FCC / ISED & Test Report

For:

u-blox AG

Model Name:

SARA-R412M

Product Description:

Cellular Module

Applied Rules and Standards:

47 CFR Parts 27
RSS-Gen Issue 5; RSS-130 Issue 1; RSS-139 Issue 3

FCC ID: XPYUBX18ZO01
IC ID: 8595A-UBX18ZO01

REPORT #: EMC_CTSMC-003-18001_FCC 27_Rev_1
DATE: 2019-1-21

A2LA Accredited

IC recognized # 3462B-2

***CETECOM* Inc.**
411 Dixon Landing Road ◆ Milpitas, CA 95035 ◆ U.S.A.
Phone: + 1 (408) 586 6200 ◆ Fax: + 1 (408) 586 6299 ◆ E-mail: info@cetecom.com ◆ http://www.cetecom.com
CETECOM Inc. is a Delaware Corporation with Corporation number: 2905571

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1 Assessment

The following device as further described in section 3 of this report was evaluated against the applicable criteria specified in the Code of Federal Regulations Title 47 parts 27, and ISED Standards: RSS-GEN; RSS-130 issue 1; RSS-139 issue 3.

No deficiencies were ascertained.

Company Name	Product Description	Model #
u-blox AG	Cellular Module	SARA-R412M

Responsible for Testing Laboratory:

Date	Section	Name	Signature
2018-12-20	Compliance	Cindy Li (Lab Manager EMC)	Cindy Li Digitally signed by Cindy Li DN: cn=Cindy Li, o=Cetecom Inc., ou=EMC, email=cindy.li@cetecom.com, c=US Date: 2019.01.22 18:31:45 -08'00'

Responsible for the Report:

Date	Section	Name	Signature
2018-12-20	Compliance	Kris Lazarov (EMC Engineer)	Digitally signed by Kris Lazarov Date: 2019.01.22 17:18:37 -08'00'

2 Administrative Data

2.1 Identification of the Testing Laboratory Issuing the EMC Test Report

Company Name:	CETECOM Inc.
Department:	Compliance
Street Address:	411 Dixon Landing Road
City/Zip Code	Milpitas, CA 95035
Country	USA
Telephone:	+1 (408) 586 6200
Fax:	+1 (408) 586 6299
Lab Manager EMC:	Cindy Li
Responsible Project Leader:	Kris Lazarov

2.2 Identification of the Client

Applicant's Name:	u-blox AG
Street Address:	Zuercherstrasse 68
City/Zip Code	Thalwil, CH-8800
Country	Switzerland

2.3 Identification of the Manufacturer

Manufacturer's Name:	Same as Applicant
Manufacturers Address:	
City/Zip Code	
Country	

3 Equipment Under Test (EUT)

3.1 EUT Specifications

Model No	SARA-R412M
HW Version	324A01
SW Version	M0.07.00
FCC-ID	XPYUBX18ZO01
IC-ID:	8595A-UBX18ZO01
HVIN:	SARA-R412M
PMN:	SARA-R412M
Product Description	Cellular Module
Transceiver Technology / Type(s) of Modulation	GSM 850 / 1900 / GMSK / 8PSK LTE Bands 2; 4; 5; 12; 13 / QPSK / 64-QAM
Frequency Range	GSM 850: Uplink: 824 – 850 MHz / Downlink: 869 – 894 MHz GSM 1900: Uplink: 1850 – 1910 MHz / Downlink: 1930 – 1990 MHz LTE Band 2: Uplink: 1850 – 1910 MHz / Downlink: 1930 – 1990 MHz LTE Band 4: Uplink: 1710 – 1755 MHz / Downlink: 2110 – 2155 MHz LTE Band 5: Uplink: 824 – 849 MHz / Downlink: 869 – 894 MHz LTE Band 12: Uplink: 699 – 716 MHz / Downlink: 729 – 746 MHz LTE Band 13: Uplink: 777 – 787 MHz / Downlink: 746 – 756 MHz
Max. declared antenna gain	GSM 850 = 1.71 dBi GSM 1900 = 2.32 dBi LTE Band 2 = 2.32 dBi LTE Band 4 = 1.57 dBi LTE Band 5 = 1.71 dBi LTE Band 12 = 2.83 dBi LTE Band 13 = 2.83 dBi
Power Supply/ Rated Operating Voltage Range	3.2VDC (Low) / 3.8VDC (Nominal) / 4.5VDC (Max)
Operating Temperature Range	–40°C ~ +85°C
Sample Revision	☐Prototype ■Production ☐ Pre-Production

3.2 EUT Sample details

EUT #	Serial Number	HW Version	SW Version	Comments
1	354679090052898	324A01	M0.07.00	

3.3 Accessory Equipment (AE) details

AE #	Type	Model	Manufacturer	Serial Number
1	AC Adapter	UUX324-1215	UNIFIVE	Jo1-0058452
2	LTE I-Bar	LTE 700~2800MHz	Taoglas	N/A

3.4 Test Sample Configuration

Set-up #	EUT / AE used for set-up	Comments
1	EUT#1+AE#1	
2	EUT#1+AE#1+AE#2	

3.5 Operating Mode

Operating Mode #	Description	Comments
1	CAT M1	Established link with base station simulator in CAT M1 mode.
2	NB IoT	Established link with base station simulator in NB IoT mode.

4 Subject of Investigation

The objective of the measurements done by CETECOM Inc. was to evaluate the compliance of the EUT against the relevant requirements specified in the Code of Federal Regulations Title 47 parts 27, and ISED Standards: RSS-GEN; RSS-130 issue 1; RSS-139 issue 3.

4.1 Dates of Testing:

10/10/2018 - 10/25/2018

4.2 Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus, with 95% confidence interval (in dB delta to result), based on a coverage factor k=1.

Radiated measurement

9 kHz to 30MHz	±2.5 dB (Magnetic Loop Antenna)
30 MHz to 1000 MHz	±2.0 dB (Biconilog Antenna)
1 GHz to 40 GHz	±2.3 dB (Horn Antenna)

Conducted measurement

150 kHz to 30 MHz	±0.7 dB (LISN)
RF conducted measurement	±0.5 dB

4.3 Environmental Conditions during Testing:

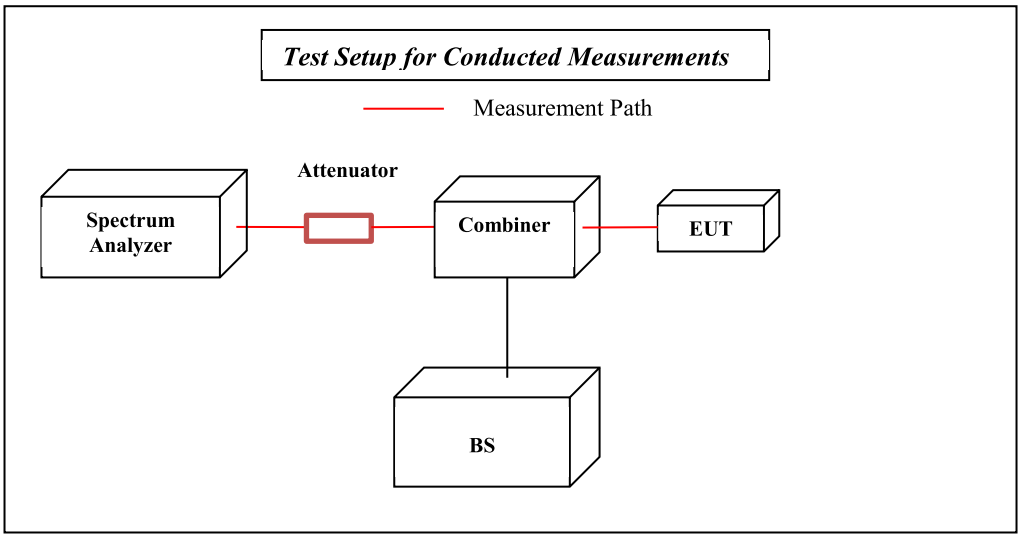
The following environmental conditions were maintained during the course of testing:

- Ambient Temperature: 20-25°C
- Relative humidity: 40-60%

Deviating test conditions are indicated at individual test description where applicable.

5 Measurement Procedures

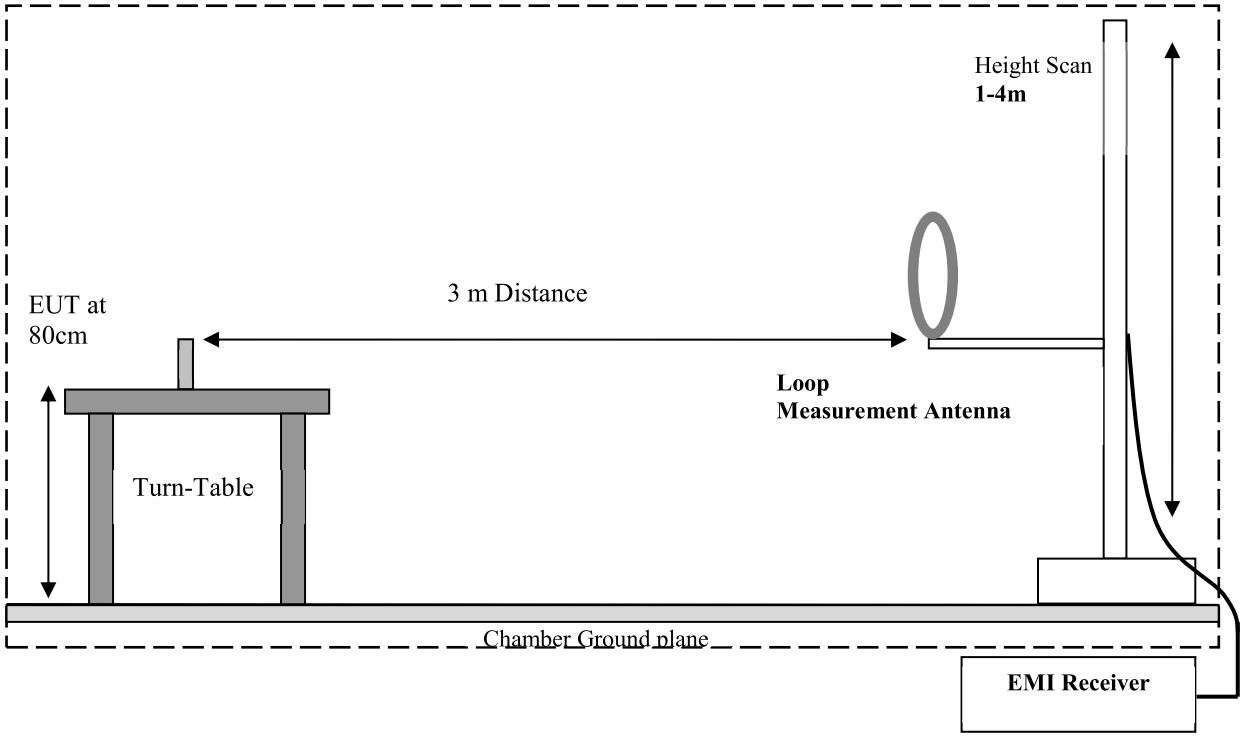
Testing is performed according to the guidelines provided in FCC publication (KDB) 971168 D01 and ANSI C63.26-2015 as detailed below.



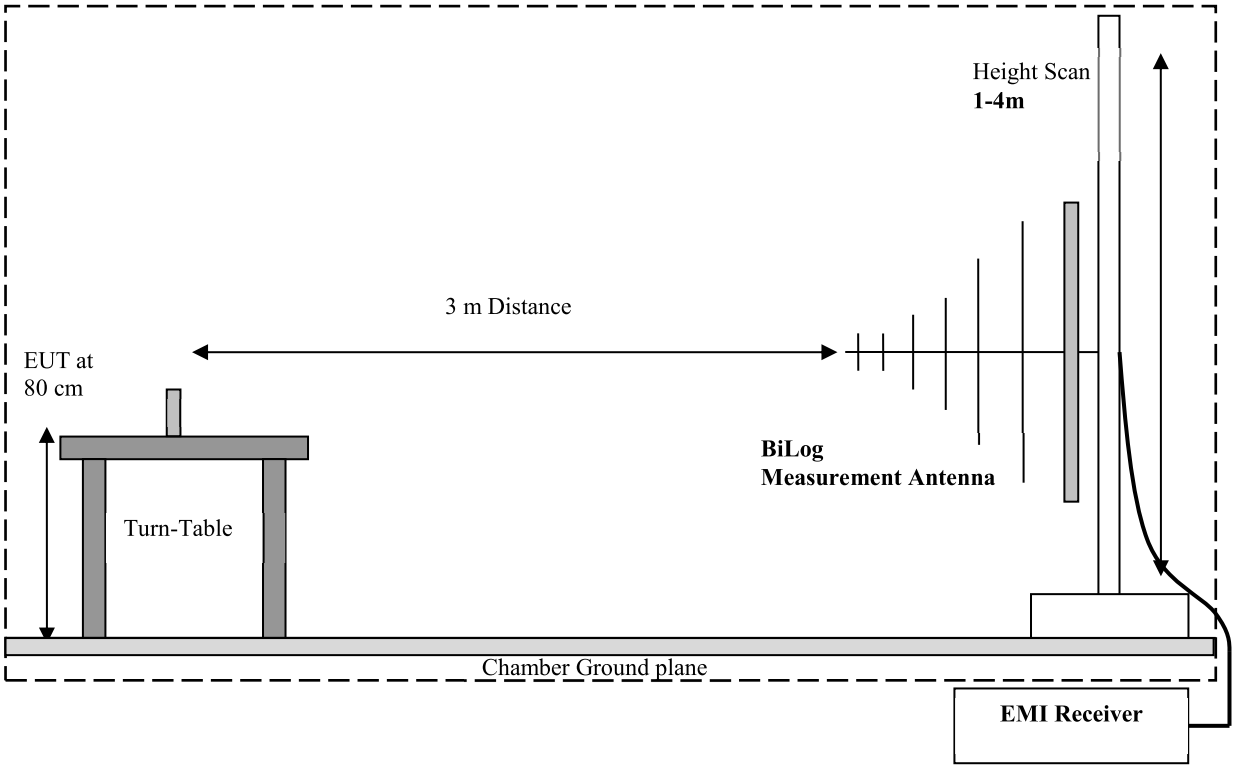
5.1 Radiated Measurement

- The exploratory measurement is accomplished by running a matrix of 16 sweeps over the required frequency range with R&S Test-SW EMC32 for 4 positions of the turntable, two orthogonal positions of the EUT and both antenna polarizations. This procedure exceeds the requirement of the above standards to cover the 3 orthogonal axis of the EUT. A max peak detector is utilized during the exploratory measurement. The Test-SW creates an overall maximum trace for all 12 sweeps and saves the settings for each point of this trace. The maximum trace is part of the test report.
- The 10 highest emissions are selected with an automatic algorithm of EMC32 searching for peaks in the noise floor and ensuring that broadband signals are not selected multiple times.
- The maxima are then put through the final measurement and again maximized in a 90deg range of the turntable, fine search in frequency domain and height scan between 1m and 4m.
- The above procedure is repeated for all possible ways of power supply to EUT and for all supported modulations.
- In case there are no emissions above noise floor level only the maximum trace is reported as described above.
- The results are split up into up to 4 frequency ranges due to antenna bandwidth restrictions. A magnetic loop is used from 9 kHz to 30 MHz, a Biconilog antenna is used from 30 MHz to 1 GHz, and two different horn antennas are used to cover frequencies up to 40 GHz.

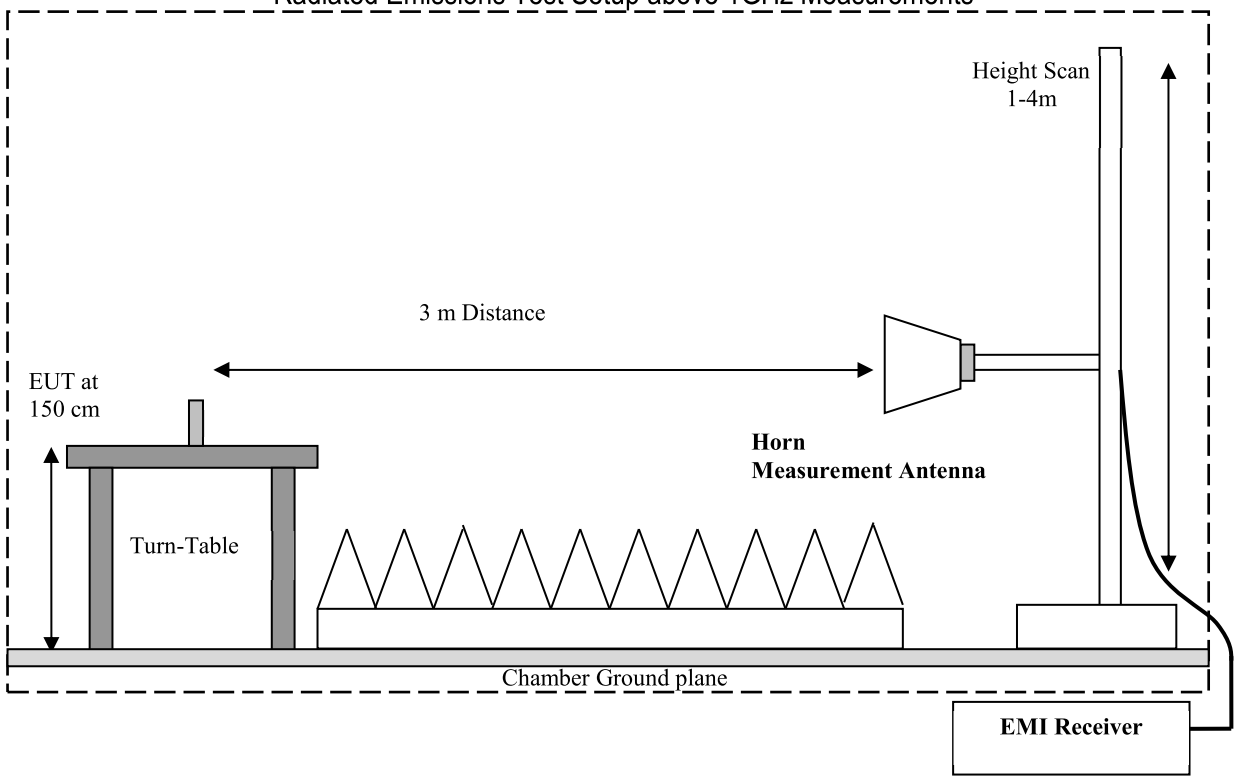
Radiated Emissions Test Setup below 30MHz Measurements



Radiated Emissions Test Setup 30MHz-1GHz Measurements



Radiated Emissions Test Setup above 1GHz Measurements



5.2 Sample Calculations for Field Strength Measurements

Field Strength is calculated from the Spectrum Analyzer/ Receiver readings, taking into account the following parameters:

- Measured reading in dBµV
- Cable Loss between the receiving antenna and SA in dB and
- Antenna Factor in dB/m

All radiated measurement plots in this report are taken from a test SW that calculates the Field Strength based on the following equation:

FS (dBµV/m) = Measured Value on SA (dBµV)- Cable Loss (dB)+ Antenna Factor (dB/m)

Example:

Frequency (MHz)	Measured SA (dBµV)	Cable Loss (dB)	Antenna Factor Correction (dB)	Field Strength Result (dBµV/m)
1000	80.5	3.5	14	98.0

6 Measurement Results Summary

Test Specification	Test Case	Temperature and Voltage Conditions	Mode	Pass	Fail	NA	NP	Result
§2.1046; §27.50 RSS-130 4.4 RSS-139 6.5	RF Output Power	Nominal	CAT M1 NB IoT	■	☐	☐	☐	Complies
§2.1055; §27.54 RSS-130 4.3 RSS-139 6.4	Frequency Stability	Extreme Temperature and Voltage	CAT M1 NB IoT	■	☐	☐	☐	Complies
§2.1049; §27.53 RSS-130 3.1 RSS-139 6.2	Occupied Bandwidth	Nominal	CAT M1 NB IoT	■	☐	☐	☐	Complies
§2.1051; §27.53 RSS-130 4.6 RSS-139 6.6	Band Edge Compliance	Nominal	CAT M1 NB IoT	■	☐	☐	☐	Complies
§2.1051; §27.53 RSS-130 4.6 RSS-139 6.6	Conducted Spurious Emissions	Nominal	CAT M1 NB IoT	■	☐	☐	☐	Complies
§2.1053; §27.53 RSS-130 4.6 RSS-139 6.6	Radiated Spurious Emissions	Nominal	CAT M1 NB IoT	■	☐	☐	☐	Complies

Note 1: NA= Not Applicable; NP= Not Performed.

Testing Notes

The RF output power and occupied bandwidth for LTE Cat M1 was tested with the TX configured to QPSK and 16QAM modulation. The results with 16QAM were the highest bandwidth, so this mode was used for the rest of testing and recorded in this report.

7 Test Result Data

7.1 RF Output Power

7.1.1 Conducted Measurement utilizing KDB 971168 D01 and ANSI C63.26-2015 Subclause 5.2.3.4

Spectrum Analyzer settings for CCDF procedure for PAPR measurements:

- RBW ≥ OBW
- Number of counts = 10000
- Sweep time ≥ 1ms
- Record the maximum PAPR level associated with a probability of 0.1%

7.1.2 Limits:

7.1.2.1 FCC Part 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 (34.8 dBm).
(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 (34.8 dBm).
(d); (4) Fixed, mobile, and portable (hand-held) stations operating in the 1710-1755 MHz band and mobile and portable stations operating in the 1695-1710 MHz and 1755-1780 MHz bands are limited to 1 watt EIRP (30 dBm).

7.1.2.2 RSS-130 Part 4.4 Transmitter Output Power

The e.i.r.p. shall not exceed 50 watts for mobile equipment or for outdoor fixed subscriber equipment, nor shall it exceed 5 watts for portable equipment or for indoor fixed subscriber equipment.
In addition, the peak-to-average power ratio (PAPR) of the transmitter shall not exceed 13 dB for more than 0.1% of the time and shall use a signal corresponding to the highest PAPR during periods of continuous transmission.

7.1.2.3 RSS-139 Part 6.5 Transmitter Output Power

The equivalent isotropically radiated power (e.i.r.p.) for mobile and portable transmitters shall not exceed one watt. The e.i.r.p. for fixed and base stations in the band 1710-1780 MHz shall not exceed one watt.
Consult SRSP-513 for e.i.r.p. limits on fixed and base stations operating in the band 2110-2180 MHz.
In addition, the peak to average power ratio (PAPR) of the equipment shall not exceed 13 dB for more than 0.1% of the time, using a signal that corresponds to the highest PAPR during periods of continuous transmission.

7.1.3 Test conditions and setup:

Ambient Temperature (C)	EUT Set-Up #	EUT operating mode	Power Input (VDC)	Measurement Path Correction (dB)
22	1	1 and 2	110V / 60 Hz	35

7.1.4 Measurement result ERP / EIRP:

Plot #	Chanel #	Frequency (MHz)	Maximum AVG Conducted Output Power (dBm)	Antenna Gain (dBi)	Calc. ERP/EIRP (dBm)	Limit (dBm)	Result
1	CAT M1 B4 16QAM 6RB / low	1710.7	21.30	1.57	22.87	< 30 ERP	Pass
	CAT M1 B4 16QAM 1RB / low	1710.7	22.81	1.57	24.38	< 30 ERP	Pass
2	CAT M1 B4 16QAM 6RB / mid	1732.5	20.29	1.57	21.86	< 30 ERP	Pass
	CAT M1 B4 16QAM 1RB / mid	1732.5	22.16	1.57	23.73	< 30 ERP	Pass
3	CAT M1 B4 16QAM 6RB / high	1754.3	20.44	1.57	22.01	< 30 ERP	Pass
	CAT M1 B4 16QAM 1RB / high	1754.3	22.05	1.57	23.62	< 30 ERP	Pass
4	CAT M1 B4 QPSK 6RB / low	1710.7	21.34	1.57	22.91	< 30 ERP	Pass
	CAT M1 B4 QPSK 1RB / low	1710.7	23.42	1.57	24.99	< 30 ERP	Pass
5	CAT M1 B4 QPSK 6RB / mid	1732.5	20.54	1.57	22.11	< 30 ERP	Pass
	CAT M1 B4 QPSK 1RB / mid	1732.5	22.46	1.57	24.03	< 30 ERP	Pass
6	CAT M1 B4 QPSK 6RB / high	1754.3	20.42	1.57	21.99	< 30 ERP	Pass
	CAT M1 B4 QPSK 1RB / high	1754.3	22.16	1.57	23.73	< 30 ERP	Pass
7	NB IoT B4 / low	1710	19.95	1.57	21.52	< 30 ERP	Pass
8	NB IoT B4 / mid	1723.5	19.63	1.57	21.2	< 30 ERP	Pass
9	NB IoT B4 / high	1754.9	19.71	1.57	21.28	< 30 ERP	Pass
10	CAT M1 B12 16QAM 6RB / low	699.7	20.13	2.83	22.96	< 37 ERP	Pass
	CAT M1 B12 16QAM 1RB / low	699.7	23.45	2.83	26.28	< 37 ERP	Pass
11	CAT M1 B12 16QAM 6RB / mid	707.5	20.08	2.83	22.91	< 37 ERP	Pass
	CAT M1 B12 16QAM 1RB / mid	707.5	23.42	2.83	26.25	< 37 ERP	Pass
12	CAT M1 B12 16QAM 6RB / high	715.3	19.92	2.83	22.75	< 37 ERP	Pass
	CAT M1 B12 16QAM 1RB / high	715.3	23.28	2.83	26.11	< 37 ERP	Pass
13	CAT M1 B12 QPSK 6RB / low	699.7	20.04	2.83	22.87	< 37 ERP	Pass
	CAT M1 B12 QPSK 1RB / low	699.7	24.09	2.83	26.92	< 37 ERP	Pass
14	CAT M1 B12 QPSK 6RB / mid	707.5	19.87	2.83	22.70	< 37 ERP	Pass
	CAT M1 B12 QPSK 1RB / mid	707.5	24.01	2.83	26.84	< 37 ERP	Pass
15	CAT M1 B12 QPSK 6RB / high	715.3	19.86	2.83	22.69	< 37 ERP	Pass
	CAT M1 B12 QPSK 1RB / high	715.3	23.98	2.83	26.81	< 37 ERP	Pass
16	NB IoT B12 / low	699	20.90	2.83	23.73	< 37 ERP	Pass
17	NB IoT B12 / mid	707.5	20.86	2.83	23.69	< 37 ERP	Pass
18	NB IoT B12 / high	715.9	20.94	2.83	23.77	< 37 ERP	Pass
19	CAT M1 B13 16QAM 6RB / low	778.24	21.94	2.83	24.77	< 37 ERP	Pass
	CAT M1 B13 16QAM 1RB / low	778.24	22.20	2.83	25.03	< 37 ERP	Pass
20	CAT M1 B13 16QAM 6RB / mid	782.5	20.80	2.83	23.63	< 37 ERP	Pass
	CAT M1 B13 16QAM 1RB / mid	782.5	23.95	2.83	26.78	< 37 ERP	Pass
21	CAT M1 B13 16QAM 6RB / high	785.8	19.56	2.83	22.39	< 37 ERP	Pass
	CAT M1 B13 16QAM 1RB / high	785.8	22.36	2.83	25.19	< 37 ERP	Pass
22	CAT M1 B13 QPSK 6RB / low	778.24	22.47	2.83	25.30	< 37 ERP	Pass
	CAT M1 B13 QPSK 1RB / low	778.24	22.13	2.83	24.96	< 37 ERP	Pass
23	CAT M1 B13 QPSK 6RB / mid	782.5	21.48	2.83	24.31	< 37 ERP	Pass
	CAT M1 B13 QPSK 1RB / mid	782.5	23.76	2.83	26.59	< 37 ERP	Pass
24	CAT M1 B13 QPSK 6RB / high	785.8	20.45	2.83	23.28	< 37 ERP	Pass
	CAT M1 B13 QPSK 1RB / high	785.8	22.43	2.83	25.26	< 37 ERP	Pass
25	NB IoT B13 / low	777	20.44	2.83	23.27	< 37 ERP	Pass
26	NB IoT B13 / mid	782	20.25	2.83	23.08	< 37 ERP	Pass
27	NB IoT B13 / high	787	20.73	2.83	23.56	< 37 ERP	Pass

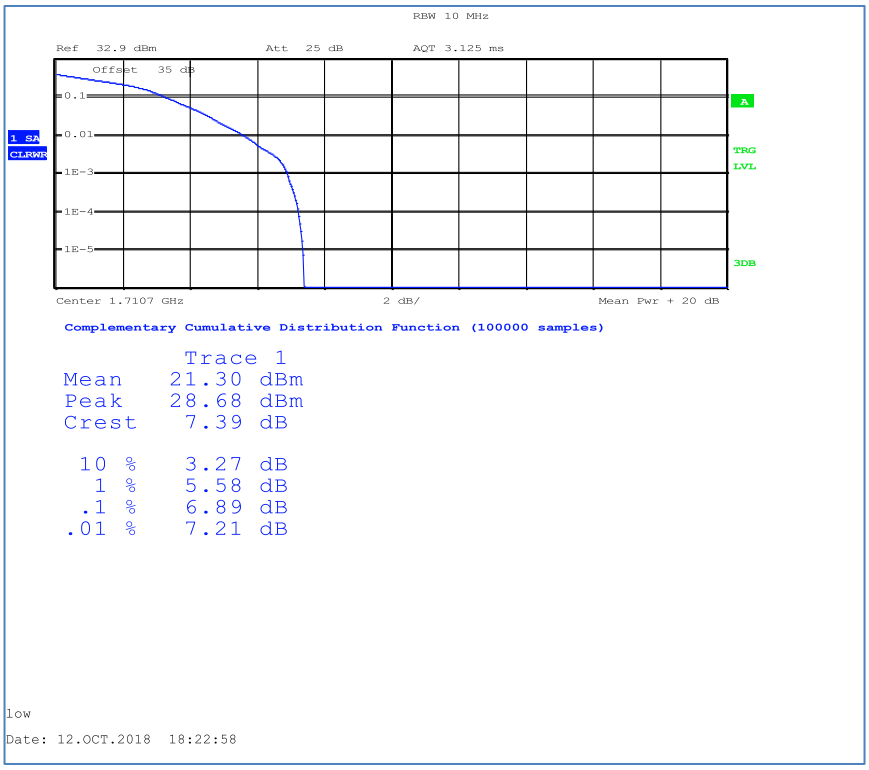
7.1.5 Peak-to-average power ratio:

Plot #	Chanel #	Frequency (MHz)	PAPR level at 0.1% probability (dB)	Limit (dB)	Result
1	CAT M1 B4 16QAM 6RB / low	1710.7	6.89	< 13	Pass
	CAT M1 B4 16QAM 1RB / low	1710.7	6.09	< 13	Pass
2	CAT M1 B4 16QAM 6RB / mid	1732.5	6.83	< 13	Pass
	CAT M1 B4 16QAM 1RB / mid	1732.5	5.99	< 13	Pass
3	CAT M1 B4 16QAM 6RB / high	1754.3	6.60	< 13	Pass
	CAT M1 B4 16QAM 1RB / high	1754.3	5.87	< 13	Pass
4	CAT M1 B4 QPSK 6RB / low	1710.7	6.03	< 13	Pass
	CAT M1 B4 QPSK 1RB / low	1710.7	5.26	< 13	Pass
5	CAT M1 B4 QPSK 6RB / mid	1732.5	5.90	< 13	Pass
	CAT M1 B4 QPSK 1RB / mid	1732.5	5.51	< 13	Pass
6	CAT M1 B4 QPSK 6RB / high	1754.3	5.71	< 13	Pass
	CAT M1 B4 QPSK 1RB / high	1754.3	5.06	< 13	Pass
7	NB IoT B4 / low	1710	8.65	< 13	Pass
8	NB IoT B4 / mid	1723.5	8.62	< 13	Pass
9	NB IoT B4 / high	1754.9	8.37	< 13	Pass
10	CAT M1 B12 16QAM 6RB / low	699.7	8.24	< 13	Pass
	CAT M1 B12 16QAM 1RB / low	699.7	5.83	< 13	Pass
11	CAT M1 B12 16QAM 6RB / mid	707.5	8.24	< 13	Pass
	CAT M1 B12 16QAM 1RB / mid	707.5	5.80	< 13	Pass
12	CAT M1 B12 16QAM 6RB / high	715.3	8.17	< 13	Pass
	CAT M1 B12 16QAM 1RB / high	715.3	5.80	< 13	Pass
13	CAT M1 B12 QPSK 6RB / low	699.7	7.24	< 13	Pass
	CAT M1 B12 QPSK 1RB / low	699.7	5.00	< 13	Pass
14	CAT M1 B12 QPSK 6RB / mid	707.5	7.28	< 13	Pass
	CAT M1 B12 QPSK 1RB / mid	707.5	4.94	< 13	Pass
15	CAT M1 B12 QPSK 6RB / high	715.3	7.24	< 13	Pass
	CAT M1 B12 QPSK 1RB / high	715.3	4.90	< 13	Pass
16	NB IoT B12 / low	699	8.33	< 13	Pass
17	NB IoT B12 / mid	707.5	8.30	< 13	Pass
18	NB IoT B12 / high	715.9	8.49	< 13	Pass
19	CAT M1 B13 16QAM 6RB / low	778.24	4.84	< 13	Pass
	CAT M1 B13 16QAM 1RB / low	778.24	7.28	< 13	Pass
20	CAT M1 B13 16QAM 6RB / mid	782.5	6.25	< 13	Pass
	CAT M1 B13 16QAM 1RB / mid	782.5	5.38	< 13	Pass
21	CAT M1 B13 16QAM 6RB / high	785.8	7.66	< 13	Pass
	CAT M1 B13 16QAM 1RB / high	785.8	7.15	< 13	Pass
22	CAT M1 B13 QPSK 6RB / low	778.24	4.29	< 13	Pass
	CAT M1 B13 QPSK 1RB / low	778.24	6.47	< 13	Pass
23	CAT M1 B13 QPSK 6RB / mid	782.5	5.58	< 13	Pass
	CAT M1 B13 QPSK 1RB / mid	782.5	4.90	< 13	Pass
24	CAT M1 B13 QPSK 6RB / high	785.8	6.76	< 13	Pass
	CAT M1 B13 QPSK 1RB / high	785.8	6.47	< 13	Pass
25	NB IoT B13 / low	777	7.69	< 13	Pass
26	NB IoT B13 / mid	782	7.95	< 13	Pass
27	NB IoT B13 / high	787	7.98	< 13	Pass

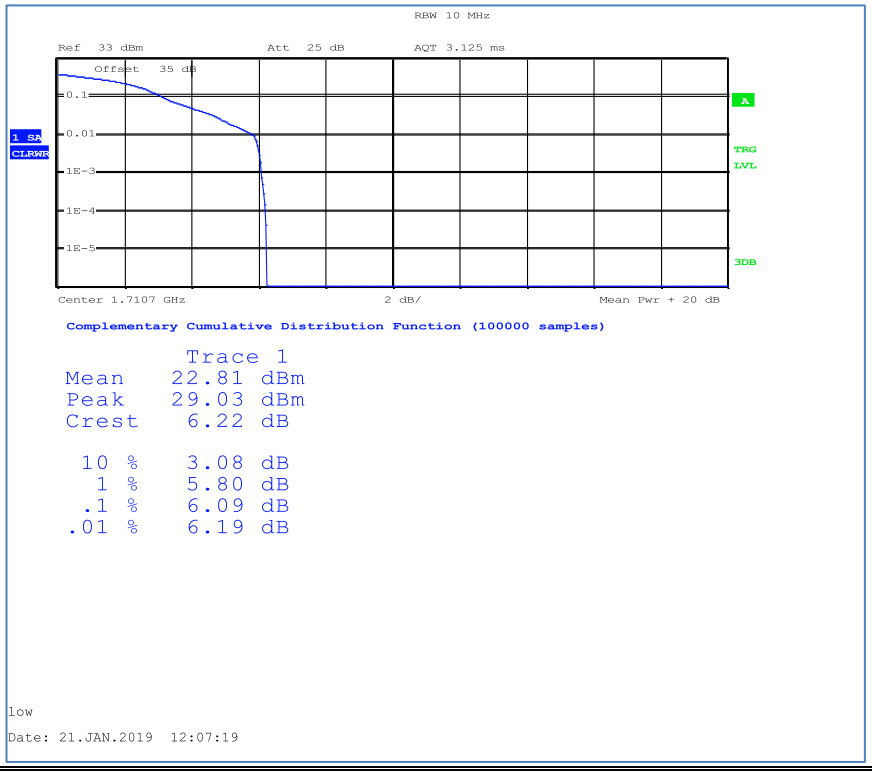
7.1.6 Measurement Plots:

