DEKRA Testing and Certification, S.A.U.
Parque Tecnológico de Andalucía,
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C.I.F. A29 507 456

FCC LISTED,
REGISTRATION NUMBER:
720267

ISED LISTED
REGISTRATION NUMBER
ISED 4621A-4

Nº 51/LE147

Test report No:

NIE: 59675RRF.004

Test report

REFERENCE STANDARD:
USA FCC Part 22 & Part 90
CANADA IC RSS-132

Identification of item tested	IOT Module
Trademark	nRF91
Model and /or type reference	nRF9160
Other identification of the product	FCC ID: 2ANPO00NRF9160 IC: 24529-NRF9160 IMEI TAC: 35265610
Features	LTE Cat-M1, LTE-NB1, GPS
Applicant	Nordic Semiconductor ASA Otto Nielsens Vei 12, 7052 Trondheim, NORWAY
Test method requested, standard	USA FCC Part 22 10-1-18 Edition. USA FCC Part 90 10-1-18 Edition. CANADA IC RSS-132 Issue 3, Jan. 2013. ANSI C63.26 – 2015 ANSI/TIA-603-E: 2016
Summary	IN COMPLIANCE
Approved by (name / position & signature)	A. Llamas RF Lab. Manager Firmado digitalmente por ALEJANDRO LLAMAS RODRIGUEZ Fecha: 2019.05.15 12:25:11 +02'00'
Date of issue	2019-05-15
Report template No	FDT08_21

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Competences and guarantees

DEKRA Testing and Certification is a testing laboratory accredited by the National Accreditation Body (ENAC - Entidad Nacional de Acreditación), to perform the tests indicated in the Certificate No. 51/LE 147.

DEKRA Testing and Certification is a laboratory with a measurement facility in compliance with the requirements of Section 2.948 of the FCC rules and has been added to the list of facilities whose measurements data will be accepted in conjuction with applications for Certification under Parts 15 or 18 of the Commission's Rules. Registration Number: 720267.

DEKRA Testing and Certification is a laboratory with a measurement site in compliance with the requirements of RSS 212, Issue 1 (Provisional) and has been added to the list of filed sites of the Canadian Certification and Engineering Bureau. Reference File Number: ISED 4621A-4.

In order to assure the traceability to other national and international laboratories, DEKRA Testing and Certification has a calibration and maintenance program for its measurement equipment.

DEKRA Testing and Certification guarantees the reliability of the data presented in this report, which is the result of the measurements and the tests performed to the item under test on the date and under the conditions stated on the report and, it is based on the knowledge and technical facilities available at DEKRA Testing and Certification at the time of performance of the test.

DEKRA Testing and Certification is liable to the client for the maintenance of the confidentiality of all information related to the item under test and the results of the test.

The results presented in this Test Report apply only to the particular item under test established in this document.

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General conditions

1. This report is only referred to the item that has undergone the test.
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4. This test report cannot be used partially or in full for publicity and/or promotional purposes without previous written permission of DEKRA Testing and Certification and the Accreditation Bodies.

Uncertainty

Uncertainty (factor k=2) was calculated according to the DEKRA Testing and Certification internal document PODT000.

Usage of samples

Samples undergoing test have been selected by: the client.

Sample S/01 is composed of the following elements:

Control Nº	Description	Model	Serial Nº	Date of reception
59678C/004	IOT Module	nRF9160	IMEI: 352656100030561	2019-01-15

1. Sample S/01 has undergone the following test(s):

All tests indicated in Appendix A.

Data provided by the client

The sample consist of a IOT Module that has Application CPU, LTE Cat-M1, Cat-NB1 Radio and GPS Receiver.

DEKRA declines any responsibility with respect to the information provided by the client and that may affect the validity of results.

Test sample description

Ports…… :	Port name and description		Cable				
			Specified length [m]	Attached during test	Shielded		
	LTE RF		2	☒	☒		
	GPS		2	☒	☒		
				☐	☐		
				☐	☐		
Supplementary information to the ports…… :	N/A						
Rated power supply ……:	Voltage and Frequency		Reference poles				
			L1	L2	L3	N	PE
	☐	AC:	☐	☐	☐	☐	☐
	☒	DC: 3.1 – 5.5Vdc.					
	☐	DC:					
Rated Power ……:	1W						
Clock frequencies ……:	32kHz, 32MHz						
Other parameters……:	---						
Software version ……:	mfw_nrf9160_0.7.0-29.alpha						

Hardware version.....:	DEV2.1.6			
Dimensions in cm (L x W x D) ....:	11x16x1.1mm			
Mounting position.....:	☐	Table top equipment		
	☐	Wall/Ceiling mounted equipment		
	☐	Floor standing equipment		
	☐	Hand-held equipment		
	☒	Other: SMD Module		
Modules/parts .....:	Module/parts of test item		Type	Manufacturer
	N/A			
Accessories (not part of the test item) .....:	Description		Type	Manufacturer
	N/A			
	N/A			
	N/A			
Documents as provided by the applicant.....:	Description		File name	Issue date
	User manual		4418_1177-0.3.1-20180905-140910-nRF9160_Objective_Product_Spec	23-Oct-2018
	Cover markings		SiP marking	23-Oct-2018

Copy of marking plate:

Identification of the client

NORDIC SEMICONDUCTOR ASA
Otto Nielsens Vei 12, 7052 Trondheim, NORWAY.

Testing period and place

Test Location	DEKRA Testing and Certification S.A.U.
Date (start)	2018-01-30
Date (finish)	2018-04-25

Document history

Report number	Date	Description
59675RRF.004	2019-05-15	First release

Environmental conditions

In the control chamber, the following limits were not exceeded during the test:

Temperature	Min. = 15 ºC Max. = 35 ºC
Relative humidity	Min. = 20 % Max. = 75 %

In the semianechoic chamber, the following limits were not exceeded during the test.

Temperature	Min. = 15 ºC Max. = 35 ºC
Relative humidity	Min. = 20 % Max. = 75 %

In the chamber for conducted measurements, the following limits were not exceeded during the test:

Temperature	Min. = 15 ºC Max. = 35 ºC
Relative humidity	Min. = 20 % Max. = 35 %

Remarks and comments

The tests have been performed by the technical personnel: José Alberto Aranda.

Used instrumentation:

Conducted Measurements

		Last Cal. date	Cal. due date
1.	Spectrum analyser Agilent E4440A	2017/10	2019/10
2.	Vector signal analyzer Rohde & Schwarz FSQ8	2018/08	2020/08
3.	Climatic chamber HERAEUS VM 04/35	2018/06	2020/06
4.	DC power supply R&S NGPE 40/40	2018/02	2021/02
5.	Universal Radio communication Tester R&S CMW50	2019/02	2020/02
6.	Spectrum analyser Rohde & Schwarz FSV40	2017/07	2019/07

Radiated Measurements

		Last Cal. date	Cal. due date
1.	Semianechoic Absorber Lined Chamber ETS FACT3 200STP	N.A.	N.A.
2.	BiconicalLog antenna ETS LINDGREN 3142E	2017/09	2020/09
3.	Multi Device Controller MESSTECHNIK DAV-RR	N.A.	N.A.
4.	Double-ridge Guide Horn antenna 1-18 GHz SCHWARZBECK BBHA 9120 D	2018/01	2021/01
5.	Spectrum analyser Rohde & Schwarz FSV40	2018/02	2020/02
6.	EMI Test Receiver R&S ESU26	2018/02	2020/02
7.	RF pre-amplifier 1-18 GHz Bonn Elektronik BLMA 0118-3A	2019/04	2020/04

Testing verdicts

Not applicable :	N/A
Pass :	P
Fail :	F
Not measured :	N/M

Summary

FCC PART 22/IC RSS-132 PARAGRAPH		
Requirement – Test case	Verdict	Remark
Clause 22.913/RSS-132 Clause 5.4: RF output power	P	
Clause 2.1047/RSS-132 Clause 5.2: Modulation characteristics	P	
Clause 22.355/RSS-132 Clause 5.3: Frequency stability	P	
Clause 2.1049: Occupied Bandwidth	P	
Clause 22.917/RSS-132 Clause 5.5: Spurious emissions at antenna terminals	P	
Clause 22.917/RSS-132 Clause 5.5: Radiated emissions	P	
Supplementary information and remarks: None		

FCC PART 90 PARAGRAPH		
Requirement – Test case	Verdict	Remark
Clause 90.635 (b): RF output power	P	
Clause 2.1047: Modulation characteristics	P	
Clause 90.213 Frequency stability	P	
Clause 2.1049: Occupied Bandwidth	P	
Clause 90.691 Spurious emissions at antenna terminals (Emission mask requirements for EA-based systems)	P	
Clause 90.691: Radiated emissions	P	
Supplementary information and remarks: None		

Appendix A: Test results for FCC Part 22 & 90 / RSS-132

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TEST CONDITIONS

Power supply (V):

Vnominal = 3.8 Vdc

Vmax = 4.37 Vdc

Vmin = 3.23 Vdc

The subscripts nom, min and max indicate voltage test conditions (nominal, minimum and maximum respectively, as declared by the applicant).

Type of power supply = DC Voltage from external power supply

Type of antenna = Integral antenna.

Declared Gain for antenna = +2.6 dBi.

TEST FREQUENCIES:

814-824MHz Band:

NBIoT. π/2 - BPSK AND π/4 - QPSK MODULATION (BAND 26)

Channel (Frequency. MHz)	
Lowest	Highest
26692 (814.2)	26788 (823.8)

Cross-rule channel (824MHz):

NBIoT. π/2 - BPSK AND π/4 - QPSK MODULATION (BAND 26)

Channel (Frequency. MHz)
26790 (824)

824-849MHz Band:

NBIoT. π/2 - BPSK AND π/4 - QPSK MODULATION (BAND 5)

Channel (Frequency. MHz)		
Lowest	Middle	Highest
20402 (824.2)	20525 (836.5)	20648 (848.8)

NBIoT. π/2 - BPSK AND π/4 - QPSK MODULATION (BAND 26)

Channel (Frequency. MHz)		
Lowest	Middle	Highest
26792 (824.2)	26915 (836.5)	27038 (848.8)

NOTE: Band 26 is completely included in band 5, so the channels of band 5 were tested to give conformity to the assigned block.

RF Output Power

SPECIFICATION

FCC §2.1046 and §22.913. The Effective Radiated Power (E.R.P.) of mobile transmitter and auxiliary test transmitter must not exceed 7 Watts (38.45 dBm E.R.P.).

RSS-132. Clause 5.4. The equivalent isotropically radiated power (e.i.r.p.) for mobile equipment shall not exceed 11.5 watts (38.45 dBm E.R.P.).

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 using a signal corresponding to the highest PAPR during periods of continuous transmission.

FCC §90.635. The maximum output power of the transmitter for mobile stations is 100 watts (20 dBw).

METHOD

The conducted RF output power measurements were made at the RF output terminals of the EUT using the power meter of the Universal Radio Communication tester R&S CMU200 and CMW500, selecting maximum transmission power of the EUT and different modes of modulation.

The peak-to-average power ratio (PAPR) is measured using an attenuator, power splitter and spectrum analyser with a Complementary Cumulative Distribution Function implemented.

The maximum equivalent isotropically radiated power (e.i.r.p.) is calculated by adding the declared maximum antenna gain (dBi).

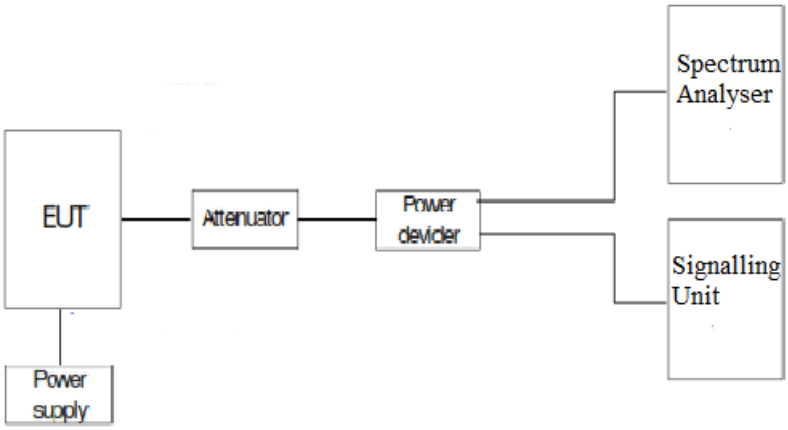
The maximum effective radiated power e.r.p. is calculated from the maximum equivalent isotropically radiated power (e.i.r.p.) by subtracting 2.15 dB:

E.R.P. = E.I.R.P. – 2.15 dB

TEST SETUP

Conducted average power.

Peak-to-average power ratio (PAPR)



RESULTS

MAXIMUM OUTPUT POWER (CONDUCTED).

814-824 MHz Band:

Ch	Freq. (MHz)	Modulation	BW (kHz)	Num. tone	Offset Tone	Average Power (dBm)
26692	814.2	π/2 - BPSK	3.75	1	0	23.02
				1	47	22.96
			15	1	0	22.99
				1	11	23.01
		π/4 - QPSK	3.75	1	0	22.95
				1	47	22.93
			15	1	0	22.98
				1	11	22.96
				3	0	22.88
				3	6	22.86
				6	0	22.20
				6	6	22.24
				12	0	21.21
26788	823.8	π/2 - BPSK	3.75	1	0	23.01
				1	47	22.69
			15	1	0	22.78
				1	11	22.79
		π/4 - QPSK	3.75	1	0	22.75
				1	47	22.69
			15	1	0	22.80
				1	11	22.96
				3	0	21.96
				3	6	22.01
				6	0	21.01
				6	6	20.91
				12	0	21.21

Cross-rule channel (824MHz):

Ch	Freq. (MHz)	Modulation	BW (kHz)	Num. tone	Offset Tone	Average Power (dBm)
26790	824	π/2 - BPSK	3.75	1	0	23.14
				1	47	23.12
			15	1	0	23.14
				1	11	23.11
		π/4 - QPSK	3.75	1	0	23.12
				1	47	23.15
			15	1	0	23.16
				1	11	23.17
				3	0	22.64
				3	6	23.16
				6	0	21.94
				6	6	21.97
				12	0	21.04

824-849MHz Band:

Ch	Freq. (MHz)	Modulation	BW (kHz)	Num. tone	Offset Tone	Average Power (dBm)	PAPR (dB)
20402	824.2	π/2 - BPSK	3.75	1	0	23.12	(*)
				1	47	23.04	(*)
			15	1	0	23.12	(*)
				1	11	23.11	(*)
		π/4 - QPSK	3.75	1	0	23.14	(*)
				1	47	23.07	(*)
			15	1	0	23.17	(*)
				1	11	23.16	(*)
				3	0	22.99	3.17
				3	6	23.31	3.11
				6	0	22.31	3.94
				6	6	22.38	3.85
				12	0	21.37	3.72
20525	836.5	π/2 - BPSK	3.75	1	0	23.05	(*)
				1	47	22.98	(*)
			15	1	0	23.04	(*)
				1	11	23	(*)
		π/4 - QPSK	3.75	1	0	23.04	(*)
				1	47	22.96	(*)
			15	1	0	23.03	(*)
				1	11	22.99	(*)
				3	0	22.71	3.21
				3	6	23.16	3.13
				6	0	21.80	3.99
				6	6	21.81	3.97
				12	0	20.78	3.72
20648	848.8	π/2 - BPSK	3.75	1	0	23.01	(*)
				1	47	23.04	(*)
			15	1	0	23.15	(*)
				1	11	23.10	(*)
		π/4 - QPSK	3.75	1	0	23	(*)
				1	47	23.03	(*)
			15	1	0	23.18	(*)
				1	11	23.1	(*)
				3	0	22.98	3.16
				3	6	23.34	3.14
				6	0	22.23	4.09
				6	6	22.31	4.02
				12	0	21.27	3.73

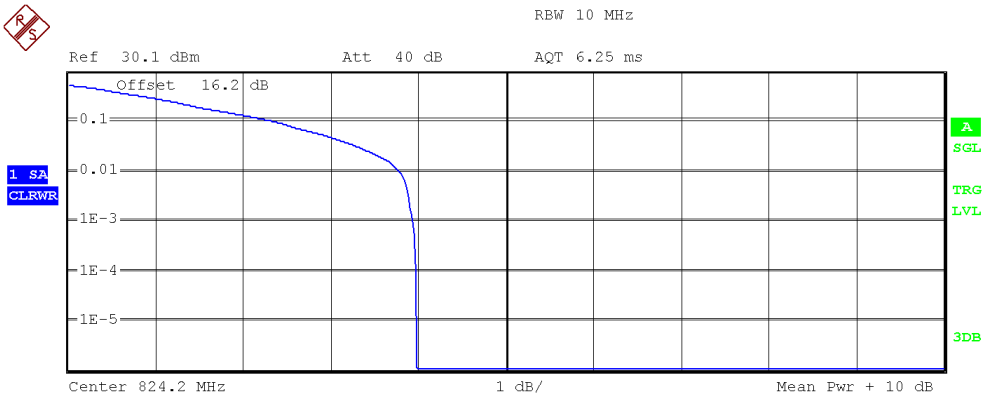
(*): Preliminary measurements determined that 3. 6 or 12 tones of 15kHz as the worst case. The results in the next tables shows the results for this configuration.

PEAK-TO-AVERAGE POWER RATIO (PAPR).

824-849MHz Band:

Preliminary measurements determined that 6 tones of 15kHz as the worst case. The results in the next tables shows the results for this configuration.

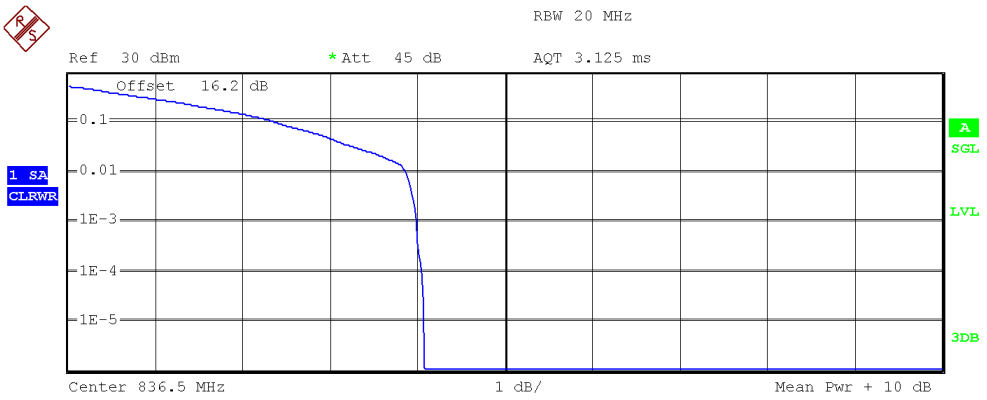
Channel Low:



Complementary Cumulative Distribution Function
NOF samples: 100000, Usable BW: 11.2MHz

	Trace 1
Mean	21.94 dBm
Peak	25.92 dBm
Crest	3.97 dB
10 %	2.36 dB
1 %	3.77 dB
.1 %	3.94 dB
.01 %	3.97 dB

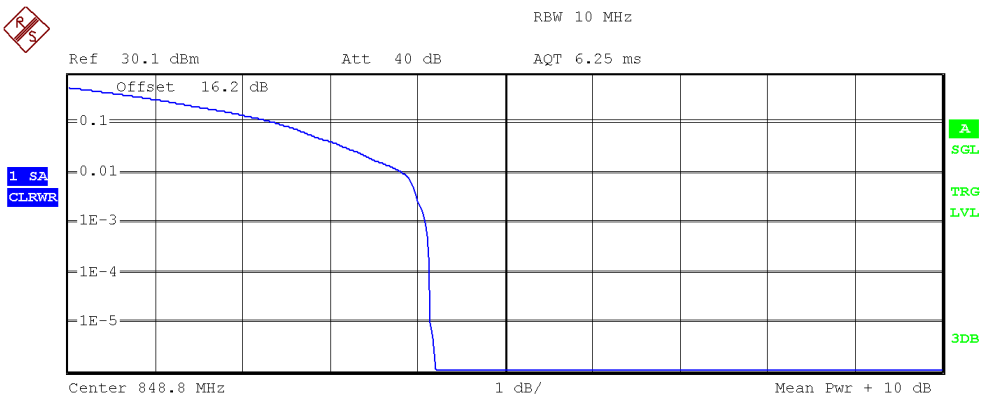
Channel Middle:



Complementary Cumulative Distribution Function
NOF samples: 100000, Usable BW: 23.7MHz

	Trace 1
Mean	21.80 dBm
Peak	25.87 dBm
Crest	4.07 dB
10 %	2.37 dB
1 %	3.86 dB
.1 %	3.99 dB
.01 %	4.05 dB

Channel High:



Complementary Cumulative Distribution Function
NOF samples: 100000, Usable BW: 11.2MHz

	Trace 1
Mean	21.76 dBm
Peak	25.97 dBm
Crest	4.21 dB
10 %	2.39 dB
1 %	3.83 dB
.1 %	4.09 dB
.01 %	4.15 dB

814-824 MHz Band:

Channel	Measured maximum average power (dBm) at antenna port	Maximum declared antenna gain (dBi)	Maximum equivalent isotropically radiated power (E.I.R.P.) (dBm)	Maximum effective radiated power E.R.P. (dBm)
Lowest	23.02	+2.6	25.62	23.47
Highest	23.01	+2.6	25.61	23.46
Measurement uncertainty (dB)	<±1.11			

Cross-rule channel (824MHz):

Channel	Measured maximum average power (dBm) at antenna port	Maximum declared antenna gain (dBi)	Maximum equivalent isotropically radiated power (E.I.R.P.) (dBm)	Maximum effective radiated power E.R.P. (dBm)
26790 (824)	23.16	+2.6	25.76	23.61
Measurement uncertainty (dB)	<±1.11			

824-849MHz Band:

Channel	Measured maximum average power (dBm) at antenna port	Maximum declared antenna gain (dBi)	Maximum equivalent isotropically radiated power (E.I.R.P.) (dBm)	Maximum effective radiated power E.R.P. (dBm)	PAPR (dB)
Lowest	23.31	+2.6	25.91	23.76	3.94
Middle	23.16	+2.6	25.76	23.61	3.99
Highest	23.34	+2.6	25.94	23.79	4.09
Measurement uncertainty (dB)	<±1.11				

Verdict: PASS

Frequency Stability

SPECIFICATION

FCC §2.1055 and §22.355. ±2.5 ppm for mobile stations operating in the range 821 to 896 MHz.

