DEKRA Testing and Certification, S.A.U.
Parque Tecnológico de Andalucía,
c/ Severo Ochoa nº 2 · 29590 Campanillas · Málaga · España
C.I.F. A29 507 456

Nº 51/LE147

Test report No:
NIE: 60433RRF.004

Partial Test report

USA FCC Part 24, Part 27 & Part 15.247
CANADA RSS-130, RSS-133, RSS-139 & RSS-247

(*) Identification of item tested	Thingy:91
(*) Trademark	Thingy:91
(*) Model and /or type reference	Thingy:91
Other identification of the product	HW version: 0.7.2 SW version: Rev0.2.1 FCC ID: 2ANPOTHINGY91 (contains FCC ID: 2ANPO00NRF9160) IC: nRF9160-SICA
(*) Features	LTE Cat-M1, LTE-NB1
Applicant	NORDIC SEMICONDUCTOR ASA Otto Nielsens Vei 12, 7052 Trondheim, Norway
Test method requested, standard	USA FCC Part 24 (10-1-18 Edition). USA FCC Part 27 (10-1-18 Edition). USA FCC Part 15.247 (10-1-18 Edition). CANADA IC RSS-130 Issue 2, Feb. 2019. CANADA IC RSS-133 Issue 6, Jan. 2013. CANADA IC RSS-139 Issue 3, Jul. 2015. CANADA RSS-247 Issue 2 (February 2017). -Transmitter out of band radiated emissions with simultaneous transmissions. Guidance for Performing Compliance Measurements on Digital Transmission System, Frequency Hopping Spread Spectrum System, and Hybrid Systems Devices Operating Under Section 15.247 of the FCC Rules. 558074 D01 Meas Guidance v05r02 dated April 2, 2019. KDB 971168 D01 Power Meas License Digital Systems v03r01, April. 2018. ANSI C63.10-2013: American National Standard for Testing Unlicensed Wireless Devices. ANSI C63.26-2015. ANSI/TIA-603-E: 2016.
Approved by (name / position & signature)	Rafael López Martín EMC Consumer & RF Lab. Manager RAFAEL LÓPEZ MARTÍN 2019.12.16 12:03:06 +01'00'
Date of issue	2019-12-16
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(*) "Data provided by the client"

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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 FCC-recognized accredited testing laboratory with appropriate scope of accreditation that include testing performed in this test report.

DEKRA Testing and Certification is an ISED-recognized accredited testing laboratory with appropriate scope of accreditation that include testing performed in this test report.

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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.

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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 S.A.U. and the Accreditation Bodies.

Uncertainty

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

Data provided by the client

The following data has been provided by the client:

1. Information relating to the description of the sample ("Identification of the item tested", "Trademark", "Model and/or type reference tested").

2. The sample consists of a Compact LTE multi-sensor prototyping platform.

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

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
60433/002	Thingy:91	Thingy:91	--	2019/04/03

Sample S/01 has undergone the following test(s): All tests indicated in Appendixes A and B for LTE Cat M1 bands 2, 4, 12, 13 and NB-IoT band 12.

- Sample S/02 is composed of the following elements:

Control Nº	Description	Model	Serial Nº	Date of reception
60433/001	Thingy:91	Thingy:91	--	2019/04/03

Sample S/02 has undergone the following test(s): All tests indicated in Appendixes A and B for NB-IoT bands 2, 4, 13.

Test sample description

Ports…….. :	Port name and description		Cable				
			Specified length [m]	Attached during test	Shielded		
	LTE RF		2	☒	☒		
	BTLE			☐	☐		
Supplementary information to the ports…… :							
Rated power supply .. :	Voltage and Frequency		Reference poles				
			L1	L2	L3	N	PE
	☐	AC:	☐	☐	☐	☐	☐
	☐	AC:	☐	☐	☐	☐	☐
	☒	DC: 4.4V - 5.25V (USB)					
	☐	DC:					
Rated Power ..... :	1W						
Clock frequencies..... :	32kHz, 32MHz						
Other parameters ..... :	Data not provided.						
Software version ..... :	Rev0.2.1						
Hardware version ..... :	0.7.2						
Dimensions in cm (W x H x D) ..... :	58x20x58 mm						
Mounting position ..... :	☒	Table top equipment					
	☐	Wall/Ceiling mounted equipment					
	☐	Floor standing equipment					
	☐	Hand-held equipment					
	☐	Other:					
Modules/parts..... :	Module/parts of test item		Type		Manufacturer		
	-						
Accessories (not part of the test item) ..... :	Description		Type		Manufacturer		
	-						
	-						

Documents as provided by the applicant ..... :	Description	File name	Issue date
	Cover markings		

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)	2019-04-04
Date (finish)	2019-05-06

Document history

Report number	Date	Description
60433RRF.004	2019-12-16	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 %
Air pressure	Min. = 860 mbar Max. = 1060 mbar

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 %
Air pressure	Min. = 860 mbar Max. = 1060 mbar

Remarks and comments

The tests have been performed by the technical personnel: Miguel Ángel Torres, Juan Carlos Fuentes, Nicolás Salguero Camarena and José Gabriel Pendón.

Used instrumentation:

Radiated Measurements

		Last Calibration	Due Calibration
1.	Semianechoic Absorber Lined Chamber ETS LINDGREN FACT 3 200 STP	N.A.	N.A.
2.	EMI Test Receiver 7 GHz ROHDE AND SCHWARZ ESR7	2018/10	2020/10
3.	RF Pre-amplifier 40 dB, 10 MHz - 6 GHz BONN ELEKTRONIK BLNA 0160-01N	2019/02	2020/08
4.	Biconical/Log Antenna 30MHz - 6GHz ETS LINDGREN 3142E	2017/09	2020/09
5.	Wideband Radio Communication Tester ROHDE AND SCHWARZ CMW500	2019/02	2020/02
6.	Signal and Spectrum Analyzer ROHDE AND SCHWARZ FSV40	2018/02	2020/02
7.	RF Pre-amplifier G>30dB, 1-18GHz BONN ELEKTRONIK BLMA 0118-3A	2019/04	2020/04
8.	RF Pre-amplifier, G>48dB, 18-40GHz NARDA JS44-18004000-33-8P	2018/02	2020/02
9.	Broadband Horn antenna 1-18 GHz SCHWARZBECK MESS-ELEKTRONIK BBHA 9120 D	2018/01	2021/01
10.	Broadband Horn antenna 18 - 40 GHz SCHWARZBECK MESS-ELEKTRONIK BBHA 9170	2018/07	2021/07

Testing verdicts

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

Summary

FCC PART 15 / FCC PART 24 /FCC PART 27 / RSS-247 / RSS-130 / RSS 133 / RSS 139 PARAGRAPH		
Requirement – Test case	**Verdict**	**Remark**
FCC 15.247 (d), RSS-247 5.5 FCC 24.238 / RSS-133 Clause 6.5 FCC 27.53 / RSS-139 Clause 6.6. / RSS-130 Clause 4.6. Emission limitations radiated (Transmitter)	P	(1)
Supplementary information and remarks: (1) Only co-location radiated spurious emission test was requested		

Appendix A: Test results FCC Part 24 / RSS-133 Issue 6

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TEST CONDITIONS

POWER SUPPLY (V):

V nonimal: 5 Vdc.

Type of Power Supply: Battery or USB.

ANTENNA:

Type of Antennas: Internal.

Antenna Gain:

Technology / Mode	Band	Antenna peak gain (dBi)
LTE	2	+2.40
Bluetooth	ISM	+1.50

TEST FREQUENCIES:

	CELLULAR LTE Cat M1 (Band 2)	
Band:	LTE Cat M1 Band 2	
Frequency Range:	1850 – 1910 MHz (FDD 1900)	
Transmit Channel:	Channel	Channel Frequency (MHz)
	Middle: 18900	1880 MHz (BW 3 MHz, RB Size 1, RB Offset 0, QPSK)

	BLUETOOTH	
Mode:	Low Energy	
Channel Spacing:	2 MHz	
Frequency Range:	2402 - 2480 MHz	
Transmit Channel:	Channel	Channel Frequency (MHz)
	Low	2402

	NB-IoT (Band 2)	
Band:	NB-IoT Band 2	
Frequency Range:	1850 – 1910 MHz (FDD 1900)	
Transmit Channel:	Channel	Channel Frequency (MHz)
	Middle: 18900	1880 MHz (BW 3.75 kHz, Tone number 1, RU Offset 0, MCS 3, Pi/2-BPSK)

The test set-up was made in accordance to the general provisions of FCC DTS Measurement 558074 D01 DTS Meas Guidance v05r02 dated April 2, 2019.

The EUT was tested in the following operating mode:

- Continuous transmission with a modulated carrier at maximum power in all required channels selecting the supported data rates/modulations types.

During transmitter test the EUT was being controlled by the SW tool to operate in a continuous transmit mode on the test channel as required and in each of the different modulation modes.

The following configurations were selected based on preliminary testing that identified those corresponding to the worst cases:

Transmission modes selected with each radio:

* CELLULAR LTE Cat M1: Transmitter radiated spurious emissions tests were performed with the EUT transmitting in LTE Cat M1 band 2 configuration as these channels were found to transmit higher EIRP than all the other LTE Channels.

* NB-IoT: Transmitter radiated spurious emissions tests were performed with the EUT transmitting in NB-IoT band 2 configuration as these channels were found to transmit higher EIRP than all the other LTE Channels.

* BLUETOOTH: Transmitter radiated spurious emissions tests were performed with the EUT transmitting in Low Energy mode configuration as this mode was found to transmit higher EIRP than all the other Channels.

Simultaneous transmission mode selected:

1. **CELLULAR LTE Cat M1 and Bluetooth Co-Location**, with the EUT configured to simultaneously transmit two signals at maximum output power, CELLULAR LTE Cat M1 in band 2 and BLUETOOTH LOW ENERGY.

2. **NB-IoT and Bluetooth Co-Location**, with the EUT configured to simultaneously transmit two signals at maximum output power, NB-IoT in band 2 and BLUETOOTH LOW ENERGY.

Radiated emissions

SPECIFICATION:

Radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c) / RSS-Gen):

Frequency Range (MHz)	Field strength (µV/m)	Field strength (dBµV/m)	Measurement distance (m)
0.009-0.490	2400/F(kHz)	-	300
0.490-1.705	24000/F(kHz)	-	30
1.705 - 30.0	30	-	30
30 - 88	100	40	3
88 - 216	150	43.5	3
216 - 960	200	46	3
960 - 25000	500	54	3

The emission limits shown in the above table are based on measurements employing CISPR quasi-peak detector except for the frequency bands 9-90 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.

For average radiated emission measurements above 1000 MHz, there is also a limit corresponding to 20 dB above the indicated values in the table is specified when measuring with peak detector function.

1. LTE Cat M1 band 2.

RSS-133 Issue 6 Clause 6.5:

i. In the 1.0 MHz bands immediately outside and adjacent to the equipment's operating frequency block, the emission power per any 1% of the emission 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, the emission power in any 1 MHz bandwidth shall be attenuated (in dB) below the transmitter output power P (dBW) by at least 43 + 10 log10p(watts). If the measurement is performed using 1% of the emission bandwidth, power integration over 1.0 MHz is required.

FCC § 24.238:

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:

$$Po\ (dBm) – [43 + 10 \log Po\ (watts)] = -13\ dBm$$

METHOD:

The measurement was performed with the EUT inside an anechoic chamber.

The spectrum was scanned from 9 kHz to at least the 10th harmonic of the highest frequency of the co-located radios till 26 GHz.

The EUT was placed on a 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 at less than 20 dB respect to the limit is substituted by the Substitution method in accordance with the ANSI/TIA-603-E: 2016.

These measurements have been performed in order to check the impact of the Co-Location of all radio interfaces (that can be transmitting simultaneously).

LIMIT:

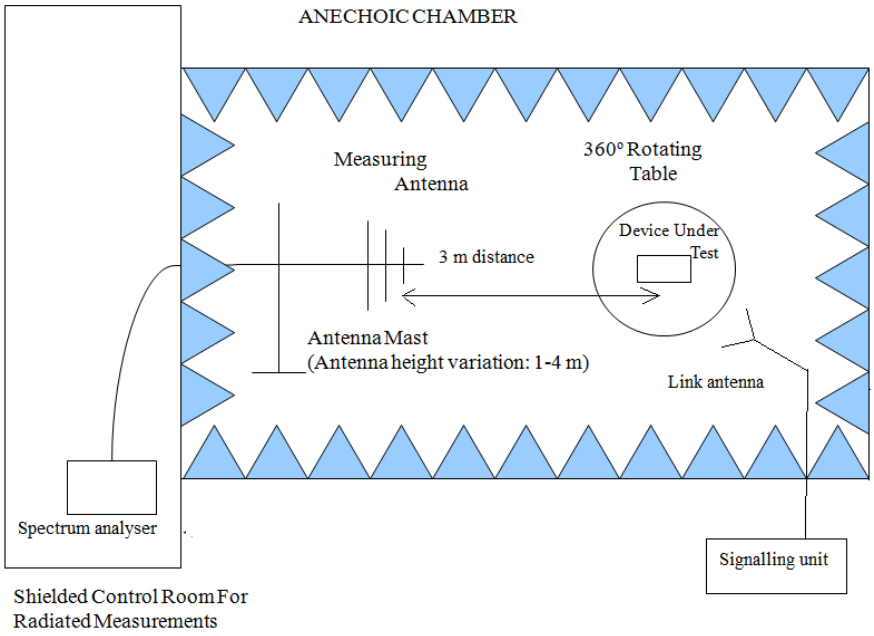
The spurious signals was measured at 3 meter. The limit of the test is determined by:

Frequency Range	Detector	Limit (dBµV/m) at 3m
30 MHz to 20 GHz	PK	43 + 10 log (P) dB = -13 dBm -> 82.23 dBµV/m
20 GHz to 26 GHz	PK	74 (*)
	AVG	54 (*)

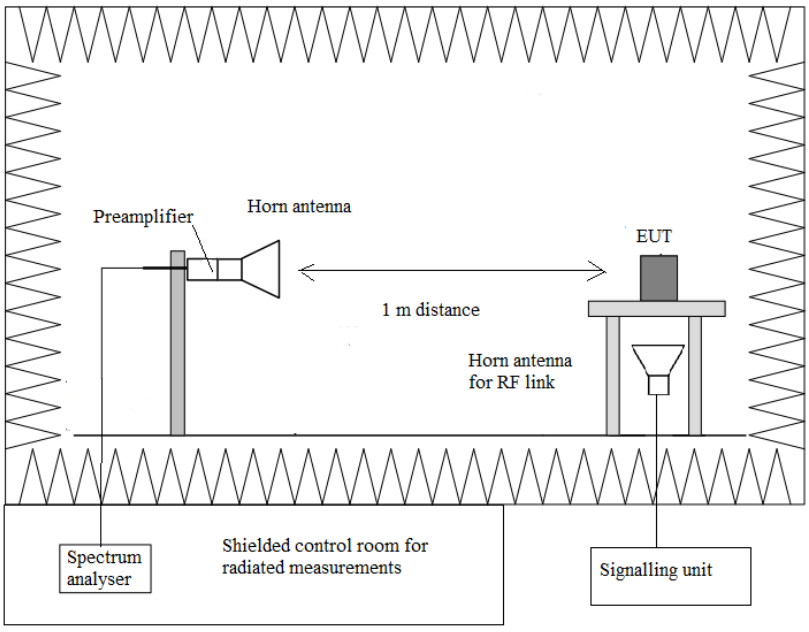
(*) Radiated emissions which fall in the restricted bands, as defined in §15.205(a).

TEST SETUP:

Radiated measurements below 1 GHz.



Radiated measurements above 1 GHz.



RESULTS:

- **Mode LTE Cat M1 Band 2 and Bluetooth Low Energy.**

QPSK and 16QAM modulations:

A preliminary scan determined the QPSK modulation in Channel Middle as the worst case.

Frequency range 30 MHz - 1 GHz

The spurious emissions below 1 GHz do not depend on either the operating channel or the modulation mode selected in the EUT.

No spurious frequencies at less than 20 dB below the limit.

Frequency range 1 - 26 GHz

Spurious frequencies at less than 20 dB below the limit:

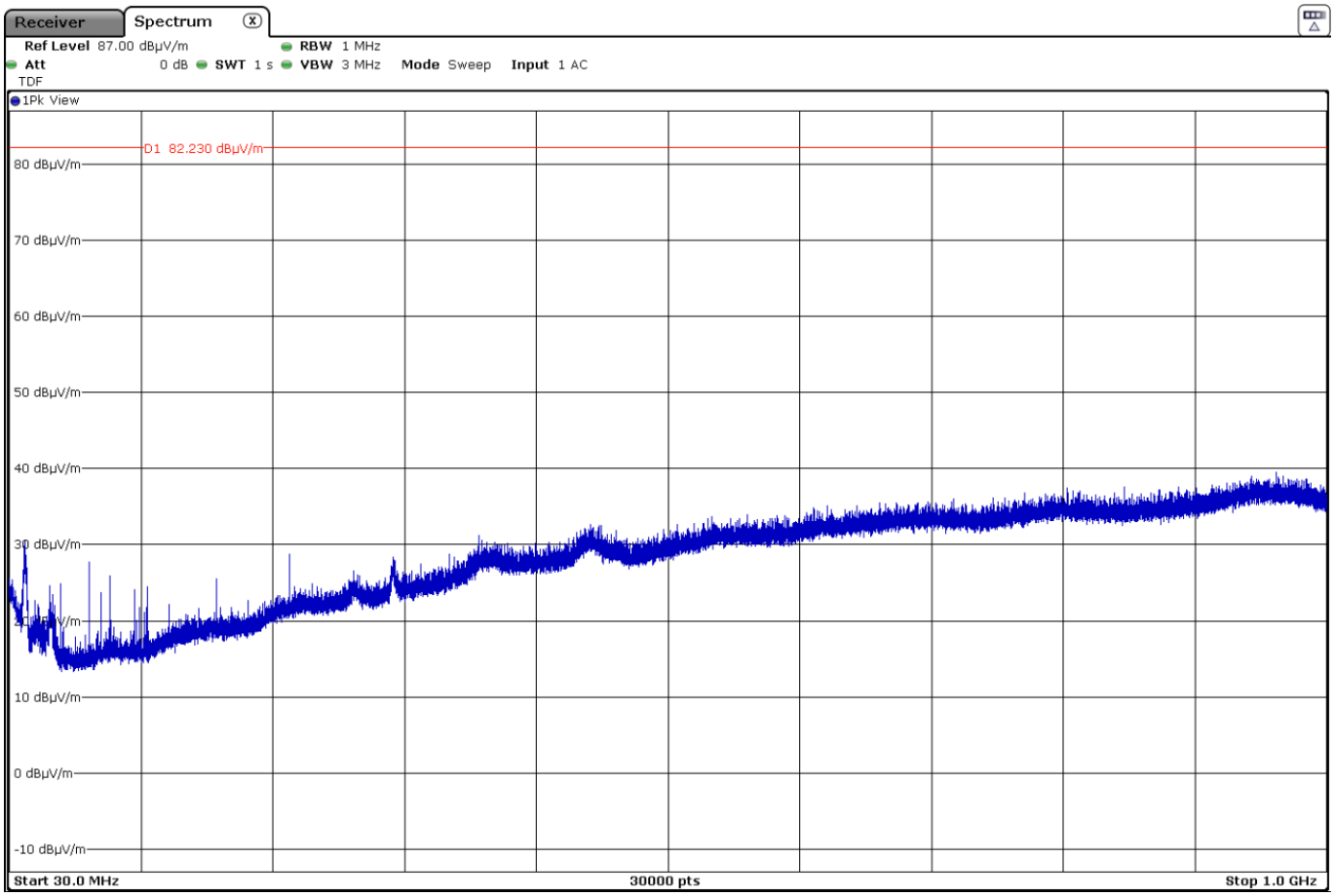
Frequency (GHz)	Instrument reading (dBm)	Polarization	(1) Generator output (dBm)	(2) Cable loss (dB)	(3) Substitution antenna gain Gi (respect to isotropic radiator) (dB)	E.I.R.P. (dBm) = (1) – (2) + (3)
1.356767	-17.71	H	-36.61	0.68	7.28	-30.01