Plot #1 Conducted Output Power

6RB

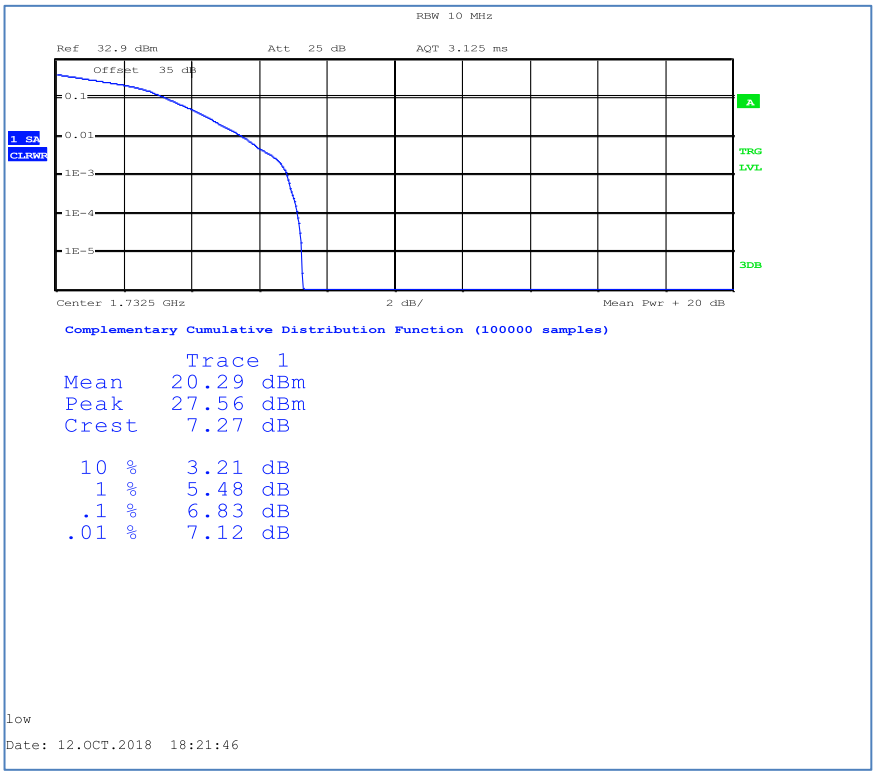


1RB



Plot #2 Conducted Output Power

6RB



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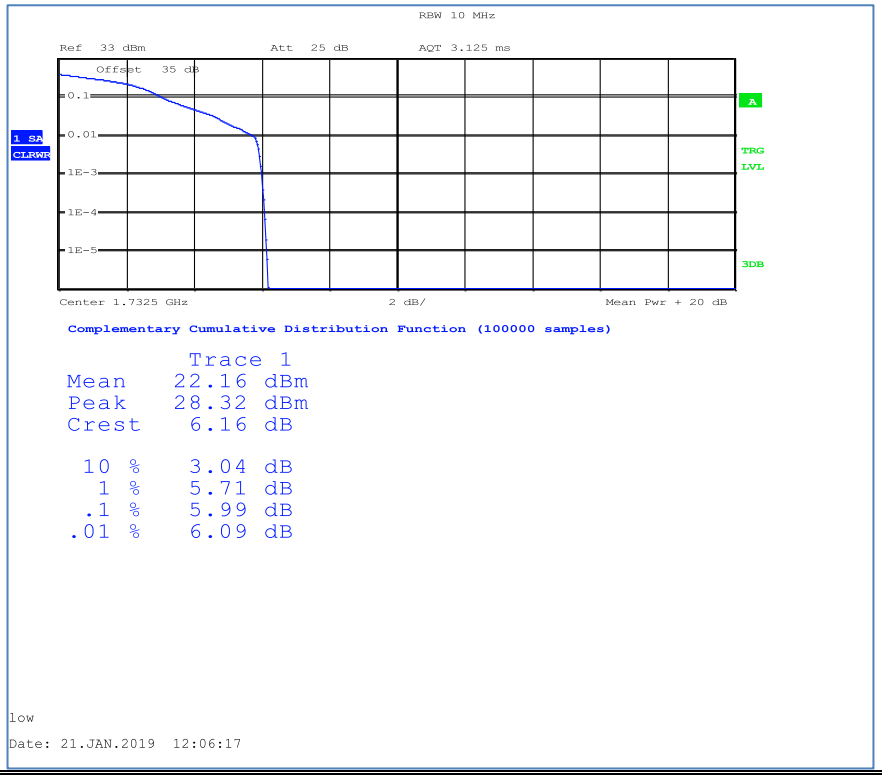
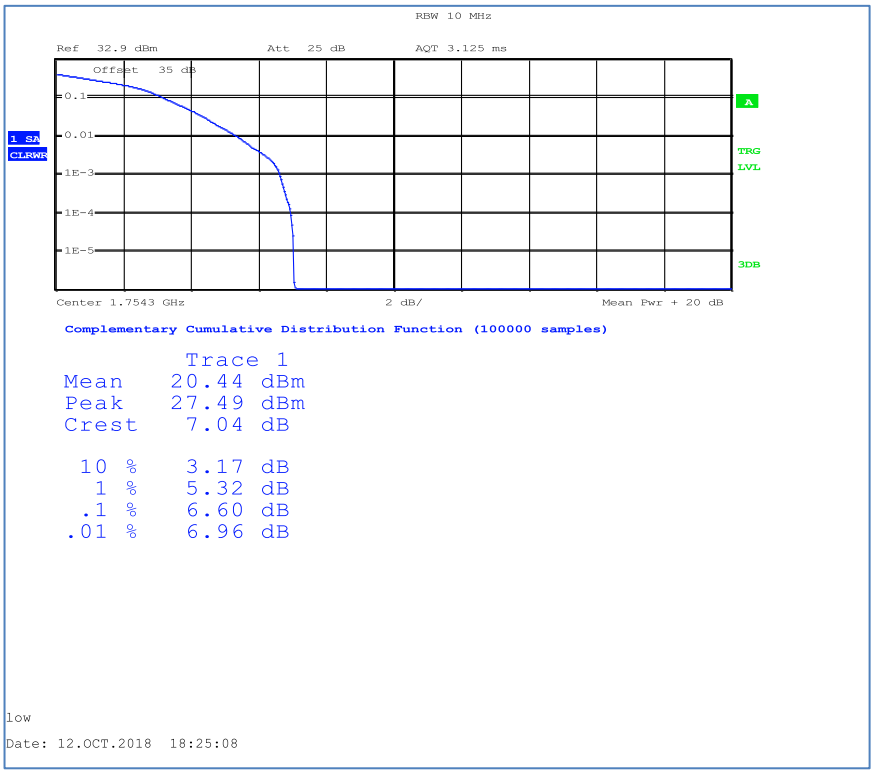
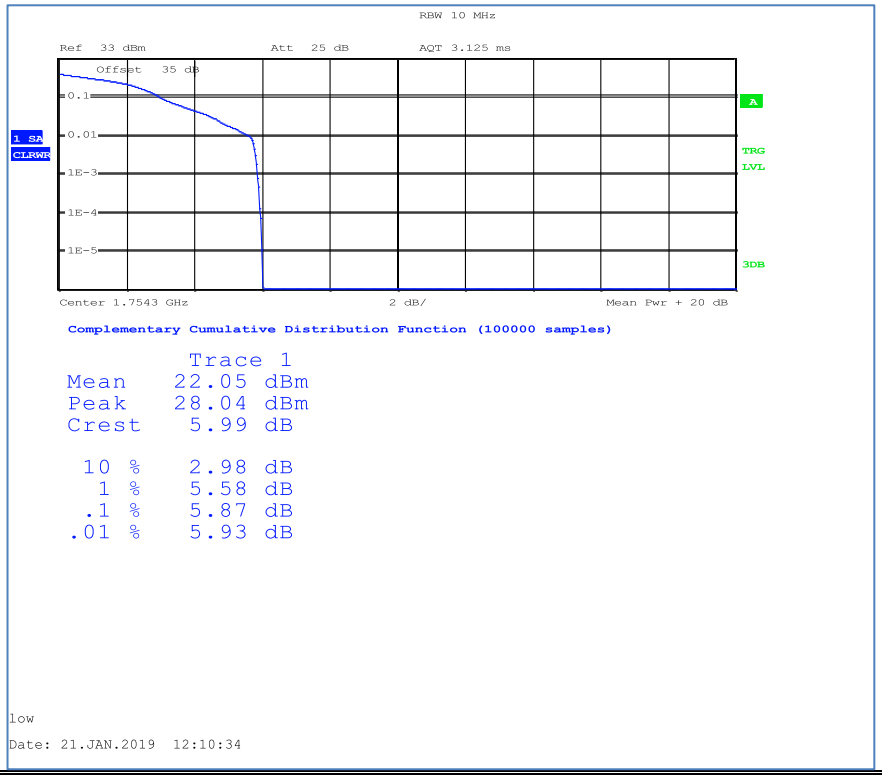


Plot #3 Conducted Output Power

6RB

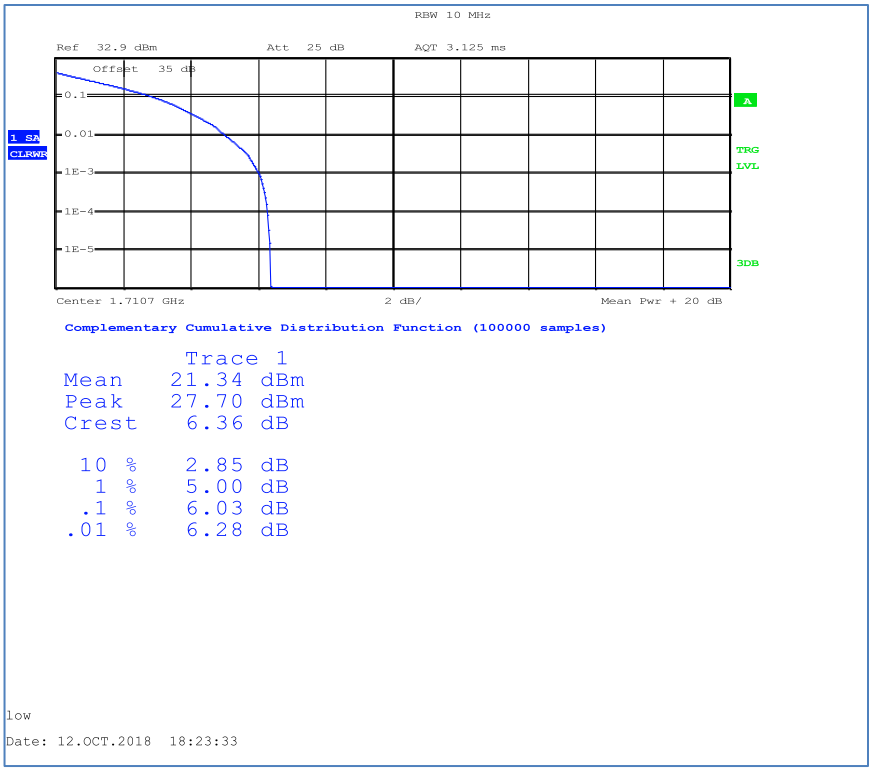


1RB



Plot #4 Conducted Output Power

6RB



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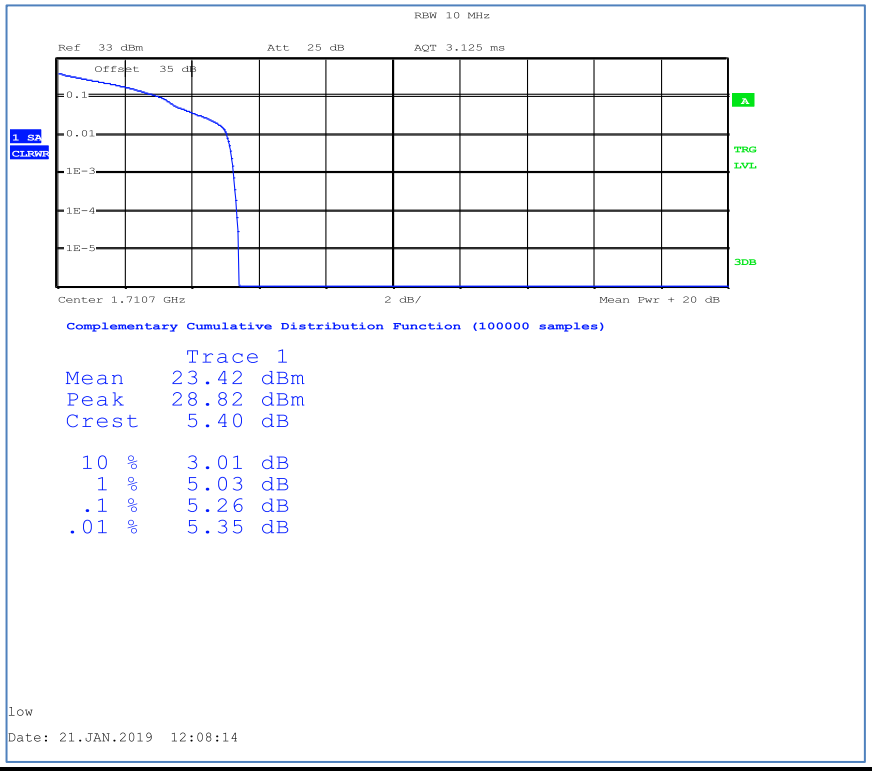
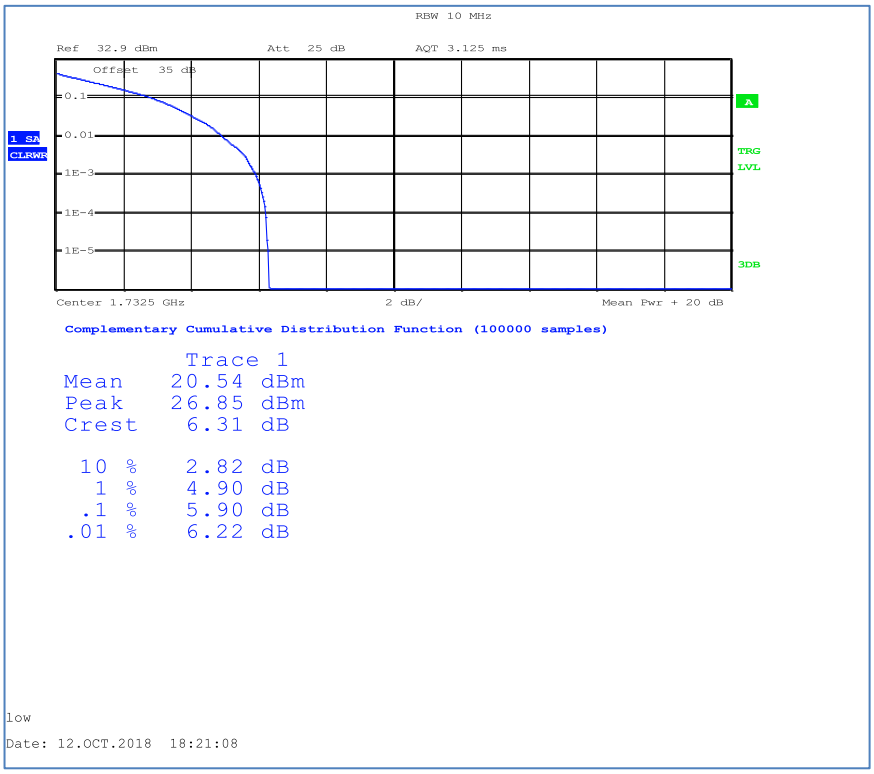
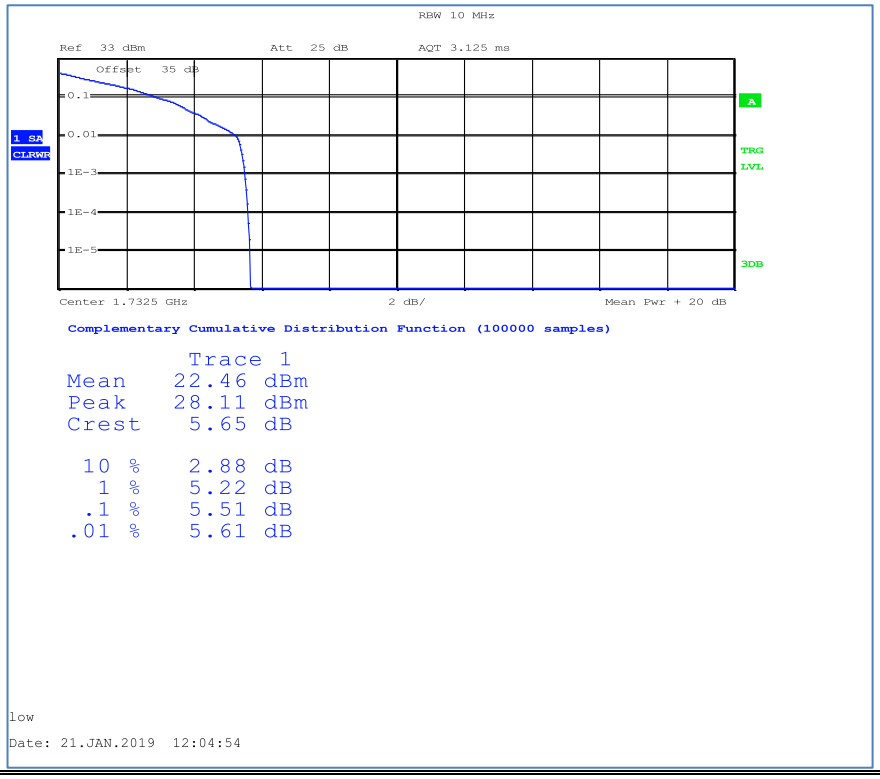


Plot #5 Conducted Output Power

6RB

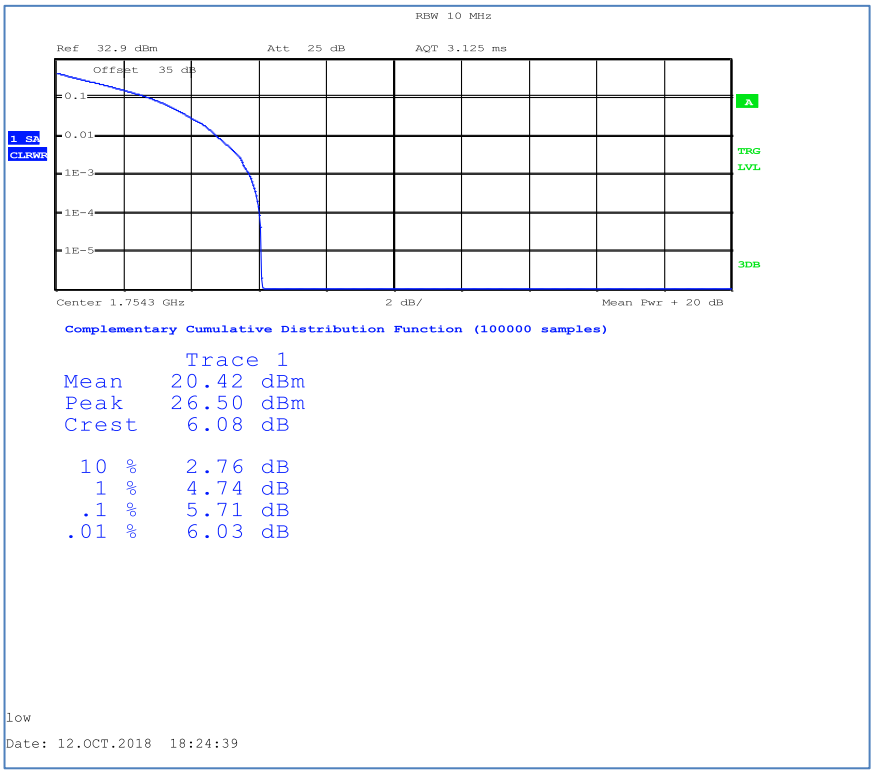


1RB

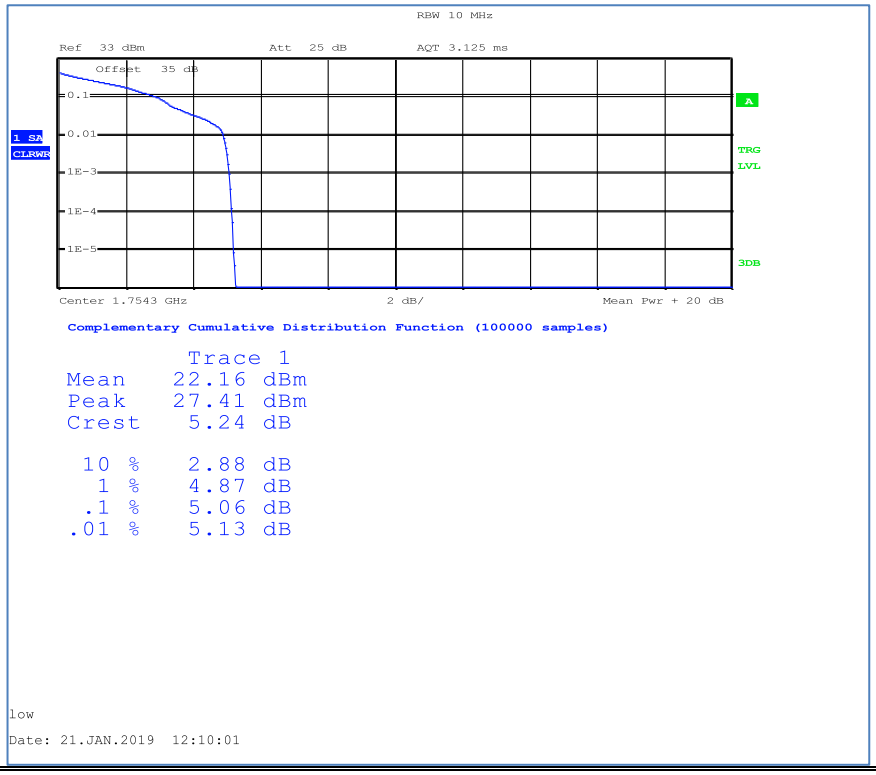


Plot #6 Conducted Output Power

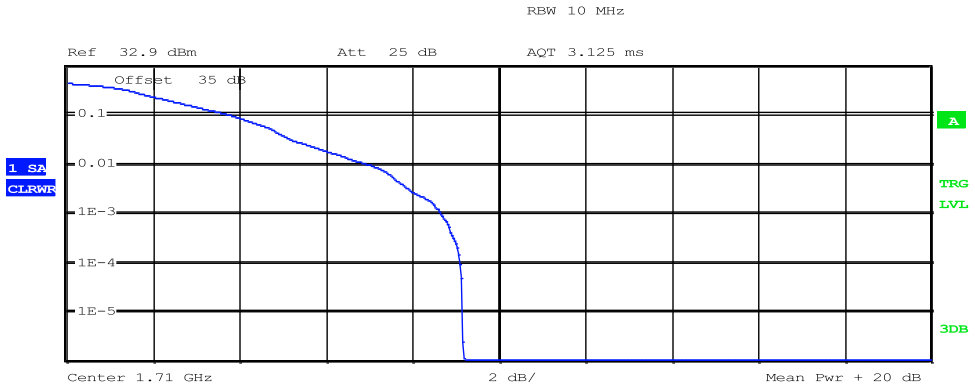
6RB



1RB



Plot #7 Conducted Output Power



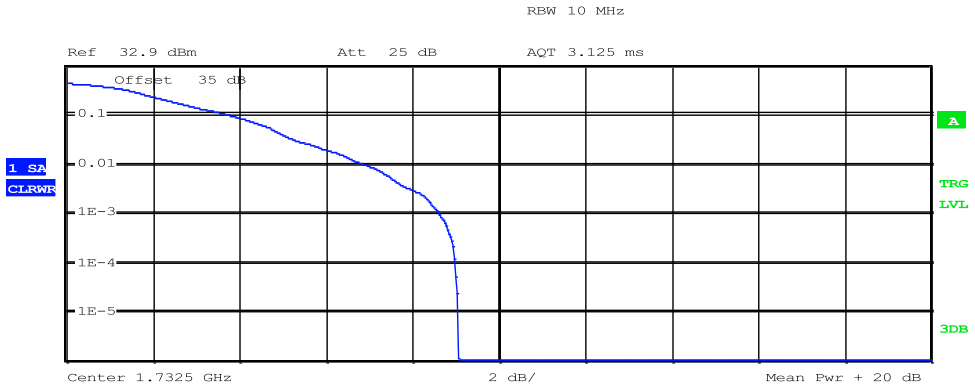
Complementary Cumulative Distribution Function (100000 samples)

	Trace 1
Mean	19.95 dBm
Peak	29.11 dBm
Crest	9.15 dB
10 %	3.81 dB
1 %	6.99 dB
.1 %	8.65 dB
.01 %	9.10 dB

low

Date: 12.OCT.2018 19:19:18

Plot #8 Conducted Output Power



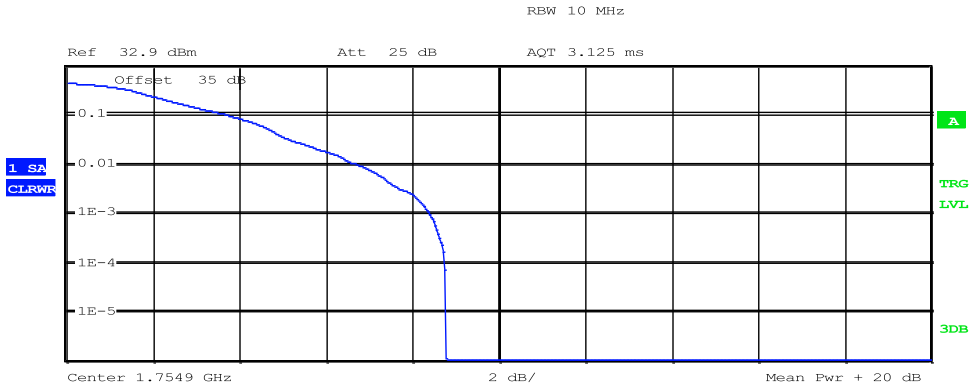
Complementary Cumulative Distribution Function (100000 samples)

	Trace 1
Mean	19.63 dBm
Peak	28.68 dBm
Crest	9.05 dB
10 %	3.78 dB
1 %	6.89 dB
.1 %	8.62 dB
.01 %	8.97 dB

low

Date: 12.OCT.2018 19:18:08

Plot #9 Conducted Output Power



Complementary Cumulative Distribution Function (100000 samples)

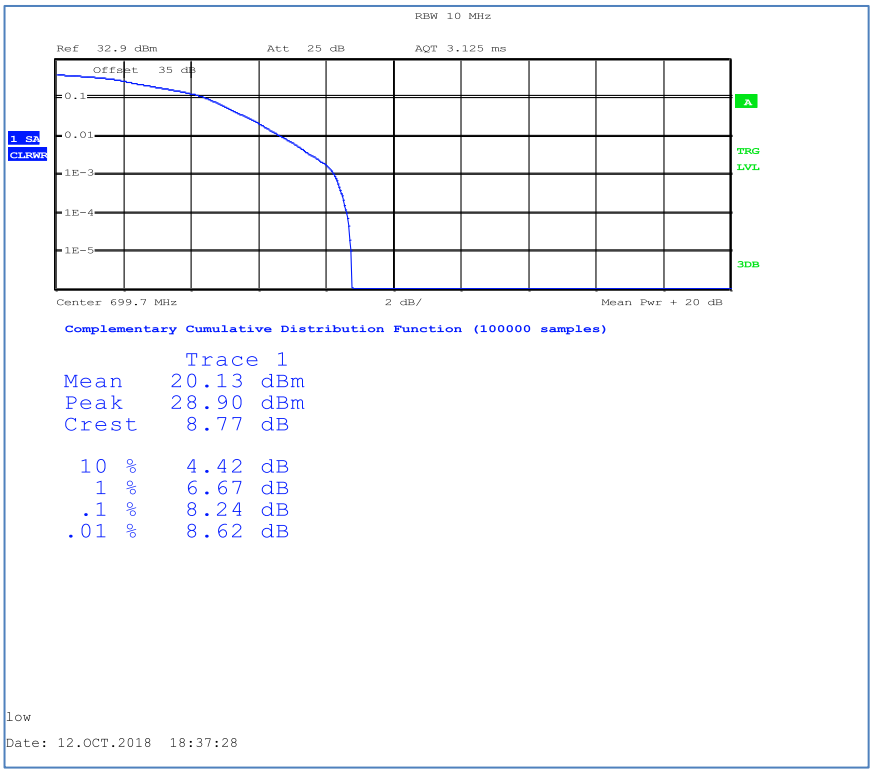
	Trace 1
Mean	19.71 dBm
Peak	28.47 dBm
Crest	8.76 dB
10 %	3.75 dB
1 %	6.73 dB
.1 %	8.37 dB
.01 %	8.75 dB