FCC §2.1055 and §90.213. ±2.5 ppm for mobile stations operating in the range 809 to 824 MHz.

RSS-132. Clause 5.3. The carrier frequency shall not depart from the reference frequency in excess of ±2.5 ppm for mobile stations.

METHOD

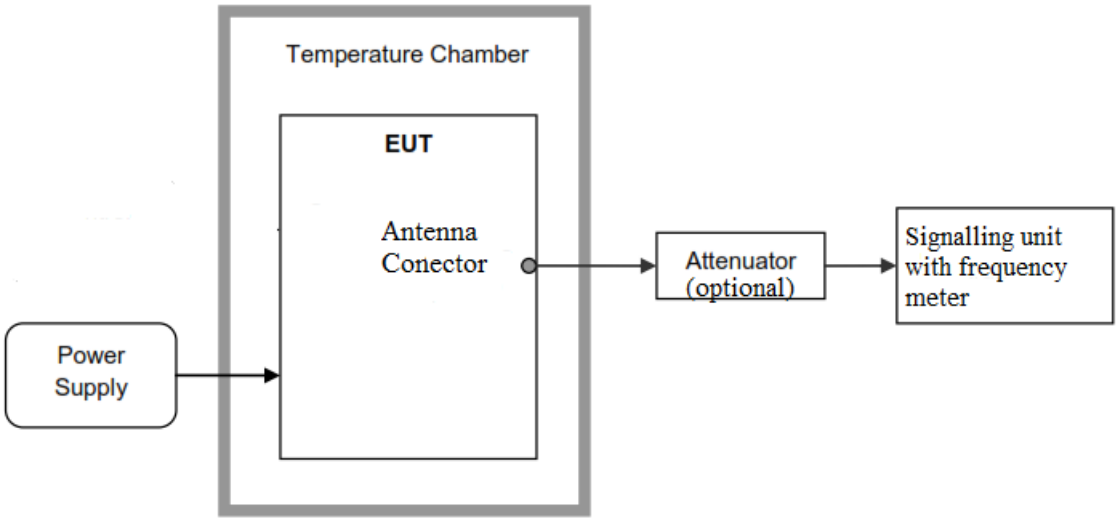
The frequency tolerance measurements over temperature variations were made over the temperature range of –30ºC to +50ºC. The EUT was placed inside a climatic chamber and the temperature was raised hourly in 10ºC steps from –30ºC up to +50ºC.
The supply voltage was varied between 85% and 115% of nominal voltage.

The EUT was set in “Radio Resource Control (RRC) mode” in the middle channel using the Universal Radio Communication tester R&S CMW500 and the maximum frequency error was measured using the built-in calibrated frequency meter.
The worst case NBIoT mode for conducted power was used for the test.

The reference point measurements were made at the RF output terminals of the EUT using an attenuator. power splitter and spectrum analyser. The EUT was controlled via the Universal Radio Communication tester R&S CMW500 selecting maximum transmission power of the EUT and different modes of modulation.

TEST SETUP

Frequency tolerance.



RESULTS

Frequency stability over temperature variations.

NBIoT Band 5 π/2 - BPSK MODULATION.

Temperature (ºC)	Frequency Error (Hz)	Frequency Error (ppm)
+50	-10.3	-0.01231
+40	24.06	0.02876
+30	-2.73	-0.00326
+20	-11.4	-0.01363
+10	16.22	0.01939
0	2.7	0.00323
-10	10.99	0.01314
-20	3.58	0.00428
-30	10.43	0.01247

NBIoT Band 26 π/2 - BPSK MODULATION

Temperature (ºC)	Frequency Error (Hz)	Frequency Error (ppm)
+50	2.06	0.00251
+40	31.07	0.03794
+30	17.77	0.02170
+20	-10.89	-0.01330
+10	1.56	0.00190
0	-4.38	-0.00535
-10	-0.4	-0.00048
-20	-22.26	-0.02718
-30	17.18	0.02098

Frequency stability over voltage variations.

NBIoT Band 5 π/2 - BPSK MODULATION.

Battery Supply voltage	Voltage (V)	Frequency Error (Hz)	Frequency Error (ppm)
Vmax	4.37	-12.02	-0.01437
Vmin	3.23	-10.13	-0.01211

NBIoT Band 26 π/2 - BPSK MODULATION.

Battery Supply voltage	Voltage (V)	Frequency Error (Hz)	Frequency Error (ppm)
Vmax	4.37	-9.68	-0.01182
Vmin	3.23	-10.37	-0.01266

Verdict: PASS

Modulation Characteristics

SPECIFICATION

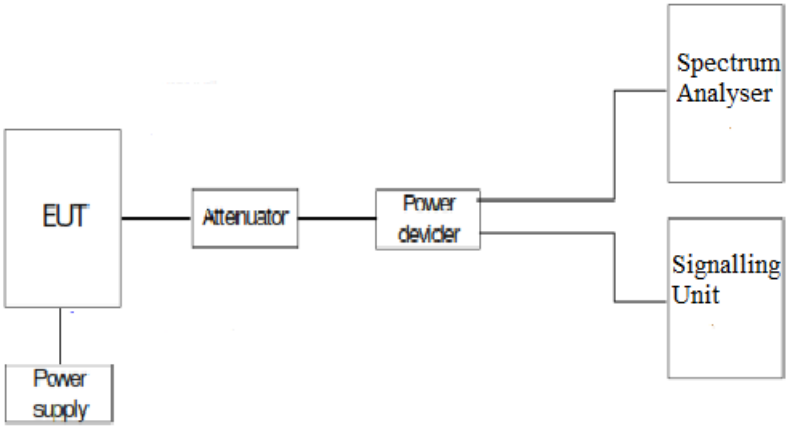
FCC §2.1047

RSS-132. Clause 5.2. Equipment certified under this standard shall use digital modulation.

METHOD

For NBIoT the EUT operates with π/2 - BPSK and π/4 - QPSK modulation modes in which the information is digitised and coded into a bit stream.

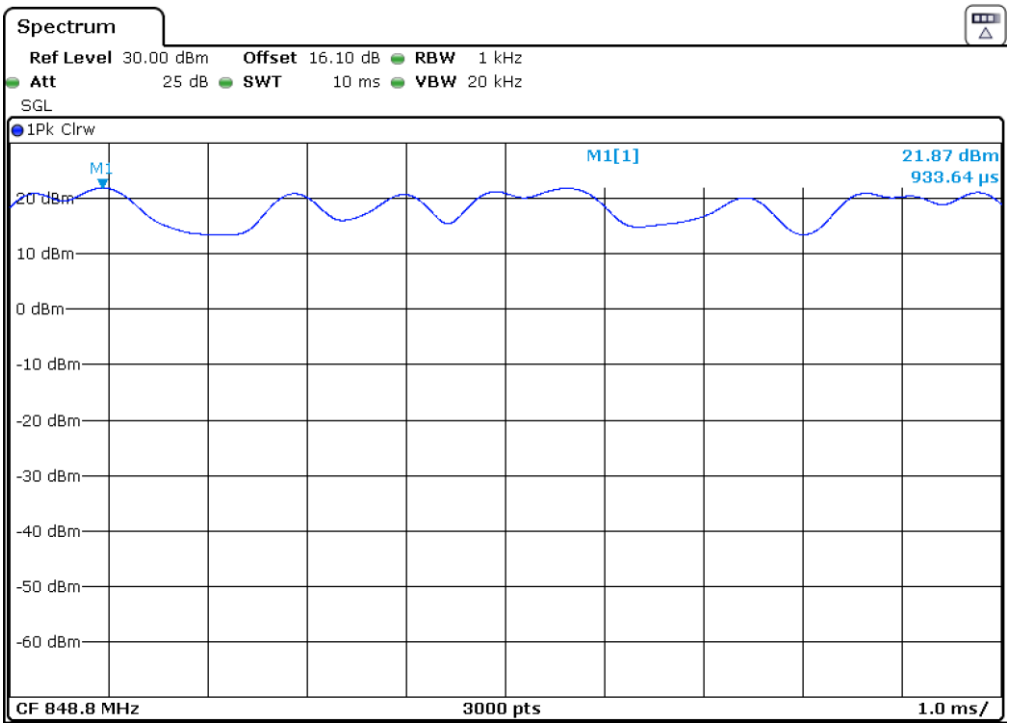
TEST SETUP



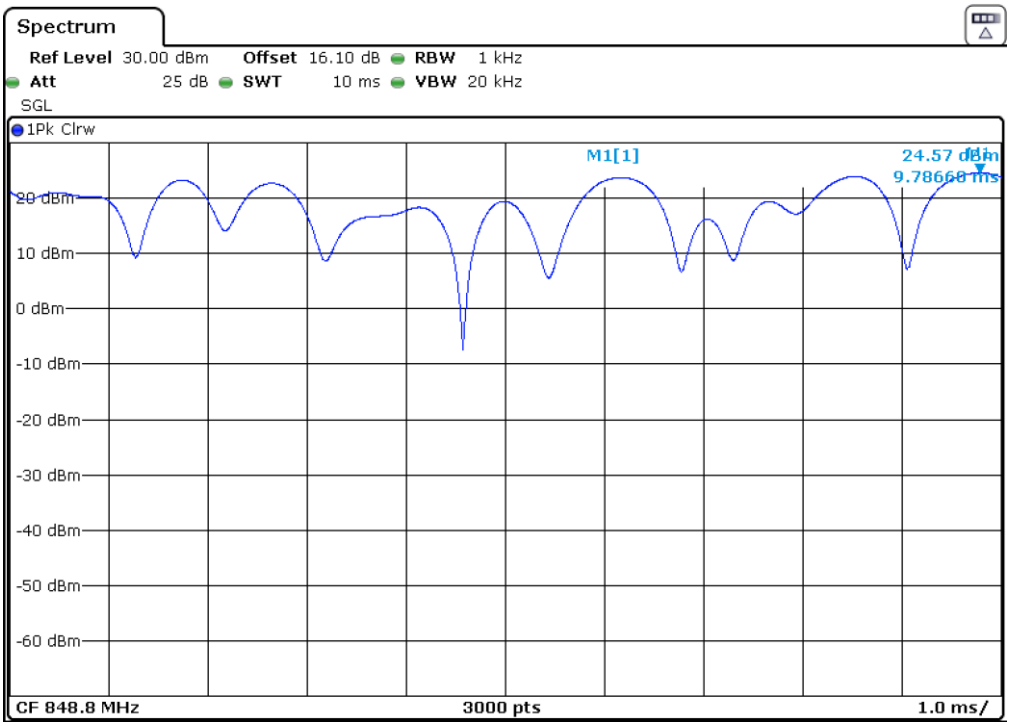
RESULTS

The following plot shows the modulation schemes in the EUT.

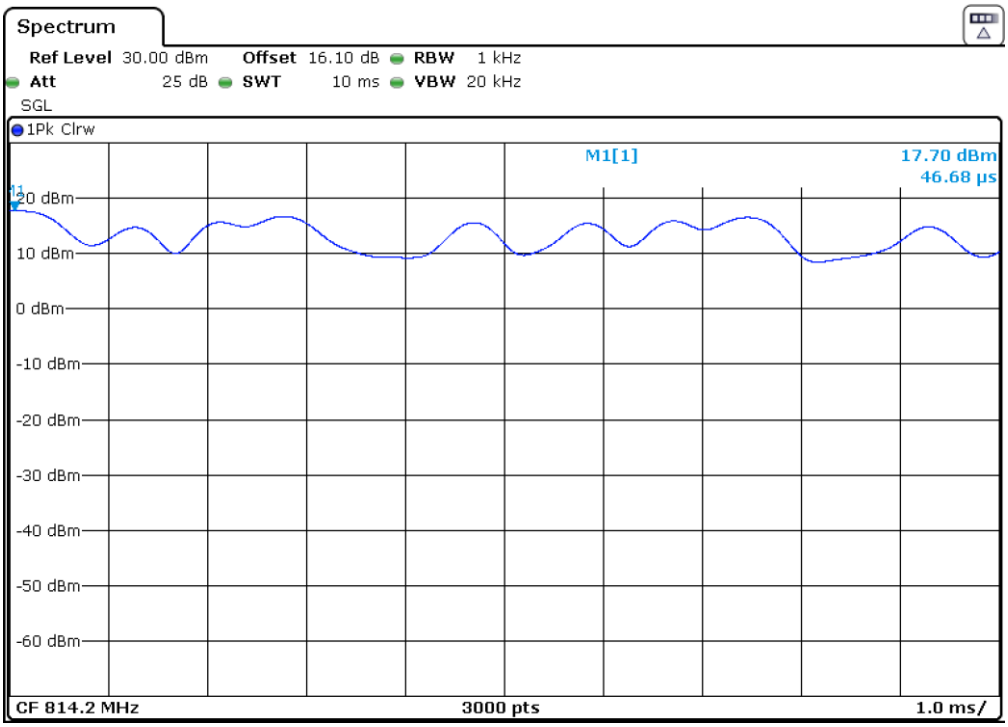
NBIoT MODULATION (Band 5). π/2 - BPSK.



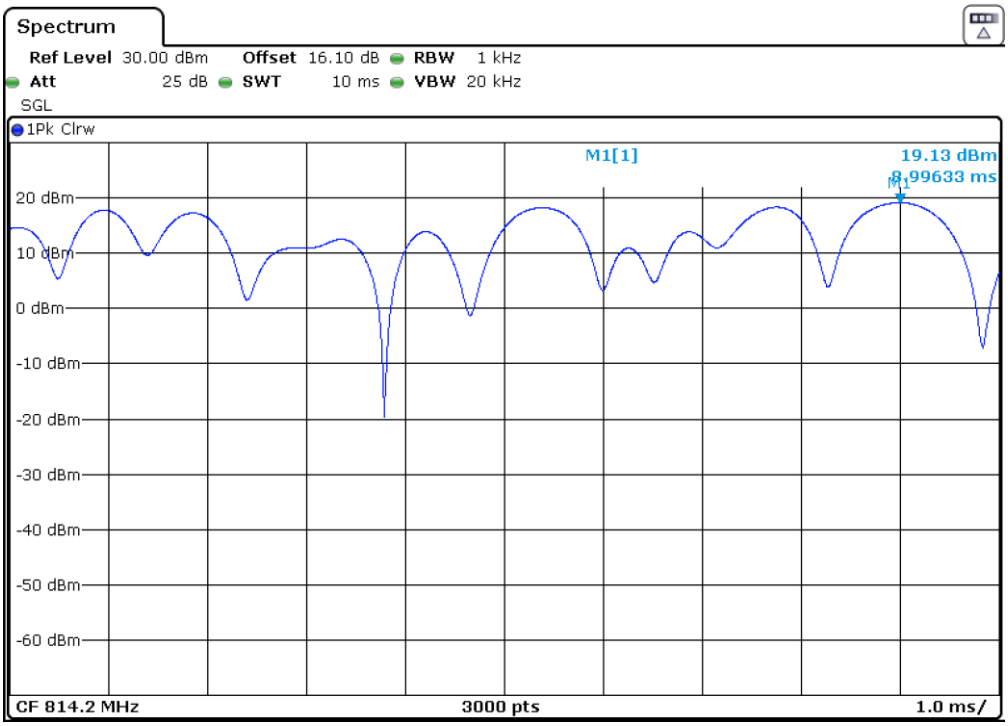
NBIoT MODULATION (Band 5). π/4 - QPSK.



NBIoT MODULATION (Band 26). π/2 - BPSK.



NBIoT MODULATION (Band 26). π/4 - QPSK.



Occupied Bandwidth

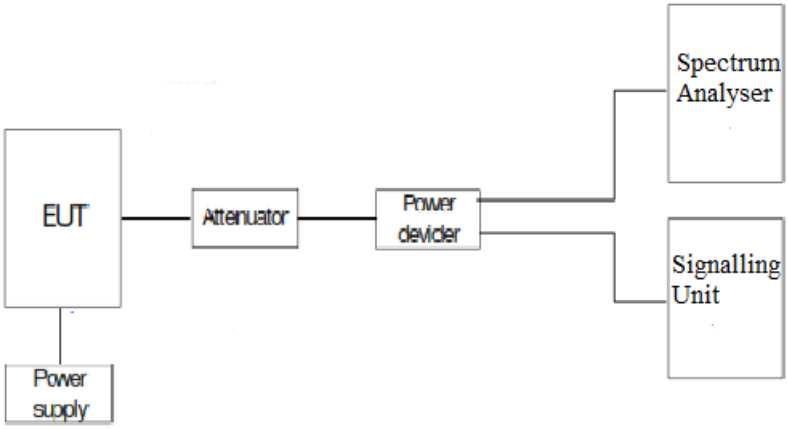
SPECIFICATION

§2.1049

METHOD

The occupied bandwidth measurement was performed at the output terminals of the EUT using an attenuator. power splitter and spectrum analyser. The EUT was controlled via the Universal Radio Communication tester R&S CMW500 selecting maximum transmission power of the EUT and different modes of modulation. The 99% occupied bandwidth and the -26 dBc bandwidth were measured directly using the built-in bandwidth measuring option of spectrum analyser.