Measurement uncertainty (dB)	<±3.88 for f < 1GHz <±3.70 for f ≥ 1 GHz up to 18 GHz <±3.33 for f ≥ 18 GHz up to 26 GHz

Verdict: PASS

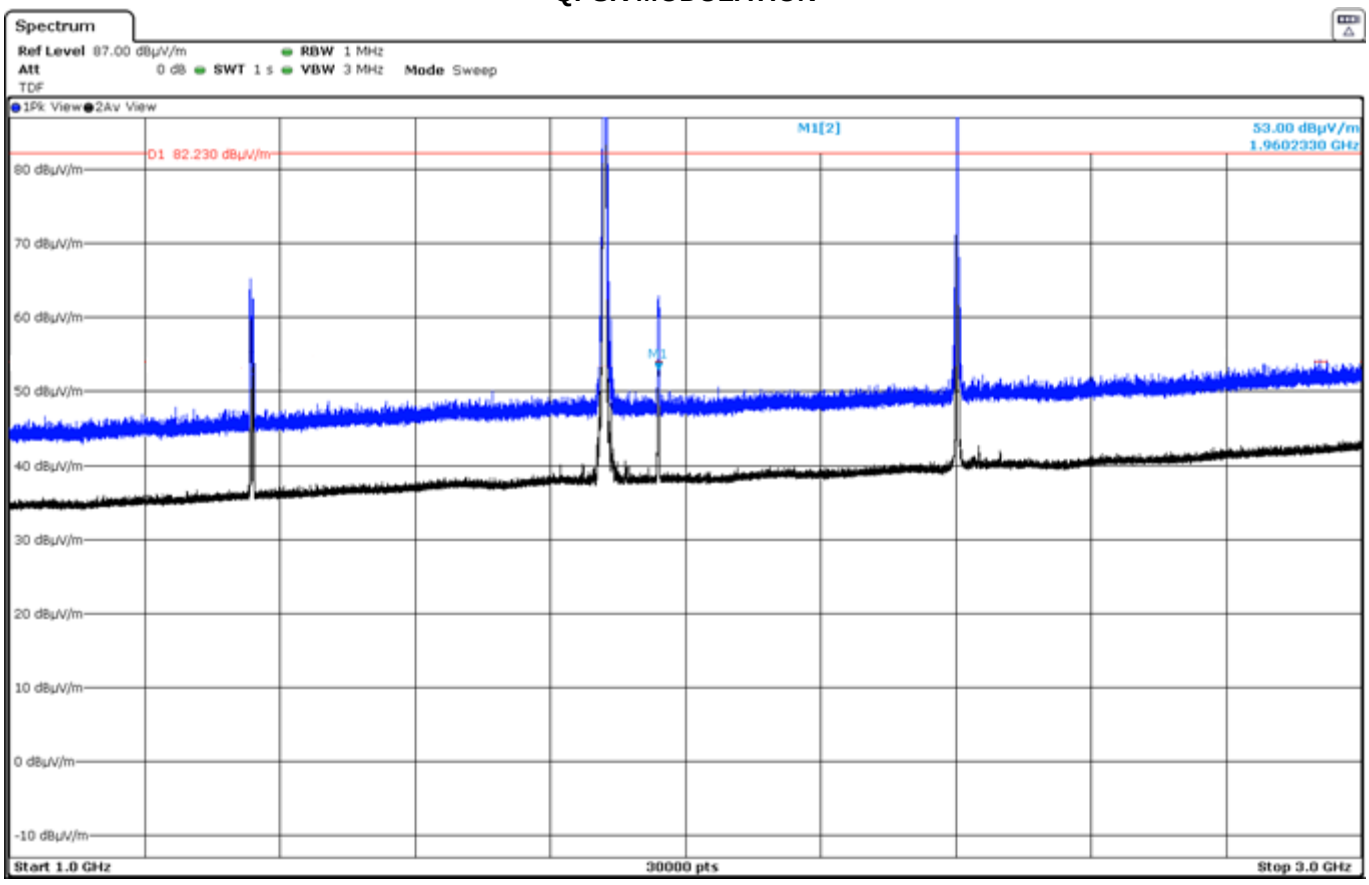
FREQUENCY RANGE 30 MHz - 1 GHz (mode LTE Cat M1 Band 2 and Bluetooth Low Energy)

QPSK MODULATION



FREQUENCY RANGE 1 - 3 GHz **(mode LTE Cat M1 Band 2 and Bluetooth Low Energy)**

QPSK MODULATION



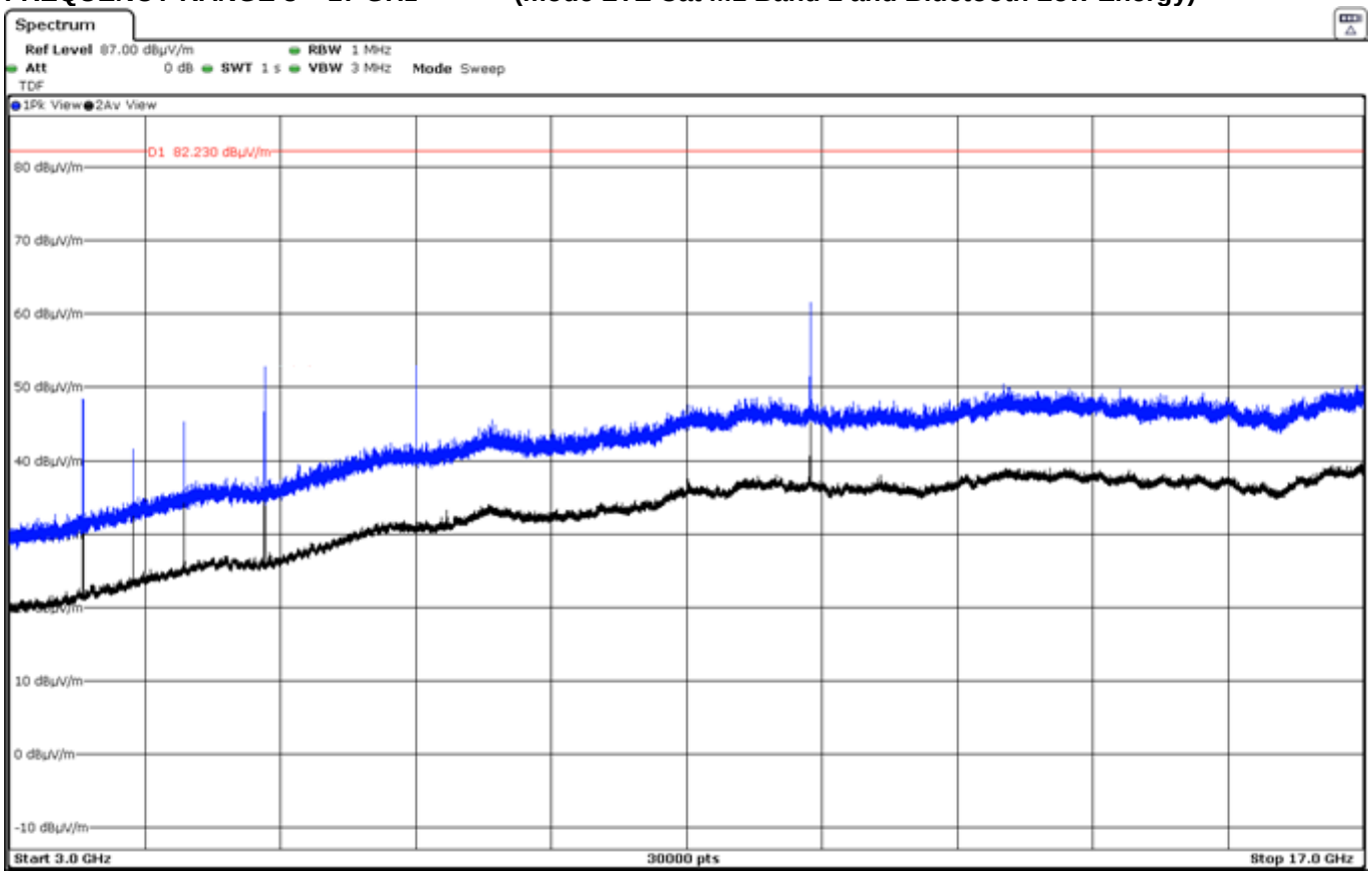
The peaks above the limit are the carrier frequencies:

LTE Cat M1 Band 2 (1880 MHz).

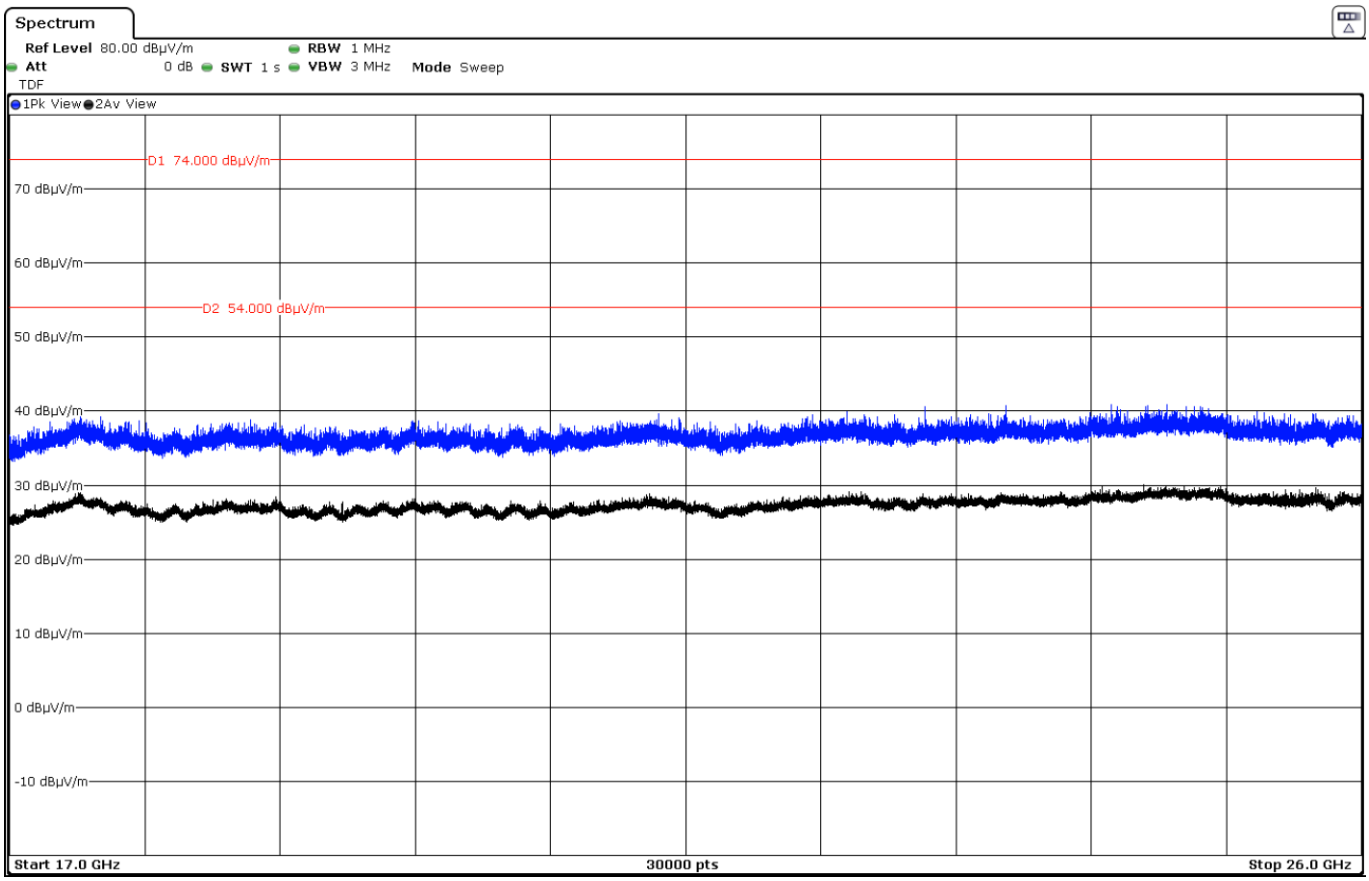
The peak at 1960 MHz corresponds to the downlink signal.

Bluetooth Low Energy (2402 MHz).

FREQUENCY RANGE 3 – 17 GHz (mode LTE Cat M1 Band 2 and Bluetooth Low Energy)



FREQUENCY RANGE 17 - 26 GHz (mode LTE Cat M1 Band 2 and Bluetooth Low Energy)



- **Mode NB-IoT Band 2 and Bluetooth Low Energy.**

QPSK, Pi/4-QPSK and Pi/2-BPSK modulations:

A preliminary scan determined the Pi/2-BPSK modulation in Channel Middle as the worst case.

Frequency range 30 MHz - 1 GHz

The spurious emissions below 1 GHz do not depend on either the operating channel or the modulation mode selected in the EUT.

No spurious frequencies at less than 20 dB below the limit.

Frequency range 1 - 26 GHz

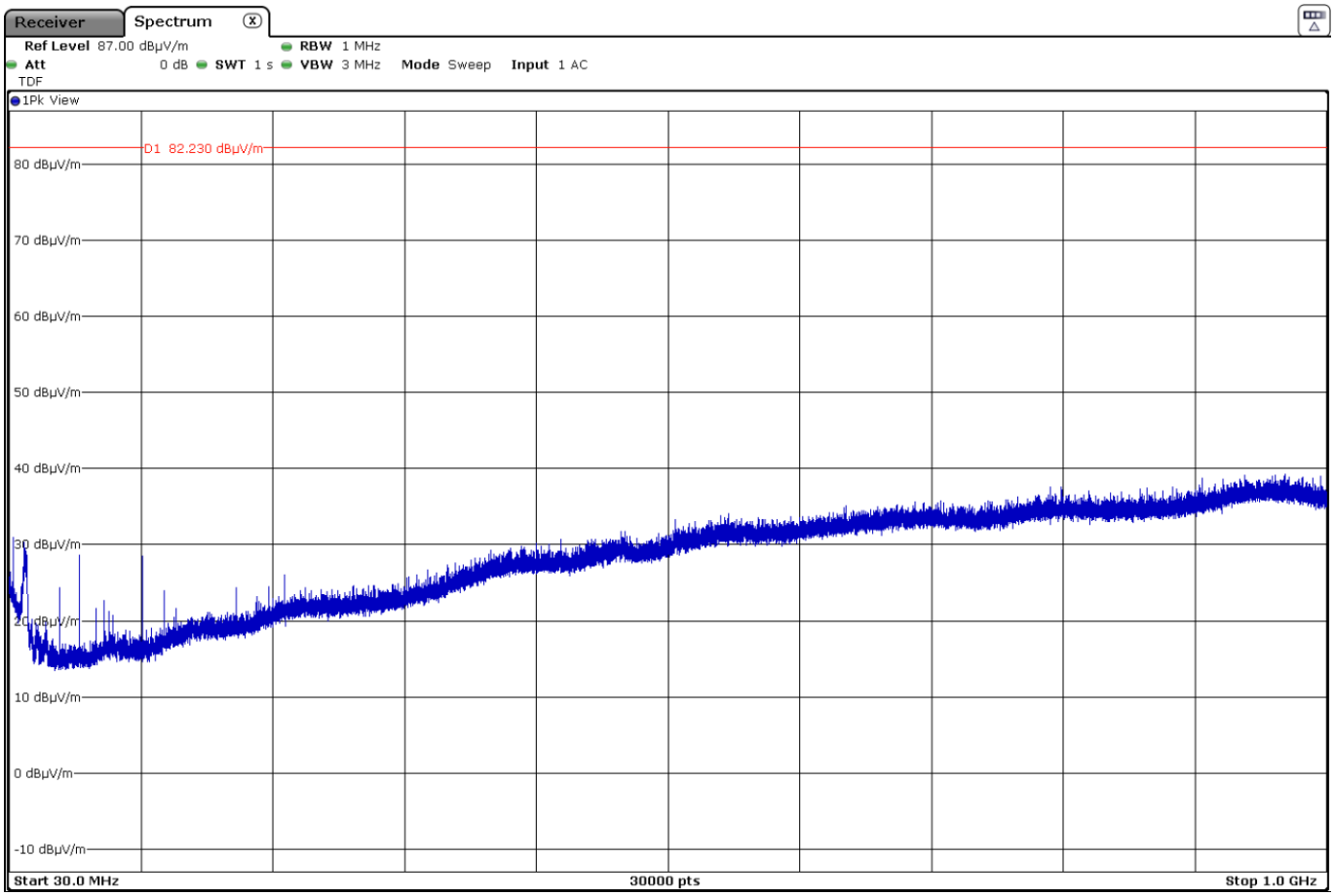
No spurious frequencies at less than 20 dB below the limit.

Measurement uncertainty (dB)	<±3.88 for f < 1GHz <±3.70 for f ≥ 1 GHz up to 18 GHz <±3.33 for f ≥ 18 GHz up to 20 GHz

Verdict: PASS

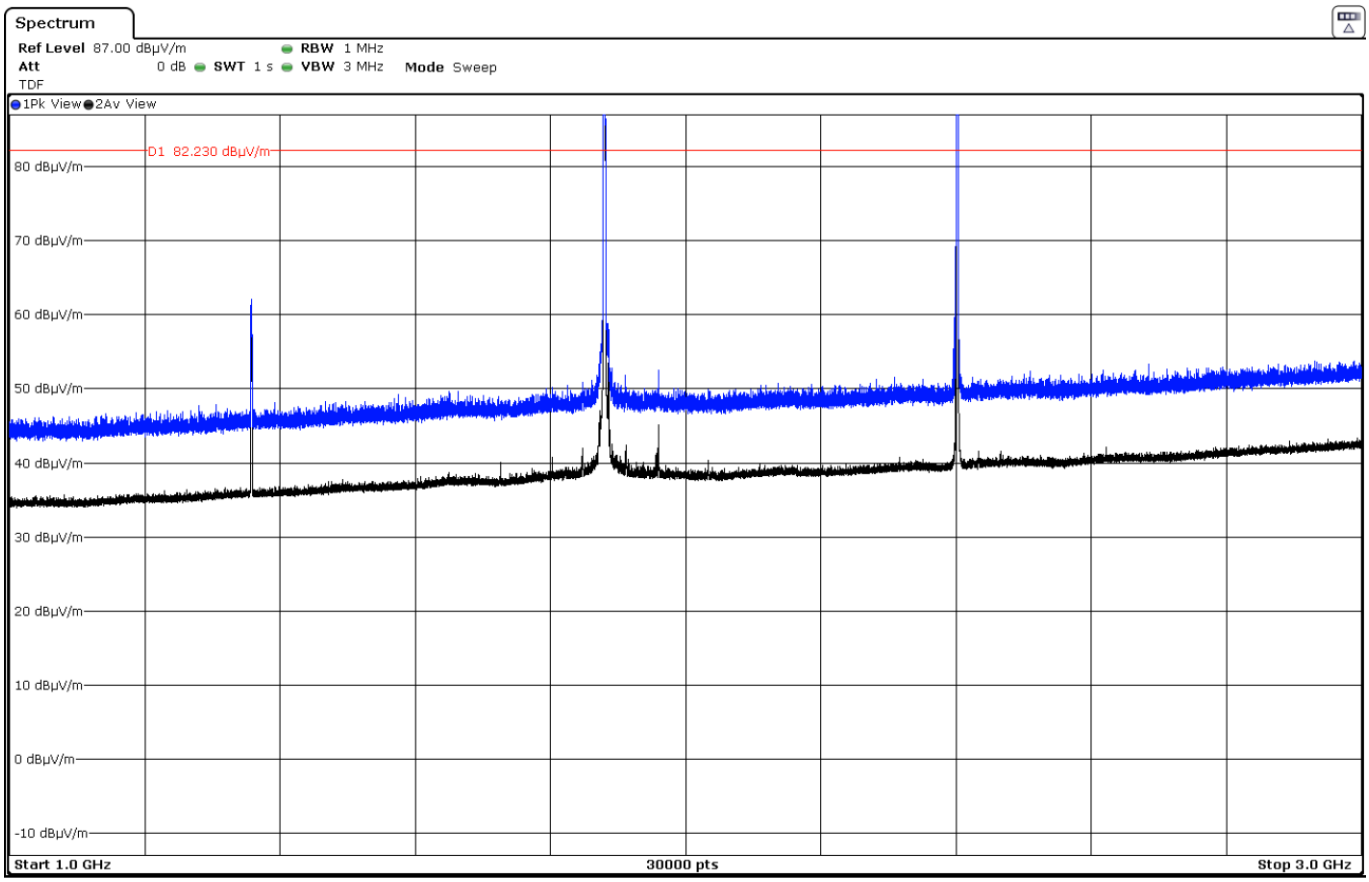
FREQUENCY RANGE 30 MHz - 1 GHz (mode NB-IoT Band 2 and Bluetooth Low Energy)

