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HAE Innovations TEST REPORT

SCOPE OF WORK
EMC TESTING – IOT WEARABLE DEVICE

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EMC TEST REPORT
(FULL COMPLIANCE)

Report Number: 104469626LEX-023
Project Number: G104469626

Report Issue Date: 7/14/2021

Product Tested: IoT Wearable Device

Standards: FCC Title 47 CFR Part 27

Tested by:
Intertek Testing Services NA, Inc.
731 Enterprise Dr.
Lexington, KY 40510
USA

Client:
HAE Innovations
14 Culnen Drive
Branchburg, NJ 08876
USA

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1 Introduction and Conclusion

The tests indicated below were performed on the product described in section 4 The remaining test sections are the verbatim text from the actual data sheets used during the investigation. 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 **complies** with the requirements of the standard(s) indicated. The results obtained in this test report pertain only to the item(s) tested. Intertek does not make any claims of compliance for samples or variants which were not tested.

2 Test Summary for Band 13 (777 – 787MHz)

FCC Rule	Test Method	Test Description	Measured Value (Worst Case)	Limit	Results
2.1033(c)(4)	---	Modulation Type	QPSK, 16QAM	Digital	Pass
27.50(b)(10)	ANSI C63.26: 2015 Section 5.2.4.2	Output Power	20.95dBm (conducted) 22.05dBm (ERP)	3W ERP (34.77dBm)	Pass
27.50(d)(5)	ANSI C63.26: 2015 Section 5.2.3.4	Peak to Average Power Ratio	11.63dB	13dB	Pass
2.1049(h)	ANSI C63.26: 2015 Section 5.4.4	99% Emission Bandwidth	1.10MHz	Stays within block	Pass
27.53(h)(3)	ANSI C62.26: 2015 Section 5.4.3	26dB Down Emission Bandwidth	1.30MHz	Stays within block	Pass
27.54	ANSI C63.26: 2015 Section 5.6	Frequency Stability	Stays within band of operation	Stays within block[1]	Pass
27.53(c)	ANSI C63.26: 2015 Section 5.7	Conducted Spurious Emissions	774.25MHz -36.32dBm	763 – 775MHz: -35dBm 793 – 805MHz: -35dBm Spurious: -13dBm	Pass
27.53(c)	ANSI C63.26: 2015 Section 5.5	Radiated Spurious Emissions	10.61kHz 62.39dBuV/m @ 3m	-13dBm 82.25dBuV/m @ 3m	Pass

1 A limit 1.5ppm was used during the testing in order to show that the emission remained within the block.

3 Client Information

This product was tested at the request of the following:

Client Information	
Client Name:	HAE Innovations
Address:	14 Culnen Drive Branchburg, NJ 08876 USA
Contact:	Hesham ElHamahmy
Telephone:	+1(732) 245-9447
Email:	hesham@haeinnovations.com
Manufacturer Information	
Manufacturer Name:	HAE Innovations
Manufacturer Address:	14 Culnen Drive Branchburg, NJ 08876 USA

4 Description of Equipment under Test and Variant Models

Equipment Under Test	
Product Name	IoT Wearable Device
Model Number	IoT Wearable Device
Serial Number	Test Sample 1
Receive Date	12/8/2020
Test Start Date	12/8/2020
Test End Date	5/26/2021
Transmit Bands Supported	Band 13 (777 – 787MHz)
Modulation Types Supported	LTE Cat M1 using QPSK or 16QAM
Antenna Information (Provided by Client)	1.1dBi Ignion Chip Antenna Part Number NN03-310
Device Received Condition	Good
Test Sample Type	Production
Rated Voltage	3.7VDC
Description of Equipment Under Test (provided by client)	
The IoT Wearable Device was a small wireless wearable device used in contact tracing applications.	

4.1 Variant Models:

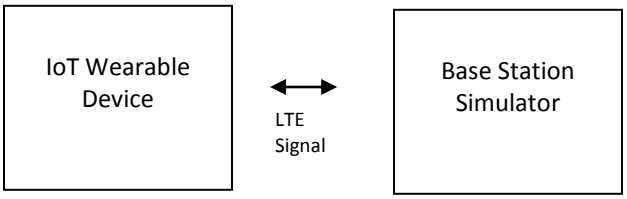
There were no variant models covered by this evaluation.

5 System Setup and Method

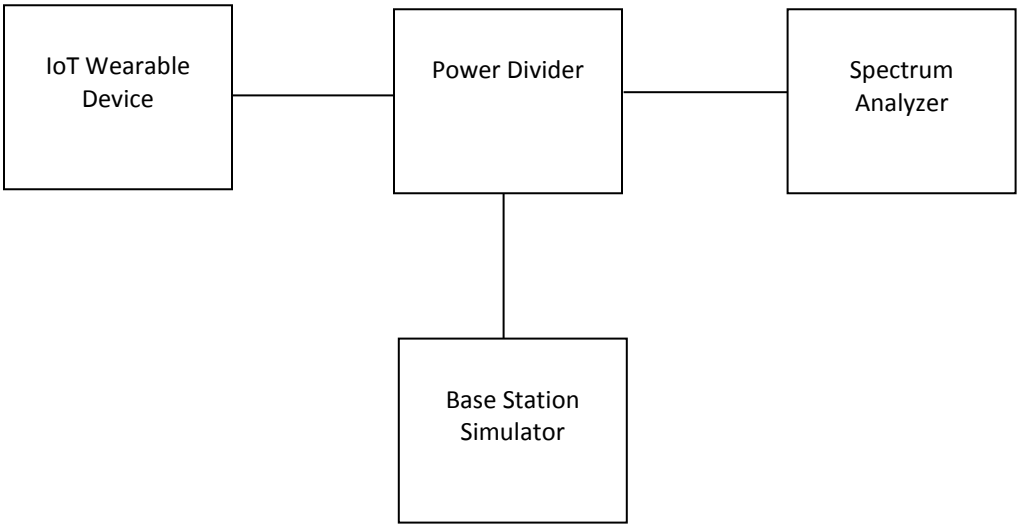
No.	Descriptions of EUT Exercising
1	A base station simulator was used to configure a connection on LTE band 13 with the test sample. The base station simulator was used to set the test sample to transmit at maximum output power using QPSK and 16QAM modulation

Cables					
Qty	Description	Length	Shielding	Ferrites	Termination
None					

5.1 EUT Block Diagram (Radiated Tests):



5.2 EUT Block Diagram (Conducted Tests):



5.3 Test Equipment Used (Conducted Antenna Port Tests):

Description	Asset	Manufacturer	Model	Cal Date	Cal Due
Base Station Simulator	8021	Rohde & Schwarz	CMW 500	9/23/2020	9/23/2021
Wideband Power Sensor	4022	Rohde&Schwarz	NRP-Z81	9/22/2020	9/22/2021
Spectrum Analyzer	3981	Rohde&Schwarz	FSU8	9/22/2020	9/22/2021
Environmental Chamber	3581	Thermotron	Chamber 6	8/6/2020	8/6/2021
Multimeter	3547	Fluke	115	8/5/2020	8/5/2021
Power Divider	1799	Weinschel	1594	Verify at Time of Use	Verify at Time of Use