low

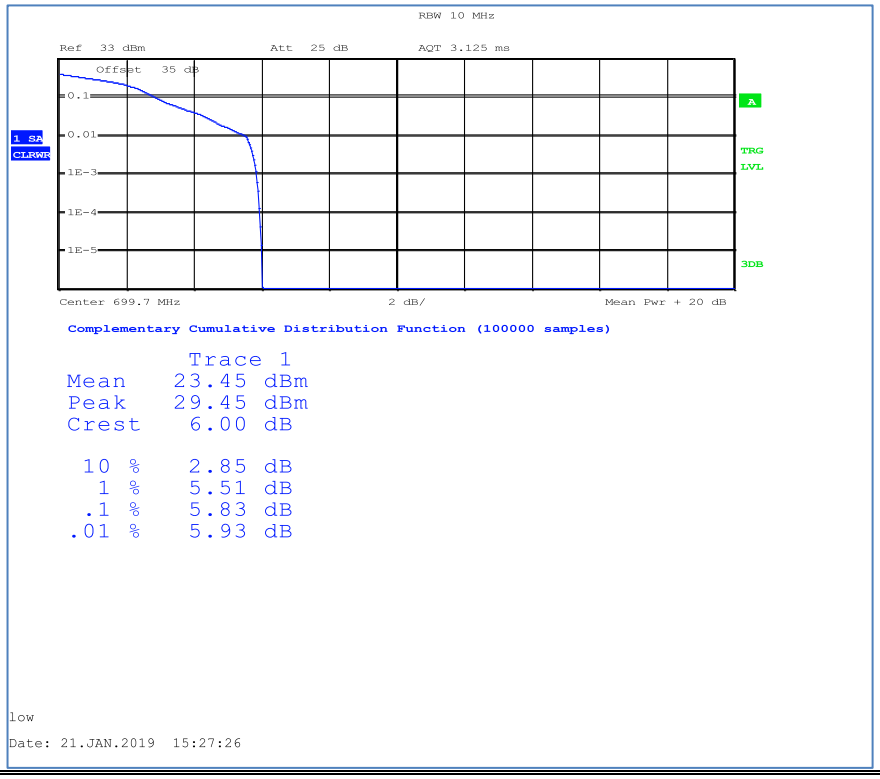
Date: 12.OCT.2018 19:20:16

Plot #10 Conducted Output Power

6RB

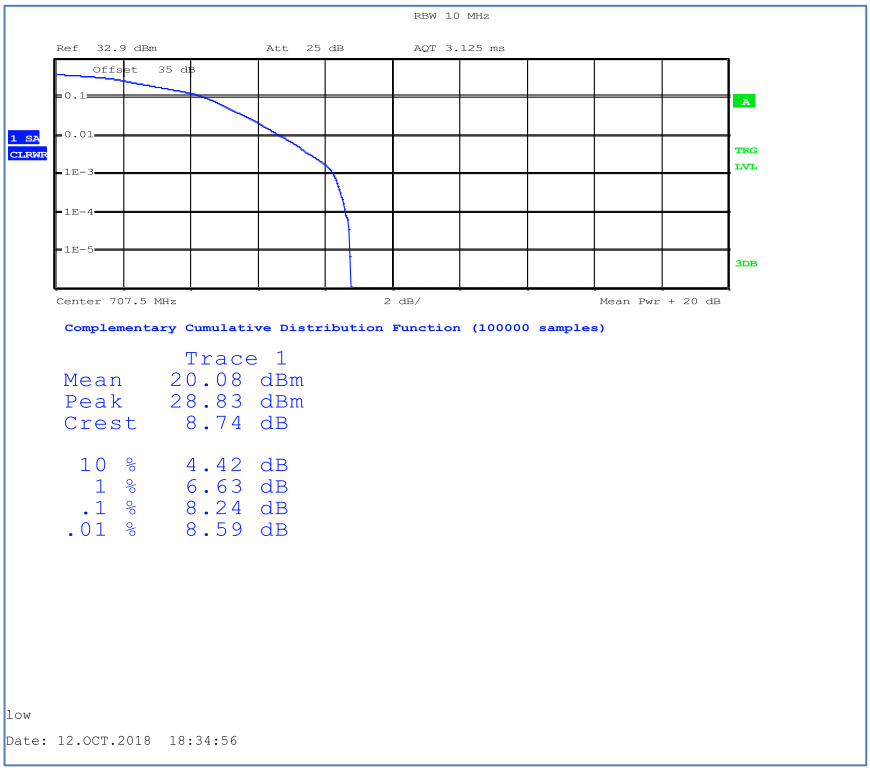


1RB

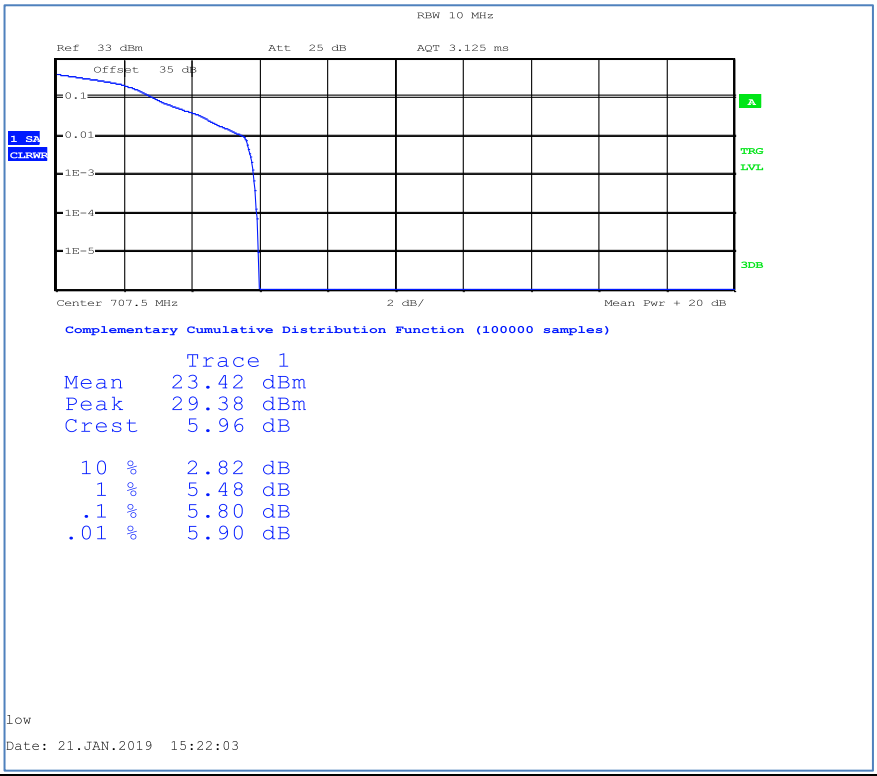


Plot #11 Conducted Output Power

6RB

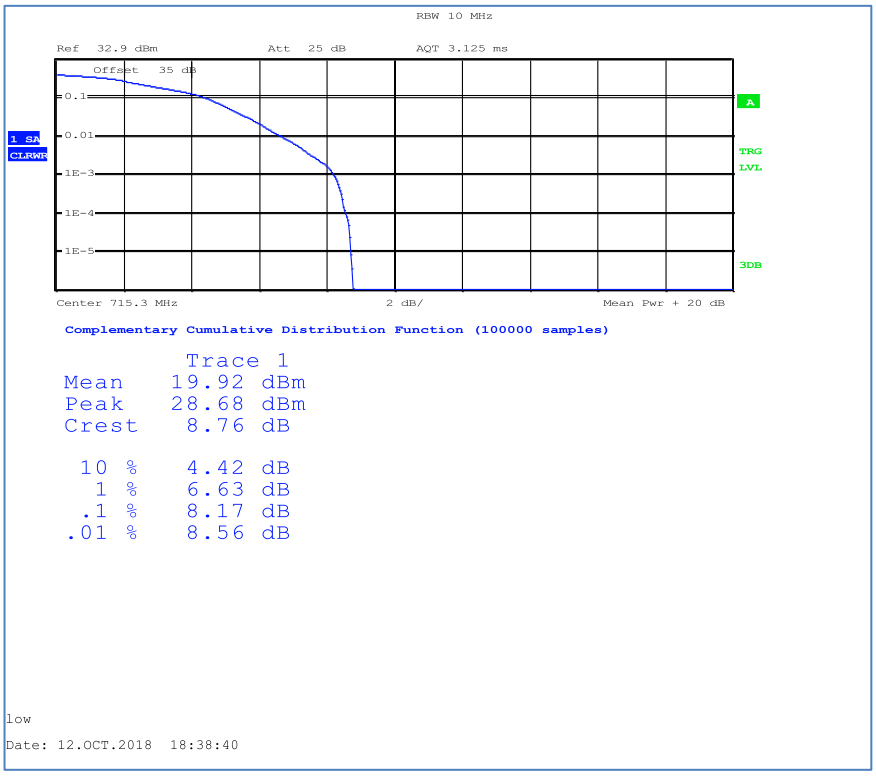


1RB

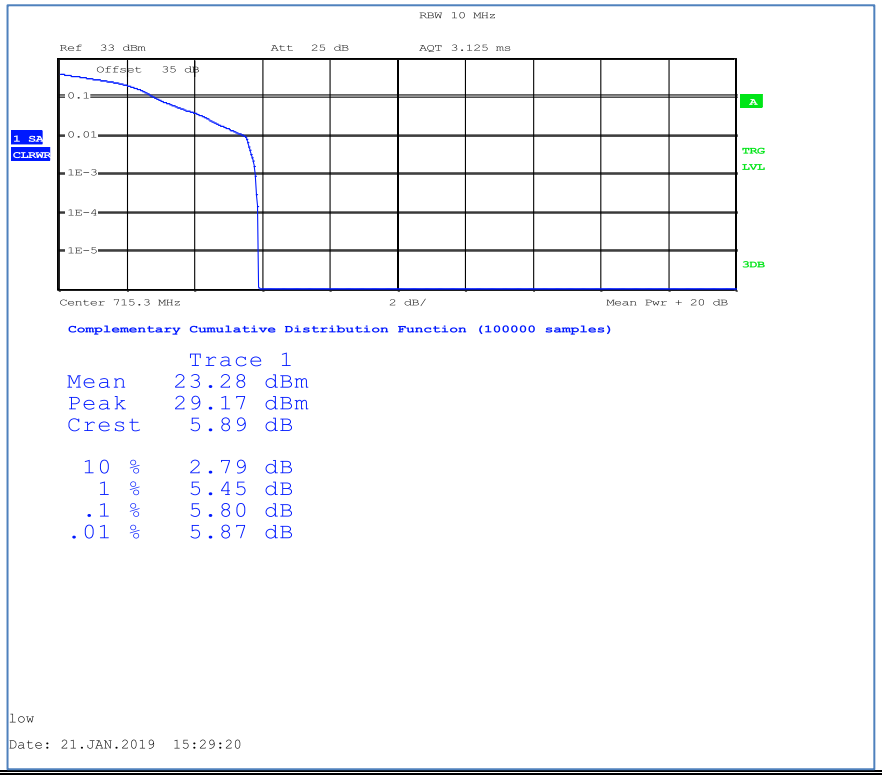


Plot #12 Conducted Output Power

6RB

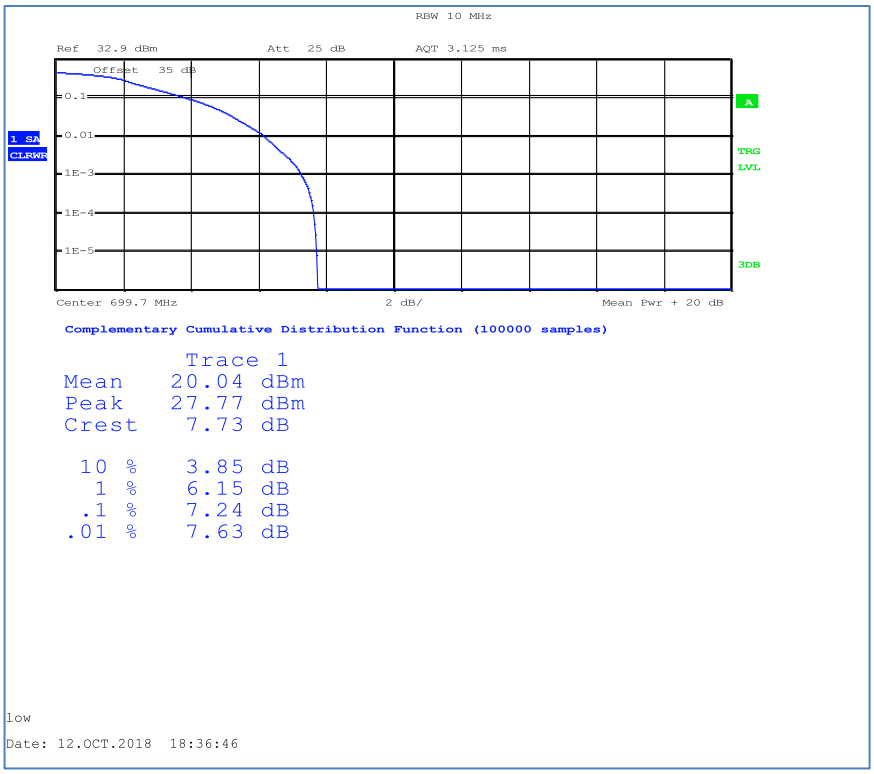


1RB

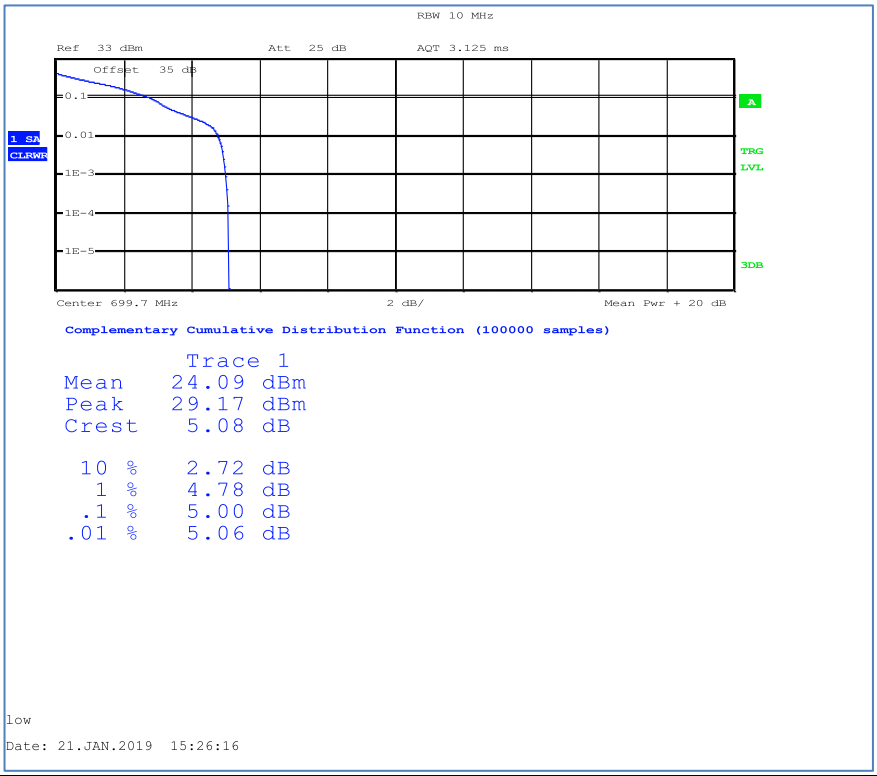


Plot #13 Conducted Output Power

6RB

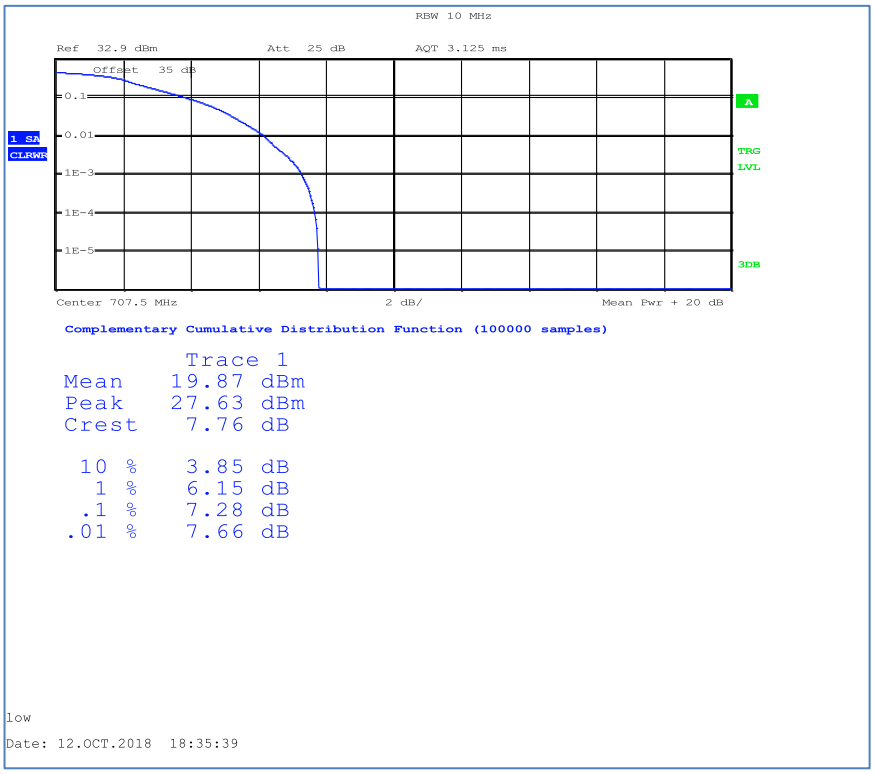


1RB

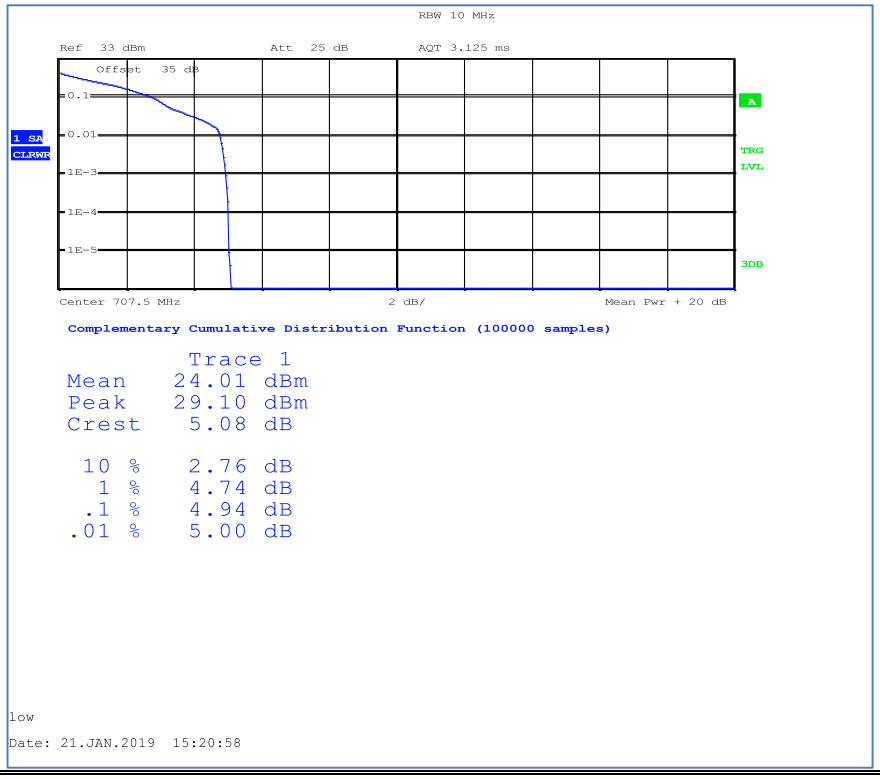


Plot #14 Conducted Output Power

6RB

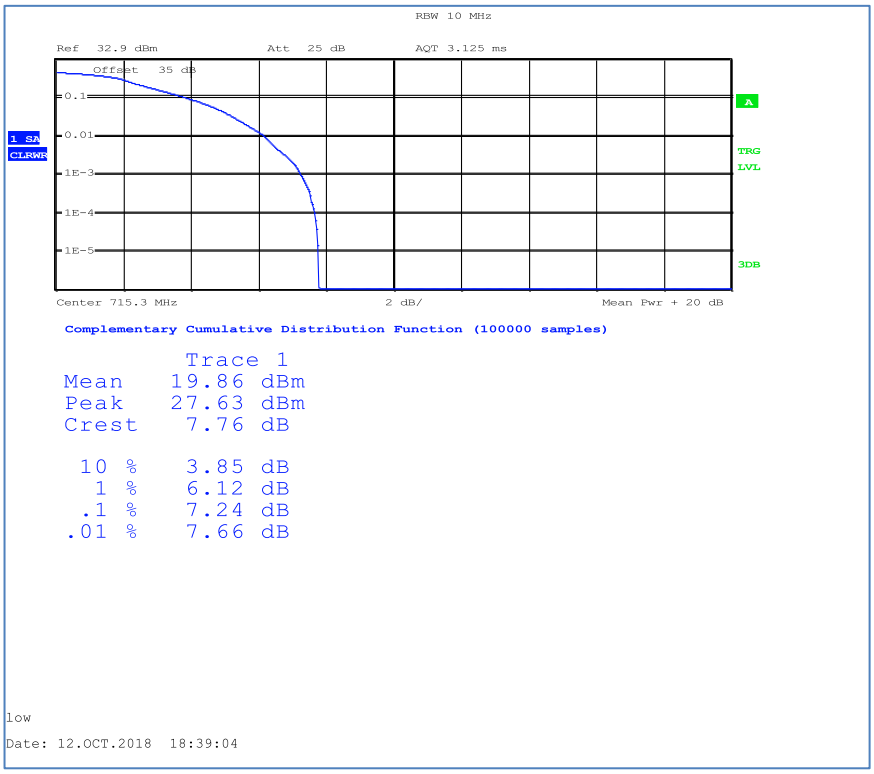


1RB

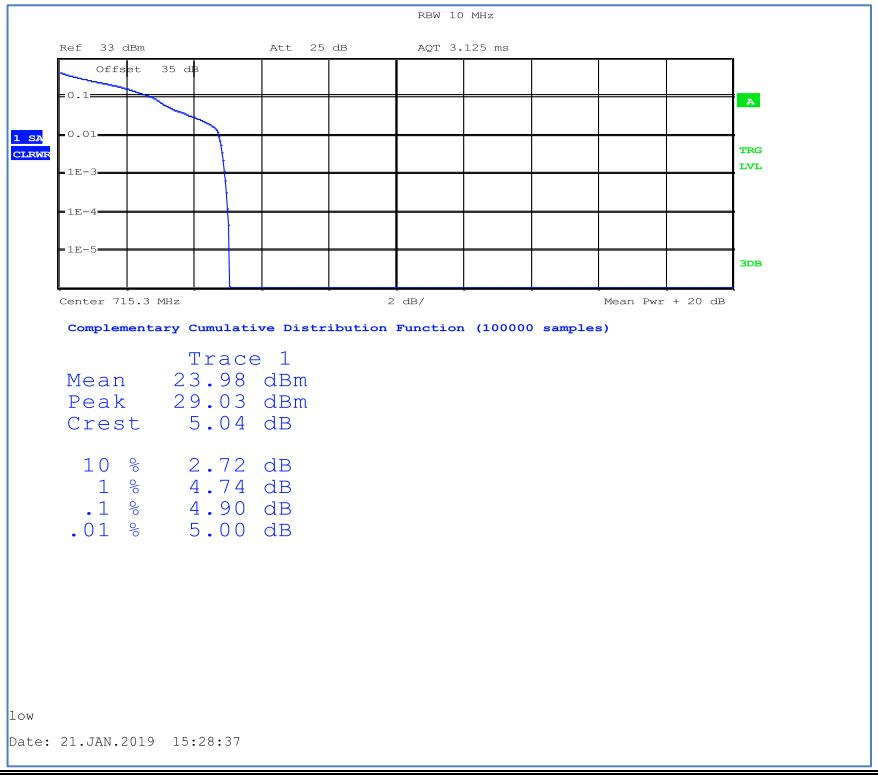


Plot #15 Conducted Output Power

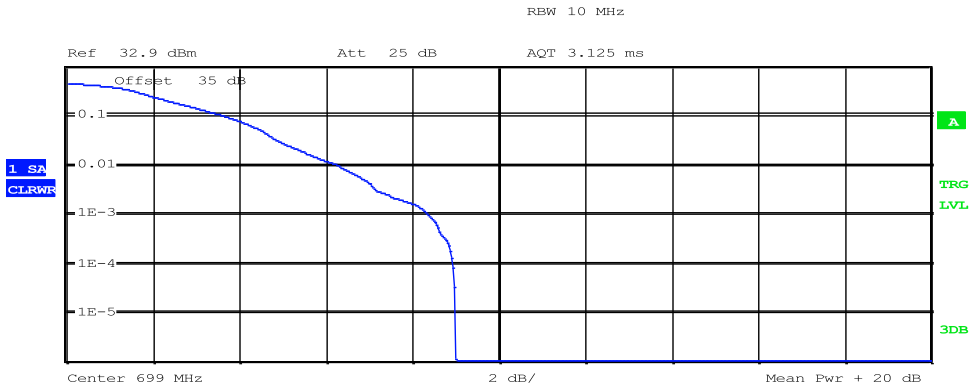
6RB



1RB



Plot #16 Conducted Output Power



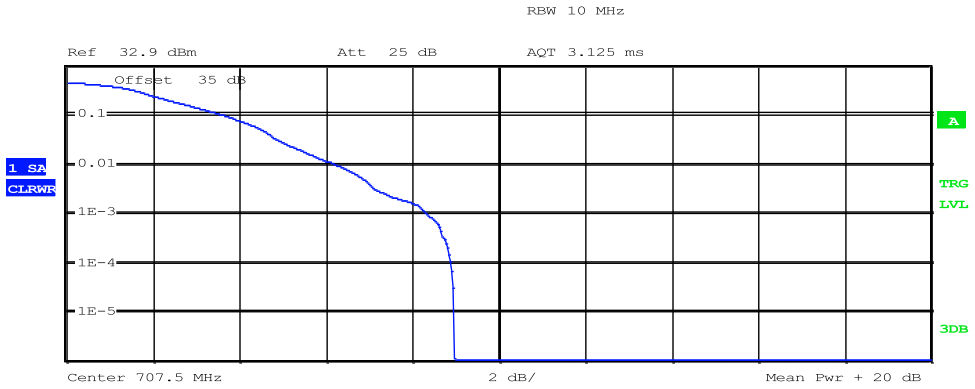
Complementary Cumulative Distribution Function (100000 samples)

	Trace 1
Mean	20.90 dBm
Peak	29.88 dBm
Crest	8.98 dB
10 %	3.65 dB
1 %	6.25 dB
.1 %	8.33 dB
.01 %	8.94 dB

low

Date: 12.OCT.2018 19:26:19

Plot #17 Conducted Output Power



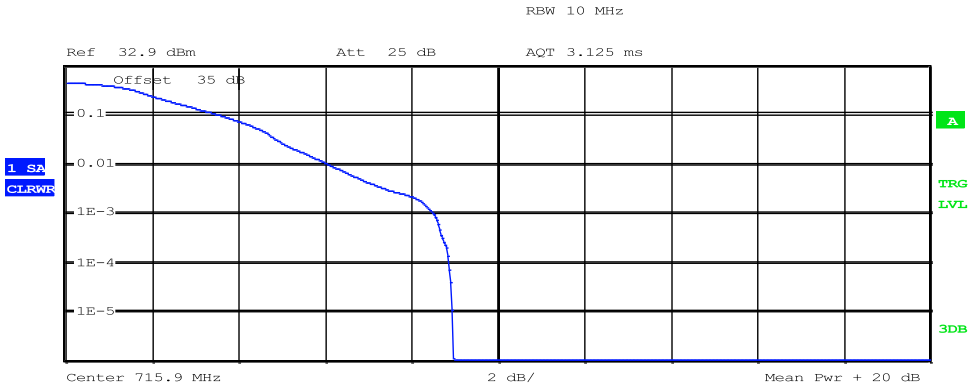
Complementary Cumulative Distribution Function (100000 samples)

	Trace 1
Mean	20.86 dBm
Peak	29.81 dBm
Crest	8.95 dB
10 %	3.65 dB
1 %	6.22 dB
.1 %	8.30 dB
.01 %	8.88 dB

low

Date: 12.OCT.2018 19:24:48

Plot #18 Conducted Output Power



Complementary Cumulative Distribution Function (100000 samples)

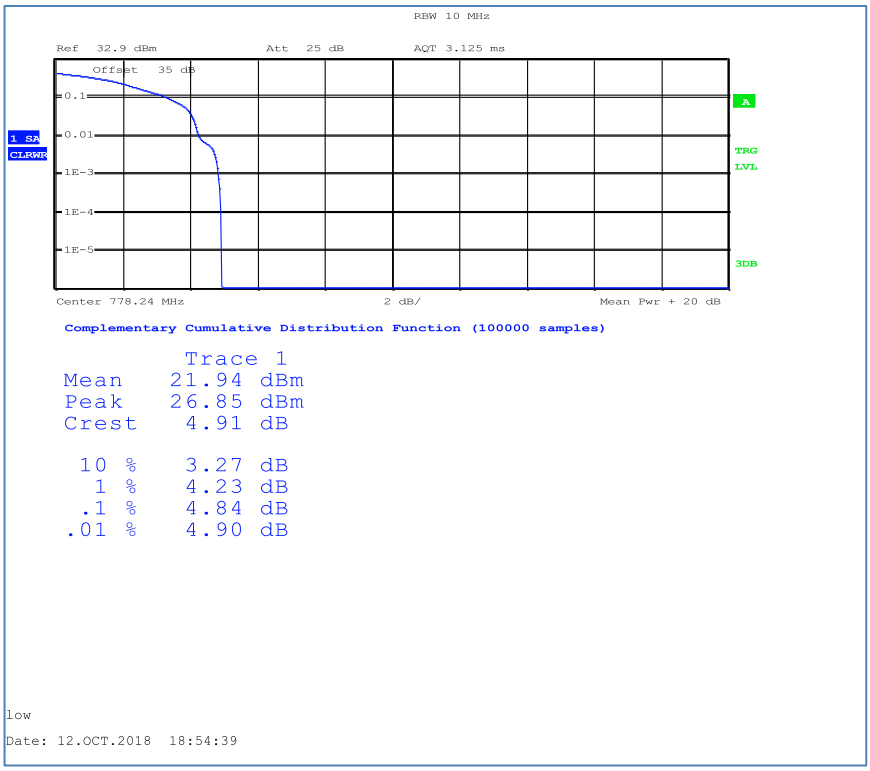
	Trace 1
Mean	20.94 dBm
Peak	29.88 dBm
Crest	8.94 dB
10 %	3.59 dB
1 %	6.09 dB
.1 %	8.49 dB
.01 %	8.88 dB

