

TEST REPORT



DT&C Co., Ltd.

42, Yurim-ro, 154Beon-gil, Cheoin-gu, Yongin-si, Gyeonggi-do, Korea, 17042
Tel : 031-321-2664, Fax : 031-321-1664

1. Report No : DRTFCC1707-0130(1)

2. Customer

- Name : SOLUM CO.,LTD.
- Address : 4,5,6th F, 357, Guseong-ro, Giheung-gu, Yongin-si, Gyeonggi-do, South Korea

3. Use of Report : FCC & IC Original Grant

4. Product Name / Model Name : ESL Gateway / SLG-CP101
FCC ID / IC : 2AFWN-SLG-CP101 / 22800-SLGCP101

5. Test Method Used : KDB 558074, ANSI C63.10-2013

Test Specification : FCC Part 15 Subpart C.247

RSS-247 Issue 1 (2015-05), RSS-GEN Issue 4 (2014-11)

6. Date of Test : 2017.04.07 ~ 2017.07.21, 2017.08.01 ~ 2017.08.02

7. Testing Environment : See appended test report.

8. Test Result : Refer to the attached test result.

Affirmation	Tested by Name : JaeHyeok Bang	Technical Manager Name : GeunKi Son
		(Signature) (Signature)

The test results presented in this test report are limited only to the sample supplied by applicant and the use of this test report is inhibited other than its purpose. This test report shall not be reproduced except in full, without the written approval of DT&C Co., Ltd.

2017 . 08 . 03 .

DT&C Co., Ltd.

If this report is required to confirmation of authenticity, please contact to report@dtnc.net

Test Report Version

Test Report No.	Date	Description
DRTFCC1707-0130	Jul. 28, 2017	Initial issue
DRTFCC1707-0130(1)	Aug. 03, 2017	Add the test data

Table of Contents

1. General Information	4
1.1 Testing Laboratory	4
1.2 Details of Applicant	4
1.3 Description of EUT	5
1.4 Declaration by the applicant / manufacturer	5
1.5 Test Conditions	5
1.6 Measurement Uncertainty.....	5
1.7 Support Equipment	6
1.8 Test Equipment List	6
1.8 Summary of Test Results	7
2. Test Methodology	8
2.1 EUT Configuration.....	8
2.2 EUT Exercise.....	8
2.3 General Test Procedures	8
2.4 Description of Test Modes.....	8
2.5 Instrument Calibration	9
3. Test Result.....	9
3.1 Maximum Peak Conducted Output Power	9
3.1.1 Test Setup.....	9
3.1.2 Test Procedures	9
3.1.3 Test Results.....	9
3.2 6 dB Bandwidth Measurement.....	14
3.2.1 Test Setup.....	14
3.2.2 Test Procedures	14
3.2.3 Test Results.....	14
3.3 Maximum Power Spectral Density.....	19
3.3.1 Test Setup.....	19
3.3.2 Test Procedures	19
3.3.3 Test Results.....	19
3.4 Unwanted Emissions (Conducted)	24
3.4.1 Test Setup.....	24
3.4.2 Test Procedures	24
3.4.3 Test Results	25
3.5 Unwanted Emissions (Radiated).....	41
3.5.1 Test Setup.....	42
3.5.2 Test Procedures	42
3.5.3 Test Results	43
3.6 Power line Conducted Emissions.....	47
3.6.1 Test Setup.....	47
3.6.2 Test Procedures	47
3.6.3 Test Results	48
3.7 Occupied Bandwidth.....	50
3.7.1 Test Setup.....	50
3.7.2 Test Procedures	50
3.7.3 Test Results	50
4. ANTENNA REQUIREMENTS	55
APPENDIX I.....	56
APPENDIX II	57
APPENDIX III	58

1. General Information

1.1 Testing Laboratory

DT&C Co., Ltd.

The 3 m test site and conducted measurement facility used to collect the radiated data are located at the 42, Yurim-ro, 154beon-gil, Cheoin-gu, Yongin-si, Gyeonggi-do, Korea [17042](#). The site is constructed in conformance with the requirements.

- FCC MRA Accredited Test Firm No. : KR0034

www.dtnc.net

Telephone	:	+ 82-31-321-2664
FAX	:	+ 82-31-321-1664

1.2 Details of Applicant

Applicant : SOLUM CO.,LTD.
Address : 4,5,6th F, 357, Guseong-ro, Giheung-gu, Yongin-si, Gyeonggi-do, South Korea
Contact person : Ki Dong Lee

1.3 Description of EUT

EUT	ESL Gateway
Model Name	SLG-CP101
Add Model Name	NA
Hardware version	2.4-Sub-GHz_RT-Gateway_R01
Software version	1.5.12_G4
Power Supply	DC 5.0 V
Frequency Range	2405 ~ 2480MHz (16 channels)
Max. RF Output Power	6.10 dBm
Modulation Technique	O-QPSK
Antenna Specification	Antenna Type: Internal Antenna <small>NOTE 1</small> Gain: 3.9 dBi(PK)

Note 1: This device has two transceivers and uses the same antenna.

1.4 Declaration by the applicant / manufacturer

- N/A

1.5 Test Conditions

Ambient Condition	
▪ Temperature	+22 °C ~ +25 °C
▪ Relative Humidity	34 % ~ 45 %

1.6 Measurement Uncertainty

The measurement uncertainties shown below were calculated in accordance with requirements of ANSI C 63.4-2014. All measurement uncertainty values are shown with a coverage factor of $k = 2$ to indicate a 95 % level of confidence. The measurement uncertainty shown below meet or exceeds the U_{CISRP} measurement uncertainty values specified in CISPR 16-4-2 and, thus, can be compared directly to specified limits to determine compliance.

Parameter	Measurement uncertainty
AC conducted emission	$\pm 2.4 \text{ dB}$ (The confidence level is about 95 %, $k = 2$)
Radiated Disturbance (Below 1 GHz)	$\pm 5.1 \text{ dB}$ (The confidence level is about 95 %, $k = 2$)
Radiated Disturbance (1 GHz ~ 18 GHz)	$\pm 5.4 \text{ dB}$ (The confidence level is about 95 %, $k = 2$)
Radiated Disturbance (Above 18 GHz)	$\pm 5.3 \text{ dB}$ (The confidence level is about 95 %, $k = 2$)

1.7 Support Equipment

Equipment	Manufacturer	Model No.	Serial No.	Note
POE	HP	PD-3501G/AC	CN35FFX099	-
-	-	-	-	-

1.8 Test Equipment List

Type	Manufacturer	Model	Cal. Date (yy/mm/dd)	Next Cal. Date (yy/mm/dd)	S/N
Spectrum Analyzer	Agilent Technologies	N9020A	17/01/11	18/01/11	MY50200828
Spectrum Analyzer	Agilent Technologies	N9020A	16/10/11	17/10/11	MY46471251
DC Power Supply	Agilent Technologies	66332A	16/09/08	17/09/08	GB42110550
Thermohygrometer	HCT	HCT-1	16/09/09	17/09/09	NONE
Signal Generator	Rohde Schwarz	SMF100A	17/04/21	18/04/21	102341
Signal Generator	Rohde Schwarz	SMBV100A	17/01/04	18/01/04	255571
Multimeter	FLUKE	17B	17/04/12	18/04/12	26030065WS
Loop Antenna	Schwarzbeck	FMZB1513	16/04/22	18/04/22	1513-128
BILOG ANTENNA	Schwarzbeck	VULB 9160	16/11/11	18/11/11	3151
Horn Antenna	ETS-LINDGREN	3117	16/05/03	18/05/03	00140394
Horn Antenna	A.H.Systems Inc.	SAS-574	17/04/25	18/04/25	154
Highpass Filter	Wainwright Instruments	WHKX12-2580-3000-18000-80SS	16/09/09	17/09/09	3
Highpass Filter	Wainwright Instruments	WHNX6-6320-8000-26500-40CC	16/09/13	17/09/13	1
PreAmplifier	Agilent	8449B	16/10/19	17/10/19	3008A02108
PreAmplifier	TSJ	MLA-010K01-B01-27	17/03/06	18/03/06	1844539
EMI Test Receiver	Rohde Schwarz	ESR7	17/02/16	18/02/16	101061
EMI Test Receiver	Rohde Schwarz	ESCI	17/02/16	18/02/16	100364
Single-Phase Master	NF	4420	16/09/08	17/09/08	3049354420023
Artificial Mains Network	Rohde Schwarz	ESH2-Z5	16/09/08	17/09/08	828739/006
Pulse limiter	Rohde Schwarz	ESH3-Z2	17/01/03	18/01/03	101334

1.8 Summary of Test Results

FCC Part	RSS Std.	Parameter	Limit	Test Condition	Status Note 1
15.247(a)	RSS-247 [5.2]	6 dB Bandwidth	> 500 kHz	Conducted	C
15.247(b)	RSS-247 [5.4]	Transmitter Output Power	< 1 Watt		C
15.247(d)	RSS-247 [5.5]	Out of Band Emissions / Band Edge	20 dBc in any 100 kHz BW		C
15.247(e)	RSS-247 [5.2]	Transmitter Power Spectral Density	< 8 dBm/3 kHz		C
-	RSS-Gen [6.6]	Occupied Bandwidth (99 %)	RSS-Gen(6.6)		C
15.247(d) 15.205 15.209	RSS-247 [5.5] RSS-Gen [8.9] RSS-Gen [8.10]	General Field Strength Limits (Restricted Bands and Radiated Emission Limits)	FCC 15.209 limits	Radiated	C
15.207	RSS-Gen [8.8]	AC Line Conducted Emissions	FCC 15.207 limits	AC Line Conducted	C
15.203	RSS-Gen [8.3]	Antenna Requirements	FCC 15.203	-	C

Note 1: C=Comply NC=Not Comply NT=Not Tested NA=Not Applicable

2. Test Methodology

Generally the tests were performed according to the KDB558074 D01 v03r05. And ANSI C63.10-2013 was used to reference appropriate EUT setup and maximizing procedures of radiated spurious emission and AC line conducted emission testing.

2.1 EUT Configuration

The EUT configuration for testing is installed on RF field strength measurement to meet the Commissions requirement and operating in a manner that intends to maximize its emission characteristics in a continuous normal application.

2.2 EUT Exercise

The EUT was operated in the test mode to fix the TX frequency that was for the purpose of the measurements. According to its specifications, the EUT must comply with the requirements of the Section 15.207, 15.209 and 15.247 under the FCC Rules Part 15 Subpart C.

2.3 General Test Procedures

Conducted Emissions

The power-line conducted emission test procedure is not described on the KDB 558074.

So this test was fulfilled with the requirements in Section 6.2 of ANSI C63.10.

The EUT is placed on the wooden table, which is 0.8 m above ground plane and the conducted emissions from the EUT measured in the frequency range between 0.15MHz and 30MHz using CISPR Quasi-peak and Average detector.

Radiated Emissions

Basically the radiated tests were performed with KDB 558074. But some requirements and procedures like test site requirements, EUT setup and maximizing procedure were fulfilled with the requirements in Section 5 and 6 of the ANSI C63.10 as stated on section 12.1 of the KDB 558074.

