

# Report on the Radio Testing of:

## Wearable Device

Model(s): ZSWW

In accordance with  
FCC 47 CFR Part 15C

Prepared for:  
Nitto Denko Asia Technical Centre Pte Ltd  
3 Biopolis Drive, #03-17/18 Synapse  
Singapore 138623



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## COMMERCIAL-IN-CONFIDENCE

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RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Project Management	Song Zhi Qun	23 Oct 2018	
Authorised Signatory	Quek Keng Huat	22 Oct 2018	

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD PSB document control rules.

### EXECUTIVE SUMMARY

A sample of this product was tested and found to be compliant with the mentioned standard(s).



LA-2007-0380-A  
LA-2007-0381-F  
LA-2007-0382-B  
LA-2007-0383-G

LA-2007-0384-G  
LA-2007-0385-E  
LA-2007-0386-C  
LA-2010-0464-D

The results reported herein have been performed in accordance with the terms of accreditation under the Singapore Accreditation Council. Inspections/Calibrations/Tests marked "Not SAC-SINGLAS Accredited" in this Report are not included in the SAC-SINGLAS Accreditation Schedule for our inspection body/laboratory.

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Page 1 of 71

## Contents

<b>1</b>	<b>Report Summary .....</b>	<b>3</b>
1.1	Report Modification Record .....	3
1.2	Introduction .....	3
1.3	Brief Summary of Results .....	4
1.4	Product Information .....	7
1.5	Deviations from the Standard .....	8
1.6	EUT Modification Record .....	8
1.7	Test Location(s) .....	8
1.8	Test Facilities Registrations .....	8
1.9	Supporting Equipment .....	9
<b>2</b>	<b>Test Details .....</b>	<b>10</b>
2.1	Conducted Emissions .....	10
2.2	Radiated Emissions (Spurious Emissions Inclusive Restricted Bands Requirement) .....	13
2.3	Spectrum Bandwidth (6db Bandwidth Measurement) .....	17
2.4	Maximum Peak Power .....	21
2.5	RF Conducted Spurious Emissions (Non-Restricted Bands) .....	23
2.6	RF Conducted Spurious Emissions (Restricted Bands) .....	28
2.7	Band Edge Compliance (Conducted) .....	41
2.8	Band Edge Compliance (Radiated) .....	44
2.9	Peak Power Spectral Density .....	49
<b>3</b>	<b>Photographs .....</b>	<b>53</b>
<b>4</b>	<b>Test Equipment .....</b>	<b>66</b>
<b>5</b>	<b>Measurement Uncertainty .....</b>	<b>68</b>
<b>6</b>	<b>Annex A – FCC Label and Position .....</b>	<b>69</b>
	<b>End of the Test Report .....</b>	<b>71</b>

## 1 Report Summary

### 1.1 Report Modification Record

Alterations and additions to this report will be issued to the holders of each copy in the form of a complete document.

Issue	Description of Change	Date of Issue
1	First Issue	23 Oct 2018

### 1.2 Introduction

Applicant	:	Nitto Denko Asia Technical Centre Pte Ltd 3 Biopolis Drive, #03-17/18 Synapse Singapore 138623
Manufacturer	:	Same as applicant
Factory	:	V.S Electronics Sdn. Bhd. Plo 47, Jalan Perindustrian 1, Senai Industrial Estate II, 81400 Senai, Johor, Malaysia
Model Number(s)	:	ZSWW
Serial Number(s)	:	Nil
Number of Samples Tested	:	1
Test Sample(s) Condition	:	Good
Quotation Reference	:	5119405
Test Specification/Issue/Date	:	FCC 47 CFR 15C
Test Sample(s) Received Date	:	06 Sep 2018
Start of Test	:	06 Sep 2018
Finish of Test	:	20 Sep 2018

### 1.3 Brief Summary of Results

A brief summary of the tests carried out in accordance with specifications as shown below.

Specification Clause	Test Description	Result	Comments/Base Standard
<b>47 CFR FCC Part 15</b>			
15.107(a), 15.207	Conducted Emissions	Pass	ANSI C63.4: 2014 ANSI C63.10: 2013 KDB 558074 D01 DTS Measurement Guidance V05: 2018
15.109(a), 15.205, 15.209	Radiated Emissions (Spurious Emissions Inclusive Restricted Bands Requirement)	Pass	ANSI C63.4: 2014 ANSI C63.10: 2013 KDB 558074 D01 DTS Measurement Guidance V05: 2018
15.247(a)(2)	Spectrum Bandwidth (6dB Bandwidth Measurement)	Pass	ANSI C63.10: 2013 KDB 558074 D01 DTS Measurement Guidance V05: 2018
15.247(b)(3)	Maximum Peak Power	Pass	ANSI C63.10: 2013 KDB 558074 D01 DTS Measurement Guidance V05: 2018
15.247(d)	RF Conducted Spurious Emissions (Non-Restricted Bands)	Pass	ANSI C63.10: 2013 KDB 558074 D01 DTS Measurement Guidance V05: 2018
15.247(d)	RF Conducted Spurious Emissions (Restricted Bands)	Pass	ANSI C63.10: 2013 KDB 558074 D01 DTS Measurement Guidance V05: 2018
15.247(d)	Band Edge Compliance (Conducted)	Pass	ANSI C63.10: 2013 KDB 558074 D01 DTS Measurement Guidance V05: 2018
15.247(d)	Band Edge Compliance (Radiated)	Pass	ANSI C63.10: 2013 KDB 558074 D01 DTS Measurement Guidance V05: 2018
15.247(e)	Peak Power Spectral Density	Pass	ANSI C63.10: 2013 KDB 558074 D01 DTS Measurement Guidance V05: 2018
15.35(c)	Duty Cycle Factor Computation	Not Applicable *See Note 4	ANSI C63.10: 2013 KDB 558074 D01 DTS Measurement Guidance V05: 2018
2.1091	Maximum Permissible Exposure	Not Applicable *See Note 5	

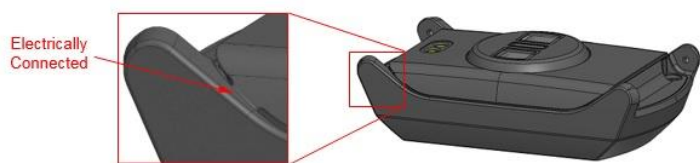
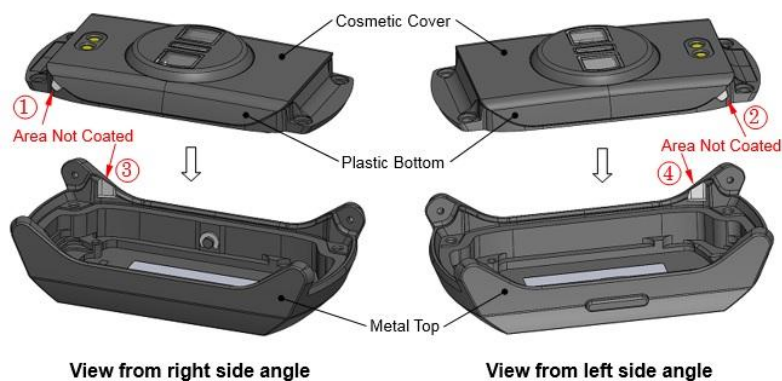
## Notes

1. All the measurements in section 15.247 were done based on conducted measurements except Band Edge Compliance (Radiated) test.
2. The EUT is a Class B device when in non-transmitting state and meets the 47 CFR FCC Part15B Class B requirements.
3. The maximum measured RF power of the Equipment Under Test is -7.62dBm.
4. The EUT was operated in continuous transmission, ie 100% duty cycle.
5. The EUT is a wearable device.



## Notes (cont'd)

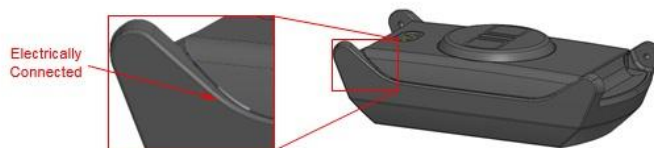
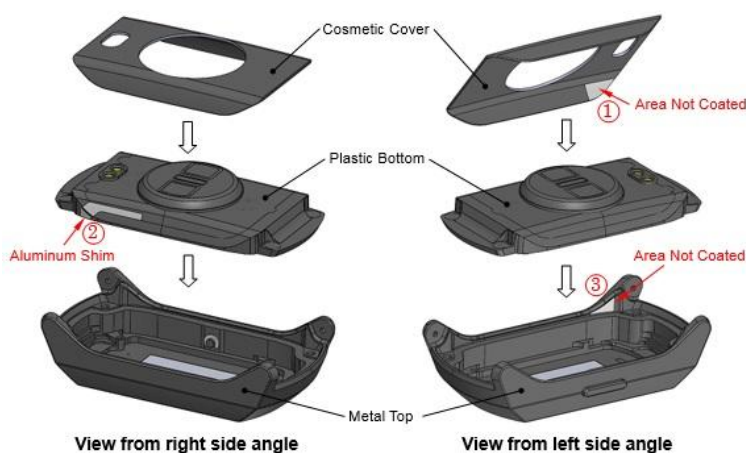
6. Nitto Denko Asia Technical Centre Pte Ltd declares that Design A & Design B achieves the primary objective of electrically connecting the Cosmetic Cover (Material SS430) to Metal Top (Material SS316) of the device and has no variation in EMC performance. Design A was officially submitted to TUV SUD as the final product.



Assembled device

Establish Electrical Connectivity: Area ① touch Area ④ OR Area ② touch Area ③

### Design A



Assembled device

Establish Electrical Connectivity: Area ① touch Area ② AND Area ② touch Area ③

### Design B

## 1.4 Product Information

### 1.4.1 Technical Description

Description	:	The Equipment Under Test(s) (EUT(s)) is a <b>Wearable Device</b> .
Microprocessor	:	Nordic Semiconductor nRF52840
Operating Frequency	:	64MHz
Clock / Oscillator Frequency	:	32.768MHz & 32MHz
Modulation	:	GFSK
Antenna Gain	:	0.0dBi
Port / Connectors	:	1 x DC Inlet
Rated Power	:	3.7VDC 120mAh 0.444Wh
Accessories	:	Charger Dock via USB

### 1.4.2 Test Configuration and Modes of Operation

Mode(s)	Description								
Maximum RF power transmission	<p>The EUT was exercised in the mode, transmitting at lower, middle and upper channels as shown below one at a time with all supported modulation schemes were evaluated. For Band Edge Compliance, only lower and upper channels were evaluated.</p> <table border="1"> <thead> <tr> <th><u>Transmit Channel</u></th><th><u>Frequency (GHz)</u></th></tr> </thead> <tbody> <tr> <td>Channel 0 (Lower Channel)</td><td>2.402</td></tr> <tr> <td>Channel 19 (Middle Channel)</td><td>2.440</td></tr> <tr> <td>Channel 39 (upper Channel)</td><td>2.480</td></tr> </tbody> </table>	<u>Transmit Channel</u>	<u>Frequency (GHz)</u>	Channel 0 (Lower Channel)	2.402	Channel 19 (Middle Channel)	2.440	Channel 39 (upper Channel)	2.480
<u>Transmit Channel</u>	<u>Frequency (GHz)</u>								
Channel 0 (Lower Channel)	2.402								
Channel 19 (Middle Channel)	2.440								
Channel 39 (upper Channel)	2.480								

## 1.5 Deviations from the Standard

Nil.

## 1.6 EUT Modification Record

No modifications were made.

## 1.7 Test Location(s)

TÜV SÜD PSB Pte Ltd  
Electrical & Electronics Centre (EEC), Product Services,  
No. 1 Science Park Drive, Singapore 118221

TÜV SÜD PSB Pte Ltd  
Electrical & Electronics Centre (EEC), Product Services,  
13 International Business Park #01-01, Singapore 609932

## 1.8 Test Facilities Registrations

Requirements	Registration Numbers
FCC	994109 (Test Firm Registration Number) SG0002 (Designation Number)
ISED	<u>Science Park</u> 2932I-1 (3m and 10m Semi-Anechoic Chamber)  <u>International Business Park</u> 2932N-1 (10m Semi-Anechoic Chamber)
VCCI	<u>Science Park</u> R-1335 (10m ANC), G-29 (10m ANC) C-2306 (C.E @ Lab 3) T-1471 (Telecom Ports @ Lab 3)  <u>International Business Park</u> R-3324 (10m ANC), G-203 (10mANC) C-4933 (C.E @ CEIBP) T-2403 (Telecom Ports @ CEIBP)
BSMI	SL2-IS-E-6001R [CNS-13803 (ISM Equipment)] SL2-IN-E-6001R [CNS-13438 (IT Equipment)] SL2-R1/R2-E-6001R [CNS-13439 (Broadcast Receivers)] SL2-A1-E-6001R [CNS-13783-1 (Household Appliances)] SL2-L1-E-6001R [CNS-14115 (Lighting Equipment)]
SABS	SABS/A-LAB/0029/2018



## 1.9 Supporting Equipment

Equipment Description (Including Brand Name)	Model, Serial & FCC ID Number	Cable Description (List Length, Type & Purpose)
nRF51 dongle	M/N: PCA10031 S/N: 680152872 FCC ID: Nil	Nil
Fujitsu Lifebook	M/N: SH561 S/N: R1705475 FCC ID: Nil	2.00m unshielded power cable 2.00m USB cable
Fujitsu AC adapter	M/N: SEC100P3-19.0 S/N: 10302433D FCC ID: Nil	2.00m unshielded power cable



## 2 Test Details

### 2.1 Conducted Emissions

#### 2.1.1 Test Limits

Frequency Range (MHz)	Limit Values (dB $\mu$ V)	
	Quasi-peak (Q-P)	Average (AV)
0.15 - 0.5	66 – 56 *	56 – 46 *
0.5 - 5.0	56	46
5.0 - 30.0	60	50
* Decreasing linearly with the logarithm of the frequency		



## 2.1.2 Test Setup

- 2.1.2.1 The EUT and supporting equipment were set up in accordance with the requirements of the standard as shown in the setup photos.
- 2.1.2.2 The power supply for the EUT was fed through a 50Ω/50μH EUT LISN, connected to filtered mains.
- 2.1.2.3 The RF OUT of the EUT LISN was connected to the EMI test receiver via a low-loss coaxial cable.
- 2.1.2.4 All other supporting equipment were powered separately from another LISN.

## 2.1.3 Test Method

- 2.1.3.1 The EUT was switched on and allowed to warm up to its normal operating condition.
- 2.1.3.2 A scan was made on the NEUTRAL line over the required frequency range using an EMI test receiver.
- 2.1.3.3 High peaks, relative to the limit line, were then selected.
- 2.1.3.4 The EMI test receiver was then tuned to the selected frequencies and the necessary measurements made with a receiver bandwidth setting of 9kHz. Both Quasi-peak and Average measurements were made.
- 2.1.3.5 The measurements were then repeated for the LIVE line .

### Sample Calculation Example

At 20 MHz

Q-P limit = 60.0 dBμV

Transducer factor of LISN, pulse limiter & cable loss at 20 MHz = 11.2 dB

Q-P reading obtained directly from EMI Receiver = 40.0 dBμV

(Calibrated for system losses)

Therefore, Q-P margin = 60.0 - 40.0 = 20.0

i.e. 20.0 dB below Q-P limit

## 2.1.4 Test Results

Operating Mode	Data Streaming & Charging	Temperature	21°C
Test Input Power	120V 60Hz (Laptop Power)	Relative Humidity	59%
Line Under Test	AC Mains	Atmospheric Pressure	1025mbar
Class	B	Tested By	Dylan Lin
		Test Date	11 Sep 2018

Frequency (MHz)	Q-P Value (dBμV)	Q-P Limit (dBμV)	Q-P Margin (dB)	AV Value (dBμV)	AV Limit (dBμV)	AV Margin (dB)	Line
0.2091	39.7	63.2	23.5	33.7	53.2	19.5	Live
0.2094	40.1	63.2	23.1	32.5	53.2	20.7	Live
0.2137	36.9	63.1	26.2	30.9	53.1	22.2	Neutral
0.3095	38.7	60.0	21.3	29.1	50.0	20.9	Live
0.4493	34.5	56.9	22.4	24.7	46.9	22.2	Live
1.4526	29.8	56.0	26.2	24.5	46.0	21.5	Live

### Notes

1.	All possible modes of operation were investigated from 150kHz to 30MHz. Only the worst case emissions measured, using the correct CISPR detectors, are reported. All other emissions were relatively insignificant.
2.	A "positive margin" indicates a PASS as it refers to the margin present below the limit line at the particular frequency. Conversely, a "negative margin" indicates a FAIL.
3.	EMI receiver Resolution Bandwidth (RBW) and Video Bandwidth (VBW) settings: <u>9kHz - 30MHz</u> RBW: 9kHz VBW: 30kHz

## 2.2 Radiated Emissions (Spurious Emissions Inclusive Restricted Bands Requirement)

### 2.2.1 Test Limits

Frequency Range (MHz)	Quasi-Peak Limit Values (dBμV/m)
0.009 - 0.490 *	20 log [2400 / F (kHz)] @ 300m
0.490 - 1.705	20 log [24000 / F (kHz)] @ 30m
1.705 - 30.0	30.0 @ 30m
30 – 88	40.0 @ 3m
88 – 216	43.5 @ 3m
216 – 960	46.0 @ 3m
Above 960 *	54.0 @ 3m

\* For frequency bands 9kHz – 90kHz, 110kHz – 490kHz and above 1GHz, average detector was used. A peak limit of 20dB above the average limit does apply.