low

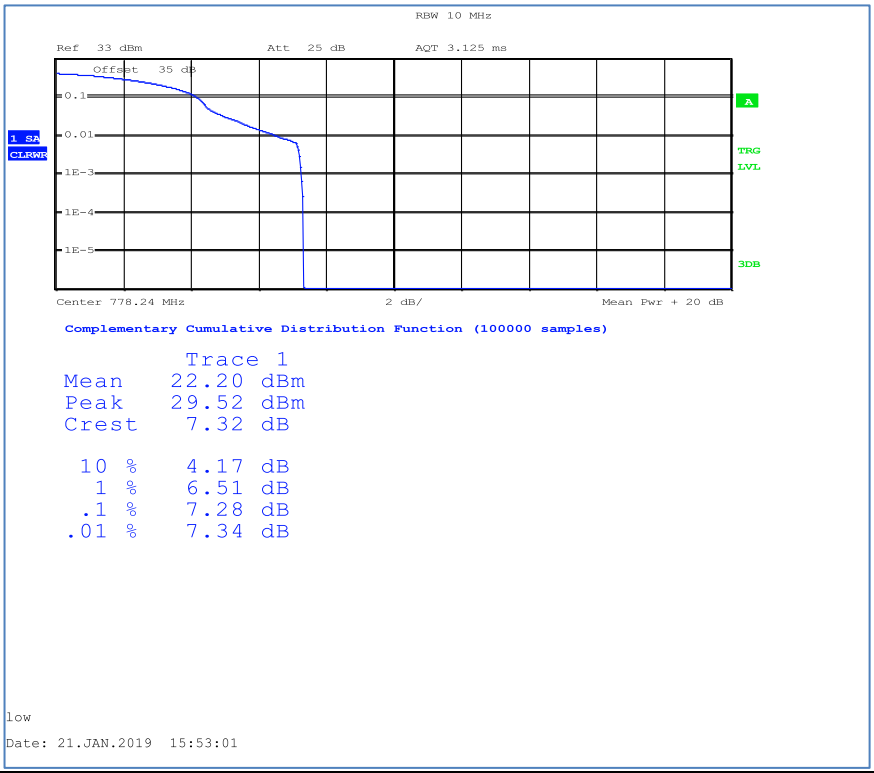
Date: 12.OCT.2018 19:27:17

Plot #19 Conducted Output Power

6RB

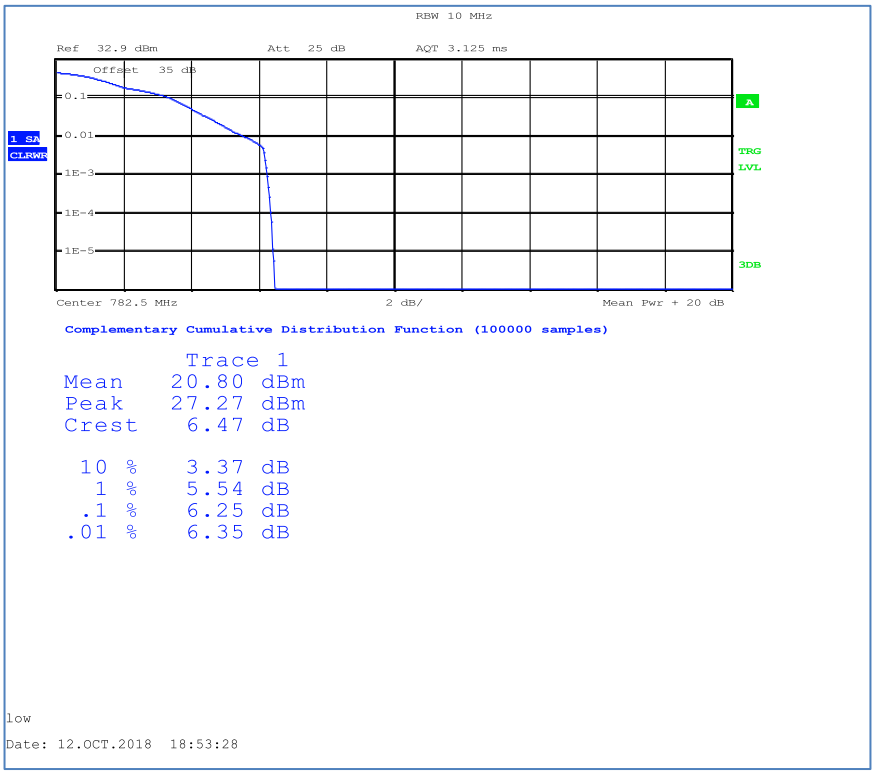


1RB

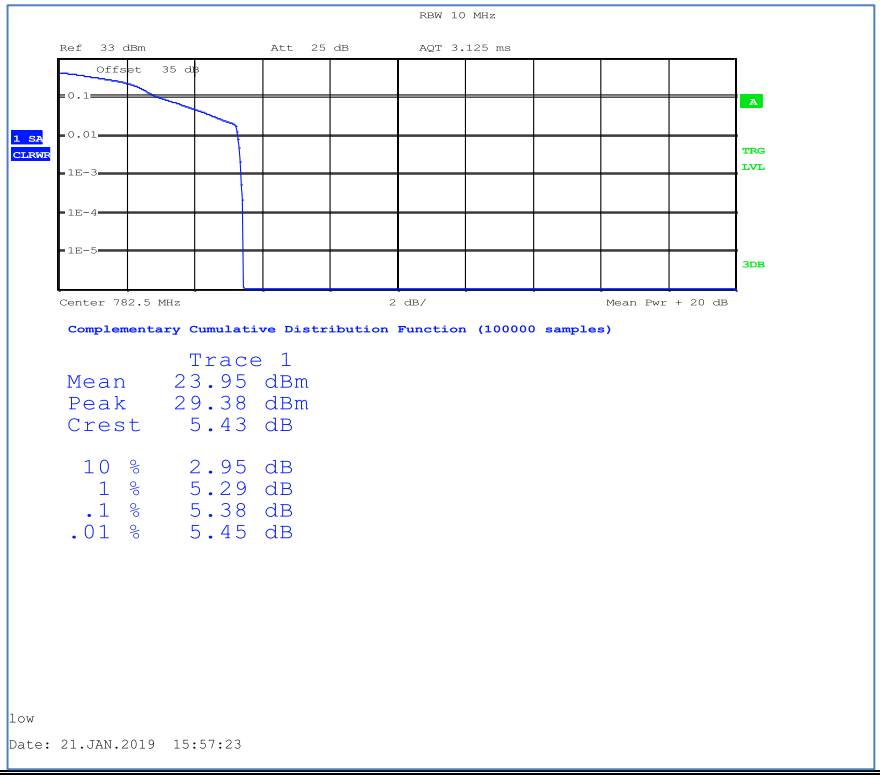


Plot #20 Conducted Output Power

6RB

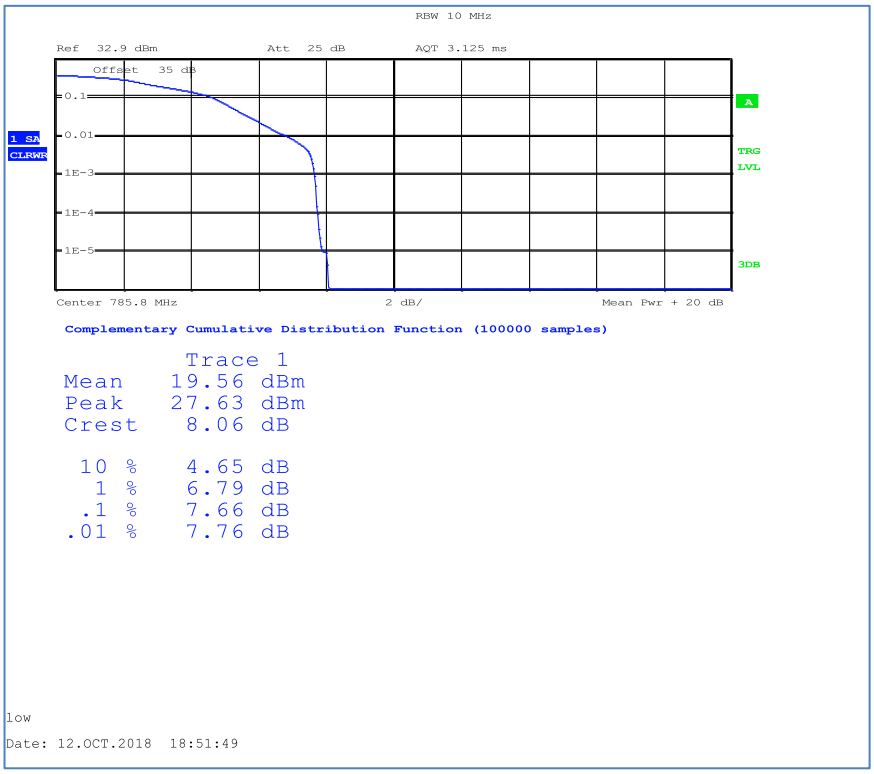


1RB

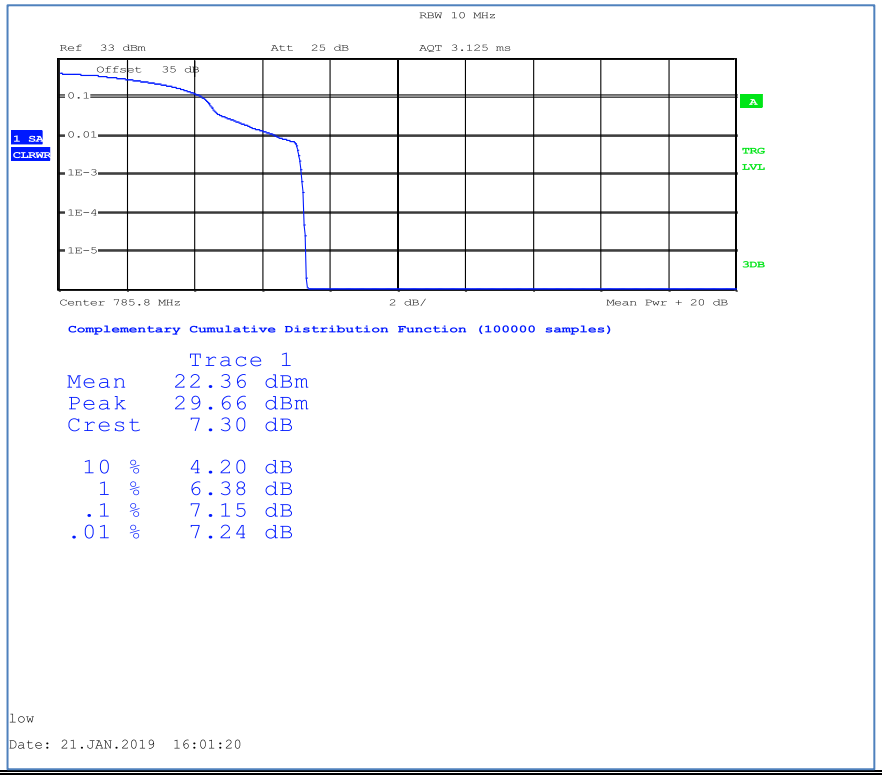


Plot #21 Conducted Output Power

6RB

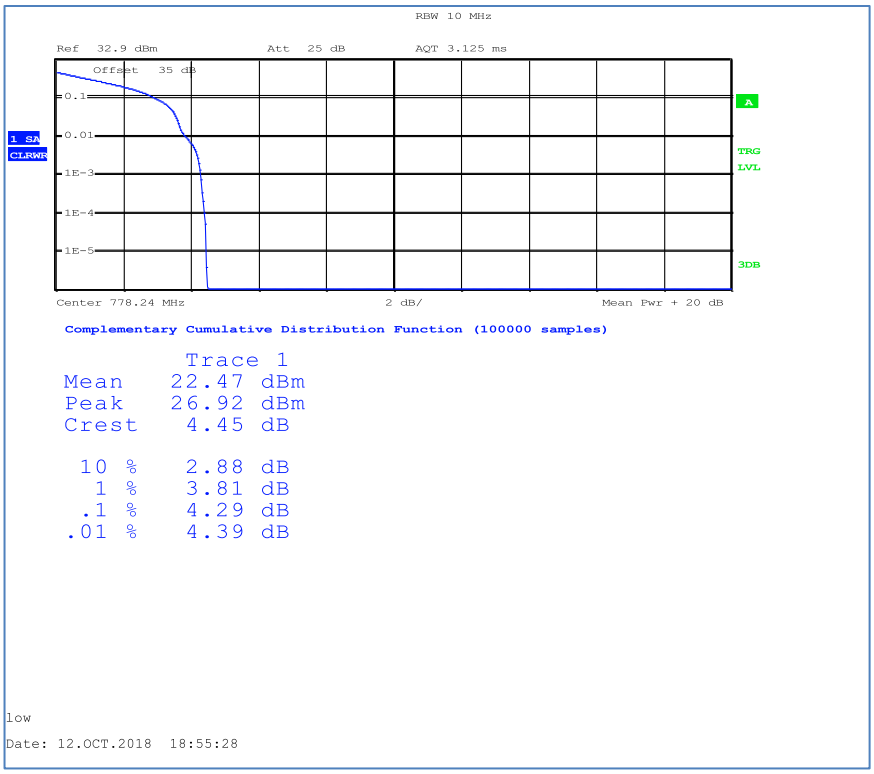


1RB

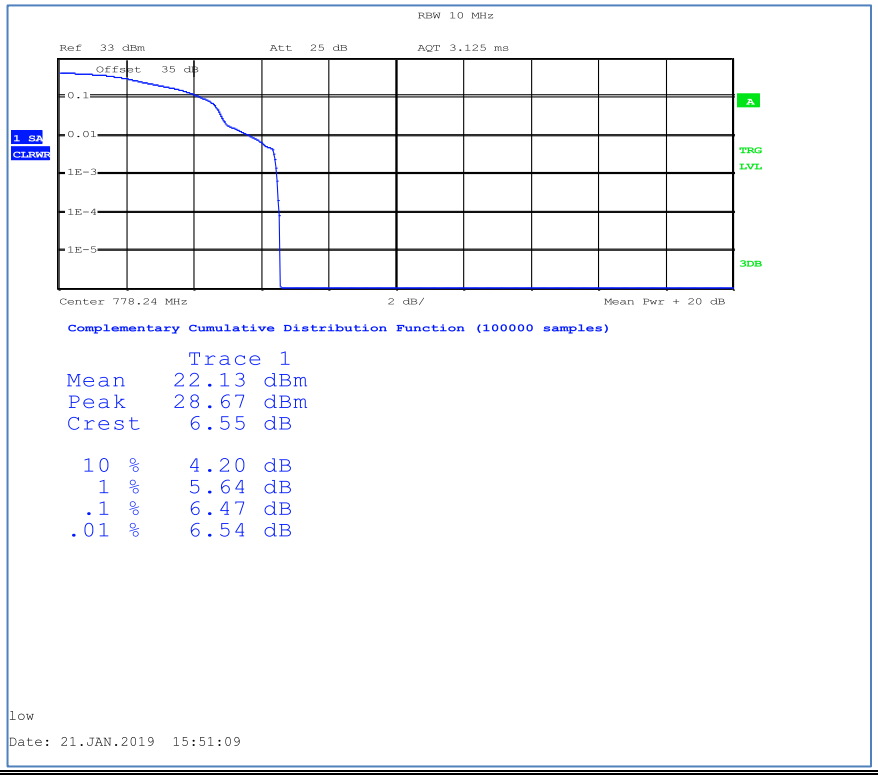


Plot #22 Conducted Output Power

6RB

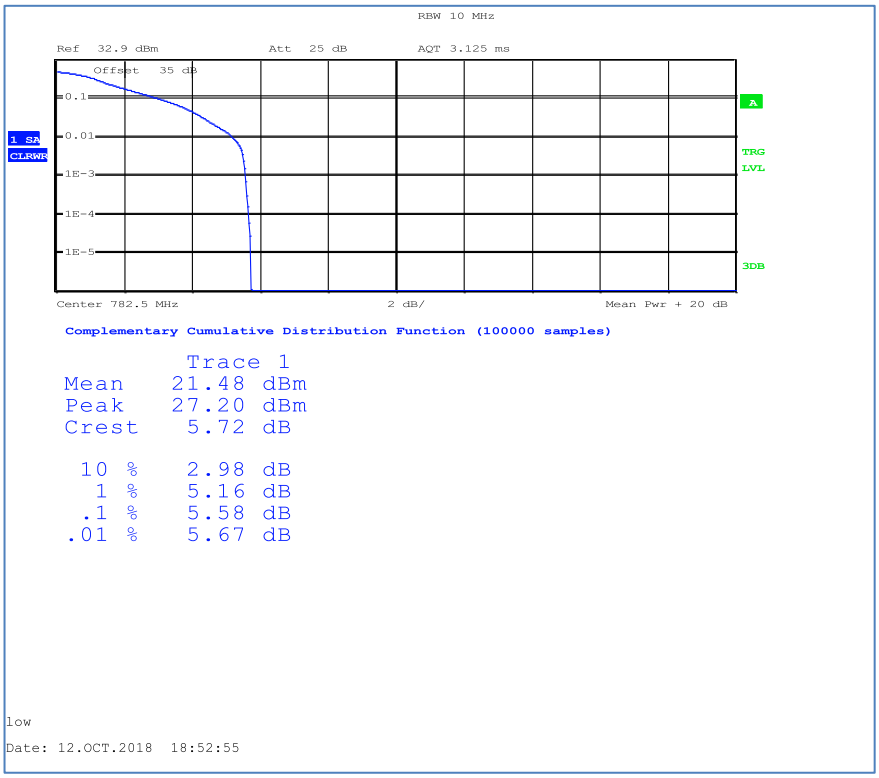


1RB

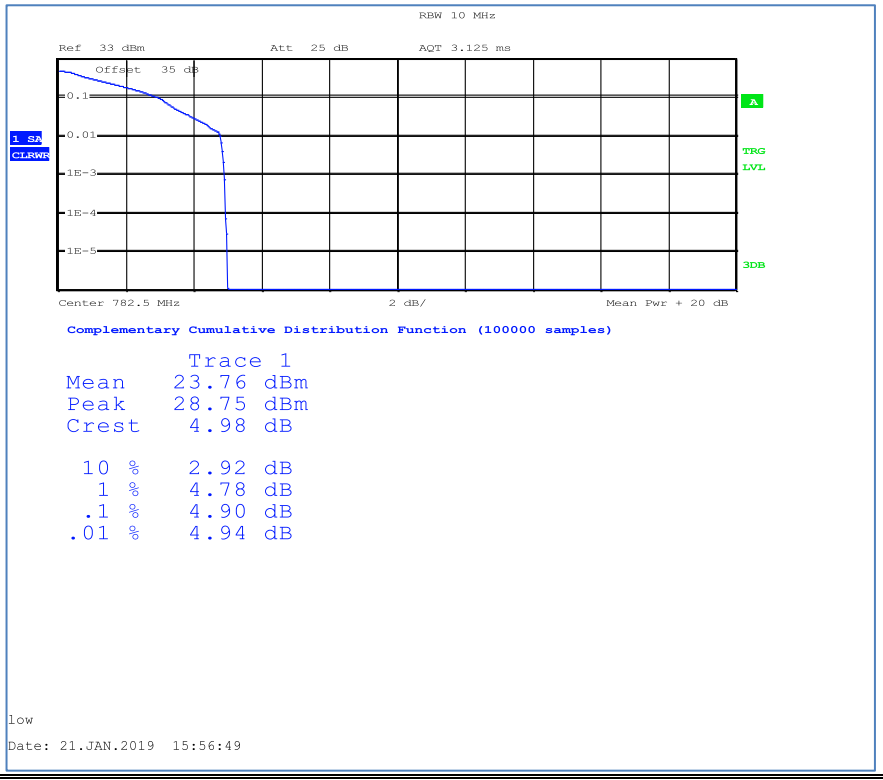


Plot #23 Conducted Output Power

6RB

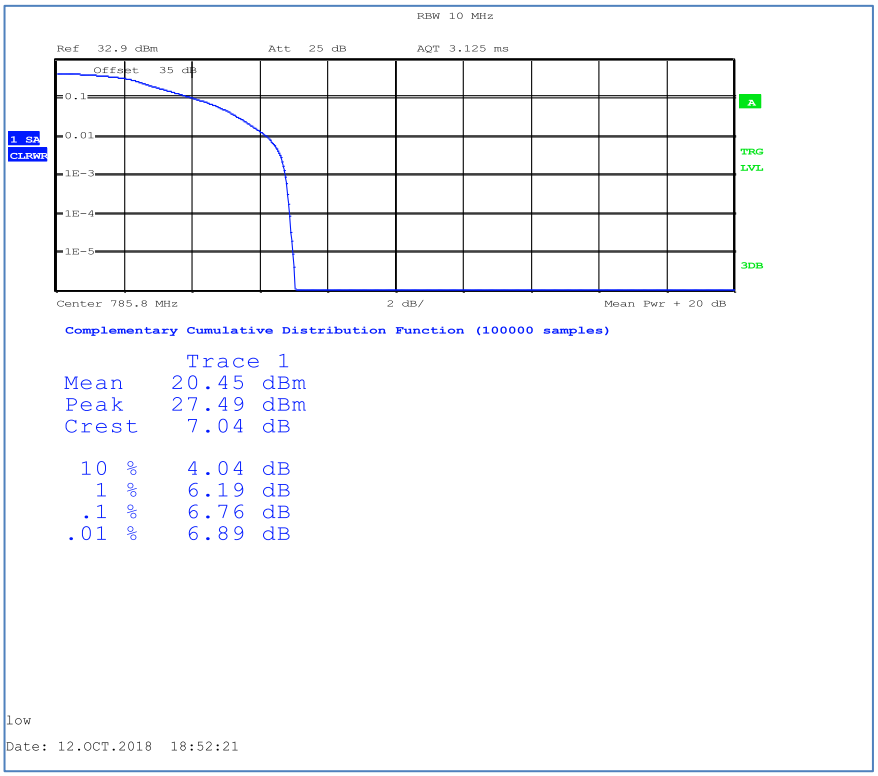


1RB

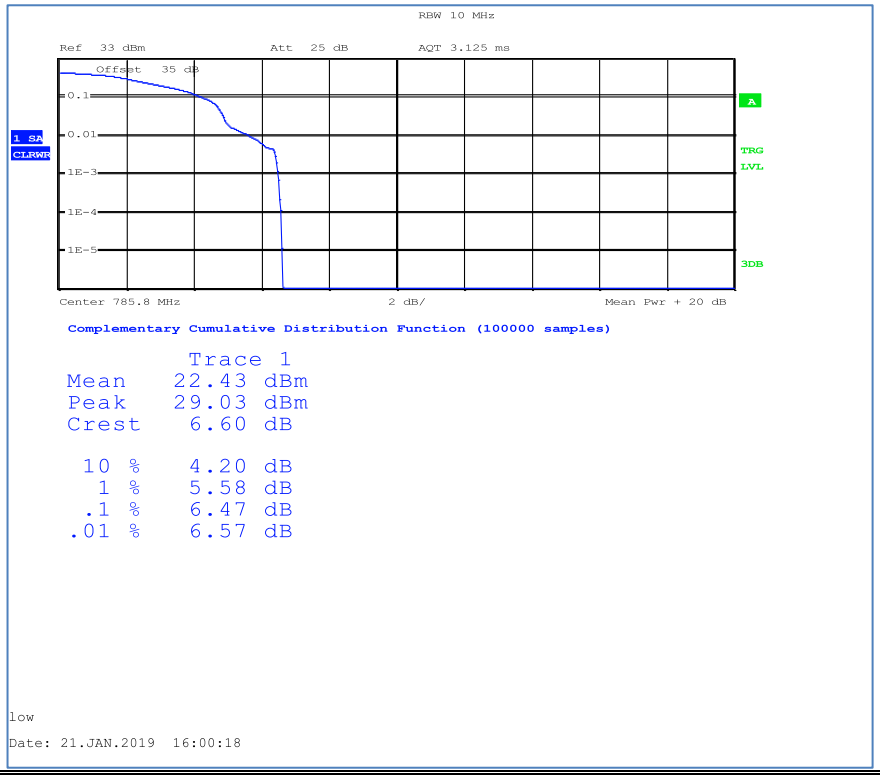


Plot #24 Conducted Output Power

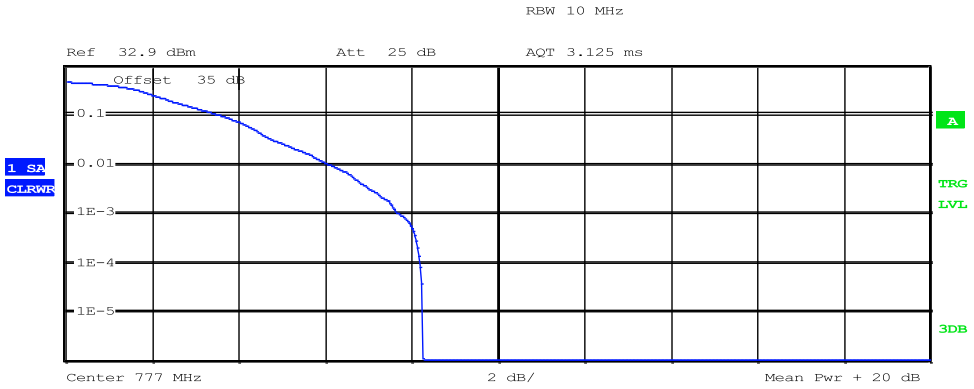
6RB



1RB



Plot #25 Conducted Output Power



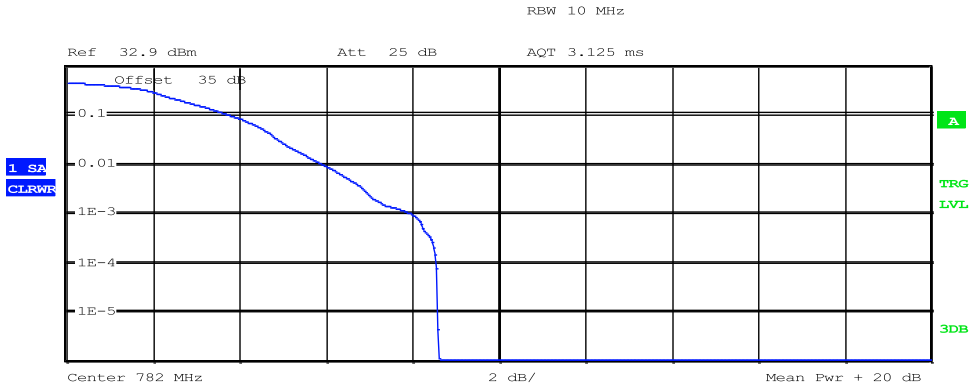
Complementary Cumulative Distribution Function (100000 samples)

	Trace 1
Mean	20.44 dBm
Peak	28.68 dBm
Crest	8.25 dB
10 %	3.59 dB
1 %	6.09 dB
.1 %	7.69 dB
.01 %	8.21 dB

low

Date: 12.OCT.2018 19:30:30

Plot #26 Conducted Output Power



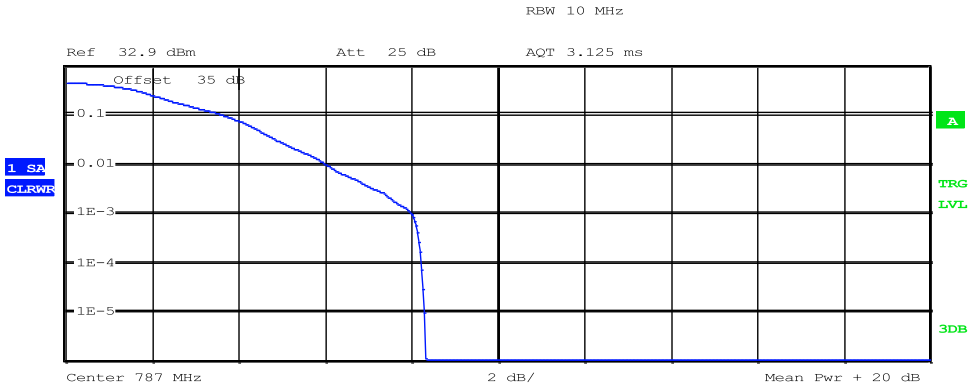
Complementary Cumulative Distribution Function (100000 samples)

	Trace 1
Mean	20.25 dBm
Peak	28.83 dBm
Crest	8.58 dB
10 %	3.78 dB
1 %	5.90 dB
.1 %	7.95 dB
.01 %	8.56 dB

low

Date: 12.OCT.2018 19:29:28

Plot #27 Conducted Output Power



Complementary Cumulative Distribution Function (100000 samples)

	Trace 1
Mean	20.73 dBm
Peak	29.04 dBm
Crest	8.30 dB
10 %	3.65 dB
1 %	6.03 dB
.1 %	7.98 dB
.01 %	8.24 dB

low

Date: 12.OCT.2018 19:31:25

7.2 Frequency Stability

7.2.1 Measurement utilizing KDB 971168 D01 and ANSI C63.26-2015 Subclause 5.6

The center frequency of transmission on middle channel was measured at the low and high supply voltage specified for the equipment in the range of 0 ºC to 50 ºC' at 10 ºC intervals. The frequency stability was calculated using the following equation:

$$ppm\ error = \left(\frac{MCF_{MHz}}{ACF_{MHz}} - 1 \right) * 10^6$$

where

MCF_{MHz} is the Measured Carrier Frequency in MHz
ACF_{MHz} is the Assigned Carrier Frequency in MHz 1

Spectrum Analyzer settings:

- RBW =30 kHz
- VBW ≥ 300Hz
- Set span = 10MHz
- Sweep time = auto couple
- Detector = Pk
- Trace mode = Max Hold
- Marker Stepsize = SWP POINTS
- Sweep Points = 10000 points
- Measure the frequency at the low and high edge (F low and F high)
- Calculate the center frequency MCF = F low + (F high – F low)/2

7.2.2 Limits:

7.2.2.1 Part 27.54 Frequency stability:

The frequency stability shall be sufficient to ensure that the fundamental emissions stay within the authorized bands of operation.

7.2.2.2 RSS-130 and RSS-139 Part 6.4 Frequency Stability

The frequency stability shall be sufficient to ensure that the occupied bandwidth stays within the operating frequency block when tested to the temperature and supply voltage variations specified in RSS-Gen.

7.2.3 Test conditions and setup:

Ambient Temperature (C)	EUT Set-Up #	EUT operating mode	Power Input (VDC)
22°C	1	1 and 2	3.8

7.2.4 Measurement result:

Temperature Frequency Stability - CAT M1 B4					
Temperature (°C)	MCF (MHz)	ACF (MHz)	Frequency Stability (ppm)	Limit (ppm)	Result
-30	1732.5038	1732.5	2.19	See 7.2.2	Pass
-20	1732.5022	1732.5	1.24	See 7.2.2	Pass
-10	1732.5021	1732.5	1.21	See 7.2.2	Pass
0	1732.5024	1732.5	1.39	See 7.2.2	Pass
10	1732.5015	1732.5	0.87	See 7.2.2	Pass
20	1732.5018	1732.5	1.04	See 7.2.2	Pass
30	1732.5005	1732.5	0.29	See 7.2.2	Pass
40	1732.5009	1732.5	0.52	See 7.2.2	Pass
50	1732.5025	1732.5	1.44	See 7.2.2	Pass

Voltage Frequency Stability - CAT M1 B4					
Voltage(VDC)	MCF (MHz)	ACF (MHz)	Frequency Stability (ppm)	Limit (ppm)	Result
3.2V	1732.5015	1732.5	0.87	See 7.2.2	Pass
3.8V	1732.5018	1732.5	1.04	See 7.2.2	Pass
4.5V	1732.5022	1732.5	1.27	See 7.2.2	Pass

Temperature Frequency Stability– NB IoT B4					
Temperature (°C)	MCF (MHz)	ACF (MHz)	Frequency Stability (ppm)	Limit (ppm)	Result
-30	1732.5016	1732.5	0.89	See 7.2.2	Pass
-20	1732.5017	1732.5	0.98	See 7.2.2	Pass
-10	1732.5021	1732.5	1.20	See 7.2.2	Pass
0	1732.5019	1732.5	1.07	See 7.2.2	Pass
10	1732.5015	1732.5	0.84	See 7.2.2	Pass
20	1732.5023	1732.5	1.30	See 7.2.2	Pass
30	1732.5017	1732.5	0.95	See 7.2.2	Pass
40	1732.5011	1732.5	0.63	See 7.2.2	Pass
50	1732.5020	1732.5	1.13	See 7.2.2	Pass

Voltage Frequency Stability - NB IoT B4					
Voltage(VDC)	MCF (MHz)	ACF (MHz)	Frequency Stability (ppm)	Limit (ppm)	Result
3.2V	1732.5019	1732.5	1.10	See 7.2.2	Pass
3.8V	1732.5018	1732.5	1.04	See 7.2.2	Pass
4.5V	1732.5019	1732.5	1.07	See 7.2.2	Pass

Temperature Frequency Stability– CAT M1 B12					
Temperature (°C)	MCF (MHz)	ACF (MHz)	Frequency Stability (ppm)	Limit (ppm)	Result
-30	707.5023	707.5	3.25	See 7.2.2	Pass
-20	707.5019	707.5	2.72	See 7.2.2	Pass
-10	707.5018	707.5	2.54	See 7.2.2	Pass
0	707.5017	707.5	2.40	See 7.2.2	Pass
10	707.5023	707.5	3.25	See 7.2.2	Pass
20	707.5018	707.5	2.54	See 7.2.2	Pass
30	707.5016	707.5	2.26	See 7.2.2	Pass
40	707.5015	707.5	2.12	See 7.2.2	Pass
50	707.5005	707.5	0.71	See 7.2.2	Pass

Voltage Frequency Stability - CAT M1 B12					
Voltage(VDC)	MCF (MHz)	ACF (MHz)	Frequency Stability (ppm)	Limit (ppm)	Result
3.2V	707.5009	707.5	1.27	See 7.2.2	Pass
3.8V	707.5018	707.5	2.42	See 7.2.2	Pass
4.5V	707.5021	707.5	2.97	See 7.2.2	Pass

Temperature Frequency Stability– NB IoT B12					
Temperature (°C)	MCF (MHz)	ACF (MHz)	Frequency Stability (ppm)	Limit (ppm)	Result
-30	707.5022	707.5	3.11	See 7.2.2	Pass
-20	707.5020	707.5	2.86	See 7.2.2	Pass
-10	707.5015	707.5	2.12	See 7.2.2	Pass
0	707.5018	707.5	2.47	See 7.2.2	Pass
10	707.5020	707.5	2.76	See 7.2.2	Pass
20	707.5018	707.5	2.58	See 7.2.2	Pass
30	707.5018	707.5	2.47	See 7.2.2	Pass
40	707.5013	707.5	1.77	See 7.2.2	Pass
50	707.5019	707.5	2.65	See 7.2.2	Pass

Voltage Frequency Stability - NB IoT B12					
Voltage(VDC)	MCF (MHz)	ACF (MHz)	Frequency Stability (ppm)	Limit (ppm)	Result
3.2V	707.5017	707.5	2.40	See 7.2.2	Pass
3.8V	707.5016	707.5	2.19	See 7.2.2	Pass
4.5V	707.5014	707.5	1.94	See 7.2.2	Pass

Temperature Frequency Stability– CAT M1 B13					
Temperature (°C)	MCF (MHz)	ACF (MHz)	Frequency Stability (ppm)	Limit (ppm)	Result
-30	782.5386	782.54	1.79	See 7.2.2	Pass
-20	782.5382	782.54	2.30	See 7.2.2	Pass
-10	782.5382	782.54	2.30	See 7.2.2	Pass
0	782.5383	782.54	2.17	See 7.2.2	Pass
10	782.5379	782.54	2.68	See 7.2.2	Pass
20	782.5381	782.54	2.43	See 7.2.2	Pass
30	782.5382	782.54	2.30	See 7.2.2	Pass
40	782.5383	782.54	2.17	See 7.2.2	Pass
50	782.5382	782.54	2.30	See 7.2.2	Pass

Voltage Frequency Stability - CAT M1 B13					
Voltage(VDC)	MCF (MHz)	ACF (MHz)	Frequency Stability (ppm)	Limit (ppm)	Result
3.2V	782.5380	782.54	2.56	See 7.2.2	Pass
3.8V	782.5381	782.54	2.43	See 7.2.2	Pass
4.5V	782.5391	782.54	1.15	See 7.2.2	Pass

Temperature Frequency Stability– NB IoT B13					
Temperature (°C)	MCF (MHz)	ACF (MHz)	Frequency Stability (ppm)	Limit (ppm)	Result
-30	782.0016	782	2.01	See 7.2.2	Pass
-20	782.0020	782	2.49	See 7.2.2	Pass
-10	782.0019	782	2.43	See 7.2.2	Pass
0	782.0020	782	2.56	See 7.2.2	Pass
10	782.0017	782	2.17	See 7.2.2	Pass
20	782.0014	782	1.73	See 7.2.2	Pass
30	782.0014	782	1.82	See 7.2.2	Pass
40	782.0014	782	1.79	See 7.2.2	Pass
50	782.0019	782	2.37	See 7.2.2	Pass

Voltage Frequency Stability - NB IoT B13					
Voltage(VDC)	MCF (MHz)	ACF (MHz)	Frequency Stability (ppm)	Limit (ppm)	Result
3.2V	782.0015	782	1.85	See 7.2.2	Pass
3.8V	782.0015	782	1.89	See 7.2.2	Pass
4.5V	782.0012	782	1.50	See 7.2.2	Pass

7.3 Occupied Bandwidth

7.3.1 Measurement utilizing KDB 971168 D01 and ANSI C63.26-2015 Subclause 5.4.4

Spectrum Analyzer settings:

- RBW ≥ 1 to 5 % of anticipated OBW.
- VBW ≥ 3 × RBW.
- Set span ≥ 2 to 5 times OBW
- Sweep time = auto couple.
- Detector = Peak
- Trace mode = Max hold.
- Allow trace to fully stabilize.
- Use the 99 % power bandwidth function of the spectrum analyzer (if available) and report the measured bandwidth.

7.3.2 Requirement: FCC Part 2.1049

7.3.2.1 FCC Part 2.1049

The occupied bandwidth, that 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 shall be measured under the following conditions as applicable:
(h) Transmitters employing digital modulation techniques—when modulated by an input signal such that its amplitude and symbol rate represent the maximum rated conditions under which the equipment will be operated. The signal shall be applied through any filter networks, pseudo-random generators or other devices required in normal service. Additionally, the occupied bandwidth shall be shown for operation with any devices used for modifying the spectrum when such devices are optional at the discretion of the user.

7.3.2.2 RSS-130 3.1, and RSS-139 Part 6.2 Types of Modulation

Equipment certified under this standard shall use digital modulation.

7.3.3 Test conditions and setup:

Ambient Temperature (C)	EUT Set-Up #	EUT operating mode	Power Input (VAC)
22	1	1 and 2	110 V / 60 Hz

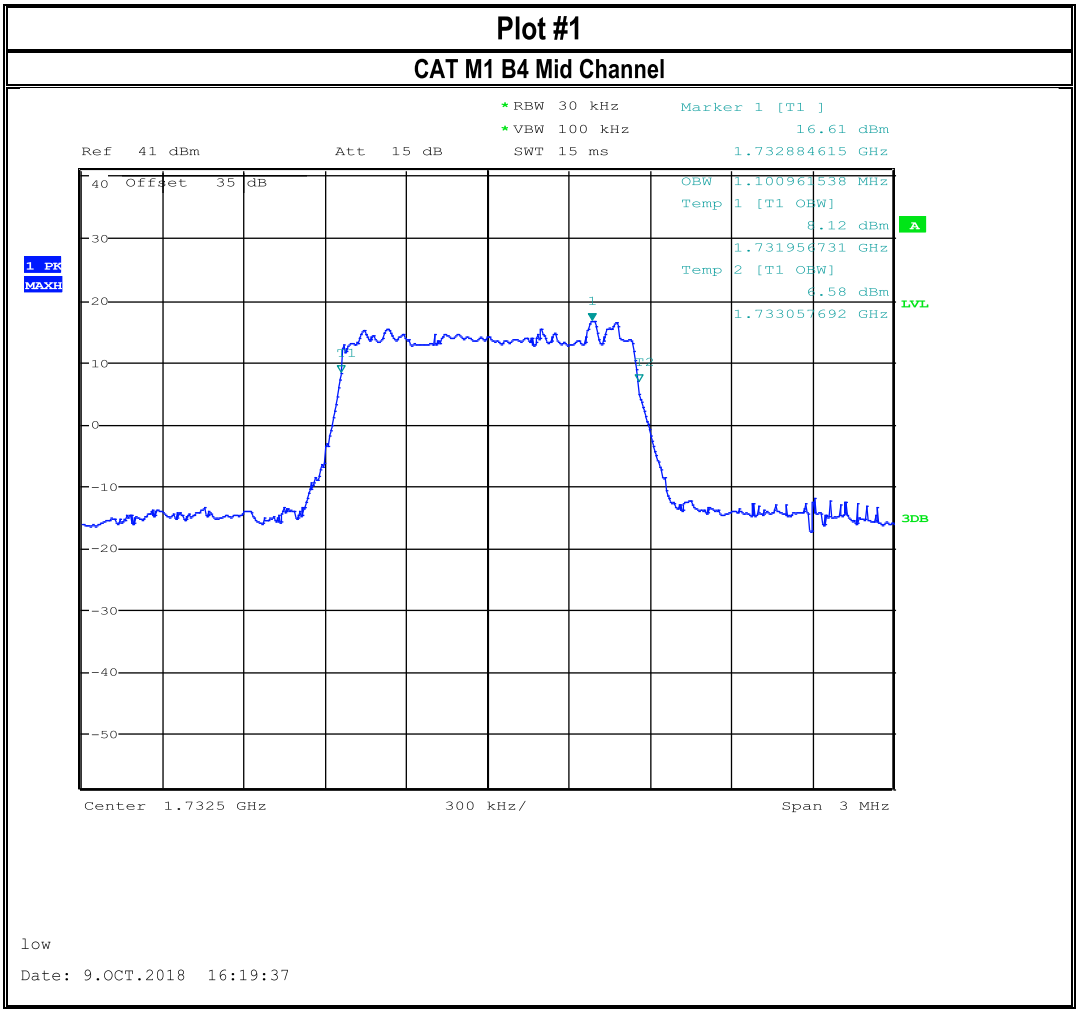
7.3.4 Measurement result:

Plot #	EUT operating mode / Modulation	OBW (MHz)
1	CAT M1 B4 / QPSK	1.101
2	CAT M1 B4 / 16-QAM	1.110
3	NB IoT B4 / mid	0.187
4	CAT M1 B12 / QPSK	1.097
5	CAT M1 B12 / 16-QAM	1.110
6	NB IoT B12 / mid	0.187
7	CAT M1 B13 / QPSK	1.187
8	CAT M1 B13 / 16-QAM	1.197
9	NB IoT B13 / mid	0.187

7.3.5 Measurement Plots:

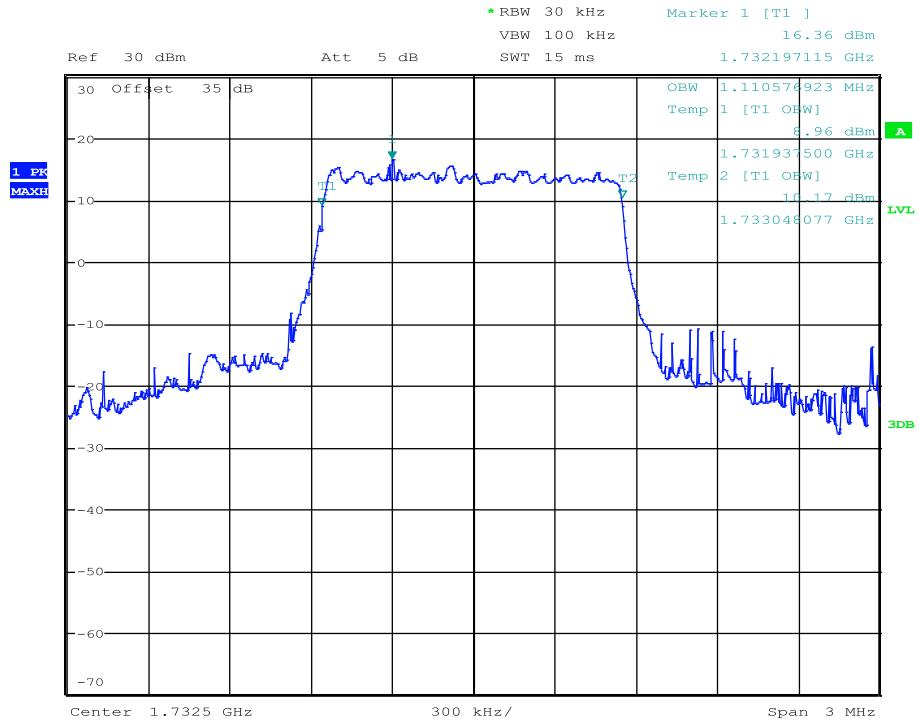
Plot #1

CAT M1 B4 Mid Channel



Plot #2

CAT M1 B4 Mid Channel

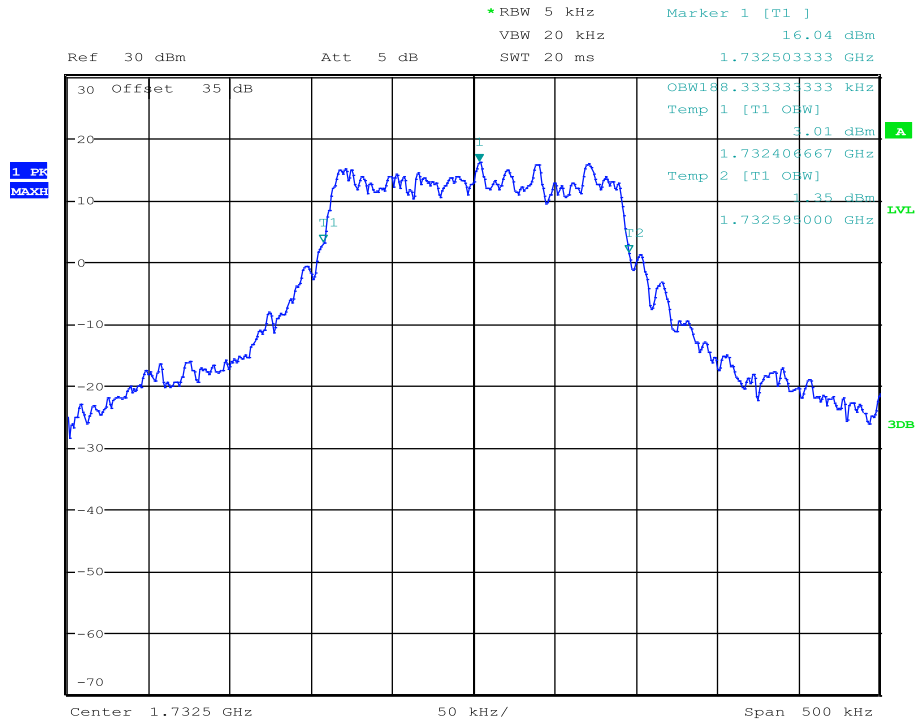


low

Date: 15.OCT.2018 12:27:32

Plot # 3

NB IoT B4 Mid Channel

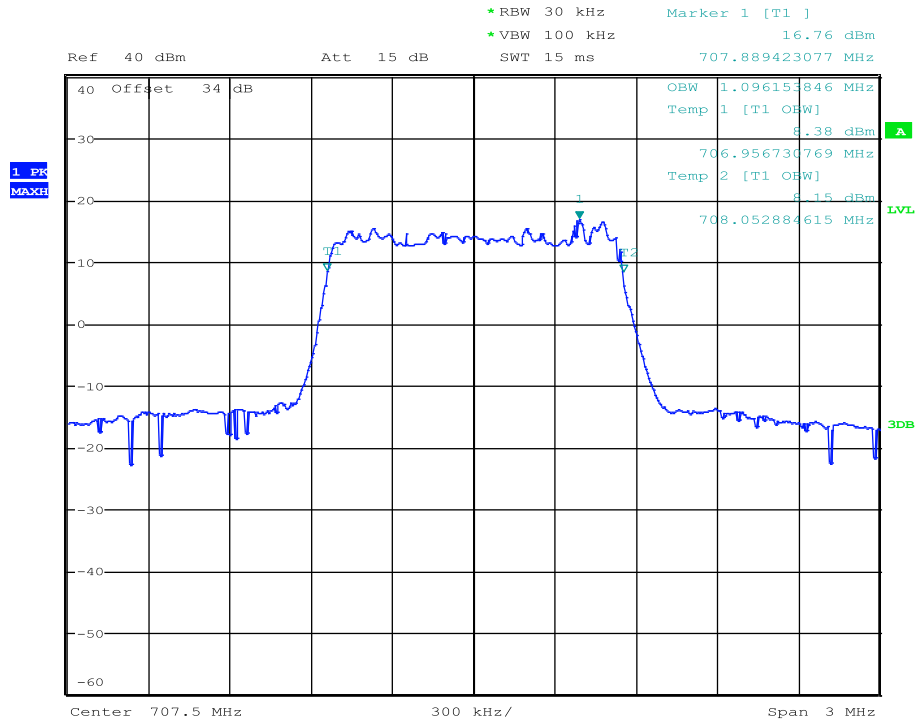


low

Date: 15.OCT.2018 15:46:51

Plot #4

CAT M1 B12 Mid Channel

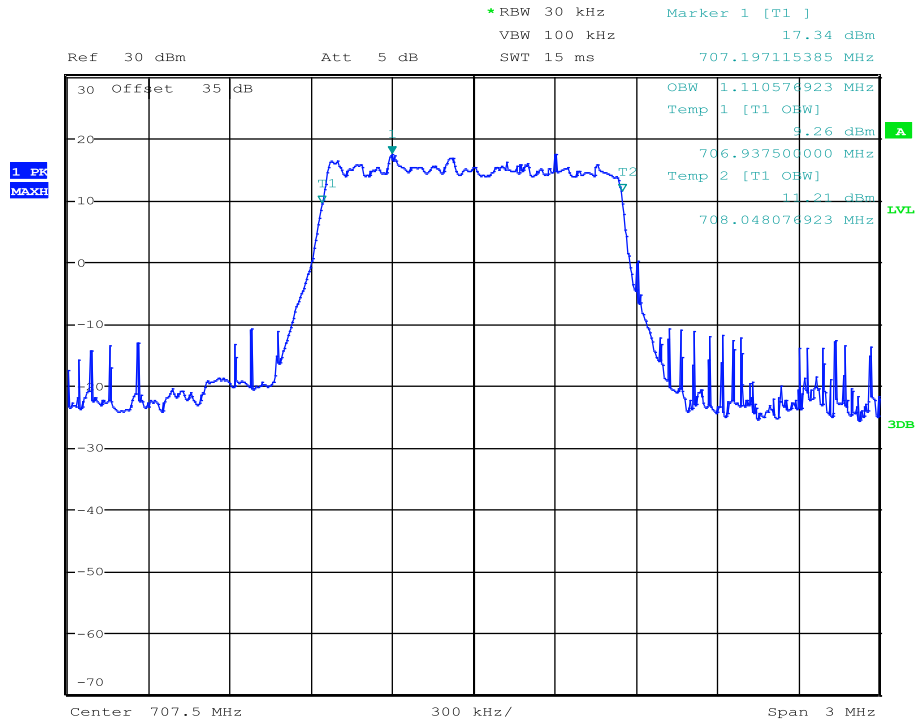


low

Date: 9.OCT.2018 16:10:30

Plot #5

CAT M1 B12 Mid Channel

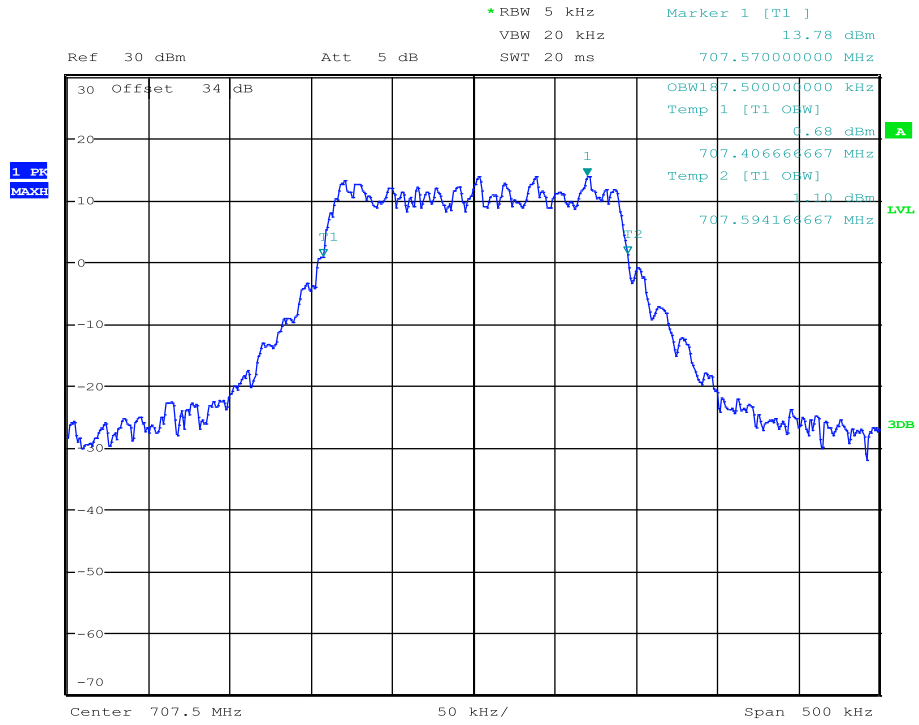


low

Date: 15.OCT.2018 12:31:01

Plot #6

NB IoT B12 Mid Channel

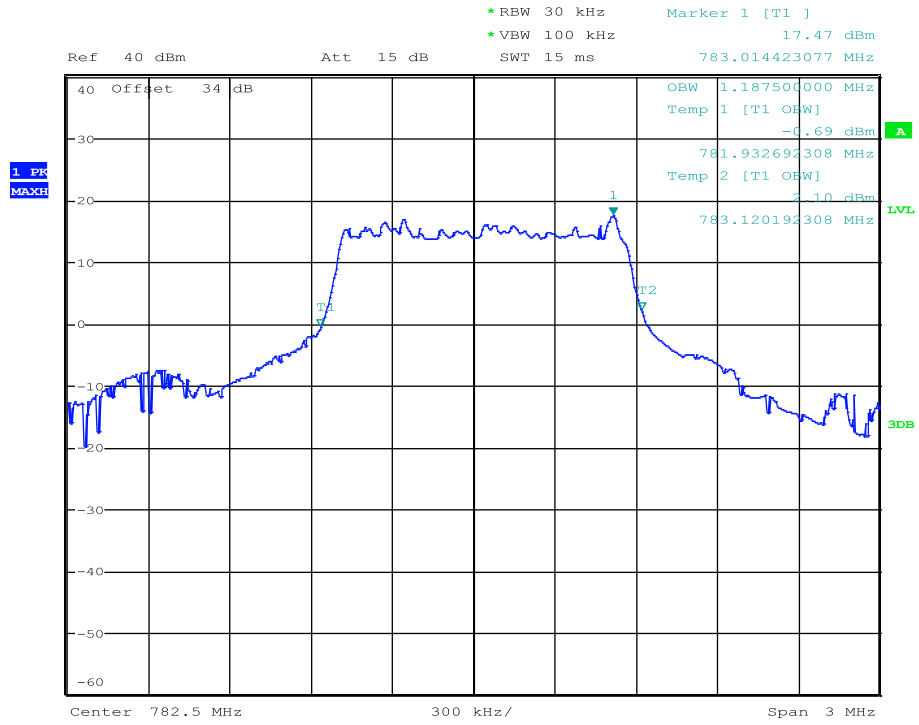


low

Date: 15.OCT.2018 15:43:03

Plot #7

CAT M1 B13 Mid Channel

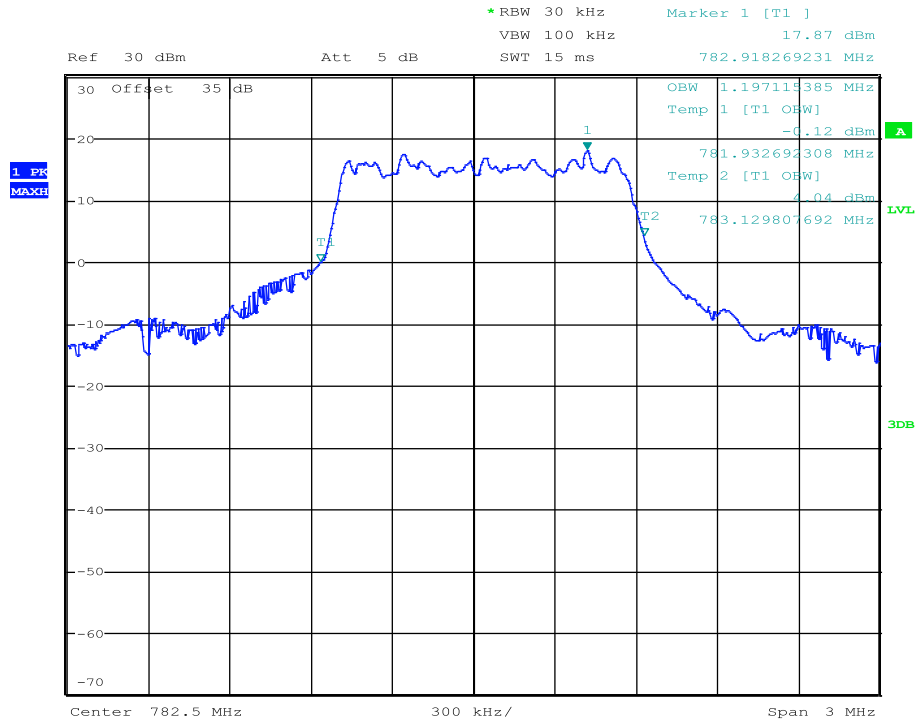


low

Date: 9.OCT.2018 15:18:10

Plot #8

CAT M1 B13 Mid Channel

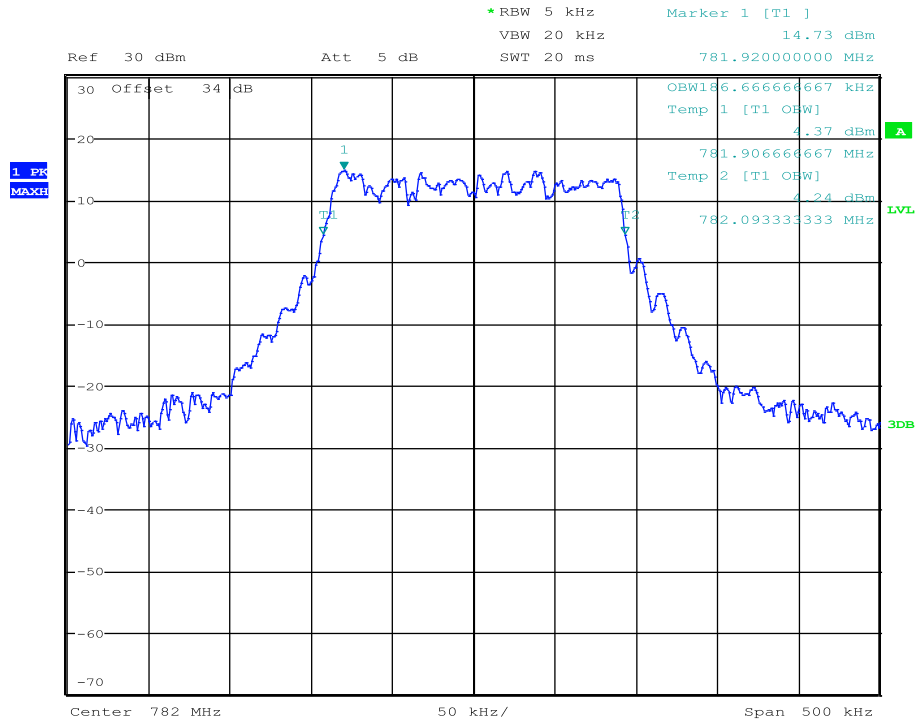


low

Date: 15.OCT.2018 12:33:51

Plot #9

NB IoT B12 Mid Channel



low

Date: 15.OCT.2018 15:44:31

7.4 Band Edge Compliance

7.4.1 Measurement utilizing KDB 971168 D01 and ANSI C63.26-2015 Subclause 5.7.3

Spectrum Analyzer settings:

- RBW ≥ 1% of OBW
- VBW ≥ 3 × RBW
- Set span ≥ 1MHz
- Sweep time = auto couple
- Detector = RMS
- Trace mode = max hold
- Allow trace to fully stabilize
- Use the peak marker function to determine the peak amplitude level

7.4.2 Limits:

7.4.2.1 FCC Part 27.53

(h) AWS emission limits—(1) General protection levels. Except as otherwise specified below, for operations in the 1695-1710 MHz, 1710-1755 MHz, 1755-1780 MHz, 1915-1920 MHz, 1995-2000 MHz, 2000-2020 MHz, 2110-2155 MHz, 2155-2180 MHz, and 2180-2200 bands, the power of any emission outside a licensee's frequency block shall be attenuated below the transmitter power (P) in watts by at least 43 + 10 log10 (P) dB.

