ENGINEERING TEST REPORT

Network Gateway and Mic Commander
Model No.: QG-H1 and QG-N3
FCC ID: Q5N-QGH1

Applicant:

Quantum5X Systems Inc.
30 Adelaide Street North
London, Ontario
Canada, N6B 3N5

In Accordance With

Federal Communications Commission (FCC)
Part 15, Subpart C, Section 15.247 Digital Modulation Systems (DTS)

UltraTech's File No.: 17Q5X052_FCC15247_DTS

This Test report is Issued under the Authority of Tri M. Luu Vice President of Engineering UltraTech Group of Labs Date: January 23, 2018	
Report Prepared by: Santhosh Fernandez Issued Date: January 23, 2018	Tested by: Hung Trinh Test Dates: December 19, 2016- & February 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 NVLAP or any agency of the US Government.*

UltraTech

3000 Bristol Circle, Oakville, Ontario, Canada, L6H 6G4
Tel.: (905) 829-1570 Fax.: (905) 829-8050
Website: www.ultratech-labs.com, Email: vic@ultratech-labs.com, Email: tri@ultratech-labs.com

91038 1309 46390-2049 AT-1945 SL2-IN-E-1119R Korea KCC-RRA CA2049

TABLE OF CONTENTS

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
Purpose of Test:	Equipment Certification for Part 15C Digital Modulation Systems (DTS) Transmitter Module
Test Procedures:	▪ ANSI C63.4 ▪ ANSI C63.10 ▪ FCC KDB Publication No. 558074 D01
Environmental Classification:	[x] Commercial, industrial or business environment [ ] 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
CISPR 16-1-1	2010	Specification for radio disturbance and immunity measuring apparatus and methods. Part 1-1: Measuring Apparatus
CISPR 16-1-2 +A1 +A2	2003 2004 2006	Specification for radio disturbance and immunity measuring apparatus and methods. Part 1-2: Conducted disturbances
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
Contact Person:	Paul Johnson
Email Address:	paul@q5x.com
Telephone No.:	519-675-6999
Fax No.:	519-667-2162

MANUFACTURER:	
Name:	Quantum5X Systems Inc
Address:	30 Adelaide Street North
Contact Person:	Paul Johnson
Email Address:	paul@q5x.com
Telephone No.:	519-675-6999 ext 2553
Fax No.:	519-667-2162

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:	Q5X
Product Name:	1. Network Gateway 2. MicCommander
Model Name or Number:	1. QG-N3 2. QG-H1
Serial Number:	Test Sample
Oscillator Frequencies:	16 MHz, 25 MHz, 32 MHz
CPU Frequencies:	24 MHz
Power input ratings:	3V, 5V, 6V 250ma (Mic commander uses battery)
Equipment Environment / Type:	Broadcast

2.3. EUT'S TECHNICAL SPECIFICATIONS

Transmitter	
Equipment Type:	Portable Mobile Base station (fixed use)
Intended Operating Environment:	Commercial, industrial or business environment
Power Supply Requirement:	3V, 5V, 6V 250ma
RF Output Power Rating:	67 mw
Operating Frequency Range:	2405 MHz to 2480 MHz
RF Output Impedance:	50 Ohm
Channel Spacing	5 MHz
Duty Cycle:	232%
Modulation Type:	IEEE 802.15.4 Direct Sequence Spread Spectrum (MSK)
Antenna Connector Type:	RP-SMA

2.4. ASSOCIATED ANTENNA DESCRIPTIONS

Antenna Type	Maximum Gain (dBi)
2.4GHz Bluetooth, Wi-Fi, WLAN, Zigbee™ Whip, Tilt RF	2

2.5. LIST OF EUT'S PORTS

List of EUT's Ports: QG-N3				
Port Number	EUT's Port Description	Number of Identical Ports	Connector Type	Cable Type (Specify minimum length and shielded/non-shielded)
1	Push Button	1	None	None
2	Barrel Connector	1	Barrel	Shielded, Length <3M
3	Mini USB Connector	1	Mini USB	Shielded, Length <3M
4	Antenna Connector	1	RP-SMA	non-shielded, Length <3M
5	Ethernet Connector	1	RJ-45	Shielded, Length >3M

List of EUT's Ports: QG-H1				
Port Number	EUT's Port Description	Number of Identical Ports	Connector Type	Cable Type (Specify minimum length and shielded/non-shielded)
1	Push Button	1	None	None
2	Barrel Connector	1	Barrel	Shielded, Length <3M
3	Mini USB Connector	1	Mini USB	Shielded, Length <3M
4	Antenna Connector	1	RP-SMA	non-shielded, Length <3M
5	Battery Connector	1	AA Battery Holder	Non-Shielded, Length >3M

List all EUT ports not connected during tests	Justification
Barrel Connector	Used only to power the unit as a back up
Mini USB Connector	Used only for factory programming and setup

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:	Lap top
Brand name:	Acer Aspire
Model Name or Number:	D257-13847; S/N: 11807650925
Connected to EUT's Port:	USB (removed after setup)

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°C
Humidity:	51%
Pressure:	102 kPa
Power Input Source:	6 VDC

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 & Hardware:	Special software provided by the Applicant to operate the EUT at each channel frequency continuously and in the range of typical modes of operation.
Transmitter Test Antenna:	The EUT is tested with the antenna fitted in a manner typical of normal intended use as non-integral antenna equipment as described with the test results.

Transmitter Test Signals	
Frequency Band(s):	2405-2480 MHz
Frequency(ies) Tested: (Near lowest, near middle & near highest frequencies in the frequency range of operation.)	2405, 2440,2480 MHz
RF Power Output: (measured maximum output power at antenna terminals) **Normal Test Modulation:** **Modulating Signal Source:**	18.26 dBm or 67 mW For QG-H1 10.73dBm or 11.8 mW for QG-N3 MSK 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.

- 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), 15.209 & 15.205	Transmitter Band-Edge and 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

Modification: Steward Ferrite HF A187102 with 2 ½ loop around RJ45 POE on QG-N3

EXHIBIT 5. MEASUREMENTS, EXAMINATIONS & TEST DATA FOR EMC EMISSIONS

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

5.1.1. Limit(s)

The equipment shall meet the limits of the following table:

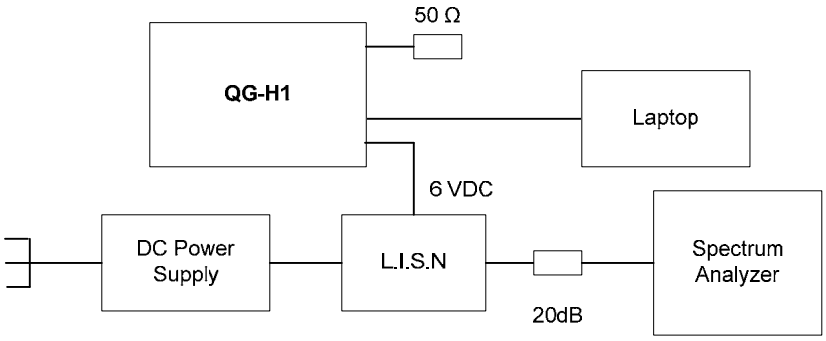
Frequency of emission (MHz)	Conducted Limits (dBμV)	
	Quasi-peak	Average
0.15–0.5 .....……..	66 to 56*	56 to 46*
0.5–5 .....……..	56	46
5-30 ……..	60 ...……..	50

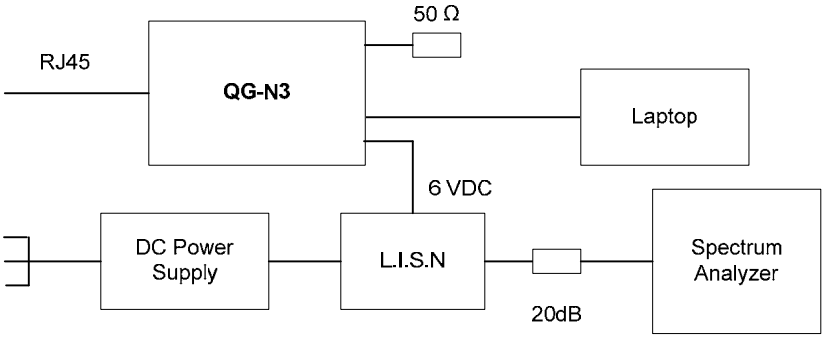
*Decreases linearly with the logarithm of the frequency

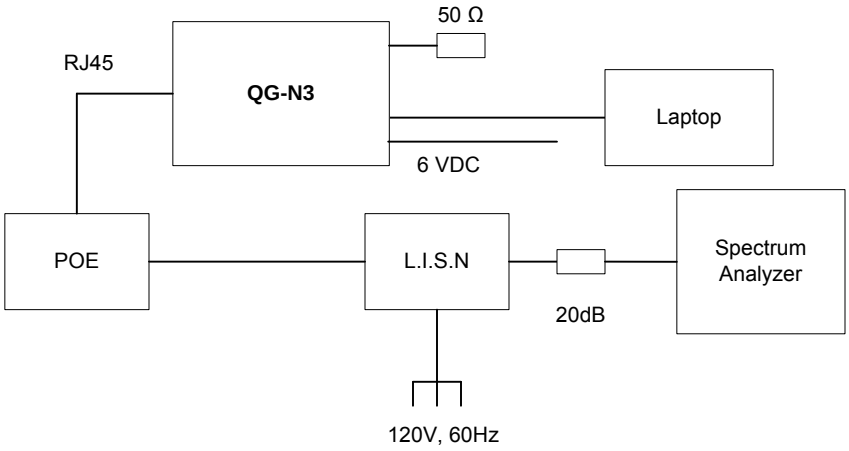
5.1.2. Method of Measurements

ANSI C63.4

5.1.3. Test Arrangement



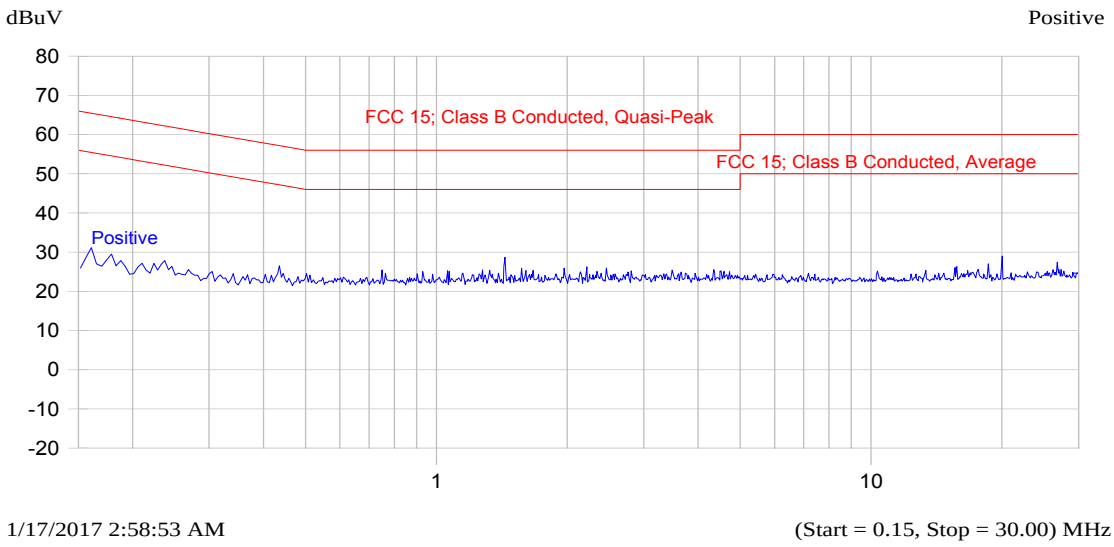




All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

5.1.4. Test Data

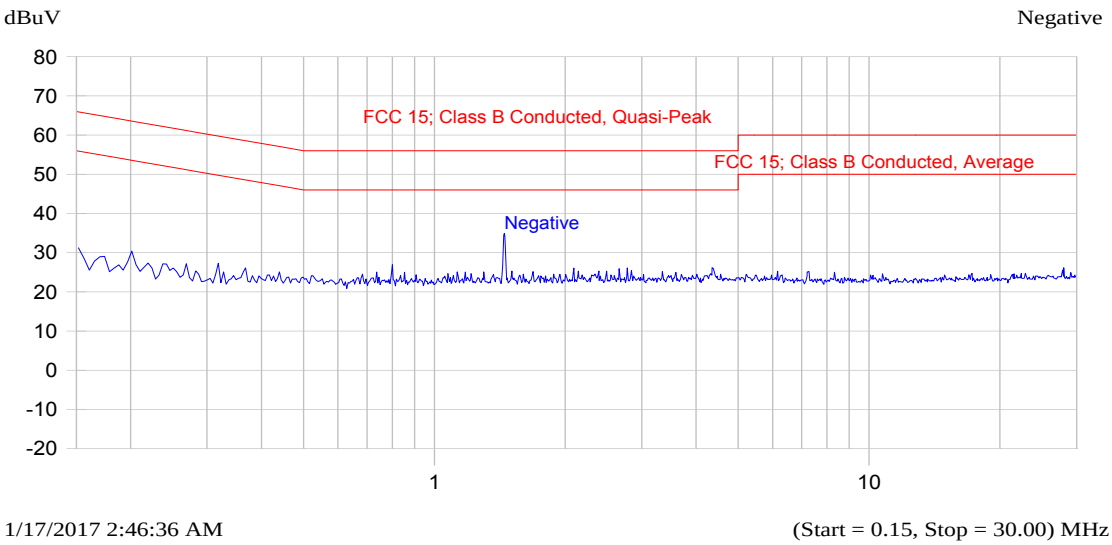
Plot 5.1.4.1. QG-H1 Power Line Conducted Emissions
Line Voltage: 6 VDC; Line Tested: Positive



Current List

Frequency MHz	Peak dBuV	QP dBuV	QP-QP Limit dB	Avg dBuV	Avg-Avg Limit dB	Trace Name
0.170	38.7	34.1	-30.9	28.7	-26.3	Positive
1.431	36.8	32.3	-23.7	27.5	-18.5	Positive

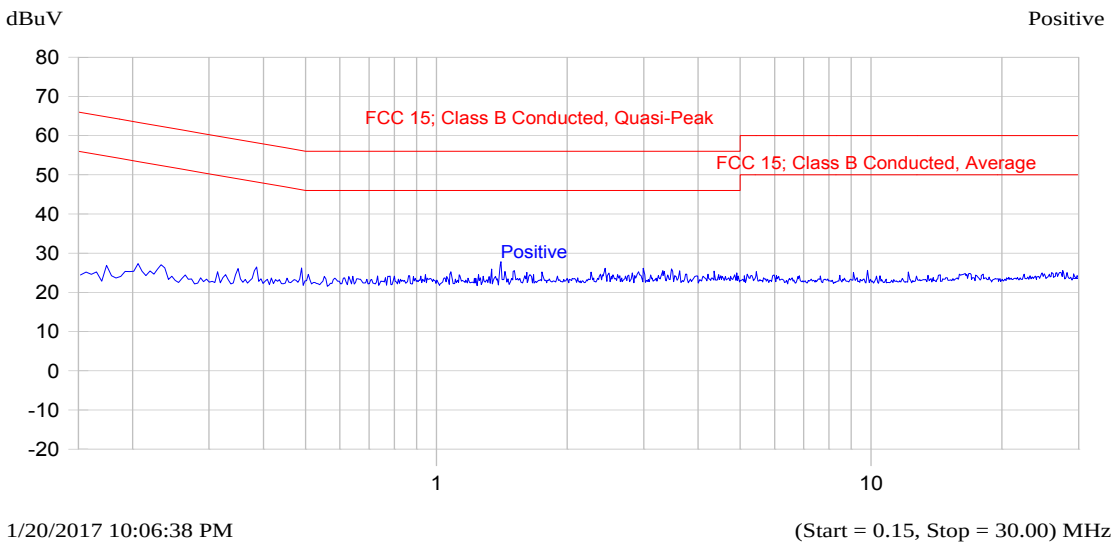
Plot 5.1.4.2. QG-H1 Power Line Conducted Emissions
Line Voltage: 6 VDC; Line Tested: Negative



Current List

Frequency MHz	Peak dBuV	QP dBuV	QP-QP Limit dB	Avg dBuV	Avg-Avg Limit dB	Trace Name
0.192	38.6	33.0	-30.9	27.5	-26.5	Negative
1.436	39.8	37.2	-18.8	33.9	-12.1	Negative

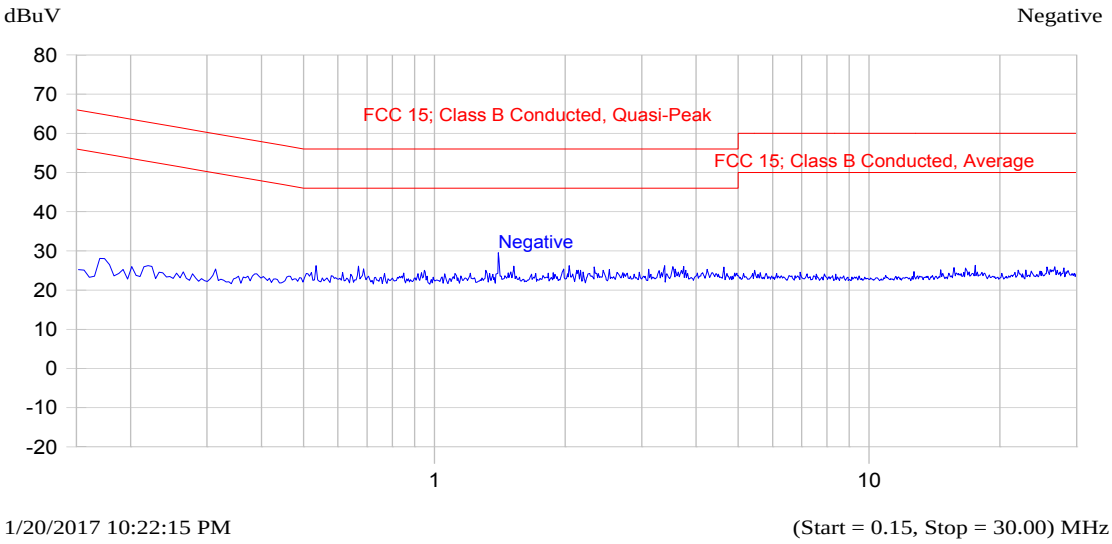
Plot 5.1.4.3. QG-N3 Power Line Conducted Emissions
Line Voltage: 6 VDC; Line Tested: Positive



Current List

Frequency MHz	Peak dBuV	QP dBuV	QP-QP Limit dB	Avg dBuV	Avg-Avg Limit dB	Trace Name
0.237	37.3	32.6	-29.6	27.3	-24.9	Positive
1.397	37.0	31.6	-24.4	26.7	-19.3	Positive

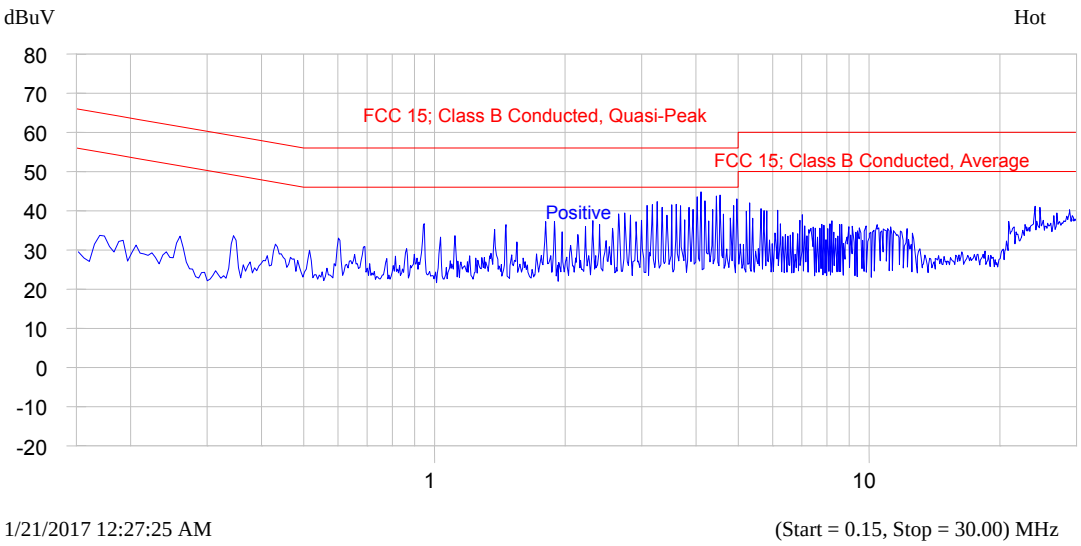
Plot 5.1.4.4. QG-N3 Power Line Conducted Emissions
Line Voltage: 6 VDC; Line Tested: Negative



Current List

Frequency MHz	Peak dBuV	QP dBuV	QP-QP Limit dB	Avg dBuV	Avg-Avg Limit dB	Trace Name
0.173	39.2	34.6	-30.2	29.7	-25.2	Negative
1.403	35.4	29.4	-26.6	23.9	-22.1	Negative

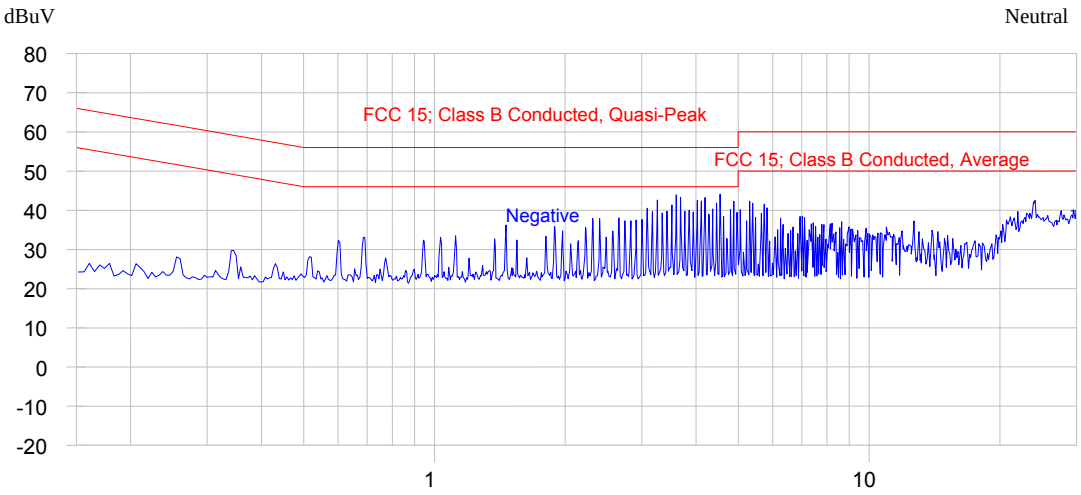
Plot 5.1.4.5. QG-N3 Power Line Conducted Emissions
Line Voltage: 120Vac; Line Tested: Hot POE Adapter



