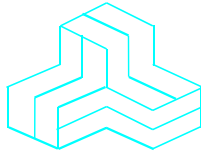


ENGINEERING TEST REPORT



QT-5000 Module
Model: QT-5000
FCC ID: Q5N-QT5000

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) Operating in 2400 – 2483.5 MHz Band

UltraTech's File No.: 15Q5X044_FCC15C247

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

Date: September 28, 2015

Report Prepared by: Dharmajit Solanki

Tested by: Hung Trinh

Issued Date: September 28, 2015

Test Dates: September 17 - 25, 2015

- *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

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91038



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NVLAP LAB
CODE 200093-0



AT-1945



SL2-IN-E-
1119R



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KCC-RRR
CA2049



TL363_B



TPTDP
DA1300

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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) Transmitter Operating in the Frequency Band 2400-2483.5 MHz.
Test Procedures:	<ul style="list-style-type: none">ANSI C63.4ANSI C63.10FCC KDB Publication No. 558074 D01 DTS Meas Guidance v03r03
Environmental Classification:	<input checked="" type="checkbox"/> Commercial, industrial or business environment <input checked="" type="checkbox"/> Residential environment

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

None

1.3. NORMATIVE REFERENCES

Publication	Year	Title
47 CFR Parts 0-19	2015	Code of Federal Regulations (CFR), Title 47 – Telecommunication
ANSI C63.4	2009 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	2009	American National Standard for Testing Unlicensed Wireless Devices
CISPR 22 & EN 55022	2008-9,Ed 6 2006	Information Technology Equipment - Radio Disturbance Characteristics - Limits and Methods of Measurement
FCC, KDB Publication No. 558074 D01 DTS Meas Guidance v03r03	2015	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1. CLIENT INFORMATION

APPLICANT	
Name:	Quantum5X Systems Inc.
Address:	30 Adelaide Street North, Suite 12 London, Ontario Canada, N6B 3N5
Contact Person:	Mr. Paul Johnson Phone #: 519-675-6999 Fax #: 519-667-2162 Email Address: paul@q5x.com

MANUFACTURER	
Name:	Quantum5X Systems Inc.
Address:	30 Adelaide Street North, Suite 12 London, Ontario Canada, N6B 3N5
Contact Person:	Mr. Paul Johnson Phone #: 519-675-6999 Fax #: 519-667-2162 Email Address: paul@q5x.com

2.2. EQUIPMENT UNDER TEST (EUT) INFORMATION

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

Brand Name:	Quantum5X Systems Inc.
Product Name:	QT-5000 Module
Model Name or Number:	QT-5000
Serial Number:	Test Sample
Type of Equipment:	Digital Transmission System (DTS)
Input Power Supply Type:	3.7V Rechargeable Internal Non-removable Battery
Primary User Functions of EUT:	Wireless Audio Microphone transmitter

2.3. EUT'S TECHNICAL SPECIFICATIONS

Transmitter	
Equipment Type:	<ul style="list-style-type: none">• Mobile• Base Station (fixed use)
Intended Operating Environment:	<ul style="list-style-type: none">▪ Commercial, Industrial or Business environment▪ Residential environment
Power Supply Requirement:	3.7V Rechargeable Internal Battery
RF Output Power Rating:	0.0007 W
Operating Frequency Range:	2405 - 2480 MHz
Channel Spacing:	5 MHz
RF Output Impedance:	50 Ω
Modulation Type:	802.15.4 Compliant OQPSK, 250 kbps
Antenna Connector Types:	Integral, Permanently soldered to PCB
Antenna Type:	¼ Wave Wire antenna, Max Gain: 3.0dBi, Freq Range: 2405-2480 MHz

2.4. LIST OF EUT'S PORTS

Port Number	EUT's Port Description	Number of Identical Ports	Connector Type	Cable Type (Shielded/Non-shielded)
1	Battery charging port	1	Micro USB	Non-shielded

2.5. 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:	Q5X Remote Gateway
Brand name:	Quantum5X Systems Inc.
Model Name or Number:	QG-N2
Connected to EUT's Port:	Wireless

Ancillary Equipment # 2	
Description:	Laptop Computer
Brand name:	Acer
Connected to EUT's Port:	Q5X Remote Gateway

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File #: 15Q5X044_FCC15C247
September 28, 2015

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EXHIBIT 3. EUT OPERATING CONDITIONS AND CONFIGURATIONS DURING TESTS

3.1. CLIMATE TEST CONDITIONS

The climate conditions of the test environment are as follows:

Temperature:	21 to 23 °C
Humidity:	45 to 58%
Pressure:	102 kPa
Power Input Source:	3.7 V Rechargeable Battery

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:	Special 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:	Remote Gateway to control the EUT
Transmitter Test Antenna:	The EUT 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:	2405 MHz, 2440 MHz, 2480 MHz
RF Power Output: (measured maximum output power at antenna terminals)	-1.81 dBm (0.66 mW) Peak
Normal Test Modulation:	OQPSK, 250 kbps
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 FCC office (FCC File No.: 91038) and Industry Canada office (Industry Canada File No.: 2049A-3). Expiry Date: 2017-04-02.

4.2. APPLICABILITY & SUMMARY OF EMC EMISSION TEST RESULTS

FCC Section(s)	Test Requirements	Compliance (Yes/No)
15.203	Antenna requirements	Yes
15.207(a)	AC Power Line Conducted Emissions	Yes
15.247(a)(2)	6 dB Bandwidth	Yes
15.247(b)(3)	Peak Conducted Output Power - DTS	Yes
15.247(d)	Band-Edge and RF Conducted Spurious Emissions at the Transmitter Antenna Terminal	Yes
15.247(d), 15.209 & 15.205	Transmitter Spurious Radiated Emissions	Yes
15.247(e)	Power Spectral Density	Yes
15.247(i), 1.1307, 1.1310, 2.1091, 2.1093	RF Exposure	Yes

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:

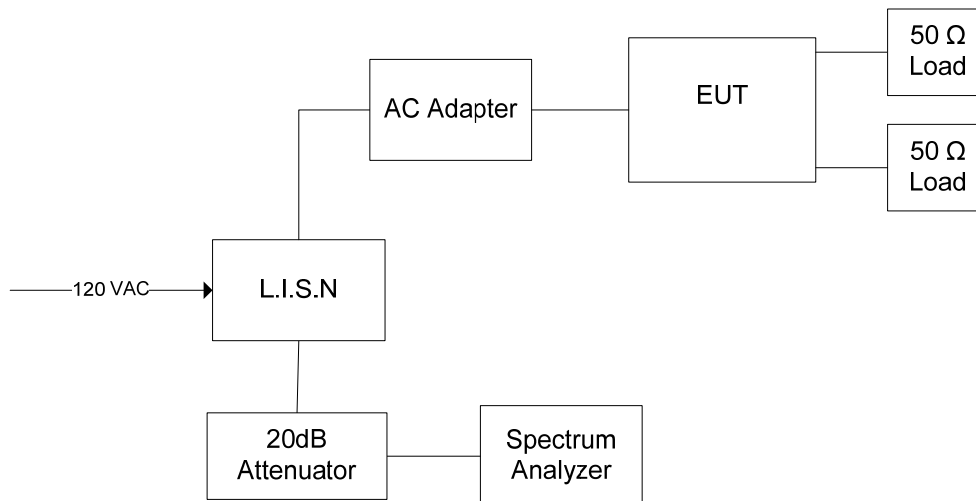
Frequency of emission (MHz)	Conducted Limits (dB μ V)	
	Quasi-peak	Average
0.15–0.5	66 to 56*	56 to 46*
0.5–5	56	46
5–30	60	50

*Decreases linearly with the logarithm of the frequency

5.1.2. Method of Measurements

ANSI C63.4-2009

5.1.3. Test Arrangement

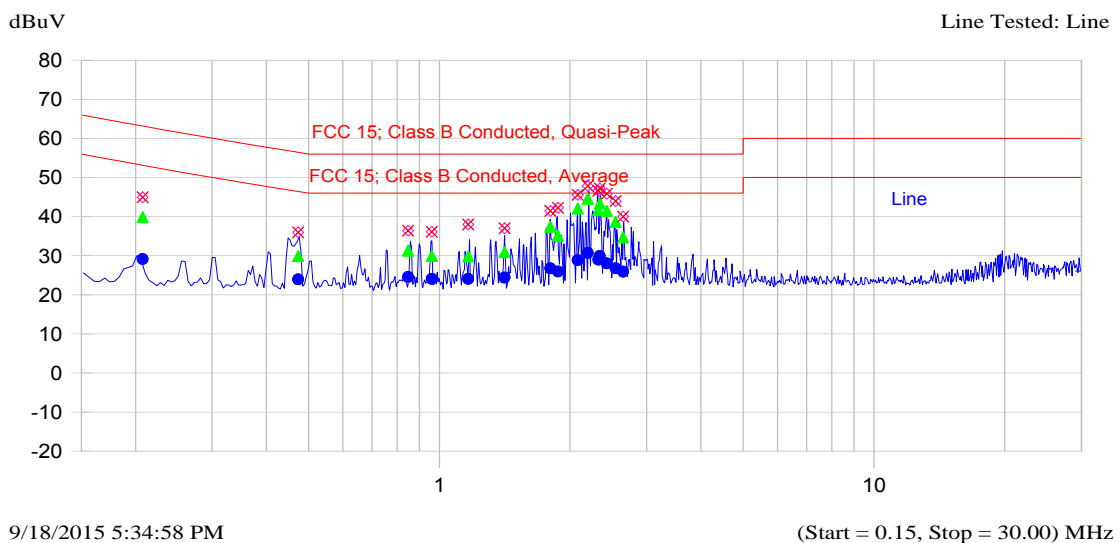


5.1.4. Test Data

Plot 5.1.4.1. Power Line Conducted Emissions; Line Voltage: 120 VAC; Line Tested: Hot

Description: AC 120V. Charge Mode.
 Setup Name: FCC 15 Class B
 Customer Name: Quantum 5X System INC.
 Project Number: Q5X-044Q
 Operator Name: Wei
 EUT Name: QT-5000
 Date Created: 9/18/2015 5:22:40 PM

Current Graph



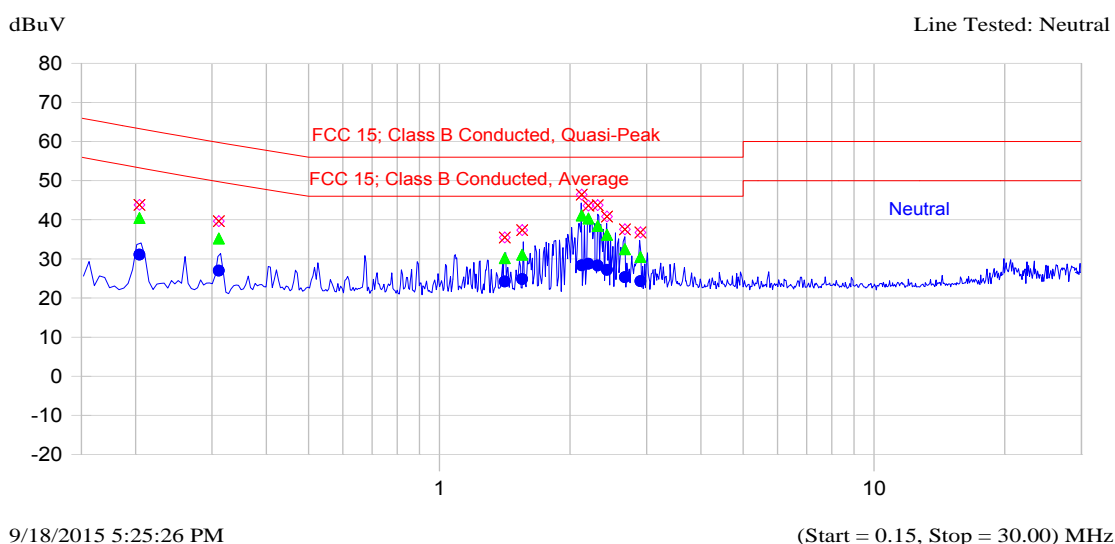
Current List

Frequency MHz	Peak dBuV	QP dBuV	Delta QP-QP Limit dB	Avg dBuV	Delta Avg-Avg Limit dB	Trace Name
0.208	44.9	39.9	-23.4	29.1	-24.2	Line
0.473	35.9	29.9	-26.6	23.9	-22.5	Line
0.847	36.4	31.3	-24.7	24.6	-21.4	Line
0.960	36.1	29.9	-26.1	24.1	-21.9	Line
1.166	37.9	29.8	-26.2	24.1	-21.9	Line
1.412	37.0	30.9	-25.1	24.4	-21.6	Line
1.801	41.4	37.4	-18.6	26.7	-19.3	Line
1.876	42.2	35.1	-20.9	25.9	-20.1	Line
2.083	45.5	42.0	-14.0	28.8	-17.2	Line
2.195	47.8	44.5	-11.5	30.7	-15.3	Line
2.323	46.6	41.7	-14.3	29.0	-17.0	Line
2.339	47.2	43.3	-12.7	29.9	-16.1	Line
2.429	45.8	41.5	-14.5	28.0	-18.0	Line
2.545	43.9	38.7	-17.3	26.7	-19.3	Line
2.646	40.0	34.7	-21.3	25.9	-20.1	Line

Plot 5.1.4.2. Power Line Conducted Emissions; Line Voltage 120 VAC; Line Tested: Neutral

Description: AC 120V. Charge Mode.
 Setup Name: FCC 15 Class B
 Customer Name: Quantum 5X System INC.
 Project Number: Q5X-044Q
 Operator Name: Wei
 EUT Name: QT-5000
 Date Created: 9/18/2015 5:22:40 PM

Current Graph



Current List

Frequency MHz	Peak dBuV	QP dBuV	Delta QP-QP Limit dB	Avg dBuV	Delta Avg-Avg Limit dB	Trace Name
0.204	43.8	40.4	-23.0	31.1	-22.4	Neutral
0.311	39.6	35.2	-24.7	27.0	-23.0	Neutral
1.415	35.5	30.2	-25.8	24.2	-21.8	Neutral
1.552	37.3	31.1	-24.9	24.8	-21.2	Neutral
2.125	46.4	41.1	-14.9	28.3	-17.7	Neutral
2.204	43.6	40.3	-15.7	28.8	-17.2	Neutral
2.315	43.7	38.4	-17.6	28.3	-17.7	Neutral
2.430	40.8	36.1	-19.9	27.2	-18.8	Neutral
2.672	37.5	32.4	-23.6	25.3	-20.7	Neutral
2.900	36.8	30.4	-25.6	24.3	-21.7	Neutral

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

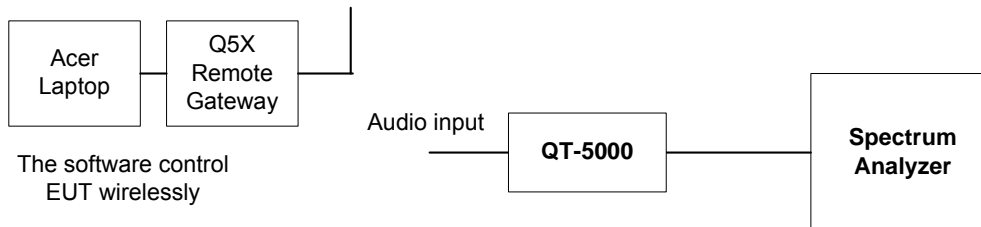
5.2.1. Limit(s)

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 V03r03, Section 8.1 Option 1

5.2.3. Test Arrangement

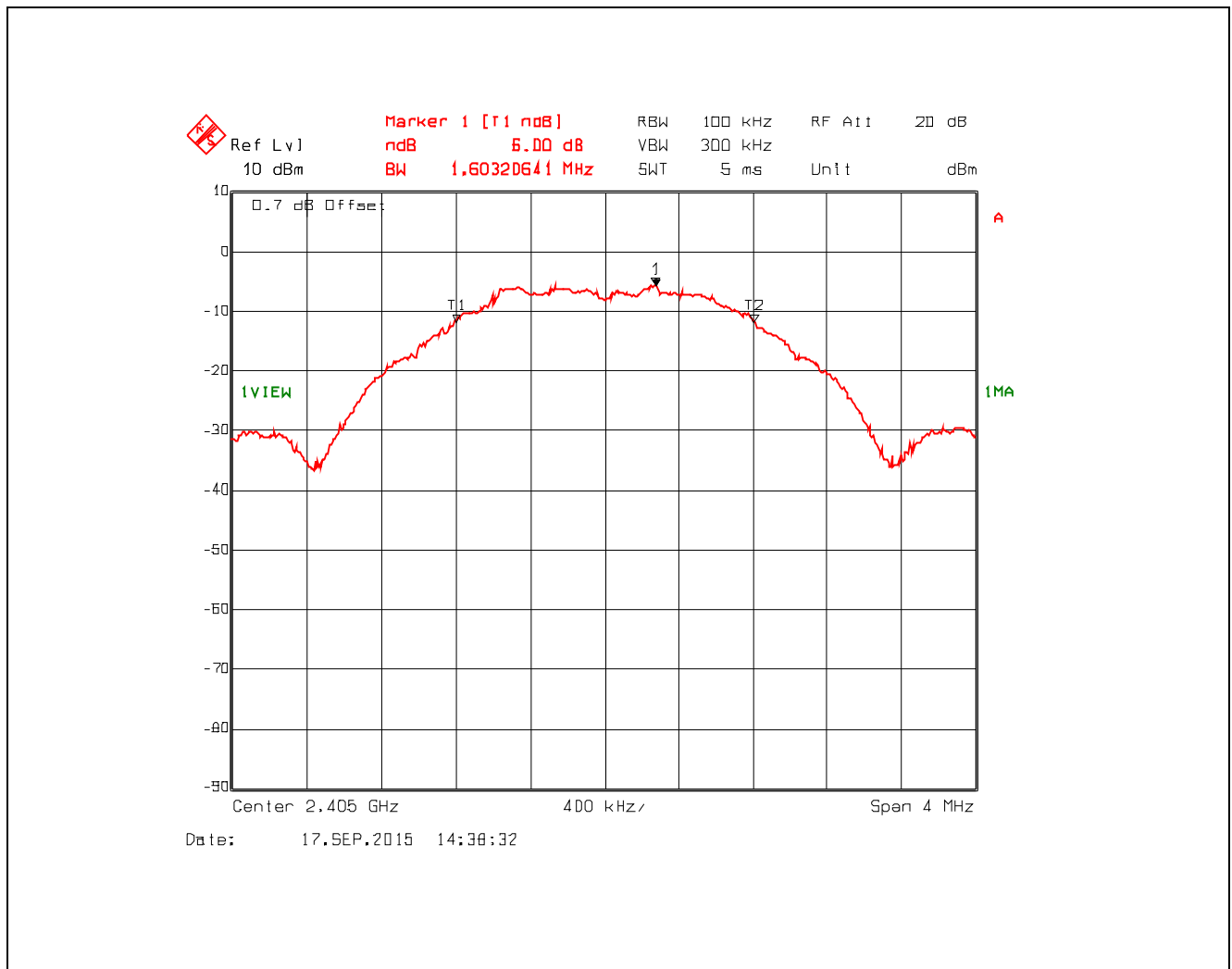


5.2.4. Test Data

Frequency (MHz)	Modulation	Data Rate (Mbps)	Channel Number	6dB BW (kHz)	Min Limit (kHz)
2405	OQPSK	250	1	1600	500
2440	OQPSK	250	8	1610	500
2480	OQPSK	250	16	1600	500

See the following plots for detailed measurements.

