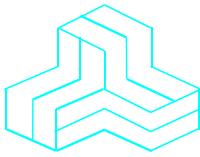


ENGINEERING TEST REPORT



QT-5100 Module
Model: QT-5100
FCC ID: Q5N-QT5100

Applicant:

Quantum5x Systems Inc.
30 Adelaide Street North Suite 12
London, Ontario
Canada N6B 3N5

In Accordance With

Federal Communications Commission (FCC)
Part 15, Subpart C, Section 15.247
Digital Modulation Systems (DTS) Operating in 2400 – 2483.5 MHz Band

UltraTech's File No.: 18Q5X047_FCC15C247B2

This Test report is Issued under the Authority of
Tri M. Luu
Vice President of Engineering
UltraTech Group of Labs

Date: March 28, 2018

Report Prepared by: Dan Huynh

Tested by: Hung Trinh

Issued Date: March 28, 2018

Test Dates: December 7 - 17, 2016
March 31, May 28, & June 8, 2017

- *The results in this Test Report apply only to the sample(s) tested, and the sample tested is randomly selected.*
- *This report must not be used by the client to claim product endorsement by any agency of the US Government.*
- *This test report shall not be reproduced, except in full, without a written approval from UltraTech*

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91038



1309



46390-2049



AT-1945



SL2-IN-E-1119R



CA2049

TABLE OF CONTENTS

EXHIBIT 1. INTRODUCTION.....	1
1.1. SCOPE	1
1.2. RELATED SUBMITTAL(S)/GRANT(S)	1
1.3. NORMATIVE REFERENCES	1
EXHIBIT 2. PERFORMANCE ASSESSMENT	2
2.1. CLIENT INFORMATION	2
2.2. EQUIPMENT UNDER TEST (EUT) INFORMATION	2
2.3. EUT'S TECHNICAL SPECIFICATIONS.....	3
2.4. ASSOCIATED ANTENNA DESCRIPTIONS	3
2.5. LIST OF EUT'S PORTS.....	3
2.6. ANCILLARY EQUIPMENT.....	4
EXHIBIT 3. EUT OPERATING CONDITIONS AND CONFIGURATIONS DURING TESTS	5
3.1. CLIMATE TEST CONDITIONS	5
3.2. OPERATIONAL TEST CONDITIONS & ARRANGEMENT FOR TESTS.....	5
EXHIBIT 4. SUMMARY OF TEST RESULTS.....	6
4.1. LOCATION OF TESTS	6
4.2. APPLICABILITY & SUMMARY OF EMC EMISSION TEST RESULTS	6
4.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES	7
EXHIBIT 5. TEST DATA	8
5.1. POWER LINE CONDUCTED EMISSIONS [§15.207(a)].....	8
5.2. OCCUPIED BANDWIDTH [§ 15.247(a)(2)].....	14
5.3. PEAK CONDUCTED OUTPUT POWER - DTS [§ 15.247(b)(3)]	17
5.4. TRANSMITTER BAND-EDGE & SPURIOUS CONDUCTED EMISSIONS [§ 15.247(d)]	20
5.5. TRANSMITTER SPURIOUS RADIATED EMISSIONS AT 3 METERS [§§ 15.247(d), 15.209 & 15.205]	37
5.6. POWER SPECTRAL DENSITY [§ 15.247(e)].....	40
5.7. RF EXPOSURE REQUIRMENTS [§§ 15.247(i), 1.1310 & 2.1091].....	43
EXHIBIT 6. TEST EQUIPMENT LIST	45
EXHIBIT 7. MEASUREMENT UNCERTAINTY	46
7.1. LINE CONDUCTED EMISSION MEASUREMENT UNCERTAINTY.....	46
7.2. RADIATED EMISSION MEASUREMENT UNCERTAINTY	46

EXHIBIT 1. INTRODUCTION

1.1. SCOPE

Reference:	FCC Part 15, Subpart C, Section 15.247
Title:	Code of Federal Regulations (CFR), Title 47 – Telecommunication, Part 15 – Radio Frequency Devices
Purpose of Test:	Equipment Certification for Digital Modulation Systems (DTS) Operating Under §15.247
Test Procedures:	<ul style="list-style-type: none">▪ ANSI C63.4▪ ANSI C63.10▪ FCC KDB Publication No. 558074 D01 DTS Meas Guidance v03r05
Environmental Classification:	<input checked="" type="checkbox"/> Commercial, industrial or business environment <input checked="" type="checkbox"/> Residential environment

1.2. RELATED SUBMITTAL(S)/GRANT(S)

None.

1.3. NORMATIVE REFERENCES

Publication	Year	Title
47 CFR Parts 0-19	2017	Code of Federal Regulations (CFR), Title 47 – Telecommunication
ANSI C63.4	2014	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 KHz to 40 GHz
ANSI C63.10	2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
FCC, KDB Publication No. 558074 D01 DTS Meas Guidance v03r05	2016	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1. CLIENT INFORMATION

Applicant	
Name:	Quantum5x Systems Inc.
Address:	30 Adelaide Street North Suite 12 London, Ontario Canada N6B 3N5
Contact Person:	Mr. Paul Johnson Phone #: 519-675-6999 Fax #: 519-667-2162 Email Address: paul@q5x.com

Manufacturer	
Name:	Quantum5x Systems Inc.
Address:	30 Adelaide Street North Suite 12 London, Ontario Canada N6B 3N5
Contact Person:	Mr. Paul Johnson Phone #: 519-675-6999 Fax #: 519-667-2162 Email Address: paul@q5x.com

2.2. EQUIPMENT UNDER TEST (EUT) INFORMATION

The following information (with the exception of the Date of Receipt) has been supplied by the applicant.

Brand Name:	Quantum5x Systems Inc.
Product Name:	QT-5100 Module
Model Name or Number:	QT-5100
Serial Number:	Test Sample
Type of Equipment:	Digital Transmission System (DTS)
Input Power Supply Type:	Lithium-Ion Battery / External DC Power
Primary User Functions of EUT:	The Primary use is to broadcast audio from the user.

2.3. EUT'S TECHNICAL SPECIFICATIONS

Transmitter	
Equipment Type:	Portable and Mobile
Intended Operating Environment:	Commercial, industrial or business environment
Power Supply Requirement:	3.7 V Lithium-Ion battery/ 5 VDC via AC adapter
RF Output Power Rating:	17.85 dBm (60.95 mW)
Operating Frequency Range:	2405 – 2480 MHz
RF Output Impedance:	50 Ω
Duty Cycle:	Continuous
Modulation Type:	MSK
Antenna Connector Types:	Integral / SSMA connector

2.4. ASSOCIATED ANTENNA DESCRIPTIONS

Antenna Type	Maximum Gain (dBi)
1/4 Wave Wire	3

2.5. LIST OF EUT'S PORTS

Port Number	EUT's Port Description	Number of Identical Ports	Connector Type	Cable Type (Shielded/Non-shielded)
1	Audio input, Single Pin Lemo	1	Single Pin Lemo	2" min length, Shielded
2	UHF Antenna	1	Hardwired	4.5"
3	802.15.4 Antenna	1	Hardwired	1 1/8"
4	Battery Charger	1	Micro USB	5', Shielded

2.6. ANCILLARY EQUIPMENT

The EUT was tested while connected to the following representative configuration of ancillary equipment necessary to exercise the ports during tests:

Ancillary Equipment # 1	
Description:	AC/DC Adapter
Brand name:	Emerson Network Power
Model Name or Number:	DCH3-050US-0002
Connected to EUT's Port:	Micro USB

Ancillary Equipment # 2	
Description:	Remote Gateway
Brand name:	Q5X
Model Name or Number:	QG-N2
Connected to EUT's Port:	N/A

Ancillary Equipment # 3	
Description:	Laptop
Brand name:	Acer
Model Name or Number:	D270-1998
Connected to EUT's Port:	N/A

EXHIBIT 3. EUT OPERATING CONDITIONS AND CONFIGURATIONS DURING TESTS

3.1. CLIMATE TEST CONDITIONS

The climate conditions of the test environment are as follows:

Temperature:	21 to 23 °C
Humidity:	45 to 58%
Pressure:	102 kPa
Power Input Source:	3.7 V Lithium-Ion battery / 5 VDC via AC adapter

3.2. OPERATIONAL TEST CONDITIONS & ARRANGEMENT FOR TESTS

Operating Modes:	The transmitter was operated in a continuous transmission mode with the carrier modulated as specified in the Test Data.
Special Test Software:	Test software provided by the Applicant to operate the EUT at each channel frequency continuously and in the range of typical modes of operation.
Special Hardware Used:	N/A
Transmitter Test Antenna:	The EUT is tested with the antenna port terminated to a 50 Ohm RF Load.

Transmitter Test Signals	
Frequency Band(s):	2405 – 2480 MHz
Frequency(ies) Tested:	2405 MHz, 2440 MHz, 2480 MHz
RF Power Output: (measured maximum output power at antenna terminals)	17.85 dBm (60.95 mW) Peak
Normal Test Modulation:	MSK
Modulating Signal Source:	Internal

EXHIBIT 4. SUMMARY OF TEST RESULTS

4.1. LOCATION OF TESTS

All of the measurements described in this report were performed at Ultratech Group of Labs located in the city of Oakville, Province of Ontario, Canada.

- AC Power Line Conducted Emissions were performed in UltraTech's shielded room, 24'(L) by 16'(W) by 8'(H).
- Radiated Emissions were performed at the Ultratech's 3-10 TDK Semi-Anechoic Chamber situated in the Town of Oakville, province of Ontario. This test site been calibrated in accordance with ANSI C63.4, and found to be in compliance with the requirements of Sec. 2.948 of the FCC Rules. The descriptions and site measurement data of the Oakville 3-10 TDK Semi-Anechoic Chamber has been filed with ANAB File No.: AT-1945.

4.2. APPLICABILITY & SUMMARY OF EMC EMISSION TEST RESULTS

FCC Section(s)	Test Requirements	Compliance (Yes/No)
15.203	Antenna requirements	Yes
15.207(a)	AC Power Line Conducted Emissions	Yes
15.247(a)(2)	6 dB Bandwidth	Yes
15.247(b)(3)	Peak Conducted Output Power - DTS	Yes
15.247(d)	Band-Edge and RF Conducted Spurious Emissions at the Transmitter Antenna Terminal	Yes
15.247(d), 15.209 & 15.205	Transmitter Spurious Radiated Emissions	Yes
15.247(e)	Power Spectral Density	Yes
15.247(i), 1.1307, 1.1310, 2.1091	RF Exposure	Yes

4.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

The device shall need a ferrite clamp on AC adapter, near micro USB connector, Stewart ferrite P/N: 28A2029-0A2 with 2 1/2 turns.



EXHIBIT 5. TEST DATA

5.1. POWER LINE CONDUCTED EMISSIONS [§15.207(a)]

5.1.1. Limit(s)

The equipment shall meet the limits of the following table:

Frequency of emission (MHz)	Conducted Limits (dB μ V)	
	Quasi-peak	Average
0.15–0.5	66 to 56*	56 to 46*
0.5–5	56	46
5–30	60	50

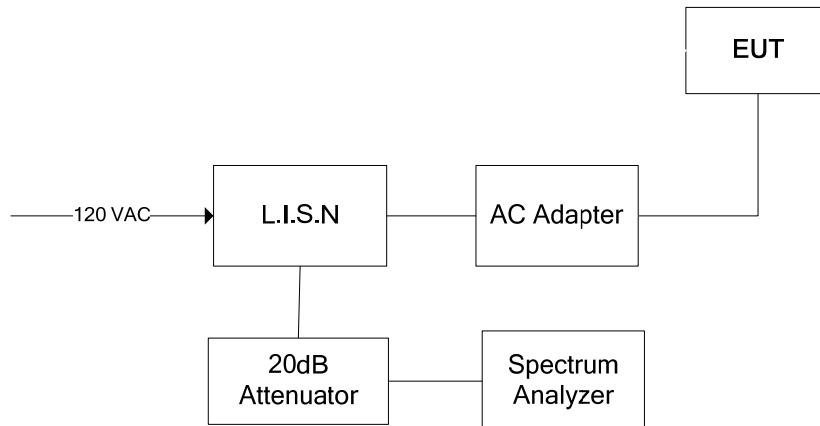
*Decreases linearly with the logarithm of the frequency

5.1.2. Method of Measurements

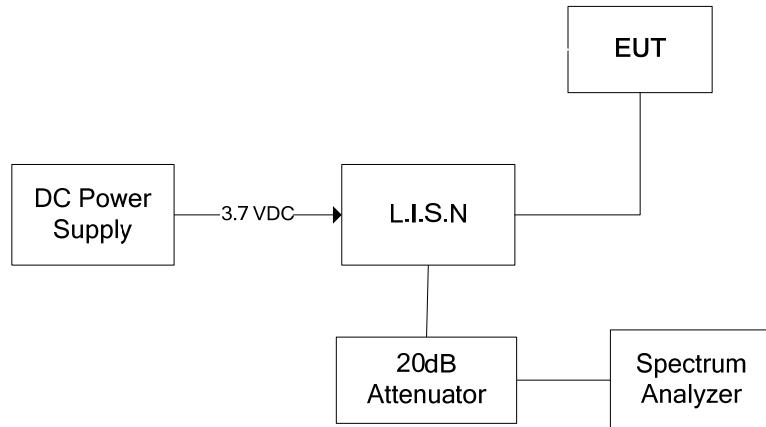
ANSI C63.4

5.1.3. Test Arrangement

Test Configuration 1: 5 VDC Via AC Adapter

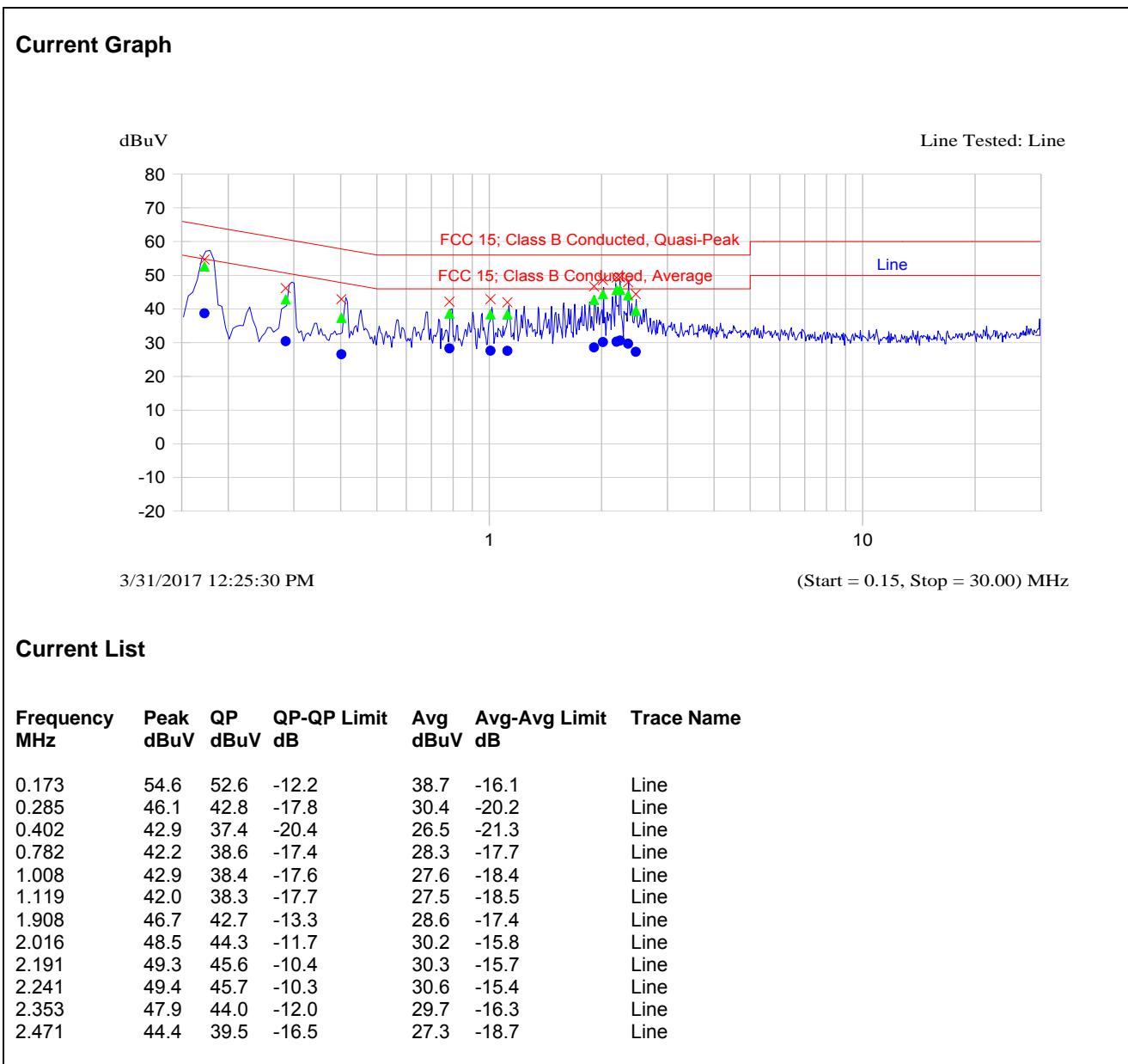


Test Configuration 2: 3.7 VDC from DC Power Supply



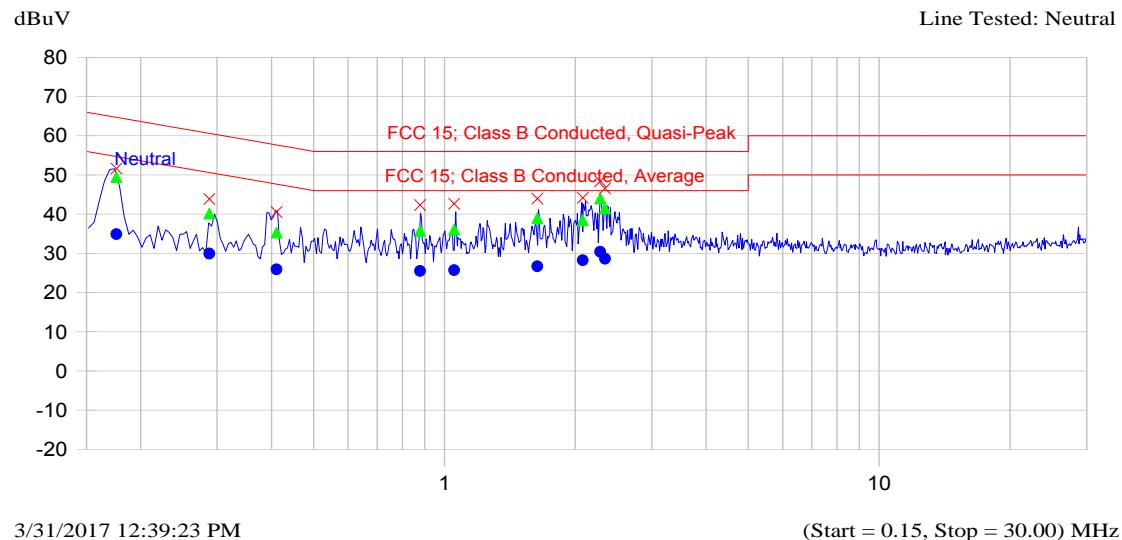
5.1.1. Test Data

Plot 5.1.1.1. Power Line Conducted Emissions, Test Configuration 1
Line Voltage: AC 120 V; Line Tested: Line



Plot 5.1.1.2. Power Line Conducted ions, Test Configuration 1
Line Voltage: AC 120 V; Line Tested: Neutral

Current Graph

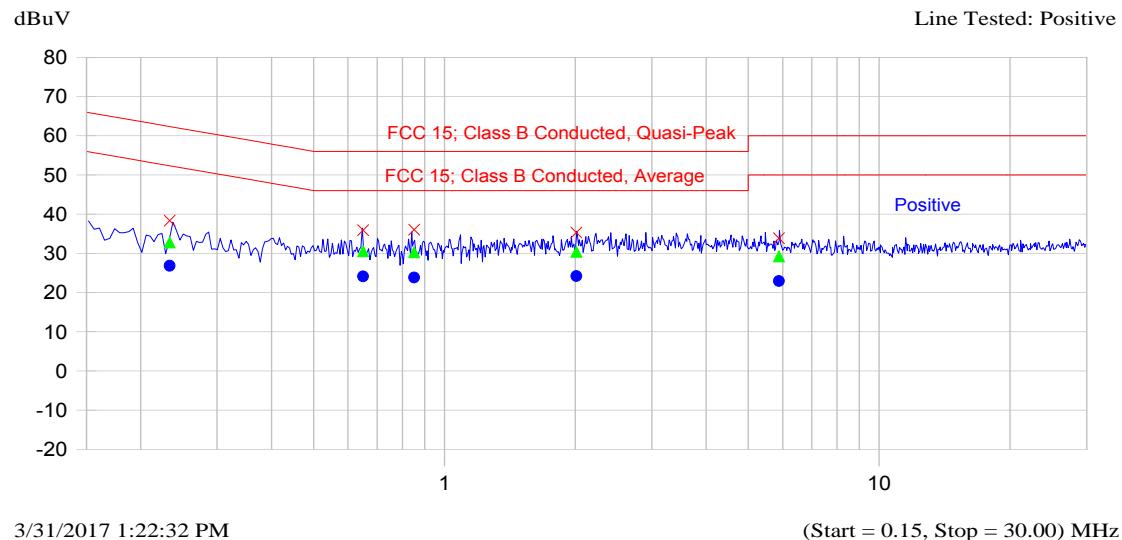


Current List

Frequency MHz	Peak dBuV	QP dBuV	QP-QP Limit dB	Avg dBuV	Avg-Avg Limit dB	Trace Name
0.176	51.6	49.5	-15.2	34.9	-19.8	Neutral
0.288	43.9	40.1	-20.4	29.9	-20.7	Neutral
0.411	40.5	35.3	-22.3	25.9	-21.7	Neutral
0.879	42.3	35.7	-20.3	25.5	-20.5	Neutral
1.052	42.6	36.1	-19.9	25.7	-20.3	Neutral
1.636	44.0	39.0	-17.0	26.7	-19.3	Neutral
2.079	44.2	38.4	-17.6	28.2	-17.8	Neutral
2.280	48.4	44.0	-12.0	30.4	-15.6	Neutral
2.341	46.6	41.5	-14.5	28.6	-17.4	Neutral