5.4 Test Equipment Used (Radiated Tests):

Description	Asset	Manufacturer	Model	Cal Date	Cal Due
Base Station Simulator	8022	Rohde & Schwarz	CMW 500	9/22/2020	9/22/2021
EMI Test Receiver	3900	Rohde&Schwarz	ESU40	10/5/2020	10/5/2021
Magnetic Loop Antenna	2366	ETS	6502	7/17/2020	7/17/2021
Bilog Antenna (JB6)	7085	SunAR	JB6	9/4/2020	9/4/2021
Horn Antenna	4001	ETS	3117	1/26/2021	1/26/2022
Horn Antenna (18-40GHz)	3779	ETS	3116c	7/23/2020	7/23/2021
Preamplifier (18-40GHz)	3921	Rohde & Schwarz	TS-PR40	12/21/2020	12/21/2021
Coaxial Cable (40GHz)	7020			12/21/2020	12/21/2021
Coaxial Cable (40GHz)	7021			12/21/2020	12/21/2021
System Controller	4096	ETS Lindgren	2090	Verify at Time of Use	Verify at Time of Use
System Controller	3957	Sunol Sciences	SC99V	Verify at Time of Use	Verify at Time of Use
Coaxial Cable	3074			12/21/2020	12/21/2021
3m Cable Preamplifier	3918	Rohde&Schwarz	TS-PR18	12/21/2020	12/21/2021
Coaxial Cable	2588			12/21/2020	12/21/2021
Coaxial Cable	2593			12/21/2020	12/21/2021
Coaxial Cable	2592			12/21/2020	12/21/2021
Coaxial Cable	3339			12/21/2020	12/21/2021

5.5 Software Utilized:

Name	Manufacturer	Version
EMC32	Rohde&Schwarz	Version 9.15.02
TILE7	ETS Lindgren	Version 7.0.6.545
GPIBShot	Rohde&Schwarz	Version 2.7.2
Power Viewer Plus	Rohde&Schwarz	Version 6.1

6 Measurement Procedures and Determination of Worst-Case Modes

The occupied bandwidth, conducted spurious emissions, and conducted band edge measurements were all performed with the IoT Wearable Device connected to a spectrum analyzer via a power divider. A base station simulator was also connected to the power divider and used to configure the transmission. Measurements were performed per the procedures outlined in ANSI C63.26: 2015. See the summary tables for specific references to the appropriate sections that were used.

The output power and peak / average power ratio measurements were performed with the IoT Wearable Device connected to a wideband power meter via a power divider. A base station simulator was also connected to the power divider and used to configure the transmission. This power meter used a complementary cumulative distribution function (CCDF) for the peak / average power ratio measurements since the signals being measured were “noise-like”.

Frequency stability measurements were performed with the IoT Wearable Device connected directly to a base station simulator which had the capability to display frequency error from the test sample.

For conducted output power, occupied bandwidth, and conducted spurious emission measurements, testing was performed with all bandwidth and modulations supported.

For radiated spurious emission measurements, testing was performed with the bandwidth setting and modulation that produced the highest output power. The frequency spectrum was investigated from 9kHz to at least 10 times the highest frequency used or generated in the device or 40GHz (whichever was lower).

QPSK modulation was used for the conducted spurious emission, frequency stability, and radiated spurious emission measurements as it was demonstrated to be worst case based on the output power measurements. See ANSI C63.26 (5.7.2 (e)).

Testing was performed using 5MHz and 10MHz bandwidth settings for band 13. Since the actual CatM1 signal had a bandwidth of approximately 1MHz, the bandwidth settings had minimal or no impact on the measured values.

7 Occupied Bandwidth Data

TX Band	Modulation	BW Setting	Channel	26dB BW	99% BW
Band 13	QPSK	5MHz	Low	1.07MHz	939.1kHz
			Mid	1.30MHz	1.10MHz
			High	1.10MHz	932.6kHz
		10MHz	Mid	1.29MHz	1.10MHz

TX Band	Modulation	BW Setting	Channel	26dB BW	99% BW
Band 13	16QAM	5MHz	Low	1.13MHz	935.8kHz
			Mid	1.27MHz	1.10MHz
			High	1.13MHz	939.1kHz
		10MHz	Mid	1.27MHz	1.10MHz

8 Output Power and Peak / Average Ratio Data

TX Band	BW Setting	Channel	Cond. Power QPSK (dBm)	Cond. Power 16QAM (dBm)	Rad. Power QPSK (dBm)	Rad. Power 16QAM (dBm)	QPSK CCDF (0.1%)	16QAM CCDF (0.1%)
13	5MHz	Low	20.91	20.89	22.01	21.99	8.97	9.9
		Mid	20.91	20.77	22.01	21.87	8.85	8.88
		High	20.72	20.41	21.82	21.51	7.6	7.53
	10MHz	Mid	20.95	20.79	22.05	21.89	9.39	9.74
			20.82	20.76	21.92	21.86	9.68	10.83

The radiated power (in ERP) is equal to the conducted power plus the antenna gain (1.1Bi).

9 Frequency Stability Data

Transmit Band: 13
Operating Frequency: 782,000,000 Hz
Reference Voltage: 3.7 VDC
Deviation Limit: 1.5 ppm

Voltage %	Voltage (VDC)	Temp (°C)	Frequency Error (Hz)	Frequency Stability (ppm)	Limit (ppm)
100%	3.7	-40	14	0.0179028	1.50
100%	3.7	-30	13	0.0166240	1.50
100%	3.7	-20	15	0.0191816	1.50
100%	3.7	-10	13	0.0166240	1.50
100%	3.7	0	12	0.0153453	1.50
100%	3.7	10	10	0.0127877	1.50
100%	3.7	20	6	0.0076726	1.50
100%	3.7	30	8	0.0102302	1.50
100%	3.7	40	13	0.0166240	1.50
100%	3.7	50	17	0.0217391	1.50
100%	3.7	55	14	0.0179028	1.50
115%	4.255	20	13	0.0166240	1.50
85%	3.145	20	15	0.0191816	1.50

10 Worst Case Conducted Spurious Emission Data

TX Band	BW Setting	Band Edge	Spurious Frequency	RMS Amplitude (dBm)	Limit (dBm)	Margin (dB)
Band 13	5MHz	Low	2.405GHz	-34.83	-13	21.83
	5MHz	Mid	830.4MHz	-35.38	-13	22.38
	5MHz	High	2.405GHz	-36.22	-13	23.22
	10MHz	Mid	2.045GHz	-33.58	-13	20.58

11 Worst Case Conducted Band-Edge Emission Data

TX Band	BW Setting	Band Edge	Measured Frequency	RMS Amplitude (dBm)	Limit (dBm)	Margin (dB)
Band 13	5MHz	Low	772.91MHz	-38.59	-35	3.59
			774.25MHz	-36.32	-35	1.32
			775.72MHz	-34.2	-13	21.2
		High	791.5MHz	-44.05	-13	31.05
			790.83MHz	-46.73	-13	33.73
	10MHz	Low	773.16MHz	-39.75	-35	4.75
			775.17MHz	-34.6	-13	21.6
		High	788.94MHz	-30.34	-13	17.34
			793.82MHz	-40.4	-35	5.4

12 Worst Case Radiated Spurious Emissions Data

The data below represents the worst-case spurious emissions data with the sample positioned in three orthogonal axis.

9kHz – 30MHz (see note 1)

Frequency	Peak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
10.61kHz	62.39	82.25	19.86	200Hz	100	V	0 - 360	19.0
26.826kHz	55.52	82.25	26.73	200Hz	100	V	0 - 360	15.3
308.03kHz	49.37	82.25	32.88	9kHz	100	V	0 - 360	11.9
2.86MHz	30.52	82.25	51.73	9kHz	100	V	0 - 360	11.5
23.90MHz	18.92	82.25	63.33	9kHz	100	V	0 - 360	9.6

(1) This data represents a peak hold throughout a full rotation of the product and is represents worst case across all transmit modes and channels.