Plot 5.2.4.1. 6 dB Bandwidth, Ch 1, 2405 MHz, OQPSK 250 kbps, Power Setting 100%



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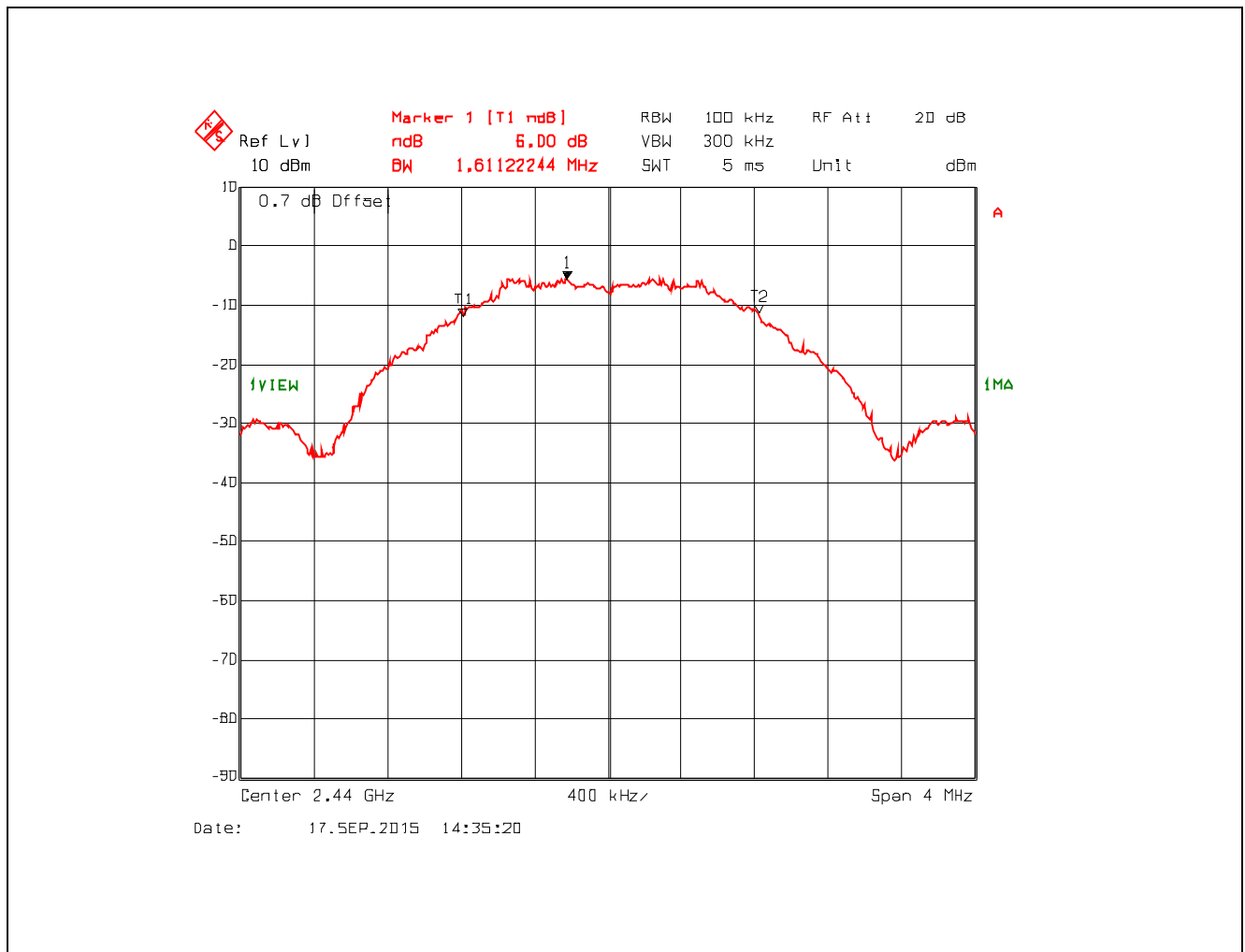
Tel. #: 905-829-1570, Fax. #: 905-829-8050, Email: yic@ultratech-labs.com, Website: <http://www.ultratech-labs.com>

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Plot 5.2.4.2. 6 dB Bandwidth, Ch 8, 2440 MHz, OQPSK 250 kbps, Power Setting 100%



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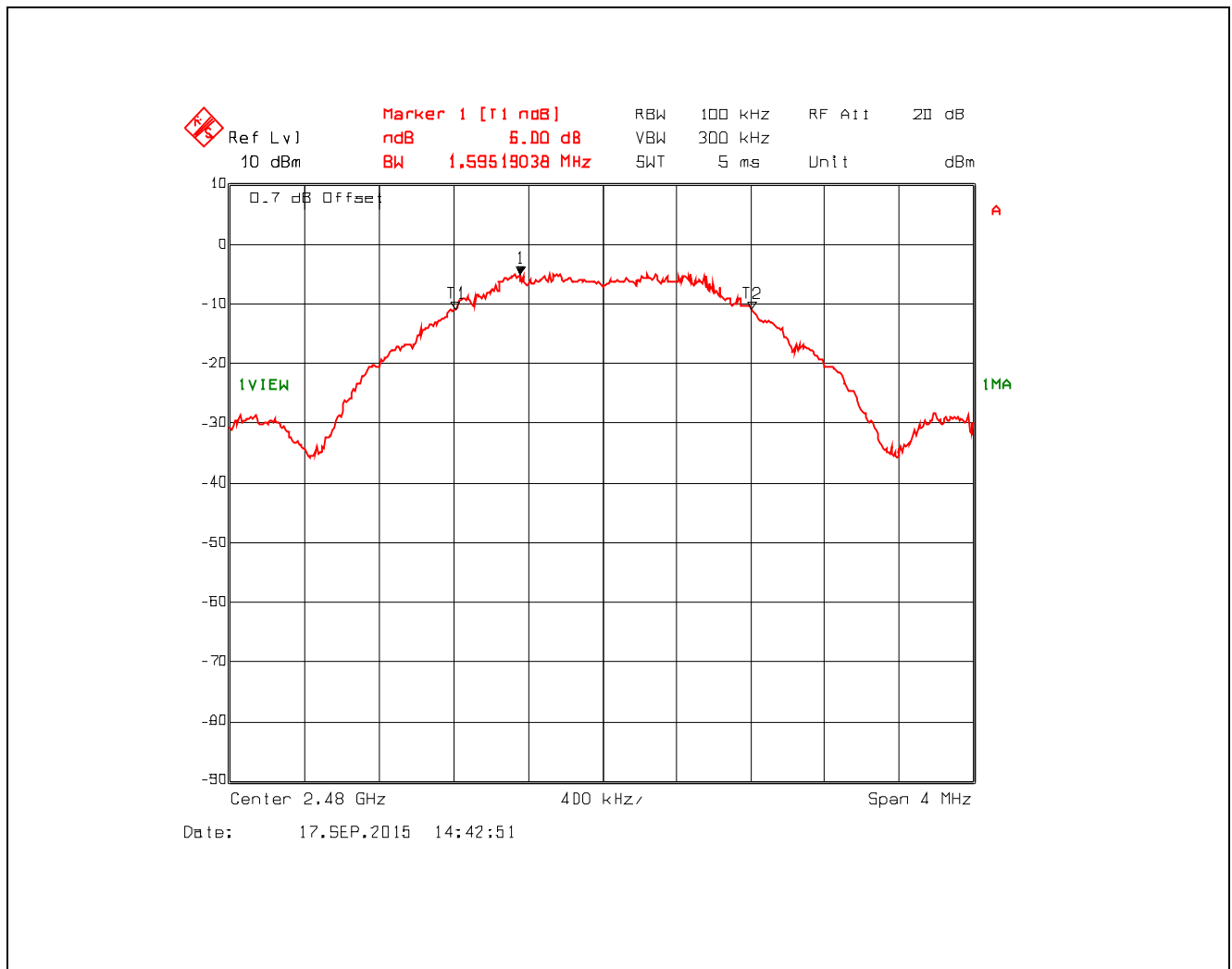
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Plot 5.2.4.3. 6 dB Bandwidth, Ch 16, 2480 MHz, OQPSK 250 kbps, Power Setting 100%



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

5.3.1. Limit(s)

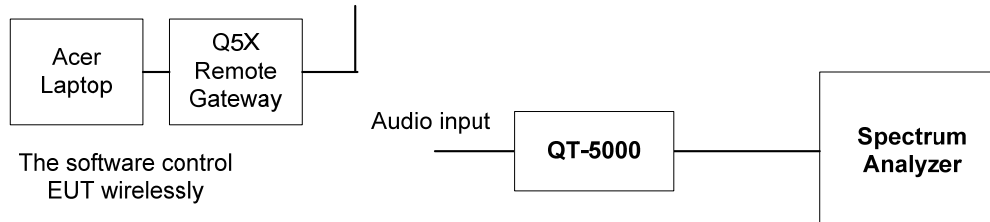
§ 15.247(b)(3): For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power 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 Publication No. 558074 D01 DTS Meas Guidance V03r03, Section 9.1.1 RBW \geq DTS Bandwidth Method.

5.3.3. Test Arrangement



5.3.4. Test Data

Frequency (MHz)	Modulation	Data Rate (Mbps)	Channel Number	Power Setting %	Peak Power (dBm)	Peak Power (mW)	EIRP (dBm)	Peak Power Limit (dBm)
2405	OQPSK	250	1	100	-2.70	0.54	0.30	30.0
2440	OQPSK	250	8	100	-2.18	0.61	0.82	30.0
2480	OQPSK	250	16	100	-1.81	0.66	1.19	30.0

*EIRP Calculation: Antenna gain = 3.0 dBi

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

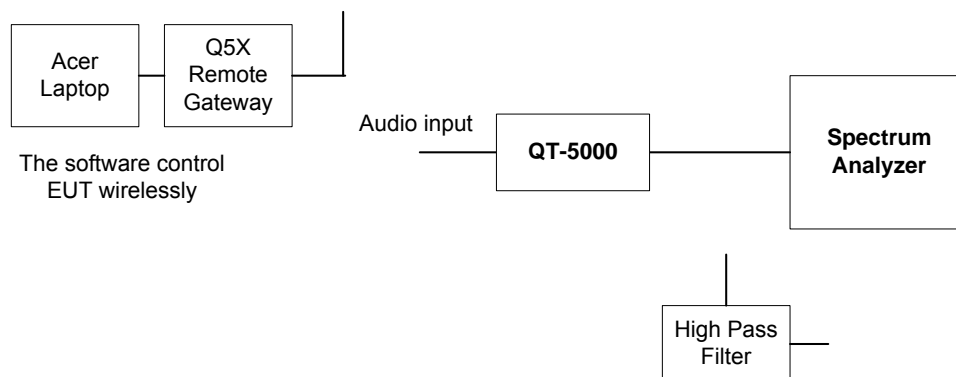
5.4.1. Limit(s)

§ 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 Publication No. 558074 D01 DTS Meas Guidance V03r03, Sections 11, 12 and 13.

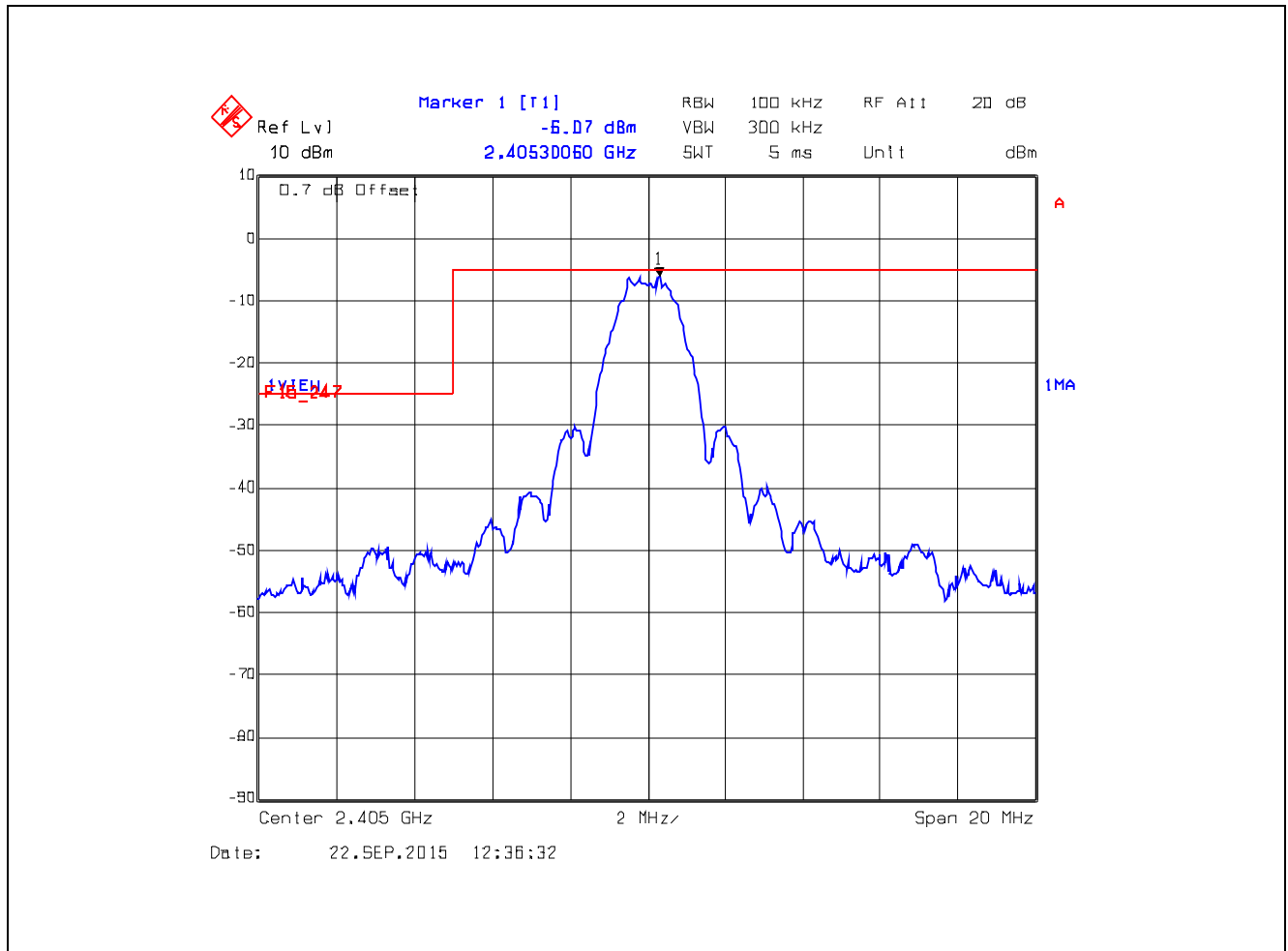
5.4.3. Test Arrangement



5.4.4. Test Data

5.4.4.1. Band-Edge RF Conducted Emissions

Plot 5.4.4.1.1. Band-Edge RF Conducted Emissions
Ch 1, 2405 MHz, OQPSK 250 kbps, Power Setting 100%, Lower Band-edge



