ENGINEERING TEST REPORT

XBee3
Model: XBEE3
FCC ID: MCQ-XBEE3

Applicant:

Digi International Inc
11001 Bren Road East
Minnetonka, MN 55343

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.: 17DIGI133_FCC15C247Z

This Test report is Issued under the Authority of Tri M. Luu Vice President of Engineering UltraTech Group of Labs Date: October 25, 2017	
Report Prepared by: Dan Huynh Issued Date: October 25, 2017	Tested by: Hung Trinh Test Dates: September 6 - 11, 2017

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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:	▪ ANSI C63.4 ▪ ANSI C63.10 ▪ FCC KDB Publication No. 558074 D01 DTS Meas Guidance v04
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
FCC, KDB Publication No. 558074 D01 DTS Meas Guidance v04	2017	Guidance for Performing Compliance Measurements for Digital Transmission Systems (DTS) Operating Under Section 15.247

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1. CLIENT INFORMATION

Applicant	
Name:	Digi International Inc
Address:	11001 Bren Road East Minnetonka, MN 55343 USA
Contact Person:	Paul Dahl Phone #: 801-765-9885 Fax #: 801-765-9895 Email Address: paul.dahl@digi.com

Manufacturer	
Name:	Digi International Inc
Address:	11001 Bren Road East Minnetonka, MN 55343 USA
Contact Person:	Dan Leveille Phone #: 952-912-4794 Fax #: n/a Email Address: dan.leveille@digi.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:	Digi International Inc
Product Name:	XBee3
Model Name or Number:	XBEE3
Serial Number:	Test Sample
Type of Equipment:	Digital Transmission System (DTS)
Input Power Supply Type:	External DC Power Supply
Primary User Functions of EUT:	802.15.4 connectivity of embedded systems, BLE connectivity

2.3. EUT'S TECHNICAL SPECIFICATIONS

Transmitter	
Equipment Type:	Mobile Base station (fixed use)
Intended Operating Environment:	Commercial, industrial or business environment
Power Supply Requirement:	3.3V (nominal)
RF Output Power Rating:	+19.45 dBm maximum conducted power
Operating Frequency Range:	2405 - 2480 MHz
RF Output Impedance:	50 Ω
Duty Cycle:	Continuous
Modulation Type:	QPSK
Antenna Connector Types:	Integral antenna, U.FL, RF Pad

2.4. ASSOCIATED ANTENNA DESCRIPTIONS

Antenna Type	Maximum Gain (dBi)
Omni-directional antenna	15
Yagi antenna	15.0
Flat Panel antenna	19.0
Dipole antenna	2.1
Integral PCB/Chip antenna	0

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	RF port	1	Integral antenna, U.FL or RF Pad	Shielded cable (N/A for integral antenna)
2	DC supply and I/O port	1	Castellated Pads	Direct connection (no cable)

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:	Test Jig
Brand name:	Digi International
Model Name or Number:	N/A
Serial Number:	N/A
Connected to EUT's Port:	Module pin signals

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 ^{o}C
Humidity:	45 to 58%
Pressure:	102 kPa
Power Input Source:	3.6 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:	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:	Test Jig
Transmitter Test Antenna:	The EUT is tested with the antenna fitted in a manner typical of normal intended use as integral / non-integral antenna equipment as described with the test results.

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)	19.45 dBm Peak
Normal Test Modulation:	QPSK
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	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

* The EUT complies with the requirement; it employs a unique (non-standard) antenna connector or integral antenna.

4.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

None.

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:

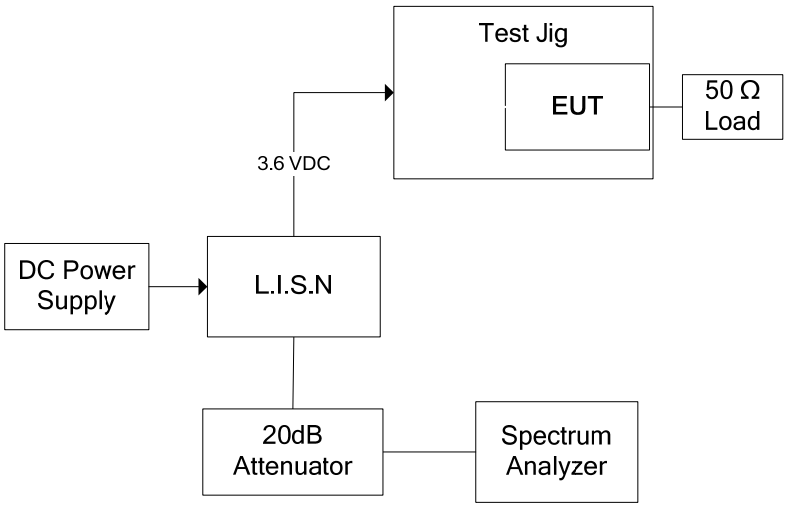
Frequency of emission (MHz)	Conducted Limits (dBμV)	
	Quasi-peak	Average
0.15–0.5 .....……..	66 to 56*	56 to 46*
0.5–5 .....……..	56	46
5-30 ……..	60 ...……..	50

*Decreases linearly with the logarithm of the frequency

5.1.2. Method of Measurements

ANSI C63.4

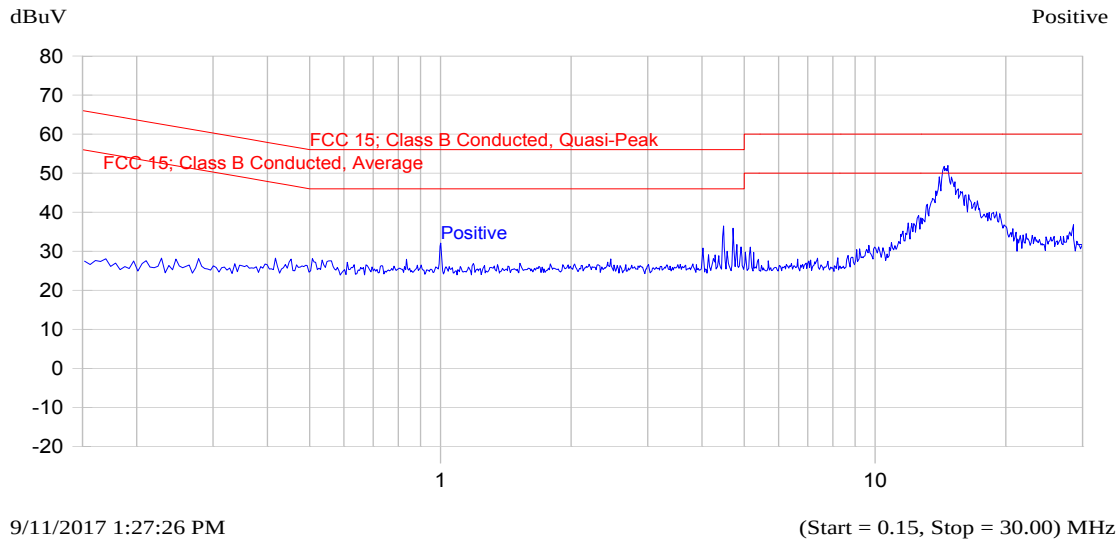
5.1.3. Test Arrangement



5.1.4. Test Data

Plot 5.1.4.1. Power Line Conducted Emissions (Tx Mode)
Line Voltage: 3.6 VDC; Line Tested: Positive

Current Graph

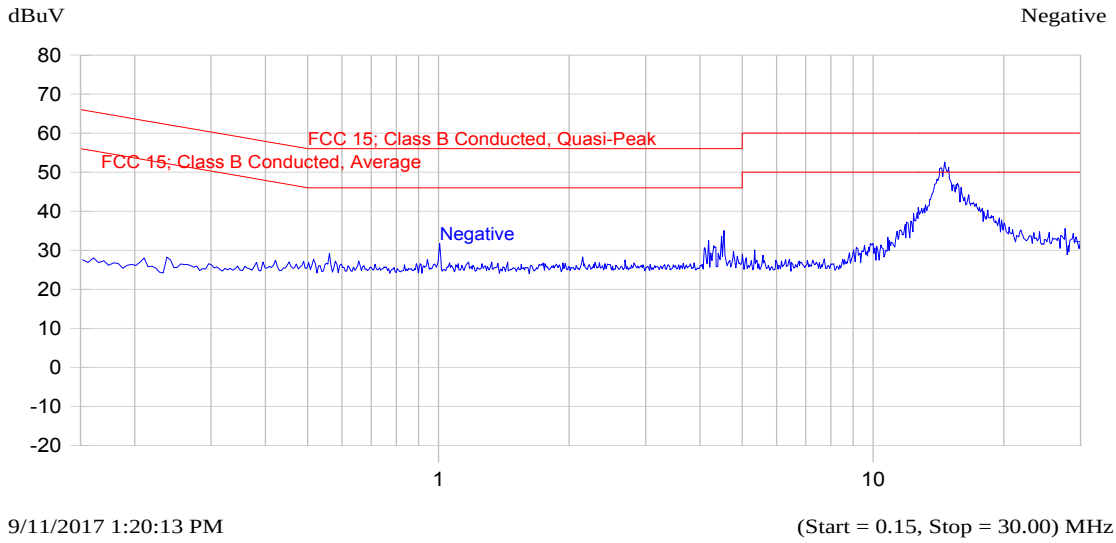


Current List

Frequency MHz	Peak dBuV	QP dBuV	QP-QP Limit dB	Avg dBuV	Avg-Avg Limit dB	Trace Name
0.999	38.5	33.6	-22.4	28.6	-17.4	Positive
4.483	38.1	29.7	-26.3	20.5	-25.5	Positive
14.691	53.8	46.3	-13.7	36.8	-13.2	Positive

Plot 5.1.4.2. Power Line Conducted Emissions (Tx Mode)
Line Voltage: 3.6 VDC; Line Tested: Negative

Current Graph

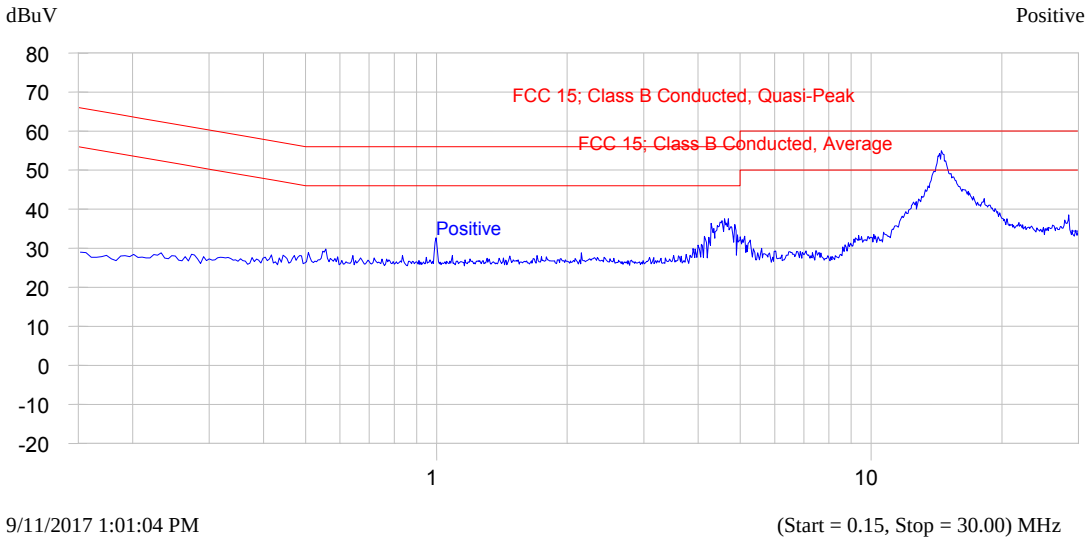


Current List

Frequency MHz	Peak dBuV	QP dBuV	QP-QP Limit dB	Avg dBuV	Avg-Avg Limit dB	Trace Name
0.999	38.5	33.8	-22.2	28.6	-17.4	Negative
4.541	38.2	30.3	-25.7	20.9	-25.1	Negative
14.626	53.3	47.2	-12.8	37.5	-12.5	Negative

Plot 5.1.4.3. Power Line Conducted Emissions (Rx Mode)
Line Voltage: 3.6 VDC; Line Tested: Positive

Current Graph

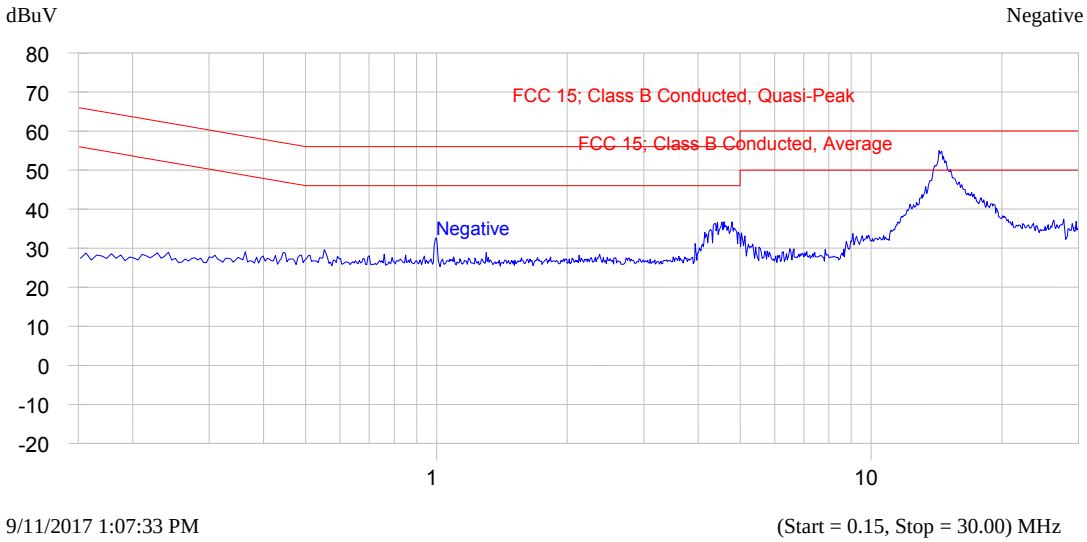


Current List

Frequency MHz	Peak dBuV	QP dBuV	QP-QP Limit dB	Avg dBuV	Avg-Avg Limit dB	Trace Name
0.999	38.2	32.9	-23.1	27.0	-19.0	Positive
4.606	37.4	30.2	-25.8	20.4	-25.6	Positive
14.511	53.4	48.2	-11.8	38.2	-11.8	Positive