### Restricted Bands

MHz	MHz	MHz	GHz
0.090 - 0.110	16.42 - 16.423	399.9 - 410	4.5 - 5.15
0.495 - 0.505	16.69475 - 16.69525	608 - 614	5.35 - 5.46
2.1735 - 2.1905	16.80425 - 16.80475	960 - 1240	7.25 - 7.75
4.125 - 4.128	25.5 - 25.67	1300 - 1427	8.025 - 8.5
4.17725 - 4.17775	37.5 - 38.25	1435 - 1626.5	9.0 - 9.2
4.20725 - 4.20775	73 - 74.6	1645.5 - 1646.5	9.3 - 9.5
6.215 - 6.218	74.8 - 75.2	1660 - 1710	10.6 - 12.7
6.26775 - 6.26825	108 - 121.94	1718.8 - 1722.2	13.25 - 13.4
6.31175 - 6.31225	123 - 138	2200 - 2300	14.47 - 14.5
8.291 - 8.294	149.9 - 150.05	2310 - 2390	15.35 - 16.2
8.362 - 8.366	156.52475 - 156.52525	2483.5 - 2500	17.7 - 21.4
8.37625 - 8.38675	156.7 - 156.9	2690 - 2900	22.01 - 23.12
8.41425 - 8.41475	162.0125 - 167.17	3260 - 3267	23.6 - 24.0
12.29 - 12.293	167.72 - 173.2	3332 - 3339	31.2 - 31.8
12.51975 - 12.52025	240 - 285	3345.8 - 3358	36.43 - 36.5
12.57675 - 12.57725	322 - 335.4	3600 - 4400	Above 38.6
13.36 - 13.41			

## 2.2.2 Test Setup

- 2.2.2.1 The EUT and supporting equipment were set up in accordance with the requirements of the standard as shown in the setup photos.
- 2.2.2.2 The filtered power supply for the EUT and supporting equipment were tapped from the appropriate power sockets located on the turntable.
- 2.2.2.3 The relevant broadband antenna was set at the required test distance away from the EUT and supporting equipment boundary.

## 2.2.3 Test Method

- 2.2.3.1 The EUT was switched on and allowed to warm up to its normal operating condition.
- 2.2.3.2 A prescan was carried out to pick the worst emission frequencies from the EUT. For EUT which is a portable device, the prescan was carried out by rotating the EUT through three orthogonal axes to determine which altitude and equipment arrangement produces such emissions.
- 2.2.3.3 The test was carried out at the selected frequency points obtained from the pre-scan. Maximization of the emissions, was carried out by rotating the EUT, changing the antenna polarization, and adjusting the antenna height in the following manner:
  - a. Vertical or horizontal polarisation (whichever gave the higher emission level over a full rotation of the EUT) was chosen.
  - b. The EUT was then rotated to the direction that gave the maximum emission.
  - c. Finally, the antenna height was adjusted to the height that gave the maximum emission
- 2.2.3.4 A Quasi-peak measurement was made for that frequency point if it was less than or equal to 1GHz. For frequency point in range of 9kHz – 90kHz, 110kHz – 490kHz and above 1GHz, both Peak and Average measurements were carried out.
- 2.2.3.5 The measurements were repeated for the next frequency point, until all selected frequency points were measured.
- 2.2.3.6 The frequency range covered was from the lowest radio frequency signal generated from the EUT, without going below 9kHz to 10<sup>th</sup> harmonics of the EUT fundamental frequency, using the loop antenna for frequency below 30MHz, Bi-log antenna for frequencies from 30MHz up to 1GHz, and the Horn antenna above 1GHz.

## Sample Calculation Example

At 300 MHz

Q-P limit = 46.0 dB $\mu$ V/m

Log-periodic antenna factor & cable loss at 300 MHz = 18.5 dB

Q-P reading obtained directly from EMI Receiver = 40.0 dB $\mu$ V/m

(Calibrated level including antenna factors & cable losses)

Therefore, Q-P margin = 46.0 - 40.0 = 6.0

i.e. 6.0 dB below Q-P limit

## 2.2.5 Test Results

Test Input Power	3.7Vdc Battery	Temperature	23°C
Test Distance	3m (≥30MHz – 25GHz)	Relative Humidity	60%
Operating Mode	Data Streaming & Charging	Atmospheric Pressure	1010mbar
		Tested By	Lim Kay Tak
		Test Date	20 Sep 2018

### Spurious Emissions ranging from 30MHz – 1GHz

Frequency (MHz)	Q-P Value (dBμV/m)	Q-P Limit (dBμV/m)	Q-P Margin (dB)	Height (cm)	Azimuth (Degrees)	Pol (H/V)	Channel
30.0000	25.9	40.0	14.1	400	271	V	High
88.7820	23.2	43.5	20.3	301	55	H	High
93.6810	30.0	43.5	13.5	100	185	V	High
98.5790	24.4	43.5	19.1	400	105	H	High
127.9700	21.6	43.5	21.9	100	67	V	High
176.9550	22.1	43.5	21.4	100	218	V	High

### Spurious Emissions above 1GHz - 25GHz

Freq (GHz)	Peak Value (dBμV/m)	Peak Limit (dBμV/m)	Peak Margin (dB)	AV Value (dBμV/m) Note 3	AV Limit (dBμV/m)	AV Margin (dB) Note 4	Height (cm)	Azimuth (Degrees)	Pol (H/V)	Ch
1.7413	34.4	74.0	39.6	--	54.0	19.6	399	245	V	Low
1.8423	34.2	74.0	39.8	--	54.0	19.8	399	154	V	Low
2.1191	39.3	74.0	34.7	--	54.0	14.7	300	156	V	Low
2.2059	35.8	74.0	38.2	--	54.0	18.2	101	178	H	Low
7.2059	45.2	74.0	28.8	--	54.0	8.8	200	320	V	Low
8.1028	48.7	74.0	25.3	--	54.0	5.3	101	29	V	Low

### Spurious Emissions above 1GHz - 25GHz

Freq (GHz)	Peak Value (dBμV/m)	Peak Limit (dBμV/m)	Peak Margin (dB)	AV Value (dBμV/m) Note 3	AV Limit (dBμV/m)	AV Margin (dB) Note 4	Height (cm)	Azimuth (Degrees)	Pol (H/V)	Ch
1.0384	31.8	74.0	42.2	--	54.0	22.2	300	330	V	Mid
1.7272	33.6	74.0	40.4	--	54.0	20.4	200	219	V	Mid
1.8504	34.0	74.0	40.0	--	54.0	20.0	300	123	V	Mid
2.1171	38.7	74.0	35.3	--	54.0	15.3	399	171	V	Mid
7.3211	45.5	74.0	28.5	--	54.0	8.5	300	305	V	Mid
--	--	--	--	--	--	--	--	--	--	--

#### Spurious Emissions above 1GHz - 25GHz

Freq (GHz)	Peak Value (dBμV/m)	Peak Limit (dBμV/m)	Peak Margin (dB)	AV Value (dBμV/m) <small>Note 3</small>	AV Limit (dBμV/m)	AV Margin (dB) <small>Note 4</small>	Height (cm)	Azimuth (Degrees)	Pol (H/V)	Ch
1.0384	31.4	74.0	42.6	--	54.0	22.6	300	190	V	High
1.0788	31.8	74.0	42.2	--	54.0	22.2	300	348	V	High
1.2848	33.3	74.0	40.7	--	54.0	20.7	200	261	V	High
1.7413	32.4	74.0	41.6	--	54.0	21.6	300	98	V	High
2.1231	36.5	74.0	37.5	--	54.0	17.5	399	348	H	High
7.4362	45.5	74.0	28.5	--	54.0	8.5	300	172	V	High

#### Notes

1.	All possible modes of operation were investigated. Only the worst case emissions measured, using the correct CISPR detectors, are reported. All other emissions were relatively insignificant.
2.	The transmitting antenna was found to be in the worst case condition when it was orientated in a vertical position.
3.	As the measured peak shows compliance to the average limit, as such no average measurement was required.
4.	The average margin indicates the margin of the measured peak value below the average limit.
5.	"--" indicates no emissions were found and shows compliance to the limits
6.	A "positive margin" indicates a PASS as it refers to the margin present below the limit line at the particular frequency. Conversely, a "negative margin" indicates a FAIL.
7.	EMI receiver Resolution Bandwidth (RBW) and Video Bandwidth (VBW) settings: <u>30MHz - 1GHz</u> RBW: 120kHz      VBW: 1MHz <u>&gt;1GHz</u> RBW: 1MHz      VBW: 3MHz
8.	The upper frequency of radiated emission investigations was according to requirements stated in Section 15.33 (a) for intentional radiators & Section 15.33 (b) for unintentional radiators.
9.	The channel in the table refers to the transmit channel of the EUT.



## **2.3 Spectrum Bandwidth (6db Bandwidth Measurement)**

### **2.3.1 Test Limits**

The EUT shows compliance to the requirements of this section, which states that the minimum bandwidth of the EUT employing digital modulation techniques shall be at least 500kHz.

### **2.3.2 Test Setup**

- 2.3.2.1 The EUT and supporting equipment were set up as shown in the set up photo.
- 2.3.2.2 The power supply for the EUT was connected to a filtered mains.
- 2.3.2.3 The RF antenna connector was connected to the spectrum analyser via a low-loss coaxial cable.
- 2.3.2.4 The resolution bandwidth (RBW) and the video bandwidth (VBW) of the spectrum analyser were respectively set to 100kHz and 3 times of RBW.
- 2.3.2.5 All other supporting equipment were powered separately from another filtered mains.

### **2.3.3 Test Method**

- 2.3.3.1 The EUT was switched on and allowed to warm up to its normal operating condition. The EUT was then configured to operate in the test mode at lower channel.
- 2.3.3.2 The center frequency of the spectrum analyser was set to the transmitting frequency with the frequency span wide enough to capture the 6dB bandwidth of the transmitting frequency.
- 2.3.3.3 The spectrum analyser was set to max hold to capture the transmitting frequency. The signal capturing was continuous until no further changes were observed.
- 2.3.3.4 The peak of the transmitting frequency was detected with the marker peak function of the spectrum analyser. The frequencies below the 6dB peak frequency at lower ( $f_L$ ) and upper ( $f_H$ ) sides of the transmitting frequency were marked and measured by using the marker-delta function of the spectrum analyser.
- 2.3.3.5 The 6dB bandwidth of the transmitting frequency is the frequency difference between the marked lower and upper frequencies,  $|f_H - f_L|$ .
- 2.3.3.6 The measurements were repeated if the EUT supports more than one modulation and data rate.
- 2.3.3.7 The measurements were repeated with the transmitting frequency was set to middle and upper channel respectively.

## 2.3.4 Test Results

Test Input Power	3.7Vdc Battery	Temperature	24°C
Attached Plots	1 – 3	Relative Humidity	60%
		Atmospheric Pressure	1030mbar
		Tested By	Chang Wai Kit
		Test Date	20 Sep 2018

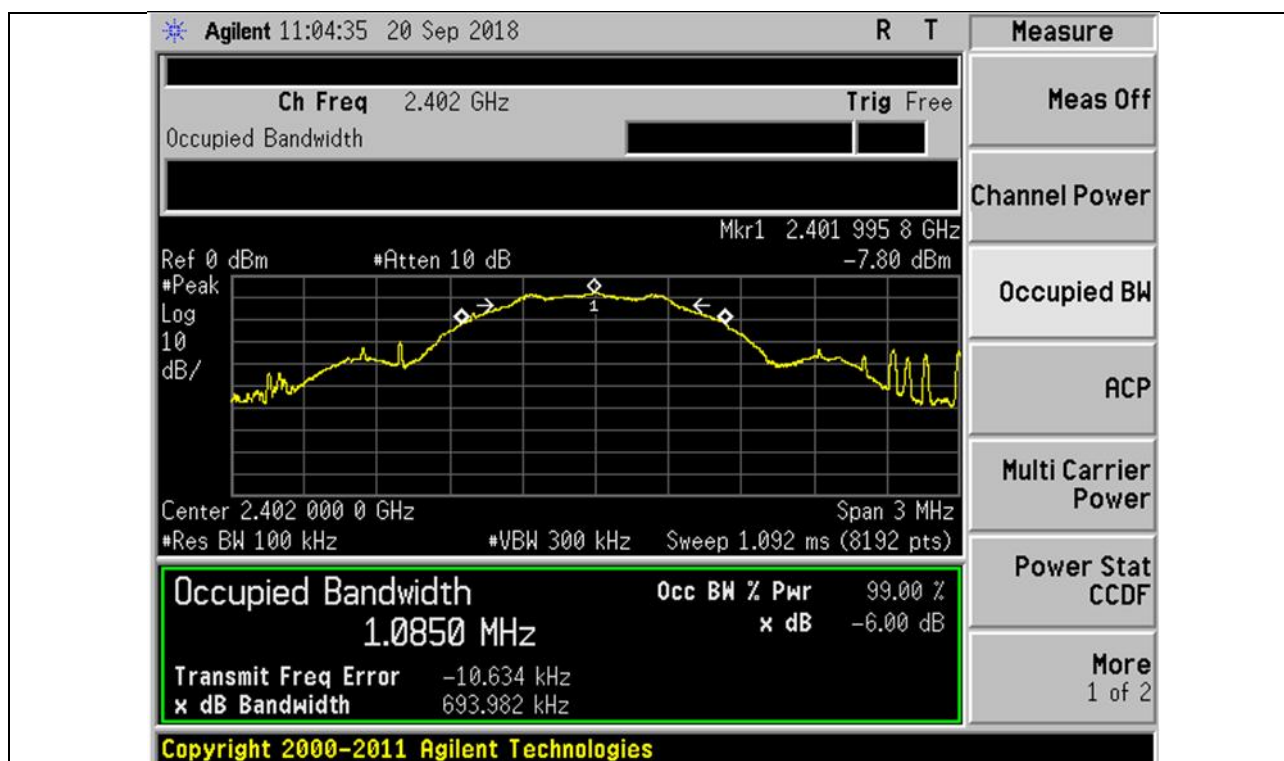
Channel	Channel Frequency (GHz)	6dB Bandwidth (MHz) *See Note 1	Limit (kHz)
Lower	2.402	1.0850	≥ 500
Middle	2.440	1.0698	≥ 500
Upper	2.480	1.0633	≥ 500

### Notes

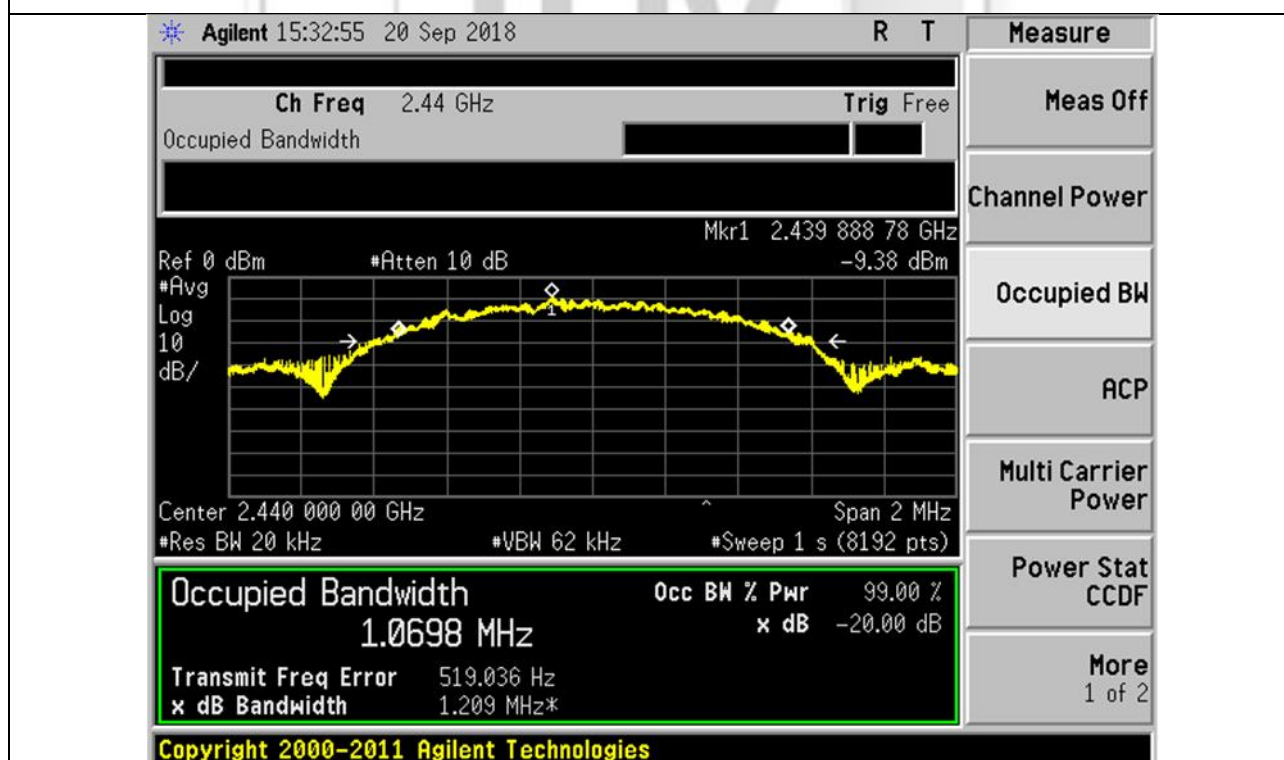
1.	Only the largest measured bandwidths were reported. Refer to plots for all measured bandwidth.
----	--



