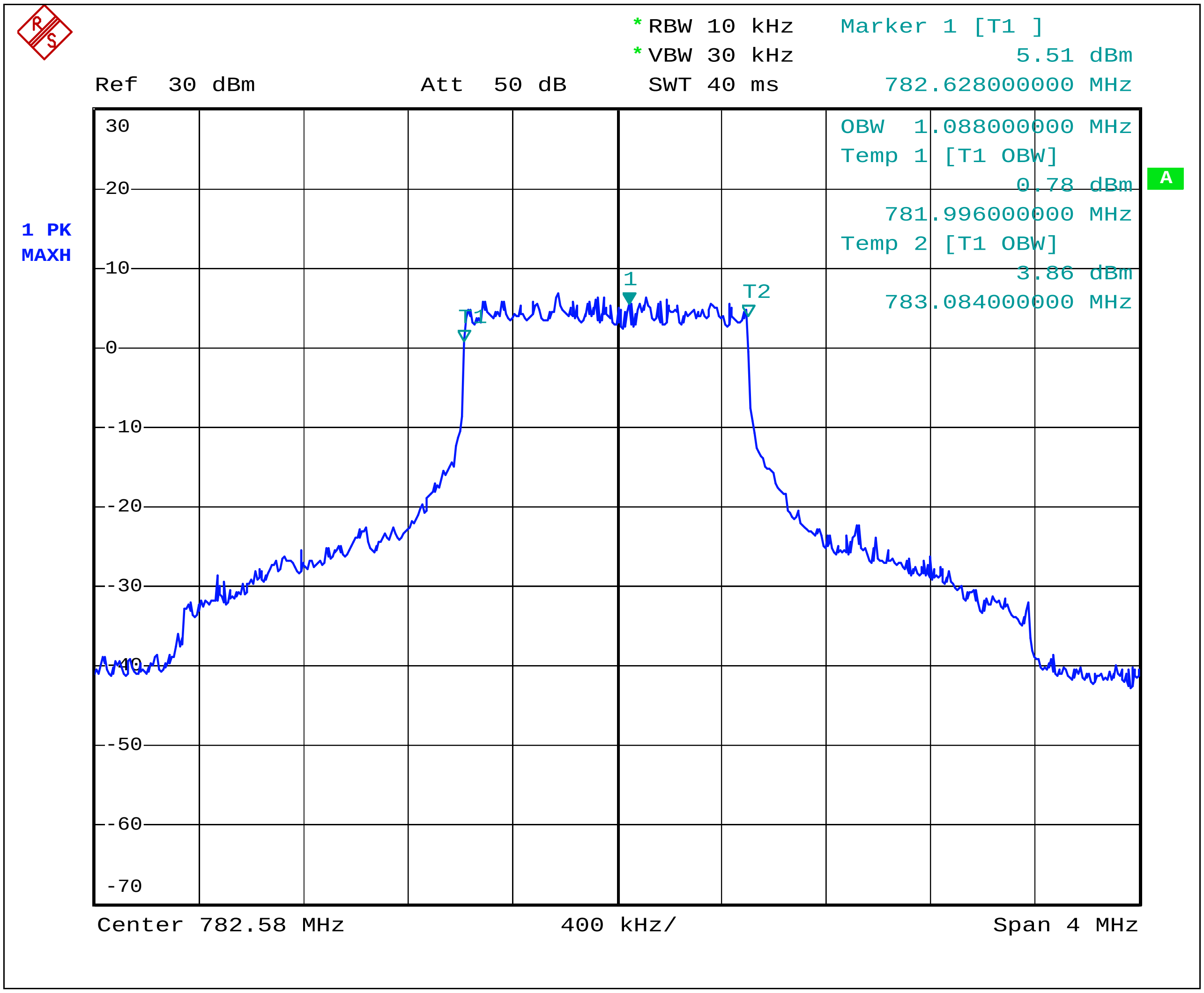
5.4 Results:

The bandwidth measurements are shown in the table below and the plots that follow.

26dB Down Bandwidth
1.40MHz



99% Down Bandwidth
1.09MHz



6 Conducted Spurious Emissions at Antenna Terminals

6.1 Test Limits

§ 27.53

(c)(2) On any frequency outside the 776-788 MHz band, the power of any emission shall be attenuated outside the band below the transmitter power (P) by at least 43 + 10 log (P) dB.

