TÜVRheinland®
Precisely Right.

Emissions
Test Report

EUT Name: Gemini

Model Nos.: Ti200, Ti300 and Ti400

CFR 47 Part 15.247 2014 and RSS 210: 2010

Prepared for:

David Lentz
Fluke Corporation.
6920 Seaway Blvd.
Everett, WA, USA 98203
Tel: (425) 446-5626

Prepared by:

TUV Rheinland of North America, Inc.
1279 Quarry Lane, Ste. A
Pleasanton, CA 94566
Tel: (925) 249-9123
Fax: (925) 249-9124
http://www.tuv.com/

Report/Issue Date: April 15, 2015
Report Number: 31560156.001
Revision Number: 0
Job Number: 0000123552

TÜVRheinland®
Precisely Right.

Statement of Compliance

Manufacturer:	*Fluke Corporation.*
	6920 Seaway Blvd. Everett, WA 98203 USA
Requester / Applicant:	*David Lentz*
Name of Equipment:	*Gemini*
Model No.	*Ti200, Ti300 and Ti400*
Type of Equipment:	*Intentional Radiator*
Application of Regulations:	*CFR 47 Part 15.247 2014 and RSS 210: 2010*
Test Dates:	*October 08 to November 25, 2014*

Guidance Documents:

Emissions: ANSI C63.10-2009

Test Methods:

Emissions: ANSI C63.10-2009

The electromagnetic compatibility test and documented data described in this report has been performed and recorded by TUV Rheinland, in accordance with the standards and procedures listed herein. As the responsible authorized agent of the EMC laboratory, I hereby declare that the equipment described above has been shown to be compliant with the EMC requirements of the stated regulations and standards based on these results. If any special accessories and/or modifications were required for compliance, they are listed in the Executive Summary of this report.

This report must not be used to claim product endorsement by A2LA. This report contains data that are not covered by A2LA accreditation. This report shall not be reproduced except in full, without the written authorization of TUV Rheinland of North America.

Suresh Kondapalli	April 15, 2015	David Spencer	
Test Engineer	Date	A2LA Signatory	Date

Testing Cert #3331.02 **US5254** **2932M-1**

1 Executive Summary

1.1 Scope

This report is intended to document the status of conformance with the requirements of the CFR 47 Part 15.247 2014 and RSS 210: 2010 based on the results of testing performed on October 08 to November 25, 2014 on the Gemini Model: Ti200, Ti300 and Ti400 manufactured by *Fluke Corporation.* This report only applies to the specific samples tested under the stated test conditions. It is the responsibility of the manufacturer to assure that additional production units of this model are manufactured with identical or EMI equivalent electrical and mechanical components. This report is further intended to document changes and modifications to the EUT throughout its life cycle. All documentation will be included as a supplement.

Gemini Model: Ti200, Ti300 and Ti400 were tested and certified Sep 2013. Additional data rates were added to the same hardware in 2014 via Test report #31362328.001. The scope present job is to obtain Class II permissive change for additional data rates (HT 20 mode) and BLE modes added.

1.2 Purpose

Testing was performed to evaluate the EMC performance of the EUT in accordance with the applicable requirements, procedures, and criteria defined in the application of regulations and application of standards listed in this report.

1.3 Summary of Test Results

Table 1: Summary of Test Results

Test	Test Method ANSI C63.4	Test Parameters (from Standard)	Result
2400 MHz to 2483.5 MHz Band			
Spurious Emission in Received Mode	CFR47 15.109, RSS-GEN Sect.7.2.3	Class B	**Complied**
Spurious Emission in Transmitted Mode	CFR47 15.209, RSS-GEN Sect.7.2.3	Class B	**Complied**
Restricted Bands of Operation	CFR47 15.205, RSS 210 Sect.2.6	Class B	**Complied**
AC Power Conducted Emission	CFR47 15.207, RSS-GEN Sect.7.2.2	Class A	**Complied**
Occupied Bandwidth	CFR47 15.247 (a2), RSS GEN Sect.4.4.1	≥ 500 kHz	**Complied**
Maximum Transmitted Power	CFR47 15.247 (b3), RSS 210 Sect. A.8.4	30 dBm	**Complied**
Peak Power Spectral Density	CFR47 15.247 (e), RSS 210 Sect. A.8.2	8 dBm/ 3 kHz.	**Complied**
Bandedge Measurement	CFR47 15.247 (d), RSS 210 Sect. A.8.5	30 dBr	**Complied**

Note: Since EUT is portable device where the end user will have the direct contact, RF Exposure/ SAR test requirements are evaluated separately

1.3.1 Measured values of key parameters

HT20 Mode

Test	Test Method ANSI C63.10	Measured value	Result
2400 MHz to 2483.5 MHz Band 802.11 HT20 mode			
Maximum Transmitted Power	CFR47 15.247 (b3), RSS 210 Sect. A.8.4	13.1mWatts	Complied
Occupied Bandwidth	CFR47 15.247 (a2), RSS GEN Sect.4.4.1	99% 16.43MHz 6dB, 16.44MHz	Complied
Peak Power Spectral Density	CFR47 15.247 (e), RSS 210 Sect. A.8.2	See plots	Complied
Spurious Emission in Transmitted Mode	CFR47 15.209, RSS-GEN Sect.7.2.3	See plots	Complied

BLE Mode

Test	Test Method ANSI C63.10	Measured value	Result
2400 MHz to 2483.5 MHz Band 802.11 BLE mode			
Maximum Transmitted Power	CFR47 15.247 (b3), RSS 210 Sect. A.8.4	5.35mW	Complied
Occupied Bandwidth	CFR47 15.247 (a2), RSS GEN Sect.4.4.1	99% , 1.034MHz	Complied
Spurious Emission in Transmitted Mode	CFR47 15.209, RSS-GEN Sect.7.2.3	See plots	Complied

1.4 Special Accessories

No special accessories were necessary in order to achieve compliance.

1.5 Equipment Modifications

None

2 Laboratory Information

2.1 Accreditations & Endorsements

2.1.1 US Federal Communications Commission

TUV Rheinland of North America EMC test facilities located at 1279 Quarry Lane, Ste. A, Pleasanton, CA, 94566, and 2305 Mission College Blvd, Ste. 105, Santa Clara, CA 95054, are recognized by the Commission for performing testing services for the general public on a fee basis. These laboratory test facilities have been fully described in reports submitted to and accepted by the FCC (Pleasanton Registration No. US5254, Santa Clara Registration No. US5251). The laboratory Scopes of Accreditation include Title 47 CFR Parts 15, 18 and 90. The accreditations are updated every three years.

2.1.2 A2LA

TUV Rheinland of North America EMC test facilities are accredited by the American Association for Laboratory Accreditation (A2LA). The laboratories have been assessed and accredited by A2LA in accordance with ISO Standard 17025:2005 (Testing Certificate #3331.02). The Scope of Laboratory Accreditation includes emission and immunity testing. The accreditations are updated annually.

2.1.3 Industry Canada

The Pleasanton 5-meter Semi-Anechoic Chamber, Registration No. 2932M-1, has been accepted by Industry Canada to perform testing to 3 and 5 meters based on the test procedures described in ANSI C63.4-2009. The Santa Clara 10-meter Semi-Anechoic Chamber, Registration No. 2932D-1, has been accepted by Industry Canada to perform testing to 3 and 10 meters based on the test procedures described in ANSI C63.4-2009.

2.1.4 Japan – VCCI

The Voluntary Control Council for Interference by Information Technology Equipment (VCCI) is a group that consists of Information Technology Equipment (ITE) manufacturers and EMC test laboratories. The purpose of the Council is to take voluntary control measures against electromagnetic interference from Information Technology Equipment, and thereby contribute to the development of a socially beneficial and responsible state of affairs in the realm of Information Technology Equipment in Japan. TUV Rheinland of North America EMC test facilities located at 1279 Quarry Lane, Ste. A, Pleasanton, CA, 94566, and 2305 Mission College Blvd, Ste. 105, Santa Clara, CA 95054, have been assessed and approved in accordance with the Regulations for Voluntary Control Measures.

2.2 Test Facilities

All of the test facilities are located at 1279 Quarry Lane, Pleasanton, California 94566, USA. The 2305 Mission College, Santa Clara, 95054, USA location is considered a Pleasanton annex.

2.2.1 Emission Test Facility

The Semi-Anechoic chamber and AC Line Conducted measurement facility used to collect the radiated and conducted data has been constructed in accordance with ANSI C63.7:TUV192. The site has been measured in accordance with and verified to comply with the theoretical normalized site attenuation requirements of ANSI C63.4-2009, at a test distance of 3 and 5 meters. The site is listed with the FCC and accredited by A2LA (Testing Cert #3331.02). The 3/5-meter semi-anechoic chamber used to collect the radiated data has been verified to comply with the theoretical normalized site attenuation requirements of ANSI C63.4-2009, at a test distance of 3 meter and 5 meters. A report detailing this site can be obtained from TUV Rheinland of North America.

2.2.2 Immunity Test Facility

ESD, EFT, Surge, and PQF: These tests are performed in an environmentally controlled room with a 3.7 m x 4.8 m x 3.175 mm thick aluminum floor connected to PE ground.

For ESD testing, tabletop equipment is placed on an insulated mat with a surface resistivity of 10^9 Ohms/square on a 1.6 m x 0.8 m x 0.8 m high non-conductive table with a 3.175 mm aluminum top (Horizontal Coupling Plane). The HCP is connected to the main ground plane via a low impedance ground strap through two 470-kΩ resistors. The Vertical Coupling Plane consists of an aluminum plate 50 cm x 50 cm x 3.175 mm thick. The VCP is connected to the main ground plane via a low impedance ground strap through two 470-kΩ resistors.

For EFT, Surge, PQF, the HCP and VCP are removed.

RF Field Immunity testing is performed in a 7.3m x 4.3m x 4.1m anechoic chamber.

RF Conducted and Magnetic Field Immunity testing is performed on a 4.8m x 3.7m x 3.175mm thick aluminum ground plane.

All test areas allow a minimum distance of 1 meter from the EUT to walls or conducting objects.

2.3 Measurement Uncertainty

Two types of measurement uncertainty are expressed in this report, per *ISO Guide To The Expression Of Uncertainty In Measurement*, 1st Edition, TUV195.

The Combined Standard Uncertainty is the standard uncertainty of the result of a measurement when that result is obtained from the values of a number of other quantities; it is equal to the positive square root of the sum of the variances or co-variances of these other quantities, weighted according to how the measurement result varies with changes in these quantities. The term *standard uncertainty* is the result of a measurement expressed as a standard deviation.

2.3.1 Sample Calculation – radiated & conducted emissions

The field strength is calculated by subtracting the Amplifier Gain and adding the Cable Loss and Antenna Correction Factor to the measured reading. The basic equation is as follows:

Field Strength (dBμV/m) = RAW - AMP + CBL + ACF

Where: RAW = Measured level before correction (dBμV)

AMP = Amplifier Gain (dB)

CBL = Cable Loss (dB)

ACF = Antenna Correction Factor (dB/m)

$$\mu V/m = 10^{\frac{dB\mu V/m}{20}}$$

Sample radiated emissions calculation @ 30 MHz

Measurement +Antenna Factor–Amplifier Gain+Cable loss=Radiated Emissions (dBuV/m)

25 dBuV/m + 17.5 dB – 20 dB + 1.0 dB = 23.5 dBuV/m

2.3.2

Per CISPR 16-4-2	**U_{lab}**	**U_{cispr}**
Radiated Disturbance @ 10 meters		
30 – 1,000 MHz	2.25 dB	4.51 dB
Radiated Disturbance @ 3 meters		
30 – 1,000 MHz	2.26 dB	4.52 dB
1 – 6 GHz	2.12 dB	4.25 dB
6 – 18 GHz	2.47 dB	4.93 dB
Conducted Disturbance @ Mains Terminals		
150 kHz – 30 MHz	1.09 dB	2.18 dB
Disturbance Power		
30 MHz – 300 MHz	3.92 dB	4.3 dB

Voltech PM6000A

The estimated combined standard uncertainty for harmonic current and flicker measurements is ± 5.0%.	Per CISPR 16-4-2 Methods

2.3.3 Measurement Uncertainty Immunity

The estimated combined standard uncertainty for ESD immunity measurements is ± 8.2%.	Per IEC 61000-4-2
The estimated combined standard uncertainty for radiated immunity measurements is ± 4.10 dB.	Per IEC 61000-4-3
The estimated combined standard uncertainty for conducted immunity measurements with CDN is ± 3.66 dB	Per IEC 61000-4-6
The estimated combined standard uncertainty for power frequency magnetic field immunity is ± 2.9%.	Per IEC 61000-4-8

Thermo KeyTek EMC Pro

The estimated combined standard uncertainty for EFT fast transient immunity measurements is ± 2.6%.
The estimated combined standard uncertainty for surge immunity measurements is ± 2.6%.
The estimated combined standard uncertainty for voltage variation and interruption measurements is ± 1.74%.

The expanded uncertainty at a level of 95% confidence is obtained by multiplying the combined standard uncertainty by a coverage factor of 2. Compliance criteria are not based on measurement uncertainty.

2.4 Calibration Traceability

All measurement instrumentation is traceable to the National Institute of Standards and Technology (NIST). Measurement method complies with ANSI/NCSL Z540-1-1994 and ISO Standard 17025:2005. Equipment calibration records are kept on file at the test facility.

2.5 Calibration Traceability

All measurement instrumentation is traceable to the National Institute of Standards and Technology (NIST). Measurement method complies with ANSI/NCSL Z540-1-TUV194 and ISO Standard 17025:2005. Equipment calibration records are kept on file at the test facility.

3 Product Information

3.1 Product Description

Gemini is Thermal Imager with Wi-fi, Bluetooth and Zigbee radios and is used as Portable measuring device.

Fluke Thermal Imagers (sometimes referred to as infrared cameras, thermal cameras, or infrared imagers) capture images of infrared energy or temperature. Using patent-pending IR-Fusion technology, Fluke Thermal Imagers combine the power of infrared images with visible light images on the same display.

Thermal imaging or thermography, detects heat patterns or temperature changes in objectsThermal imaging or thermography, detects heat patterns or temperature changes in objects.

The Thermal Imagers have three Models: Ti200, Ti300, and Ti400. The model differences are with Infrared Resolution, Temperature Measurements Ranges, and Thermal Sensitivity. The models use the same hardware. Software settings are used to configure the models

The protocol used will be similar to Zigbee but tailored to meet Fluke proprietary requirements**.**

Additional data rates were added to the same hardware approved Sep 2013. This report presents additional tests required for added data rate (HT 20 mode) and BLE mode.

3.2 Equipment Configuration

A description of the equipment configuration is given in the Test Plan Section. The EUT was tested as called for in the test standard and was configured and operated in a manner consistent with test standards. The EUT was programed to rated power and allowed to reach intended operating conditions. The placement of the EUT system components was guided by the test standard and selected to represent typical installation conditions.

In the case of EUT that can operate in more than one configuration, preliminary testing was performed to determine the configuration that produced maximum radiation.

The final configuration was selected to produce the worst case radiation for emissions testing and to place the EUT in the most susceptible state for immunity testing.

3.3 Operating Mode

A description of the operation mode is given in the Test Plan Section. In the case of an EUT that can operate in more than one state, preliminary testing was performed to determine the operating mode that produced maximum radiation.

EUT was programed to operate at > 99% duty for the purpose of testing. This operating mode was selected to produce the worst case radiation for emissions testing and to place the EUT in the most susceptible state for immunity testing.

3.4 Duty Cycle:

None

3.5 Unique Antenna Connector

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of CFR47 Parts 15.211, 15.213, 15.217, 15.2TUV1, or 15.221.

3.5.1 Results

The Gemini has one internal antenna. EUT is compliant. Antenna details are provided as separate exhibit.

4 Emission Requirements – 2400 MHz to 2483.5 MHz Band

Testing was performed in accordance with CFR 47 Part 15.247: 2014 and RSS 210 Annex 8: 2010. These test methods are listed under the laboratory's A2LA Scope of Accreditation. This test measures the levels emanating from the EUT, thus evaluating the potential for the EUT to cause radio frequency interference to other electronic devices. Procedures described in section 8 of the standard were used.

4.1 Output Power Requirements

The maximum output power requirement is the maximum equivalent isotropic radiated power delivering at the transmitting antenna under specified conditions of measurements in the presence of modulation.

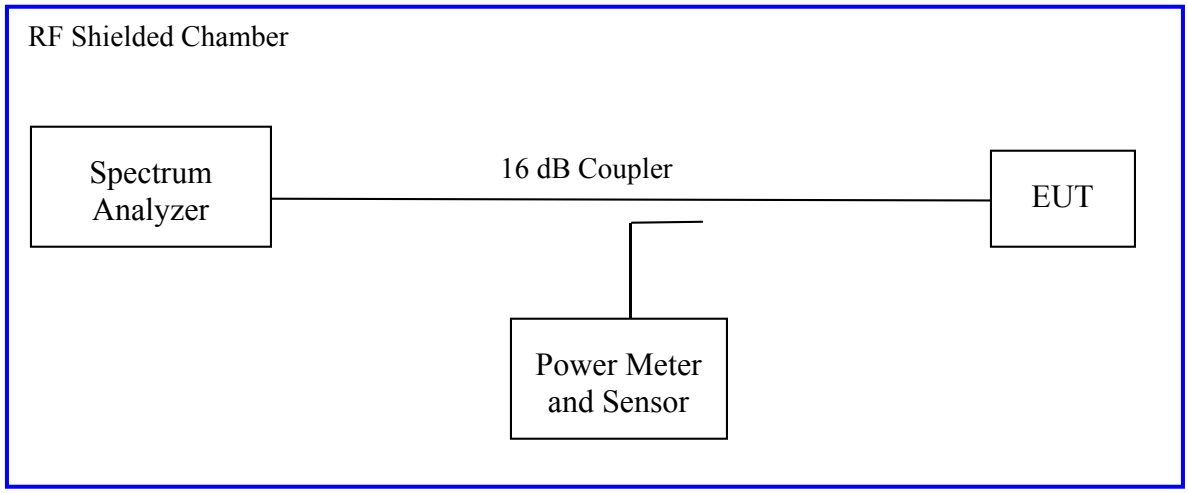
The maximum output power and harmonics shall not exceed CFR47 Part 15.247 (b3) and RSS 210 A.8.4: 2010

The maximum transmitted power is +30 dBm or 1 Watt.

4.1.1 Test Method

The conducted method was used to measure the channel power output according to ANSI C63.10:2009 Section 6.10.3.1. The measurement was performed with modulation per CFR47 Part 15.247 (b3):2011 and RSS 210 A.8.4. The worst mode result indicated below.

Test Setup:



Method #1 of "Measurement of Digital Transmission Systems Operating under Section 15.247"applies since the EUT continuously transmit; where T, Transmission Duration Pulse, is greater than analyzer sweep time.

4.1.2 Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 2: RF Output Power at the Antenna Port – Test Results

Test Conditions: Conducted Measurement, Normal Temperature				
Antenna Type: Internal			**Power Setting:** See test plan	
Max. Antenna Gain: +1.5 dBi				
Ambient Temp.: 21 °C			**Relative Humidity:**39%	
802.11 HT20 Mode				
Operating Channel	**Limit [dBm]**	**[dBm]**	**Power [mWatts]**	**Margin [dB]**
2412 MHz	+30.00	11.18	13.1	-18.82
2437MHz	+30.00	10.12	10.3	-19.70
2462MHz	+30.00	10.19	10.4	-19.60
Note: EUT has duty cycle EUT was modified to transmit continuously for test purpose. EUT normal data rate is 6.5Mbps. No duty cycle was applied				

802.11 BLE Mode				
Operating Channel	**Limit [dBm]**	**[dBm]**	**Power [mWatts]**	**Margin [dB]**
2402 MHz	30	5.35	3.42	-24.65
2440 MHz	30	5.28	3.37	-24.72
2480 MHz	30	4.85	3.05	-25.15
Note: EUT has duty cycle EUT was modified to transmit continuously for test purpose. EUT normal data rate is 1Mbps.				

.