Plot 5.1.4.4. Power Line Conducted Emissions (Rx Mode)
Line Voltage: 3.6 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
0.996	38.5	33.5	-22.5	28.0	-18.0	Negative
4.589	38.3	31.1	-24.9	20.6	-25.4	Negative
14.332	52.9	47.8	-12.2	38.1	-11.9	Negative

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

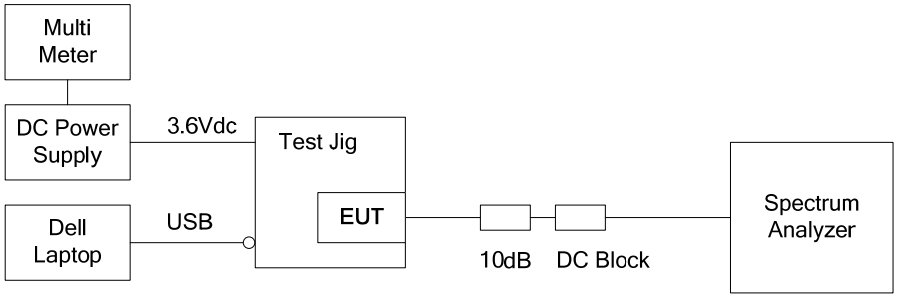
5.2.1. Limit(s)

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

5.2.2. Method of Measurements

KDB 558074 D01 DTS Meas Guidance v04, Section 8.2 Option 2.

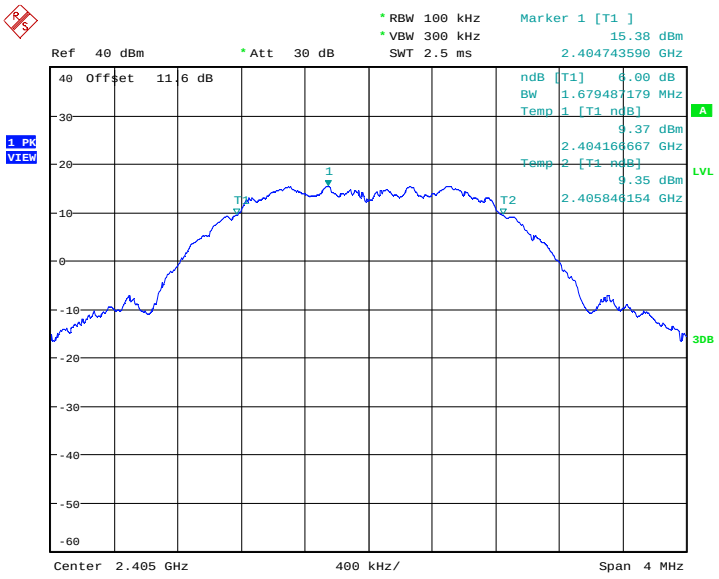
5.2.3. Test Arrangement



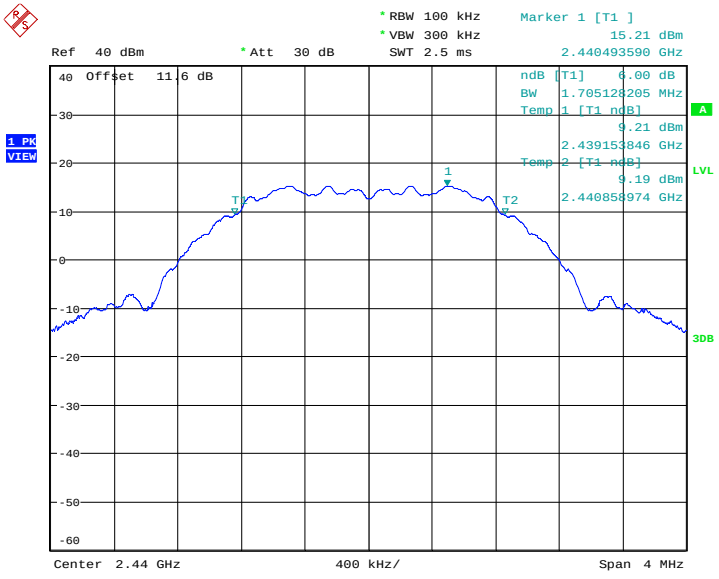
5.2.4. Test Data

Modulation	Power Setting	Channel	Frequency (MHz)	6dB BW (MHz)	Min. Limit (kHz)
QPSK	High Power (20)	11	2405	1.68	500
		18	2440	1.71	500
		26	2480	1.67	500

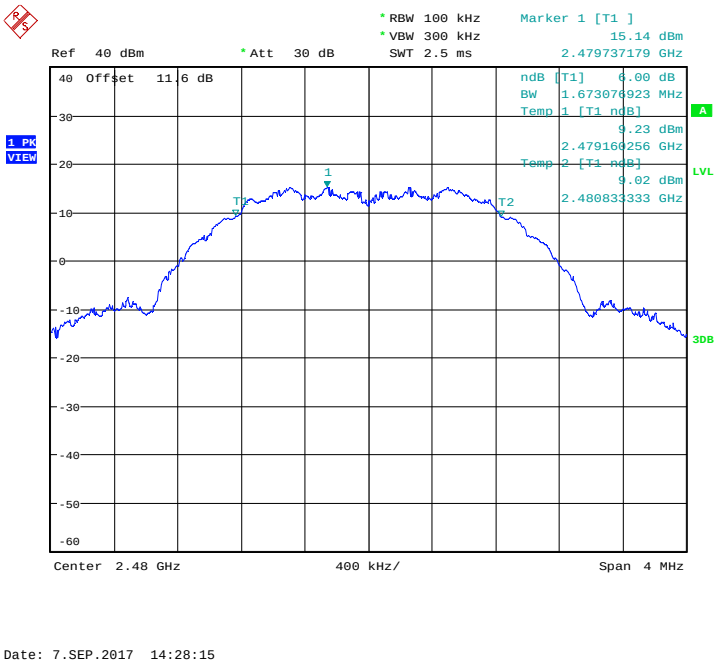
Plot 5.2.4.1. 6 dB Bandwidth, QPSK Modulation, Power Setting at 20, Channel 11, 2405 MHz



Plot 5.2.4.2. 6 dB Bandwidth, QPSK Modulation, Power Setting at 20, Channel 18, 2440 MHz



Plot 5.2.4.3. 6 dB Bandwidth, QPSK Modulation, Power Setting at 20, Channel 26, 2480 MHz



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

5.3.1. Limit(s)

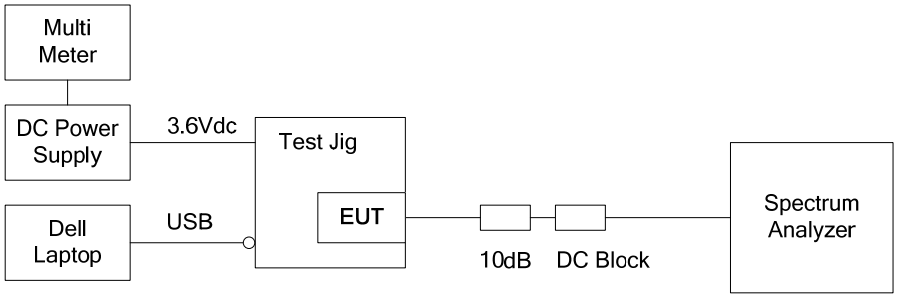
§ 15.247(b)(3): For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power 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.

§ 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.

5.3.2. Method of Measurements & Test Arrangement

KDB 558074 D01 DTS Meas Guidance V04, Section 9.1.1 RBW ≥ DTS bandwidth

5.3.3. Test Arrangement



5.3.4. Test Data

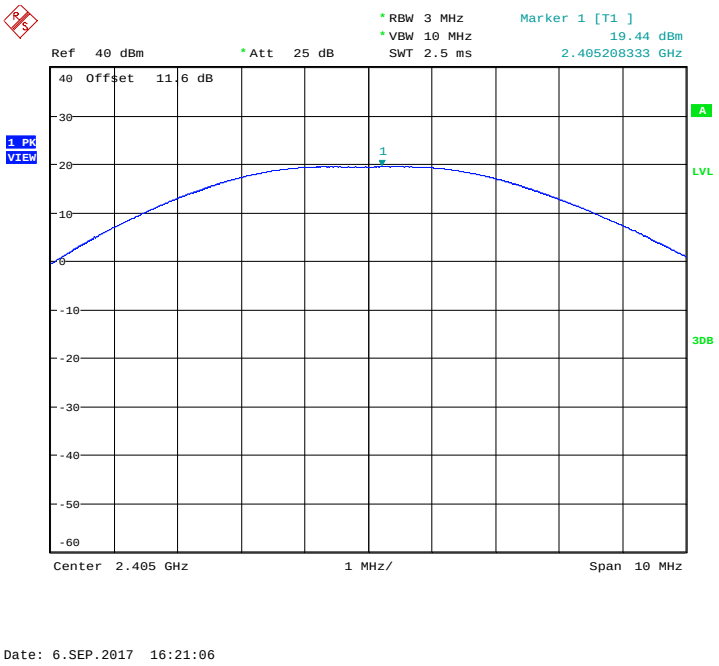
Peak Conducted Power at High and Low Power Settings

Modulation	Power Setting	Channel	Frequency (MHz)	Peak Power (dBm)	Peak Power Limit (dBm)
QPSK	High Power (20)	11	2405	19.44	30
		18	2440	19.38	30
		26	2480	19.45	30
	Low Power (-5)	11	2405	-5.99	30
		18	2440	-6.08	30
		26	2480	-6.01	30

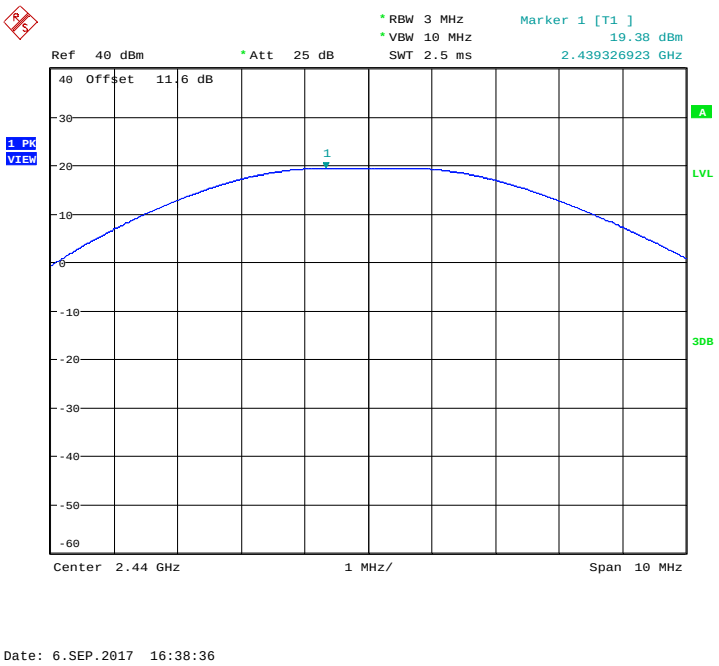
Power Level, Antenna Details and Resulting EIRP Values

Maximum Conducted Power: 19.45 dBm				
Assembly #	**Antenna Type**	**Maximum Gain (dBi)**	**Minimum Insertion / Cable Loss (dBm)**	**EIRP (dBm)**
1	Omni-directional antenna	15	1.5	32.95
2	Yagi antenna	15	1.5	32.95
3	Flat Panel antenna	19	4.5	33.95
4	Dipole antenna	2.1	0.75	20.80
5	Integral PCB/Chip antenna	0	0	19.45

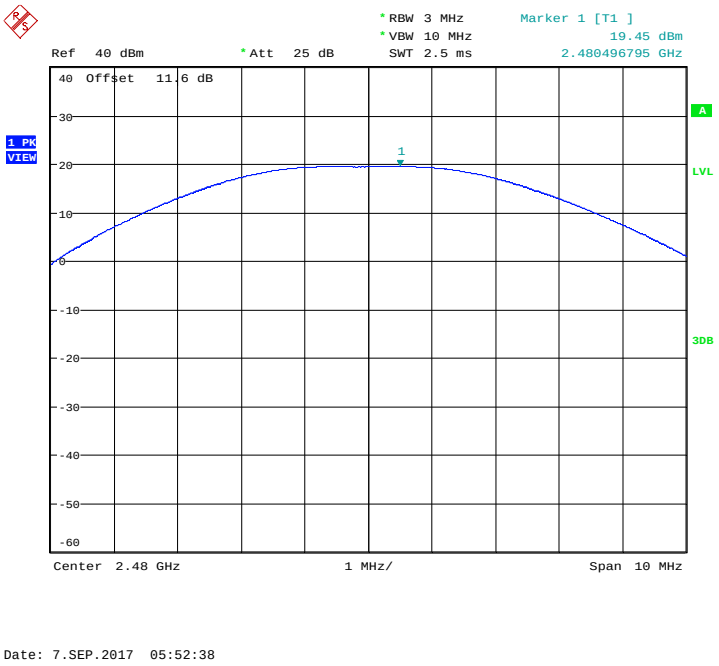
Plot 5.3.4.1. Maximum Peak Conducted Output Power, QPSK Modulation, High Power, Ch 11, 2405 MHz