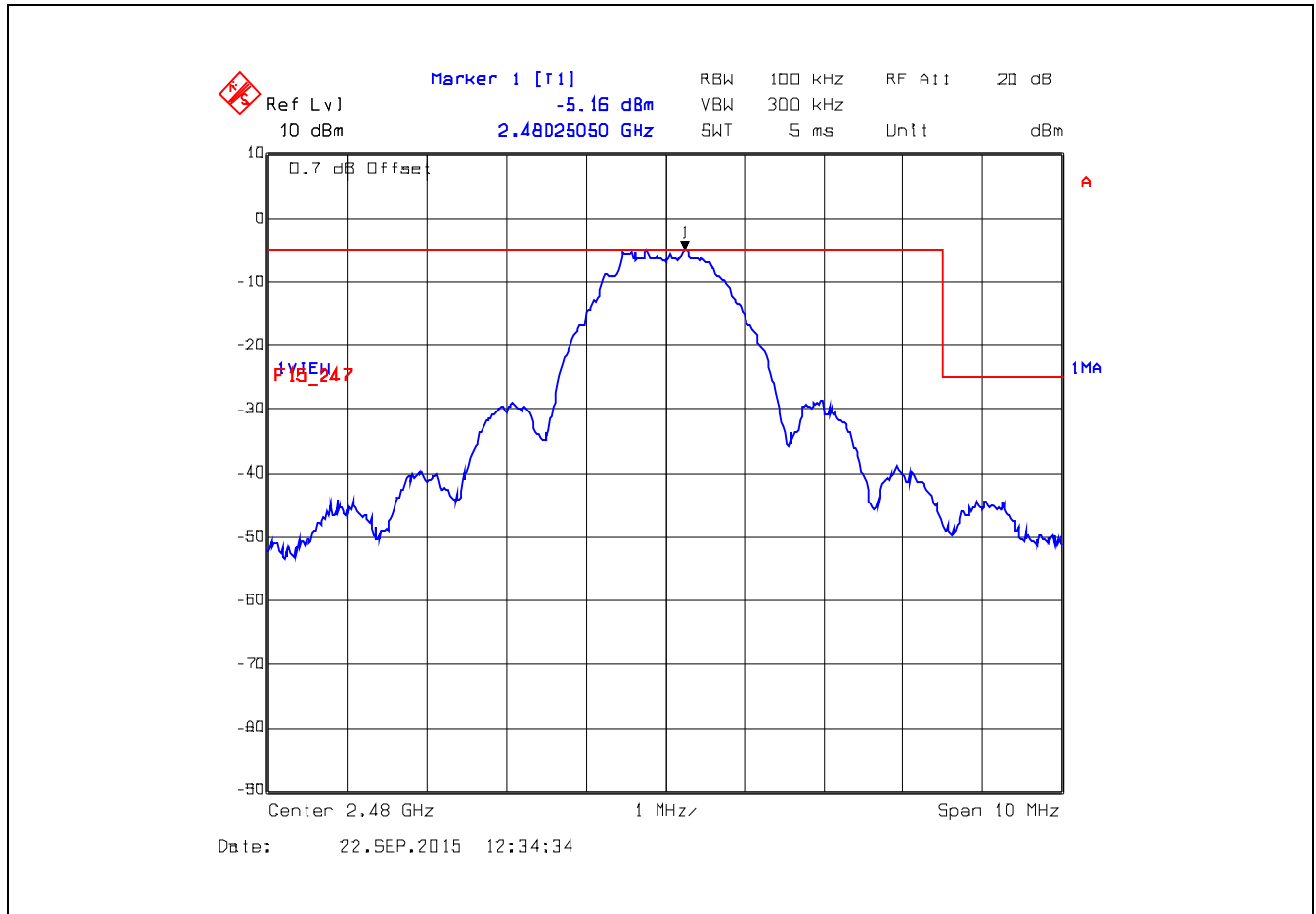
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Plot 5.4.4.1.2. Band-Edge RF Conducted Emissions
Ch 16, 2480 MHz, QPSK 250 kbps, Power Setting 100%, Higher Band-edge



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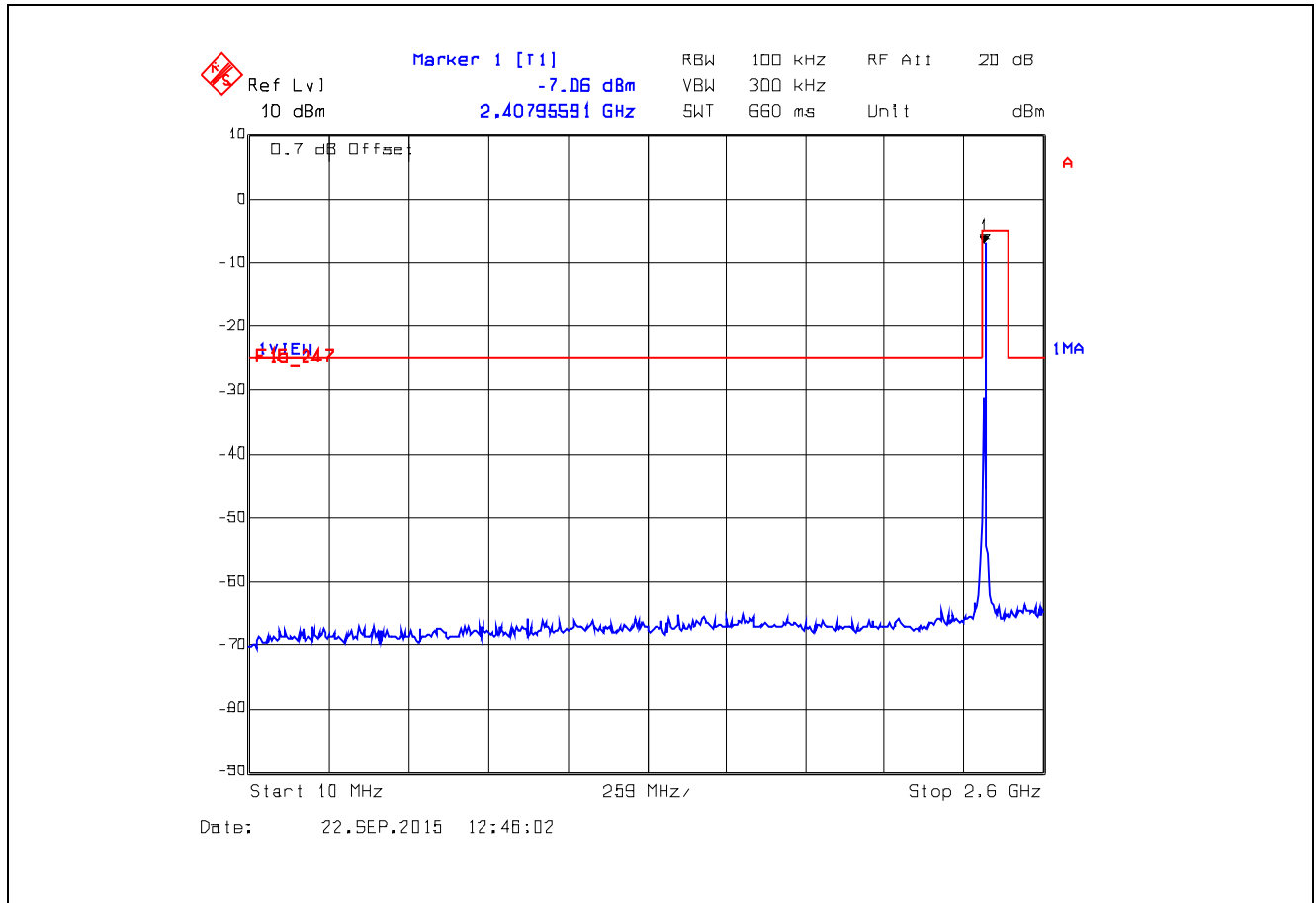
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5.4.4.2. Spurious RF Conducted Emissions in Non-restricted Frequency Bands

Plot 5.4.4.2.1. Conducted Spurious Emissions in Non-restricted Frequency Bands
Ch 1, 2405 MHz, OQPSK 250 kbps, Power Setting 100%, 10 MHz – 2.6 GHz



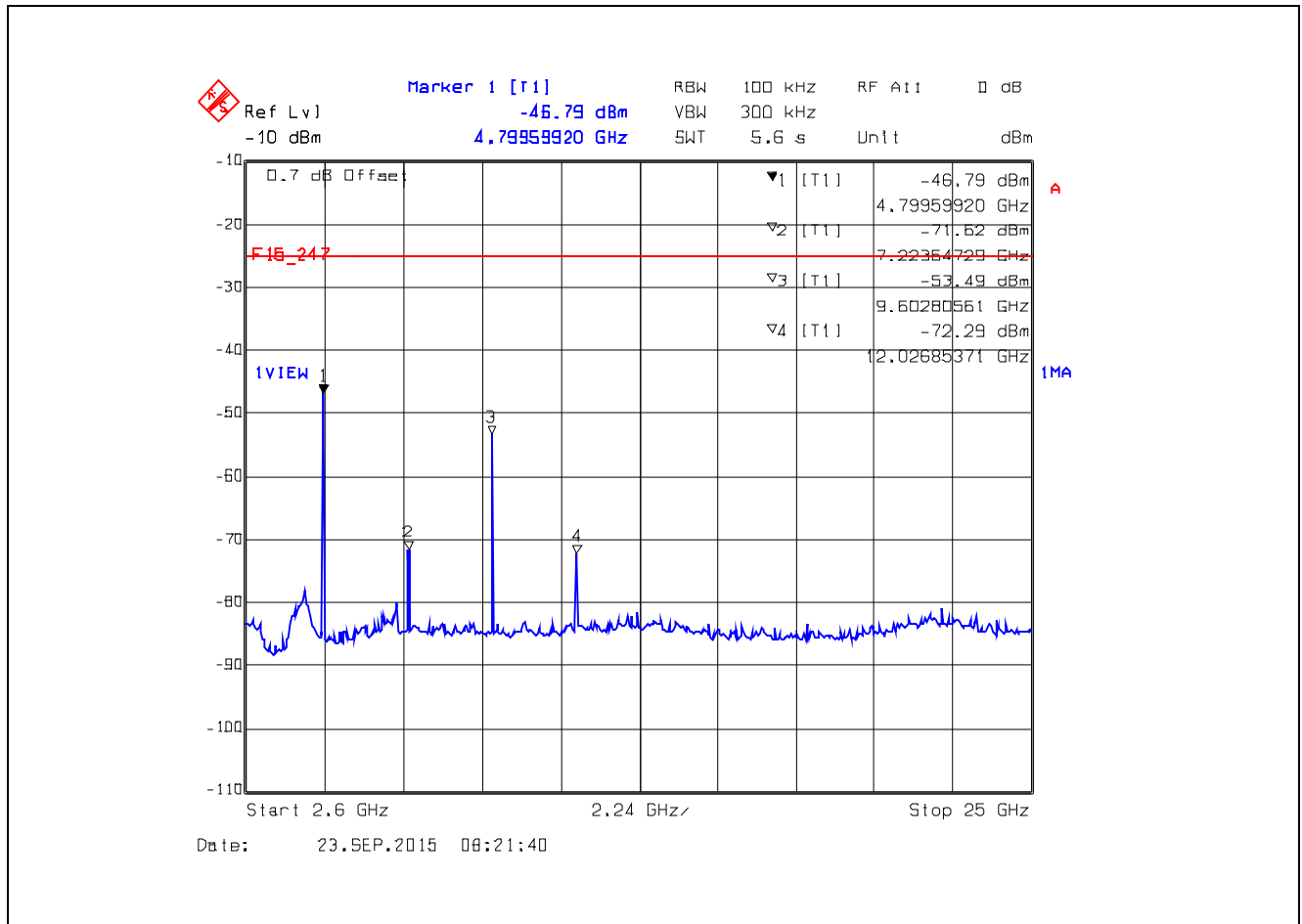
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File #: 15Q5X044_FCC15C247
September 28, 2015

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Plot 5.4.4.2.2. Conducted Spurious Emissions in Non-restricted Frequency Bands
 Ch 1, 2405 MHz, OQPSK 250 kbps, Power Setting 100%, 2.6 GHz – 25 GHz



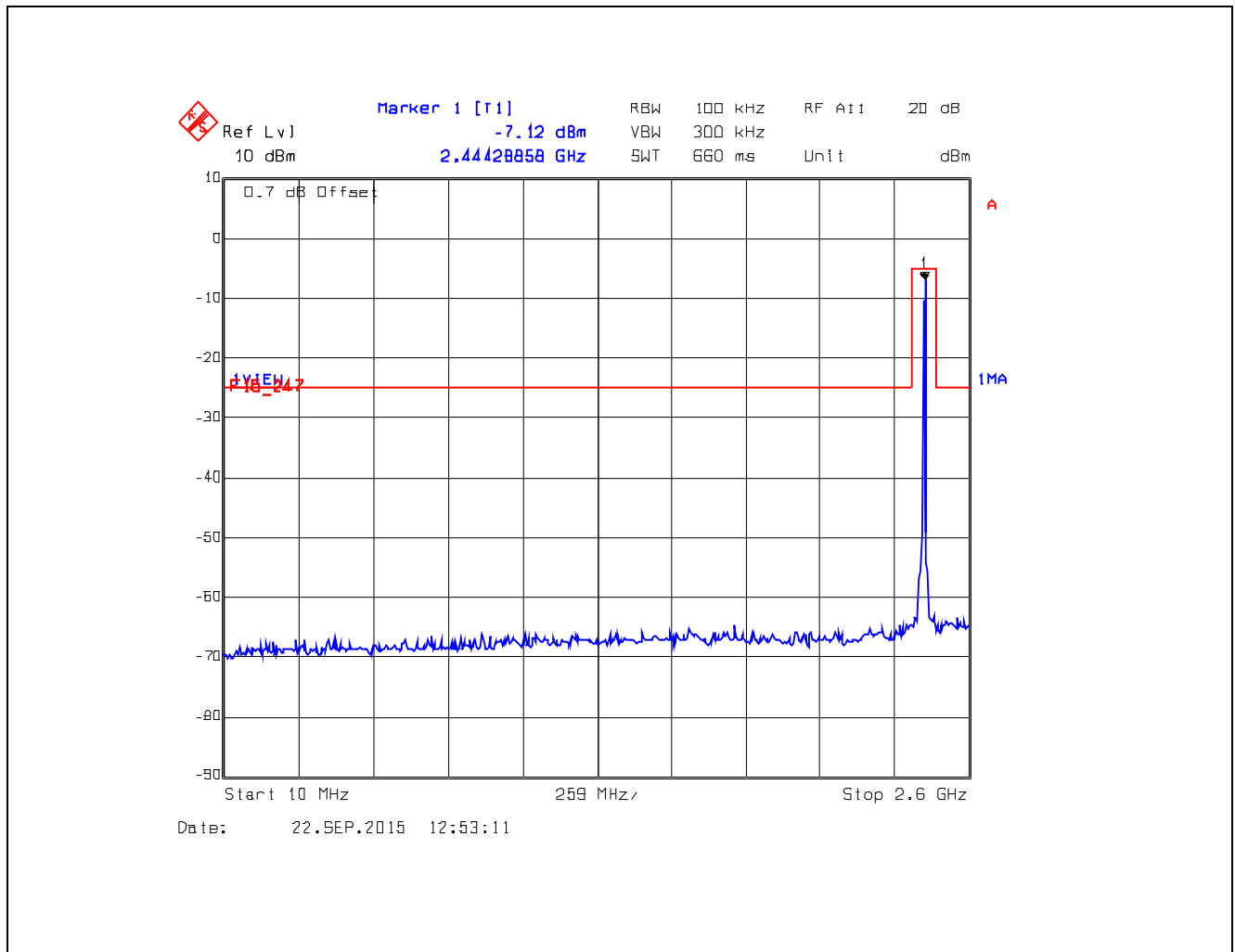
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File #: 15Q5X044_FCC15C247
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All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

Plot 5.4.4.2.3. Conducted Spurious Emissions in Non-restricted Frequency Bands
Ch 8, 2440 MHz, OQPSK 250 kbps, Power Setting 100%, 10 MHz – 2.6 GHz



ULTRATECH GROUP OF LABS

3000 Bristol Circle, Oakville, Ontario, Canada L6H 6G4

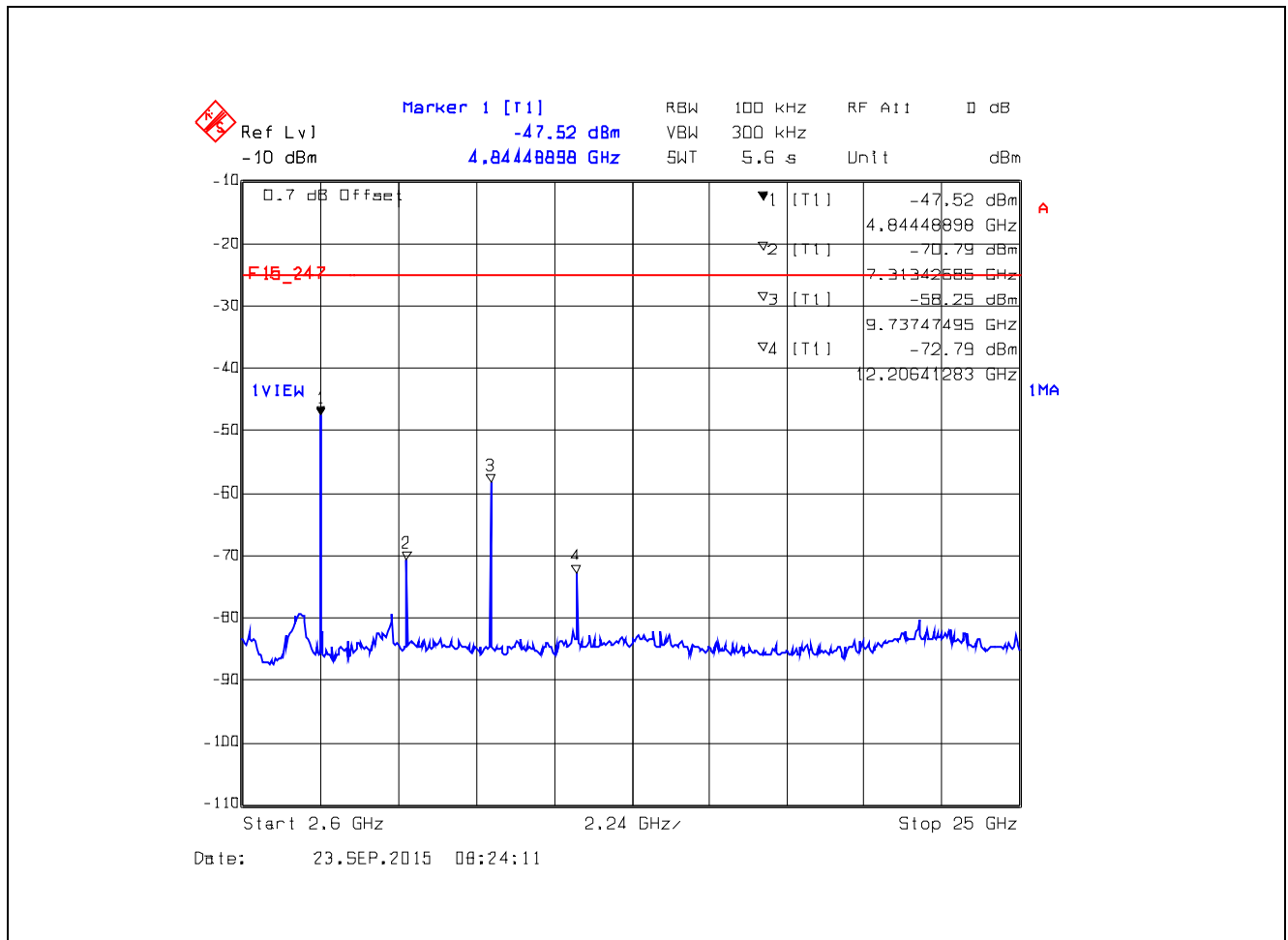
Tel. #: 905-829-1570, Fax. #: 905-829-8050, Email: yic@ultratech-labs.com, Website: <http://www.ultratech-labs.com>