Current List

Frequency MHz	Peak dBuV	QP dBuV	QP-QP Limit dB	Avg dBuV	Avg-Avg Limit dB	Trace Name
0.343	39.6	35.7	-23.4	30.7	-18.5	Hot
0.941	40.1	36.3	-19.7	31.6	-14.4	Hot
4.108	45.7	43.0	-13.0	37.1	-8.9	Hot

Plot 5.1.4.6. QG-N3 Power Line Conducted Emissions
Line Voltage: 120Vac; Line Tested: Neutral POE Adapter



Current List

Frequency MHz	Peak dBuV	QP dBuV	QP-QP Limit dB	Avg dBuV	Avg-Avg Limit dB	Trace Name
0.690	36.1	30.5	-25.5	25.4	-20.6	Neutral
4.536	46.1	44.1	-11.9	37.8	-8.2	Neutral
23.883	40.8	37.9	-22.1	34.3	-15.7	Neutral

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

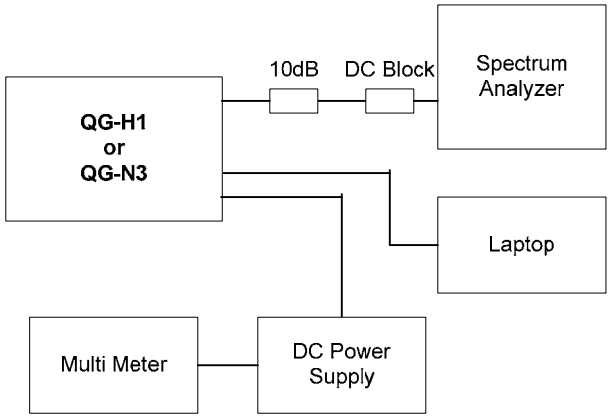
5.2.1. Limit(s)

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

5.2.2. Method of Measurements

KDB Publication No. 558074 D01 DTS Meas Guidance V03r05, Section 8.2 Option 2

5.2.3. Test Arrangement

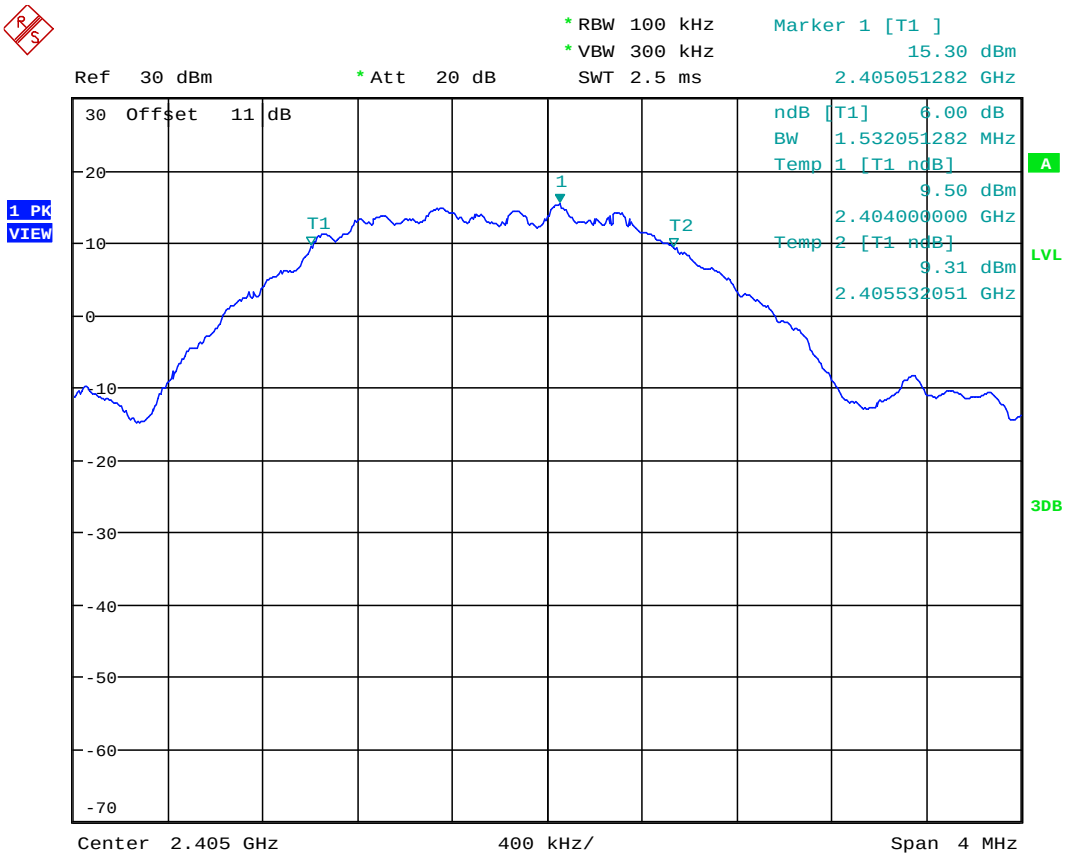


5.2.4. Test Data

Modulation	Channel Number	Frequency (MHz)	QG-H1 6dB BW (MHz)	QG-N3 6dB BW (MHz)	Min Limit (kHz)
MSK	Low	2405	1.53	1.58	500
MSK	Mid	2440	1.53	1.59	500
MSK	High	2480	1.49	1.58	500

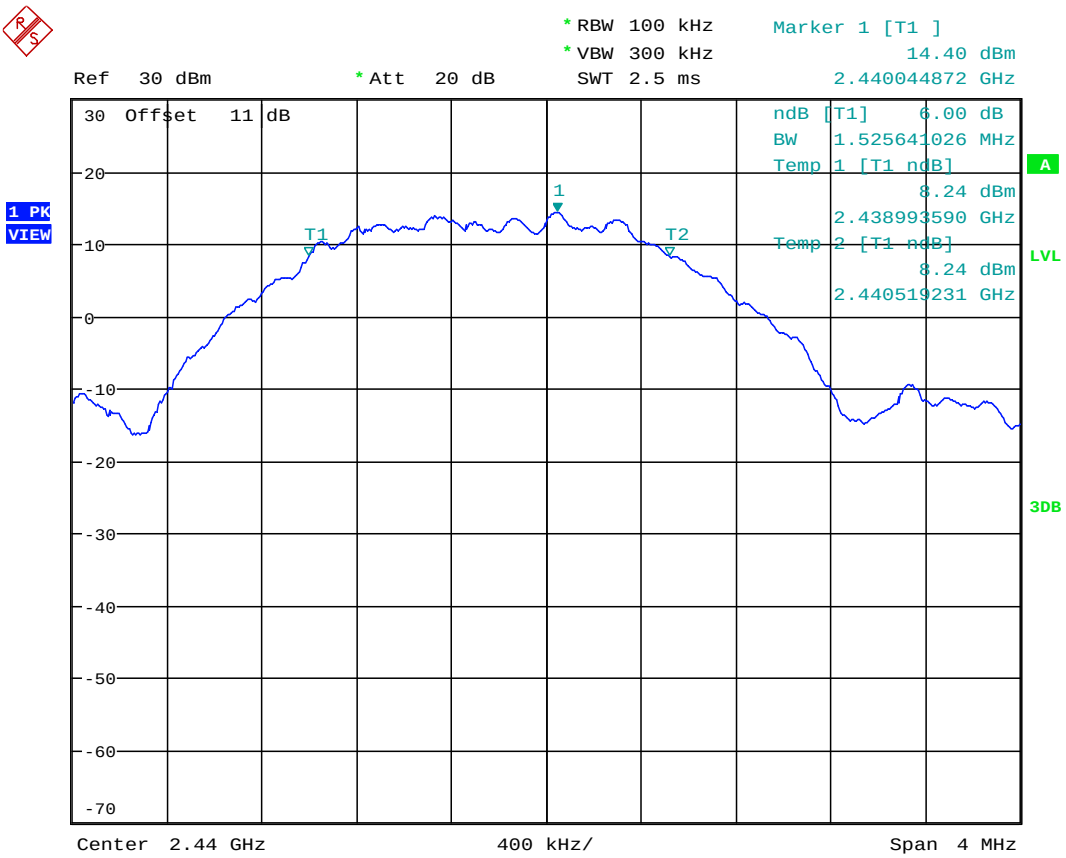
See the following plots for detailed measurements.

Plot 5.2.4.1. QG-H1 6 dB Bandwidth, Channel Low, 2405 MHz



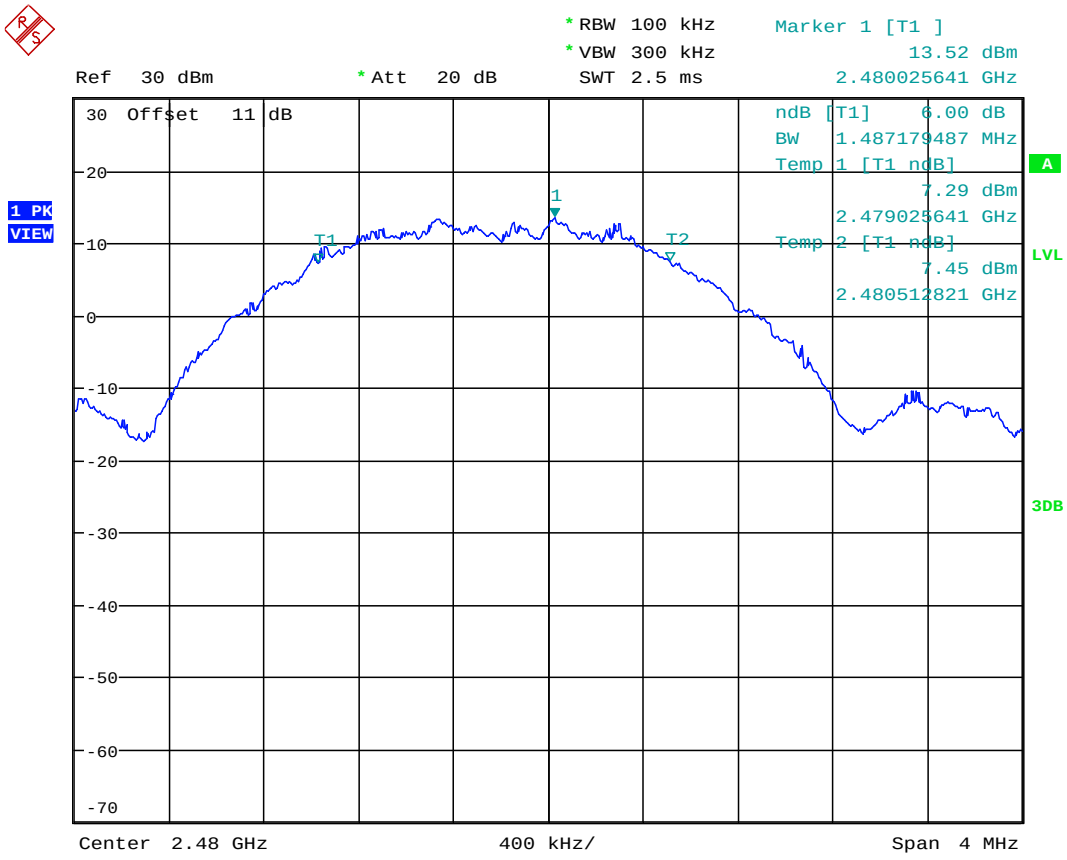
Date: 11.JAN.2017 09:33:38

Plot 5.2.4.2. QG-H1 6 dB Bandwidth, Channel Mid, 2440 MHz,



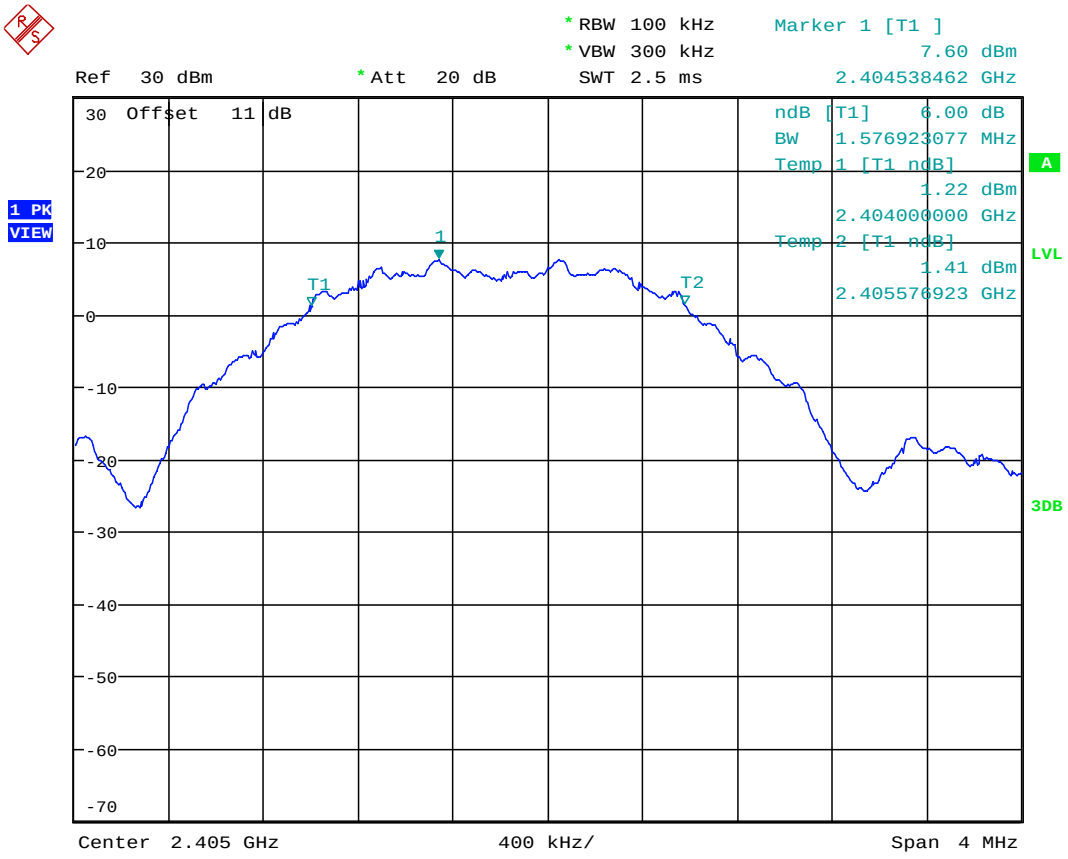
Date: 11.JAN.2017 09:36:25

Plot 5.2.4.3. QG-H1 6 dB Bandwidth, Channel High, 2480 MHz



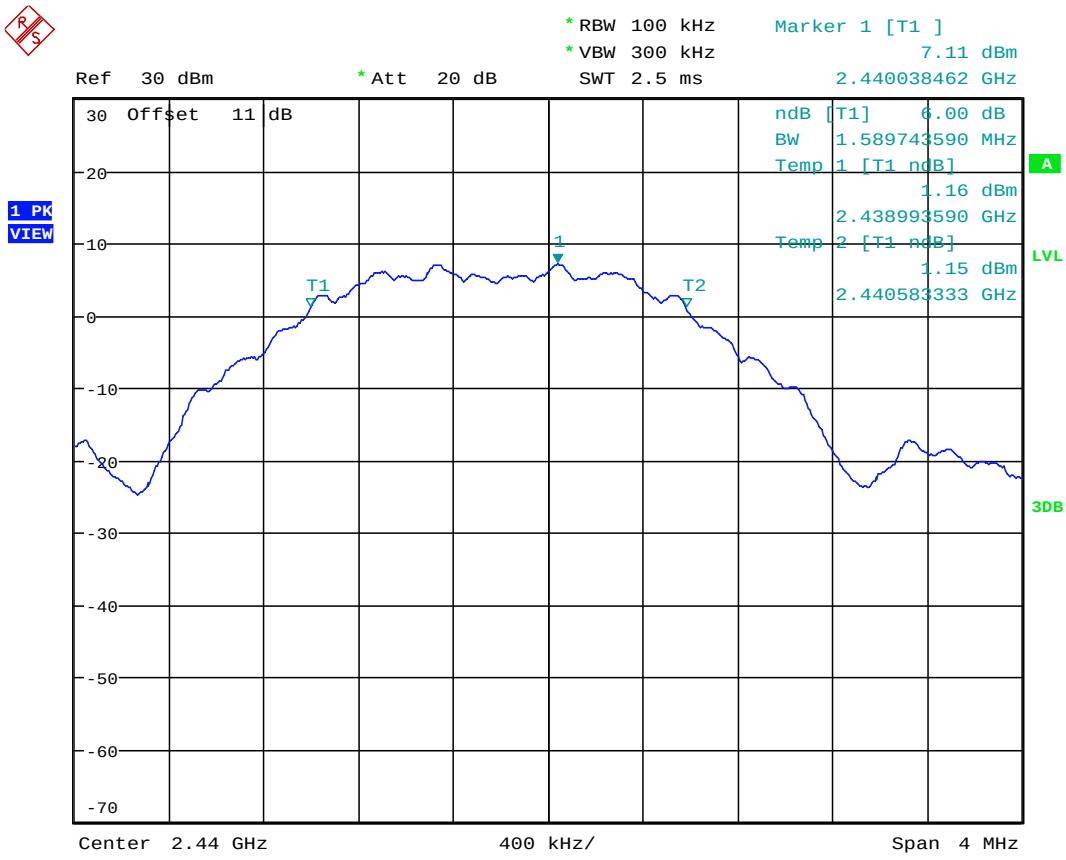
Date: 11.JAN.2017 09:38:08

Plot 5.2.4.4. QG-HN3 6 dB Bandwidth, Channel Low, 2405 MHz



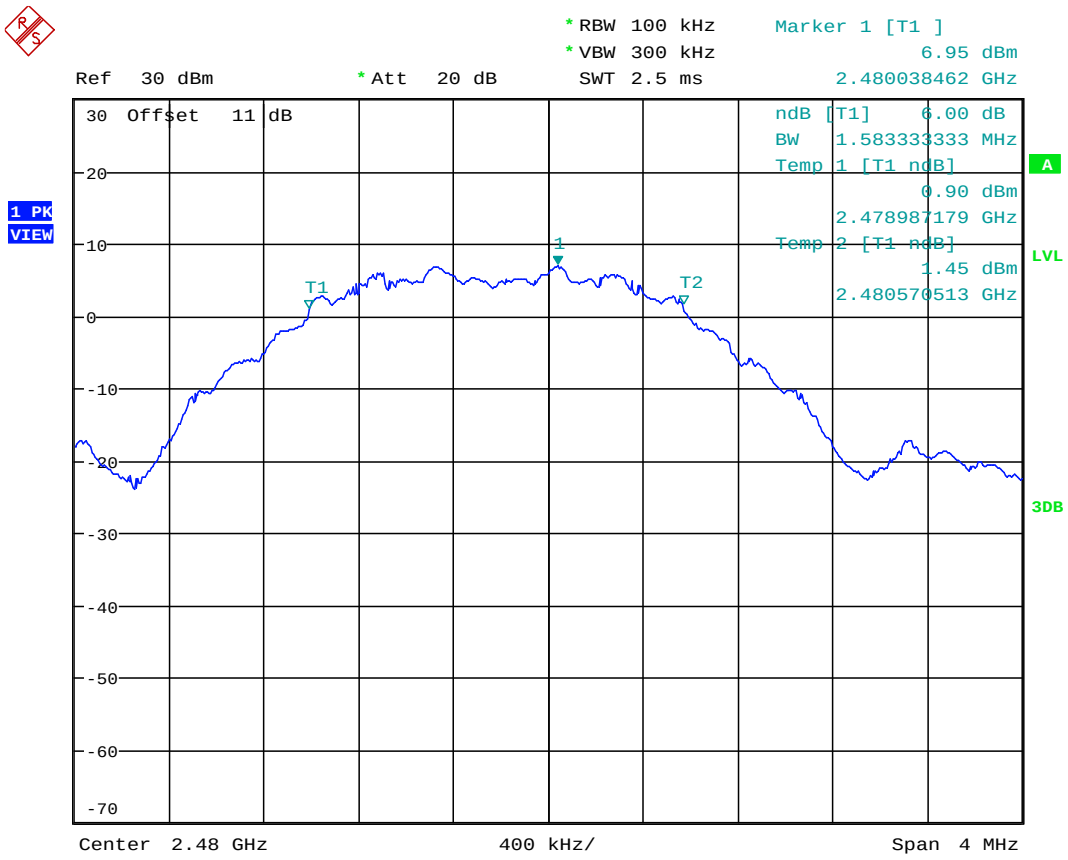
Date: 11.JAN.2017 09:20:14

Plot 5.2.4.5. QG-HN3 6 dB Bandwidth, Channel Mid, 2440 MHz,



Date: 11.JAN.2017 09:27:11

Plot 5.2.4.6. QG-HN3 6 dB Bandwidth, Channel High, 2480 MHz



Date: 11.JAN.2017 09:29:19

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

5.3.1. Limits

§ 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.