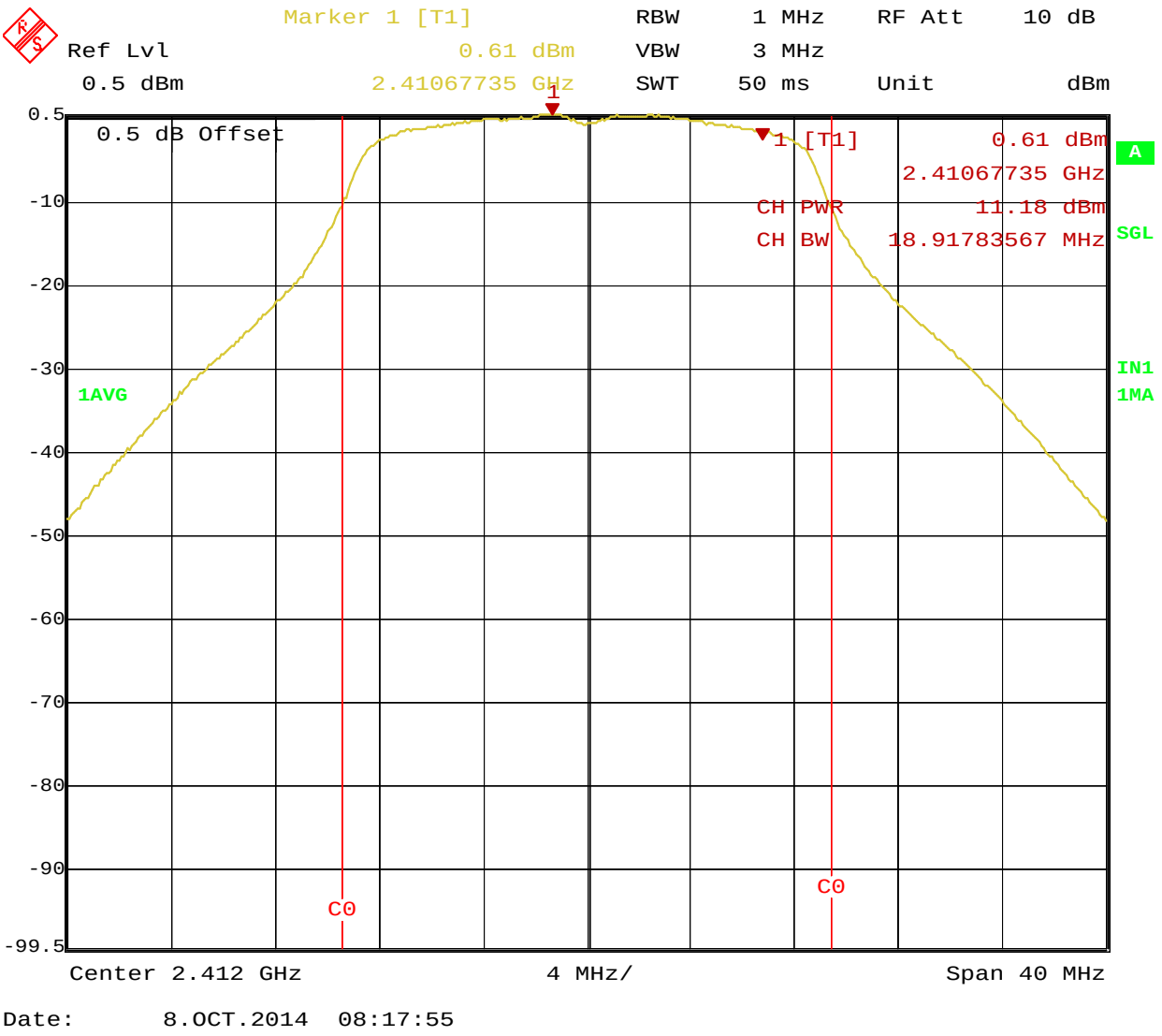


Figure 1: Maximum Transmitted Power, 2412 MHz HT 20 mode

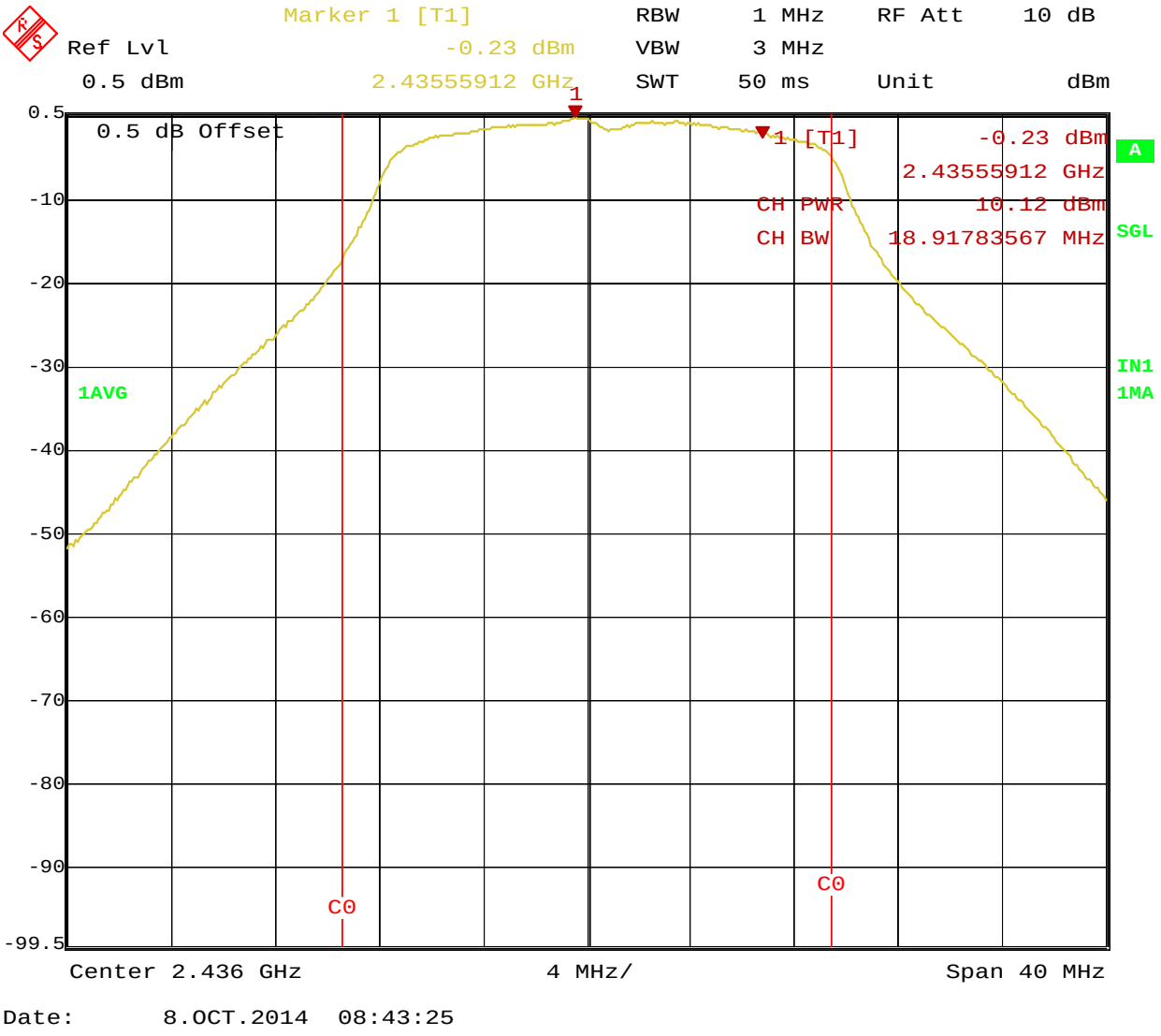


Figure 2: Maximum Transmitted Power, 2437MHz

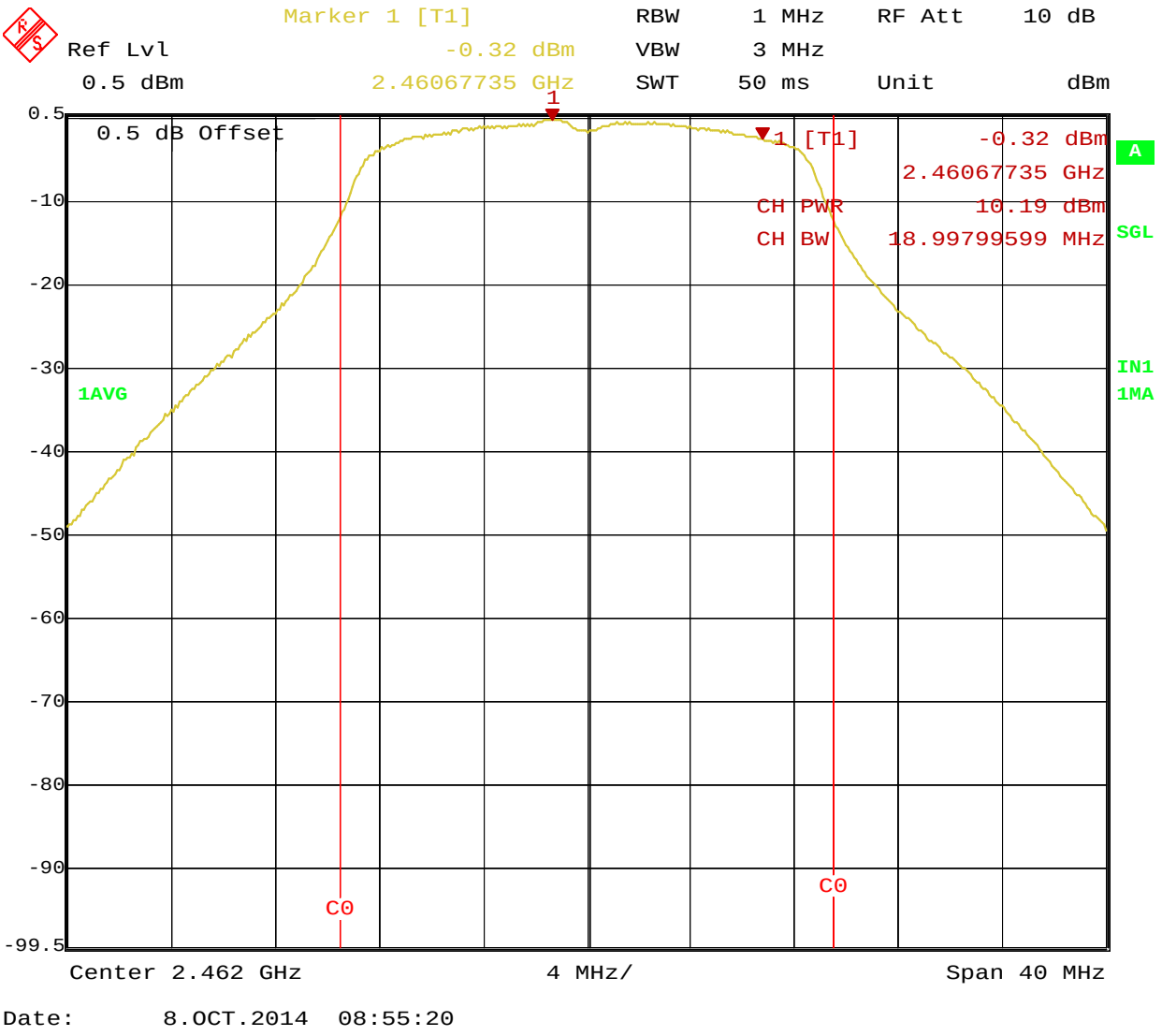


Figure 3: Maximum Transmitted Power, 2462 MHz, 6.5 Mbps

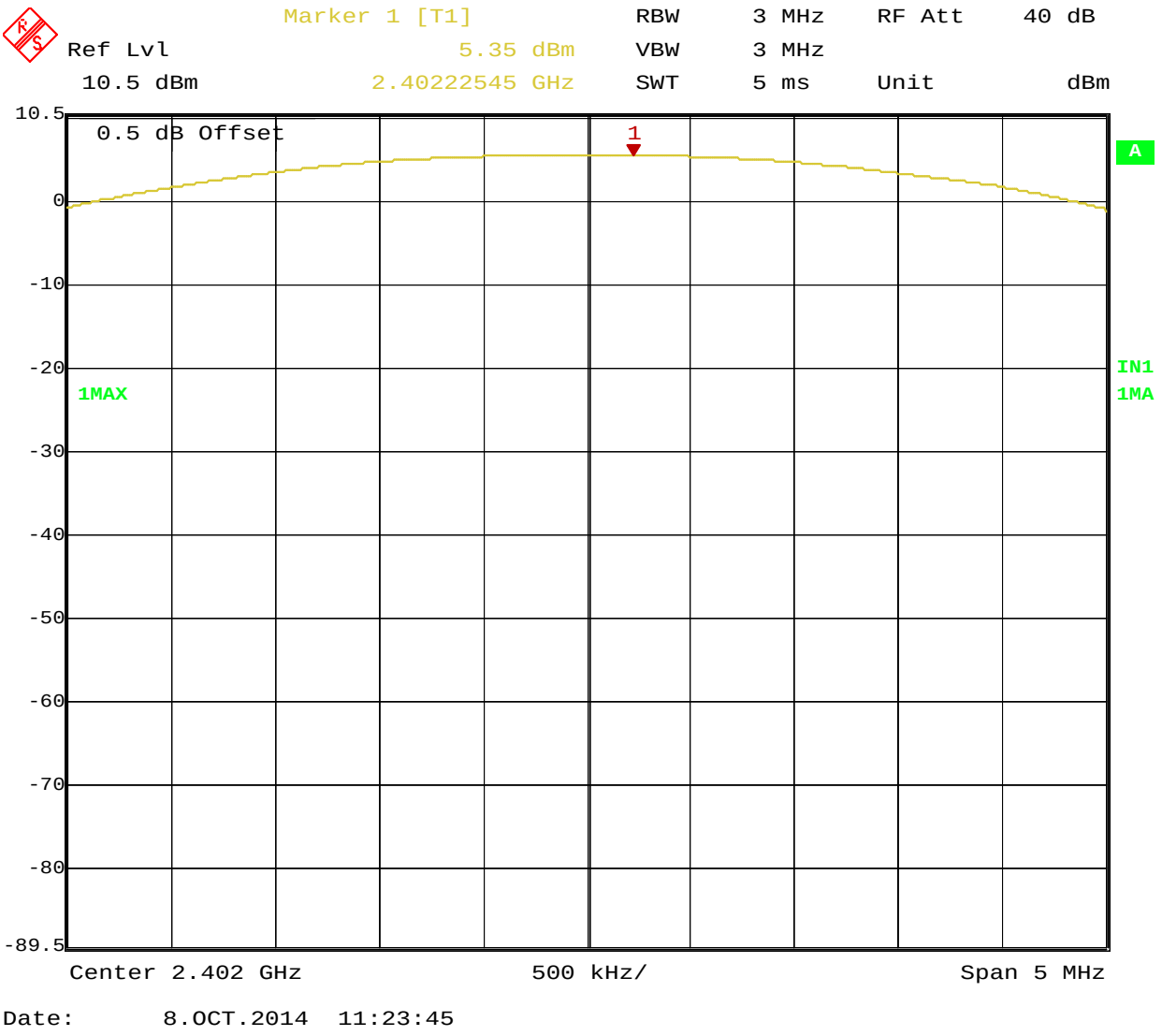


Figure 4: Maximum Transmitted Power, 2402 MHz, BLE mode 1 Mbps

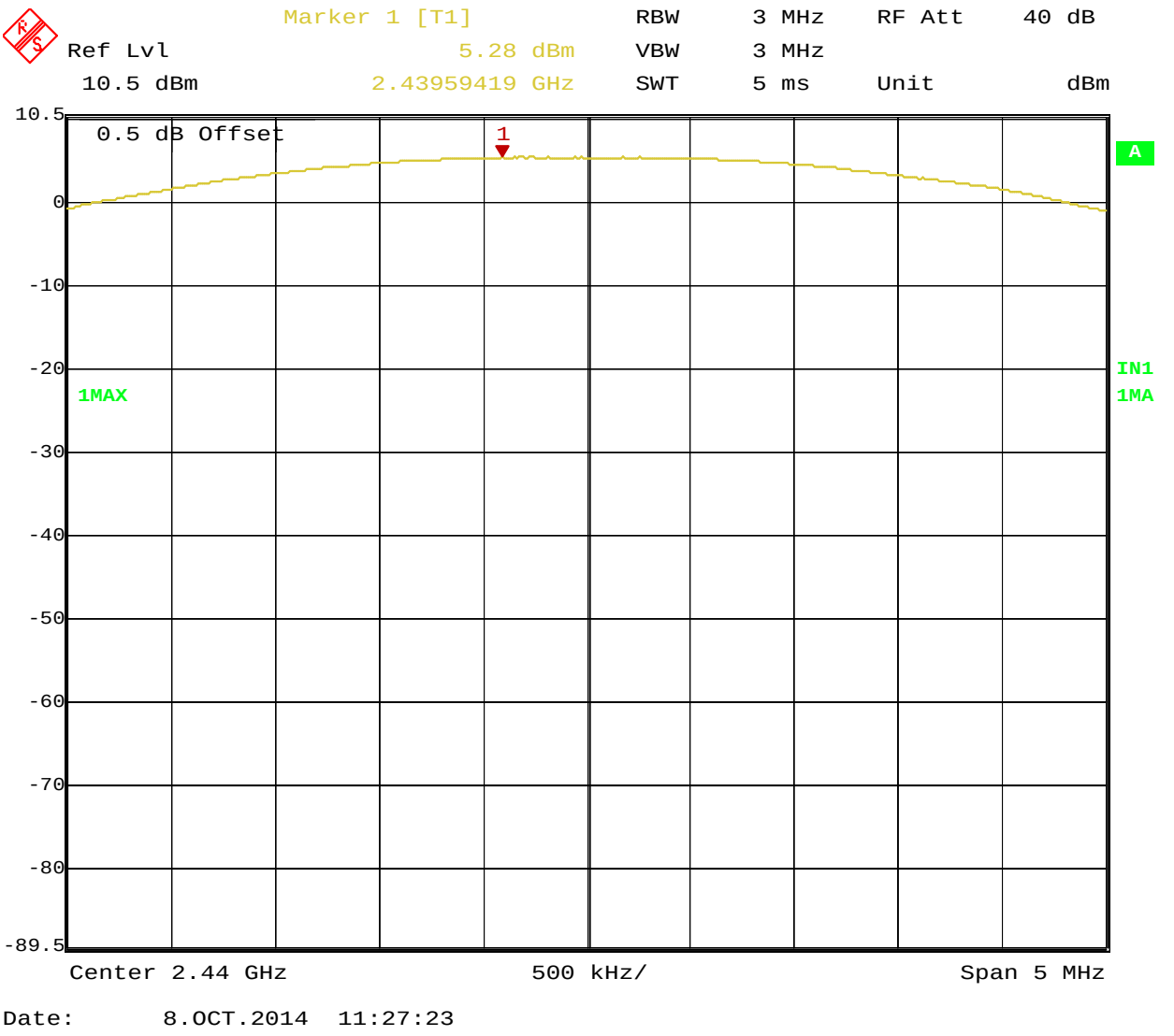


Figure 5: Maximum Transmitted Power, 2440 MHz, BLE mode 1 Mbps

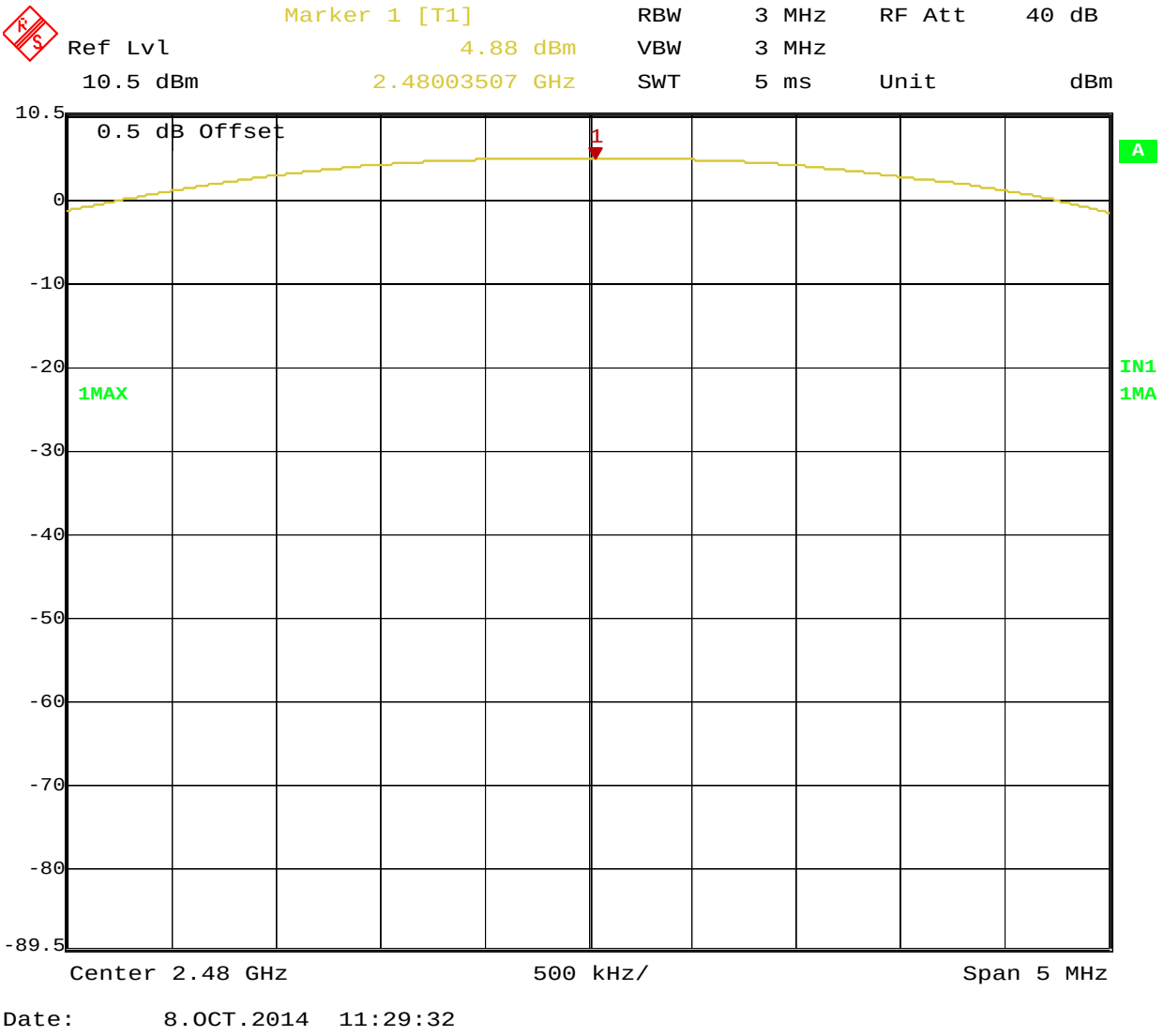


Figure 6: Maximum Transmitted Power, 2480 MHz, BLE mode 1 Mbps

4.2 Occupied Bandwidth

The occupied bandwidth is measured at an amplitude level reduced from the reference level by a specified ratio. The reference level is the level of the highest amplitude signal observed from the transmitter at the fundamental frequency.

The 99% bandwidth is the bandwidth in which 99% of the transmitted power occupied.

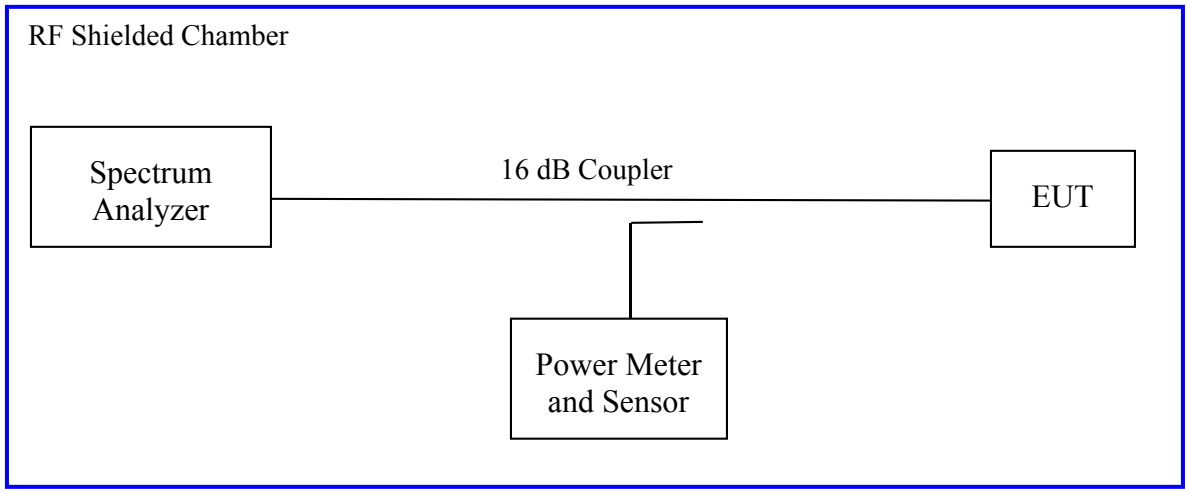
The 6 dB bandwidth is defined the bandwidth of 6 dBr from highest transmitted level of the fundamental frequency.

The bandwidth shall be at least 500 kHz per Section CFR47 15.247(a2) 2011and RSS Gen Sect. 4.4.1: 2010.

4.2.1 Test Method

The conducted method was used to measure the occupied bandwidth. The measurement was performed with modulation per CFR47 15.247(a2) 2014 and RSS Gen Sect. 4.4.1:2010.The worst sample result indicated below.

Test Setup:



4.2.2 Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 3: Occupied Bandwidth – Test Results

Test Conditions: Conducted Measurement, Normal Temperature and Voltage only				
Antenna Type: Internal		**Power Setting:** See test plan		
Max. Antenna Gain: +1.5 dBi		**Signal State:** Modulated		
Ambient Temp.: 21 °C		**Relative Humidity:**33%		
Bandwidth (MHz) for 802.11 HT20mode				
Freq. (MHz)	**Limit (kHz)**	**99% BW (MHz)**	**6 dB BW (MHz)**	**Results**
2412	500	16.40	16.44	Pass
2437	500	16.43	16.44	Pass
2462	500	16.40	16.45	Pass

Test Conditions: Conducted Measurement, Normal Temperature and Voltage only			
Antenna Type: Internal		**Power Setting:** See test plan	
Max. Antenna Gain: +1.5 dBi		**Signal State:** Modulated	
Ambient Temp.: 21 °C		**Relative Humidity:**33%	
Bandwidth (MHz) for 802.11 BLE mode			
Freq. (MHz)	**99% BW (MHz)**	**6 dB BW (MHz)**	**Results**
2402	1.034	1.176	Pass
2440	1.034	1.176	Pass
2480	1.034	1.176	Pass

Note:

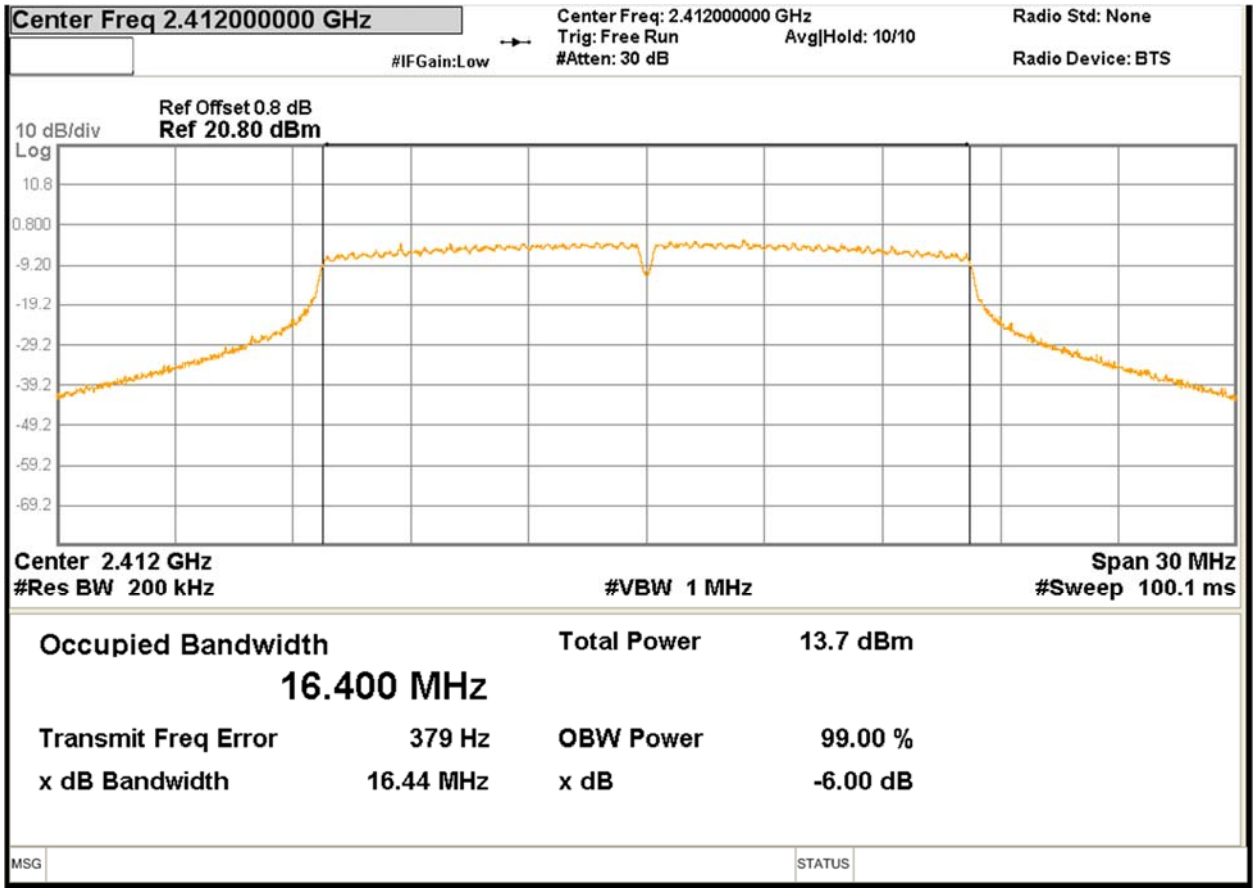


Figure 7: 6 dB Bandwidth at – Operating Channel 2412 MHz

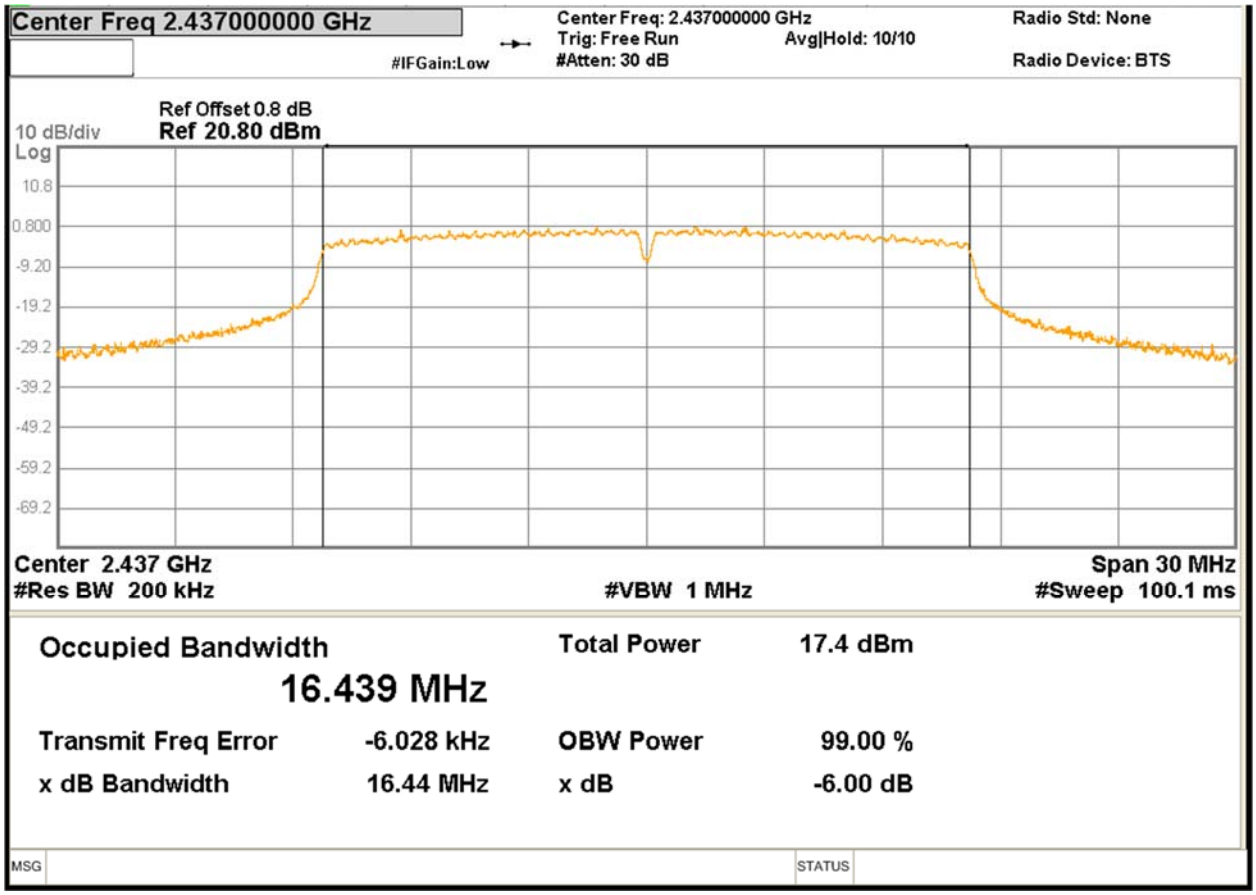
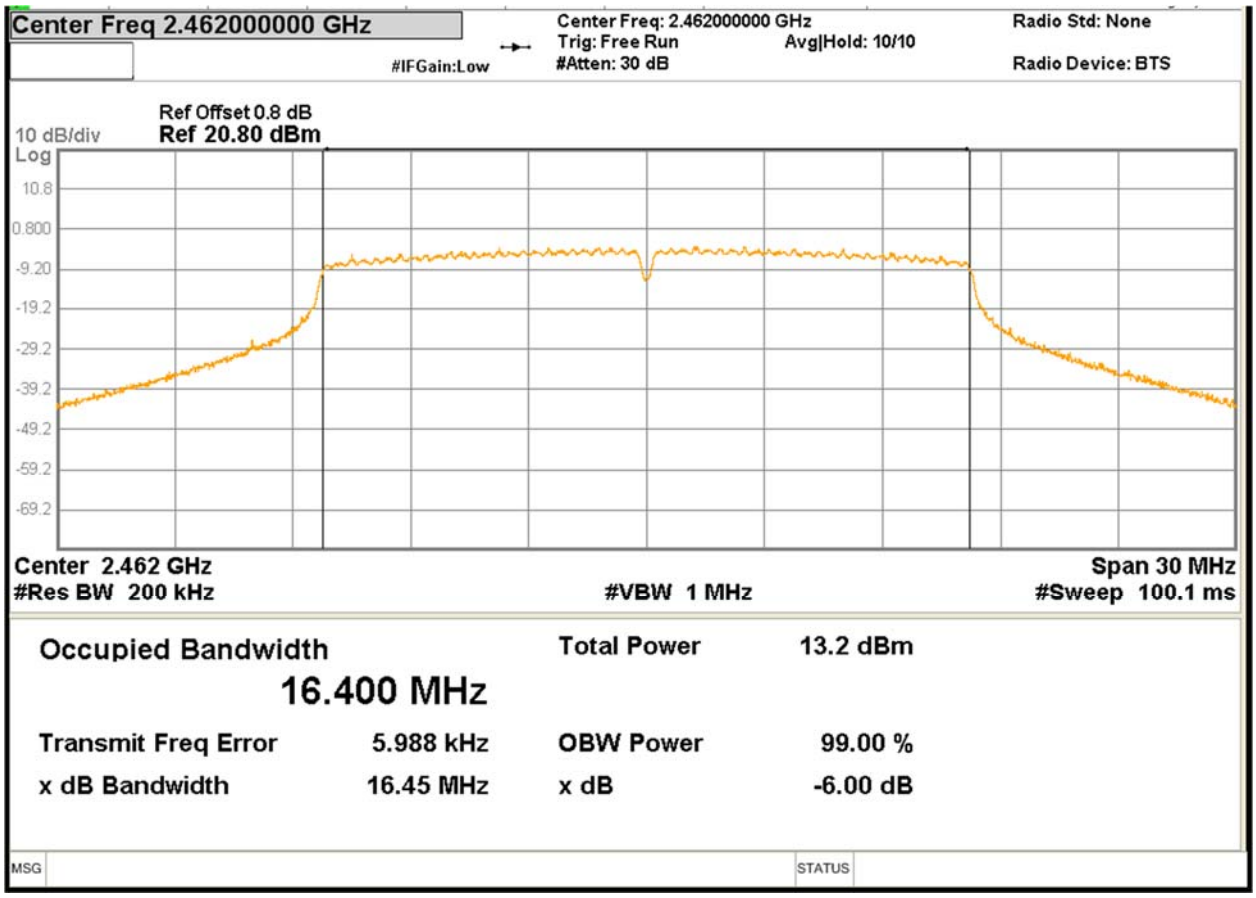


Figure 8: 6 dB Bandwidth at – Operating Channel 2437 MHz



F**igure 9:** 6 dB Bandwidth at– Operating Channel 2462MHz

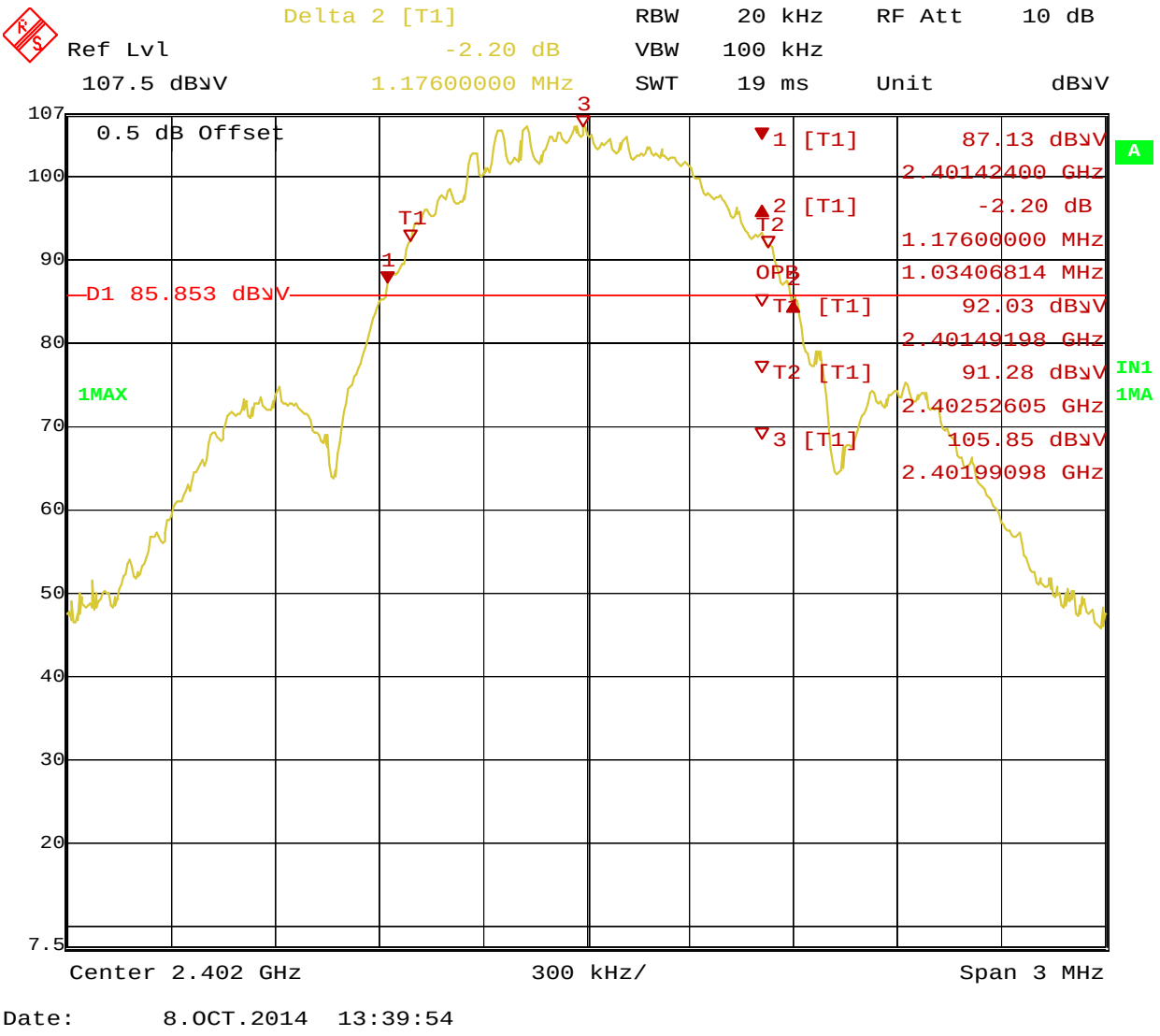


Figure 10: 6 dB Bandwidth at– Operating Channel 2402MHz

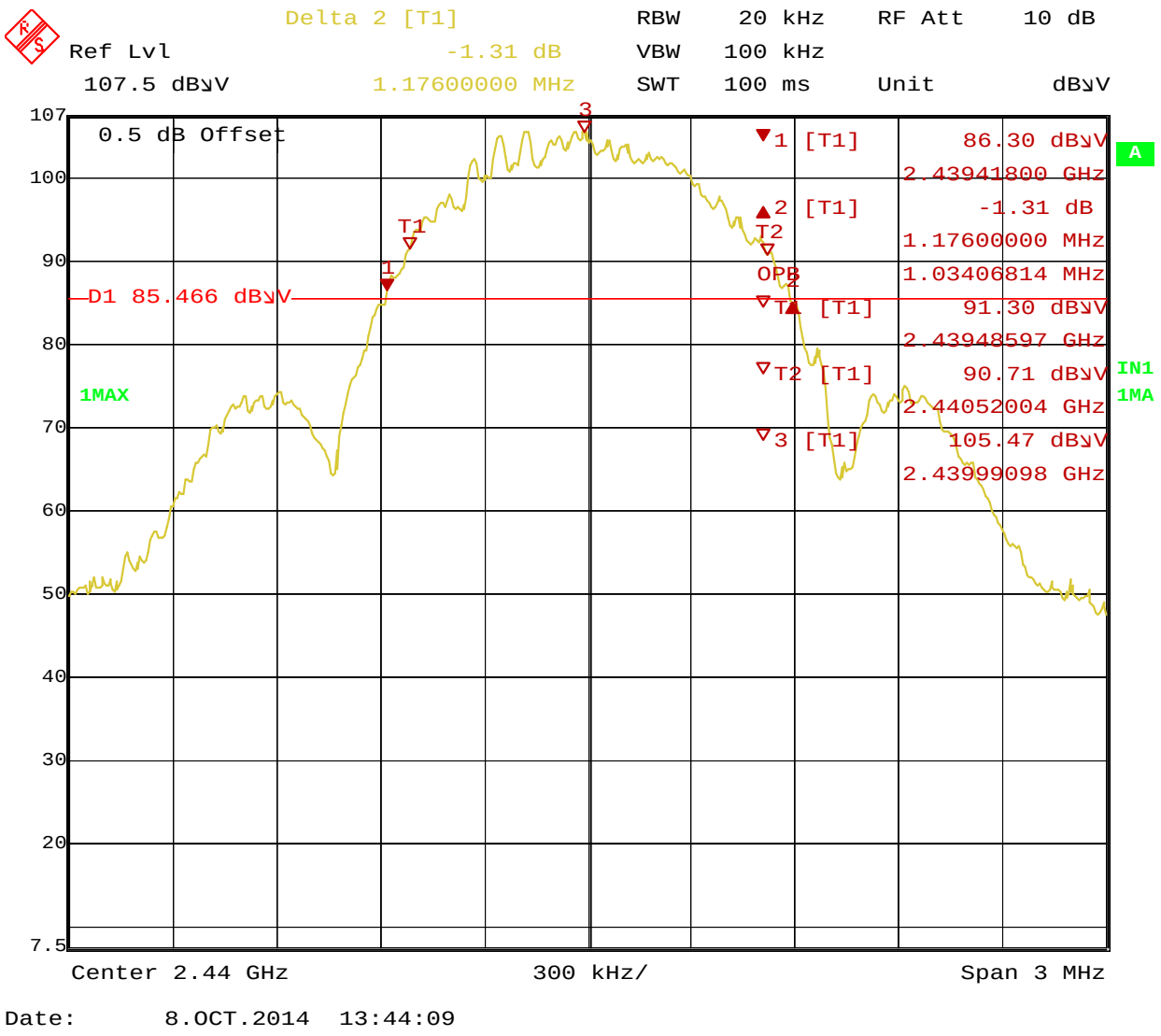


Figure 11: 6 dB Bandwidth at– Operating Channel 2440MHz

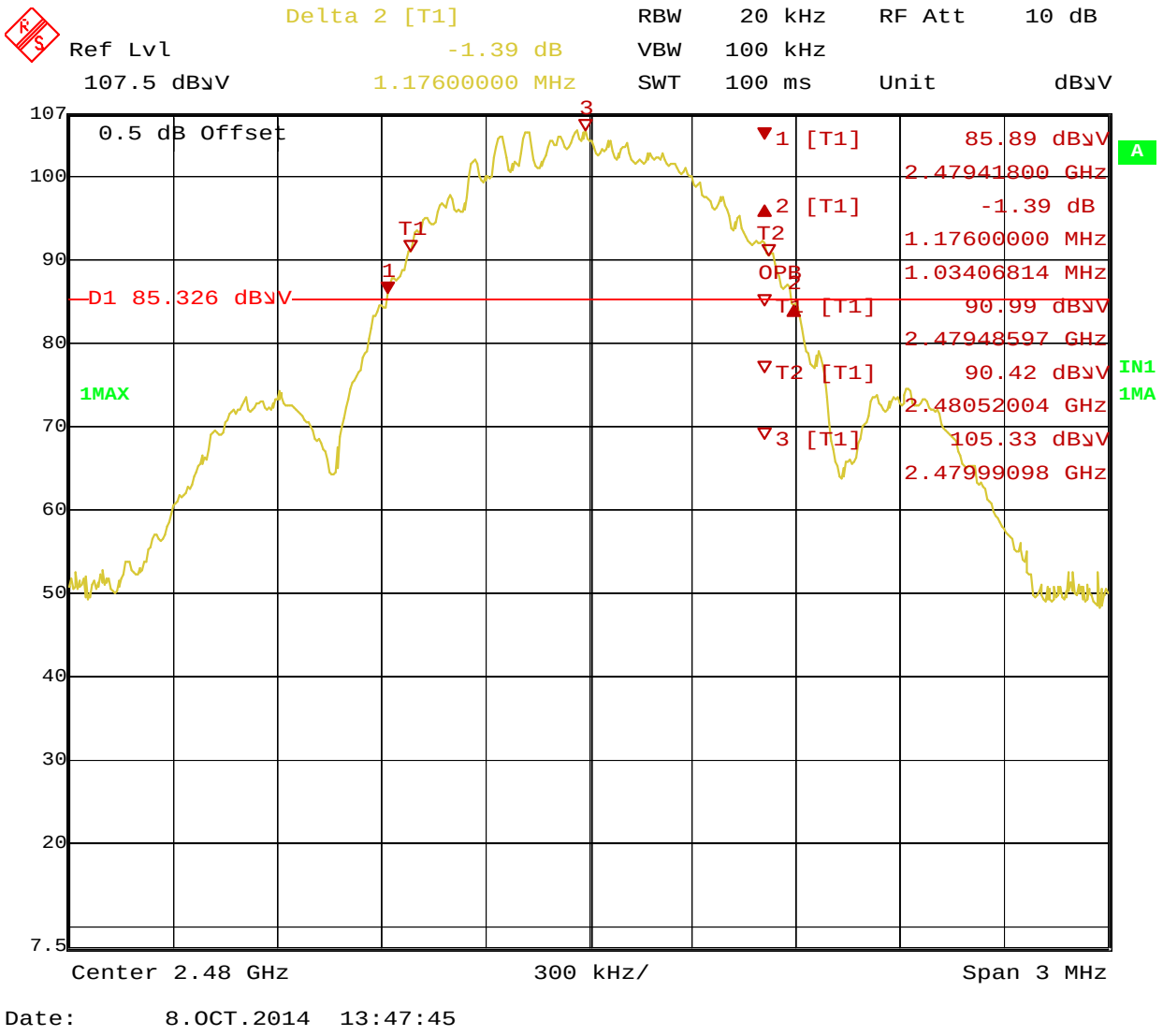


Figure 12: 6 dB Bandwidth at– Operating Channel 2480MHz

4.3 Band-edge Requirements

The setup was identical to RF output power measurement. Intentional radiators operating under the alternative provisions to the general emission limits, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If the frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

Any frequency outside the band of 2400 MHz to 2483.5 MHz, the power output level must be below 20 dB from the in-band transmitting signal; CFR 47 Part 15.215, 15.247(d) and RSS 210 A8.5

4.3.1 Results

The Out of band emission was performed on the conducted test Sample.

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 4: Band-Edge Requirements – Test Results

Test Conditions: Conducted Measurement, Normal Temperature and Voltage only				
Antenna Type: Internal		**Power Setting:** See test plan		
Max. Antenna Gain: +1.5 dBi		**Signal State:** Modulated		
Ambient Temp.: 21 °C		**Relative Humidity:**39%		
-20 dB Band-Edge Results				
Operating Freq.	**Mode**	**Limit (dBm)**	**Measured Value (dBm)**	**Result**
2412 MHz	6.5Mbps	-33.57	-44.34	Pass
2437MHz	6.5Mbps	-32.89	-70.22	Pass
2462MHz	6.5Mbps	-33.87	-69.45	Pass
Note: The stated limits for 30 dBr are relative to each individual output per KDB 662911 Method.				

Note: All bandedge measurements were performed as indicated in the above table. Only worst case/ limited number of plots are placed in the report.