## Spectrum Bandwidth (6dB Bandwidth Measurement) Plots

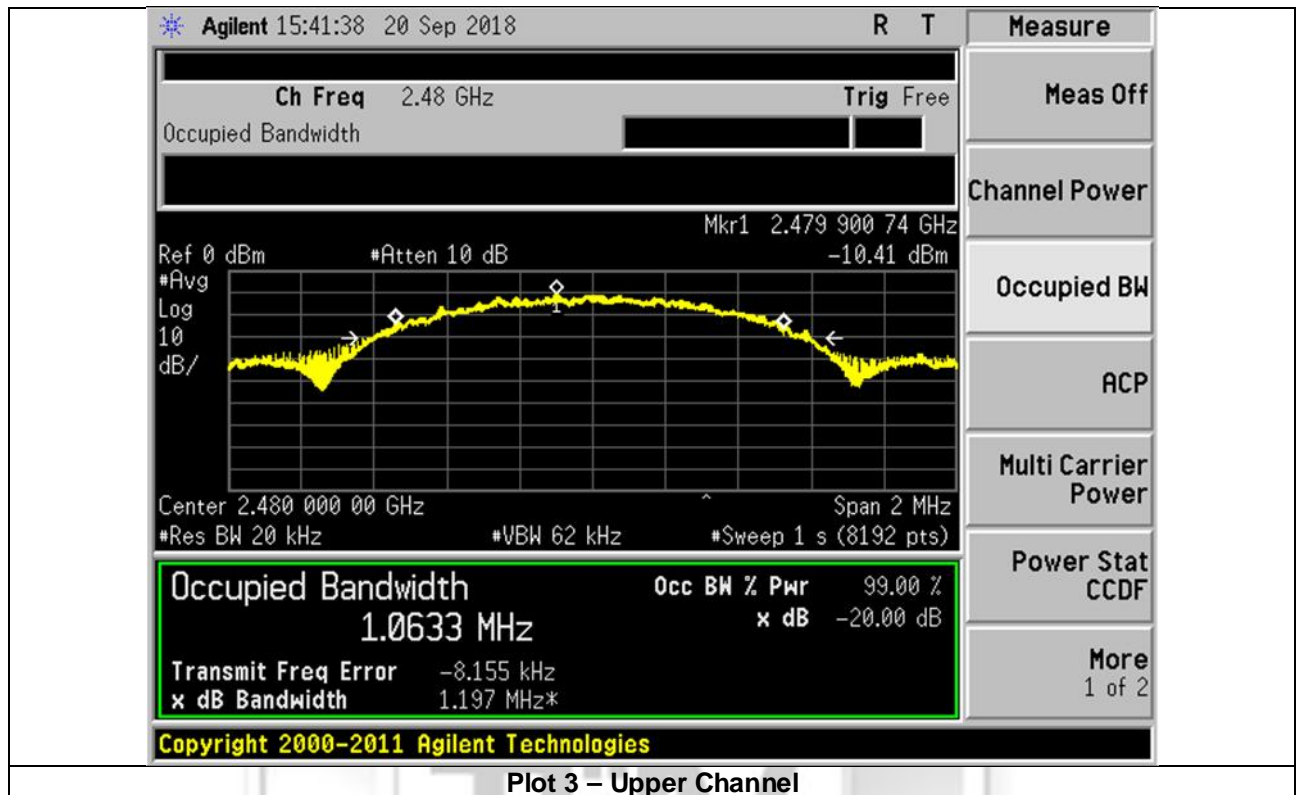


Plot 1 – Lower Channel



Plot 2 – Middle Channel

### Spectrum Bandwidth (6dB Bandwidth Measurement) Plots



Plot 3 – Upper Channel

## **2.4 Maximum Peak Power**

### **2.4.1 Test Limits**

The EUT shows compliance to the requirements of this section, which states the maximum peak power of the EUT employing digital modulation shall not exceed 1W (30dBm).

### **2.4.2 Test Setup**

- 2.4.2.1 The EUT and supporting equipment were set up as shown in the setup photo.
- 2.4.2.2 The power supply for the EUT was connected to a filtered mains.
- 2.4.2.3 The RF antenna connector was connected to a power meter.
- 2.4.2.4 All other supporting equipment were powered separately from another filtered mains.

### **2.4.3 Test Method**

- 2.4.3.1 The EUT was switched on and allowed to warm up to its normal operating condition. The EUT was then configured to operate in the test mode at lower channel.
- 2.4.3.2 The maximum peak power of the transmitting frequency was detected and recorded.
- 2.4.3.3 The measurements were repeated if the EUT supports more than one modulation and data rate.
- 2.4.3.4 The measurement was repeated with the transmitting frequency was set to middle channel and upper channel respectively.

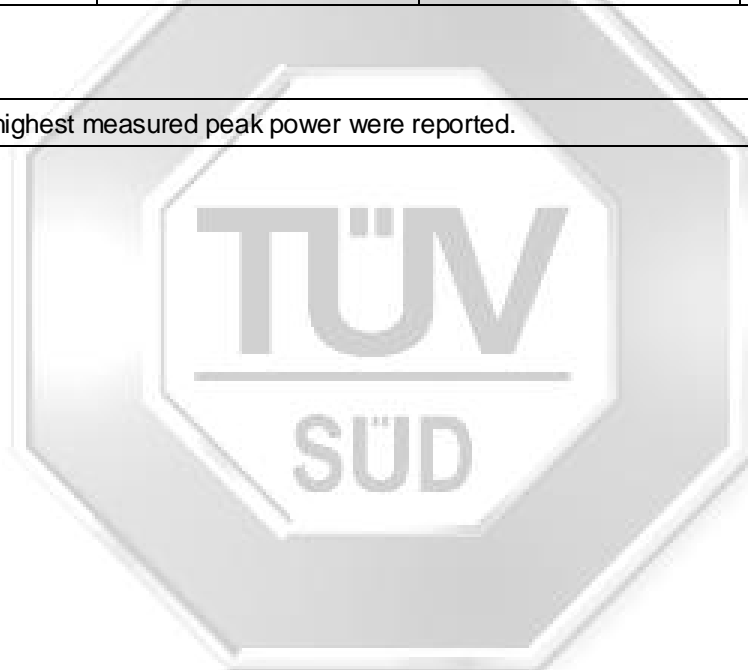
#### 2.4.4 Test Results

Test Input Power	3.7Vdc Battery	Temperature	24°C
Antenna Gain	0 dBi	Relative Humidity	60%
		Atmospheric Pressure	1030mbar
		Tested By	Chang Wai Kit
		Test Date	20 Sep 2018

Channel	Channel Frequency (GHz)	Maximum Peak Power (W) *See Note 1	Limit (W)
Lower	2.402	0.0001548	1.0
Middle	2.440	0.0001530	1.0
Upper	2.480	0.0001535	1.0

#### Notes

1.	Only the highest measured peak power were reported.
----	---



## **2.5 RF Conducted Spurious Emissions (Non-Restricted Bands)**

### **2.5.1 Test Limits**

The EUT shows compliance to the requirements of this section, which states in any 100kHz bandwidth outside the frequency band in which the spread spectrum intentional radiator (EUT) is operating, the radio frequency power that is produced by the EUT shall be at least 20dB below that in the 100kHz bandwidth within the band that contains the highest level of desired power.

### **2.5.2 Test Setup**

- 2.5.2.1 The EUT and supporting equipment were set up as shown in the setup photo.
- 2.5.2.2 The power supply for the EUT was connected to a filtered mains.
- 2.5.2.3 The RF antenna connector was connected to the spectrum analyser via a low-loss coaxial cable.
- 2.5.2.4 The resolution bandwidth (RBW) and the video bandwidth (VBW) of the spectrum analyser were respectively set to 100kHz and 3 times of RBW.
- 2.5.2.5 All other supporting equipment were powered separately from another filtered mains.

### **2.5.3 Test Method**

- 2.5.3.1 The EUT was switched on and allowed to warm up to its normal operating condition. The EUT was then configured to operate in the test mode, with transmitting frequency at lower channel.
- 2.5.3.2 The start and stop frequencies of the spectrum analyser were set to 30MHz and 10GHz.
- 2.5.3.3 The spectrum analyser was set to max hold to capture any spurious emissions within the span. The signal capturing was continuous until no further spurious emissions were detected.
- 2.5.3.4 The measurements were repeated with frequency span was set from 10GHz to 25GHz.
- 2.5.3.5 The measurements were repeated if the EUT supports more than one modulation and data rate.
- 2.5.3.6 The measurements were repeated with the transmitting frequency was set to middle channel and upper channel respectively.

#### 2.5.4 Test Results

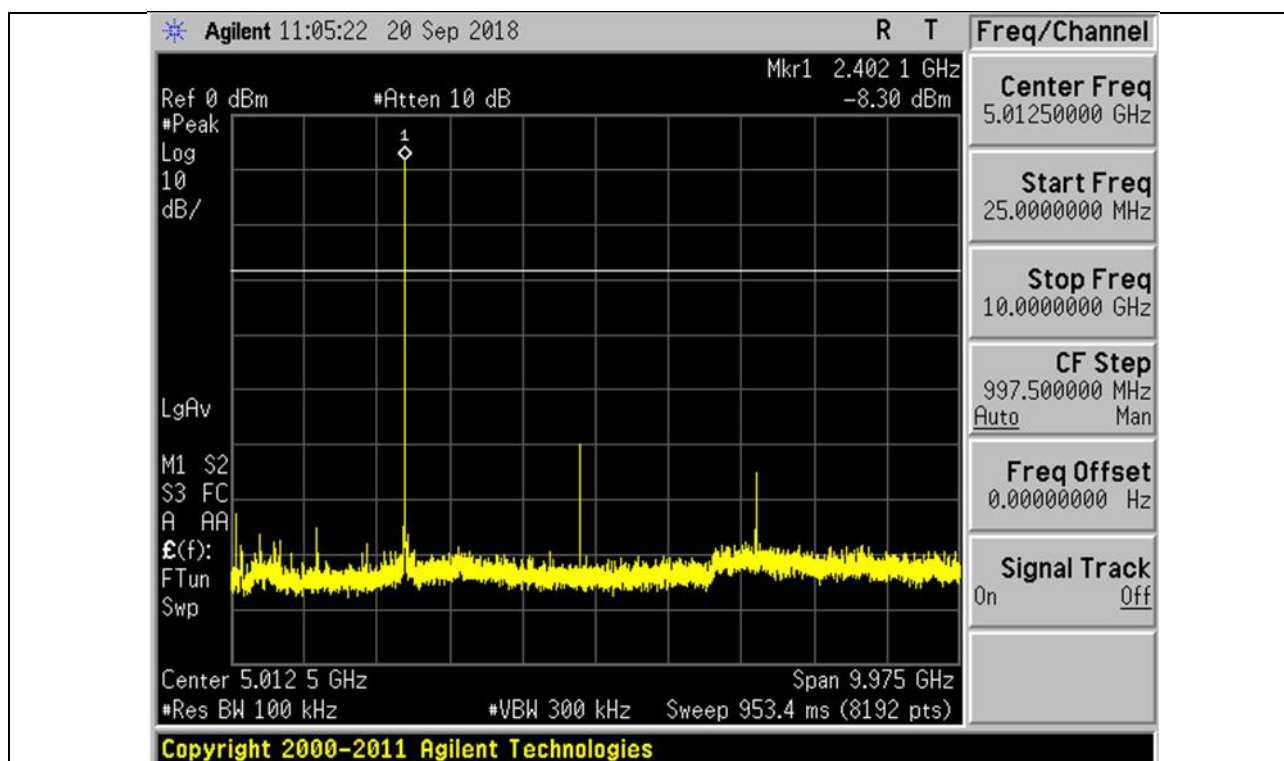
Test Input Power	3.7Vdc Battery	Temperature	24°C
Attached Plots	4 – 9	Relative Humidity	60%
		Atmospheric Pressure	1030mbar
		Tested By	Chang Wai Kit
		Test Date	20 Sep 2018

All spurious signals found were below the specified limit. Please refer to the attached plots.