The EUT is placed on a non-conductive table, which is above ground plane. The turntable shall rotate 360 degrees to determine the position of maximum emission level. EUT is set 1 or 3 m away from the receiving antenna, which varied from 1 m to 4 m to find out the highest emission. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical. In order to find out the highest emission, the relative positions of the EUT were rotated through three orthogonal axes.

2.4 Description of Test Modes

The EUT has been tested with the operating condition for maximizing the emission characteristics. A test program is used to control the EUT for staying in continuous transmitting. The lowest, middle and highest channels were tested and reported.

Test Mode [TM]		Test Frequency [MHz]			
		Lowest channel	Middle channel	Highest channel	
TM 1	Transceiver 1 (ZIGBEE - Modem#2)	DC Adapter	2405	2440	2480
TM 2	Transceiver 2 (ZIGBEE - Modem#4)	DC Adapter	2405	2440	2480
TM 3	Transceiver 1 (ZIGBEE - Modem#2)	POE	2405	2440	2480
TM 4	Transceiver 2 (ZIGBEE - Modem#4)	POE	2405	2440	2480

2.5 Instrument Calibration

The measuring equipment, which was utilized in performing the tests documented herein, has been calibrated in accordance with the manufacturer's recommendations for utilizing calibration equipment, which is traceable to recognized national standards.

3. Test Result

3.1 Maximum Peak Conducted Output Power

Test Requirements and limit, §15.247(b) & RSS-247 [5.4]

A transmitter antenna terminal of EUT is connected to the input of a spectrum analyzer.

Measurement is made while the EUT is operating in transmission mode at the appropriate frequencies.

The maximum permissible conducted output power is 1 Watt.

3.1.1 Test Setup

Refer to the APPENDIX I.

3.1.2 Test Procedures

Maximum Peak Conducted Output Power is measured using Measurement Procedure of **KDB558074**

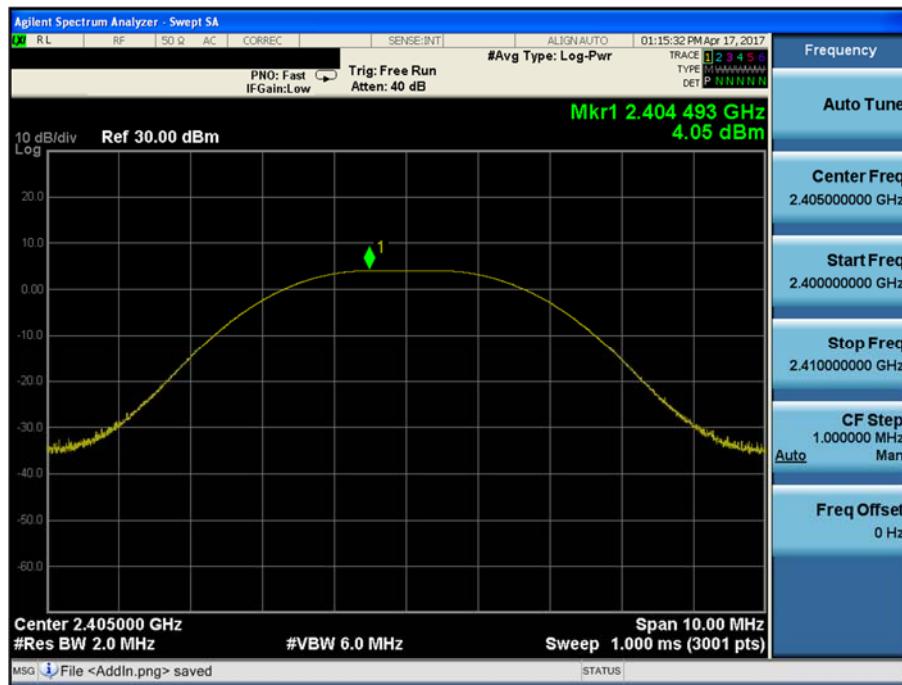
1. Set the RBW \geq DTS bandwidth. **Actual RBW = 2 MHz**
2. Set VBW $\geq 3 \times$ RBW. **Actual VBW = 6 MHz**
3. Set span $\geq 3 \times$ RBW.
4. Sweep time = **auto couple**
5. Detector = **peak**
6. Trace mode = **max hold**
7. Allow trace to fully stabilize
8. Use peak marker function to determine the peak amplitude level.

3.1.3 Test Results

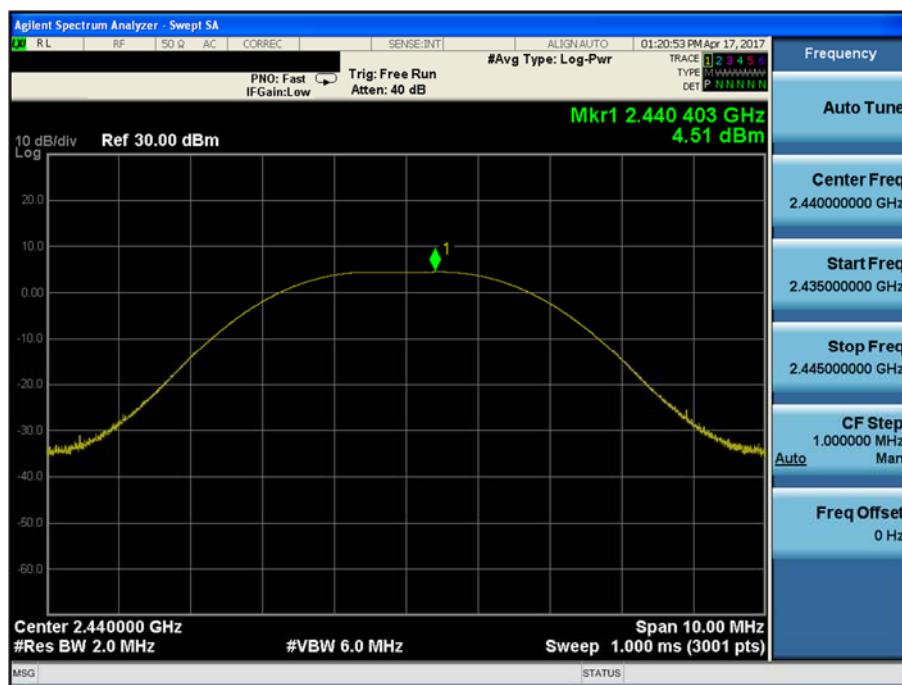
Test Mode	Tested Channel	Frame Average Output Power	Peak Output Power
		dBm	dBm
TM 1	Lowest	-	4.05
	Middle	-	4.51
	Highest	-	6.10
TM 2	Lowest	-	3.77
	Middle	-	4.04
	Highest	-	4.36