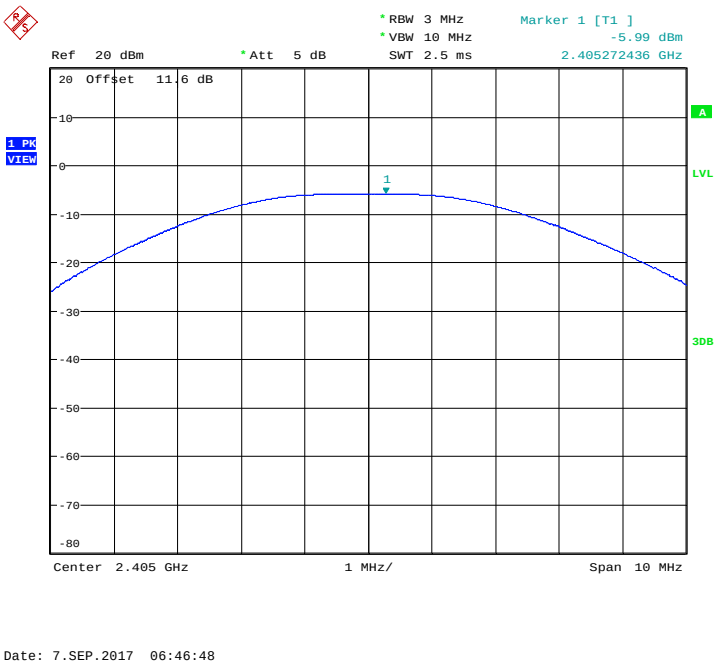
Plot 5.3.4.2. Maximum Peak Conducted Output Power, QPSK Modulation, High Power, Ch 18, 2440 MHz



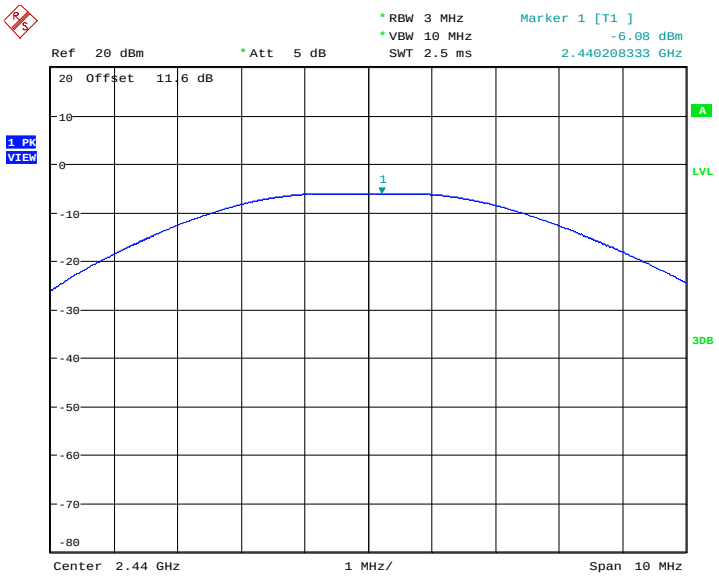
Plot 5.3.4.3. Maximum Peak Conducted Output Power, QPSK Modulation, High Power, Ch 26, 2480 MHz



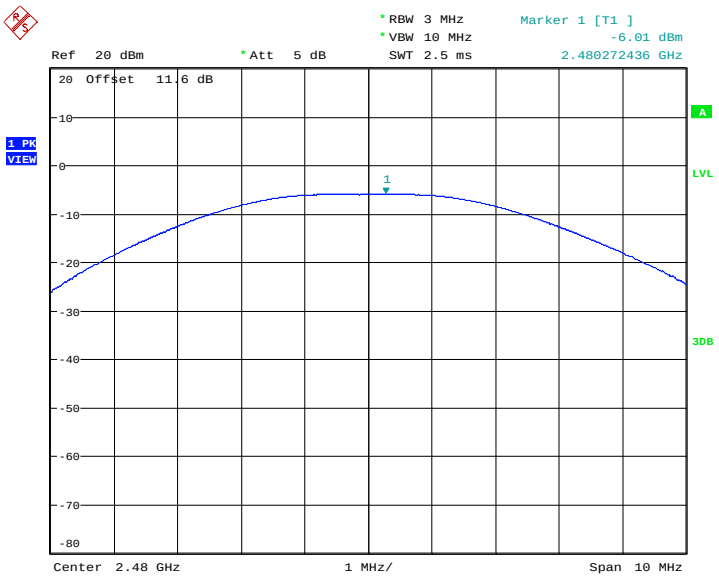
Plot 5.3.4.4. Maximum Peak Conducted Output Power, QPSK Modulation, Low Power, Ch 11, 2405 MHz



Plot 5.3.4.5. Maximum Peak Conducted Output Power, QPSK Modulation, Low Power, Ch 18, 2440 MHz



Plot 5.3.4.6. Maximum Peak Conducted Output Power, QPSK Modulation, Low Power, Ch 26, 2480 MHz



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

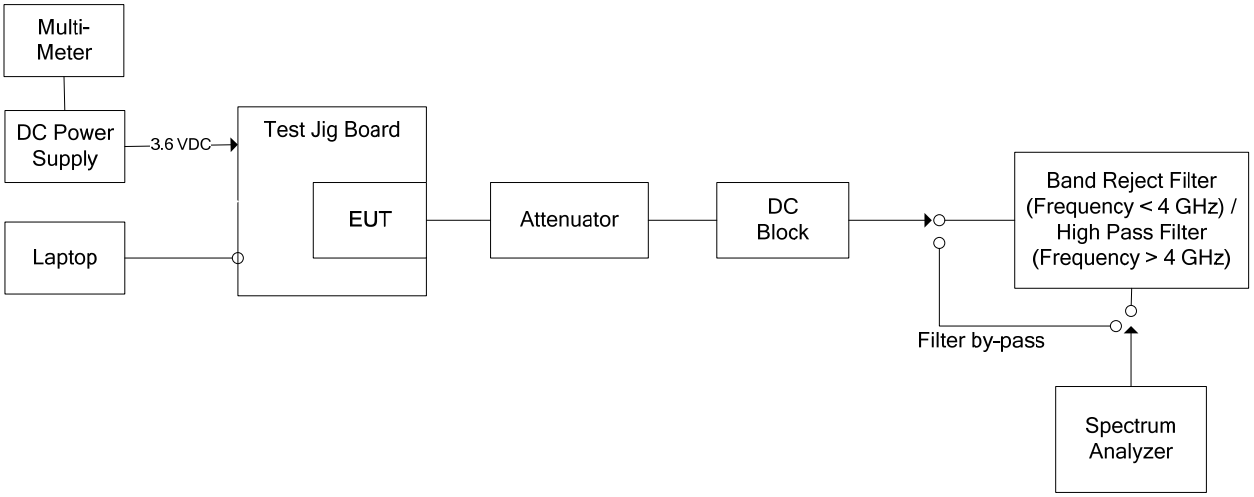
5.4.1. Limit(s)

§ 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 V04, Sections 10, 11 and 13.
ANSI C63.10-2013, 6.10.6.2

5.4.3. Test Arrangement

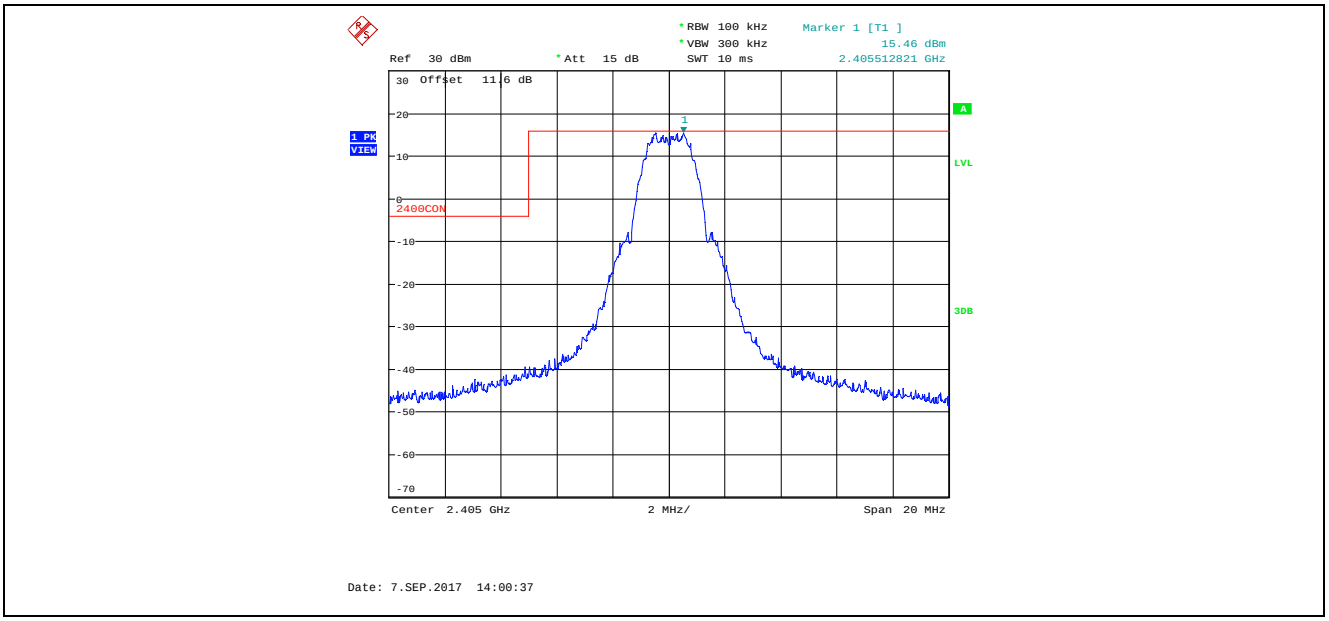


5.4.4. Test Data

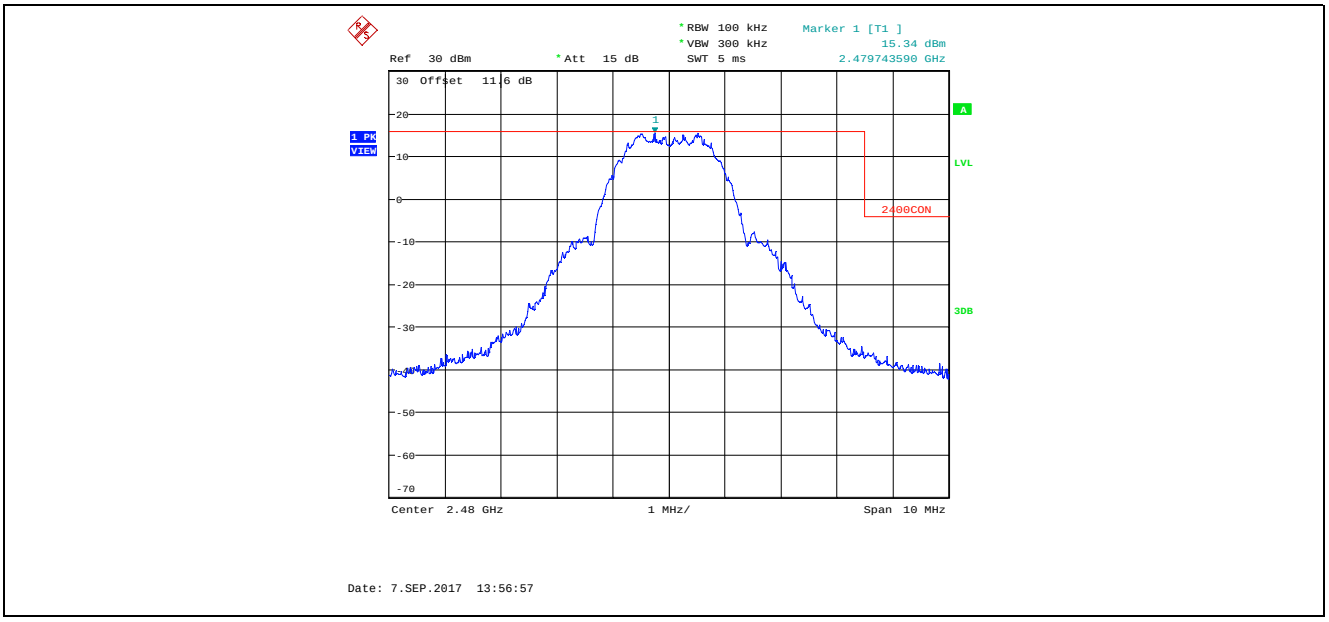
Remark(s): Exploratory tests performed to determined worst-case test configurations, the following test results represent the worst-case.