Pi/2-BPSK MODULATION



FREQUENCY RANGE 1 - 3 GHz (mode NB-IoT Band 2 and Bluetooth Low Energy)

Pi/2-BPSK MODULATION

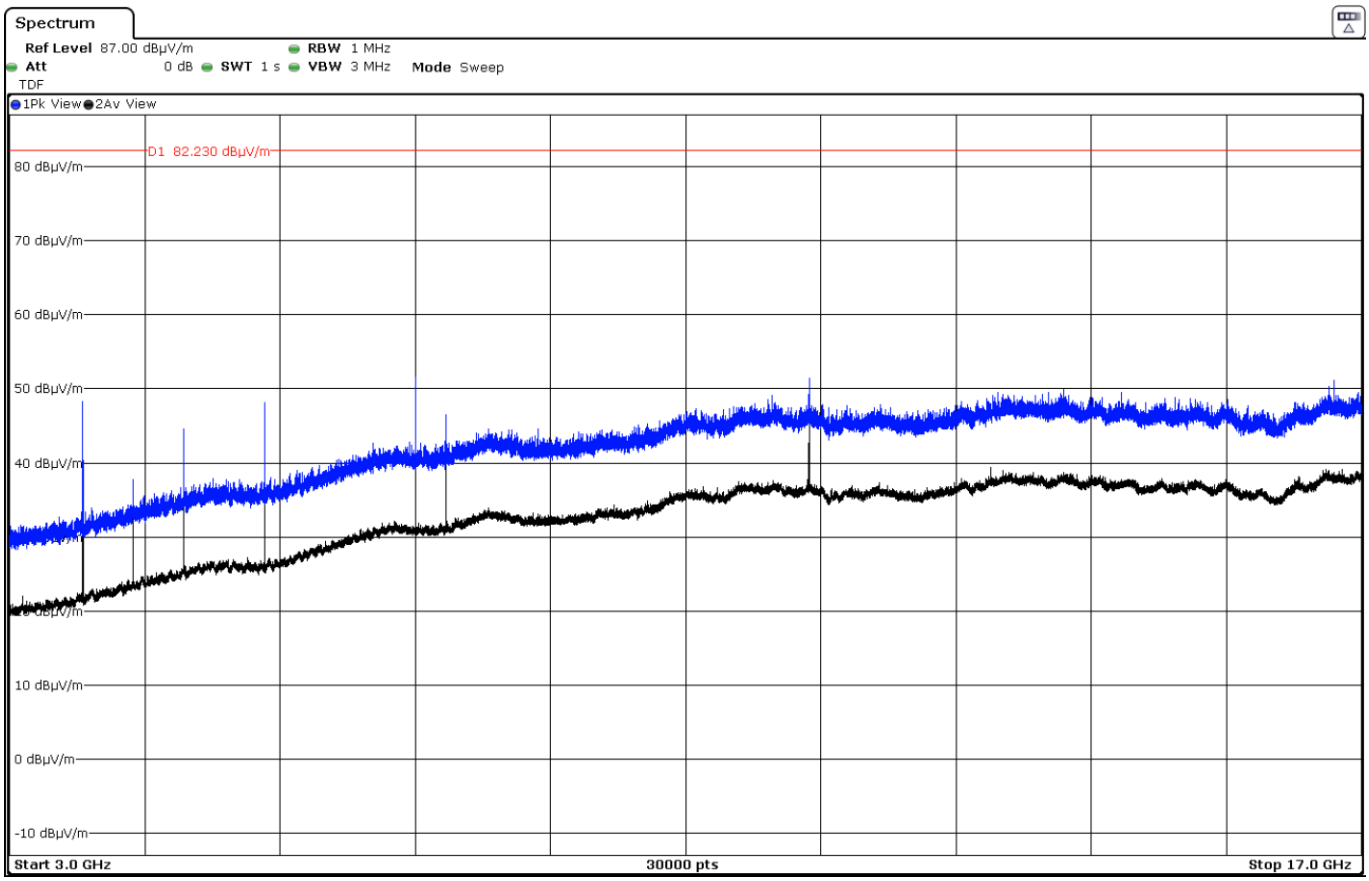


The peaks above the limit are the carrier frequencies:

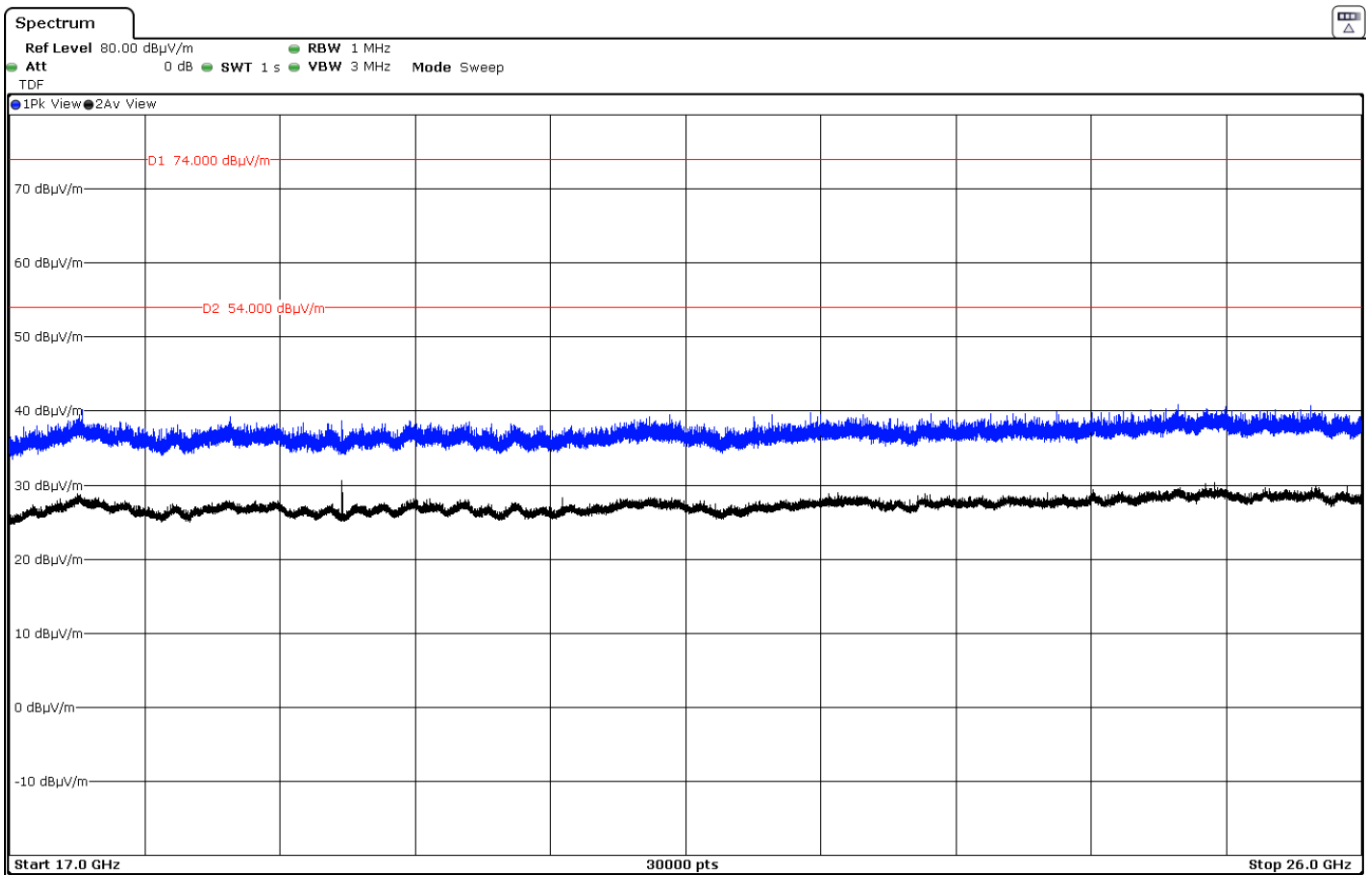
LTE Cat NB1 Band 2 (1880 MHz).

Bluetooth Low Energy (2402 MHz).

FREQUENCY RANGE 3 – 17 GHz (mode NB-IoT Band 2 and Bluetooth Low Energy)



FREQUENCY RANGE 17 - 26 GHz (mode NB-IoT Band 2 and Bluetooth Low Energy)



Appendix B: Test results FCC Part 27 / RSS-139 Issue 3, RSS-130 Issue 2

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TEST CONDITIONS

POWER SUPPLY (V):

V nonimal: 5 Vdc.

Type of Power Supply: DC voltage (USB).

ANTENNA:

Type of Antennas: Internal.

Antenna Gain:

Technology / Mode	Band	Antenna peak gain (dBi)
LTE	4	+2.40
LTE	12	+1.10
LTE	13	+1.10
Bluetooth	ISM	+1.50

TEST FREQUENCIES - FCC PART 27:

	CELLULAR LTE Cat M1 (Bands 4, 12, 13)	
Band:	LTE Cat M1 Band 4	
Frequency Range:	1710 – 1755 MHz (FDD 1700)	
Transmit Channel:	Channel	Channel Frequency (MHz)
	Middle: 20175	1732.50 MHz (BW 5 MHz, RB Size 1, RB Offset 0, QPSK)
Band:	LTE Cat M1 Band 12	
Frequency Range:	699 – 716 MHz (FDD 700)	
Transmit Channel:	Channel	Channel Frequency (MHz)
	Middle: 23095	707.50 MHz (BW 5 MHz, RB Size 1, RB Offset 0, QPSK)
Band:	LTE Cat M1 Band 13	
Frequency Range:	777 – 787 MHz (FDD 700)	
Transmit Channel:	Channel	Channel Frequency (MHz)
	Middle: 23230	782 MHz (BW 5 MHz, RB Size 1, RB Offset 0, QPSK)

	BLUETOOTH	
Mode:	Low Energy	
Channel Spacing:	2 MHz	
Frequency Range:	2402 - 2480 MHz	
Transmit Channel:	Channel	Channel Frequency (MHz)
	Low	2402

	NB-IoT (Bands 4, 12, 13)	
Band:	NB-IoT Band 4	
Frequency Range:	1710 – 1755 MHz (FDD 1700)	
Transmit Channel:	Channel	Channel Frequency (MHz)
	Middle: 20175	1732.50 MHz (BW 3.75 kHz, Tone number 1, RU Offset 47, MCS 3, Pi/4-QPSK)
Band:	NB-IoT Band 12	
Frequency Range:	699 – 716 MHz (FDD 700)	
Transmit Channel:	Channel	Channel Frequency (MHz)
	Middle: 23012	699.2 MHz (BW 15 kHz, Tone number 3, RU Offset 6, MCS 5, Pi/4-QPSK)
Band:	NB-IoT Band 13	
Frequency Range:	777 – 787 MHz (FDD 700)	
Transmit Channel:	Channel	Channel Frequency (MHz)
	Middle: 23230	782 MHz (BW 3.75 kHz, Tone number 1, RU Offset 1, MCS 0, Pi/2-BPSK)

The test set-up was made in accordance to the general provisions of FCC DTS Measurement 558074 D01 DTS Meas Guidance v05 dated 24/08/2018 and FCC Unlicensed National Information Infrastructure (U-NII) Devices 789033 D02 General U-NII Test Procedures New Rules v02r01 dated Dec 14, 2017.

The EUT was tested in the following operating mode:

- Continuous transmission with a modulated carrier at maximum power in all required channels selecting the supported data rates/modulations types.

During transmitter test the EUT was being controlled by the SW tool to operate in a continuous transmit mode on the test channel as required and in each of the different modulation modes.

The following configurations were selected based on preliminary testing that identified those corresponding to the worst cases:

Transmission modes selected with each radio:

* CELLULAR LTE Cat M1: Transmitter radiated spurious emissions tests were performed with the EUT transmitting in LTE Cat M1 bands 4, 12, 13 configuration as these channels were found to transmit higher EIRP than all the other LTE Channels.

* NB-IoT: Transmitter radiated spurious emissions tests were performed with the EUT transmitting in NB-IoT bands 4, 12, 13 configuration as these channels were found to transmit higher EIRP than all the other LTE Channels.

* BLUETOOTH: Transmitter radiated spurious emissions tests were performed with the EUT transmitting in Low Energy mode configuration as this mode was found to transmit higher EIRP than all the other Channels.

Simultaneous transmission mode selected:

1. **CELLULAR LTE Cat M1 and Bluetooth Co-Location**, with the EUT configured to simultaneously transmit two signals at maximum output power, CELLULAR LTE Cat M1 in band 4 and BLUETOOTH LOW ENERGY.

2. **CELLULAR LTE Cat M1 and Bluetooth Co-Location**, with the EUT configured to simultaneously transmit two signals at maximum output power, CELLULAR LTE Cat M1 in band 12 and BLUETOOTH LOW ENERGY.

3. **CELLULAR LTE Cat M1 and Bluetooth Co-Location**, with the EUT configured to simultaneously transmit two signals at maximum output power, CELLULAR LTE Cat M1 in band 13 and BLUETOOTH LOW ENERGY.

4. **NB-IoT and Bluetooth Co-Location**, with the EUT configured to simultaneously transmit two signals at maximum output power, NB-IoT in band 4 and BLUETOOTH LOW ENERGY.

5. **NB-IoT and Bluetooth Co-Location**, with the EUT configured to simultaneously transmit two signals at maximum output power, NB-IoT in band 12 and BLUETOOTH LOW ENERGY.

6. **NB-IoT and Bluetooth Co-Location**, with the EUT configured to simultaneously transmit two signals at maximum output power, NB-IoT in band 13 and BLUETOOTH LOW ENERGY.

Radiated emissions

SPECIFICATION:

Radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c) / RSS-Gen):

Frequency Range (MHz)	Field strength (µV/m)	Field strength (dBµV/m)	Measurement distance (m)
0.009-0.490	2400/F(kHz)	-	300
0.490-1.705	24000/F(kHz)	-	30
1.705 - 30.0	30	-	30
30 - 88	100	40	3
88 - 216	150	43.5	3
216 - 960	200	46	3
960 - 25000	500	54	3

The emission limits shown in the above table are based on measurements employing CISPR quasi-peak detector except for the frequency bands 9-90 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.

For average radiated emission measurements above 1000 MHz, there is also a limit corresponding to 20 dB above the indicated values in the table is specified when measuring with peak detector function.

1. LTE Band 4. FCC §2.1053 & §27.53 (h) / RSS-139 Issue 3 Clause 6.6.

FCC §27.53 (h):

> (h) 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.

RSS-139 Clause 6.6:

> 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.

LIMIT:

The spurious signals was measured at 3 meter. The limit of the test is determined by:

Frequency Range	Detector	Limit (dBµV/m) at 3m
30 MHz to 20 GHz	PK	43 + 10 log (P) dB = -13 dBm -> 82.23 dBµV/m
20 GHz to 26 GHz	PK	74 (*)
	AVG	54 (*)

(*) Radiated emissions which fall in the restricted bands, as defined in §15.205(a).

2. LTE Band 12. FCC §2.1053 & §27.53 (g) / RSS-130 Issue 2 Clause 4.7.1.

FCC §27.53 (g):

> (g) For operations in the 600 MHz band and the 698-746 MHz band, the power of any emission outside a licensee's frequency band(s) of operation shall be attenuated below the transmitter power (P) within the licensed band(s) of operation, measured in watts, by at least 43 + 10 log (P) dB. Compliance with this provision is based on the use of measurement instrumentation employing a resolution bandwidth of 100 kilohertz or greater. However, in the 100 kilohertz bands immediately outside and adjacent to a licensee's frequency block, a resolution bandwidth of at least 30 kHz may be employed.

RSS-130 Issue 2 Clause 4.7.1:

> 4.7.1. The power of any unwanted emissions in any 100 kHz bandwidth on any frequency outside the frequency range(s) within which the equipment is designed to operate shall be attenuated below the transmitter power, P (dBW), by at least 43 + 10 log10 p (watts), dB. However, in the 100 kHz band immediately outside the equipment's operating frequency range, a resolution bandwidth of 30 kHz may be employed.

LIMIT:

The spurious signals was measured at 3 meter. The limit of the test is determined by:

Frequency Range	Detector	Limit (dBµV/m) at 3m
30 MHz to 8 GHz	PK	43 + 10 log (P) dB = -13 dBm -> 82.23 dBµV/m
8 GHz to 26 GHz	PK	74 (*)
	AVG	54 (*)

(*) Radiated emissions which fall in the restricted bands, as defined in §15.205(a).

3. LTE Band 13. FCC §2.1053 & §27.53 (c) (2) (4) & (f) / RSS-130 Issue 2 Clause 4.7.1.

FCC §27.53 (c) (2) (4) & (f):

> (c) (2) On any frequency outside the 776-788 MHz band, the power of any emission shall be attenuated outside the band below the transmitter power (P) by at least 43 + 10 log (P) dB.
>
> (c) (4) On all frequencies between 763-775 MHz and 793-805 MHz, by a factor not less than 65 + 10 log (P) dB in a 6.25 kHz band segment, for mobile and portable stations.
>
> (f) For operations in the 746-758 MHz, 775-788 MHz, and 805-806 MHz bands, emissions in the band 1559-1610 MHz shall be limited to −70 dBW (-40 dBm)/MHz equivalent isotropically radiated power (EIRP) for wideband signals, and −80 dBW (-50 dBm) EIRP for discrete emissions of less than 700 Hz bandwidth. For the purpose of equipment authorization, a transmitter shall be tested with an antenna that is representative of the type that will be used with the equipment in normal operation.

RSS-130 Issue 2 Clause 4.7.1:

> 4.7.1. The power of any unwanted emissions in any 100 kHz bandwidth on any frequency outside the frequency range(s) within which the equipment is designed to operate shall be attenuated below the transmitter power, P (dBW), by at least 43 + 10 log10 p (watts), dB. However, in the 100 kHz band immediately outside the equipment's operating frequency range, a resolution bandwidth of 30 kHz may be employed.

LIMIT:

The spurious signals was measured at 3 meter. The limit of the test is determined by:

Frequency Range	Detector	Limit (dBµV/m) at 3m
30 MHz to 8 GHz	PK	43 + 10 log (P) dB = -13 dBm -> 82.23 dBµV/m or 74 (*)-> -21.23 dBm
8 GHz to 26 GHz	PK	74 (*)
	AVG	54 (*)

(*) Radiated emissions which fall in the restricted bands, as defined in §15.205(a).

METHOD:

The measurement was performed with the EUT inside an anechoic chamber.

The spectrum was scanned from 9 kHz to at least the 10th harmonic of the highest frequency of the co-located radios till 26 GHz.