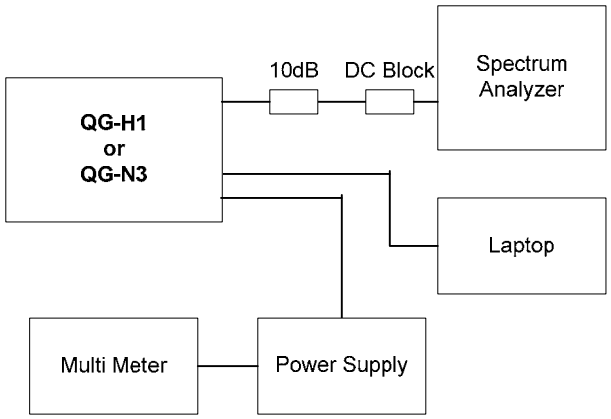
§ 15.247(b)(4): The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

§ 15.247 (b)(4)(i) & (c)(1)(i) Systems operating in the 2400-2483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum conducted output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

5.3.2. Method of Measurements & Test Arrangement

KDB Publication No. 558074 D01 DTS Measurement Guidance V03r05, Section 9.1 RBW ≥ DTS bandwidth

5.3.3. Test Arrangement



5.3.4. Test Data

QG-H1, Peak Conducted Output Power, Power setting 4 (range 1-6)
QG-H1 powered by 3V (2 x AA battery), 5VDC (from USB Mini B), or 6VDC AC/DC adapter (testing used DC power supply)

Power configuration	Modulation	Channel Number	Frequency (MHz)	PCOP (dBm)	Limit (dBm)
3V (2 x AA battery)	MSK	11	2405	18.26	30
	MSK	18	2440	17.65	30
	MSK	26	2480	16.98	30
5VDC (from USB Mini B)	MSK	11	2405	18.07	30
	MSK	18	2440	17.43	30
	MSK	26	2480	16.77	30
6VDC (using DC power supply)	MSK	11	2405	18.05	30
	MSK	18	2440	17.28	30
	MSK	26	2480	16.69	30

QG-N3, Peak Conducted Output Power, Power setting 2 (range 1-6)
QG-N3 powered by POE, 5VDC (from USB Mini B),
or 6VDC AC/DC adapter (testing used DC power supply)

Power configuration	Modulation	Channel Number	Frequency (MHz)	PCOP (dBm)	Limit (dBm)
POE	MSK	11	2405	10.15	30
	MSK	18	2440	9.98	30
	MSK	26	2480	9.83	30
5VDC (from USB Mini B)	MSK	11	2405	10.38	30
	MSK	18	2440	10.19	30
	MSK	26	2480	10.12	30
6VDC (using DC power supply)	MSK	11	2405	10.73	30
	MSK	18	2440	10.41	30
	MSK	26	2480	10.22	30

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

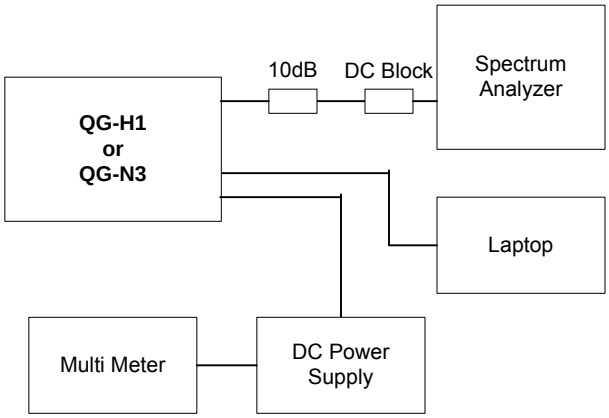
5.4.1. Limit

§ 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 Publication No. 558074 D01 DTS Meas Guidance V03r05, Sections 11, 12 and 13.

5.4.3. Test Arrangement

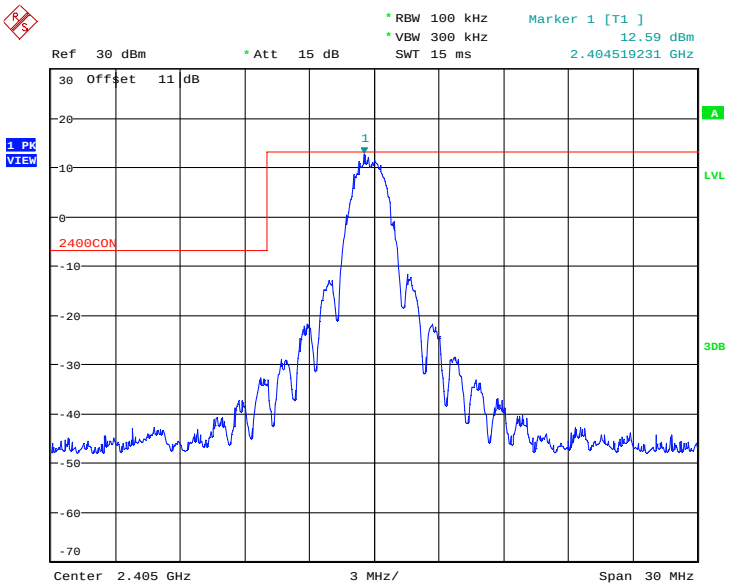


5.4.4. Test Data

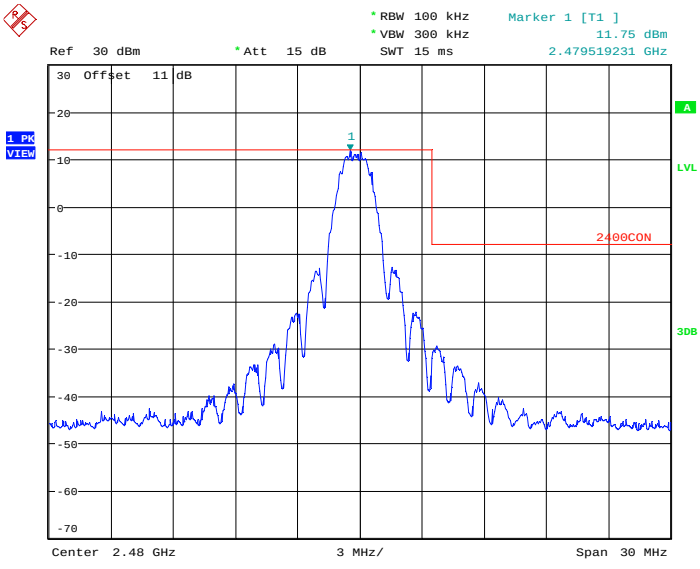
Remark(s): Exploratory tests performed to determined worst-case test configurations, the following test results represent the worst-case.

1.1.1.1. Band-Edge RF Conducted Emissions

Band-Edge RF Conducted Emissions (QG-H1)

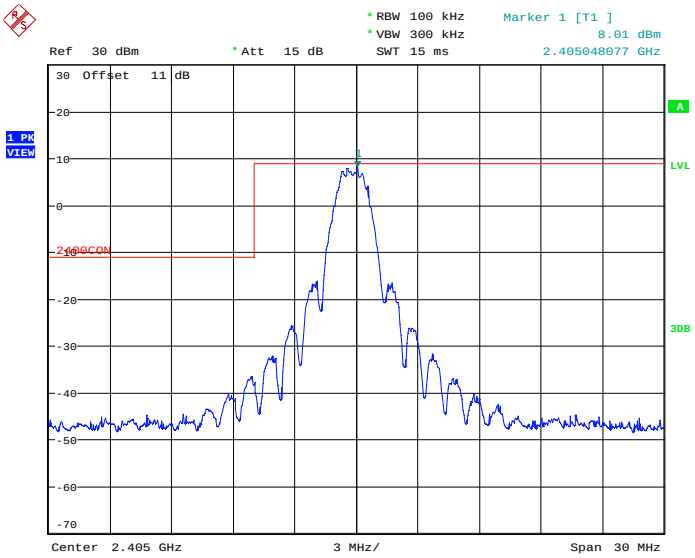


Date: 28.MAY.2017 06:59:30

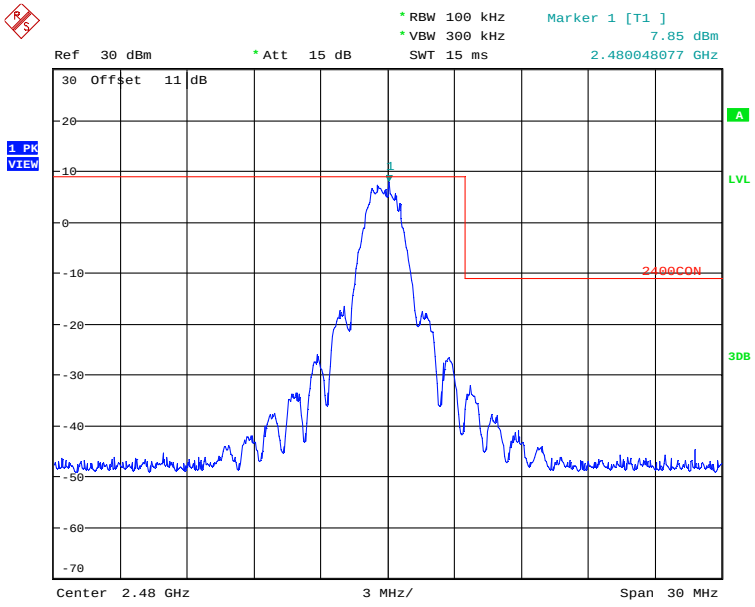


Date: 28.MAY.2017 06:56:52

Band-Edge RF Conducted Emissions (QG-N3)



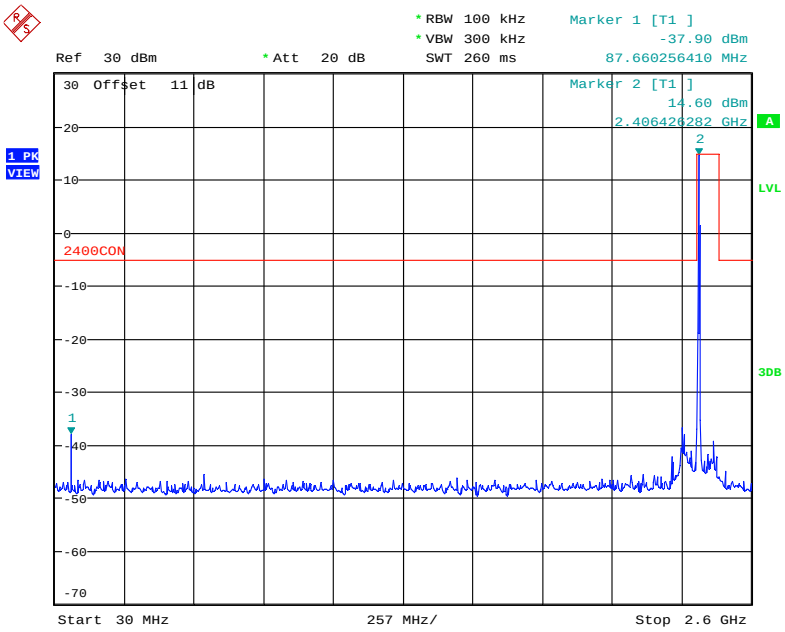
Date: 28.MAY.2017 07:06:19



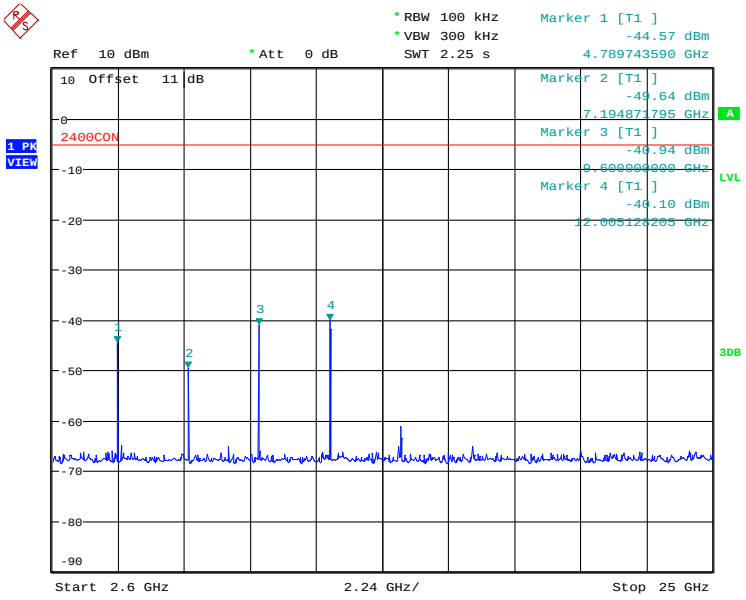
Date: 28.MAY.2017 07:07:36

5.4.5. FCC 15.247 (d), RSS 247 5.5 Emissions in non restricted frequency bands

QG-H1 @ 2405 (30 MHz-25 GHz)

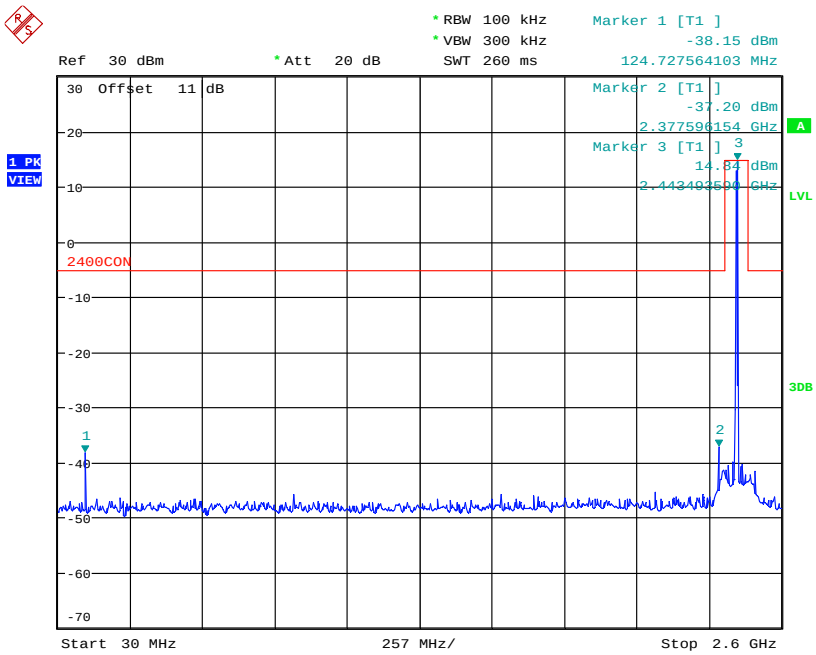


Date: 20.DEC.2016 10:18:01

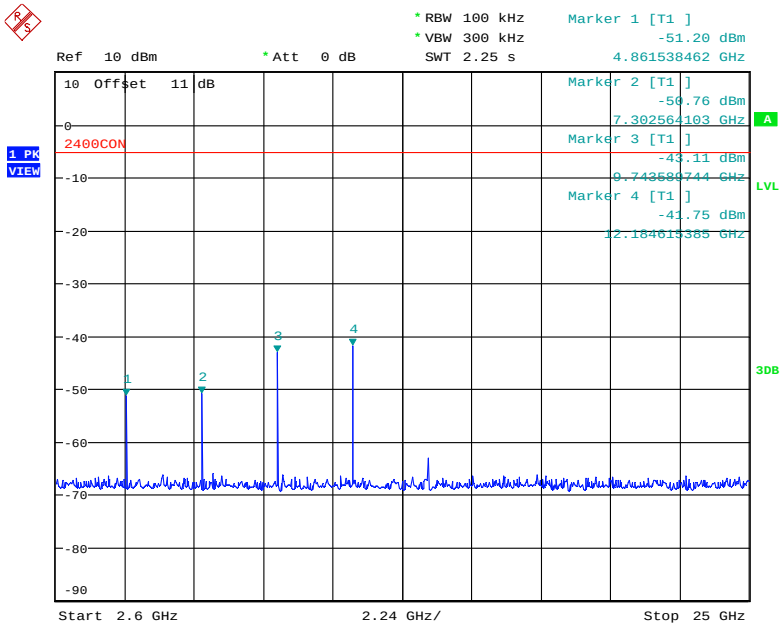


Date: 20.DEC.2016 11:28:05

QG-H1 @2440 (30 MHz-25 GHz)

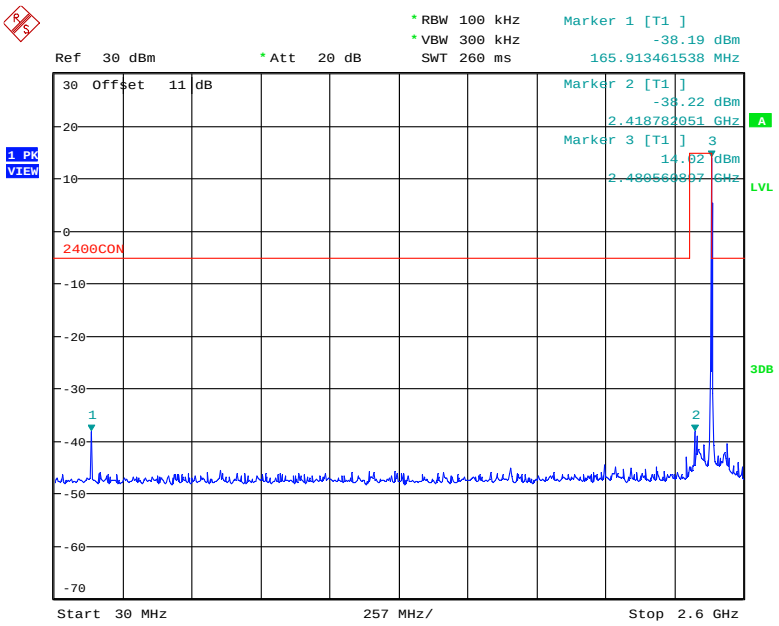


Date: 20.DEC.2016 10:21:13

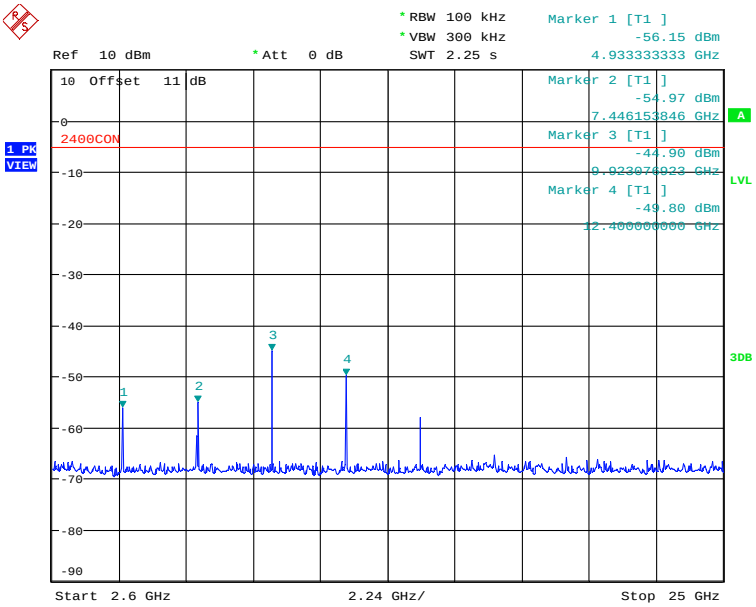


Date: 20.DEC.2016 10:37:58

2480 QG-H1 @2480 (30 MHz-25 GHz)

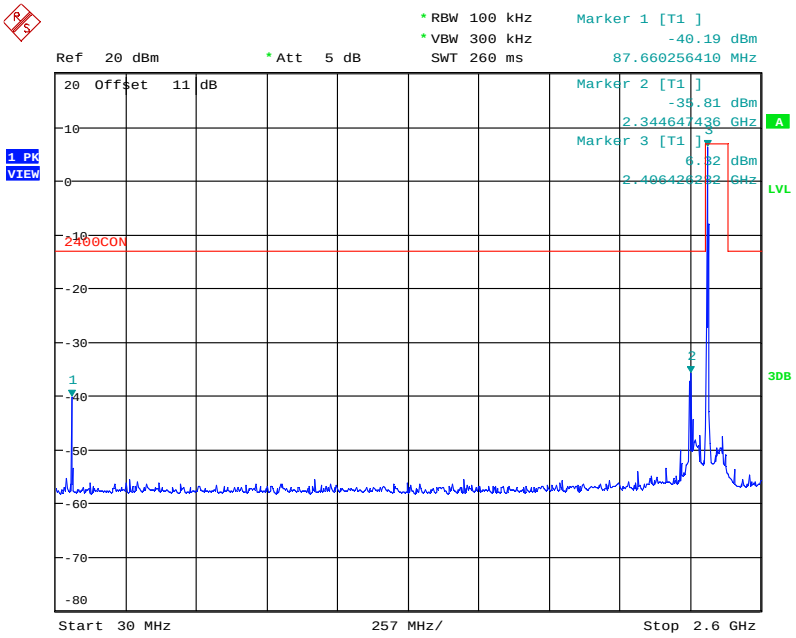


Date: 20.DEC.2016 10:24:03

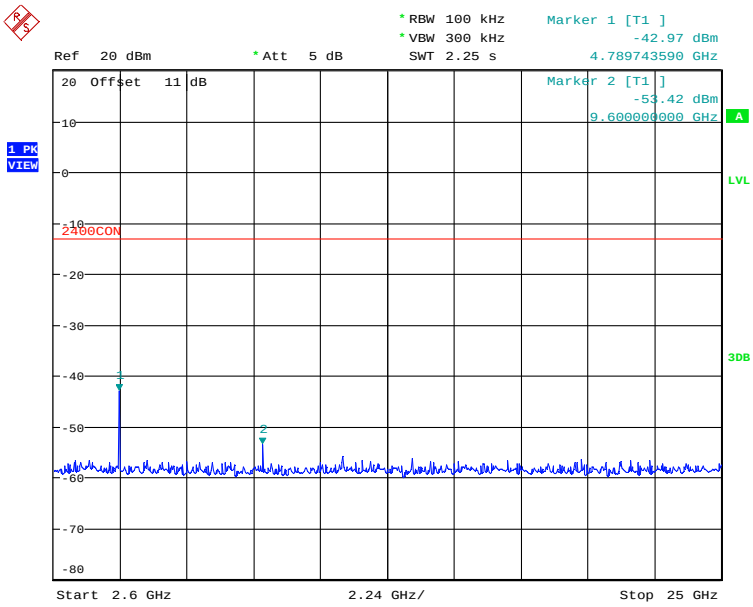


Date: 20.DEC.2016 11:25:02

QG-N3 @2405 (30 MHz-25 GHz)