TEST SETUP



RESULTS (see next plots)

814-824MHz Band:

Tone 3.75 kHz. π/2 - BPSK MODULATION

Channel	Lowest	Highest
99% Occupied bandwidth (kHz)	59.067	59.800
-26 dBc bandwidth (kHz)	41.600	41.467
Measurement uncertainty (kHz)	<±0.05	

Tone 3.75 kHz. π/4 - QPSK MODULATION

Channel	Lowest	Highest
99% Occupied bandwidth (kHz)	62.460	63.000
-26 dBc bandwidth (kHz)	41.933	41.867
Measurement uncertainty (kHz)	<±0.05	

Tone 15 kHz. π/2 - BPSK MODULATION

Channel	Lowest	Highest
99% Occupied bandwidth (kHz)	139.060	139.200
-26 dBc bandwidth (kHz)	127.470	127.600
Measurement uncertainty (kHz)	<±0.10	

12 Tones 15 kHz. π/4 - QPSK MODULATION

Channel	Lowest	Highest
99% Occupied bandwidth (kHz)	205.400	204.200
-26 dBc bandwidth (kHz)	330.600	318.000
Measurement uncertainty (kHz)	<±0.10	

Cross-rule channel (824MHz):

Tone 3.75 kHz. π/2 - BPSK MODULATION

Channel	26790
99% Occupied bandwidth (kHz)	59.067
-26 dBc bandwidth (kHz)	41.600
Measurement uncertainty (kHz)	<±0.05

Tone 3.75 kHz. π/4 - QPSK MODULATION

Channel	26790
99% Occupied bandwidth (kHz)	62.670
-26 dBc bandwidth (kHz)	41.867
Measurement uncertainty (kHz)	<±0.05

Tone 15 kHz. π/2 - BPSK MODULATION

Channel	26790
99% Occupied bandwidth (kHz)	138.133
-26 dBc bandwidth (kHz)	127.200
Measurement uncertainty (kHz)	<±0.10

12 Tones 15 kHz. π/4 - QPSK MODULATION

Channel	26790
99% Occupied bandwidth (kHz)	200.000
-26 dBc bandwidth (kHz)	324.800
Measurement uncertainty (kHz)	<±0.12

824-849MHz Band:

Tone 3.75 kHz. π/2 - BPSK MODULATION

Channel	Lowest	Middle	Highest
99% Occupied bandwidth (kHz)	60.000	60.000	60.800
-26 dBc bandwidth (kHz)	41.467	41.533	41.600
Measurement uncertainty (kHz)	<±0.05		

Tone 3.75 kHz. π/4 - QPSK MODULATION

Channel	Lowest	Middle	Highest
99% Occupied bandwidth (kHz)	63.460	63.460	64.400
-26 dBc bandwidth (kHz)	41.933	42.000	41.933
Measurement uncertainty (kHz)	<±0.05		

Tone 15 kHz. π/2 - BPSK MODULATION

Channel	Lowest	Middle	Highest
99% Occupied bandwidth (kHz)	139.467	139.200	140.000
-26 dBc bandwidth (kHz)	127.600	127.470	127.800
Measurement uncertainty (kHz)	<±0.10		

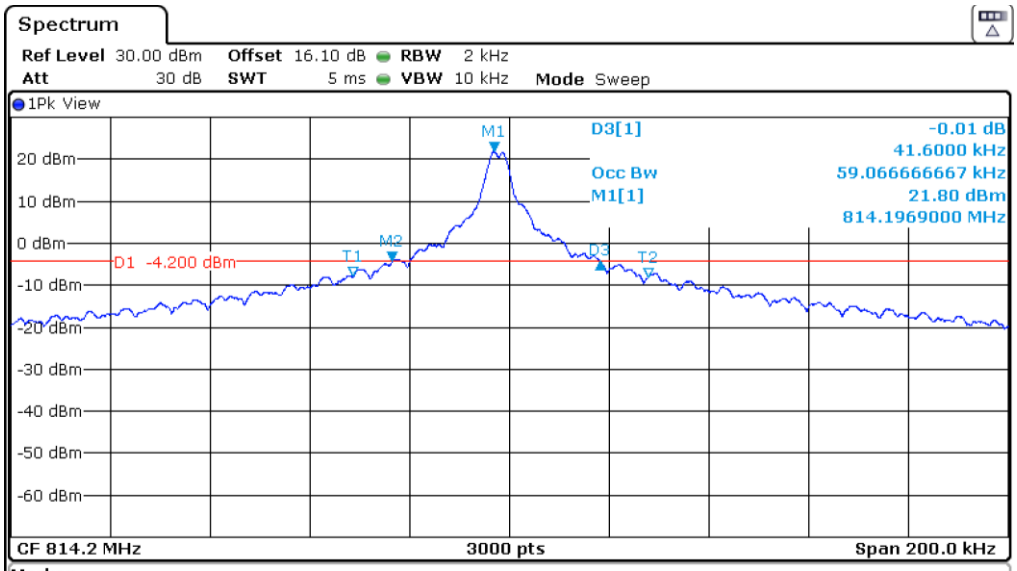
12 Tones 15 kHz. π/4 - QPSK MODULATION

Channel	Lowest	Middle	Highest
99% Occupied bandwidth (kHz)	201.467	203.200	203.060
-26 dBc bandwidth (kHz)	309.730	318.930	318.920
Measurement uncertainty (kHz)	<±0.12		

814-824MHz Band:

Tone 3.75 kHz. π/2 - BPSK MODULATION

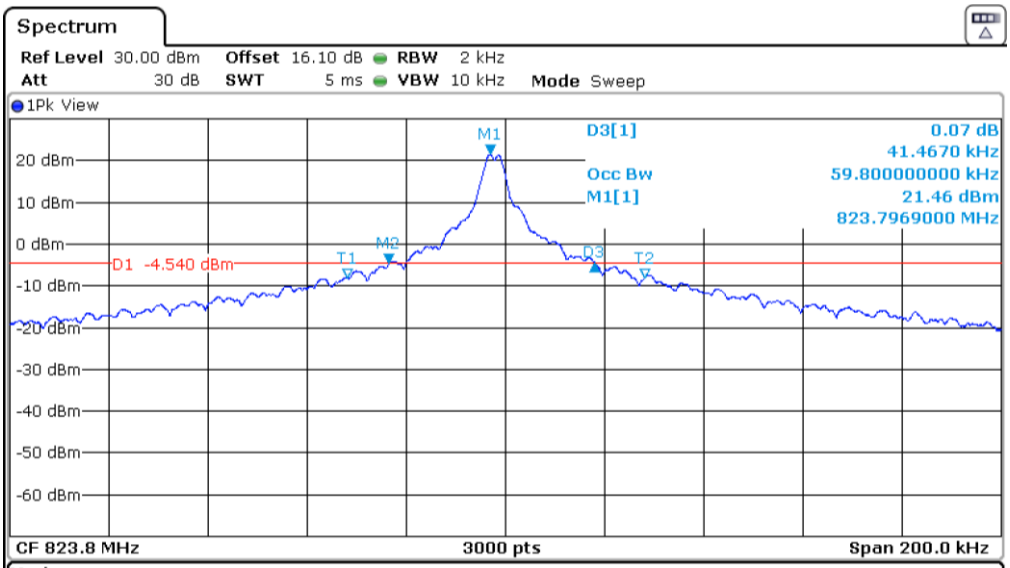
Lowest Channel



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	814.1969 MHz	21.80 dBm		
T1		1	814.1687 MHz	-7.79 dBm	Occ Bw	59.066666667 kHz
T2		1	814.2277667 MHz	-8.28 dBm		
M2		1	814.176567 MHz	-4.26 dBm		
D3	M2	1	41.6 kHz	-0.01 dB		

Highest Channel

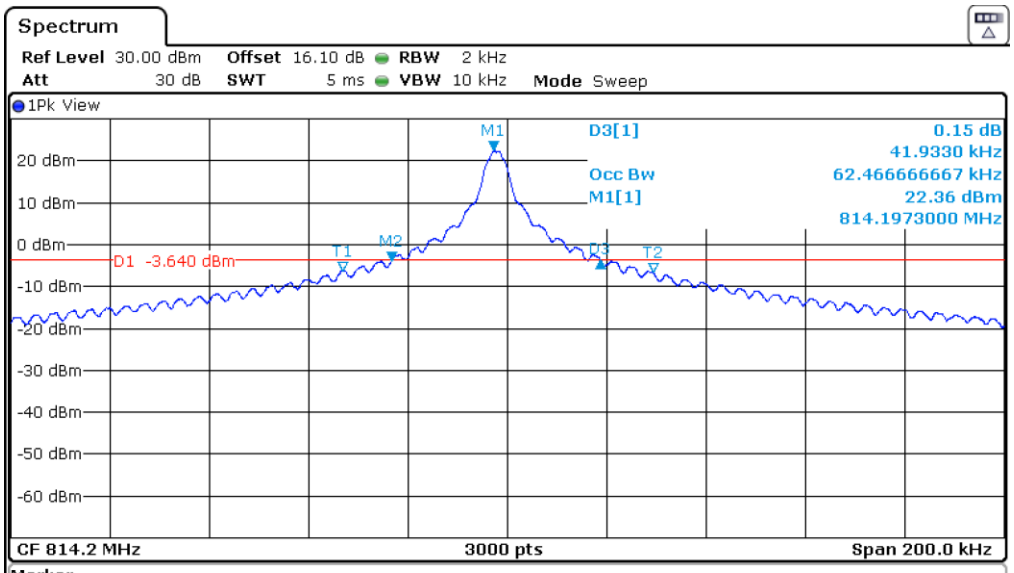


Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	823.7969 MHz	21.46 dBm		
T1		1	823.7682333 MHz	-8.24 dBm	Occ Bw	59.8 kHz
T2		1	823.8280333 MHz	-8.07 dBm		
M2		1	823.776567 MHz	-4.57 dBm		
D3	M2	1	41.467 kHz	0.07 dB		

Tone 3.75 kHz. π/4 - QPSK MODULATION

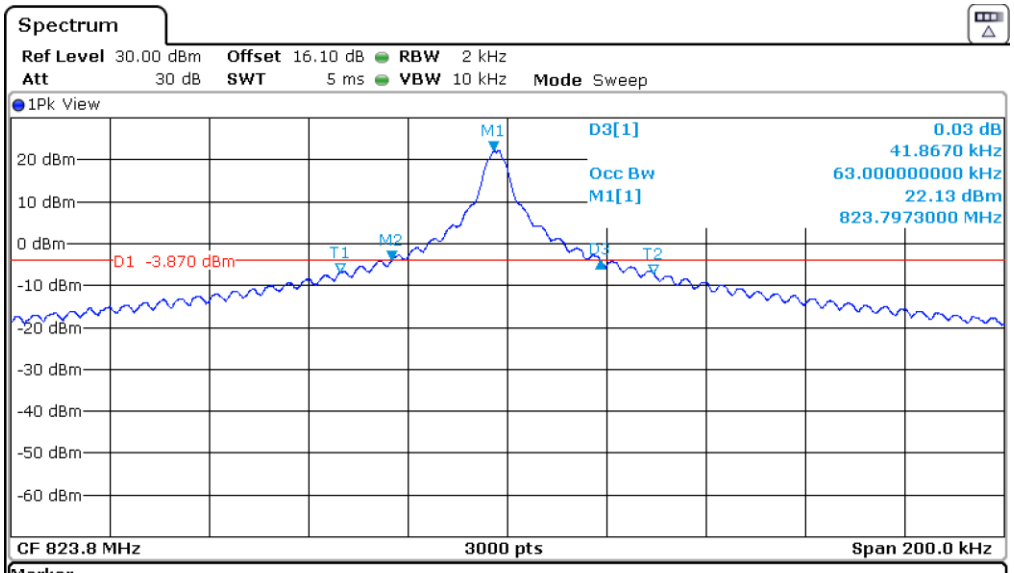
Lowest Channel



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	814.1973 MHz	22.36 dBm		
T1		1	814.1667667 MHz	-6.35 dBm	Occ Bw	62.466666667 kHz
T2		1	814.2292333 MHz	-6.77 dBm		
M2		1	814.1767 MHz	-3.79 dBm		
D3	M2	1	41.933 kHz	0.15 dB		

Highest Channel

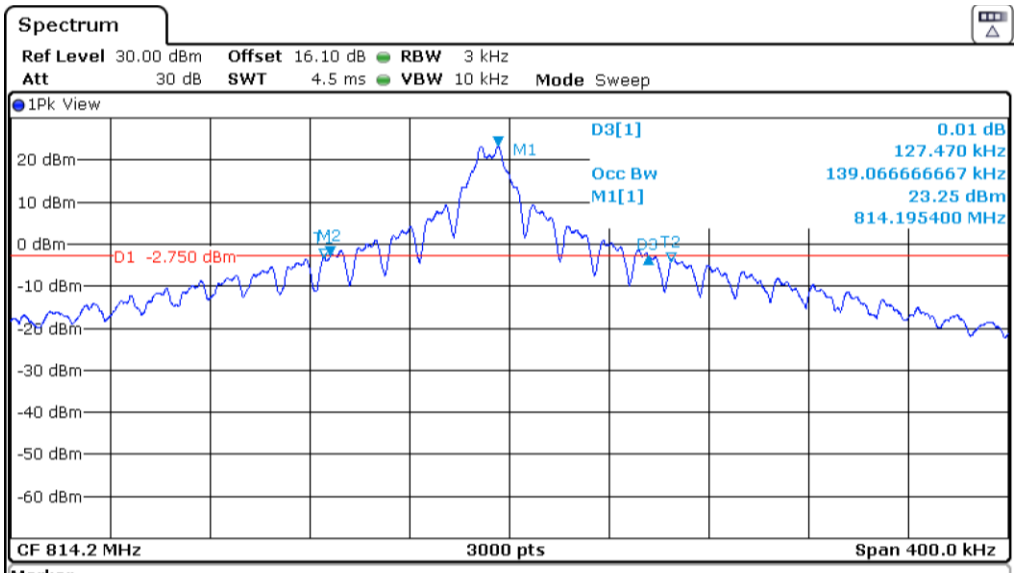


Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	823.7973 MHz	22.13 dBm		
T1		1	823.7664333 MHz	-6.88 dBm	Occ Bw	63.0 kHz
T2		1	823.8294333 MHz	-7.23 dBm		
M2		1	823.776767 MHz	-3.95 dBm		
D3	M2	1	41.867 kHz	0.03 dB		

Tone 15 kHz. π/2 - BPSK MODULATION

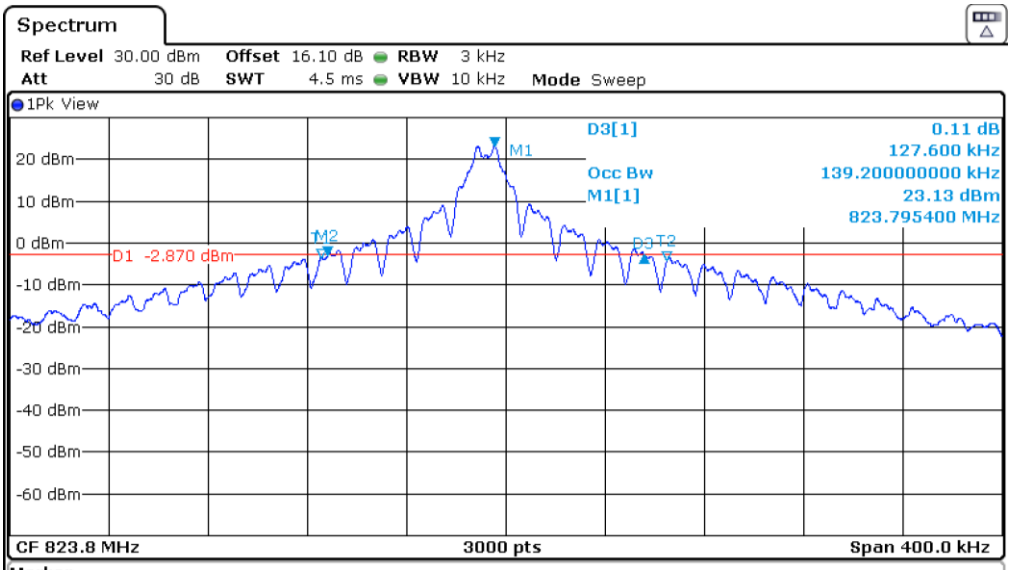
Lowest Channel



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	814.1954 MHz	23.25 dBm		
T1		1	814.125667 MHz	-3.38 dBm	Occ Bw	139.066666667 kHz
T2		1	814.264733 MHz	-4.09 dBm		
M2		1	814.1282 MHz	-2.83 dBm		
D3	M2	1	127.47 kHz	0.01 dB		

Highest Channel

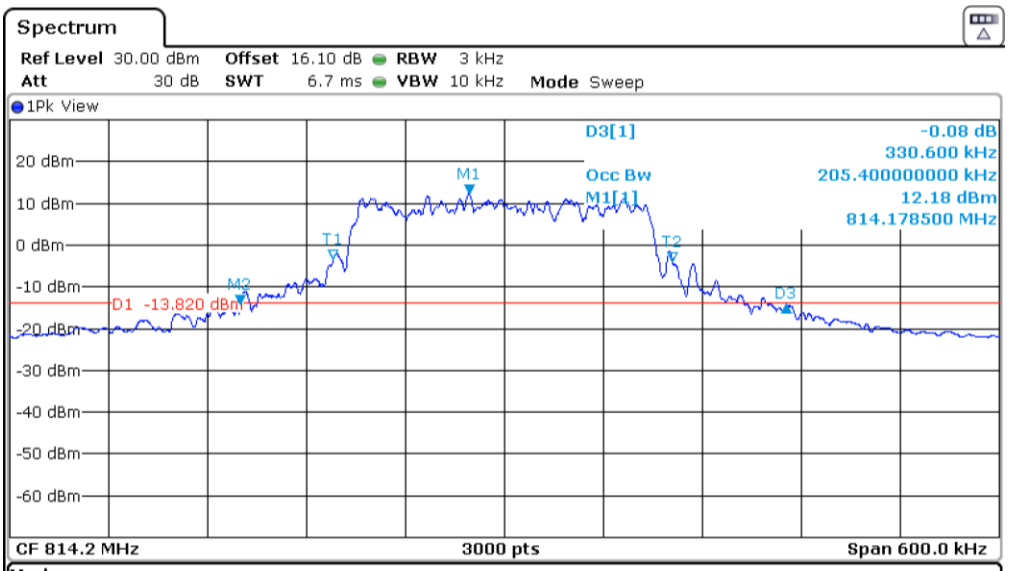


Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	823.7954 MHz	23.13 dBm		
T1		1	823.725533 MHz	-3.64 dBm	Occ Bw	139.2 kHz
T2		1	823.864733 MHz	-4.24 dBm		
M2		1	823.72807 MHz	-2.99 dBm		
D3	M2	1	127.6 kHz	0.11 dB		

12 Tones 15 kHz. π/4 - QPSK MODULATION

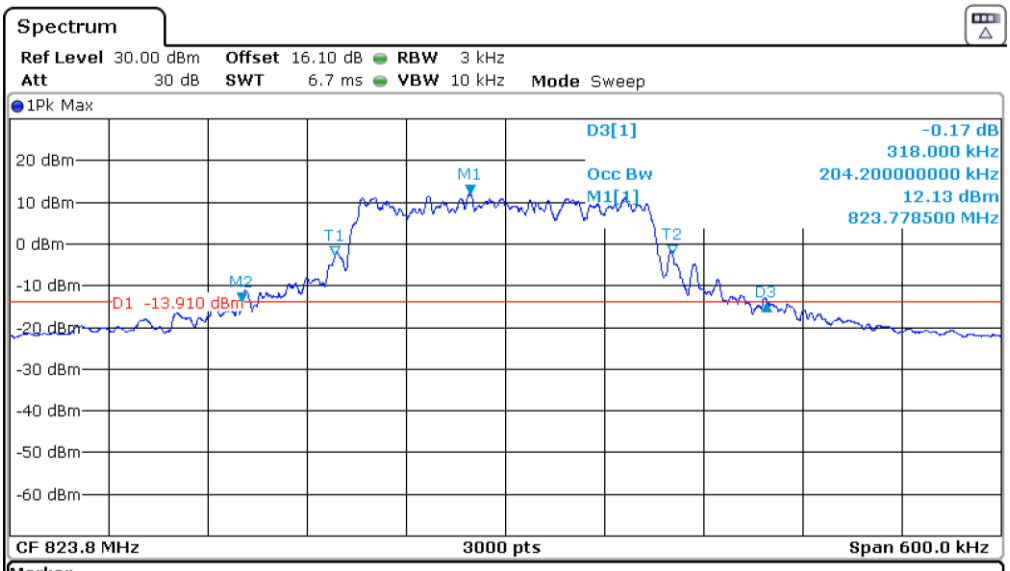
Lowest Channel



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	814.1785 MHz	12.18 dBm		
T1		1	814.0963 MHz	-3.46 dBm	Occ Bw	205.4 kHz
T2		1	814.3017 MHz	-3.82 dBm		
M2		1	814.0401 MHz	-14.11 dBm		
D3	M2	1	330.6 kHz	-0.08 dB		