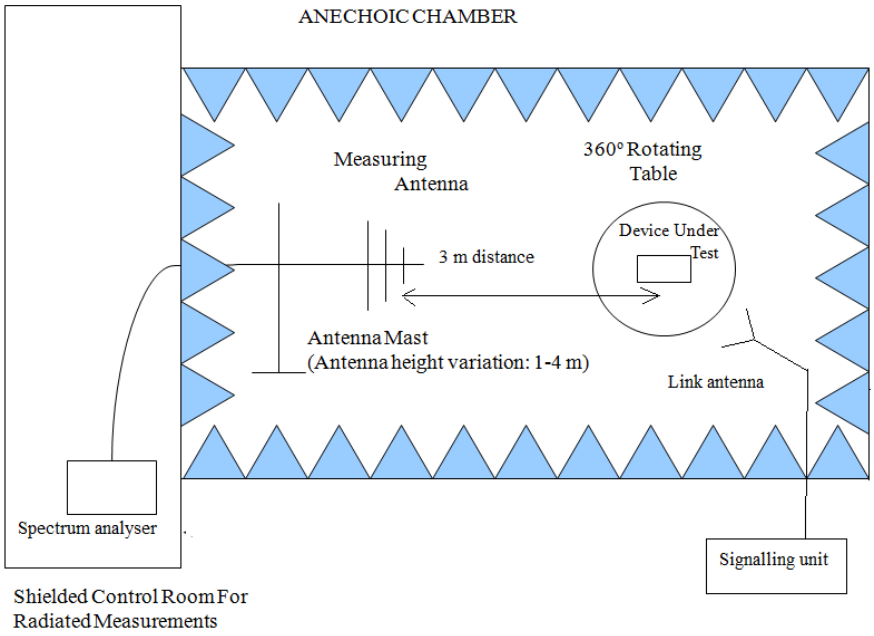
The EUT was placed on a non-conductive stand at a 3 meter distance from the measuring antenna for measurements below 1 GHz and at 1 m distance for measurements above 1 GHz.
Detected emissions were maximized at each frequency by rotating the EUT and adjusting the measuring antenna height and polarization. The maximum meter reading was recorded.
The radiated emissions were measured with peak detector and 1 MHz bandwidth.

Each detected emission at less than 20 dB respect to the limit is substituted by the Substitution method in accordance with the ANSI/TIA-603-E: 2016.

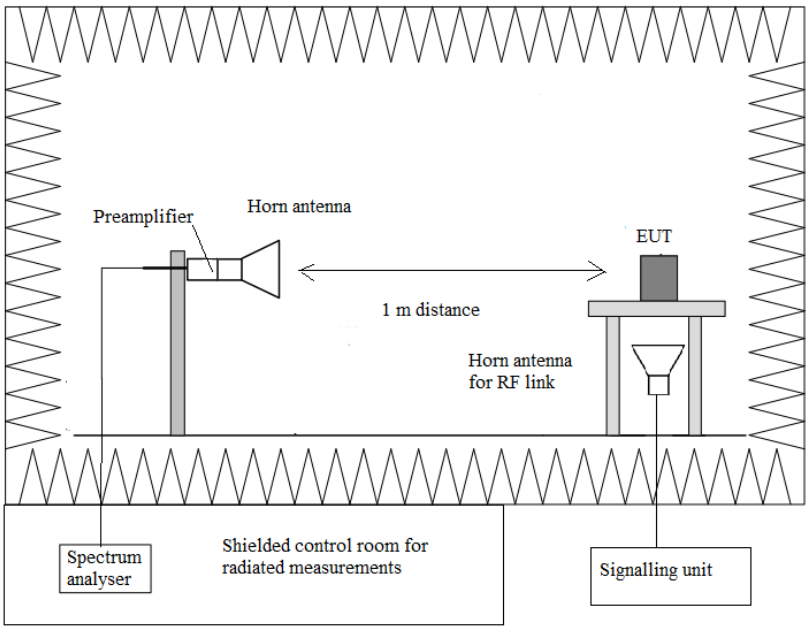
These measurements have been performed in order to check the impact of the Co-Location of all radio interfaces (that can be transmitting simultaneously).

TEST SETUP:

Radiated measurements below 1 GHz.



Radiated measurements above 1 GHz.



RESULTS:

- **1. Mode LTE Cat M1 Band 4 and Bluetooth Low Energy.**

QPSK and 16QAM modulations:

A preliminary scan determined the QPSK modulation in Channel Middle as the worst case.

Frequency range 30 MHz - 1 GHz

The spurious emissions below 1 GHz do not depend on either the operating channel or the modulation mode selected in the EUT.

No spurious frequencies at less than 20 dB below the limit.

Frequency range 1 - 26 GHz

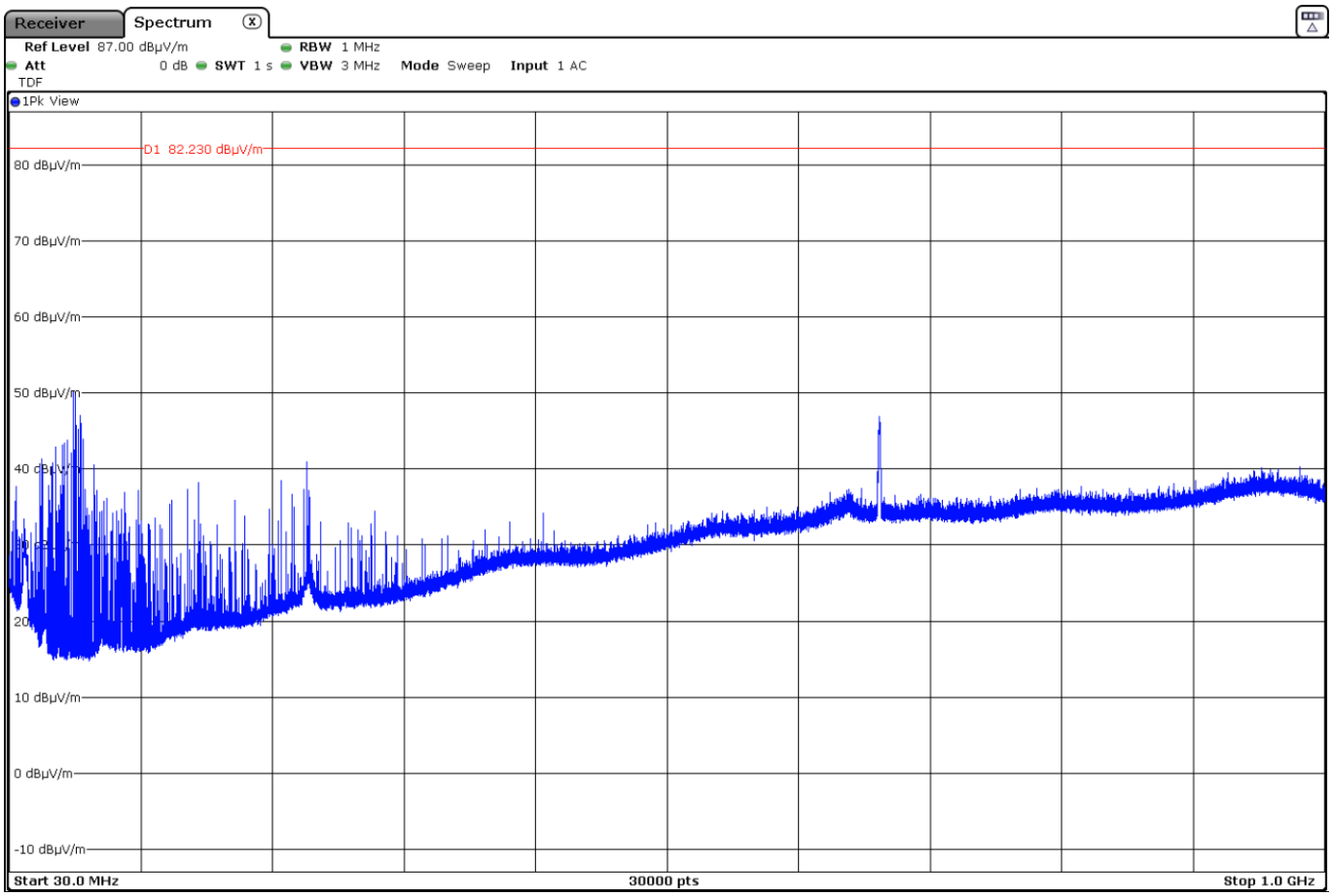
Spurious frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
10.40763	51.99	V	Peak	<±4.70

Measurement uncertainty (dB)	<±3.88 for f < 1GHz <±3.70 for f ≥ 1 GHz up to 18 GHz <±3.33 for f ≥ 18 GHz up to 20 GHz

Verdict: PASS

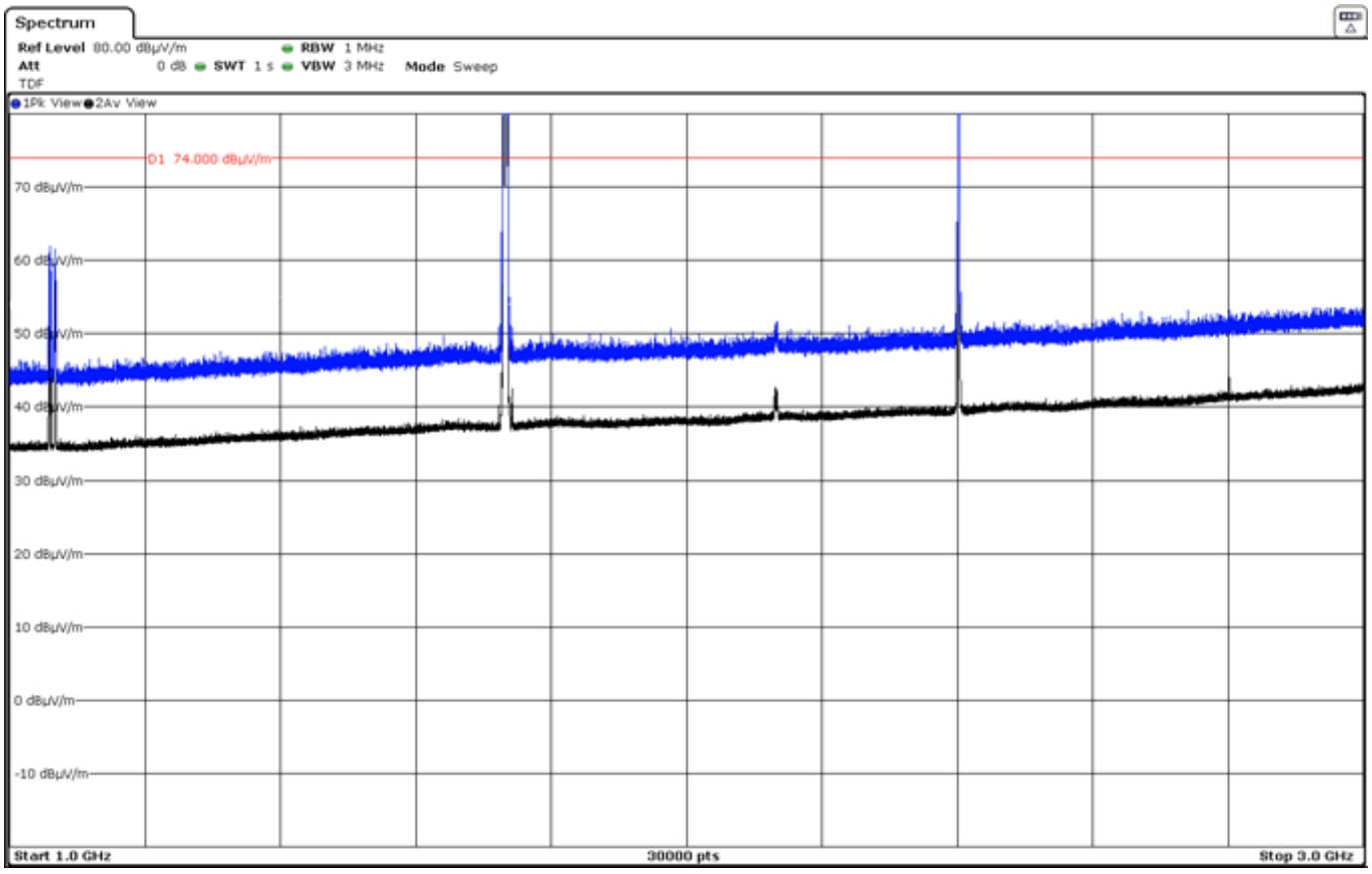
FREQUENCY RANGE 30 MHz - 1 GHz (mode LTE Cat M1 Band 4 and Bluetooth Low Energy)

QPSK MODULATION



FREQUENCY RANGE 1 - 3 GHz **(mode LTE Cat M1 Band 4 and Bluetooth Low Energy)**

QPSK MODULATION

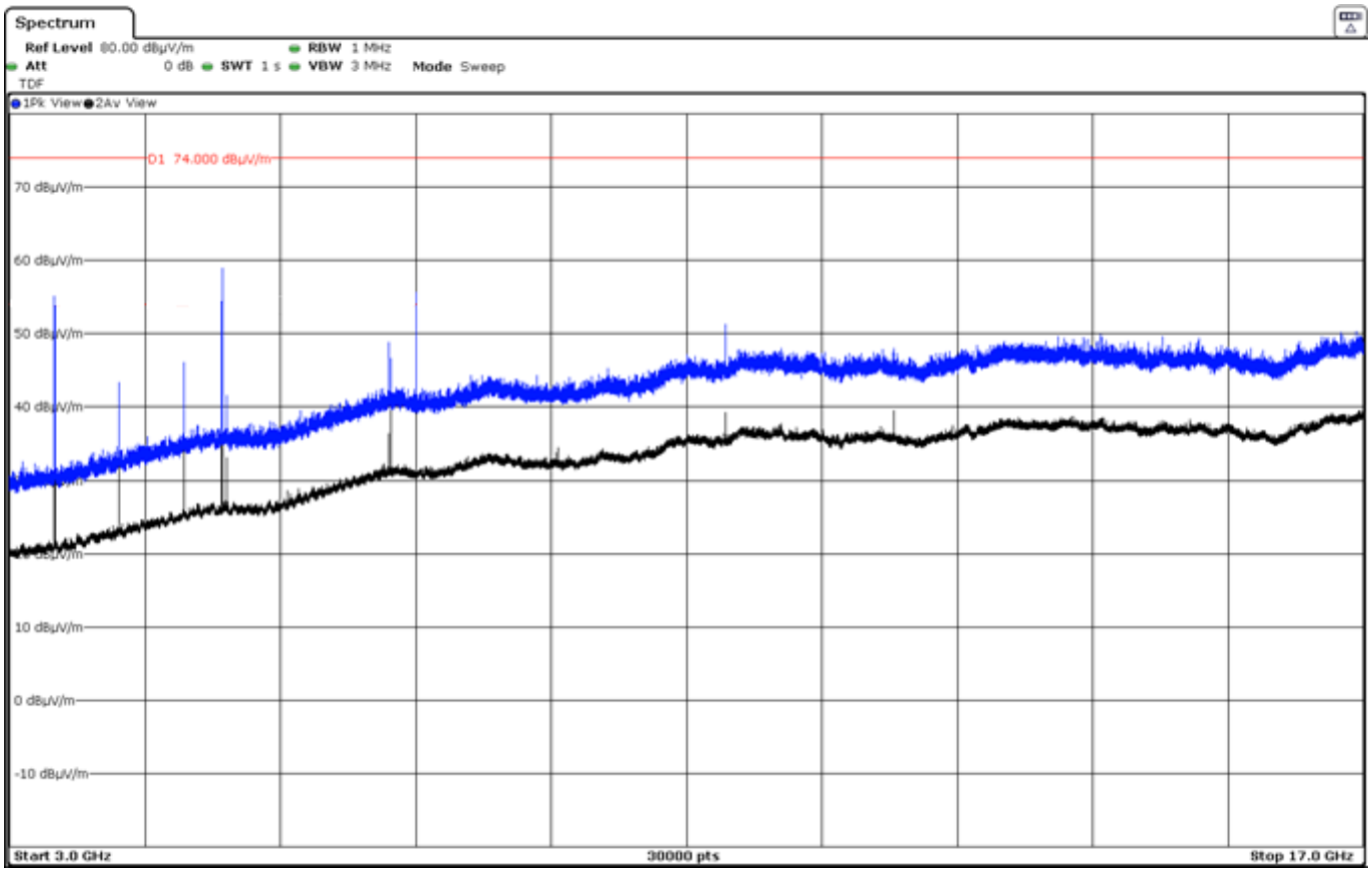


The peaks above the limit are the carrier frequencies:

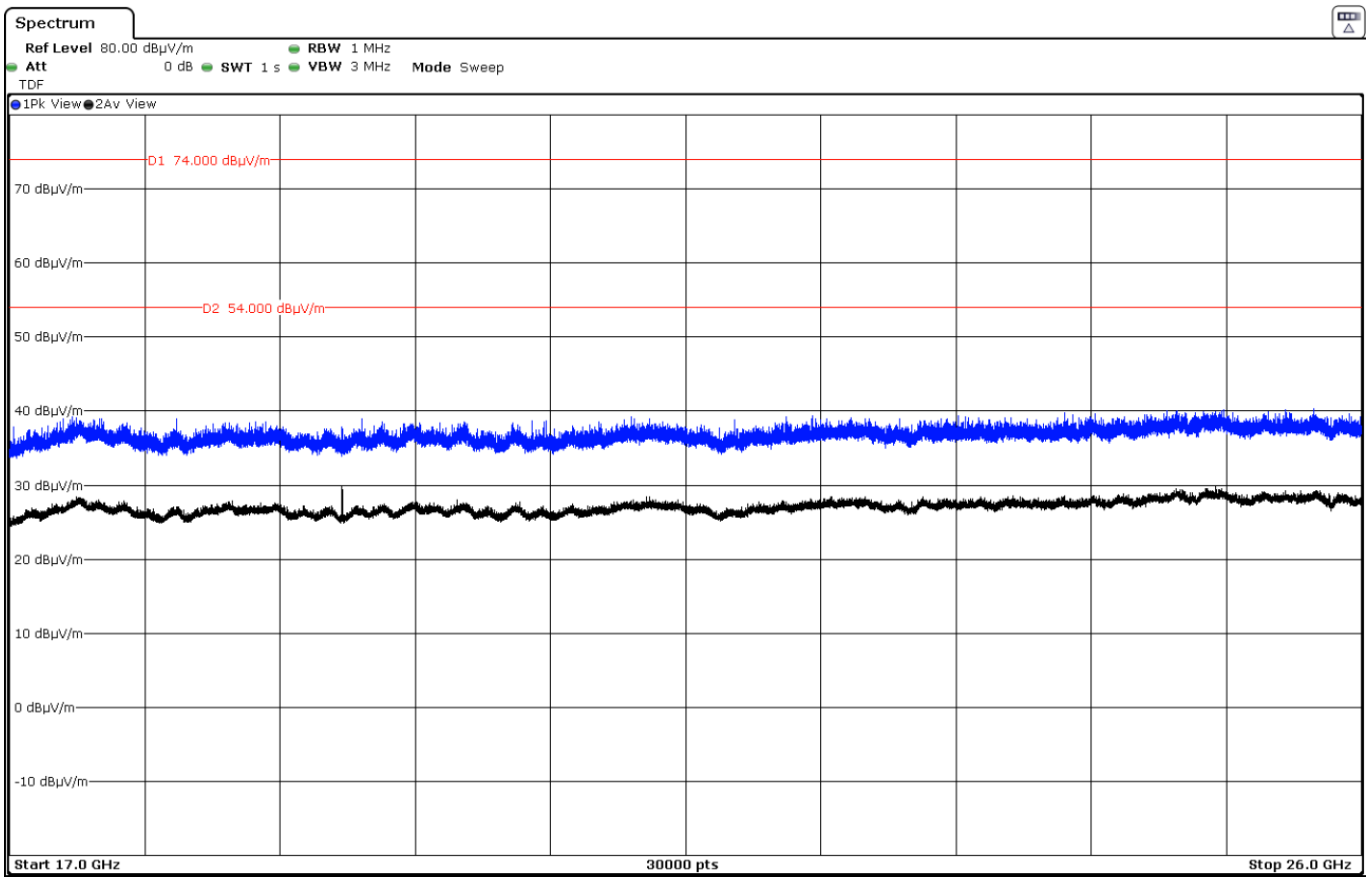
LTE Cat M1 Band 4 (1732.50 MHz).

Bluetooth Low Energy (2402 MHz).

FREQUENCY RANGE 3 – 17 GHz (mode LTE Cat M1 Band 4 and Bluetooth Low Energy)



FREQUENCY RANGE 17 - 26 GHz (mode LTE Cat M1 Band 4 and Bluetooth Low Energy)



- **2. Mode NB-IoT Band 4 and Bluetooth Low Energy.**

QPSK, Pi/4-QPSK and Pi/2-BPSK modulations:

A preliminary scan determined the Pi/4-QPSK modulation in Channel Middle as the worst case.