Plot 5.1.1.3. Power Line Conducted Emissions, Test Configuration 2
Line Voltage: 3.7 VDC; Line Tested: Positive

Current Graph

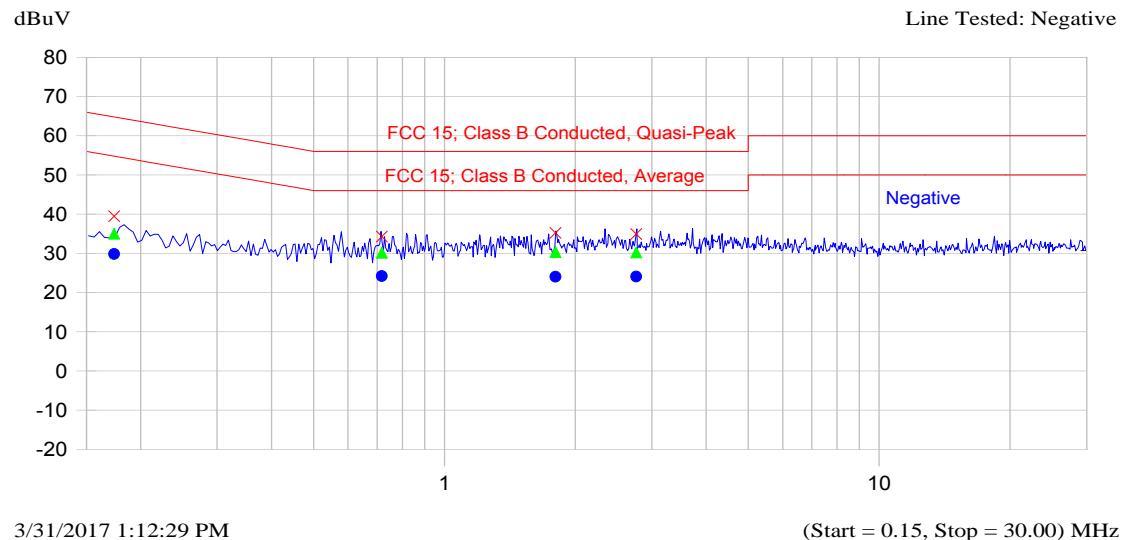


Current List

Frequency MHz	Peak dBuV	QP dBuV	QP-QP Limit dB	Avg dBuV	Avg-Avg Limit dB	Trace Name
0.233	38.3	32.8	-29.6	26.8	-25.5	Positive
0.650	35.9	30.5	-25.5	24.1	-21.9	Positive
0.852	36.0	30.3	-25.7	23.8	-22.2	Positive
2.012	35.3	30.4	-25.6	24.2	-21.8	Positive
5.876	33.8	29.2	-30.8	22.9	-27.1	Positive

Plot 5.1.1.4. Power Line Conducted ions, Test Configuration 2
Line Voltage: 3.7 VDC; Line Tested: Negative

Current Graph



Current List

Frequency MHz	Peak dBuV	QP dBuV	QP-QP Limit dB	Avg dBuV	Avg-Avg Limit dB	Trace Name
0.174	39.5	35.0	-29.8	29.8	-25.0	Negative
0.717	34.3	30.2	-25.8	24.2	-21.8	Negative
1.801	35.2	30.3	-25.7	24.0	-22.0	Negative
2.761	34.9	30.2	-25.8	24.1	-21.9	Negative

5.2. OCCUPIED BANDWIDTH [§ 15.247(a)(2)]

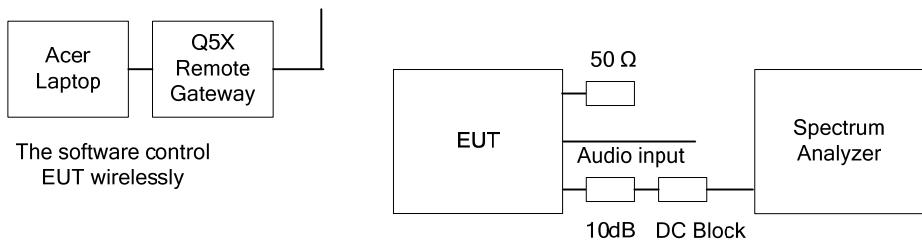
5.2.1. Limit(s)

The minimum 6 dB bandwidth shall be at least 500 kHz.

5.2.2. Method of Measurements

KDB 558074 D01 DTS Meas Guidance V03r05, Section 8.2 Option 1

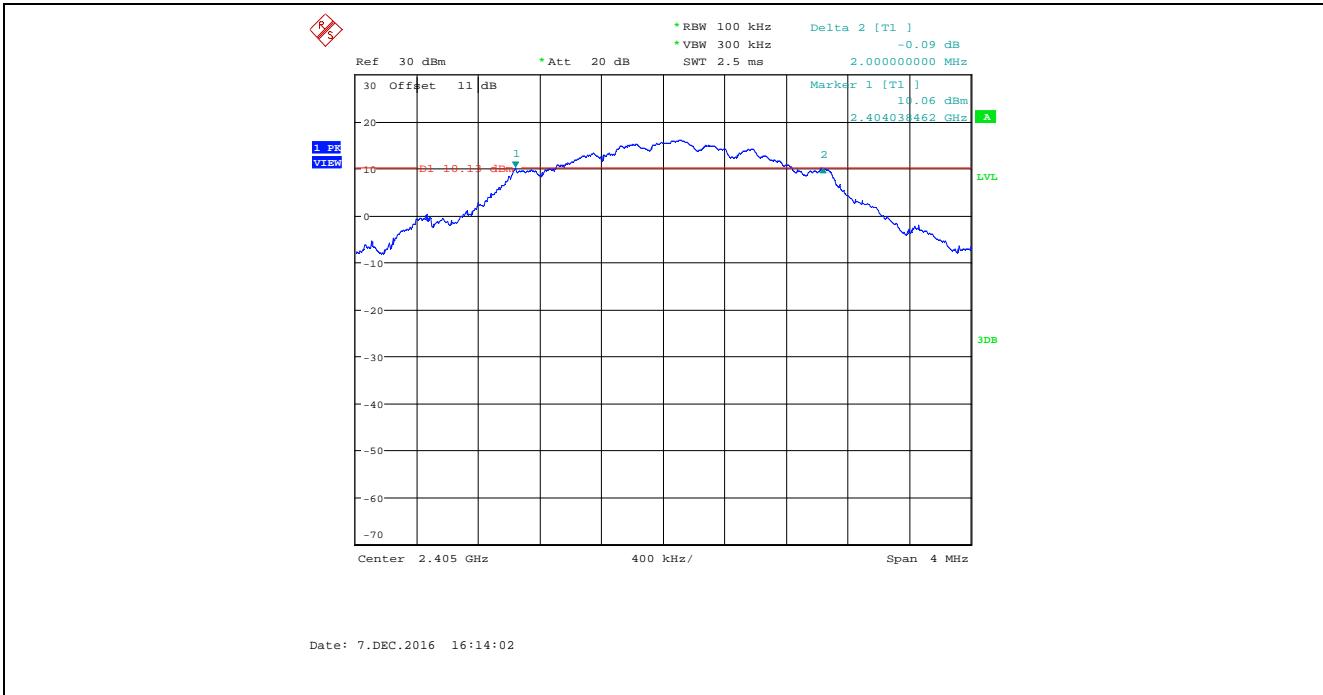
5.2.3. Test Arrangement



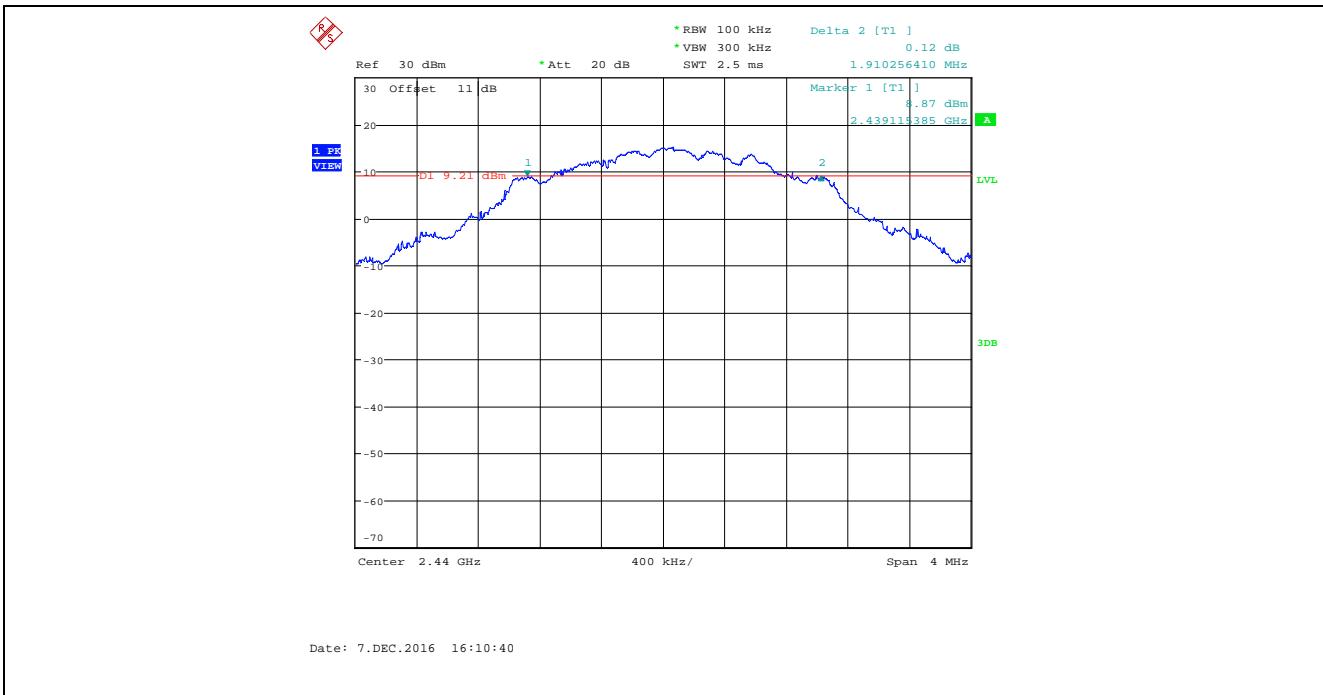
5.2.4. Test Data

Modulation	Channel Number	Frequency (MHz)	6dB BW (MHz)	Min. Limit (kHz)
MSK	1	2405	2.00	500
	8	2440	1.91	500
	16	2480	1.78	500

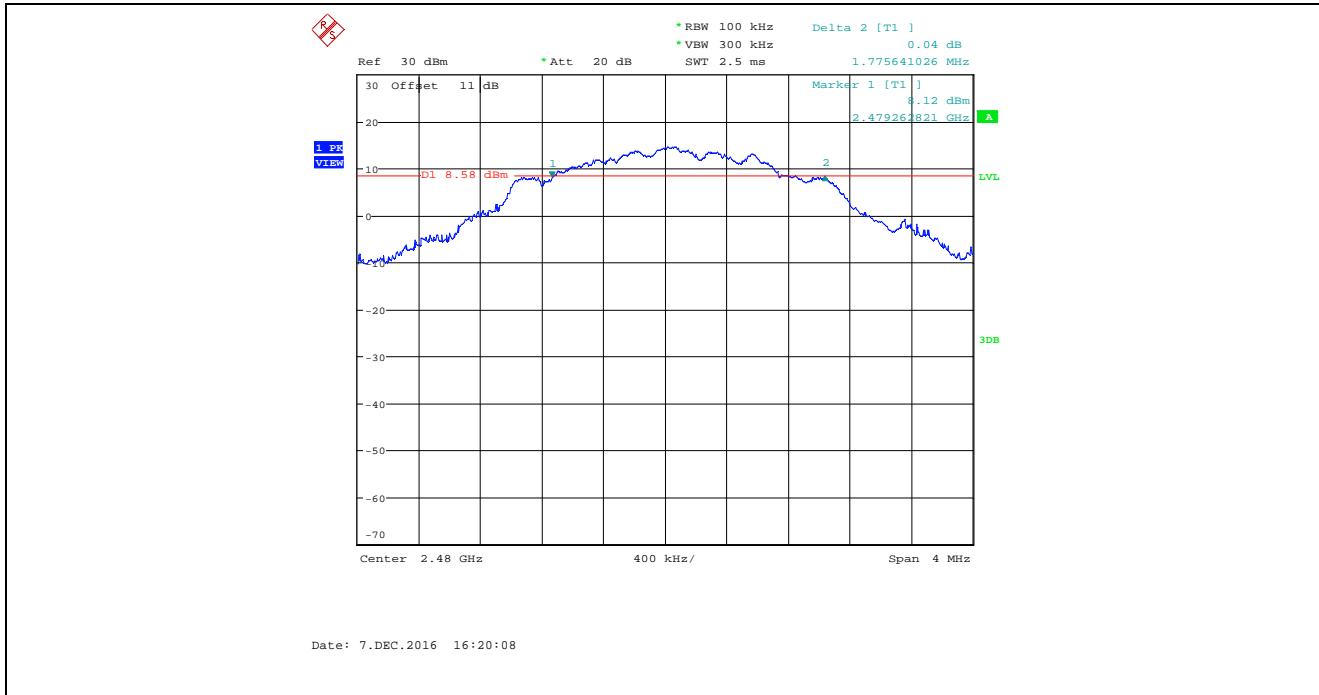
Plot 5.2.4.1. 6 dB Bandwidth, Channel 1, 2405 MHz



Plot 5.2.4.2. 6 dB Bandwidth, Channel 8, 2440 MHz



Plot 5.2.4.3. 6 dB Bandwidth, Channel 16, 2480 MHz



5.3. PEAK CONDUCTED OUTPUT POWER - DTS [§ 15.247(b)(3)]

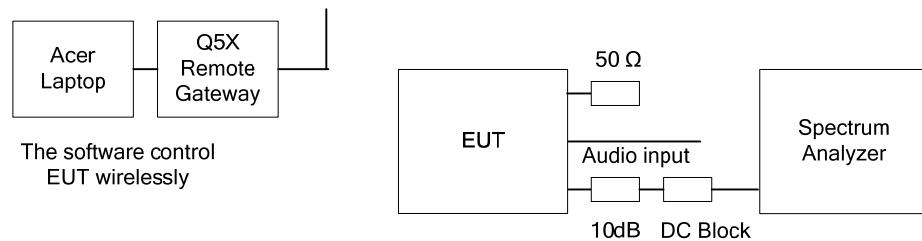
5.3.1. Limit(s)

§ 15.247(b)(3): For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the *maximum conducted output power* is the highest total transmit power occurring in any mode.

5.3.2. Method of Measurements & Test Arrangement

KDB 558074 D01 DTS Meas Guidance V03r05, Section 9.1 RBW \geq DTS bandwidth

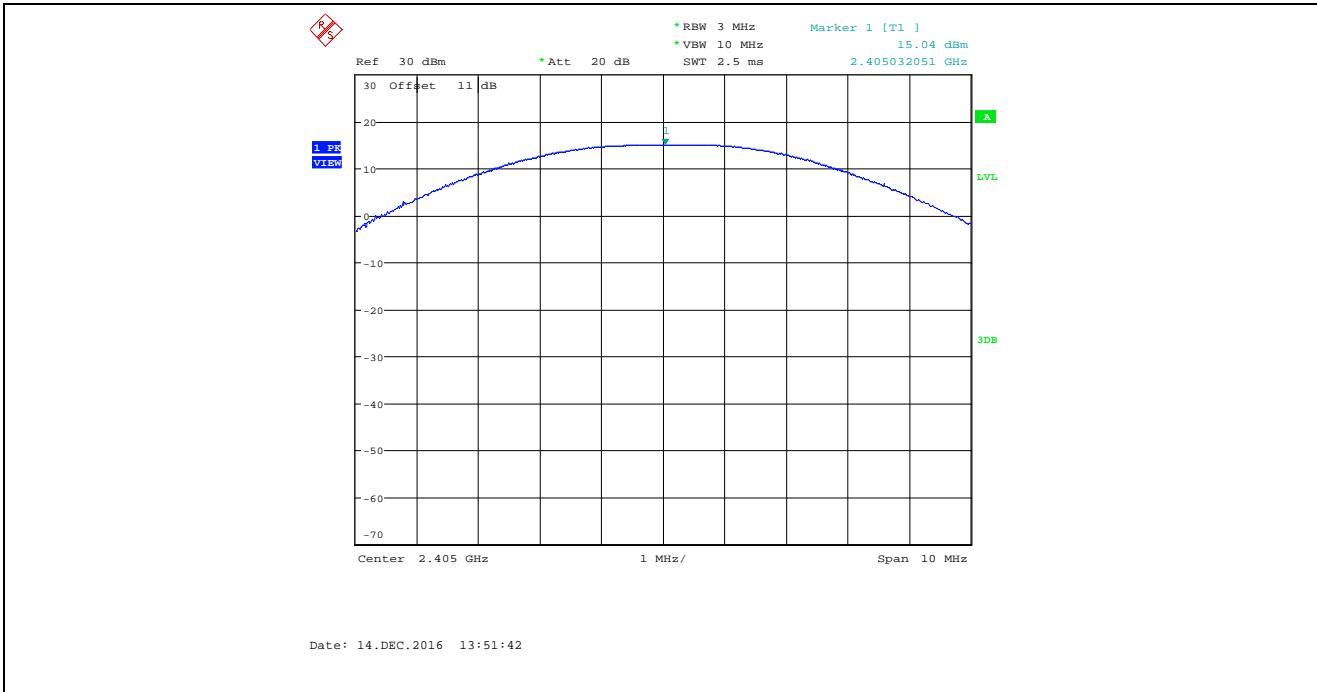
5.3.3. Test Arrangement



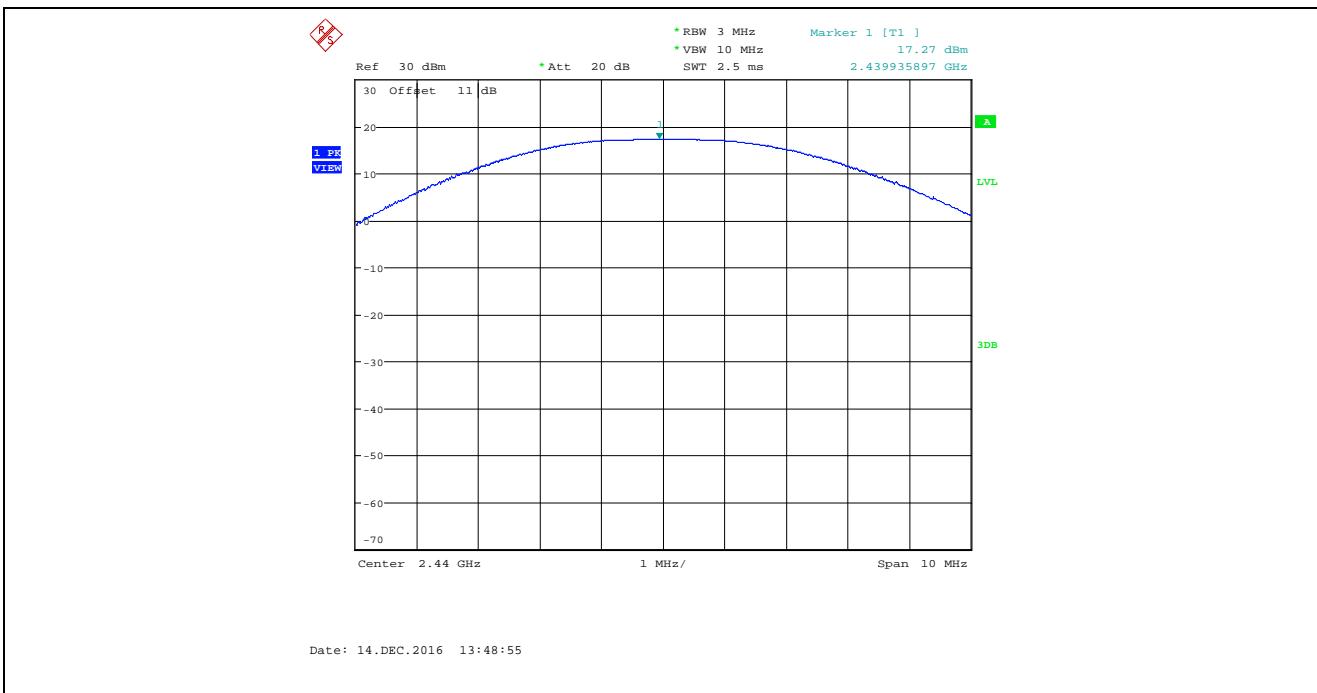
5.3.4. Test Data

Power Setting	Modulation	Channel Number	Frequency (MHz)	Max. Peak Conducted Output Power (dBm)	Limit (dBm)
12	MSK	1	2405	15.04	30
	MSK	8	2440	17.27	30
	MSK	16	2480	17.85	30