Highest Channel

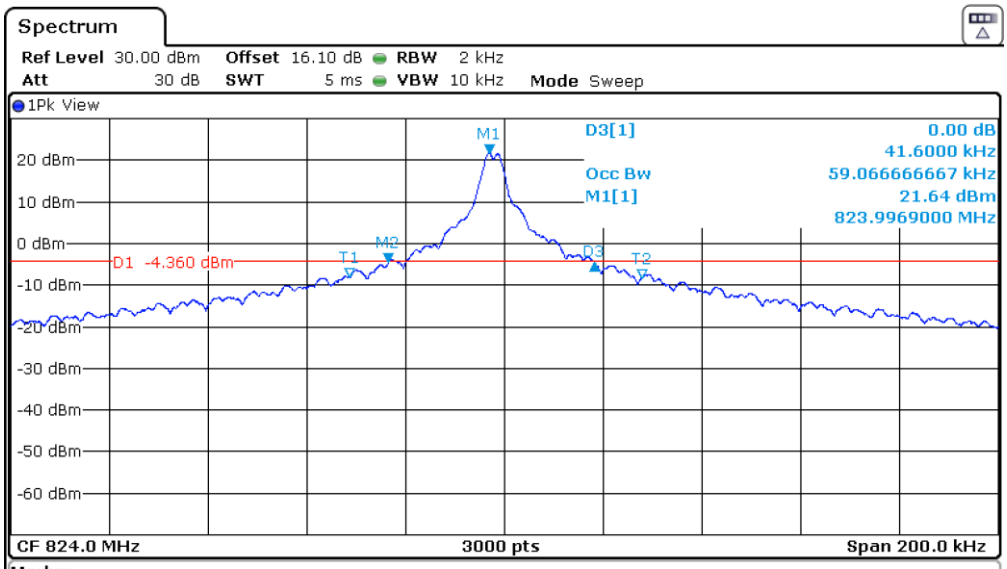


Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	823.7785 MHz	12.13 dBm		
T1		1	823.6969 MHz	-2.80 dBm	Occ Bw	204.2 kHz
T2		1	823.9011 MHz	-2.36 dBm		
M2		1	823.6403 MHz	-13.91 dBm		
D3	M2	1	318.0 kHz	-0.17 dB		

Cross-rule channel (824MHz):

Tone 3.75 kHz. π/2 - BPSK MODULATION



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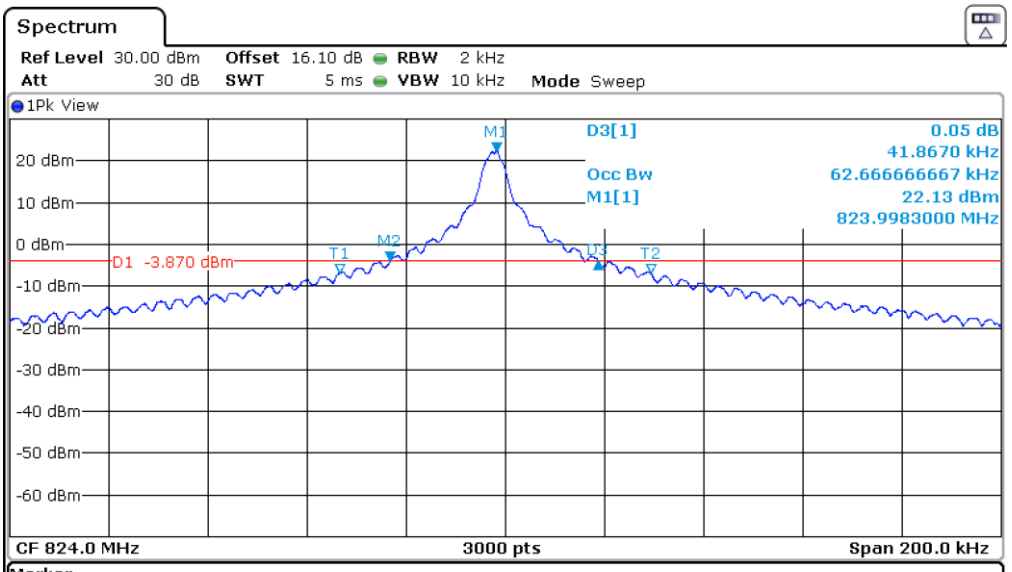
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	823.9969 MHz	21.64 dBm		
T1		1	823.9687 MHz	-8.10 dBm	Occ Bw	59.066666667 kHz
T2		1	824.0277667 MHz	-8.47 dBm		
M2		1	823.976567 MHz	-4.47 dBm		
D3	M2	1	41.6 kHz	-0.00 dB		

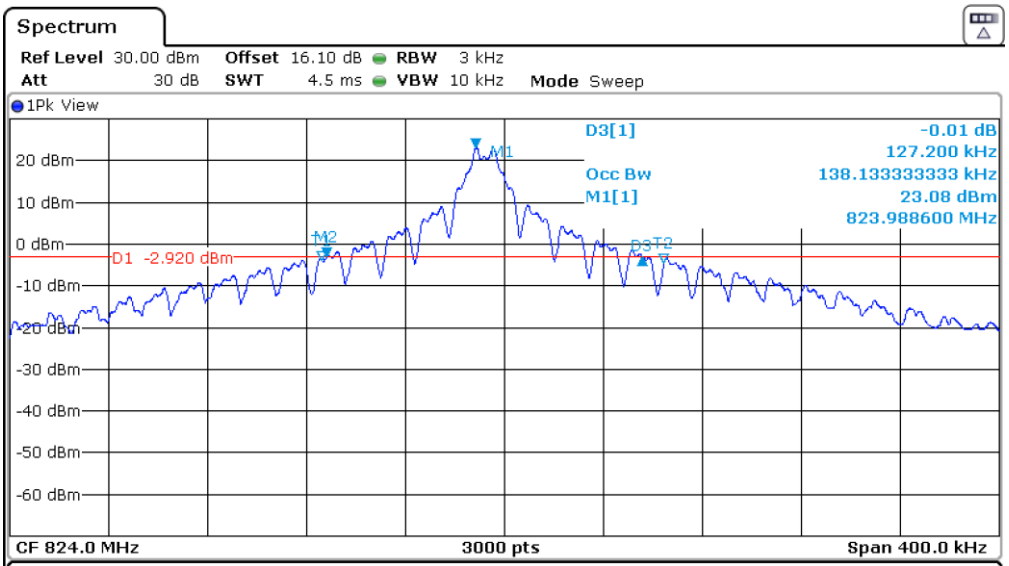
Tone 3.75 kHz. π/4 - QPSK MODULATION



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	823.9983 MHz	22.13 dBm		
T1		1	823.9667 MHz	-6.83 dBm	Occ Bw	62.666666667 kHz
T2		1	824.0293667 MHz	-7.08 dBm		
M2		1	823.976767 MHz	-3.96 dBm		
D3	M2	1	41.867 kHz	0.05 dB		

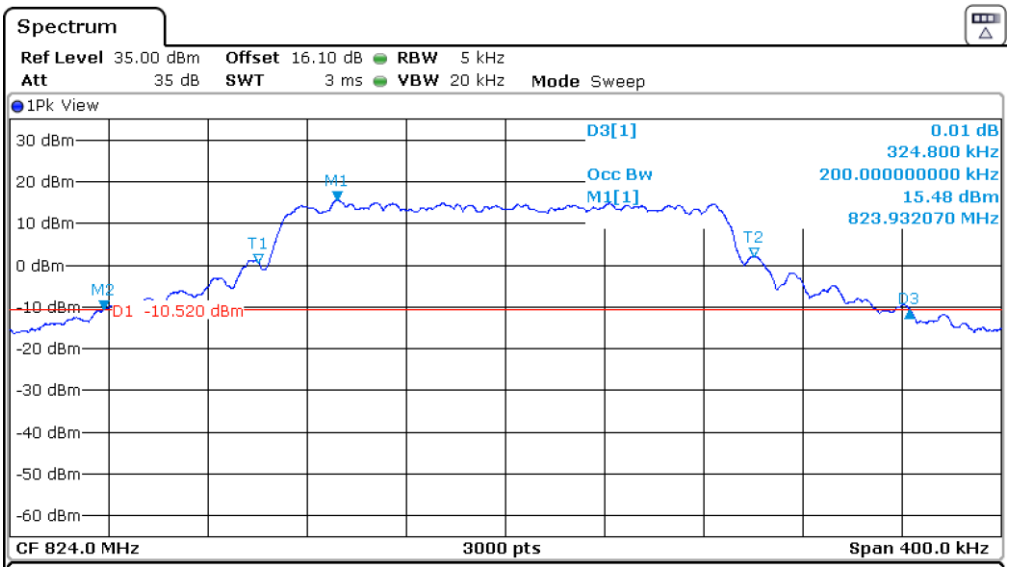
Tone 15 kHz. π/2 - BPSK MODULATION



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	823.9886 MHz	23.08 dBm		
T1		1	823.926333 MHz	-3.96 dBm	Occ Bw	138.133333333 kHz
T2		1	824.064467 MHz	-4.59 dBm		
M2		1	823.92837 MHz	-2.92 dBm		
D3	M2	1	127.2 kHz	-0.01 dB		

12 Tones 15 kHz. π/4 - QPSK MODULATION



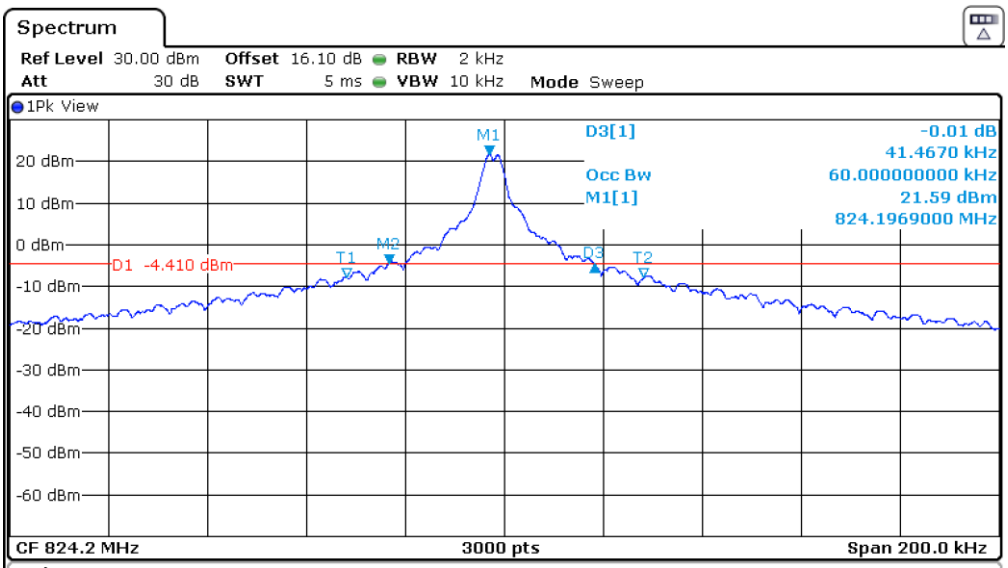
Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	823.93207 MHz	15.48 dBm		
T1		1	823.900467 MHz	0.58 dBm	Occ Bw	200.0 kHz
T2		1	824.100467 MHz	2.01 dBm		
M2		1	823.8381 MHz	-10.53 dBm		
D3	M2	1	324.8 kHz	0.01 dB		

824-849MHz Band:

Tone 3.75 kHz. π/2 - BPSK MODULATION

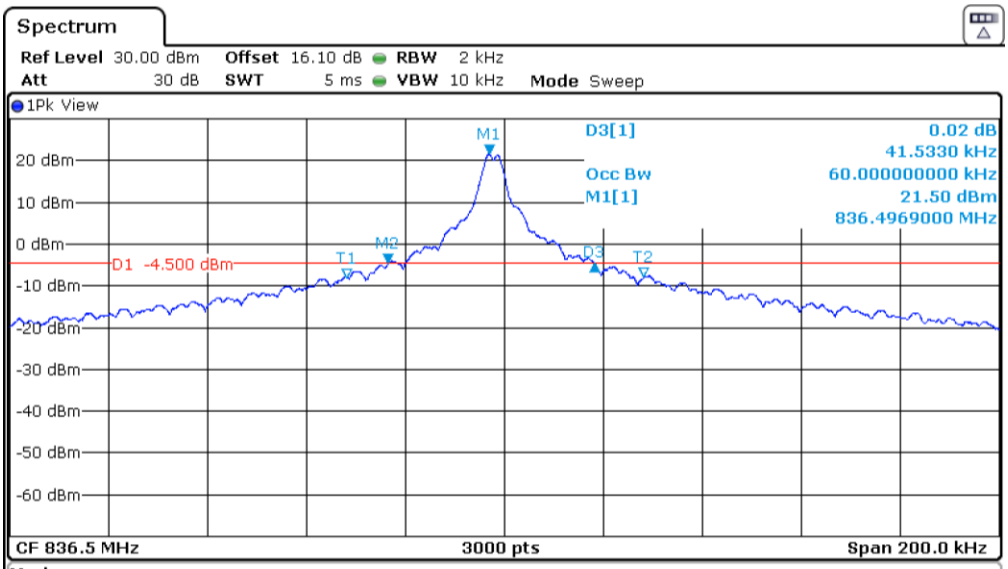
Lowest Channel



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	824.1969 MHz	21.59 dBm		
T1		1	824.1681667 MHz	-7.93 dBm	Occ Bw	60.0 kHz
T2		1	824.2281667 MHz	-7.79 dBm		
M2		1	824.176633 MHz	-4.41 dBm		
D3	M2	1	41.467 kHz	-0.01 dB		

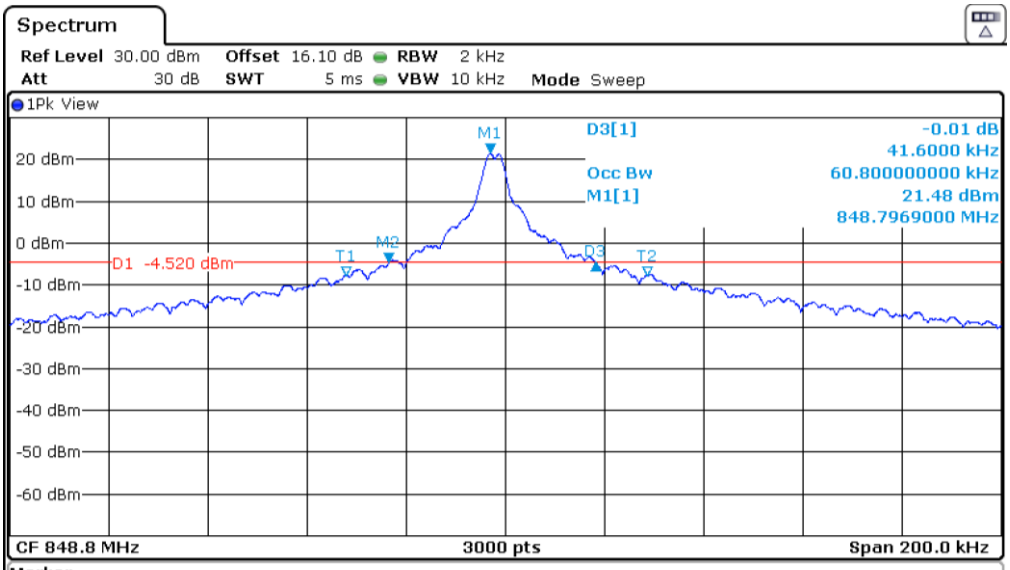
Middle Channel



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	836.4969 MHz	21.50 dBm		
T1		1	836.4681667 MHz	-8.09 dBm	Occ Bw	60.0 kHz
T2		1	836.5281667 MHz	-7.92 dBm		
M2		1	836.476567 MHz	-4.54 dBm		
D3	M2	1	41.533 kHz	0.02 dB		

Highest Channel

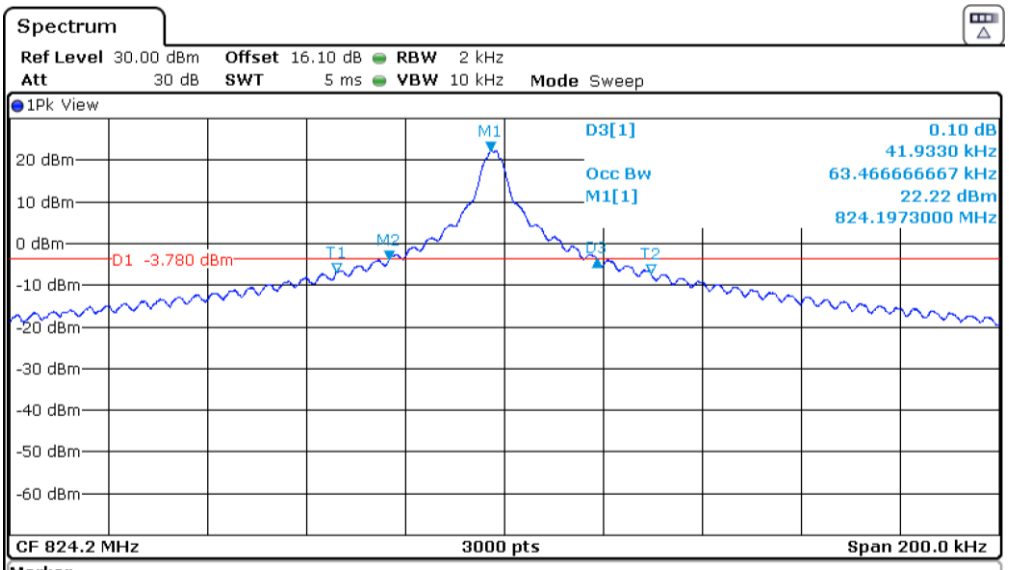


Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	848.7969 MHz	21.48 dBm		
T1		1	848.7677667 MHz	-7.73 dBm	Occ Bw	60.8 kHz
T2		1	848.8285667 MHz	-7.71 dBm		
M2		1	848.776567 MHz	-4.58 dBm		
D3	M2	1	41.6 kHz	-0.01 dB		

Tone 3.75 kHz. π/4 - QPSK MODULATION

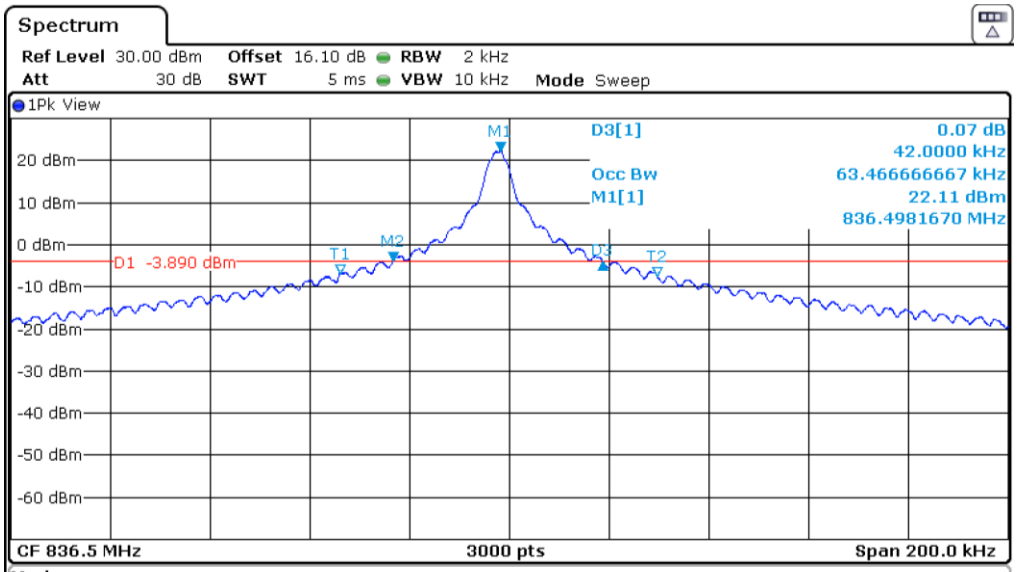
Lowest Channel



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	824.1973 MHz	22.22 dBm		
T1		1	824.1661667 MHz	-6.81 dBm	Occ Bw	63.466666667 kHz
T2		1	824.2296333 MHz	-7.34 dBm		
M2		1	824.1767 MHz	-3.88 dBm		
D3	M2	1	41.933 kHz	0.10 dB		