Peak Output Power

TM 1 & Test Channel : Lowest

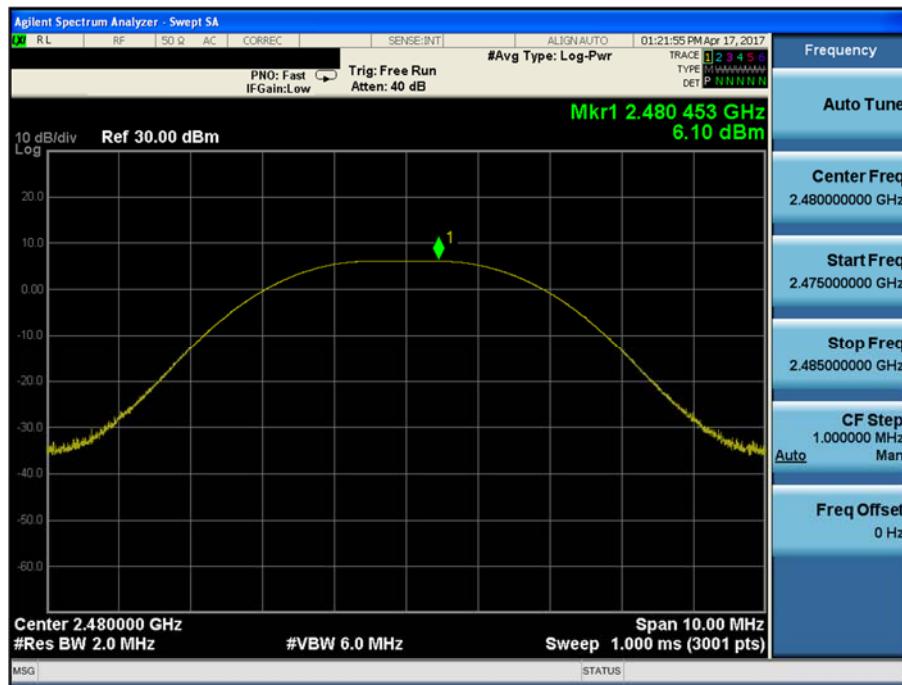

Peak Output Power

TM 1 & Test Channel : Middle



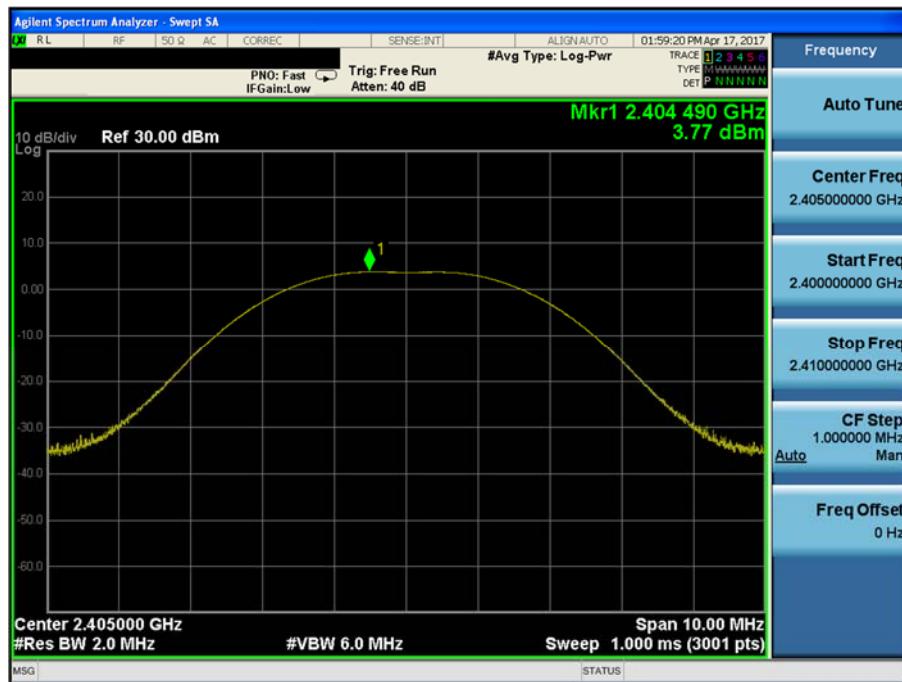
Peak Output Power

TM 1 & Test Channel : Highest

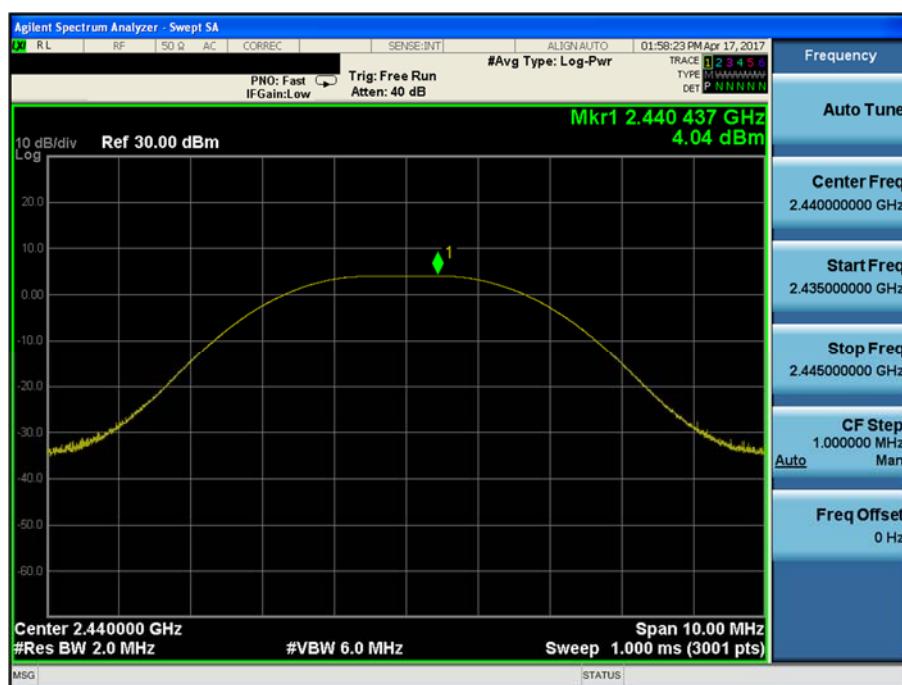


Peak Output Power

TM 2 & Test Channel : Lowest


Peak Output Power

TM 2 & Test Channel : Middle



Peak Output Power

TM 2 & Test Channel : Highest



3.2 6 dB Bandwidth Measurement

Test Requirements and limit, §15.247(a) & RSS-247 [5.2]

The bandwidth at 6 dB down from the highest in-band spectral density is measured with a spectrum analyzer connected to the EUT's antenna terminal while the EUT is operating in transmission mode at the appropriate frequencies.

The minimum permissible 6 dB bandwidth is 500 kHz.

3.2.1 Test Setup

Refer to the APPENDIX I.

3.2.2 Test Procedures

The transmitter output is connected to the Spectrum Analyzer and used following test procedure of **KDB558074**.

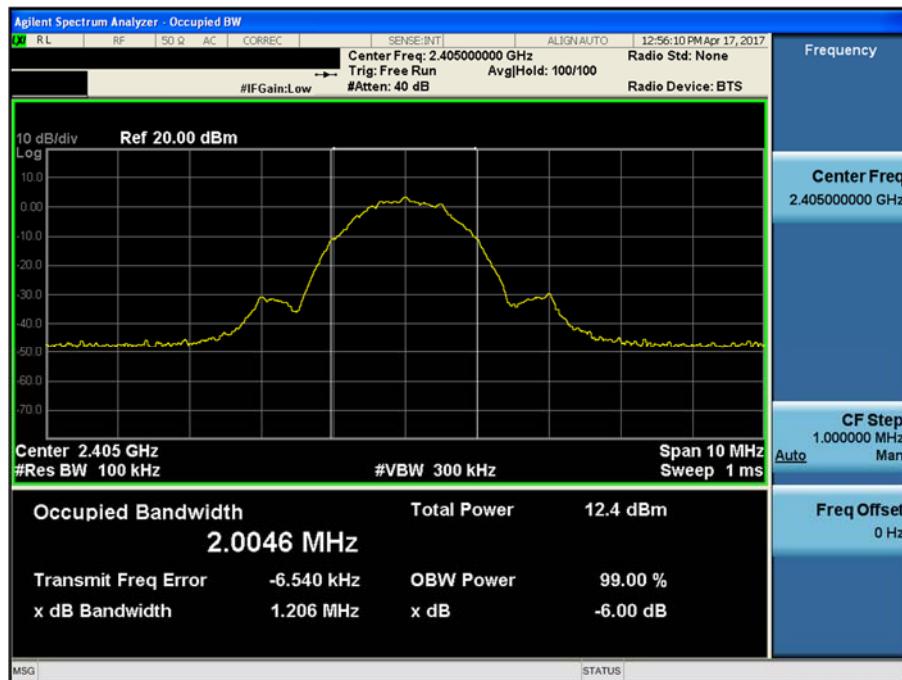
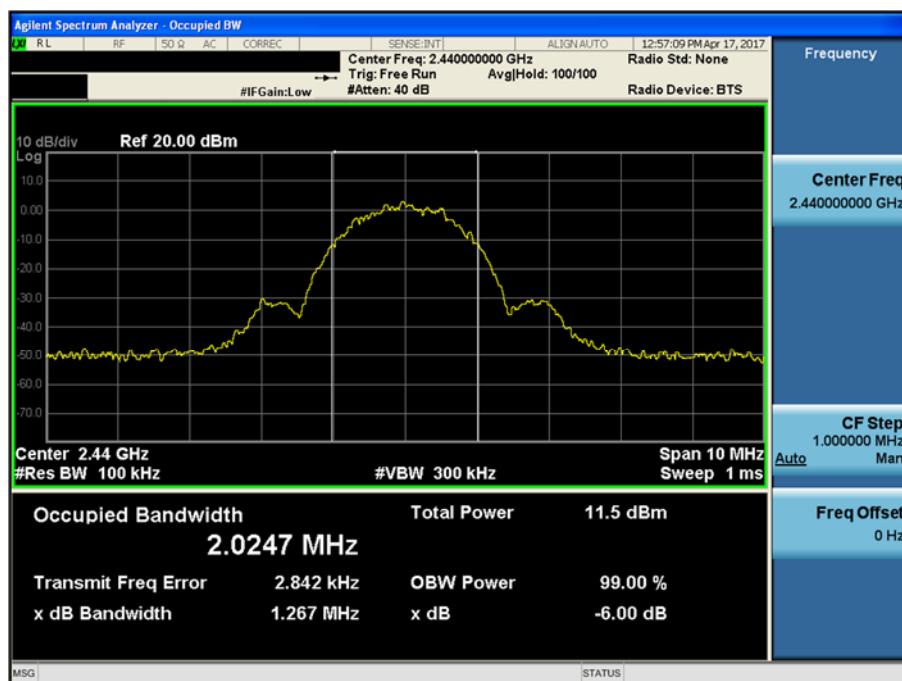
1. Set resolution bandwidth (RBW) = 100 kHz.
2. Set the video bandwidth (VBW) $\geq 3 \times$ RBW.

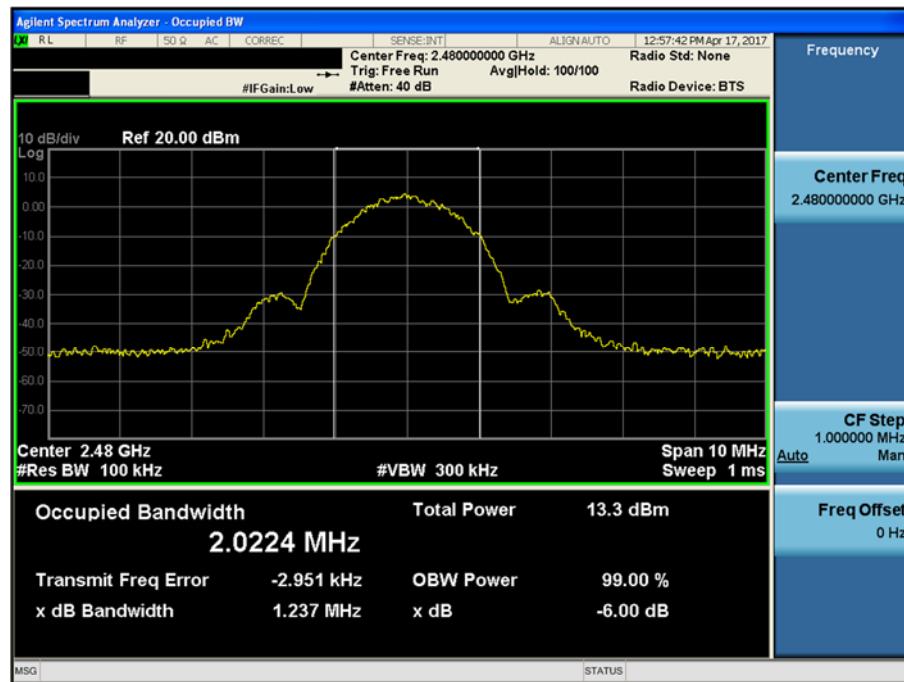
(RBW : 100 kHz / VBW : 300 kHz)

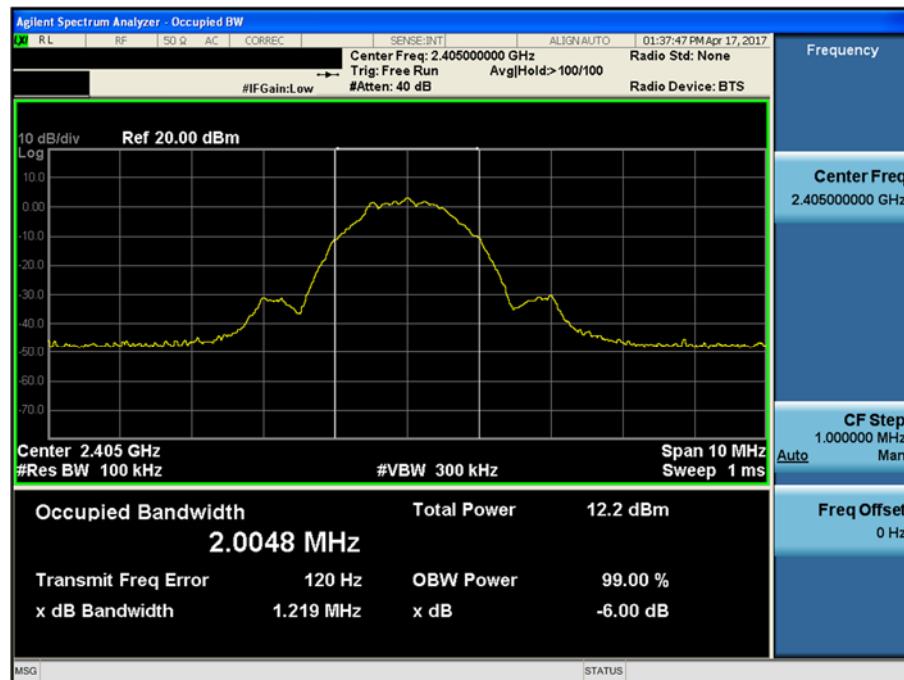
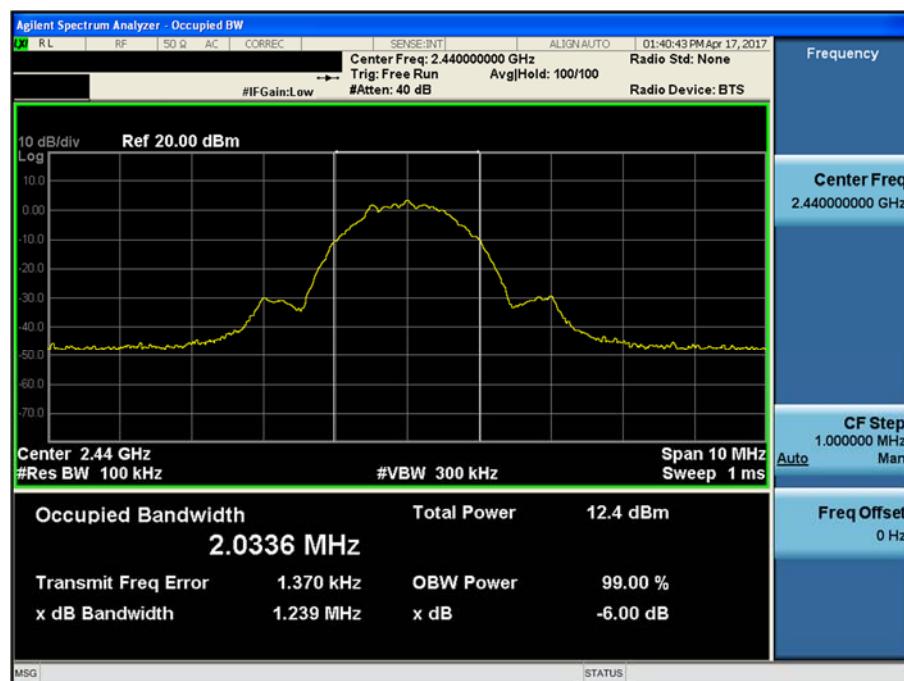
3. Detector = **Peak**.
4. Trace mode = **max hold**.
5. Sweep = **auto couple**.
6. Allow the trace to stabilize.
7. Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