Table 5: Out of band Conducted Emission – Test Results

HT20 mode

Operating Freq.	Mode	Result
2412MHz	1Mbps	Pass
2437MHz	1Mbps	Pass
2462 MHz	1Mbps	Pass

BLE mode

Operating Freq.	Mode	Result
2402MHz	1Mbps	Pass
2440 MHz	1Mbps	Pass
2480 MHz	1Mbps	Pass

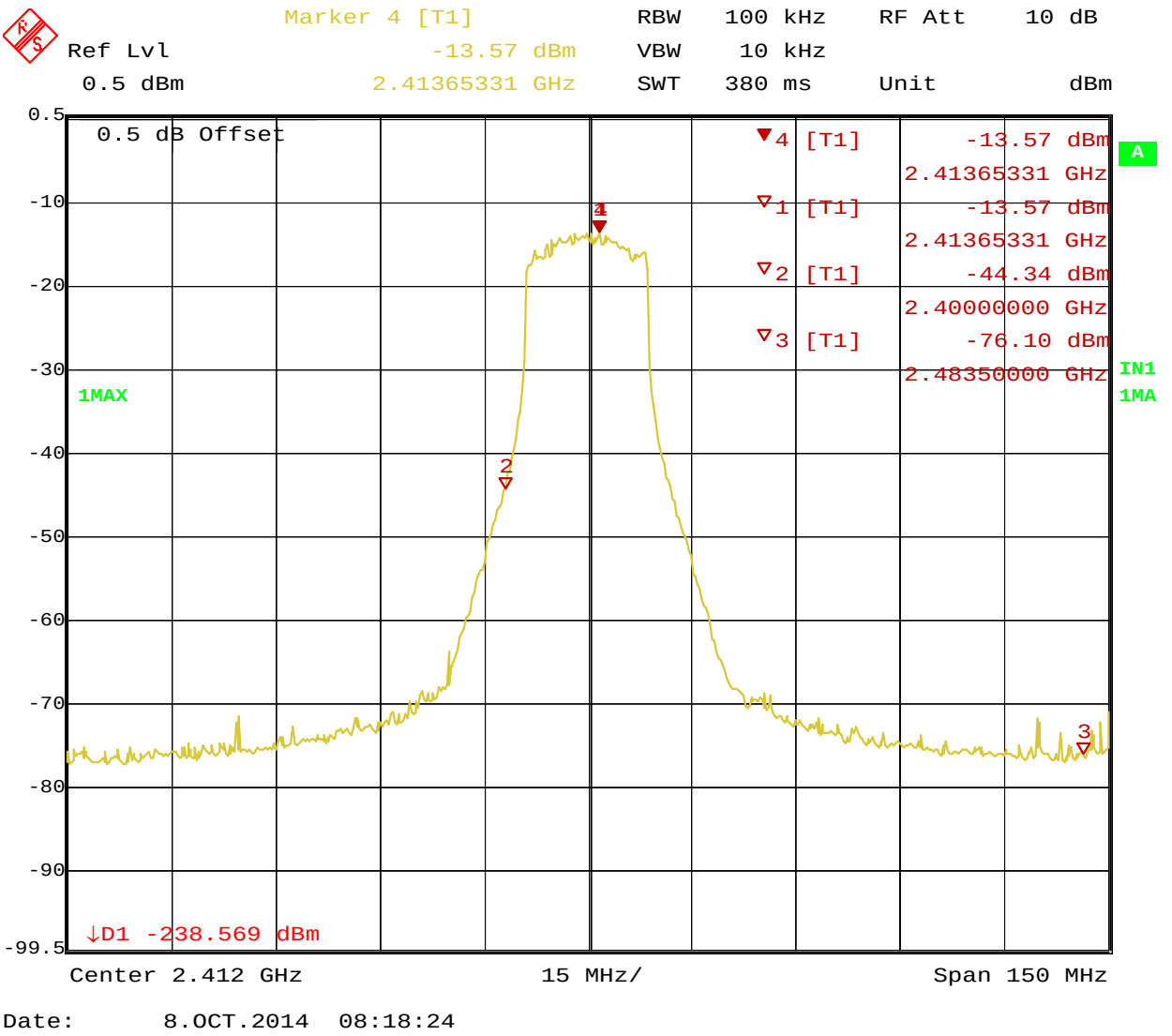


Figure 13: Band-edge Requirement at Operating Channel 2412 MHz

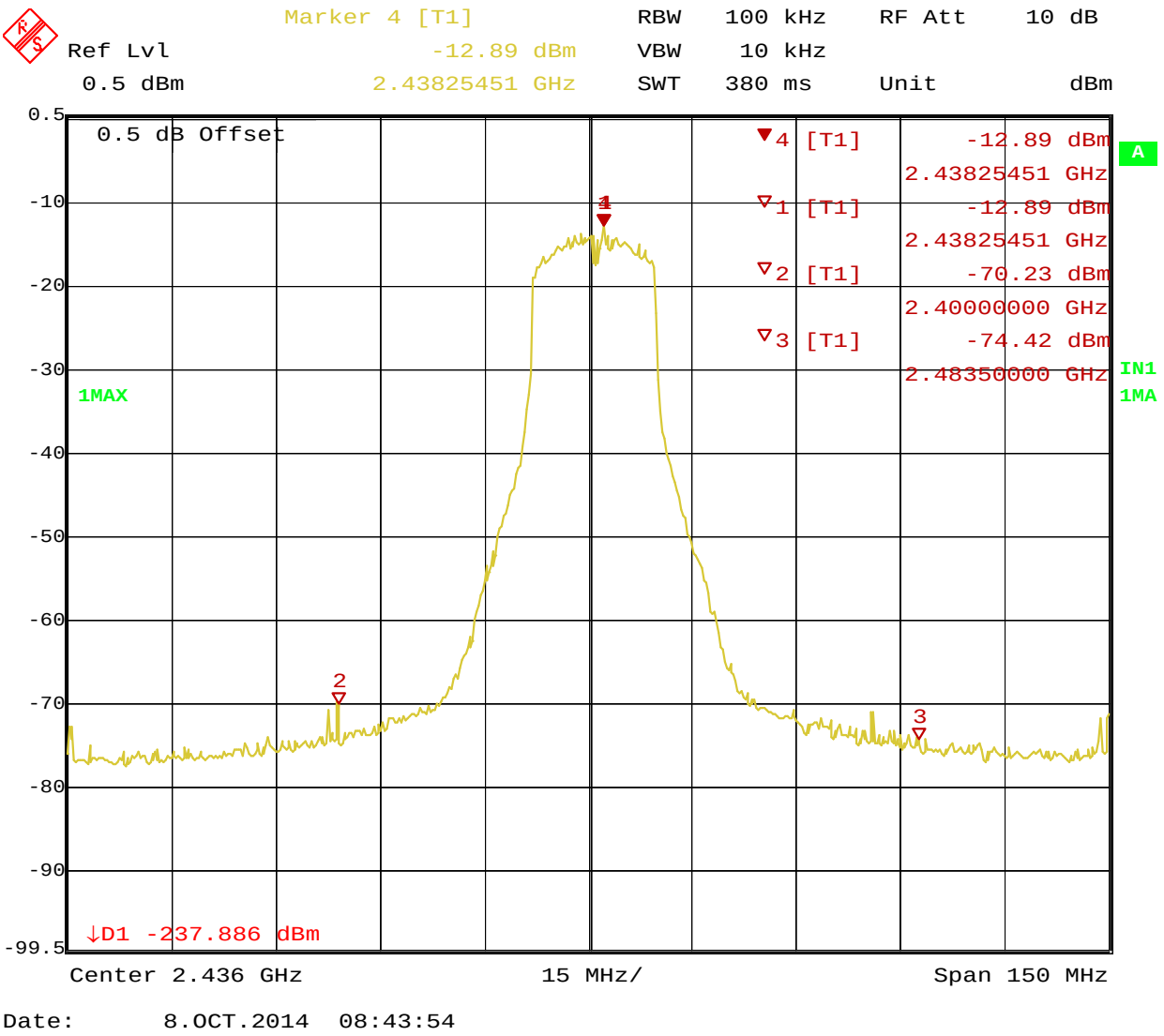


Figure 14: Band-edge Requirement at Operating Channel 2437 MHz

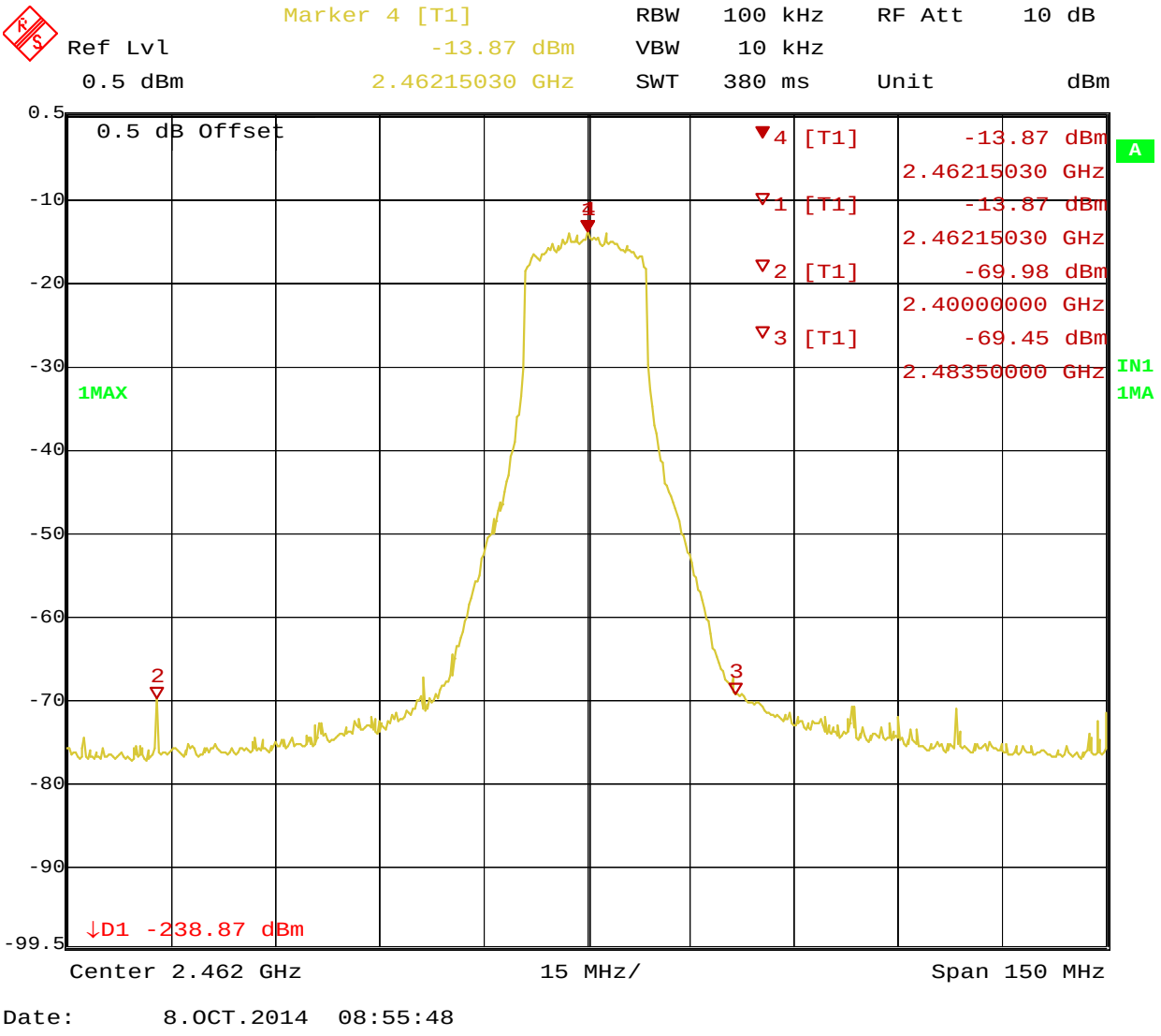


Figure 15: Band-edge Requirement at Operating Channel 2462 MHz

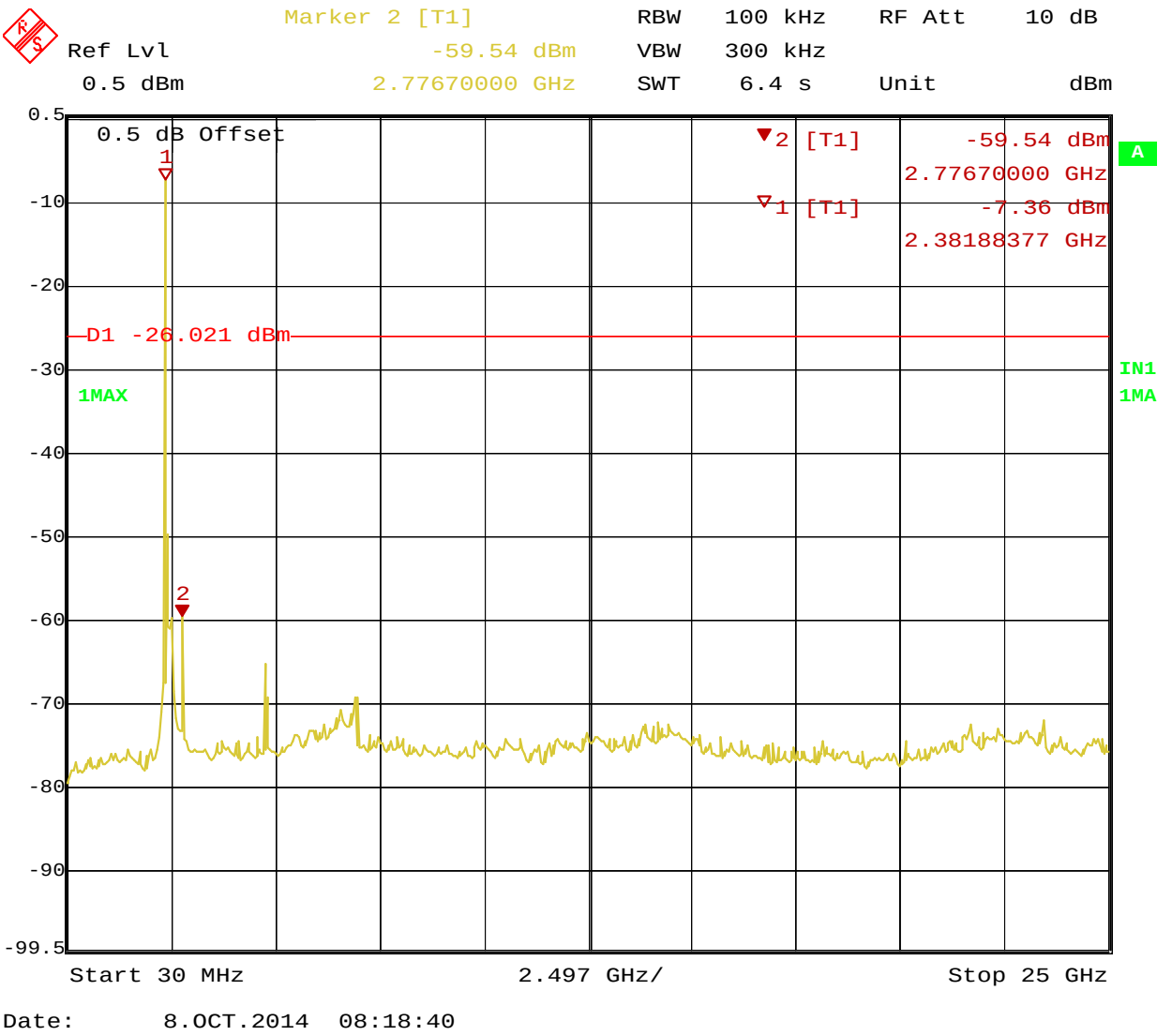


Figure 16: Out of band emissions at Operating Channel 2412 MHz

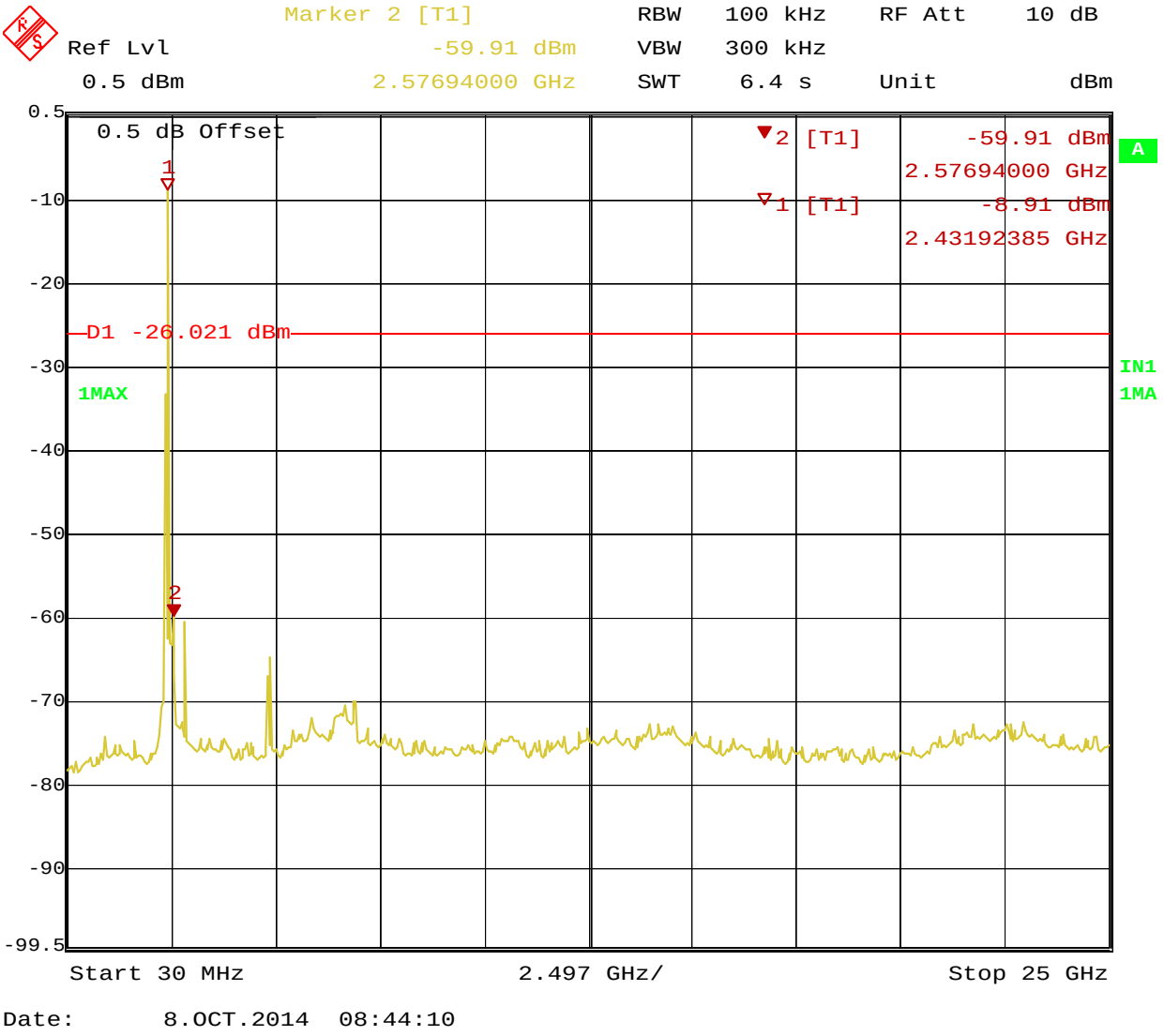


Figure 17: Out of band emissions at Operating Channel 2437MHz

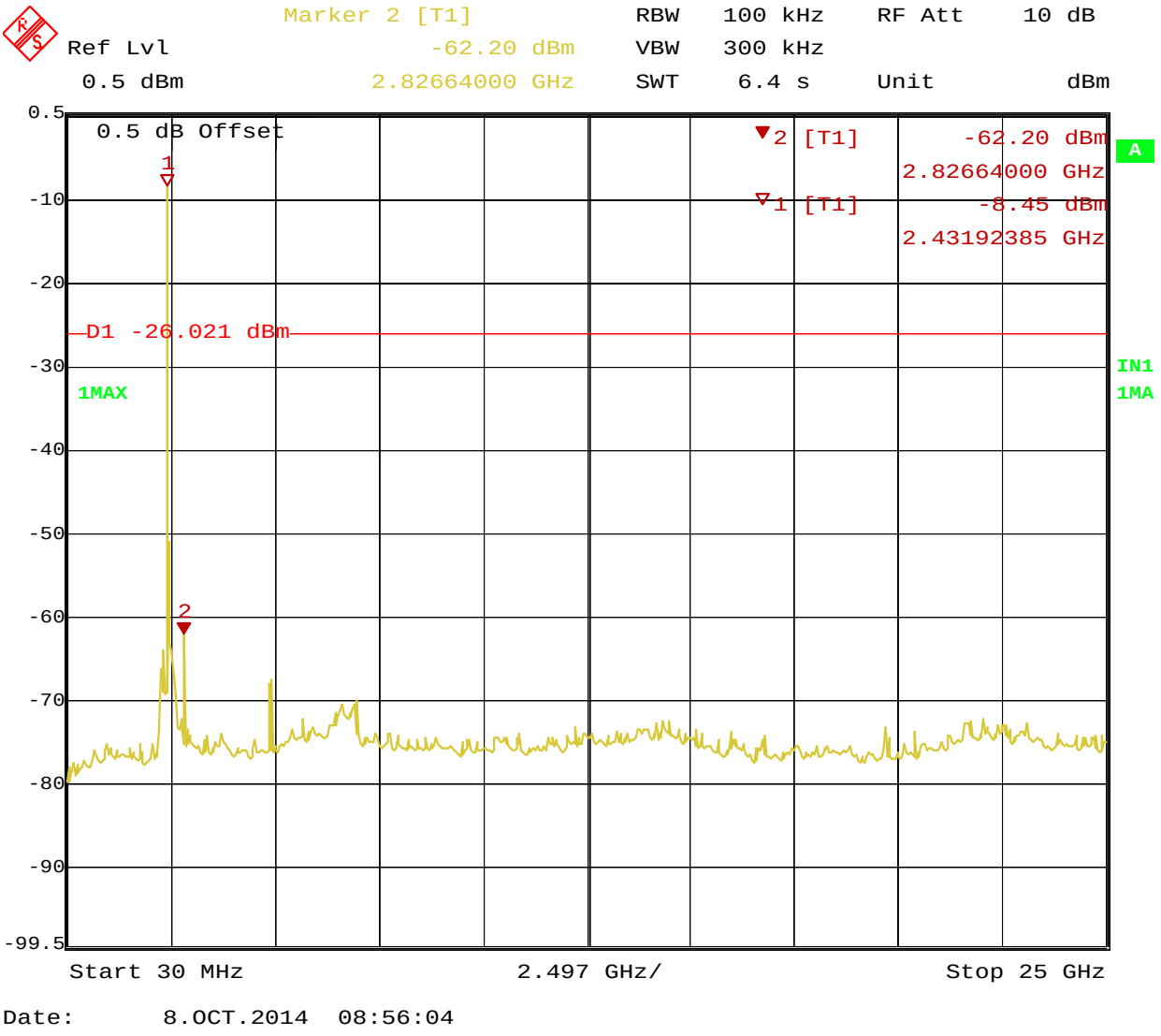


Figure 18: Out of band emissions at Operating Channel 2462 MHz HT20 Mode

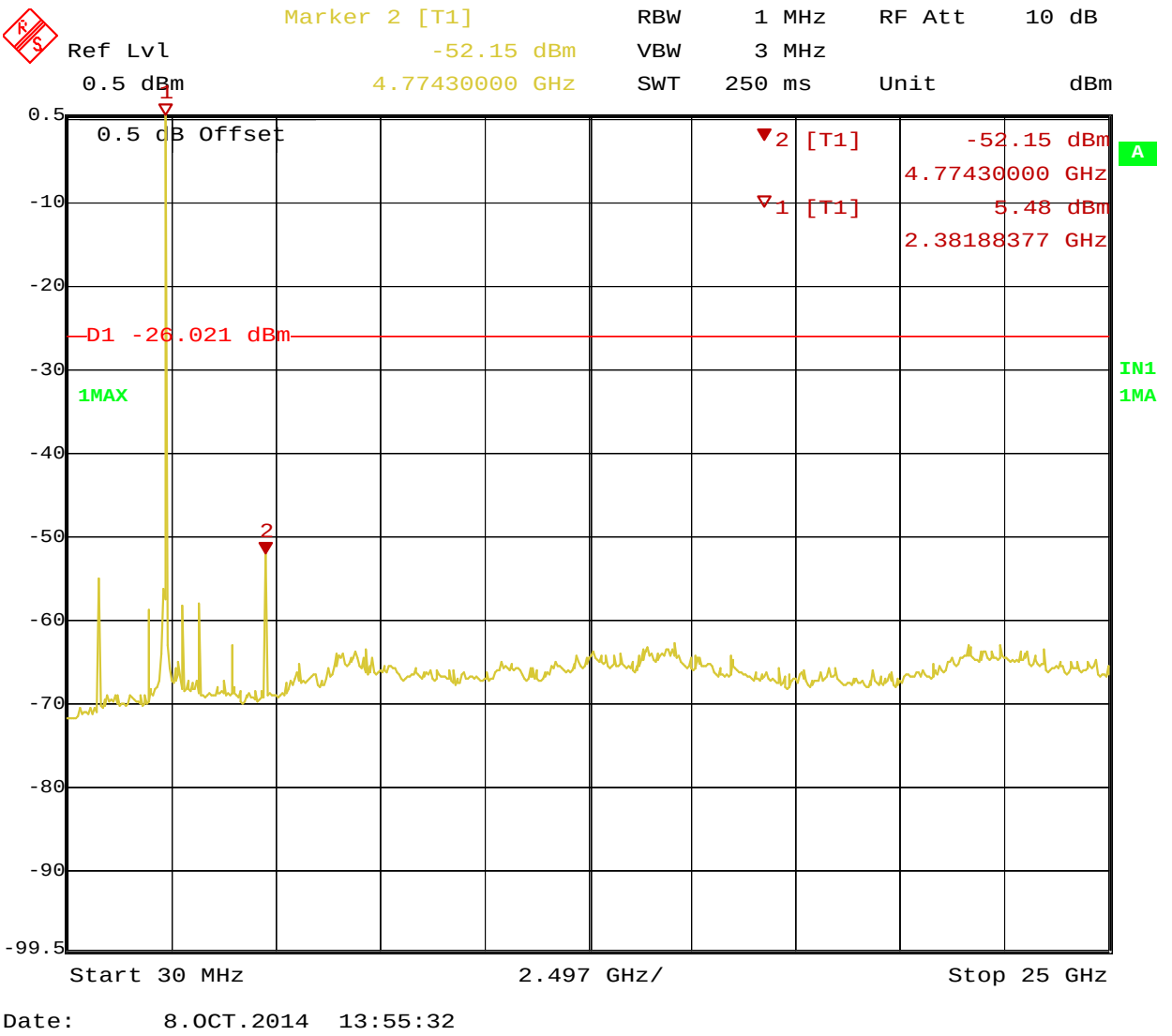


Figure 19: Out of band emissions at Operating Channel 2402 MHz BLE Mode

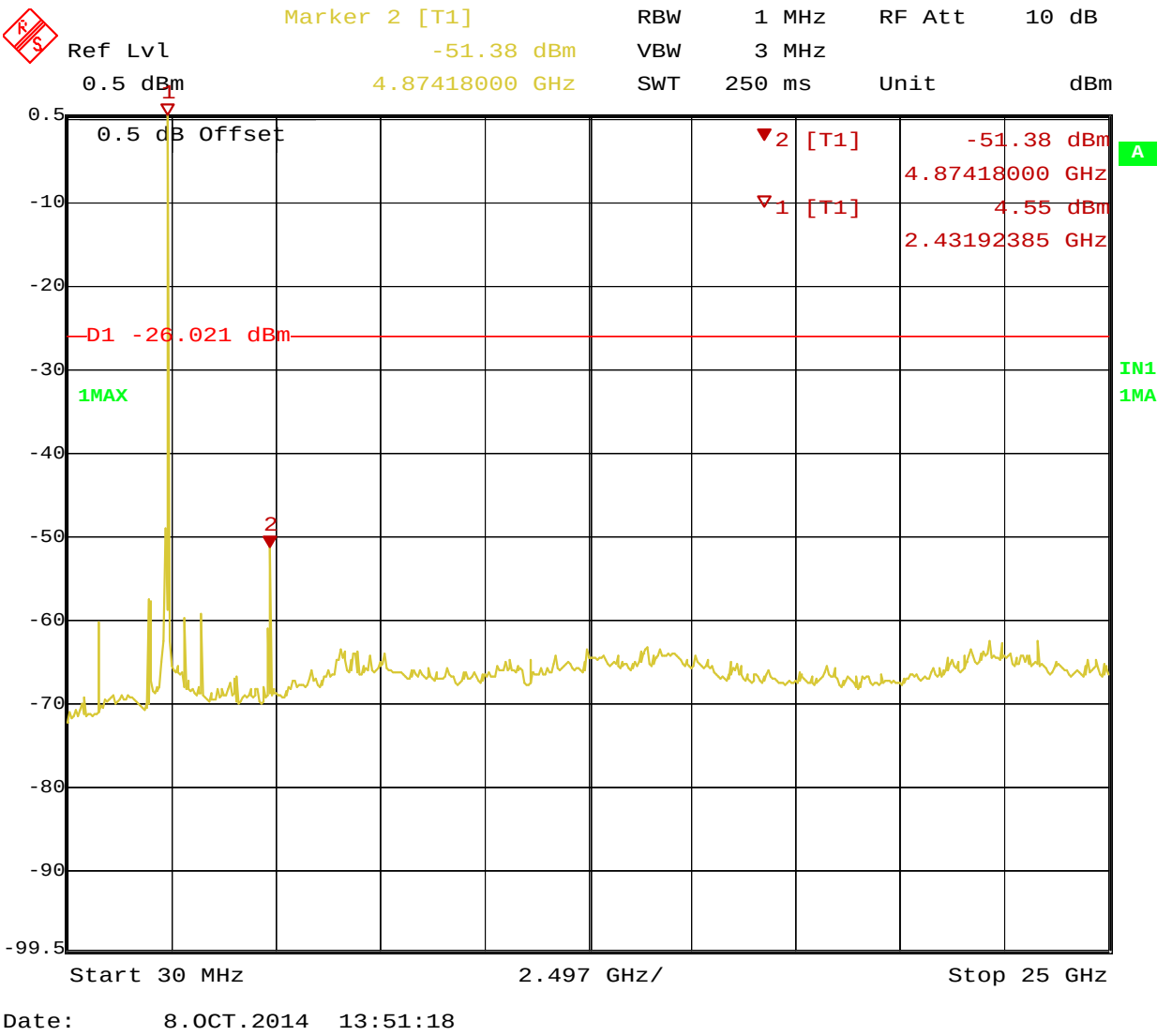


Figure 20: Out of band emissions at Operating Channel 2440MHz BLE Mode

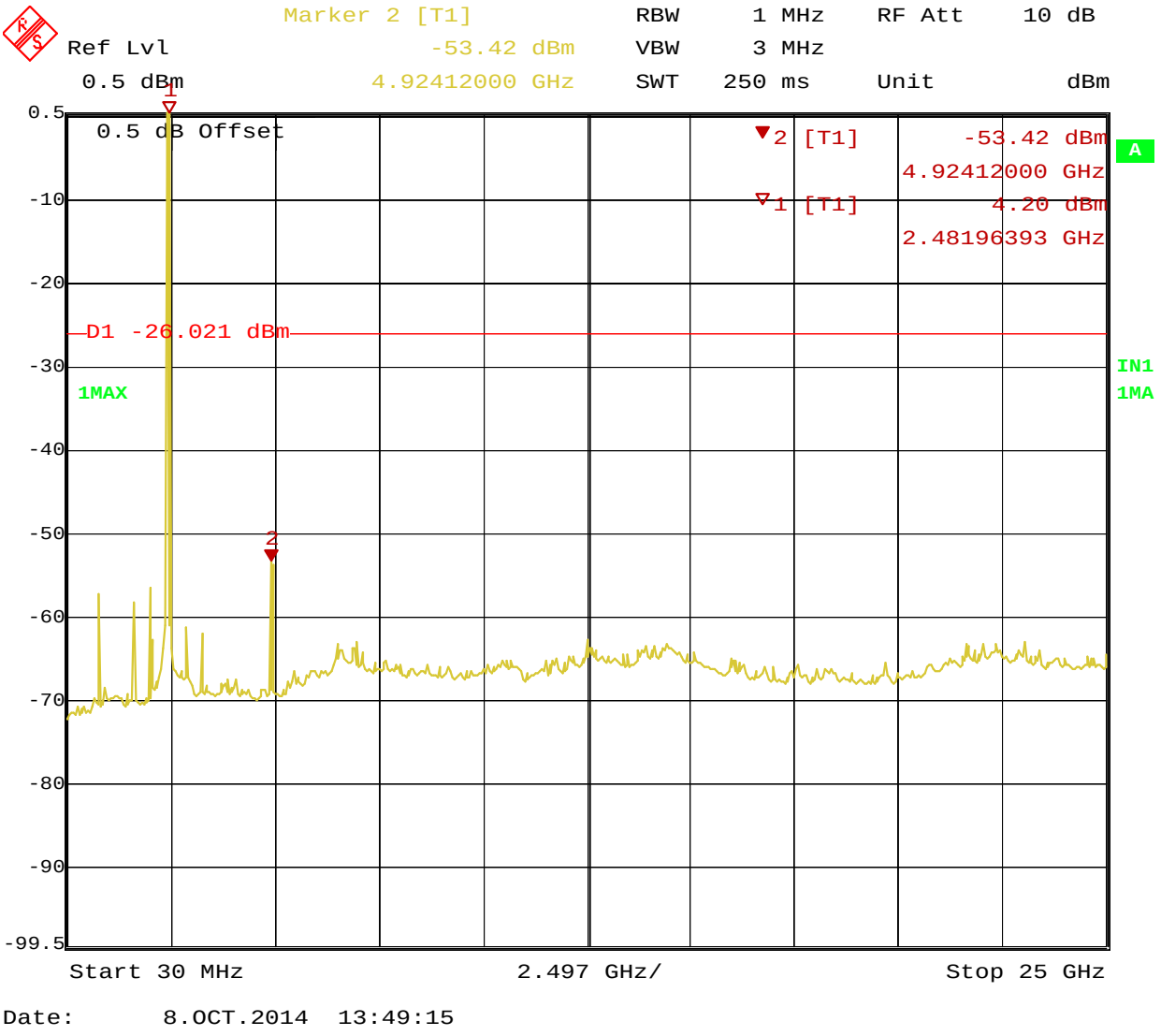


Figure 21: Out of band emissions at Operating Channel 2480MHz BLE Mode

4.4 Peak Power Spectral Density

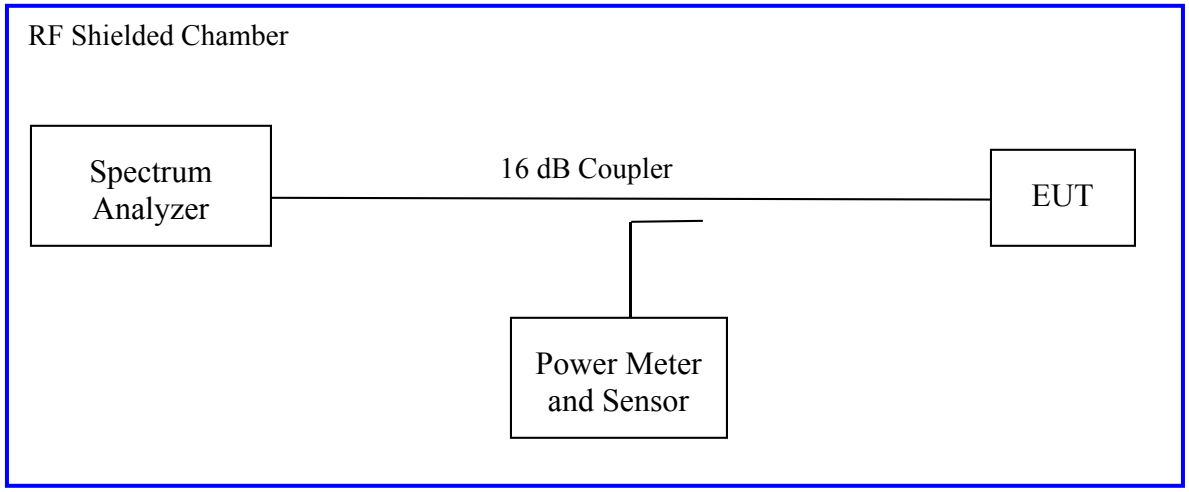
According to the CFR47 Part 15.247 (e) and RSS 210 (A8.2), the spectral power density output of the antenna port shall be less than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

4.4.1 Test Method

The conducted method was used to measure the channel power output per ANSI C63.10:2009 Section 6.11.2

The measurement was performed with modulation per CFR47 Part 15.247 (e) and RSS 210 (A8.2). The worst sample result indicated below.