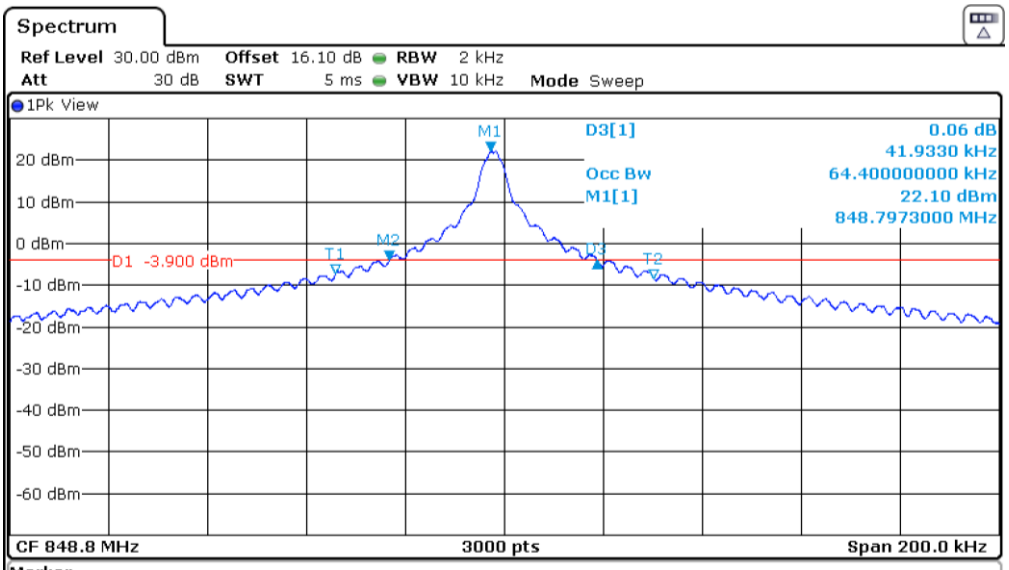
Middle Channel



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	836.498167 MHz	22.11 dBm		
T1		1	836.4661667 MHz	-6.84 dBm	Occ Bw	63.466666667 kHz
T2		1	836.5296333 MHz	-7.62 dBm		
M2		1	836.476633 MHz	-3.95 dBm		
D3	M2	1	42.0 kHz	0.07 dB		

Highest Channel

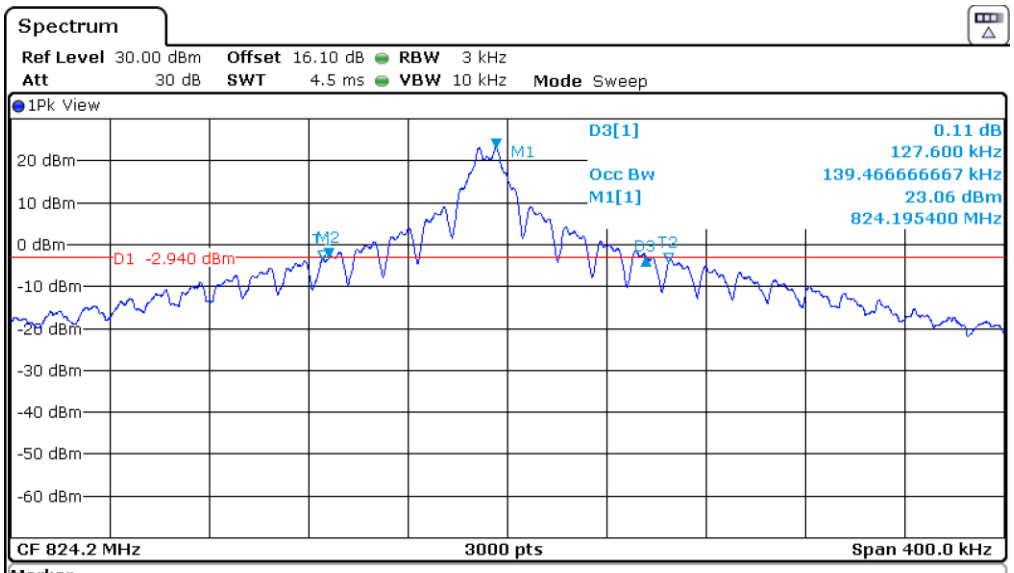


Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	848.7973 MHz	22.10 dBm		
T1		1	848.7658333 MHz	-7.23 dBm	Occ Bw	64.4 kHz
T2		1	848.8302333 MHz	-8.53 dBm		
M2		1	848.7767 MHz	-4.02 dBm		
D3	M2	1	41.933 kHz	0.06 dB		

Tone 15 kHz. π/2 - BPSK MODULATION

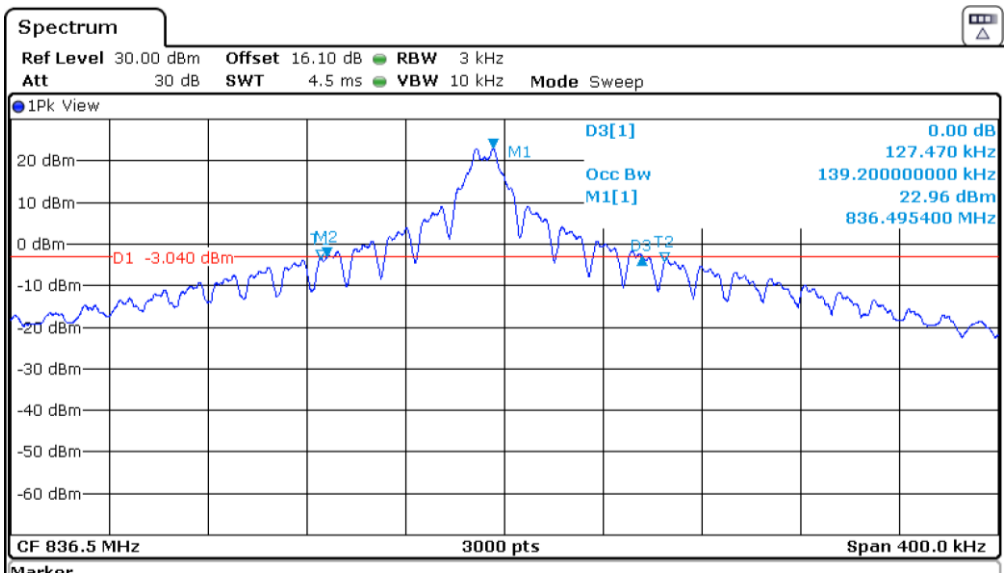
Lowest Channel



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	824.1954 MHz	23.06 dBm		
T1		1	824.1254 MHz	-3.56 dBm	Occ Bw	139.466666667 kHz
T2		1	824.264867 MHz	-4.15 dBm		
M2		1	824.12807 MHz	-3.12 dBm		
D3	M2	1	127.6 kHz	0.11 dB		

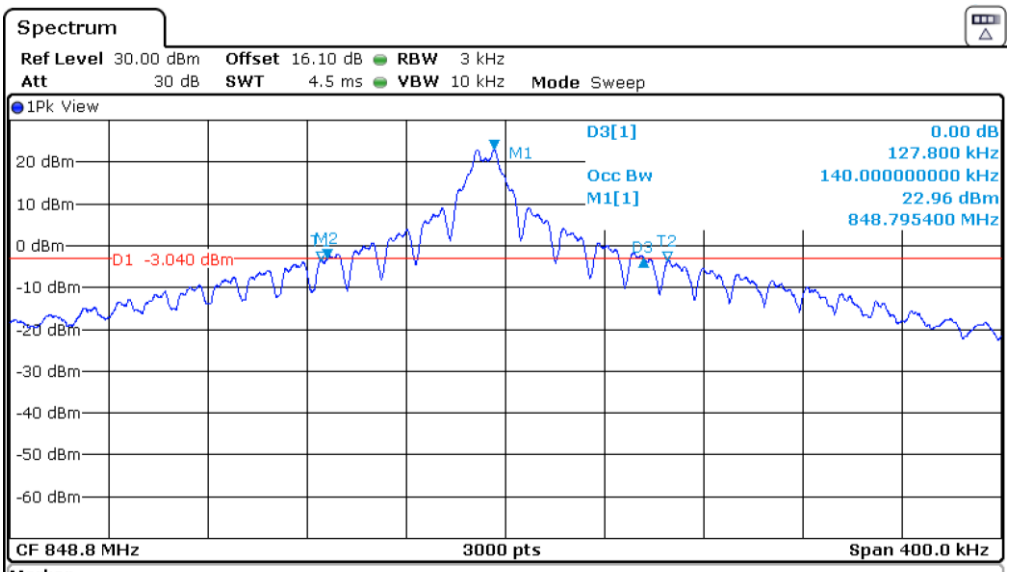
Middle Channel



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	836.4954 MHz	22.96 dBm		
T1		1	836.425667 MHz	-3.52 dBm	Occ Bw	139.2 kHz
T2		1	836.564867 MHz	-4.11 dBm		
M2		1	836.4282 MHz	-3.05 dBm		
D3	M2	1	127.47 kHz	0.00 dB		

Highest Channel

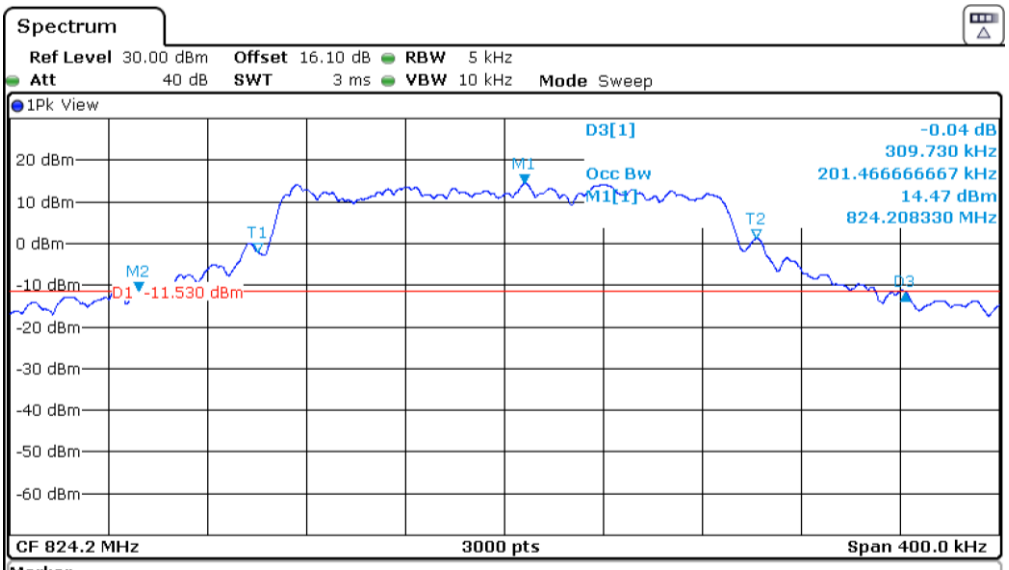


Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	848.7954 MHz	22.96 dBm		
T1		1	848.7254 MHz	-3.48 dBm	Occ Bw	140.0 kHz
T2		1	848.8654 MHz	-3.61 dBm		
M2		1	848.72803 MHz	-3.13 dBm		
D3	M2	1	127.8 kHz	-0.00 dB		

12 Tones 15 kHz. π/4 - QPSK MODULATION

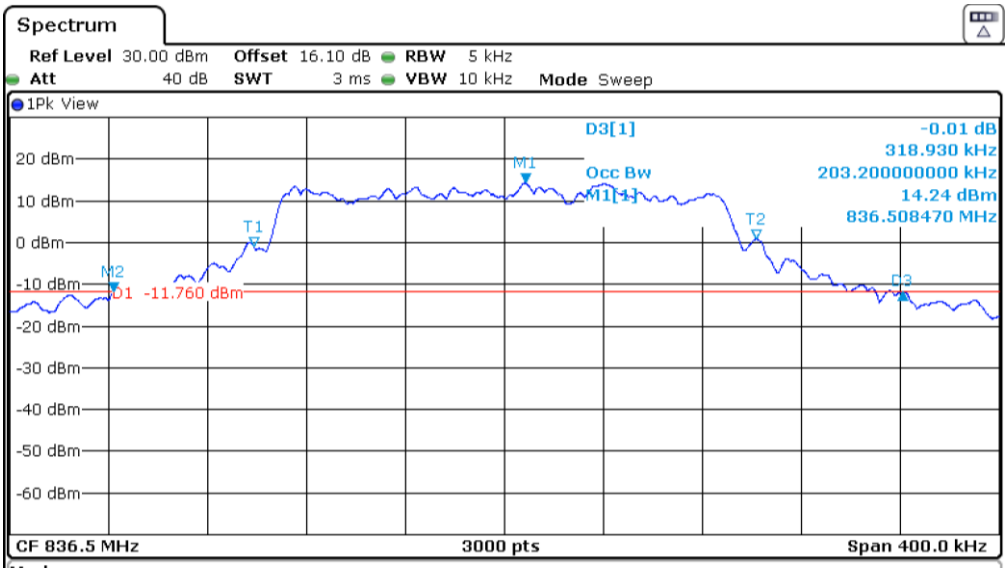
Lowest Channel



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	824.20833 MHz	14.47 dBm		
T1		1	824.100333 MHz	-2.05 dBm	Occ Bw	201.466666667 kHz
T2		1	824.3018 MHz	1.16 dBm		
M2		1	824.05233 MHz	-11.55 dBm		
D3	M2	1	309.73 kHz	-0.04 dB		

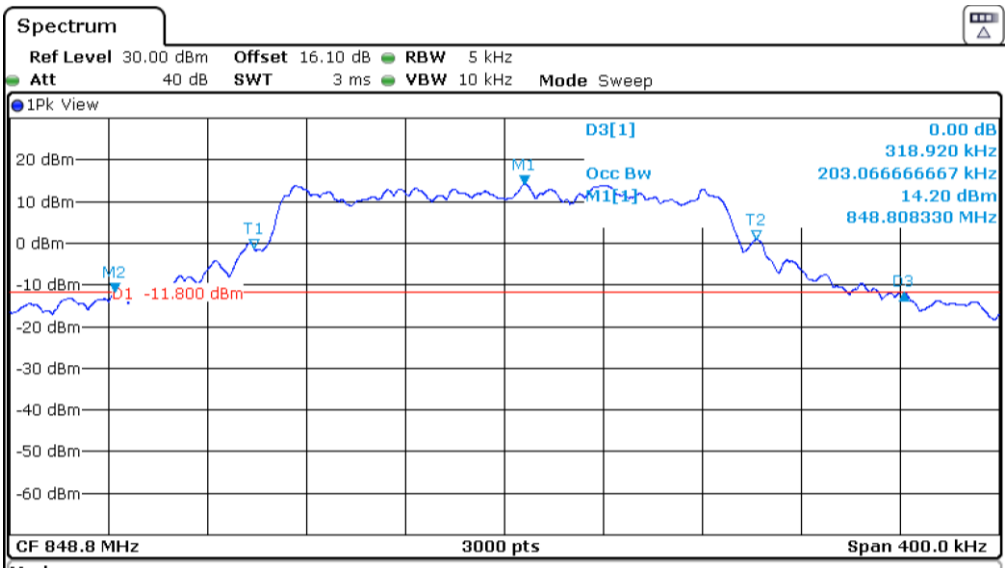
Middle Channel



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	836.50847 MHz	14.24 dBm		
T1		1	836.398733 MHz	-1.04 dBm	Occ Bw	203.2 kHz
T2		1	836.601933 MHz	0.81 dBm		
M2		1	836.34193 MHz	-11.76 dBm		
D3	M2	1	318.93 kHz	-0.01 dB		

Highest Channel



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	848.80833 MHz	14.20 dBm		
T1		1	848.698867 MHz	-1.28 dBm	Occ Bw	203.066666667 kHz
T2		1	848.901933 MHz	0.80 dBm		
M2		1	848.64275 MHz	-11.80 dBm		
D3	M2	1	318.92 kHz	0.00 dB		

Spurious emissions at antenna terminals

SPECIFICATION

FCC §2.1051 and §22.917

RSS-132. Clause 5.5.

The power of emissions shall be attenuated below the transmitter power (P) by a factor of at least 43 + 10 log (P) dB. P in watts.

METHOD

The EUT RF output connector was connected to a spectrum analyser and to the Universal Radio Communication tester R&S CMW500 (selecting maximum transmission power of the EUT and different modes of modulation) using a 50 ohm attenuator and a power divider.

The spectrum was investigated from 9 kHz to 10th harmonic for NBIoT Band 5 and 26.

The reading of the spectrum analyser is corrected with the attenuation loss of connection between output terminal of EUT and input of the spectrum analyser.

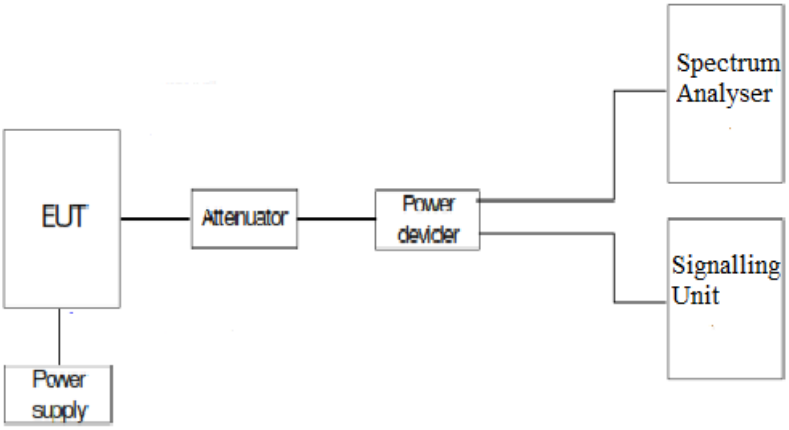
The configuration of Resource Blocks and modulation which is the worst case for conducted power was used.