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Plot 5.4.4.2.4. Conducted Spurious Emissions in Non-restricted Frequency Bands
Ch 8, 2440 MHz, OQPSK 250 kbps, Power Setting 100%, 2.6 GHz – 25 GHz



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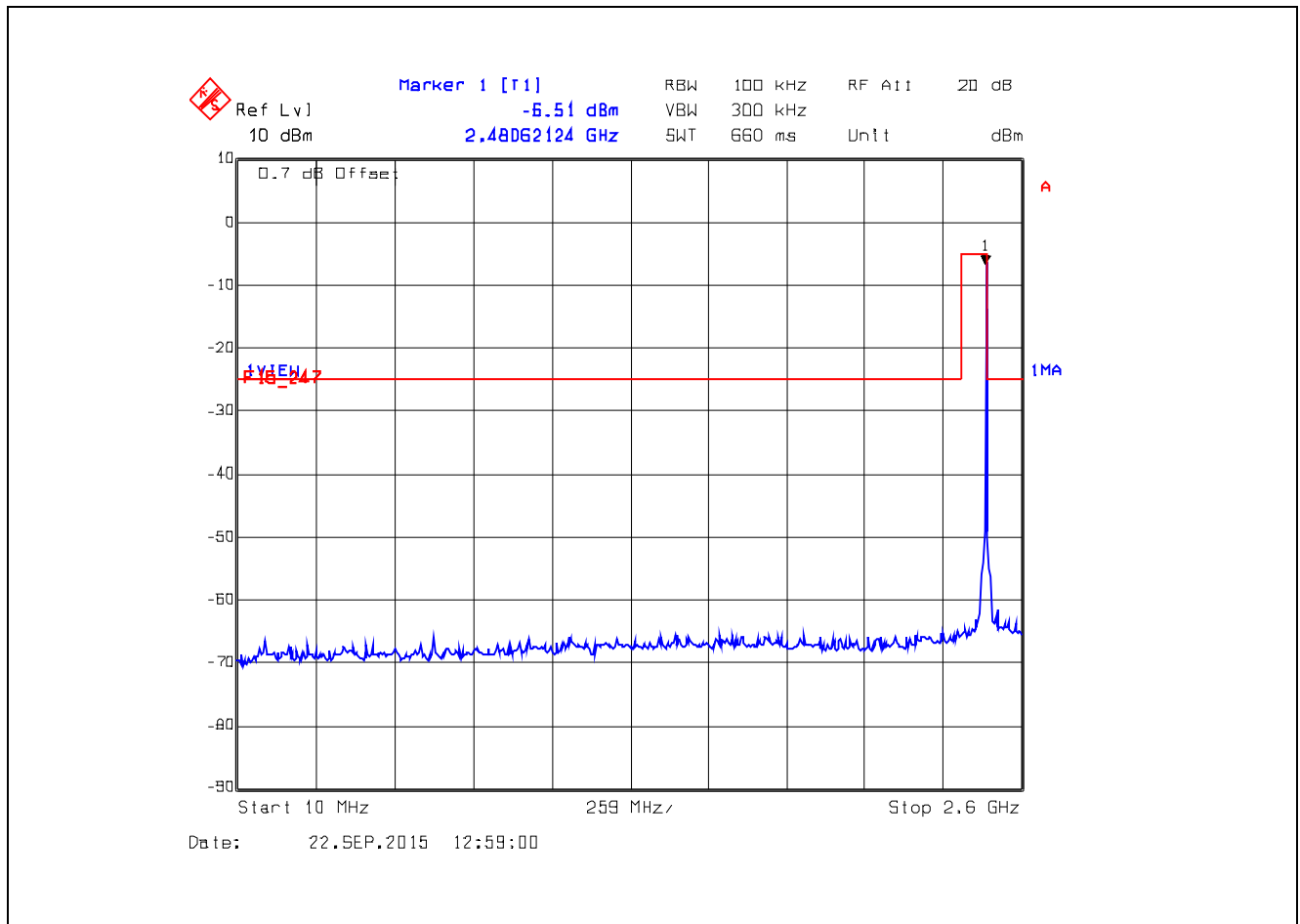
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File #: 15Q5X044_FCC15C247

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Plot 5.4.4.2.5. Conducted Spurious Emissions in Non-restricted Frequency Bands
Ch 16, 2480 MHz, OQPSK 250 kbps, Power Setting 100%, 10 MHz – 2.6 GHz



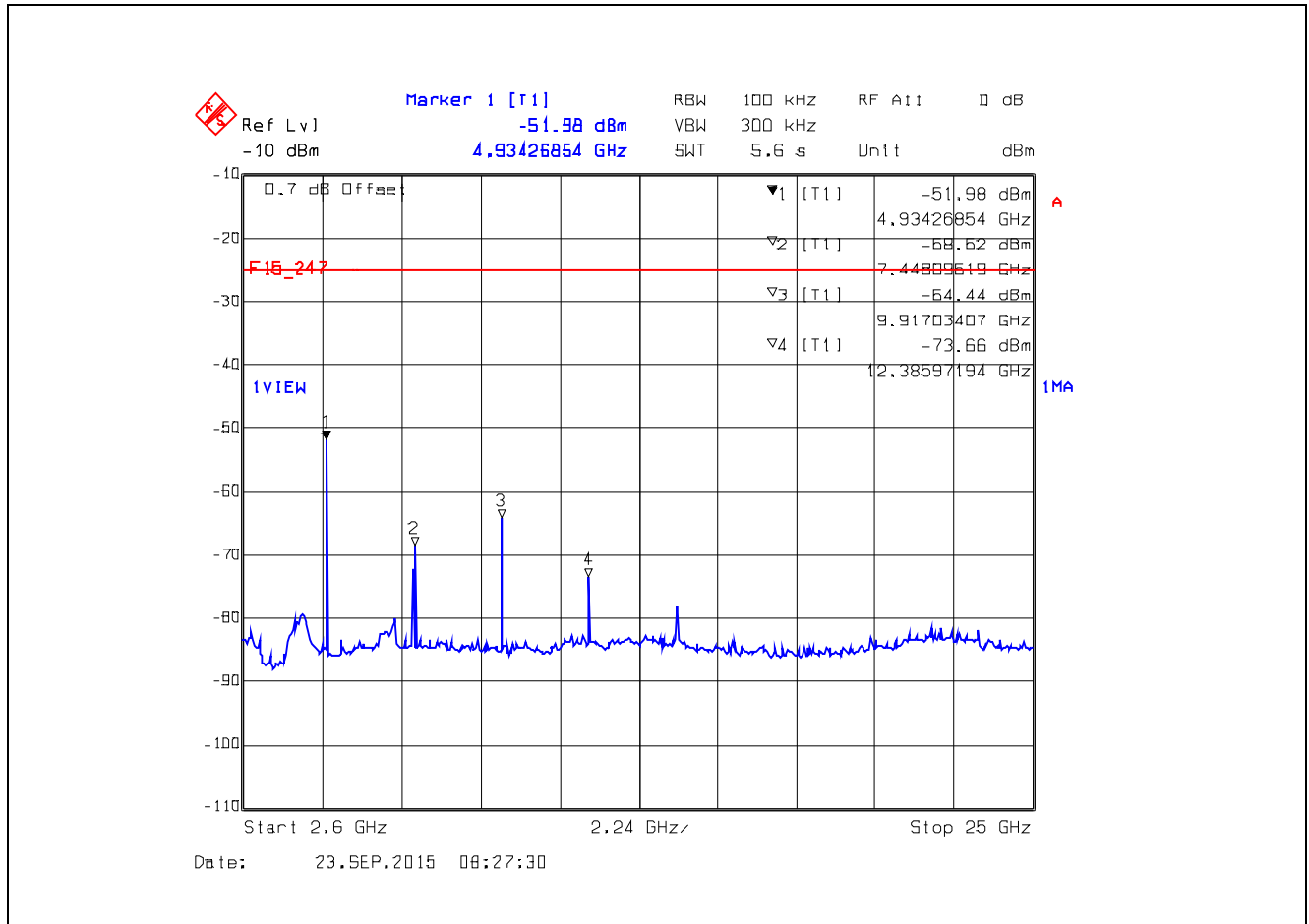
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Plot 5.4.4.2.6. Conducted Spurious Emissions in Non-restricted Frequency Bands
 Ch 16, 2480 MHz, OQPSK 250 kbps, Power Setting 100%, 2.6 GHz – 25 GHz



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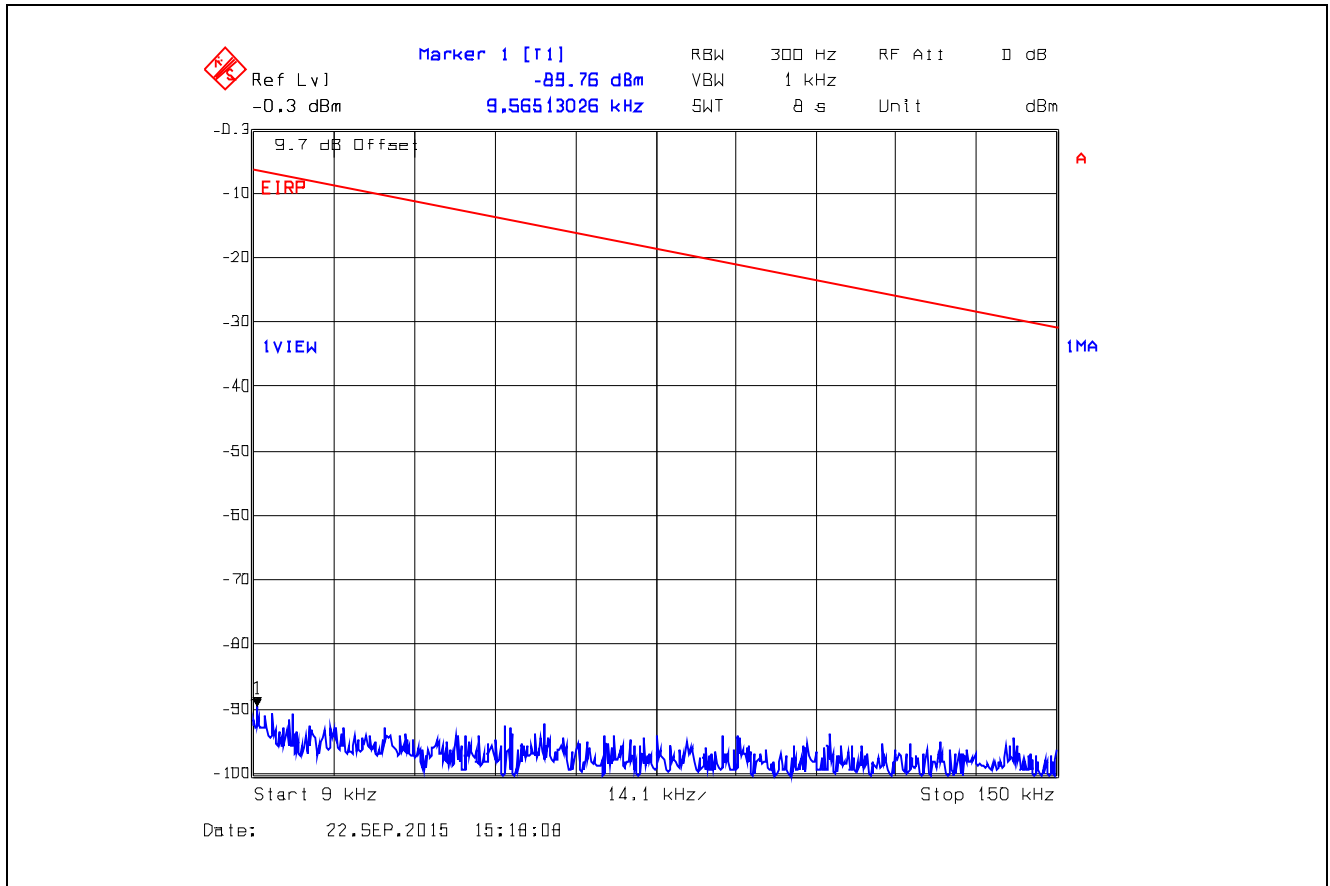
All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

5.4.4.3. Conducted Spurious Emissions in Restricted Frequency Bands, Highest Power Setting

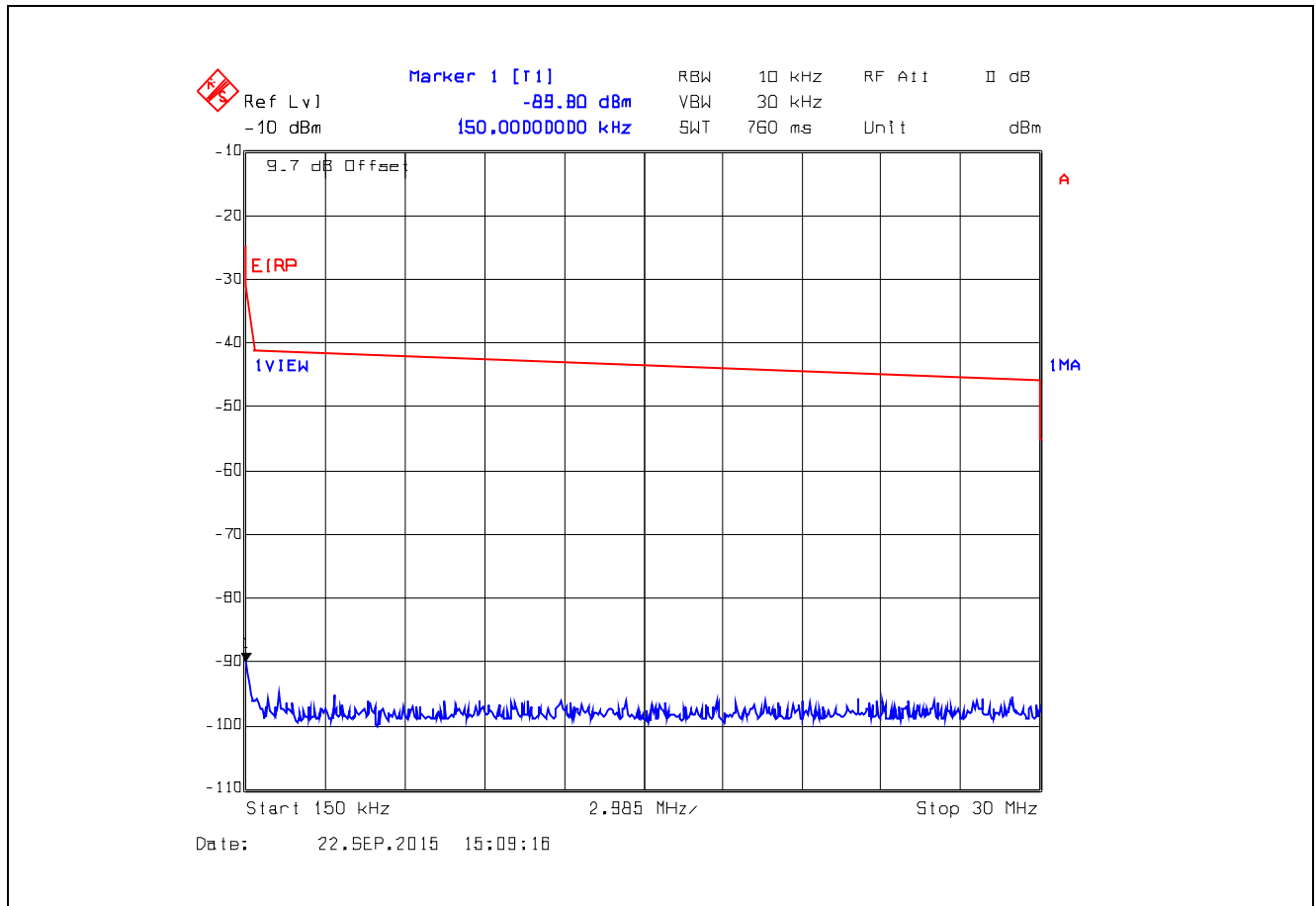
Remark: Offset = [Insertion Loss] + [Transmit Antenna Gain (in dBi)] + [Maximum Ground Reflection Factor]

Note: If the peak-detected amplitude can be shown to comply with the average limit, then it is not necessary to perform a separate average measurement.