5.4.4.1. Band-Edge RF Conducted Emissions

Plot 5.4.4.1.1. Band-Edge RF Conducted Emissions
QPSK Modulation, High Power, Ch 11, 2405 MHz, Lower Band-edge

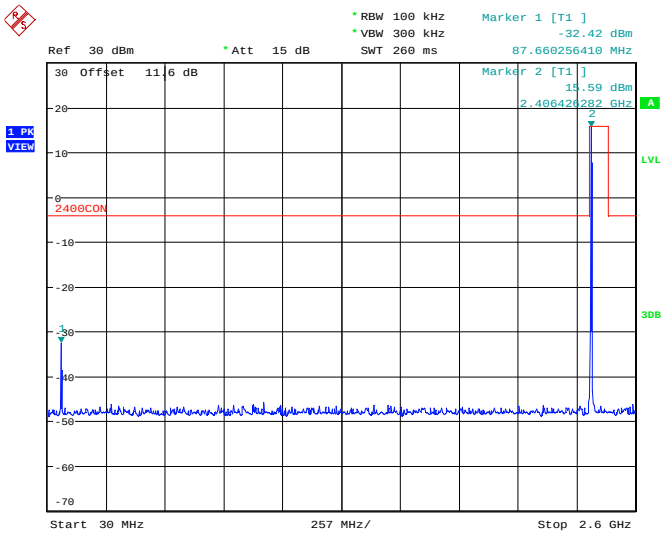


Plot 5.4.4.1.2. Band-Edge RF Conducted Emissions
QPSK Modulation, High Power, CH 26, 2480 MHz, Higher Band-edge

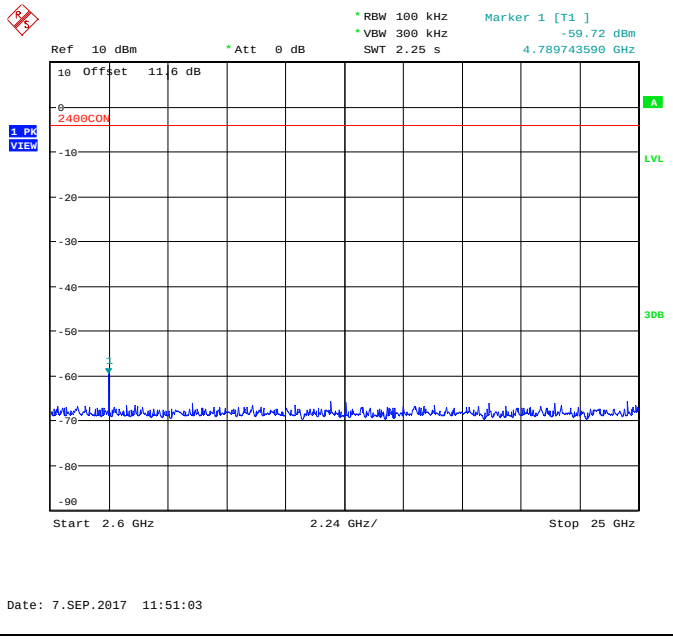


5.4.4.2. Conducted Spurious Emissions in Non-Restricted Frequency Bands, at High and Low Power Levels

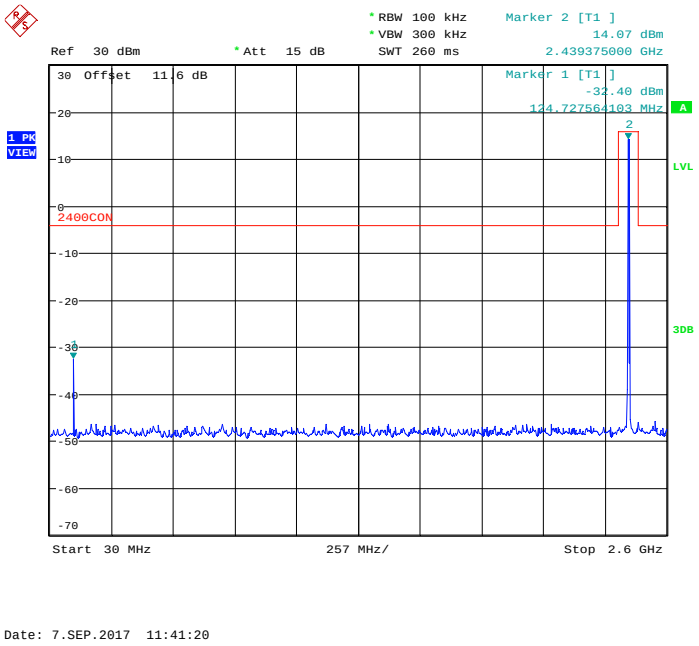
Plot 5.4.4.2.1. Conducted Spurious Emissions in Non-Restricted Frequency Bands, High Power 2405 MHz, QPSK Modulation, 30 MHz – 2.6 GHz, Peak Detector



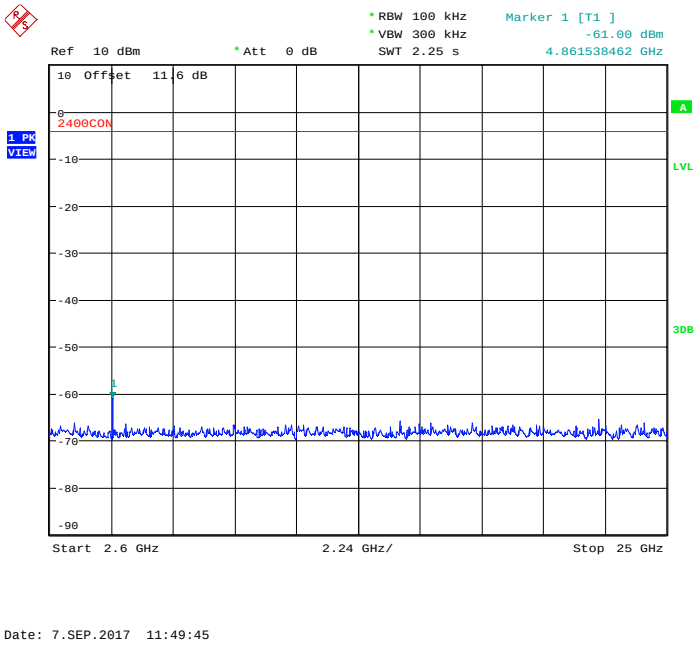
Plot 5.4.4.2.2. Conducted Spurious Emissions in Non-Restricted Frequency Bands, High Power 2405 MHz, QPSK Modulation, 2.6 GHz – 25 GHz, Peak Detector



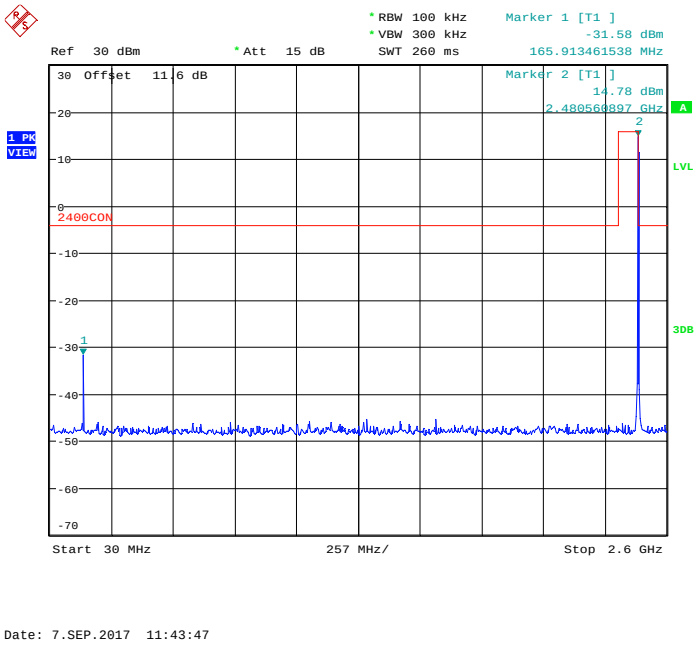
Plot 5.4.4.2.3. Conducted Spurious Emissions in Non-Restricted Frequency Bands, High Power 2440 MHz, QPSK Modulation, 30 MHz – 2.6 GHz, Peak Detector



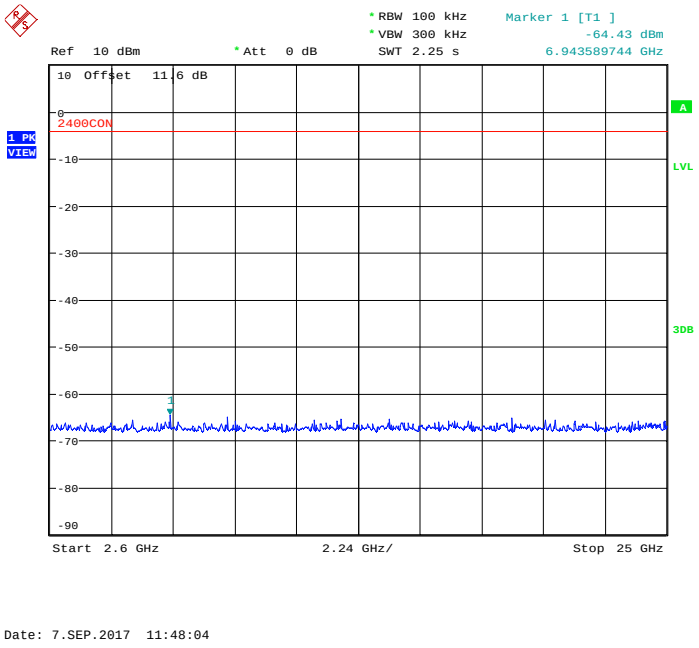
Plot 5.4.4.2.4. Conducted Spurious Emissions in Non-Restricted Frequency Bands, High Power 2440 MHz, QPSK Modulation, 2.6 GHz – 25 GHz, Peak Detector



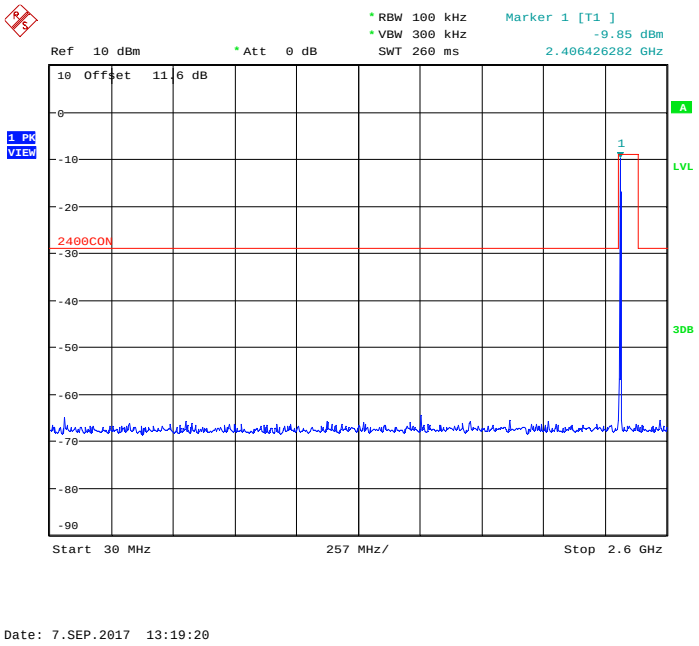
Plot 5.4.4.2.5. Conducted Spurious Emissions in Non-Restricted Frequency Bands, High Power 2480 MHz, QPSK Modulation, 30 MHz – 2.6 GHz, Peak Detector



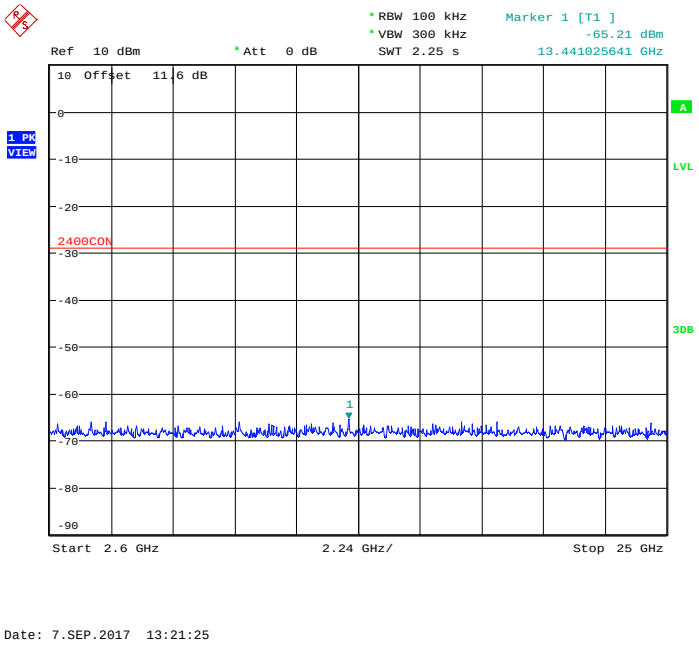
Plot 5.4.4.2.6. Conducted Spurious Emissions in Non-Restricted Frequency Bands, High Power 2480 MHz, QPSK Modulation, 2.6 GHz – 25 GHz, Peak Detector