7.4.2.2 RSS-130 6.4, and RSS-139 Part 6.6 Transmitter Unwanted Emissions

i.In the first 1.0 MHz bands immediately outside and adjacent to the equipment's smallest operating frequency block, which can contain the equipment's occupied bandwidth, the emission power per any 1% of the emission bandwidth shall be attenuated below the transmitter output power P (in dBW) by at least 43 + 10 log10 p (watts) dB.
ii.After the first 1.0 MHz outside the equipment's smallest operating frequency block, which can contain the equipment's occupied bandwidth, the emission power in any 1 MHz bandwidth shall be attenuated below the transmitter output power P (in dBW) by at least 43 + 10 log10 p (watts) dB.

Note: The limit calculation result is a constant of -13dBm.

7.4.3 Test conditions and setup:

Ambient Temperature (C)	EUT Set-Up #	EUT operating mode	Power Input (VDC)	Measurement Path Correction (dB)
22	1	1 and 2	110V / 60 Hz	35

7.4.4 Measurement result:

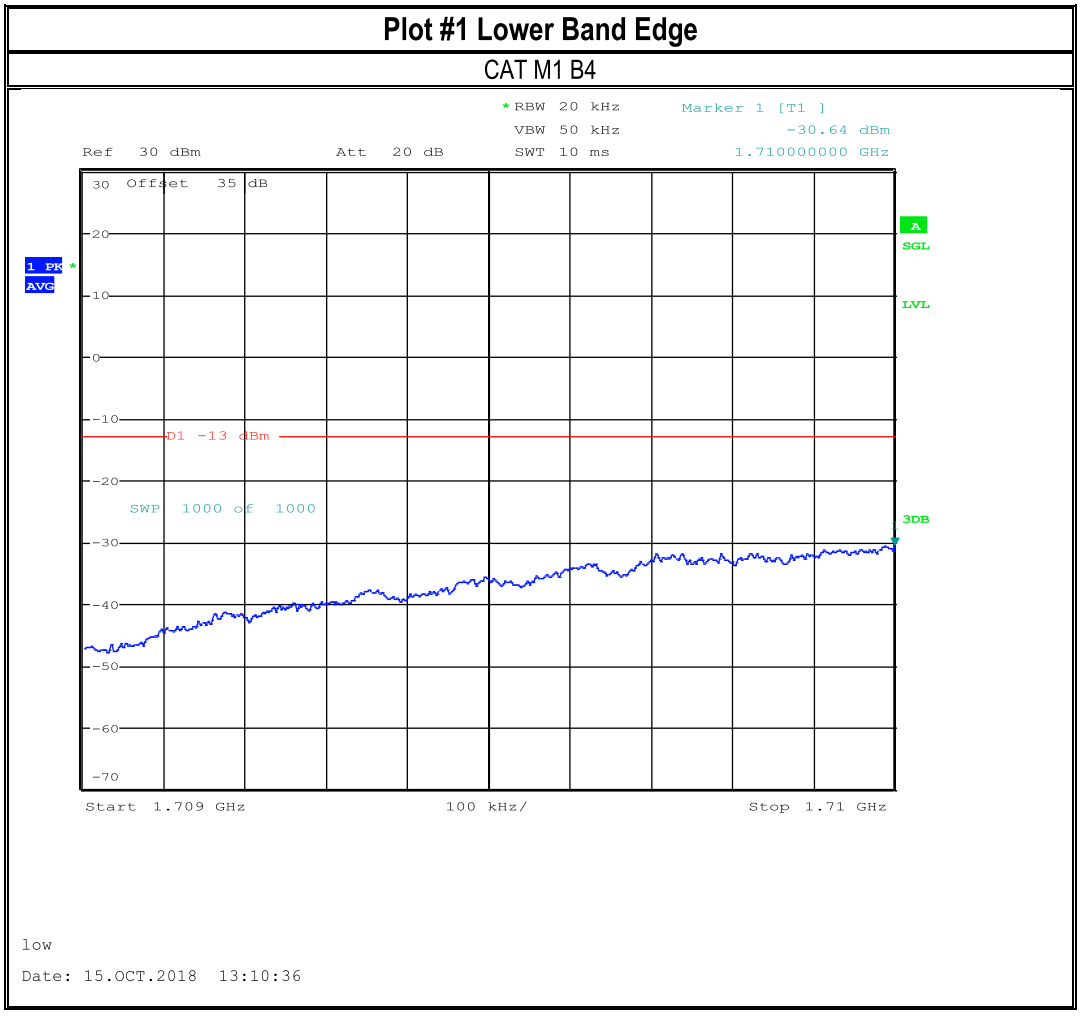
Plot #	EUT operating mode	Band Edge	RMS RF Power (dBm) See Note 1	Limit (dBm)	Result
1	CAT M1 B4	Lower Band Edge	-28.64	-13	Pass
2	CAT M1 B4	Upper Band Edge	-32.35	-13	Pass
3	NB IoT B4	Lower Band Edge	-26.68	-13	Pass
4	NB IoT B4	Upper Band Edge	-24.09	-13	Pass
5	CAT M1 B12	Lower Band Edge	-32.98	-13	Pass
6	CAT M1 B12	Upper Band Edge	-34.35	-13	Pass
7	NB IoT B12	Lower Band Edge	-27.47	-13	Pass
8	NB IoT B12	Upper Band Edge	-27.87	-13	Pass
9	CAT M1 B13	Lower Band Edge	-30.55	-13	Pass
10	CAT M1 B13	Upper Band Edge	-34.95	-13	Pass
11	NB IoT B13	Lower Band Edge	-23.9	-13	Pass
12	NB IoT B13	Upper Band Edge	-25.76	-13	Pass

Note 1: RF Power is adjusted for 2 dBi antenna gain in band 4, and 2.83 dBi in bands 12, and 13.

7.4.5 Measurement Plots:

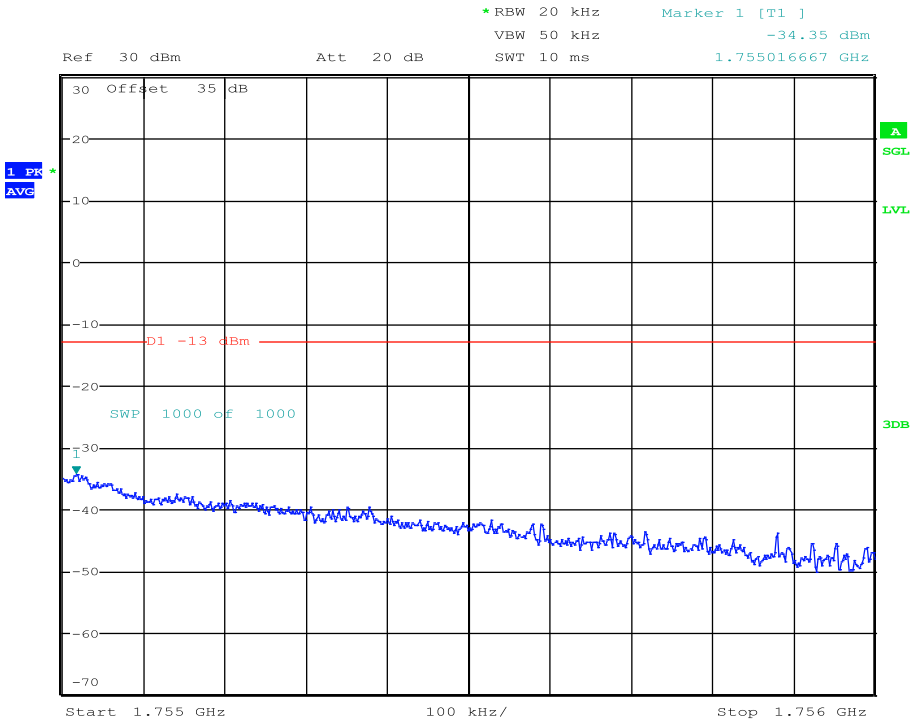
Plot #1 Lower Band Edge

CAT M1 B4



Plot #2 Upper Band Edge

CAT M1 B4

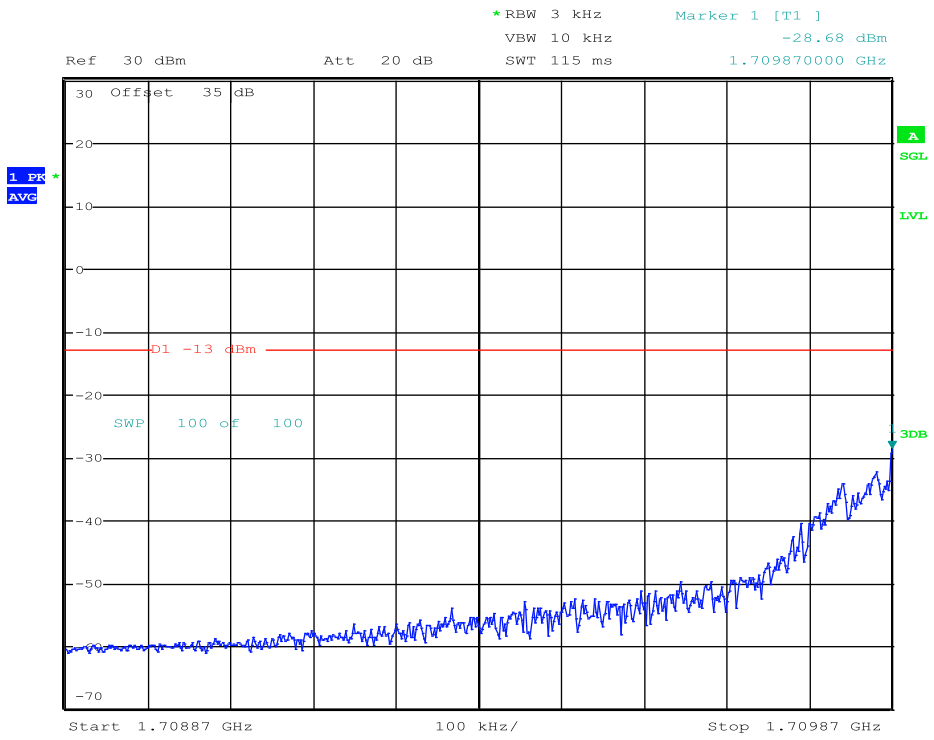


low

Date: 15.OCT.2018 13:13:28

Plot #3 Lower Band Edge

NB IoT B4

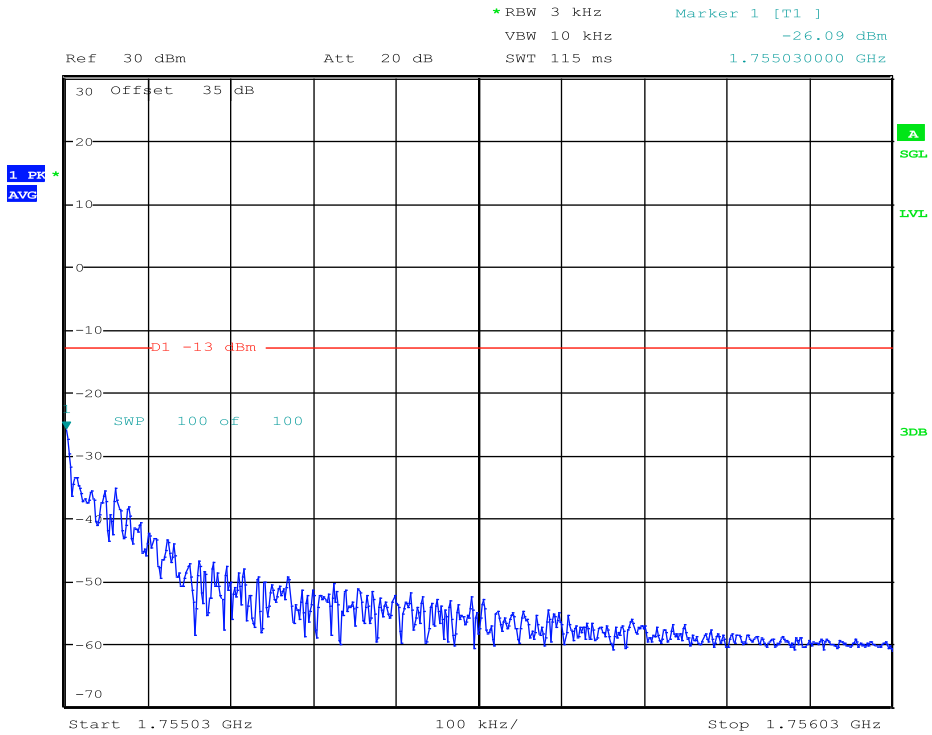


low

Date: 15.OCT.2018 16:56:24

Plot #4 Upper Band Edge

NB IoT B4

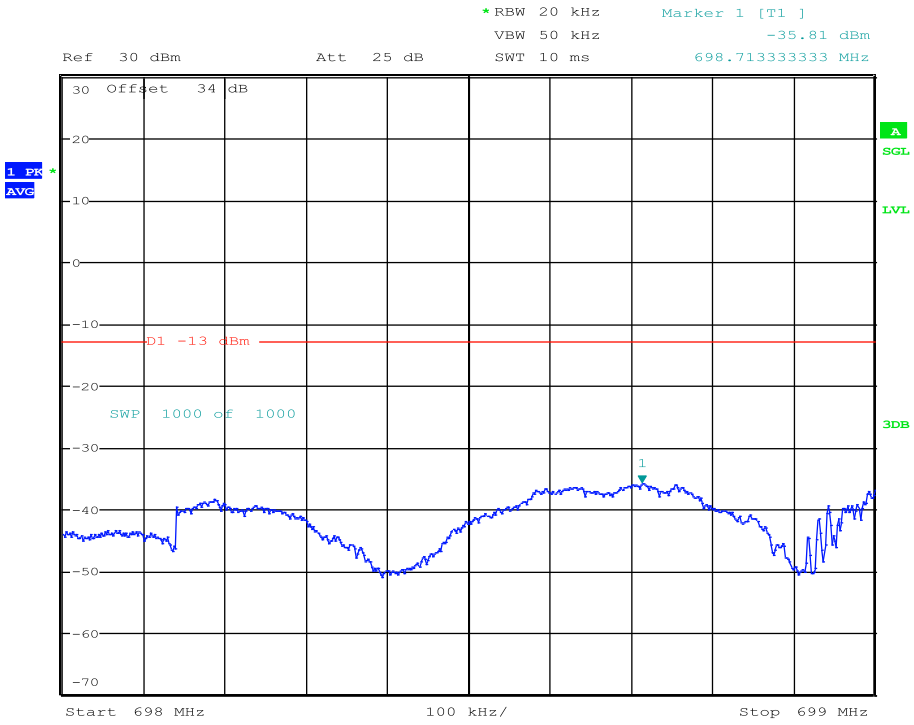


low

Date: 15.OCT.2018 16:58:27

Plot #5 Lower Band Edge

CAT M1 B12

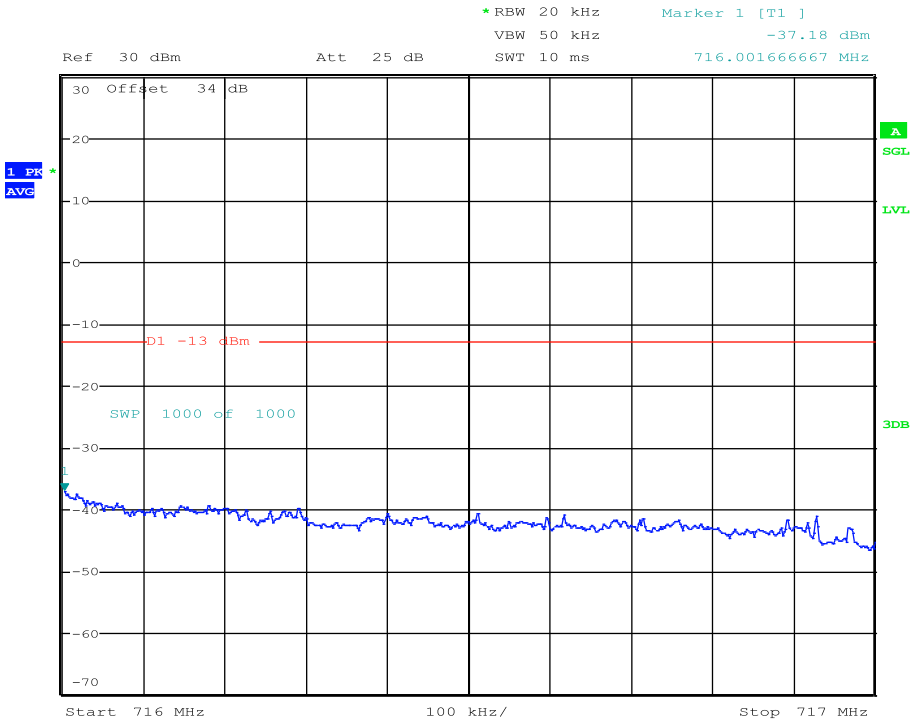


low

Date: 15.OCT.2018 12:49:57

Plot #6 Upper Band Edge

CAT M1 B12

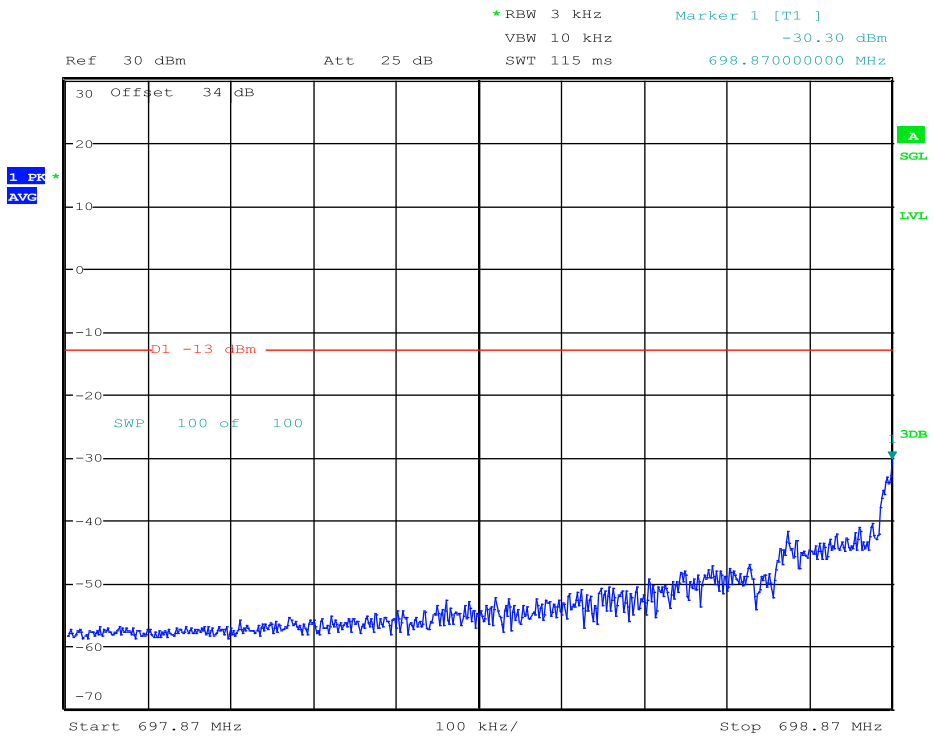


low

Date: 15.OCT.2018 12:54:27

Plot #7 Lower Band Edge

NB IoT B12

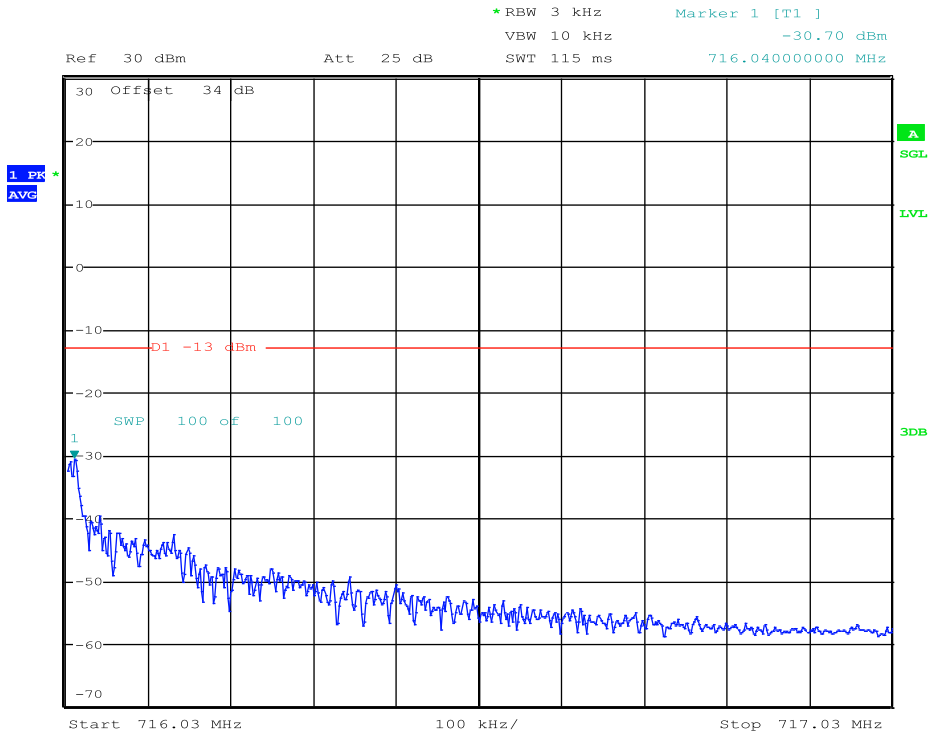


low

Date: 15.OCT.2018 17:23:56

Plot #8 Upper Band Edge

NB IoT B12

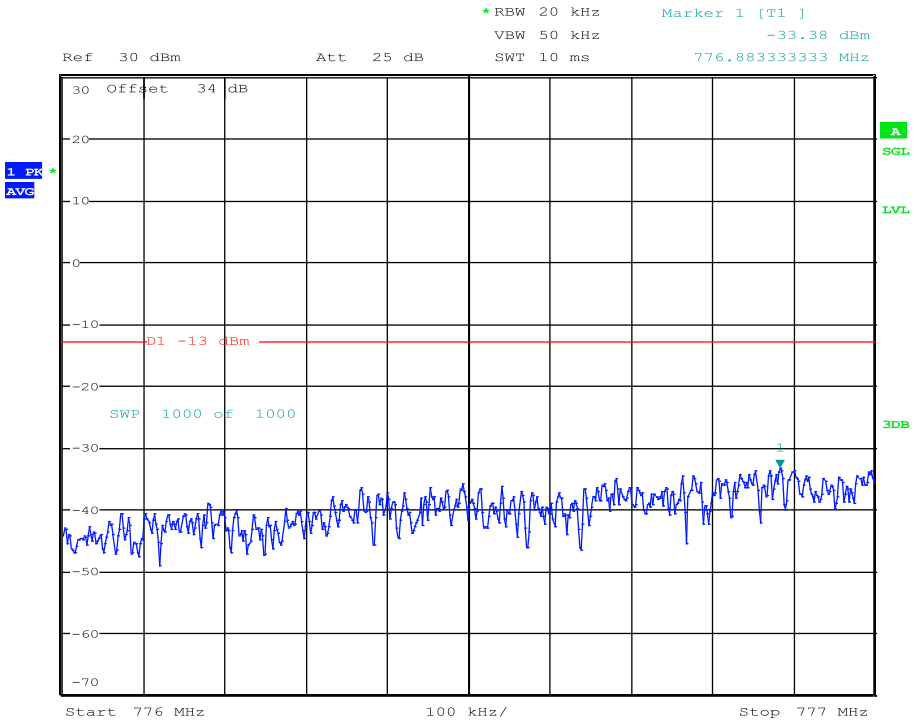


low

Date: 15.OCT.2018 17:27:24

Plot #9 Lower Band Edge

CAT M1 B13

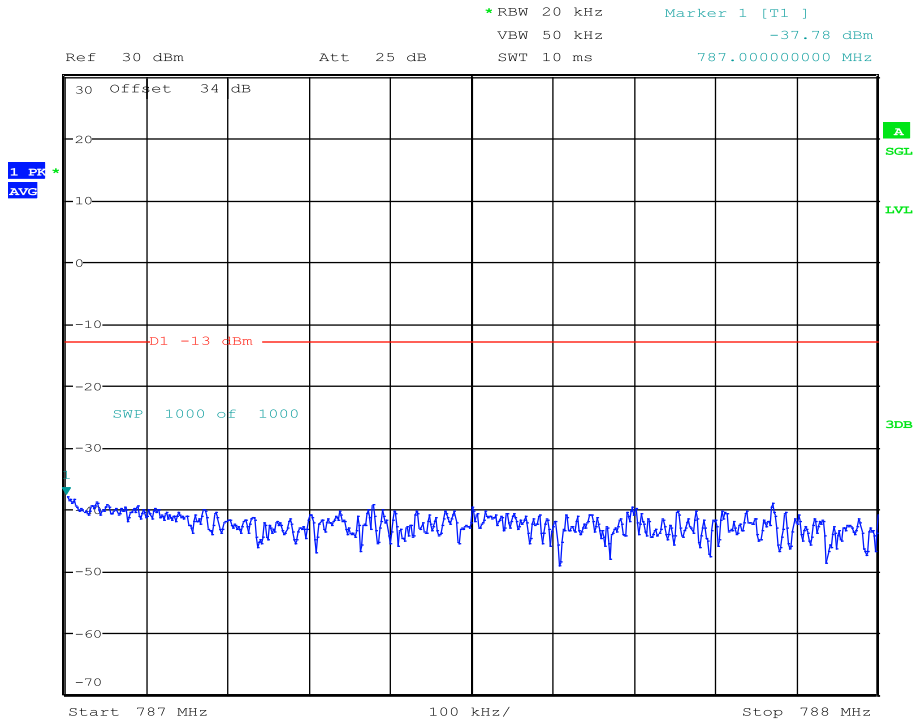


low

Date: 15.OCT.2018 12:42:55

Plot #10 Upper Band Edge

CAT M1 B13

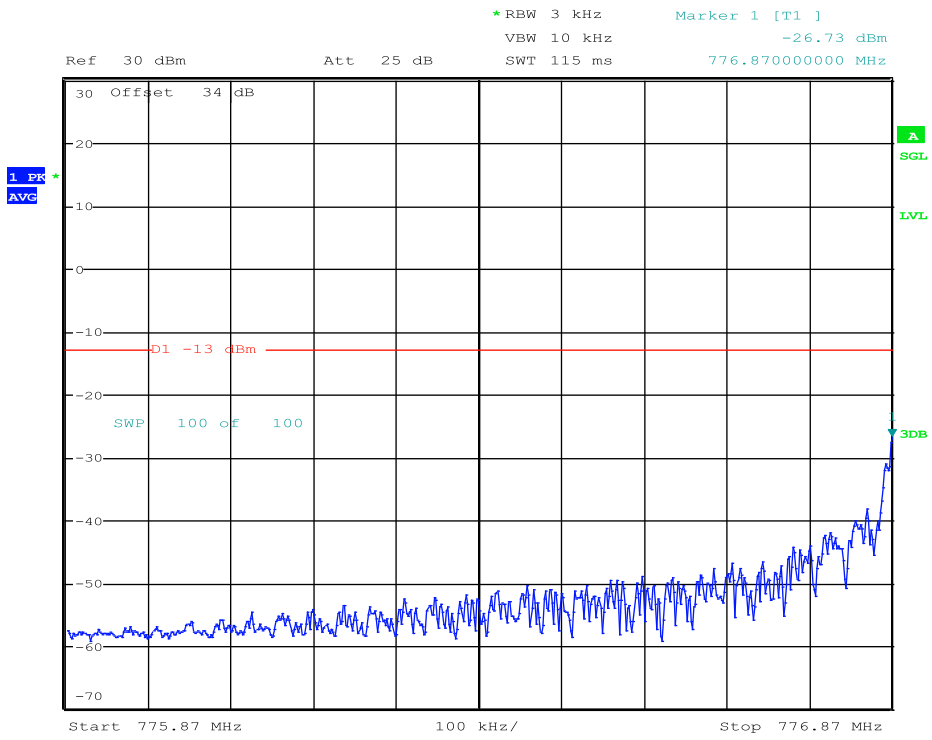


low

Date: 15.OCT.2018 12:39:40

Plot #11 Lower Band Edge

NB IoT B13

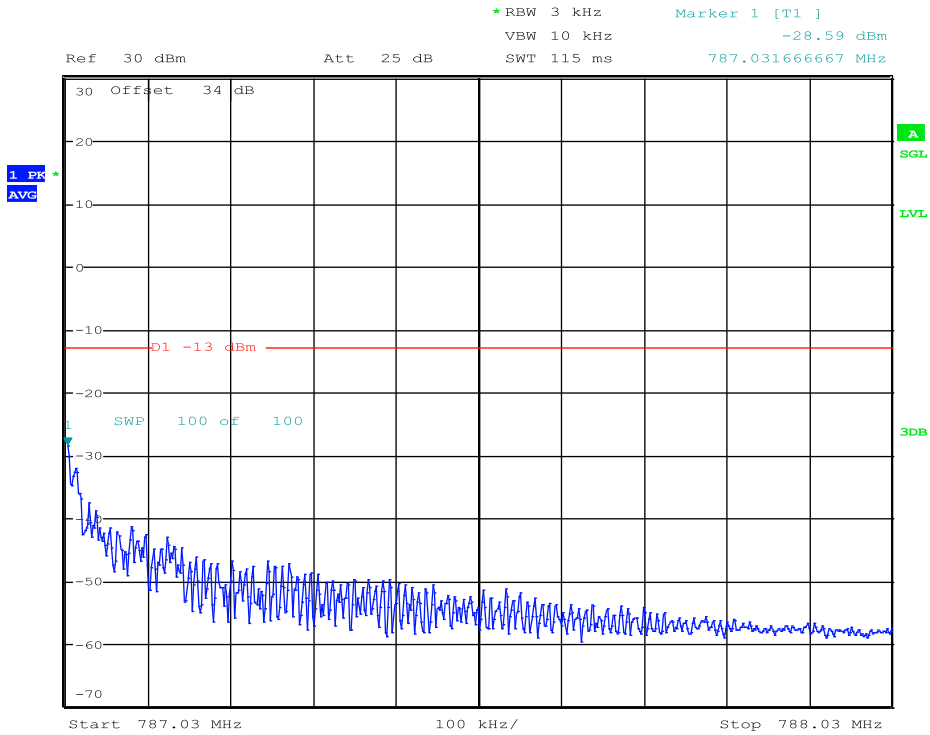


low

Date: 15.OCT.2018 17:32:45

Plot #12 Upper Band Edge

NB IoT B13



low

Date: 15.OCT.2018 17:30:20

7.5 Conducted Spurious Emissions

7.5.1 Measurement utilizing KDB 971168 D01 and ANSI C63.26-2015 Subclause 5.7.4

Spectrum Analyzer settings:

- RBW = 1 MHz
- VBW = 3 MHz
- Sweep time = Auto couple
- Detector = RMS
- Trace mode = Max Hold

7.5.2 Limits:

7.5.2.1 FCC Part 27.53

Out of band emissions. 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.

7.5.2.2 RSS-130 6.4, and RSS-139 Part 6.6 Transmitter Unwanted Emissions

Mobile and base station equipment shall comply with the limits in (i) and (ii) below.

i.In the first 1.0 MHz band immediately outside and adjacent to each of the sub-bands specified in Section 5.1, the power of emissions per any 1% of the occupied bandwidth shall be attenuated (in dB) below the transmitter output power P (dBW) by at least 43 + 10 log10p (watts).

ii.After the first 1.0 MHz immediately outside and adjacent to each of the sub-bands, the power of emissions in any 100 kHz bandwidth shall be attenuated (in dB) below the transmitter output power P (dBW) by at least 43 + 10 log10 p (watts). If the measurement is performed using 1% of the occupied bandwidth, power integration over 100 kHz is required.

Note: The limit calculation result is a constant of -13 dBm.