6.2 Test Procedure

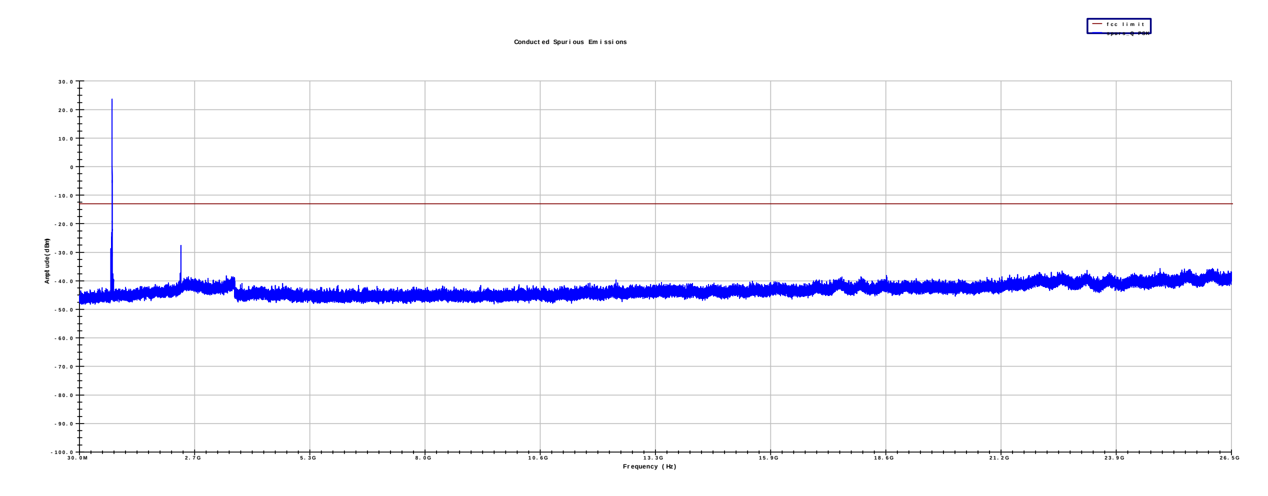
The RF output of the EUT was connected to a spectrum analyzer through appropriate attenuation. The base station simulator was set to force the EUT to its maximum power setting. The resolution bandwidth of the spectrum analyzer was set at 100kHz or 1MHz depending on the transmit band and the detector was set to peak detection for general scans up to the 10^{th} harmonic. Emissions scans near the fundamental were measured using an RMS detector. Sufficient scans were taken to show the out of band Emissions if any up to 10th harmonic.

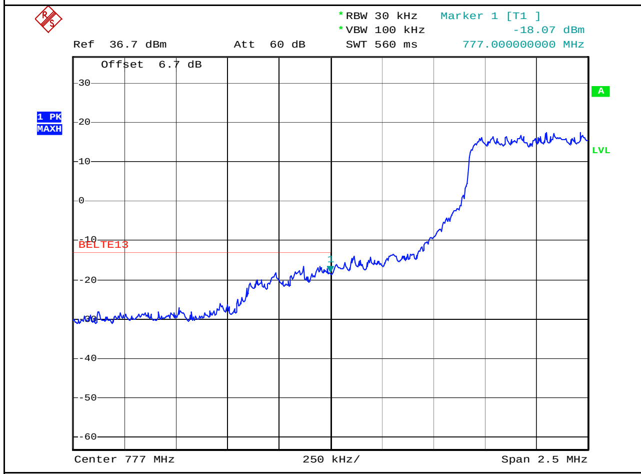
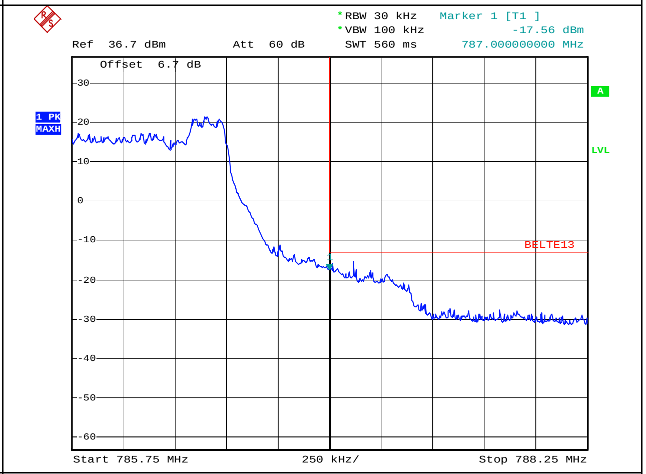
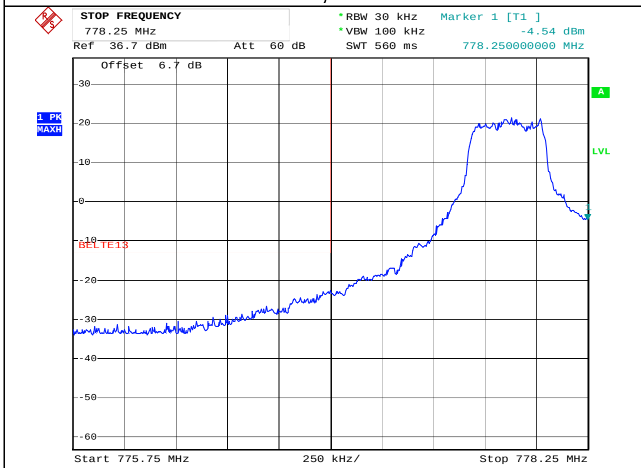
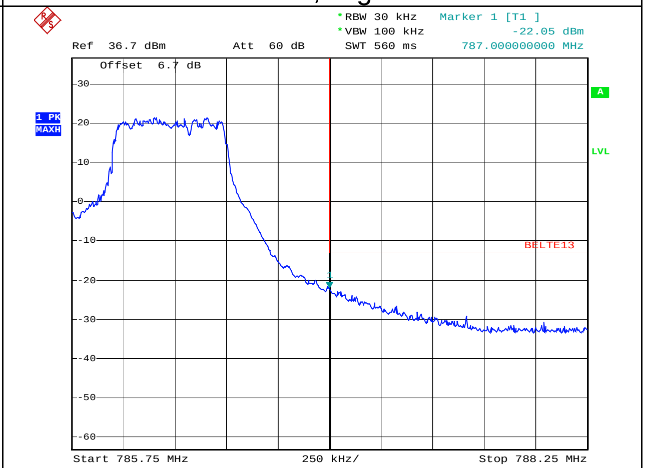
6.3 Test Equipment Used:

Description	Serial Number	Manufacturer	Model	Cal. Date	Cal. Due
Base Station Simulator	3917	Rohde & Schwarz	CMW500	9/20/2016	9/20/2017
Spectrum Analyzer	3099	Rohde & Schwarz	FSP7	9/20/2016	9/20/2017
Spectrum Analyzer	3720	Rohde & Schwarz	FSEK30	9/26/2016	9/26/2017
Power Divider	E18106	Weinschell Engineering	1506A	Time of Use	Time of Use

6.4 Results:

The following plots show that all spurious emissions are attenuated below the transmitting power (P) by a factor of at least 43 + 10 log(P) dB. Plots for emissions within 1MHz of the transmit block edge as well as for emission outside of this range are shown.



<table>
<tr><td>Narrow Band Setting 1, 778MHz
Below 777MHz</td><td>Narrow Band Setting 8, 786MHz
Above 787MHz</td></tr>
<tr><td>6 RB</td><td>6 RB</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>2 RB, Low</td><td>2RB, High</td></tr>
<tr><td>
</td><td>
</td></tr>
</table>

7 Radiated Output Power

7.1 Test Limits

§ 27.50

(b) (10) Portable stations (hand-held devices) transmitting in the 746-757 MHz, 776-788 MHz, and 805-806 MHz bands are limited to 3 watts ERP.

7.2 Test Procedure

The radiated output power was determined by adding the peak antenna gain to the highest measured conducted output power to determine the maximum radiated power. The peak antenna gain was calculated by taking into account the ERP / EIRP limits as well as the Maximum Permissible Exposure (MPE) limits at 20cm.

$$ERP = ConductedOutputPower(dBm) + AntennaGain(dBi) - 2.15$$

$$EIRP = ConductedOutputPower(dBm) + AntennaGain(dBi)$$

7.3 Results:

The Cat M1 Module meets the radiated power requirements of FCC §22.91, §24.232, and §27.50. The ERP / EIRP results are shows as well as the MPE calculations used to determine the maximum allowable gain for each frequency band.

The calculated maximum permissible antenna gain is 10.1615 dBi.