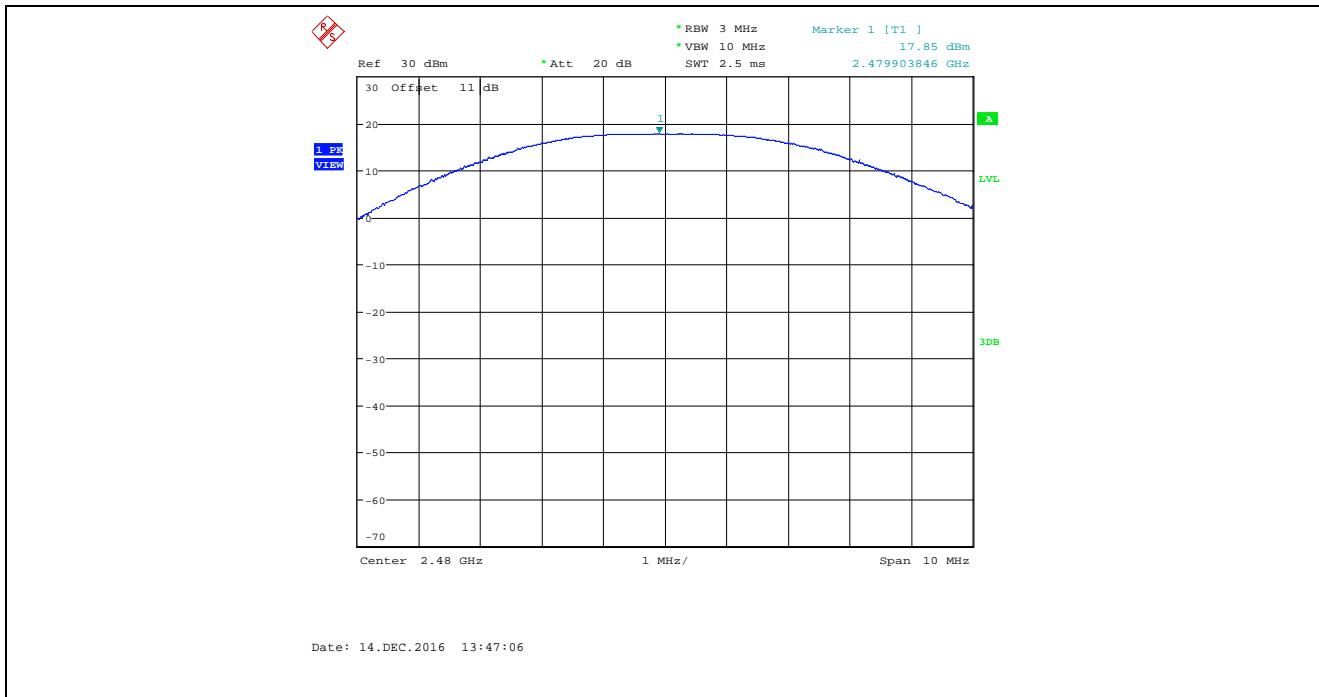
Plot 5.3.4.1. Maximum Peak Conducted Output Power, Channel 1, 2405 MHz



Plot 5.3.4.2. Maximum Peak Conducted Output Power, Channel 8, 2440 MHz



Plot 5.3.4.3. Maximum Peak Conducted Output Power, Channel 16, 2480 MHz



5.4. TRANSMITTER BAND-EDGE & SPURIOUS CONDUCTED EMISSIONS [§ 15.247(d)]

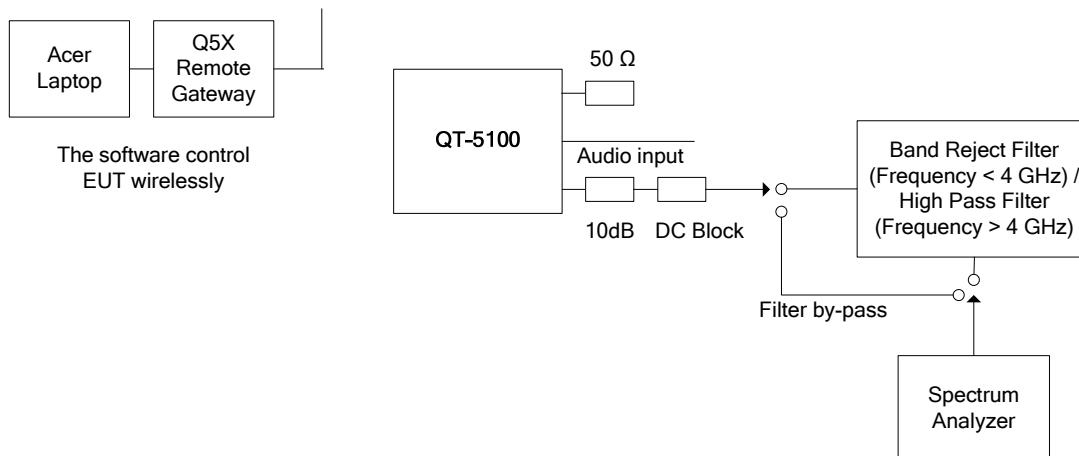
5.4.1. Limit(s)

§ 15.247 (d): In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, 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)).

5.4.2. Method of Measurements

KDB 558074 D01 DTS Meas Guidance V03r05, Sections 8.2 Option 2, 11 and 12.

5.4.3. Test Arrangement

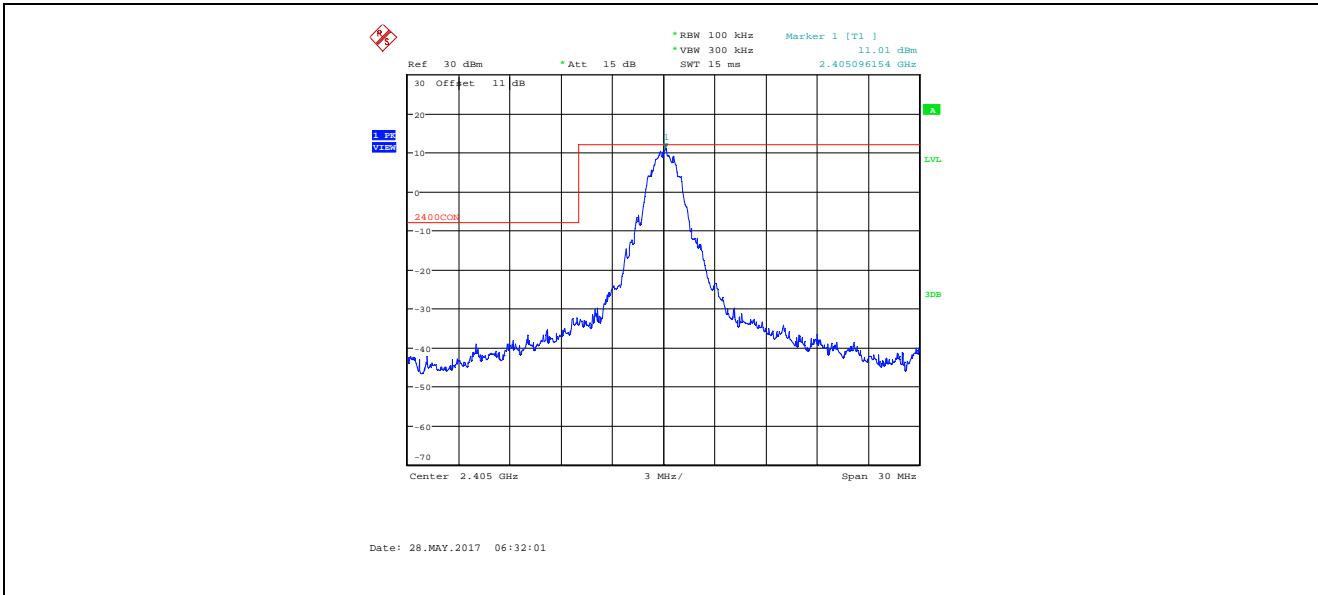


5.4.4. Test Data

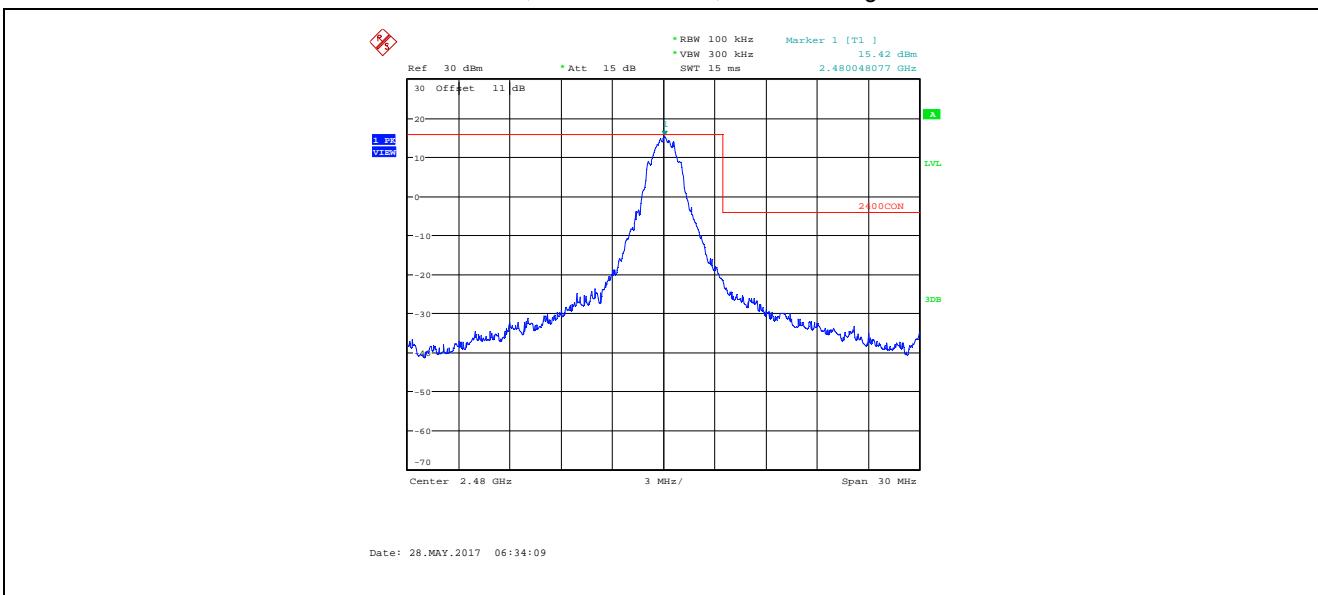
Remark(s): Exploratory tests performed to determined worst-case test configurations, the following test results represent the worst-case.

5.4.4.1. Band-Edge RF Conducted Emissions

Plot 5.4.4.1.1. Band-Edge RF Conducted Emissions, Lowest Channel Frequency
2405 MHz, MSK Modulation, Power Setting 13

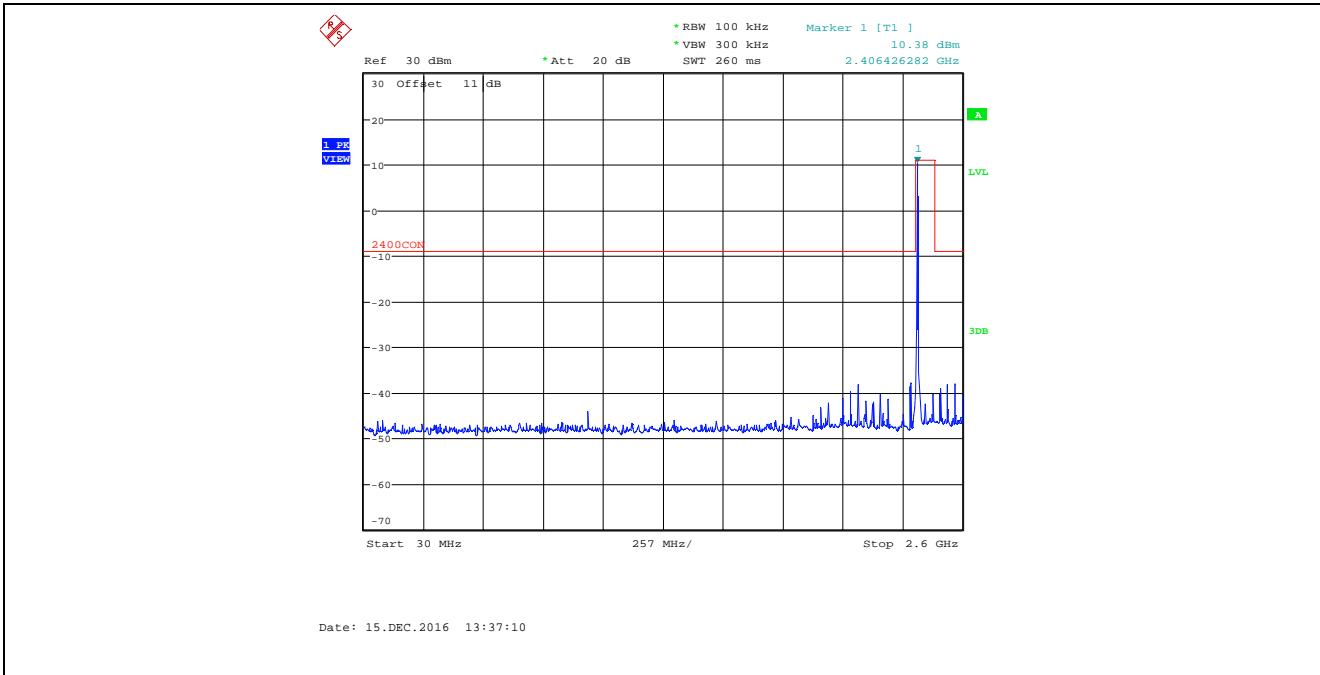


Plot 5.4.4.1.2. Band-Edge RF Conducted Emissions, Highest Channel Frequency
2480 MHz, MSK Modulation, Power Setting 13

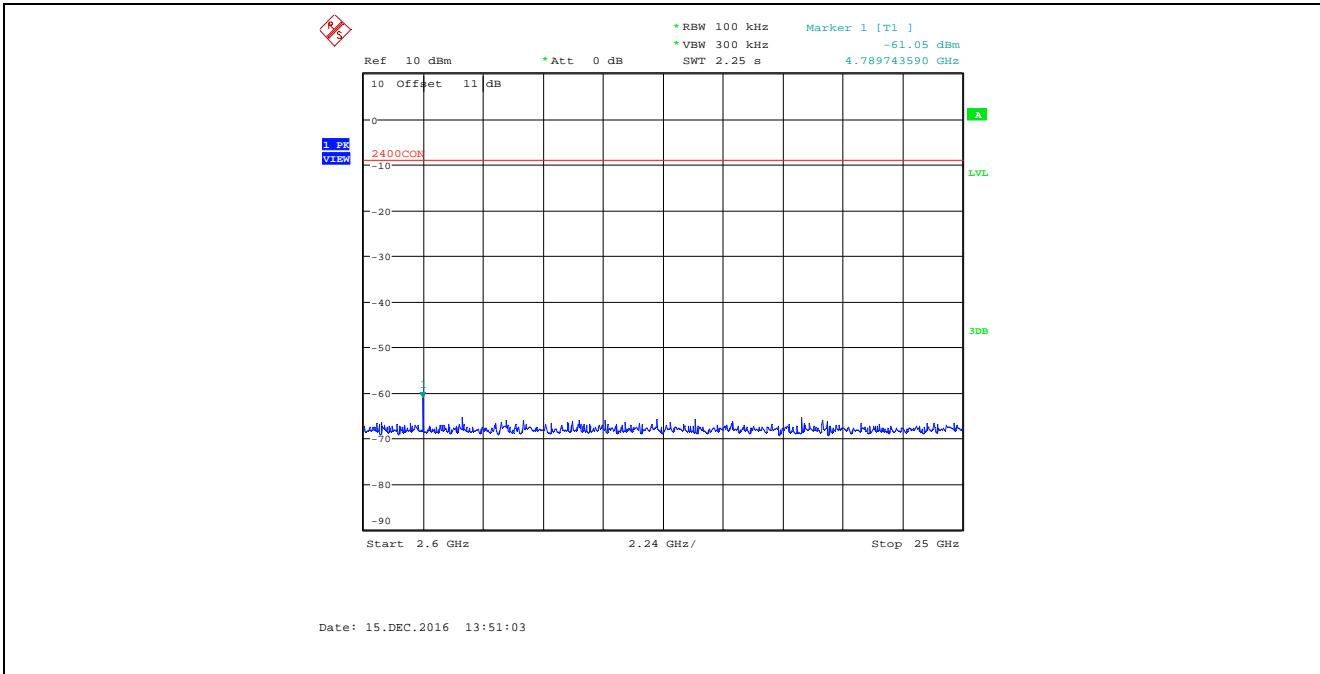


5.4.4.2. Spurious RF Conducted Emissions in Non-restricted Frequency Bands

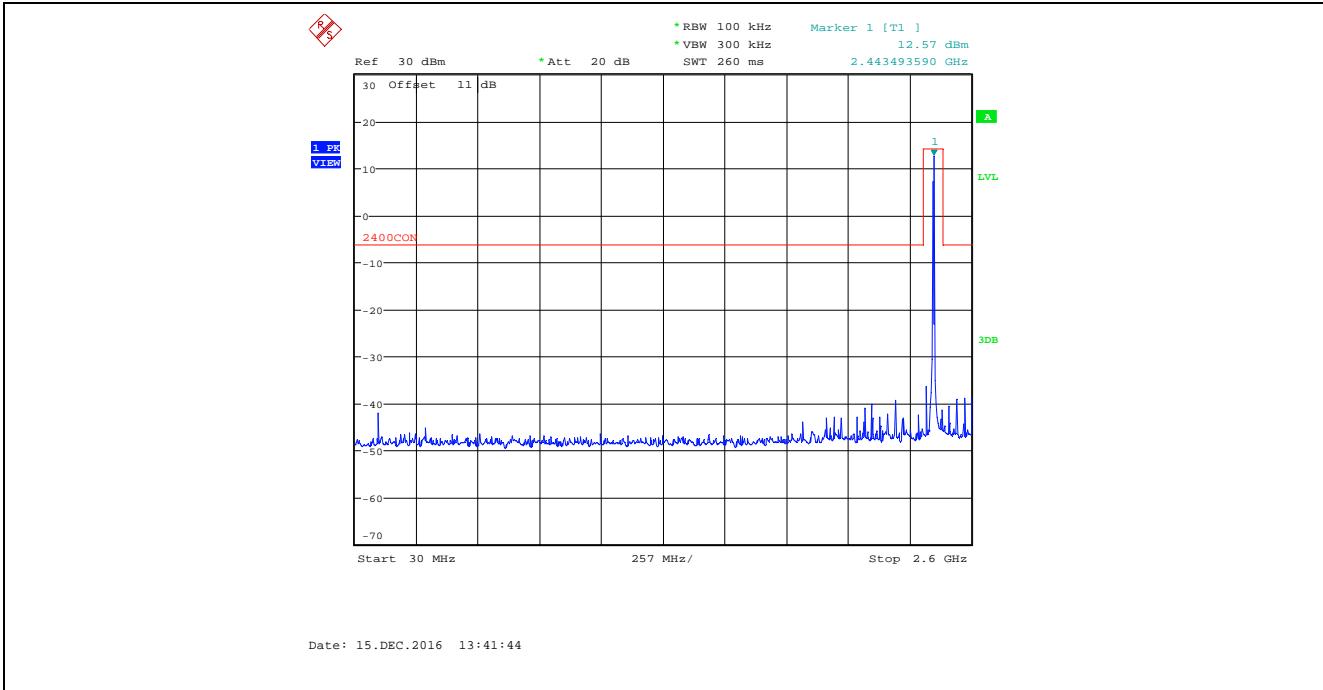
Plot 5.4.4.2.1. Conducted Spurious Emissions in Non-restricted Frequency Bands
MSK Modulation, Power Setting 12, Channel 1, 2405 MHz, 30 MHz – 2.6 GHz