7.5.3 Test conditions and setup:

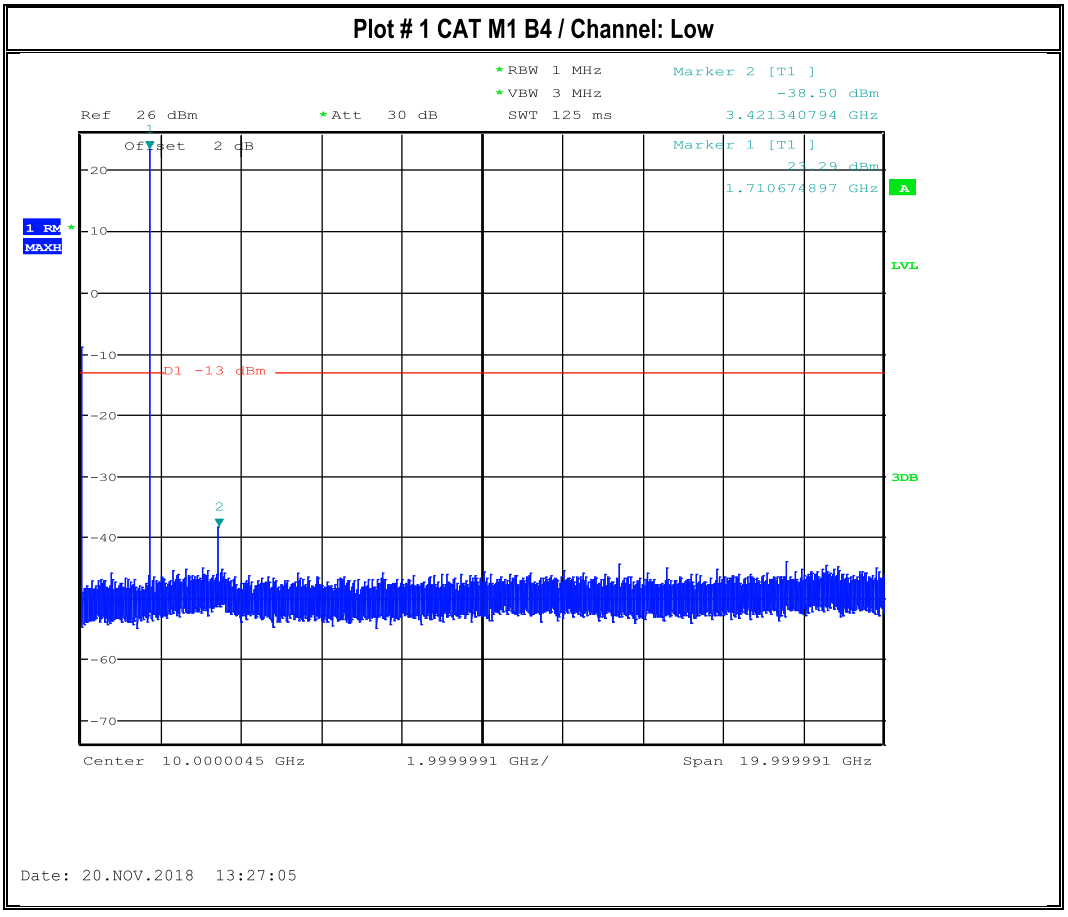
Ambient Temperature (C)	EUT Set-Up #	EUT operating mode	Power Input
22	1	1 and 2	110 V / 60 Hz

7.5.4 Measurement result:

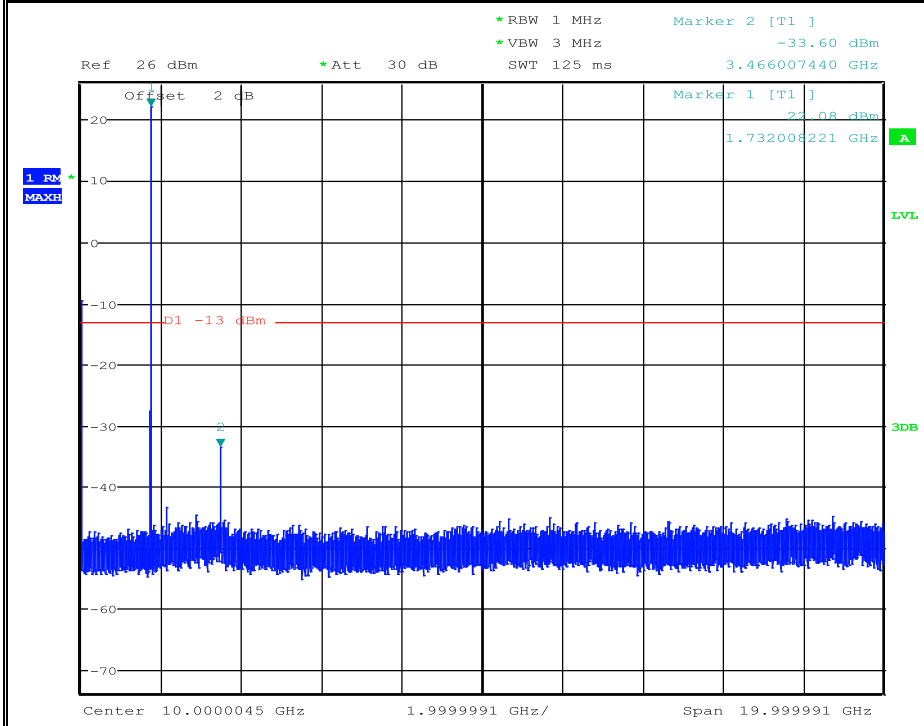
Plot #	Channel	EUT operating mode	Scan Frequency	Limit (dBm)	Result
1	Low	CAT M1 B4	9 kHz – 20 GHz	-13	Pass
2	Mid	CAT M1 B4	9 kHz – 20 GHz	-13	Pass
3	High	CAT M1 B4	9 kHz – 20 GHz	-13	Pass
4	Low	NB IoT B4	9 kHz – 20 GHz	-13	Pass
5	Mid	NB IoT B4	9 kHz – 20 GHz	-13	Pass
6	High	NB IoT B4	9 kHz – 20 GHz	-13	Pass
7	Low	CAT M1 B12	9 kHz – 10 GHz	-13	Pass
8	Mid	CAT M1 B12	9 kHz – 10 GHz	-13	Pass
9	High	CAT M1 B12	9 kHz – 10 GHz	-13	Pass
10	Low	NB IoT B12	9 kHz – 10 GHz	-13	Pass
11	Mid	NB IoT B12	9 kHz – 10 GHz	-13	Pass
12	High	NB IoT B12	9 kHz – 10 GHz	-13	Pass
13	Low	CAT M1 B13	9 kHz – 10 GHz	-13	Pass
14	Mid	CAT M1 B13	9 kHz – 10 GHz	-13	Pass
15	High	CAT M1 B13	9 kHz – 10 GHz	-13	Pass
16	Low	NB IoT B13	9 kHz – 10 GHz	-13	Pass
17	Mid	NB IoT B13	9 kHz – 10 GHz	-13	Pass
18	High	NB IoT B13	9 kHz – 10 GHz	-13	Pass

7.5.5 Measurement Plots:

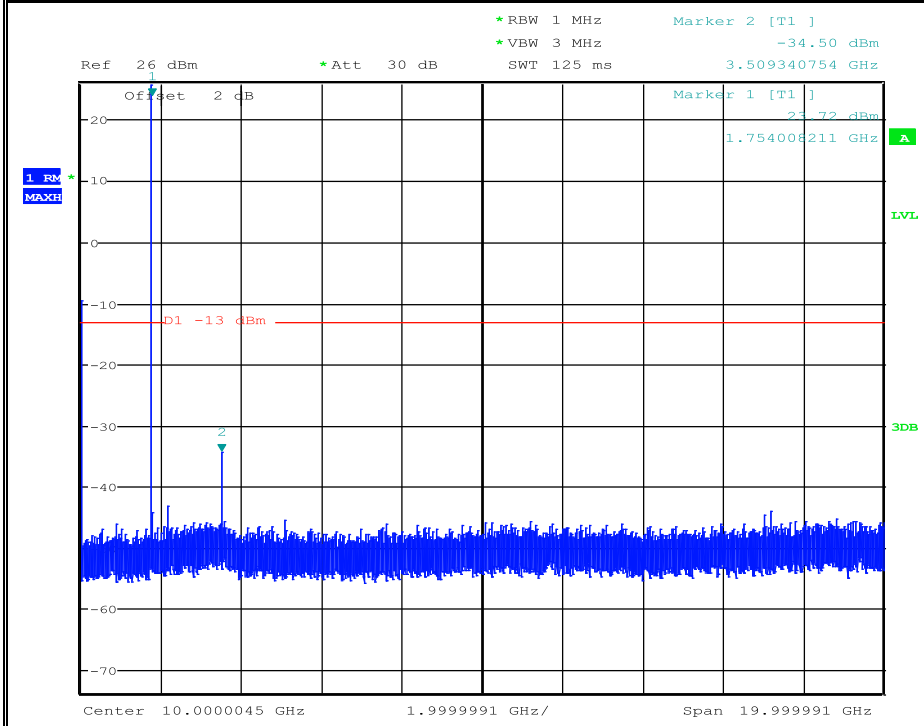
Plot # 1 CAT M1 B4 / Channel: Low



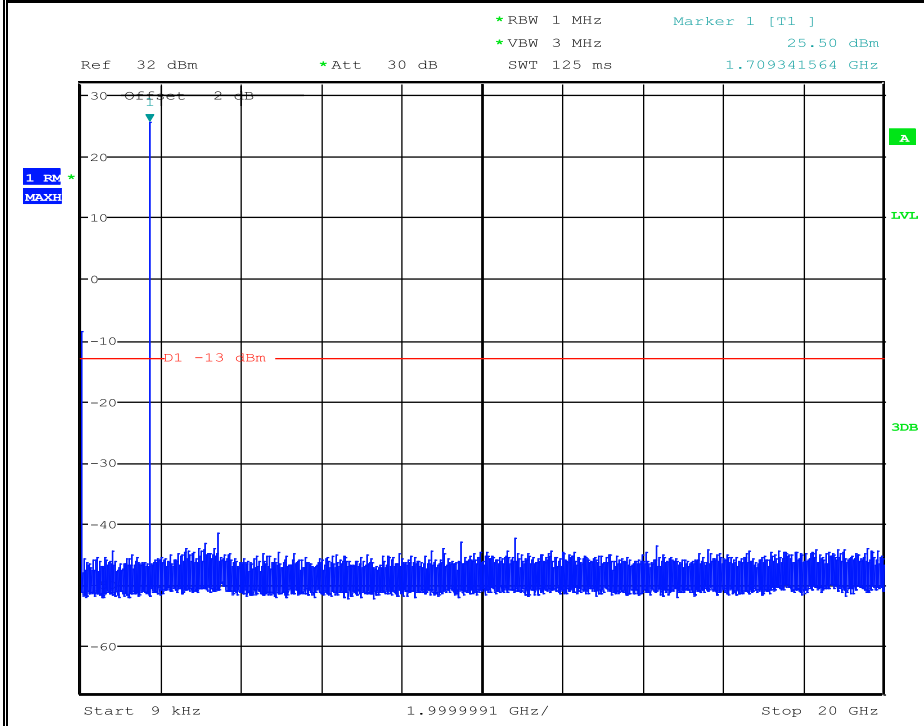
Plot # 2 CAT M1 B4 / Channel: Mid



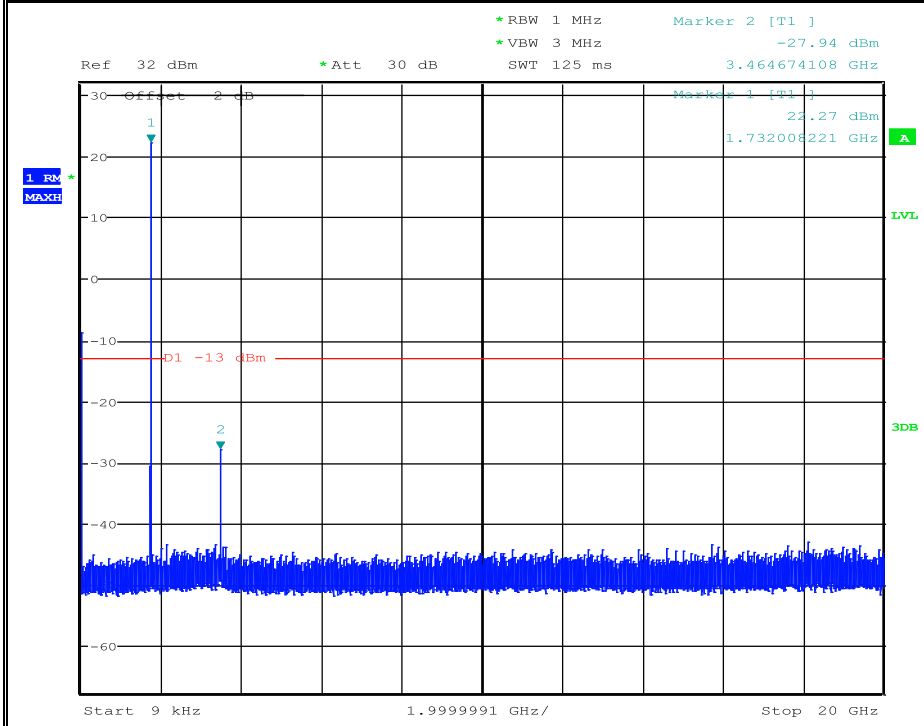
Plot # 3 CAT M1 B4 / Channel: Hi



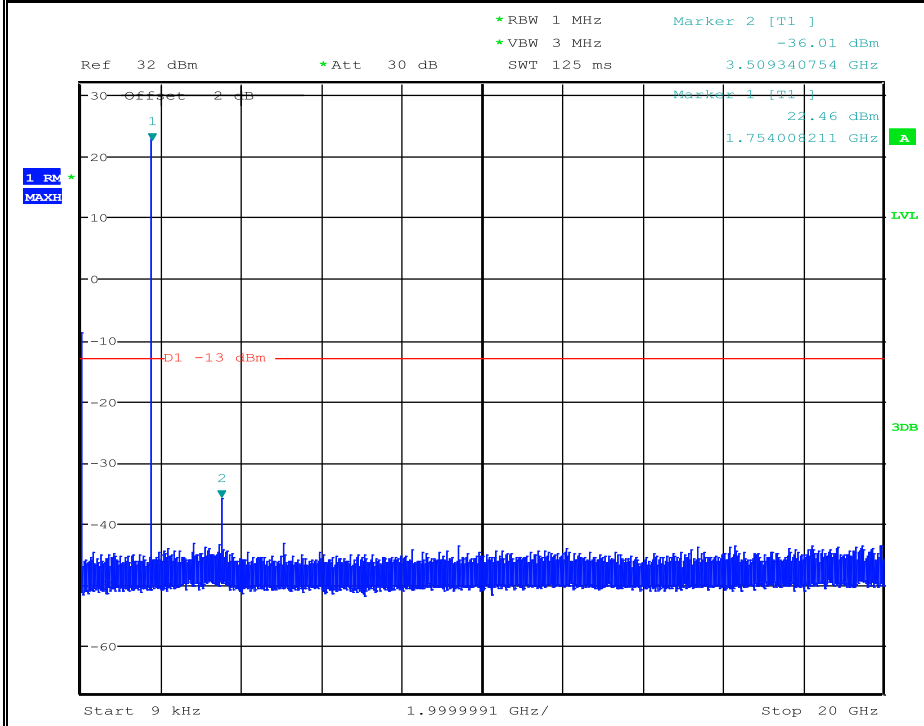
Plot # 4 NB IoT B4 / Channel: Low



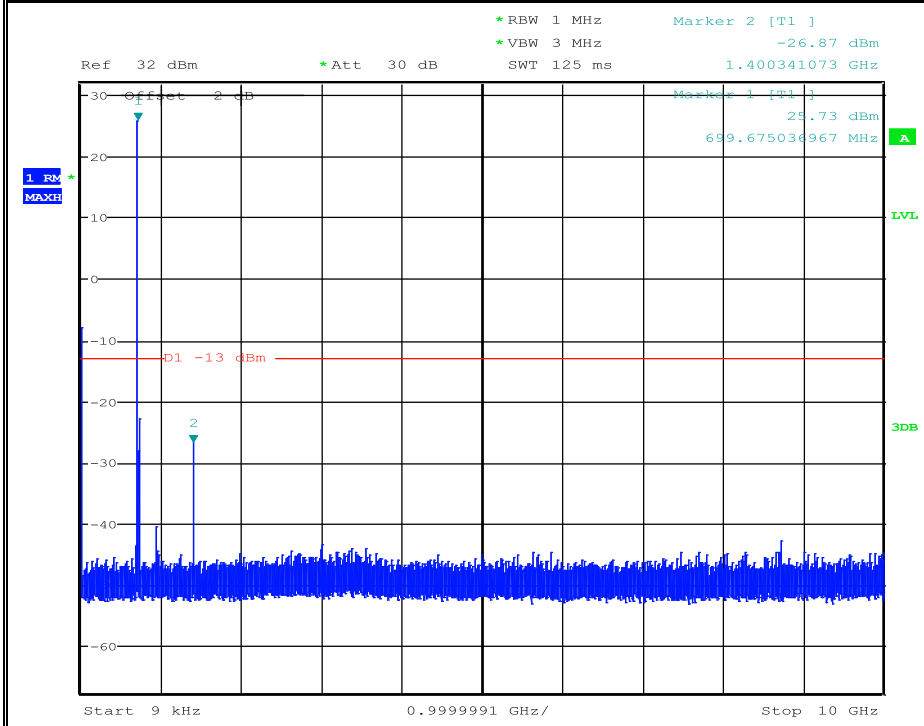
Plot # 5 NB IoT B4 / Channel: Mid



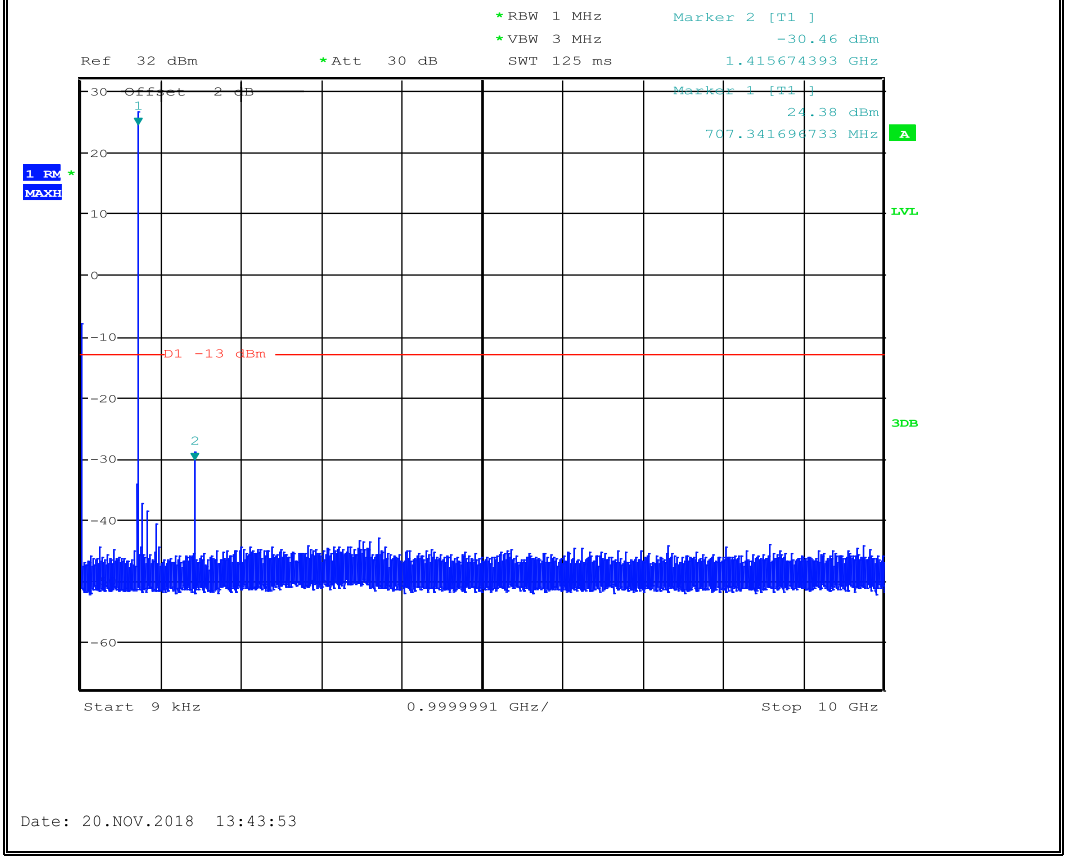
Plot # 6 NB IoT B4 / Channel: Hi



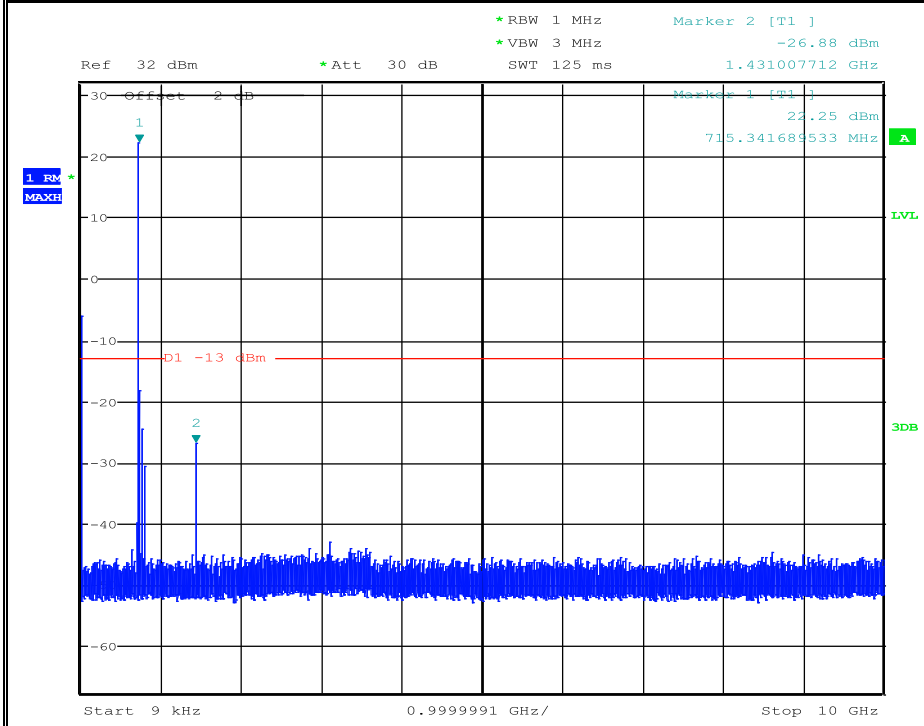
Plot # 7 CAT M1 B12 / Channel: Low



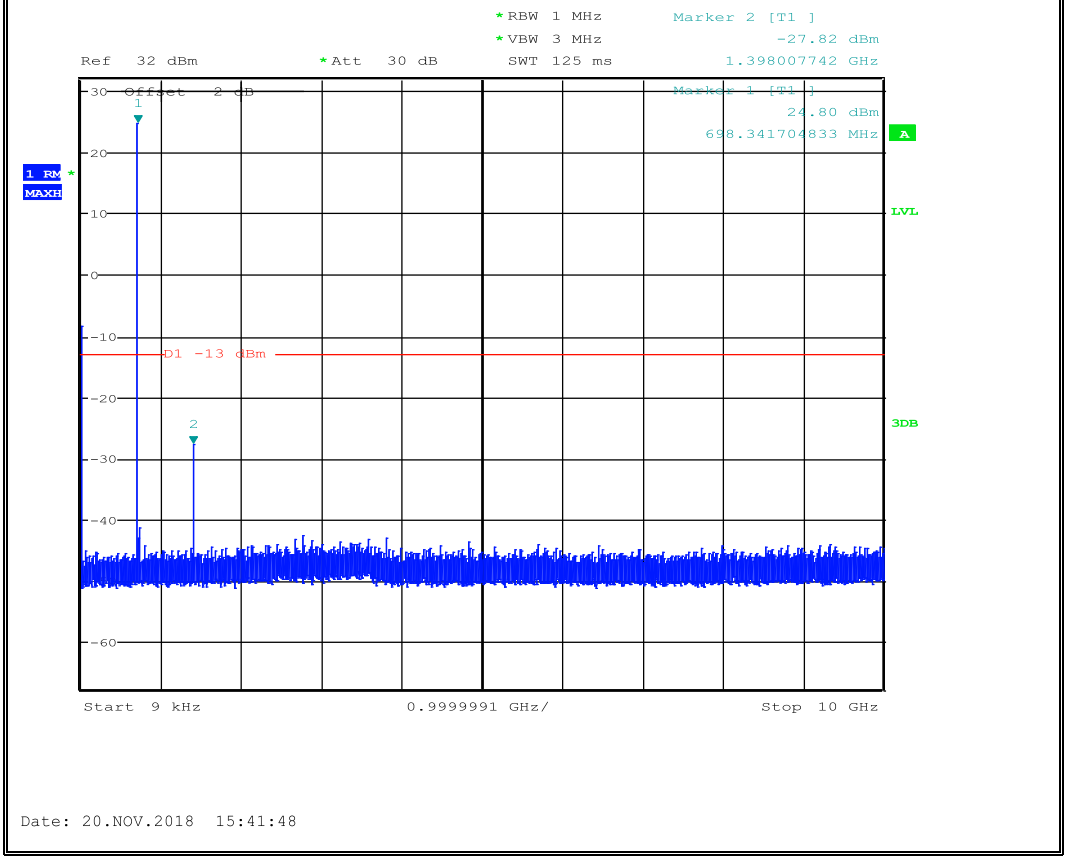
Plot # 8 CAT M1 B12 / Channel: Mid



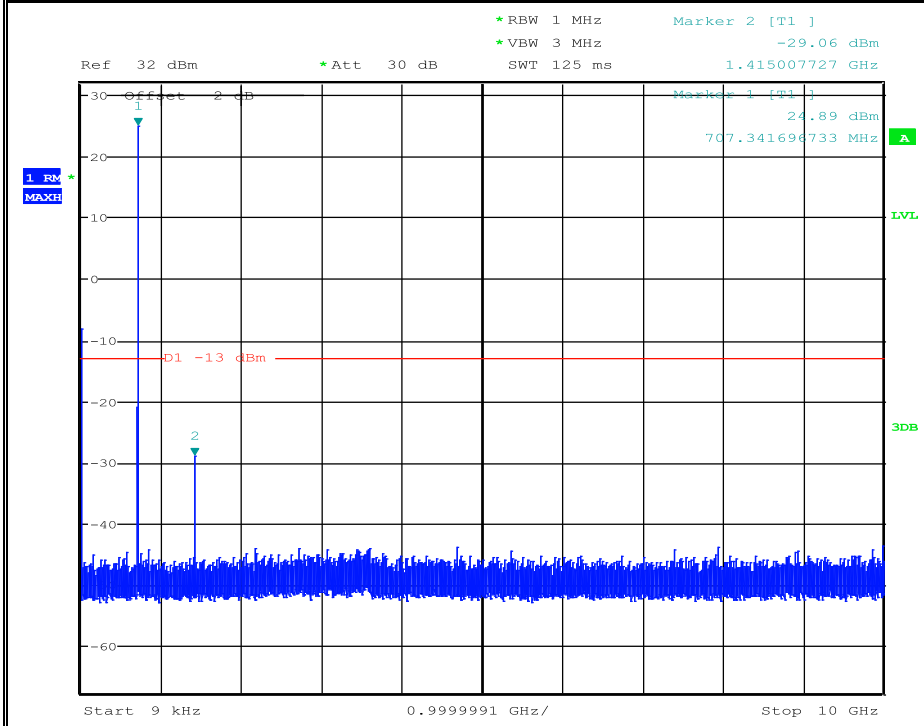
Plot # 9 CAT M1 B12 / Channel: Hi



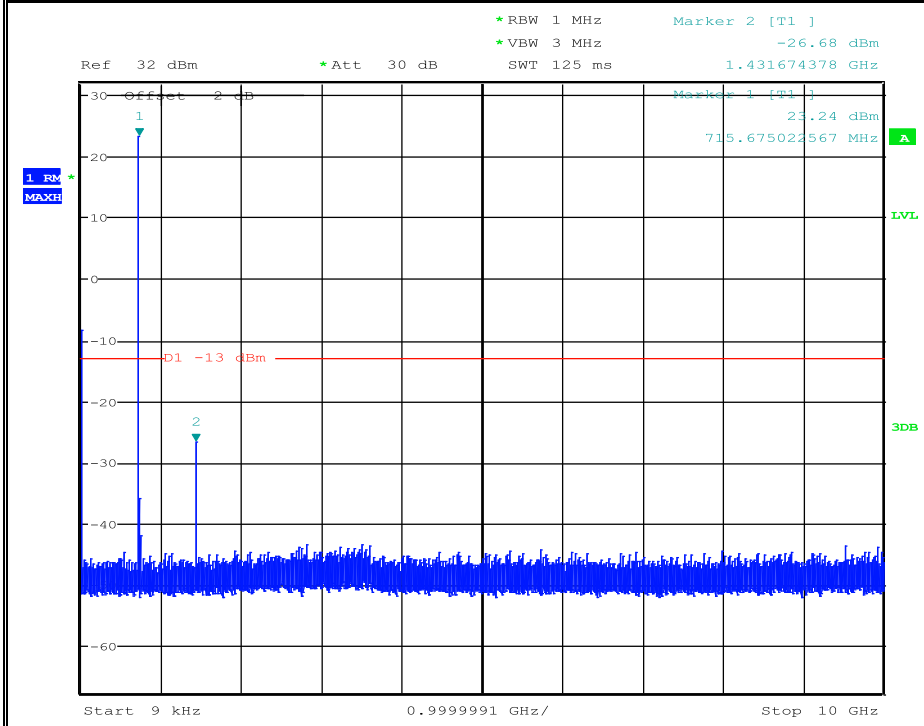
Plot # 10 NB IoT B12 / Channel: Low



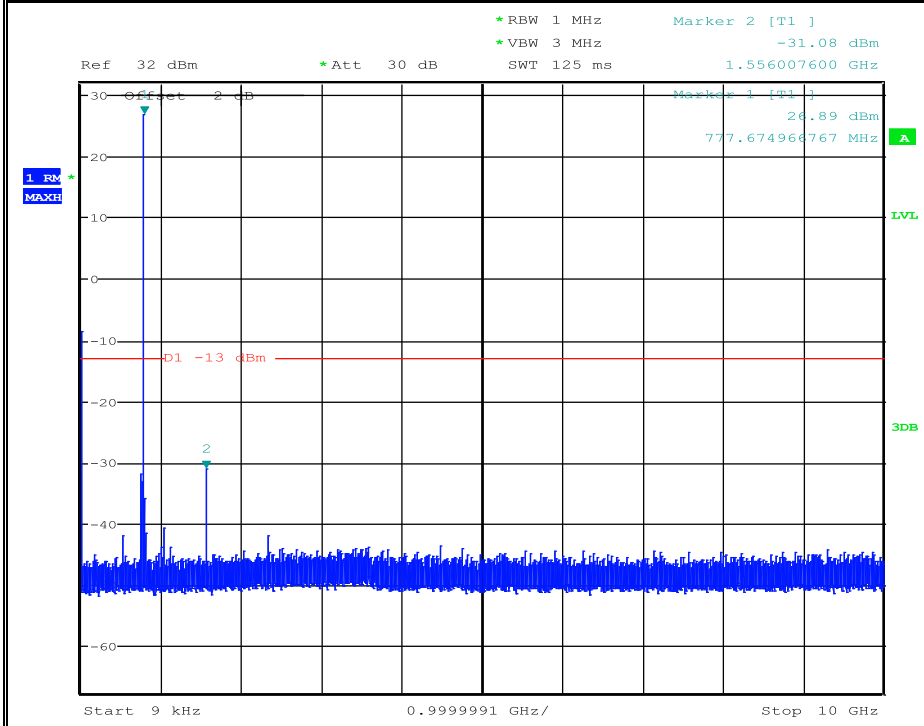
Plot # 11 NB IoT B12 / Channel: Mid



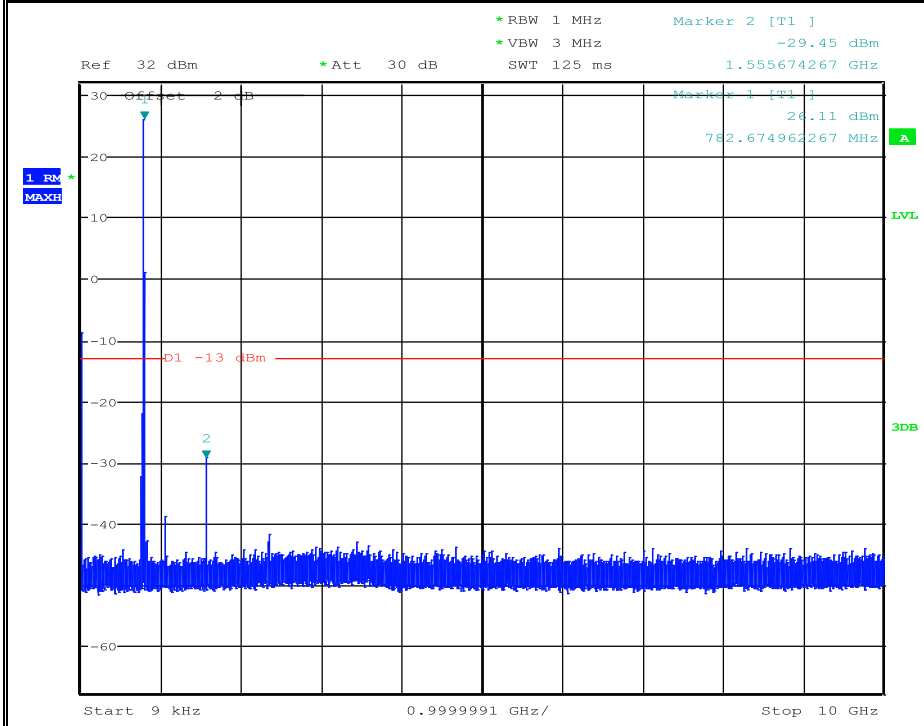
Plot # 12 NB IoT B12 / Channel: Hi



Plot # 13 CAT M1 B13 / Channel: Low



Plot # 14 CAT M1 B13 / Channel: Mid



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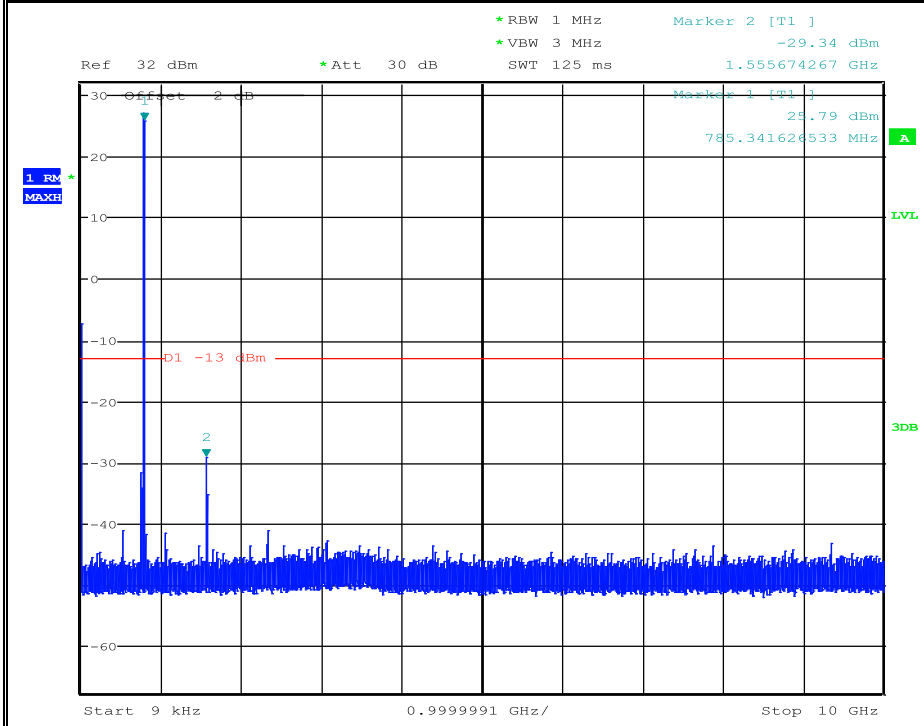
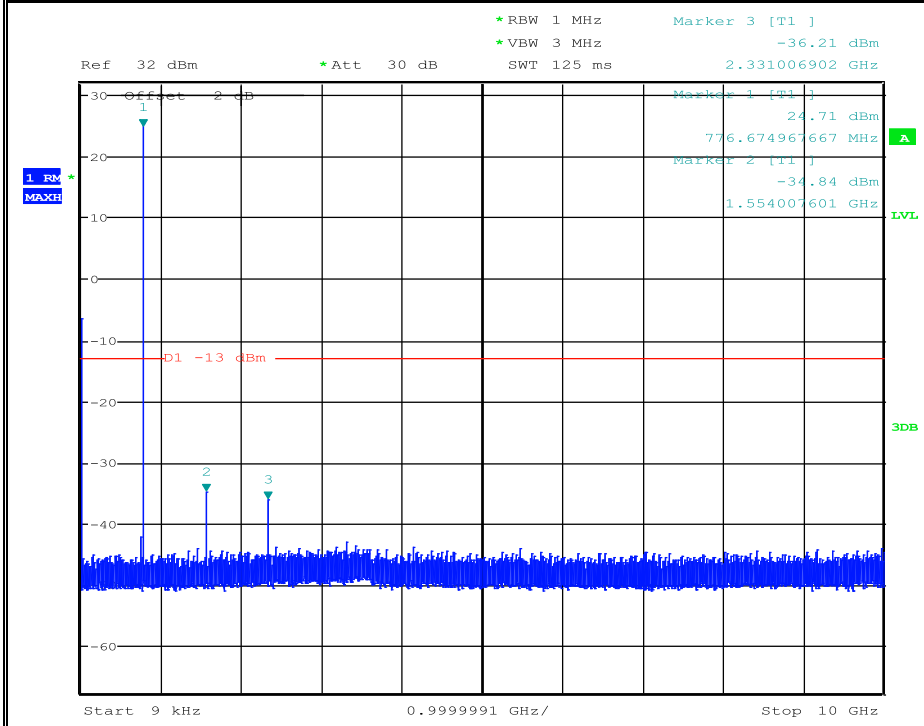
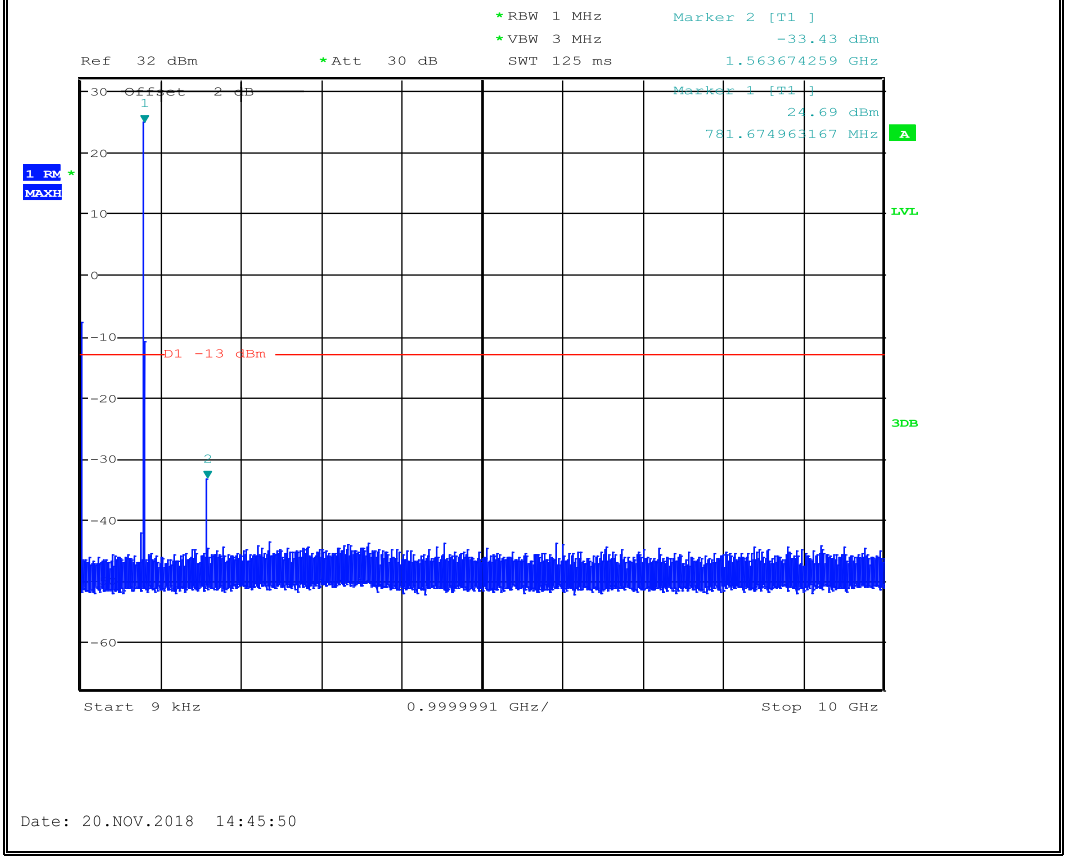
Plot # 15 CAT M1 B13 / Channel: Hi



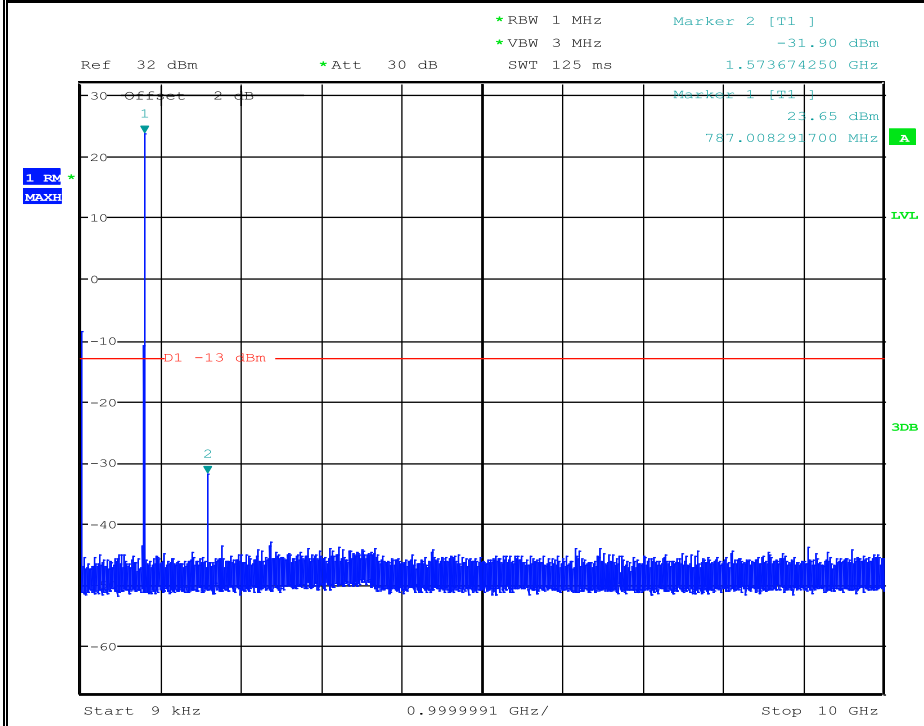
Plot # 16 NB IoT B13 / Channel: Low



Plot # 17 NB IoT B13 / Channel: Mid



Plot # 18 NB IoT B13 / Channel: Hi



7.6 Radiated Spurious Emissions

7.6.1 Measurement utilizing KDB 971168 D01 and ANSI C63.26-2015 Subclause 5.5.4

Frequency Range	30MHz – 1 GHz	1 – 2.7 GHz	2.7 – 18 GHz	18 – 19.1 GHz
Resolution Bandwidth	100 kHz	1 MHz	1 MHz	1 MHz
Video Bandwidth	100 kHz	1 MHz	1 MHz	1 MHz
Detector	Peak	Peak	Peak	Peak
Trace Mode	Max Hold	Max Hold	Max Hold	Max Hold
Sweep Time	Auto	Auto	Auto	Auto

7.6.2 Limits:

7.6.2.1 FCC Part 27.53

Out of band emissions. 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.