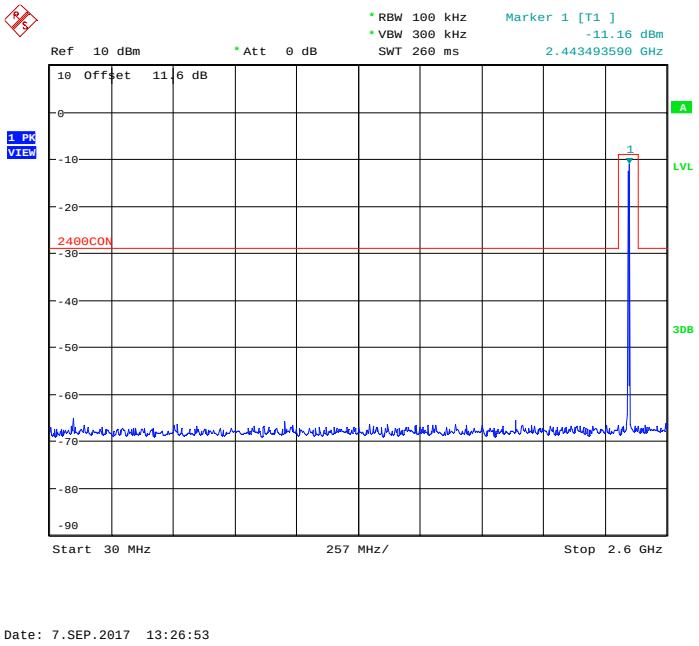
Plot 5.4.4.2.7. Conducted Spurious Emissions in Non-Restricted Frequency Bands, Low Power 2405 MHz, QPSK Modulation, 30 MHz – 2.6 GHz, Peak Detector



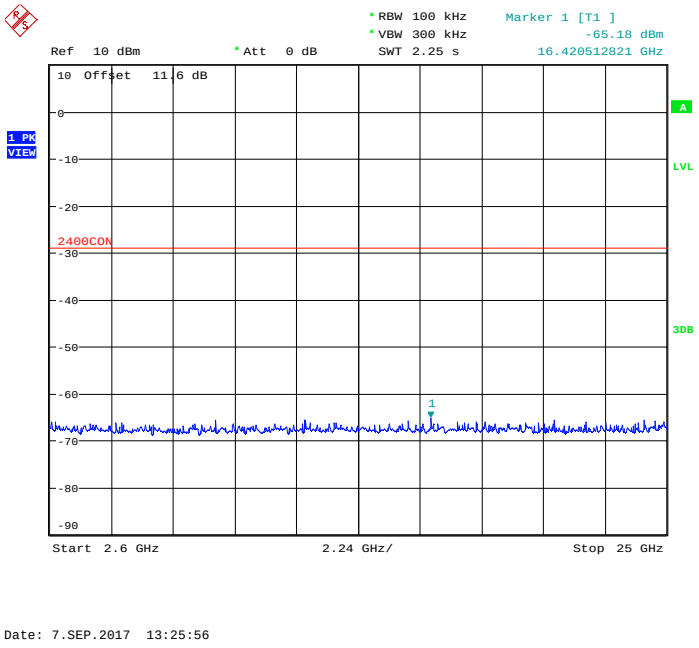
Plot 5.4.4.2.8. Conducted Spurious Emissions in Non-Restricted Frequency Bands, Low Power 2405 MHz, QPSK Modulation, 2.6 GHz – 25 GHz, Peak Detector



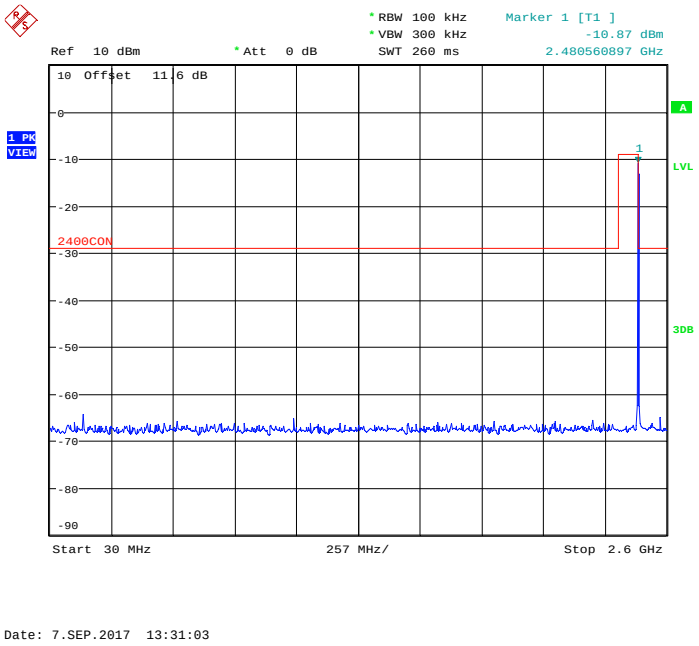
Plot 5.4.4.2.9. Conducted Spurious Emissions in Non-Restricted Frequency Bands, Low Power 2440 MHz, QPSK Modulation, 30 MHz – 2.6 GHz, Peak Detector



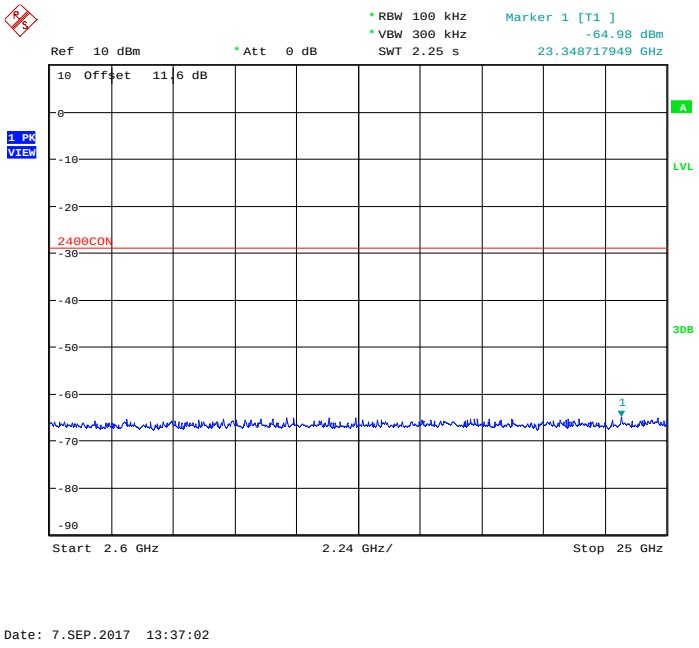
Plot 5.4.4.2.10. Conducted Spurious Emissions in Non-Restricted Frequency Bands, Low Power 2440 MHz, QPSK Modulation, 2.6 GHz – 25 GHz, Peak Detector



Plot 5.4.4.2.11. Conducted Spurious Emissions in Non-Restricted Frequency Bands, Low Power 2480 MHz, QPSK Modulation, 30 MHz – 2.6 GHz, Peak Detector



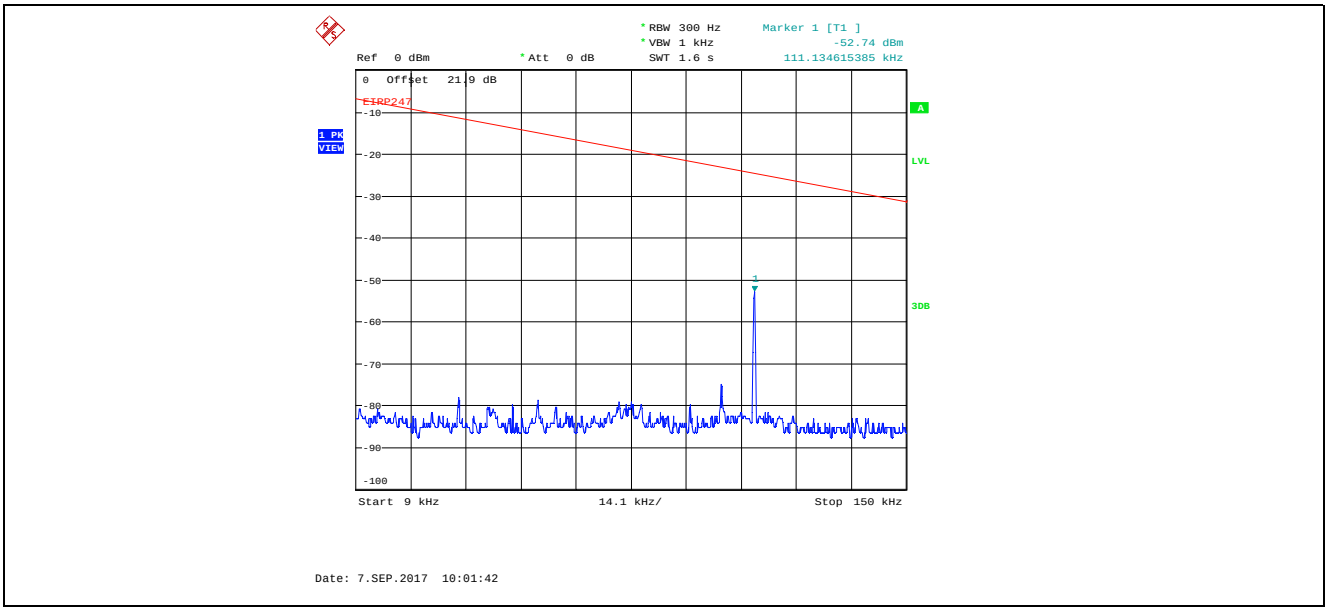
Plot 5.4.4.2.12. Conducted Spurious Emissions in Non-Restricted Frequency Bands, Low Power 2480 MHz, QPSK Modulation, 2.6 GHz – 25 GHz, Peak Detector



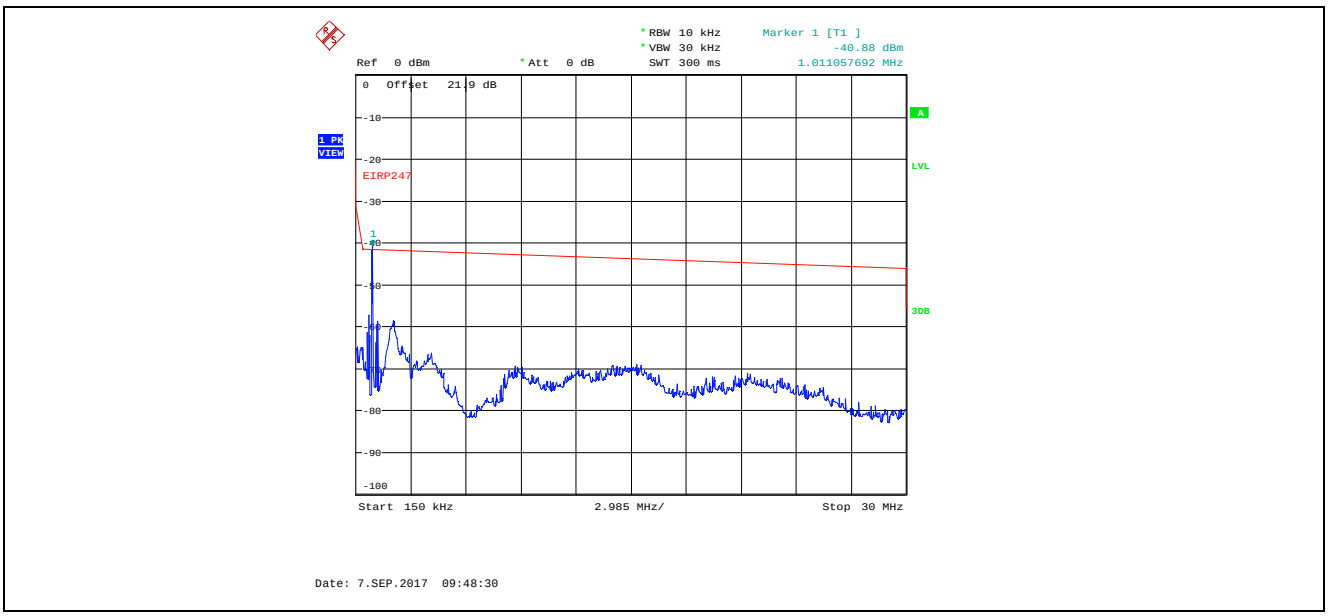
5.4.4.3. Conducted Spurious Emissions in Restricted Frequency Bands with Antenna Assembly Gain of 14.5 dBi)

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

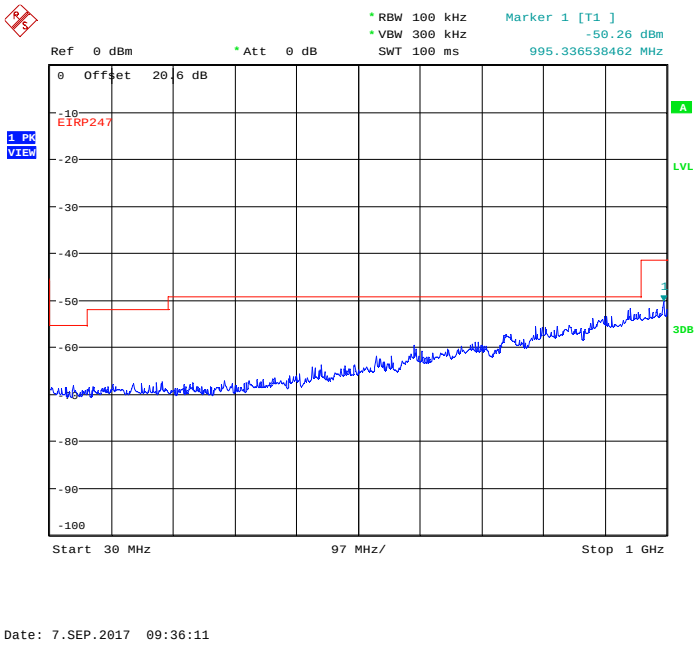
Plot 5.4.4.3.1. Conducted Spurious Emissions in Restricted Frequency Bands, High Power
2405 MHz, QPSK Modulation, 9 kHz - 150 kHz, Peak Detector