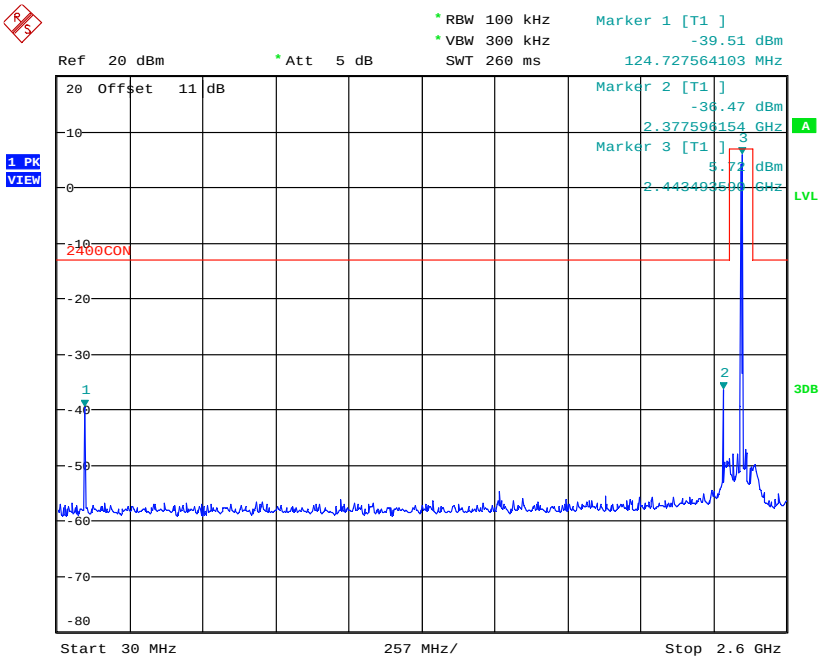


Date: 10.JAN.2017 11:14:01

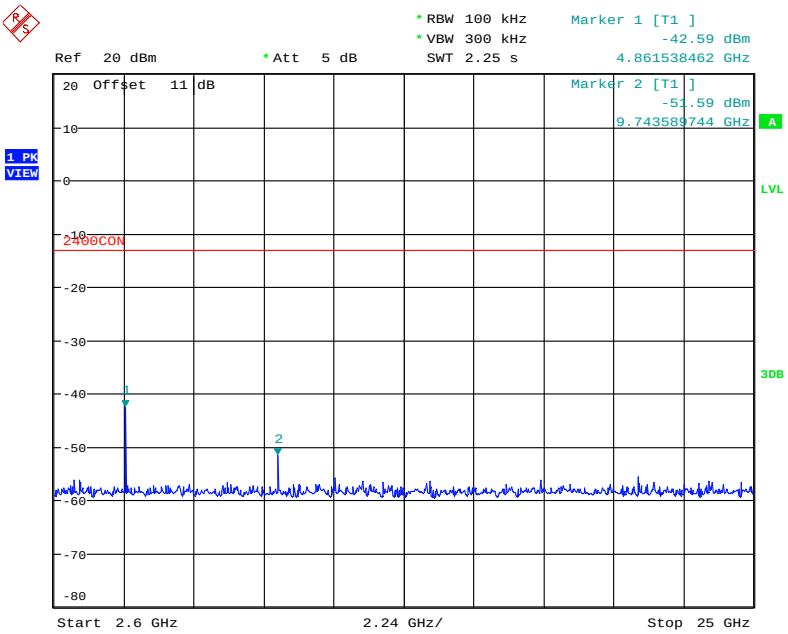


Date: 10.JAN.2017 11:32:25

QG-N3 @2440 (30 MHz-25 GHz)

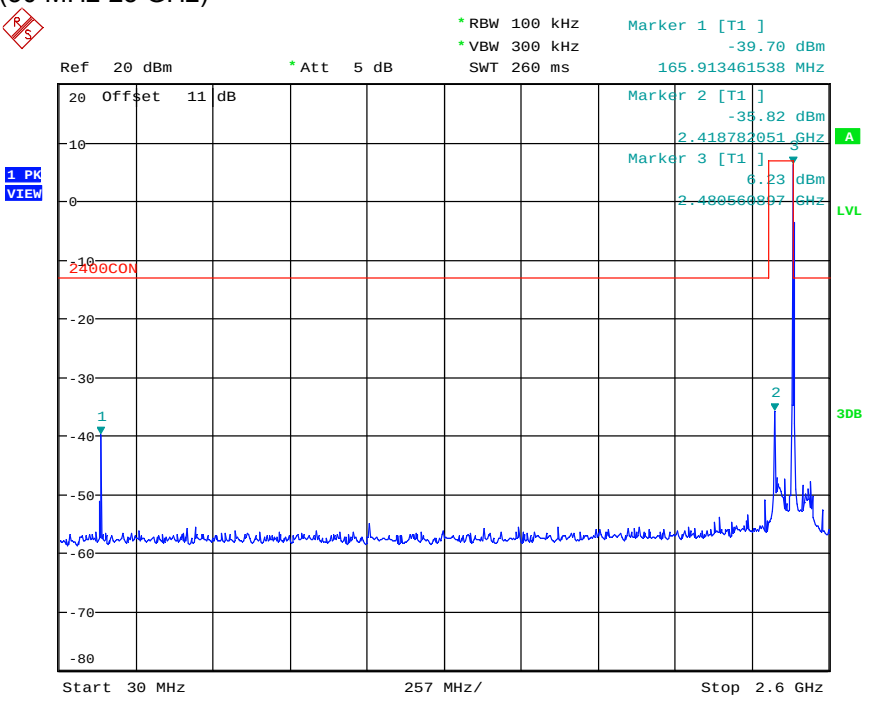


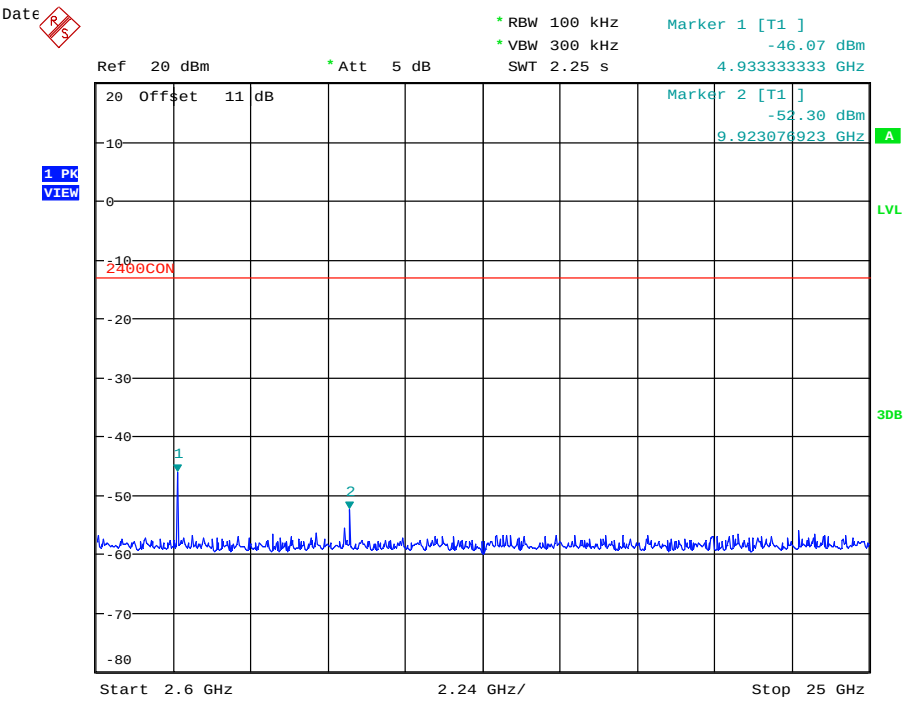
Date: 10.JAN.2017 11:16:12



Date: 10.JAN.2017 11:30:59

QG- N3 @ 2480 (30 MHz-25 GHz)



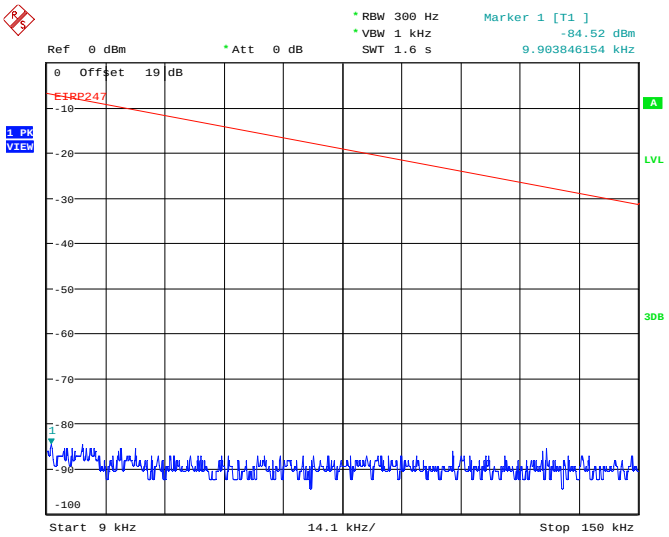


Date: 10.JAN.2017 11:29:25

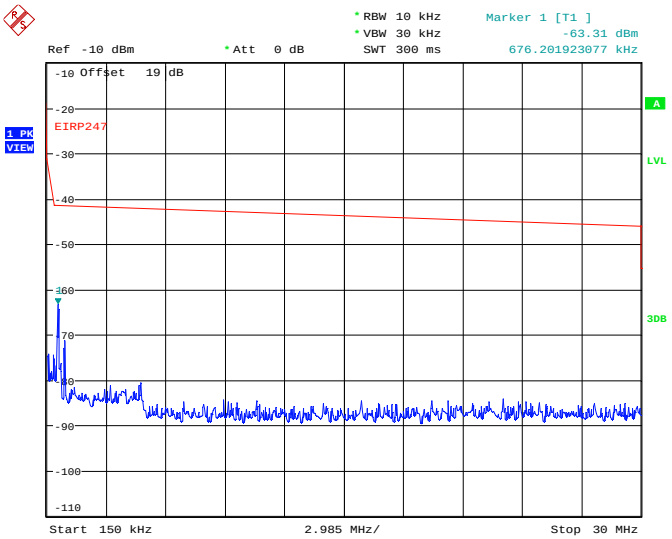
Emissions in Restricted Frequency Bands

Note: The tests below, Antenna gain of 2dBi was factored along with test cable loss and applicable GP factor.

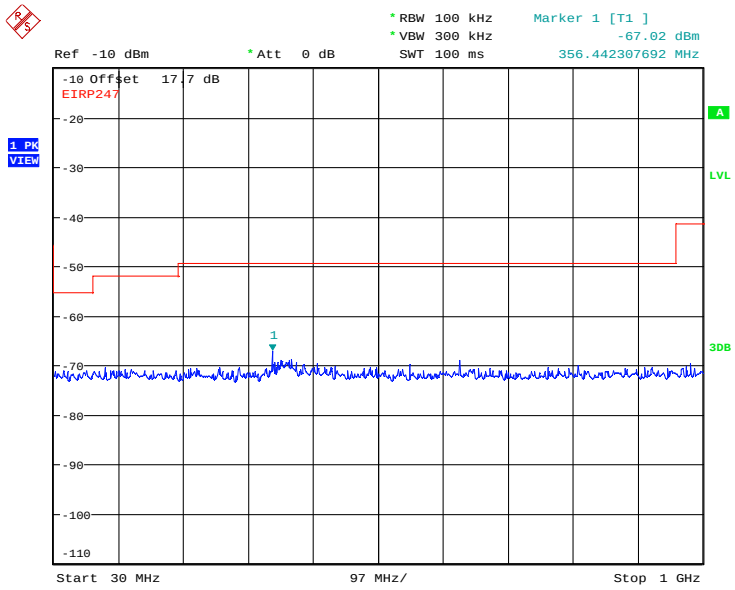
QG-H1 @ 2405MHz- plots 9kHz- 1GHz



Date: 19.DEC.2016 15:11:37

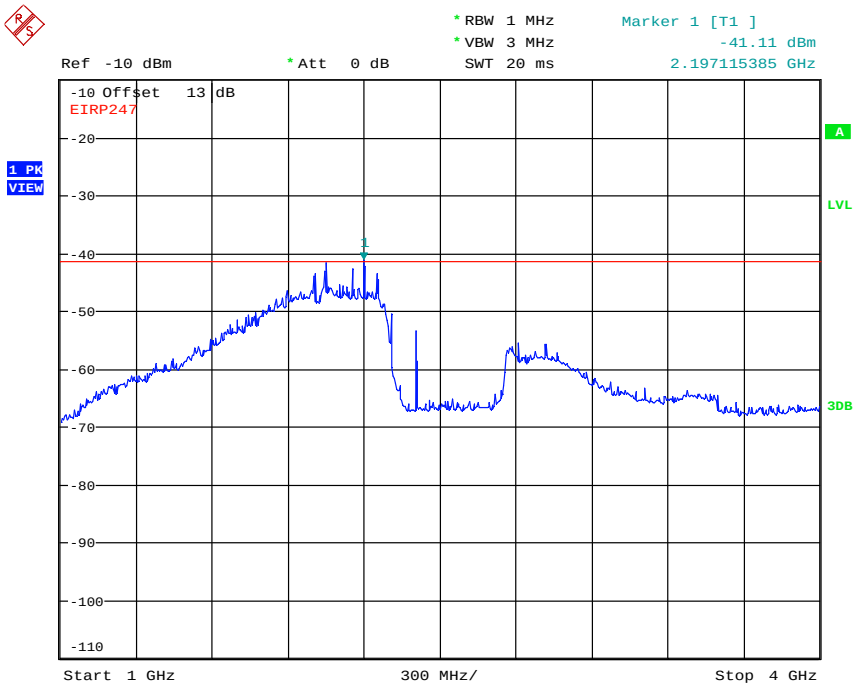


Date: 19.DEC.2016 15:03:13

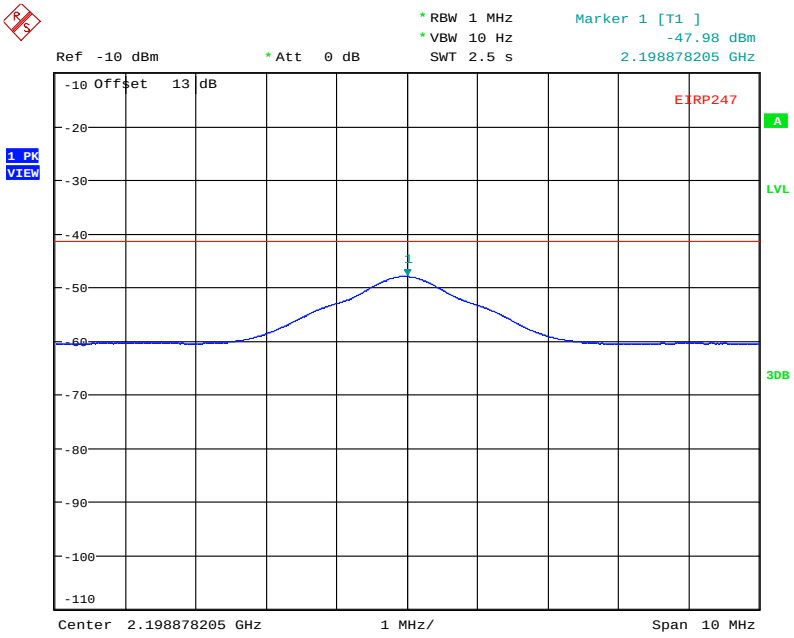


Date: 10.JAN.2017 13:48:45

QG-H1 @ 2405MHz- plots 1GHz - 4GHz and Avg plot of Marker 1



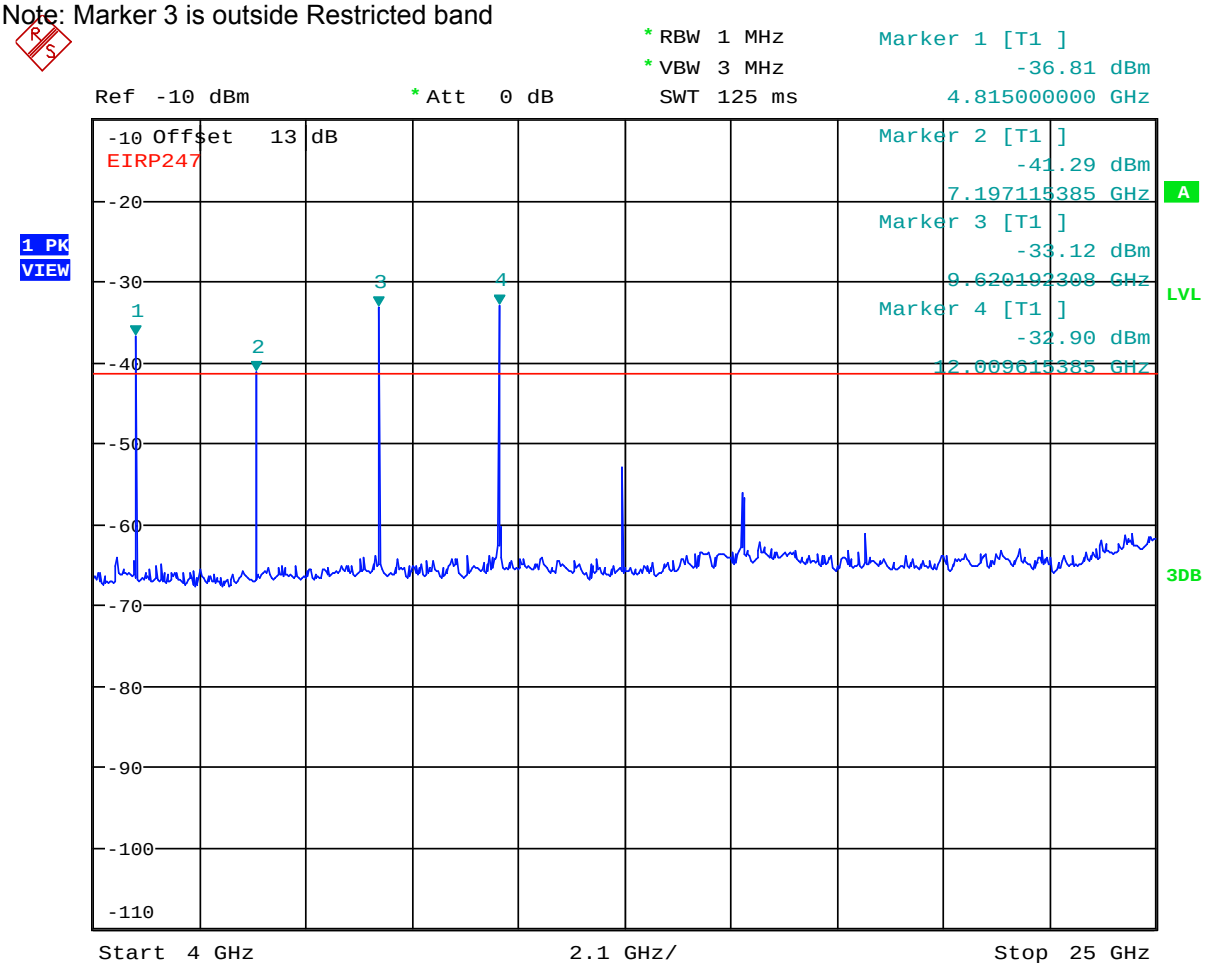
Date: 19.DEC.2016 14:47:30



Date: 19.DEC.2016 14:48:49

QG-H1 @2405 MHz- 4 GHz- 25 GHz

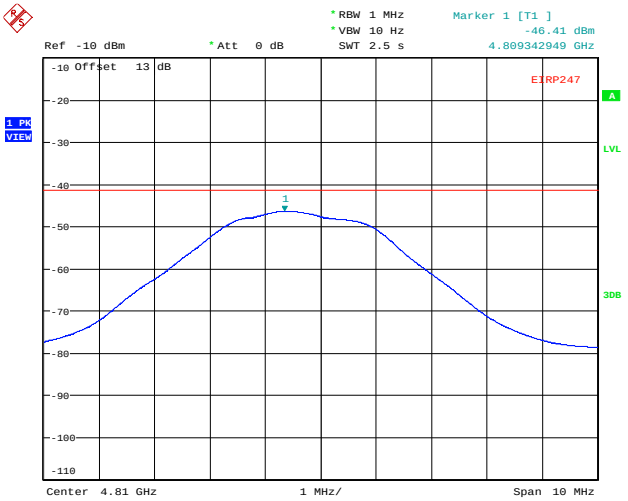
Note: Marker 3 is outside Restricted band



Date: 19.DEC.2016 13:00:43

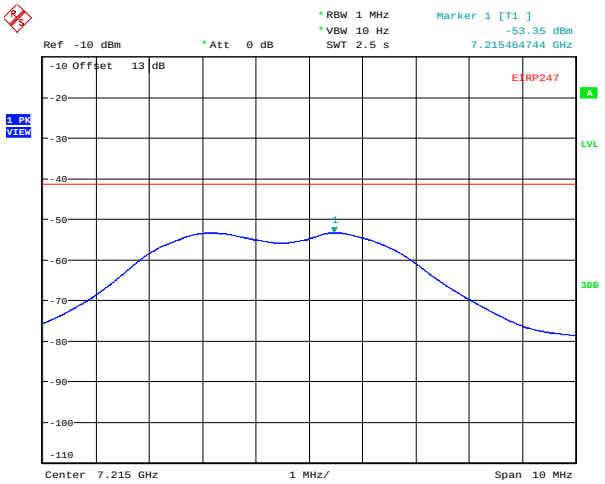
QG-H1 @2405 MHz- AVG Measurements at near