Frequency range 30 MHz - 1 GHz

The spurious emissions below 1 GHz do not depend on either the operating channel or the modulation mode selected in the EUT.

No spurious frequencies at less than 20 dB below the limit.

Frequency range 1 - 26 GHz

Spurious frequencies at less than 20 dB below the limit:

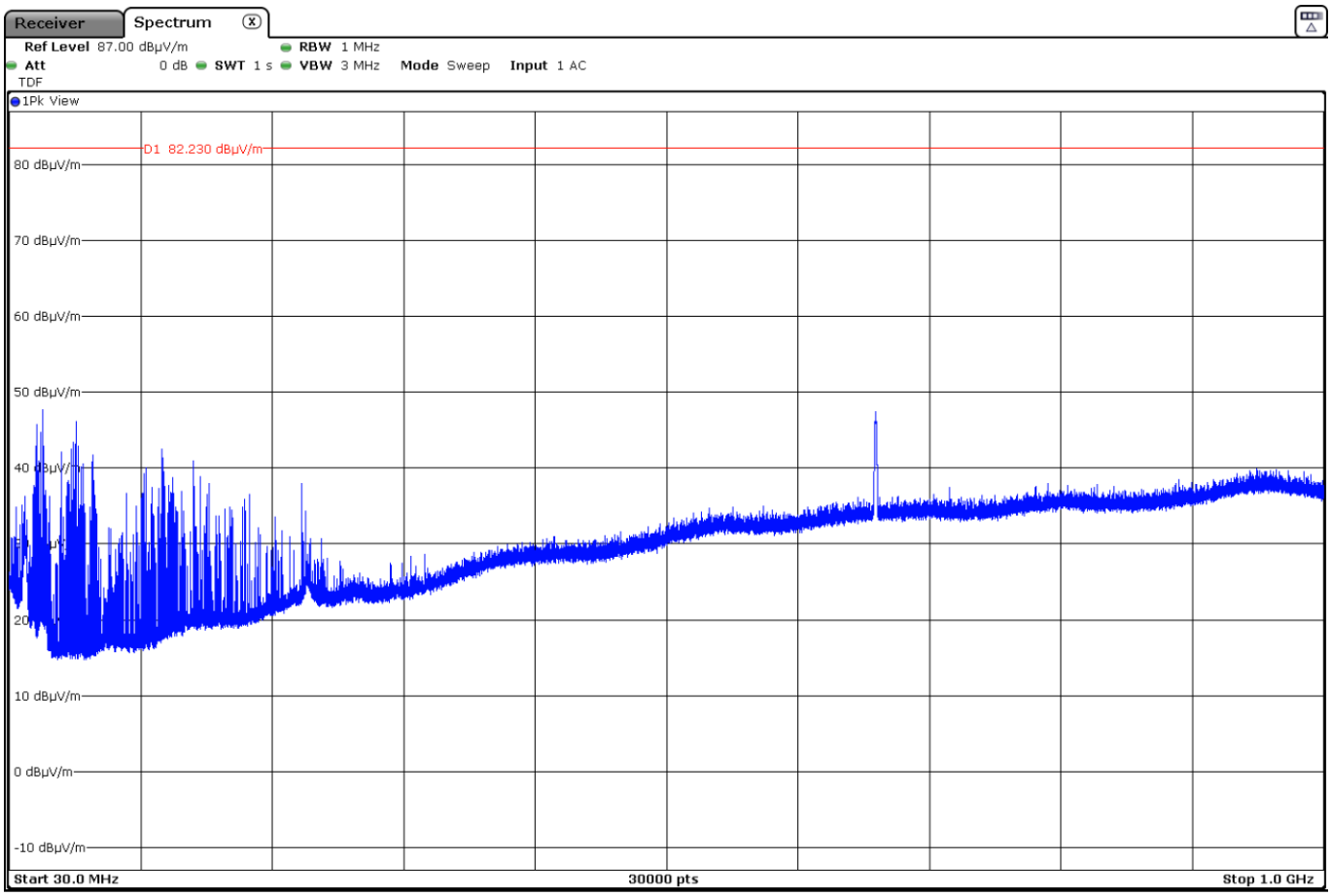
Frequency (GHz)	Instrument reading (dBm)	Polarization	(1) Generator output (dBm)	(2) Cable loss (dB)	(3) Substitution antenna gain Gi (respect to isotropic radiator) (dB)	E.I.R.P. (dBm) = (1) – (2) + (3)
1.062833	-54.03	H	-72.55	0.54	5.81	-32.12

Measurement uncertainty (dB)	<±3.88 for f < 1GHz <±3.70 for f ≥ 1 GHz up to 18 GHz <±3.33 for f ≥ 18 GHz up to 26 GHz

Verdict: PASS

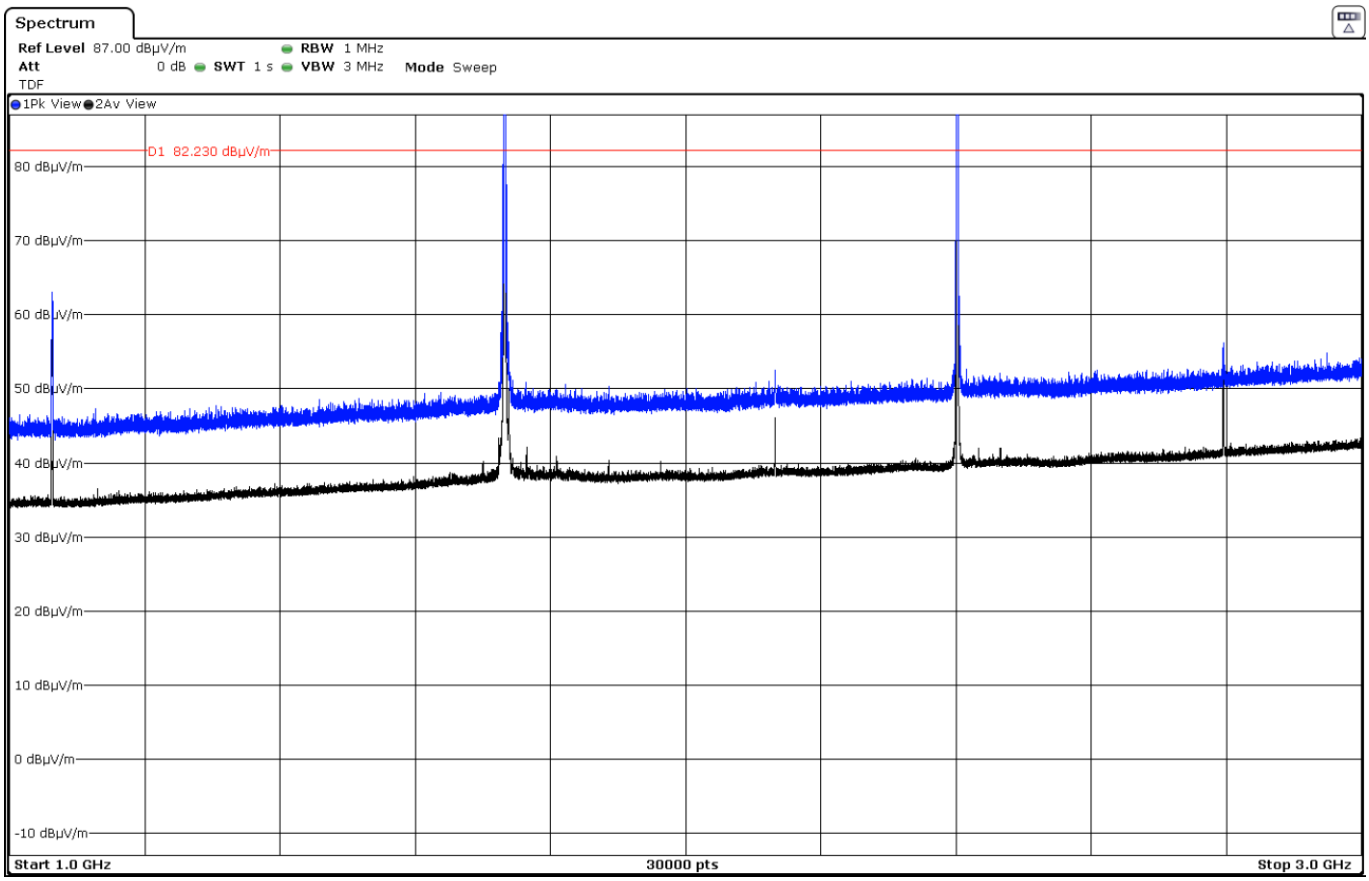
FREQUENCY RANGE 30 MHz - 1 GHz (mode NB-IoT Band 4 and Bluetooth Low Energy)

Pi/4-QPSK MODULATION



FREQUENCY RANGE 1 - 3 GHz (mode NB-IoT Band 4 and Bluetooth Low Energy)

Pi/4-QPSK MODULATION

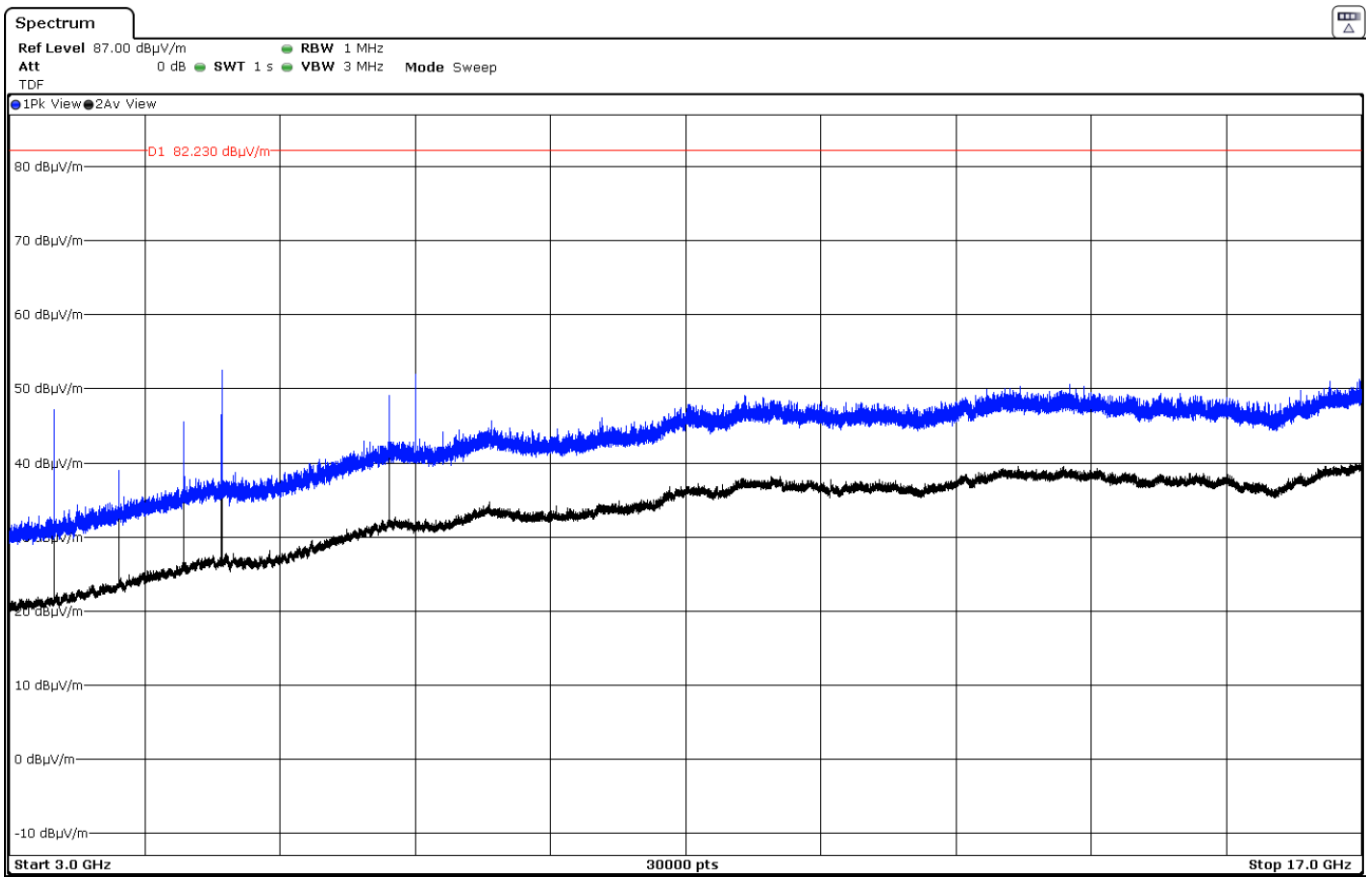


The peaks above the limit are the carrier frequencies:

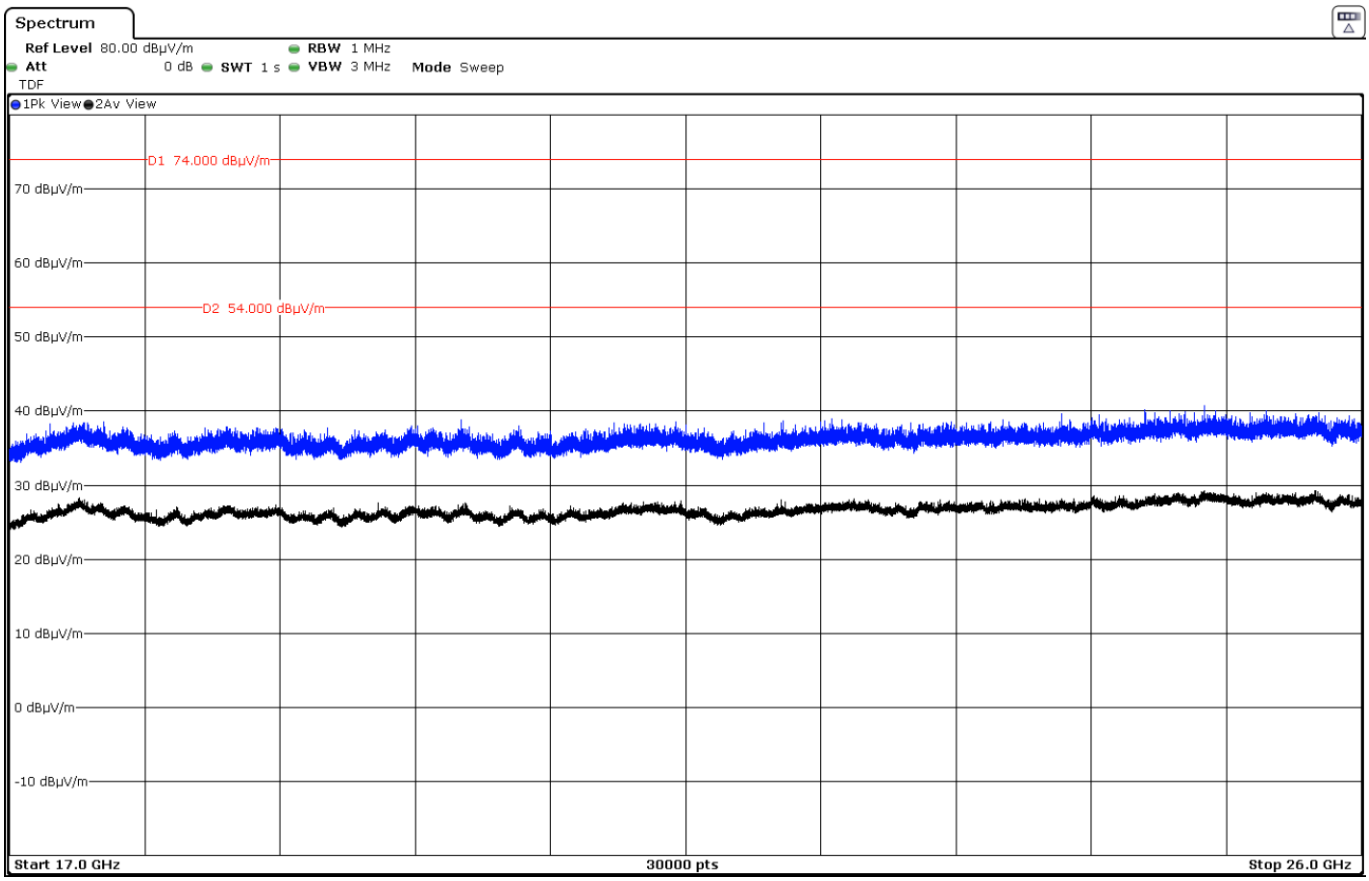
LTE Cat NB1 Band 4 (1732.50 MHz).

Bluetooth Low Energy (2402 MHz).

FREQUENCY RANGE 3 – 17 GHz (NB-IoT Band 4 and Bluetooth Low Energy)



FREQUENCY RANGE 17 - 26 GHz (NB-IoT Band 4 and Bluetooth Low Energy)



- **3. Mode LTE Cat M1 Band 12 and Bluetooth Low Energy.**

QPSK and 16QAM modulations:

A preliminary scan determined the QPSK modulation in Channel Middle as the worst case.

Frequency range 30 MHz - 1 GHz

The spurious emissions below 1 GHz do not depend on either the operating channel or the modulation mode selected in the EUT.

No spurious frequencies at less than 20 dB below the limit.