Plot 5.4.4.3.1. Conducted Spurious Emissions in Restricted Frequency Bands
 Ch 1, 2405 MHz, OQPSK 250 kbps, Power Setting 100%, 9 kHz - 150 kHz, Peak Detector



Plot 5.4.4.3.2. Conducted Spurious Emissions in Restricted Frequency Bands
 Ch 1, 2405 MHz, OQPSK 250 kbps, Power Setting 100%, 150 kHz - 30 MHz, Peak Detector



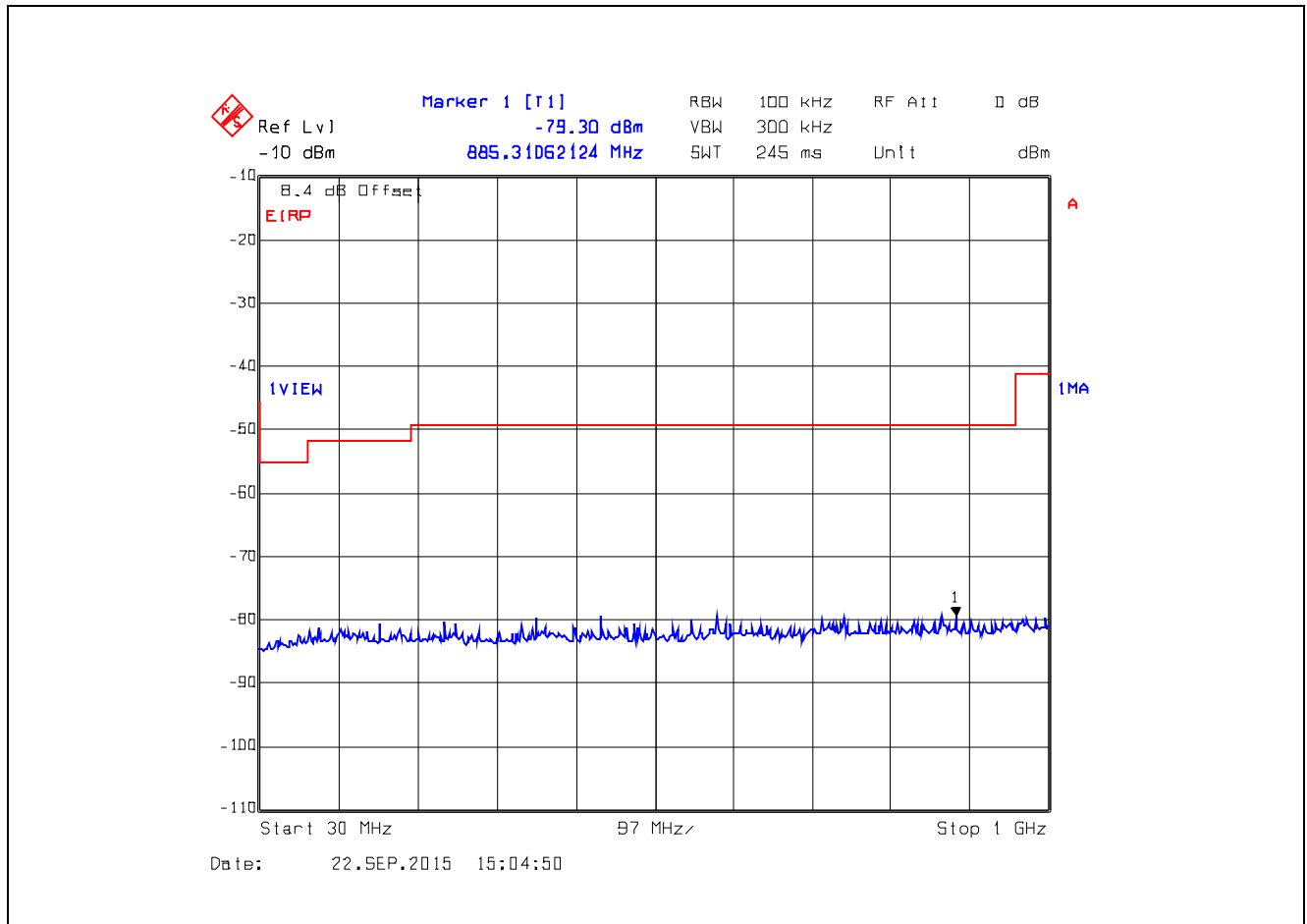
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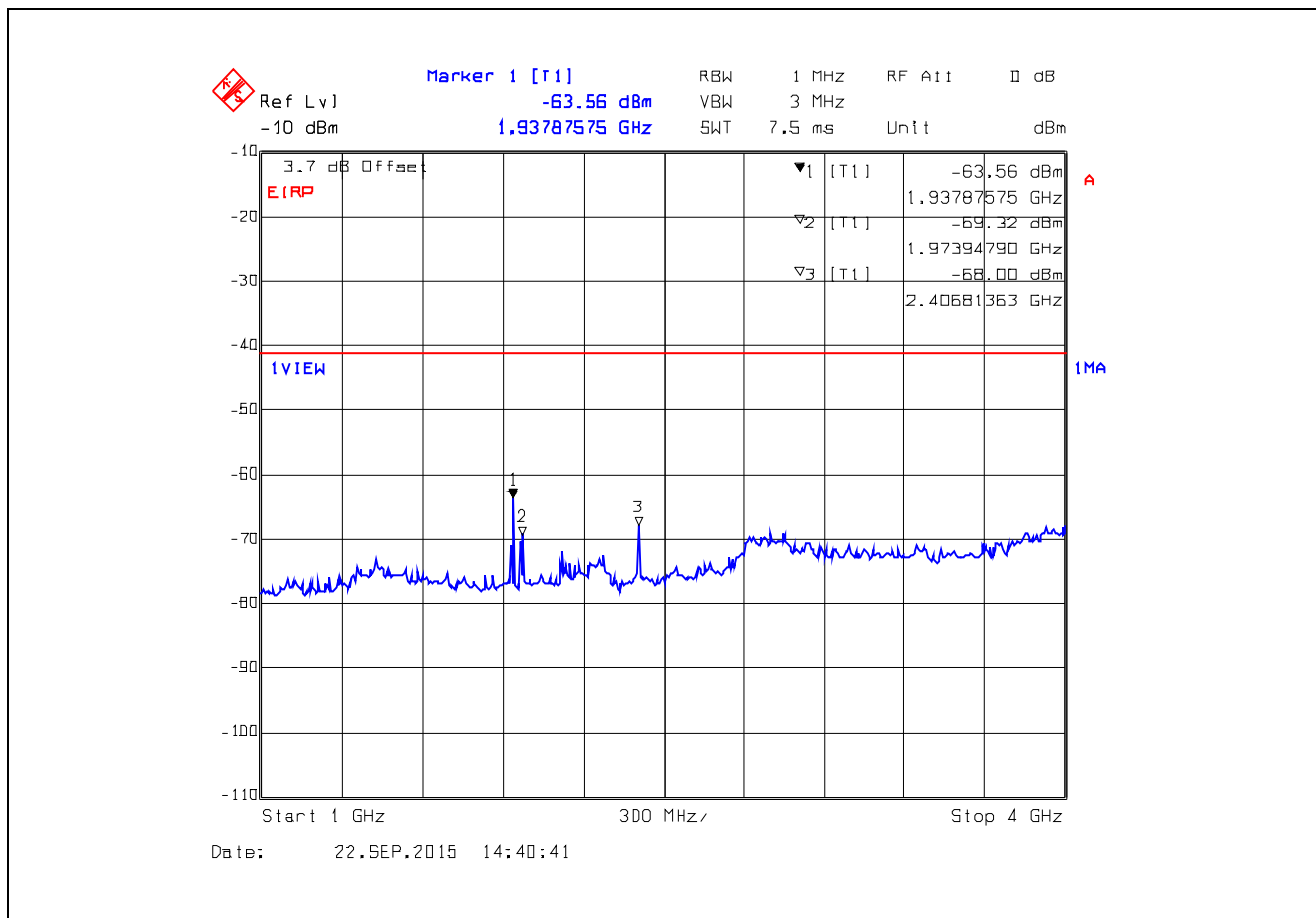
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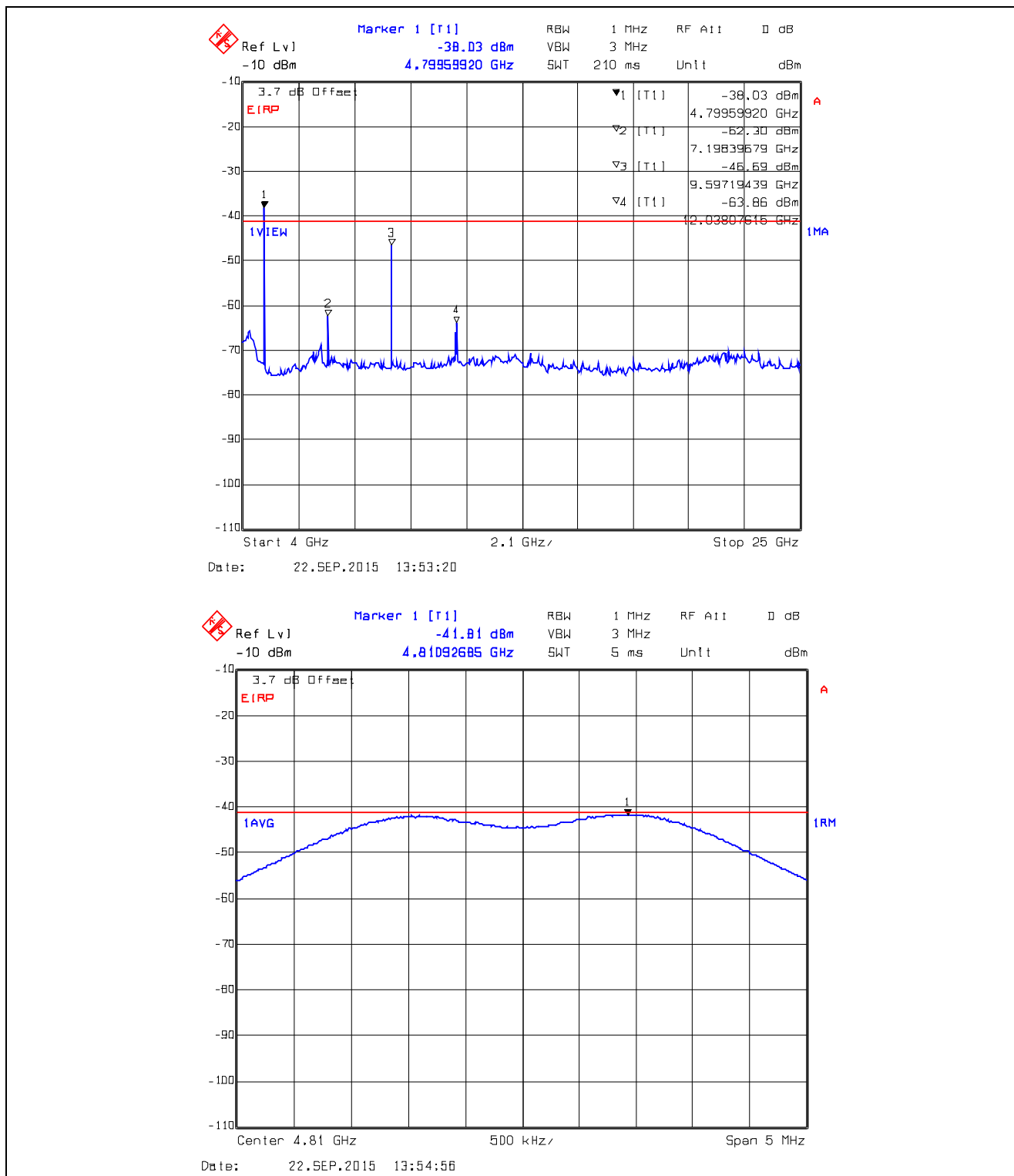
Plot 5.4.4.3.3. Conducted Spurious Emissions in Restricted Frequency Bands
Ch 1, 2405 MHz, OQPSK 250 kbps, Power Setting 100%, 30 MHz - 1 GHz, Peak Detector



Plot 5.4.4.3.4. Conducted Spurious Emissions in Restricted Frequency Bands
 Ch 1, 2405 MHz, OQPSK 250 kbps, Power Setting 100%, 1 GHz - 4 GHz, Peak Detector



Plot 5.4.4.3.5. Conducted Spurious Emissions in Restricted Frequency Bands
 Ch 1, 2405 MHz, OQPSK 250 kbps, Power Setting 100%, 4 GHz - 25 GHz, Peak Detector



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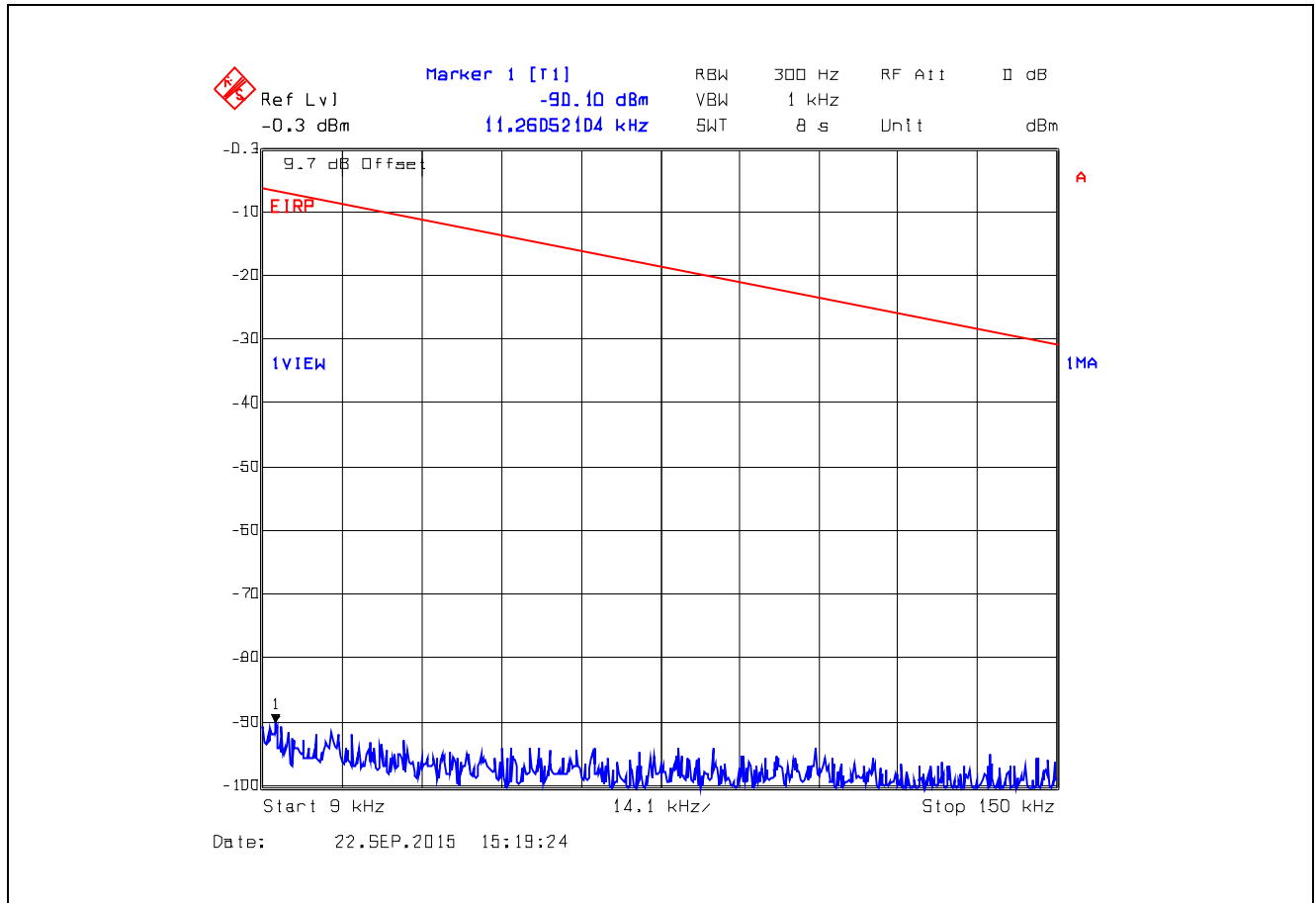
Tel. #: 905-829-1570, Fax. #: 905-829-8050, Email: vic@ultratech-labs.com, Website: <http://www.ultratech-labs.com>

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Plot 5.4.4.3.6. Conducted Spurious Emissions in Restricted Frequency Bands
 Ch 8, 2440 MHz, OQPSK 250 kbps, Power Setting 100%, 9 kHz - 150 kHz, Peak Detector



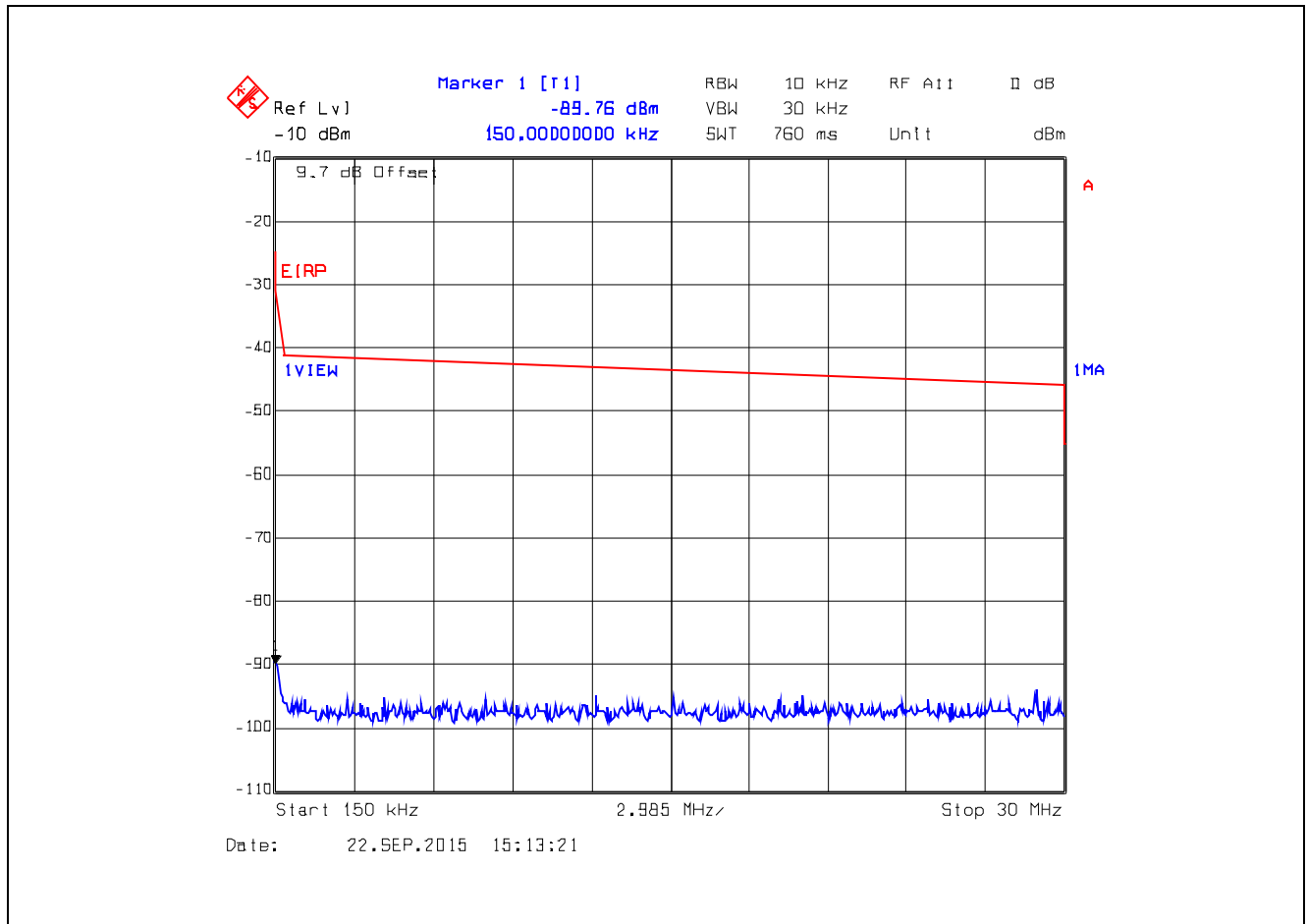
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Plot 5.4.4.3.7. Conducted Spurious Emissions in Restricted Frequency Bands
 Ch 8, 2440 MHz, OQPSK 250 kbps, Power Setting 100%, 150 kHz - 30 MHz, Peak Detector