LTE Band 13	Value	Unit	Comments
Frequency	778	MHz	
Distance	20	cm	
Maximum Scaled Power	24	dBm	Measured conducted power
TX Antenna Gain	10.1615	dBi	From datasheet, or calculated from peak radiated field strength and measured conducted power
Source Based Duty Cycle	100	%	Percent of time transmitter is active
EIRP	**34.1615**	**dBm**	Maximum Scaled Power x Antenna Gain
Source Based Output Power	**34.2**	**dBm**	EIRP x Duty Cycle
Power Density @ Distance	**0.5187**	**mW/cm^2**	(Source Based Output Power, mW) / (4π x (distance, cm)^2)
FCC Limit	**0.5187**	**mW/cm^2**	.0007 x f^1
Ratio of Power Density to Limit	**1.0000**		Power Density / FCC Limit
Maximum Permissible Antenna Gain	**10.16**	**dBi**	((Limit, mW/cm^2) x 4π x (distance, cm)^2) / ((Maximum Scaled Power, mW) x Source Based Duty Cycle)

8 Radiated Spurious Emissions (Transmitter)

8.1 Test Limits

§ 27.53

(c) (2) On any frequency outside the 776-788 MHz band, the power of any emission shall be attenuated outside the band below the transmitter power (P) by at least 43 + 10 log (P) dB.

8.2 Test Procedure

The EUT was placed on a non-conductive turntable. The measurement antenna was placed at a distance of 3 meters from the EUT. The EUT was forced to transmit at its maximum output power setting. During the tests, the antenna height and EUT azimuth were varied in order to identify the maximum level of emissions from the EUT.

The frequency range up to tenth harmonic was investigated in order to identify the spurious emission. Once the spurious emissions were identified, the power of the emission was determined using the substitution method described in TIA-603-C. The spurious emissions attenuation was calculated as the difference between radiated power at the fundamental frequency and at the spurious emissions frequency.

8.3 Test Equipment Used:

Description	Serial Number	Manufacturer	Model	Cal. Date	Cal. Due
EMI Test Receiver	1302.6005.40	Rohde&Schwarz	ESU40	9/26/2016	9/26/2017
Preamplifier	122005	Rohde&Schwarz	TS-PR18	Included in Cable Cal	
Horn Antenna	00156319	ETS	3117	6/3/2016	6/3/2017
Horn Antenna	00154521	ETS	3117	11/14/2016	11/4/2017
Bilog Antenna	00051864	ETS	3142C	3/23/2016	3/23/2017
System Controller	121701-1	Sunol Sciences	SC99V	Time of Use	Time of Use
High Pass Filter	1	Wainwright	WHKX12-2533.85-2710-18000-40SS	Time of Use	Time of Use
High Pass Filter	25	Wainwright	WHKX12-1028.5-1100-1500-40SS	Time of Use	Time of Use
Base Station Simulator	3917	Rohde & Schwarz	CMW500	9/20/2016	9/20/2017
Signal Generator	3915	Rohde&Schwarz	SMB100A	9/20/2016	9/20/2017

8.4 Results:

All radiated spurious emissions were attenuated below the transmitting power (P) by a factor of at least 43 + 10 log(P) dB which is equivalent to -13dBm. The emissions were measured using an RMS detector and the analyzer was gated so that the emission was only measured during the on-times of the transmitter.

Radiated Spurious Emissions Measurement

Test Engineer: Brian Daffin **Start Date:** 1/13/2017 **End Date:** 1/13/2017
Temperature: 22.5 C **Humidity:** 29.10% **Pressure:** 982mbar
RBW: 1MHz **VBW:** 3MHz
Notes: Results represent the worst case from 3 orthogonal axis positions.