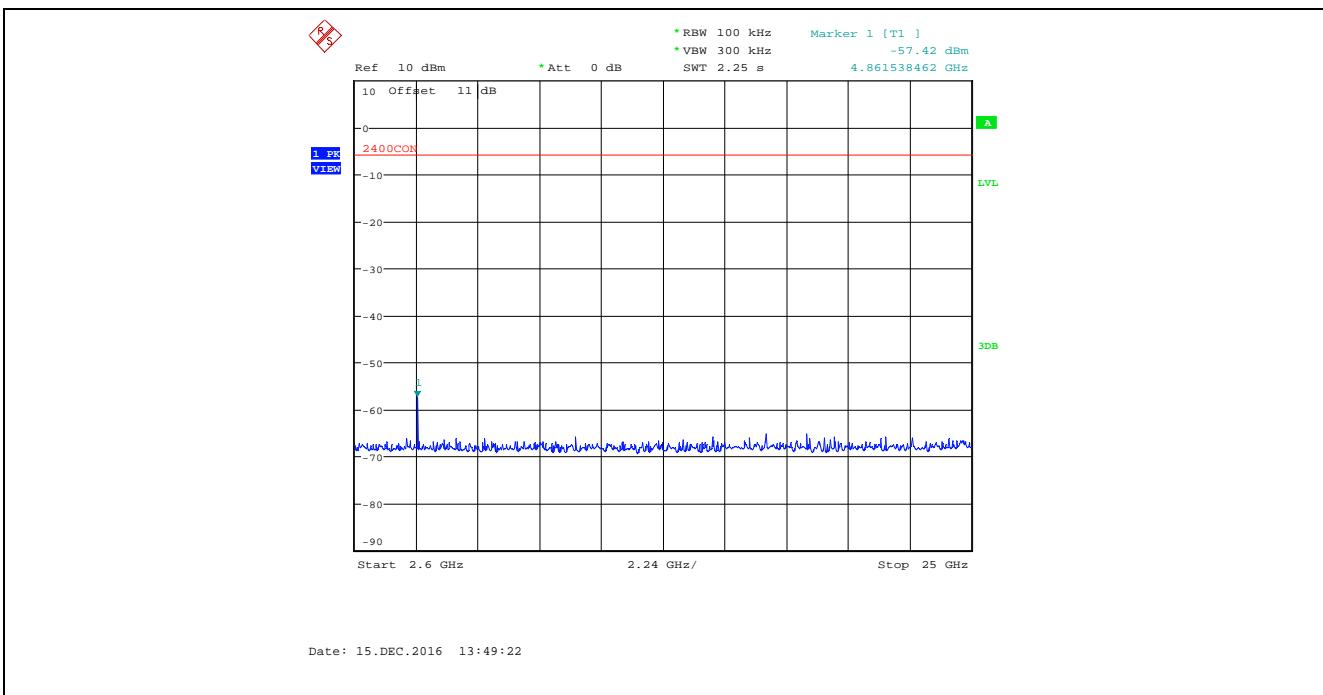
Plot 5.4.4.2.2. Conducted Spurious Emissions in Non-restricted Frequency Bands
MSK Modulation, Power Setting 12, Channel 1, 2405 MHz, 2.6 GHz – 25 GHz



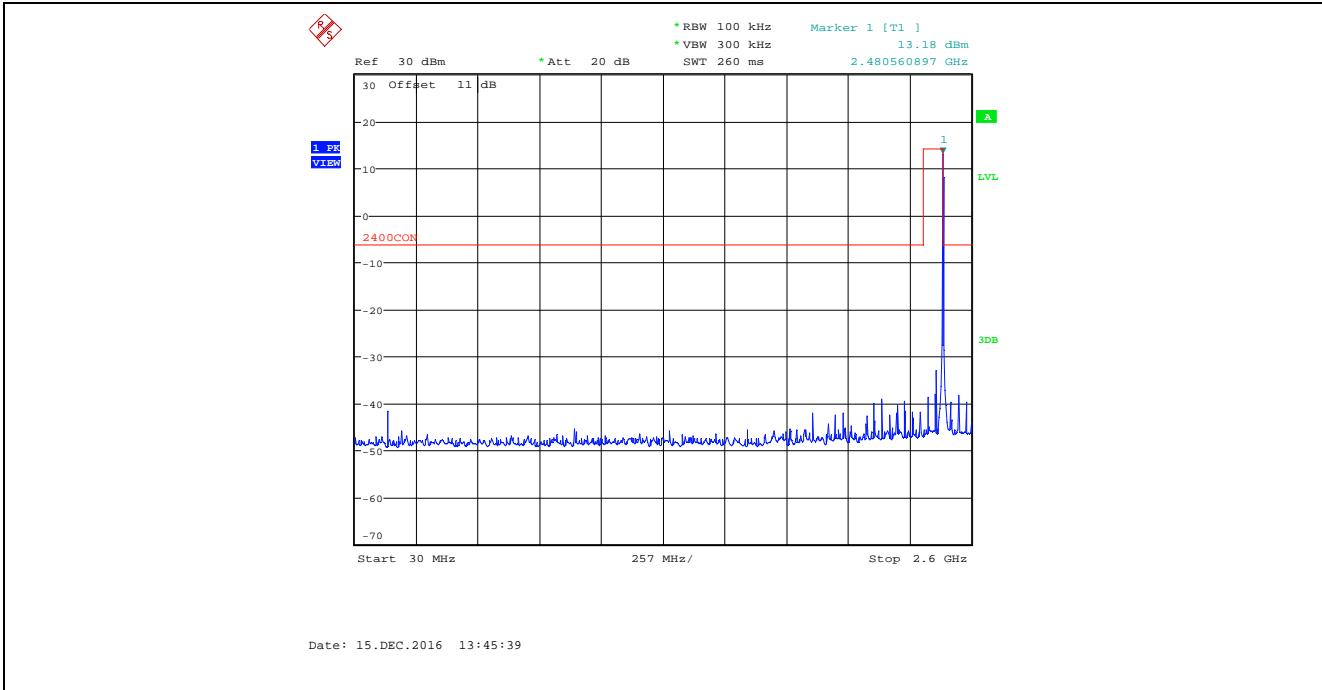
Plot 5.4.4.2.3. Conducted Spurious Emissions in Non-restricted Frequency Bands
MSK Modulation, Power Setting 12, Channel 8, 2440 MHz, 30 MHz – 2.6 GHz



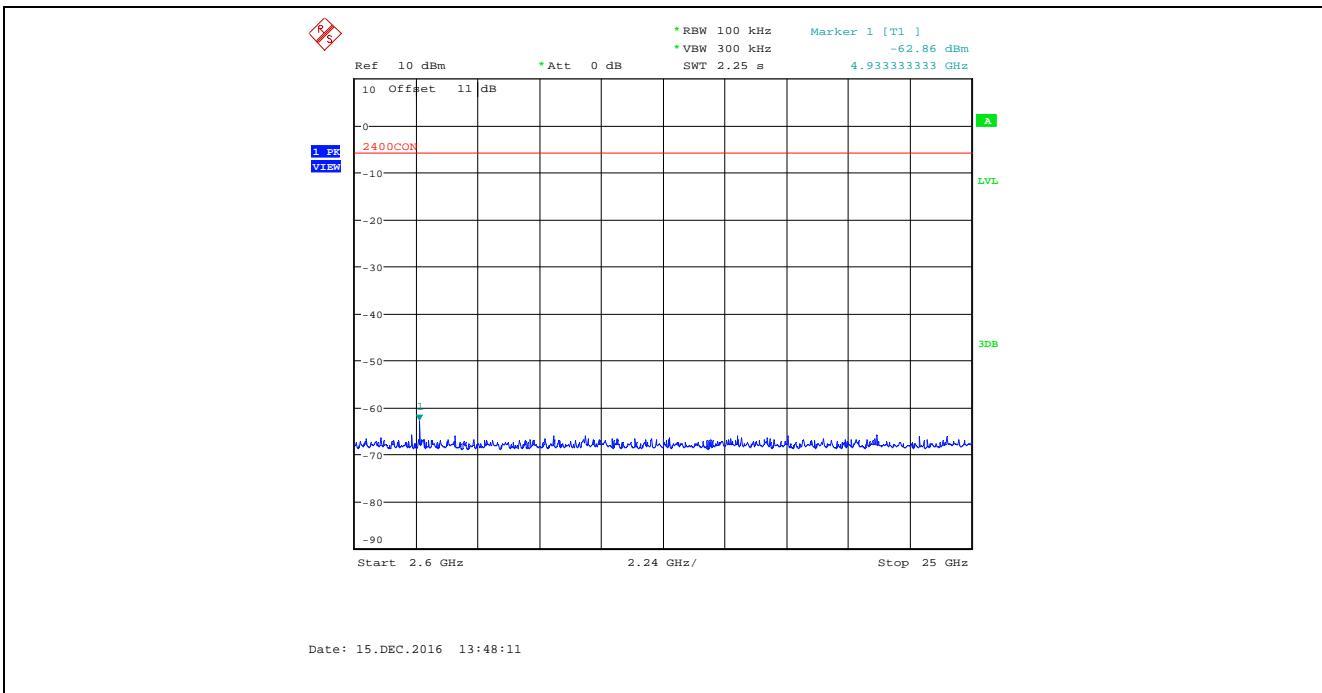
Plot 5.4.4.2.4. Conducted Spurious Emissions in Non-restricted Frequency Bands
MSK Modulation, Power Setting 12, Channel 8, 2440 MHz, 2.6 GHz – 25 GHz



Plot 5.4.4.2.5. Conducted Spurious Emissions in Non-restricted Frequency Bands
 MSK Modulation, Power Setting 12, Channel 16, 2480 MHz, 30 MHz – 2.6 GHz



Plot 5.4.4.2.6. Conducted Spurious Emissions in Non-restricted Frequency Bands
 MSK Modulation, Power Setting 12, Channel 16, 2480 MHz, 2.6 GHz – 25 GHz

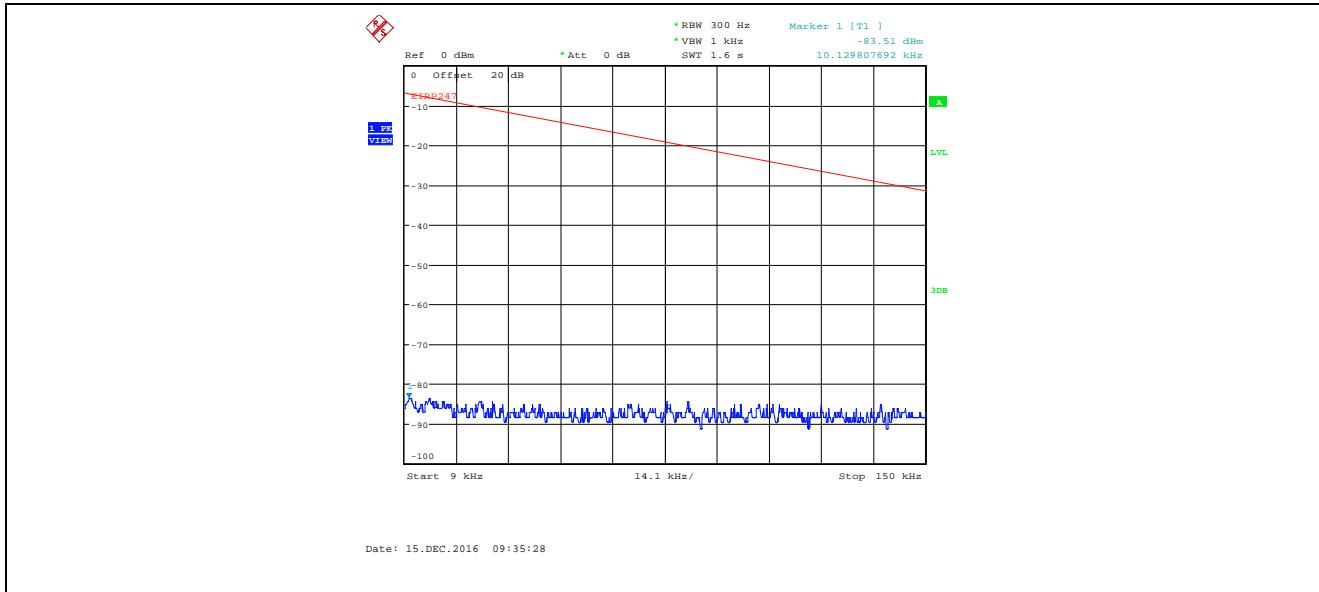


5.4.4.3. Conducted Spurious Emissions in Restricted Frequency Bands, Power Setting 12, 3 dBi Antenna Gain

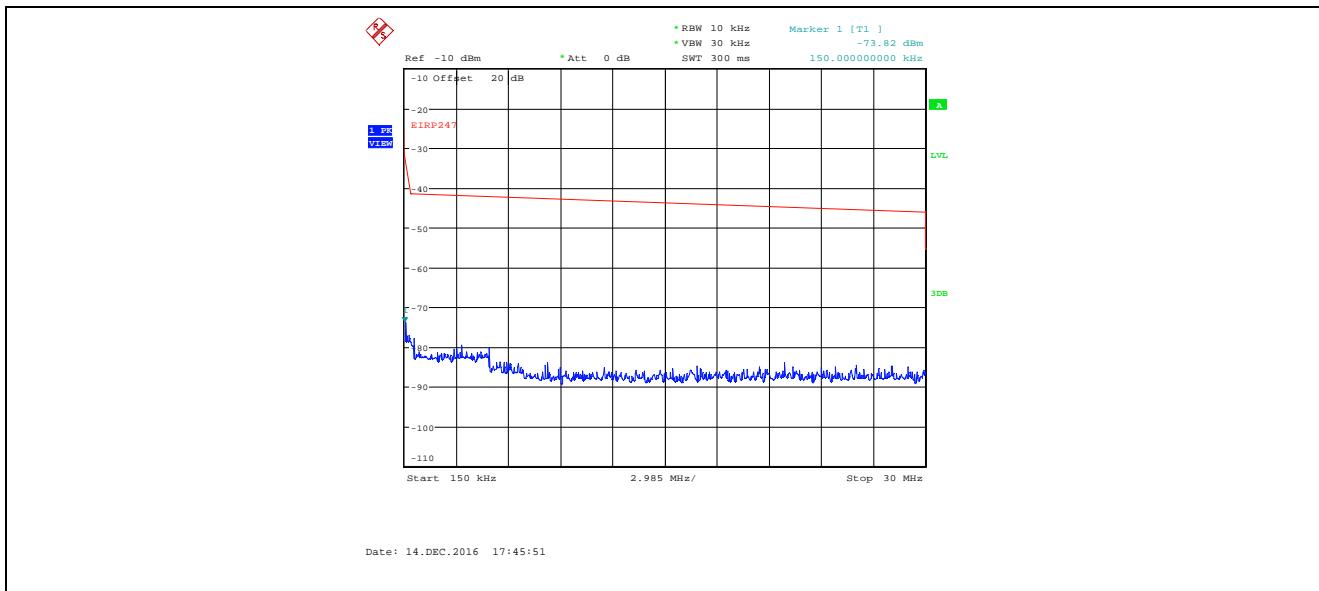
Remarks: Offset = [Insertion Loss] + [Transmit Antenna Gain (in dBi)] + [Maximum Ground Reflection Factor]

Testing cable loss: 11.02dB, Antenna Gain: 3dBi, Maximum Ground Reflection Factor: 6dB (\leq 30 MHz), 4.7 dB (30-1000MHz), 0 dB (>1000 MHz)

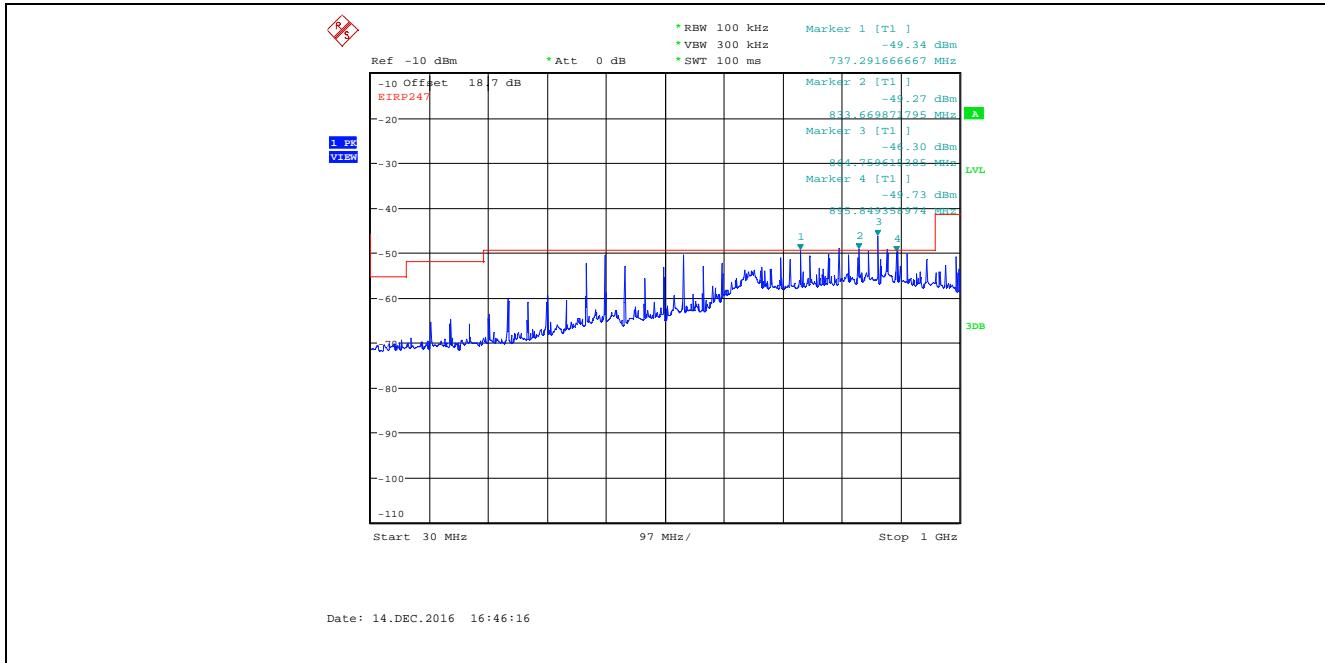
Plot 5.4.4.3.1. Conducted Spurious Emissions in Restricted Frequency Bands
Channel 1, 2405 MHz, MSK Modulation, Power Setting 12, 9 kHz - 150 kHz, Peak Detector



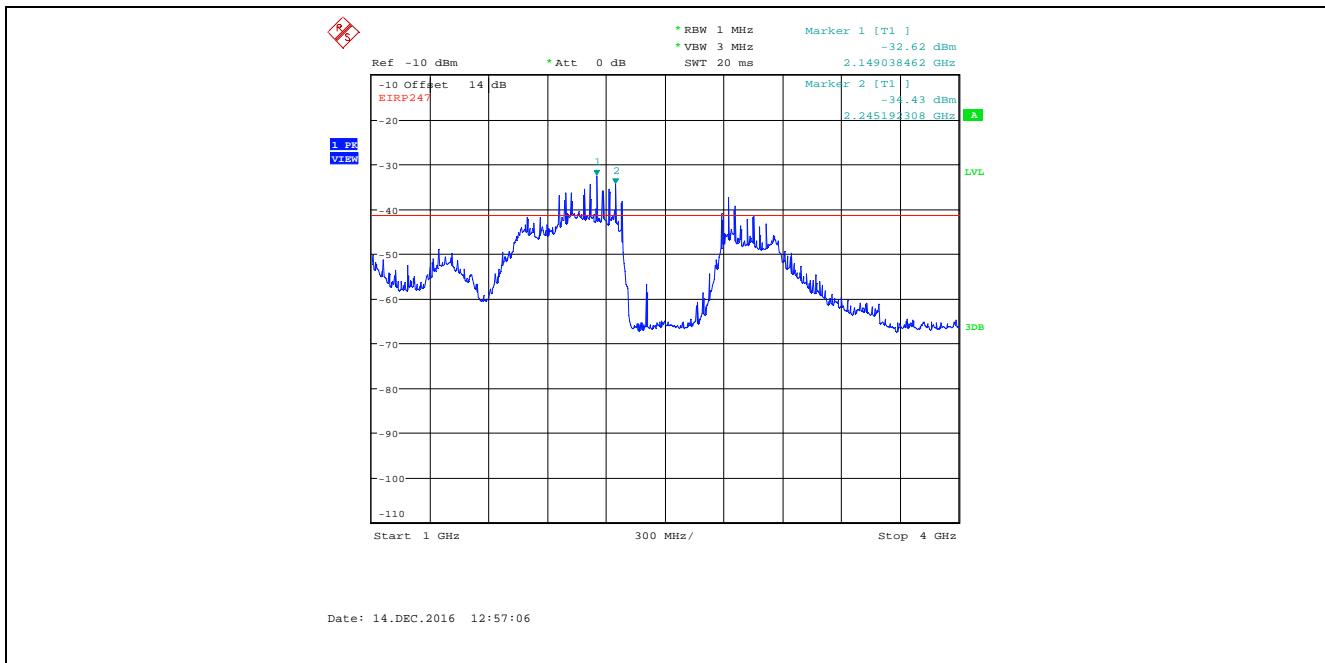
Plot 5.4.4.3.2. Conducted Spurious Emissions in Restricted Frequency Bands
Channel 1, 2405 MHz, MSK Modulation, Power Setting 12, 150 kHz - 30 MHz, Peak Detector