Frequency range 1 - 26 GHz

Spurious frequencies at less than 20 dB below the limit:

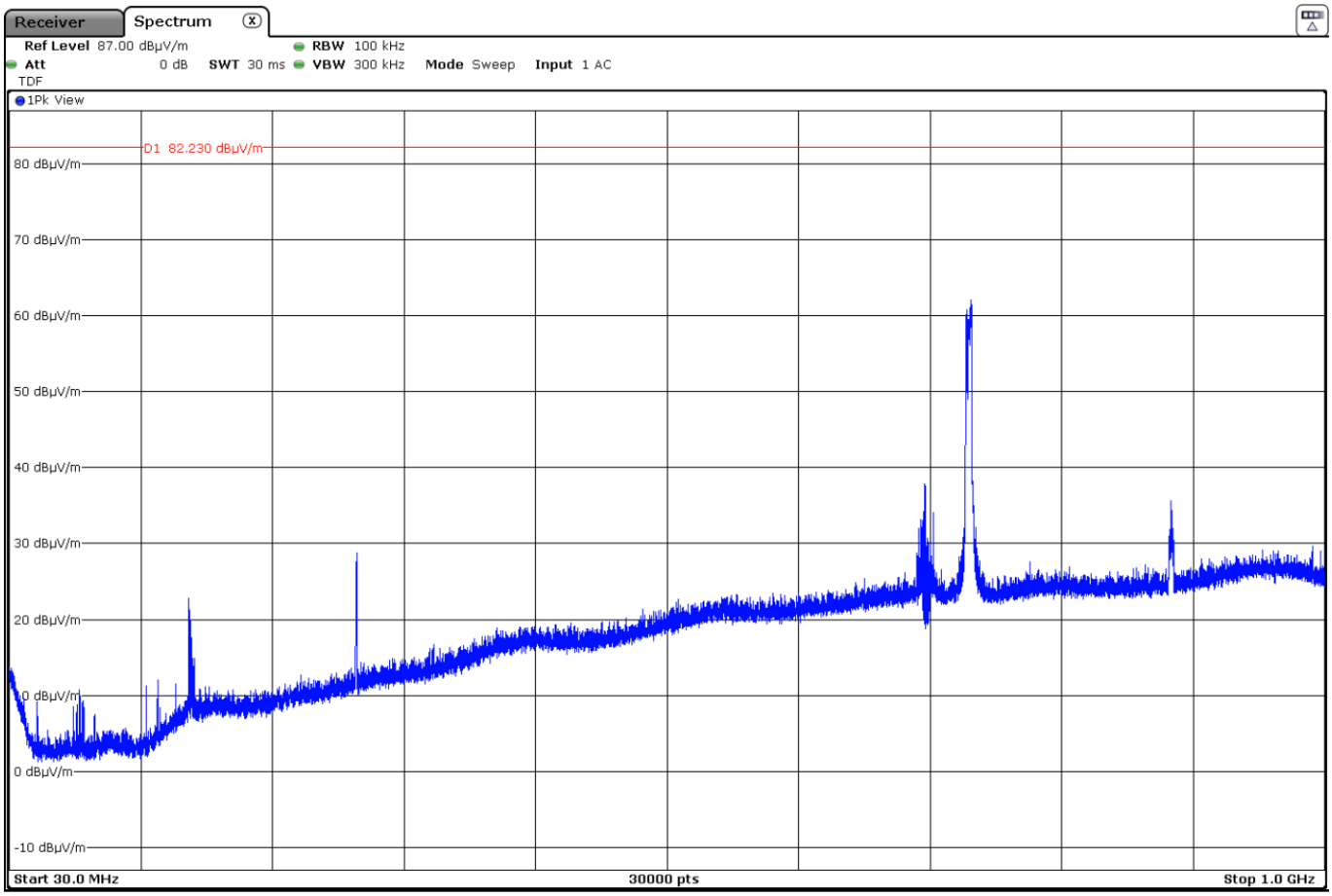
Frequency (GHz)	Instrument reading (dBm)	Polarization	(1) Generator output (dBm)	(2) Cable loss (dB)	(3) Substitution antenna gain Gi (respect to isotropic radiator) (dB)	E.I.R.P. (dBm) = (1) – (2) + (3)
1.410367	-13.70	V	-32.67	0.71	7.55	-25.83
4.23223	-19.81	V	-35.29	1.44	11.86	-24.87

Measurement uncertainty (dB)	<±3.88 for f < 1GHz <±3.70 for f ≥ 1 GHz up to 18 GHz <±3.33 for f ≥ 18 GHz up to 20 GHz

Verdict: PASS

FREQUENCY RANGE 30 MHz - 1 GHz (mode LTE Cat M1 Band 12 and Bluetooth Low Energy)

QPSK MODULATION

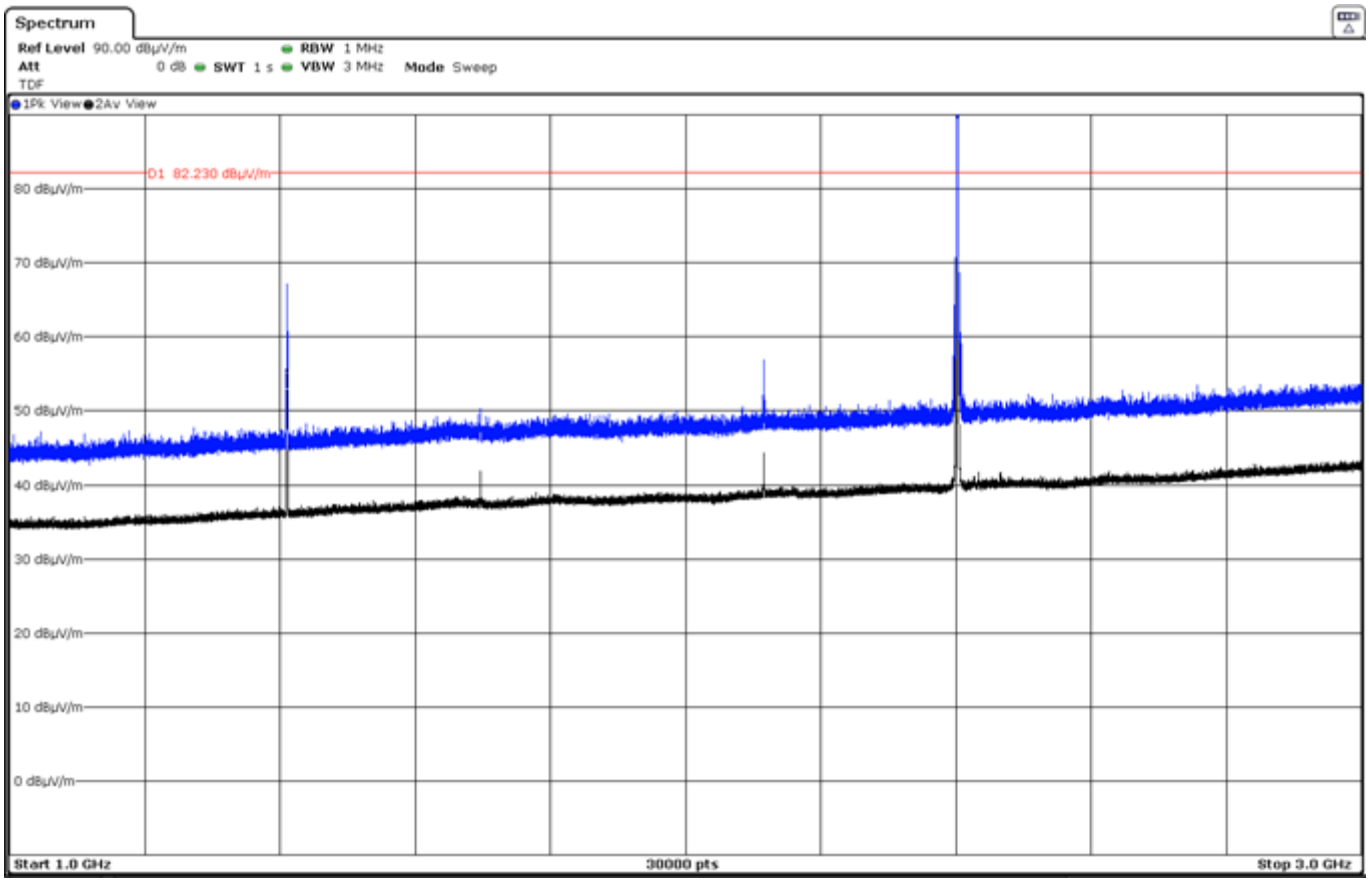


The highest peak is the carrier frequency:

LTE Cat M1 Band 12 (707.5 MHz).

FREQUENCY RANGE 1 - 3 GHz **(mode LTE Cat M1 Band 12 and Bluetooth Low Energy)**

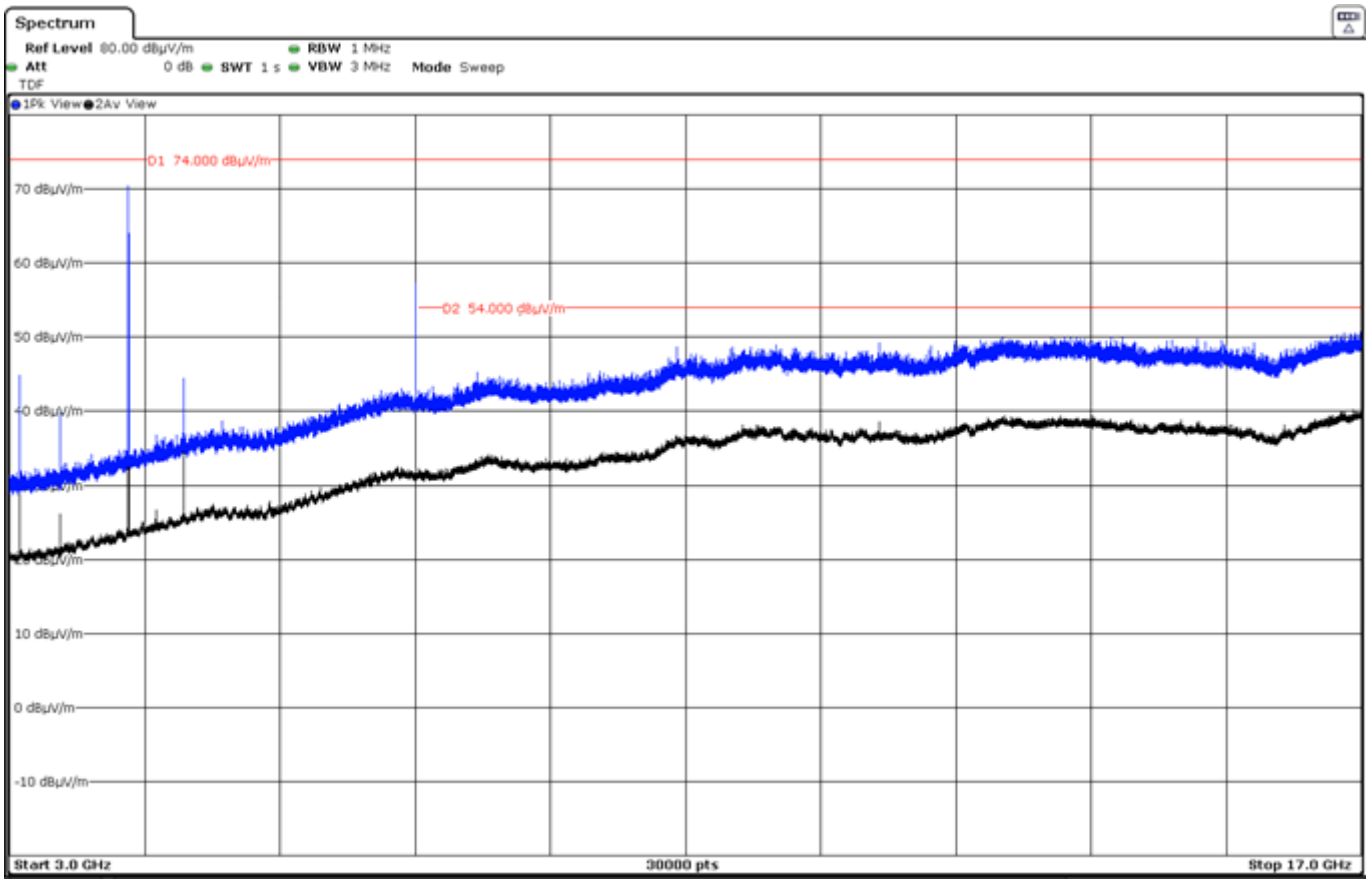
QPSK MODULATION



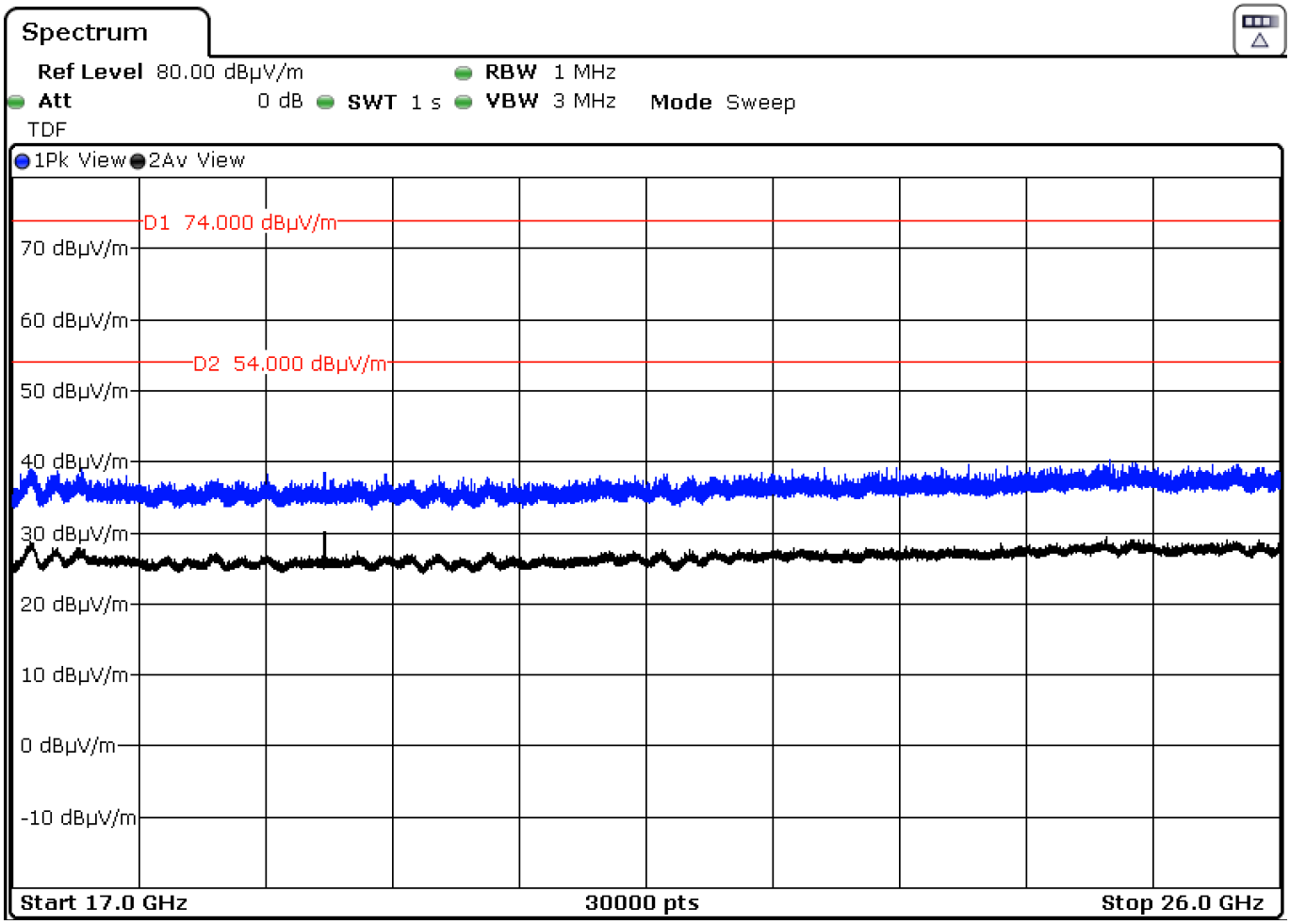
The peak above the limit is the carrier frequency:

Bluetooth Low Energy (2402 MHz).

FREQUENCY RANGE 3 – 17 GHz (mode LTE Cat M1 Band 12 and Bluetooth Low Energy)



FREQUENCY RANGE 17 - 26 GHz (mode LTE Cat M1 Band 12 and Bluetooth Low Energy)



- **4. Mode NB-IoT Band 12 and Bluetooth Low Energy.**

QPSK, Pi/4-QPSK and Pi/2-BPSK modulations:

A preliminary scan determined the Pi/4-QPSK modulation in Channel Middle as the worst case.

Frequency range 30 MHz - 1 GHz

The spurious emissions below 1 GHz do not depend on either the operating channel or the modulation mode selected in the EUT.

No spurious frequencies at less than 20 dB below the limit.

Frequency range 1 - 26 GHz

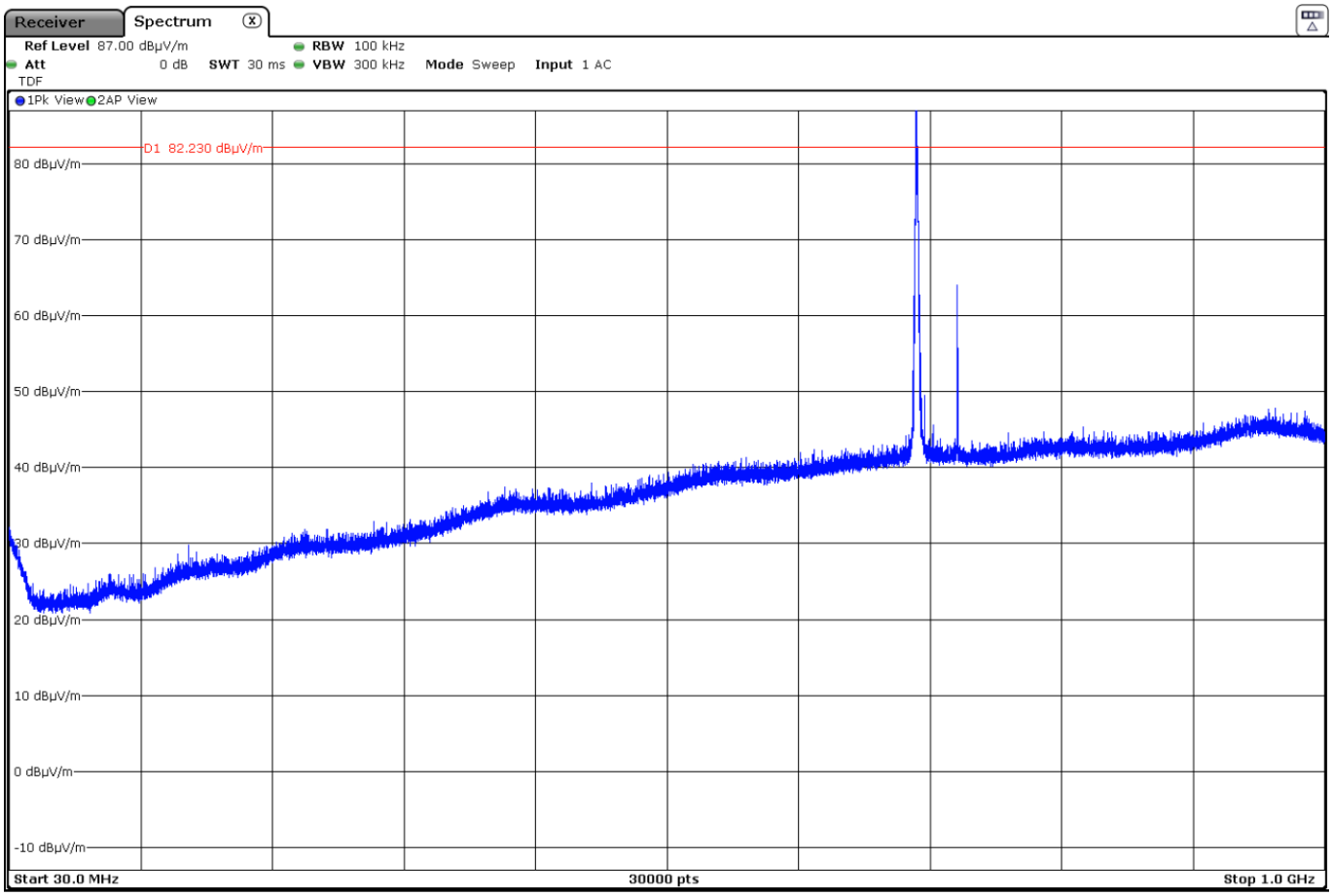
Spurious frequency (GHz)	Emission Level (dBµV/m)	Polarization	Detector	Measurement Uncertainty (dB)
7.20677	54.79	V	Peak	<±4.70
	50.38		Average	<±4.70
19.21595	39.43	V	Peak	<±4.70

Measurement uncertainty (dB)	<±3.88 for f < 1GHz <±3.70 for f ≥ 1 GHz up to 18 GHz <±3.33 for f ≥ 18 GHz up to 20 GHz

Verdict: PASS

FREQUENCY RANGE 30 MHz - 1 GHz (mode NB-IoT Band 12 and Bluetooth Low Energy)

Pi/4-QPSK MODULATION



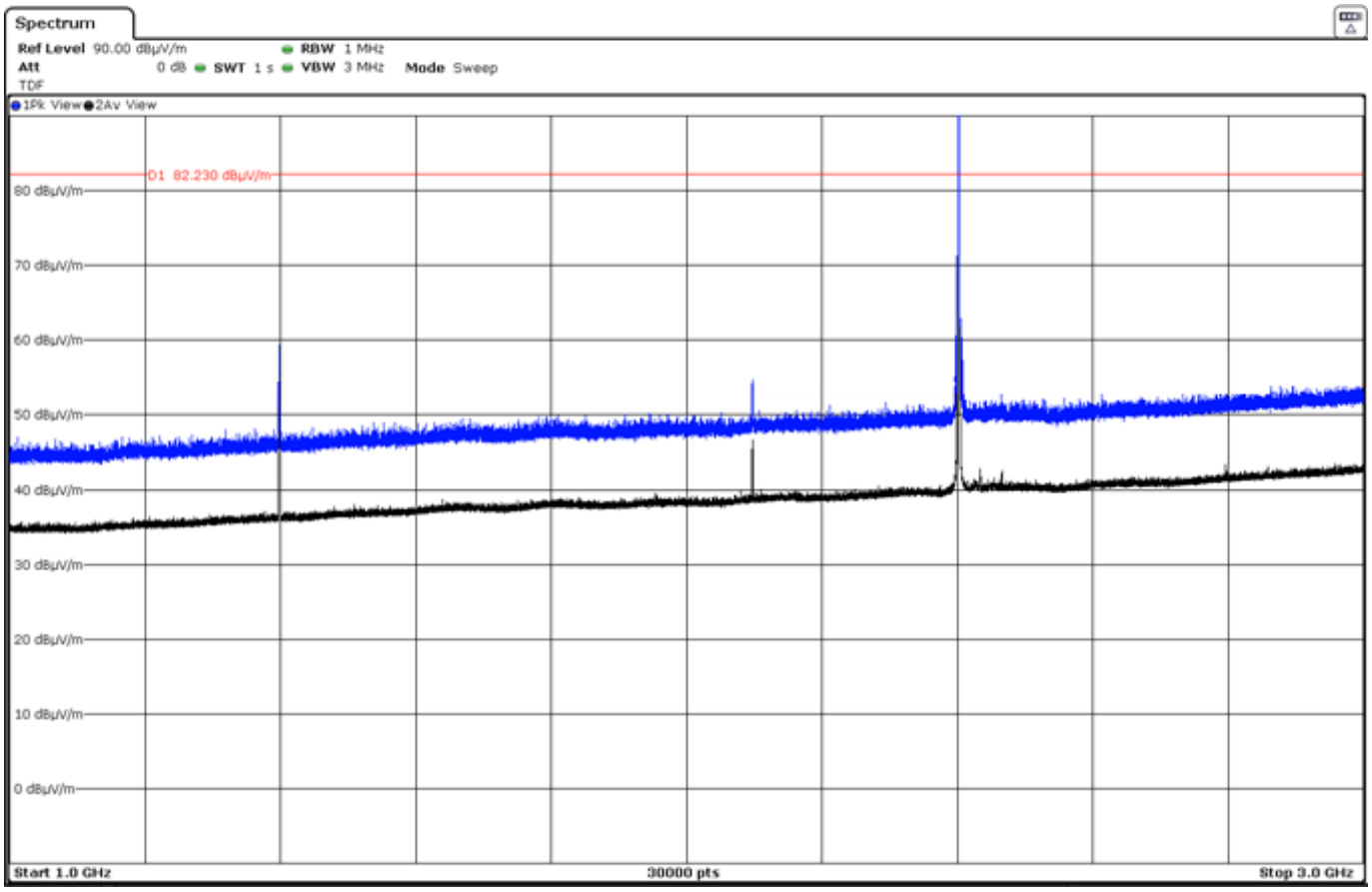
The peak above the limit is the carrier frequency:

LTE Cat NB1 Band 12 (699.2 MHz).