4.81 GHz



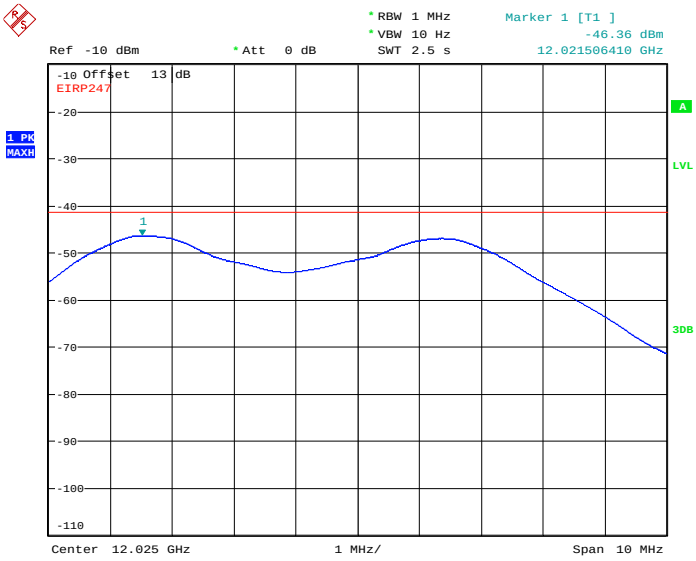
Date: 19.DEC.2016 13:02:26

7.215 GHz



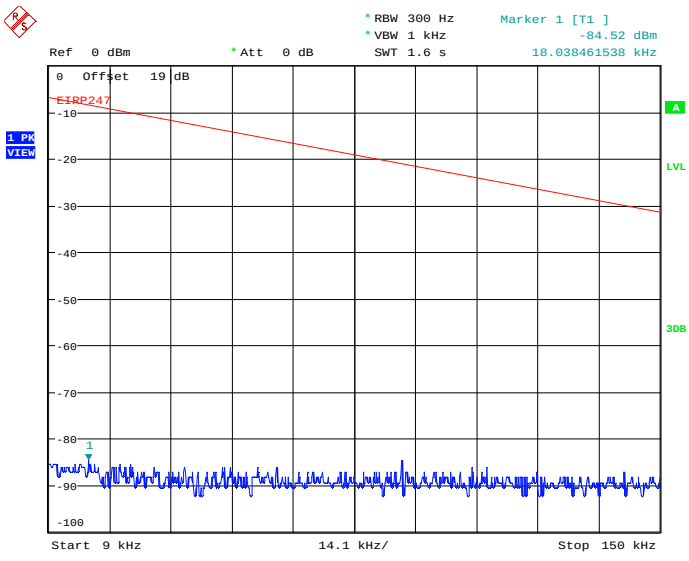
Date: 19.DEC.2016 13:05:01

12.025 GHz

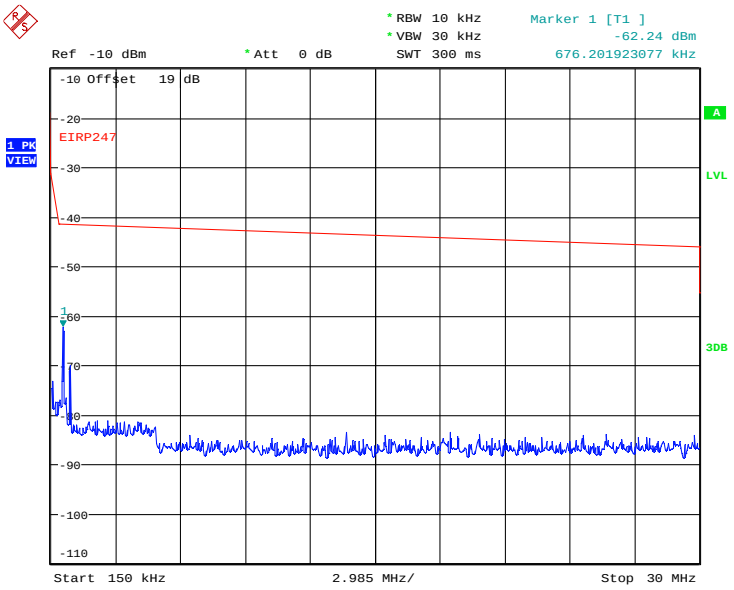


Date: 19.DEC.2016 13:06:13

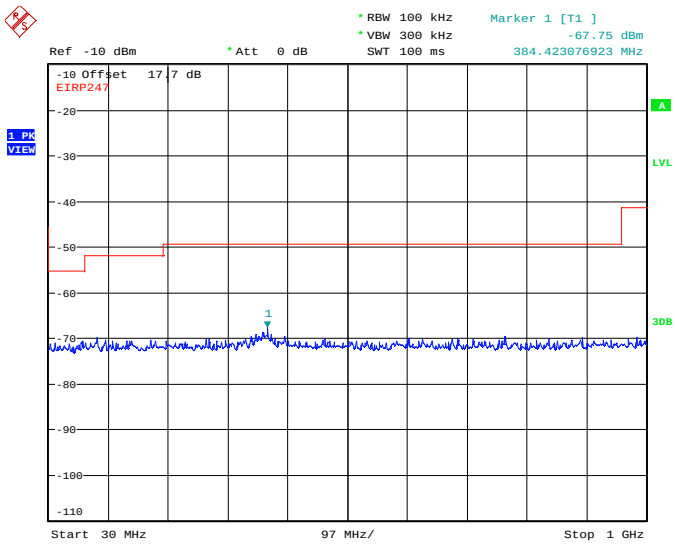
QG-H1 @2440 MHz- 9kHz-4 GHz



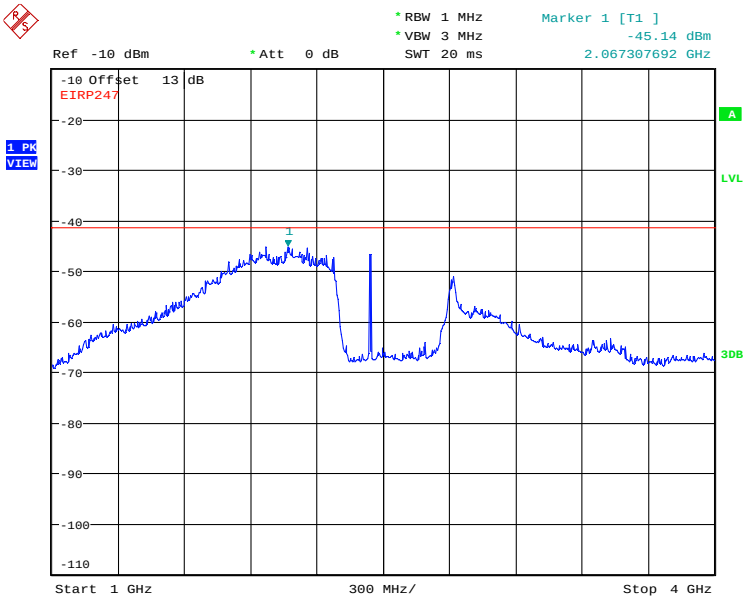
Date: 19.DEC.2016 15:13:27



Date: 19.DEC.2016 15:04:57

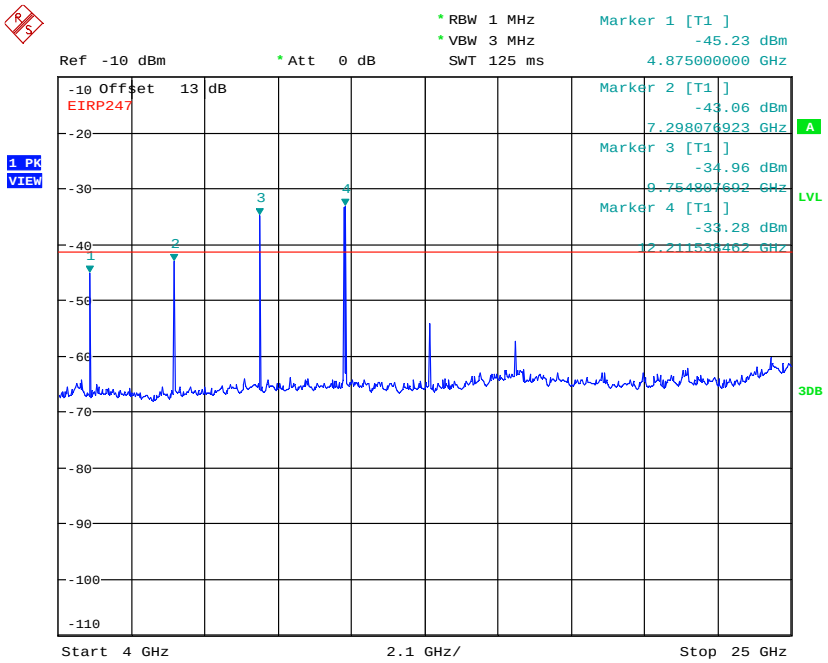


Date: 10.JAN.2017 13:54:29

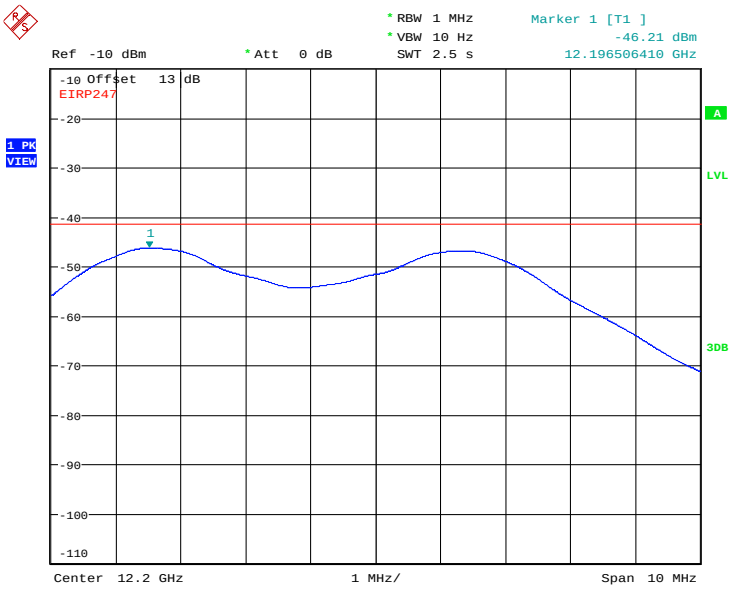


Date: 19.DEC.2016 14:52:02

QG-H1 @2440 MHz- band 4 GHz – 25 GHz
Marker 1 4880 MHz & marker 2 7320 MHz below limit. Marker 3 9760 MHz is outside of restricted band, Marker 4 Avg found in plot below

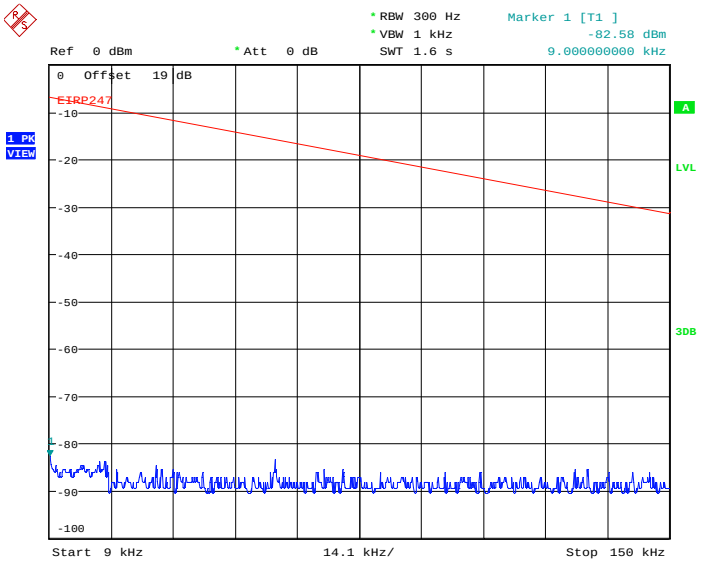


Date: 19.DEC.2016 14:44:10

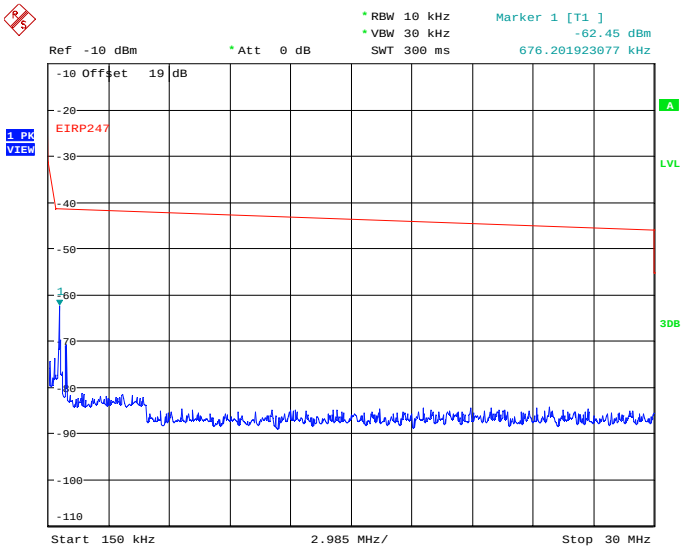


Date: 19.DEC.2016 14:31:53

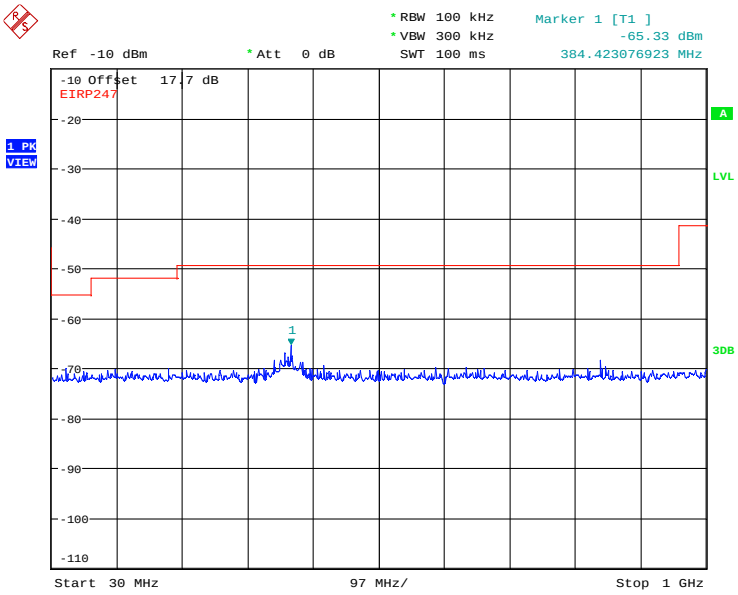
QG-H1 @2480 MHz- 9kHz- 1Ghz



Date: 19.DEC.2016 15:19:22

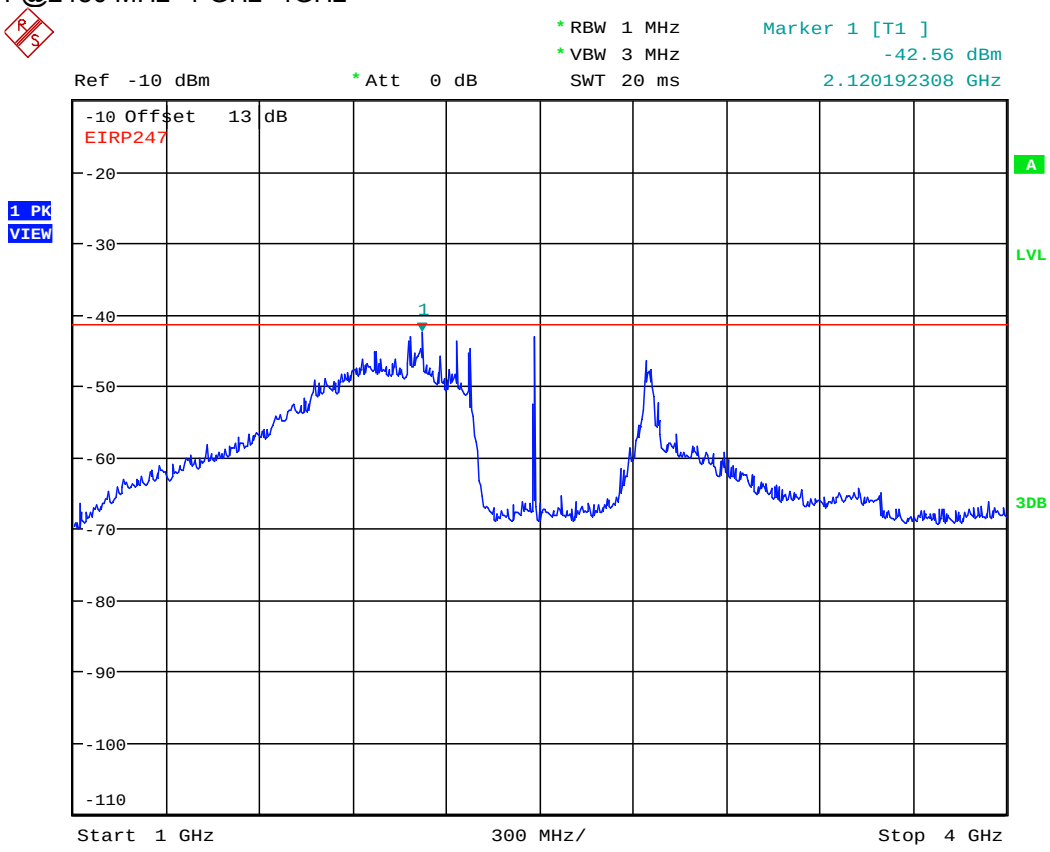


Date: 19.DEC.2016 15:07:50



Date: 10.JAN.2017 13:56:19

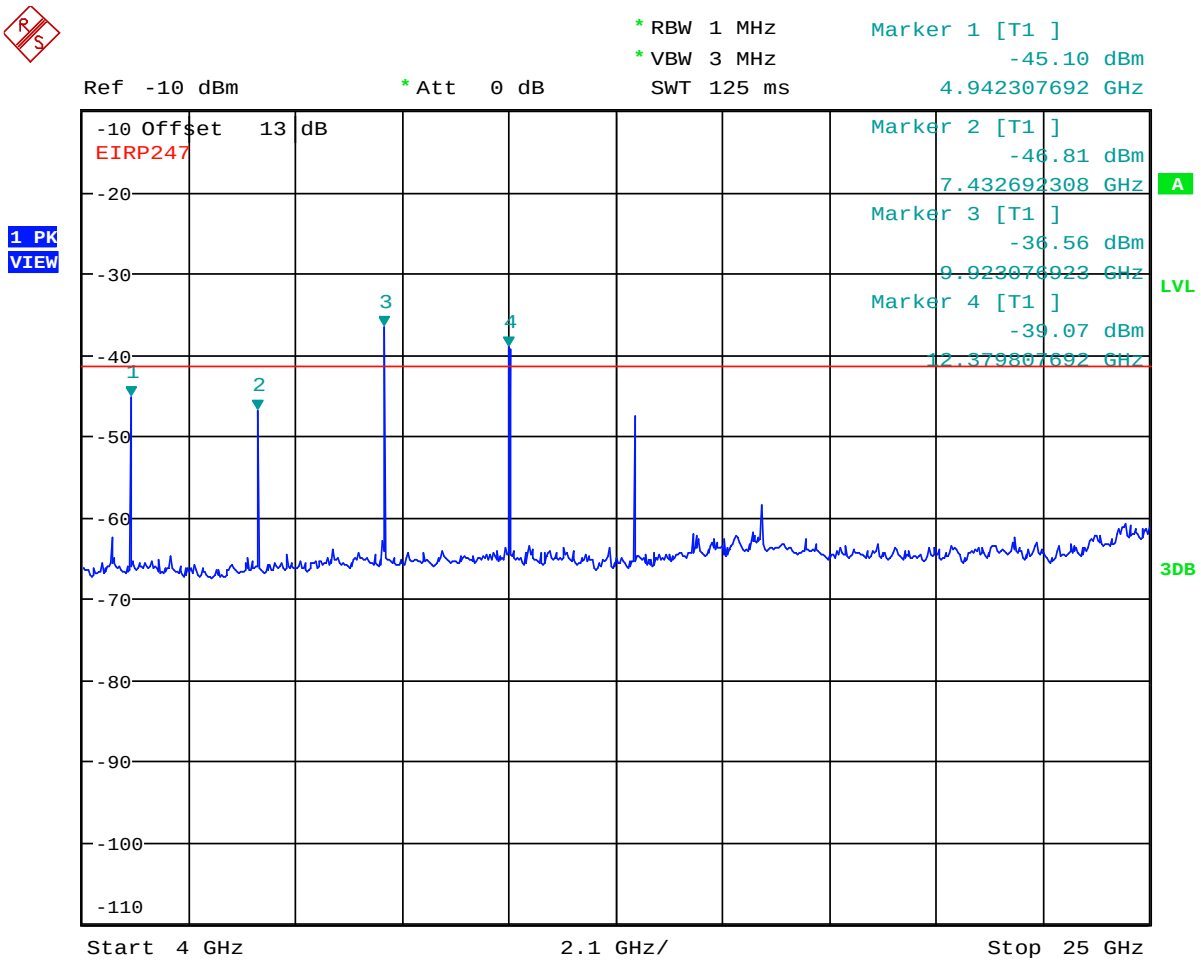
QG-H1 @2480 MHz- 1 GHz- 4GHz



(Marker 1 level measured is below the limit line)

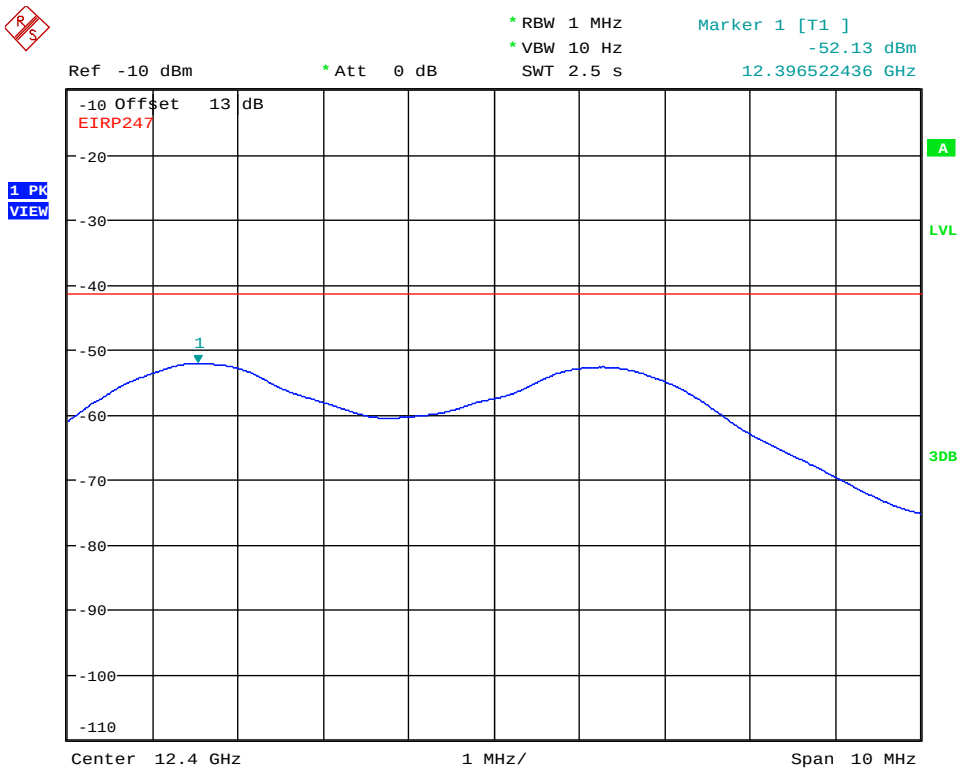
QG-H1 @2480MHz- 4GHz- 25GHz

Marker 1 4960 MHz & marker 2 7440 MHz below limit. Marker 3 9920 MHz is outside of restricted band