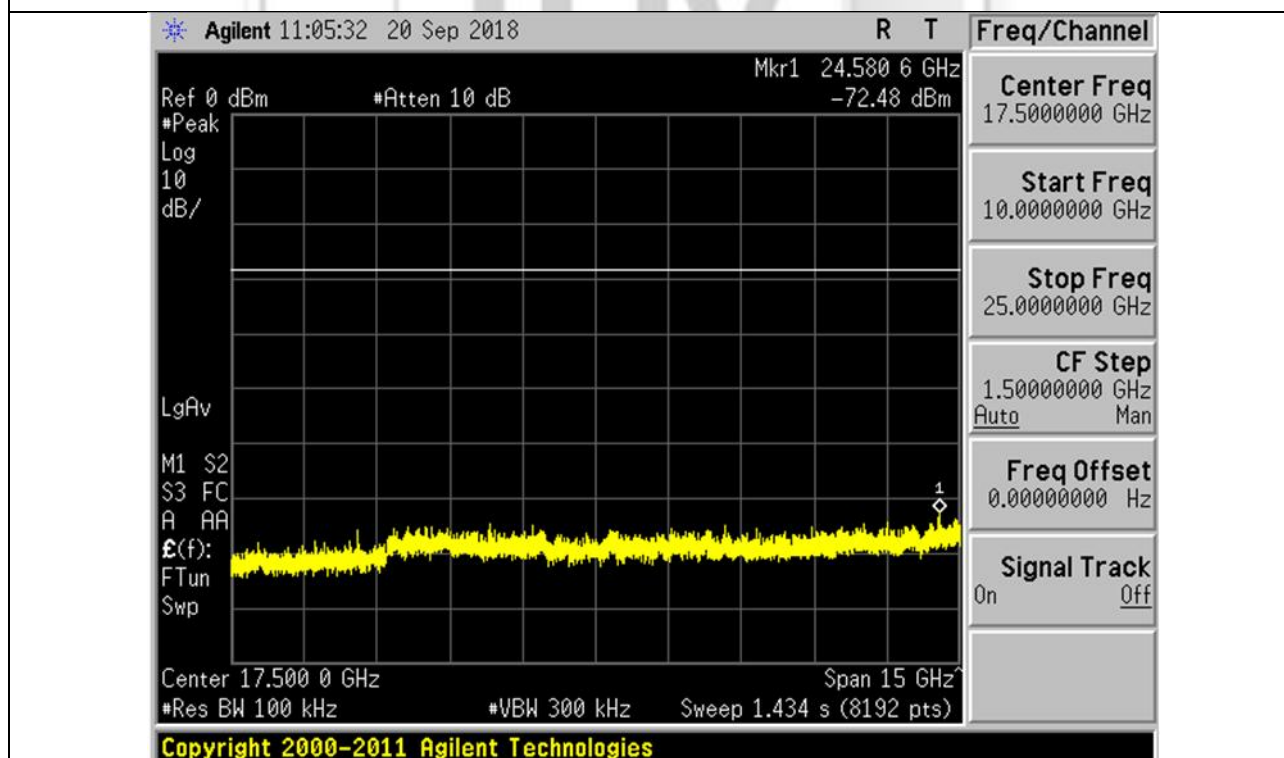




## RF Conducted Spurious Emissions (Non-Restricted Bands) Plots

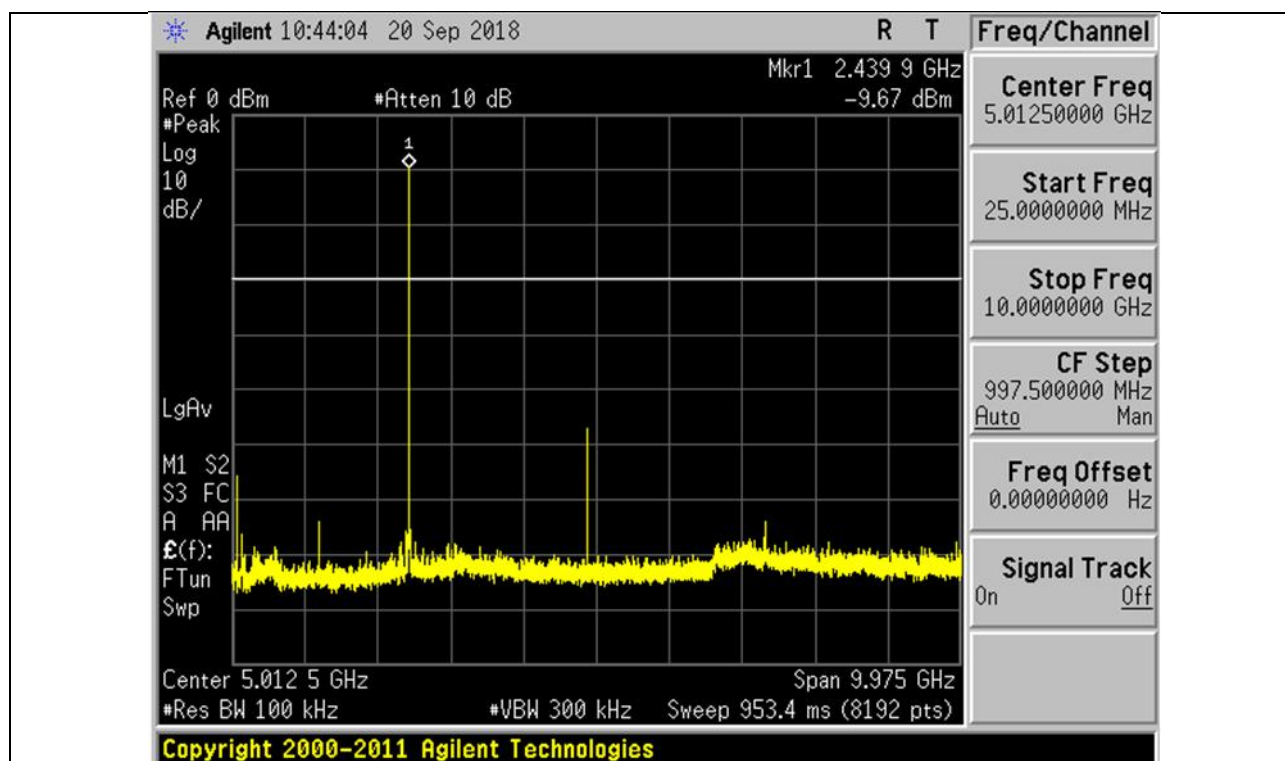


Plot 4 – Lower Channel

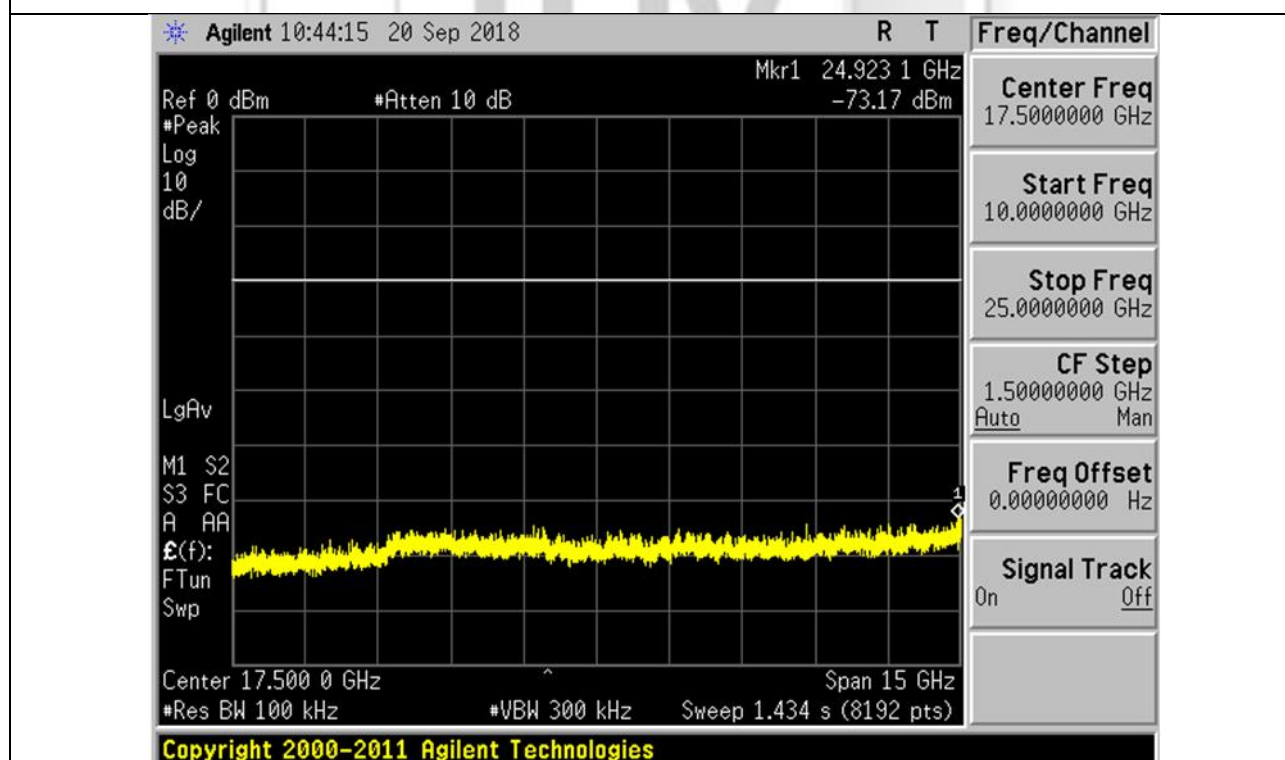


Plot 5 – Lower Channel

## RF Conducted Spurious Emissions (Non-Restricted Bands) Plots

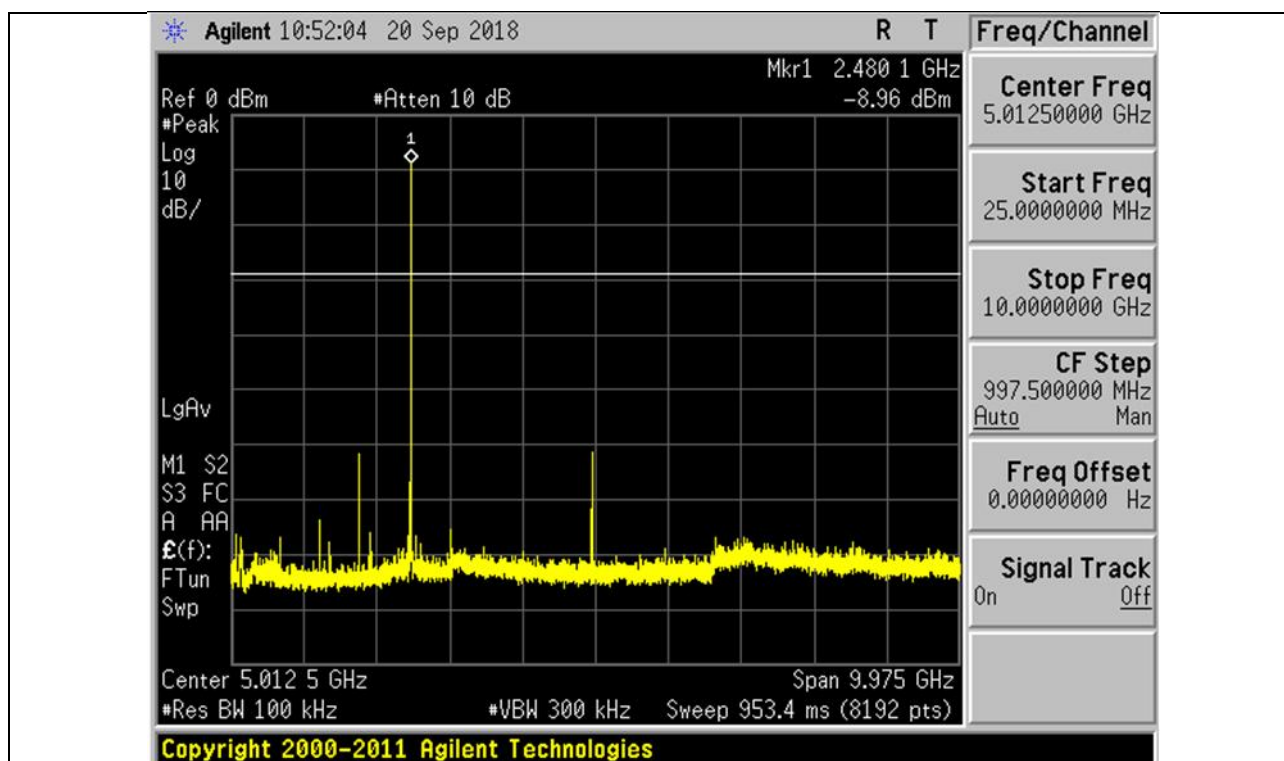


Plot 6 – Middle Channel

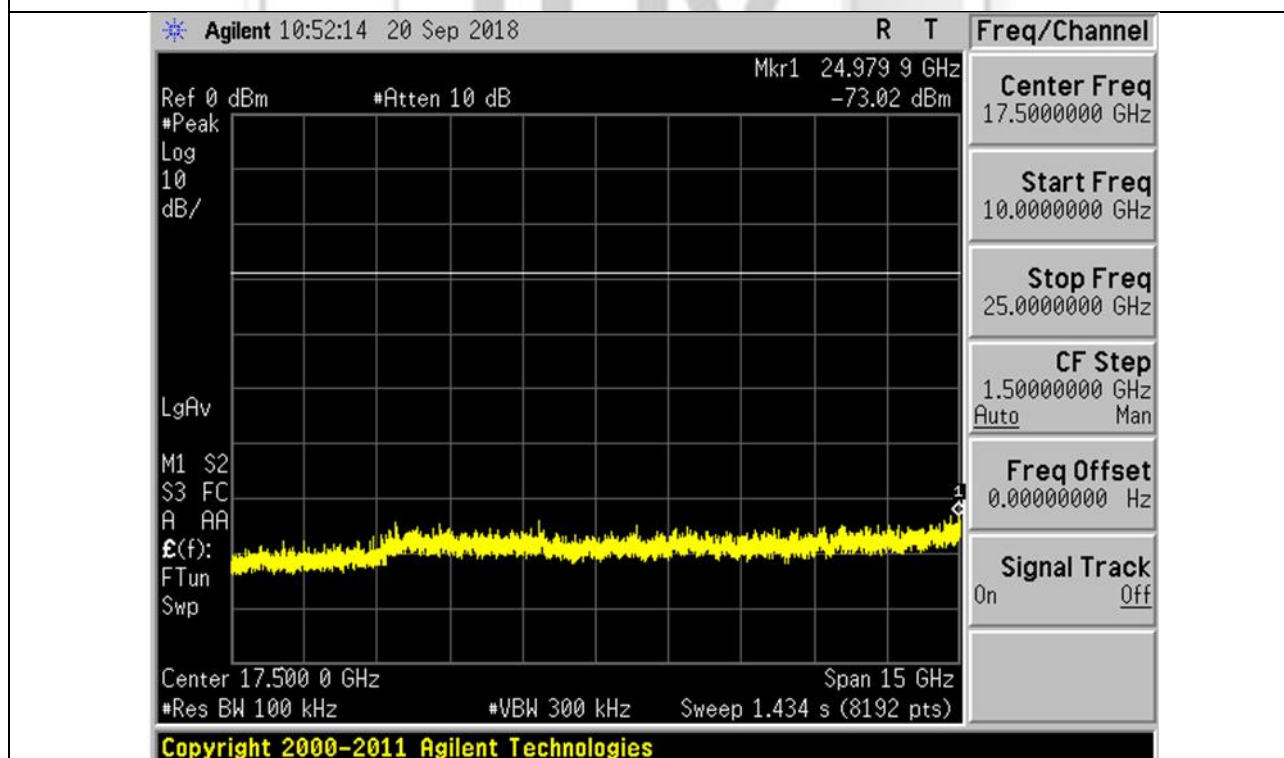


Plot 7 – Middle Channel

## RF Conducted Spurious Emissions (Non-Restricted Bands) Plots



Plot 8 – Upper Channel



Plot 9 – Upper Channel

## 2.6 RF Conducted Spurious Emissions (Restricted Bands)

### 2.6.1 Test Limits

The EUT shows compliance to the requirements of this section, which states that emissions which fall in the restricted bands must comply with the radiated emission limits specified in the table below:

Frequency Range (MHz)	EIRP (dBm)	Radiated Emissions (dBμV/m)
0.009 – 0.490	-6.7 – (-41.4) **	67.6 – 20logF* @ 300m **
0.490 – 1.705	-41.4 – (-52.3) **	87.6 – 20logF* @ 30m **
1.705 – 30	-45.7	29.5 @ 30m
30 - 88	-55.2	40.0 @ 3m
88 - 216	-51.7	43.5 @ 3m
216 - 960	-49.2	46.0 @ 3m
>960	-41.2 ***	54.0 @ 3m ***
* F is frequency in kHz.		
** Decreasing linearly with the logarithm of the frequency.		
*** Above 1GHz, a peak limit of 20dB above the average limit does apply.		

### 47 CFR FCC Part 15.205 Restricted Bands

MHz	MHz	MHz	GHz
0.090 - 0.110	16.42 - 16.423	399.9 - 410	4.5 - 5.15
0.495 - 0.505	16.69475 - 16.69525	608 - 614	5.35 - 5.46
2.1735 - 2.1905	16.80425 - 16.80475	960 - 1240	7.25 - 7.75
4.125 - 4.128	25.5 - 25.67	1300 - 1427	8.025 - 8.5
4.17725 - 4.17775	37.5 - 38.25	1435 - 1626.5	9.0 - 9.2
4.20725 - 4.20775	73 - 74.6	1645.5 - 1646.5	9.3 - 9.5
6.215 - 6.218	74.8 - 75.2	1660 - 1710	10.6 - 12.7
6.26775 - 6.26825	108 - 121.94	1718.8 - 1722.2	13.25 - 13.4
6.31175 - 6.31225	123 - 138	2200 - 2300	14.47 - 14.5
8.291 - 8.294	149.9 - 150.05	2310 - 2390	15.35 - 16.2
8.362 - 8.366	156.52475 - 156.52525	2483.5 - 2500	17.7 - 21.4
8.37625 - 8.38675	156.7 - 156.9	2690 - 2900	22.01 - 23.12
8.41425 - 8.41475	162.0125 - 167.17	3260 - 3267	23.6 - 24.0
12.29 - 12.293	167.72 - 173.2	3332 - 3339	31.2 - 31.8
12.51975 - 12.52025	240 - 285	3345.8 - 3358	36.43 - 36.5
12.57675 - 12.57725	322 - 335.4	3600 - 4400	Above 38.6
13.36 - 13.41			

## 2.6.2 Test Setup

- 2.6.2.1 The EUT and supporting equipment were set up as shown in the setup photo.
- 2.6.2.2 The power supply for the EUT was connected to a filtered mains.
- 2.6.2.3 The RF antenna connector was connected to the spectrum analyser via a low-loss coaxial cable.
- 2.6.2.4 The resolution bandwidth (RBW) of the spectrum analyser was set to the following settings. The video bandwidth (VBW) was set to at least three times of the RBW.

Frequency (MHz)	RBW (kHz)
0.009 – 0.150	0.2
0.150 – 30.0	9.0
30.0 - 1000	100.0
> 1000	1000.0

- 2.6.2.5 The detector of the spectrum analyser was set to peak detection mode.
- 2.6.2.6 All other supporting equipment were powered separately from another filtered mains.

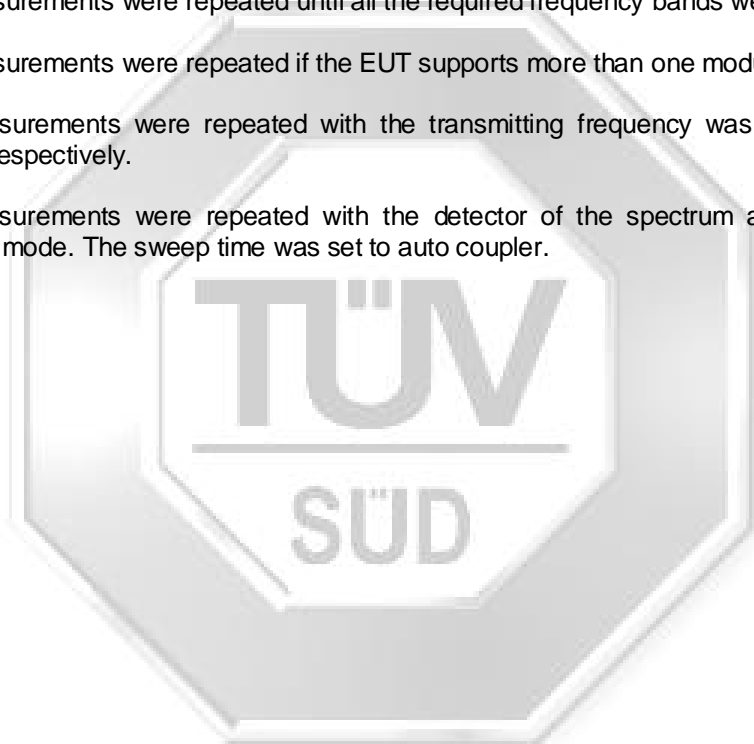
## 2.6.3 Test Method

### Measurement in the range 9kHz – 1000MHz

- 2.6.3.1 The EUT was switched on and allowed to warm up to its normal operating condition. The EUT was then configured to operate in the test mode, with the transmitting frequency was set to lower channel.
- 2.6.3.2 The start and stop frequencies of the spectrum analyser were set according to the supported RBW.
- 2.6.3.3 The spectrum analyser was set to max hold to capture any spurious emissions within the span. The signal capturing was continuous until no further spurious emissions were detected. The antenna gain of the EUT was added to the captured spurious emissions.
- 2.6.3.4 No further measurement was required if all the captured emissions complied to the limits. Else, the spectrum analyser was set to zoom to the captured emission with the detector of the spectrum analyser was set to quasi-peak. The emission level of the captured frequency was measured.
- 2.6.3.5 The measurements were repeated until all the captured emissions which exceeding the limits were measured.
- 2.6.3.6 The measurements were repeated if the EUT supports more than one modulation and data rate.
- 2.6.3.7 The measurements were repeated with the transmitting frequency was set to middle and upper channel respectively

#### Measurement above 1000MHz

- 2.6.3.8 The EUT was switched on and allowed to warm up to its normal operating condition. The EUT was then configured to operate in the test mode, with the transmitting frequency was set to lower channel.
- 2.6.3.9 The start and stop frequencies of the spectrum analyser were set according to the supported frequency band of the set RBW with the number of points in a sweep was set to equal or greater than 2 times of the ratio of span over RBW.
- 2.6.3.10 The detector of the spectrum analyser was set to power average (RMS) mode with the sweep time was set to equal or greater than 10 times of the product of number of measurement points in a sweep and transmission symbol time.
- 2.6.3.11 The spectrum analyser was then allowed to capture any spurious emissions within a single sweep. The peak marker function of the spectrum analyser was used to locate the highest power level. The antenna gain of the EUT was added to the captured spurious emissions.
- 2.6.3.12 The measurements were repeated until all the required frequency bands were measured.
- 2.6.3.13 The measurements were repeated if the EUT supports more than one modulation and data rate.
- 2.6.3.14 The measurements were repeated with the transmitting frequency was set to middle and upper channel respectively.
- 2.6.3.15 The measurements were repeated with the detector of the spectrum analyser was set to peak detecting mode. The sweep time was set to auto coupler.