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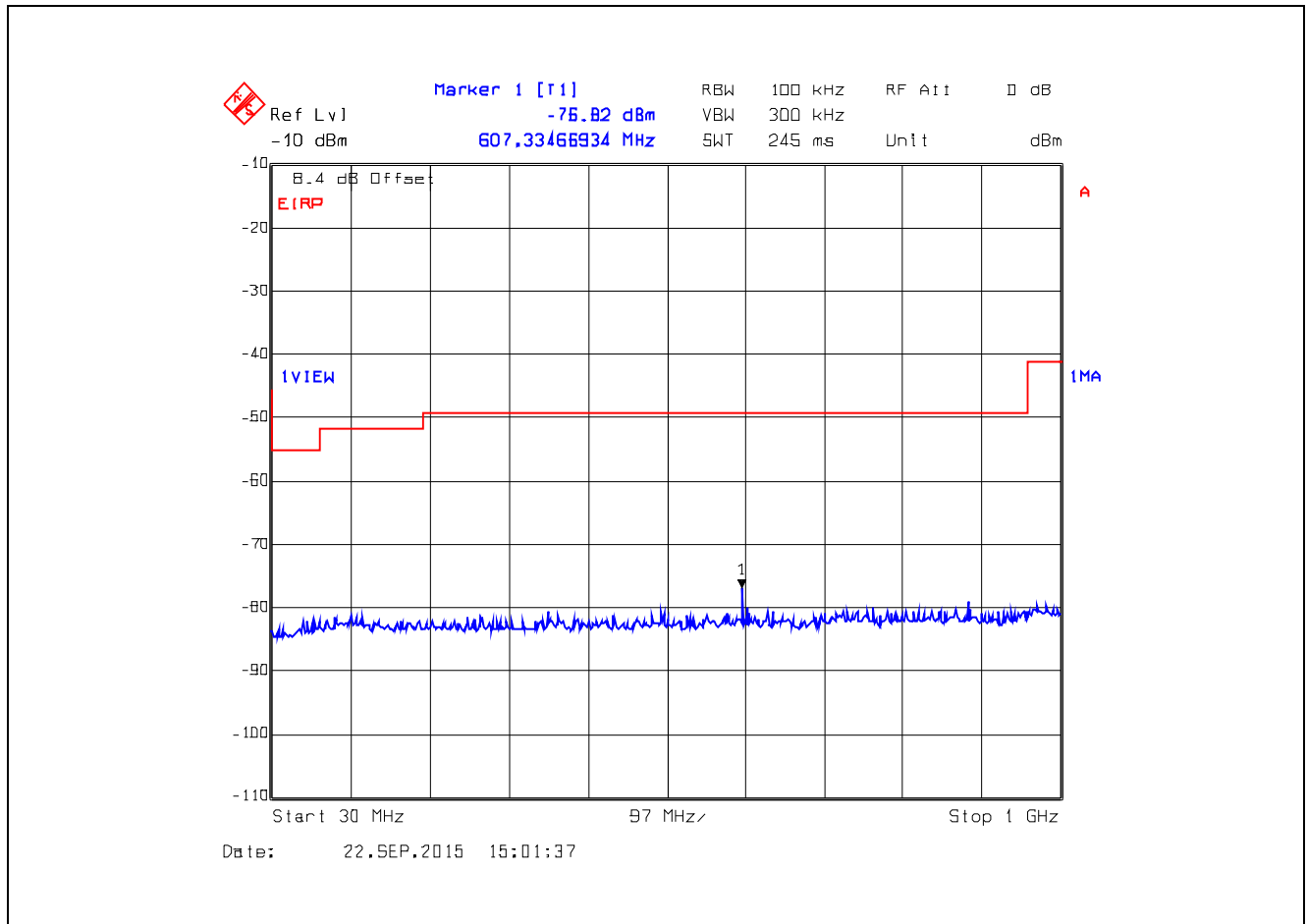
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 Tel. #: 905-829-1570, Fax. #: 905-829-8050, Email: yic@ultratech-labs.com, Website: <http://www.ultratech-labs.com>

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Plot 5.4.4.3.8. Conducted Spurious Emissions in Restricted Frequency Bands
 Ch 8, 2440 MHz, OQPSK 250 kbps, Power Setting 100%, 30 MHz - 1 GHz, Peak Detector



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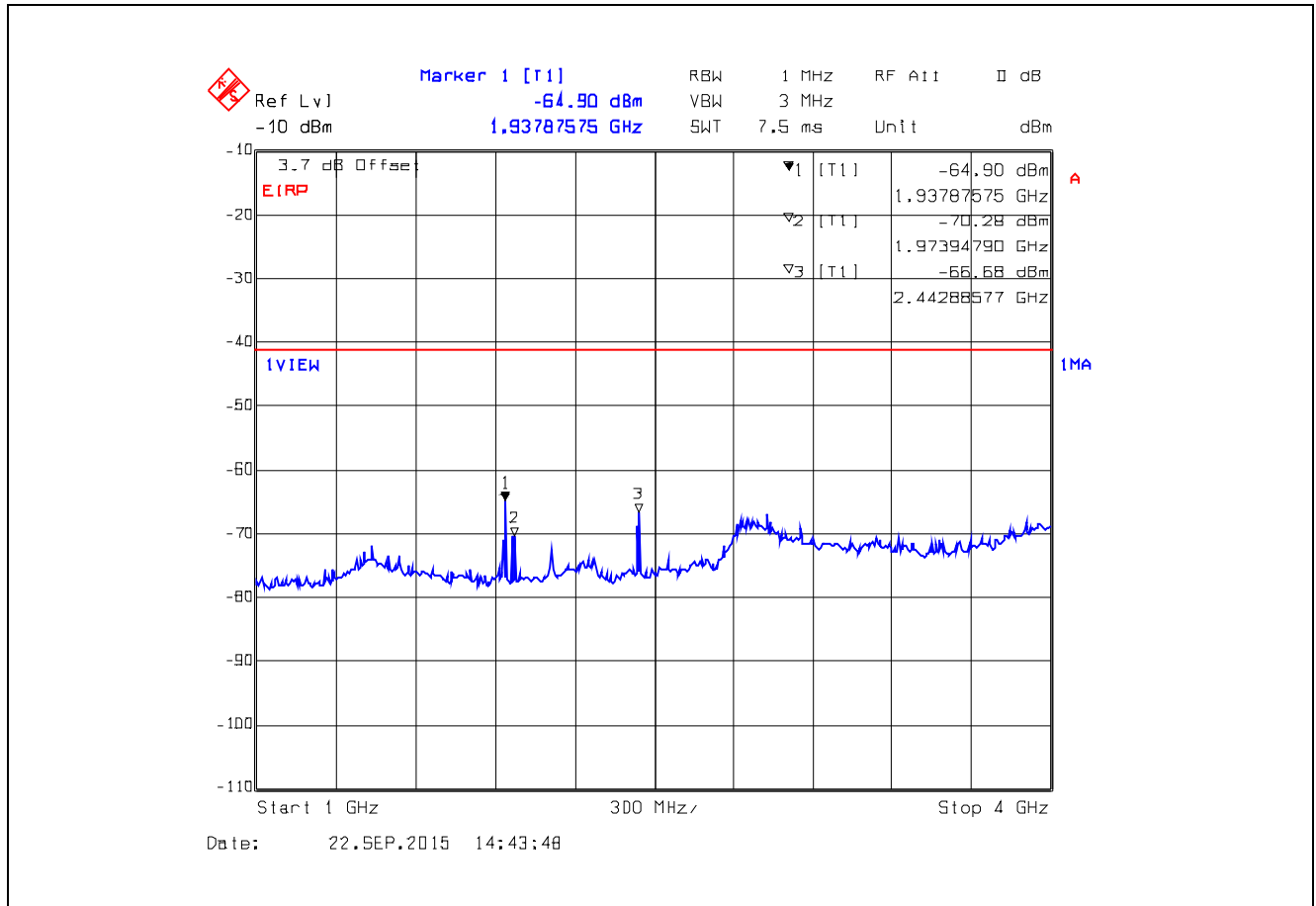
3000 Bristol Circle, Oakville, Ontario, Canada L6H 6G4
 Tel. #: 905-829-1570, Fax. #: 905-829-8050, Email: yic@ultratech-labs.com, Website: <http://www.ultratech-labs.com>

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Plot 5.4.4.3.9. Conducted Spurious Emissions in Restricted Frequency Bands
 Ch 8, 2440 MHz, OQPSK 250 kbps, Power Setting 100%, 1 GHz - 4 GHz, Peak Detector



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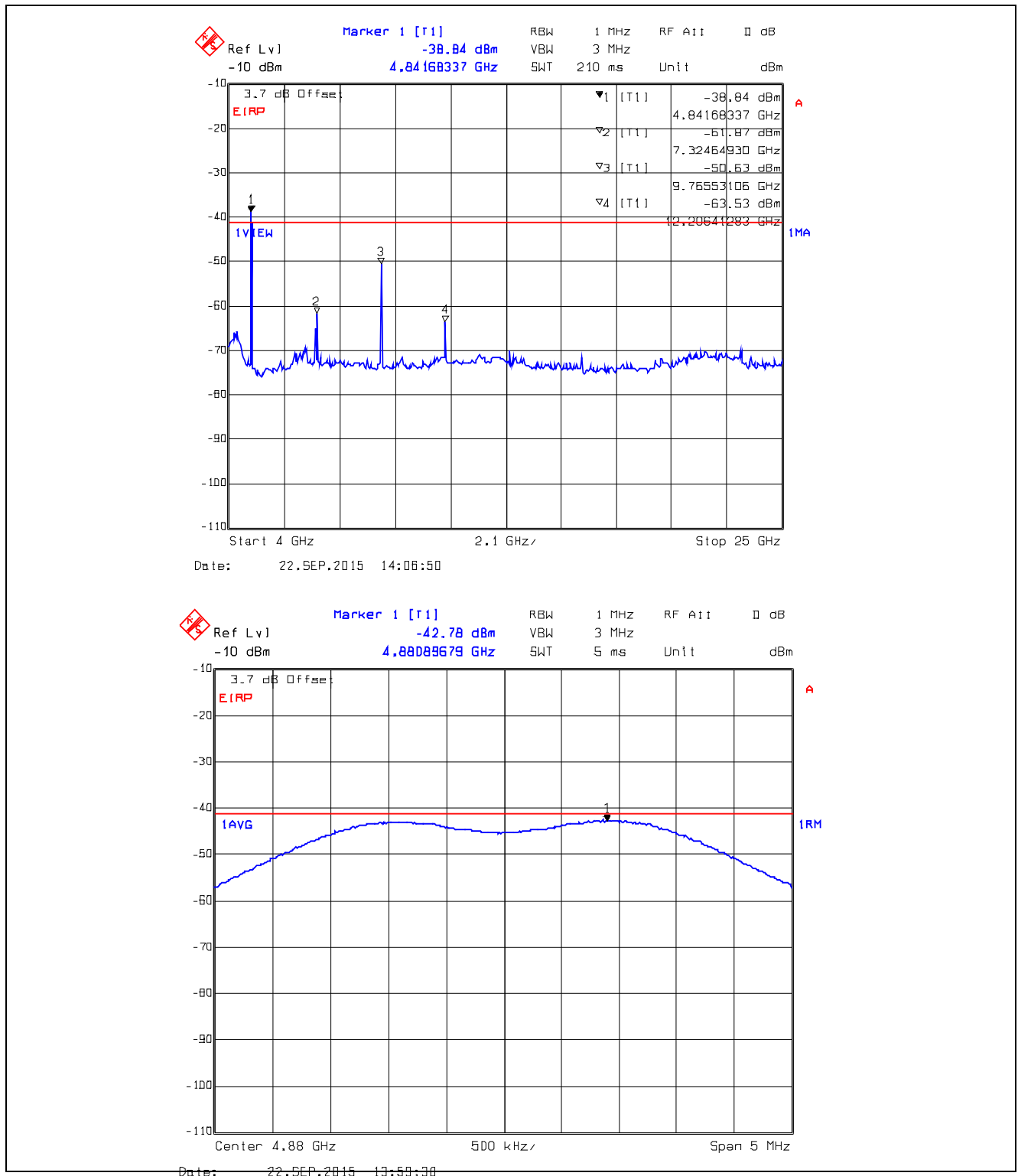
Tel. #: 905-829-1570, Fax. #: 905-829-8050, Email: vic@ultratech-labs.com, Website: <http://www.ultratech-labs.com>

File #: 15Q5X044_FCC15C247

September 28, 2015

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Plot 5.4.4.3.10. Conducted Spurious Emissions in Restricted Frequency Bands
 Ch 8, 2440 MHz, OQPSK 250 kbps, Power Setting 100%, 4 GHz - 25 GHz, Peak Detector



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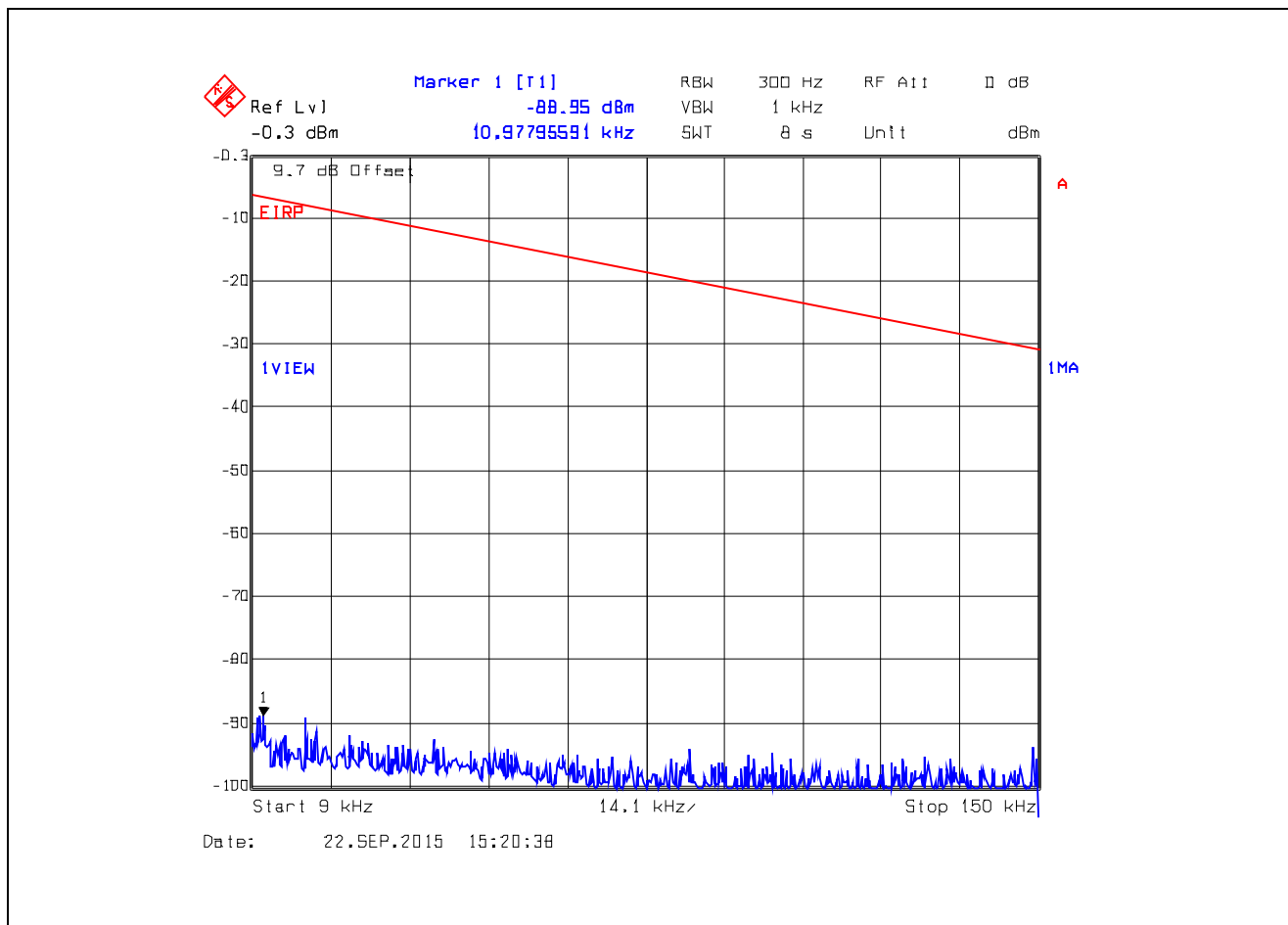
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File #: 15Q5X044_FCC15C247

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Plot 5.4.4.3.11. Conducted Spurious Emissions in Restricted Frequency Bands
 Ch 16, 2480 MHz, OQPSK 250 kbps, Power Setting 100%, 9 kHz - 150 kHz, Peak Detector