7.6.2.2 RSS-130 6.4, and RSS-139 Part 6.6 Transmitter Unwanted Emissions

Mobile and base station equipment shall comply with the limits in (i) and (ii) below.

i.In the first 1.0 MHz band immediately outside and adjacent to each of the sub-bands specified in Section 5.1, the power of emissions per any 1% of the occupied bandwidth shall be attenuated (in dB) below the transmitter output power P (dBW) by at least 43 + 10 log10p (watts).

ii.After the first 1.0 MHz immediately outside and adjacent to each of the sub-bands, the power of emissions in any 100 kHz bandwidth shall be attenuated (in dB) below the transmitter output power P (dBW) by at least 43 + 10 log10 p (watts). If the measurement is performed using 1% of the occupied bandwidth, power integration over 100 kHz is required.

Note: The limit calculation result is a constant of -13 dBm.

7.6.3 Test conditions and setup:

Ambient Temperature (C)	EUT Set-Up #	EUT operating mode	Power Input
22	2	1 and 2	110 V / 60 Hz

7.6.4 Measurement result:

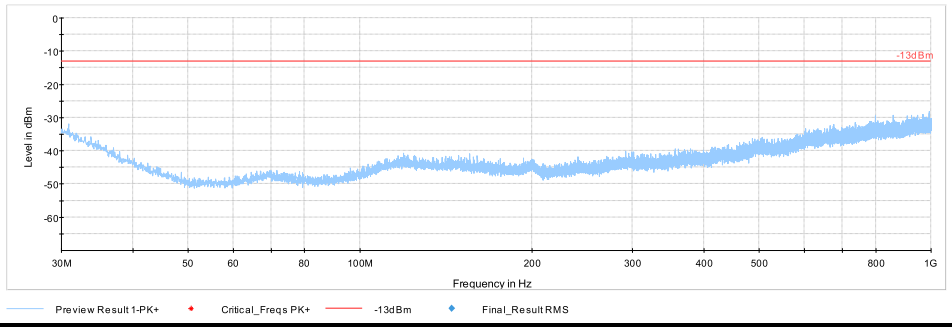
Plot #	Channel	EUT operating mode	Scan Frequency	Limit (dBm)	Result
1-3	Low	CAT M1 B4	30 MHz – 9 GHz	-13	Pass
4-8	Mid	CAT M1 B4	9 kHz – 22 GHz	-13	Pass
9-11	High	CAT M1 B4	30 MHz – 9 GHz	-13	Pass
12-14	Low	NB IoT B4	30 MHz – 9 GHz	-13	Pass
15-19	Mid	NB IoT B4	9 kHz – 22 GHz	-13	Pass
20-22	High	NB IoT B4	30 MHz – 9 GHz	-13	Pass
23-25	Low	CAT M1 B12	30 MHz – 9 GHz	-13	Pass
26-29	Mid	CAT M1 B12	9 kHz – 9 GHz	-13	Pass
30-32	High	CAT M1 B12	30 MHz – 9 GHz	-13	Pass
33-35	Low	NB IoT B12	30 MHz – 9 GHz	-13	Pass
36-39	Mid	NB IoT B12	9 kHz – 9 GHz	-13	Pass
40-42	High	NB IoT B12	30 MHz – 9 GHz	-13	Pass
43-45	Low	CAT M1 B13	30 MHz – 9 GHz	-13	Pass
46-49	Mid	CAT M1 B13	9 kHz – 9 GHz	-13	Pass
50-52	High	CAT M1 B13	30 MHz – 9 GHz	-13	Pass
53-55	Low	NB IoT B13	30 MHz – 9 GHz	-13	Pass
56-59	Mid	NB IoT B13	9 kHz – 9 GHz	-13	Pass
60-62	High	NB IoT B13	30 MHz – 9 GHz	-13	Pass

7.6.5 Measurement Plots:

7.6.6 CAT M1 B4

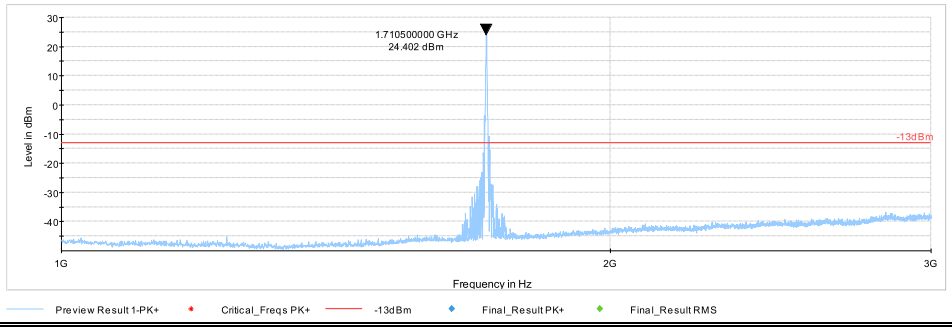
Plot #1 Radiated Emissions: 30 MHz – 1GHz

Channel: Low



Plot # 2 Radiated Emissions: 1-3 GHz

Channel: Low

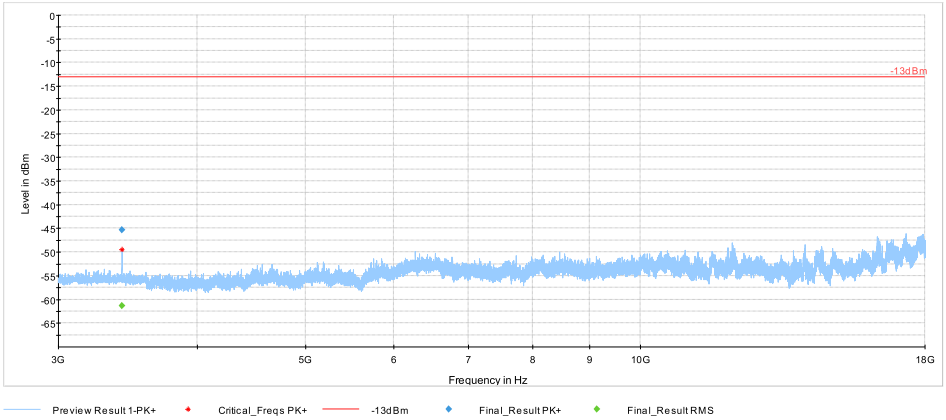


Note: Due to limited resolution during radiated measurements on the Band edges the manual conducted measurement from section 7.4 prevails.

Plot # 3 Radiated Emissions: 3-18 GHz

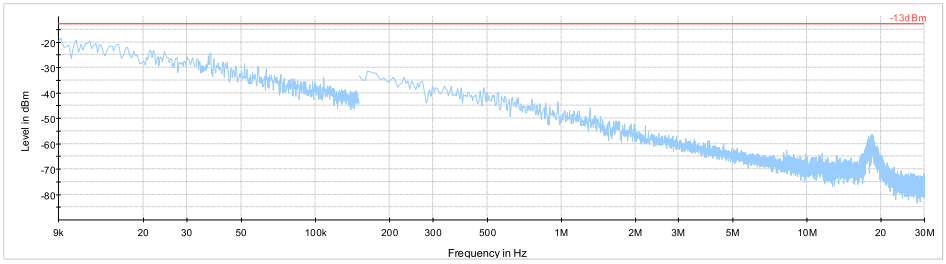
Channel: Low

Frequency (MHz)	MaxPeak (dBm)	RMS (dBm)	Limit (dBm)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
3421.511333	---	-61.38	---	---	322.0	V	251.0	-103.1
3421.511333	-45.27	---	-13.00	32.27	322.0	V	251.0	-103.1



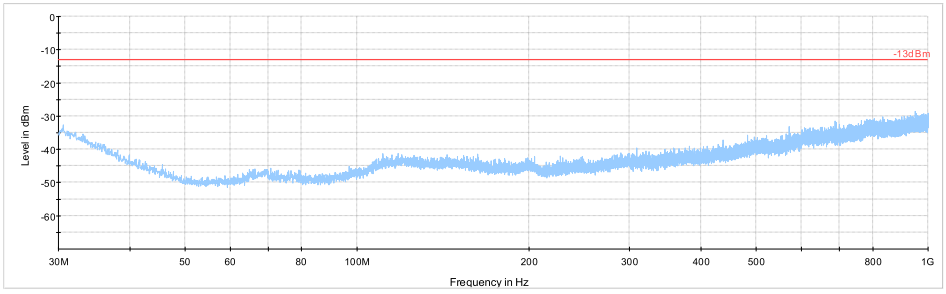
Plot # 4 Radiated Emissions: 9 kHz-30 MHz

Channel: Mid



Plot #5 Radiated Emissions: 30 MHz – 1GHz

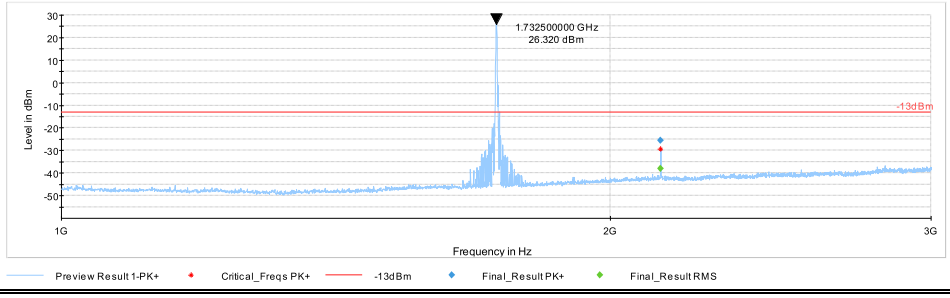
Channel: Mid



Plot #6 Radiated Emissions: 1-3 GHz

Channel: Mid

Frequency (MHz)	MaxPeak (dBm)	RMS (dBm)	Limit (dBm)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2132.386375	---	-38.05	---	---	140.0	H	7.0	-60.8
2132.386375	-25.44	---	-13.00	12.44	140.0	H	7.0	-60.8

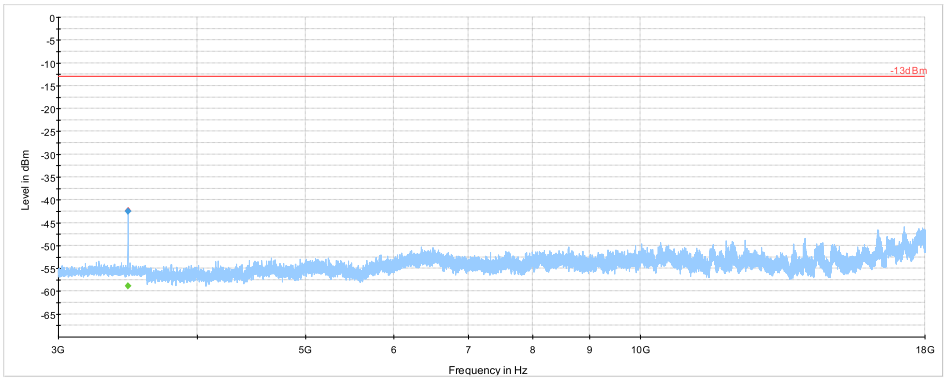


Note: Due to limited resolution during radiated measurements on the Band edges the manual conducted measurement from section 7.4 prevails.

Plot #7 Radiated Emissions: 3 – 18 GHz

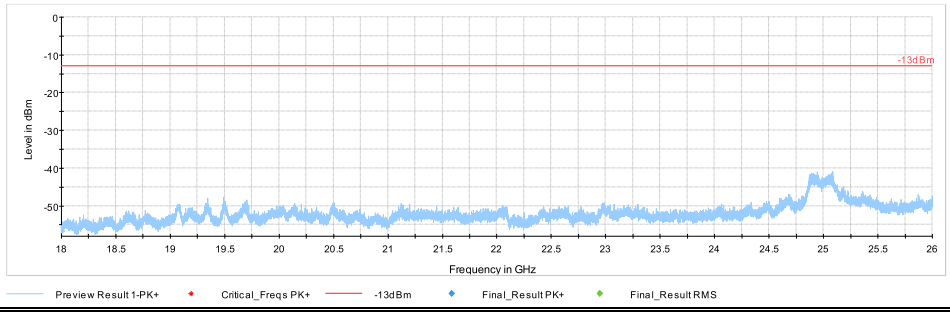
Channel: Mid

Frequency (MHz)	MaxPeak (dBm)	RMS (dBm)	Limit (dBm)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
3465.028833	---	-58.91	---	---	244.0	H	62.0	-103.0
3465.028833	-42.55	---	-13.00	29.55	244.0	H	62.0	-103.0



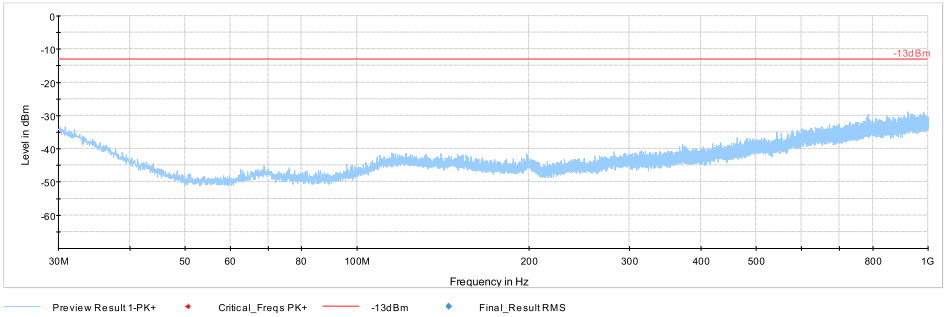
Plot #8 Radiated Emissions: 18 – 22 GHz

Channel: Mid



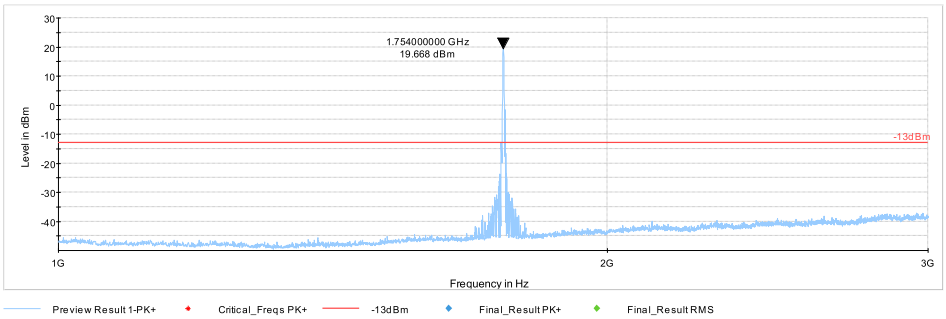
Plot #9 Radiated Emissions: 30 MHz – 1GHz

Channel: High



Plot #10 Radiated Emissions: 1-3 GHz

Channel: High

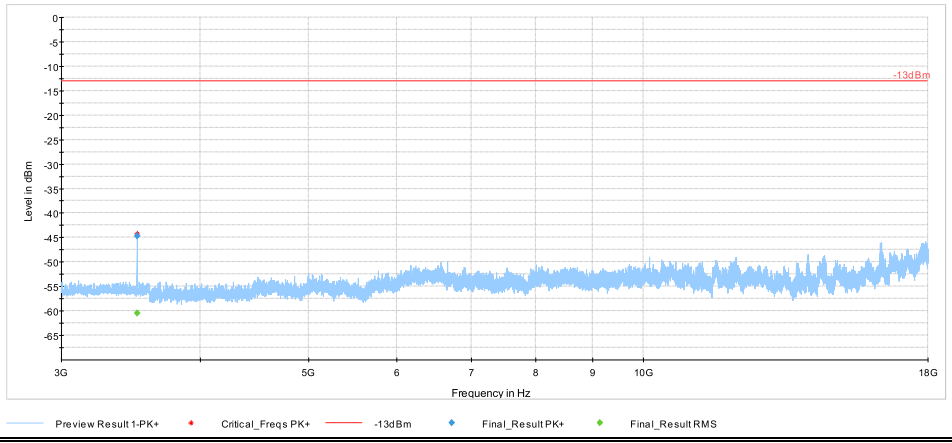


Note: Due to limited resolution during radiated measurements on the Band edges the manual conducted measurement from section 7.4 prevails.

Plot #11 Radiated Emissions: 3 – 18 GHz

Channel: High

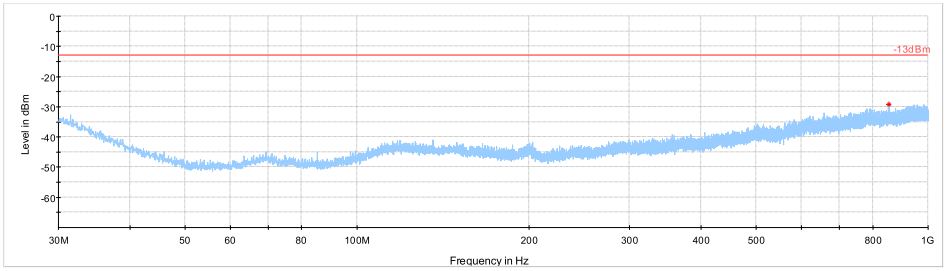
Frequency (MHz)	MaxPeak (dBm)	RMS (dBm)	Limit (dBm)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
3508.382500	---	-60.52	---	---	306.0	H	61.0	-102.8
3508.382500	-44.65	---	-13.00	31.65	306.0	H	61.0	-102.8



7.6.7 NB IoT B4

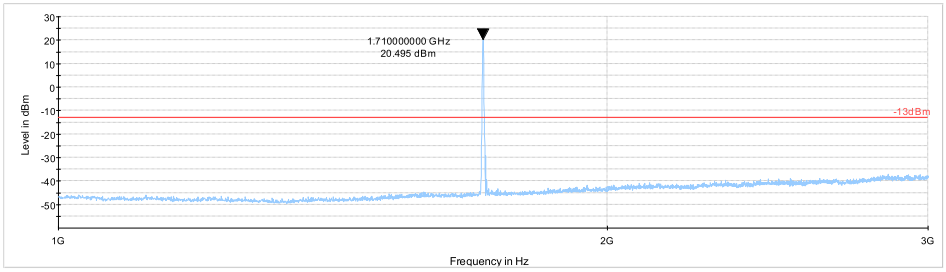
Plot #12 Radiated Emissions: 30 MHz – 1GHz

Channel: Low



Plot # 13 Radiated Emissions: 1-3 GHz

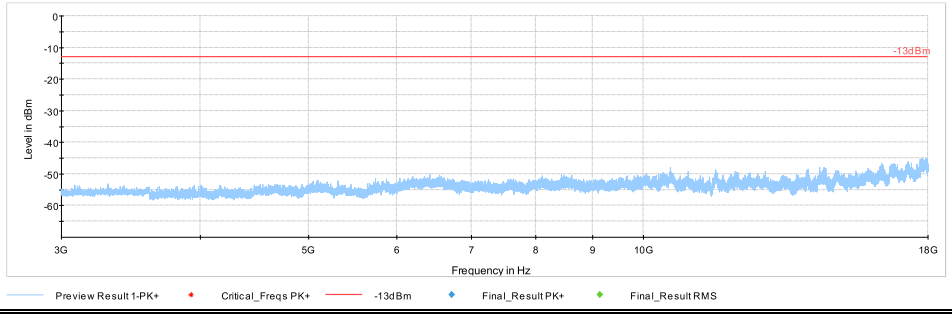
Channel: Low



Note: Due to limited resolution during radiated measurements on the Band edges the manual conducted measurement from section 7.4 prevails.

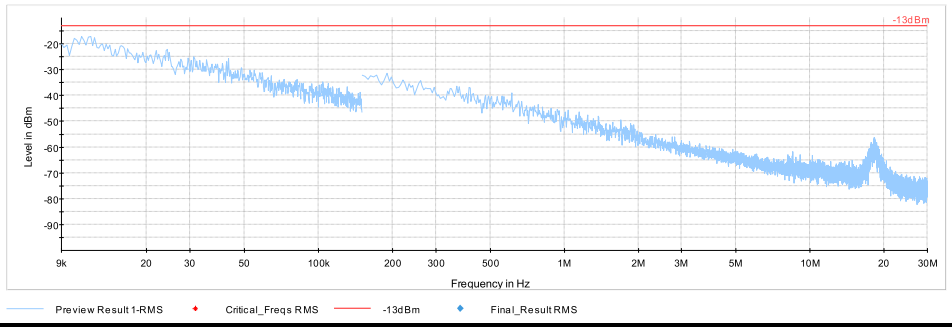
Plot # 14 Radiated Emissions: 3-18 GHz

Channel: Low



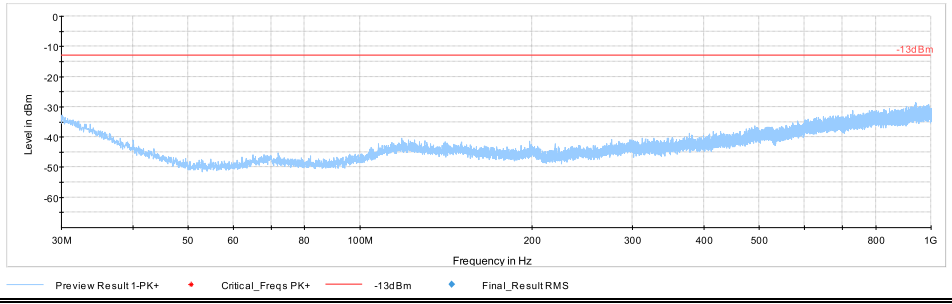
Plot # 15 Radiated Emissions: 9 kHz-30 MHz

Channel: Mid



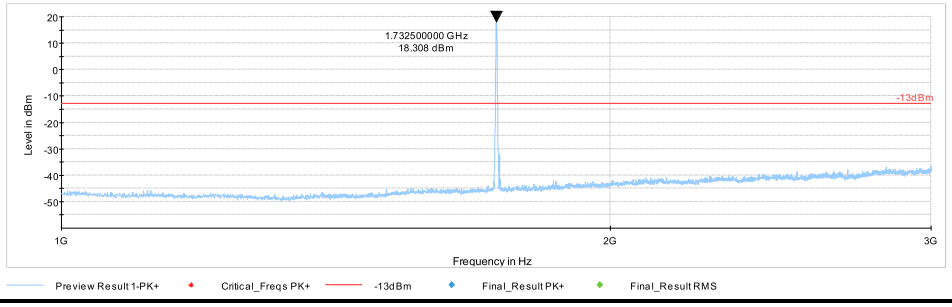
Plot #16 Radiated Emissions: 30 MHz – 1GHz

Channel: Mid



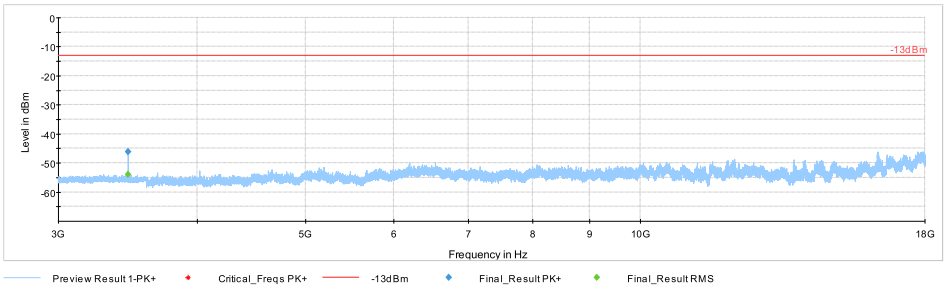
Plot #17 Radiated Emissions: 1-3 GHz

Channel: Mid

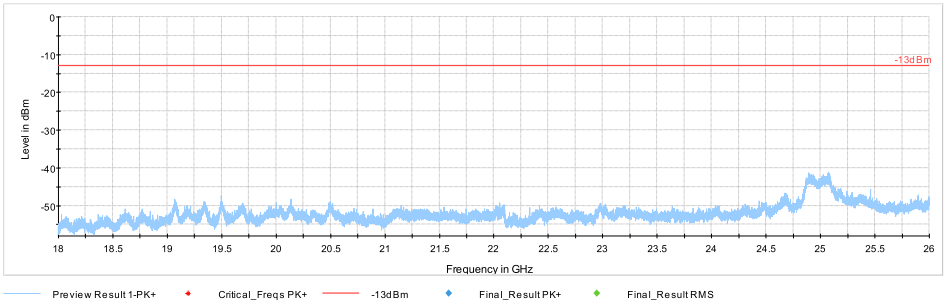


Note: Due to limited resolution during radiated measurements on the Band edges the manual conducted measurement from section 7.4 prevails.

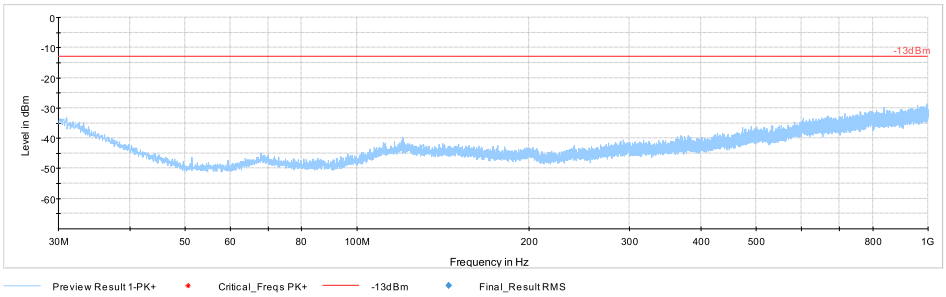
Plot #18 Radiated Emissions: 3-18 GHz
Channel: Mid



Plot #19 Radiated Emissions: 18-22 GHz
Channel: Mid

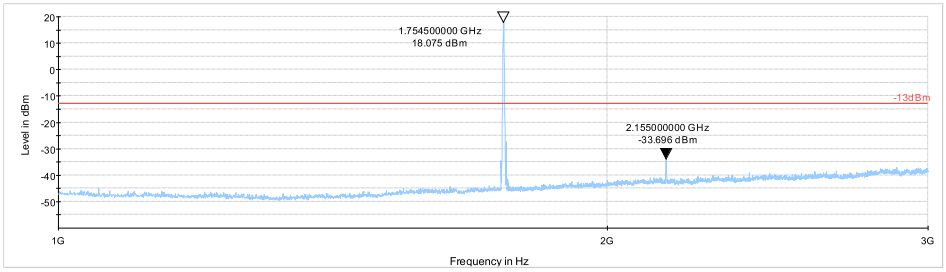


Plot #20 Radiated Emissions: 30 MHz – 1GHz
Channel: High



Plot #21 Radiated Emissions: 1-3 GHz

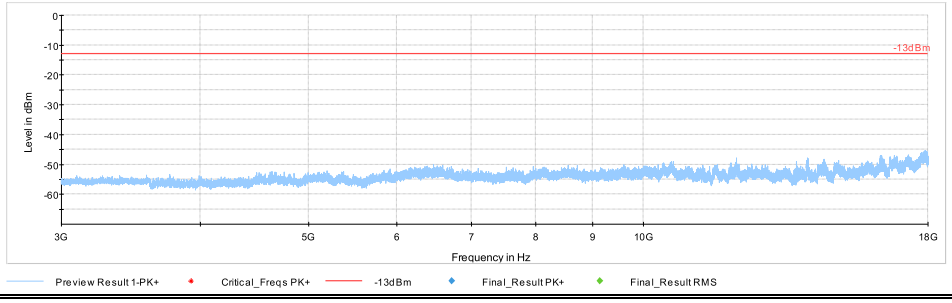
Channel: High



Note: Due to limited resolution during radiated measurements on the Band edges the manual conducted measurement from section 7.4 prevails.

Plot #22 Radiated Emissions: 3-18 GHz

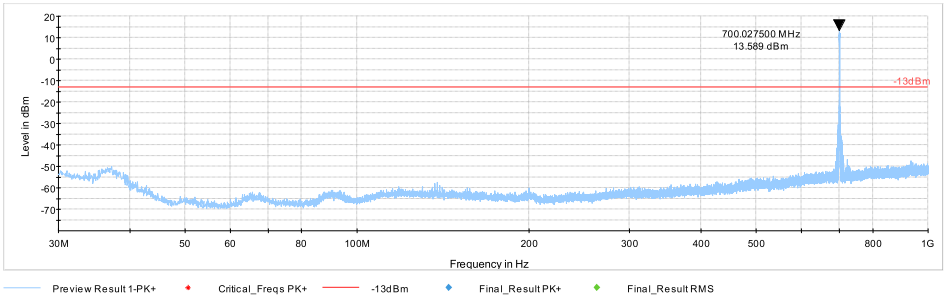
Channel: High



7.6.8 CAT M1 B12

Plot #23 Radiated Emissions: 30 MHz – 1GHz

Channel: Low

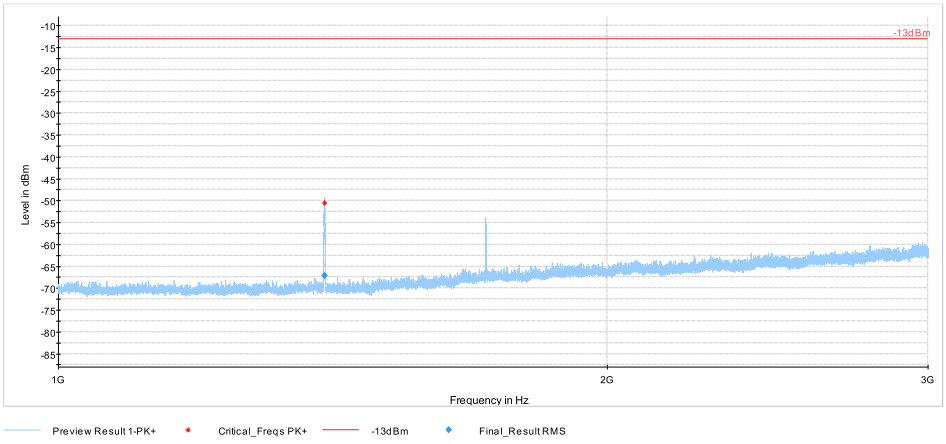


Note: Due to limited resolution during radiated measurements on the Band edges the manual conducted measurement from section 7.4 prevails.

Plot # 24 Radiated Emissions: 1-3 GHz

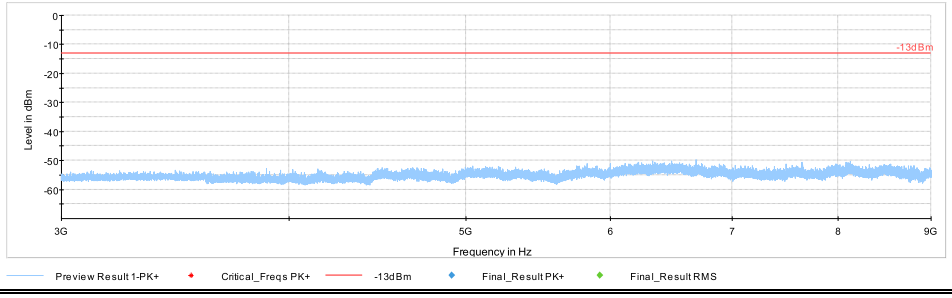
Channel: Low

Frequency (MHz)	RMS (dBm)	Limit (dBm)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
1399.377833	-67.13	-13.00	54.13	255.0	H	280.0	-97.8



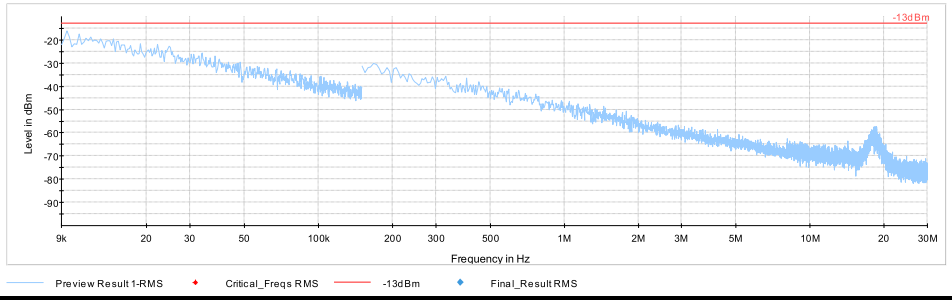
Plot # 25 Radiated Emissions: 3-9 GHz

Channel: Low



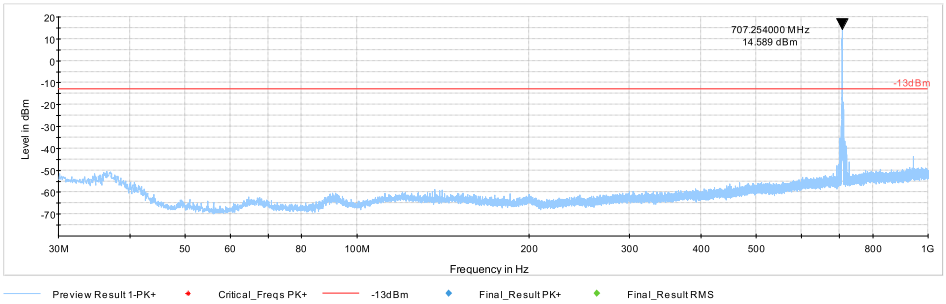
Plot # 26 Radiated Emissions: 9 kHz-30 MHz

Channel: Mid



Plot #27 Radiated Emissions: 30 MHz – 1GHz

Channel: Mid

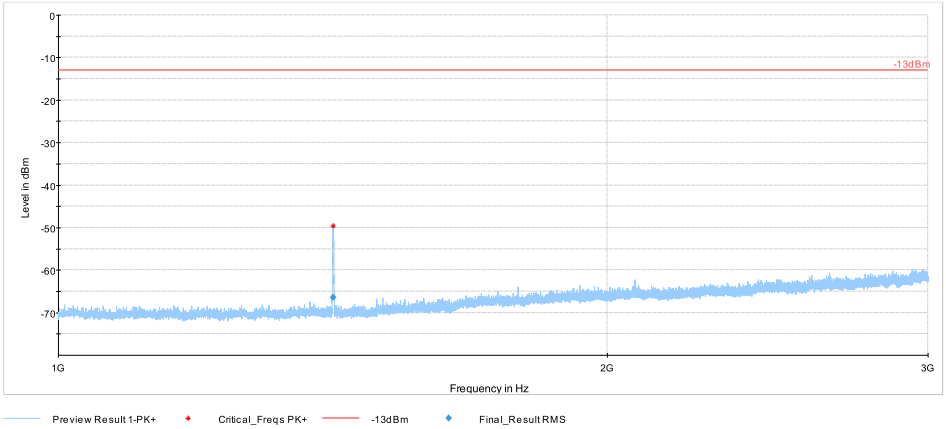


Note: Due to limited resolution during radiated measurements on the Band edges the manual conducted measurement from section 7.4 prevails.

Plot #28 Radiated Emissions: 1-3 GHz

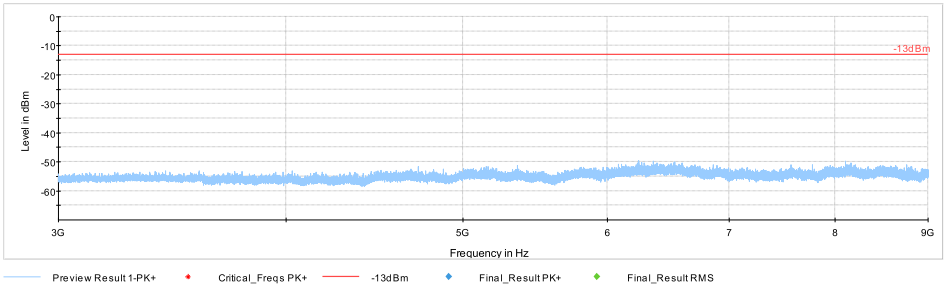
Channel: Mid

Frequency (MHz)	RMS (dBm)	Limit (dBm)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
1414.964917	-66.44	-13.00	53.44	158.0	H	58.0	-98.0



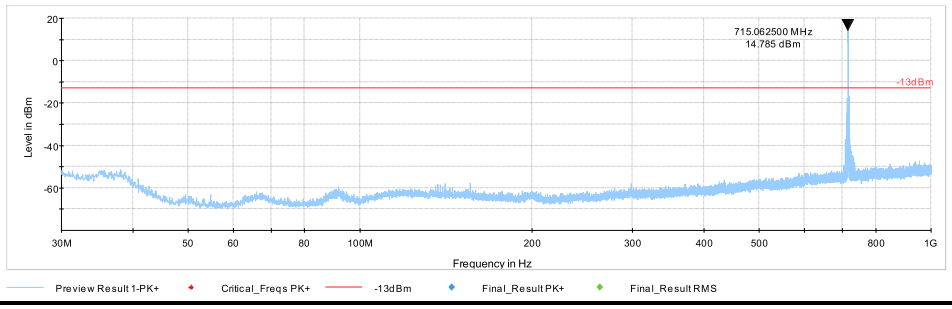
Plot #29 Radiated Emissions: 3-9 GHz

Channel: Mid



Plot #30 Radiated Emissions: 30 MHz – 1GHz

Channel: High

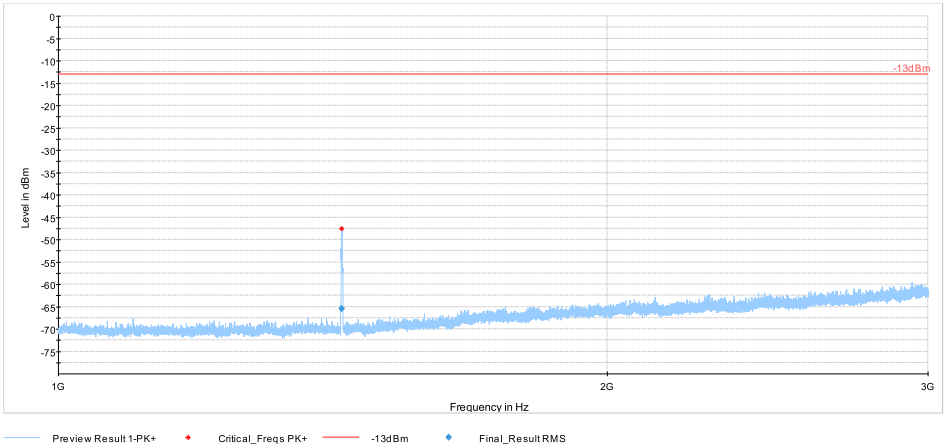


Note: Due to limited resolution during radiated measurements on the Band edges the manual conducted measurement from section 7.4 prevails.