#### 2.6.4 Test Results

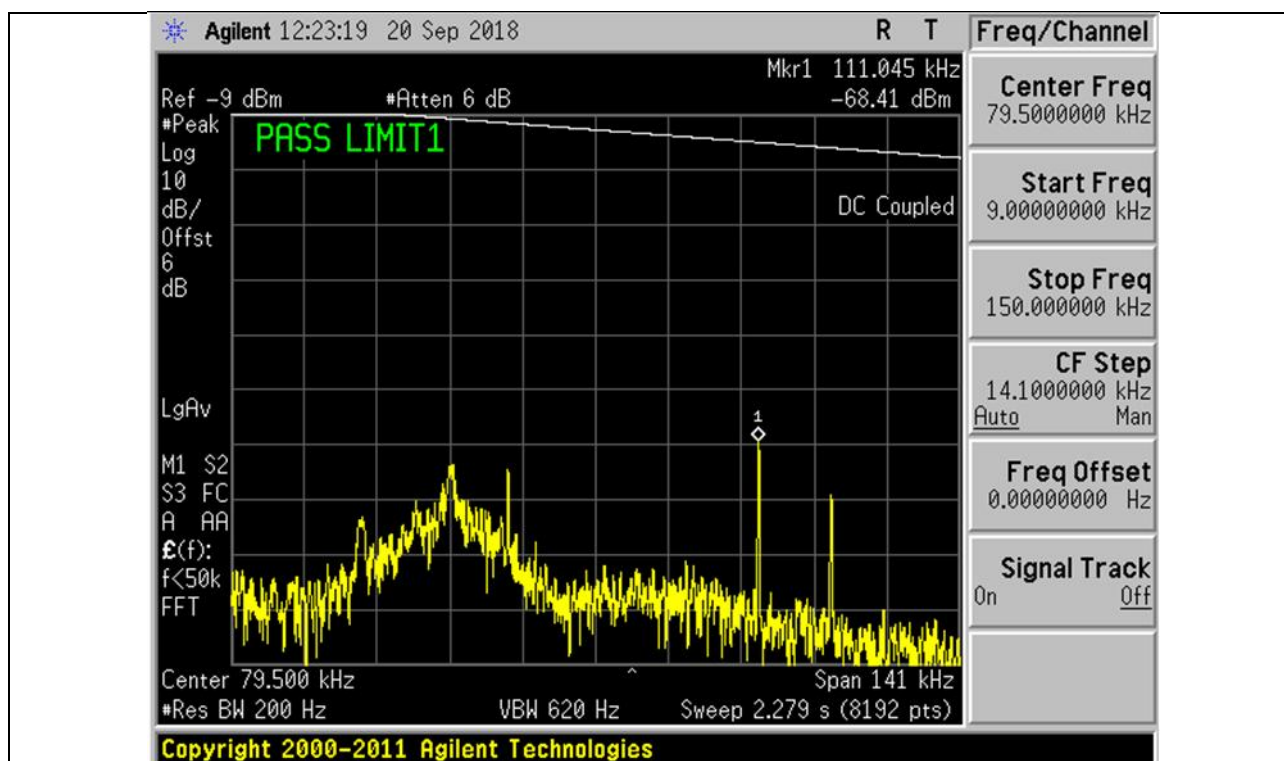
Test Input Power	3.7Vdc Battery	Temperature	24°C
Attached Plots	10 – 27 (Peak)	Relative Humidity	60%
		Atmospheric Pressure	1030mbar
		Tested By	Chang Wai Kit
		Test Date	20 Sep 2018

All spurious signals found were below the specified limit. Please refer to the attached plots.