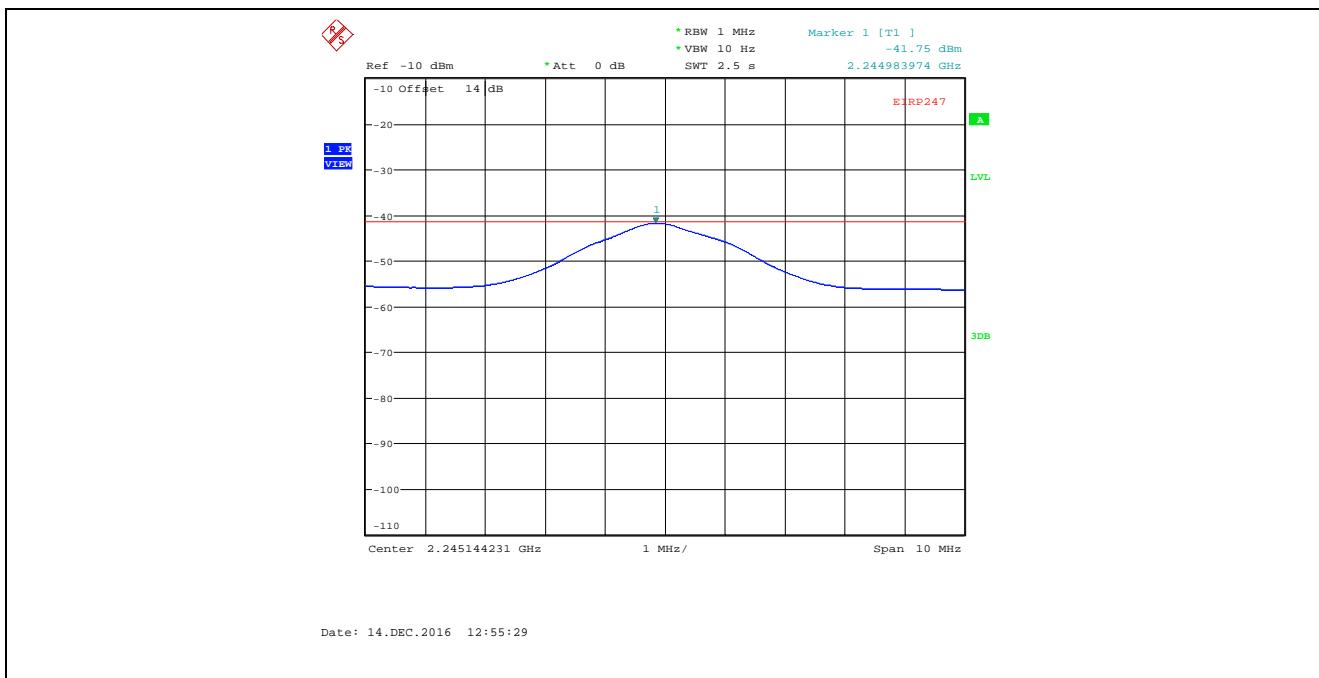
Plot 5.4.4.3.3. Conducted Spurious Emissions in Restricted Frequency Bands
 Channel 1, 2405 MHz, MSK Modulation, Power Setting 12, 30 MHz - 1 GHz, Peak Detector
 Marker 1, 2, 3, 4 are outside of restricted bands



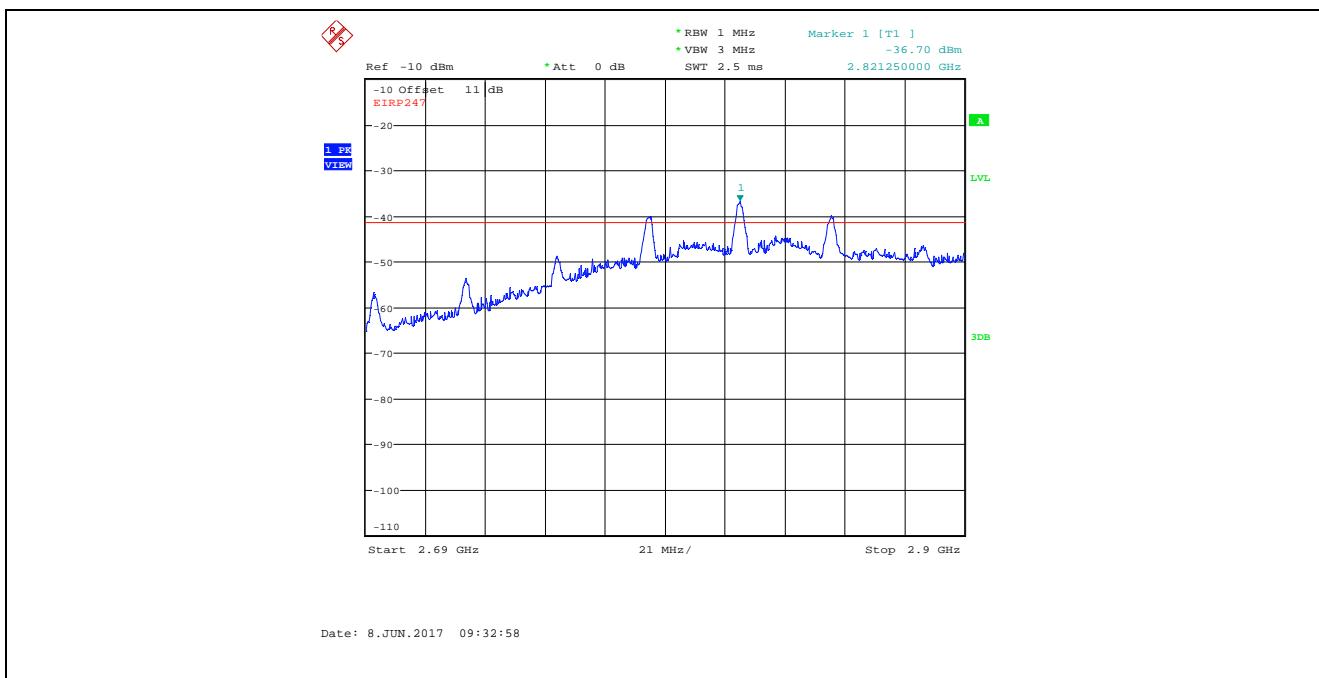
Plot 5.4.4.3.4. Conducted Spurious Emissions in Restricted Frequency Bands
 Channel 1, 2405 MHz, MSK Modulation, Power Setting 12, 1 GHz - 4 GHz, Peak Detector



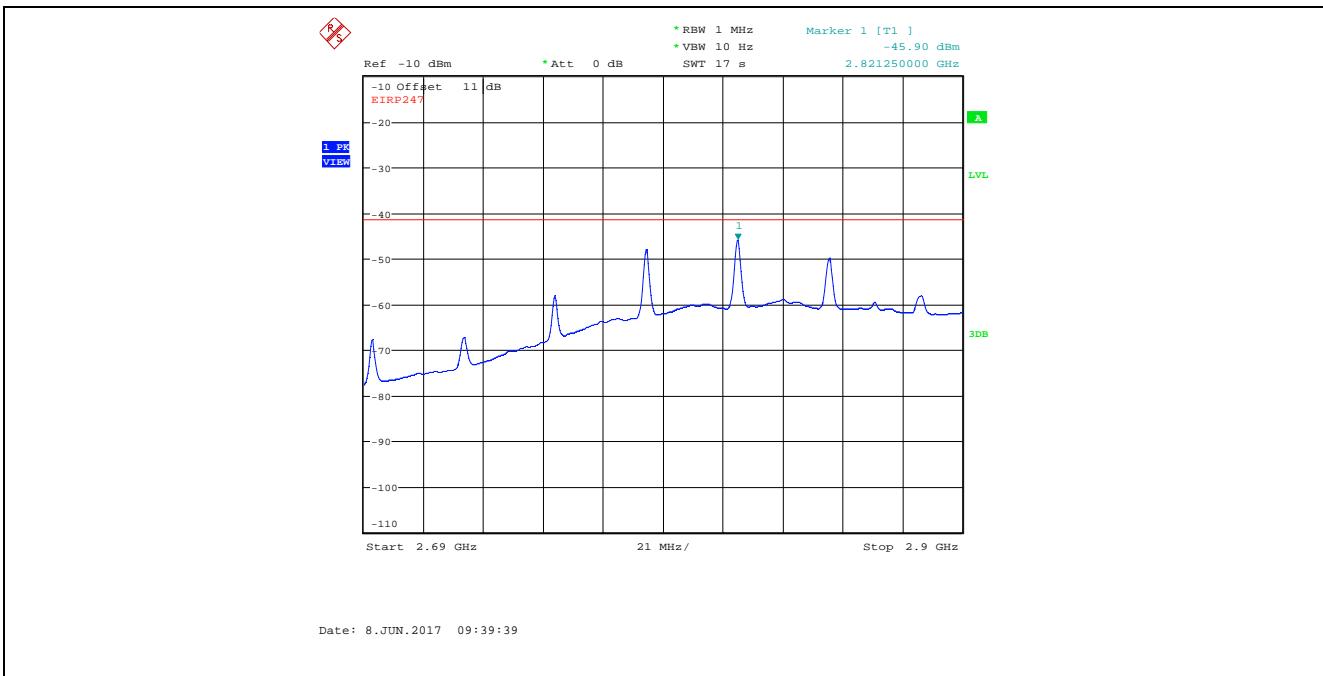
Plot 5.4.4.3.5. Conducted Spurious Emissions in Restricted Frequency Bands
 Channel 1, 2405 MHz, MSK Modulation, Power Setting 12, 2.2401 - 2.2501GHz, Average Detector



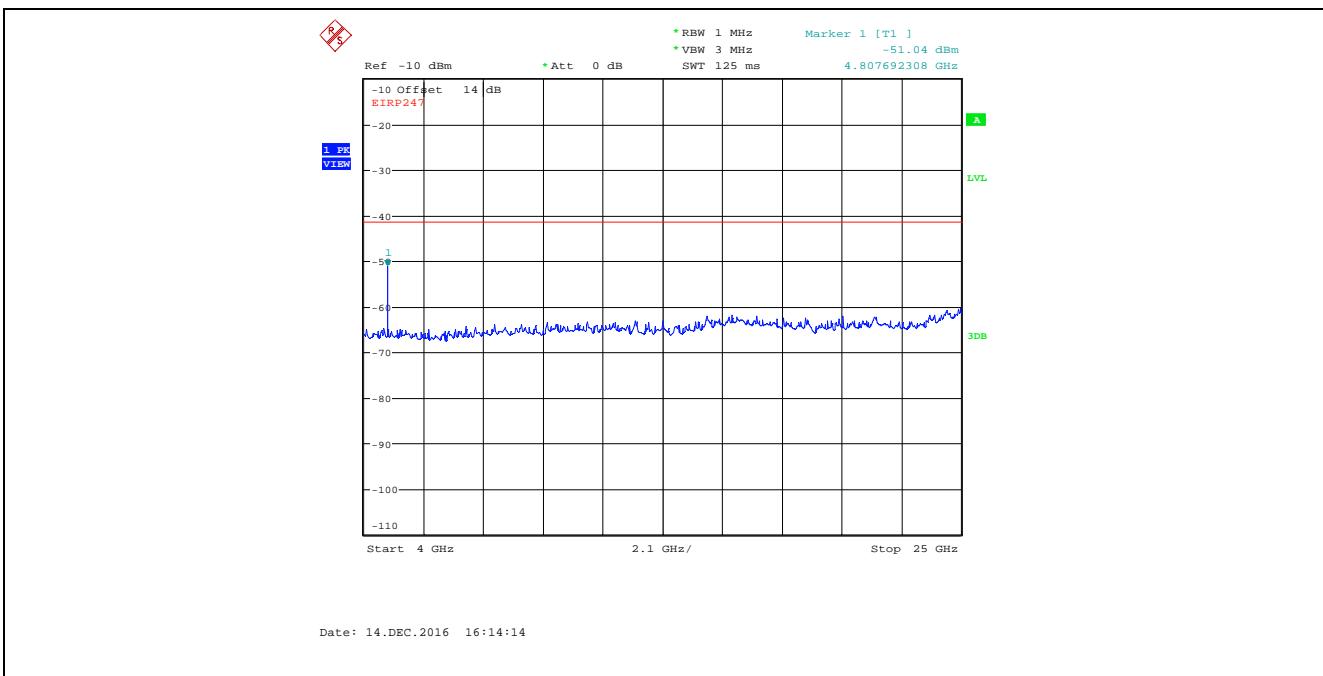
Plot 5.4.4.3.6. Conducted Spurious Emissions in Restricted Frequency Bands
 Channel 1, 2405 MHz, MSK Modulation, Power Setting 12, 2.69 - 2.9 GHz, Peak Detector



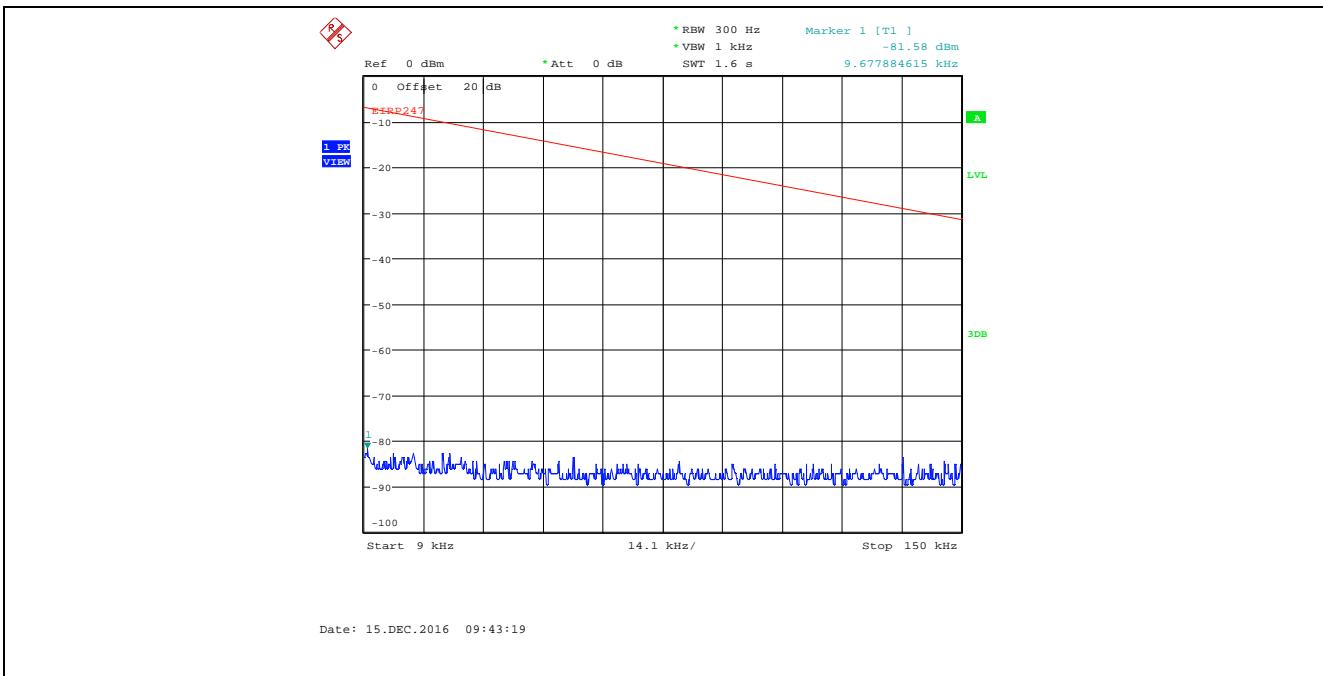
Plot 5.4.4.3.7. Conducted Spurious Emissions in Restricted Frequency Bands
 Channel 1, 2405 MHz, MSK Modulation, Power Setting 12, 2.69 - 2.9 GHz, Average Detector



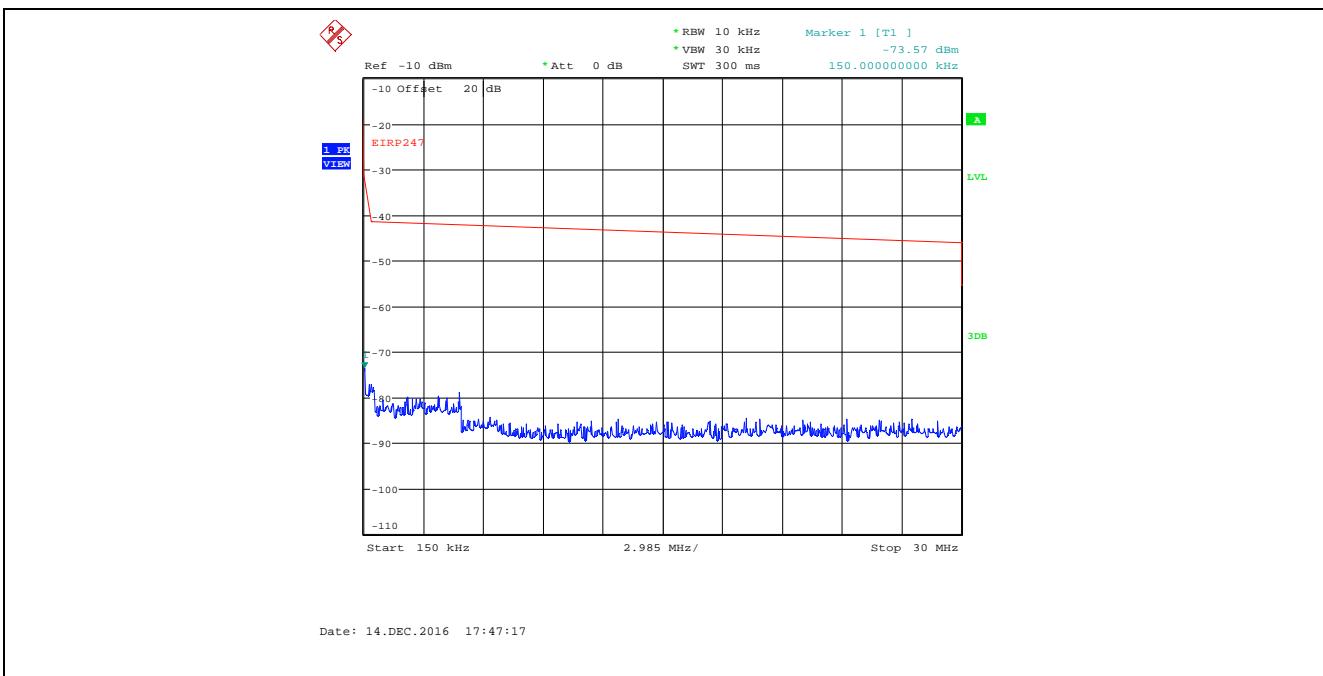
Plot 5.4.4.3.8. Conducted Spurious Emissions in Restricted Frequency Bands
 Channel 1, 2405 MHz, MSK Modulation, Power Setting 12, 4 GHz - 25 GHz, Peak Detector



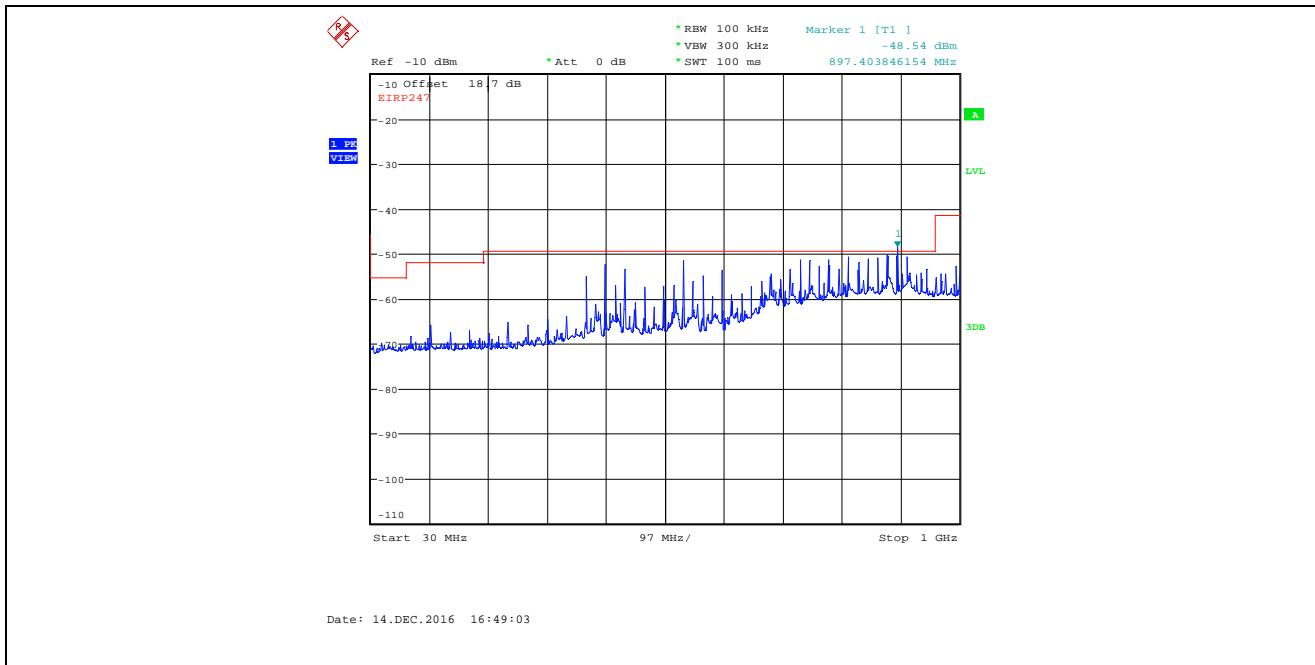
Plot 5.4.4.3.9. Conducted Spurious Emissions in Restricted Frequency Bands
 Channel 8, 2440 MHz, MSK Modulation, Power Setting 12, 9 kHz - 150 kHz, Peak Detector