30MHz – 1GHz (see note 2)

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
46.436111	13.52	82.25	68.73	120.000	374.0	V	295.0	16.4
58.561111	15.25	82.25	67.00	120.000	104.1	V	74.0	14.8
69.877778	13.18	82.25	69.07	120.000	214.9	H	158.0	15.7
89.008333	13.78	82.25	68.47	120.000	342.6	V	64.0	16.8
114.497778	19.08	82.25	63.17	120.000	378.1	V	72.0	21.5
199.803889	20.17	82.25	62.08	120.000	105.0	V	144.0	21.9
405.066667	24.56	82.25	57.69	120.000	106.2	V	291.0	26.7
943.578333	37.38	82.25	44.87	120.000	189.7	H	72.0	37.4

(2) This data represents the worst case across all transmit modes and channels.

1GHz – 18GHz (low channel)

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
1556.000000	21.33	82.25	60.92	1000.000	109.0	H	0.0	-1.4
1572.500000	21.48	82.25	60.77	1000.000	295.0	H	191.0	-1.4
2334.000000	31.11	82.25	51.14	1000.000	100.0	H	282.0	3.6
2359.000000	25.30	82.25	56.95	1000.000	109.0	H	264.0	3.7
3145.500000	26.19	82.25	56.06	1000.000	100.0	H	214.0	5.3
3932.000000	27.83	82.25	54.42	1000.000	109.0	V	0.0	7.0
4718.500000	28.62	82.25	53.63	1000.000	109.0	H	291.0	8.0

1GHz – 18GHz (Mid channel)

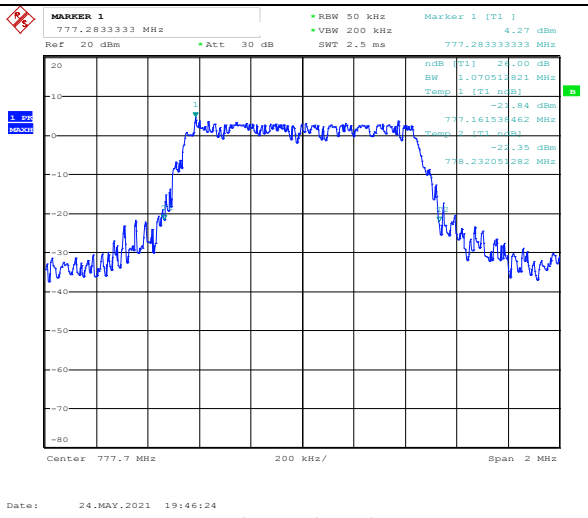
Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
1560.500000	27.62	82.25	54.63	1000.000	357.0	H	97.0	0.3
2173.500000	26.07	82.25	56.18	1000.000	140.0	V	82.0	4.0
2440.500000	27.15	82.25	55.10	1000.000	100.0	H	158.0	5.6
3323.500000	27.29	82.25	54.96	1000.000	100.0	V	304.0	6.8
4881.500000	29.53	82.25	52.72	1000.000	100.0	V	0.0	10.0
5752.000000	30.73	82.25	51.52	1000.000	100.0	V	252.0	10.8

1GHz – 18GHz (High channel)

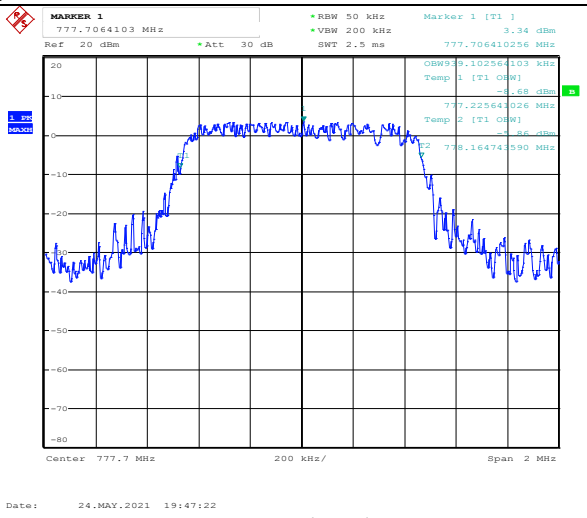
Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
1574.000000	22.55	82.25	59.70	1000.000	100.0	H	208.0	0.3
2352.000000	26.07	82.25	56.18	1000.000	100.0	V	302.0	5.1
3131.500000	27.16	82.25	55.09	1000.000	100.0	H	-1.0	6.6
3913.500000	27.54	82.25	54.71	1000.000	100.0	H	302.0	8.5

13 ANNEX A: Occupied Bandwidth Plots

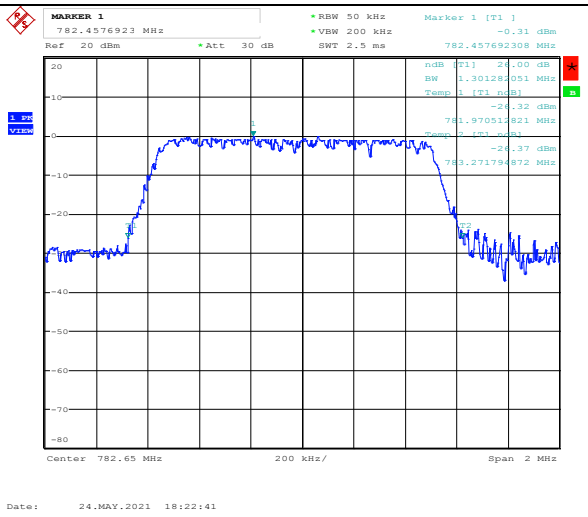
Band 13 QPSK Modulation, 5MHz Ch. Bandwidth