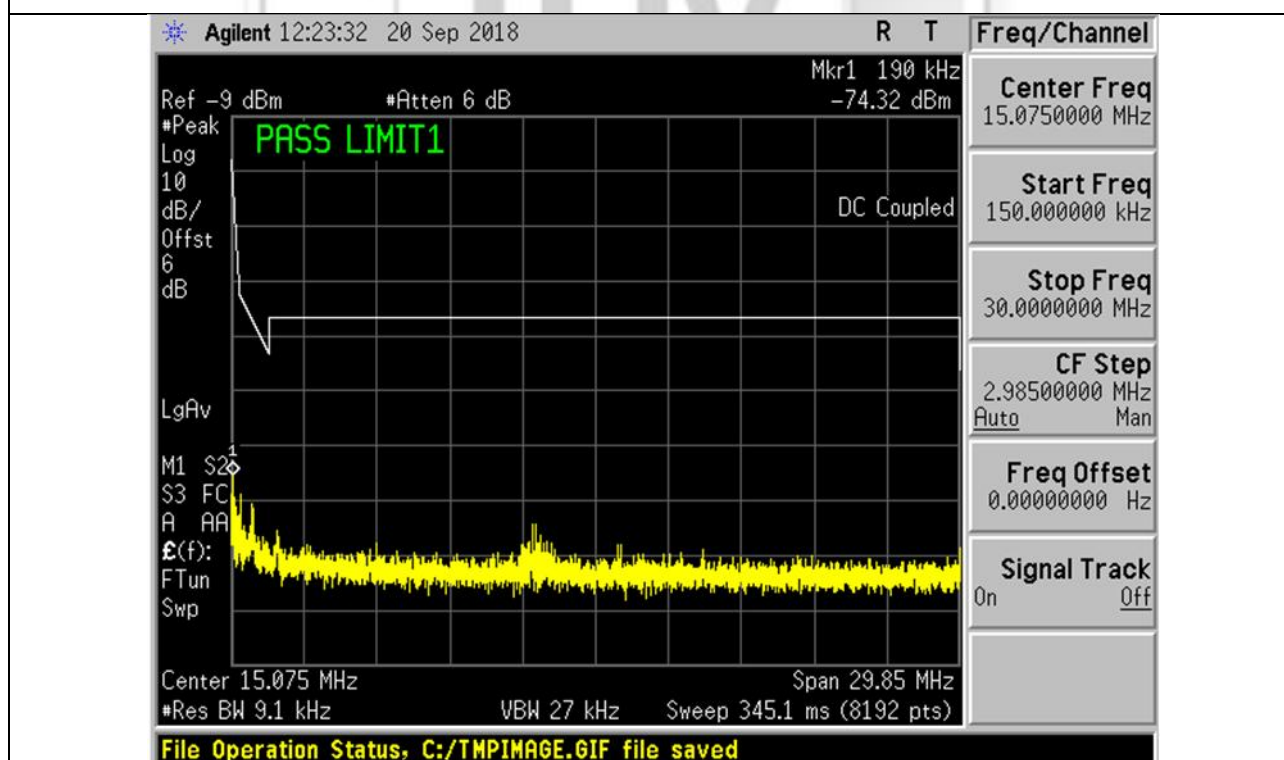




## RF Conducted Spurious Emissions (Restricted Bands) Plots – Peak



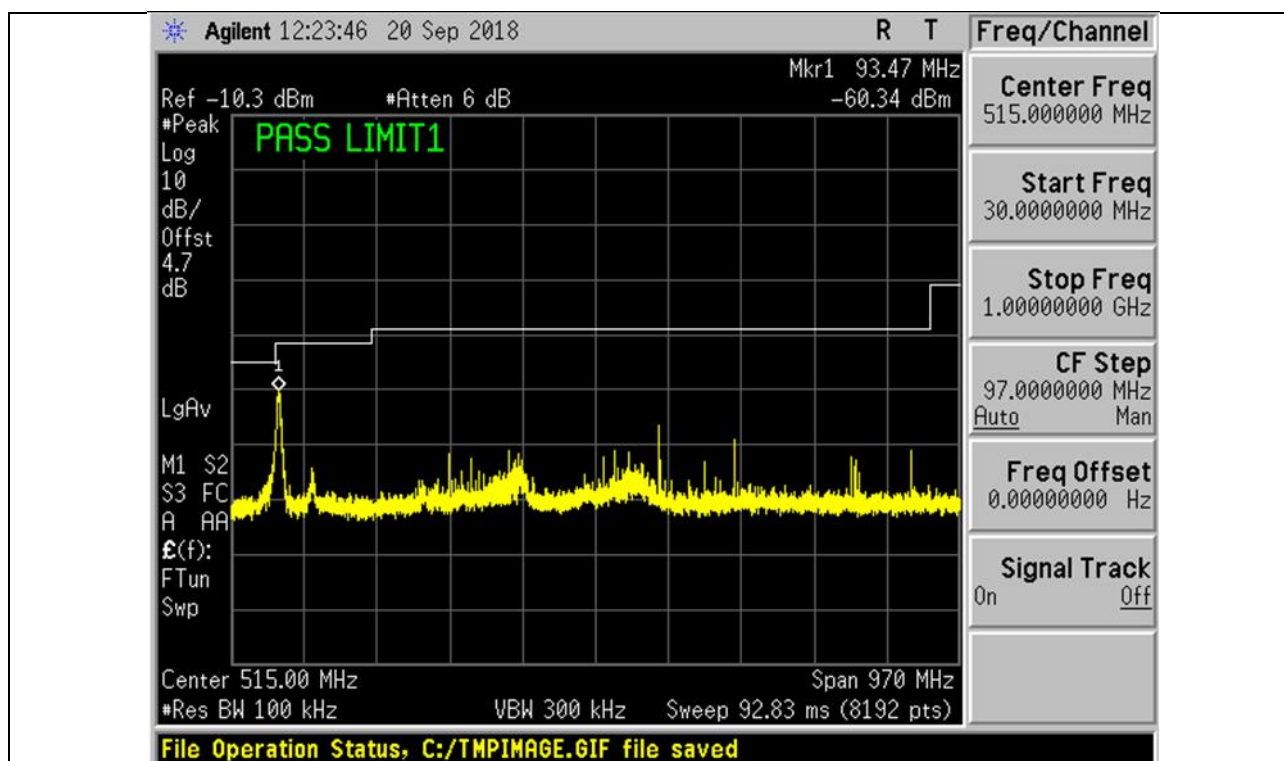
Plot 10 – Lower Channel



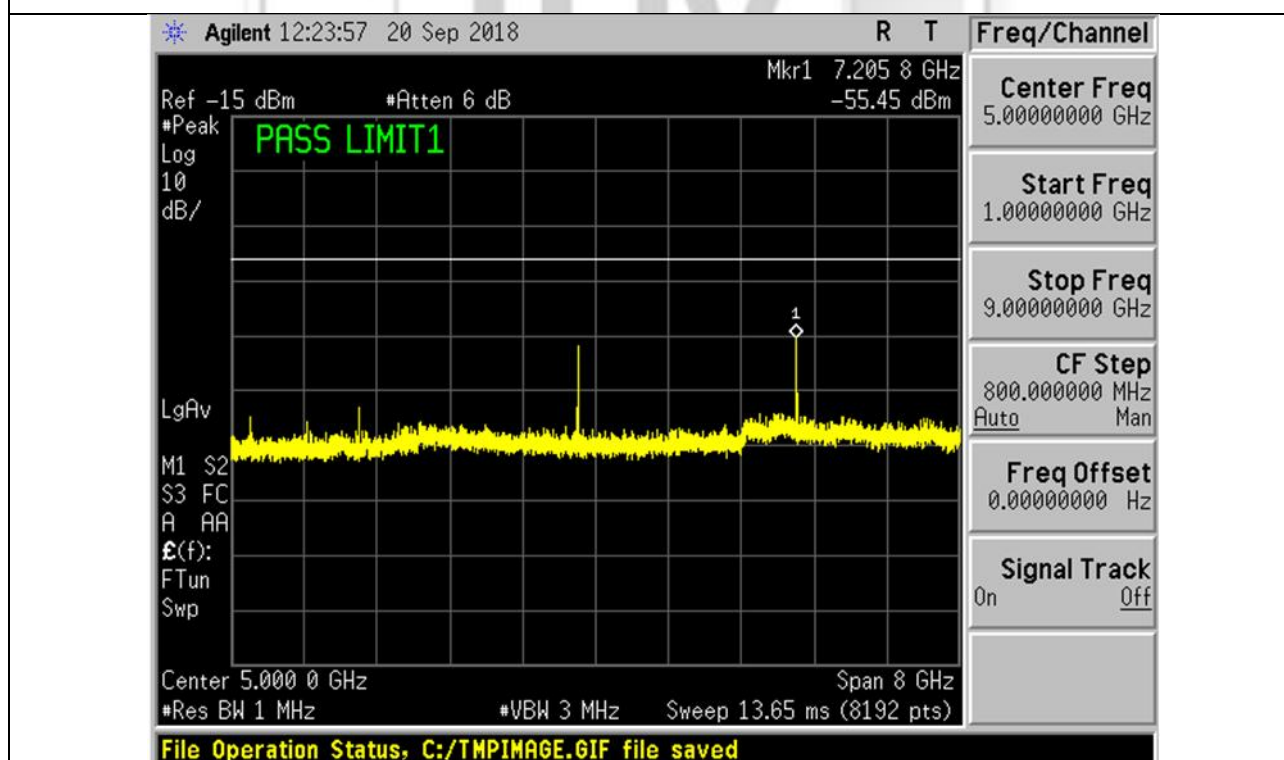
Plot 11 – Lower Channel



## RF Conducted Spurious Emissions (Restricted Bands) Plots – Peak

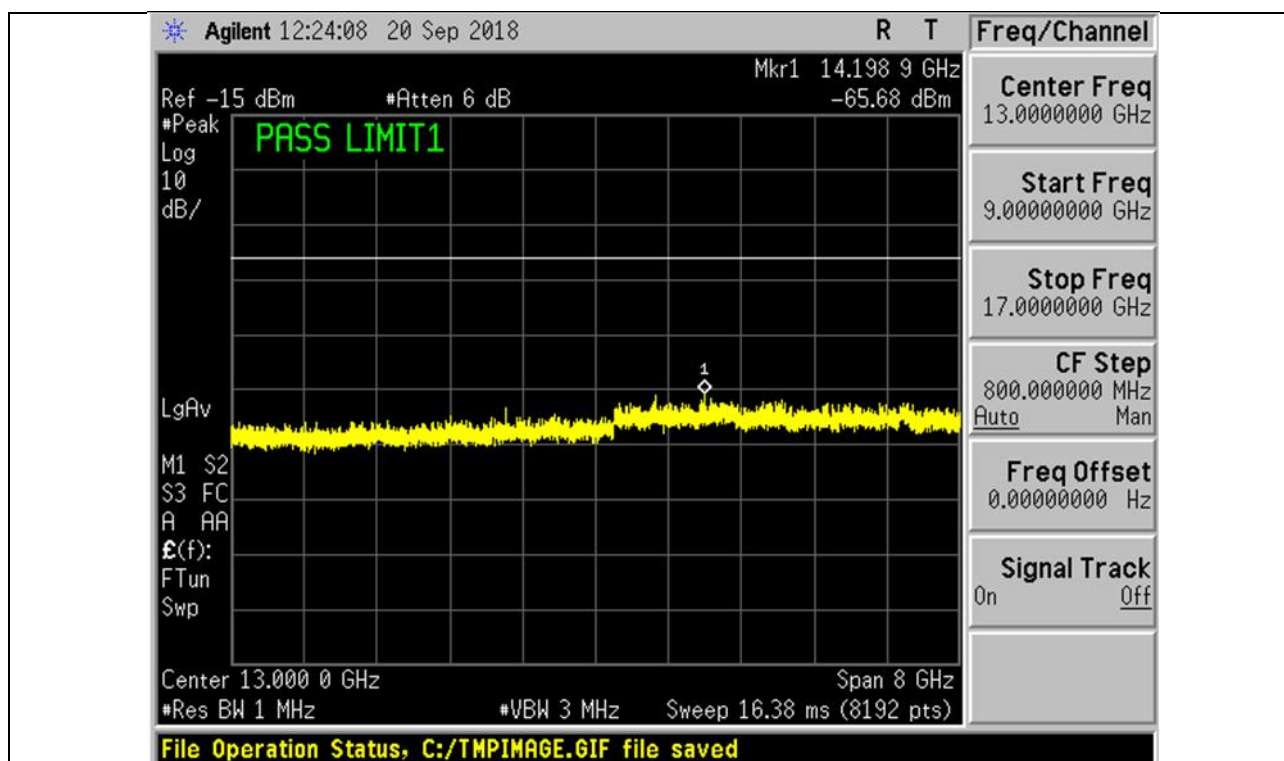


Plot 12 – Lower Channel

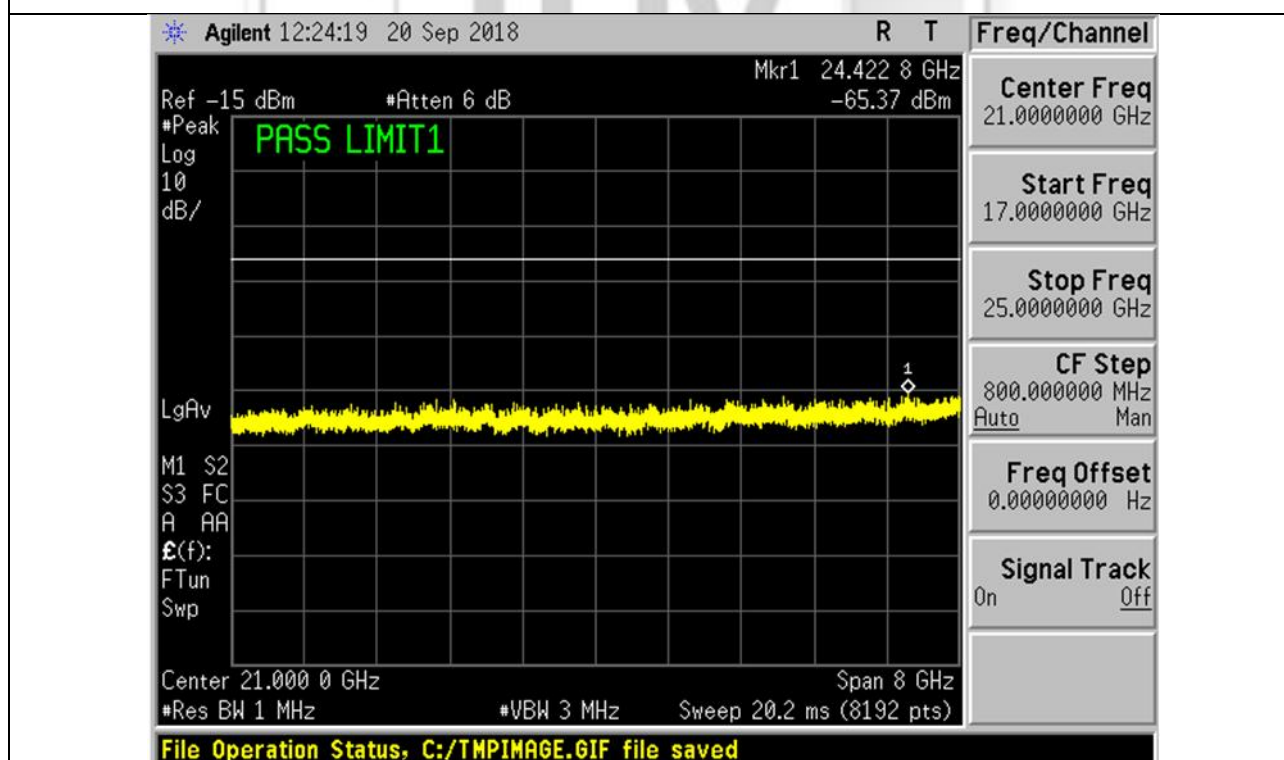


Plot 13 – Lower Channel

## RF Conducted Spurious Emissions (Restricted Bands) Plots – Peak

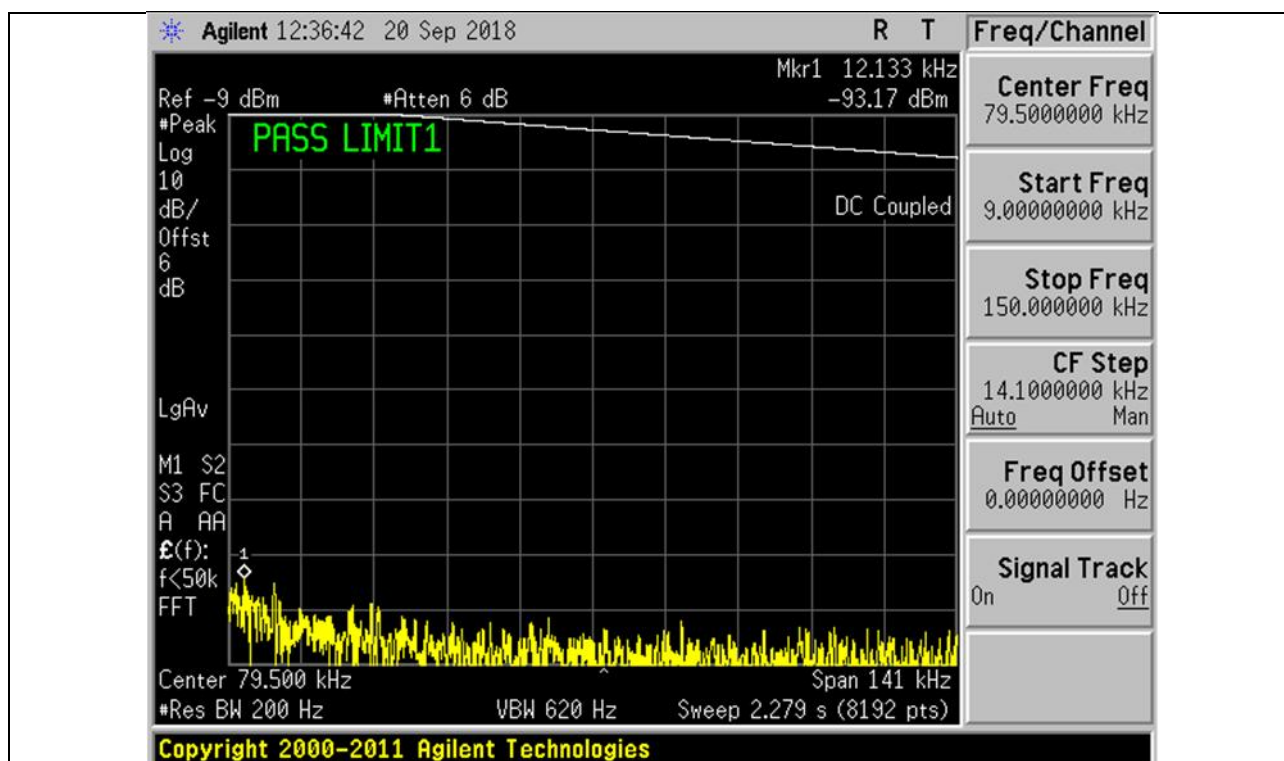


Plot 14 – Lower Channel

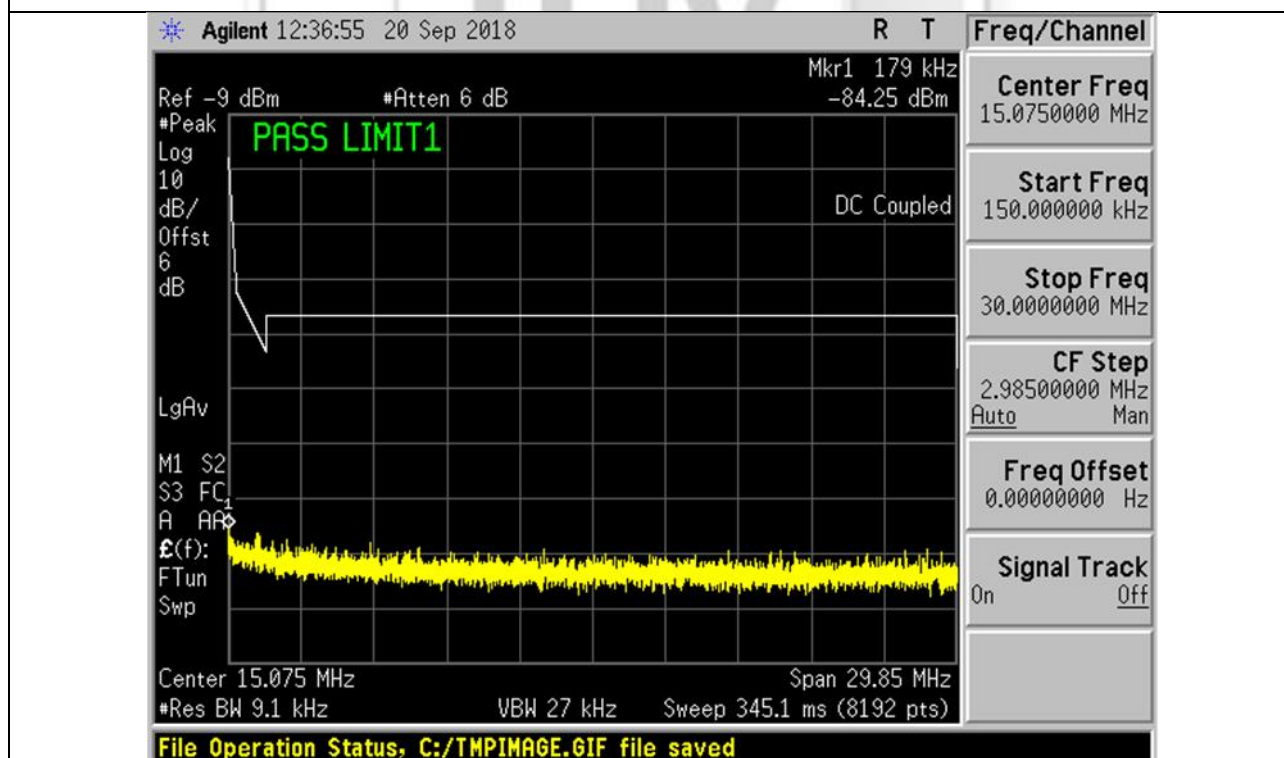


Plot 15 – Lower Channel

## RF Conducted Spurious Emissions (Restricted Bands) Plots – Peak

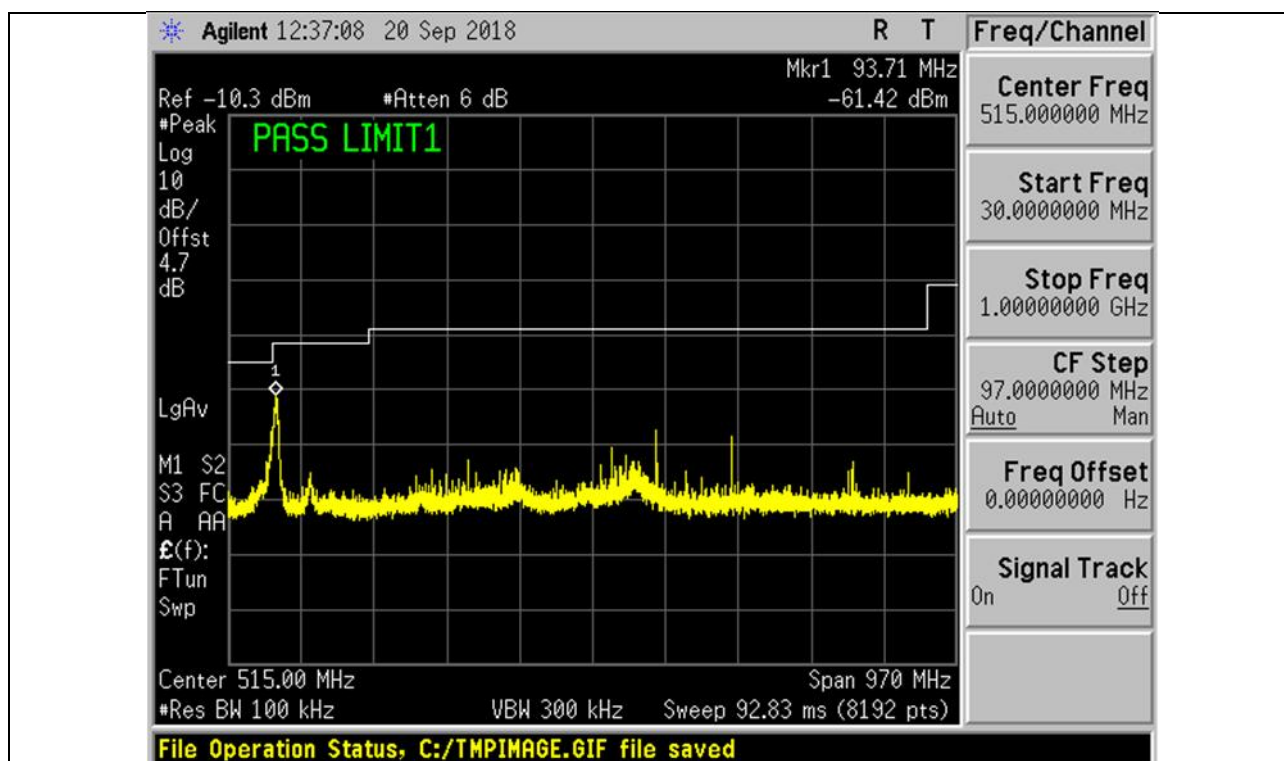