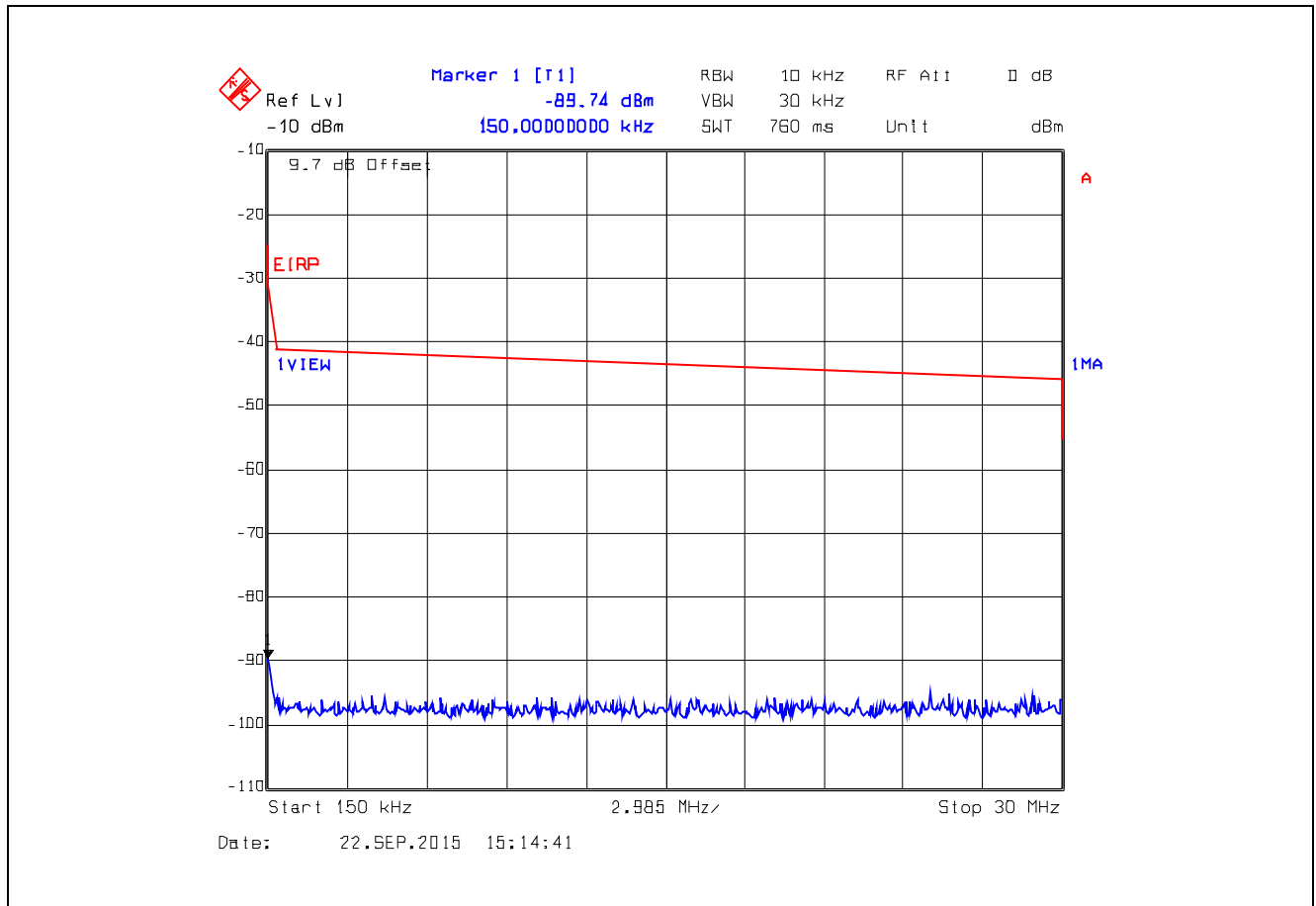
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Plot 5.4.4.3.12. Conducted Spurious Emissions in Restricted Frequency Bands
Ch 16, 2480 MHz, OQPSK 250 kbps, Power Setting 100%, 150 kHz - 30 MHz, Peak Detector



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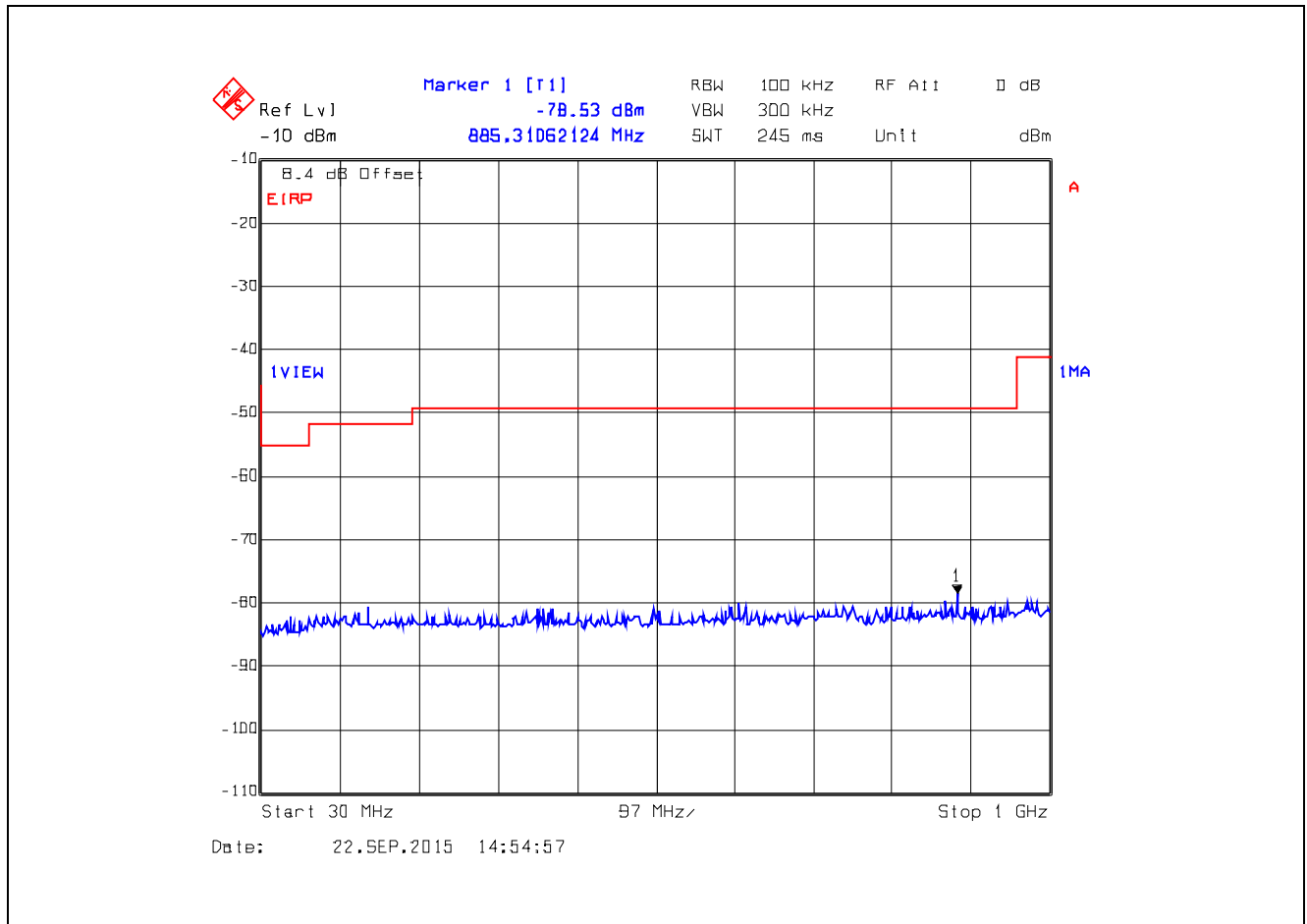
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File #: 15Q5X044_FCC15C247

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Plot 5.4.4.3.13. Conducted Spurious Emissions in Restricted Frequency Bands
 Ch 16, 2480 MHz, OQPSK 250 kbps, Power Setting 100%, 30 MHz - 1 GHz, Peak Detector



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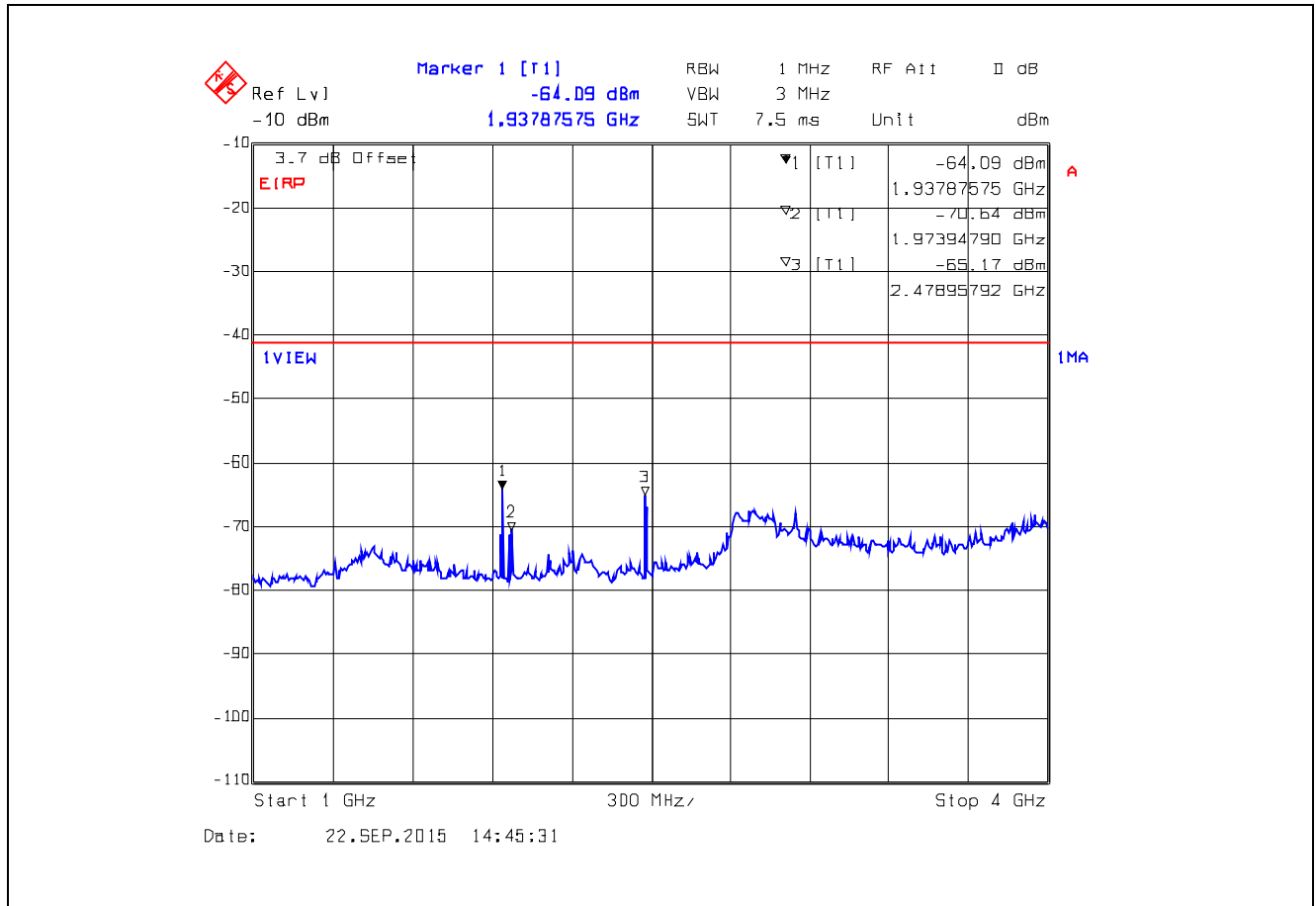
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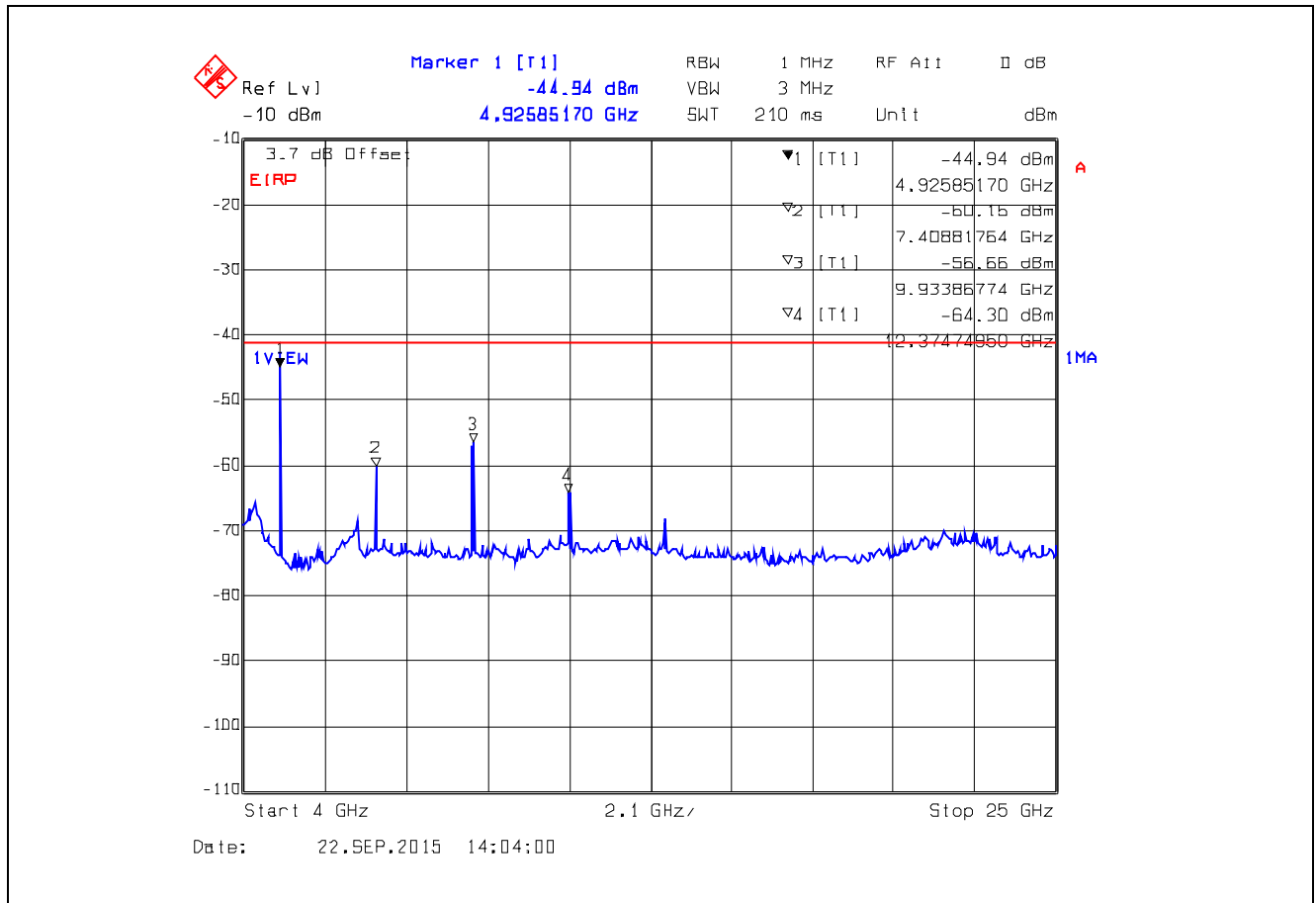
September 28, 2015

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

Plot 5.4.4.3.14. Conducted Spurious Emissions in Restricted Frequency Bands
 Ch 16, 2480 MHz, OQPSK 250 kbps, Power Setting 100%, 1 GHz - 4 GHz, Peak Detector



Plot 5.4.4.3.15. Conducted Spurious Emissions in Restricted Frequency Bands
 Ch 16, 2480 MHz, OQPSK 250 kbps, Power Setting 100%, 4 GHz - 25 GHz, Peak Detector



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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

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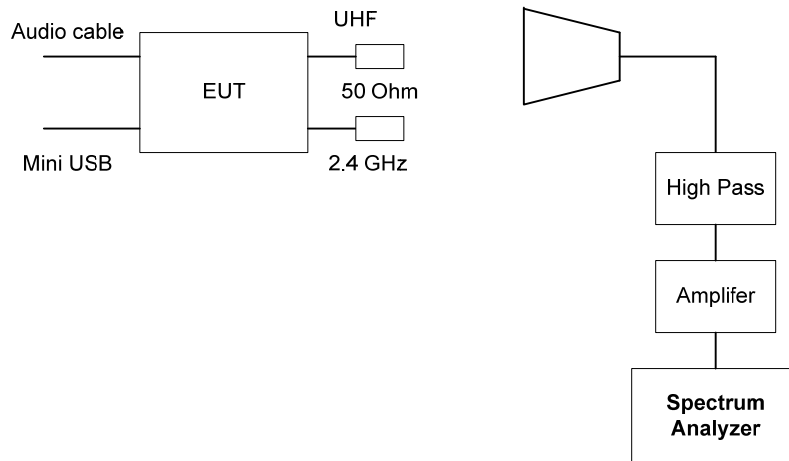
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5.5.2. Method of Measurements

KDB Publication No. 558074 D01 DTS Meas Guidance V03r03, 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:
 $E = (EIRP - 20\log(d) + 104.8) - 20 = (36 \text{ dBm} - 20\log(3) + 104.8) - 20 = 111.3 \text{ dB}\mu\text{V/m}$
- Exploratory tests performed to determined worst-case test configurations, the following test results at high power setting represent the worst-case.

5.5.4.1. OQPSK, 250 kbps, O/p Power Setting 100%

Fundamental Frequency:		2405 MHz					
Frequency Test Range:		30 MHz – 25 GHz					
Frequency (MHz)	RF Peak Level (dB μ V/m)	RF Avg Level (dB μ V/m)	Antenna Plane (H/V)	Limit 15.209 (dB μ V/m)	Limit 15.247 (dB μ V/m)	Margin (dB)	Pass/Fail
4810	53.68	42.38	V	54.0	111.3	-11.6	Pass*
4810	52.12	39.27	H	54.0	111.3	-14.7	Pass*
All other spurious emissions and harmonics are more than 20 dB below the applicable limit.							

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

Fundamental Frequency:		2440 MHz					
Frequency Test Range:		30 MHz – 25 GHz					
Frequency (MHz)	RF Peak Level (dB μ V/m)	RF Avg Level (dB μ V/m)	Antenna Plane (H/V)	Limit 15.209 (dB μ V/m)	Limit 15.247 (dB μ V/m)	Margin (dB)	Pass/Fail
4880	55.15	45.97	V	54.0	111.3	-8.0	Pass*
4880	53.01	41.75	H	54.0	111.3	-12.2	Pass*
All other spurious emissions and harmonics are more than 20 dB below the applicable limit.							

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

Fundamental Frequency:		2480 MHz					
Frequency Test Range:		30 MHz – 25 GHz					
Frequency (MHz)	RF Peak Level (dB μ V/m)	RF Avg Level (dB μ V/m)	Antenna Plane (H/V)	Limit 15.209 (dB μ V/m)	Limit 15.247 (dB μ V/m)	Margin (dB)	Pass/Fail
4960	53.18	41.97	V	54.0	111.3	-12.0	Pass*
4960	51.61	38.52	H	54.0	111.3	-15.5	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.