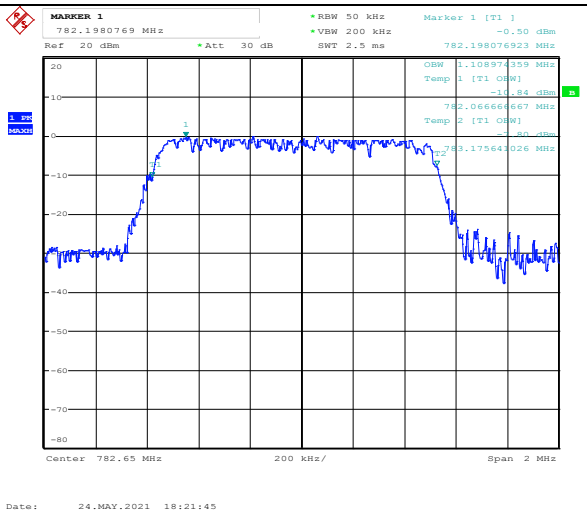
26dB Low Channel



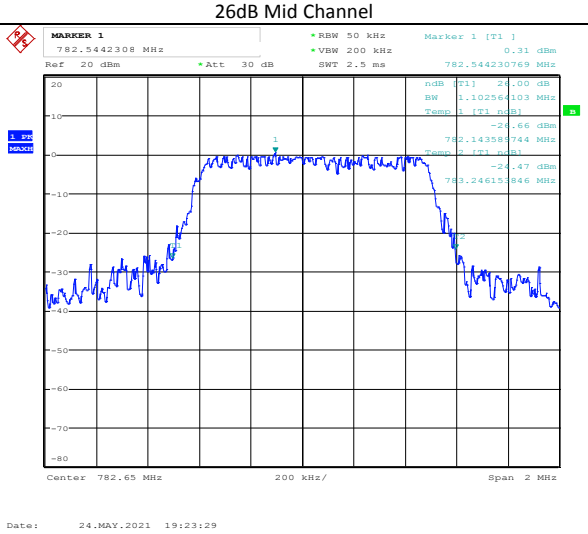
99% Low Channel



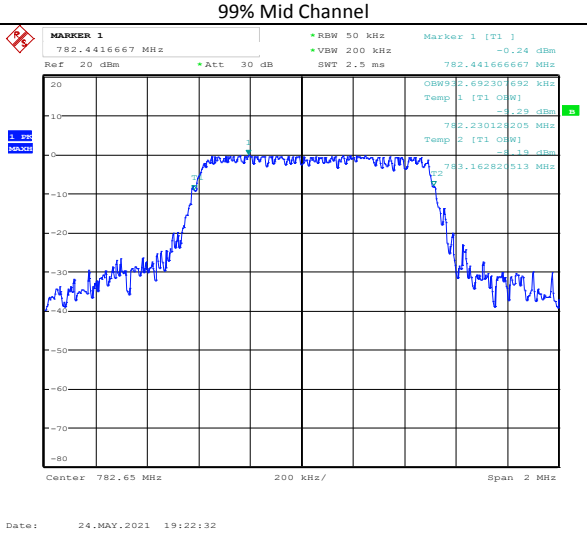
26dB Mid Channel



99% Mid Channel

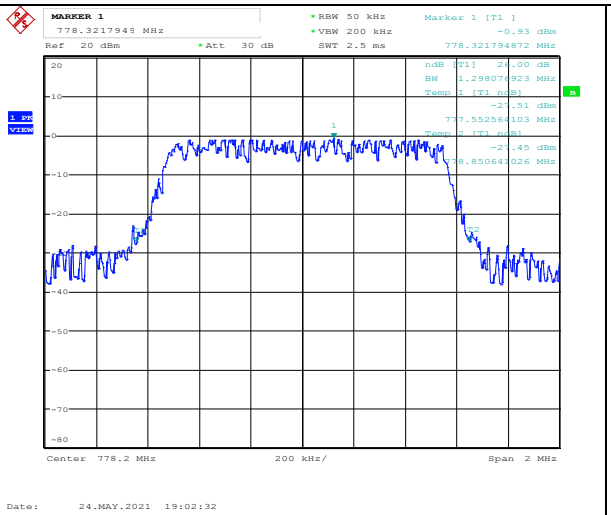


26dB High Channel

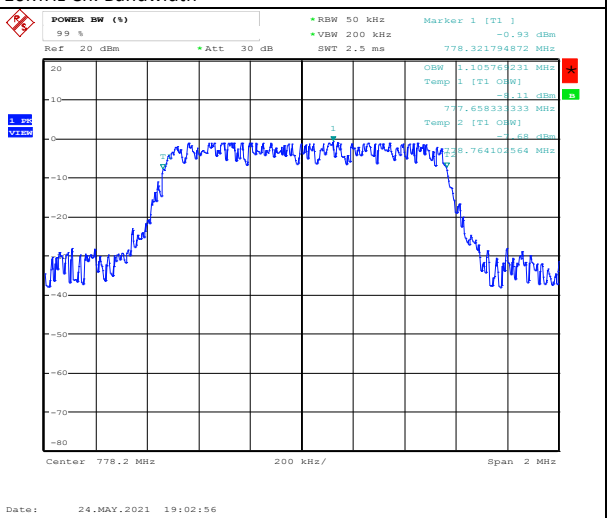


99% High Channel

Band 13 QPSK Modulation, 10MHz Ch. Bandwidth

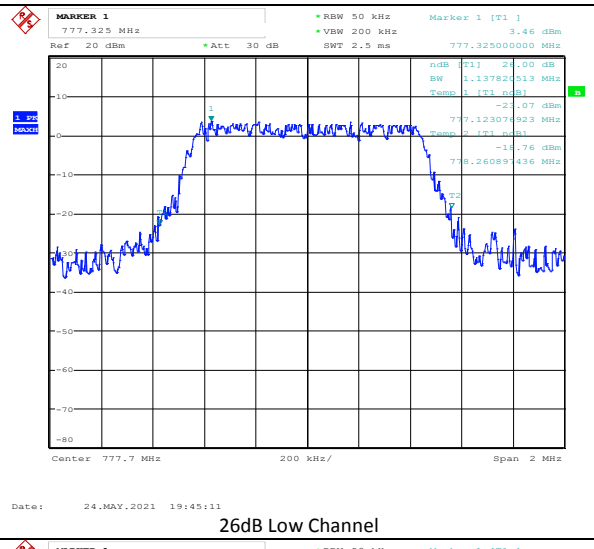


26dB Mid Channel

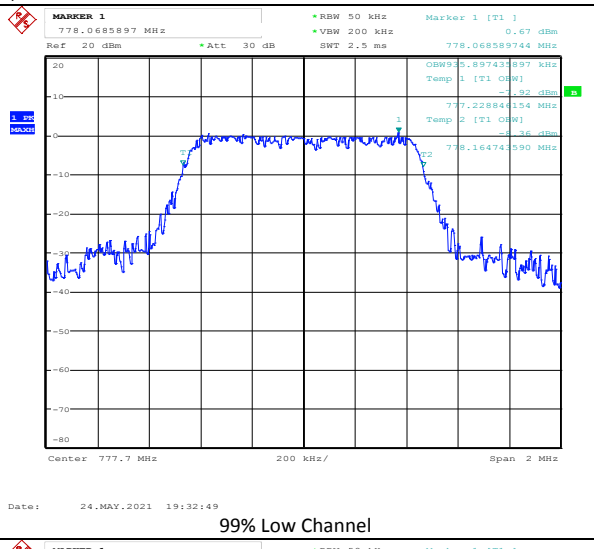


99% Mid Channel

Band 13 16QAM Modulation, 5MHz Ch. Bandwidth



26dB Low Channel



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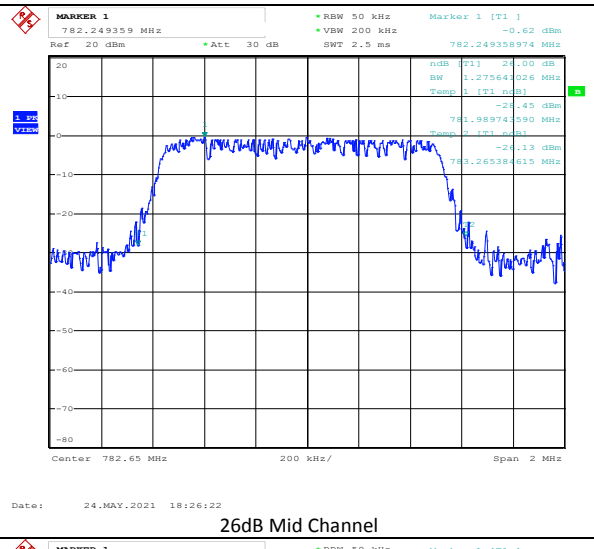
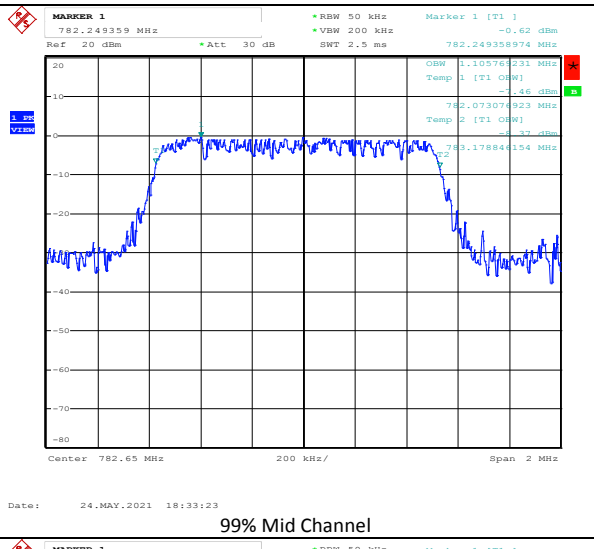
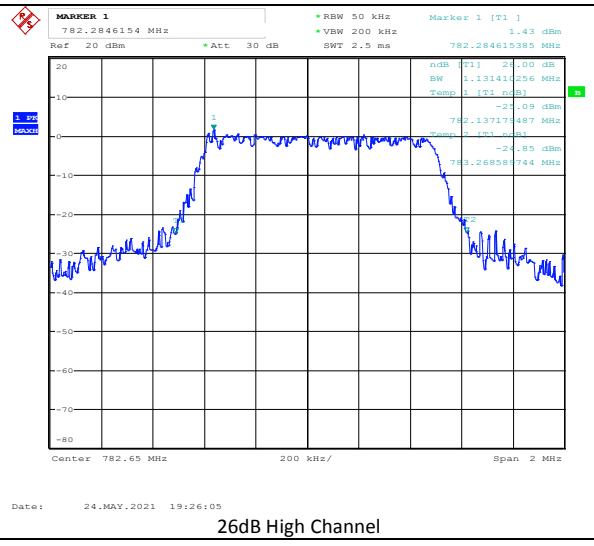