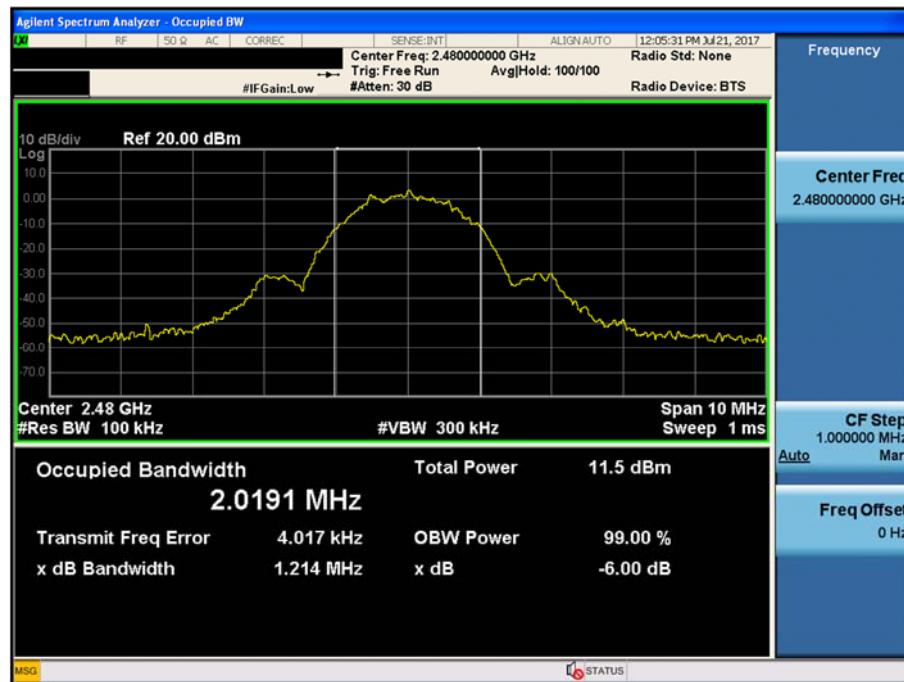
3.2.3 Test Results

Test Mode	Tested Channel	Test Results [MHz]
TM 1	Lowest	1.206
	Middle	1.267
	Highest	1.237
TM 2	Lowest	1.219
	Middle	1.239
	Highest	1.214

6 dB Bandwidth**TM 1 & Test Channel : Lowest****6 dB Bandwidth****TM 1 & Test Channel : Middle**

6 dB Bandwidth**TM 1 & Test Channel : Highest**

6 dB Bandwidth**TM 2 & Test Channel : Lowest****6 dB Bandwidth****TM 2 & Test Channel : Middle**

6 dB Bandwidth**TM 2 & Test Channel : Highest**

3.3 Maximum Power Spectral Density.

Test requirements and limit, §15.247(e) & RSS-247 [5.2]

The peak power density is measured with a spectrum analyzer connected to the antenna terminal while the EUT is operating in transmission mode at the appropriate frequencies.

Minimum Standard

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

3.3.1 Test Setup

Refer to the APPENDIX I.

3.3.2 Test Procedures

Method PKPSD of KDB558074 is used.

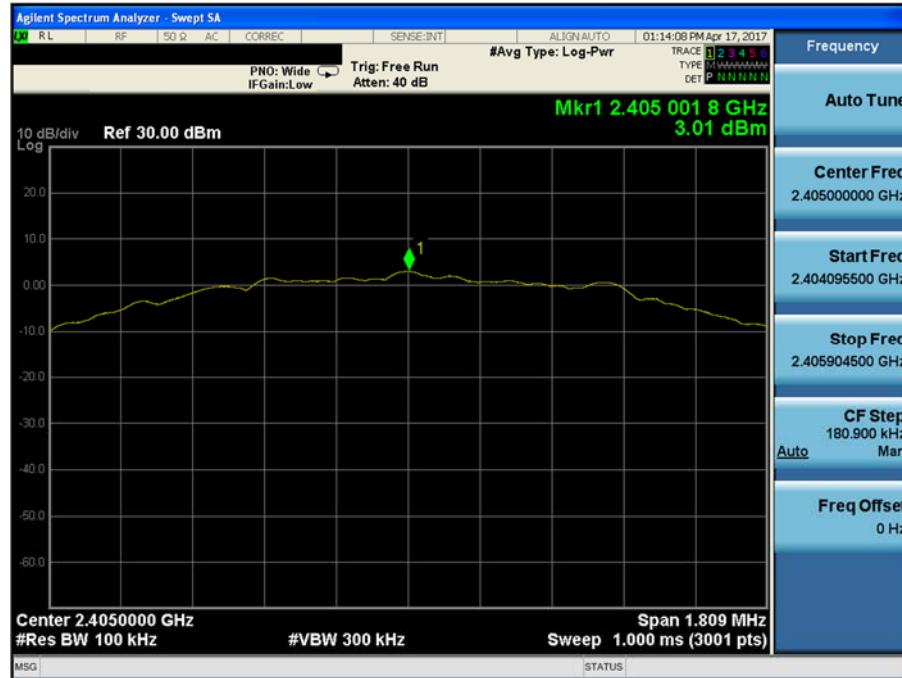
1. Set analyzer center frequency to DTS channel center frequency.
2. Set the span to **1.5 times** the DTS bandwidth.
3. Set the RBW: **3 kHz ≤ RBW ≤ 100 kHz**.
4. Set the VBW **≥ 3 x RBW**.
5. Detector = **peak**.
6. Sweep time = **auto couple**.
7. Trace mode = **max hold**.
8. Allow trace to fully stabilize.
9. Use the **peak marker function** to determine the maximum amplitude level within the RBW.
10. If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.

3.3.3 Test Results

Test Mode	Tested Channel	PKPSD [dBm]
TM 1	Lowest	3.01
	Middle	3.43
	Highest	5.09
TM 2	Lowest	2.72
	Middle	3.41
	Highest	3.27

Maximum PKPSD

TM 1& Test Channel : Lowest



Maximum PKPSD

TM 1& Test Channel : Middle



Maximum PKPSD

TM 1 & Test Channel : Highest



Maximum PKPSD**TM 2 & Test Channel : Lowest****Maximum PKPSD****TM 2 & Test Channel : Middle**

Maximum PKPSD

TM 2 & Test Channel : Highest



3.4 Unwanted Emissions (Conducted)

Test requirements and limit, §15.247(d) & RSS-247 [5.5]

§15.247(d) specifies that in any 100 kHz bandwidth outside of the authorized frequency band, the power shall be attenuated according to the following conditions:

If **the peak output power procedure** is used to measure the fundamental emission power to demonstrate compliance to **15.247(b)(3)** requirements, then the peak conducted output power measured within any 100 kHz outside the authorized frequency band shall be attenuated **by at least 20 dB** relative to the maximum measured in-band peak PSD level.

If the average output power procedure is used to measure the fundamental emission power to demonstrate compliance to **15.247(b)(3)** requirements, then the power in any 100 kHz outside of the authorized frequency band shall be attenuated by at least 30 dB relative to the maximum measured in-band average PSD level.

In either case, attenuation to levels below the general emission limits specified in **§15.209(a)** is not required.

3.4.1 Test Setup

Refer to the APPENDIX I.

3.4.2 Test Procedures

The transmitter output is connected to a spectrum analyzer.

- Measurement Procedure 1 – Reference Level

1. Set instrument center frequency to DTS channel center frequency.
2. Set the span to ≥ 1.5 times the DTS bandwidth.
3. Set the RBW = 100 kHz.
4. Set the VBW $\geq 3 \times$ RBW.
5. Detector = peak.
6. Sweep time = auto couple.
7. Trace mode = max hold.
8. Allow trace to fully stabilize.
9. Use the peak marker function to determine the maximum PSD level

LIMIT LINE = 20 dB below of the reference level.

- Measurement Procedure 2 - Unwanted Emissions

1. Set the center frequency and span to encompass frequency range to be measured.
2. Set the RBW = 100 kHz.(Actual 1 MHz , See below note)
3. Set the VBW $\geq 3 \times$ RBW.(Actual 3 MHz, See below note)
4. Detector = peak.
5. Ensure that the number of measurement points \geq span / RBW
6. Sweep time = auto couple.
7. Trace mode = max hold.
8. **Allow the trace to stabilize** (this may take some time, depending on the extent of the span).
9. Use the peak marker function to determine the maximum amplitude level.

Note : The conducted spurious emission was tested with below settings.