Test Setup:



4.4.2 Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 6: Peak Power Spectral Density – Test Results

Test Conditions: Conducted Measurement, Normal Temperature and Voltage only				
Antenna Type: *Internal*		**Power Setting:** See test plan		
Max. Antenna Gain: 1.5 dBi		**Signal State:** Modulated		
Ambient Temp.: 21 °C		**Relative Humidity:**39%		
Peak Power Spectral Density				
Freq. (MHz)	**Mode**	**Max. PPSD [dBm]**	**Limit [dBm]**	**Margin [dB]**
2412	6.5Mbps	-19.63	8.00	-26.63
2437	6.5Mbps	-20.40	8.00	-28.40
2462	6.5Mbps	-20.55	8.00	-28.55

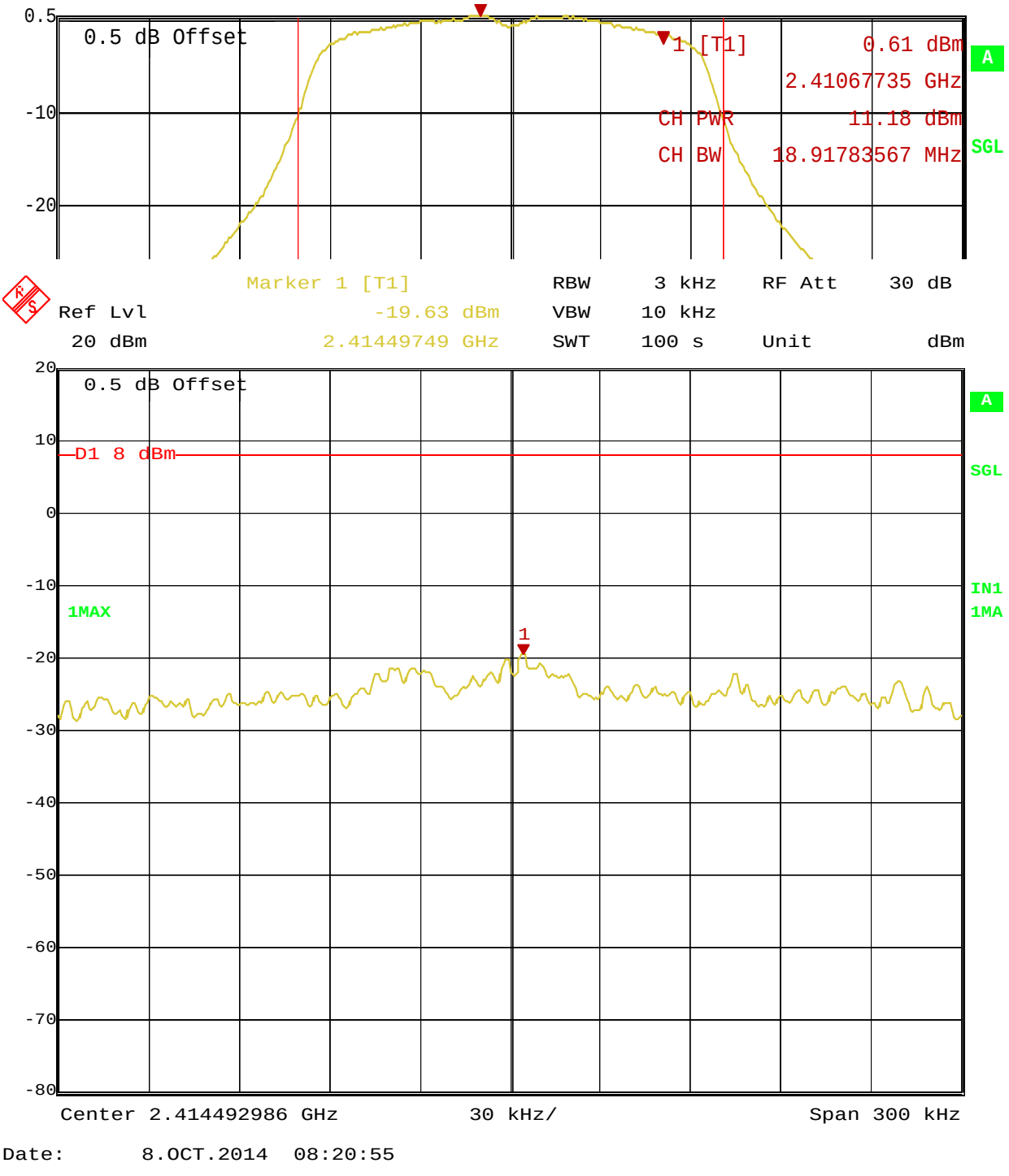


Figure 22: Peak Power Spectral Density for Operating Channel 2412MHz

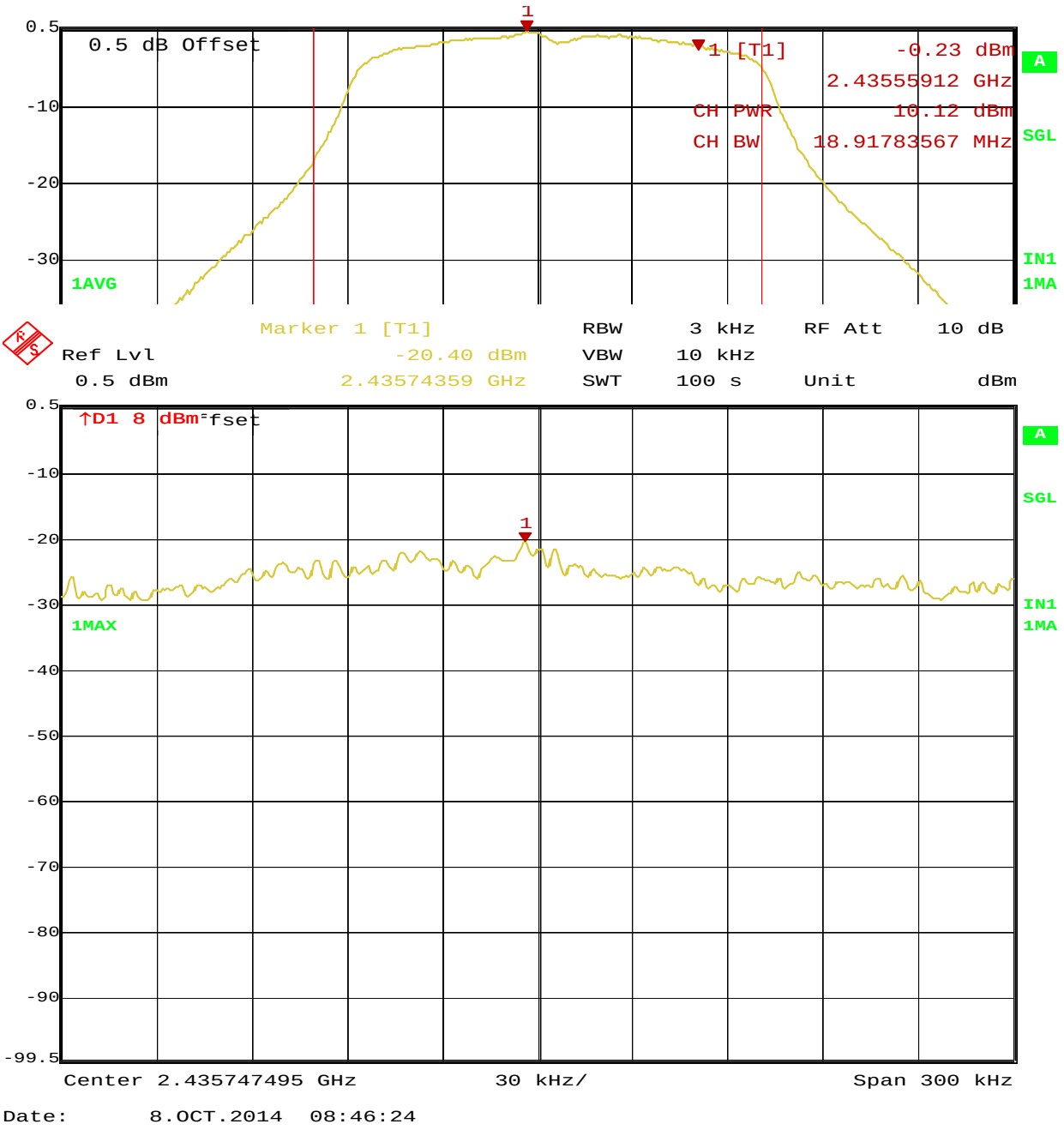


Figure 23: Peak Power Spectral Density for Operating Channel 2437 MHz

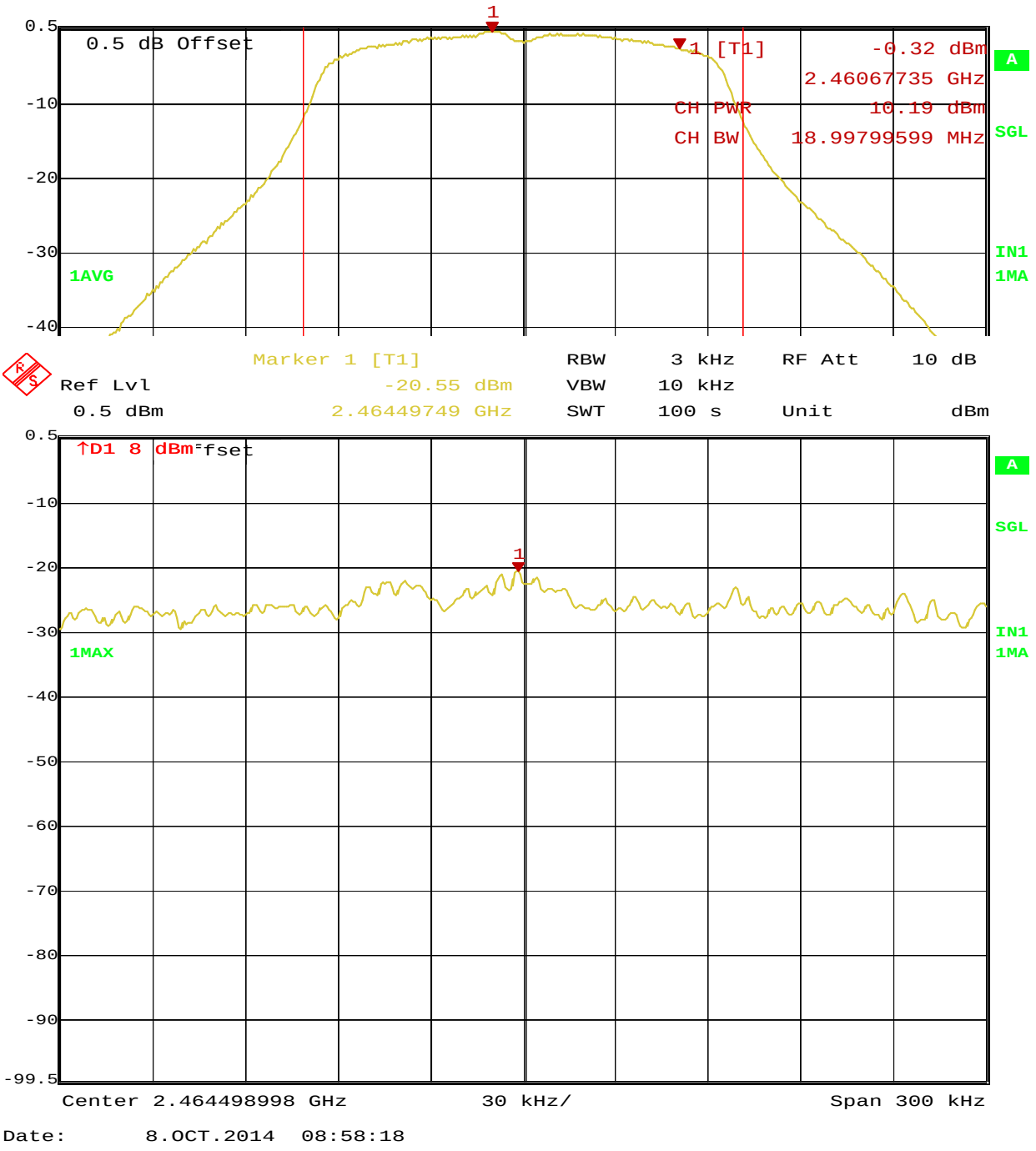


Figure 24: Peak Power Spectral Density for Operating Channel 2462 MHz

4.5 Hopping Frequency Requirements

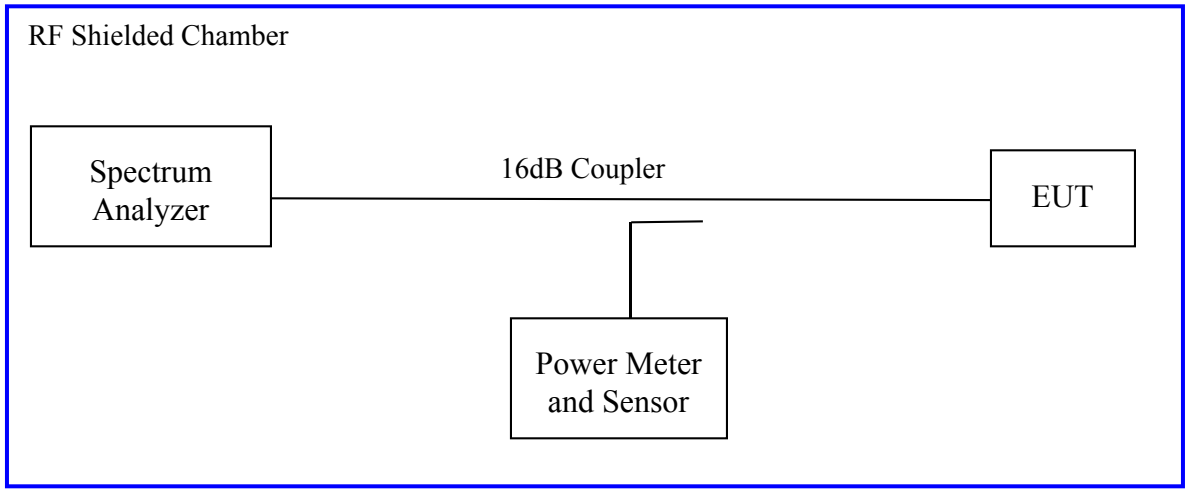
The Frequency Hopping Requirements are applicable to the equipment using Frequency Hopping Spread Spectrum (FHSS) modulation.

Asper 15.247 (a)(1) (iii), frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed.

4.5.1 Test Method

The conducted method was used to measure the channel power output per ***Error! Reference source not found.***. The measurement was performed with modulation per. This test was conducted on 3 channels of Sample. The worst sample result indicated below.

Test Setup:



4.5.2 Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 7: Frequency Hopping Requirements

Test Conditions: Conducted Measurement, Normal Temperature			
Antenna Type: ***Error! Reference source not found.***		**Power Setting:** Fixed	
Antenna Gain: +1.5 dBi		**Directional Gain:** Na	
Signal State: Modulated		**Duty Cycle:** 100%	
Ambient Temp.: 23 °C		**Relative Humidity:**35%	
Minimum Channel Separation			
Operating Channel (MHz)	**Hopping Separation (kHz)**	**Limit (kHz)**	**Result**
2402	1002.00401	25.0	Pass
2441	1002.00401	25.0	Pass
2480	1002.00401	25.0	Pass
Note: All channels have separation greater than 25kHz.			

Minimum Number of Channels				
Range #1 (2400 MHz -2430 MHz)	**Range #2** (2430 MHz – 2460 MHz)	**Range #3** (2460 MHz – 2483.5 MHz)	**Min. Channel Limit**	**Result**
29	30	20	15	Pass
Note: The Bluetooth dongle uses total 79 hopping channels.				

Average Occupancy Time				
Pulse Width (ms)	**# of Pulses in 3.16s**	**Ave. Time (ms)**	**Limit (s)**	**Result**
0.156	33	51.48	< 0.4	Pass
Note: The Bluetooth module was hopping pseudo randomly across 79 allocated channels. Average dwell time was taken in 3.16 S at 2441 MHz, (1/10th of the total time).				

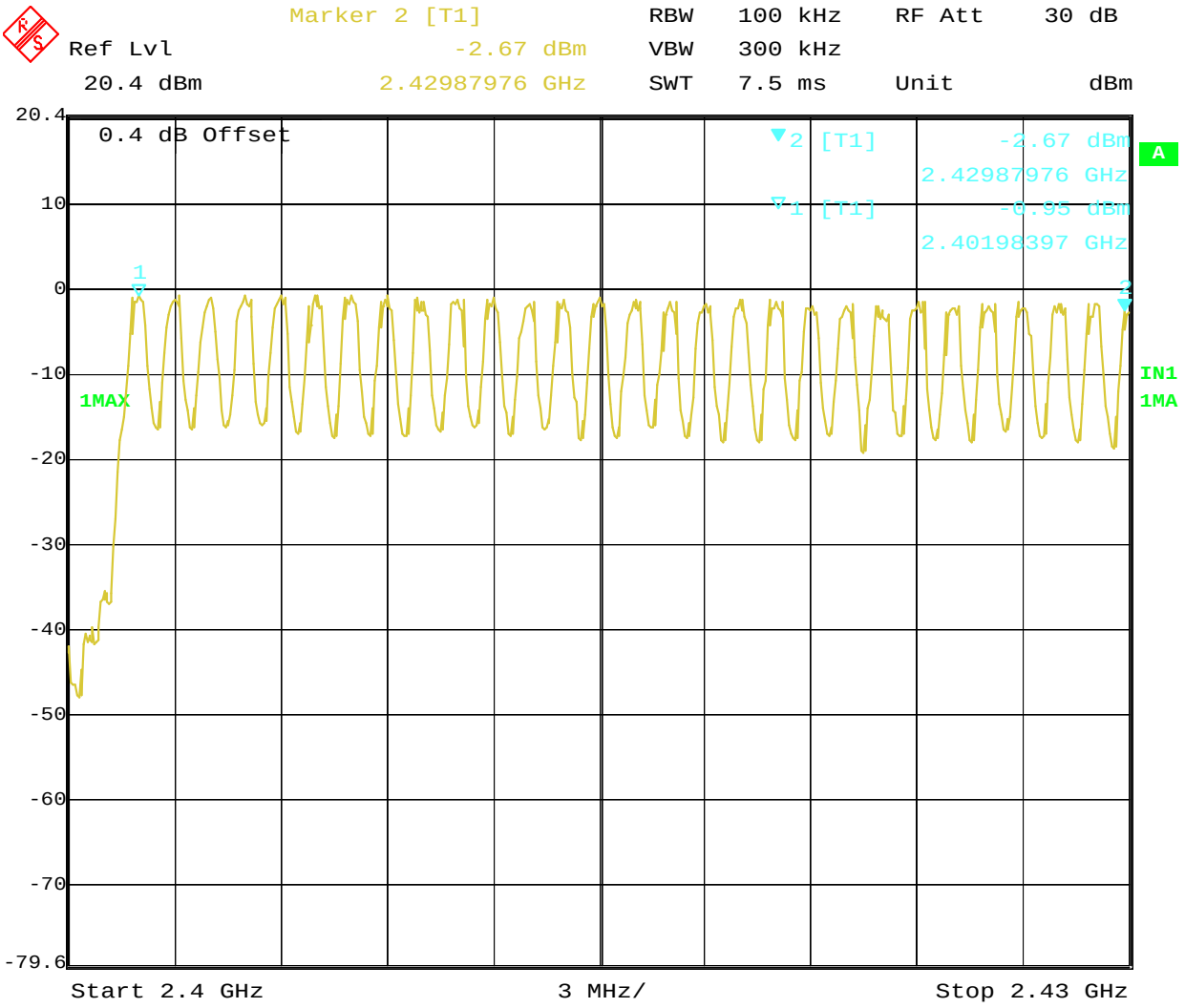


Figure 25: Number of Operating Channel from 2400 MHz to 2430 MHz (29 Channels)

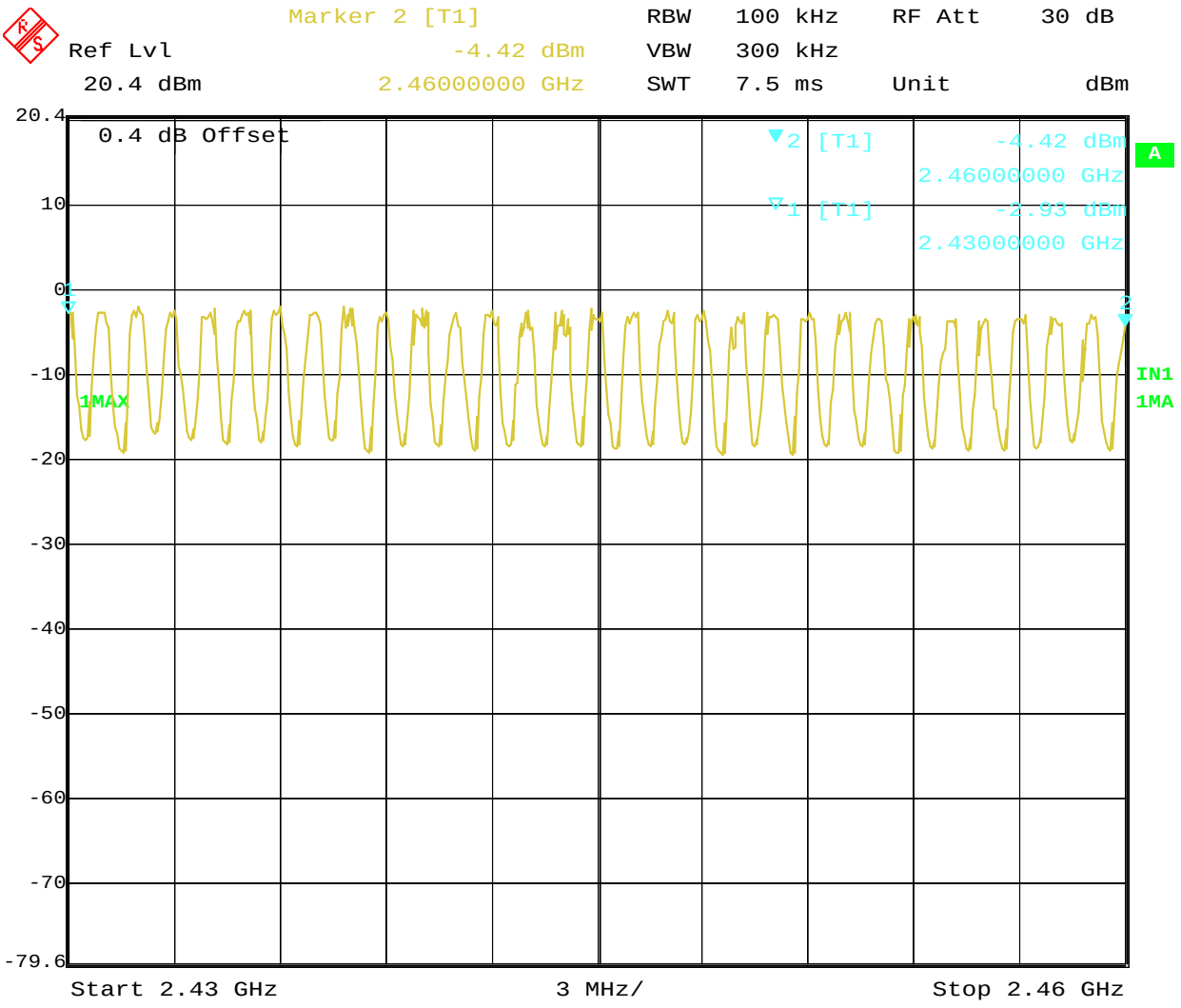


Figure 26: Number of Operating Channel from 2430 MHz to 2460 MHz (30 Channels)

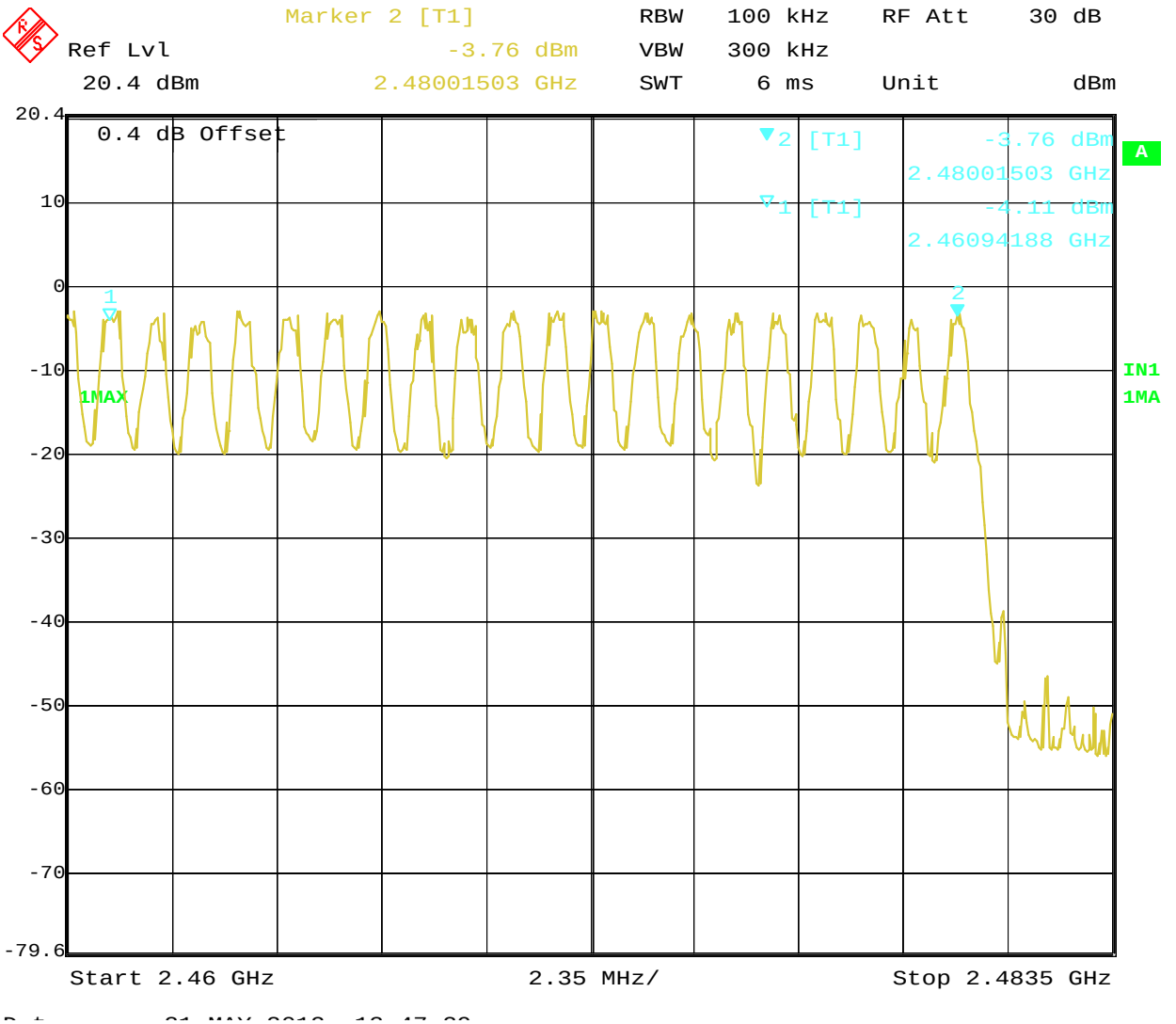


Figure 27: Number of Operating Channel from 2460 MHz to 2483.5 MHz (20 Channels)