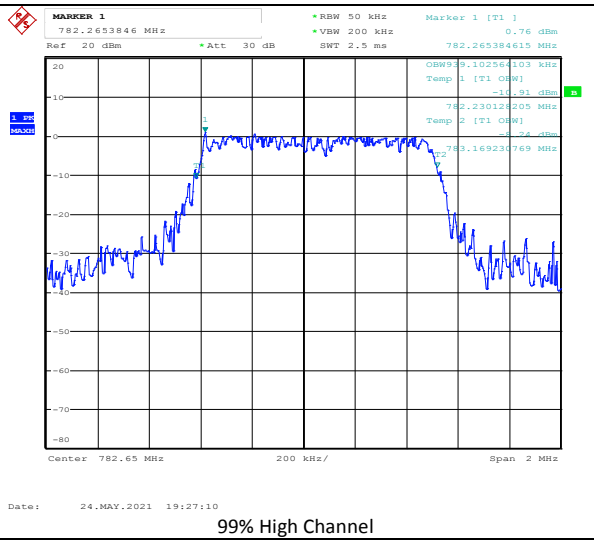
26dB Mid Channel



99% Mid Channel

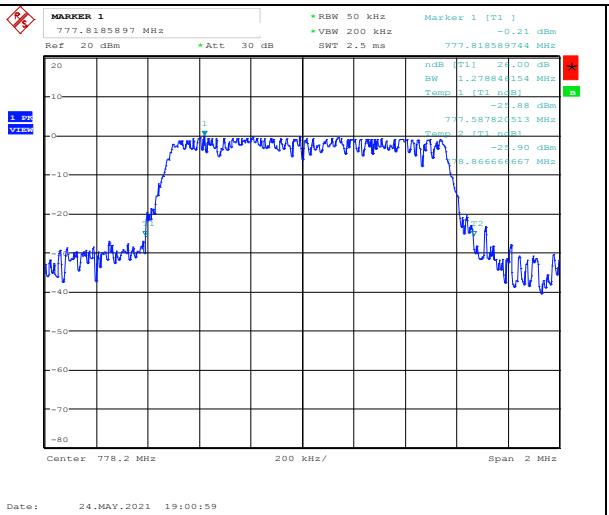


26dB High Channel

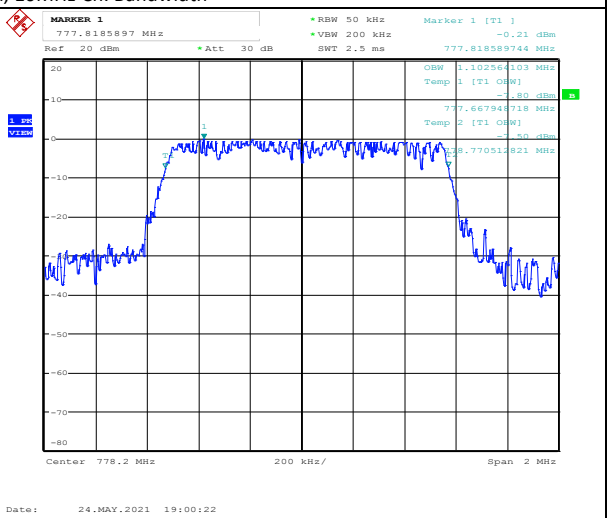


99% High Channel

Band 13 16QAM Modulation, 10MHz Ch. Bandwidth

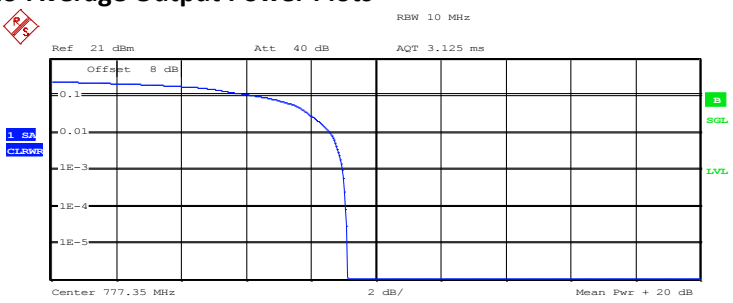


26dB Mid Channel



99% Mid Channel

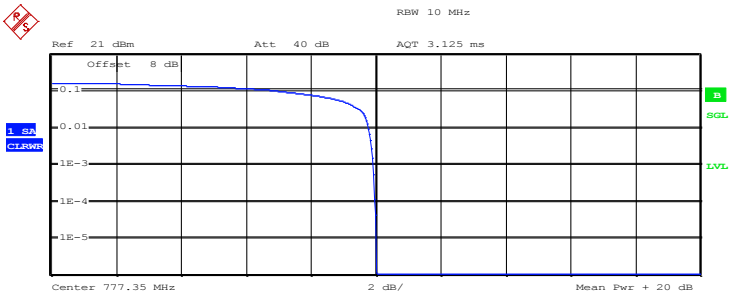
14 ANNEX B: Peak-to-Average Output Power Plots



Complementary Cumulative Distribution Function (100000 samples)

	Trace 1
Mean	9.86 dBm
Peak	18.96 dBm
Crest	9.11 dB
10% @	6.35 dB
1% @	8.56 dB
.1% @	8.97 dB

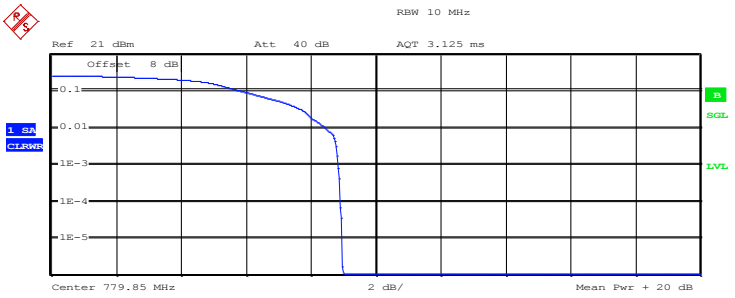
Peak to Average, Low Channel, 5MHz Channel Bandwidth, QPSK



Complementary Cumulative Distribution Function (100000 samples)

	Trace 1
Mean	7.83 dBm
Peak	17.83 dBm
Crest	10.00 dB
10% @	7.05 dB
1% @	9.78 dB
.1% @	9.90 dB