Measurement Limit:

According to specification. the power of emissions shall be attenuated below the transmitter power (P) by a factor of at least 43 + 10 log (P) dB. P in watts.
At Po transmitting power. the specified minimum attenuation becomes 43+10log (Po). and the level in dBm relative Po becomes:

Po (dBm) – [43 + 10 log (Po in mwatts) - 30] = - 13 dBm

TEST SETUP



RESULTS (see plots in next pages)

814-824MHz Band:

1. CHANNEL: LOWEST
No spurious signals were found at less than 20dB respect to the limit in all the range.

2. CHANNEL: HIGHEST
No spurious signals were found at less than 20dB respect to the limit in all the range.

Cross-rule channel (824MHz):

1. CHANNEL (26790) 824MHz:
No spurious signals were found at less than 20dB respect to the limit in all the range.

824-849MHz Band:

1. CHANNEL: LOWEST
No spurious signals were found at less than 20dB respect to the limit in all the range.

2. CHANNEL: MIDDLE
No spurious signals were found at less than 20dB respect to the limit in all the range.

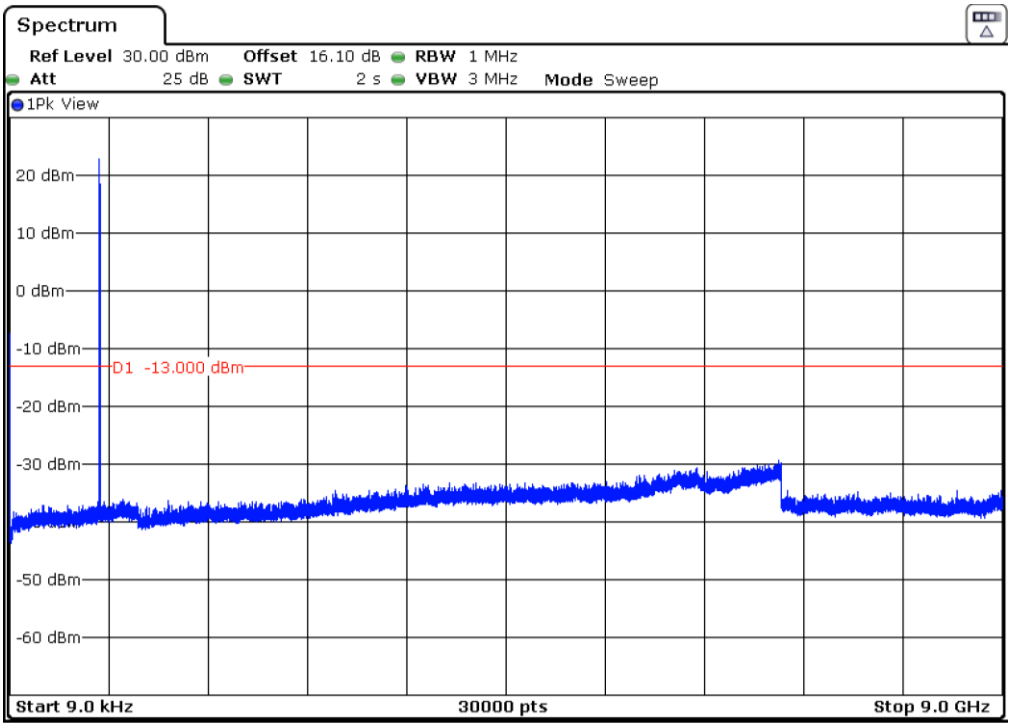
3. CHANNEL: HIGHEST
No spurious signals were found at less than 20dB respect to the limit in all the range.

Verdict: PASS

814-824MHz Band:

1. CHANNEL: LOWEST

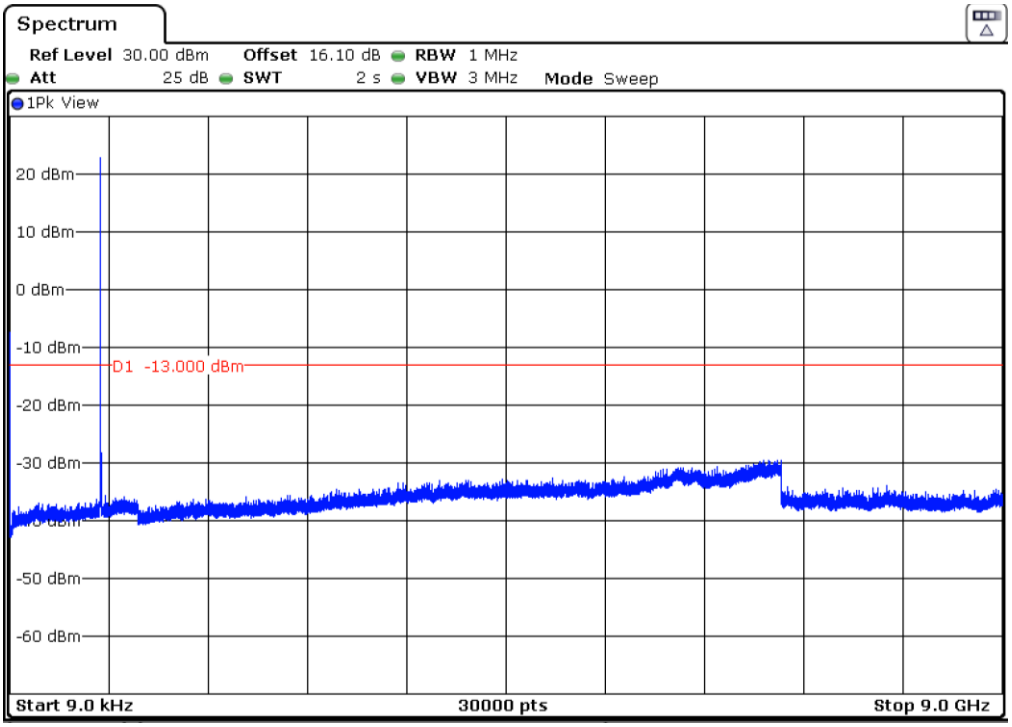
Frequency Range 9 kHz – 9 GHz



Note: The peak above the limit is the carrier frequency.

2. CHANNEL: HIGHEST

Frequency Range 9 kHz – 9 GHz

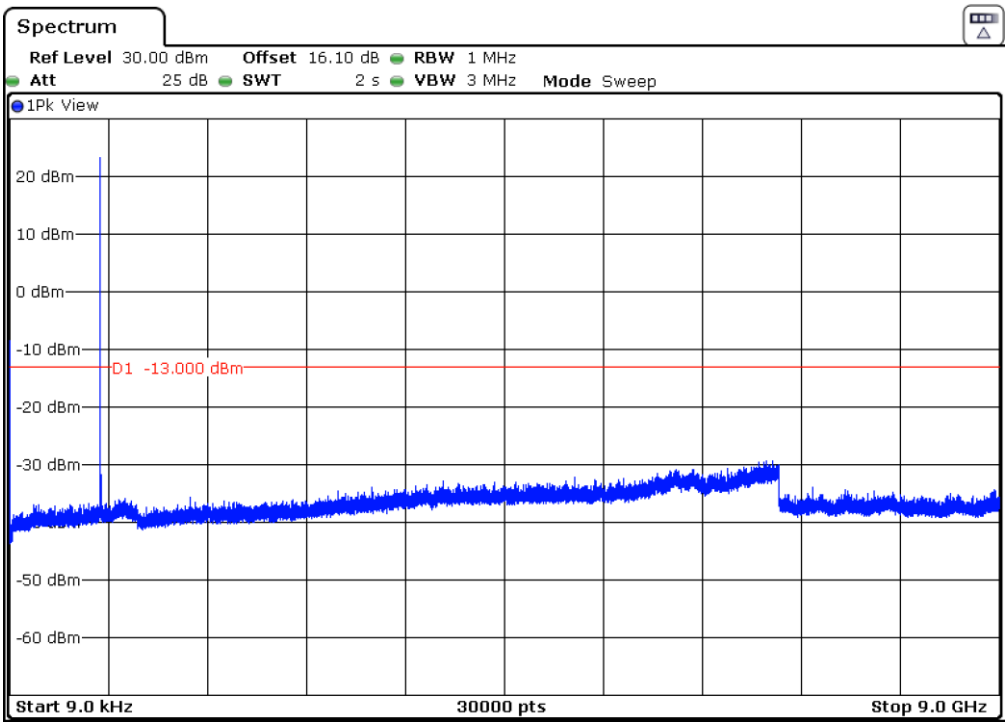


Note: The peak above the limit is the carrier frequency.

Cross-rule channel (824MHz):

CHANNEL (26790) 824MHz:

Frequency Range 9 kHz – 9 GHz

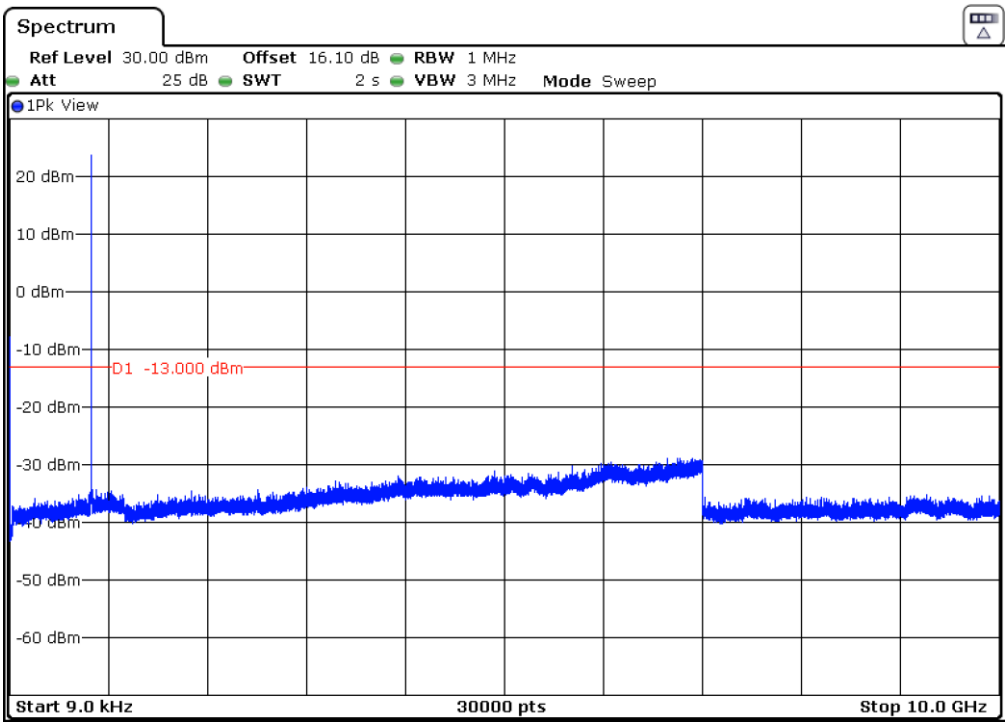


Note: The peak above the limit is the carrier frequency.

824-849MHz Band:

1. CHANNEL: LOWEST

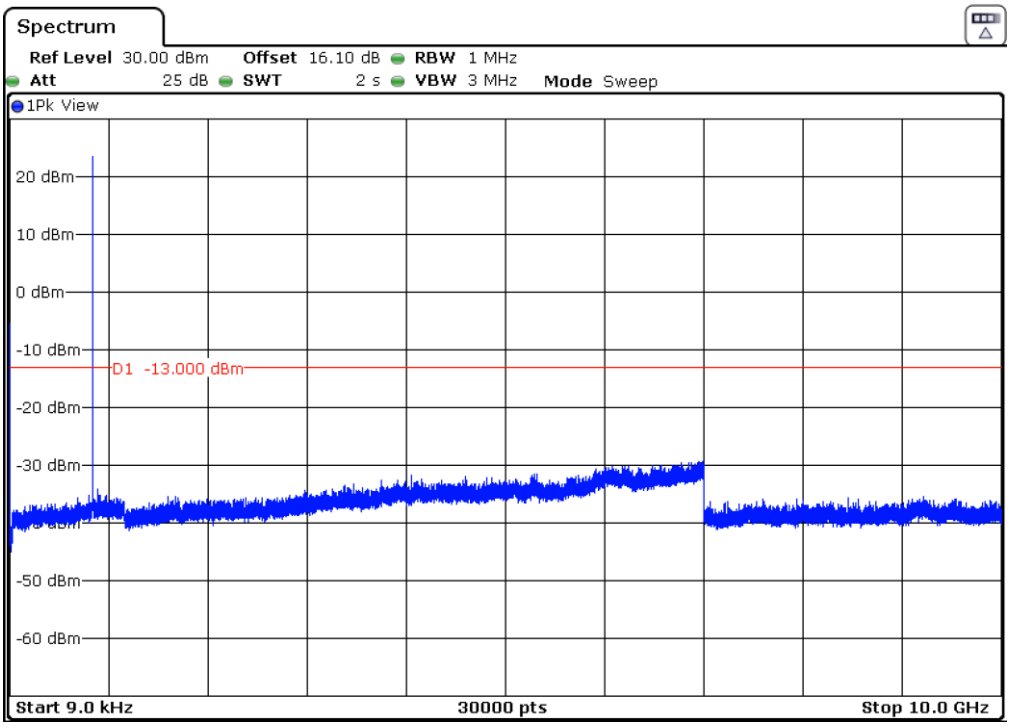
Frequency Range 9 kHz – 10 GHz



Note: The peak above the limit is the carrier frequency.

2. CHANNEL: MIDDLE

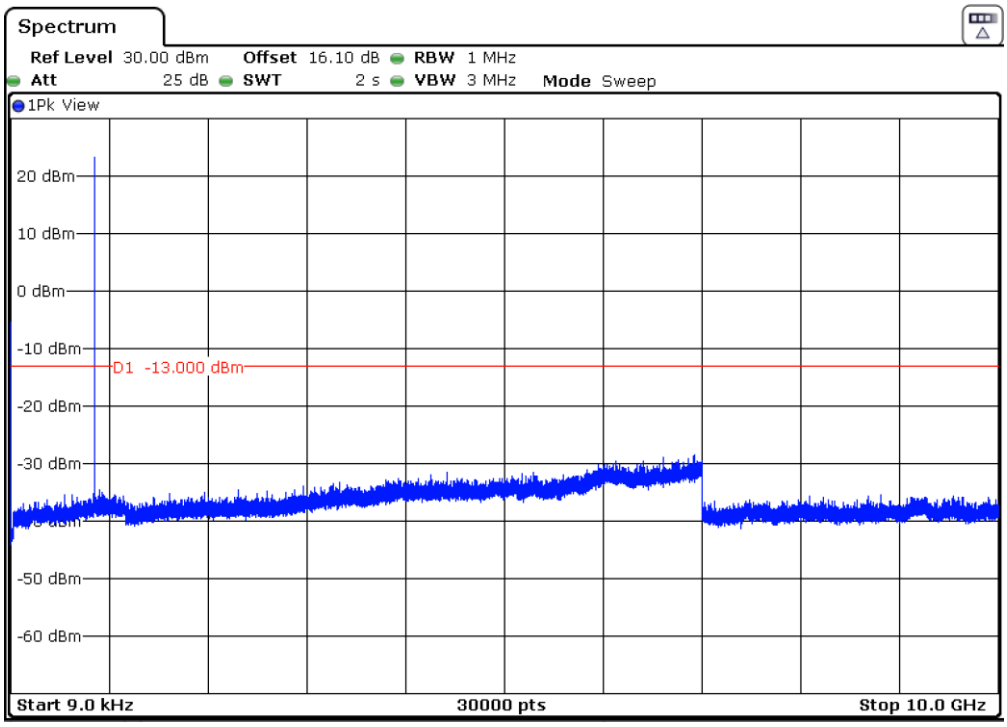
Frequency Range 9 kHz – 10 GHz



Note: The peak above the limit is the carrier frequency.

3. CHANNEL: HIGHEST

Frequency Range 9 kHz – 10 GHz



Note: The peak above the limit is the carrier frequency.

Spurious emissions at antenna terminals at Block Edges

SPECIFICATION

FCC §2.1051 and §22.917
RSS-132. Clause 5.5.

The power of emissions shall be attenuated below the transmitter power (P) by a factor of at least 43 + 10 log (P) dB. P in watts.

FCC §90.691. Emission mask requirements for EA-based systems. Out-of-band emission requirement shall apply only to the "outer" channels included in an EA license and to spectrum adjacent to interior channels used by incumbent licensees. The emission limits are as follows:
(1) For any frequency removed from the EA licensee's frequency block by up to and including 37.5 kHz, the power of any emission shall be attenuated below the transmitter power (P) in watts by at least 116 Log10(f/6.1) decibels or 50 + 10 Log10(P) decibels or 80 decibels, whichever is the lesser attenuation, where f is the frequency removed from the center of the outer channel in the block in kilohertz and where f is greater than 12.5 kHz.
(2) For any frequency removed from the EA licensee's frequency block greater than 37.5 kHz, the power of any emission shall be attenuated below the transmitter power (P) in watts by at least 43 + 10Log10(P) decibels or 80 decibels, whichever is the lesser attenuation, where f is the frequency removed from the center of the outer channel in the block in kilohertz and where f is greater than 37.5 kHz.

METHOD

The EUT RF output connector was connected to a spectrum analyser and to the Universal Radio Communication tester R&S CMW500 (selecting maximum transmission power of the EUT and different modes of modulation) using a 50 ohm attenuator and a power splitter.

The reading of the spectrum analyser is corrected with the attenuation loss of connection between output terminal of EUT and input of the spectrum analyser.

The configuration of modulation which is the worst case for conducted power was used.

As indicated in FCC part 22, in the 1 MHz bands immediately outside and adjacent to the frequency block or band a resolution bandwidth of at least one percent of the emission bandwidth of the fundamental emission of the transmitter may be employed.

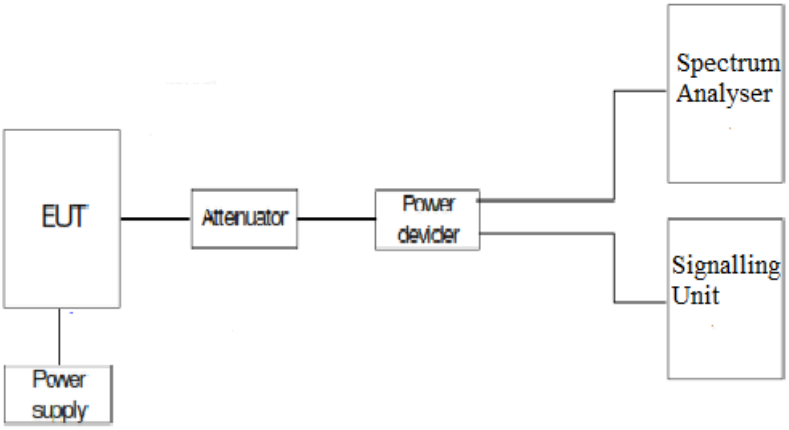
Measurement Limit:

According to specification. the power of emissions shall be attenuated below the transmitter power (P) by a factor of at least 43 + 10 log (P) dB. P in watts.

At Po transmitting power. the specified minimum attenuation becomes 43+10log (Po). and the level in dBm relative Po becomes:

Po (dBm) – [43 + 10 log (Po in mwatts) - 30] = - 13 dBm

TEST SETUP


Spectrum Analyser
EUT
Attenuator
Power devider
Signalling Unit
Power supply

RESULTS (see plots in next pages)

824-849MHz Band:

Preliminary measurements determined a tone with nominal bandwidth of 15 kHz as the worst case. The results in the next tables shows the results for this configuration.

(Channels in Band 25):	Tone= 15 kHz. Offset=0. π/2 - BPSK
Maximum measured level at lowest Block Edge at antenna port (dBm)	-24.16

(Channels in Band 25):	Tone= 15 kHz. Offset=11. π/2 - BPSK
Maximum measured level at highest Block Edge at antenna port (dBm)	-23.73

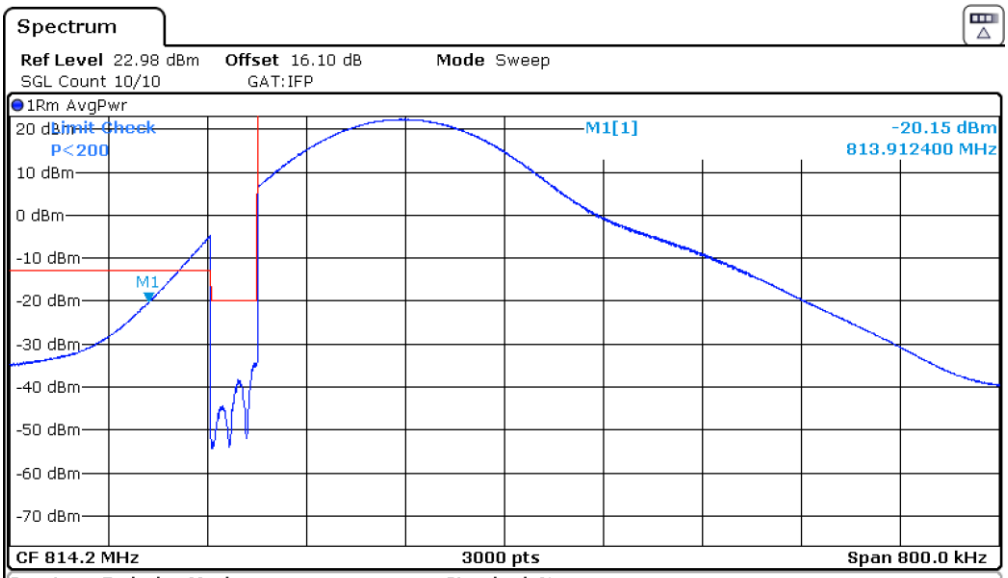
Measurement uncertainty = <±1.20 dB.