Frequency range	RBW	VBW	Detector	Trace	Sweep Point
9 kHz ~ 30 MHz	100 kHz	300 kHz	Peak	Max Hold	40001
30 MHz ~ 10 GHz	1 MHz	3 MHz			
10 GHz ~ 25 GHz	1 MHz	3 MHz			

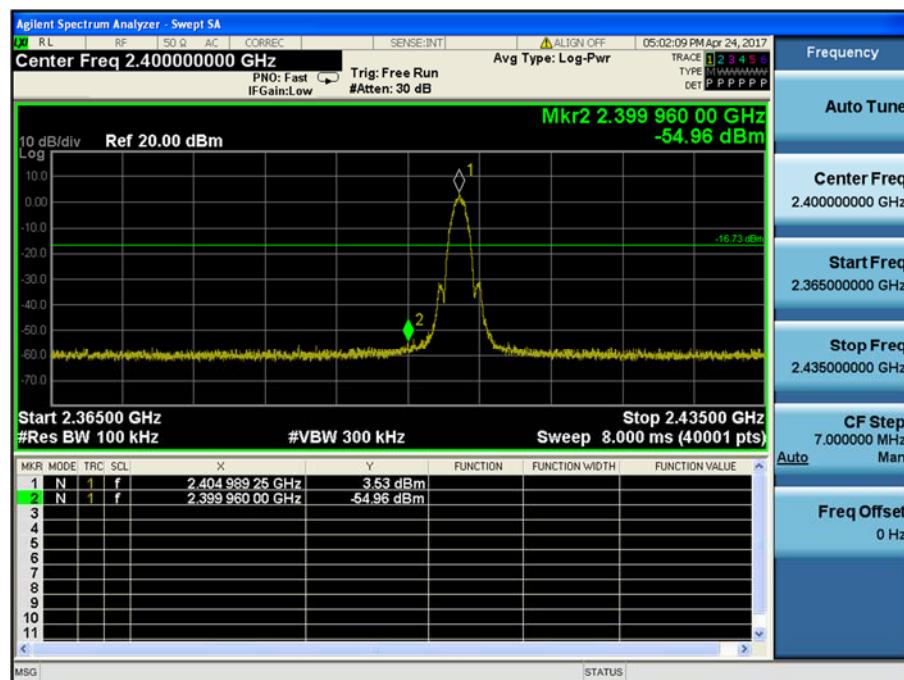
If the emission level with above setting was close to the limit (ie, less than 3 dB margin) then zoom scan is required using RBW = 100 kHz, VBW = 300 kHz, SPAN = 100 MHz and BINS = 2001 to get accurate emission level within 100 kHz BW.

3.4.3 Test Results

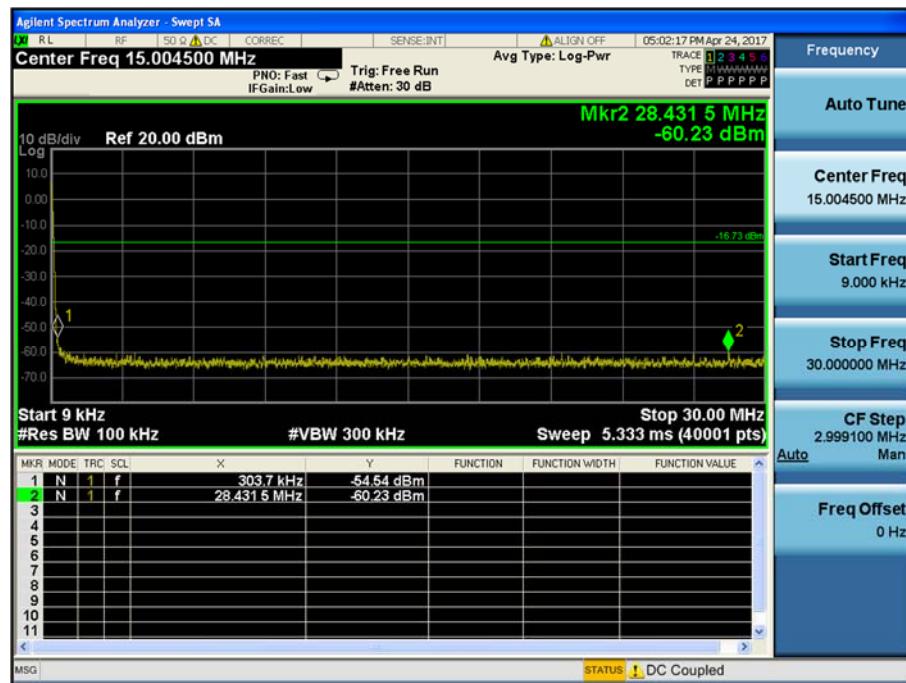
Reference (TM 1 & Test Channel : Lowest)



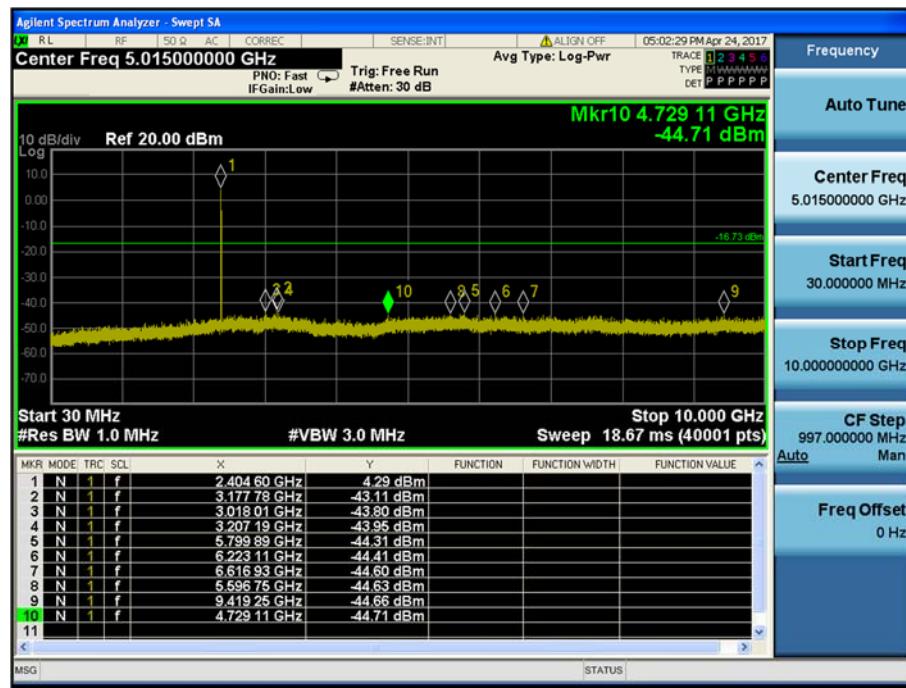
Low Band-edge

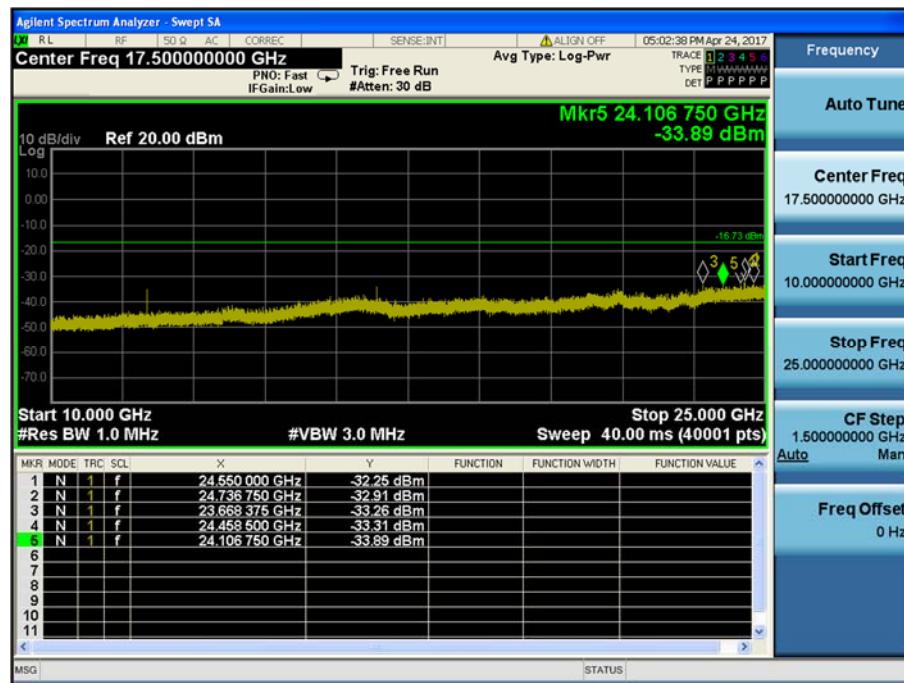


Conducted Spurious Emissions 1 (TM 1 & Test Channel : Lowest)



Conducted Spurious Emissions 2 (TM 1 & Test Channel : Lowest)

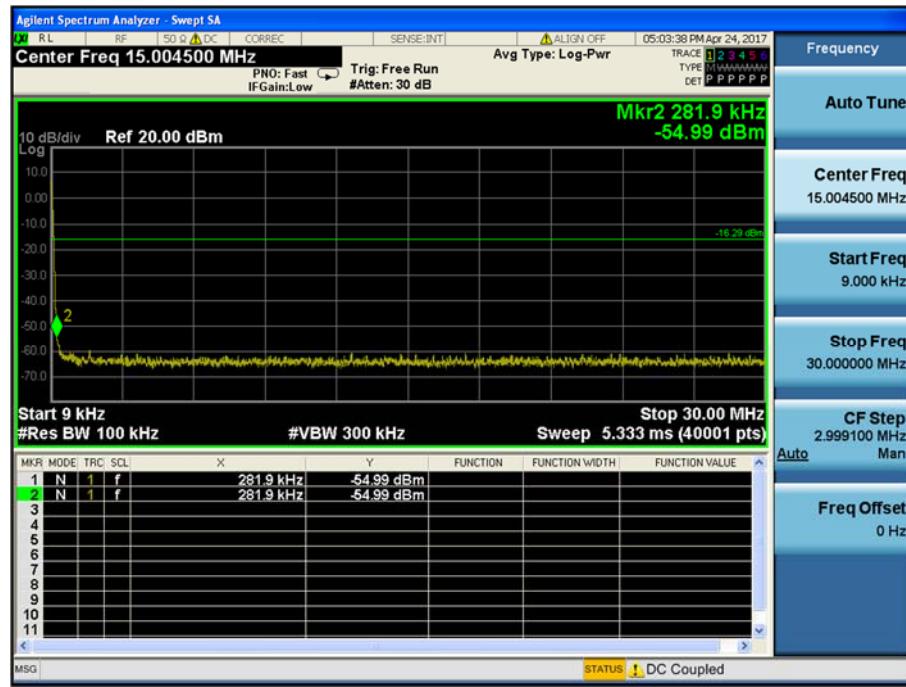


Conducted Spurious Emissions 3 (TM 1 & Test Channel : Lowest)