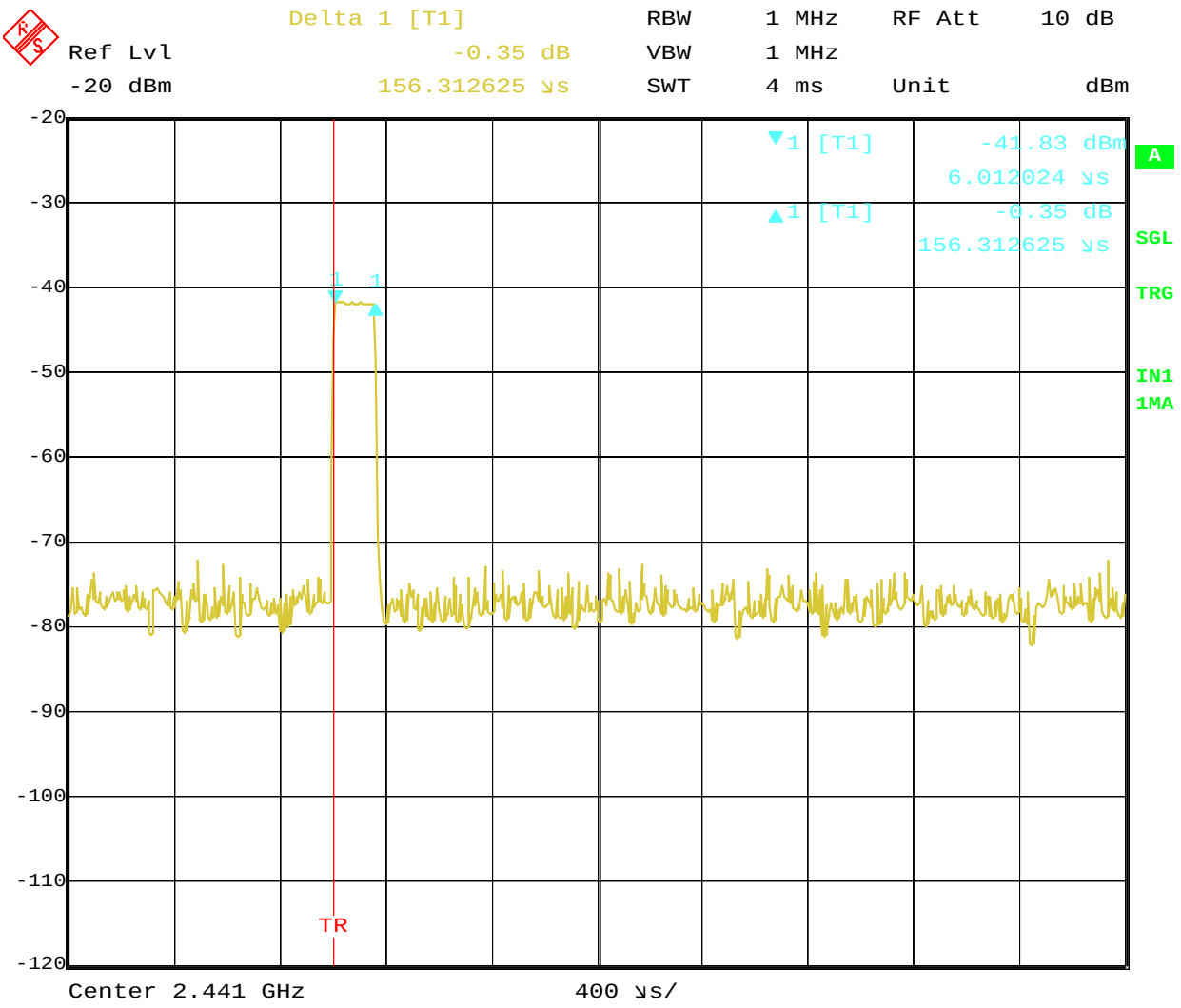


Figure 28: Average Dwell Time – Channel 2441 MHz Pulse Width

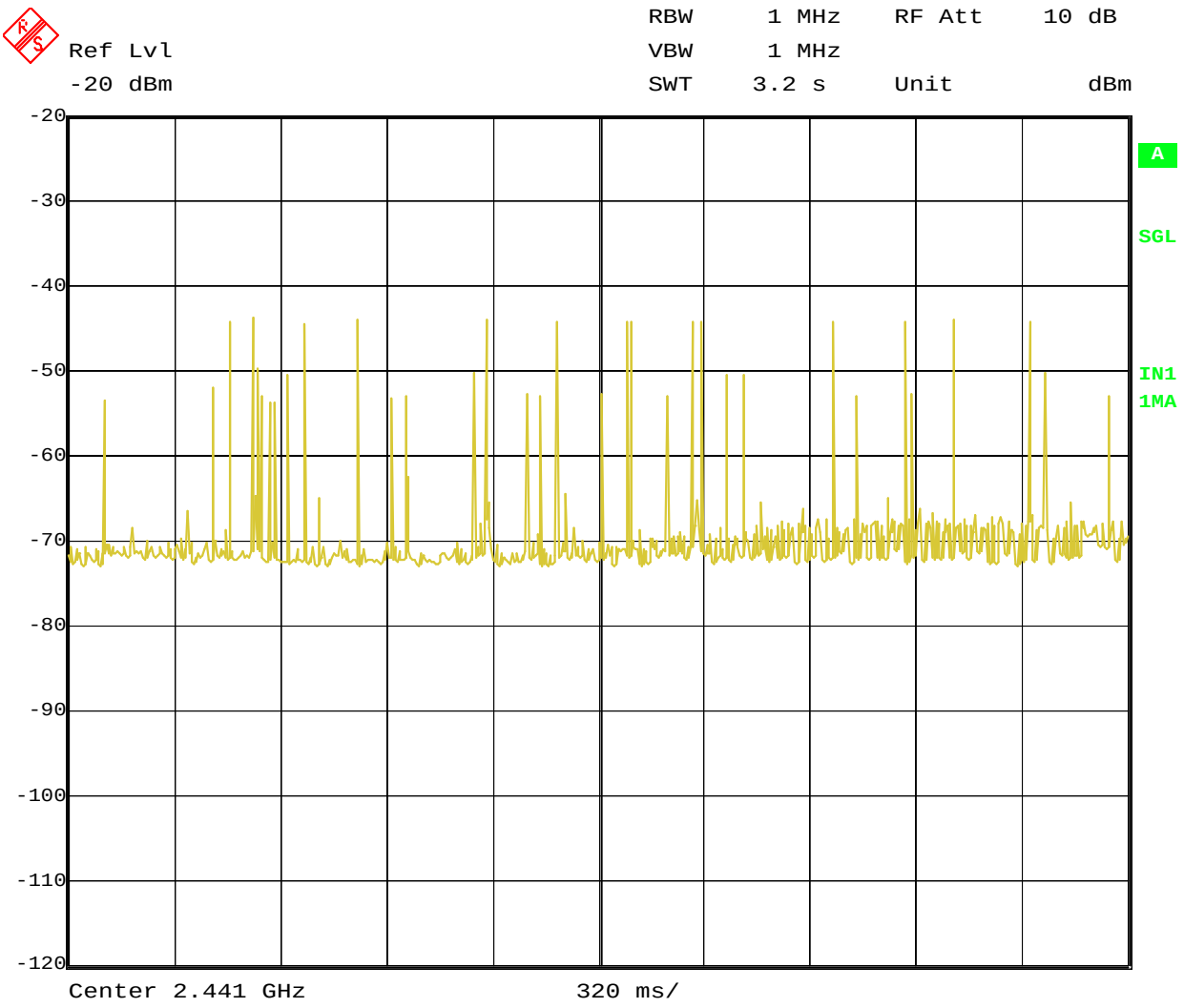


Figure 29: Average Dwell Time - Channel 2441 MHz – 33 Pulses

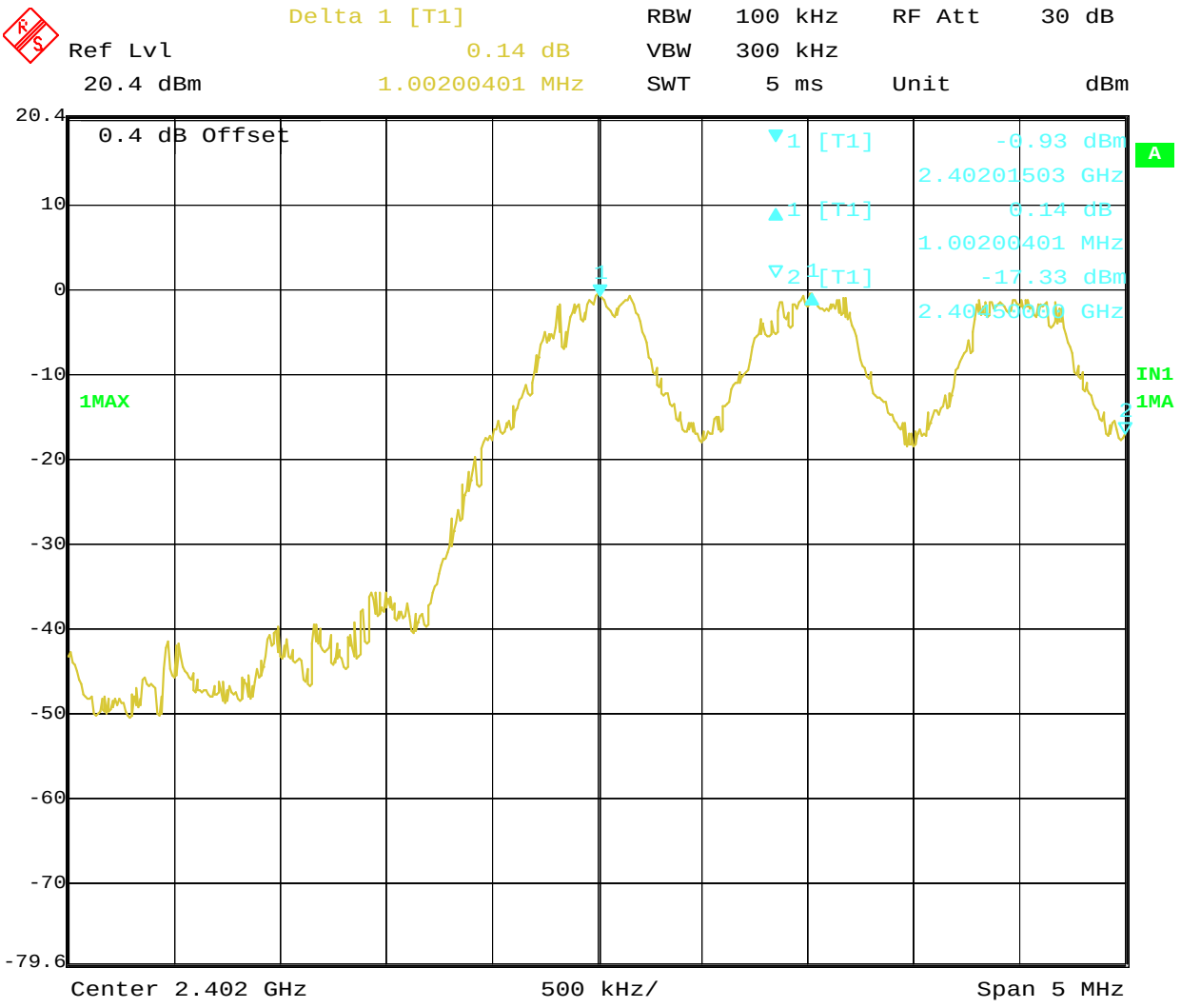


Figure 30: Channel Separation at Operating Frequency 2402 MHz

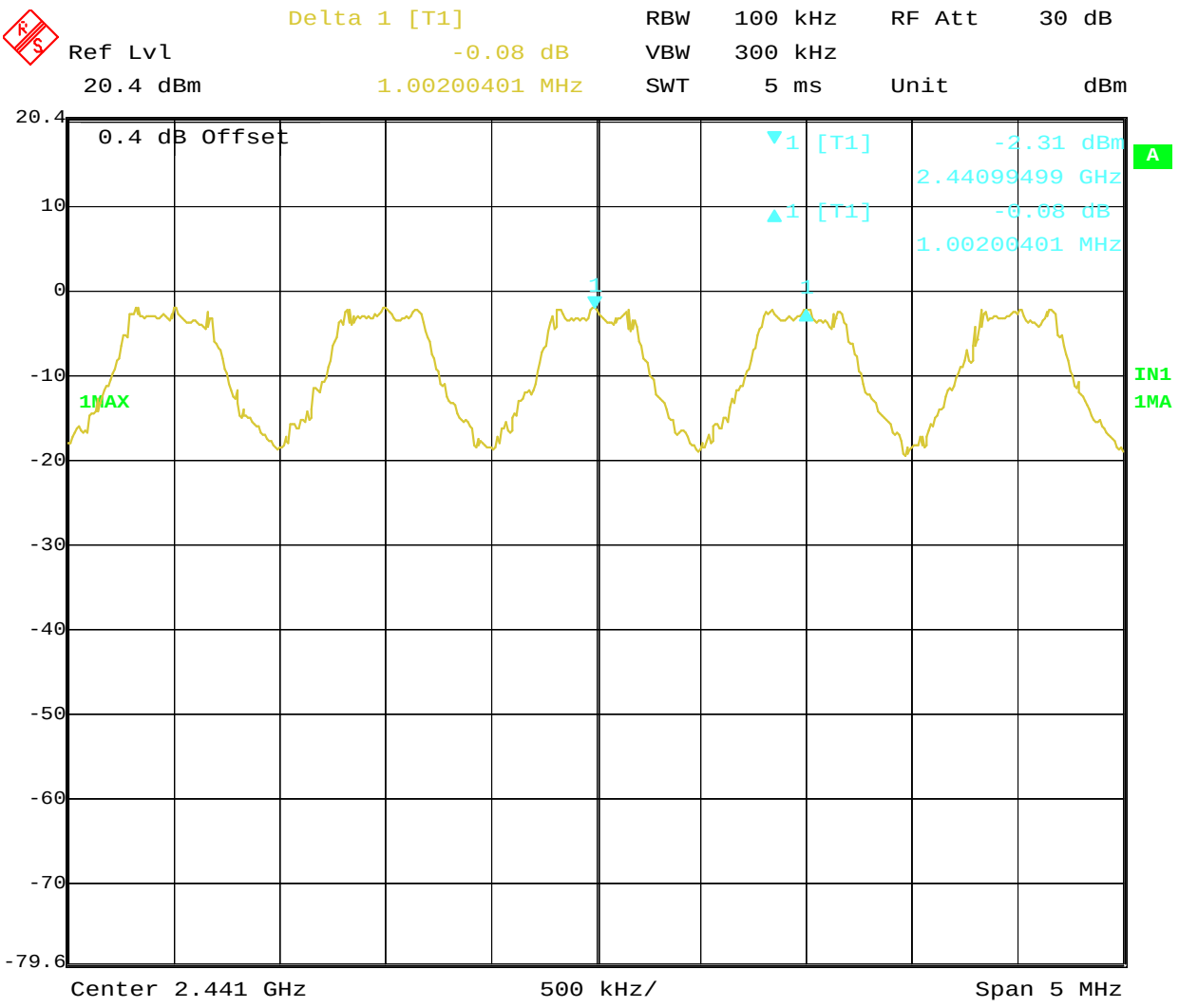


Figure 31: Channel Separation at Operating Frequency 2441 MHz

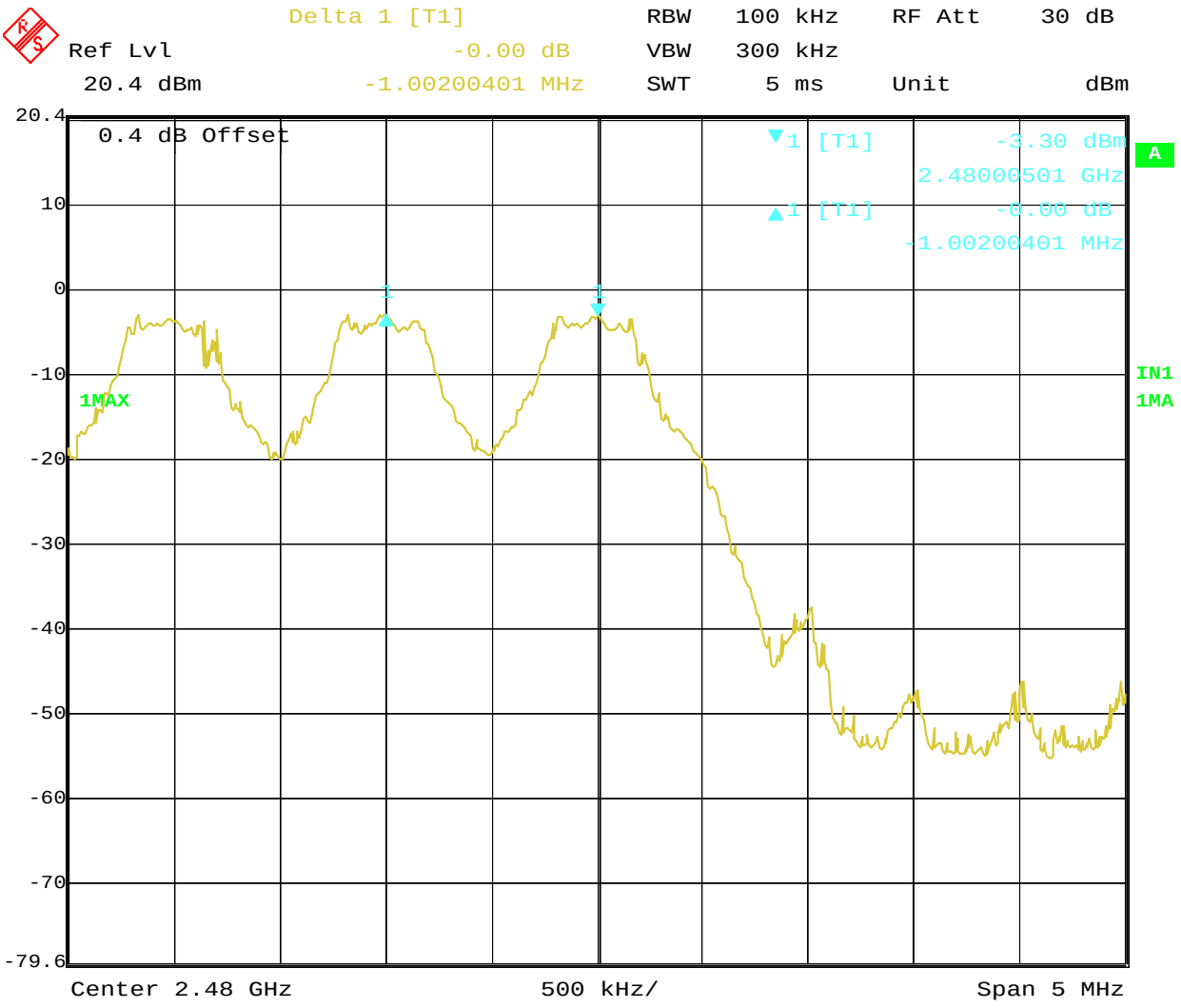


Figure 32: Channel Separation at Operating Frequency 2480 MHz

4.6 Transmitter Spurious Emissions

Transmitter spurious emissions are emissions outside the frequency range of the equipment when the equipment is in transmitting mode; per requirement of CFR47 15.205, 15.209, 15.247(d), RSS 210 Sect. A.8.5

4.6.1 Test Methodology

4.6.1.1 *Preliminary Test*

A test program that controls instrumentation and data logging was used to automate the preliminary RF emission test procedure. The frequency range of interest was divided into sub-ranges to yield a frequency resolution of approximately 120 kHz and provide a reading at each frequency for no more than 12° of turntable rotation. For each frequency sub-range the turntable was rotated 360° while peak emission data was recorded and plotted over the frequency range of interest in horizontal and vertical antenna polarization's.

Preliminary emission profile testing was performed inside the anechoic chamber. The EUT was placed on a 1.0m x 1.5m non-conductive table 80cm above the floor. The EUT was positioned as shown in the setup photographs. The receiving antenna was placed at a distance of 3m at a fixed height of 1m. Measurement equipment was located outside of the chamber. A video camera was placed inside the chamber to view the EUT.

4.6.1.2 *Final Test*

For each frequency measured, the peak emission was maximized by manipulating the receiving antenna from 1 to 4 meters above the ground plane and placing it at the position that produced the maximum signal strength reading. The turntable was then rotated through 360° while observing the peak signal and placing the EUT at the position that produced maximum radiation. The six highest emissions relative to the limit were measured unless such emissions were more than 20 dB below the limit. If less than six emissions are within 20 dB of the limit, than the noise level of the receiver is measured at frequencies where emissions are expected. Multiples of all oscillator and microprocessor frequencies were also checked.

Final testing was performed on an NSA compliant test site. The EUT was placed on a 1.0m x 1.5m non-conductive table 80cm above the ground plane. The placement of EUT and cables were the same as for preliminary testing and is shown in the setup photographs.

The final scans performed on the worst axis, Y-Axis, for three operating channels;

2405 MHz, 2430 MHz, and 2480 MHz at 1Mbit/s

4.6.1.3 *Deviations*

None.

4.6.2 Transmitter Spurious Emission Limit

The spurious emissions of the transmitter shall not exceed the values in CFR47 Part 15.205, 15.209: 2011 and RSS 210 A1.1.2 2010.

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490.....	2400/F(kHz)	300
0.490-1.705.....	24000/F (kHz)	30
1.705-30.0.....	30	30
30-88.....	100 **	3
88-216.....	150 **	3
216-960.....	200 **	3
Above 960.....	500	3

All harmonics and spurious emission which are outside of the restricted band shall be 20 dB below the in-band emission.

4.6.3 Test Results

The final measurement data was taken under the worst case operating modes, configurations, and/or cable positions. It also reflects the results including any modifications and/or special accessories listed in Sections 1.4 and Test Plan.

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 8: Transmit Spurious Emission at Band-Edge Requirements

Test Conditions: Radiated Measurement, at 3 meters								
Antenna Type: Internal				**Power Setting:** See test plan				
Max. Antenna Gain: + 1.5 dBi				**Signal State:** Modulated at 99%				
Ambient Temp.: 22 °C				**Relative Humidity:**34%				
Band-Edge Results 802.11 HT20 mode								
Operating Channel MHz	**Polarity**	**Peak Field Strength Measured dBuV**	**Peak Limit dBuV**	**Margin dB**	**Avg Field Strength Measured dBuV**	**Avg Limit dBuV**	**Margin dB**	**Result**
2412	H	41.96	74.0	-32.04	30.93	54.00	-23.07	Pass
2412	V	42.72	74.0	-31.28	31.12	54.00	-22.88	Pass
2462	H	43.17	74.0	-30.83	41.04	54.00	-12.96	Pass
2462	V	42.21	74.0	-31.79	31.20	54.00	-22.80	Pass

Figure 33: Radiated Emission at the Edge for Channel 2405 MHz at 1Mbps – Horizontal (Peak)

Test Conditions: Radiated Measurement, at 3 meters								
Antenna Type: Internal			**Power Setting:** See test plan					
Max. Antenna Gain: + 1.5 dBi			**Signal State:** Modulated at 99%					
Ambient Temp.: 22 °C			**Relative Humidity:**34%					
Band-Edge Results 802.11 BLE mode								
Operating Channel MHz	**Polarity**	**Peak Field Strength Measured dBuV**	**Peak Limit dBuV**	**Margin dB**	**Avg Field Strength Measured dBuV**	**Avg Limit dBuV**	**Margin dB**	**Result**
2402	H	41.10	74	-32.90	29.91	54	-24.09	Pass
2402	V	40.63	74	-33.37	29.81	54	-24.19	Pass
2480	H	42.58	74	-31.42	30.56	54	-23.44	Pass
2480	V	42.08	74	-31.92	30.59	54	-23.41	Pass

Power Setting used:

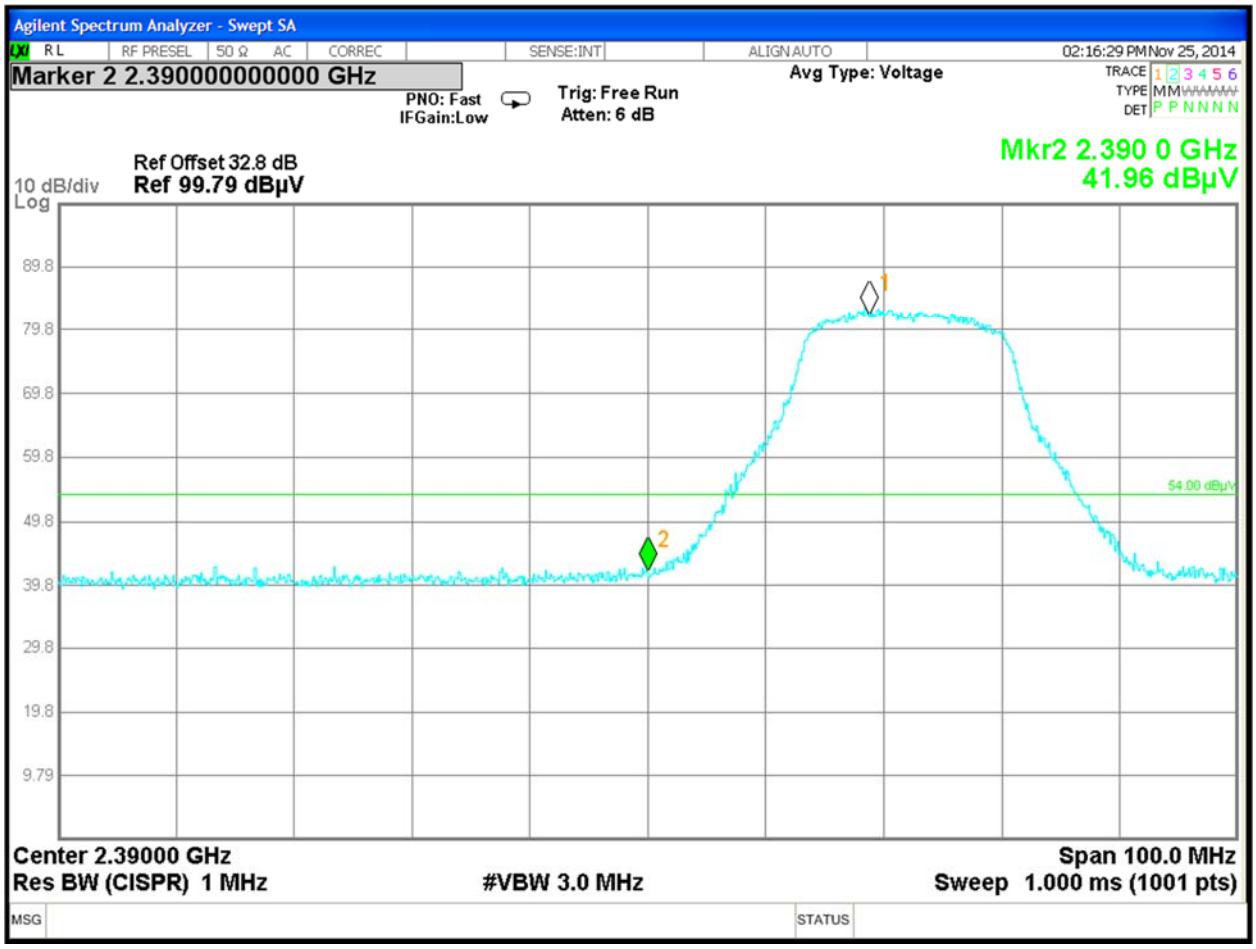


Figure 34: Radiated Emission at the Edge for Channel 2412 MHz at 6.5Mbps – Horizontal (Pk)

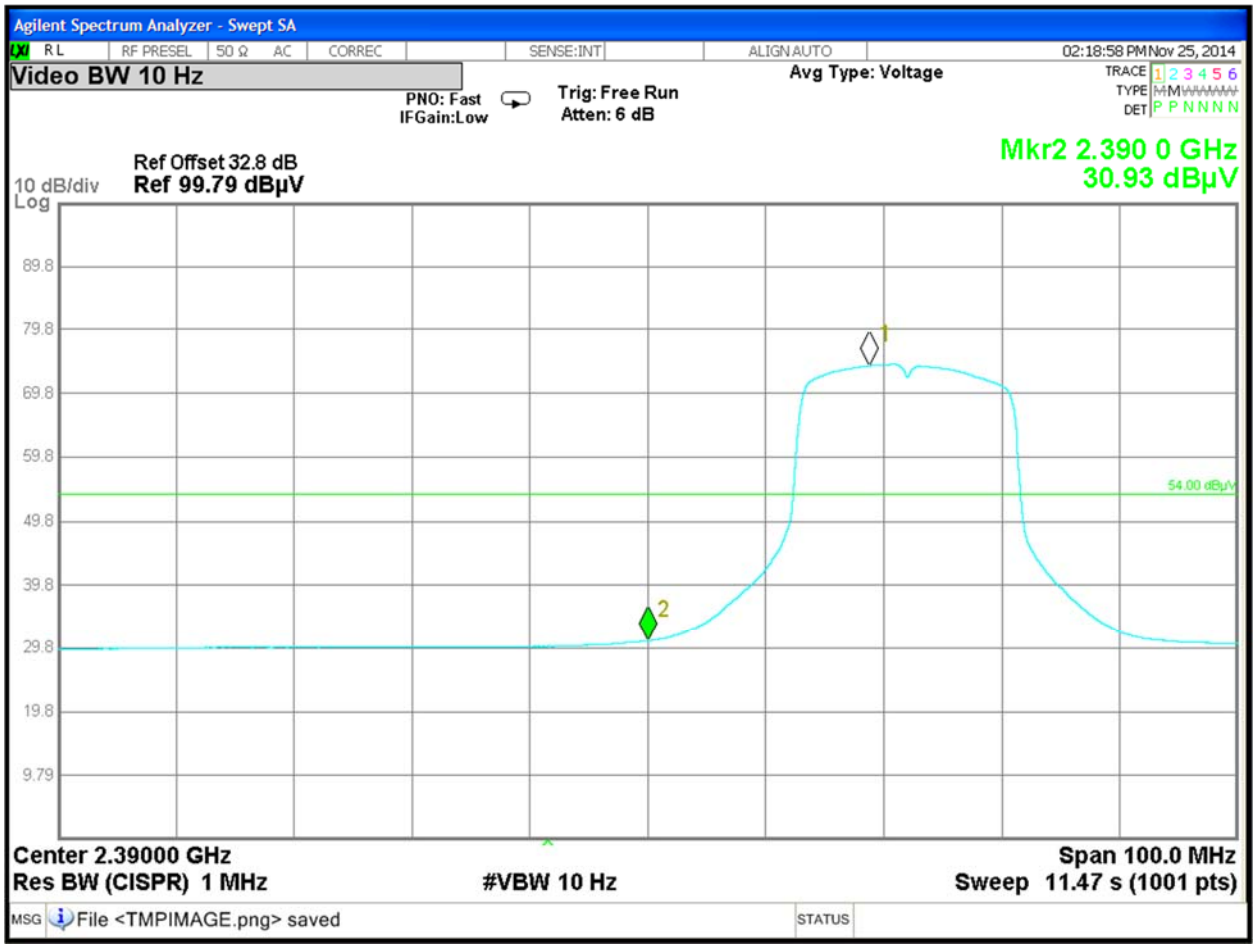


Figure 35: Radiated Emission at the Edge for Channel 2412 MHz at 6.5Mbps – Horizontal (Avg)

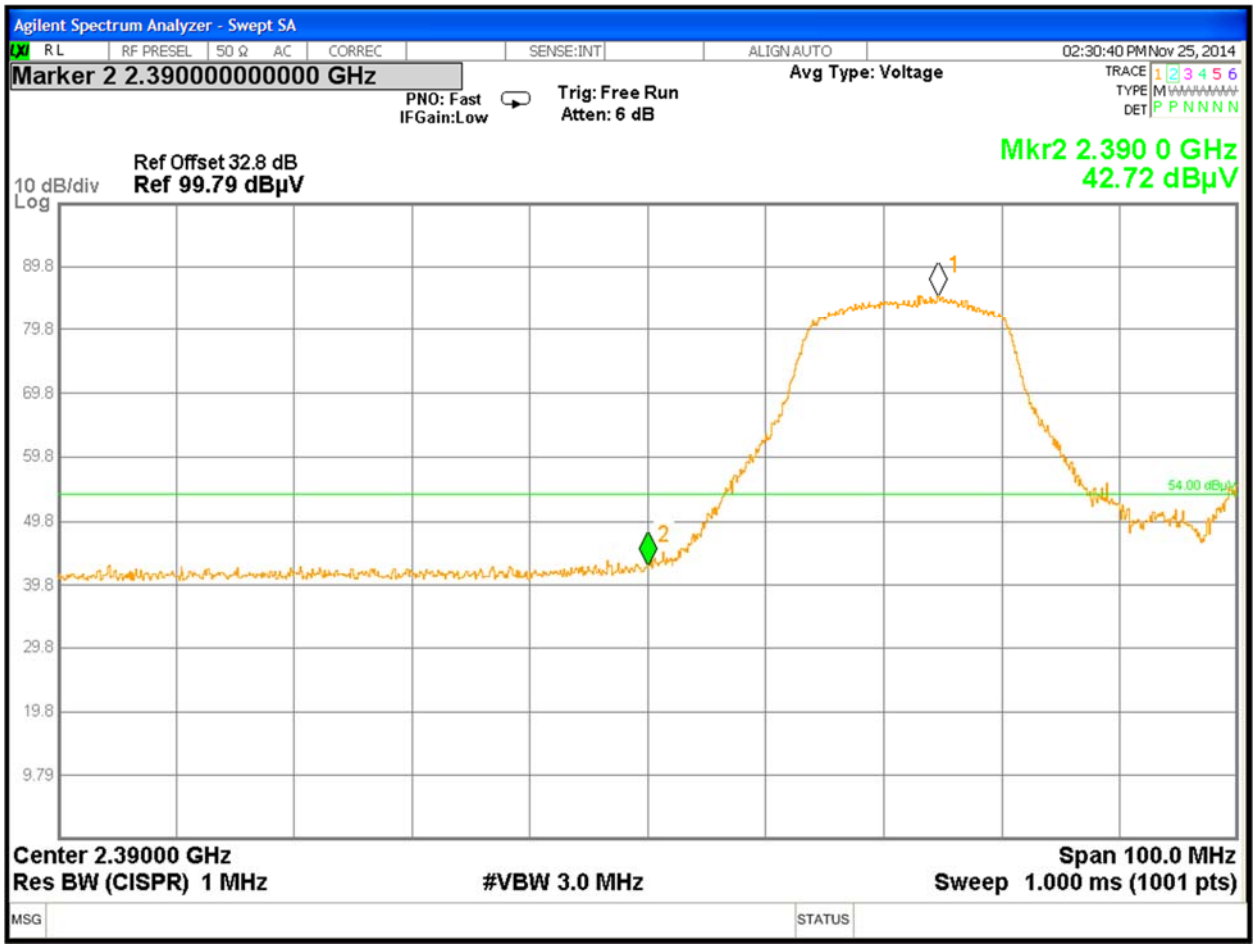


Figure 36: Radiated Emission at the Edge for Channel 2412 MHz at 1Mbps – Vertical (PK)

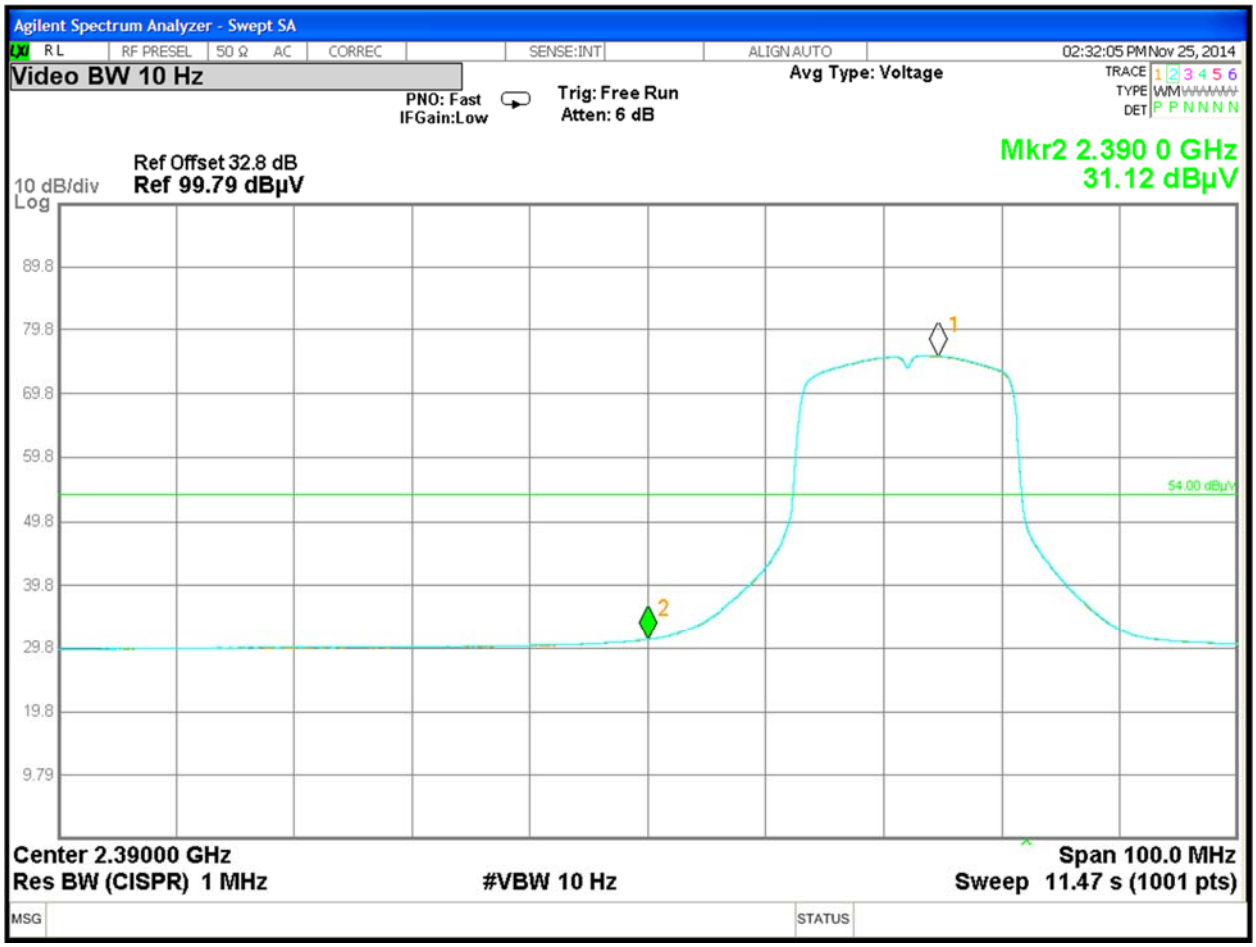


Figure 37: Radiated Emission at the Edge for Channel 2412 MHz at 1Mbps – Vertical (Avg)

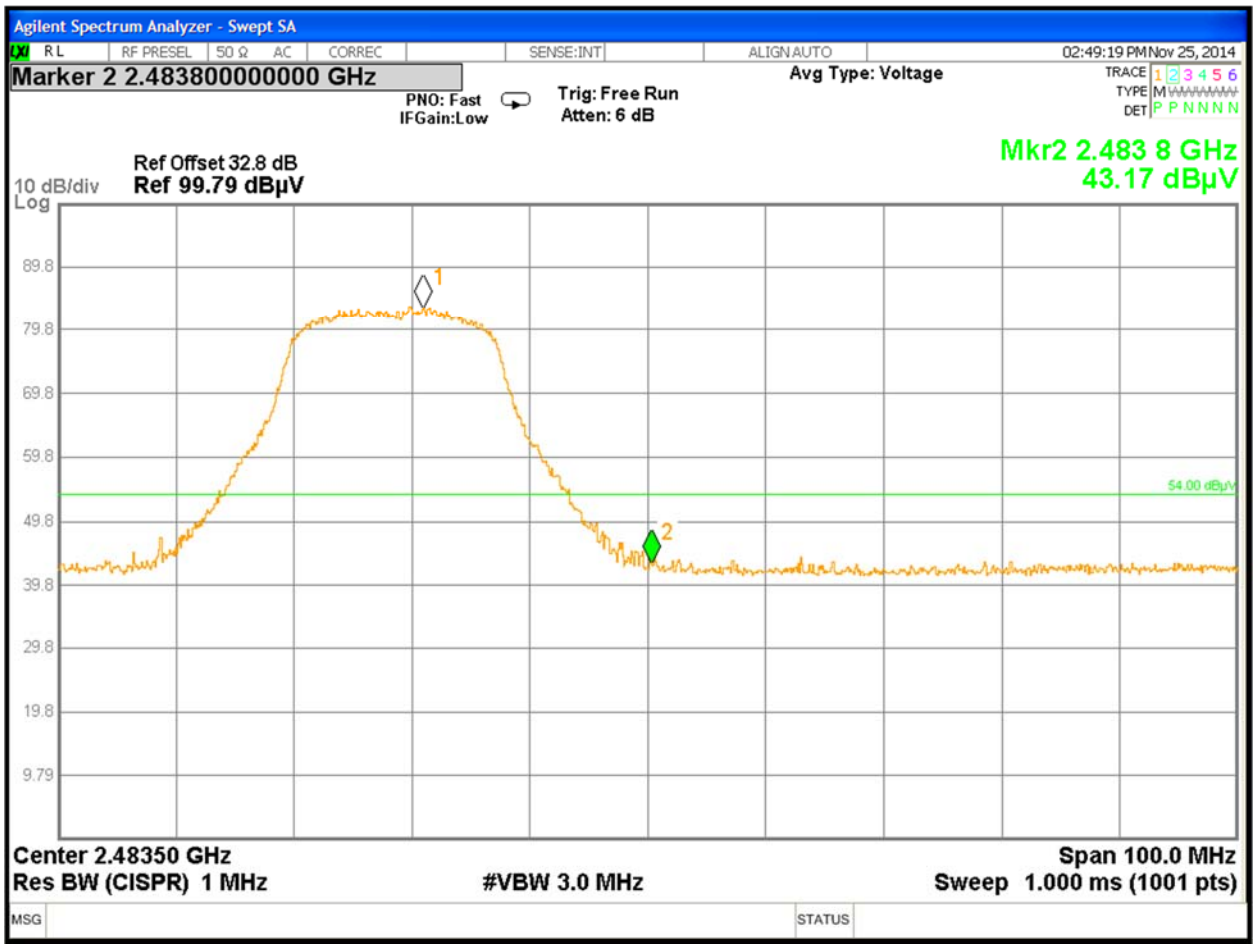


Figure 38: Radiated Emission at the Edge for Channel 2462 MHz at 6.5Mbps – Horizontal (Pk)

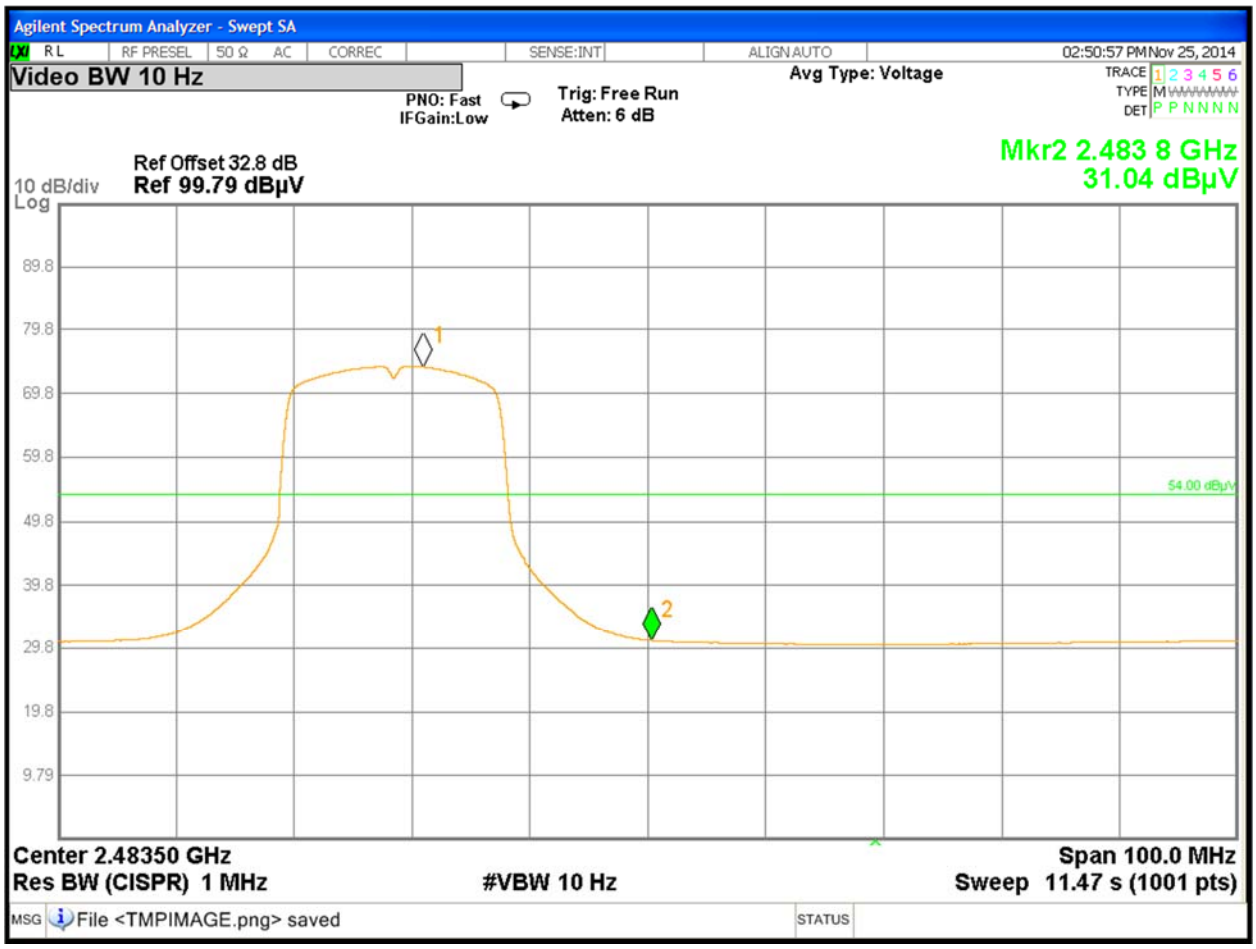


Figure 39: Radiated Emission at the Edge for Channel 2480 MHz at 6.5Mbps– Horizontall (Avg)