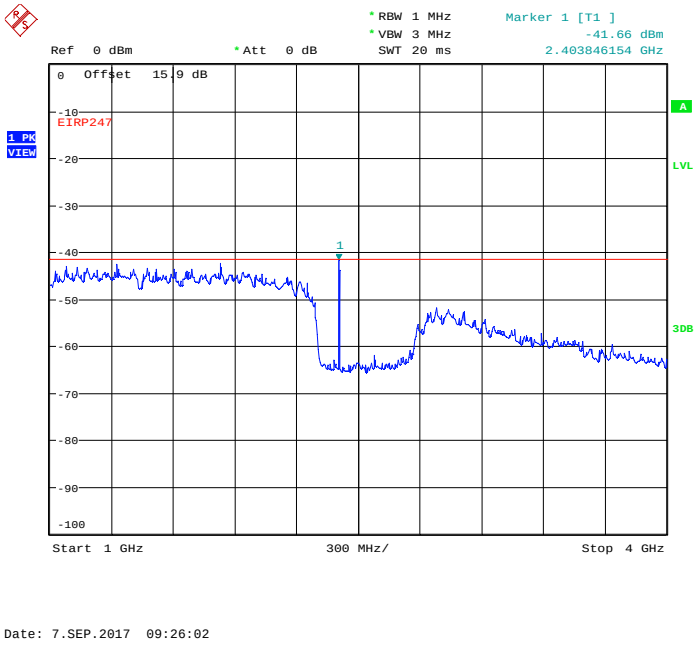
Plot 5.4.4.3.2. Conducted Spurious Emissions in Restricted Frequency Bands, High Power
2405 MHz, QPSK Modulation, 150 kHz - 30 MHz, Peak Detector
Marker 1 is Outside of the Restricted Bands



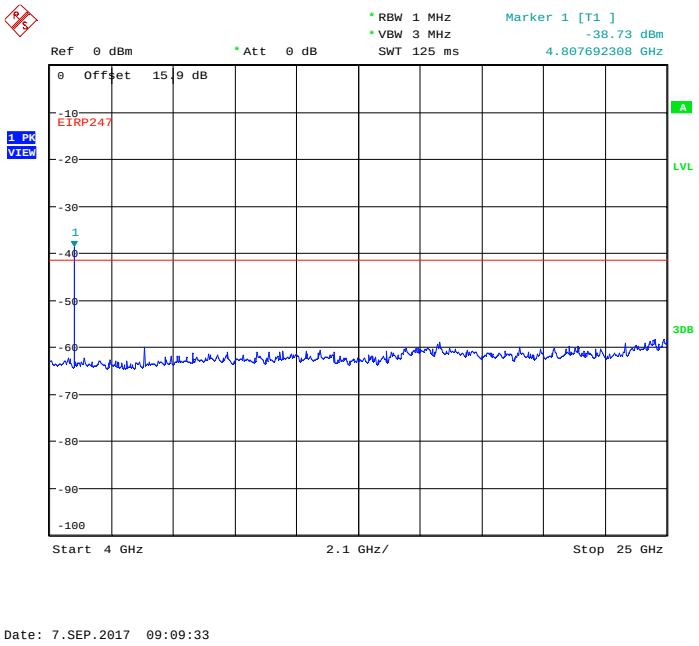
Plot 5.4.4.3.3. Conducted Spurious Emissions in Restricted Frequency Bands, High Power
2405 MHz, QPSK Modulation, 30 MHz - 1 GHz, Peak Detector



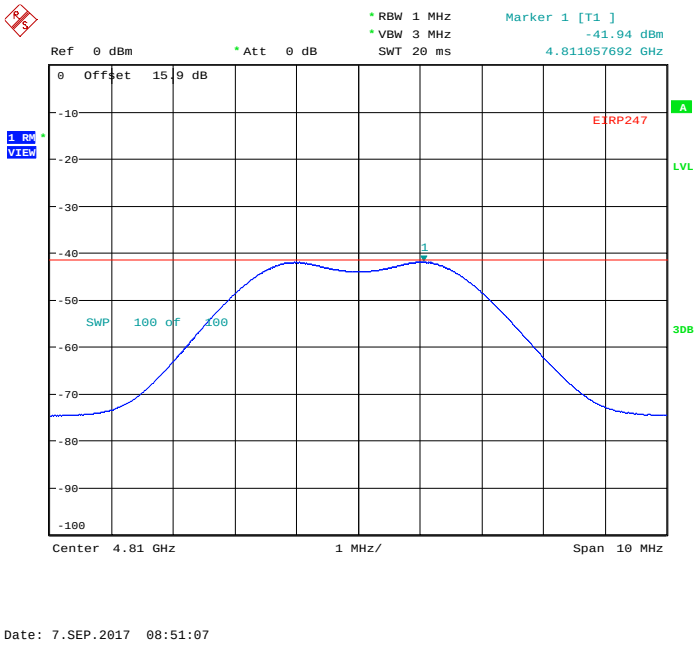
Plot 5.4.4.3.4. Conducted Spurious Emissions in Restricted Frequency Bands, High Power
2405 MHz, QPSK Modulation, 1 GHz - 4 GHz, Peak Detector
Marker 1 is the Fundamental Frequency



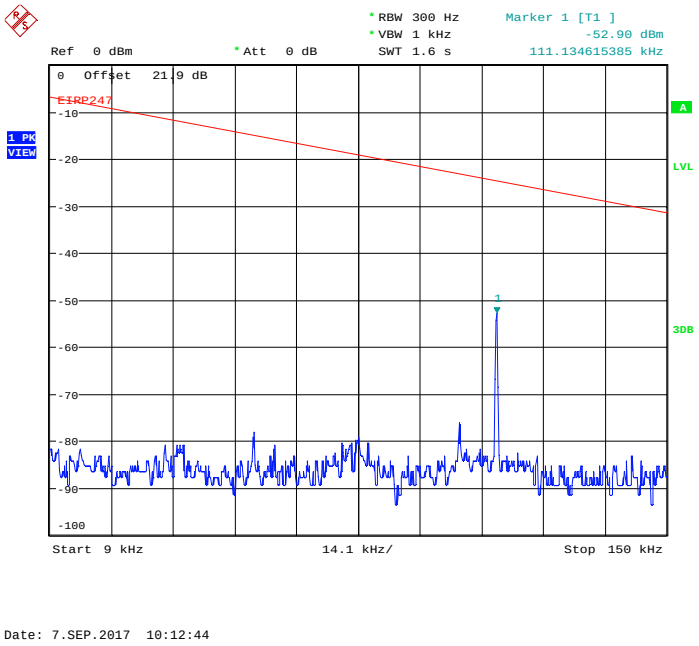
Plot 5.4.4.3.5. Conducted Spurious Emissions in Restricted Frequency Bands, High Power
2405 MHz, QPSK Modulation, 4 GHz - 25 GHz, Peak Detector



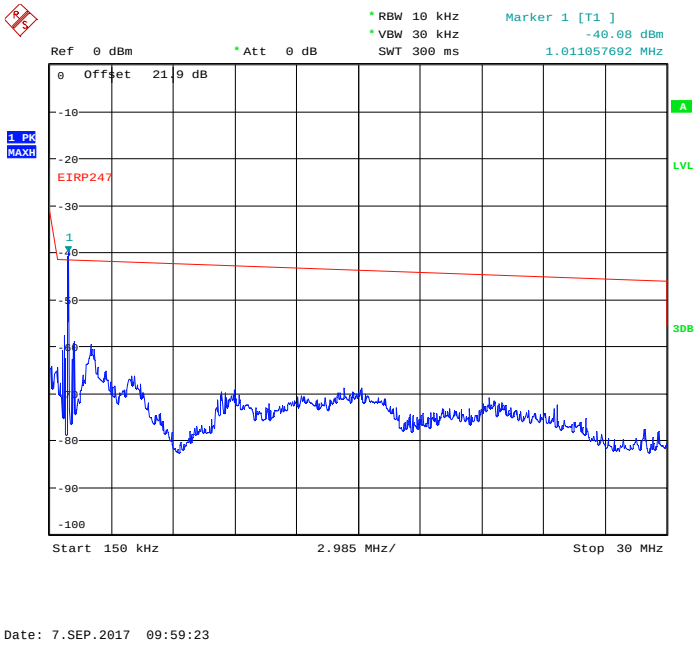
Plot 5.4.4.3.6. Conducted Spurious Emissions in Restricted Frequency Bands, High Power
2405 MHz, QPSK Modulation, Marker 1 (-41.94 dBm < -41.26 dBm Limit), Trace Averaging RMS Detector



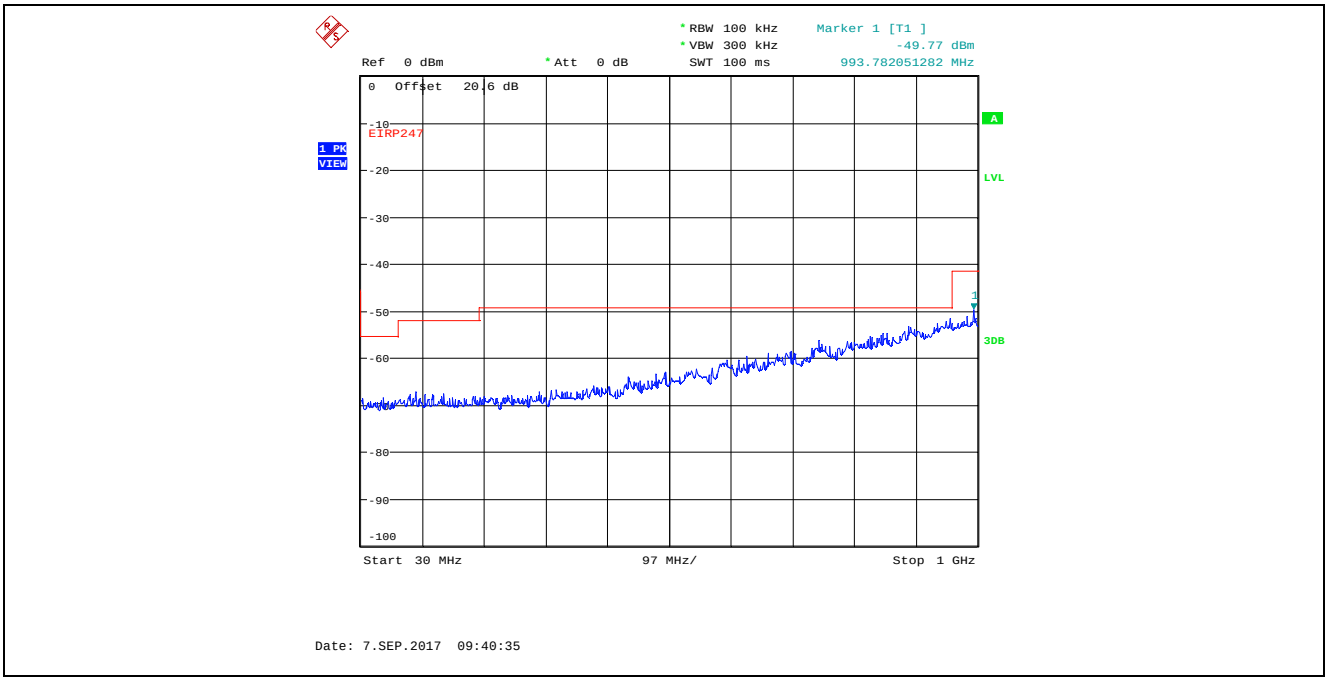
Plot 5.4.4.3.7. Conducted Spurious Emissions in Restricted Frequency Bands, High Power
2440 MHz, QPSK Modulation, 9 kHz - 150 kHz, Peak Detector



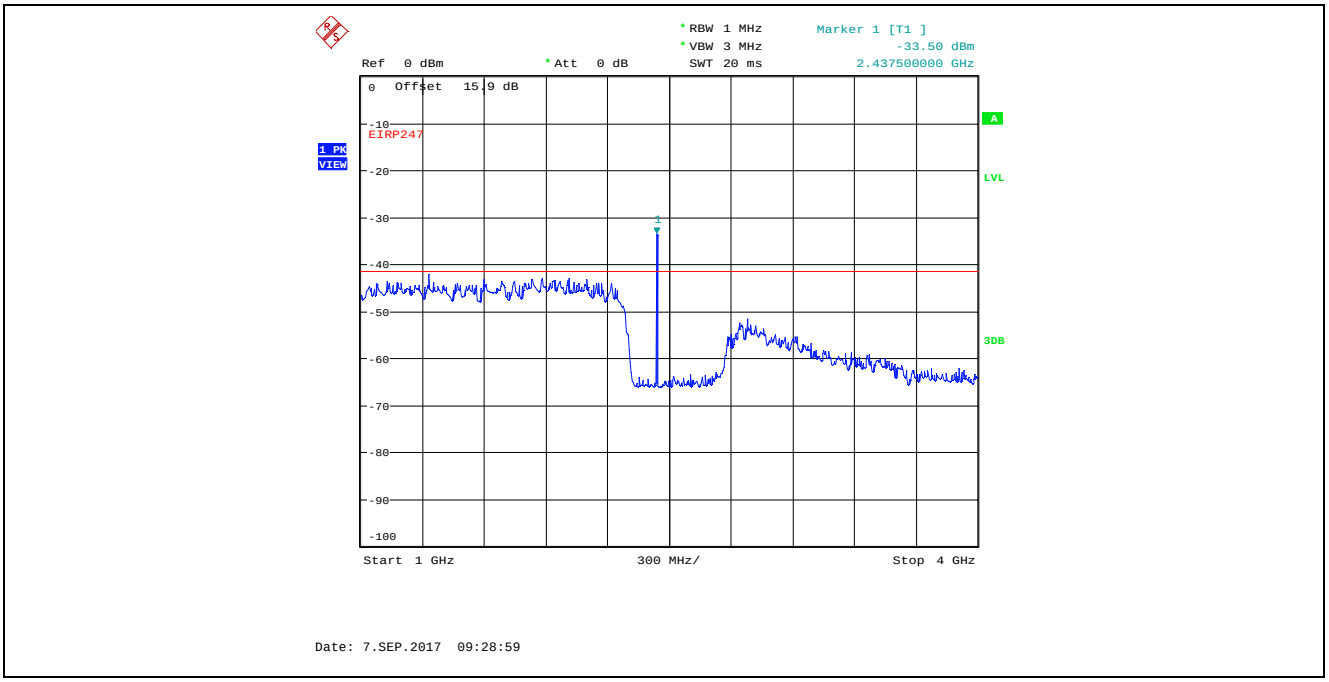
Plot 5.4.4.3.8. Conducted Spurious Emissions in Restricted Frequency Bands, High Power
2440 MHz, QPSK Modulation, 150 kHz - 30 MHz, Peak Detector
Marker 1 is Outside of the Restricted Bands