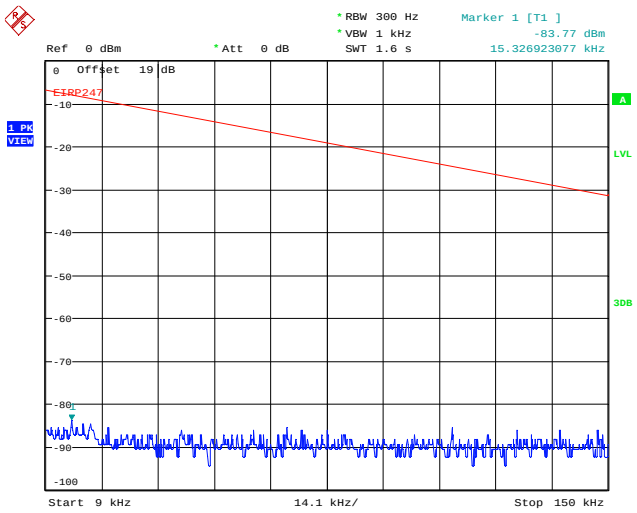
Date: 19.DEC.2016 14:36:43

QG-H1 @2480MHz- 12.4 GHz Avg

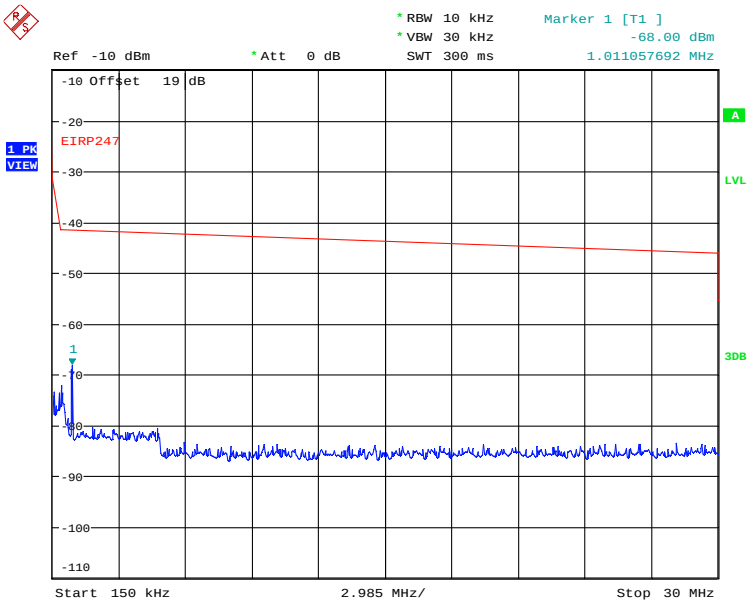


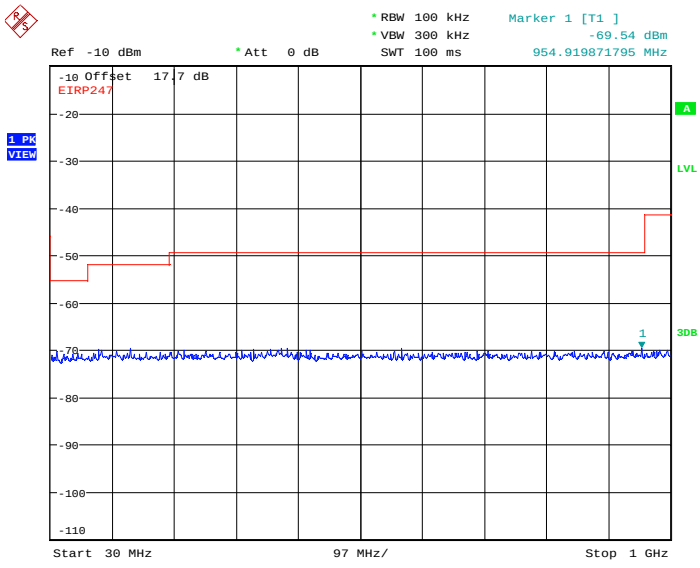
Date: 19.DEC.2016 14:38:00

QG- N3 @2405 MHz - 9kHz- 4Ghz

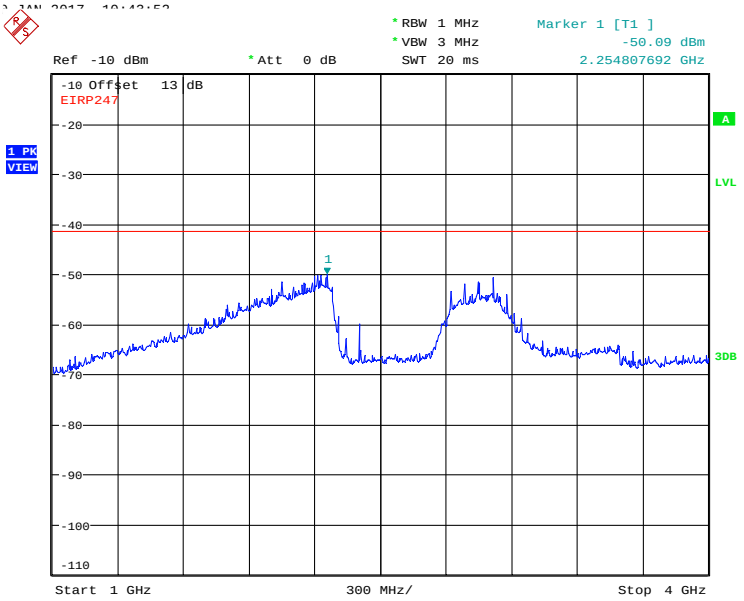


Date: 10.JAN.2017 10:50:03



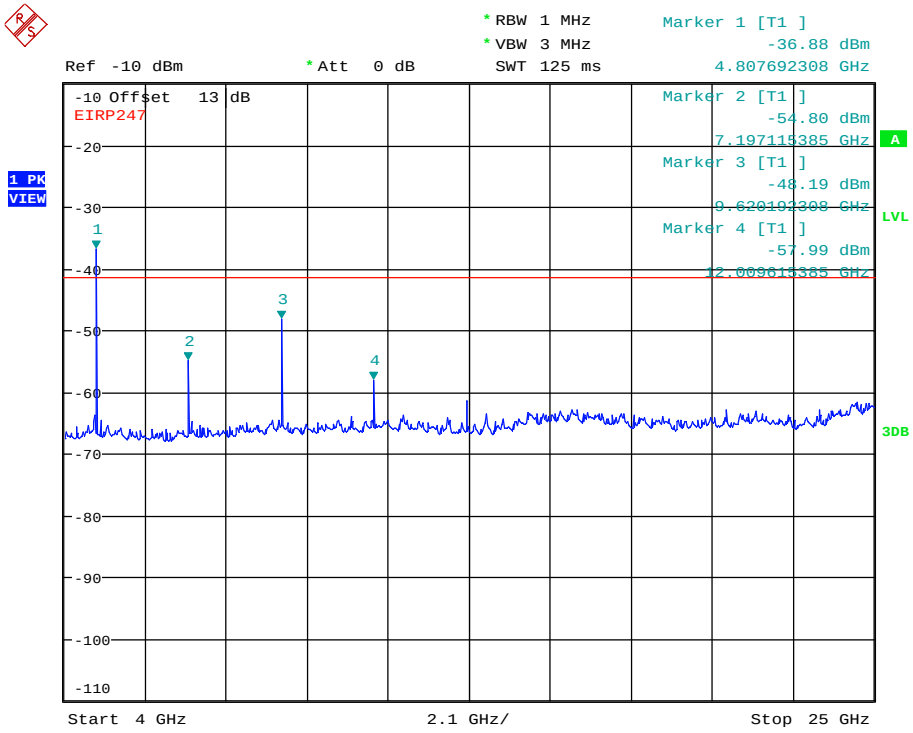


Date: 10.JAN.2017 10:35:47

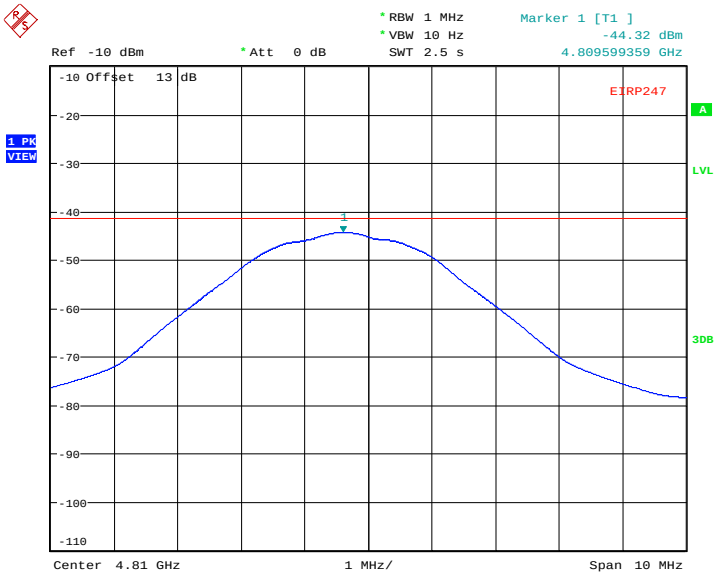


Date: 10.JAN.2017 10:30:57

QG- N3 @2405 MHz – 4GHz- 25GHz

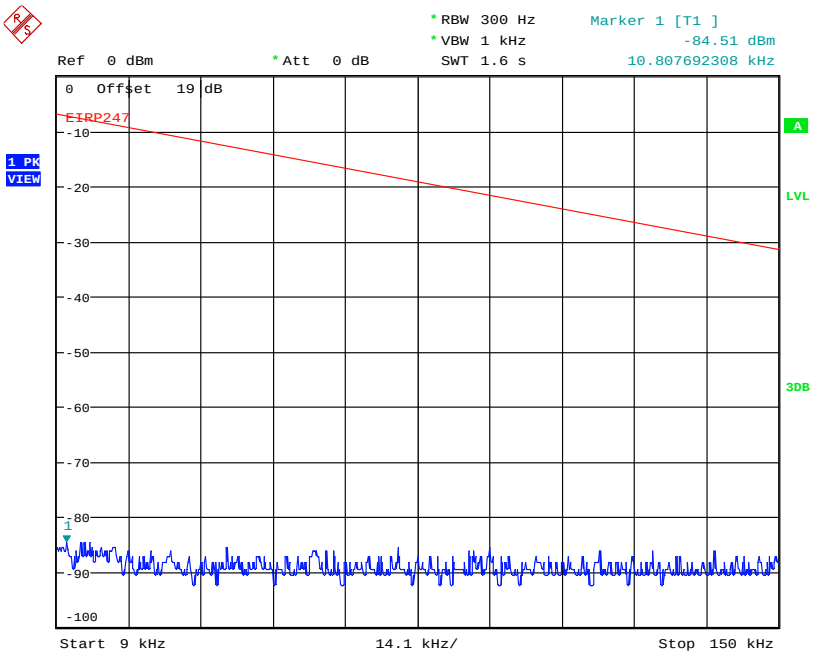


Date: 10.JAN.2017 09:53:29

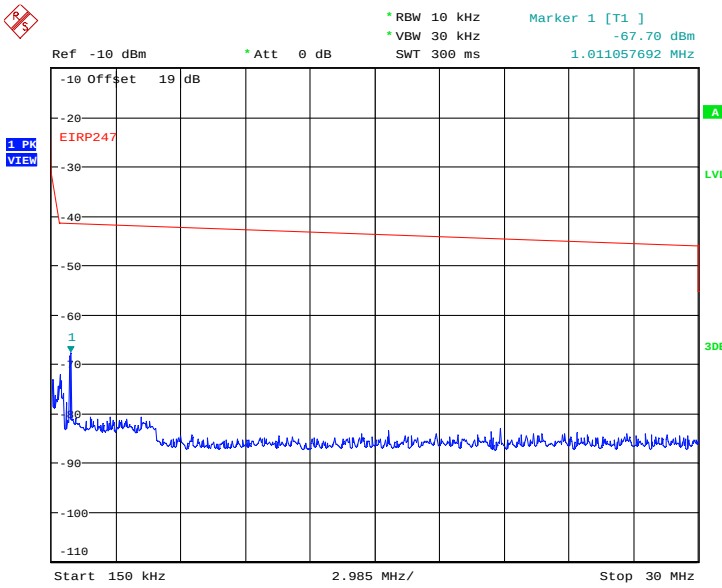


Date: 10.JAN.2017 09:58:47

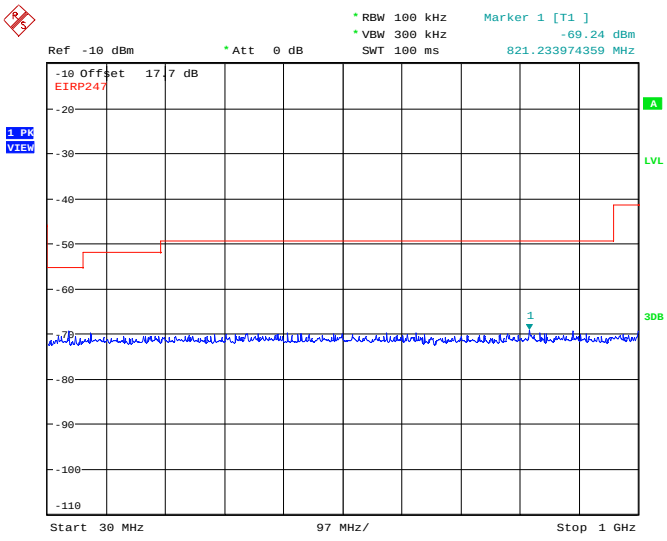
QG- N3 @2440 MHz - 9kHz- 4GHz



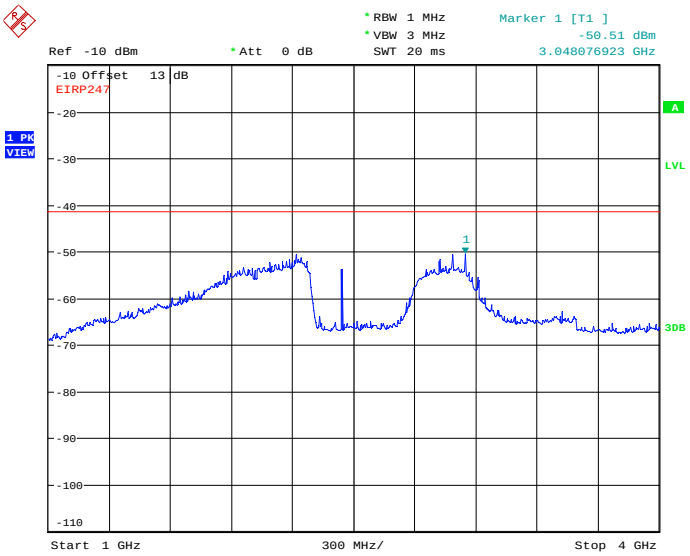
Date: 10.JAN.2017 10:52:51



Date: 10.JAN.2017 10:45:42

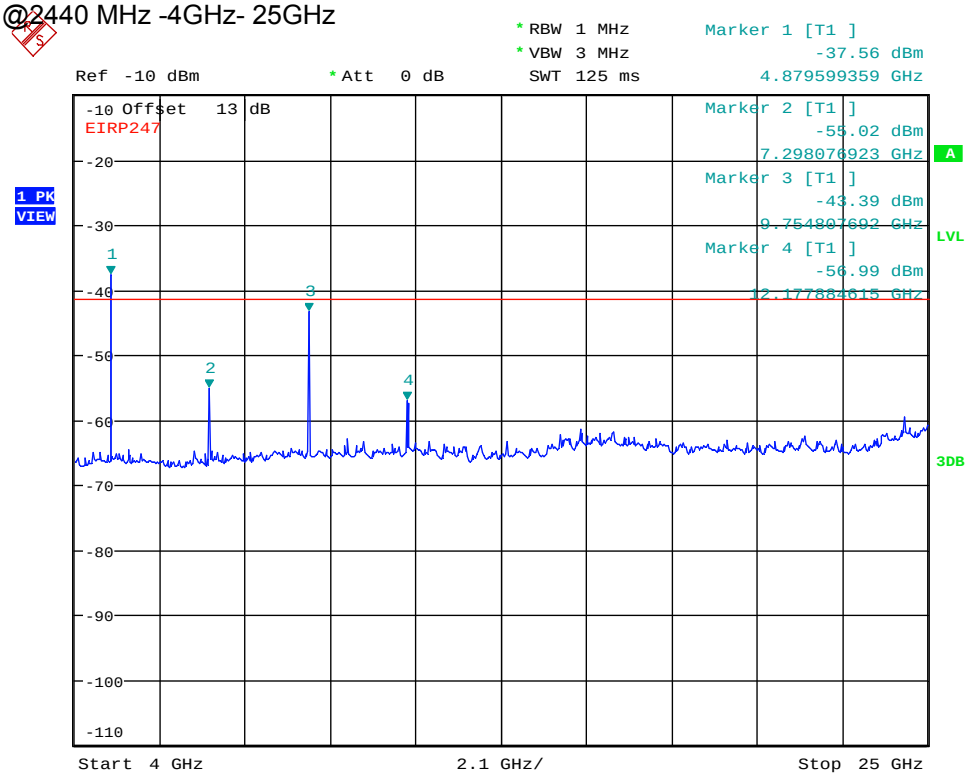


Date: 10.JAN.2017 10:38:01

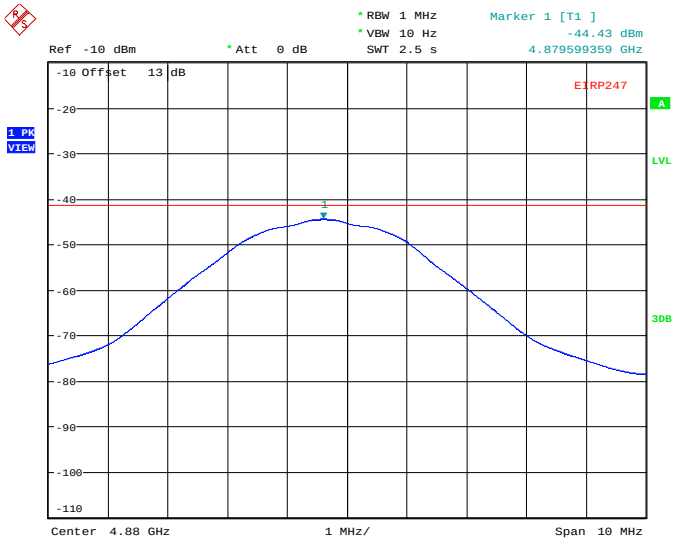


Date: 10.JAN.2017 10:26:40

QG- N3 @2440 MHz -4GHz- 25GHz

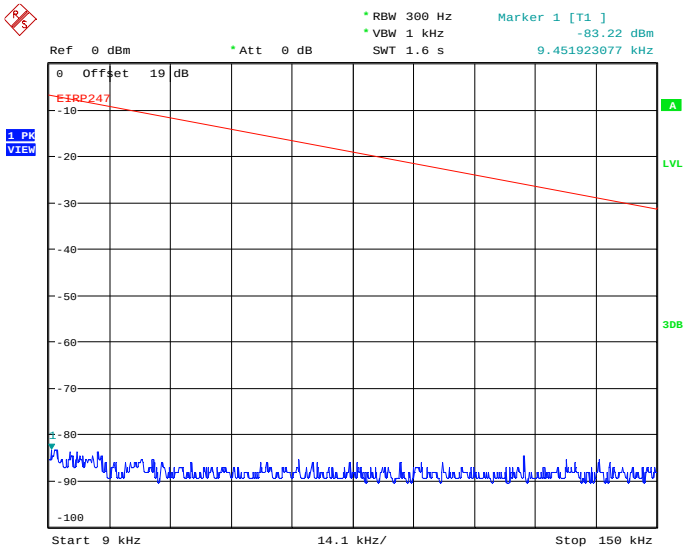


Date: 10.JAN.2017 10:05:36

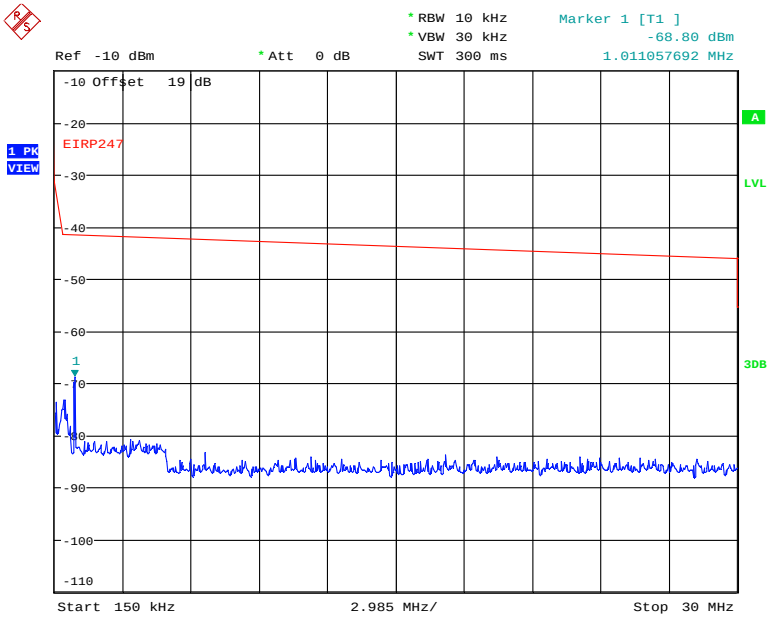


Date: 10.JAN.2017 10:01:59

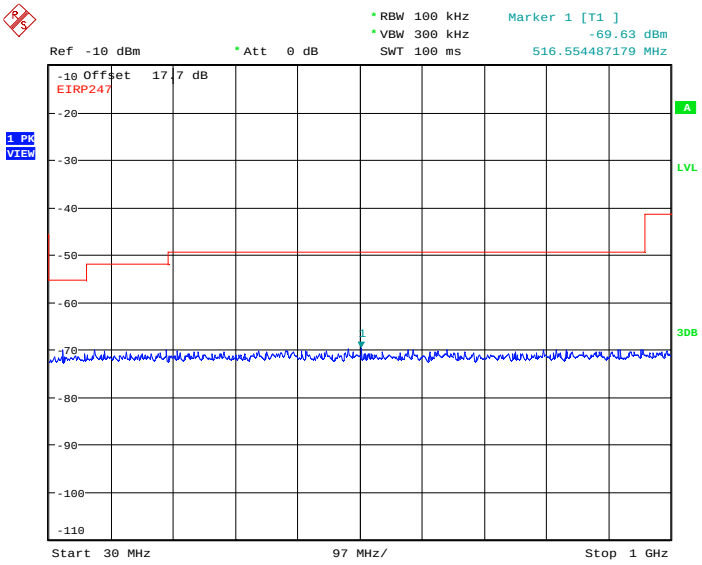
QG- N3 @2480 MHz - 9kHz- 4GHz



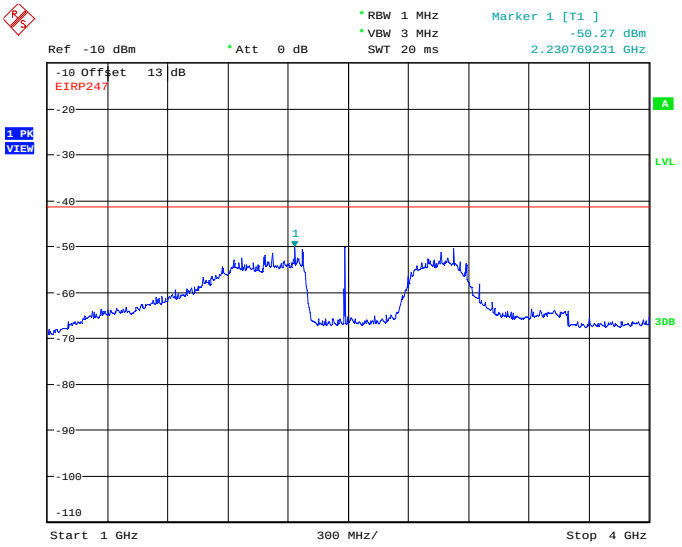
Date: 10.JAN.2017 10:55:45



Date: 10.JAN.2017 10:48:16

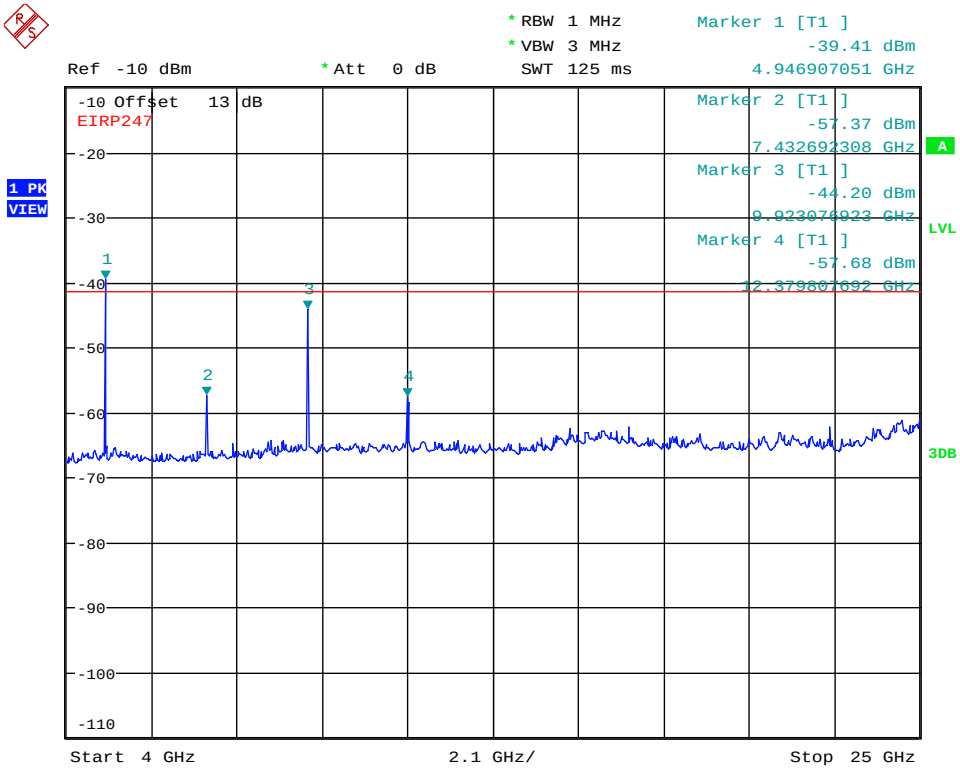


Date: 10.JAN.2017 10:40:38

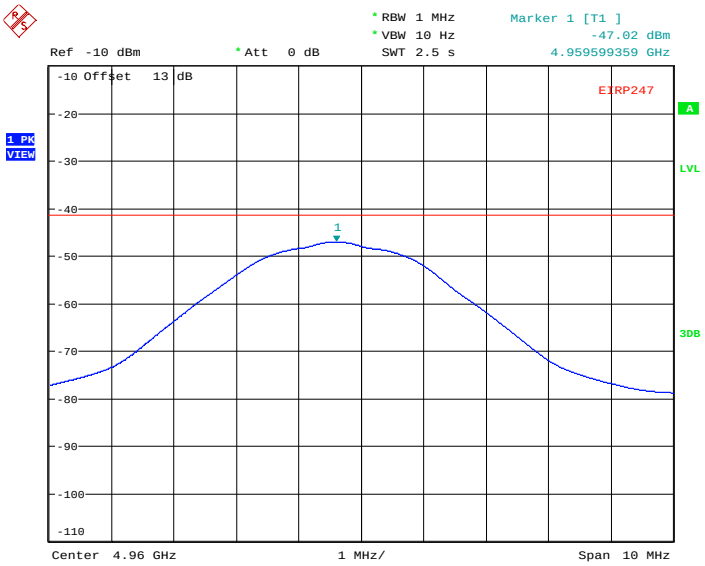


Date: 10.JAN.2017 10:23:05

QG- N3 @2480 MHz -4GHz- 25GHz



Date: 10.JAN.2017 10:13:58



Date: 10.JAN.2017 10:16:49

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

5.5.1. Limit

§ 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)).

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] 0.495–0.505	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

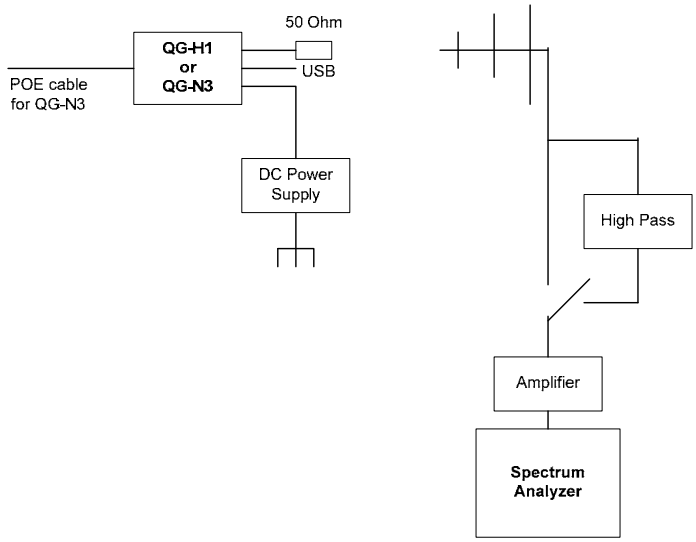
Section 15.209(a) - Field Strength Limits within Restricted Frequency Bands

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

ANSI C63.10 and ANSI 63.4 test procedures.

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.

1.1.1.2. EUT with 50 ohm load

Spurious Radiated Emissions QG-H1

Fundamental Frequency:	2405 MHz
Measured Conducted Power:	18.05 dBm
Frequency Test Range:	30 MHz – 25 GHz

Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
2405		--	V	--	--	--	--
2405		--	H	--	--	--	--
4810	56.04	45.35	V	54.0	93.3	-8.65	Pass*
4810	57.63	47.67	H	54.0	93.3	-6.33	Pass*
7215	64.98	53.38	V	54.0	93.3	-39.92	Pass
7215	65.97	54.73	H	54.0	93.3	-38.57	Pass

Fundamental Frequency:	2440 MHz
Measured Conducted Power:	17.28 dBm