Plot #31 Radiated Emissions: 1-3 GHz

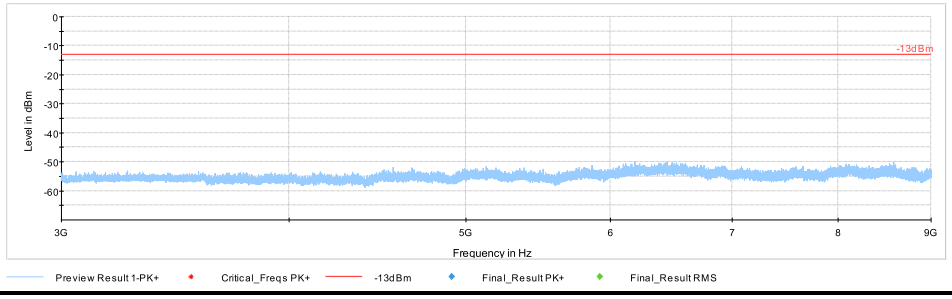
Channel: High

Frequency (MHz)	RMS (dBm)	Limit (dBm)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
1430.073833	-65.47	-13.00	52.47	166.0	H	50.0	-98.1



Plot #32 Radiated Emissions: 3-9 GHz

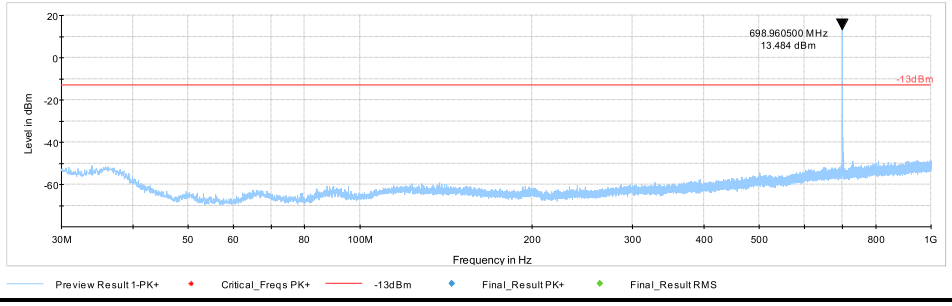
Channel: High



7.6.9 NB IoT B12

Plot #33 Radiated Emissions: 30 MHz – 1GHz

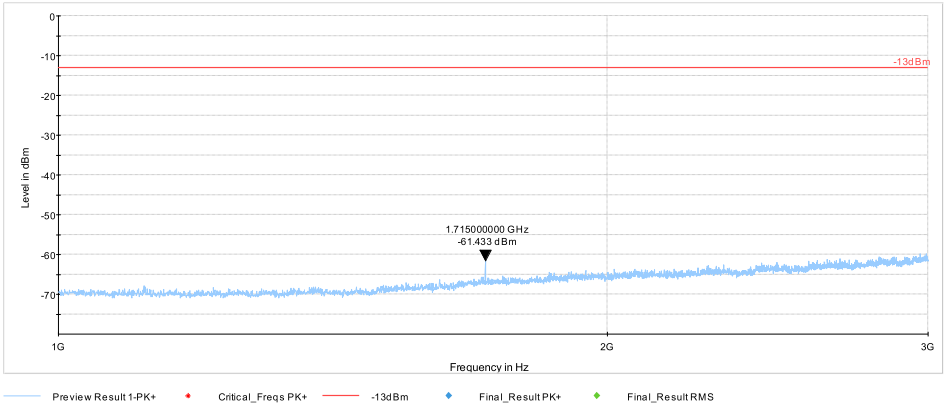
Channel: Low



Note: Due to limited resolution during radiated measurements on the Band edges the manual conducted measurement from section 7.4 prevails.

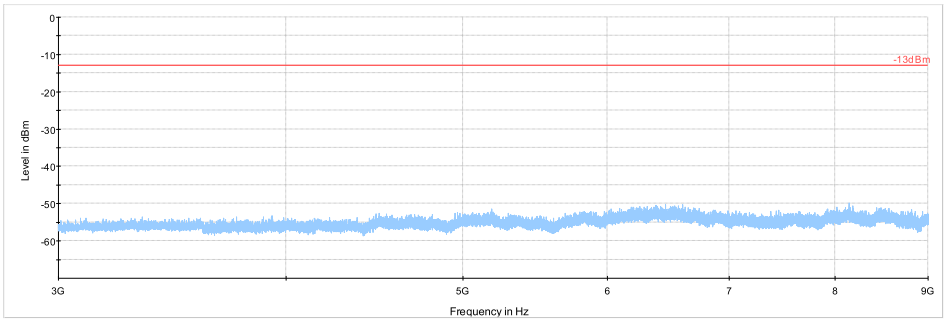
Plot # 34 Radiated Emissions: 1-3 GHz

Channel: Low



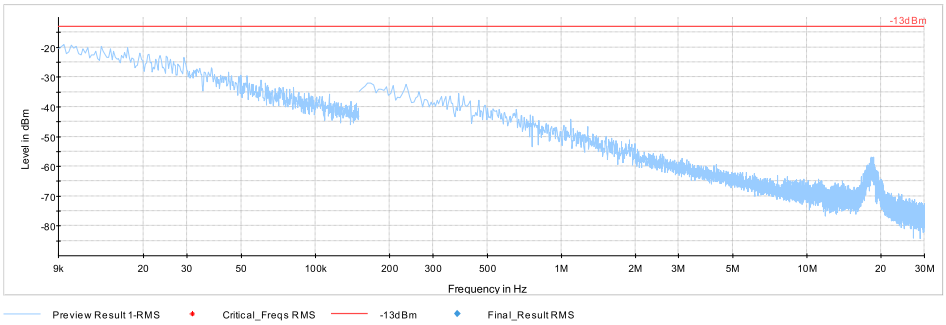
Plot # 35 Radiated Emissions: 3-9 GHz

Channel: Low



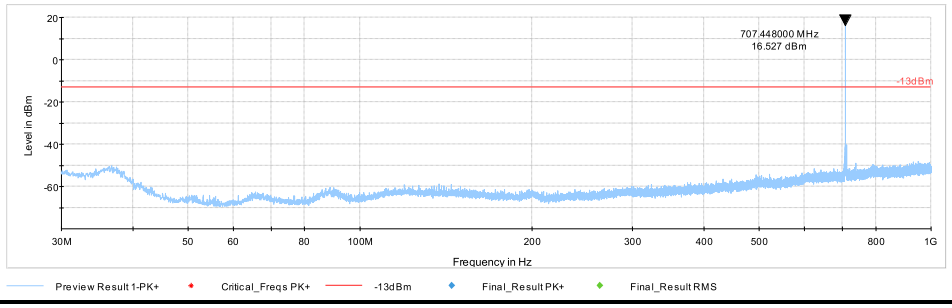
Plot # 36 Radiated Emissions: 9 kHz-30 MHz

Channel: Mid



Plot #37 Radiated Emissions: 30 MHz – 1GHz

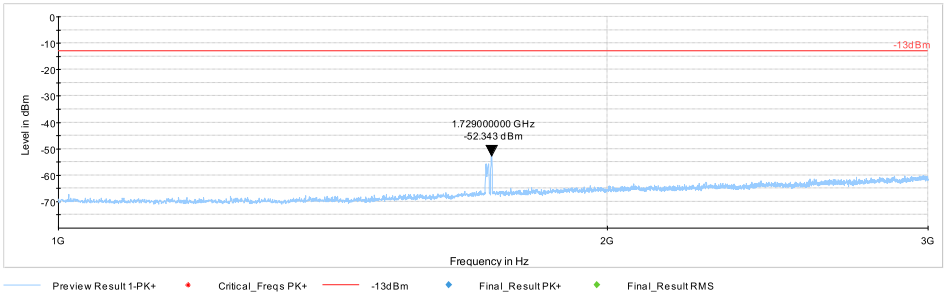
Channel: Mid



Note: Due to limited resolution during radiated measurements on the Band edges the manual conducted measurement from section 7.4 prevails.

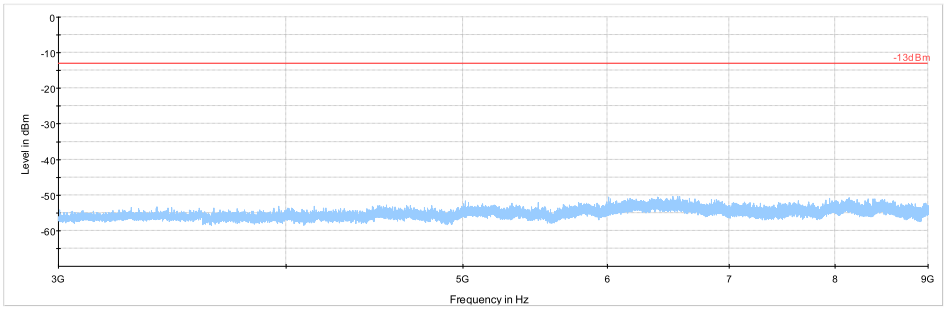
Plot #38 Radiated Emissions: 1-3 GHz

Channel: Mid



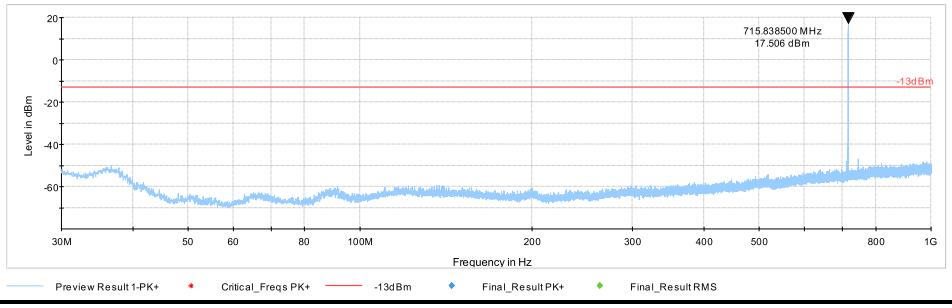
Plot #39 Radiated Emissions: 3-9 GHz

Channel: Mid



Plot #40 Radiated Emissions: 30 MHz – 1GHz

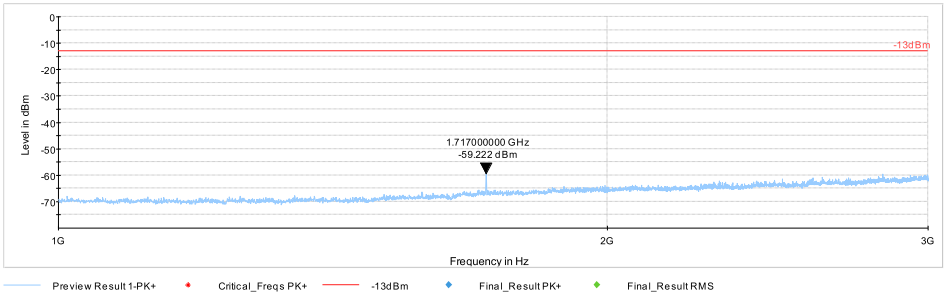
Channel: High



Note: Due to limited resolution during radiated measurements on the Band edges the manual conducted measurement from section 7.4 prevails.

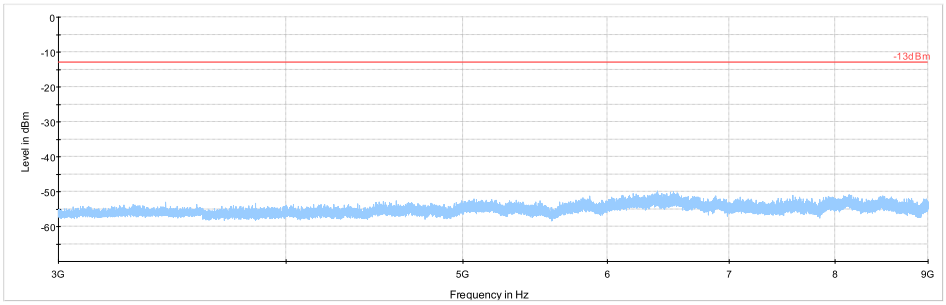
Plot #41 Radiated Emissions: 1-3 GHz

Channel: High



Plot #42 Radiated Emissions: 3-9 GHz

Channel: High



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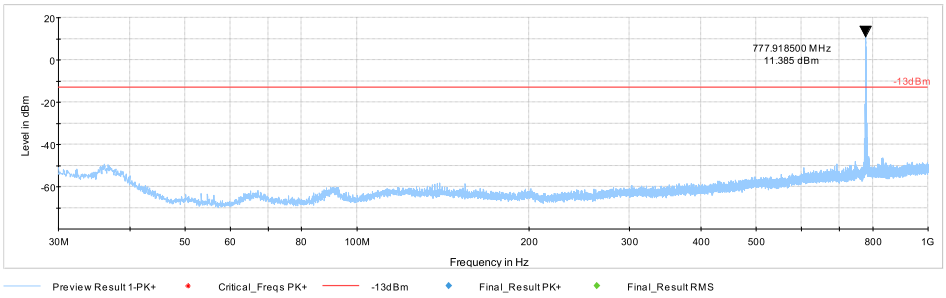
Plot #43 Radiated Emissions: 30 MHz – 1GHz

Channel: Low

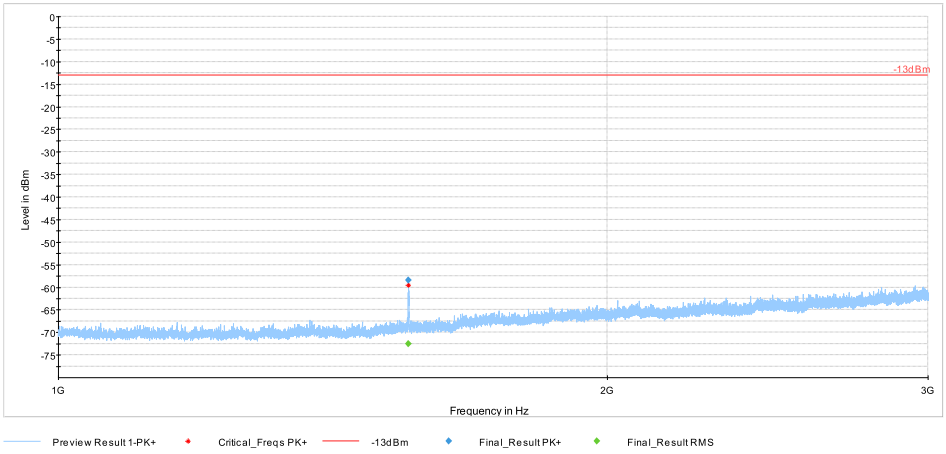


Note: Due to limited resolution during radiated measurements on the Band edges the manual conducted measurement from section 7.4 prevails.

Plot # 44 Radiated Emissions: 1-3 GHz

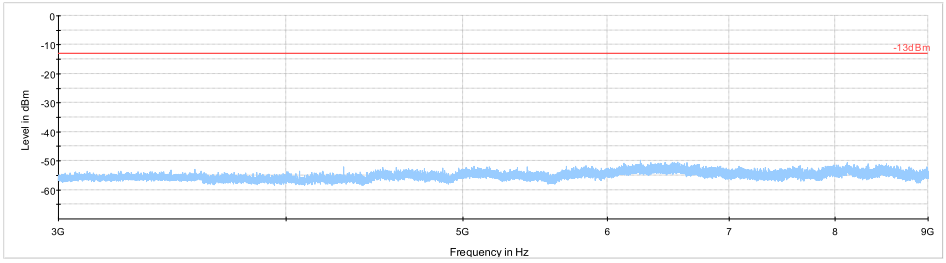
Channel: Low

Frequency (MHz)	MaxPeak (dBm)	RMS (dBm)	Limit (dBm)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
1555.813833	---	-72.53	---	---	140.0	H	12.0	-96.9
1555.813833	-58.46	---	-13.00	45.46	140.0	H	12.0	-96.9



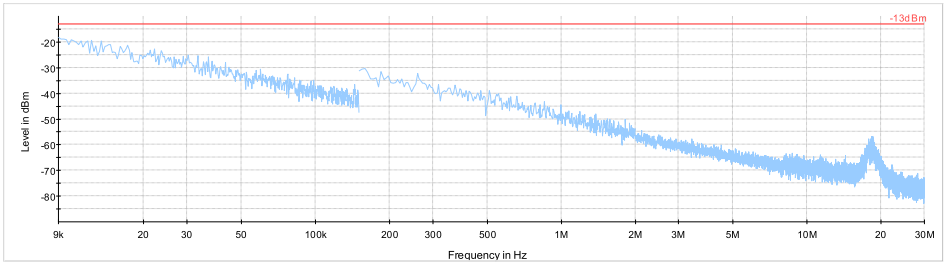
Plot # 45 Radiated Emissions: 3-9 GHz

Channel: Low



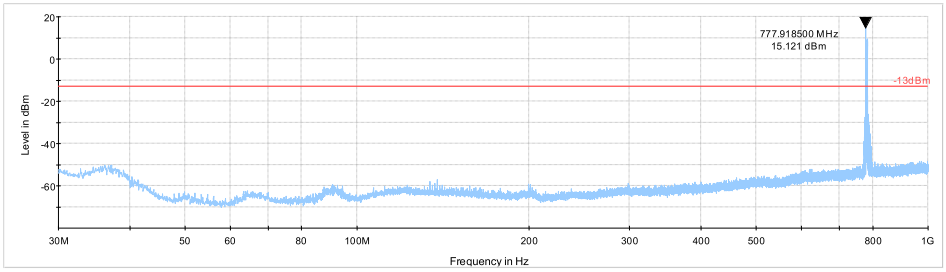
Plot # 46 Radiated Emissions: 9 kHz-30 MHz

Channel: Mid



Plot #47 Radiated Emissions: 30 MHz – 1GHz

Channel: Mid

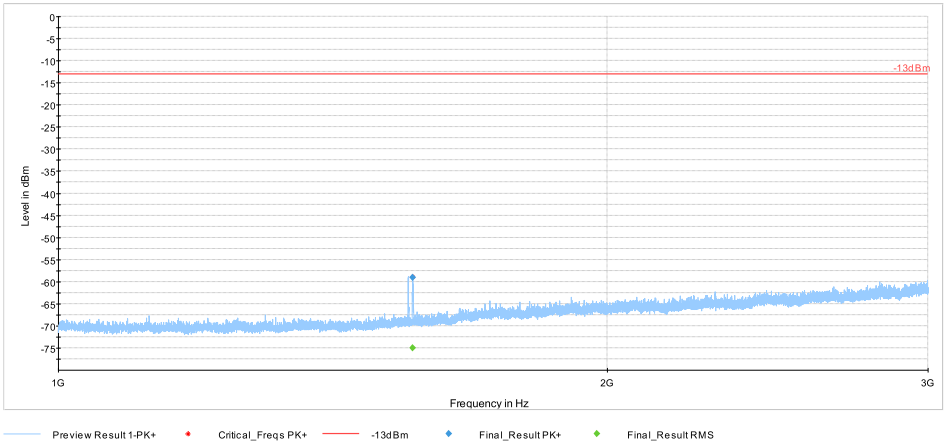


Note: Due to limited resolution during radiated measurements on the Band edges the manual conducted measurement from section 7.4 prevails.

Plot #48 Radiated Emissions: 1-3 GHz

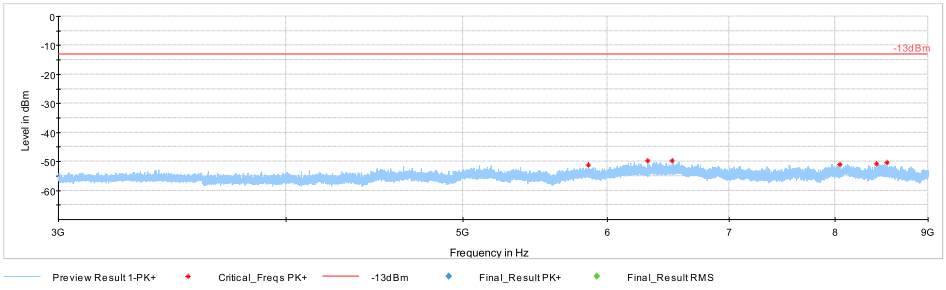
Channel: Mid

Frequency (MHz)	MaxPeak (dBm)	RMS (dBm)	Limit (dBm)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
1565.095333	---	-75.08	---	---	140.0	H	8.0	-96.8
1565.095333	-59.11	---	-13.00	46.11	140.0	H	8.0	-96.8



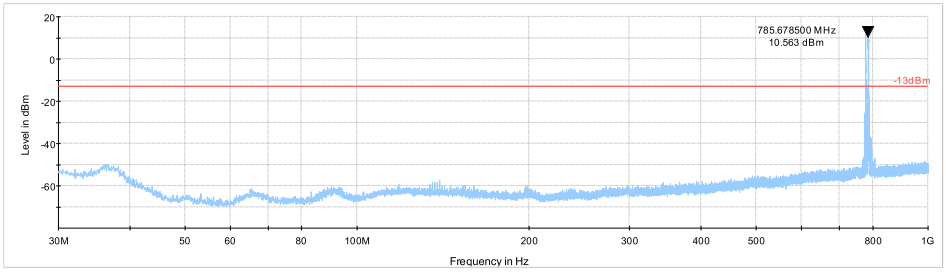
Plot #49 Radiated Emissions: 3-9 GHz

Channel: Mid



Plot #50 Radiated Emissions: 30 MHz – 1GHz

Channel: High

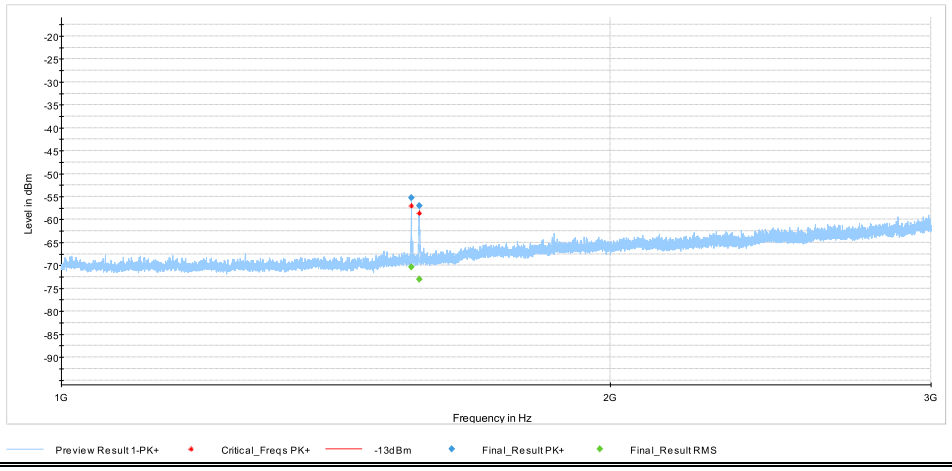


Note: Due to limited resolution during radiated measurements on the Band edges the manual conducted measurement from section 7.4 prevails.

Plot #51 Radiated Emissions: 1-3 GHz

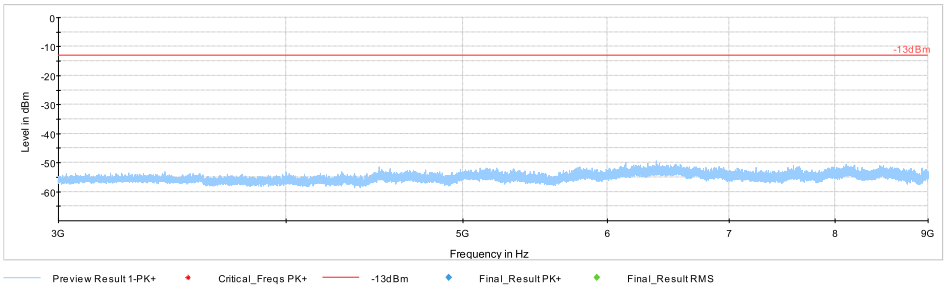
Channel: High

Frequency (MHz)	MaxPeak (dBm)	RMS (dBm)	Limit (dBm)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
1555.818583	---	-70.32	---	---	243.0	H	11.0	-96.9
1555.818583	-55.29	---	-13.00	42.29	243.0	H	11.0	-96.9
1571.559250	---	-73.01	---	---	150.0	H	10.0	-96.8
1571.559250	-57.05	---	-13.00	44.05	150.0	H	10.0	-96.8



Plot #52 Radiated Emissions: 3-9 GHz

Channel: High



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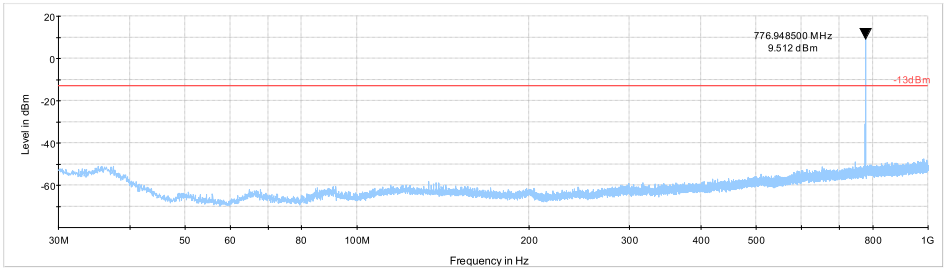
Plot #53 Radiated Emissions: 30 MHz – 1GHz

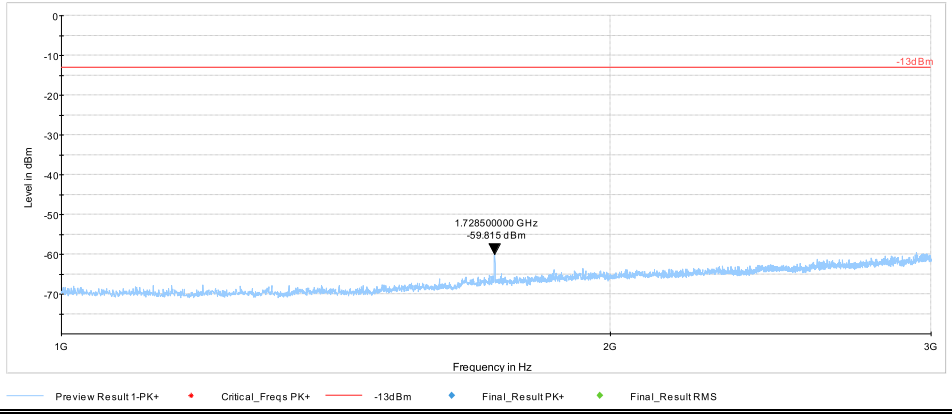
Channel: Low



Note: Due to limited resolution during radiated measurements on the Band edges the manual conducted measurement from section 7.4 prevails.

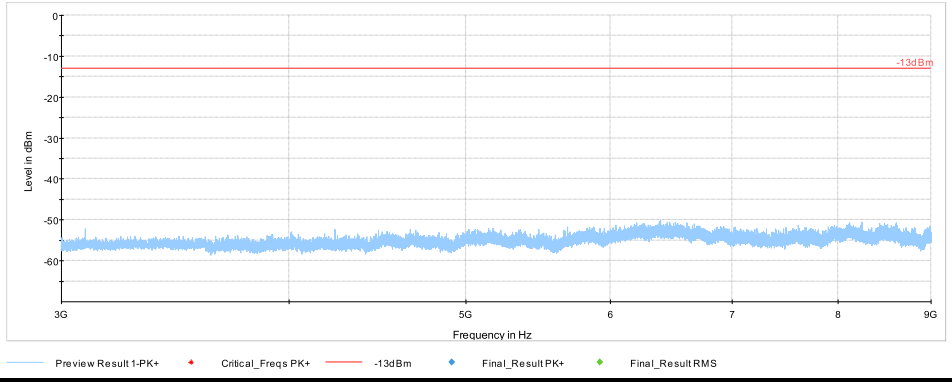
Plot # 54 Radiated Emissions: 1-3 GHz

Channel: Low

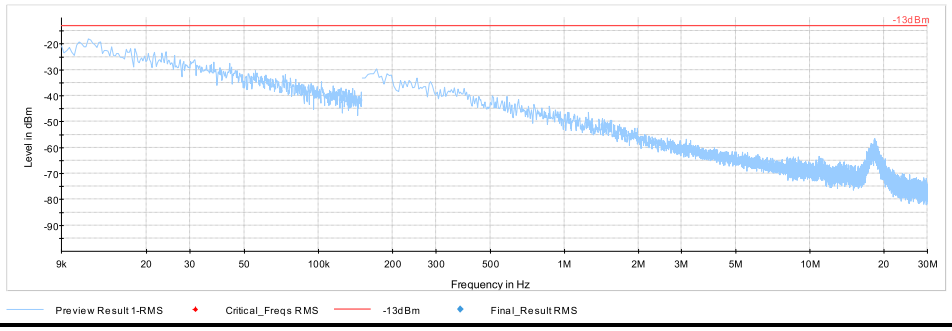


Plot # 55 Radiated Emissions: 3-9 GHz

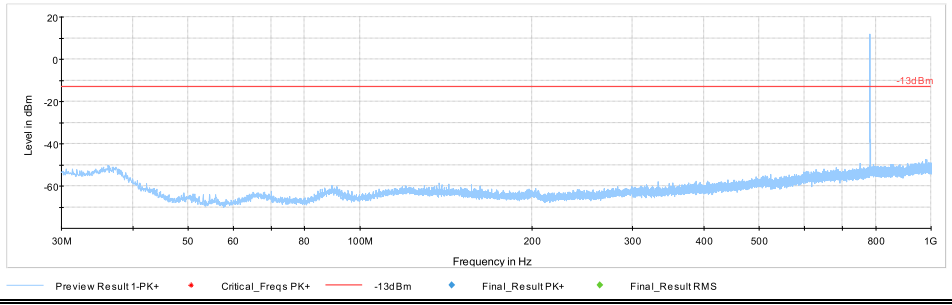
Channel: Low



Plot # 56 Radiated Emissions: 9 kHz-30 MHz
Channel: Mid

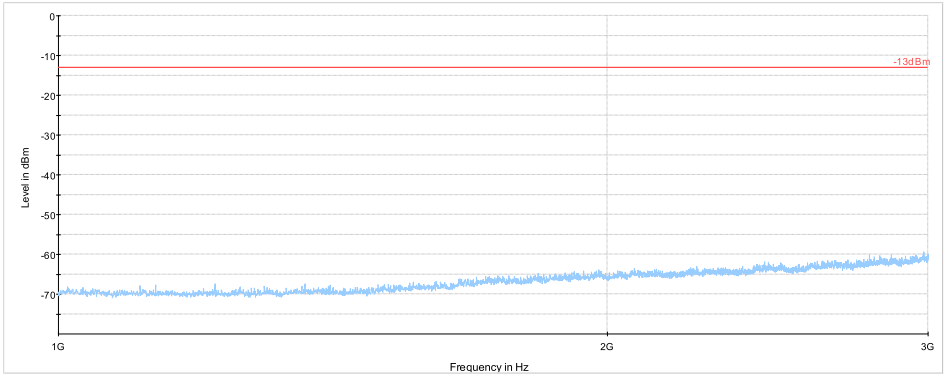


Plot #57 Radiated Emissions: 30 MHz – 1GHz
Channel: Mid



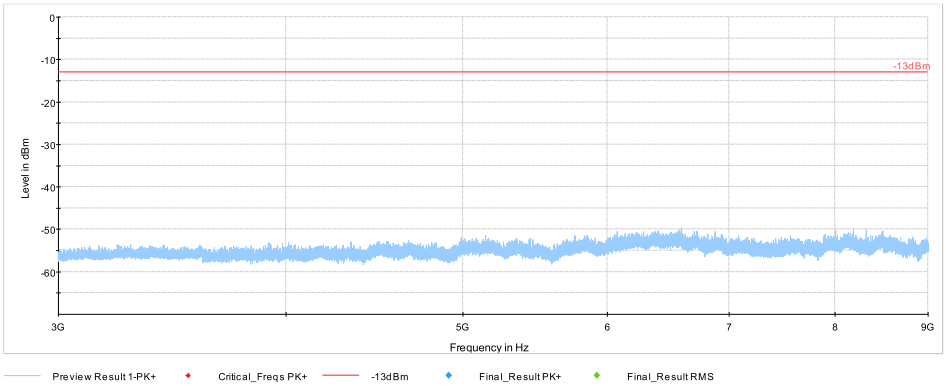
Note: Due to limited resolution during radiated measurements on the Band edges the manual conducted measurement from section 7.4 prevails.

Plot #58 Radiated Emissions: 1-3 GHz
Channel: Mid



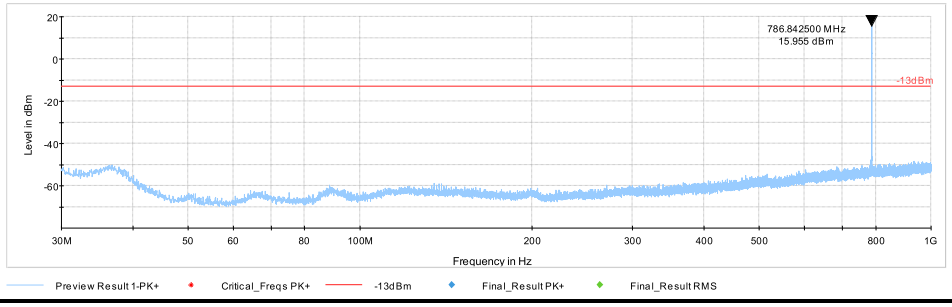
Plot #59 Radiated Emissions: 3-9 GHz

Channel: Mid



Plot #60 Radiated Emissions: 30 MHz – 1GHz

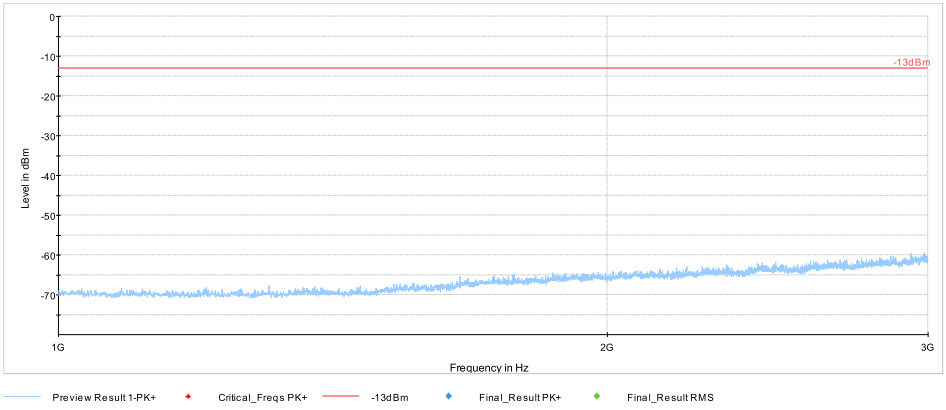
Channel: High



Note: Due to limited resolution during radiated measurements on the Band edges the manual conducted measurement from section 7.4 prevails.

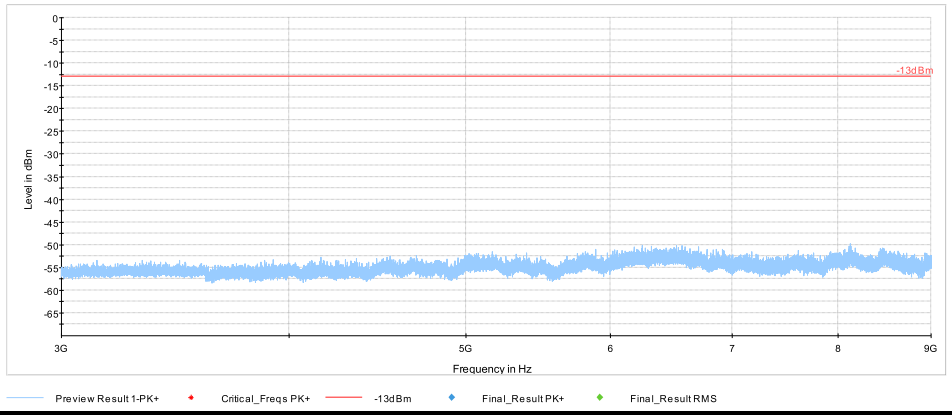
Plot #61 Radiated Emissions: 1-3 GHz

Channel: High



Plot #62 Radiated Emissions: 3-9 GHz

Channel: High



8 Test setup photos

Setup photos are included in supporting file name: “EMC_ CTSMC-003-18001_FCC_Setup_photos.pdf”

9 Test Equipment And Ancillaries Used For Testing

Equipment Type	Manufacturer	Model	Serial #	Last Calibration Date
Loop Antenna	ETS Lindgren	6507	161344	10/26/2017
Biconlog Antenna	EMCO	3142E	166067	06/27/2017
Horn Antenna	EMCO	3115	35114	07/31/2017
Horn Antenna	ETS Lindgren	3117-PA	215984	01/26/2018
EMI Test Receiver	Rohde & Schwarz	ESU40	100251	01/31/2018
Spectrum Analyzer	Rohde & Schwarz	FSU40	101022	7/5/2017
Compact Digital Barometer	Control Company	35519-055	91119547	6/8/2017
Thermometer Humidity	Dickson	TM325	16253651	11/02/2017

Equipment used meets the measurement uncertainty requirements as required per applicable standards for 95% confidence levels.
Calibration due dates, unless defined specifically, falls on the last day of the month. Items indicated “N/A” for cal status either do not specifically require calibration or is internally characterized before use.

10 Revision History

Date	Report Name	Changes to report	Report prepared by
2018-10-26	EMC_CTSMC-003-18001_FCC_27	Initial Version	Kris Lazarov
2019-1-21	EMC_CTSMC-003-18001_FCC_27_Rev_1	Added RSS-130 assessment; Updated the power table in section 7.1.4 and 7.1.5; Updated the plots in section 7.1.6	Kris Lazarov