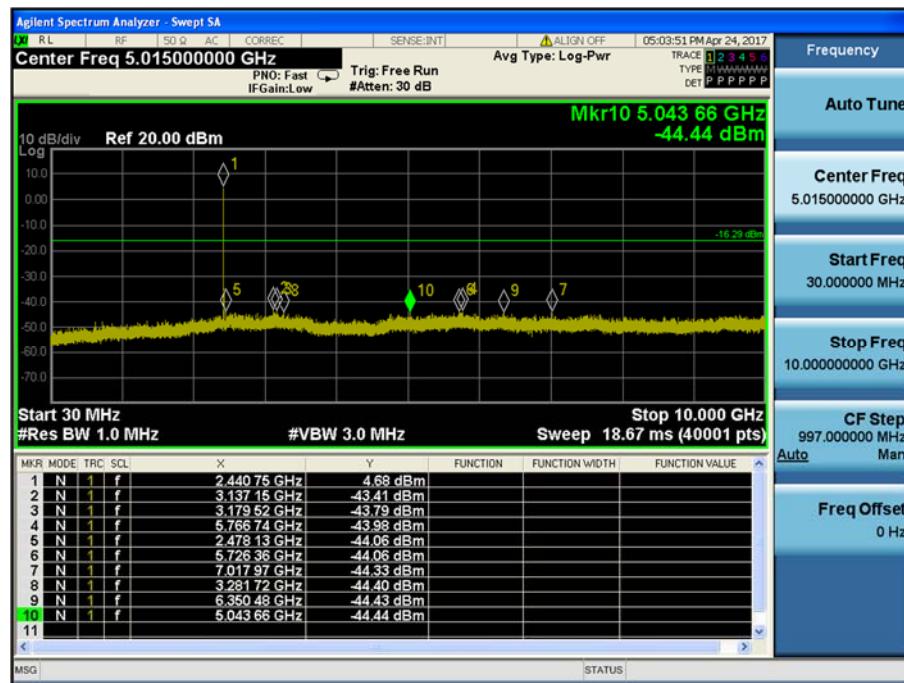
Reference (TM 1 & Test Channel : Middle)



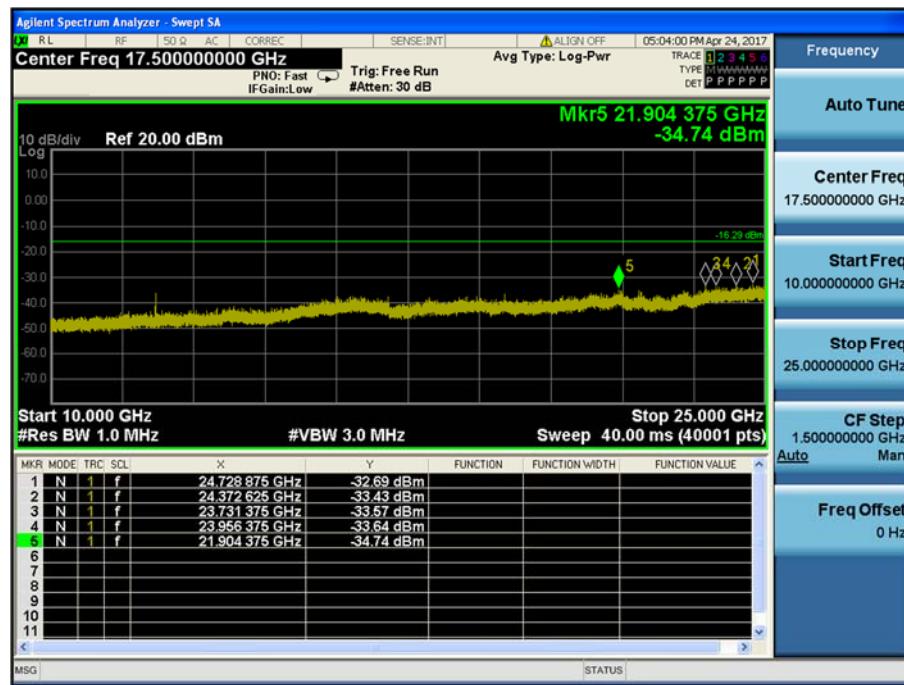
Conducted Spurious Emissions 1 (TM 1 & Test Channel : Middle)



Conducted Spurious Emissions 2 (TM 1 & Test Channel : Middle)



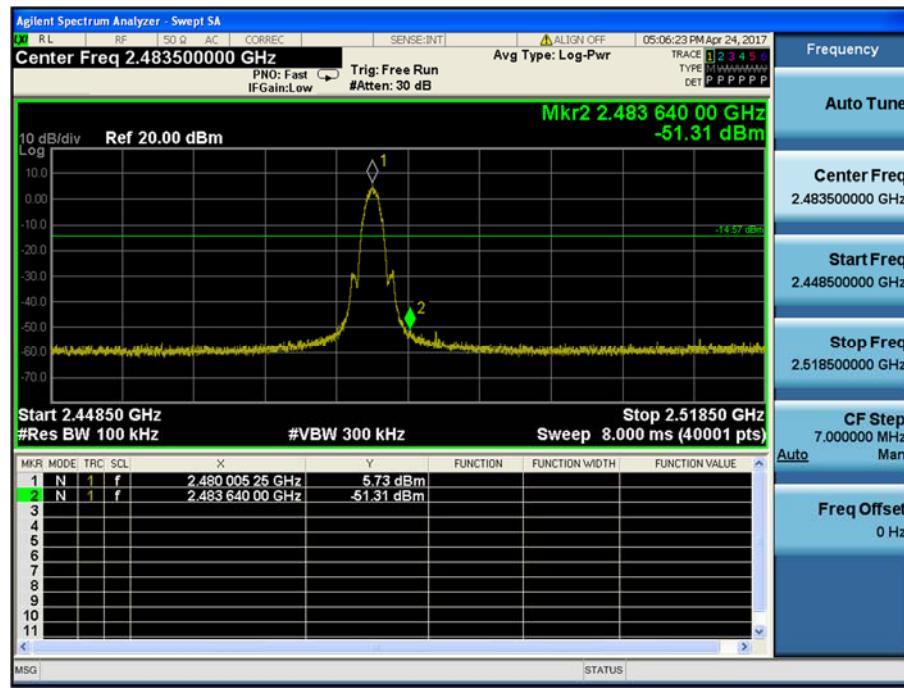
Conducted Spurious Emissions 3 (TM 1 & Test Channel : Middle)



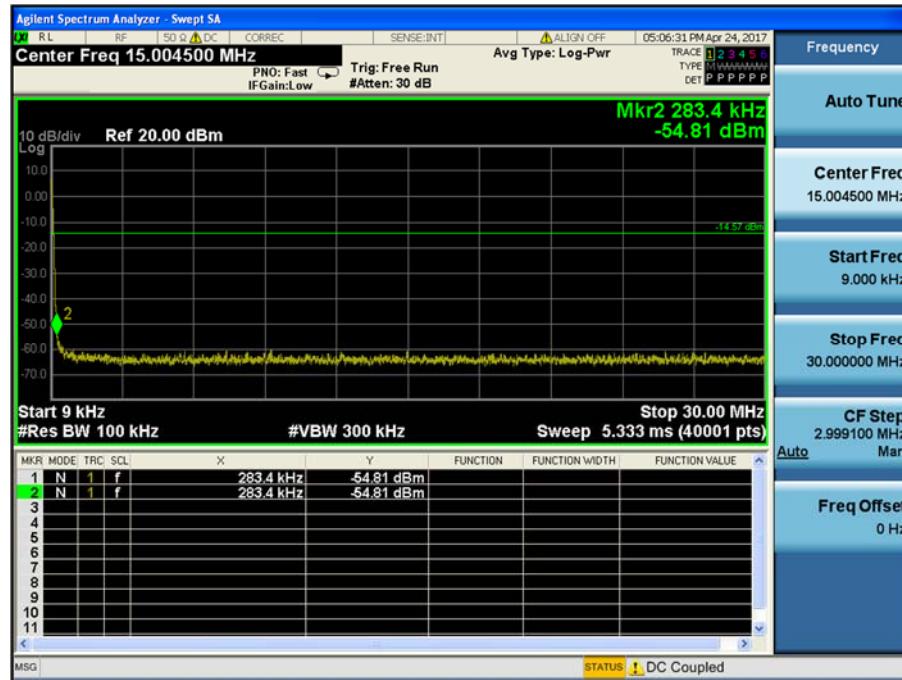
Reference (TM 1 & Test Channel : Highest)



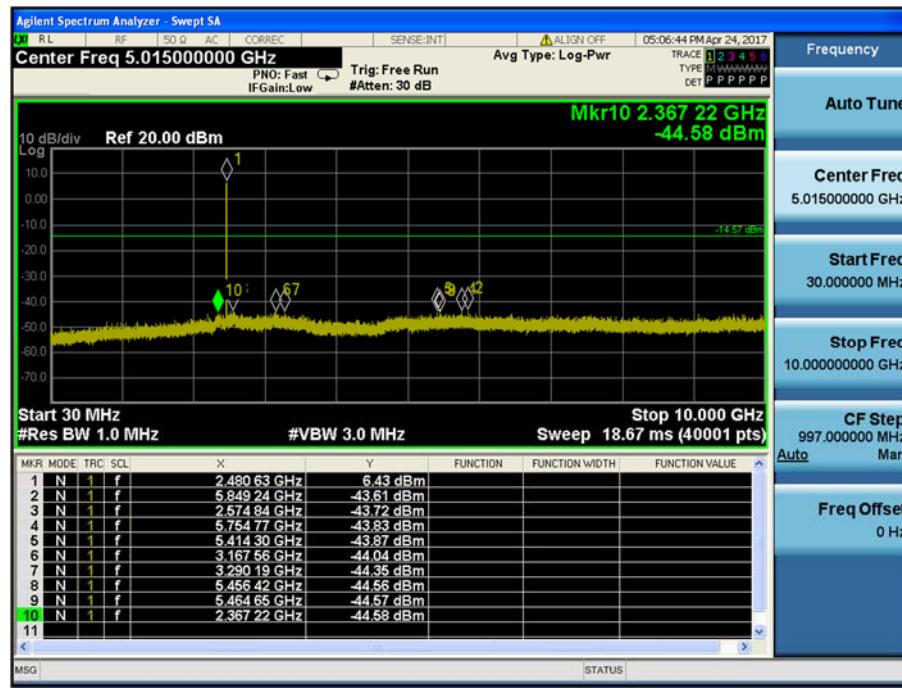
High Band-edge (TM 1 & Test Channel : Highest)



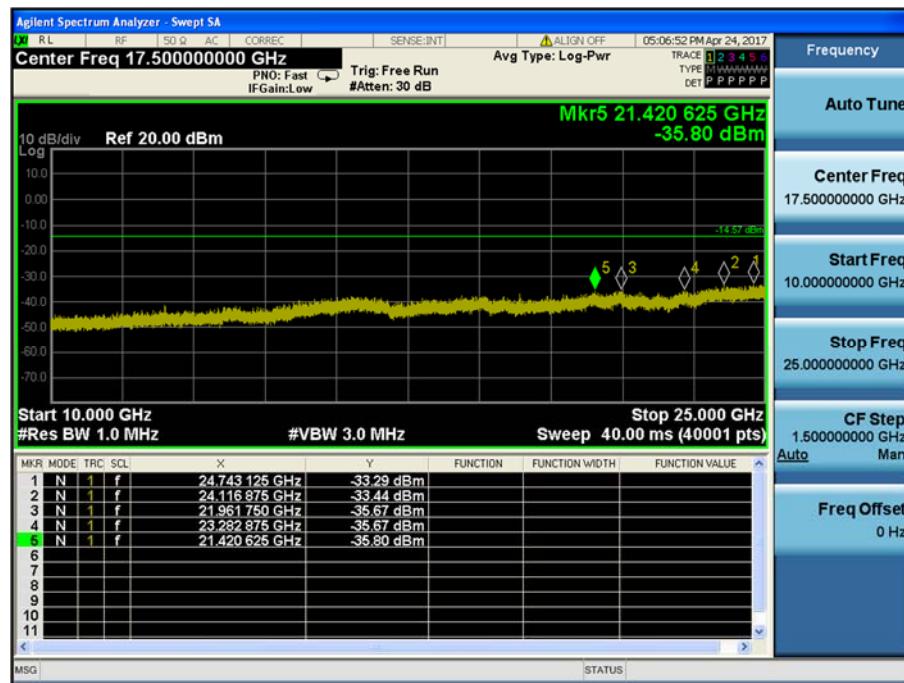
Conducted Spurious Emissions 1 (TM 1 & Test Channel : Highest)