			A	B	C	D	E	F
Band/Channel	**Spurious Frequency (MHz)**	**Polarity**	**Device Reading (dBm)**	**Signal Generator Level (dBm)**	**Cable Loss (dB)**	**Tx Antenna Gain (dBd)**	**Limit (dBm)**	**Radiated Spurious Emission Level (dBm)**
Band 13 Narrow Band = 1 (778 MHz)	1556.0	H	-50.46	-45.36	2.75	5.40	-13	-42.71
	1556.0	V	-54.23	-48.78	2.75	5.40	-13	-46.13
	2334.0	H	-39.28	-20.87	3.42	6.07	-13	-18.22
	2334.0	V	-45.92	-28.38	3.42	6.07	-13	-25.73
	3112.0	H	-68.33	-58.3	4.15	7.09	-13	-55.36
	3112.0	V	-68.69	-57.57	4.15	7.09	-13	-54.63
	3890.0	H	-49.86	-36.65	4.59	8.25	-13	-32.99
	3890.0	V	-51.28	-35.16	4.59	8.25	-13	-31.50
	4668.0	H	-66.76	-47.6	5.22	9.33	-13	-43.49
	4668.0	V	-66.61	-51.38	5.22	9.33	-13	-47.27
Band 13 Narrow Band =5 (782 MHz)	1564.0	H	-50.45	-45.12	2.75	5.40	-13	-42.47
	1564.0	V	-54.60	-49.16	2.75	5.40	-13	-46.51
	2346.0	H	-41.32	-21.73	3.42	6.07	-13	-19.08
	2346.0	V	-51.11	-33.4	3.42	6.07	-13	-30.75
	3128.0	H	-68.23	-57.98	4.15	7.09	-13	-55.04
	3128.0	V	-68.59	-57.2	4.15	7.09	-13	-54.26
	3910.0	H	-46.89	-33.94	4.59	8.43	-13	-30.10
	3910.0	V	-49.76	-34.46	4.59	8.43	-13	-30.62
	4692.0	H	-66.20	-45.63	5.22	9.33	-13	-41.52
	4692.0	V	-66.29	-49.55	5.22	9.33	-13	-45.44
Band 13 Narrow Band = 8 (786 MHz)	1572.0	H	-51.34	-46.43	2.75	5.40	-13	-43.78
	1572.0	V	-54.76	-49.24	2.75	5.40	-13	-46.59
	2358.0	H	-39.21	-18.64	3.42	6.07	-13	-15.99
	2358.0	V	-46.14	-28.99	3.42	6.07	-13	-26.34
	3144.0	H	-67.76	-57.3	4.15	7.09	-13	-54.36
	3144.0	V	-68.31	-56.83	4.15	7.09	-13	-53.89
	3930.0	H	-47.21	-34.72	4.68	8.43	-13	-30.97
	3930.0	V	-51.54	-36.66	4.68	8.43	-13	-32.91
	4716.0	H	-66.44	-43.99	5.22	9.39	-13	-39.82
	4716.0	V	-66.41	-47.6	5.22	9.39	-13	-43.43
								F=B-C+D

9 Frequency Stability

9.1 Test Limits

§ 27.54
The frequency stability of the transmitter was required to maintain a ±2.5ppm tolerance.

9.2 Test Procedure

The equipment under test was connected to a DC power source and the RF output was connected to a Base Station Simulator. The Base Station Simulator was set to force the EUT to its maximum power setting. The EUT was placed inside the temperature chamber. The DC leads and RF output cable exited the chamber through an opening made for that purpose. After the temperature stabilized for approximately 30 minutes, the frequency error was read from the base station simulator. At 20C the input voltage was varied from 85% to 115% and the frequency stability vs input voltage was recorded.

9.3 Test Equipment Used:

Description	Serial Number	Manufacturer	Model	Cal. Date	Cal. Due
Base Station Simulator	3917	Rohde & Schwarz	CMW500	9/20/2016	9/20/2017
Environmental Chamber	32692	Thermotron	SM-8C	4/25/2016	4/25/2017
Multimeter	1694	Fluke	115	3/29/2016	3/29/2017
Power Supply	3513	Gwinstek	GPS1850	NCR	NCR

9.4 Results:

The tables below show the frequency stability data. In all cases the test sample met the ±2.5ppm limit.

Voltage (%)	Voltage (DC)	Temp (C)	Frequency Error (Hz)	Deviation (%)	Deviation (ppm)
100	5	-30	1.74	0.00000022	0.002225
100	5	-20	1.29	0.00000016	0.00165
100	5	-10	1.47	0.00000019	0.00188
100	5	0	-1.14	-0.00000015	-0.00146
100	5	10	0.20	0.00000003	0.000256
100	5	20	-1.20	-0.00000015	-0.00153
100	5	30	-1.77	-0.00000023	-0.00226
100	5	40	0.31	0.00000004	0.000396
100	5	50	-0.90	-0.00000012	-0.00115
100	5	60	-0.93	-0.00000012	-0.00119
115	5.75	20	-2.10	-0.00000027	-0.00269
85	4.25	20	-0.99	-0.00000013	-0.00127

10 Measurement Uncertainty

The measured value related to the corresponding limit will be used to decide whether the equipment meets the requirements.

The measurement uncertainty figures were calculated and correspond to a coverage factor of k = 2, providing a confidence level of respectively 95.45 % in the case where the distributions characterizing the actual measurement uncertainties are normal (Gaussian).

Measurement uncertainty Table

Parameter	Uncertainty	Notes
Radiated emissions, 30 to 1000 MHz	±3.9dB	
Radiated emissions, 1 to 18 GHz	±4.2dB	
Radiated emissions, 18 to 40 GHz	±4.3dB	
Power Port Conducted emissions, 150kHz to 30 MHz	+2.8dB	

11 Revision History

Revision Level	Date	Report Number	Notes
0	2/23/2017	102859212LEX-001	Original Issue