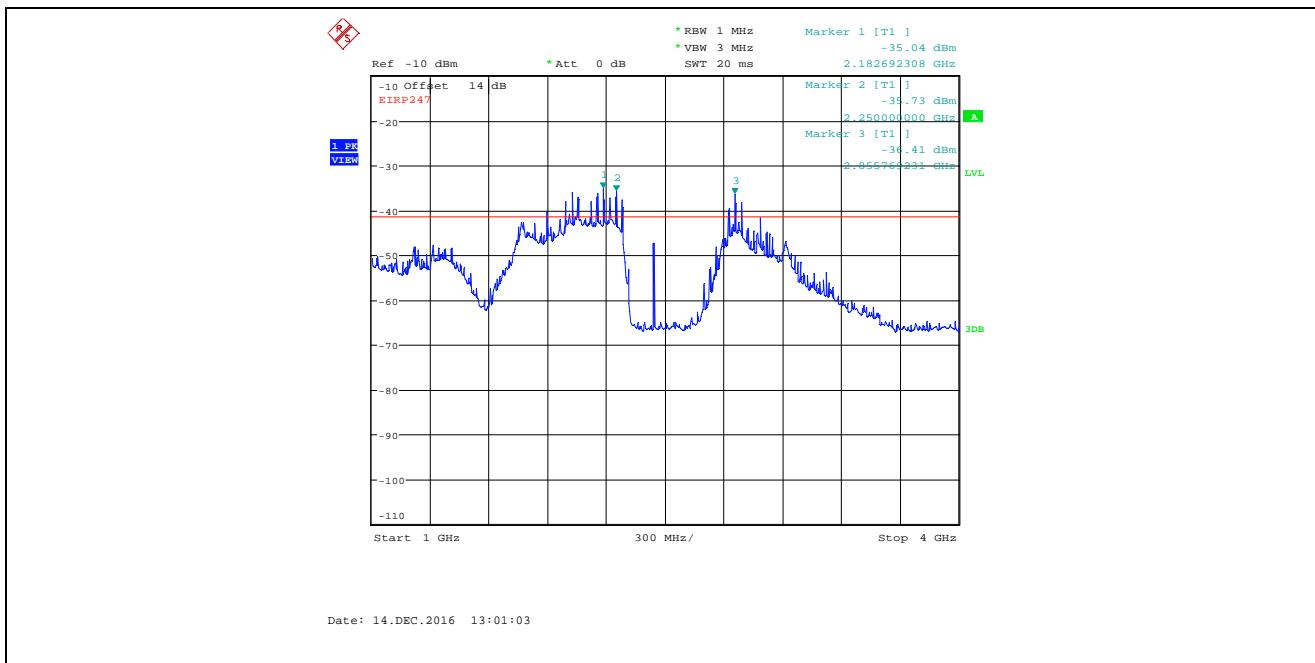
Plot 5.4.4.3.10. Conducted Spurious Emissions in Restricted Frequency Bands
 Channel 8, 2440 MHz, MSK Modulation, Power Setting 12, 150 kHz - 30 MHz, Peak Detector



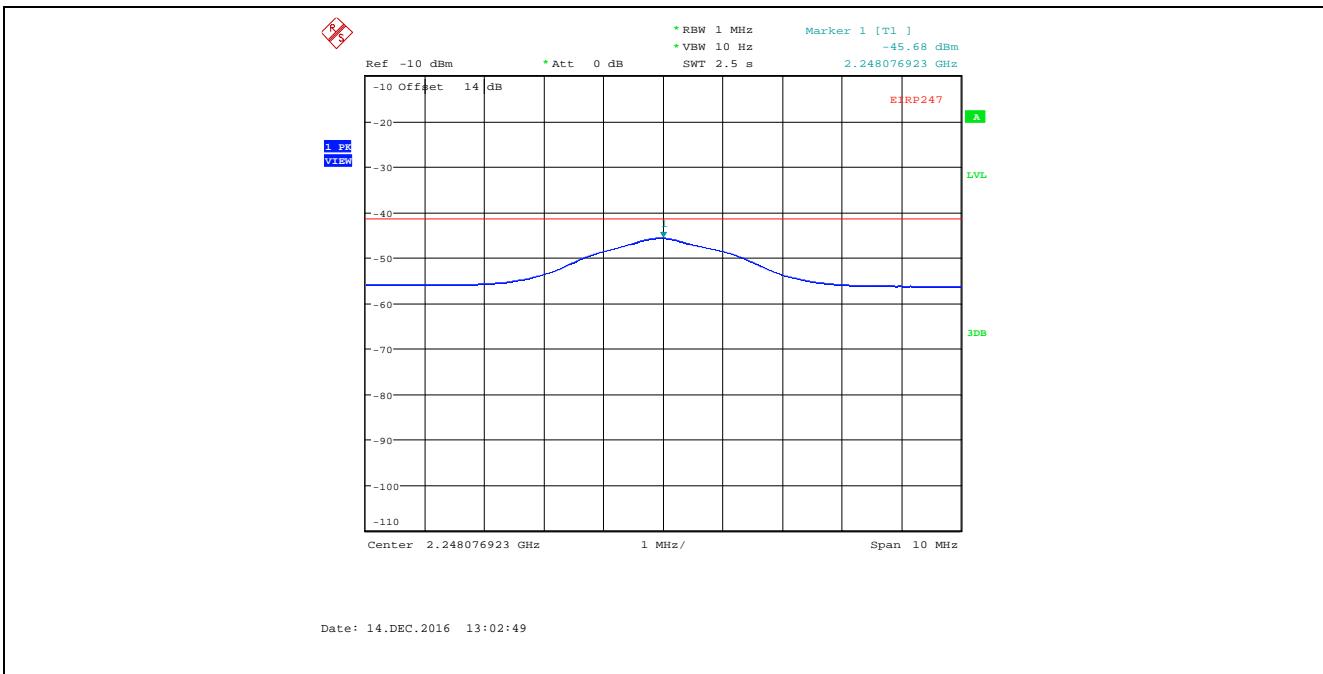
Plot 5.4.4.3.11. Conducted Spurious Emissions in Restricted Frequency Bands
 Channel 8, 2440 MHz, MSK Modulation, Power Setting 12, 30 MHz - 1 GHz, Peak Detector
 Marker 1 is outside of restricted bands



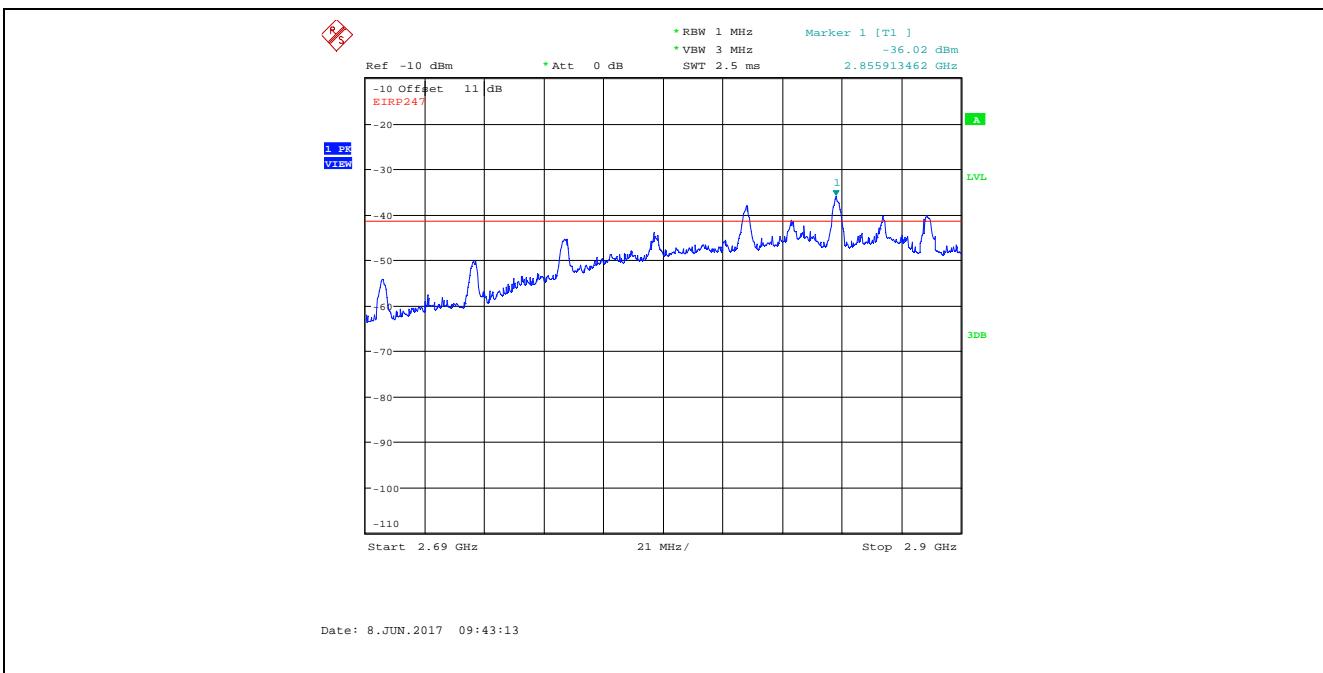
Plot 5.4.4.3.12. Conducted Spurious Emissions in Restricted Frequency Bands
 Channel 8, 2440 MHz, MSK Modulation, Power Setting 12, 1 GHz - 4 GHz, Peak Detector



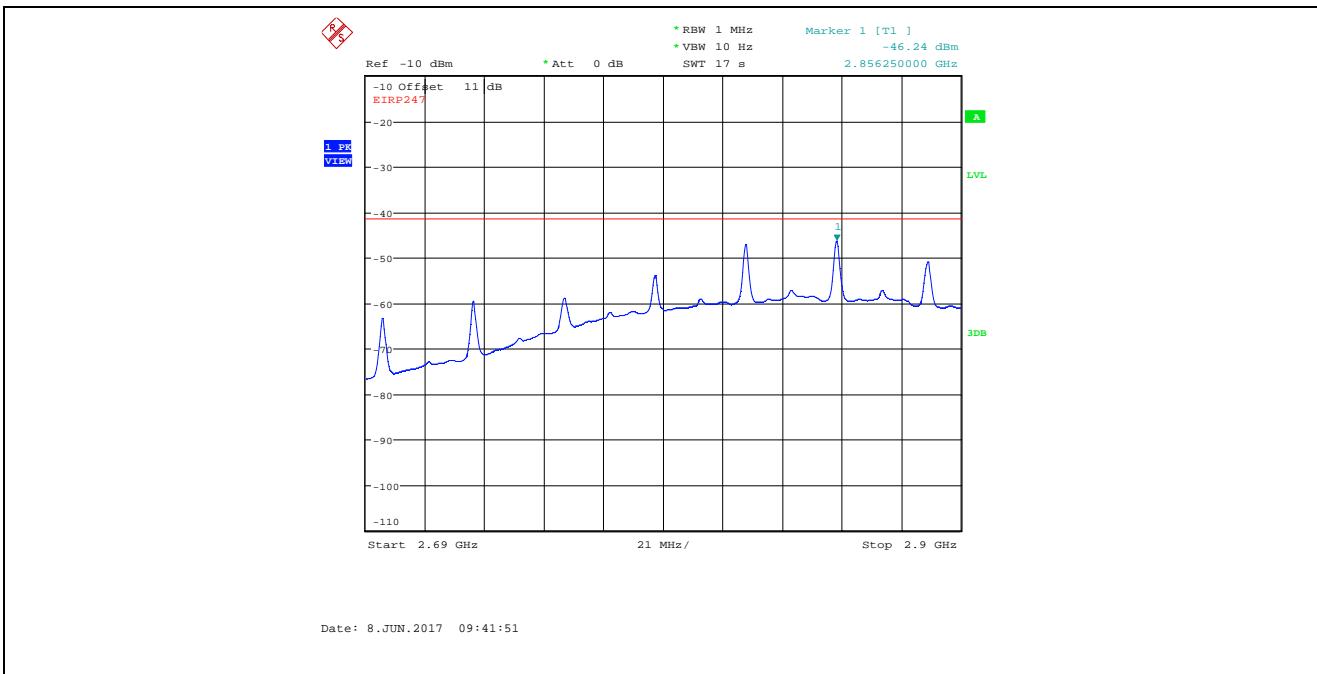
Plot 5.4.4.3.13. Conducted Spurious Emissions in Restricted Frequency Bands
 Channel 8, 2440 MHz, MSK Modulation, Power Setting 12, 2.2431 - 2.2531 GHz, Average Detector



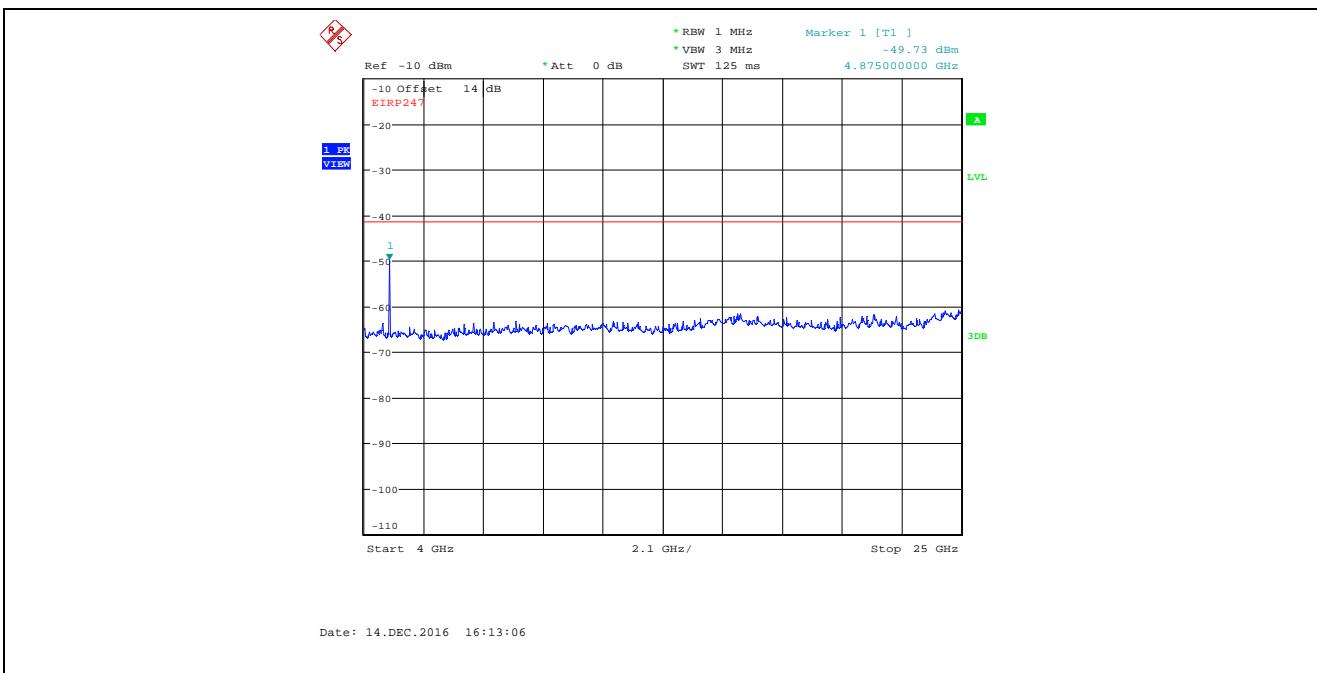
Plot 5.4.4.3.14. Conducted Spurious Emissions in Restricted Frequency Bands
 Channel 8, 2440 MHz, MSK Modulation, Power Setting 12, 2.69 - 2.9 GHz, Peak Detector



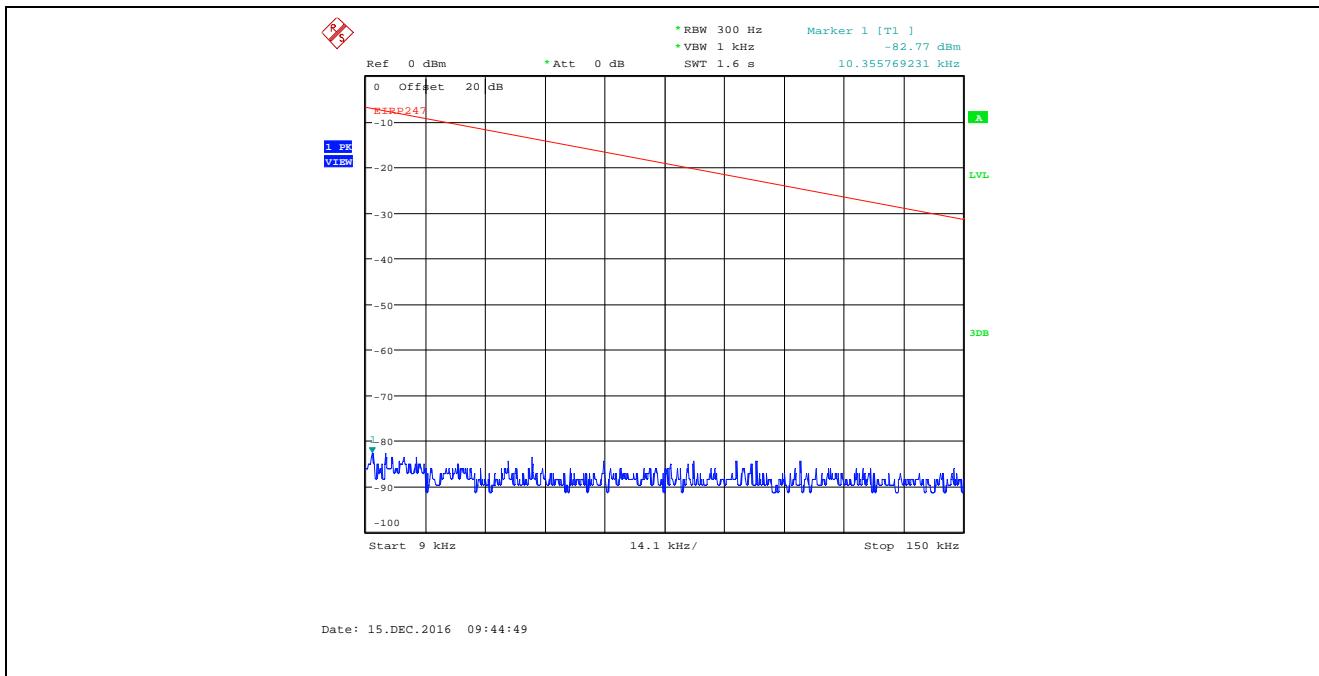
Plot 5.4.4.3.15. Conducted Spurious Emissions in Restricted Frequency Bands
 Channel 8, 2440 MHz, MSK Modulation, Power Setting 12, 2.69 - 2.9 GHz, Average Detector



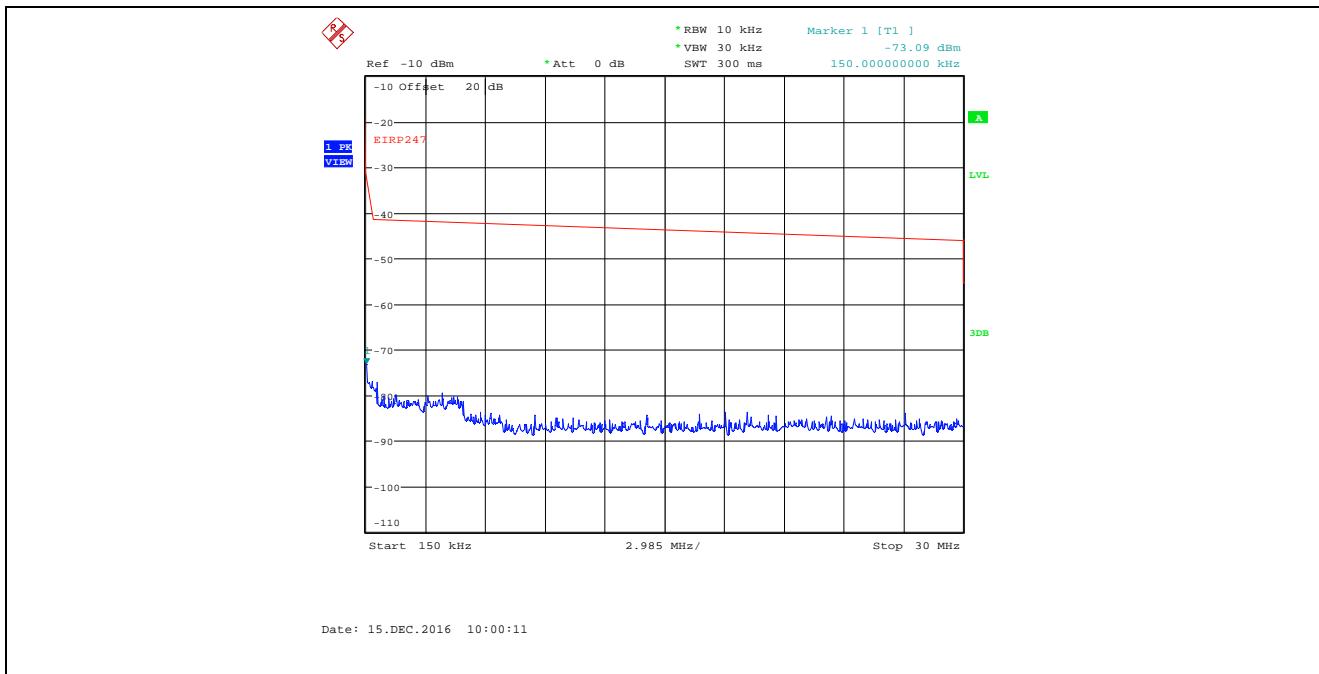
Plot 5.4.4.3.16. Conducted Spurious Emissions in Restricted Frequency Bands
 Channel 8, 2440 MHz, MSK Modulation, Power Setting 12, 4 GHz - 25 GHz, Peak Detector