Conducted Spurious Emissions 2 (TM 1 & Test Channel : Highest)



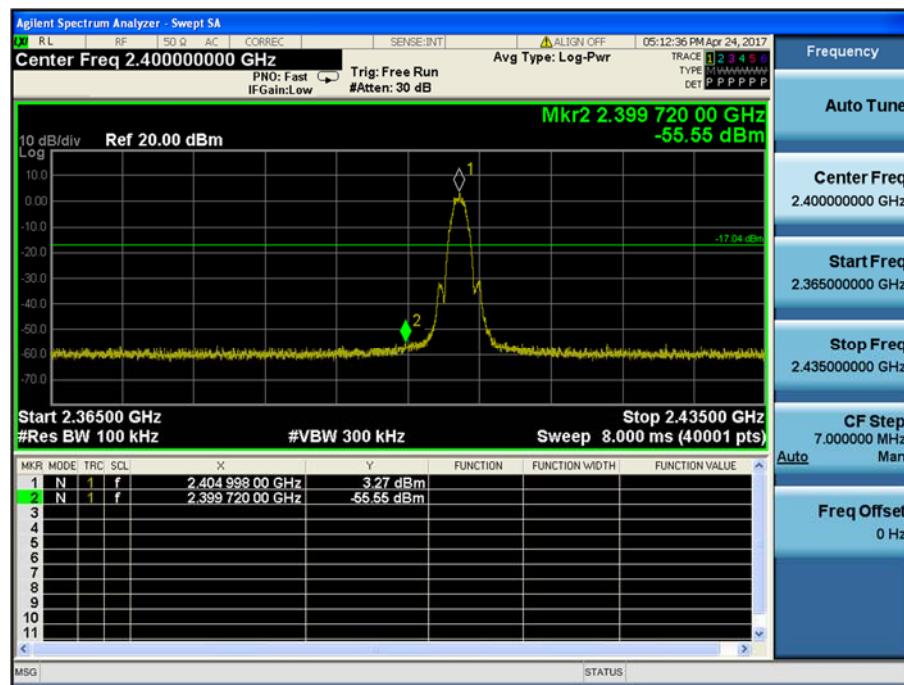
Conducted Spurious Emissions 3 (TM 1 & Test Channel : Highest)



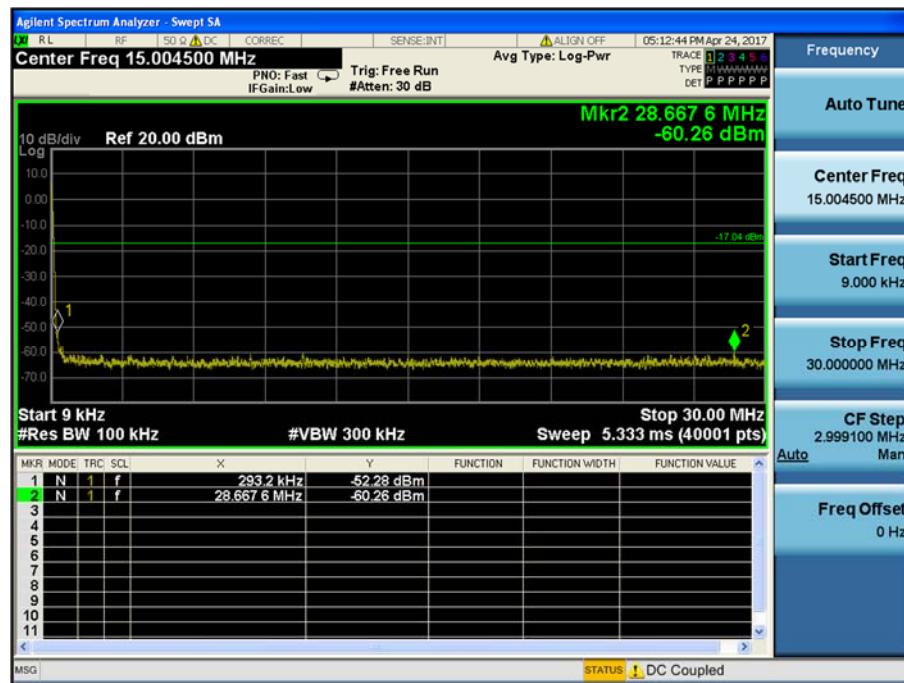
Reference (TM 2 & Test Channel : Lowest)



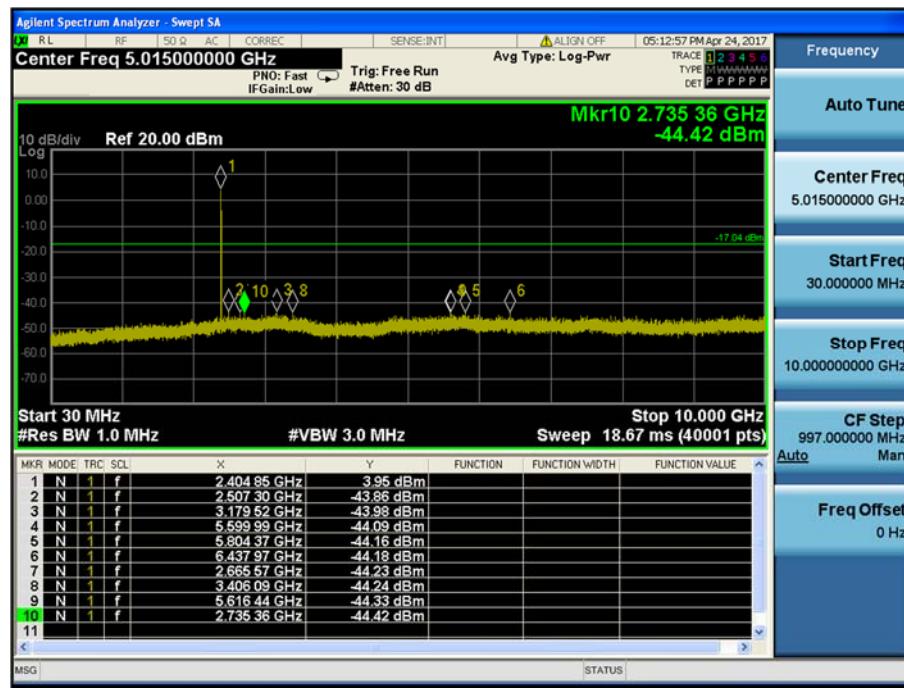
Low Band-edge



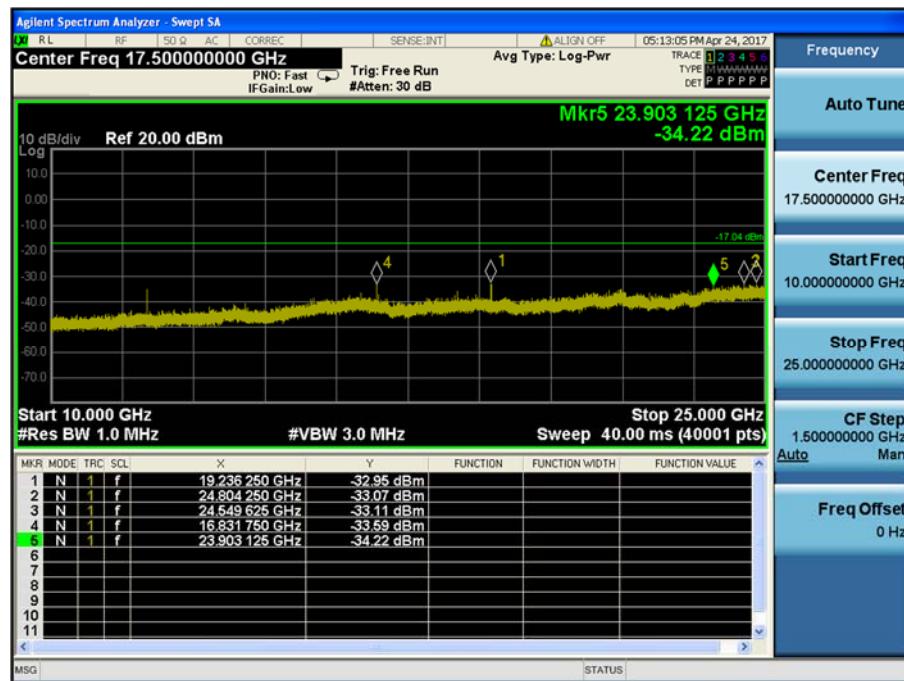
Conducted Spurious Emissions 1 (TM 2 & Test Channel : Lowest)



Conducted Spurious Emissions 2 (TM 2 & Test Channel : Lowest)



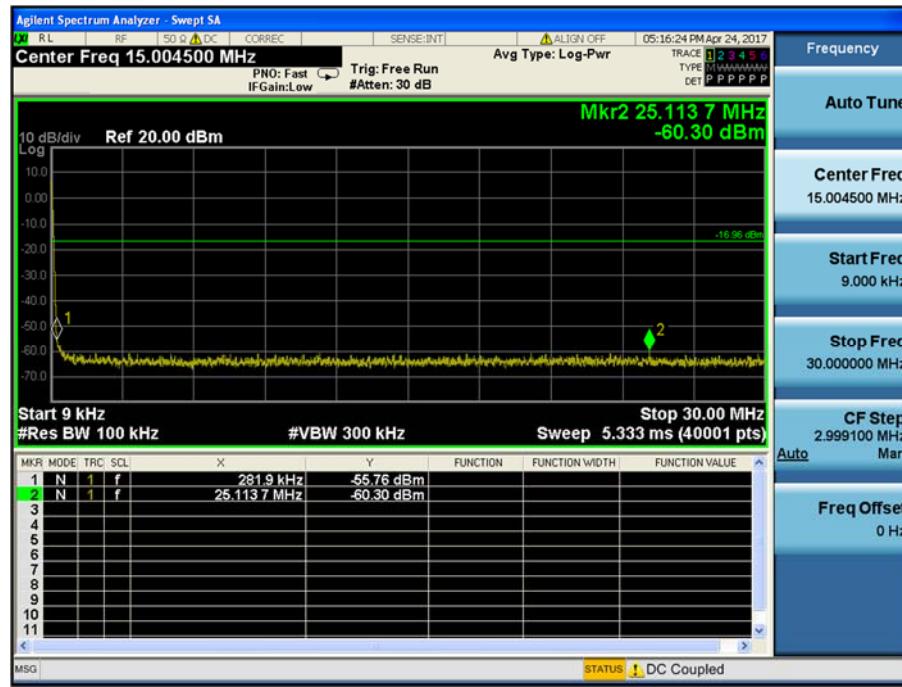
Conducted Spurious Emissions 3 (TM 2 & Test Channel : Lowest)