The peak at 729.225 MHz corresponds to the downlink signal.

FREQUENCY RANGE 1 - 3 GHz (mode NB-IoT Band 12 and Bluetooth Low Energy)

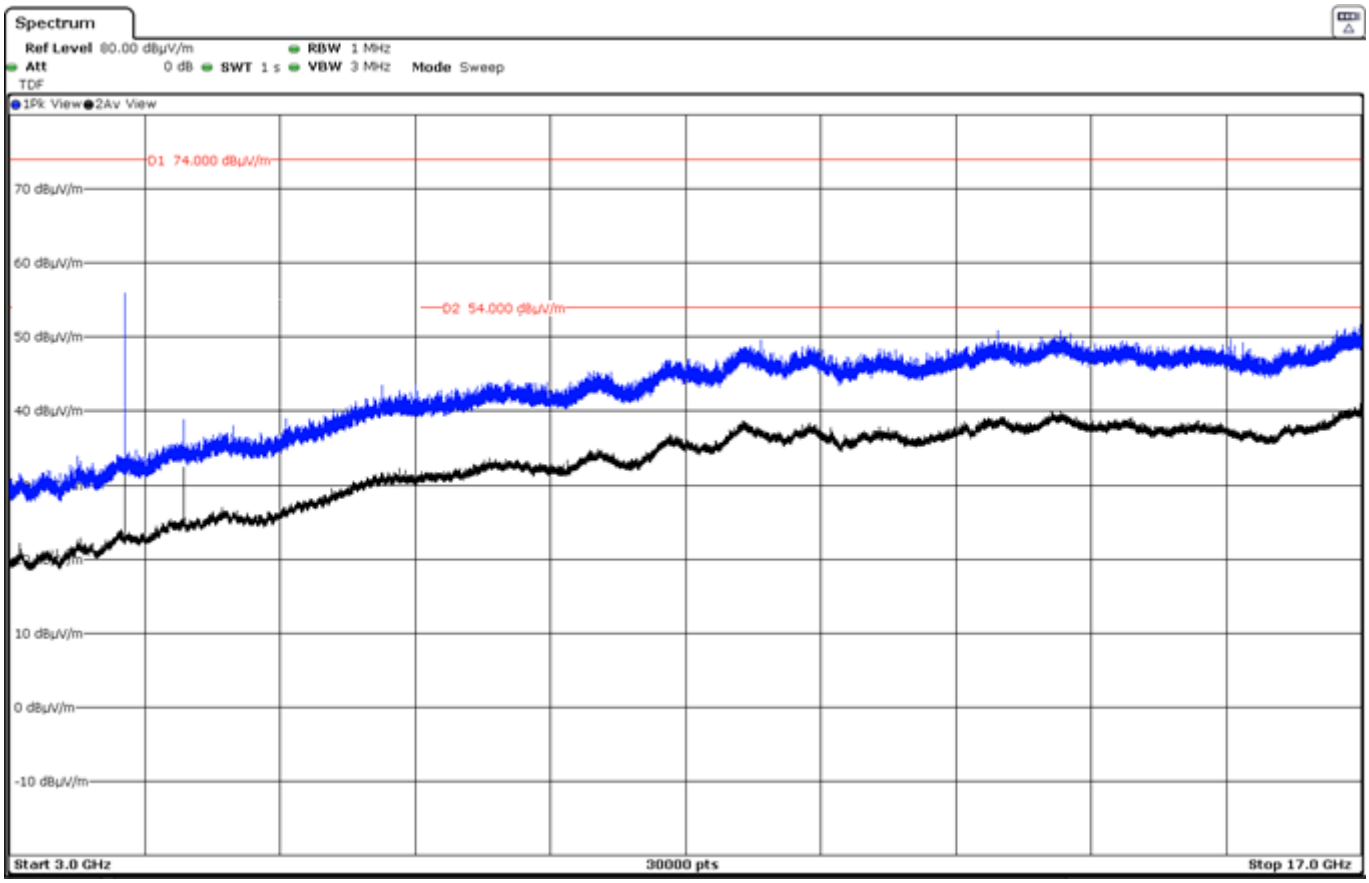
Pi/4-QPSK MODULATION



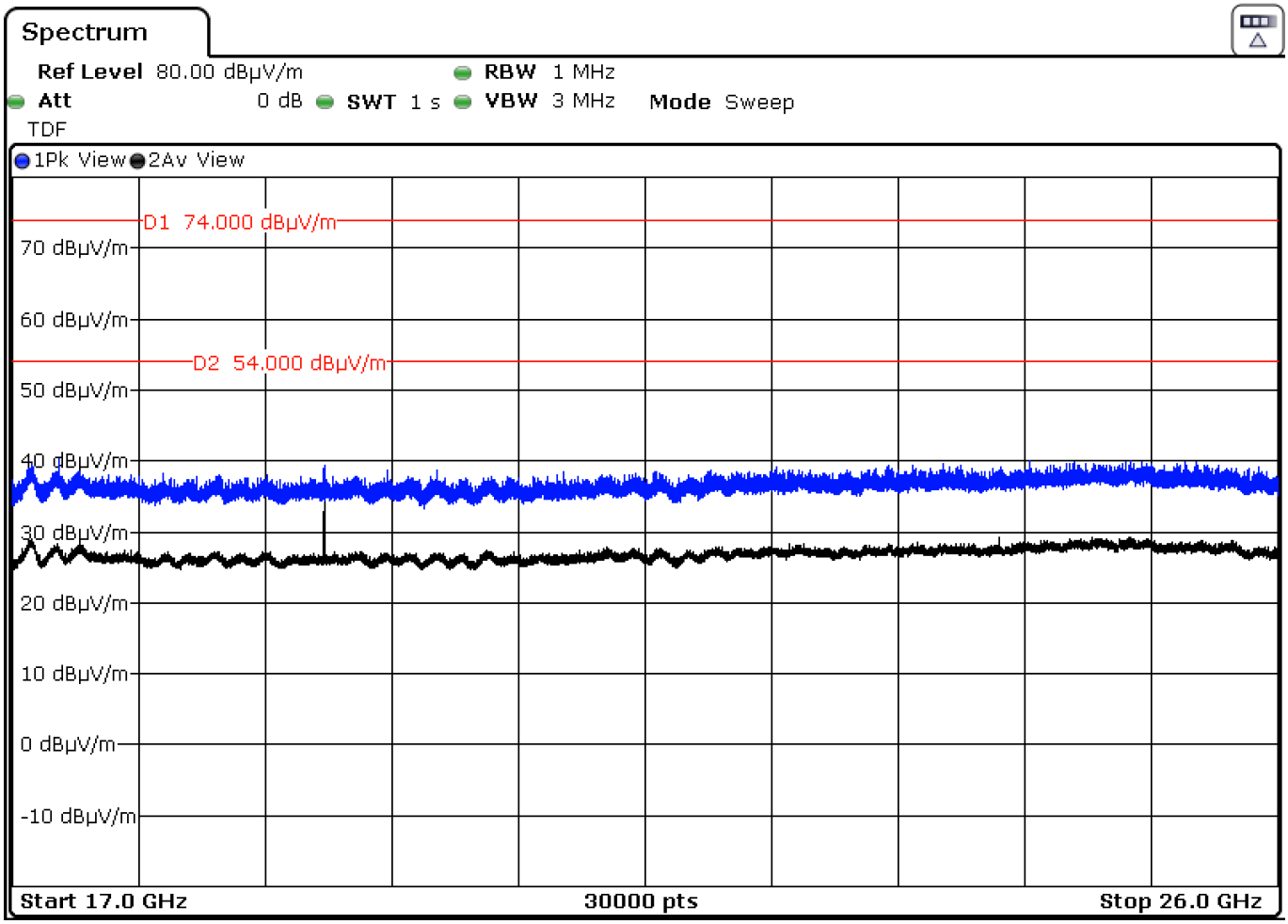
The peak above the limit is the carrier frequency:

Bluetooth Low Energy (2402 MHz).

FREQUENCY RANGE 3 – 17 GHz (mode NB-IoT Band 12 and Bluetooth Low Energy)



FREQUENCY RANGE 17 - 26 GHz (mode NB-IoT Band 12 and Bluetooth Low Energy)



- **5. Mode LTE Cat M1 Band 13 and Bluetooth Low Energy.**

QPSK and 16QAM modulations:

A preliminary scan determined the QPSK modulation in Channel Middle as the worst case.

Frequency range 30 MHz - 1 GHz

The spurious emissions below 1 GHz do not depend on either the operating channel or the modulation mode selected in the EUT.

No spurious frequencies at less than 20 dB below the limit.

Frequency range 1 - 26 GHz

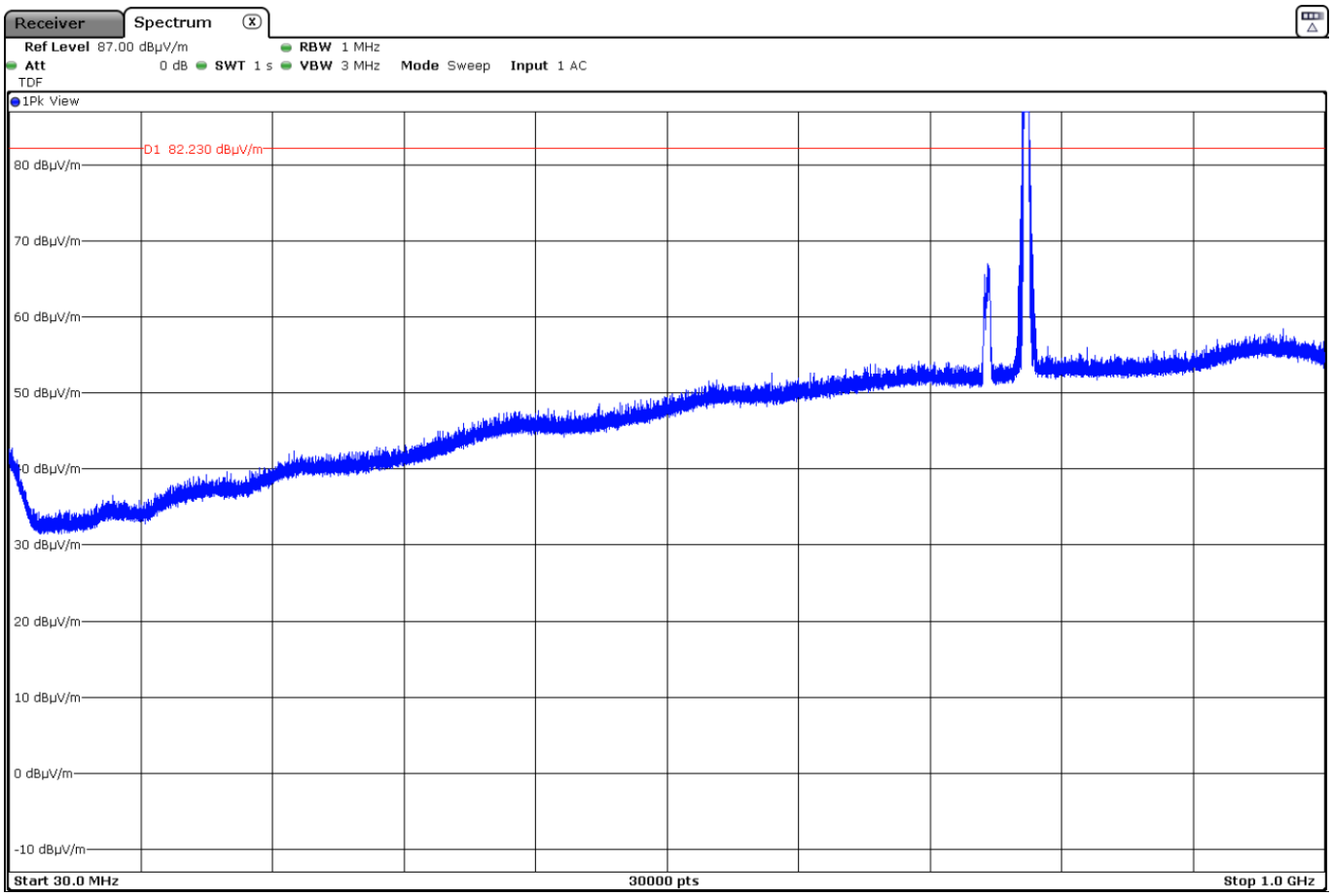
No spurious frequencies at less than 20 dB below the limit.

Measurement uncertainty (dB)	<±3.88 for f < 1GHz <±3.70 for f ≥ 1 GHz up to 18 GHz <±3.33 for f ≥ 18 GHz up to 20 GHz

Verdict: PASS

FREQUENCY RANGE 30 MHz - 1 GHz (mode LTE Cat M1 Band 13 and Bluetooth Low Energy)

QPSK MODULATION



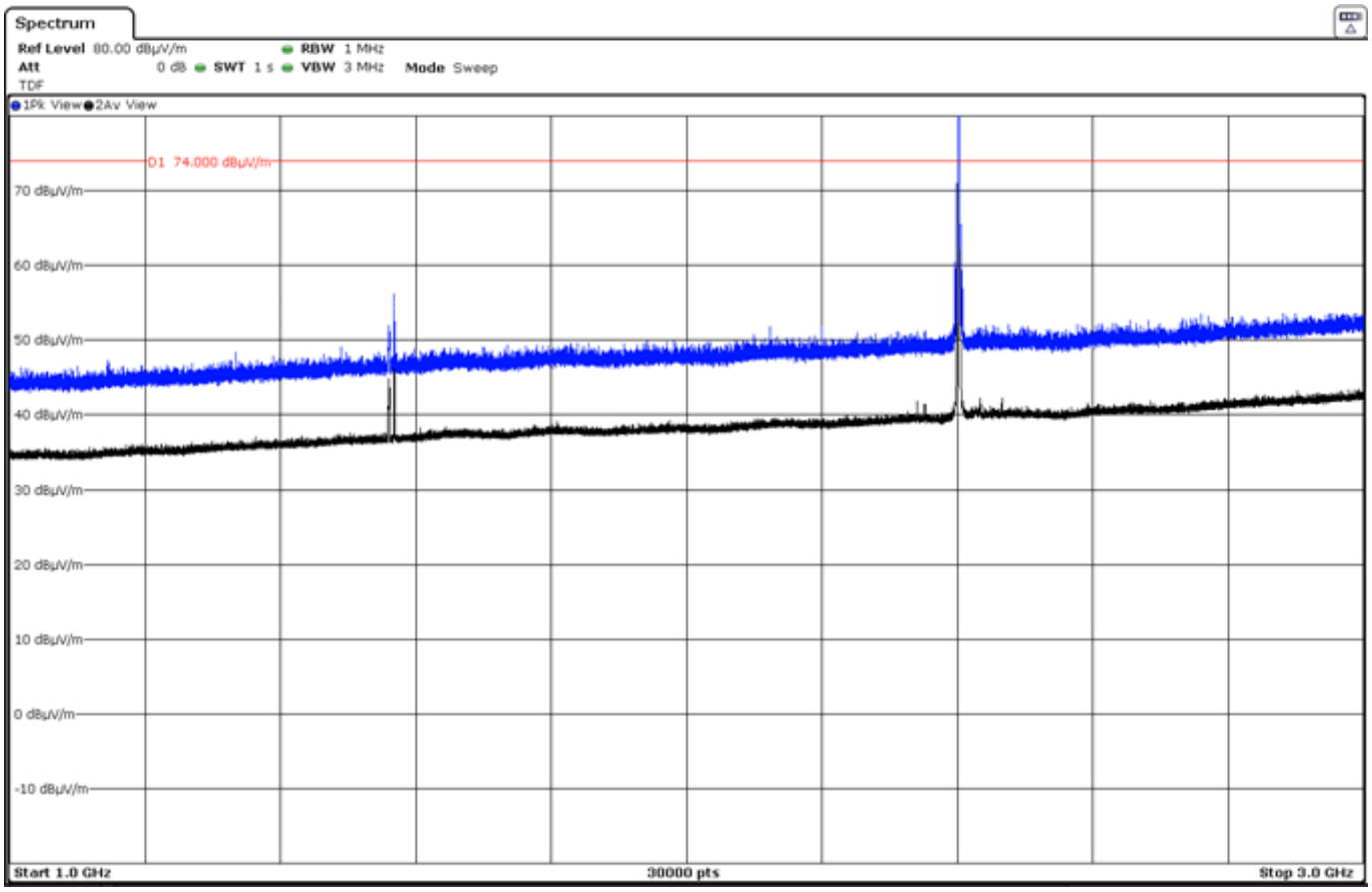
The highest peak is the carrier frequency:

LTE Cat M1 Band 13 (782 MHz).

The peak at 751 MHz corresponds to the downlink signal.