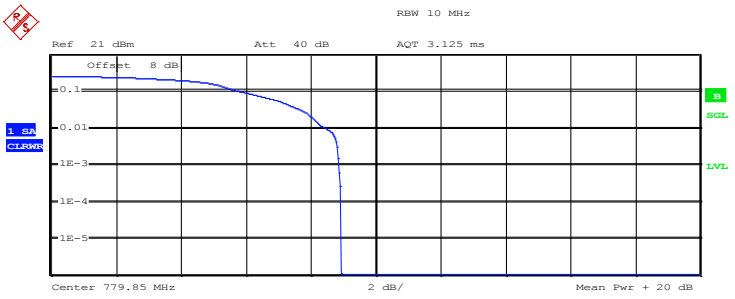
Peak to Average, Low Channel, 5MHz Channel Bandwidth, 16QAM



Complementary Cumulative Distribution Function (100000 samples)

	Trace 1
Mean	9.51 dBm
Peak	18.47 dBm
Crest	8.96 dB
10% @	5.87 dB
1% @	8.43 dB
.1% @	8.85 dB

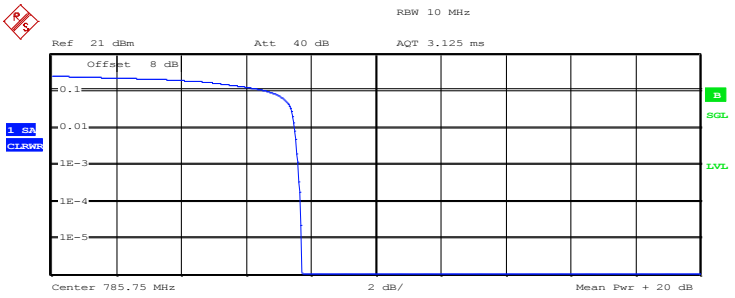
Peak to Average, Mid Channel, 5MHz Channel Bandwidth, QPSK



Complementary Cumulative Distribution Function (100000 samples)

	Trace 1
Mean	9.48 dBm
Peak	18.40 dBm
Crest	8.92 dB
10% @	5.83 dB
1% @	8.43 dB
.1% @	8.88 dB

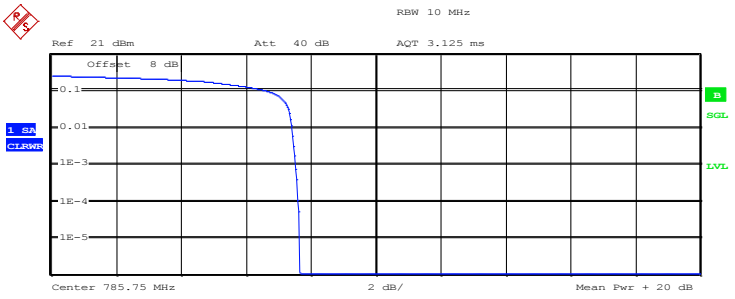
Peak to Average, Mid Channel, 5MHz Channel Bandwidth, 16QAM



Complementary Cumulative Distribution Function (100000 samples)

	Trace 1
Mean	11.14 dBm
Peak	18.82 dBm
Crest	7.68 dB
10% @	6.63 dB
1% @	7.50 dB
.1% @	7.60 dB

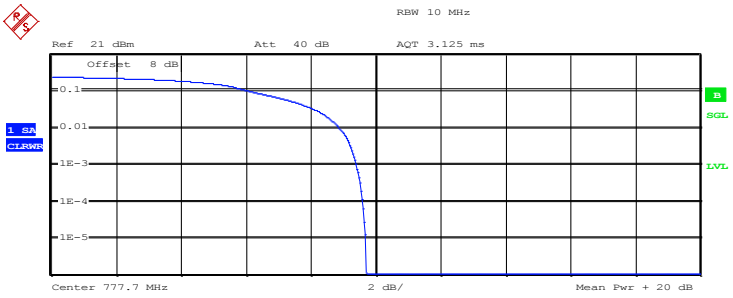
Peak to Average, High Channel, 5MHz Channel Bandwidth, QPSK



Complementary Cumulative Distribution Function (100000 samples)

	Trace 1
Mean	11.25 dBm
Peak	18.89 dBm
Crest	7.65 dB
10% @	6.63 dB
1% @	7.40 dB
.1% @	7.53 dB

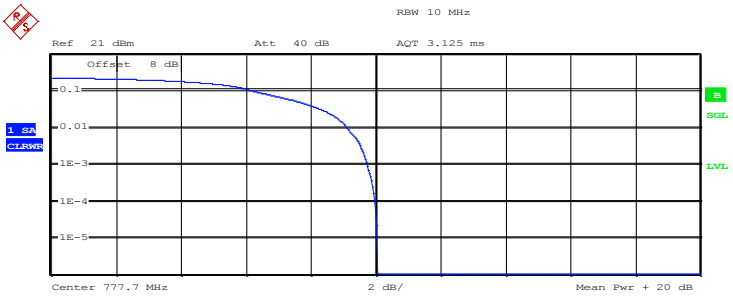
Peak to Average, High Channel, 5MHz Channel Bandwidth, 16QAM



Complementary Cumulative Distribution Function (100000 samples)

	Trace 1
Mean	9.34 dBm
Peak	19.03 dBm
Crest	9.69 dB
10% @	6.09 dB
1% @	8.85 dB
.1% @	9.39 dB

Peak to Average, 10MHz Channel Bandwidth, QPSK

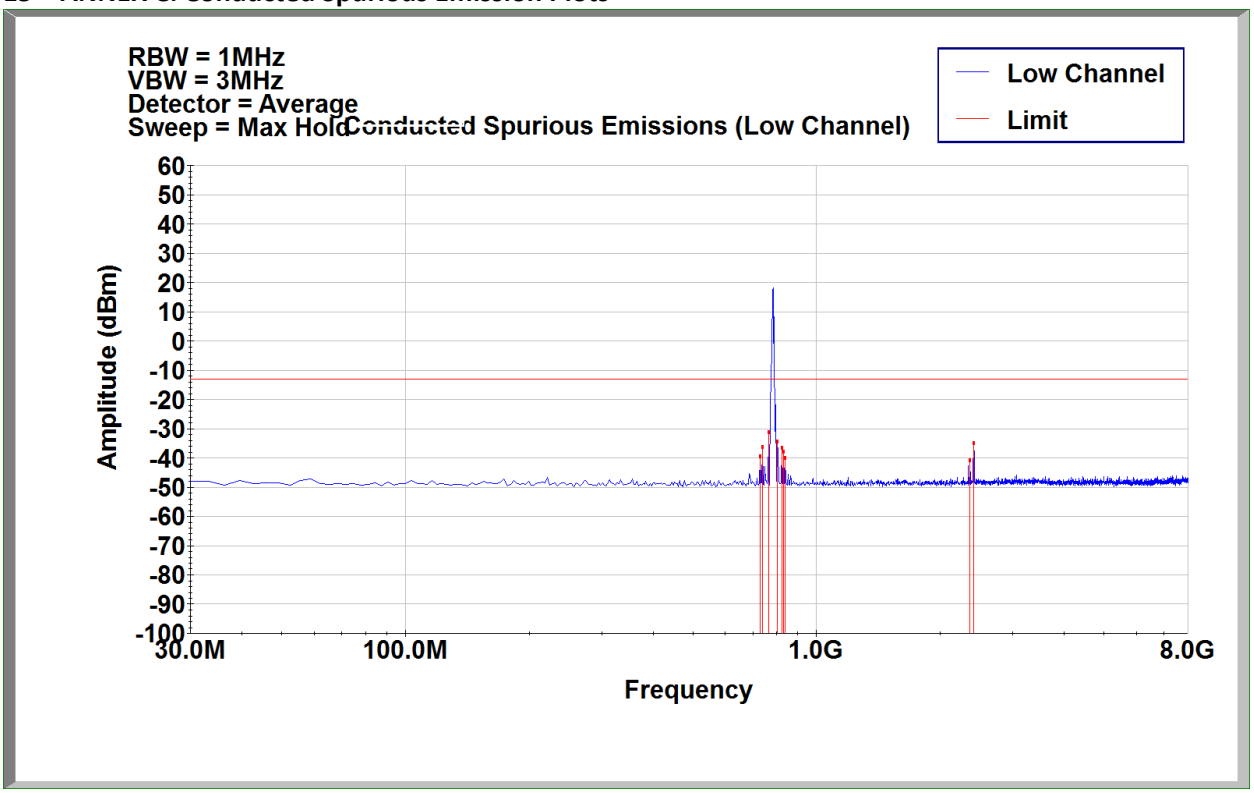


Complementary Cumulative Distribution Function (100000 samples)