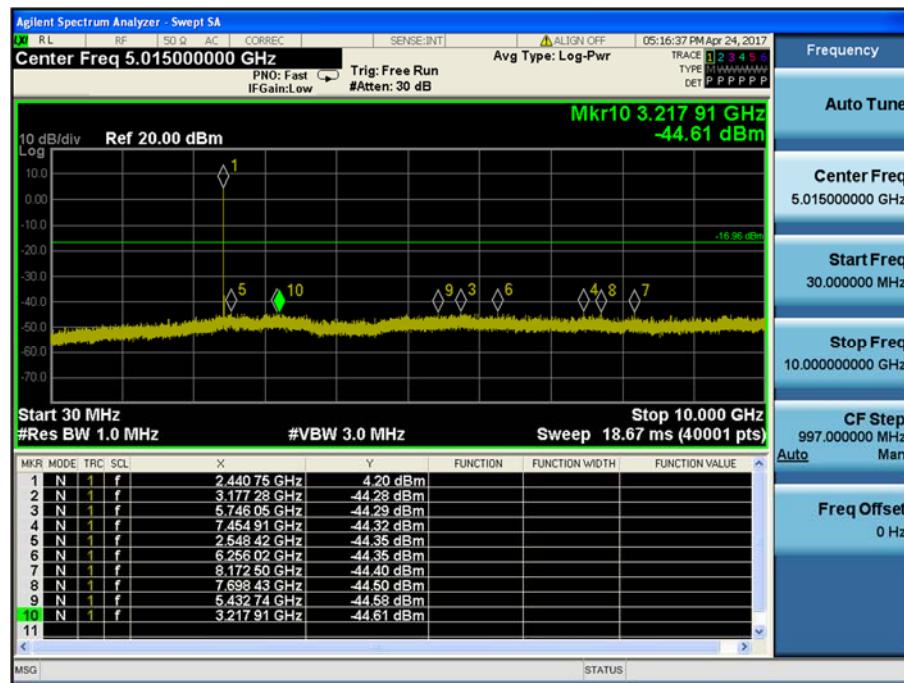
Reference (TM 2 & Test Channel : Middle)



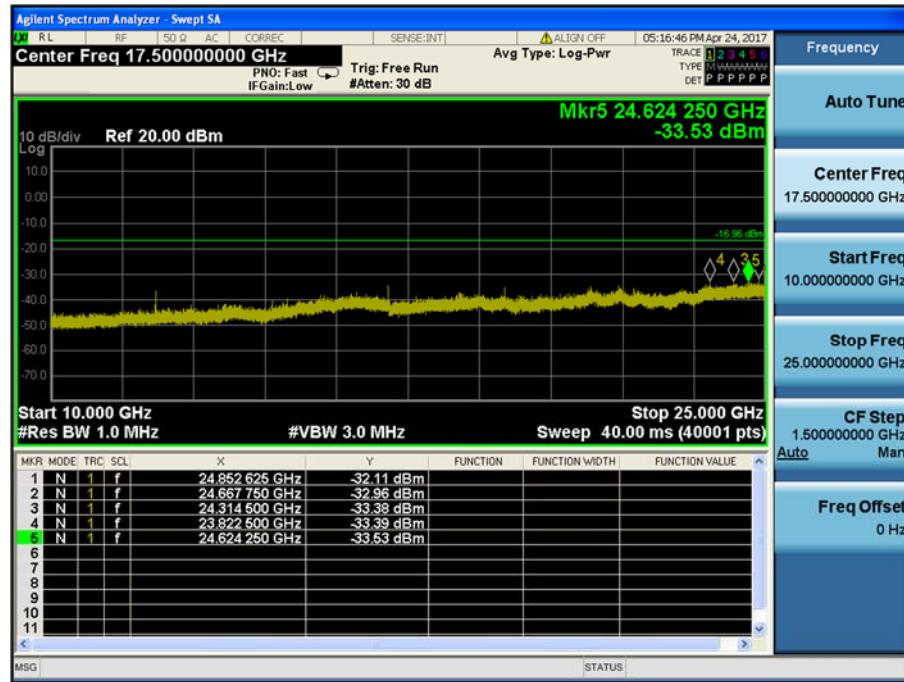
Conducted Spurious Emissions 1 (TM 2 & Test Channel : Middle)



Conducted Spurious Emissions 2 (TM 2 & Test Channel : Middle)



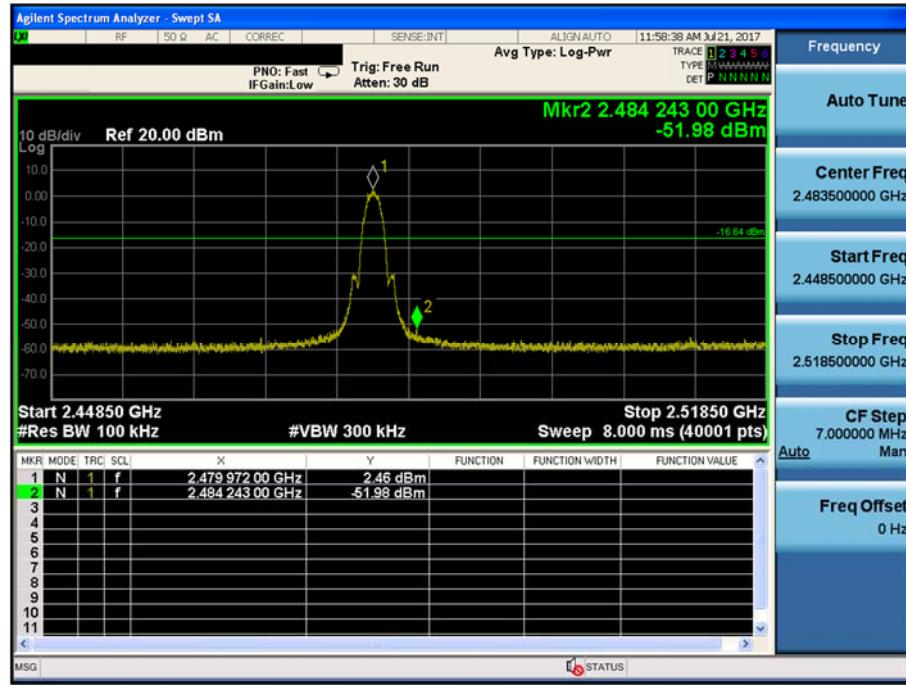
Conducted Spurious Emissions 3 (TM 2 & Test Channel : Middle)



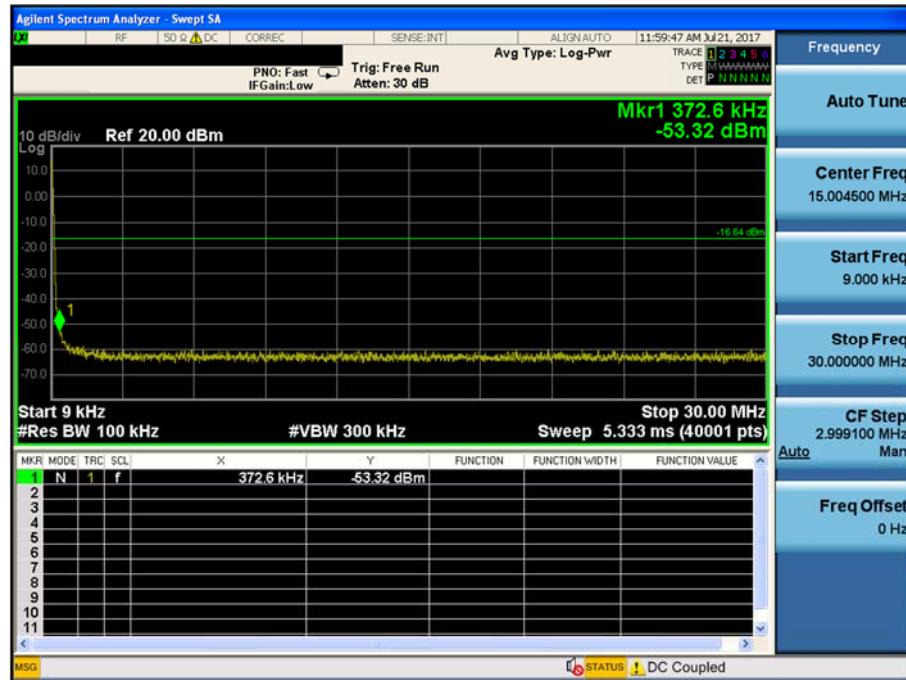
Reference (TM 2 & Test Channel : Highest)



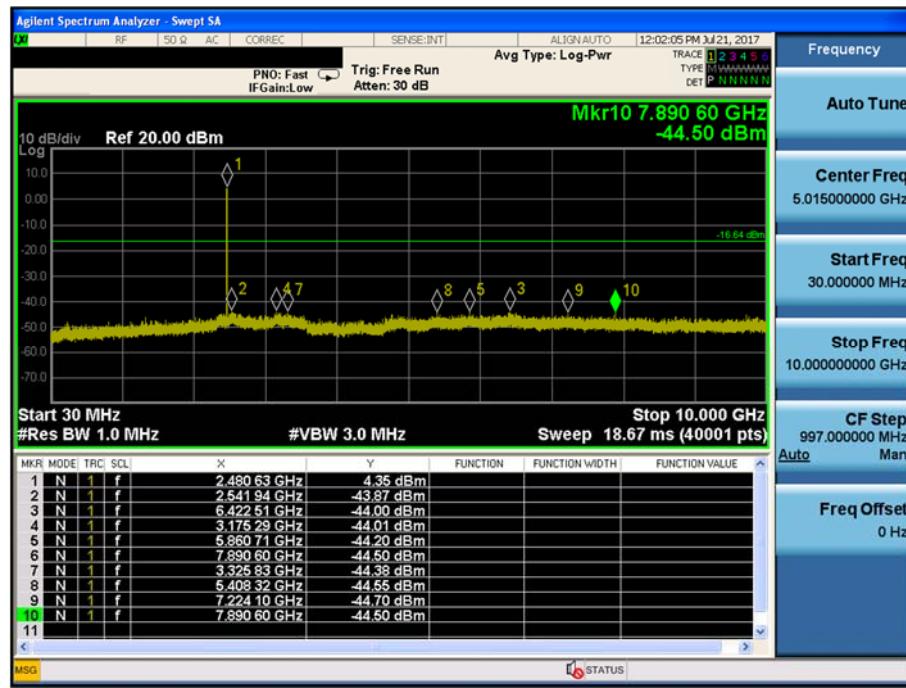
High Band-edge (TM 2 & Test Channel : Highest)



Conducted Spurious Emissions 1 (TM 2 & Test Channel : Highest)



Conducted Spurious Emissions 2 (TM 2 & Test Channel : Highest)



Conducted Spurious Emissions 3 (TM 2 & Test Channel : Highest)