Frequency Test Range:	30 MHz – 25 GHz

Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
2440		--	V	--	--	--	--
2440		--	H	--	--	--	--
4880	56.29	47.02	V	54.0	92.5	-6.98	Pass*
4880	56.58	47.16	H	54.0	92.5	-6.84	Pass*
7320	63.79	52.25	V	54.0	92.5	-1.75	Pass*
7320	63.47	52.73	H	54.0	92.5	-1.27	Pass*

Fundamental Frequency:	2480 MHz
Measured Conducted Power:	16.69 dBm
Frequency Test Range:	30 MHz – 25 GHz

Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
2480		--	V	--	--	--	--
2480		--	H	--	--	--	--
4960	56.45	47.13	V	54.0	91.9	-6.87	Pass*
4960	56.96	47.04	H	54.0	91.9	-6.96	Pass*
7440	62.49	51.11	V	54.0	91.9	-2.89	Pass*
7440	64.62	52.99	H	54.0	91.9	-1.01	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.

Spurious Radiated Emissions QG-N3

Fundamental Frequency:	2405 MHz
Measured Conducted Power:	10.73 dBm
Frequency Test Range:	30 MHz – 25 GHz

Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
2405		--	V	--	--	--	--
2405		--	H	--	--	--	--
4810	53.46	43.36	V	54.0	85.9	-10.64	Pass*
4810	53.73	42.86	H	54.0	85.9	-11.14	Pass*
7215	54.78	42.3	V	54.0	85.9	-11.7	Pass
7215	53.94	40.81	H	54.0	85.9	-13.19	Pass

Fundamental Frequency:	2440 MHz
Measured Conducted Power:	10.41 dBm
Frequency Test Range:	30 MHz – 25 GHz

Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
2440		--	V	--	--	--	--
2440		--	H	--	--	--	--
4880	53.74	43.27	V	54.0	85.6	-11.39	Pass*
4880	54.17	42.61	H	54.0	85.6	-11.74	Pass*
7320	53.73	42.26	V	54.0	85.6	-12.25	Pass*
7320	53.69	41.75	H	54.0	85.6	-11.39	Pass*

Fundamental Frequency:	2480 MHz
Measured Conducted Power:	10.22 dBm
Frequency Test Range:	30 MHz – 25 GHz

Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
2480		--	V	--	--	--	--
2480		--	H	--	--	--	--
4960	56.45	42.34	V	54.0	85.4	-11.66	Pass*
4960	56.96	41.69	H	54.0	85.4	-12.31	Pass*
7440	54.25	41.74	V	54.0	85.4	-12.26	Pass*
7440	54.98	42.84	H	54.0	85.4	-11.16	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)]

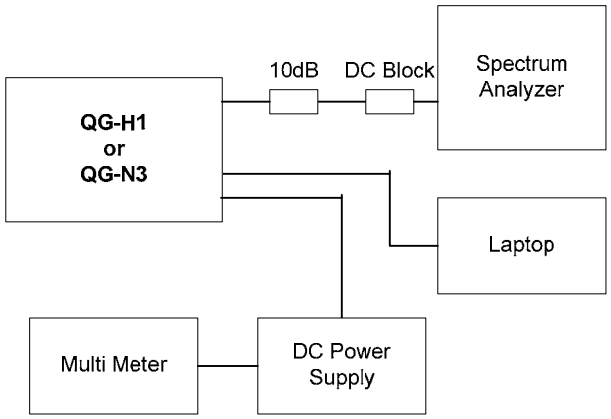
5.6.1. Limit(s)

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

Publication No. KDB Publication No. 558074 D01 DTS Meas Guidance V03r05, Section 10.2 Method PKPSD

5.6.3. Test Arrangement



5.6.4. Test Data

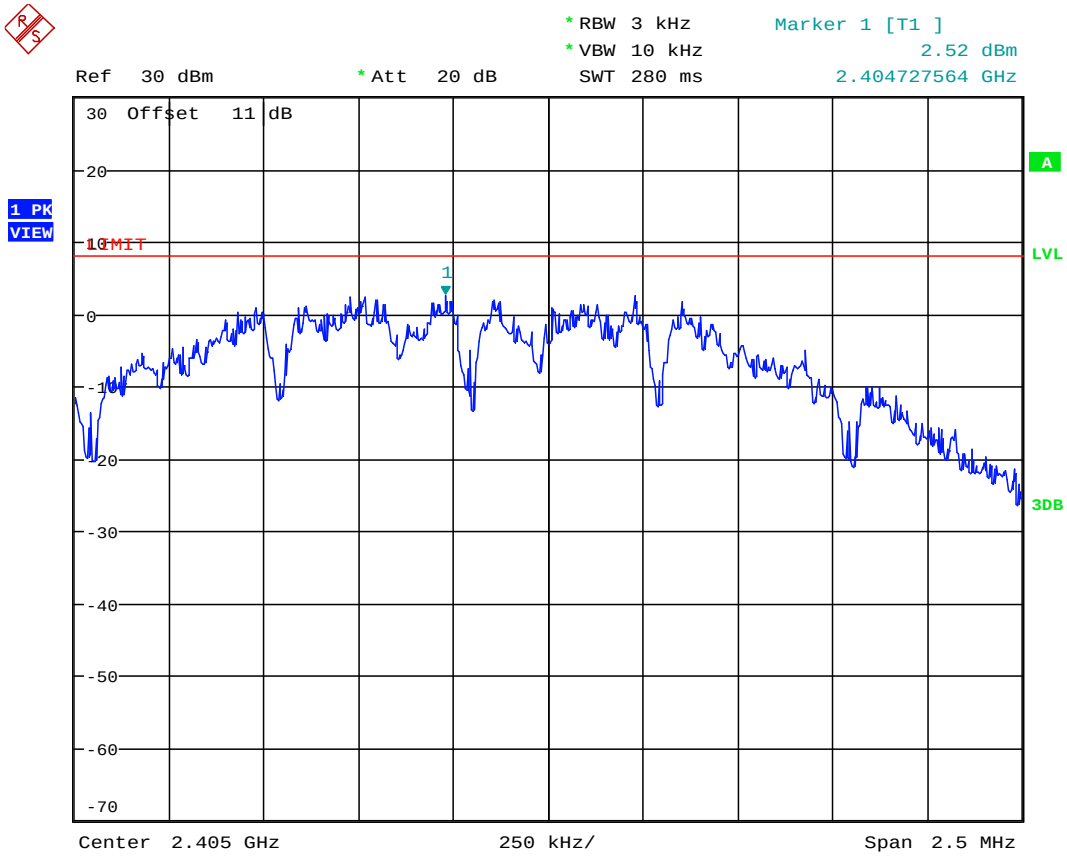
QG-H1 (setting 4), QG-N3 (setting 2), Power Spectral Density

Modulation	Channel Number	Frequency (MHz)	**PSD QG-H1** (dBm)	**PSD QG-N3** (dBm)	Limit (dBm)
MSK	11	2405	2.52	-5.57	8
MSK	18	2440	1.96	-6.37	8
MSK	26	2480	1.90	-5.86	8

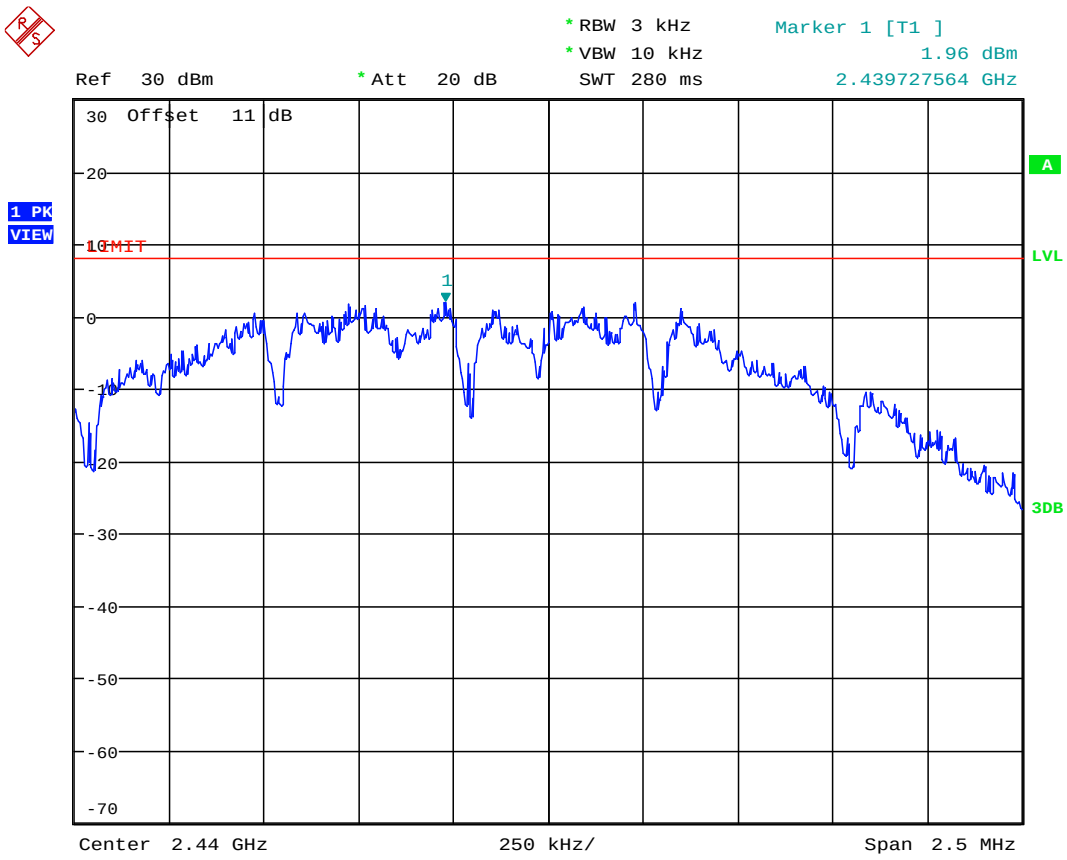
*See the following plots for measurement details.