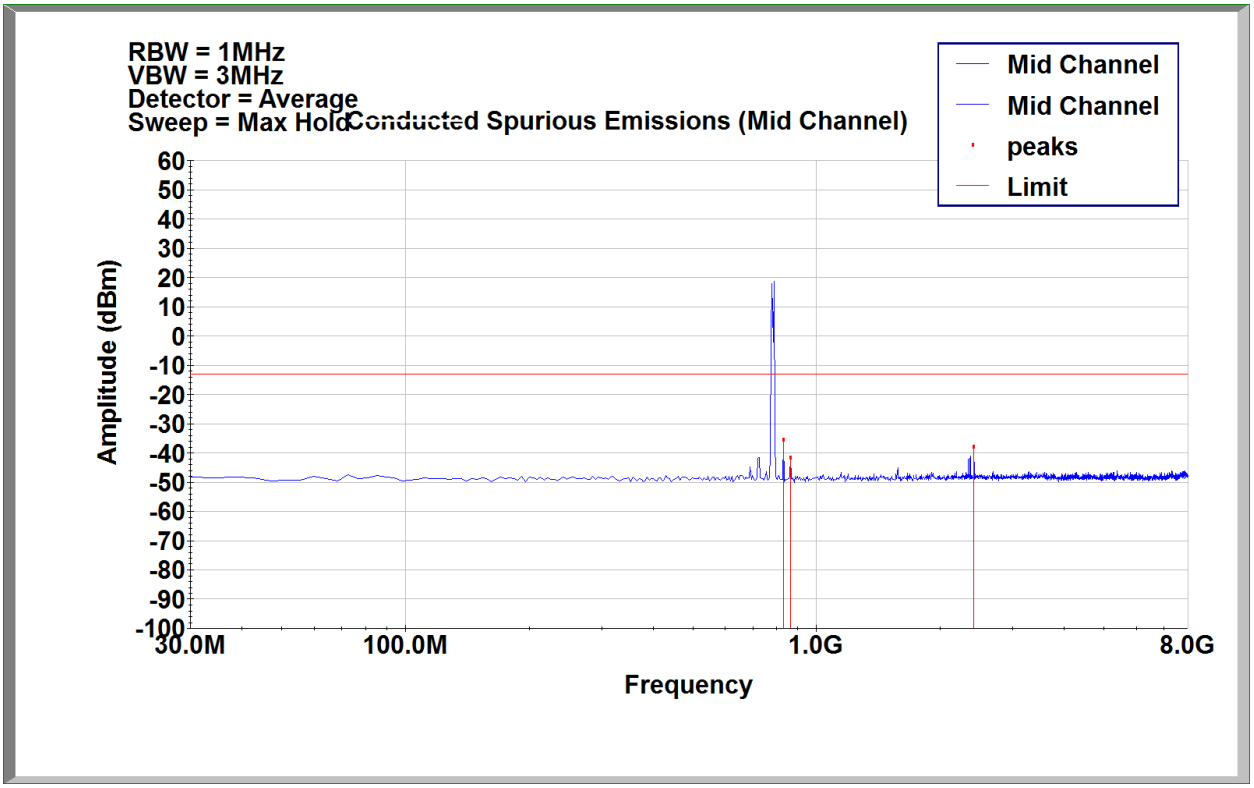
	Trace 1
Mean	8.92 dBm
Peak	18.96 dBm
Crest	10.04 dB
10% @	6.25 dB
1% @	9.10 dB
.1% @	9.74 dB

Peak to Average, 10MHz Channel Bandwidth, 16QAM

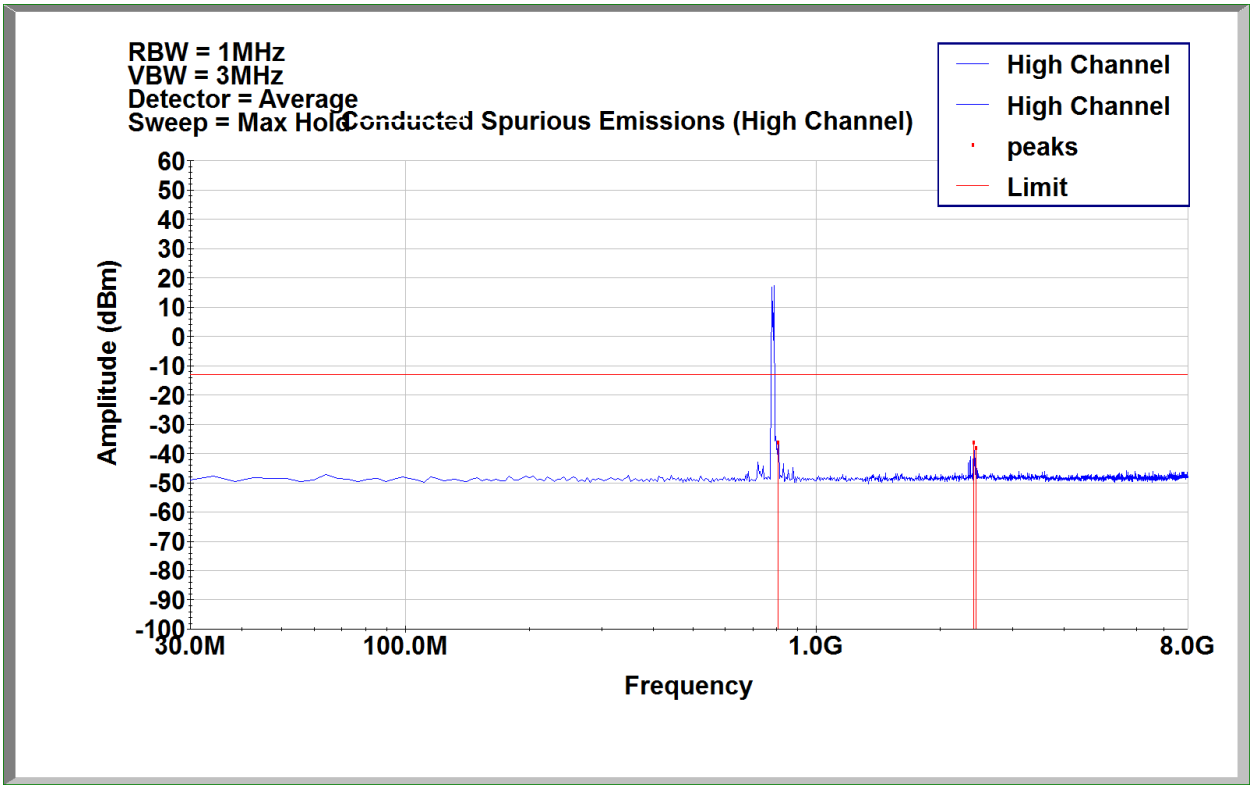
15 ANNEX C: Conducted Spurious Emission Plots