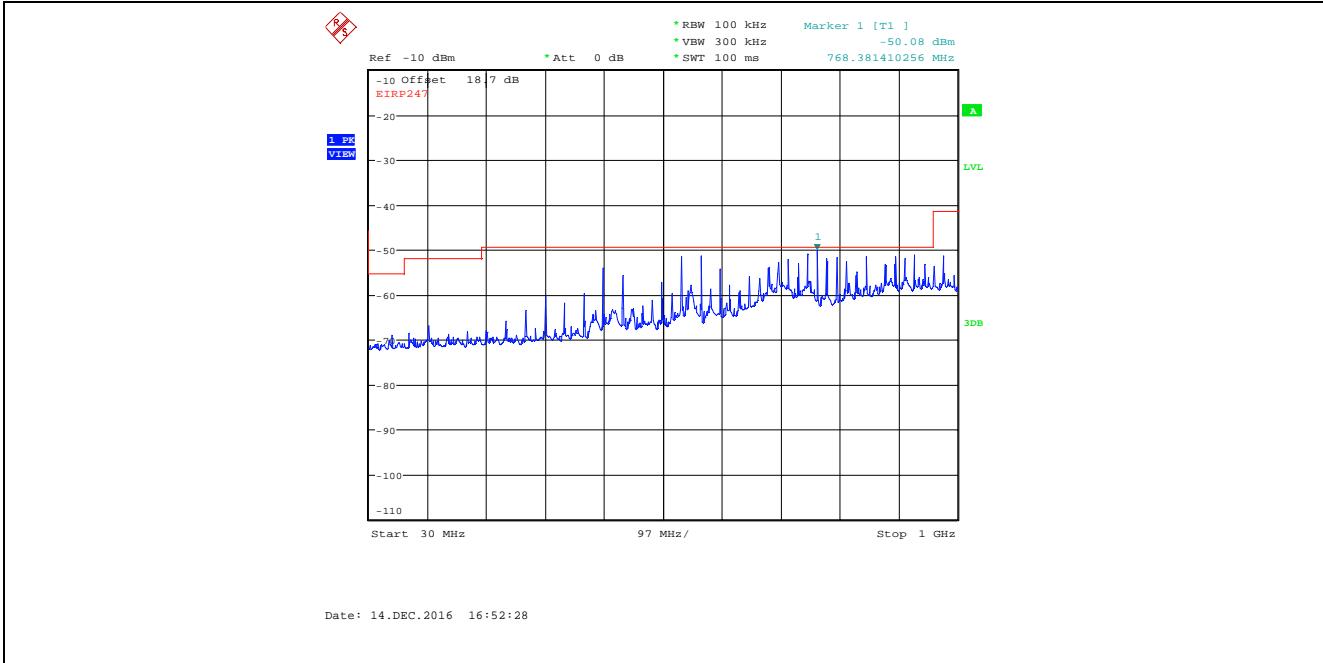
Plot 5.4.4.3.17. Conducted Spurious Emissions in Restricted Frequency Bands
 Channel 16, 2480 MHz, MSK Modulation, Power Setting 12, 9 kHz - 150 kHz, Peak Detector



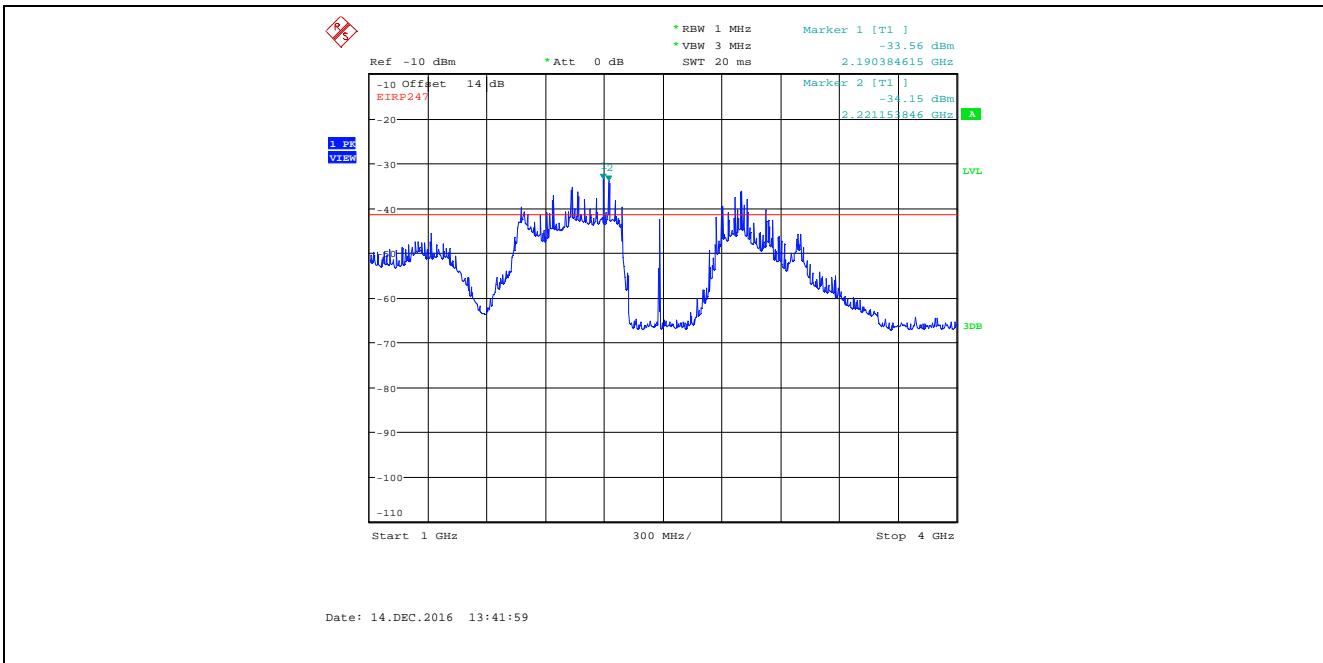
Plot 5.4.4.3.18. Conducted Spurious Emissions in Restricted Frequency Bands
 Channel 16, 2480 MHz, MSK Modulation, Power Setting 12, 150 kHz - 30 MHz, Peak Detector



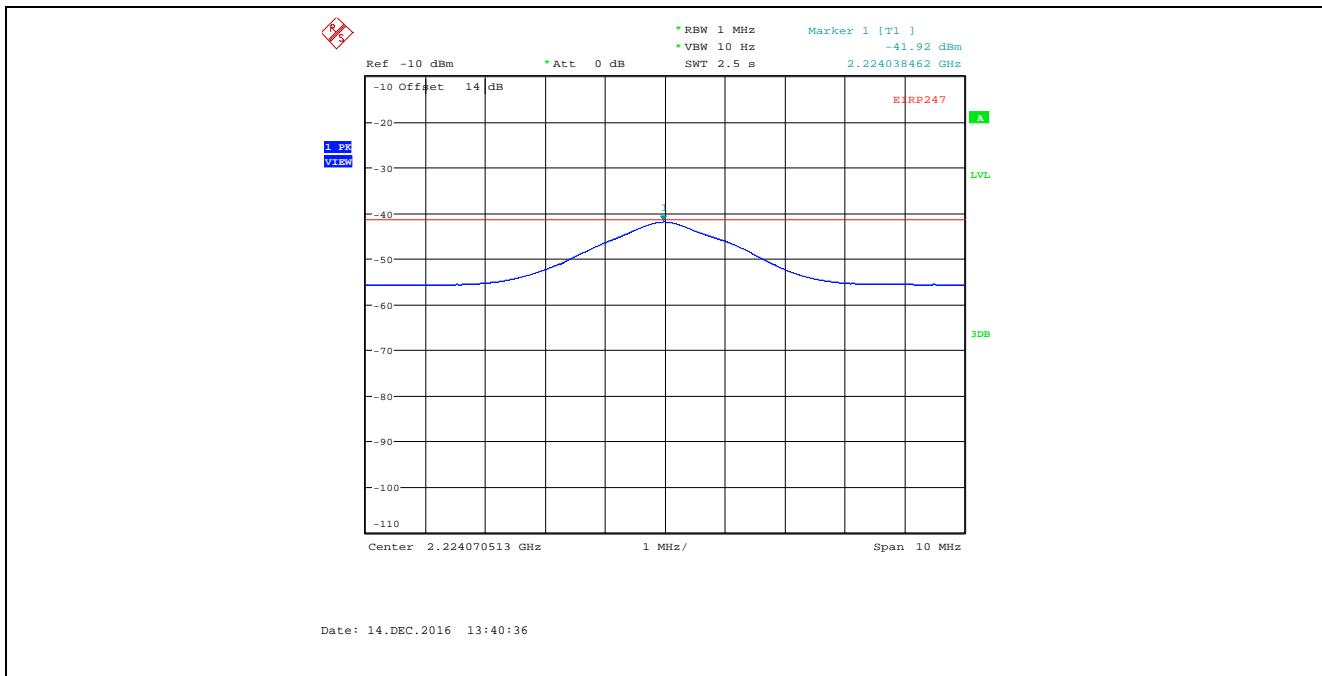
Plot 5.4.4.3.19. Conducted Spurious Emissions in Restricted Frequency Bands
 Channel 16, 2480 MHz, MSK Modulation, Power Setting 12, 30 MHz - 1 GHz, Peak Detector
 Marker 1 is outside of restricted bands



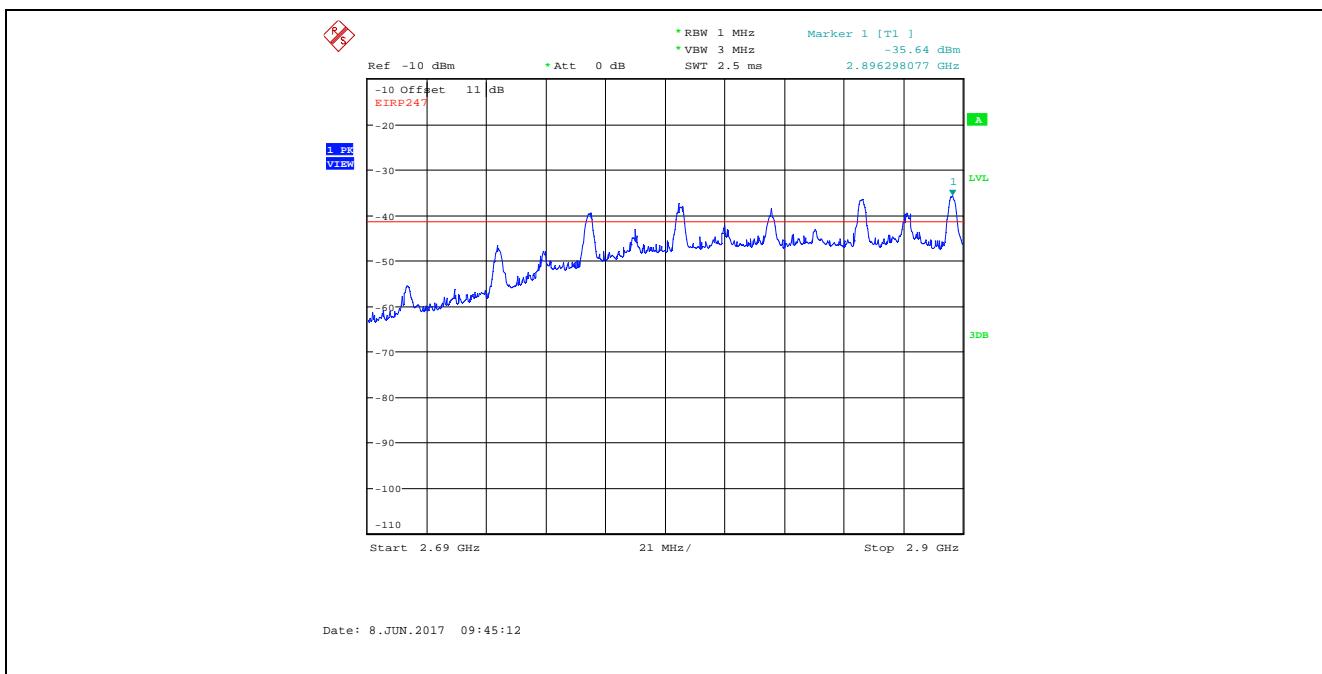
Plot 5.4.4.3.20. Conducted Spurious Emissions in Restricted Frequency Bands
 Channel 16, 2480 MHz, MSK Modulation, Power Setting 12, 1 GHz - 4 GHz, Peak Detector



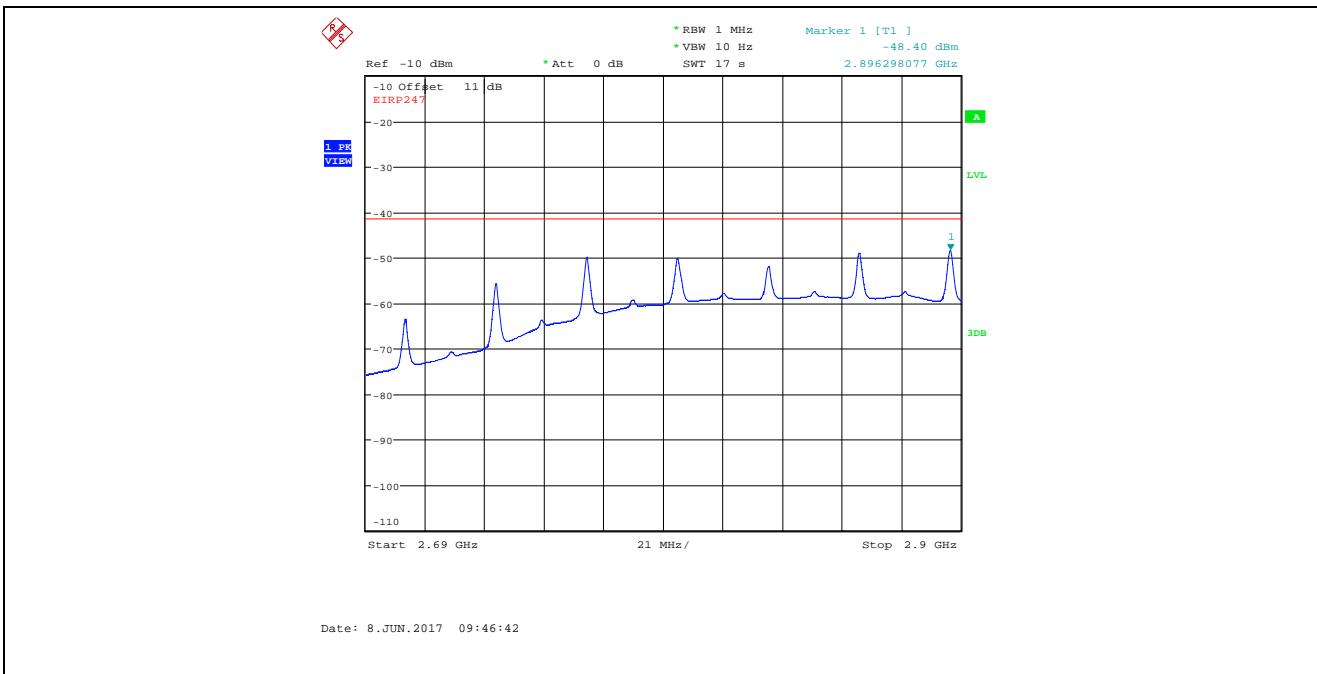
Plot 5.4.4.3.21. Conducted Spurious Emissions in Restricted Frequency Bands
 Channel 16, 2480 MHz, MSK Modulation, Power Setting 12, 2.2191 - 2.2291 GHz, Average Detector



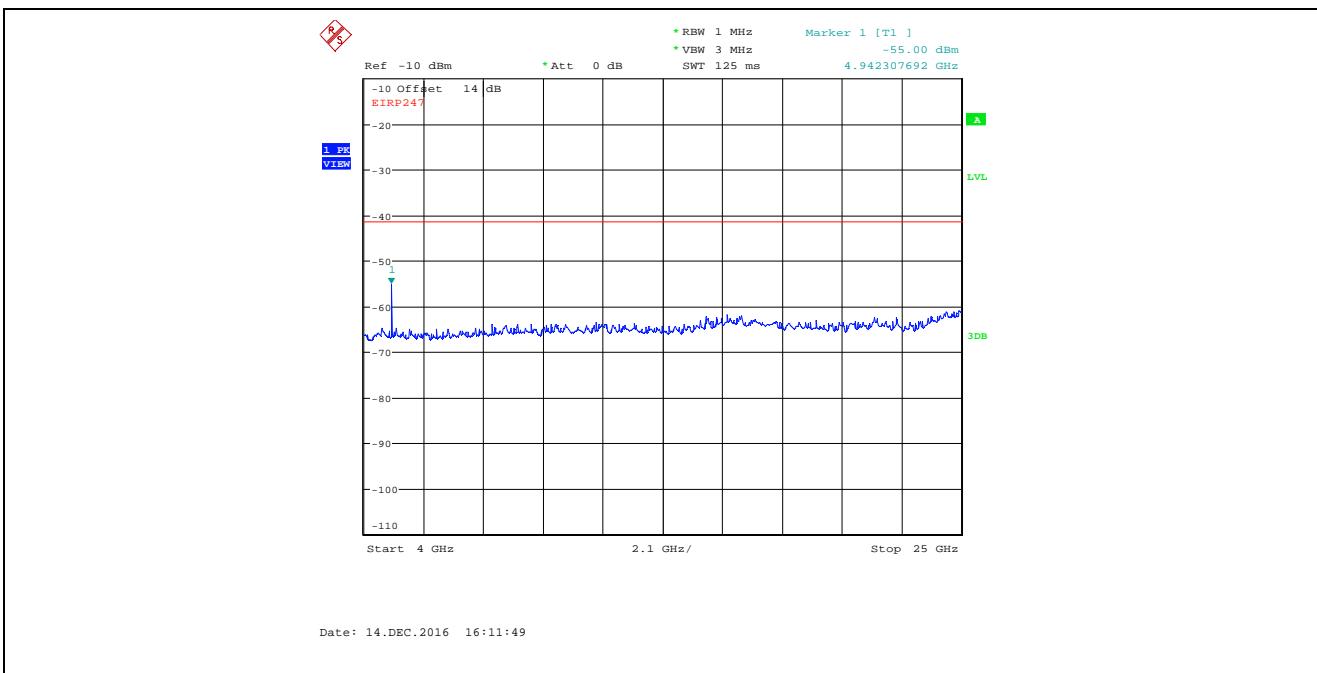
Plot 5.4.4.3.22. Conducted Spurious Emissions in Restricted Frequency Bands
 Channel 16, 2480 MHz, MSK Modulation, Power Setting 12, 2.69 - 2.9 GHz, Peak Detector



Plot 5.4.4.3.23. Conducted Spurious Emissions in Restricted Frequency Bands
 Channel 16, 2480 MHz, MSK Modulation, Power Setting 12, 2.69 - 2.9 GHz, Average Detector



Plot 5.4.4.3.24. Conducted Spurious Emissions in Restricted Frequency Bands
 Channel 16, 2480 MHz, MSK Modulation, Power Setting 12, 4 GHz - 25 GHz, Peak Detector



5.5. TRANSMITTER SPURIOUS RADIATED EMISSIONS AT 3 METERS [§§ 15.247(d), 15.209 & 15.205]

5.5.1. Limit(s)

§ 15.247 (d): In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

Section 15.205(a) - Restricted Bands of Operation

MHz	MHz	MHz	GHz
0.090–0.110	16.42–16.423	399.9–410	4.5–5.15
1.0495–0.505	16.69475–16.69525	608–614	5.35–5.46
2.1735–2.1905	16.80425–16.80475	960–1240	7.25–7.75
4.125–4.128	25.5–25.67	1300–1427	8.025–8.5
4.17725–4.17775	37.5–38.25	1435–1626.5	9.0–9.2
4.20725–4.20775	73–74.6	1645.5–1646.5	9.3–9.5
6.215–6.218	74.8–75.2	1660–1710	10.6–12.7
6.26775–6.26825	108–121.94	1718.8–1722.2	13.25–13.4
6.31175–6.31225	123–138	2200–2300	14.47–14.5
8.291–8.294	149.9–150.05	2310–2390	15.35–16.2
8.362–8.366	156.52475–156.52525	2483.5–2500	17.7–21.4
8.37625–8.38675	156.7–156.9	2655–2900	22.01–23.12
8.41425–8.41475	162.0125–167.17	3260–3267	23.6–24.0
12.29–12.293	167.72–173.2	3332–3339	31.2–31.8
12.51975–12.52025	240–285	3345.8–3358	36.43–36.5
12.57675–12.57725	322–335.4	3600–4400	(²)
13.36–13.41.			

¹ Until February 1, 1999, this restricted band shall be 0.490–0.510 MHz.