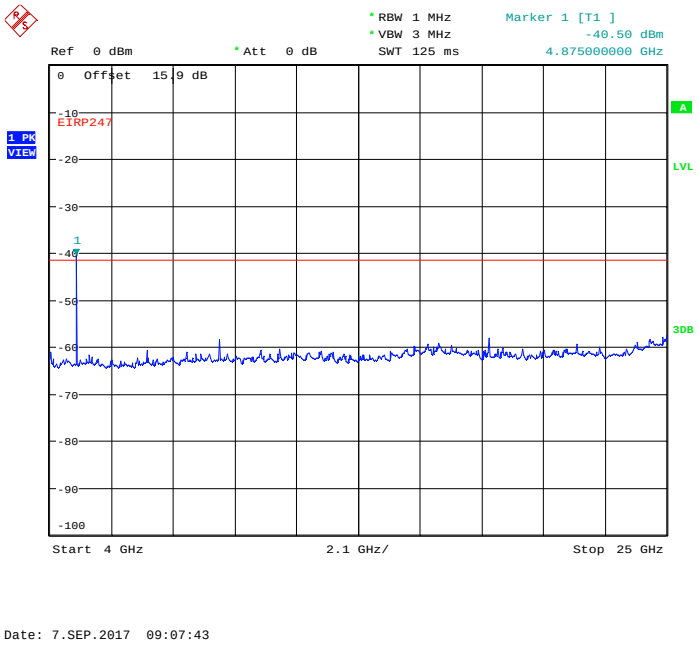
Plot 5.4.4.3.9. Conducted Spurious Emissions in Restricted Frequency Bands, High Power
2440 MHz, QPSK Modulation, 30 MHz - 1 GHz, Peak Detector



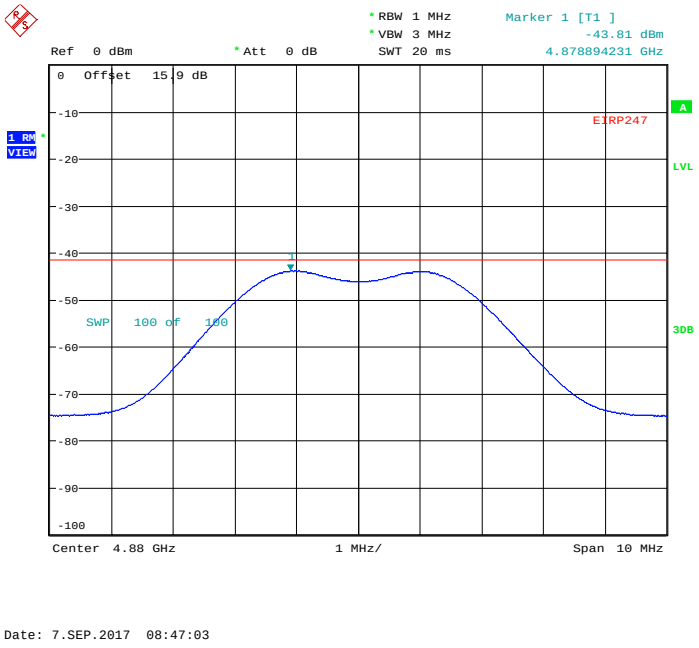
Plot 5.4.4.3.10. Conducted Spurious Emissions in Restricted Frequency Bands, High Power
2440 MHz, QPSK Modulation, 1 GHz - 4 GHz, Peak Detector
Marker 1 is the Fundamental Frequency



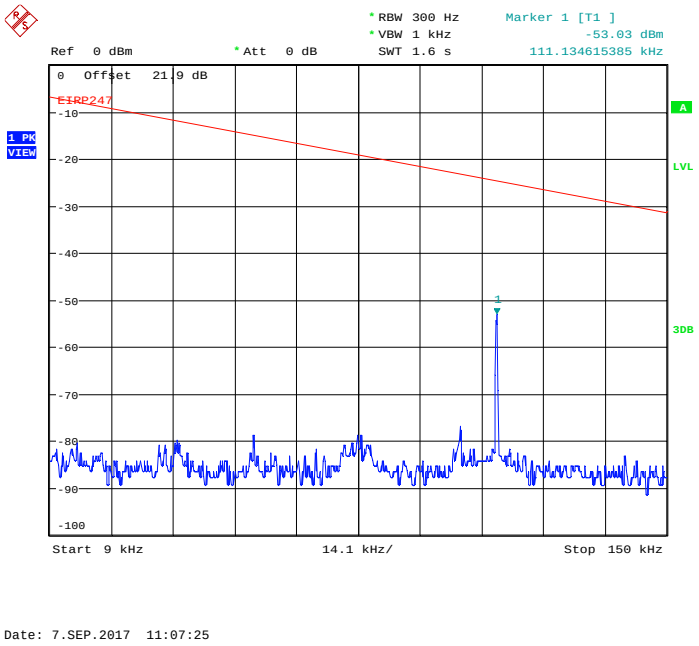
Plot 5.4.4.3.11. Conducted Spurious Emissions in Restricted Frequency Bands, High Power
2440 MHz, QPSK Modulation, 4 GHz - 25 GHz, Peak Detector



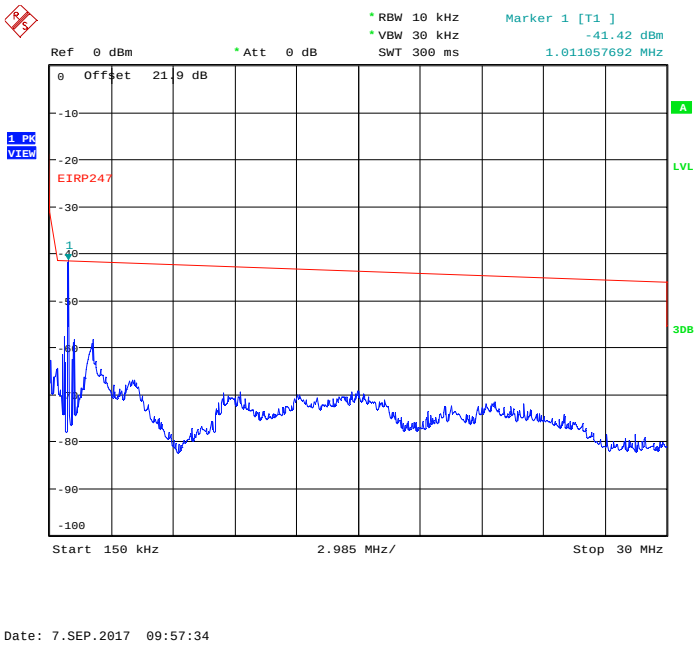
Plot 5.4.4.3.12. Conducted Spurious Emissions in Restricted Frequency Bands, High Power
2440 MHz, QPSK Modulation, Marker 1, Trace Averaging RMS Detector



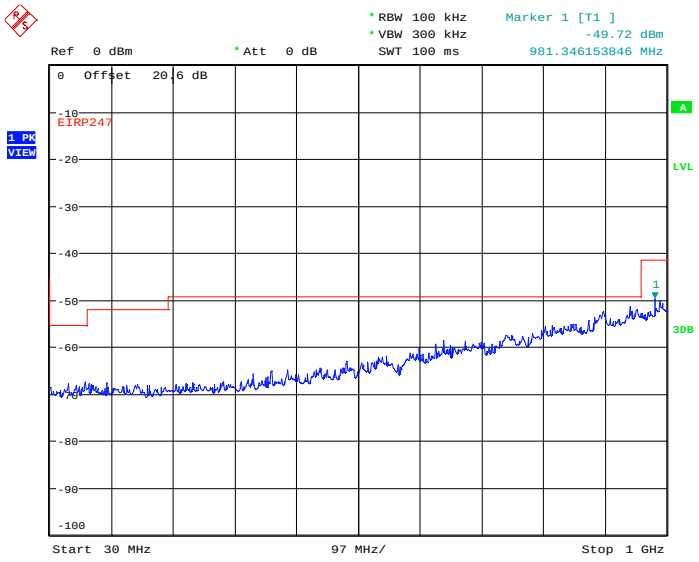
Plot 5.4.4.3.13. Conducted Spurious Emissions in Restricted Frequency Bands, High Power
2480 MHz, QPSK Modulation, 9 kHz - 150 kHz, Peak Detector



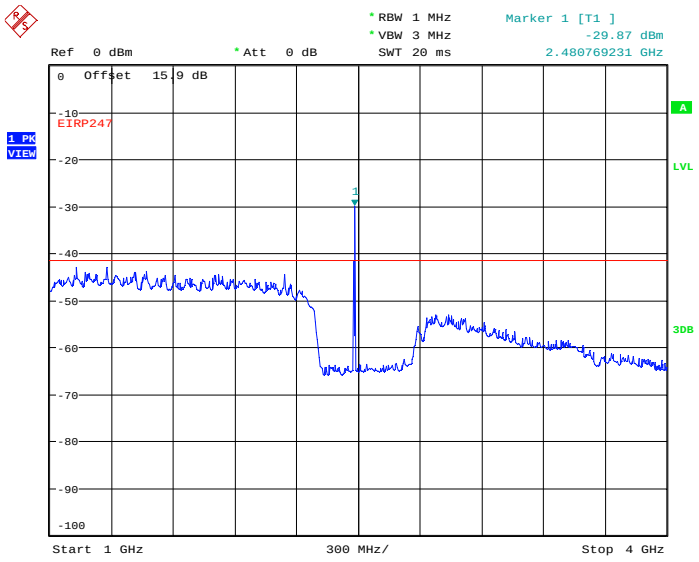
Plot 5.4.4.3.14. Conducted Spurious Emissions in Restricted Frequency Bands, High Power
2480 MHz, QPSK Modulation, 150 kHz - 30 MHz, Peak Detector
Marker 1 is Outside of the Restricted Bands



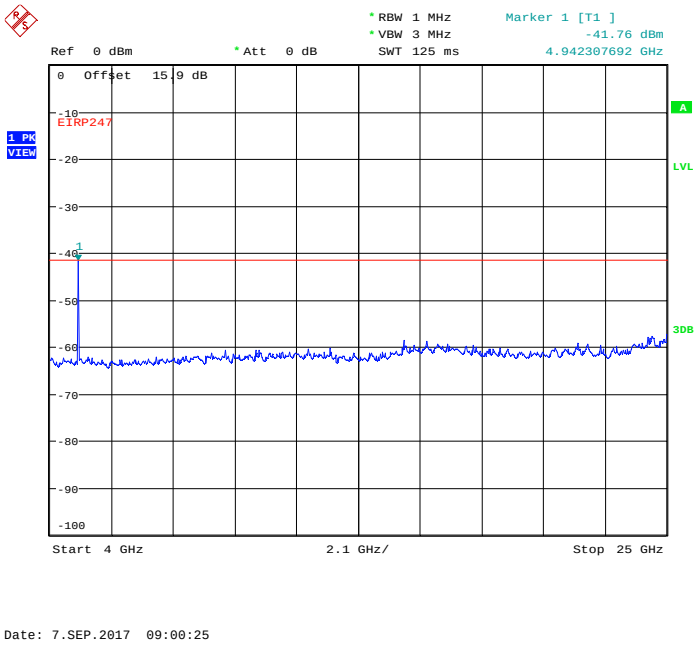
Plot 5.4.4.3.15. Conducted Spurious Emissions in Restricted Frequency Bands, High Power
2480 MHz, QPSK Modulation, 30 MHz - 1 GHz, Peak Detector