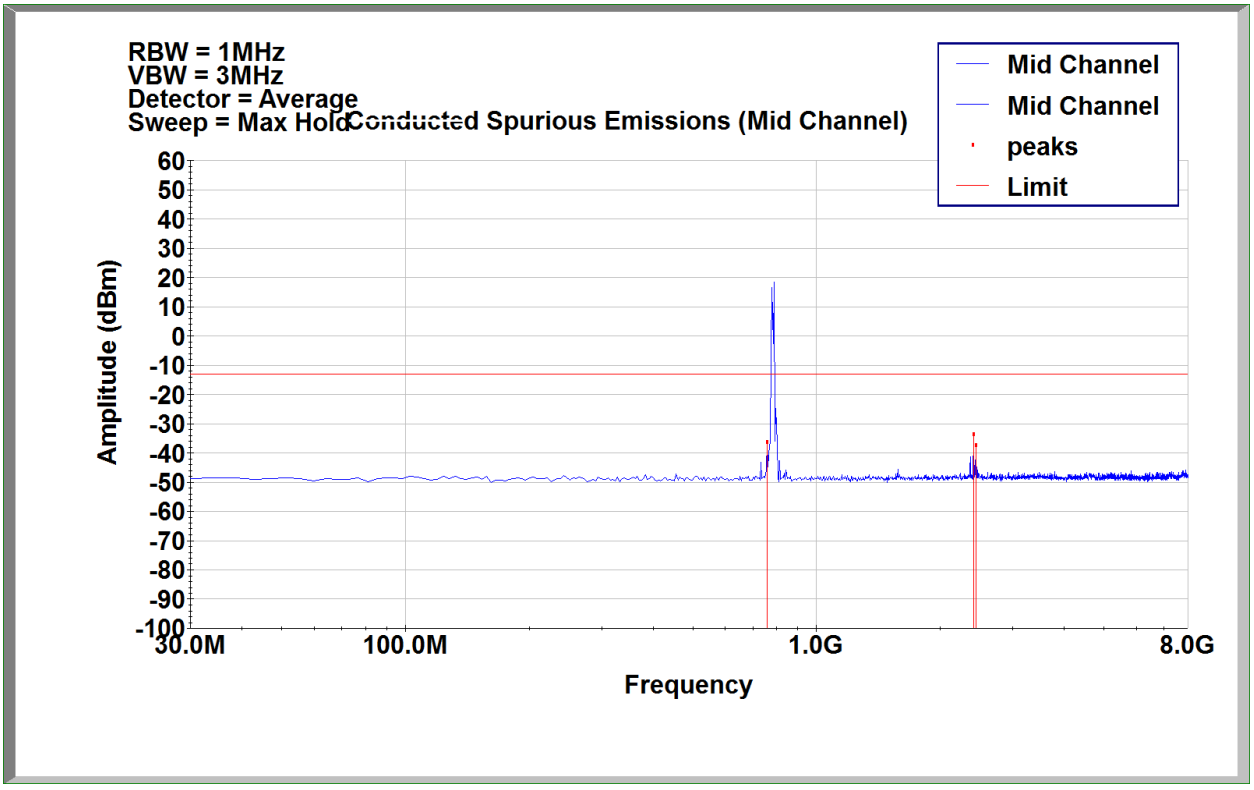
Conducted Spurious Emissions, 5MHz BW, Low Channel



Conducted Spurious Emissions, 5MHz BW, Mid Channel



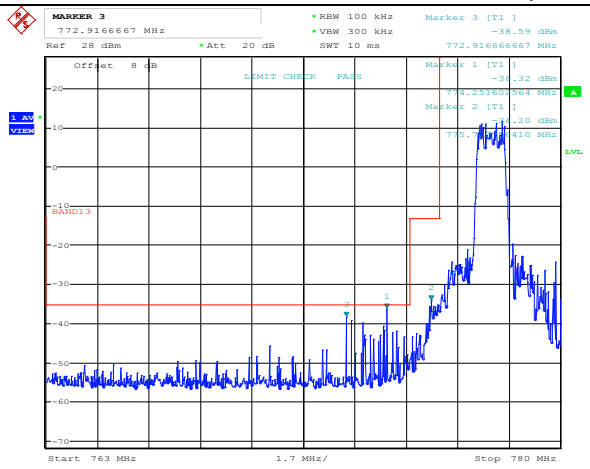
Conducted Spurious Emissions, 5MHz BW, High Channel



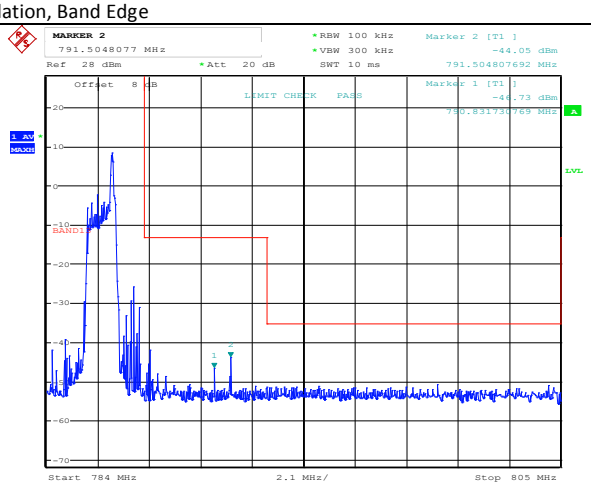
Conducted Spurious Emissions, 10MHz BW, Mid Channel

16 ANNEX D: Conducted Band Edge Plots

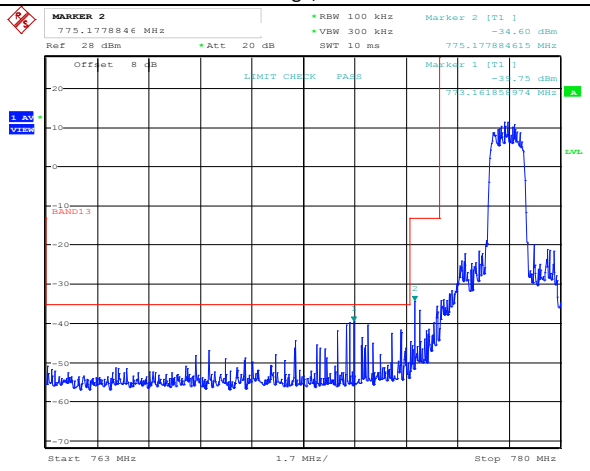
Band 13 QPSK Modulation, Band Edge



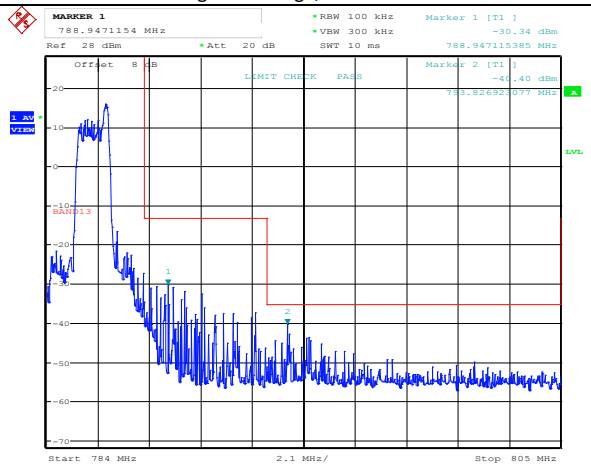
Low Band Edge, 5MHz BW



High Band Edge, 5MHz BW



Low Band Edge, 10MHz BW



High Band Edge, 10MHz BW

17 Revision History

Revision Level	Date	Report Number	Prepared By	Reviewed By	Notes
0	7/14/2021	104469626LEX-023	BCT	BL	Original Issue