FREQUENCY RANGE 1 - 3 GHz **(mode LTE Cat M1 Band 13 and Bluetooth Low Energy)**

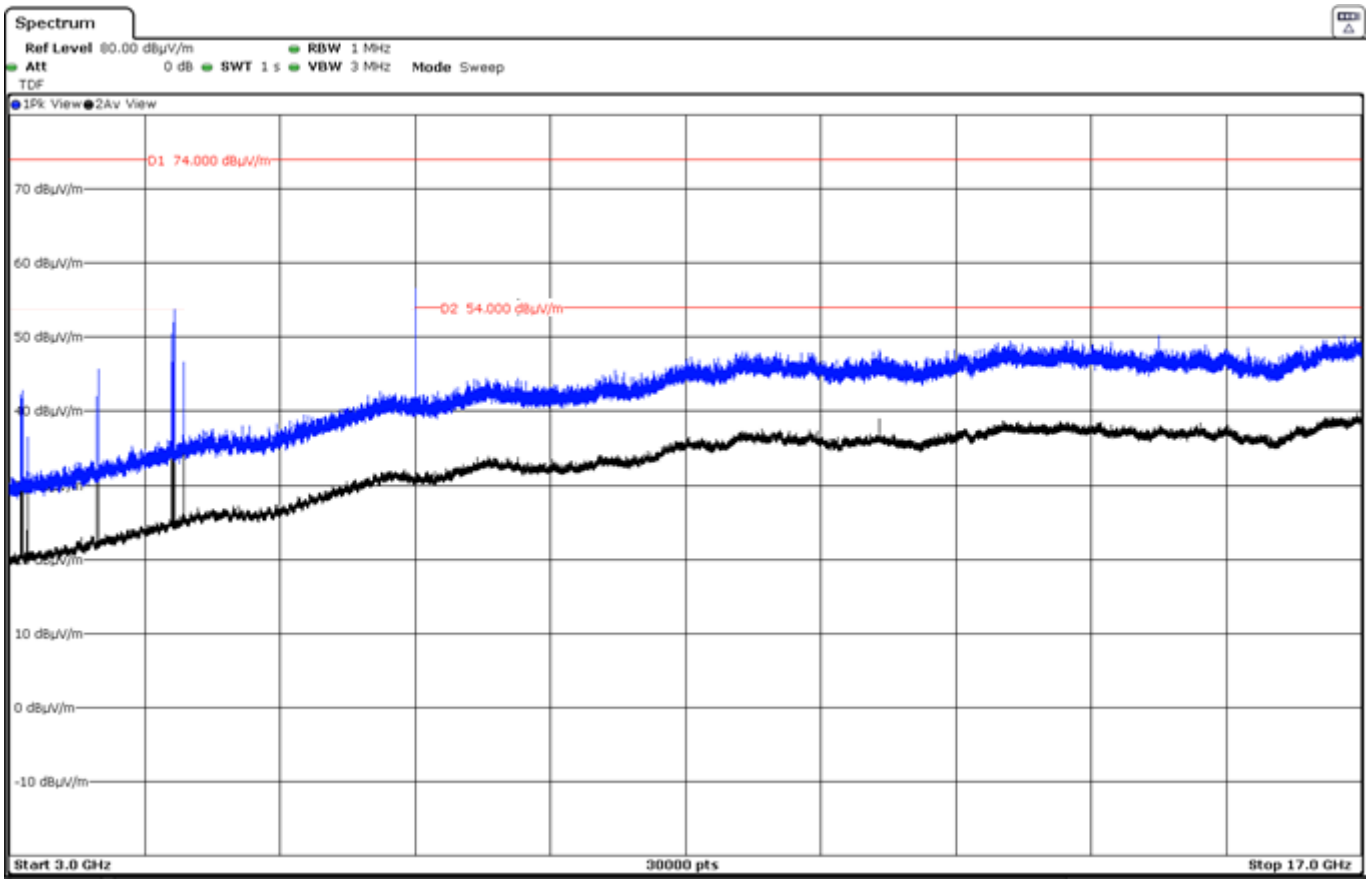
QPSK MODULATION



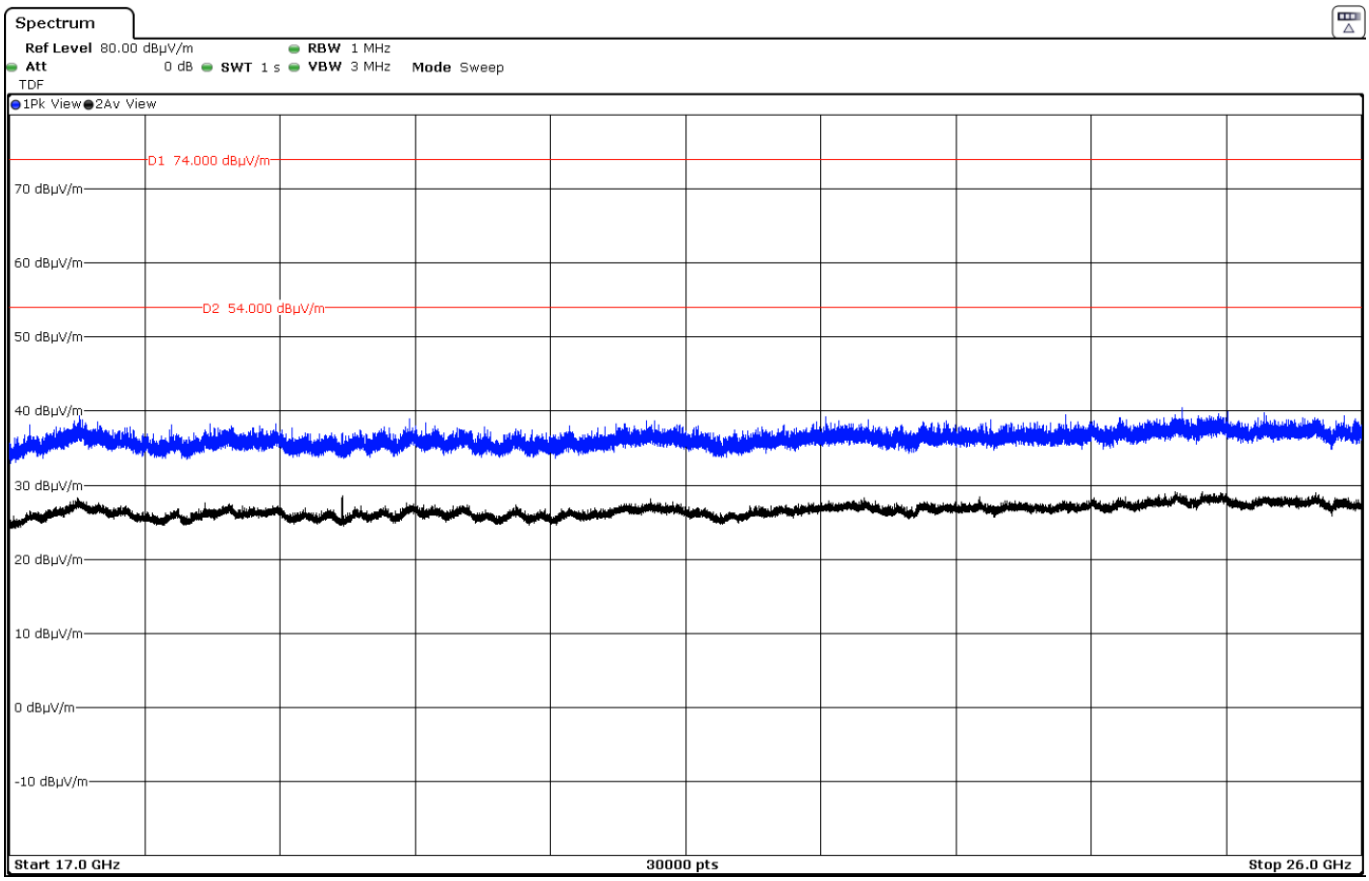
The peak above the limit is the carrier frequency:

Bluetooth Low Energy (2402 MHz).

FREQUENCY RANGE 3 – 17 GHz (mode LTE Cat M1 Band 13 and Bluetooth Low Energy)



FREQUENCY RANGE 17 - 26 GHz (mode LTE Cat M1 Band 13 and Bluetooth Low Energy)



- **6. Mode NB-IoT Band 13 and Bluetooth Low Energy.**

QPSK, Pi/4-QPSK and Pi/2-BPSK Modulations:

A preliminary scan determined the Pi/4-QPSK modulation in Channel Middle as the worst case.

Frequency range 30 MHz - 1 GHz

The spurious emissions below 1 GHz do not depend on either the operating channel or the modulation mode selected in the EUT.

No spurious frequencies at less than 20 dB below the limit.

Frequency range 1 - 26 GHz

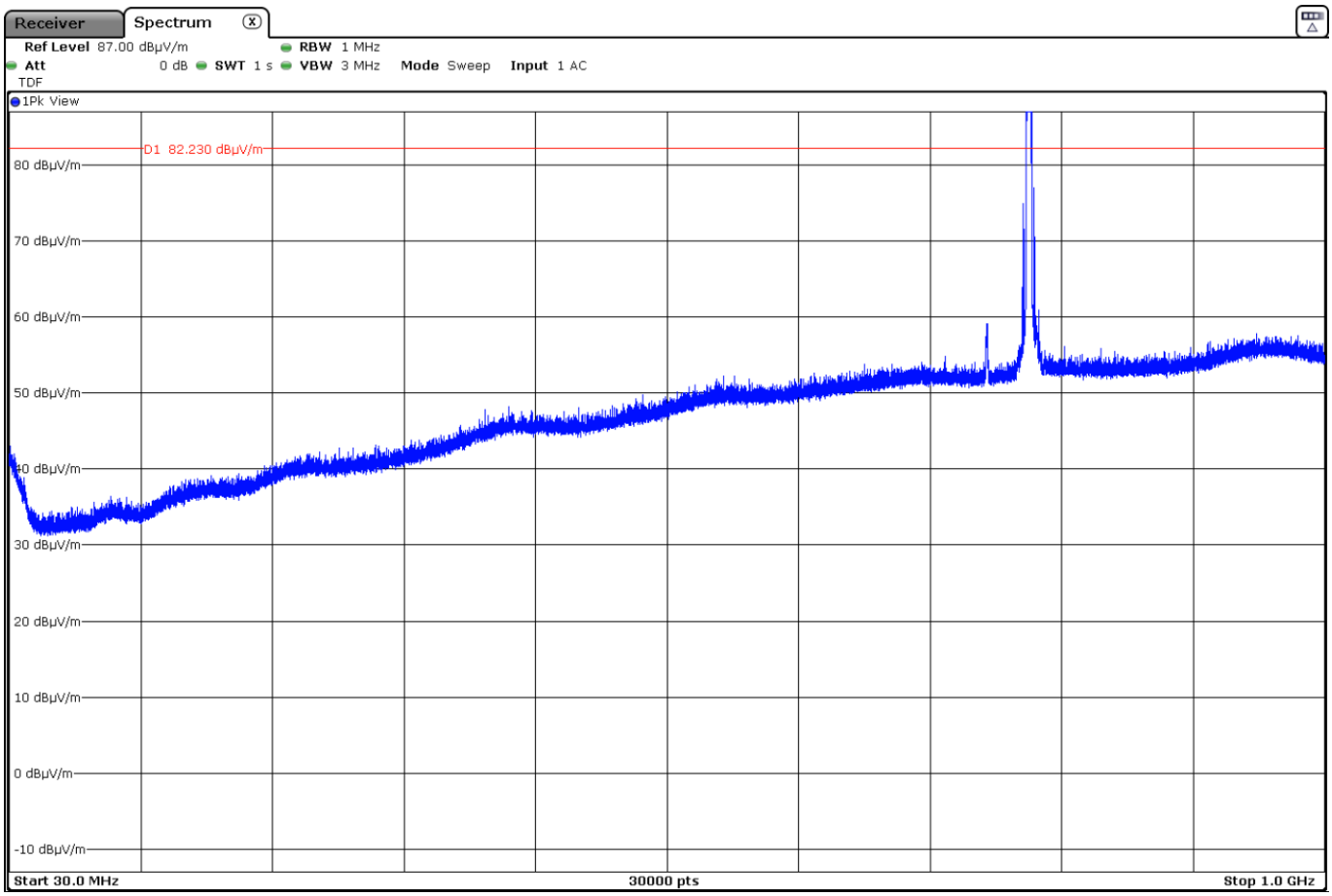
No spurious frequencies at less than 20 dB below the limit.

Measurement uncertainty (dB)	<±3.88 for f < 1GHz <±3.70 for f ≥ 1 GHz up to 18 GHz <±3.33 for f ≥ 18 GHz up to 20 GHz

Verdict: PASS

FREQUENCY RANGE 30 MHz - 1 GHz (mode NB-IoT Band 13 and Bluetooth Low Energy)

Pi/4-QPSK MODULATION

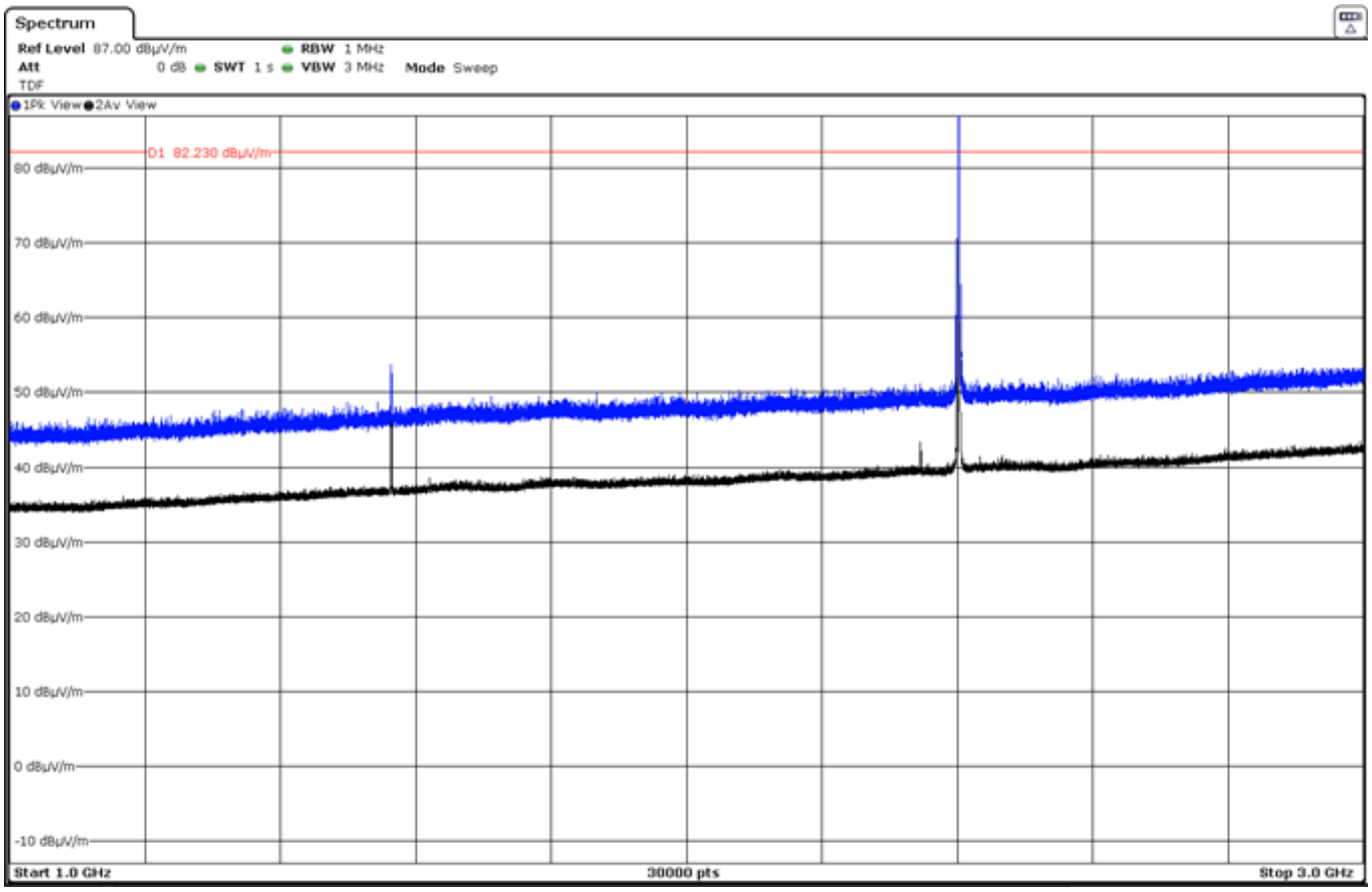


The peak above the limit is the carrier frequency:

LTE Cat M1 Band 12 (782 MHz).

FREQUENCY RANGE 1 - 3 GHz (mode NB-IoT Band 13 and Bluetooth Low Energy)

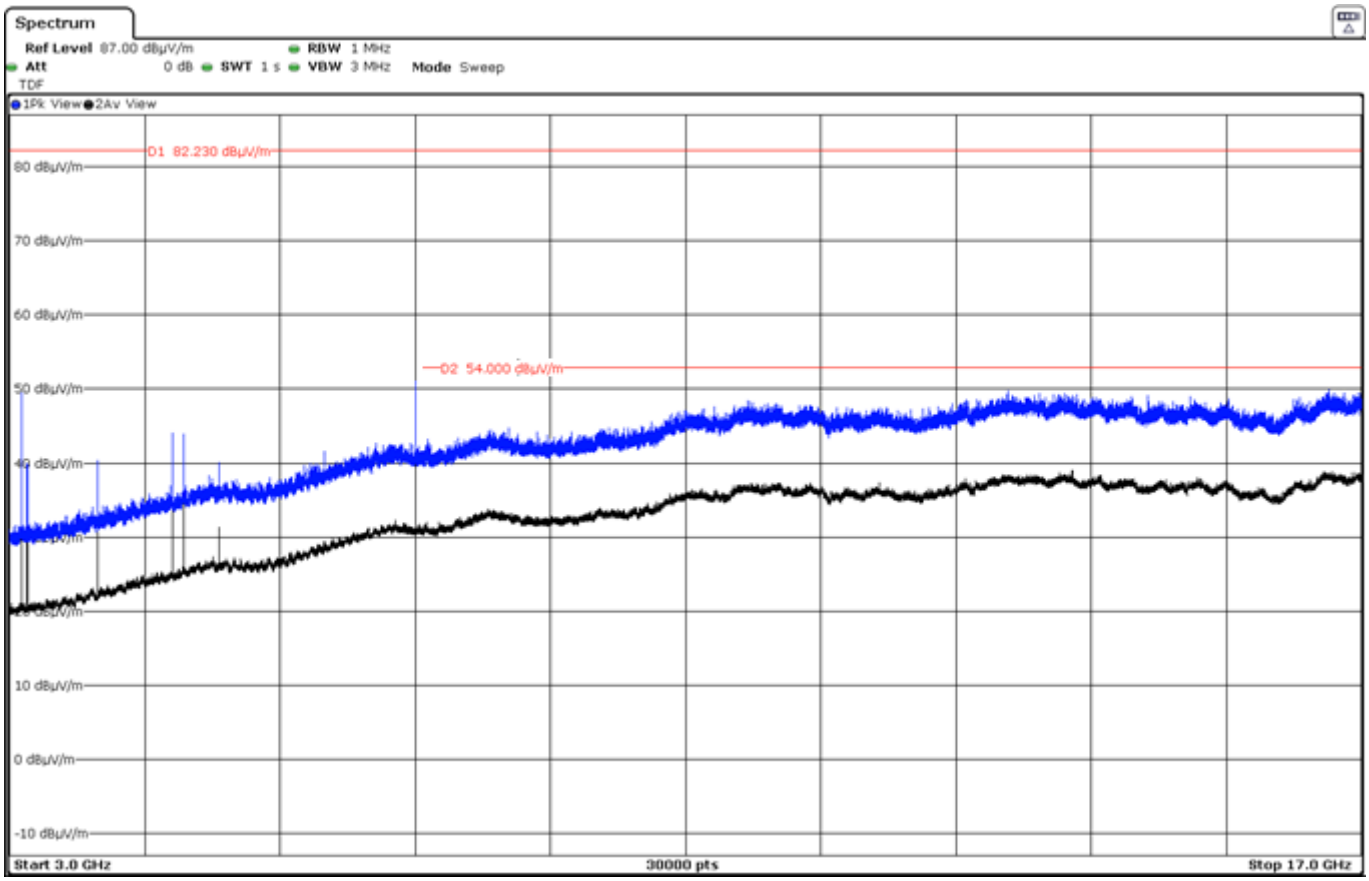
Pi/4-QPSK MODULATION



The peak above the limit is the carrier frequency:

Bluetooth Low Energy (2402 MHz).

FREQUENCY RANGE 3 – 17 GHz (mode NB-IoT Band 13 and Bluetooth Low Energy)



FREQUENCY RANGE 17 - 26 GHz (mode NB-IoT Band 13 and Bluetooth Low Energy)