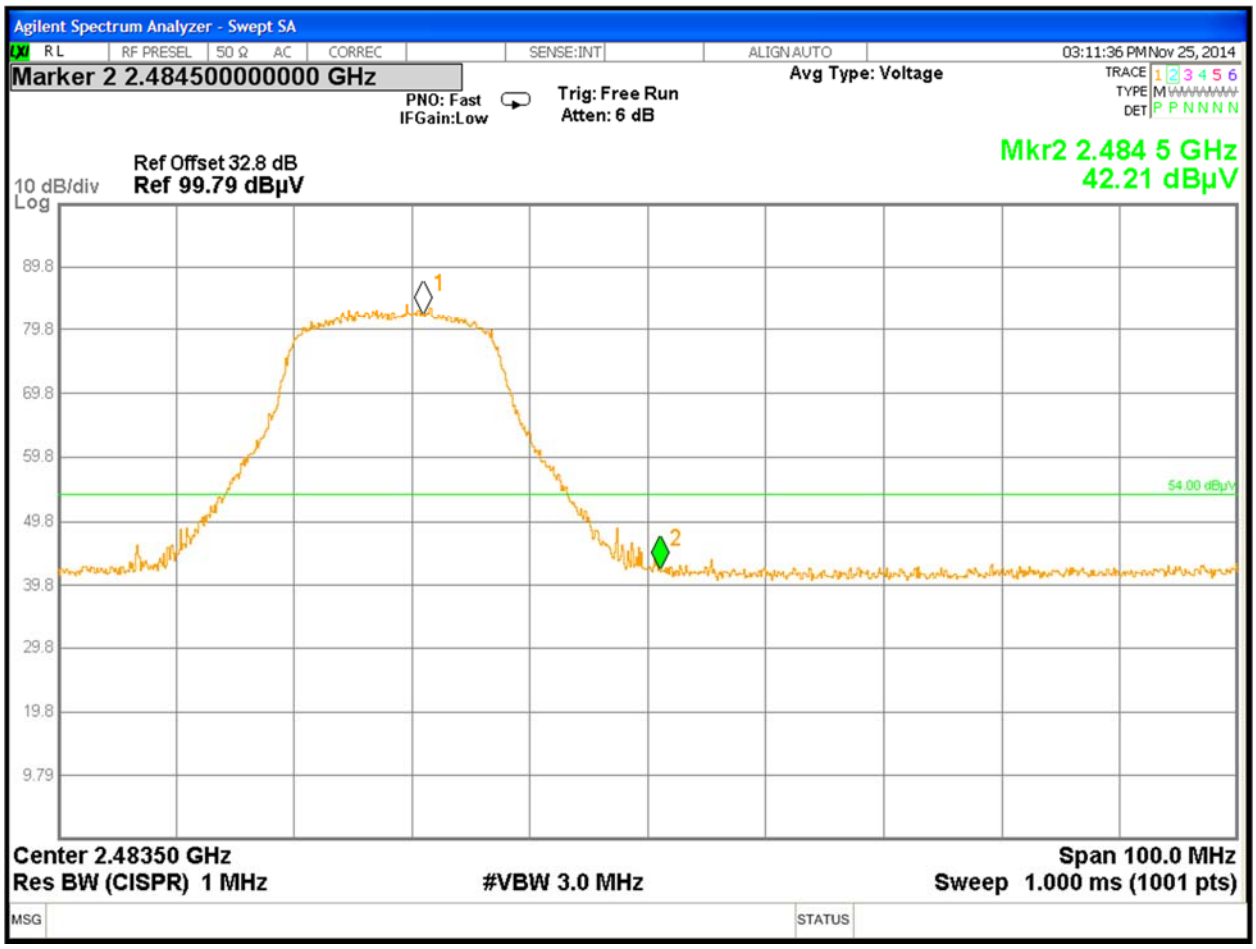


Figure 40: Radiated Emission at the Edge for Channel 2462 MHz at 6.5Mbps – Vertical (PK)

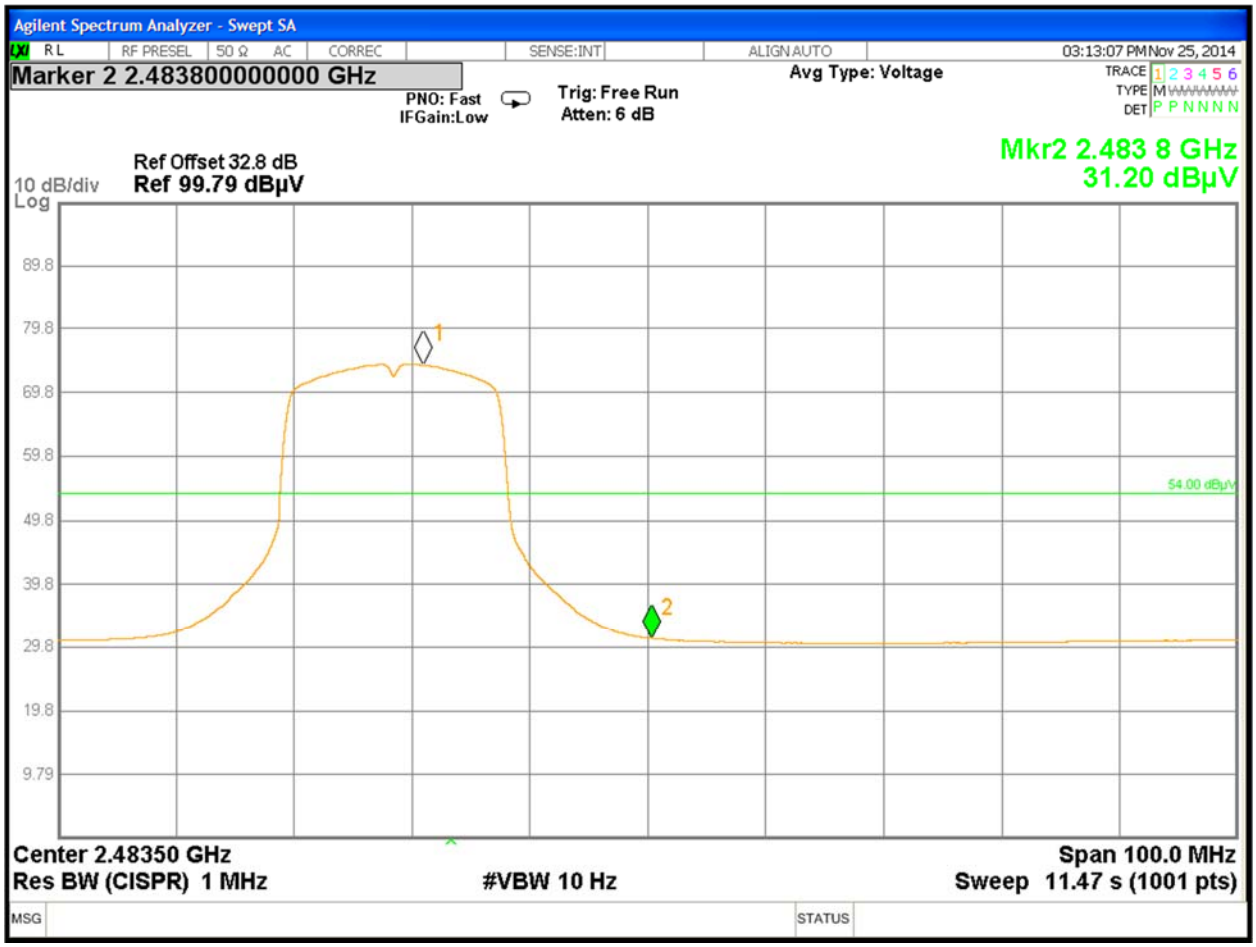


Figure 41: Radiated Emission at the Edge for Channel 2462 MHz at 6.5Mbps HT20 mode– Horizontal (Avg)

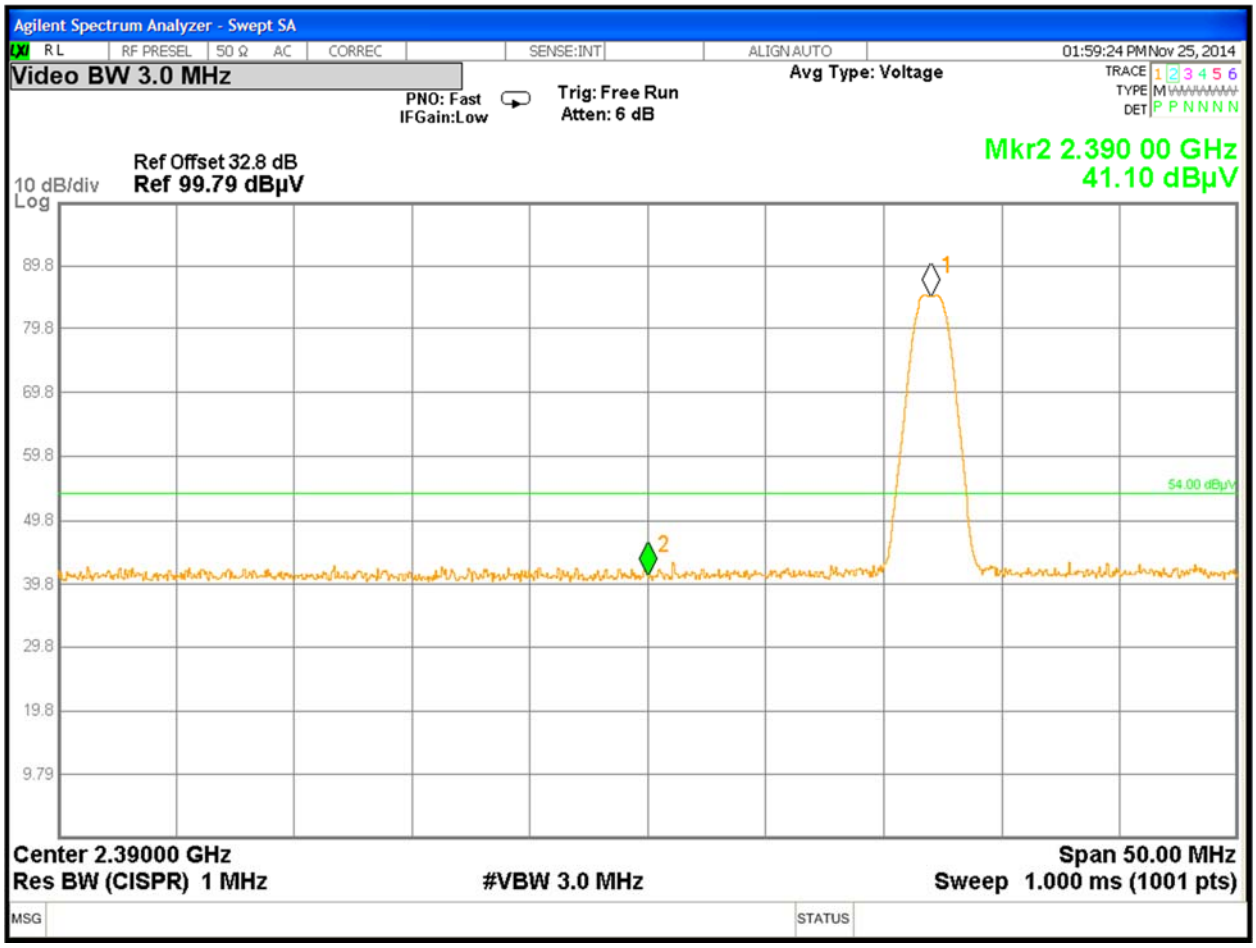


Figure 42: Radiated Emission at the Edge for Channel 2402 MHz at 1Mbps BLE mode– Horizontal (Pk)

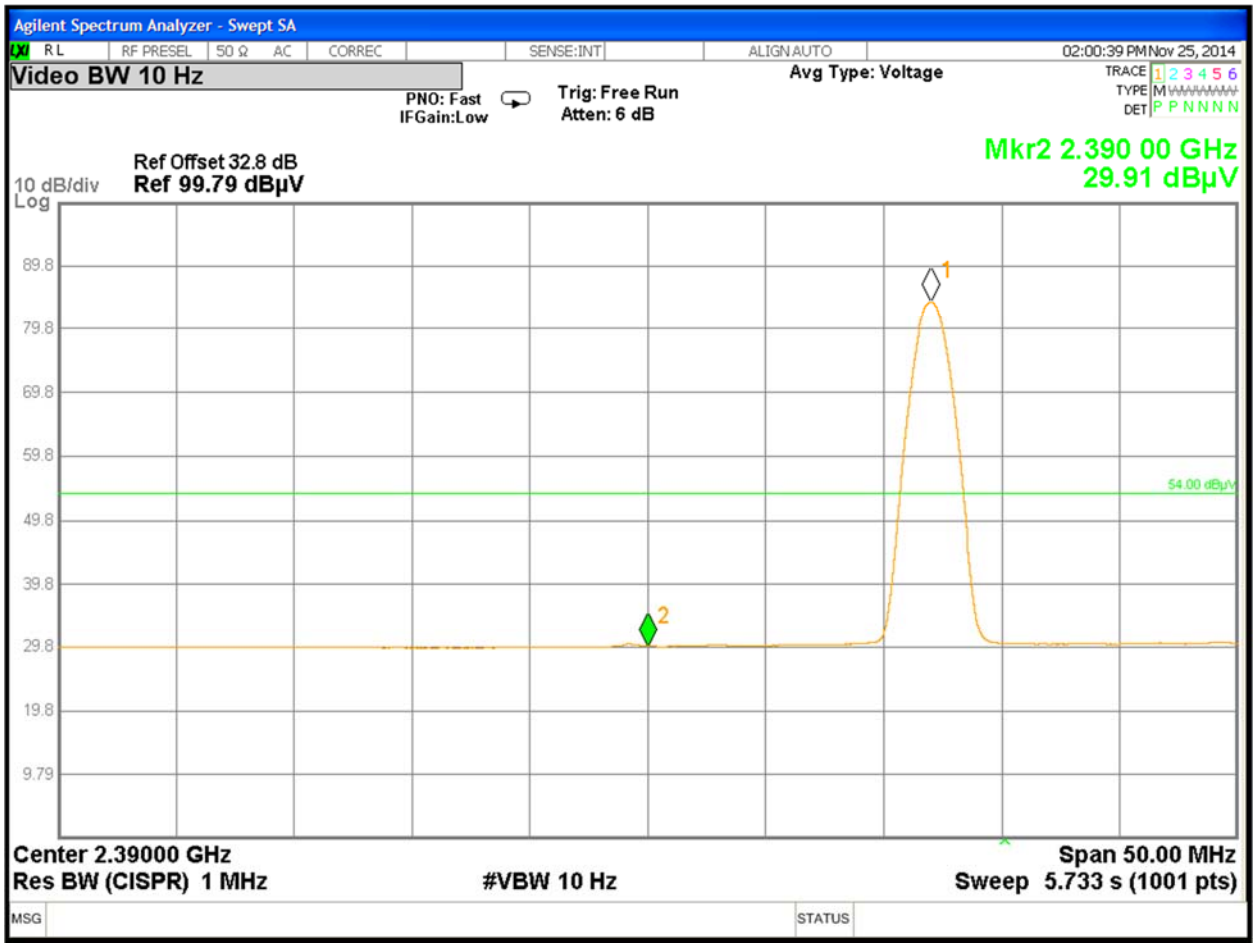


Figure 43: Radiated Emission at the Edge for Channel 2412 MHz at 1Mbps BLE mode– Horizontal (Avg)

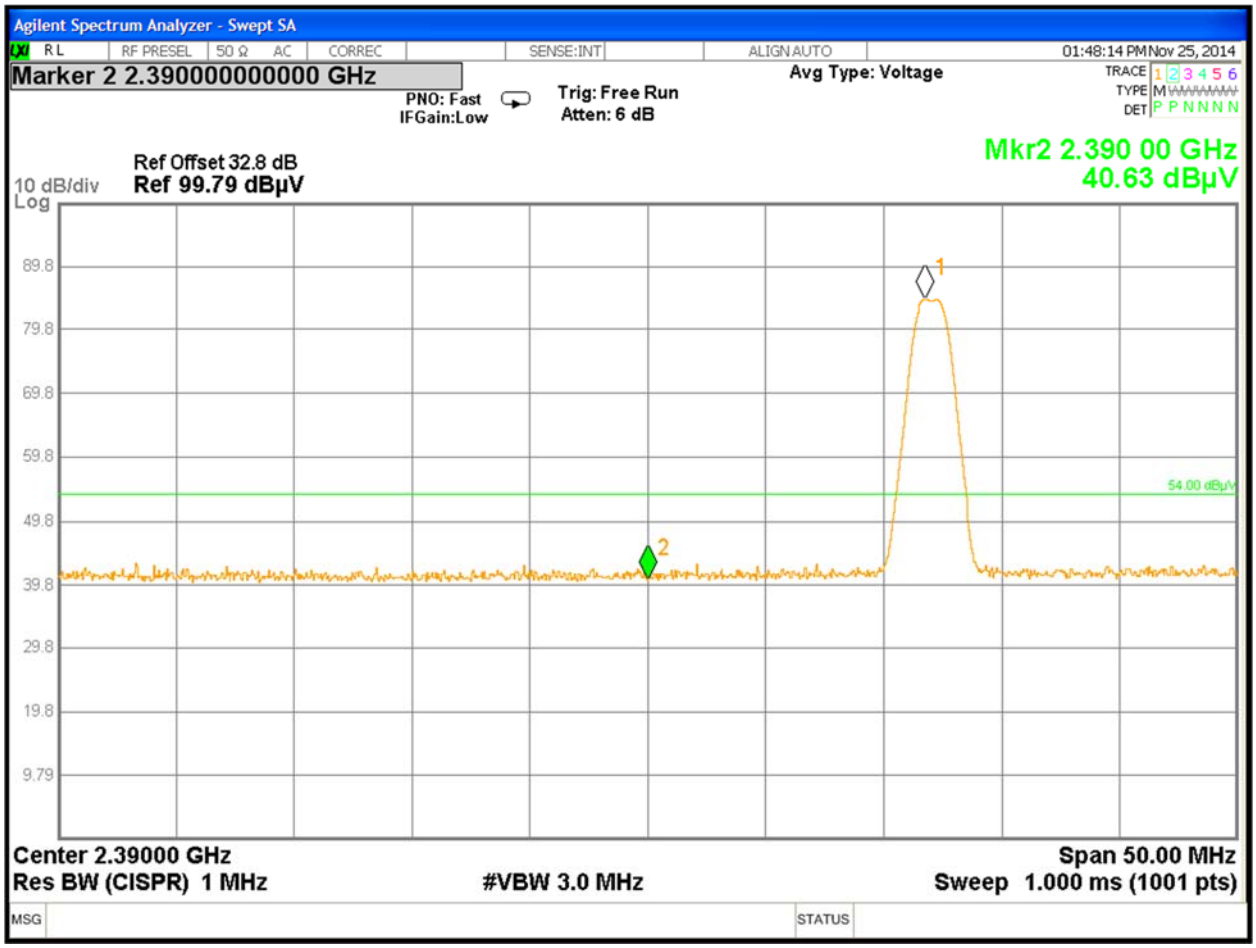


Figure 44: Radiated Emission at the Edge for Channel 2402 MHz at 1Mbps BLE mode– Vertical (PK)

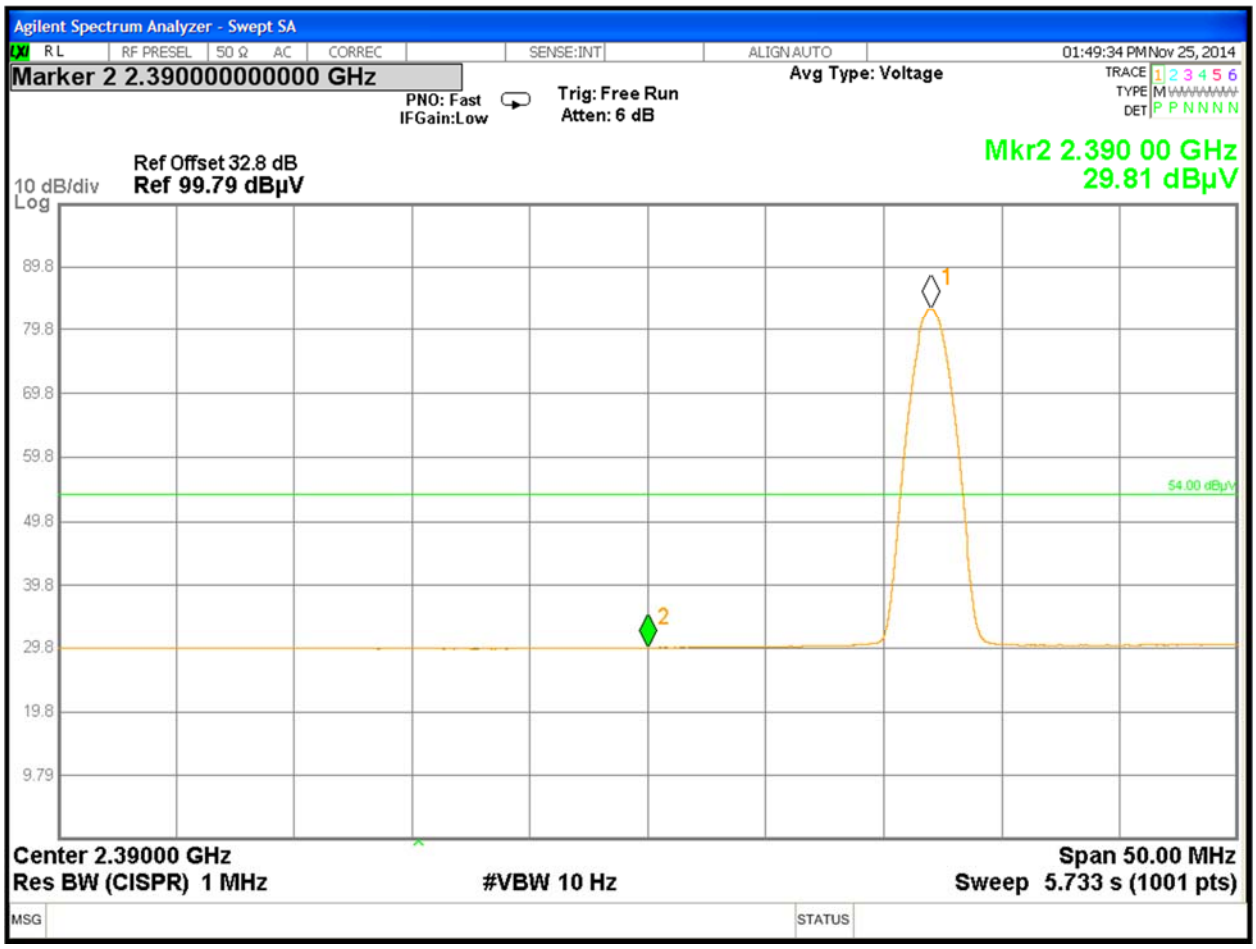


Figure 45: Radiated Emission at the Edge for Channel 2480 MHz at 1Mbps BLE mode– Vertical (Avg)

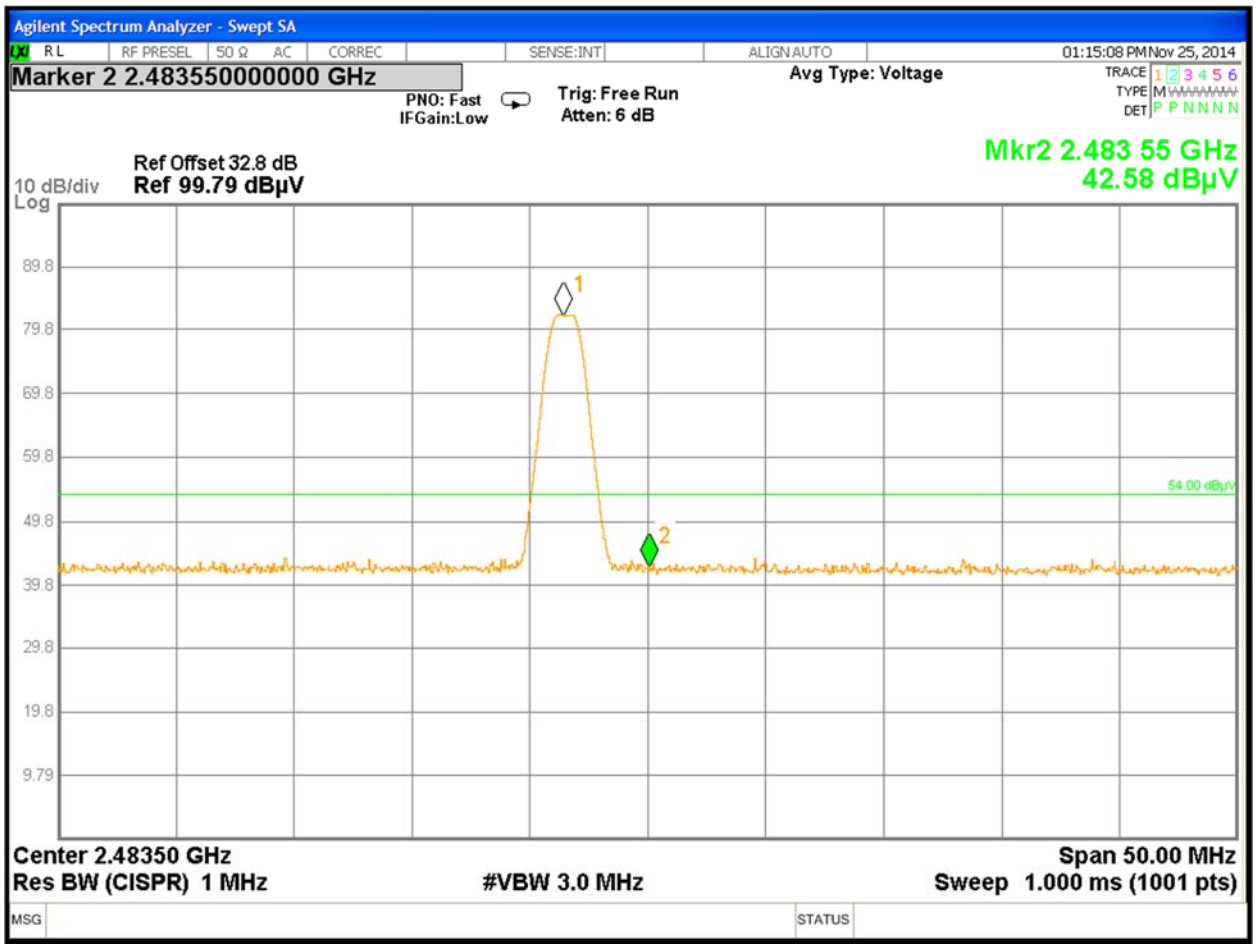


Figure 46: Radiated Emission at the Edge for Channel 2480 MHz at 1Mbps BLE mode– Vertical(PK)

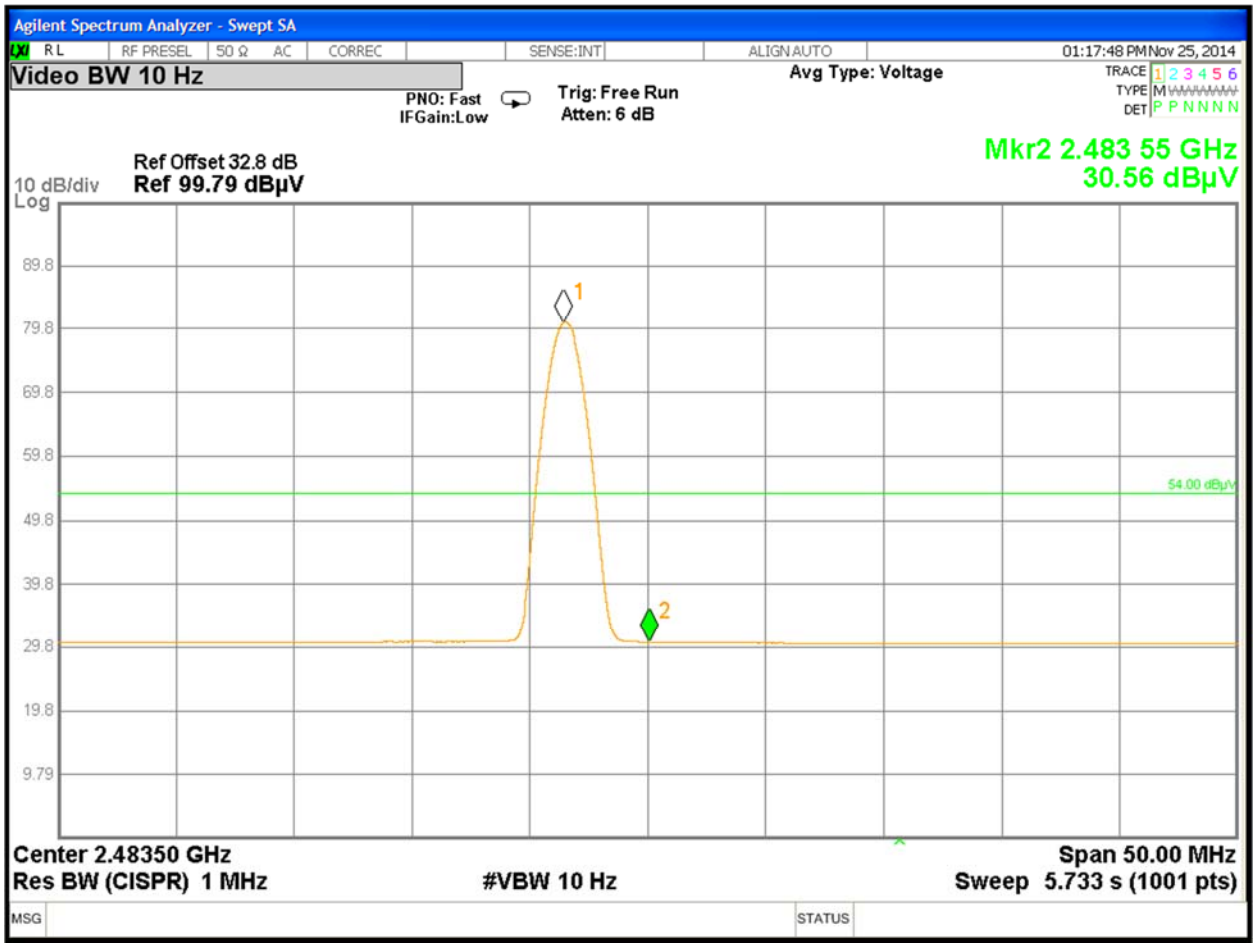


Figure 47: Radiated Emission at the Edge for Channel 2480 MHz at 1Mbps BLE mode– Horizontal (Avg)

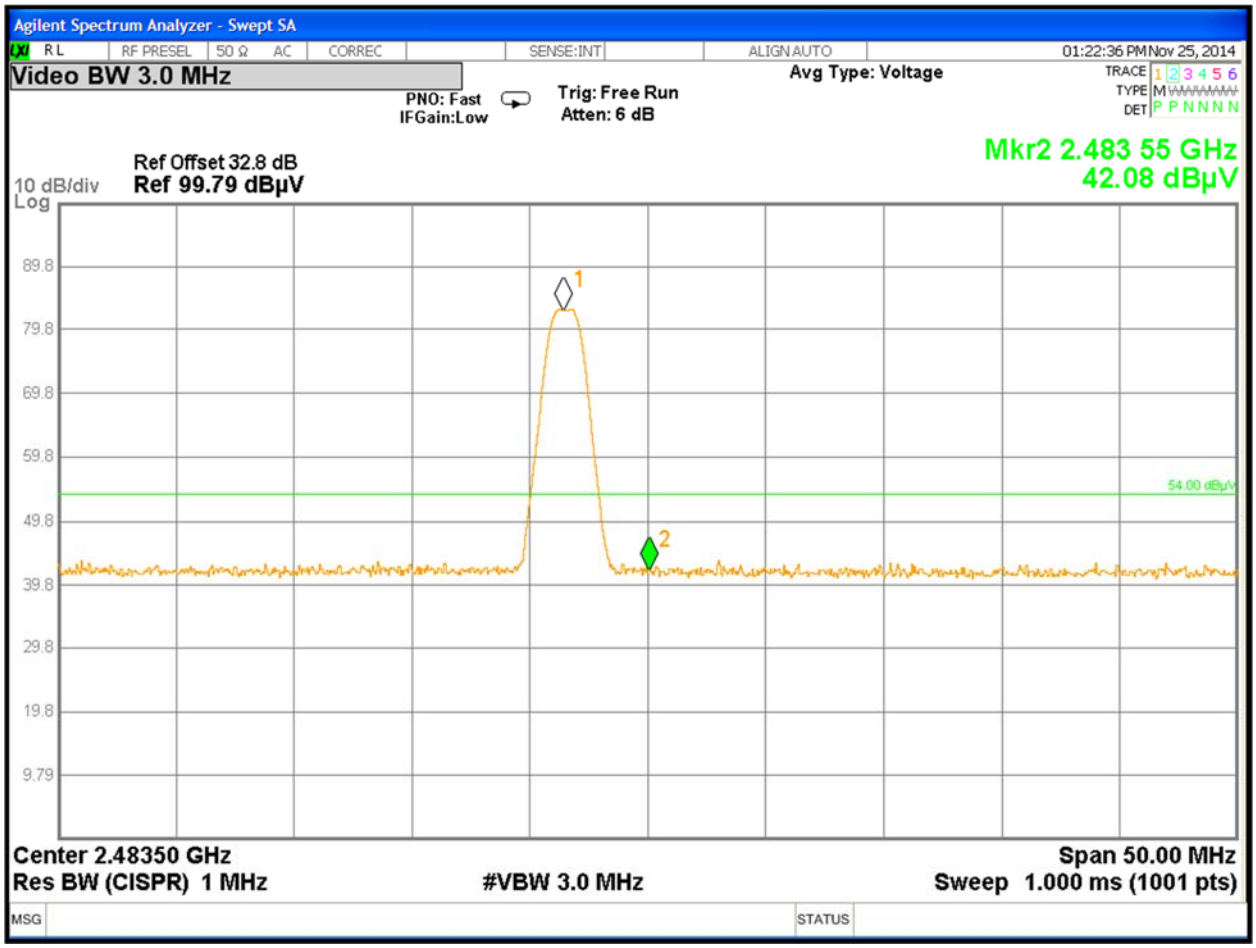


Figure 48: Radiated Emission at the Edge for Channel 2480 MHz at 1Mbps BLE mode– Vertical (PK)