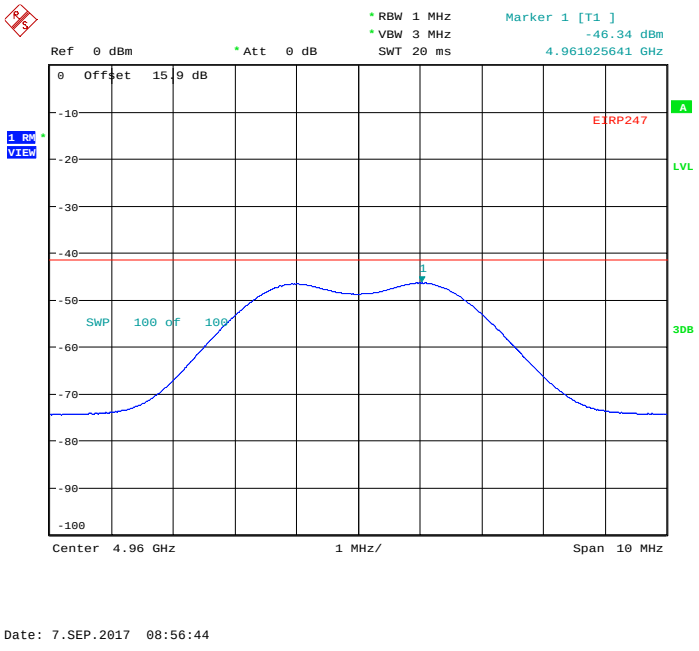
Plot 5.4.4.3.16. Conducted Spurious Emissions in Restricted Frequency Bands, High Power
2480 MHz, QPSK Modulation, 1 GHz - 4 GHz, Peak Detector
Marker 1 is the Fundamental Frequency



Plot 5.4.4.3.17. Conducted Spurious Emissions in Restricted Frequency Bands, High Power
2480 MHz, QPSK Modulation, 4 GHz - 25 GHz, Peak Detector



Plot 5.4.4.3.18. Conducted Spurious Emissions in Restricted Frequency Bands, High Power
2480 MHz, QPSK Modulation, Marker 1, Trace Averaging RMS 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] 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

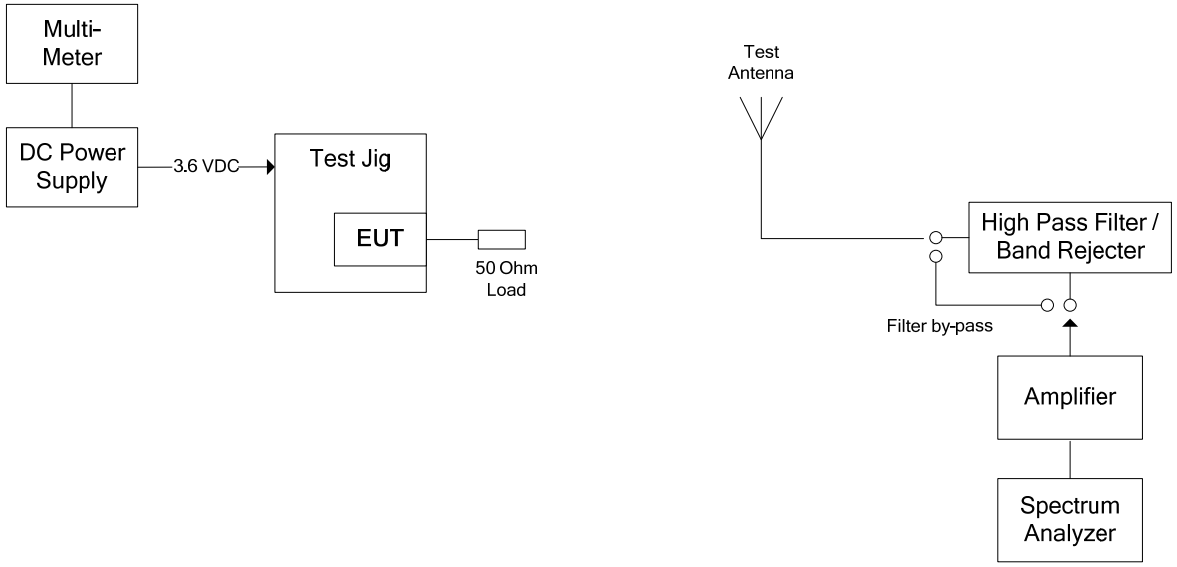
Section 15.209(a) - Field Strength Limits within Restricted Frequency Bands

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

KDB 558074 D01 DTS Meas Guidance v04 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 = (EIRP - 20log(d) + 104.8) – 20 =(33.95 dBm – 20log(3) + 104.8) – 20 = 109.2 dBµV/m
- 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						
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**
4810	52.80	42.07	V	54.0	109.2	-11.9	Pass*
4810	51.58	40.45	H	54.0	109.2	-13.6	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.

Fundamental Frequency:	2440 MHz						
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**
4880	50.82	39.25	V	54.0	109.2	-14.8	Pass*
4880	52.84	41.75	H	54.0	109.2	-12.3	Pass*
7320	50.84	38.66	V	54.0	109.2	-15.3	Pass*
7320	50.35	38.07	H	54.0	109.2	-15.9	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						
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**
4960	51.14	39.62	V	54.0	109.2	-14.4	Pass*
4960	52.69	41.27	H	54.0	109.2	-12.7	Pass*
7440	52.77	40.19	V	54.0	109.2	-13.8	Pass*
7440	53.55	41.43	H	54.0	109.2	-12.6	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)]

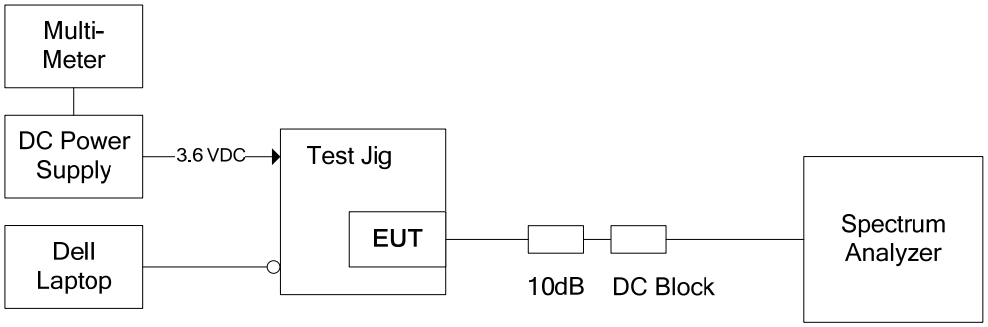
5.6.1. Limit(s)

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 V04, Section 10.2 Method PKPSD (peak PSD)

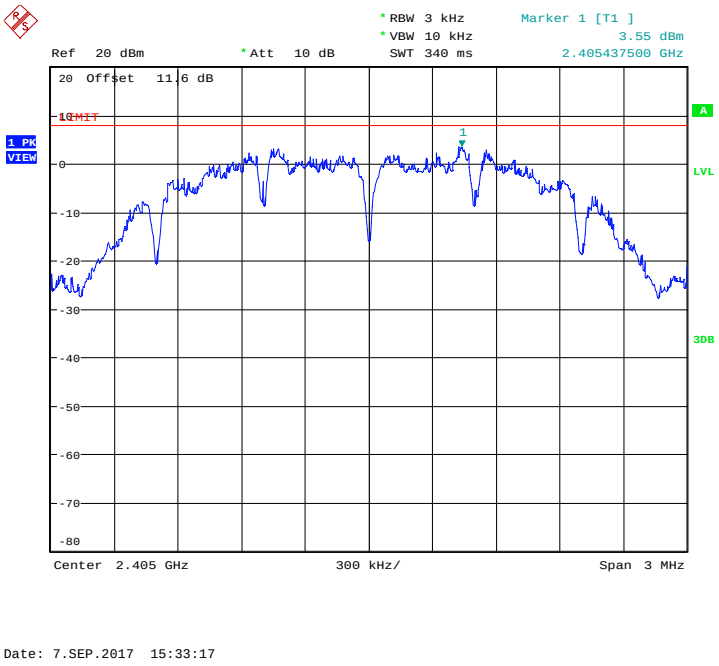
5.6.3. Test Arrangement



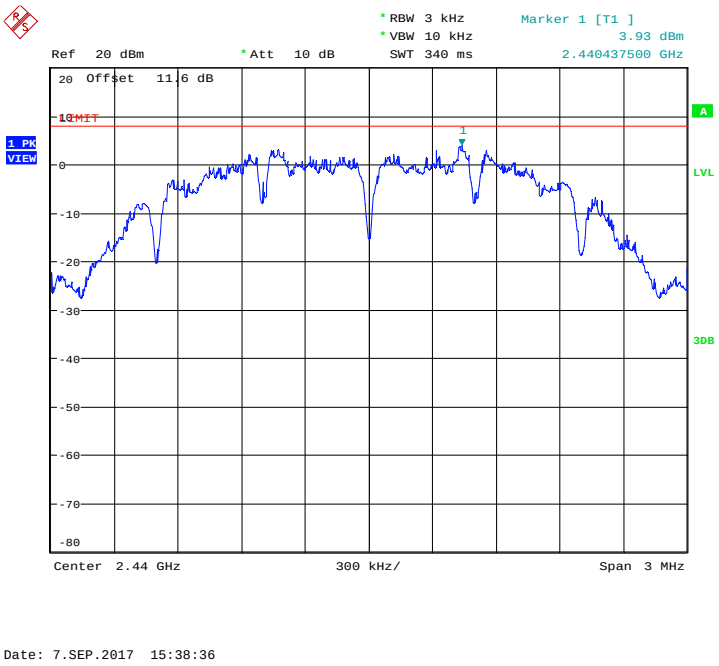
5.6.4. Test Data

Modulation	Power Setting	Channel	Frequency (MHz)	PSD (dBm)	Max. Limit (dBm)	Margin (dBm)
QPSK	High Power (20)	11	2405	3.55	8	-4.45
		18	2440	3.93	8	-4.07
		26	2480	3.98	8	-4.02

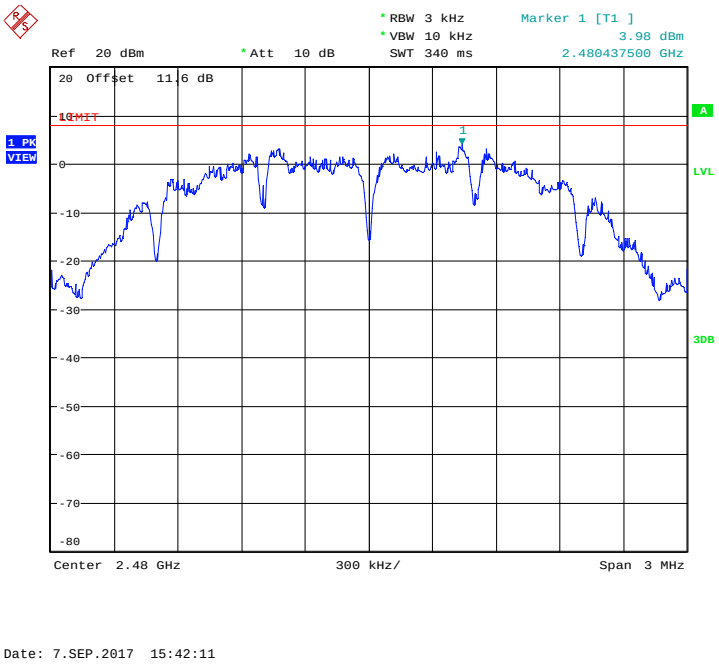
Plot 5.6.4.1. Power Spectral Density, QPSK Modulation, High Power, Channel 11, 2405 MHz



Plot 5.6.4.2. Power Spectral Density, QPSK Modulation, High Power, Channel 18, 2440 MHz



Plot 5.6.4.3. Power Spectral Density, QPSK Modulation, High Power, Channel 26, 2480 MHz



5.7. RF EXPOSURE REQUIRMENTS [§§ 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/cm^2
G: numeric gain of antenna relative to isotropic radiator
r: distance to centre of radiation in cm

5.7.3. RF Evaluation

Frequency (MHz)	EIRP (dBm)	EIRP (mW)	Evaluation Distance, r (cm)	Power Density, S (mW/cm^2)	MPE Limit (mW/cm^2)	Margin (mW/cm^2)
2405	33.95	2483.13	20	0.4940	1.0	-0.5060

EXHIBIT 6. TEST EQUIPMENT LIST

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range	Cal. Due Date
Spectrum Analyzer	Hewlett Packard	HP 8593EM	3710A00223	9 kHz – 22 GHz	04 Oct 2017
Attenuator	Pasternack	PE7010-20	09	DC – 2 GHz	13 Mar 2018
LISN Used	EMCO	3825/2	1531	10 kHz – 100 MHz	11 Nov 2017
DC Power Supply	Xantrex	HPD 60-5SX	63903	0 – 60 VDC	See Note 1
Spectrum Analyzer	Rohde & Schwarz	FSU26	200946	20 Hz - 26.5 GHz	21 Jul 2018
Attenuator	Hewlett Packard	8493C	0465	DC - 18 GHz	See Note 1
DC Block	Hewlett Packard	11742A	12460	0.045 – 26.5 GHz	See Note 1
Multi-meter	Fluke	8842A	4142058	20 mV – 1 kV	13 Sep 2018
Laptop	Dell	PP011	1F922A02	--	--
High Pass Filter	K & L	11SH10-4000/T12000	4	Cut off 2.4 GHz	See Note 1
Band Reject Filter	Micro-Tronics	BRM50701	105	Cut off 2.4 - 2.483 GHz	See Note 1
EMI Receiver	Rohde & Schwarz	ESU40	100037	20 Hz – 40 GHz	09 May 2018
RF Amplifier	Com-Power	PAM-0118A	551052	0.5 – 18 GHz	17 Jul 2018
RF Amplifier	Hewlett Packard	84498	3008A00769	1 – 26.5 GHz	01 May 2018
Biconilog	EMCO	3142	9601-1005	26 - 1000 MHz	12 May 2018
Horn Antenna	EMCO	3155	6570	1 – 18 GHz	13 Oct 2018
Horn Antenna	ETS-Lindgren	3160-09	001183858	18 – 26.5 GHz	11 Oct 2018
Note 1: Internal Verification/Calibration check					

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**