Verdict: PASS

814-824MHz Band "EA MASK":

1 tone π/2 – BPSK. BW=15 kHz Offset = 0

CHANNEL LOWEST



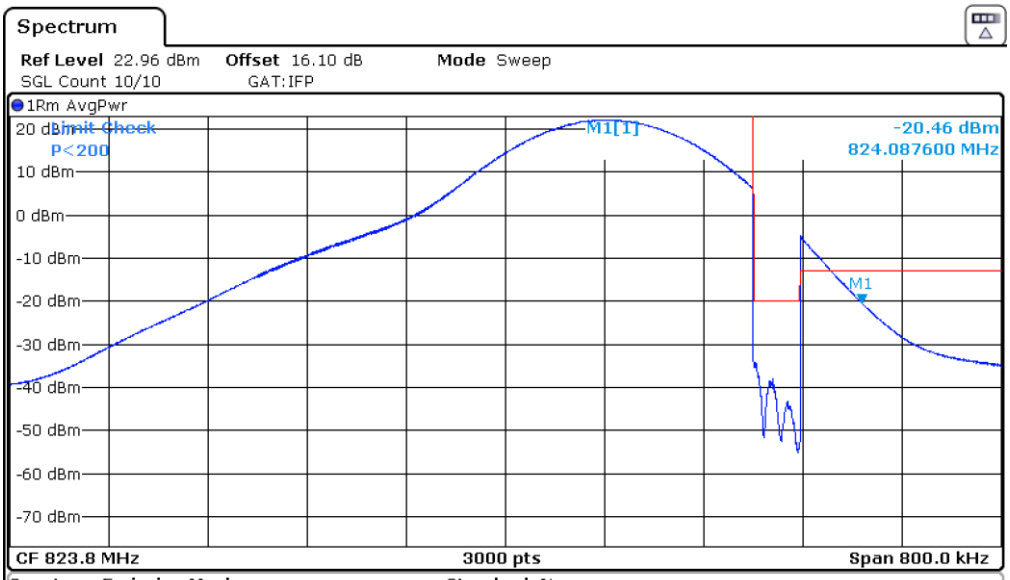
Spectrum Emission Mask — Standard: None
Tx Power --- — Tx Bandwidth 3.840 MHz — RBW 100.000 kHz

Range Low	Range Up	RBW	Frequency	Power Abs	Power Rel	ΔLimit
-400.000 kHz	-237.500 kHz	100.000 kHz	813.96237 MHz	-4.74 dBm	71.37 dB	8.26 dB
-237.500 kHz	-200.000 kHz	300.000 Hz	813.99799 MHz	-34.42 dBm	41.70 dB	-14.42 dB
200.000 kHz	237.500 kHz	100.000 kHz	814.40013 MHz	-13.99 dBm	62.13 dB	-43.99 dB
237.500 kHz	400.000 kHz	100.000 kHz	814.43790 MHz	-19.21 dBm	56.90 dB	-49.21 dB

NOTE: The equipment transmits at the maximum output power

1 tone π/2 – BPSK. BW=15 kHz Offset = 11

CHANNEL HIGHEST



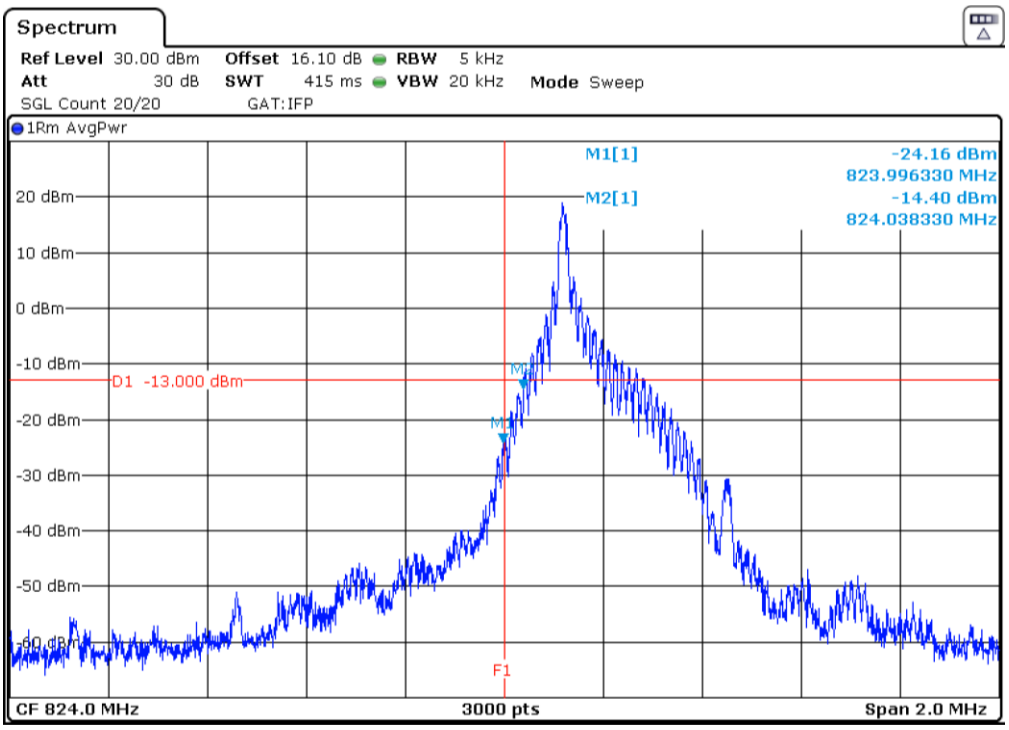
Spectrum Emission Mask Standard: None
Tx Power --- Tx Bandwidth 3.840 MHz RBW 100.000 kHz

Range Low	Range Up	RBW	Frequency	Power Abs	Power Rel	ΔLimit
-400.000 kHz	-237.500 kHz	100.000 kHz	823.56237 MHz	-19.43 dBm	56.68 dB	-49.43 dB
-237.500 kHz	-200.000 kHz	100.000 kHz	823.59987 MHz	-14.20 dBm	61.92 dB	-44.20 dB
200.000 kHz	237.500 kHz	300.000 Hz	824.00040 MHz	-34.27 dBm	41.84 dB	-14.27 dB
237.500 kHz	400.000 kHz	100.000 kHz	824.03763 MHz	-4.83 dBm	71.29 dB	8.17 dB

824-849MHz Band:

1 tone π/2 – BPSK. BW=15 kHz Offset = 0

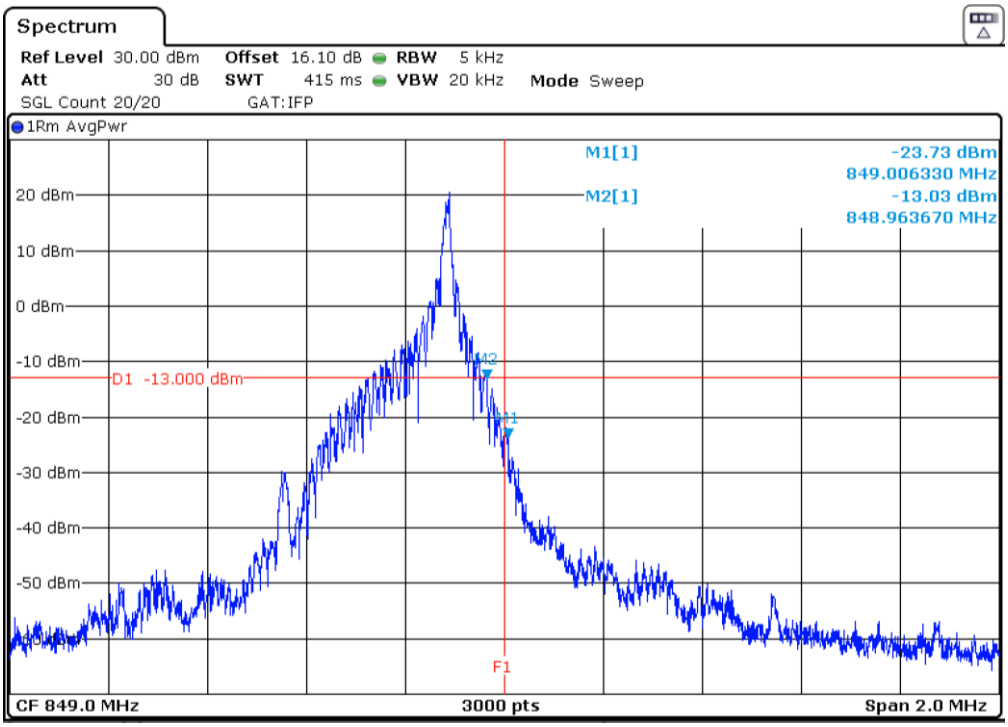
CHANNEL LOWEST



NOTE: The equipment transmits at the maximum output power

1 tone π/2 – BPSK. BW=15 kHz Offset = 11

CHANNEL HIGHEST



Verdict: PASS

Radiated emissions

SPECIFICATION

FCC § 22.917

RSS-132. Clause 5.5.

FCC §2.1051, §90.691

Emission mask requirements for EA-based systems.

For any frequency removed from the EA licensee's frequency block greater than 37.5 kHz, the power of any emission shall be attenuated below the transmitter power (P) in watts by at least 43 + 10Log10(P) decibels or 80 decibels, whichever is the lesser attenuation, where f is the frequency removed from the center of the outer channel in the block in kilohertz and where f is greater than 37.5 kHz.

METHOD

The measurement was performed with the EUT inside an anechoic chamber. The spectrum was scanned from 30 MHz to at least the 10th harmonic of the highest frequency generated within the equipment.
The EUT was placed on a 1 meter high non-conductive stand at a 3 meter distance from the measuring antenna for measurements below 1 GHz and at 1 m distance for measurements above 1 GHz.
Detected emissions were maximized at each frequency by rotating the EUT and adjusting the measuring antenna height and polarization. The maximum meter reading was recorded. The radiated emissions were measured with peak detector and 1 MHz bandwidth.
Each detected emission is substituted by the Substitution method, in accordance with the ANSI/TIA/EIA-603-C: 2004.

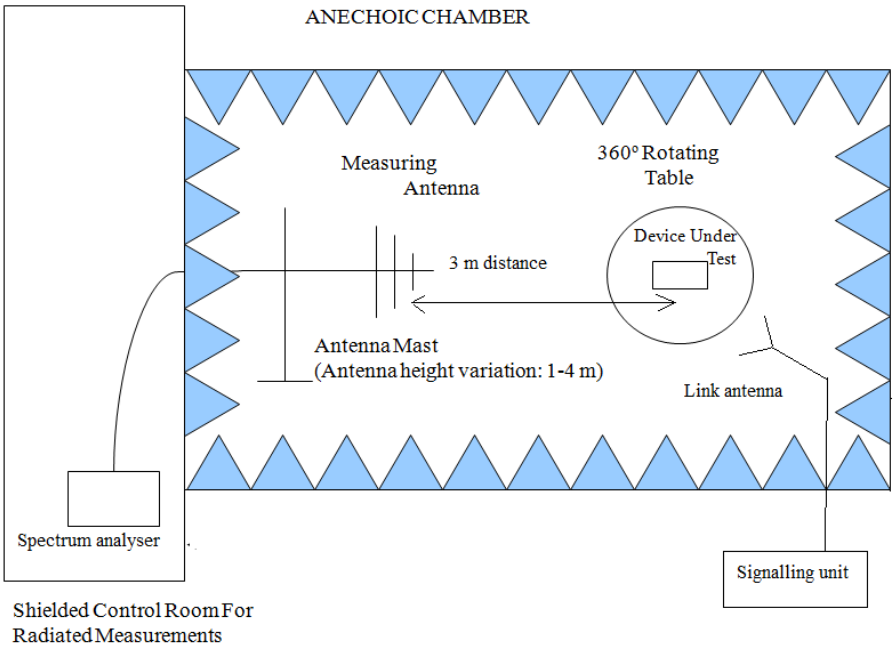
Measurement Limit:

According to specification. the power of emissions shall be attenuated below the transmitter power (P) by a factor of at least 43 + 10 log (P) dB. P in watts.
At Po transmitting power. the specified minimum attenuation becomes 43+10log (Po). and the level in dBm relative Po becomes:

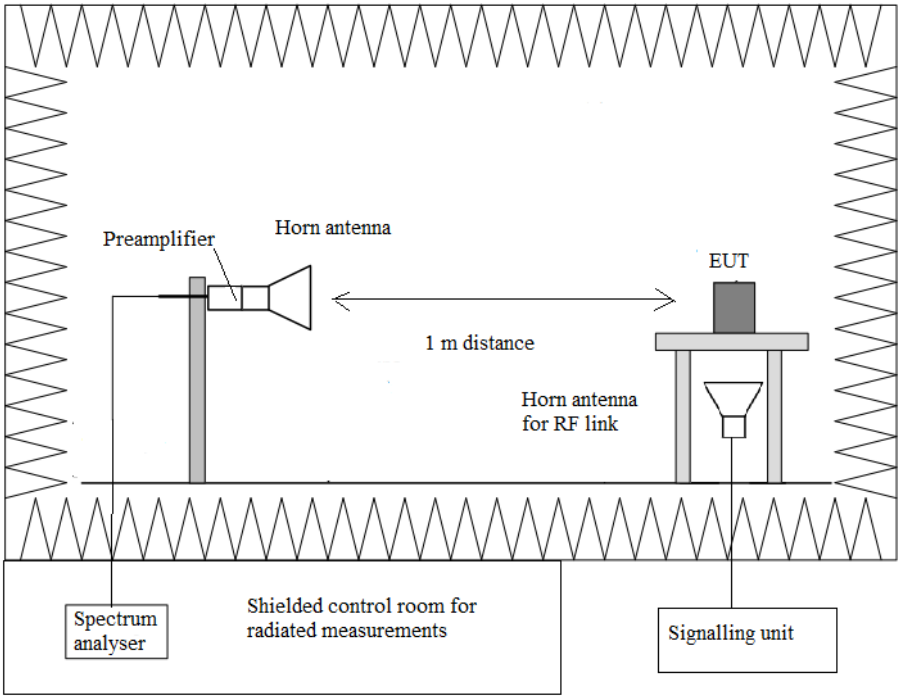
Po (dBm) – [43 + 10 log (Po in mwatts) - 30] = - 13 dBm

TEST SETUP

Radiated measurements below 1 GHz.



Radiated measurements above 1 GHz.



RESULTS

814-824MHz Band:

Preliminary measurements determined that 3 tones of 15kHz as the worst case. The results in the next tables shows the results for this configuration.

1. CHANNEL: LOWEST

Frequency range 30 MHz-1000 MHz.
No radiated spurious signals were detected at less than 20 dB respect to the limit.

Frequency range 1 GHz-10 GHz.
No radiated spurious signals were detected at less than 20 dB respect to the limit.

2. CHANNEL: HIGHEST

Frequency range 30 MHz-1000 MHz.
No radiated spurious signals were detected at less than 20 dB respect to the limit.

Frequency range 1 GHz-10 GHz.
No radiated spurious signals were detected at less than 20 dB respect to the limit.

Verdict: PASS

824-849MHz Band:

Preliminary measurements determined that 3 tones of 15kHz as the worst case. The results in the next tables shows the results for this configuration.

1. CHANNEL: LOWEST

Frequency range 30 MHz-1000 MHz.
No radiated spurious signals were detected at less than 20 dB respect to the limit.

Frequency range 1 GHz-10 GHz.
No radiated spurious signals were detected at less than 20 dB respect to the limit.

2. CHANNEL: MIDDLE

Frequency range 30 MHz-1000 MHz.
No radiated spurious signals were detected at less than 20 dB respect to the limit.

Frequency range 1 GHz-10 GHz.
No radiated spurious signals were detected at less than 20 dB respect to the limit.

3. CHANNEL: HIGHEST

Frequency range 30 MHz-1000 MHz.
No radiated spurious signals were detected at less than 20 dB respect to the limit.

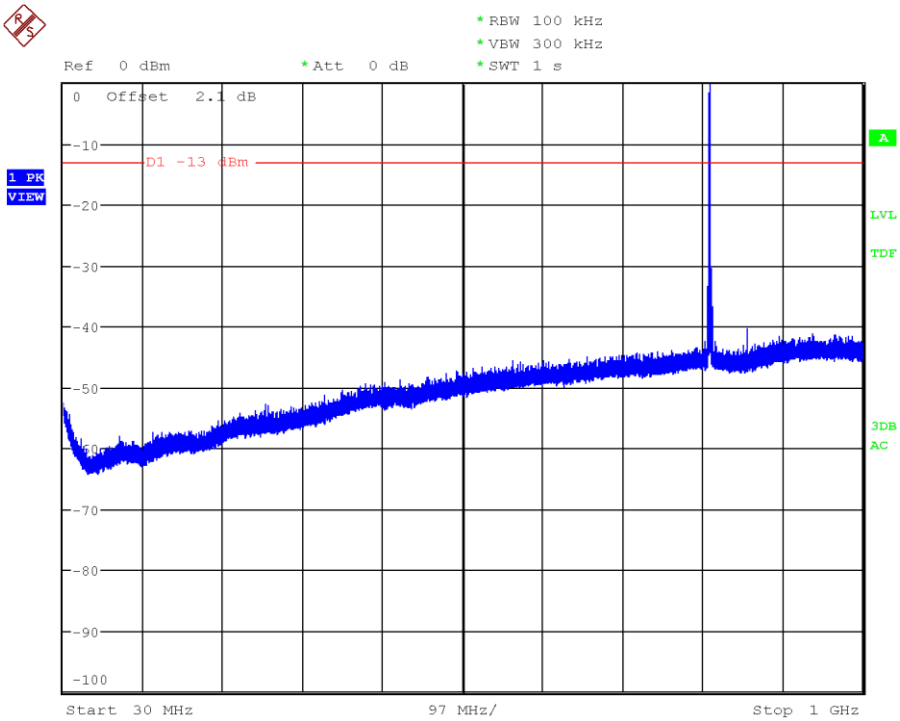
Frequency range 1 GHz-10 GHz.
No radiated spurious signals were detected at less than 20 dB respect to the limit.

Verdict: PASS

814-824MHz Band:

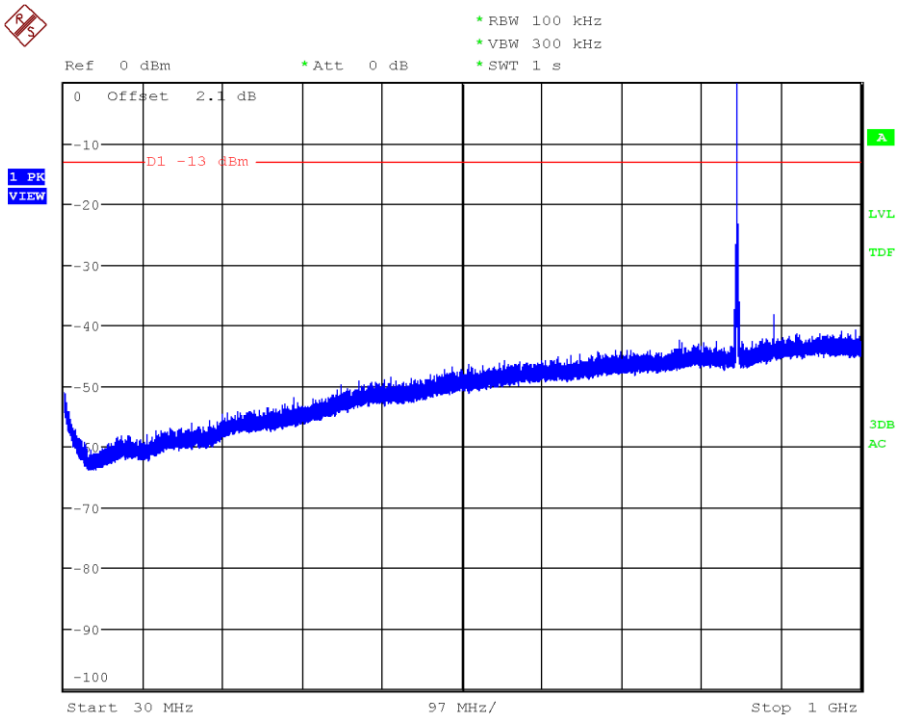
FREQUENCY RANGE 30 MHz-1000 MHz.