Plot 16 – Middle Channel

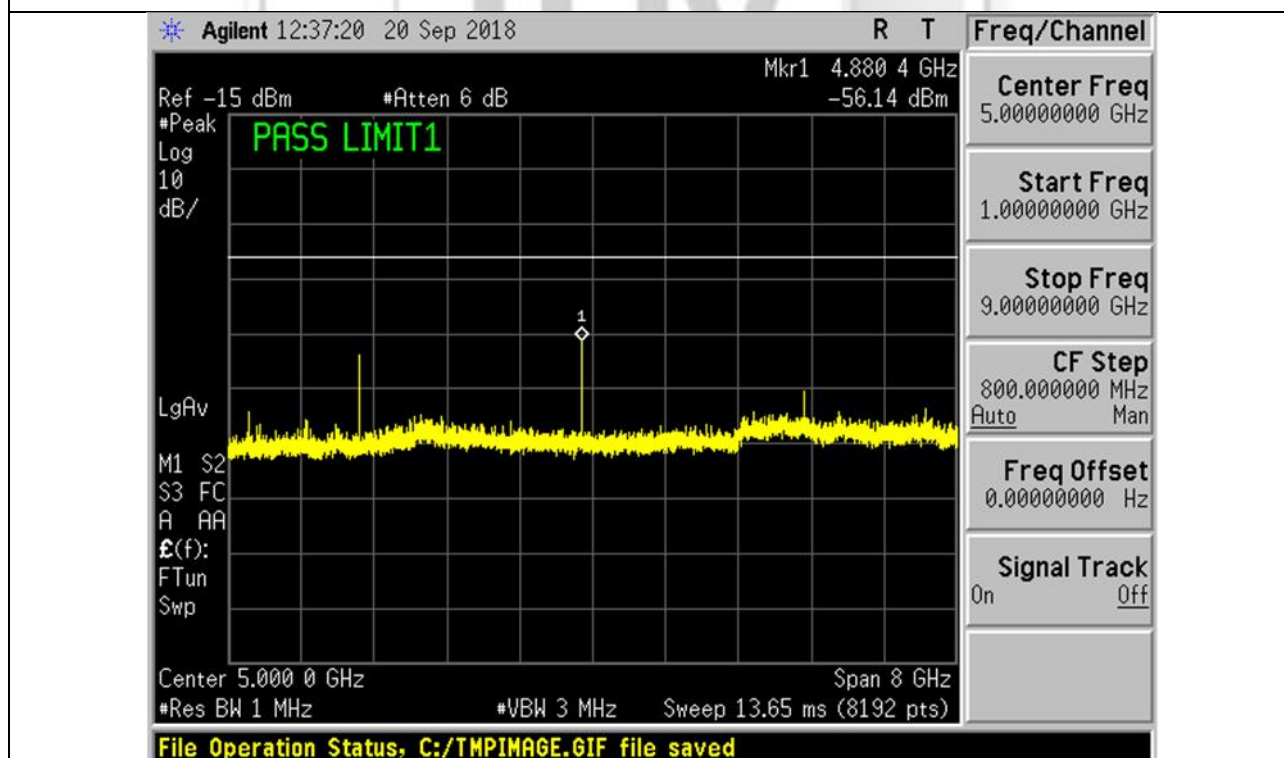


Plot 17 – Middle Channel

## RF Conducted Spurious Emissions (Restricted Bands) Plots – Peak



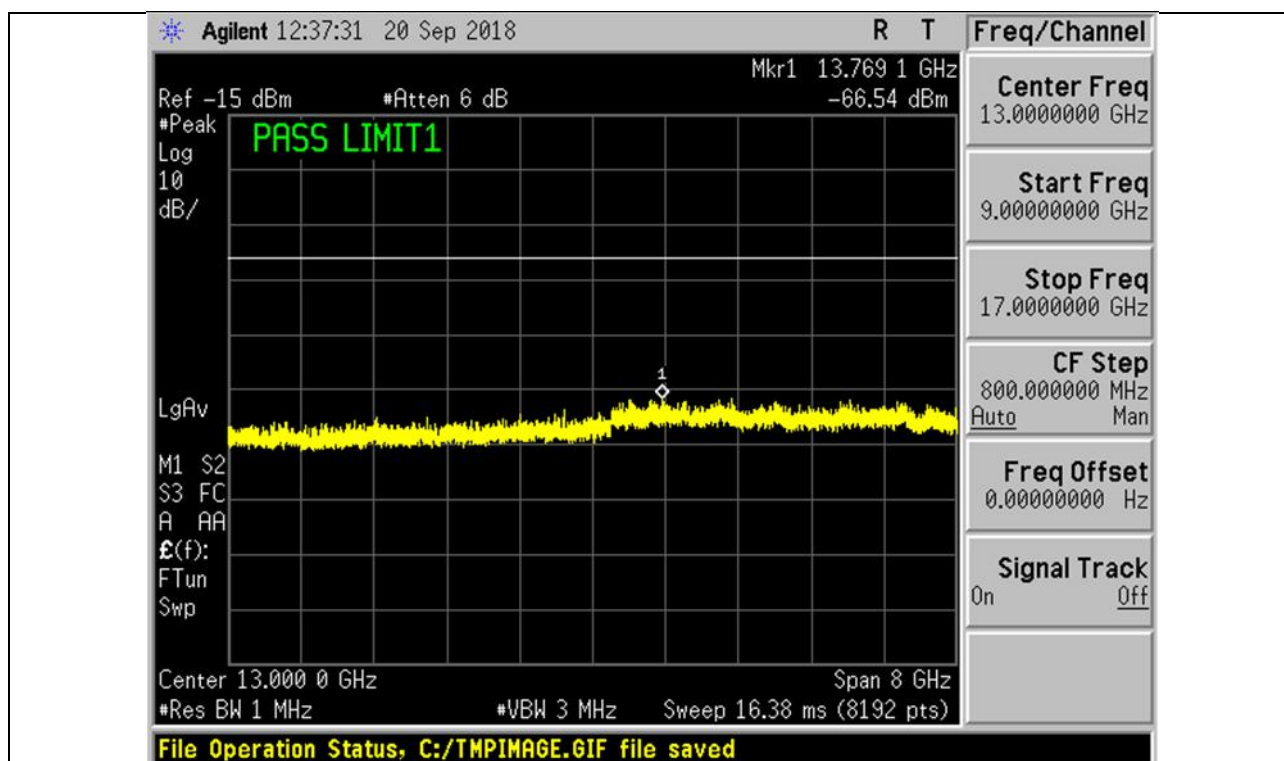
Plot 18 – Middle Channel



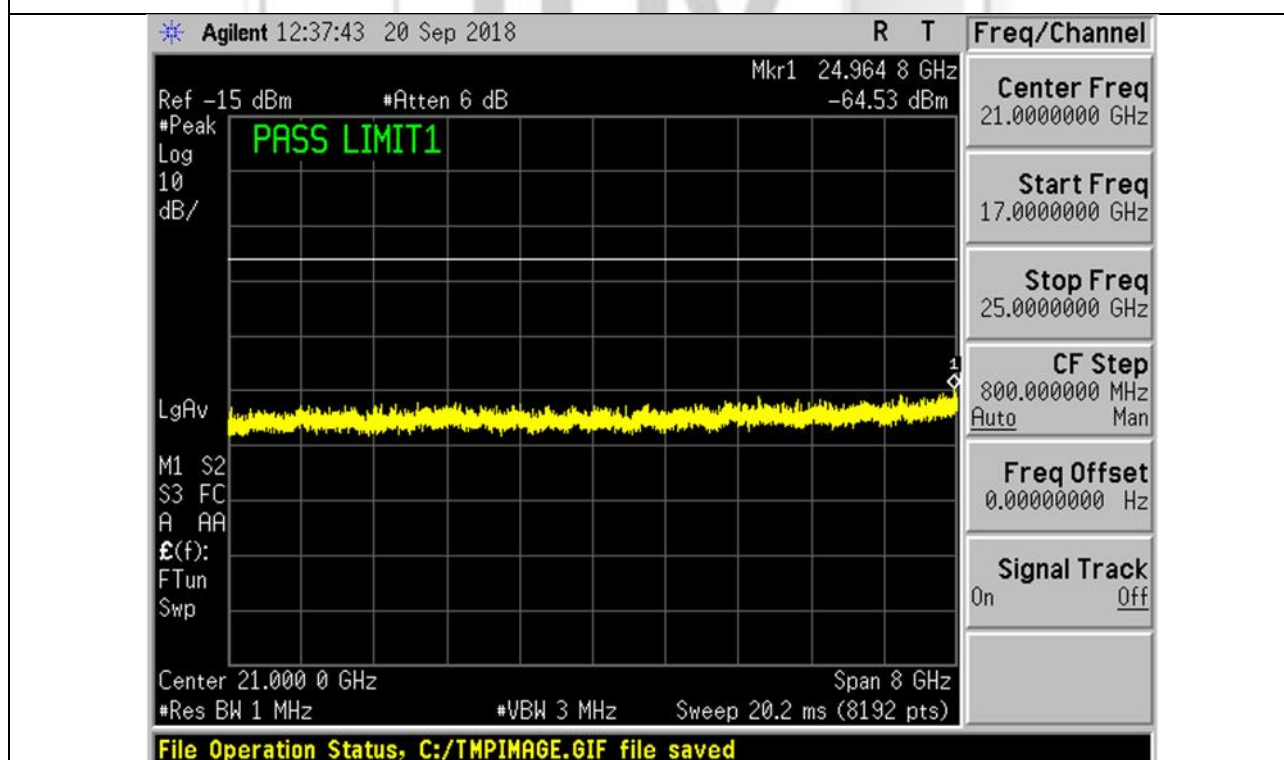
Plot 19 – Middle Channel



## RF Conducted Spurious Emissions (Restricted Bands) Plots – Peak

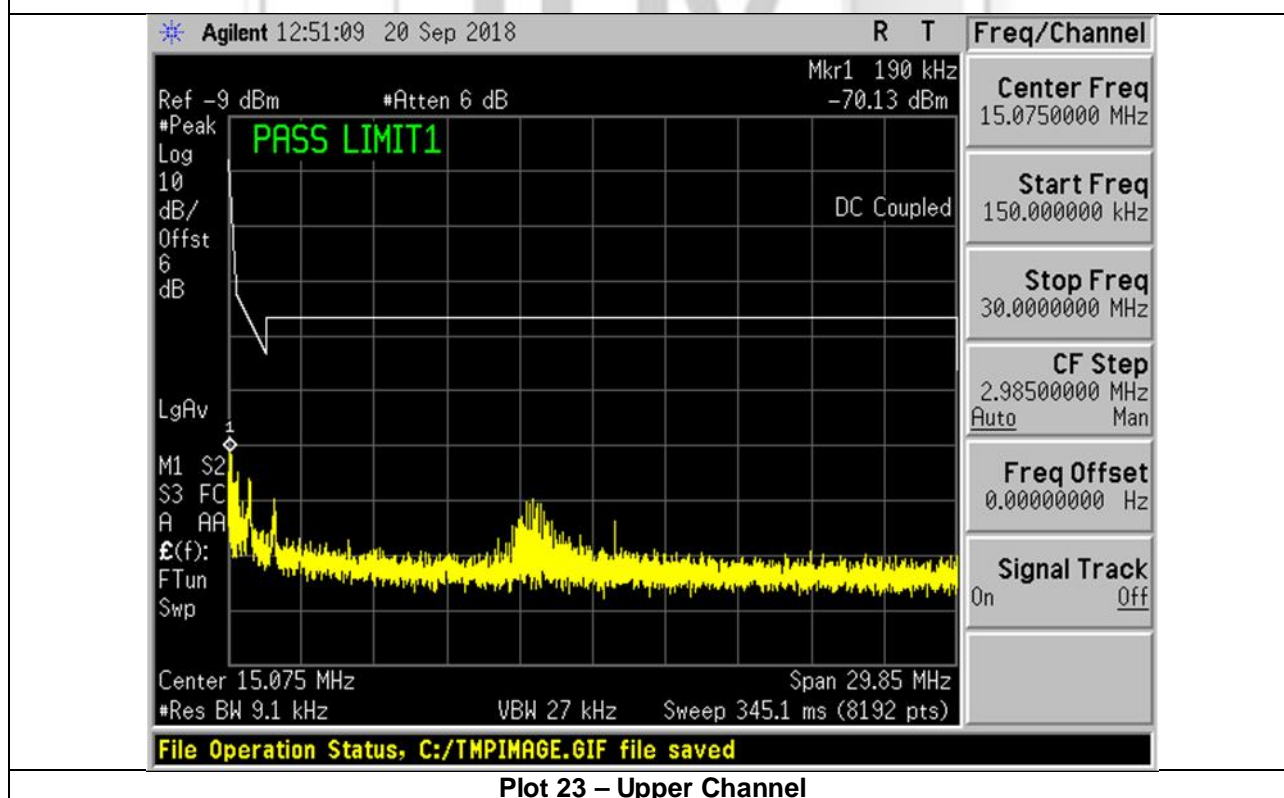
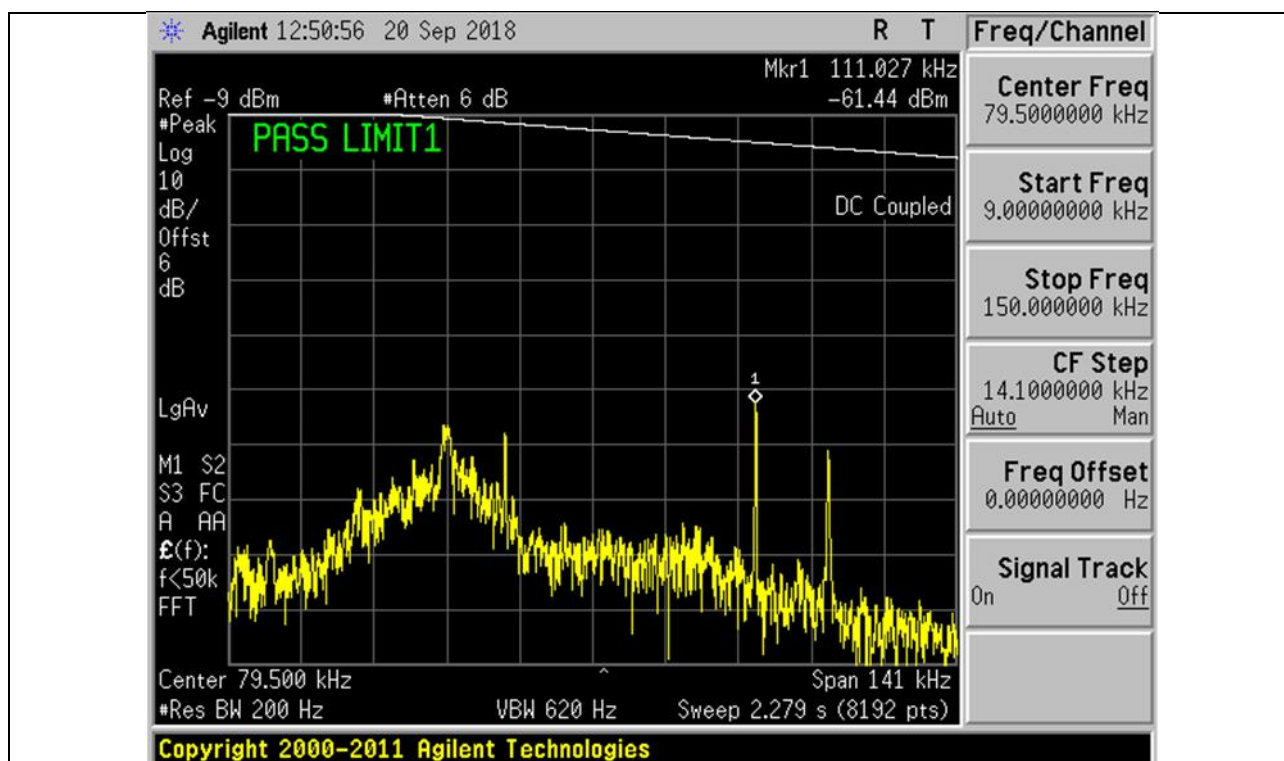


Plot 20 – Middle Channel

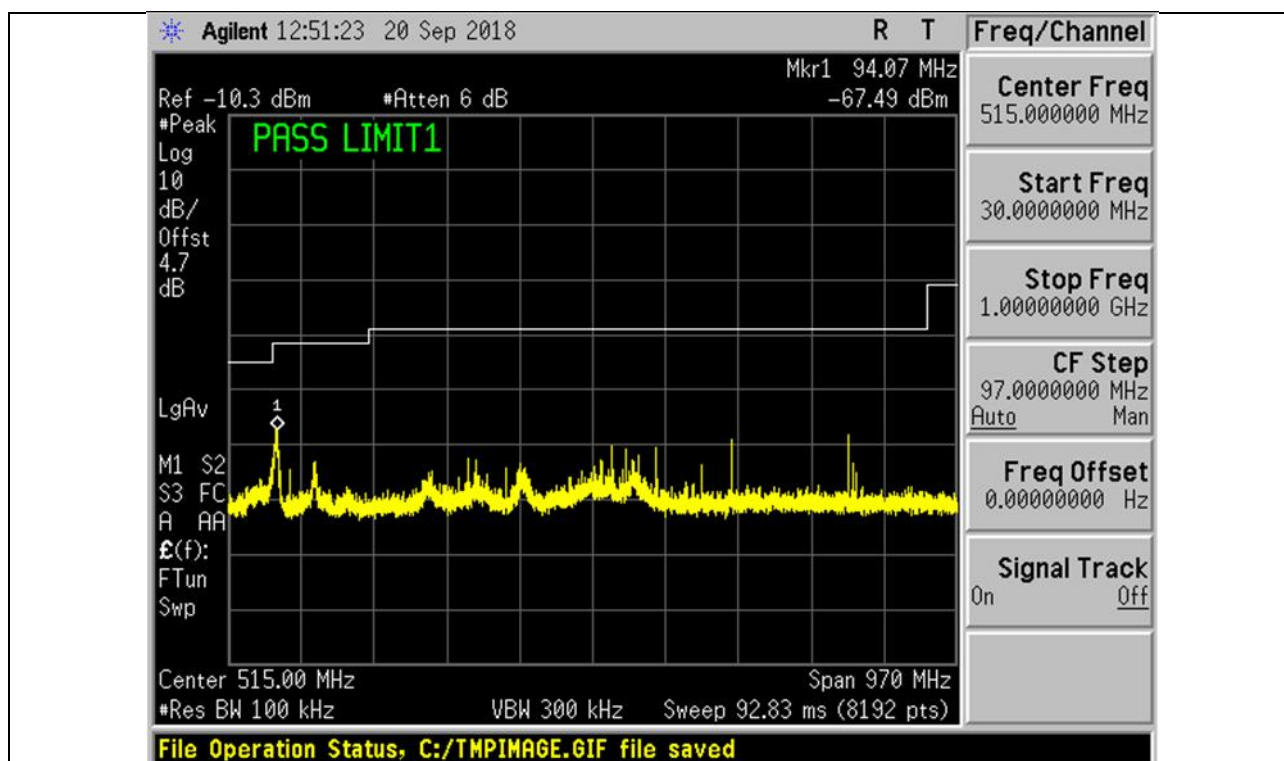


Plot 21 – Middle Channel

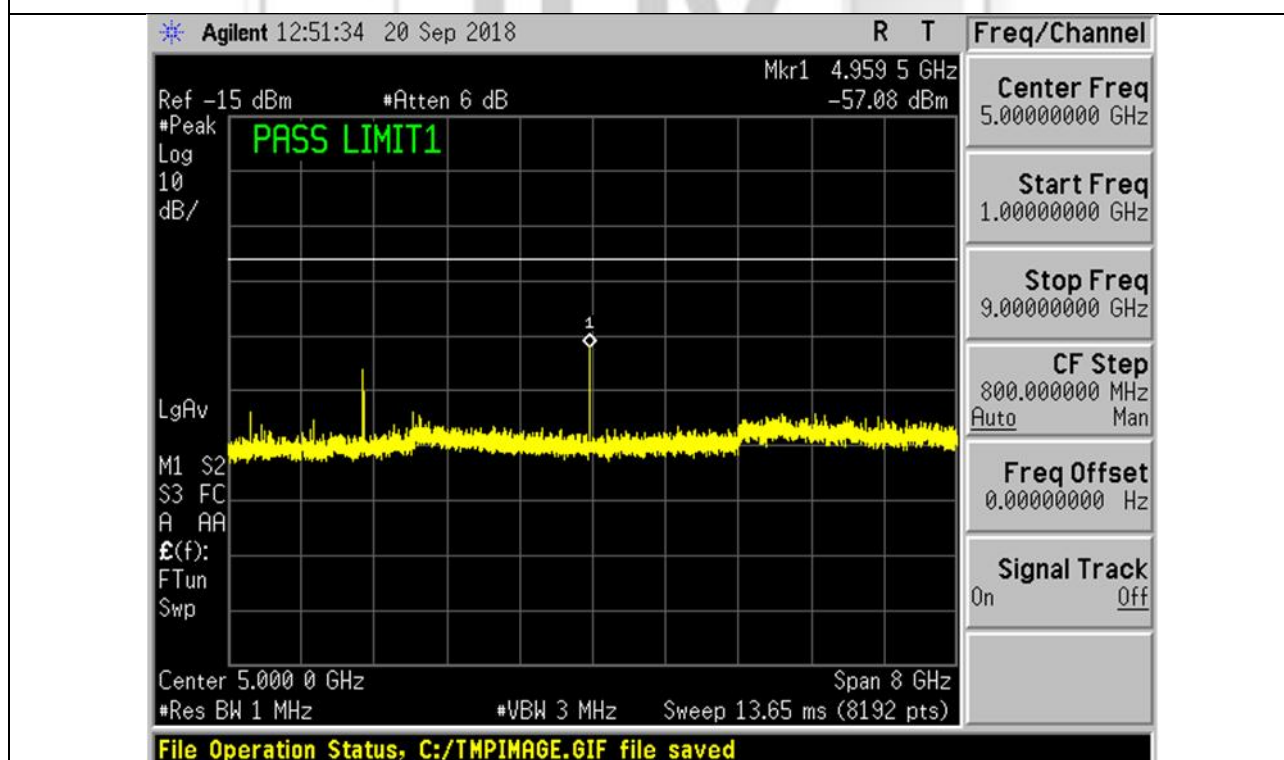
## RF Conducted Spurious Emissions (Restricted Bands) Plots – Peak