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

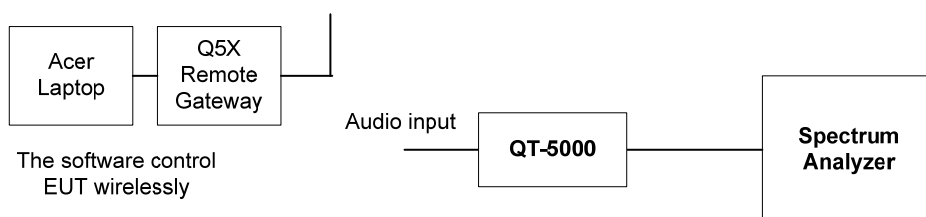
5.6.1. Limit(s)

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 V03r03, Section 10.2 Method PKPSD

5.6.3. Test Arrangement

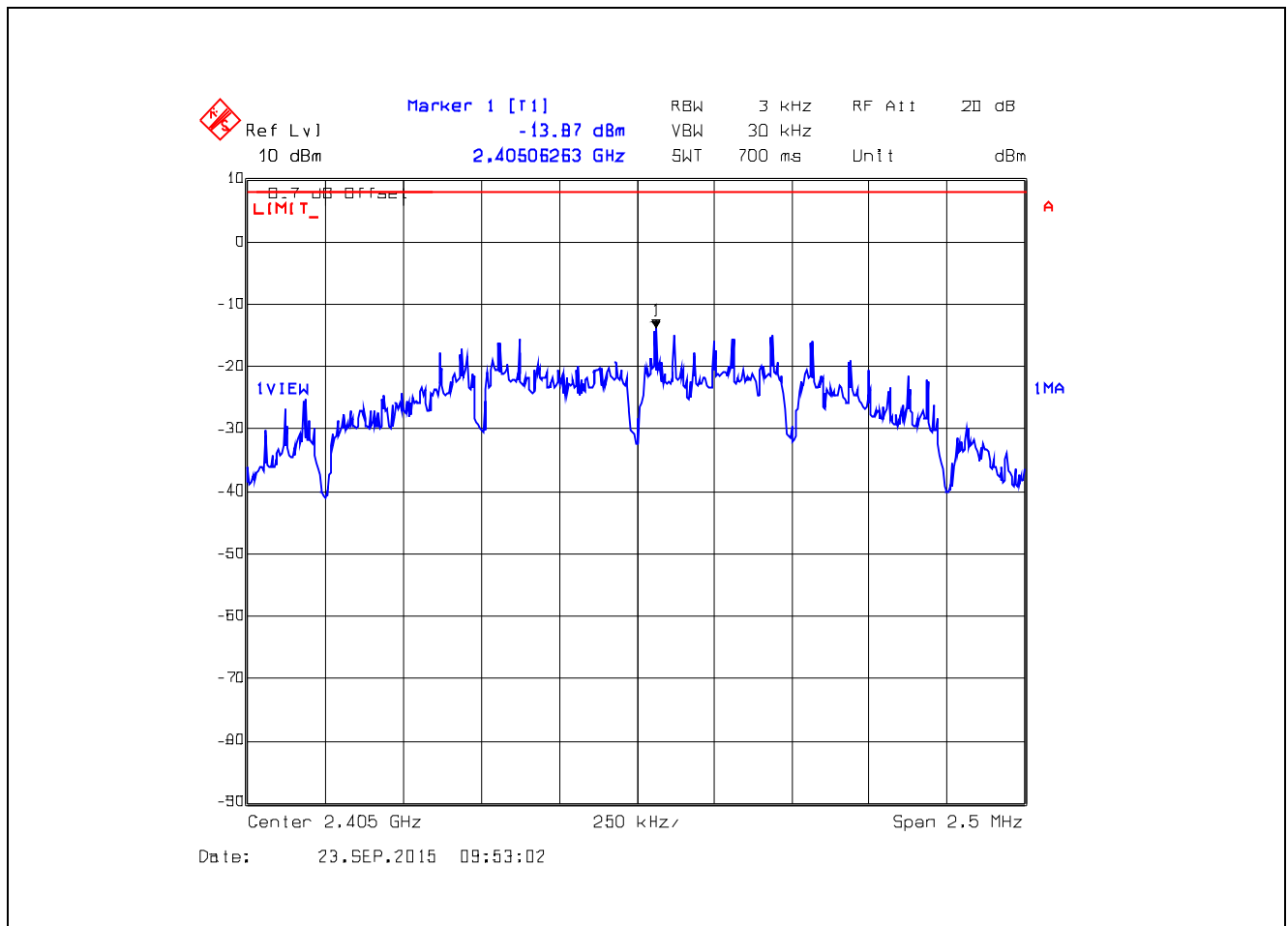


5.6.4. Test Data

Frequency (MHz)	Modulation	Data Rate (Mbps)	Channel Number	PSD (dBm)	Limit (dBm)
2405	OQPSK	250	1	-13.87	8
2440	OQPSK	250	8	-13.51	8
2480	OQPSK	250	16	-13.37	8

See the following plots for detailed measurements.

Plot 5.6.4.1. Peak PSD, Ch 1, 2405 MHz, OQPSK 250 kbps, Power Setting 100%



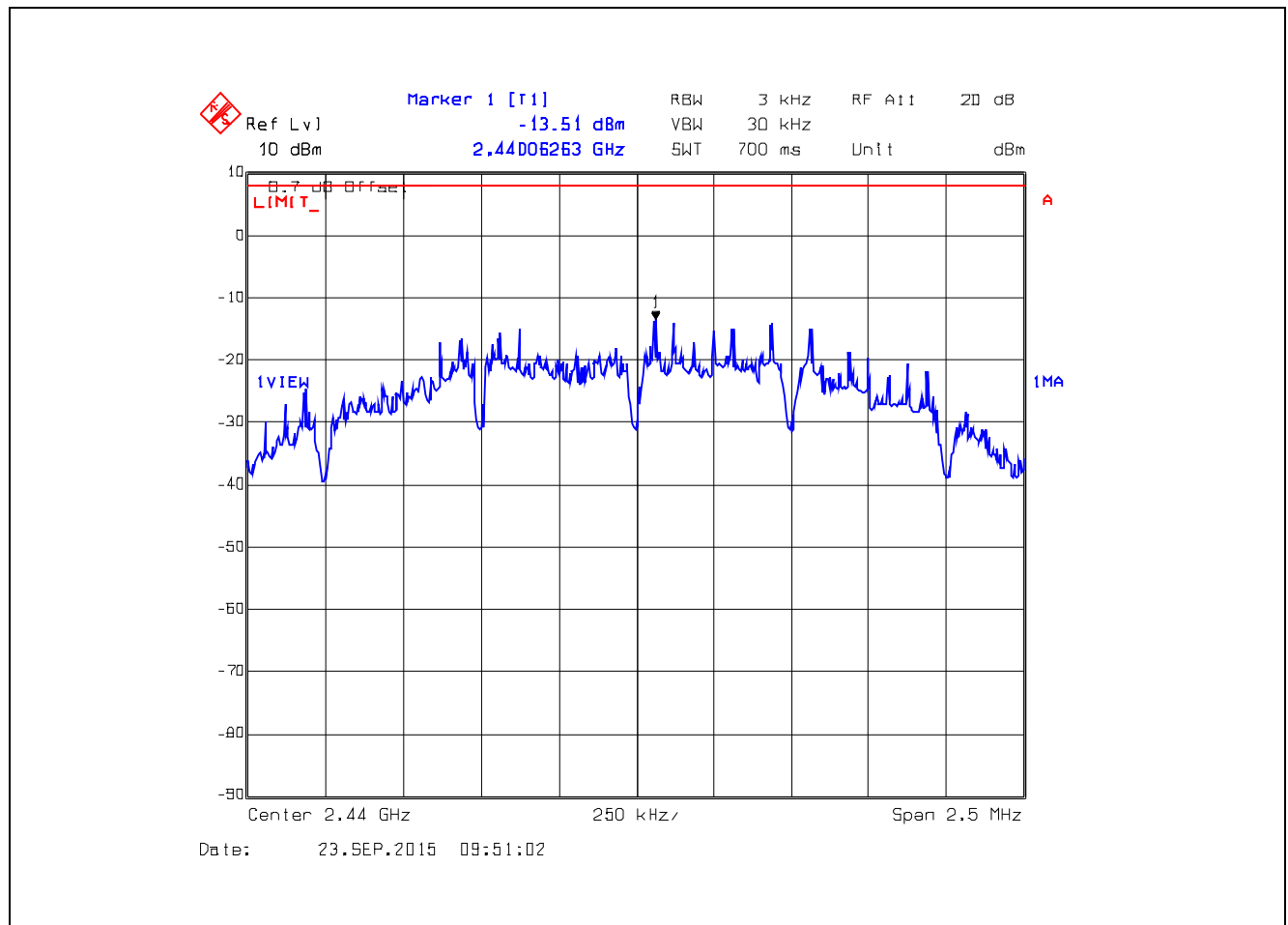
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Plot 5.6.4.2. Peak PSD, Ch 8, 2440 MHz, OQPSK 250 kbps, Power Setting 100%



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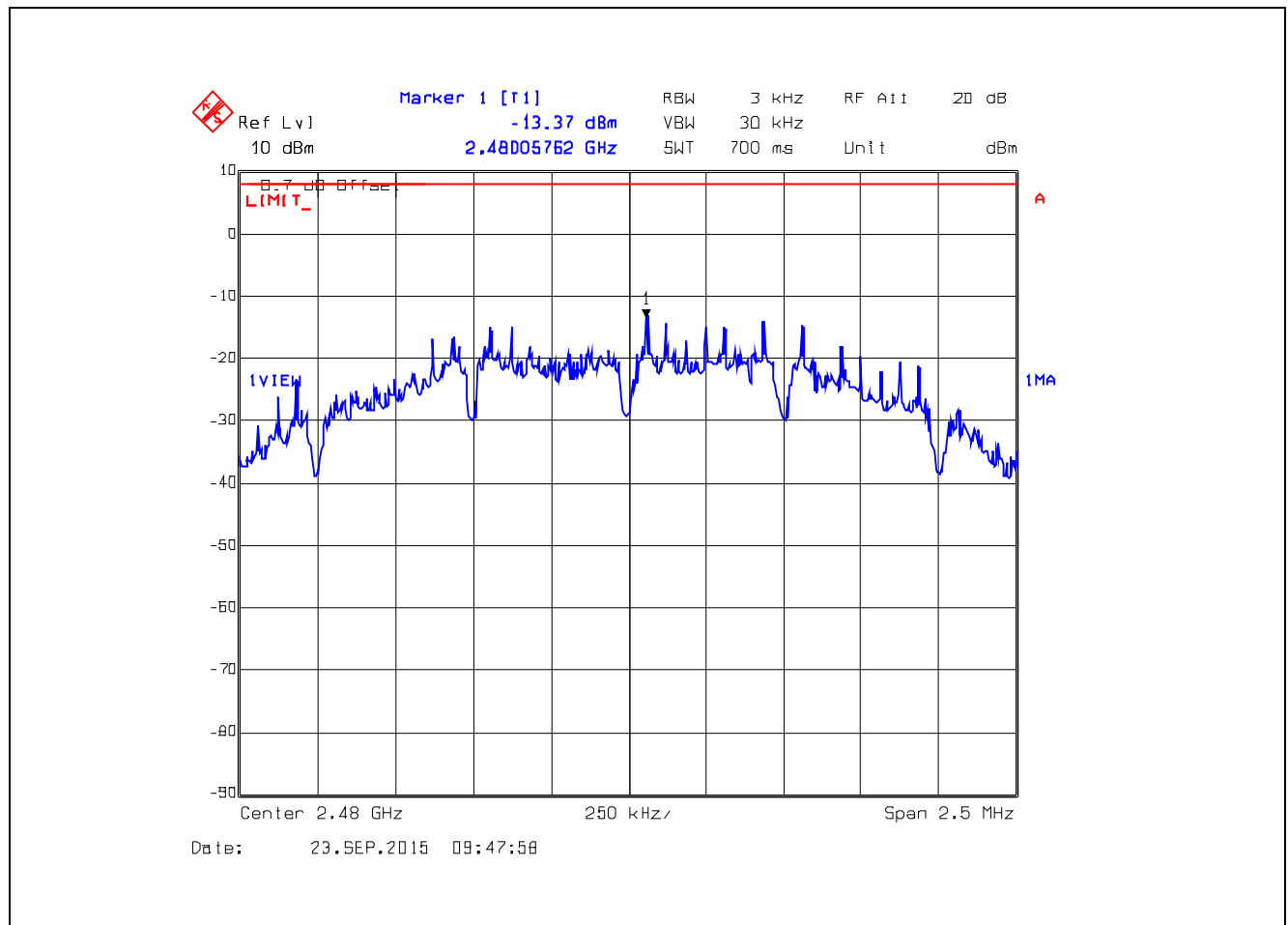
Tel. #: 905-829-1570, Fax. #: 905-829-8050, Email: yic@ultratech-labs.com, Website: <http://www.ultratech-labs.com>

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Plot 5.6.4.3. Peak PSD, Ch 16, 2480 MHz, OQPSK 250 kbps, Power Setting 100%



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5.7. RF EXPOSURE REQUIREMENTS [§§ 15.247(i), 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 v05r02, 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 section 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	

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.

In order to verify the SAR test exclusion as specified in Sec 4.3.1; for Standalone SAR test exclusion consideration and Sec 4.3.2; for Simultaneous transmission SAR test exclusion considerations for this module to be qualified with only the specified host (tap shoes), the following calculations performed. SAR extremity exposure condition applied.

Standalone SAR test exclusion threshold condition for each 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:

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

- f_{GHz} is the RF channel transmit frequency in GHz
- Power and distance are rounded to the nearest mW and mm before calculation²⁶
- 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

1. **UHF Radio: 697.8 MHz with Max 81.1 mw conducted power**

$$= (81.1)/(X) (\sqrt{.6978}) < 7.5$$

So minimum separation distance X = 9.1 mm so we use **10 mm**.

2. **802.15.4 Radio: 2.48 GHz with Max 0.7 mw conducted power @ 10 mm separation distance**

$$= (.7)/10 \times (\sqrt{2.48}) < 7.5$$

= **0.11** < 7.5, so it comfortably satisfies with 10 mm separation distance.

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Since it is possible that both radios can transmit simultaneously, we shall also verify the **Simultaneous transmission SAR test exclusion** condition as given in Sec 4.3.2 as shown below for the 10mm separation distance from the user.

- 2) When the standalone SAR test exclusion of section 4.3.1 is applied to an antenna that transmits simultaneously with other antennas, the standalone SAR must be estimated according to the following to determine simultaneous transmission SAR test exclusion:³⁰

- $(\text{max. power of channel, including tune-up tolerance, mW}) / (\text{min. test separation distance, mm}) \cdot [\sqrt{f_{\text{GHz}}}/x] \text{ W/kg}$ for test separation distances $\leq 50 \text{ mm}$;
where $x = 7.5$ for 1-g SAR, and $x = 18.75$ for 10-g SAR.

This SAR estimation formula has been considered, in conjunction with the *SAR Test Exclusion Thresholds*, to result in substantially conservative SAR values of $\leq 0.4 \text{ W/kg}$. When SAR is

1. UHF Radio: 697.8 MHz @ 81.1 mw conducted power

$$= (81.1)/(10) (\sqrt{.6978}/18.75) = 0.36 \text{ W/kg} < 0.4 \text{ W/kg}$$

2. 802.15.4 Radio: 2.48 GHz @ .7 mw

$$= (0.7)/(10) (\sqrt{2.48}/18.75) = 0.006 \text{ W/kg} < 0.4 \text{ W/kg}$$

The estimated SAR is only used to determine simultaneous transmission SAR test exclusion; it should not be reported as the standalone SAR. When SAR is estimated, it must be applied to determine the sum of 1-g SAR test exclusion.

Combined Estimated SAR = 0.366 W/kg < 0.4 W/kg

So we demonstrate compliance with SAR exclusion threshold when final installation of this module into the qualified host shall always maintain more than 10mm separation distance from the user feet.

EXHIBIT 6. TEST EQUIPMENT LIST

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range	Cal. Due Date
Spectrum Analyzer	Hewlett Packard	HP 8593EM	3412A00103	9 kHz–26.5 GHz	09 Apr 2017
Attenuator	Pasternack	PE7010-20	-	DC–2 GHz	02 Jan 2016
L.I.S.N	EMCO	3825/2	1165	0.10 -100 MHz	26 Sep 2016
Spectrum Analyzer	Rohde & Schwarz	FSEK30	100077	20Hz–40 GHz	21 Nov 2015
Attenuator	Pasternack	7024-20	6	DC–26.5 GHz	Cal on use
DC Block	Picosecond Pulse Labs	5501A	4678	0.7 kHz–26 GHz	Cal on use
Peak Power Analyzer	Hewlett Packard	8990A	3314A00602	0.5 - 40 GHz	11 Nov 2015
Peak Power Sensor	Hewlett Packard	84814A	3205A00175	0.5 - 40 GHz	13 Nov 2015
DC Block	Hewlett Packard	11742A	12460	0.045 – 26.5 GHz	Cal on use
High Pass Filter	K & L	11SH10-4000/T12000	4	Cut off 2400 MHz	Cal on use
Attenuator	Pasternack	7024-10	4	DC–26.5 GHz	Cal on use
Band Reject Filter	Micro-Tronics	BRM50701	105	Cut off 2.4-2.483 GHz	Cal on use
Spectrum Analyzer	Rohde & Schwarz	ESU40	100037	20Hz–40 GHz	08 May 2017
RF Amplifier	Hewlett Packard	84498	3008A00769	1 – 26.5 GHz	04 Feb 2016
RF Amplifier	Com-Power	PAM-118A	551016	0.5 – 18 GHz	06 Jan 2016
Biconilog	EMCO	3142C	26873	26-3000 MHz	14 Apr 2016
Horn Antenna	EMCO	3155	5955	1 – 18 GHz	26 Mar 2016
Horn Antenna	EMCO	3160-09	118385	18 – 26.5 GHz	04 Aug 2016

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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 <u>standard</u> 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 <u>standard</u> 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 <u>standard</u> 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 <u>standard</u> 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