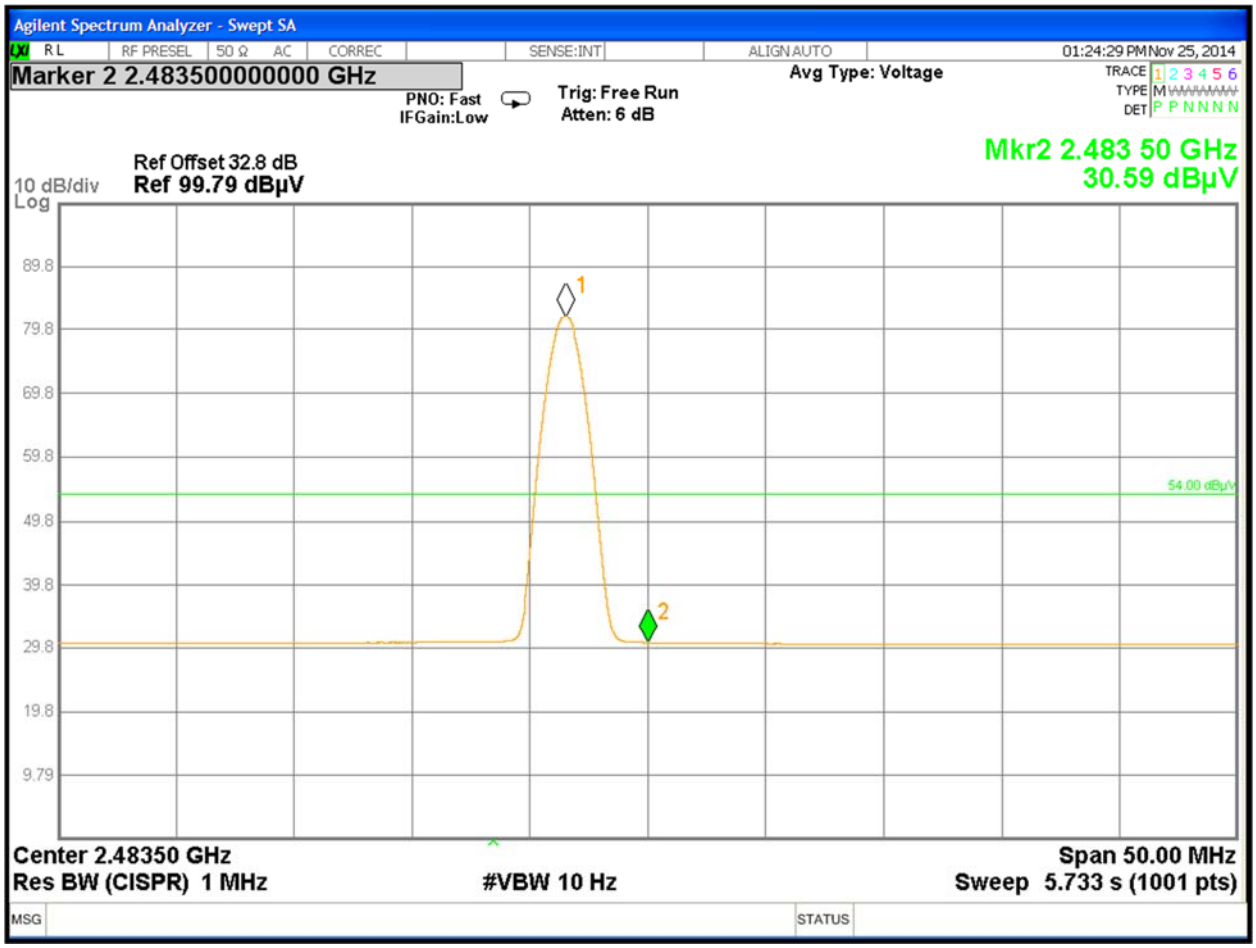


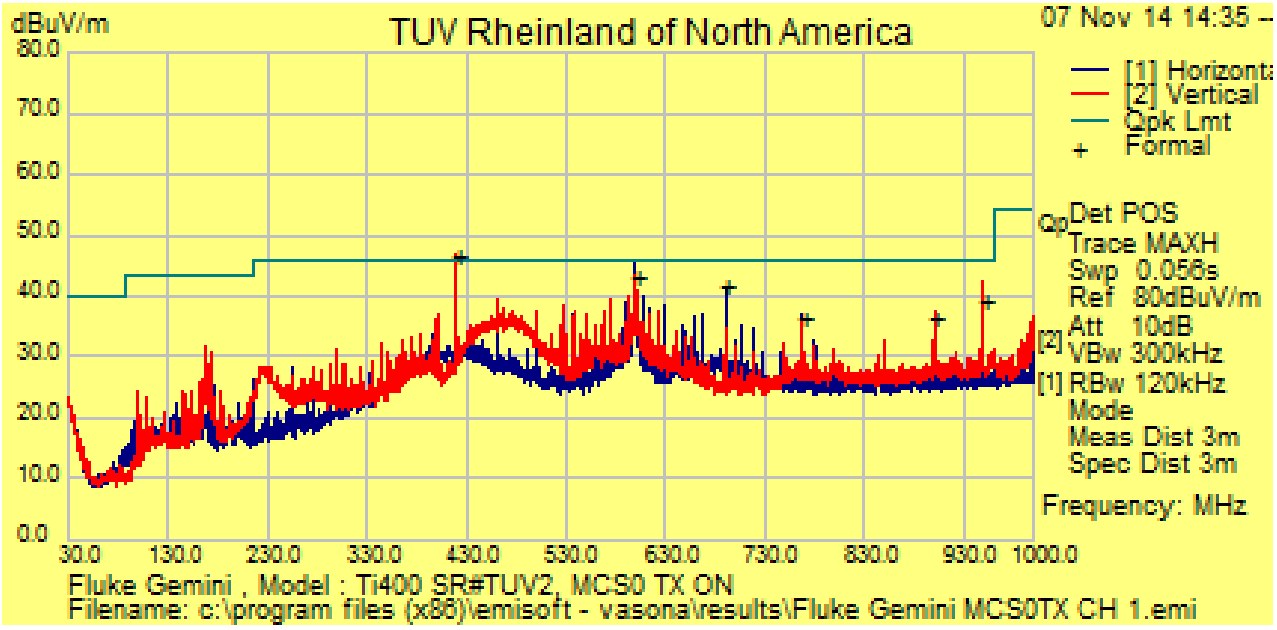
Figure 49: Radiated Emission at the Edge for Channel 2480 MHz at 1Mbps BLE mode– Vertical (Avg)

802.11 HT20 Mode

SOP 1 Radiated Emissions — Tracking # 31560156.001 Page 1 of 11

EUT Name	Gemini	**Date**	Nov 07, 2014
EUT Model	Ti200, Ti300 and Ti400	**Temp / Hum in**	23°C / 39%rh
EUT Serial	TUV2	**Temp / Hum out**	N/A
EUT Config.	HT20 Mode 6.5Mbps	**Line Voltgae**	15 Vdc
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	1 MHz / 3 MHz
Dist/Ant Used	3m - EMCO3115 / 1m - RA42-K-F-4B-C	**Performed by**	Suresh Kondapalli

30MHz - 1 GHz Plots for HT 20Transmit Mode at 2412 MHz, 6.5Mbit/s



Notes: 30MHz to 1GHz Setting: RBW = 120KHz MHz/ VBW = 300KHz 1 GHz – 10 GHz Setting: RBW = 1 MHz/ VBW = 3 MHz
Note: The emission at 420MHz is from Camera Elctronics and device is Class A device

SOP 1 Radiated Emissions — Tracking # 31560156.001 Page 2 of 11

EUT Name	Radio Module	**Date**	Nov 07, 2014
EUT Model	Ti200, Ti300 and Ti400	**Temp / Hum in**	23°C / 39%rh
EUT Serial	TUV1	**Temp / Hum out**	N/A
EUT Comfit.	Y-Axis, HT20	**Line Voltage**	15 Vdc
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	3m / EMCO3115 / 1m - RA42-K-F-4B-C	**Performed by**	Suresh Kondapalli

HT20 Transmit Mode at, 6.5Mbit/s Channel# 1, 2412MHz

Freq	Raw	Cable	AF	Final Level	Measurement	Pol	Ant Hgt	Azt	Limit	Margin	Result
MHz	dBuV	dB	dB	dBuV	Pk/Avg	-	cm	Deg	dBuV	dB	
600.02	48.85	2.47	-8.15	43.17	QP	H	120	64	46.00	-2.83	Pass
691.19	45.67	2.59	-6.71	41.56	QP	H	102	278	46.00	-4.44	Pass
768.01	39.26	2.70	-5.68	36.27	QP	H	162	268	46.00	-9.73	Pass
899.98	37.60	2.86	-4.35	36.11	QP	V	115	361	46.00	-9.89	Pass
949.97	40.18	2.92	-3.64	39.46	QP	V	105	12	46.00	-6.54	Pass
HT20 Transmit Mode at, 6.5Mbit/s Channel# 11, 2462MHz											
600.06	47.53	2.47	-8.15	41.85	QP	H	112	283	46.00	-4.15	Pass
691.21	45.24	2.59	-6.71	41.13	QP	H	101	276	46.00	-4.87	Pass
175.01	42.75	1.72	-14.46	30.01	QP	V	105	42	43.50	-13.49	Pass
950.00	40.84	2.92	-3.64	40.13	QP	V	103	-8	46.00	-5.88	Pass
900.00	39.50	2.86	-4.35	38.01	QP	V	152	340	46.00	-7.99	Pass

Spec Margin = E-Field QP - Limit, E-Field QP = FIM QP+ Total CF ± Uncertainty
Total CF= Amp Gain + Cable Loss + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 3.2 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

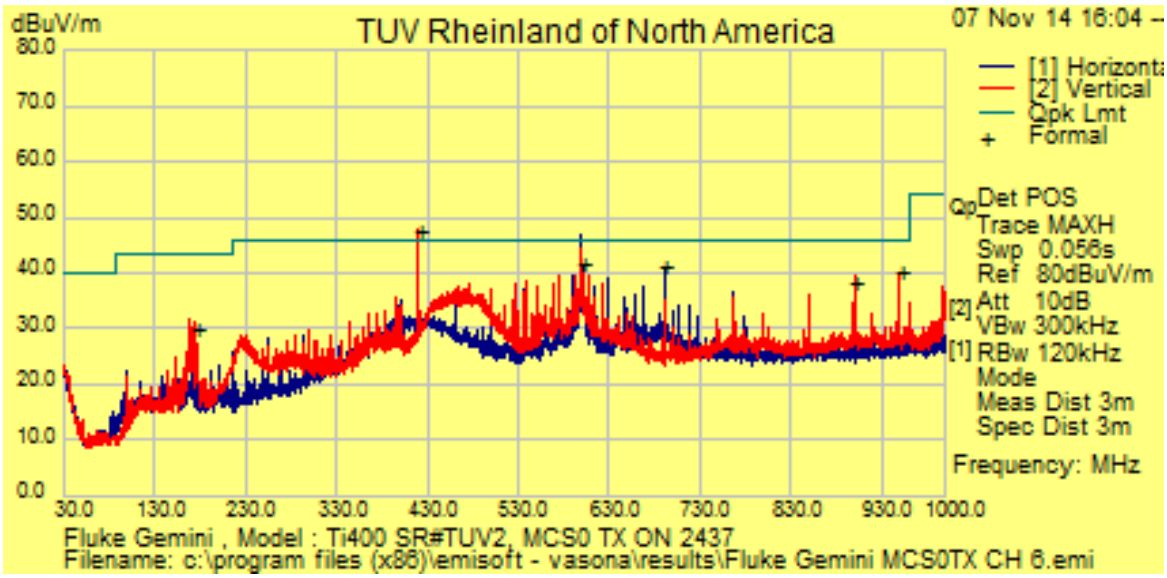
Notes: Worst case was observed on Y-axis, 1 Mbps. No duty cycle reduction was applied. Low, mid and high channels were evaluated for 30 MHz to 26 MHz, only worst case results are reported here.
Note: The emission at 420MHz is from Camera Elctronics and device is Class A device

SOP 1 Radiated Emissions

Tracking # 31560156.001 Page 3 of 11

EUT Name	Gemini	**Date**	Nov 14, 2014
EUT Model	Ti200, Ti300 and Ti400	**Temp / Hum in**	23°C / 39%rh
EUT Serial	TUV1	**Temp / Hum out**	N/A
EUT Config.	Y-Axis, HT20 6.5 Mbps	**Line Voltage**	15 Vdc
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	120 kHz/300 kHz
Dist/Ant Used	3m - EMCO3115 / 1m - RA42-K-F-4B-C	**Performed by**	Suresh Kondapalli

30MHz to 1GHz HT20 Transmit Mode at 2462MHz 6.5Mbit/s



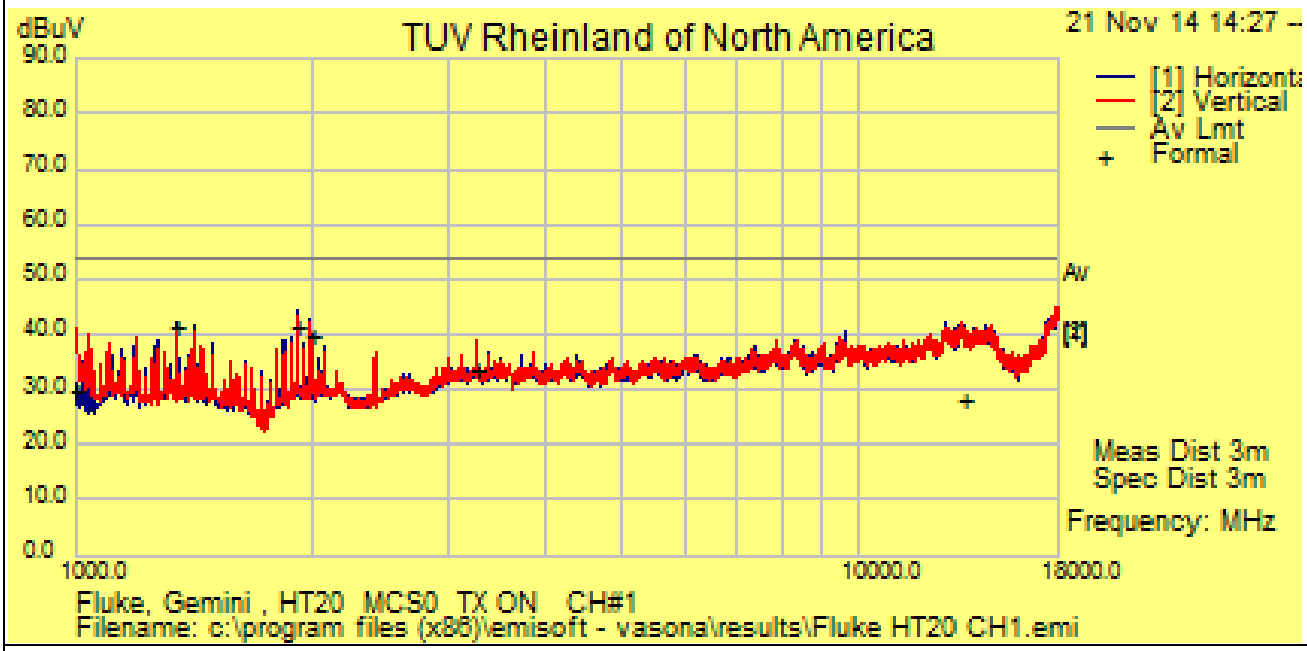
Notes: Notes: 30MHz to 1GHz Setting: RBW = 120KHz MHz/ VBW = 300KHz 1 GHz – 25 GHz Setting: RBW = 1 MHz/ VBW = 3 MHz

SOP 1 Radiated Emissions

Tracking # 31560156.001 Page 4 of 11

EUT Name	Gemini	**Date**	Nov 21, 2014
EUT Model	Ti200, Ti300 and Ti400	**Temp / Hum in**	23°C / 39%rh
EUT Serial	TUV1	**Temp / Hum out**	N/A
EUT Config.	Y-Axis, HT20	**Line Voltage**	15 Vdc
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	1 MHz / 3 MHz
Dist/Ant Used	3m - EMCO3115 / 1m - RA42-K-F-4B-C	**Performed by**	Suresh Kondapalli

1 -18GHz Plots for HT20 Transmit Mode at 2412 MHz, 6.5Mbit/s



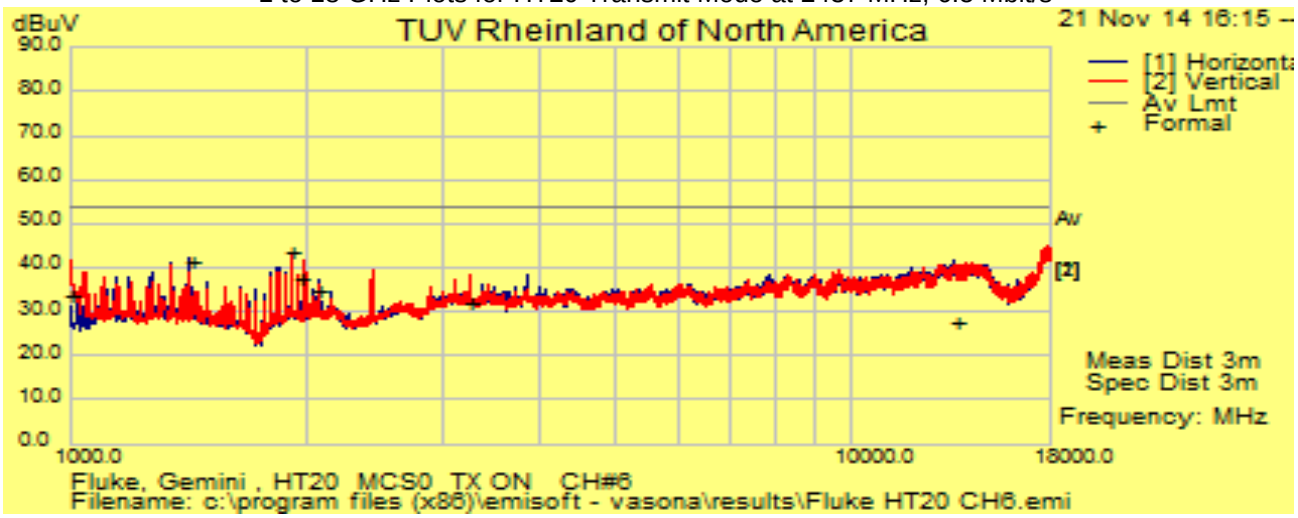
Notes: All Emissions 18 to 26 GHz were at least 20 dB below the limt
1 GHz – 25 GHz Setting: RBW = 1 MHz/ VBW = 3 MHz

SOP 1 Radiated Emissions

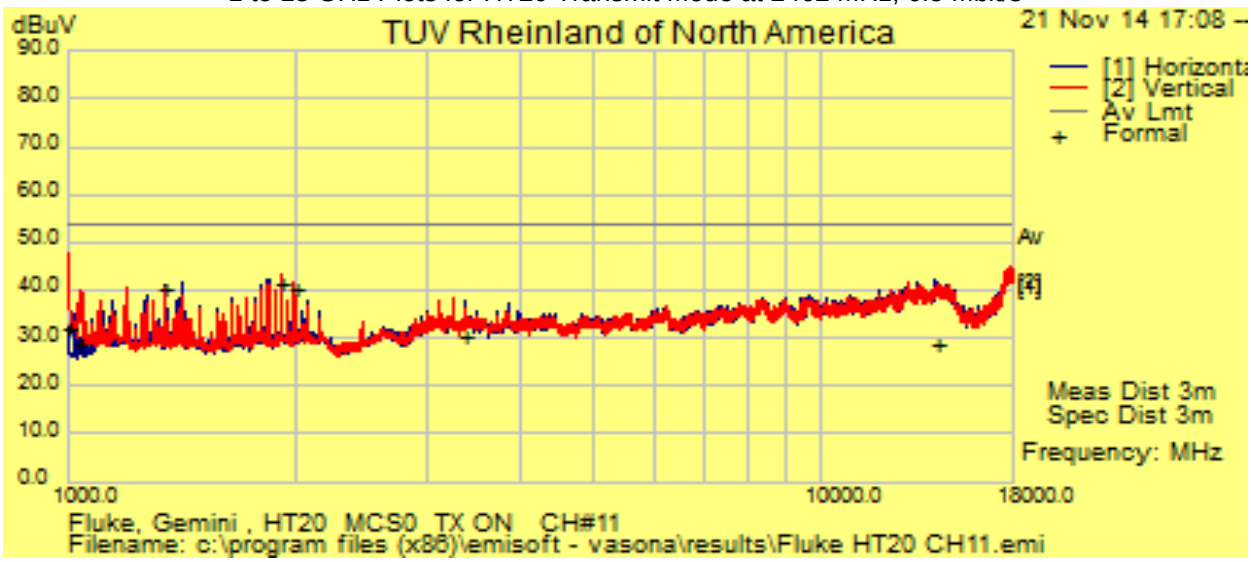
Tracking # 31560156.001 Page 5 of 11

EUT Name	Gemini	**Date**	Nov 24, 2014
EUT Model	Ti200, Ti300 and Ti400	**Temp / Hum in**	23°C / 39%rh
EUT Serial	TUV1	**Temp / Hum out**	N/A
EUT Config.	Y-Axis, HT20	**Line Voltage**	15 Vdc
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	1 MHz / 3 MHz
Dist/Ant Used	3m - EMCO3115 / 1m - RA42-K-F-4B-C	**Performed by**	Suresh Kondapalli

1 to 18 GHz Plots for HT20 Transmit Mode at 2437 MHz, 6.5 Mbit/s



1 to 18 GHz Plots for HT20 Transmit Mode at 2462 MHz, 6.5 Mbit/s



Notes: All Emissions 18 to 26 GHz were at least 20 dB below the limt
1 GHz – 25 GHz Setting: RBW = 1 MHz/ VBW = 3 MHz

SOP 1 Radiated Emissions — Tracking # 31560156.001 Page 6 of 11

EUT Name	Radio Module	**Date**	August 30, 2013
EUT Model	Ti200, Ti300 and Ti400	**Temp / Hum in**	23°C / 39%rh
EUT Serial	TUV1	**Temp / Hum out**	N/A
EUT Comfit.	Y-Axis, HT20 mode 1 Mbps	**Line Voltage**	15 Vdc
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	3m / EMCO3115 / 1m - RA42-K-F-4B-C	**Performed by**	Suresh Kondapalli

Sprurious Emissions TX on 2412 MHz

Freq	Raw	Cable	AF	Final Level	Measurement	Pol	Ant Hgt	Azt	Limit	Margin	Result
MHz	dBuV	dB	dB	dBuV	Pk/Avg	-	cm	Deg	dBuV	dB	
1343.96	65.95	0.86	-25.51	41.30	Avg	H	159	178	54.00	-12.70	Pass
1919.96	63.81	1.03	-23.71	41.13	Avg	H	125	342	54.00	-12.87	Pass
1996.69	62.48	1.05	-23.72	39.81	Avg	H	116	328	54.00	-14.19	Pass
3240.15	52.11	1.34	-19.66	33.79	Avg	H	121	330	54.00	-20.21	Pass
1000.00	55.90	0.73	-26.56	30.08	Avg	V	106	272	54.00	-23.93	Pass
13552.50	34.58	2.91	-9.59	27.90	Avg	V	184	-8	54.00	-26.10	Pass
Sprurious Emissions TX on 2437 MHz											
1420.79	66.33	0.88	-25.61	41.60	Avg	H	139	164	54.00	-12.40	Pass
2073.65	57.05	1.06	-23.30	34.82	Avg	H	195	326	54.00	-19.18	Pass
3239.65	50.26	1.34	-19.67	31.94	Avg	H	171	338	54.00	-22.06	Pass
13570.35	34.19	2.92	-9.54	27.57	Avg	H	154	324	54.00	-26.43	Pass
1000.00	59.23	0.73	-26.56	33.40	Avg	V	104	338	54.00	-20.60	Pass
1919.87	66.17	1.03	-23.71	43.49	Avg	V	121	62	54.00	-10.51	Pass
1958.35	60.12	1.03	-23.71	37.44	Avg	V	121	64	54.00	-16.56	Pass

Note1: These emissions were confirmed to be from Digital parts. EUT passed Class A from digital Parts

Spec Margin = E-Field QP - Limit, E-Field QP = FIM QP+ Total CF ± Uncertainty
Total CF= Amp Gain + Cable Loss + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 3.2 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

Notes: Worst case was observed on Y-axis, 1 Mbps. No duty cycle reduction was applied. Low, mid and high channels were evaluated for 30 MHz to 26 GHz, only worst case results are reported here.

SOP 1 Radiated Emissions — Tracking # 31560156.001 Page 7 of 11

EUT Name	Radio Module	**Date**	Nov 14, 2014
EUT Model	Ti200, Ti300 and Ti400	**Temp / Hum in**	23°C / 39%rh
EUT Serial	TUV1	**Temp / Hum out**	N/A
EUT Comfit.	Y-Axis, HT20 6.5 Mbps	**Line Voltage**	15 Vdc
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	3m / EMCO3115 / 1m - RA42-K-F-4B-C	**Performed by**	Suresh Kondapalli

Sprurious Emissions TX on 2462 MHz HT20

Freq	Raw	Cable	AF	Final Level	Measur e-ment	P ol	Ant Hgt	Azt	Limit	Margin	Result
MHz	dBuV	dB	dB	dBuV	Pk/Avg	-	cm	Deg	dBuV	dB	
1343.98	64.91	0.86	-25.51	40.26	Avg	H	159	158	54.00	-13.74	Pass
1919.90	64.28	1.03	-23.71	41.60	Avg	H	126	332	54.00	-12.40	Pass
3359.82	48.13	1.37	-19.26	30.24	Avg	H	165	42	54.00	-23.76	Pass
14193.28	34.34	2.99	-8.45	28.88	Avg	H	121	118	54.00	-25.12	Pass
1000.00	57.83	0.73	-26.56	32.00	Avg	V	101	-3	54.00	-22.00	Pass
1034.73	54.47	0.74	-26.35	28.87	Avg	V	101	6	54.00	-25.13	Pass
1996.76	62.75	1.05	-23.72	40.08	Avg	V	115	70	54.00	-13.92	Pass

@ These emissions were confirmed to be from Digital parts. EUT passed Class A from digital Parts

Spec Margin = E-Field QP - Limit, E-Field QP = FIM QP+ Total CF ± Uncertainty
Total CF= Amp Gain + Cable Loss + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 3.2 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

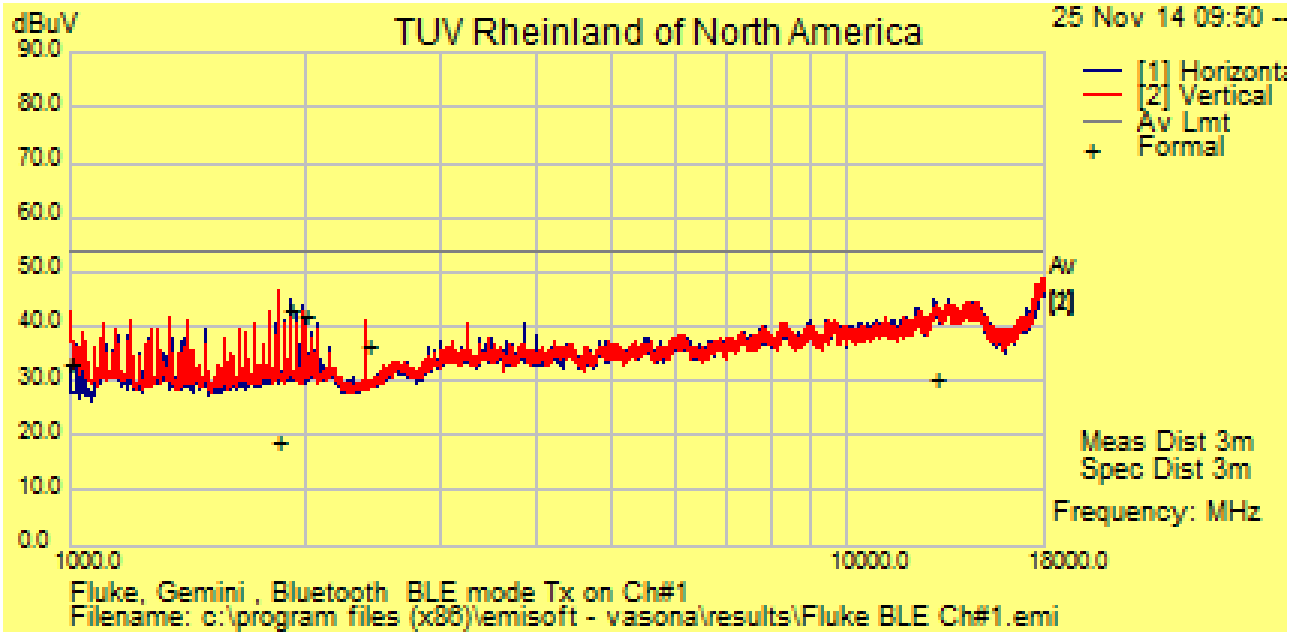
Notes: Worst case was observed on Y-axis, 1 Mbps. No duty cycle reduction was applied. Low, mid and high channels were evaluated for 30 MHz to 26 GHz, only worst case results are reported here.

BLE Mode

SOP 1 Radiated Emissions — Tracking # 31560156.001 Page 8 of 11

EUT Name	Gemini	**Date**	Nov 25, 2014
EUT Model	Ti200, Ti300 and Ti400	**Temp / Hum in**	23°C / 39%rh
EUT Serial	TUV1	**Temp / Hum out**	N/A
EUT Config.	Y-Axis, BLE mode	**Line Voltage**	15 Vdc
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	1 MHz / 3 MHz
Dist/Ant Used	3m - EMCO3115 / 1m - RA42-K-F-4B-C	**Performed by**	Suresh Kondapalli

Above 1 GHz Plots for Transmit Mode at 2402 MHz, 1Mbit/s



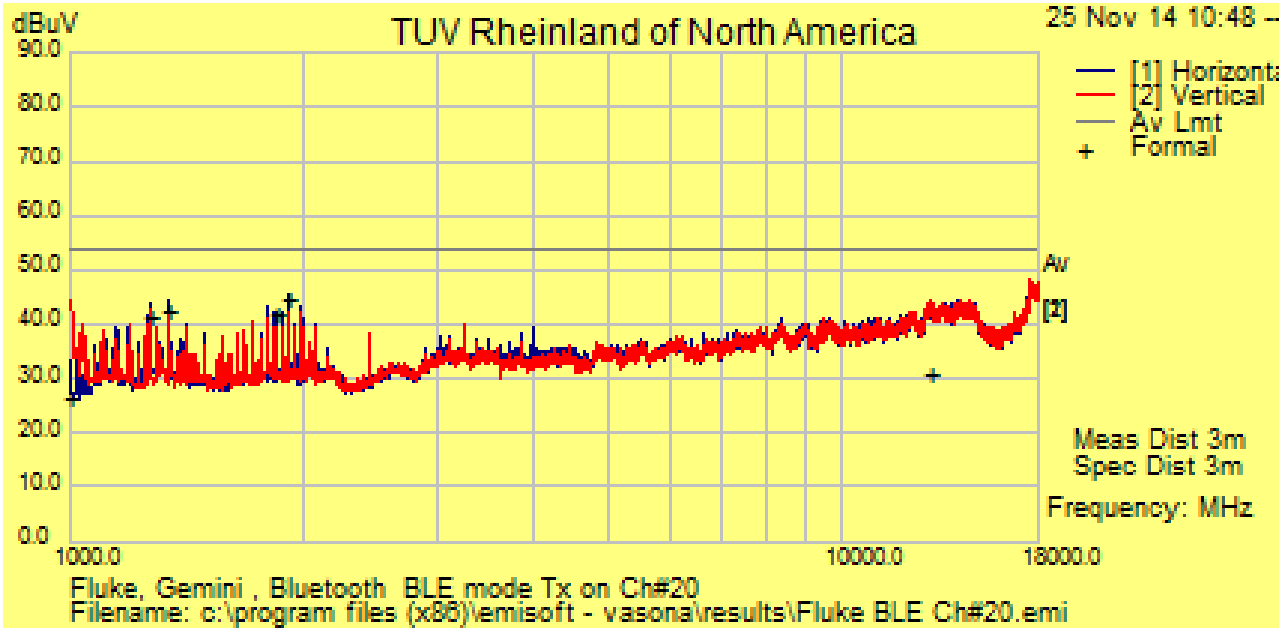
Notes: All Emissions 18 to 26 GHz were at least 20 dB below the limt
1 GHz – 10 GHz Setting: RBW = 1 MHz/ VBW = 3 MHz

SOP 1 Radiated Emissions

Tracking # 31560156.001 Page 9 of 11

EUT Name	Gemini	**Date**	Nov 25, 2014
EUT Model	Ti200, Ti300 and Ti400	**Temp / Hum in**	23°C / 39%rh
EUT Serial	TUV1	**Temp / Hum out**	N/A
EUT Config.	Y-Axis, BLE mode	**Line Voltage**	15 Vdc
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	1 MHz / 3 MHz
Dist/Ant Used	3m - EMCO3115 / 1m - RA42-K-F-4B-C	**Performed by**	Suresh Kondapalli

Above 1 GHz Plots for Transmit Mode at 2440 MHz, 1Mbit/s



Notes: All Emissions 18 to 26 GHz were at least 20 dB below the limt
1 GHz – 10 GHz Setting: RBW = 1 MHz/ VBW = 3 MHz

SOP 1 Radiated Emissions		Tracking # 31560156.001 Page 9 of 11	
EUT Name	Radio Module	**Date**	Nov 25, 2014
EUT Model	Ti200, Ti300 and Ti400	**Temp / Hum in**	23°C / 39%rh
EUT Serial	TUV1	**Temp / Hum out**	N/A
EUT Comfit.	Y-Axis, BLE mode 1 Mbps	**Line Voltage**	15 Vdc
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	3m / EMCO3115 / 1m - RA42-K-F-4B-C	**Performed by**	Suresh Kondapalli

1-18GHz Emissions for Transmit Mode at 2402 MHz, 1Mbit/s

Freq	Raw	Cable	AF	Final Level	Measurement	Pol	Ant Hgt	Azt	Limit	Margin	Result
MHz	dBuV	dB	dB	dBuV	Pk/Avg	-	cm	Deg	dBuV	dB	
1919.97	65.53	1.03	-23.71	42.85	Avg	H	150	344	54.00	-11.15	Pass
1996.74	64.72	1.05	-23.72	42.04	Avg	H	149	318	54.00	-11.96	Pass
2402.04	57.56	1.15	-22.40	36.31	Avg	H	193	333	54.00	-17.69	Pass
12992.60	37.27	2.84	-9.58	30.53	Avg	H	180	120	54.00	-23.48	Pass
1000.00	59.16	0.73	-26.56	33.33	Avg	V	188	58	54.00	-20.67	Pass
1852.53	41.37	1.01	-23.81	18.57	Avg	V	150	78	54.00	-35.43	Pass
1-18GHz Emissions for Transmit Mode at 2440 MHz, 1Mbit/s											
1267.27	65.82	0.83	-25.49	41.16	Avg	H	200	50	54.00	-12.84	Pass
1343.92	67.32	0.86	-25.51	42.67	Avg	H	200	248	54.00	-11.33	Pass
1843.24	64.94	1.01	-23.83	42.12	Avg	H	102	140	54.00	-11.89	Pass
1919.98	67.22	1.03	-23.71	44.55	Avg	H	101	147	54.00	-9.45	Pass
1002.00	52.18	0.73	-26.55	26.37	Avg	V	101	66	54.00	-27.63	Pass
13020.77	37.83	2.85	-9.51	31.17	Avg	V	105	112	54.00	-22.83	Pass