QG-H1

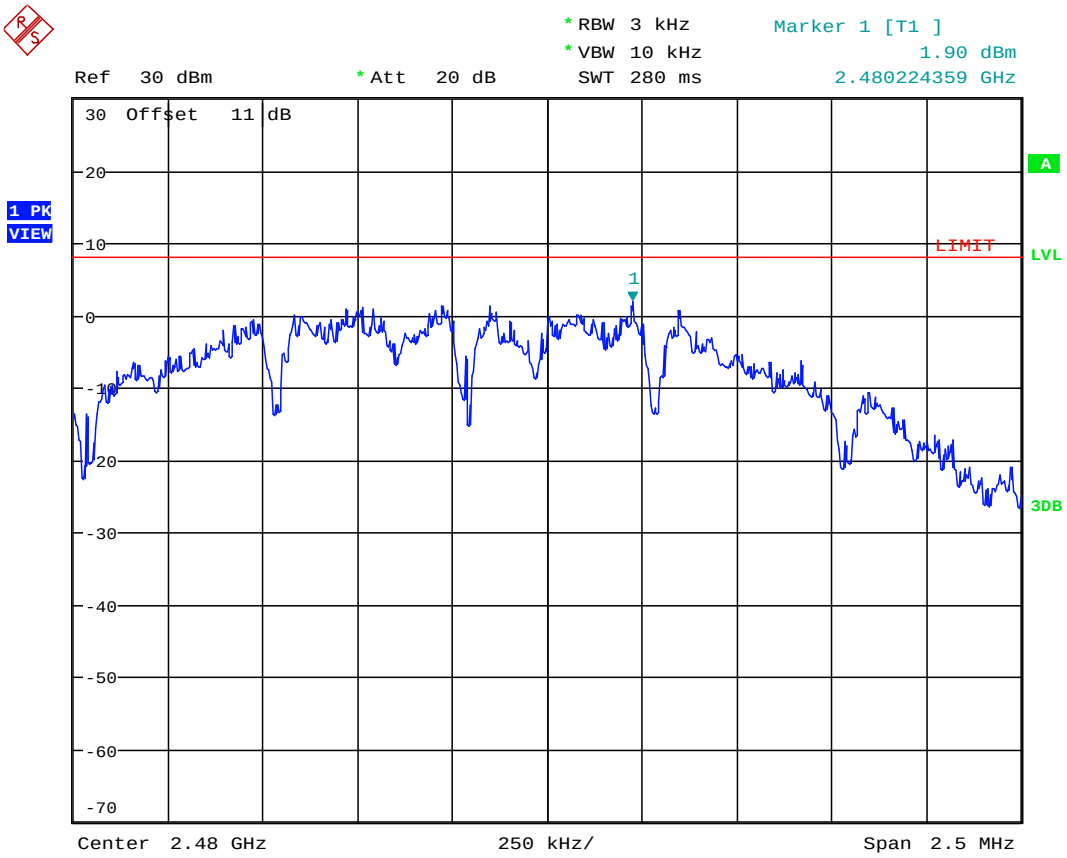
Plot 5.6.4.1. Power Spectral Density, Channel Low, 2405 MHz, **QG-H1**



Plot 5.6.4.2. Power Spectral Density, Channel Mid, 2440 MHz, **QG-H1**



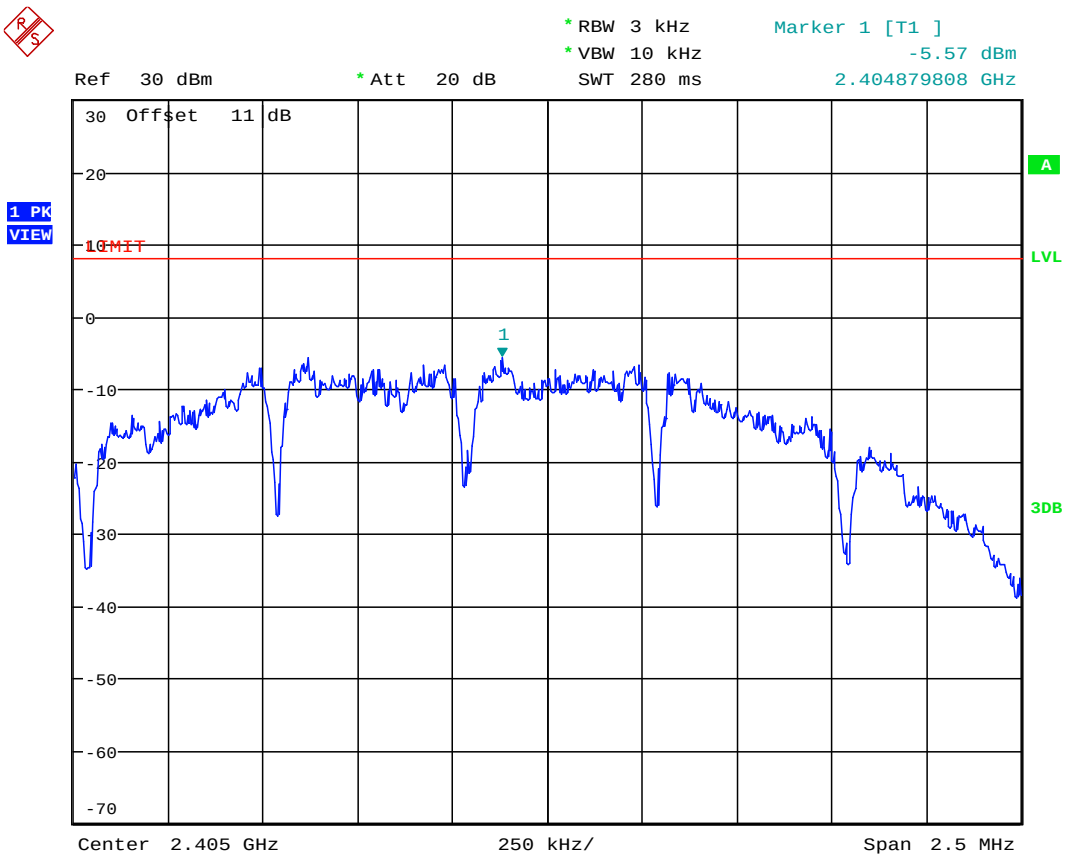
Plot 5.6.4.3. Power Spectral Density, Channel High, 2480 MHz, **QG-H1**



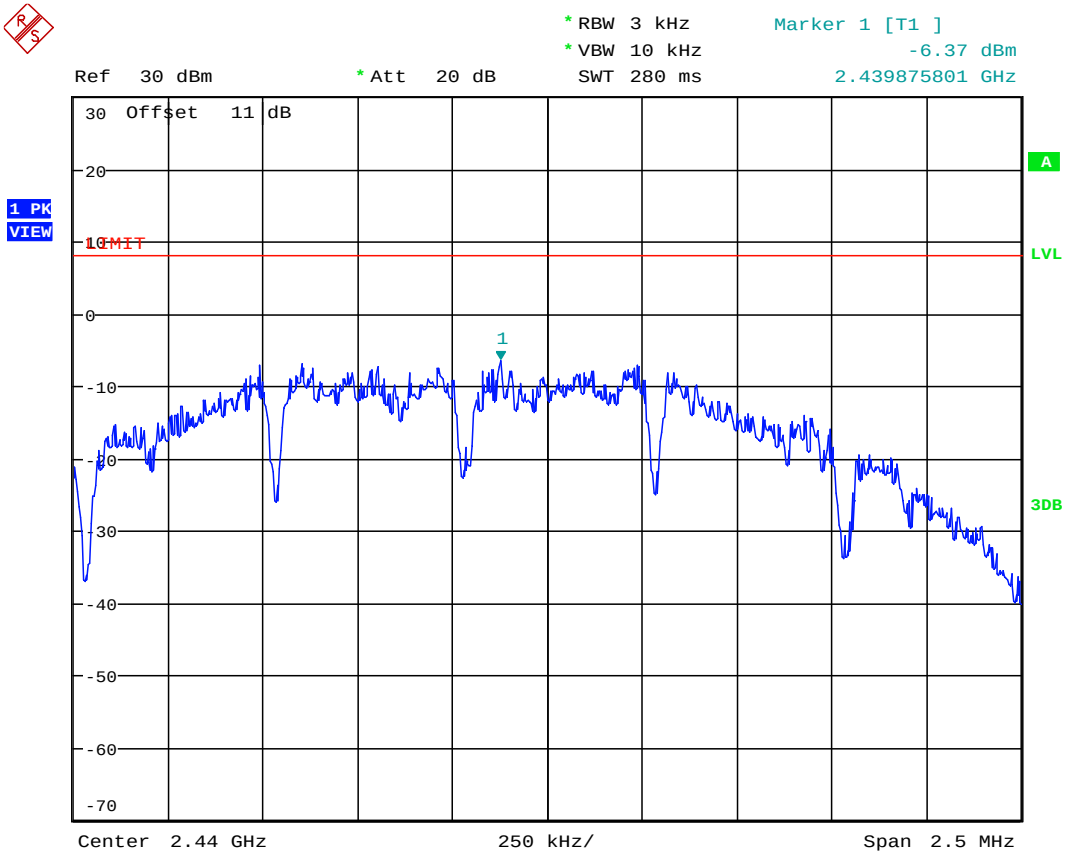
Date: 20.DEC.2016 14:40:54

QG-N3

Plot 5.6.4.4. Power Spectral Density, Channel Low, 2405 MHz, **QG-N3**

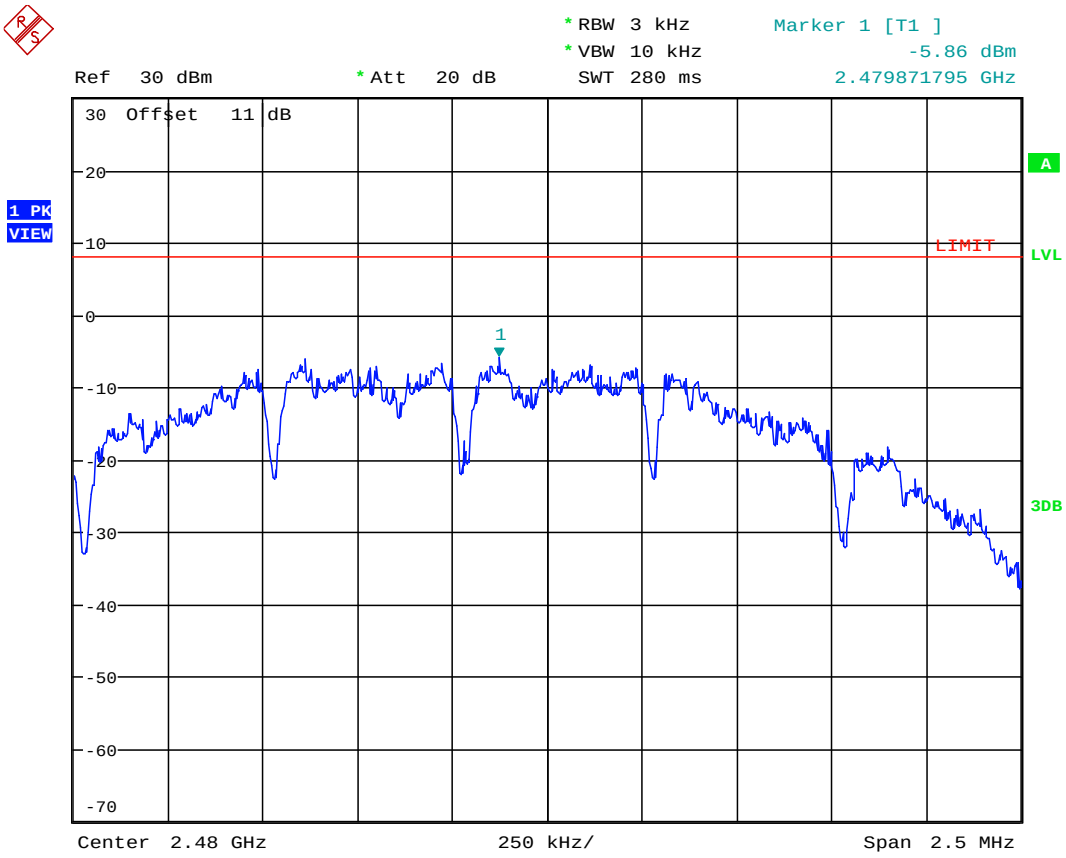


Plot 5.6.4.5. Power Spectral Density, Channel Mid, 2440 MHz, **QG-N3**



Date: 10.JAN.2017 15:40:20

Plot 5.6.4.6. Power Spectral Density, Channel High, 2480 MHz, **QG-N3**



Date: 10.JAN.2017 16:15:10

5.7. RF EXPOSURE REQUIRMENTS @ 1.1310, 2.1091 & 2.1093

5.7.1. Limits

FCC has specified the general guidance for meeting RF Exposure requirements in KDB 447498 D01 General RF Exposure Guidance v06, the following are the applicable sections for this module summarized from this guidance.

1) The RF exposure requirements for devices operating in mobile and portable exposure conditions are different. When both exposure conditions apply to a device, compliance is determined according to the rules and policies established for both exposure conditions. Equipment authorization for devices that are categorically excluded from routine RF exposure evaluation according to §2.1091(c) and §2.1093(c).
2) Standalone and simultaneous transmission use conditions for mobile and portable exposure conditions must be determined according to the host platform and product operating configuration requirements
3) Transmitter modules must be approved according to one of the following host platform exposure conditions, with respect to the product configurations tested or evaluated for equipment approval for incorporation in qualified host products. The approved host platform exposure condition(s) must be identified on the grant of equipment certification. When transmitter modules are incorporated in host devices that qualify for RF exposure test exclusion and no other testing or equipment approval is required, the standalone and simultaneous transmission configurations and test exclusion conditions must be fully documented in the grantee's records.
4) *(a) Mobile exposure host* platform evaluation procedures can only be applied if all transmitters in the host devices support mobile exposure conditions. Transmitters and modules approved only for use in the *mobile exposure host* platform cannot operate in hosts and product configurations that require standalone or simultaneous transmission operations in portable exposure conditions. The *portable exposure host* platform or the *mixed mobile and portable exposure* platform is required to support portable exposure conditions in qualified host configurations.
5) *(b) Portable exposure host* platform evaluation procedures can only be applied if all transmitters in the host devices support portable exposure conditions. Transmitters and modules approved for use in the *portable exposure host* platform may be used for standalone operations in *mobile exposure host* platforms, without further equipment approval, only when the same identical transmitter and antenna required for portable exposure conditions are used.
6) Transmitters operating in consumer products must satisfy the general population exposure limits required for either mobile or portable RF exposure conditions as appropriate. The test configurations used to qualify for test exclusion or used for compliance testing must be sufficiently conservative for all required operations to demonstrate compliance.
7) As required by §§ 2.1033(b)(3) and 2.1033(c)(3), users and installers shall be furnished with the required operating and installation instructions. These are reviewed for acceptance during equipment approval. The applicable instructions must be provided to installers, integrators and end users to ensure proper installation and operation of the devices for meeting compliance.
8) Extremity exposure conditions: Devices that are designed or intended for use on extremities or mainly operated in extremity only exposure conditions; i.e., hands, wrists, feet and ankles, may require extremity SAR evaluation. 10-g extremity *SAR Test Exclusion Thresholds* in section 4.3 should be applied to determine SAR test requirements.

Appendix A

SAR Test Exclusion Thresholds for 100 MHz – 6 GHz and ≤ 50 mm

Approximate SAR Test Exclusion Power Thresholds at Selected Frequencies and Test Separation Distances are illustrated in the following Table. The equation and threshold in 4.3.1 must be applied to determine SAR test exclusion.

MHz	5	10	15	20	25	mm
150	39	77	116	155	194	*SAR Test Exclusion Threshold* (mW)
300	27	55	82	110	137	
450	22	45	67	89	112	
835	16	33	49	66	82	
900	16	32	47	63	79	
1500	12	24	37	49	61	
1900	11	22	33	44	54	
2450	10	19	29	38	48	
3600	8	16	24	32	40	
5200	7	13	20	26	33	
5400	6	13	19	26	32	
5800	6	12	19	25	31	

Note: 10-g Extremity SAR Test Exclusion Power Thresholds are 2.5 times higher than the 1-g SAR Test Exclusion Thresholds indicated above. These thresholds do not apply, by extrapolation or other means, to occupational exposure limits.

Standalone SAR test exclusion threshold condition for radio is verified as per below.

1) The 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at *test separation distances* ≤ 50 mm are determined by:

   [(*max. power of channel, including tune-up tolerance, mW*)/(*min. test separation distance, mm*)] · [$\sqrt{f_{(GHz)}}$] ≤ 3.0 for 1-g SAR and ≤ 7.5 for 10-g extremity SAR,[25] where

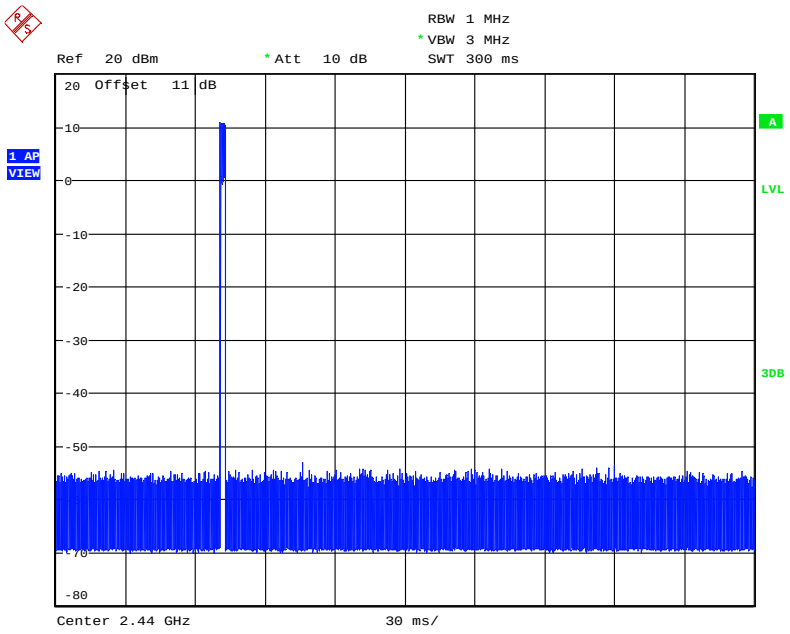
   - $f_{(GHz)}$ is the RF channel transmit frequency in GHz
   - Power and distance are rounded to the nearest mW and mm before calculation[26]
   - The result is rounded to one decimal place for comparison
   - 3.0 and 7.5 are referred to as the numeric thresholds in the step 2 below

Radio: 2.48 GHz with 18.26dbm, Antenna gain 2 dBi and duty Cycle of 2.32% conducted power @ 5 mm separation distance; EUT is a handheld device with antenna on the top directed away from the hand.
Power= 2.46 mW

= (2.46)/5 x (√2.48) < 3

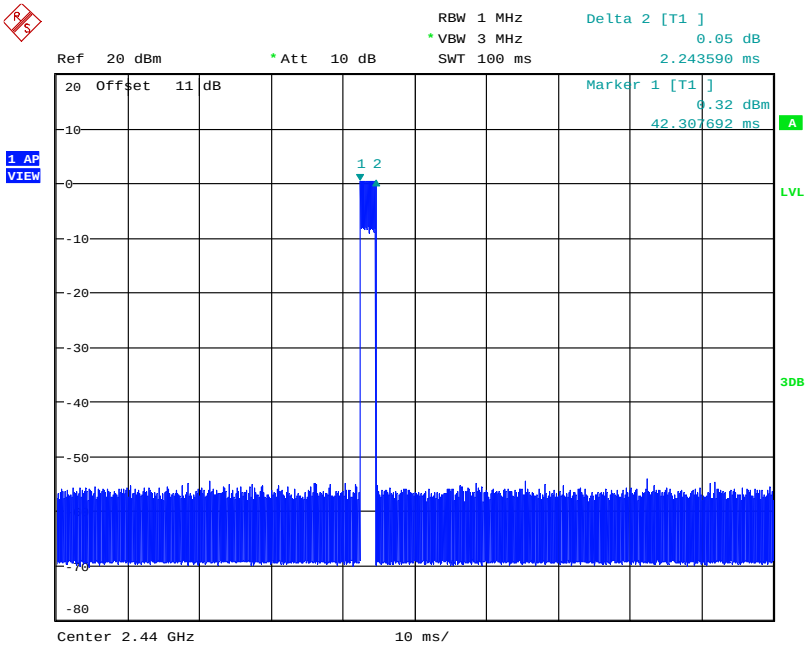
= 0.77 < 3, satisfies the exclusion threshold.

5.8. Duty Cycle Analysis



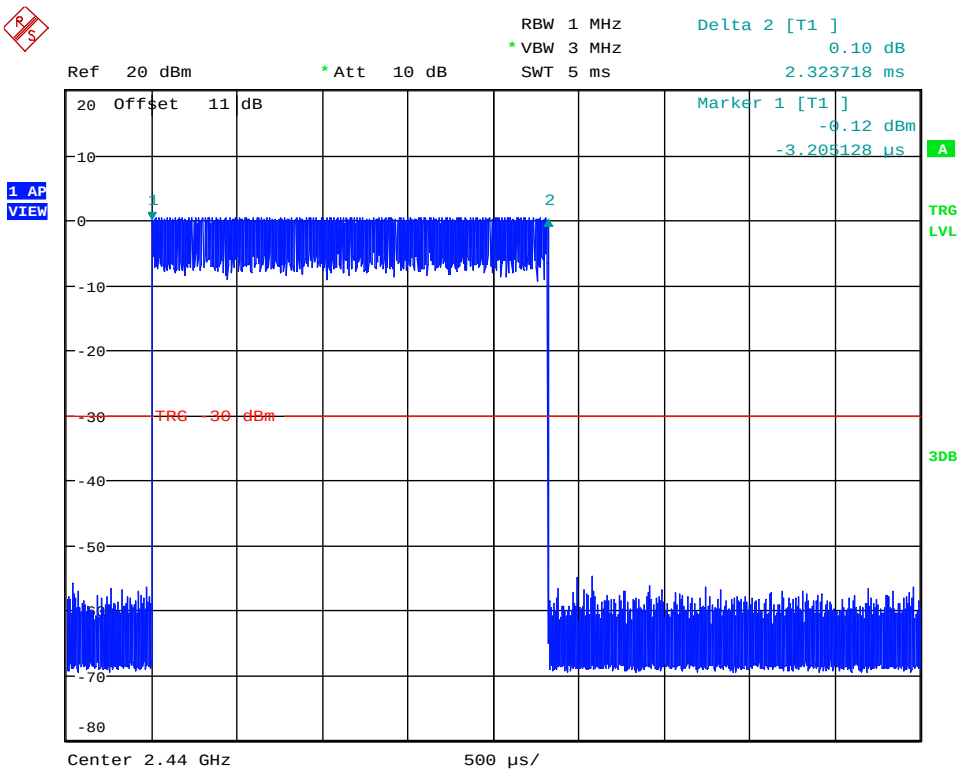
Date: 8.DEC.2017 15:11:29

100ms time Plot



Date: 10.NOV.2017 13:56:06

5ms time Plot



Calculation

Duty cycle=Txon/(Txon+Txoff)= 2.32/100= 0.0.23 (2.32%)

EXHIBIT 6. TEST EQUIPMENT LIST

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range	Calibration Due Date
Spectrum Analyzer	Hewlett Packard	HP 8593EM	3412A00103	9 kHz–26.5 GHz	Apr 9, 2017
Attenuator	Pasternack	PE7010-20	07	DC–2 GHz	Mar 26, 2017
L.I.S.N	EMCO	3825/2	1531	0.10 -100 MHz	Nov 11, 2017
DC Power Supply	Xantrex	HPD 60-5SX	63903	0-60 VDC	Not required
POE Adaptor	Power Dsine	3001	---	-	Not required
Spectrum Analyzer	Rohde & Schwarz	FSU26	200946	20Hz–26.5 GHz	Jul 21, 2018
Attenuator	Pasternack	7024-10	4	DC–26.5 GHz	Cal on use
DC Block	Hewlett Packard	11742A	12460	0.045 – 26.5 GHz	Cal on use
Laptop	Acer	D257-13847	11807650925	-	Not required
Multi-meter	Extech	EX530	12070737	0.01mV - 1kV	May 14, 2017
EMI Receiver	Rohde & Schwarz	ESU40	100037	20Hz–40 GHz	May 8, 2017
Spectrum Analyzer	Rohde & Schwarz	FSEK30	100077	20Hz–40 GHz	Dec 5, 2018
RF Amplifier	Com-Power	PAM-0118A	551052	0.5 – 18 GHz	Jul 14, 2017
RF Amplifier	Hewlett Packard	84498	3008A00769	1 – 26.5 GHz	May 5, 2017
Biconilog	Emco	3142	9601-1005	26-1000 MHz	May 12, 2018
Horn Antenna	Emco	3155	6570	1 – 18 GHz	Oct 13, 2018
High Pass Filter	K & L	11SH10-4000/T12000	4	Cut off 2400 MHz	Cal on use
Band Reject Filter	Micro-Tronics	BRM50701	105	Cut off 2.4-2.483 GHz	Cal on use

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**