² Above 38.6

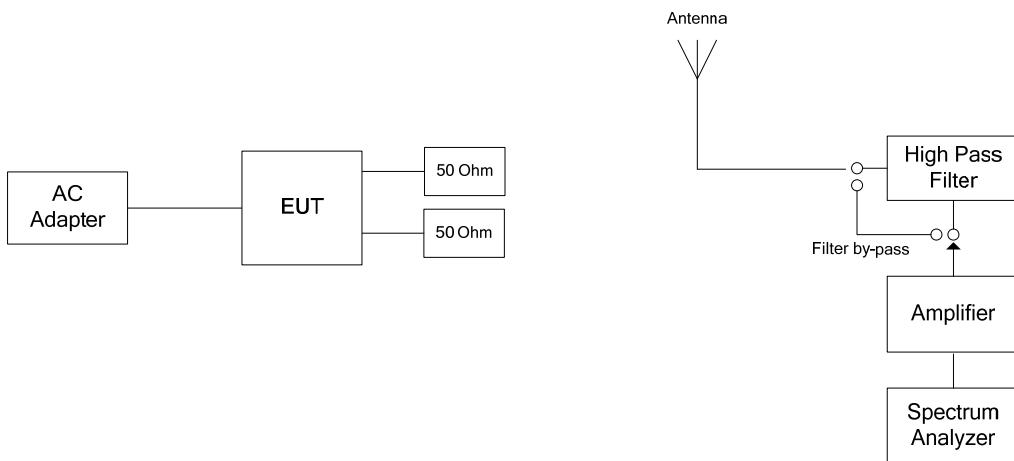
Section 15.209(a) - Field Strength Limits within Restricted Frequency Bands

Frequency (MHz)	Field Strength (microvolts/meter)	Measurement Distance (meters)
0.009 - 0.490	2,400 / F (kHz)	300
0.490 - 1.705	24,000 / F (kHz)	30
1.705 - 30.0	30	30
30 - 88	100	3
88 - 216	150	3
216 - 960	200	3
Above 960	500	3

5.5.2. Method of Measurements

KDB 558074 D01 DTS Meas Guidance v03r05, Section 12.2.7 and ANSI C63.10.

5.5.3. Test Arrangement



5.5.4. Test Data

Remark(s):

- All spurious emissions that are in excess of 20 dB below the specified limit shall be recorded.
- EUT shall be tested in three orthogonal positions.
- § 15.247 (d) spurious emission limit:

$$E_{dB\mu V/m} = EIRP_{dBm} - 20\log(d) + 104.8 - 20 = EIRP_{dBm} - 20\log(3) + 84.8$$
- Exploratory tests performed to determined worst-case test configurations, the following test results at high power setting represent the worst-case.

Fundamental Frequency: 2405 MHz EIRP: 18.05 dBm Frequency Test Range: 30 MHz – 25 GHz							
Frequency (MHz)	RF Peak Level (dB μ V/m)	RF Avg Level (dB μ V/m)	Antenna Plane (H/V)	Limit 15.209 (dB μ V/m)	Limit 15.247 (dB μ V/m)	Margin (dB)	Pass/ Fail
4810	49.23	37.21	V	54.0	93.3	-16.8	Pass*
4810	48.61	36.35	H	54.0	93.3	-17.7	Pass*
All other spurious emissions and harmonics are more than 20 dB below the applicable limit.							

*Field strength of emissions appearing within restricted frequency bands shall not exceed the limits in § 15.209.

Fundamental Frequency: 2440 MHz EIRP: 20.27 dBm Frequency Test Range: 30 MHz – 25 GHz							
Frequency (MHz)	RF Peak Level (dB μ V/m)	RF Avg Level (dB μ V/m)	Antenna Plane (H/V)	Limit 15.209 (dB μ V/m)	Limit 15.247 (dB μ V/m)	Margin (dB)	Pass/ Fail
4880	50.74	39.13	V	54.0	95.5	-14.9	Pass*
4880	48.56	35.82	H	54.0	95.5	-18.2	Pass*
All other spurious emissions and harmonics are more than 20 dB below the applicable limit.							

*Field strength of emissions appearing within restricted frequency bands shall not exceed the limits in § 15.209.

Fundamental Frequency: 2480 MHz EIRP: 20.85 dBm Frequency Test Range: 30 MHz – 25 GHz							
Frequency (MHz)	RF Peak Level (dB μ V/m)	RF Avg Level (dB μ V/m)	Antenna Plane (H/V)	Limit 15.209 (dB μ V/m)	Limit 15.247 (dB μ V/m)	Margin (dB)	Pass/ Fail
4960	47.74	35.54	V	54.0	96.1	-18.5	Pass*
4960	48.85	35.42	H	54.0	96.1	-18.6	Pass*
All other spurious emissions and harmonics are more than 20 dB below the applicable limit.							

*Field strength of emissions appearing within restricted frequency bands shall not exceed the limits in § 15.209.

5.6. POWER SPECTRAL DENSITY [§ 15.247(e)]

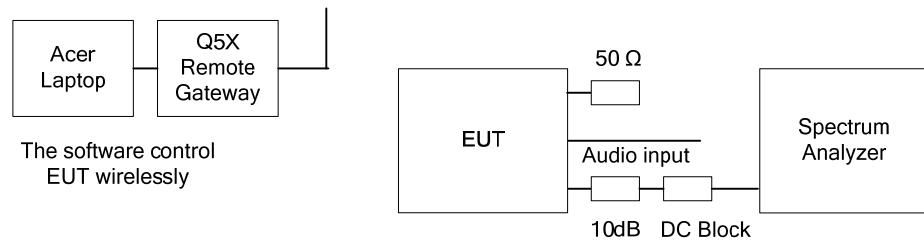
5.6.1. Limit(s)

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

5.6.2. Method of Measurements

KDB 558074 D01 DTS Meas Guidance v03r05, Section 10.2 PKPSD

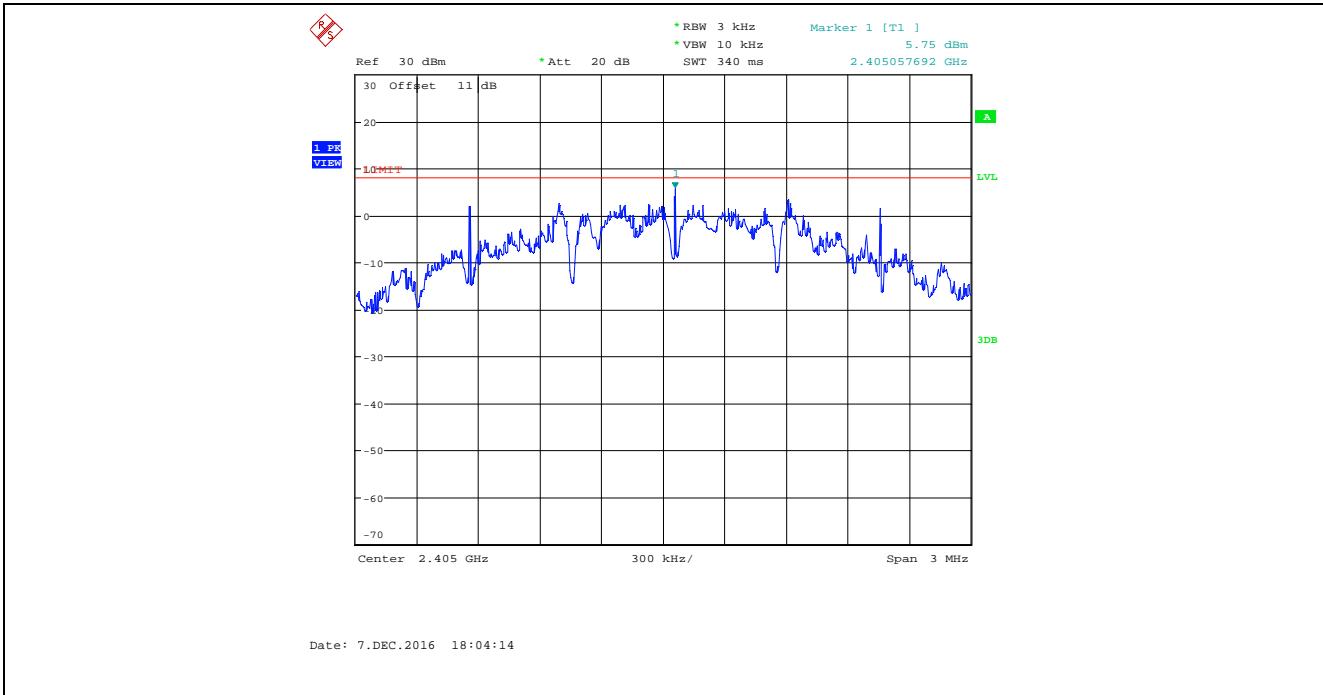
5.6.3. Test Arrangement



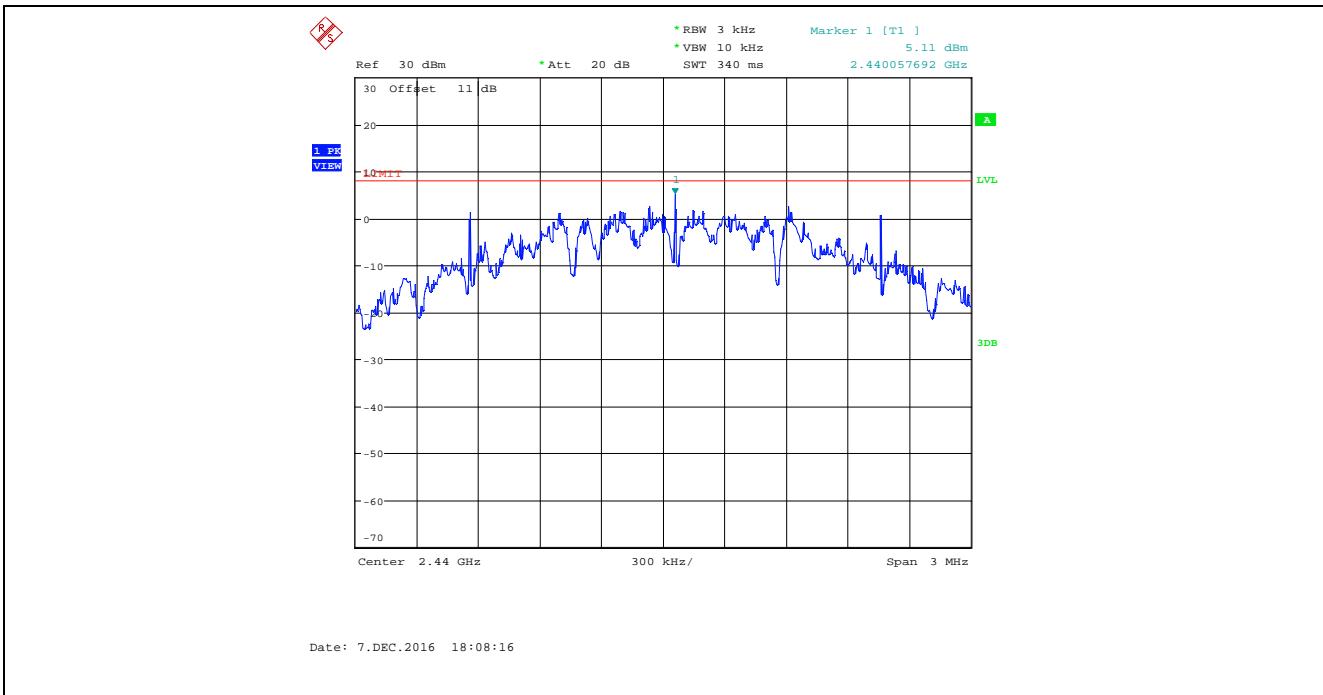
5.6.4. Test Data

Modulation	Channel Number	Frequency (MHz)	PSD (dBm)	Limit (dBm)
MSK	1	2405	5.75	8
	8	2440	5.11	8
	16	2480	4.77	8

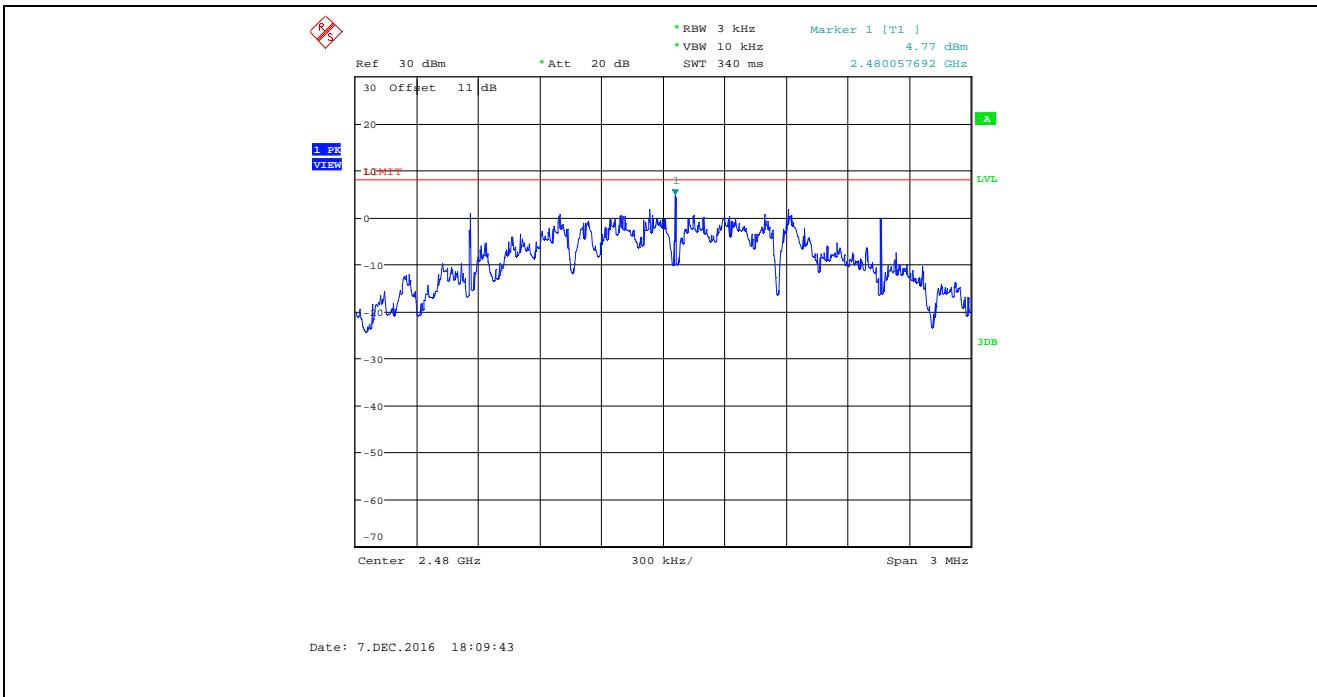
Plot 5.6.4.1. Power Spectral Density, Channel 1, 2405 MHz, MSK modulation, Power Setting 12



Plot 5.6.4.2. Power Spectral Density, Channel 8, 2440 MHz, MSK modulation, Power Setting 12



Plot 5.6.4.3. Power Spectral Density, Channel 16, 2480 MHz, MSK modulation, Power Setting 12



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3000 Bristol Circle, Oakville, Ontario, Canada L6H 6G4
Tel. #: 905-829-1570, Fax. #: 905-829-8050, Email: vic@ultratech-labs.com, Website: <http://www.ultratech-labs.com>

File #: 18Q5X047_FCC15C247B2

March 28, 2018

All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

5.7. RF EXPOSURE REQUIREMENTS [§§ 15.247(i), 1.1310 & 2.1091]

5.7.1. Limits

§ 1.1310: The criteria listed in the following table shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in 1.1307(b).

Limits for Maximum Permissible Exposure (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm ²)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposures				
0.3-3.0	614	1.63	*(100)	6
3.0-30	1842/f	4.89/f	*(900/f ²)	6
30-300	61.4	0.163	1.0	6
300-1500			f/300	6
1500-100,000			5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*(100)	30
1.34-30	824/f	2.19/f	*(180/f ²)	30
30-300	27.5	0.073	0.2	30
300-1500			f/1500	30
1500-100,000			1.0	30

f = frequency in MHz

* = Plane-wave equivalent power density

Note 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

Note 2: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

5.7.2. Method of Measurements

Calculation Method of Power Density/RF Safety Distance:

$$S = \frac{PG}{4\pi \cdot r^2} = \frac{EIRP}{4\pi \cdot r^2}$$

Where, P: power input to the antenna in mW

EIRP: Equivalent (effective) isotropic radiated power.

S: power density mW/cm²

G: numeric gain of antenna relative to isotropic radiator

r: distance to centre of radiation in cm

5.7.3. RF Evaluation for Mobile Applications

Pursuant to FCC KDB 447498 D01 General RF Exposure Guidance v06, Section 7.2:

Simultaneous transmission MPE test exclusion applies when the sum of the MPE ratios for all simultaneously transmitting antennas incorporated in a host device is ≤ 1.0, according to calculated/estimated, numerically modeled, or measured field strengths or power density.

The following table addresses the co-location of the EUT dual band operation.

EUT Co-located MPE for Dual Band Operation at an Evaluation Distance of 20cm										
Frequency Band (MHz)	Frequency	Conducted Output Power (mW)	Conducted Output Power (dBm)	Antenna Gain (dBi)	Max EUT EIRP (dBm)	Averaged Max EUT EIRP (mW)	Evaluation Distance (cm)	Power Density (mW/cm ²)	Power Density FCC Limit (mW/cm ²)	FCC Power Density MPE Ratio
2405-2480	2405.0	60.95	17.85	3	20.85	121.62	20	0.024	1.000	0.024
525.000 - 600.000	525.000	250	23.98	3	26.98	498.88	20	0.099	0.350	0.284
Worst case sum of the MPE ratios for all simultaneously transmitting antennas:										0.308

5.7.4. RF Evaluation for Portable Applications

For portable applications, refer to SAR test report for portable host products with the module integrated.

EXHIBIT 6. TEST EQUIPMENT LIST

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range	Cal. Due Date
Spectrum Analyzer	Rohde & Schwarz	FSU26	200946	20 Hz - 26.5 GHz	21 Jul 2018
Attenuator	Pasternack	7024-10	4	DC - 26.5 GHz	Note 1
DC Block	Hewlett Packard	11742A	12460	0.045 - 26.5 GHz	Note 1
High Pass Filter	K & L	11SH10-4000/T12000	4	Cut off 2400 MHz	Note 1
Band Reject Filter	Micro-Tronics	BRM50701	105	Stopband: 2400 to 2500 MHz	Note 1
EMI Receiver	Rohde & Schwarz	ESU40	100037	20Hz-40 GHz	08 May 2017*
Spectrum Analyzer	Rohde & Schwarz	FSEK30	100077	20Hz-40 GHz	05 Dec 2018
RF Amplifier	Com-Power	PAM-0118A	551016	0.5 – 18 GHz	14 Jul 2017
RF Amplifier	Hewlett Packard	84498	3008A00769	1 – 26.5 GHz	05 May 2017*
Biconilog	EMCO	3142	9601-1005	26-2000 MHz	12 May 2018
Horn Antenna	EMCO	3115	6570	1 – 18 GHz	13 Oct 2018
Horn Antenna	ETS-Lindgren	3160-09	001183858	18 – 26.5 GHz	11 Oct 2018
Spectrum Analyzer	Agilent	E7405A	US39440181	9 kHz – 26.5 GHz	04 Jan 2018
Attenuator	Pasternack	PE7010-20	07	DC – 2 GHz	13 Mar 2018
Power Supply	Tenma	72-7295	490300297	1-40V DC 5A	Note 1
L.I.S.N.	EMCO	3825/2	8907-1531	10 kHz – 100 MHz	11 Nov 2017

Note 1: Internal Verification/Calibration check

* Equipment used before calibration due date.

EXHIBIT 7. MEASUREMENT UNCERTAINTY

The measurement uncertainties stated were calculated in accordance with the requirements of CISPR 16-4-2 @ IEC:2003 and JCGM 100:2008 (GUM 1995) – Guide to the Expression of Uncertainty in Measurement.

7.1. LINE CONDUCTED EMISSION MEASUREMENT UNCERTAINTY

	Line Conducted Emission Measurement Uncertainty (9 kHz – 30 MHz):	Measured	Limit
u_c	Combined standard uncertainty: $u_c(y) = \sqrt{\sum_{i=1}^m u_i^2(y)}$	± 1.44	± 1.8
U	Expanded uncertainty U: $U = 2u_c(y)$	± 2.89	± 3.6

7.2. RADIATED EMISSION MEASUREMENT UNCERTAINTY

	Radiated Emission Measurement Uncertainty @ 3m, Horizontal (30-1000 MHz):	Measured (dB)	Limit (dB)
u_c	Combined standard uncertainty: $u_c(y) = \sqrt{\sum_{i=1}^m u_i^2(y)}$	± 2.39	± 2.6
U	Expanded uncertainty U: $U = 2u_c(y)$	± 4.79	± 5.2

	Radiated Emission Measurement Uncertainty @ 3m, Vertical (30-1000 MHz):	Measured (dB)	Limit (dB)
u_c	Combined standard uncertainty: $u_c(y) = \sqrt{\sum_{i=1}^m u_i^2(y)}$	± 2.39	± 2.6
U	Expanded uncertainty U: $U = 2u_c(y)$	± 4.78	± 5.2

	Radiated Emission Measurement Uncertainty @ 3 m, Horizontal & Vertical (1 – 18 GHz):	Measured (dB)	Limit (dB)
u_c	Combined standard uncertainty: $u_c(y) = \sqrt{\sum_{i=1}^m u_i^2(y)}$	± 1.87	Under consideration
U	Expanded uncertainty U: $U = 2u_c(y)$	± 3.75	Under consideration