1-18GHz Emissions for Transmit Mode at 2480 MHz, 1Mbit/s											
1267.13	67.06	0.83	-25.49	42.40	Avg	H	198	44	54.00	-11.60	Pass
1343.94	68.07	0.86	-25.51	43.42	Avg	H	141	254	54.00	-10.58	Pass
1804.76	66.13	0.99	-23.94	43.18	Avg	H	102	136	54.00	-10.82	Pass
1920.05	64.59	1.03	-23.71	41.91	Avg	H	100	134	54.00	-12.09	Pass
4000.06	47.01	1.50	-17.52	30.99	Avg	H	170	186	54.00	-23.01	Pass
2073.64	59.21	1.06	-23.30	36.97	Avg	V	100	51	54.00	-17.03	Pass

Spec Margin = E-Field QP - Limit, E-Field QP = FIM QP+ Total CF ± Uncertainty
Total CF= Amp Gain + Cable Loss + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 3.2 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

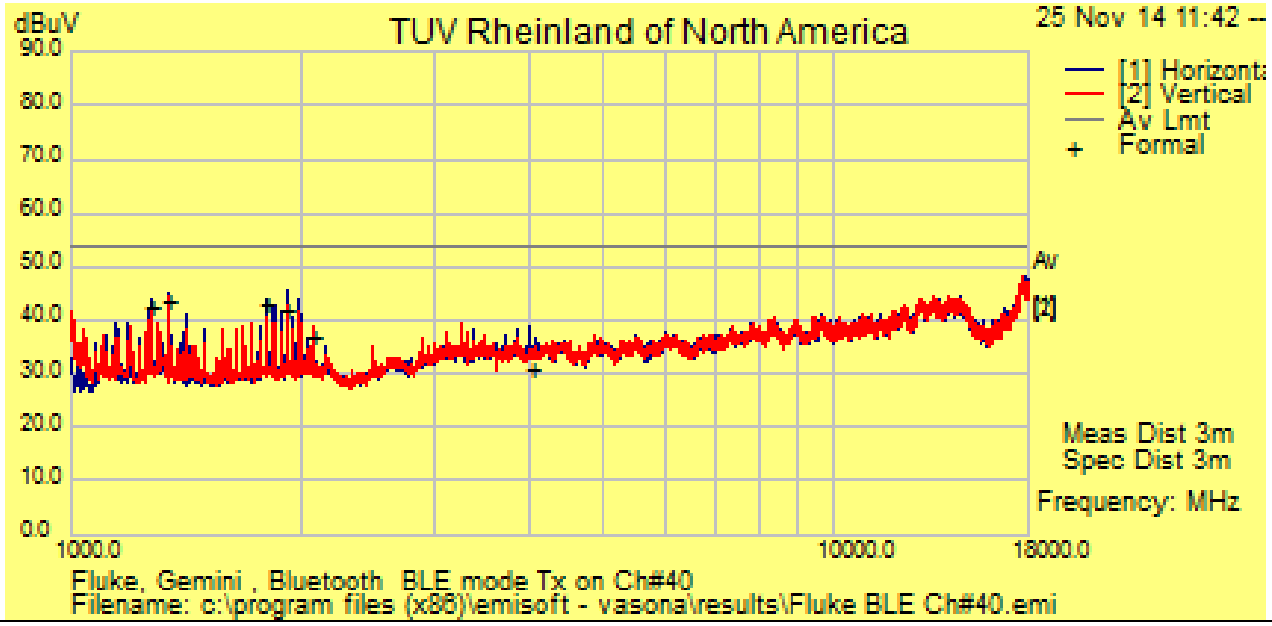
Notes: Worst case was observed on Y-axis, 1 Mbps. No duty cycle reduction was applied. Low, mid and high channels were evaluated for 30 MHz to 26 GHz, only worst case results are reported here.
Note: All Emissions 18-26GHz were 20dB below the limit

BLE Mode

SOP 1 Radiated Emissions — Tracking # 31560156.001 Page 10 of 11

EUT Name	Gemini	**Date**	Nov 25, 2014
EUT Model	Ti200, Ti300 and Ti400	**Temp / Hum in**	23°C / 39%rh
EUT Serial	TUV1	**Temp / Hum out**	N/A
EUT Config.	Y-Axis, BLE mode	**Line Voltage**	15 Vdc
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	1 MHz / 3 MHz
Dist/Ant Used	3m - EMCO3115 / 1m - RA42-K-F-4B-C	**Performed by**	Suresh Kondapalli

Plot for Transmit Mode 802.11 BLE at 2480 MHz, 1Mbit/s



Notes: All Emissions 18 to 26 GHz were at least 20 dB below the limt
1 GHz – 25 GHz Setting: RBW = 1 MHz/ VBW = 3 MHz

SOP 1 Radiated Emissions		Tracking # 31560156.001 Page 11 of 11	
EUT Name	Radio Module	**Date**	Nov 25, 2014
EUT Model	Ti200, Ti300 and Ti400	**Temp / Hum in**	23°C / 39%rh
EUT Serial	TUV1	**Temp / Hum out**	N/A
EUT Comfit.	Y-Axis, BLE mode	**Line Voltage**	15 Vdc
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	1 MHz/ 3 MHz
Dist/Ant Used	3m / EMCO3115 / 1m - RA42-K-F-4B-C	**Performed by**	Suresh Kondapalli

1-18GHz TX Emissions at 2480Mz BLE mode

Freq	Raw	Cable	AF	Final Level	Measurement	Pol	Ant Hgt	Azt	Limit	Margin	Result
MHz	dBuV	dB	dB	dBuV	Pk/Av	-	cm	Deg	dBuV	dB	
1267.13	67.06	0.83	-25.49	42.40	Avg	H	198	44	54.00	-11.60	Pass
1343.94	68.07	0.86	-25.51	43.42	Avg	H	141	254	54.00	-10.58	Pass
1804.76	66.13	0.99	-23.94	43.18	Avg	H	102	136	54.00	-10.82	Pass
1920.05	64.59	1.03	-23.71	41.91	Avg	H	100	134	54.00	-12.09	Pass
4000.06	47.01	1.50	-17.52	30.99	Avg	H	170	186	54.00	-23.01	Pass
2073.64	59.21	1.06	-23.30	36.97	Avg	V	100	51	54.00	-17.03	Pass

Spec Margin = E-Field QP - Limit, E-Field QP = FIM QP+ Total CF ± Uncertainty
Total CF= Amp Gain + Cable Loss + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 3.2 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

Notes: Worst case was observed on Y-axis, 1 Mbps. No duty cycle reduction was applied. Low, mid and high channels were evaluated for 30 MHz to 26 GHz, only worst case results are reported here.

4.6.4 Sample Calculation

The field strength is calculated by subtracting the Amplifier Gain and adding the Cable Loss and Antenna Correction Factor to the measured reading. The basic equation is as follows:

Field Strength (dBμV/m) = FIM - AMP + CBL + ACF

Where: FIM = Field Intensity Meter (dBμV)
AMP = Amplifier Gain (dB)
CBL = Cable Loss (dB)
ACF = Antenna Correction Factor (dB/m)

$$\mu V/m = 10^{\frac{dB\mu V/m}{20}}$$

4.7 AC Conducted Emissions

Testing was performed in accordance with ANSI C63.4-2009. These test methods are listed under the laboratory's A2LA Scope of Accreditation.

This test measures the levels emanating from the EUT's AC input port, thus evaluating the potential for the EUT to cause radio frequency interference to other electronic devices.

The AC conducted emissions of equipment under test shall not exceed the values in CFR47 Part 15.207: 2011 and RSS 210: 2010.

4.7.1 Test Methodology

A test program that controls instrumentation and data logging was used to automate the AC Power Line Conducted emission test procedure. The frequency range of interest was divided into sub-ranges such as to yield a frequency resolution of 9 kHz. Each phase and neutral of the AC power line were measured with respect to ground. Measurements were performed using a set of 50µH / 50Ω LISNs.

Testing is either performed inLab 5. The setup photographs clearly identify which site was used. The vertical ground plane used in the semi-anechoic chamber is a 2m x 2m solid aluminum frame and panel, and it is bonded to the horizontal ground plane.

In the case of tabletop equipment, the EUT is placed on a 1.0m x 1.5m non-conductive table 80cm above the ground plane and 40cm from a vertical ground reference plane. The rear of the EUT was positioned flush with the backside of the table and directly over the LISNs. The power and I/O cables were routed over the edge of the table and bundled approximately 40cm from the ground plane. Support equipment was powered from a separate LISN.

4.7.1.1 *Deviations*

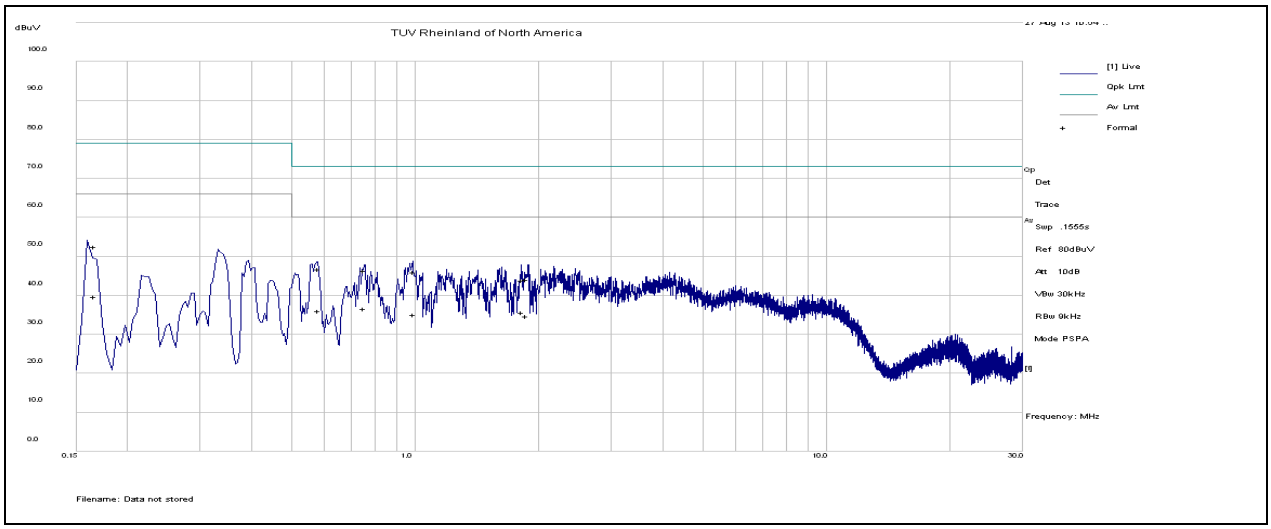
There were no deviations from this test methodology.

4.7.2 Test Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

NOTES:

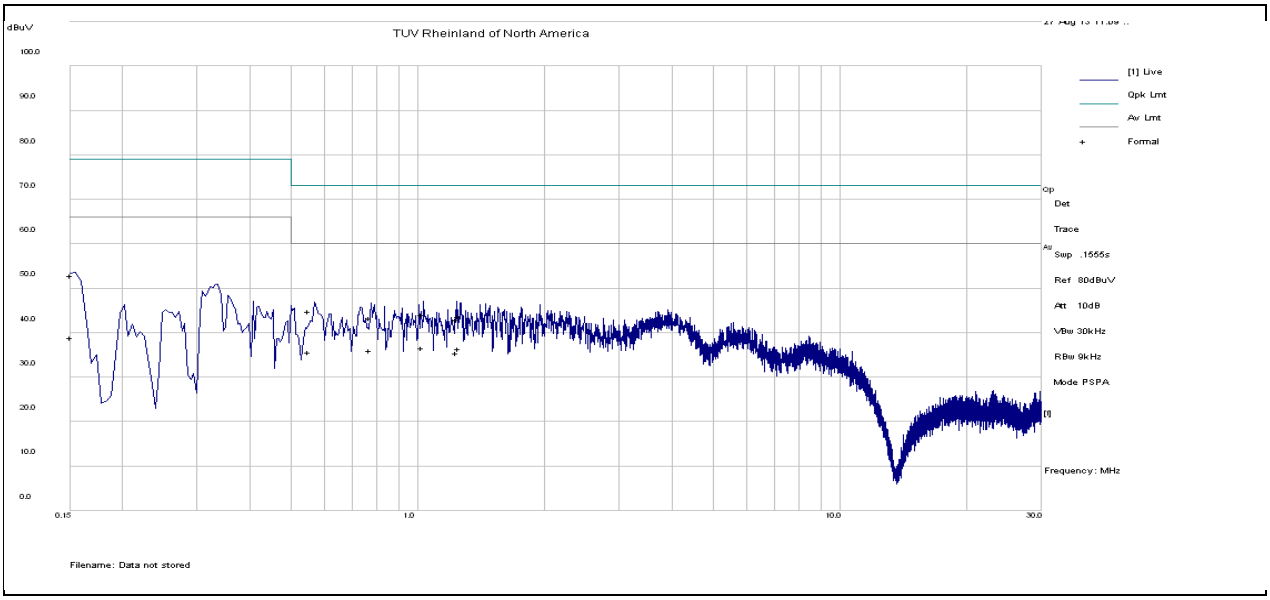
Conducted Emissions @ 110 Vac/60 Hz Line



Frequency	Raw	Cable	Factors	Level	Measurement Type	Line	Limit	Margin	Pass /Fail
MHz	dBuV	dB	dB	dBuV			dBuV	dB	
0.17	49.72	2.87	-0.09	52.5	QP	Live	79	-26.5	Pass
0.17	36.87	2.87	-0.09	39.65	Avg	Live	66	-26.35	Pass
0.58	43.91	2.9	-0.04	46.77	QP	Live	73	-26.23	Pass
0.58	33.1	2.9	-0.04	35.96	Avg	Live	60	-24.04	Pass
0.75	43.47	2.9	-0.04	46.33	QP	Live	73	-26.67	Pass
0.75	33.8	2.9	-0.04	36.66	Avg	Live	60	-23.34	Pass
0.99	43.2	2.87	-0.04	46.03	QP	Live	73	-26.97	Pass
0.99	32.29	2.87	-0.04	35.12	Avg	Live	60	-24.88	Pass
1.83	41.07	2.9	-0.04	43.93	QP	Live	73	-29.07	Pass
1.83	32.87	2.9	-0.04	35.73	Avg	Live	60	-24.27	Pass
1.87	41.26	2.91	-0.04	44.13	QP	Live	73	-28.87	Pass
1.87	31.81	2.91	-0.04	34.68	Avg	Live	60	-25.32	Pass

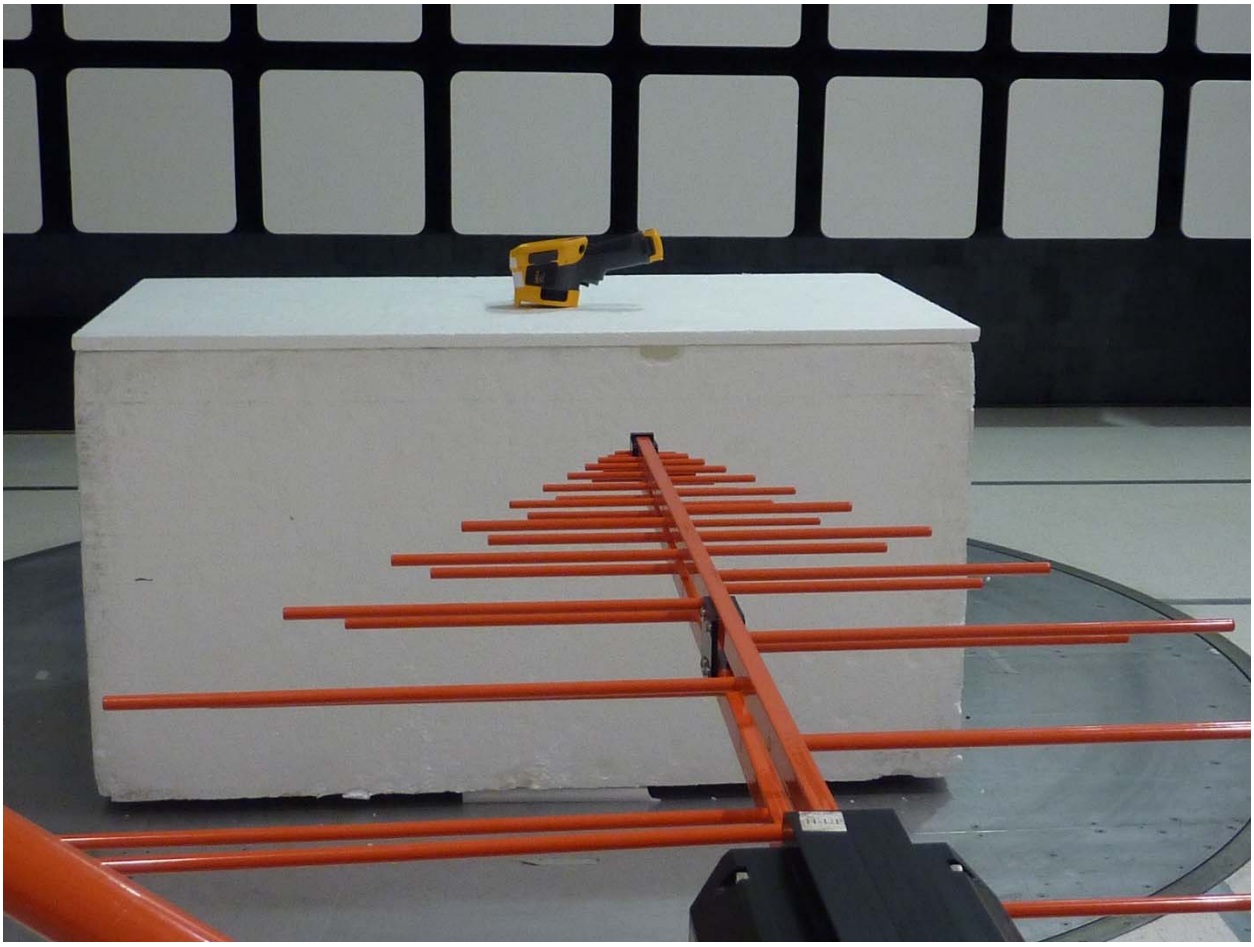
NOTES:

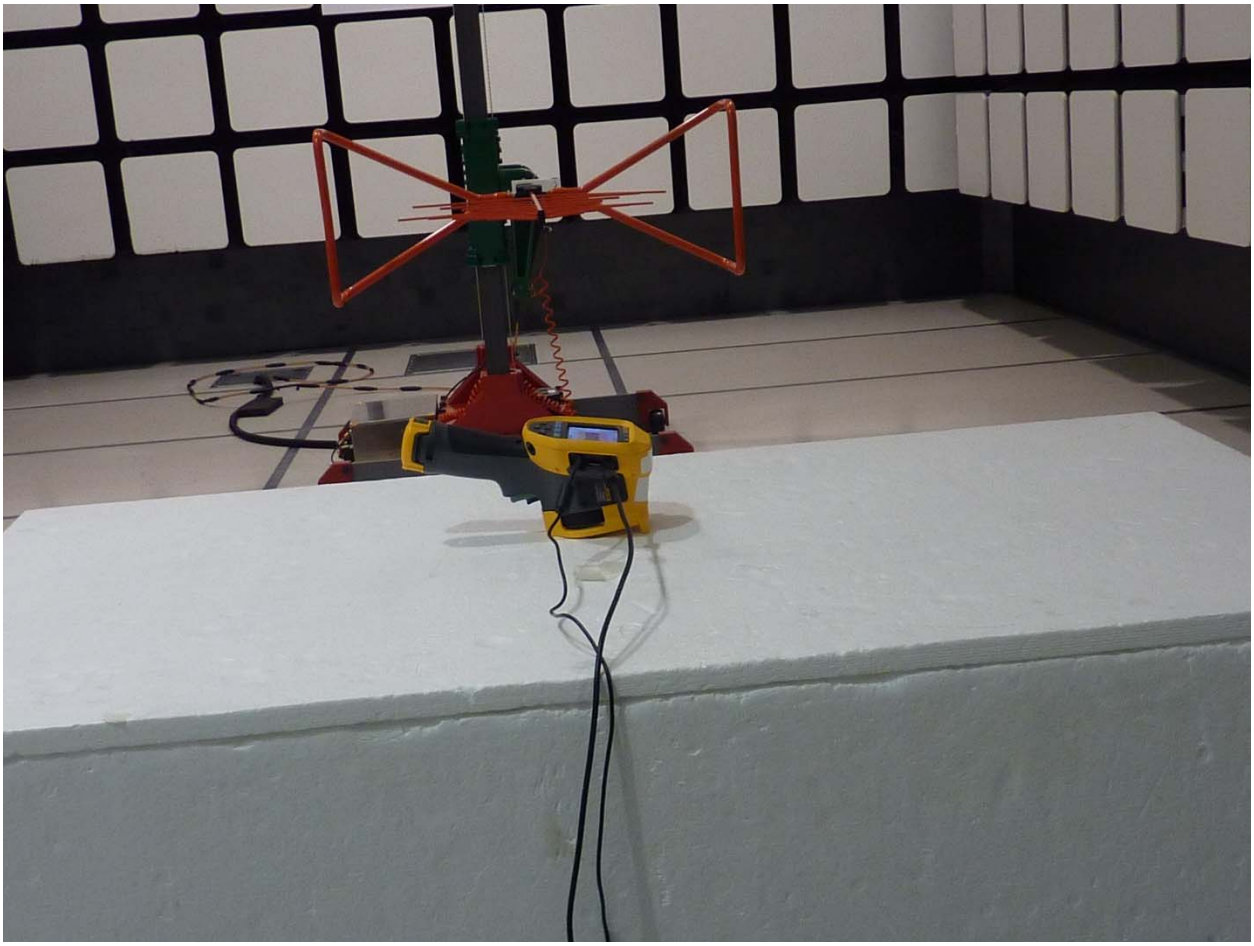
Conducted Emissions @ 110 Vac/60 Hz Neutral

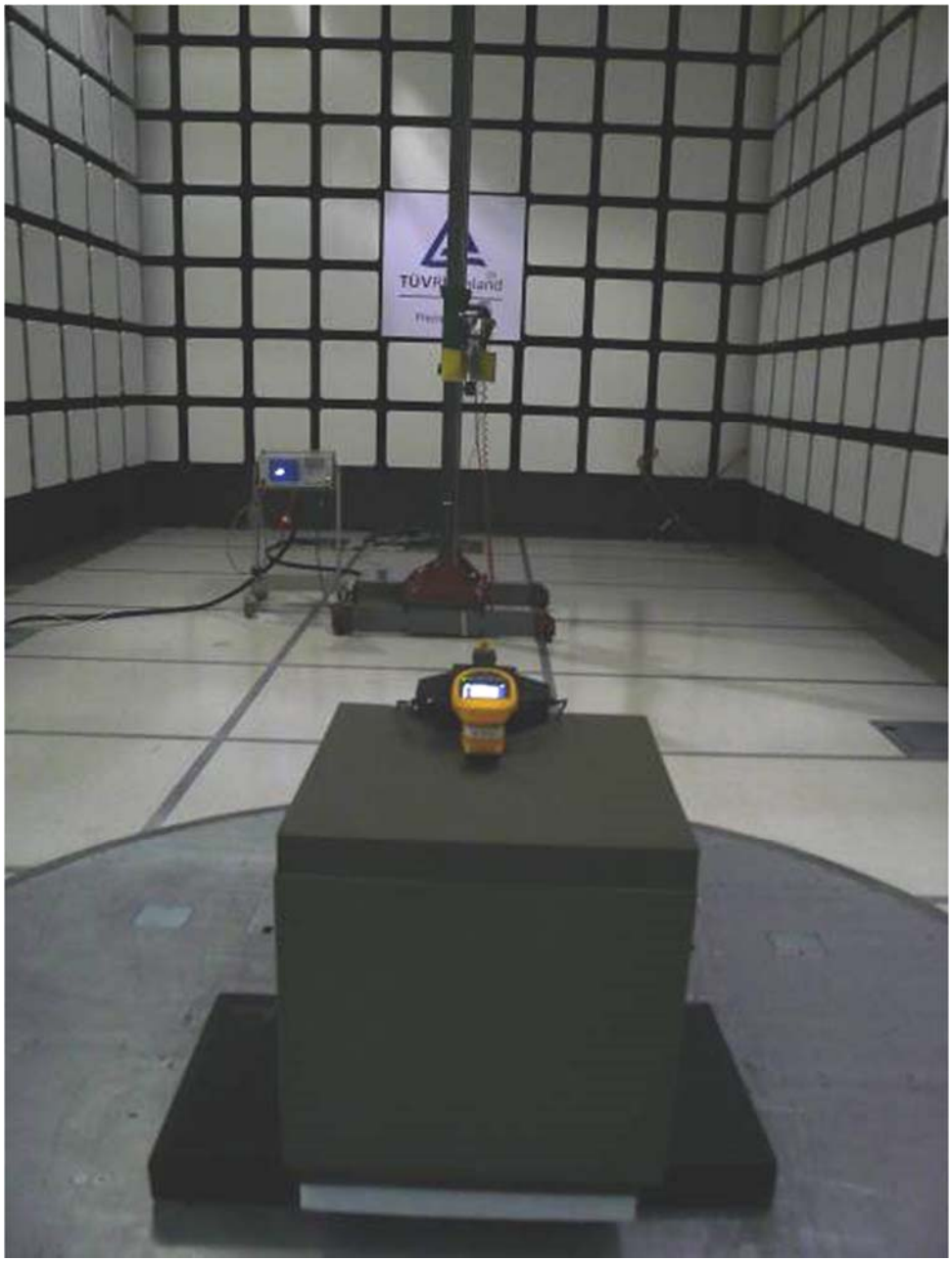


Frequency	Raw	Cable	Factors	Level	Measurement Type	Line	Limit	Margin	Pass /Fail
MHz	dBuV	dB	dB	dBuV			dBuV	dB	
0.15	50.04	2.87	-0.1	52.81	QP	Neutral	79	-26.19	Pass
0.15	36.12	2.87	-0.1	38.89	Avg	Neutral	66	-27.11	Pass
0.55	42.04	2.90	-0.04	44.9	QP	Neutral	73	-28.1	Pass
0.55	32.88	2.90	-0.04	35.74	Avg	Neutral	60	-24.26	Pass
0.77	40.47	2.90	-0.04	43.33	QP	Neutral	73	-29.67	Pass
0.77	33.27	2.90	-0.04	36.13	Avg	Neutral	60	-23.87	Pass
1.03	41.32	2.87	-0.04	44.15	QP	Neutral	73	-28.85	Pass
1.03	33.71	2.87	-0.04	36.54	Avg	Neutral	60	-23.46	Pass
1.24	40.16	2.88	-0.04	43	QP	Neutral	73	-30.00	Pass
1.24	32.55	2.88	-0.04	35.39	Avg	Neutral	60	-24.61	Pass
1.25	40.82	2.88	-0.04	43.66	QP	Neutral	73	-29.34	Pass
1.25	33.66	2.88	-0.04	36.5	Avg	Neutral	60	-23.5	Pass

4.7.3 Test Setup Photos








TÜVRheinland
Precisely Right.

5 Test Equipment Use List

5.1 Equipment List

Equipment	Manufacturer	Model #	Serial/Inst #	Last Cal mm/dd/yy	Next Cal mm/dd/yy
Bilog Antenna	Sunol Sciences	JB3	A102606	05/15/2014	05/15/2016
Horn Antenna	EMCO	3115	9211-3969	03/18/2013	03/18/2015
Antenna (18-26GHz)	CMT	RA42-K-F-4B-C	020131-004	07/24/2014	07/24/2015
Antenna (26-40 GHz)	CMT	RA28-K-F-4B-C	011469R-003	01//11/2015	01/11/2016
Preamplifier	Sonoma Instrument	310	213221	09/30/2014	09/30/2015
Bilog Antenna	Sunol Sciences	JB3	A020502	04/12/2013	04/12/2015
Preamplifier	Milteq	TIA-30-HG-	1842452	01/13/2015	01/13/2016
Spectrum Analyzer	Rhode Schwarz	ESIB	832427/002	01/08/2015	01/08/2016
Amplifier	Rohde & Schwarz	TS-PR26	100011	07/24/2014	07/24/2015
Amplifier	Rohde & Schwarz	TS-PR40	100012	01//11/2015	01/11/2016
Signal Generator	Anritsu	MG3694A	42803	01/13/2015	01/13/2016
Notch Filter	Micro-Tronics	BRM50702	37	07/18/2014	07/18/2015
Notch Filter	Micro-Tronics	BRC50703	11	07/18/2014	07/18/2015
Notch Filter	Micro-Tronics	BRC50704	8	07/18/2014	07/18/2015
Notch Filter	Micro-Tronics	BRC50705	9	07/18/2014	07/18/2015
High Pass Filter (8.5 GHz)	Micro-Tronics	HPM50107	4	01/16/2015	01/16/2016
Power Meter	Agilent	E4418B	MY45103902	01/09/2015	01/09/2016
Power Sensor	Hewlett Packard	8482A	55-5131	01/09/2015	01/09/2016
Thermo Chamber	Espec	BTZ-133	0613436	03/11/2014	03/11/2015
Spectrum Analyzer	Agilent	N9038A	MY51210195	01/08/2015	01/08/2016

* Calibration of equipment past due for re-calibration will be performed expeditiously. If any equipment is found to be out of tolerance at that time, affected customers will be notified accordingly.

6 EMC Test Plan

6.1 Introduction

This section provides a description of the Equipment Under Test (EUT), configurations, operating conditions, and performance acceptance criteria. It is an overview of information provided by the manufacturer so that the test laboratory may perform the requested testing.

6.2 Customer

Table 9: Customer Information

Company Name	Fluke Corporation.
Address	6920 Seaway Blvd.
City, State, Zip	Everett, WA 98203
Country	U.S.A.
Phone	(425) 446-5626
Fax	None

Table 10: Technical Contact Information

Name	David Lentz
E-mail	David.Lentz@fluke.com
Phone	(425) 446-5626

Equipment Under Test (EUT)

Table 11: EUT Specifications

EUT Specification	
Dimensions	10.5 x 6.5 x 4.5 Inches
Power	EUT is Battery Operated Battery 7.2 Vdc Model: D2038707_001 Input Voltage: 15 Vdc (15 Vdc at input of the device from wall charger) Input Current: 2.0 A
Environment	Portable
Operating Temperature Range:	-10 to +50 degrees C
Multiple Feeds:	☐ Yes and how many ☒ No
Hardware Version	None
Part Number	None
RF Software Version	None
Radio Module s 802.15.1 Bluetooth, 802.11 Wifi	
Operating Modes	EUT Operates on 802.15.4 (Zigbee), 802.11b, g (Wi-fi), HT20 and 802.15.1 Bluetooth
Transmitter Frequency Band	2.400 GHz to 2.4835 GHz
Max. Rated Power Output	See Channel Planning Table.
Power Setting @ Operating Channel	See Channel Planning Table.
Antenna Type	Internal Antenna 1.5 dBi
Modulation Type	☐ AM ☐ FM ☒ DSSS ☒ OFDM ☒Other describe: CCK, OQPSK
Data Rate	250 kbps to 55 Mbps EUT Operates on 802.11 protocol
TX/RX Chain (s)	1
Directional Gain Type	☒ Uncorrelated ☒ No Beam-Forming ☐ Other describe:
Type of Equipment	☐ Table Top ☐Wall-mount ☐ Floor standing cabinet ☒Other *Portable*

Table 12: EUT Channel Power Specifications

No.	Frequency (MHz)	802.15.1 BLE mode
1	2402	<5 mW
2	2440	<5 mW
3	2480	<5 mW
Note: 1. The power levels shown here are with 100% duty cycle. Duty cycle factor for a comparison with limits. 2. This report is only documented for frequency ranges, 2400-2483.5 MHz		

Table 13: Interface Specifications:

EUT Port	Connected To	Location	Cable Type				
			Length	Shielded Yes / No		Bead Yes / No	
HDMI (mini type C)	HDMI Monitor	Left side EUT	2.5m	☒	☐	☒	☐
USB (type mini-B)	Computer/ laptop	Right side of EUT	2.5m	☒	☐	☒	☐
DC Power	Wall adopter	Right side of EUT	2.0m	☐	☐	☒	☐

HDMI cable was not used during testing. USB is was used with Laptop for radio setup.

Table 14: Supported Equipment :

Reference Designation	Manufacturer	Model	Serial Number	Comments
Laptop	Lenovo	G560	CBU4508268	Used for radio set up

Table 15: Description of Sample used for Testing

Device	Serial	RF Connection	CFR47 Part 15 C
Gemini	TUV1 & 2	Internal Antenna	TX Emissions, Band Edges
	TUV 3 & 4	SMA Connector (This was setup by Fluke corporation for test purposes only)	RF Power Output, Out of Band Emission, Peak Power Spectral Density, Occupied Bandwidth

Table 16: Description of Test Configuration used for Radiated Measurement.

Device	Antenna	Mode	Setup Photo (X-Axis)	Setup Photo (Y-Axis)	Setup Photo (Z-Axis)
Gemini Themal Imager	Internal	* Transmit * Receive	 EUT on side	 EUT Flat on table	 EUT vertical
Note: Pre-scans were performed in 3orthogonal axes and **Y-Axis was worst case.**					

Table 17: Final Test Mode for The EUT

The Thermal Imagers have three Models: Ti200, Ti300, and Ti400. The model differences are with Infrared Resolution, Temperature Measurements Ranges, and Thermal Sensitivity. The models use the same hardware. Software settings are used to configure the models. Please see the following chart.

Model	Ti200	Ti300	Ti400
IR Resolution	200x150	240x180	320x240
Thermal Sensitivity	≤ 70mK	≤ 50 mK	≤ 50 mK
Temperature Measurement Range	-20 to 650°C	-20 to 650°C	-20 to 1200°C
IR Frame Rate	9 / 60 Hz		
Standard Lens	HFOV = 24°, VFOV = 18°		
Focus	Autofocus using laser rangefinder with manual focus override		
Optional Lens	Wide angle (48° x 36°), telephoto (12° x 9°)		
Display	3.5" color LCD (640x480) with multi-touch touchscreen		
Visible Light Camera	5 Mpixel with LED torch		
Wireless Interfaces	WIFI transceiver (801.11 g/n, power = TBD) Zigbee transceiver (802.15.4 Zigbee , power <5 mW) Bluetooth transceiver Headset Profile (802.15 BT ; class 2, power = 2.5 mW) GPS receiver (what is the standard?) Compass (magnetically susceptible)		
Other interfaces	HDMI video out (ATSC) USB A to thumb drive USB mini B for cabling to PC Micro SD removable storage Speaker Microphone Laser pointer 12 Vdc power jack		
Physical	Removable battery IP54 Ingress Protection 2 M drop Hand strap Size ~2.3 lbs.		
Accessories	AC / DC Adapter plugs into 15 Vdc power jack of Thermal Imager. External battery charger for charging removable batteries. One USB Cable < 3 meters in length : male mini-B to male standard-A One 6 ft. HDMI Cable < 3 meters in length: mini (type C) to std (type A Optional car adapter		

Test Plan for the device:

1) Addition of HT20 mode, Evaluation of HT 20 mode Wifi radio shall be performed. Band edges, Power levels and Radiated spurious emissions shall be evalauted.

2) Bluetooth BLE mode is added. There is no change in basic and Enchansed modes of Bluetooth Operation. There are no hardware changes, BLE mode enabled. All conducted tests results of module previously tested are applicable. Number of hopping channels, Channel sepration and dwell time test performed for Basic rate mode are applicable here. The test data and measurements performed earlier was used inthis report.

6.3 Test Specifications

Testing requirements

Table 18: Test Specifications

Emissions and Immunity	
Standard	**Requirement**
CFR 47 Part 15.247:2011	All
RSS 210 Issue 8, 2010	All

7 Revision History

Revisions

Revision No.	Date MM/DD/YYYY	Reason for Change	Author
0	04/15/2015	Original Document	N/A
1	07/25/2015	Added additional graphs for PSD	SK

Note: Latest revision report will replace all previous reports.

END OF REPORT