CHANNEL: LOWEST



Note: The peak above the limit is the carrier frequency.

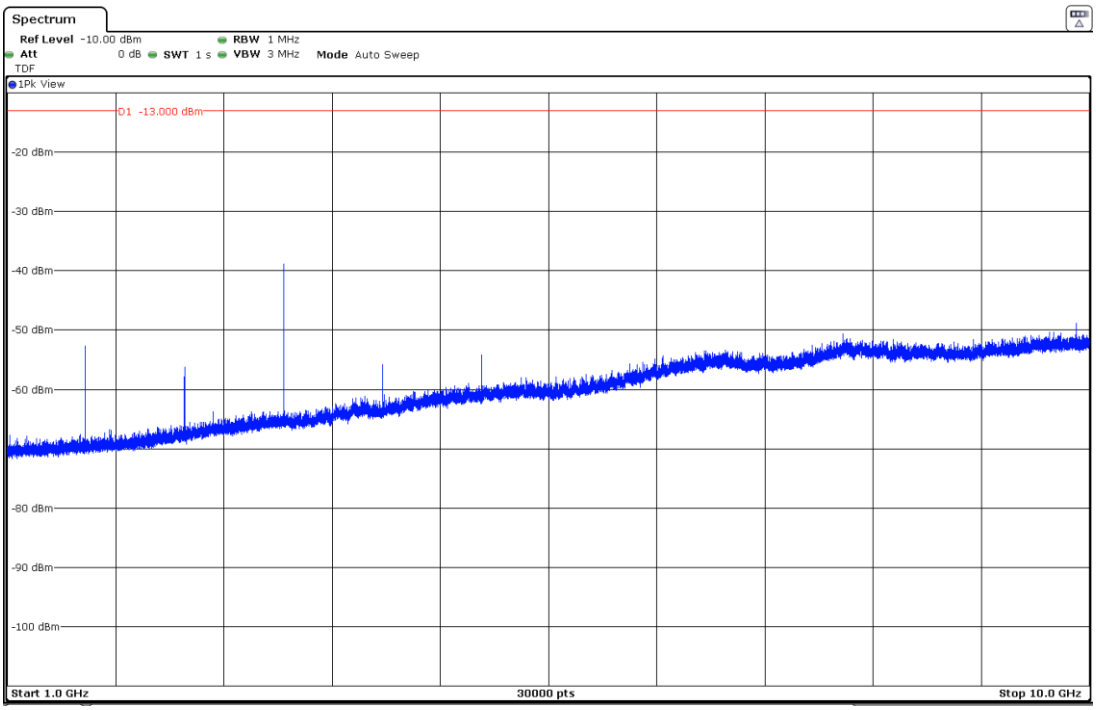
CHANNEL: HIGHEST



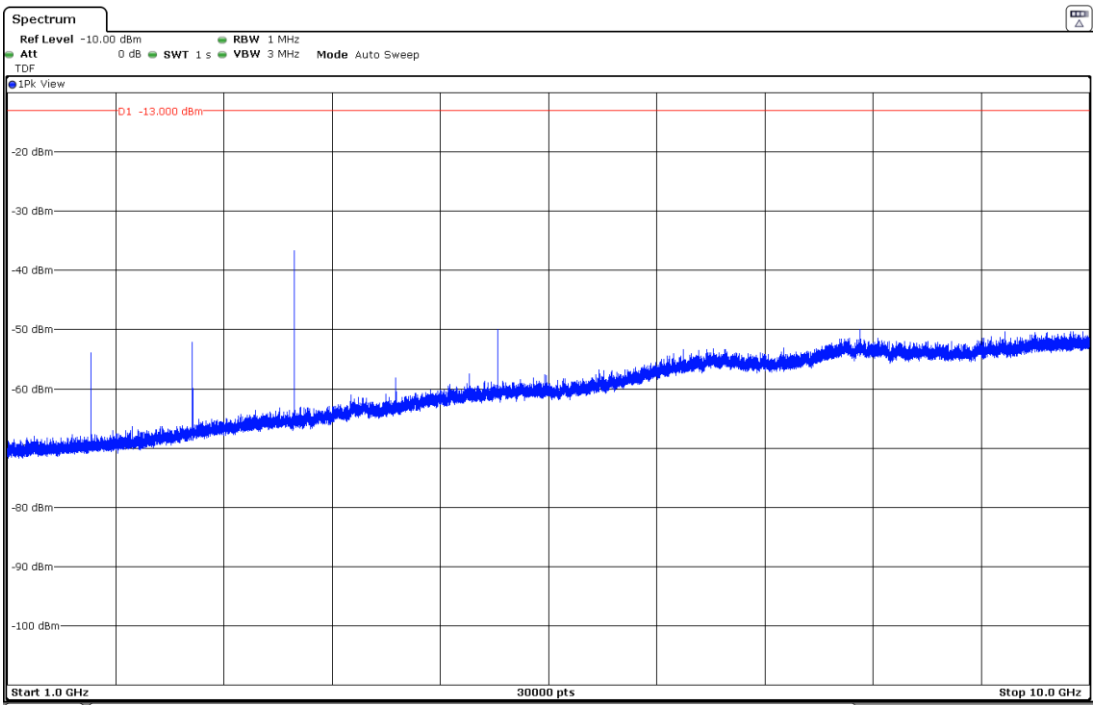
Note: The peak above the limit is the carrier frequency.

FREQUENCY RANGE 1 GHz to 10 GHz.

CHANNEL: LOWEST



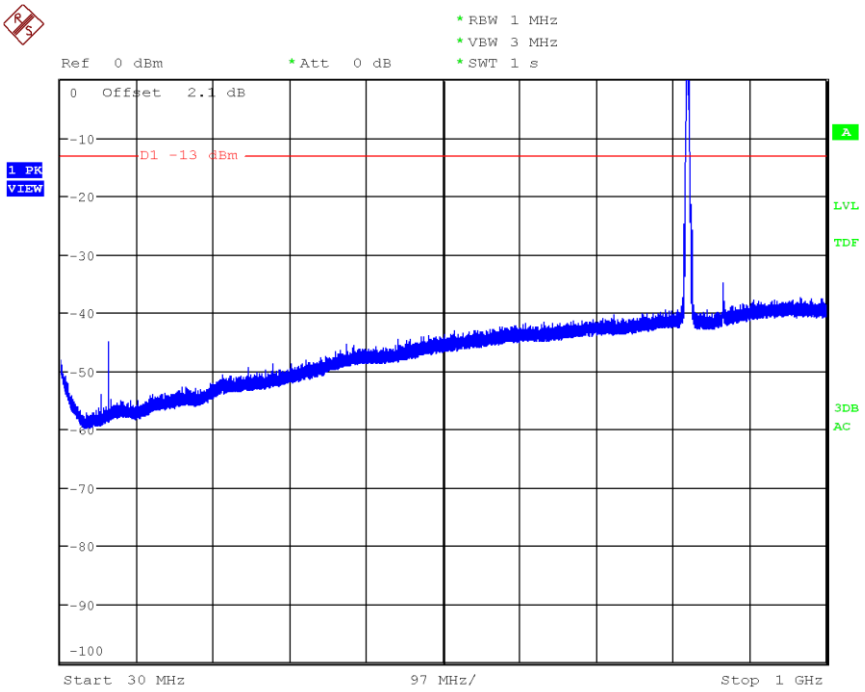
CHANNEL: HIGHEST



824-849MHz Band:

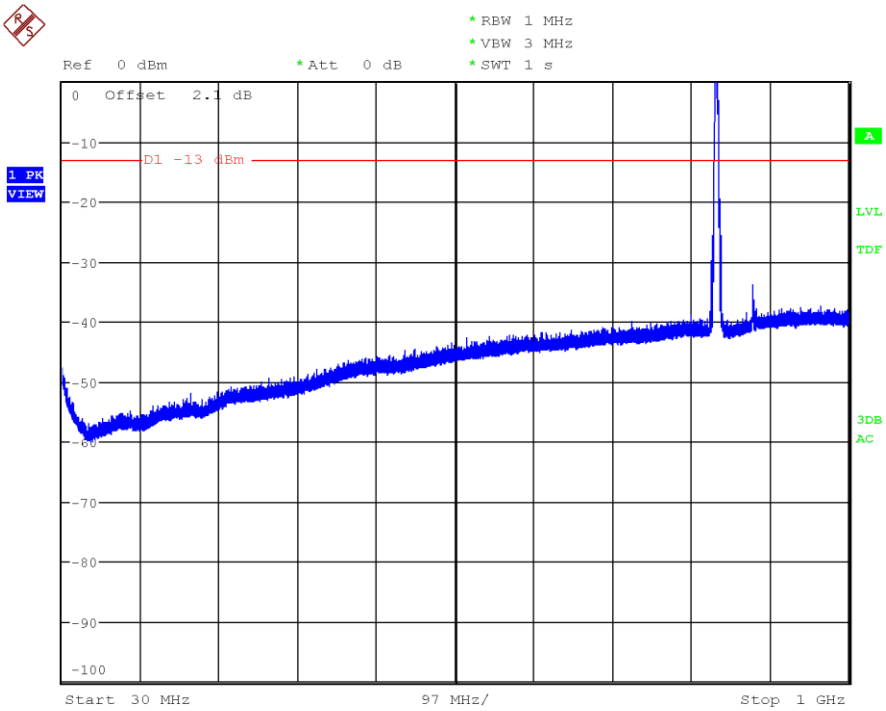
FREQUENCY RANGE 30 MHz-1000 MHz.

CHANNEL: LOWEST



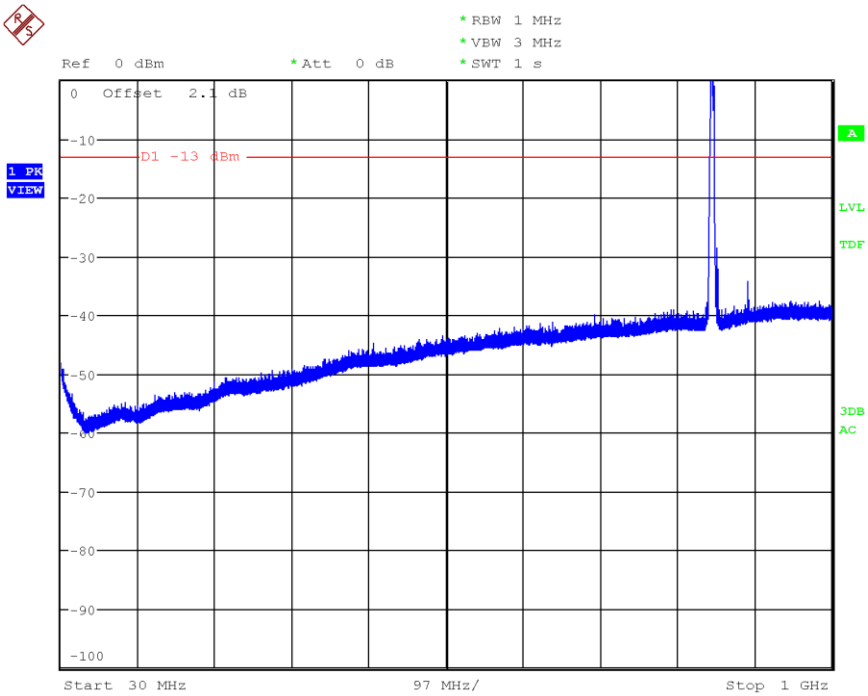
Note: The peak above the limit is the carrier frequency.

CHANNEL: MIDDLE



Note: The peak above the limit is the carrier frequency.

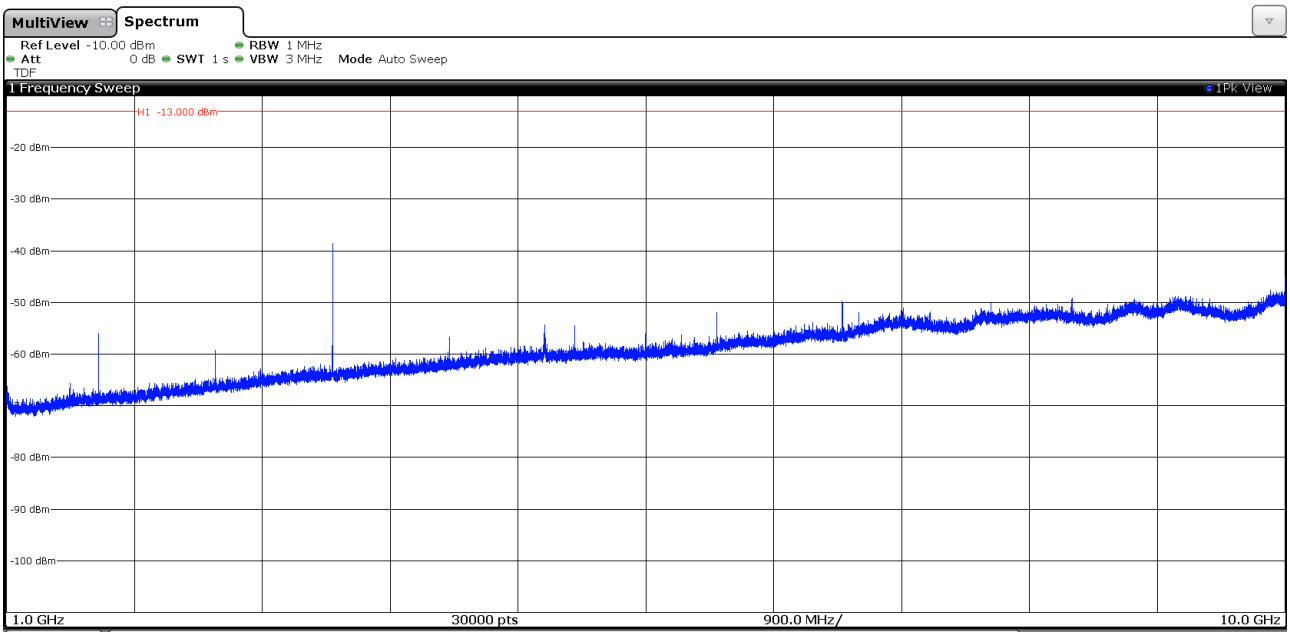
CHANNEL: HIGHEST



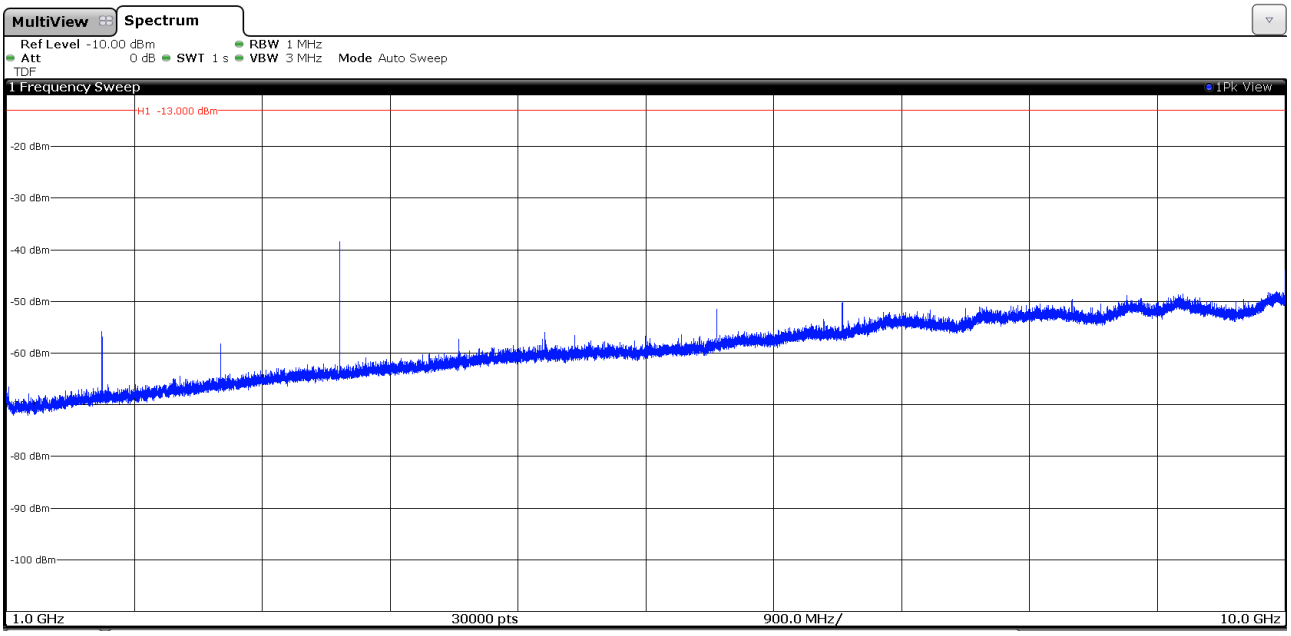
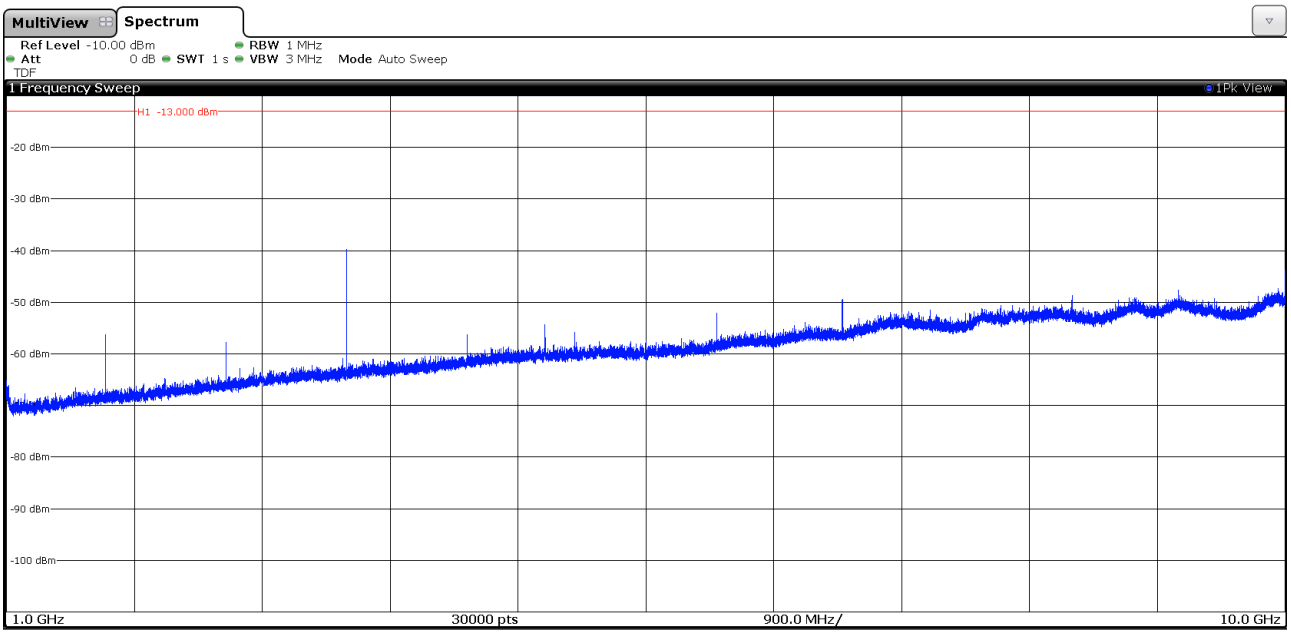
Note: The peak above the limit is the carrier frequency.

FREQUENCY RANGE 1 GHz to 10 GHz.

CHANNEL: LOWEST



CHANNEL: MIDDLE



CHANNEL: HIGHEST