## RF Conducted Spurious Emissions (Restricted Bands) Plots – Peak

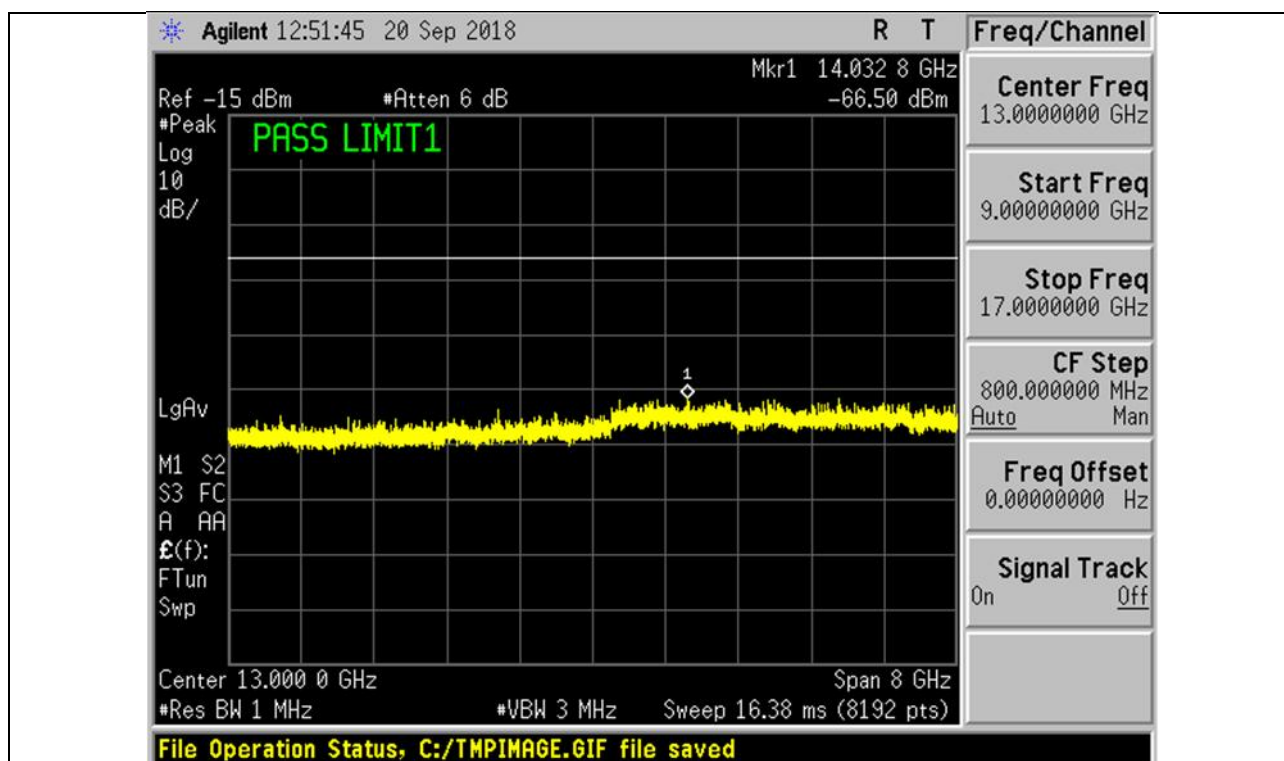


Plot 24 – Upper Channel

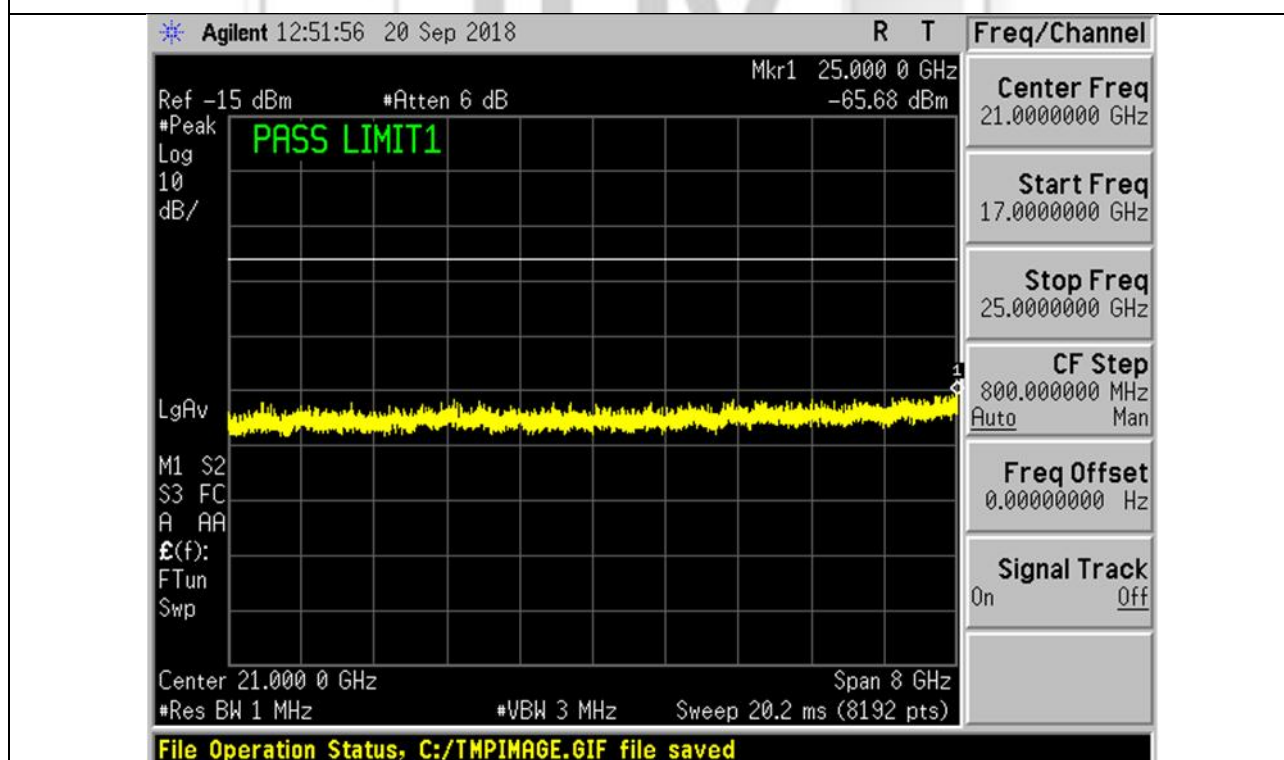


Plot 25 – Upper Channel

## RF Conducted Spurious Emissions (Restricted Bands) Plots – Peak



Plot 26 – Upper Channel



Plot 27 – Upper Channel



## **2.7 Band Edge Compliance (Conducted)**

### **2.7.1 Test Limits**

The EUT shows compliance to the requirements of this section, which states in any 100kHz bandwidth outside the frequency band in which the spread spectrum intentional radiator (EUT) is operating, the radio frequency power that is produced by the EUT shall be at least 20dB below that in the 100kHz bandwidth within the band that contains the highest level of desired power.

### **2.7.2 Test Setup**

- 2.7.2.1 The EUT and supporting equipment were set up as shown in the setup photo.
- 2.7.2.2 The power supply for the EUT was connected to a filtered mains.
- 2.7.2.3 The RF antenna connector was connected to the spectrum analyser via a low-loss coaxial cable.
- 2.7.2.4 The resolution bandwidth (RBW) and the video bandwidth (VBW) of the spectrum analyser were respectively set to 100kHz and 300kHz.
- 2.7.2.5 All other supporting equipment were powered separately from another filtered mains.

### **2.7.3 Test Method**

- 2.7.3.1 The EUT was switched on and allowed to warm up to its normal operating condition. The EUT was then configured to operate in the test mode.
- 2.7.3.2 The frequency span of the spectrum analyser was set to wide enough to capture the lower band edge of the transmission band, 2.400GHz and any spurious emissions at the band edge (within 2MHz of the band edge).
- 2.7.3.3 The spectrum analyser was set to max hold to capture any spurious emissions within the span. The signal capturing was continuous until no further spurious emissions were detected.
- 2.7.3.4 The measurements were repeated if the EUT supports more than one modulation and data rate.
- 2.7.3.5 The measurements were repeated with the frequency span of the spectrum analyser was set to wide enough to capture the upper band edge frequency of the transmission band, 2.4835GHz and the any spurious emissions at the band-edge.

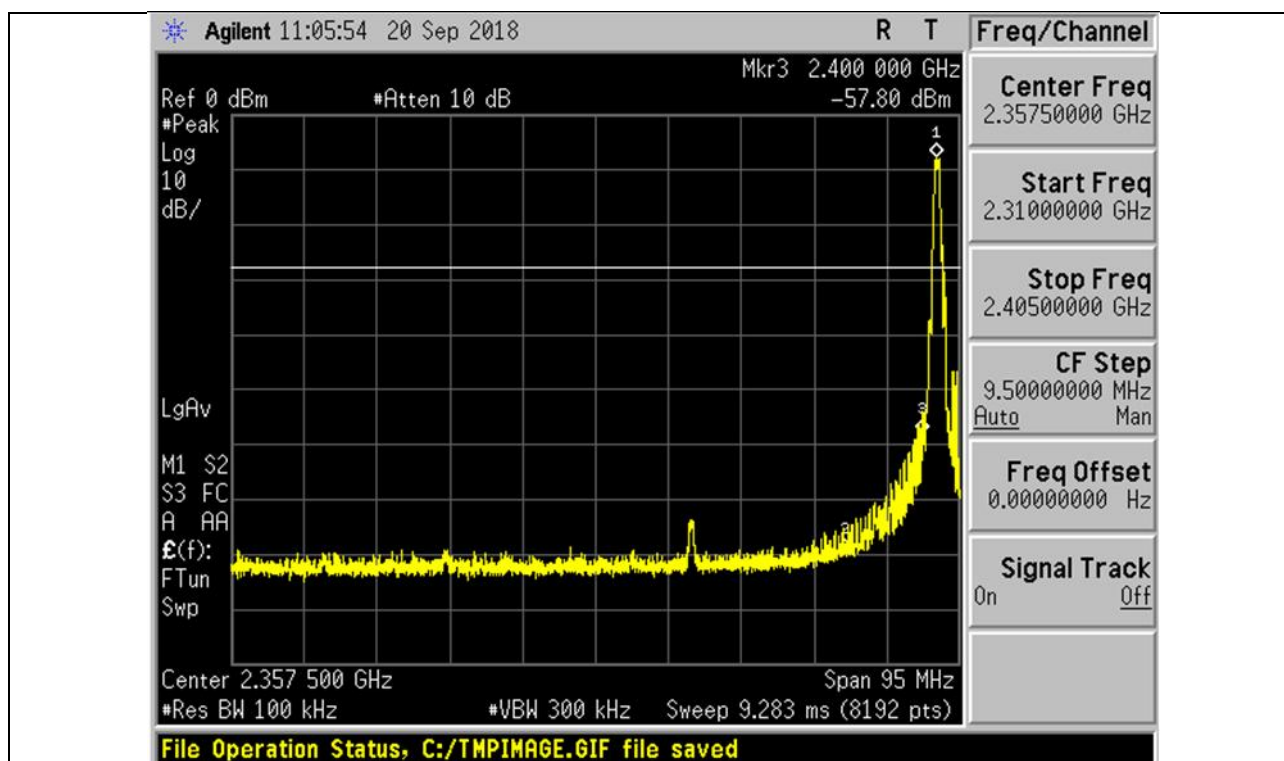
#### 2.7.4 Test Results

Test Input Power	3.7Vdc Battery	Temperature	24°C
Attached Plots	28 – 29	Relative Humidity	60%
		Atmospheric Pressure	1030mbar
		Tested By	Chang Wai Kit
		Test Date	20 Sep 2018

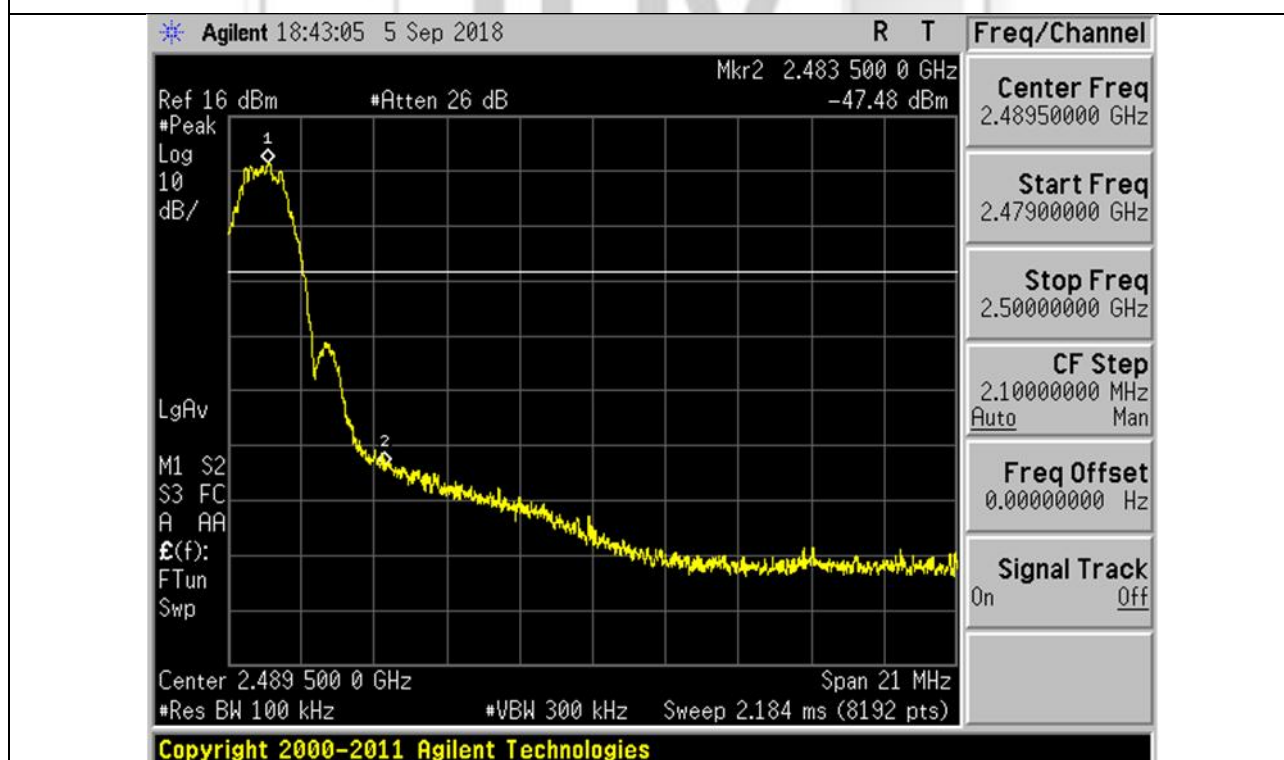
No significant signal was found and they were below the specified limit.



## Band Edge Compliance (Conducted) Plots



Plot 28 – Lower Band Edge at 2.4000GHz



Plot 29 – Upper Band Edge at 2.4835GHz

## **2.8 Band Edge Compliance (Radiated)**

### **2.8.1 Test Limits**

The EUT shows compliance to the requirements of this section, which states in any 100kHz bandwidth outside the frequency band in which the spread spectrum intentional radiator (EUT) is operating, the radio frequency power that is produced by the EUT shall be at least 20dB below that in the 100kHz bandwidth within the band that contains the highest level of the desired power. In addition, radiated emissions which fall in the restricted bands shall comply to the radiated emission limits specified in 15.209.

### **2.8.2 Test Setup**

2.8.2.1 The EUT and supporting equipment were set up as shown in the setup photo.

2.8.2.2 The power supply for the EUT was connected to a filtered mains.

2.8.2.3 The resolution bandwidth (RBW) and the video bandwidth (VBW) of the spectrum analyser were respectively set to 100kHz and 300kHz to show compliance of spurious at band edges are at least 20dB below the carriers. For restricted band spurious at band edges, peak and average measurement plots were taken using the following setting:

- a. Peak Plot:  
RBW = 1MHz, VBW = 3RBW
- b. Average Plot  
RBW = 1MHz, VBW = 10Hz

2.8.2.4 All other supporting equipment were powered separately from another filtered mains.

### **2.8.3 Test Method**

2.8.3.1 The EUT was switched on and allowed to warm up to its normal operating condition. The EUT was then configured to operate in the test mode.

2.8.3.2 The frequency span of the spectrum analyser was set to wide enough to capture the lower band edge of the transmission band, 2.400GHz and any spurious emissions at the band edge.

2.8.3.3 The spectrum analyser was set to max hold to capture any spurious emissions within the span. The signal capturing was continuous until no further spurious emissions were detected.

2.8.3.4 The measurements were repeated if the EUT supports more than one modulation and data rate.

2.8.3.5 The measurements were repeated with the frequency span of the spectrum analyser was set to wide enough to capture the upper band edge frequency of the transmission band, 2.4835GHz and the any spurious emissions at the band-edge.

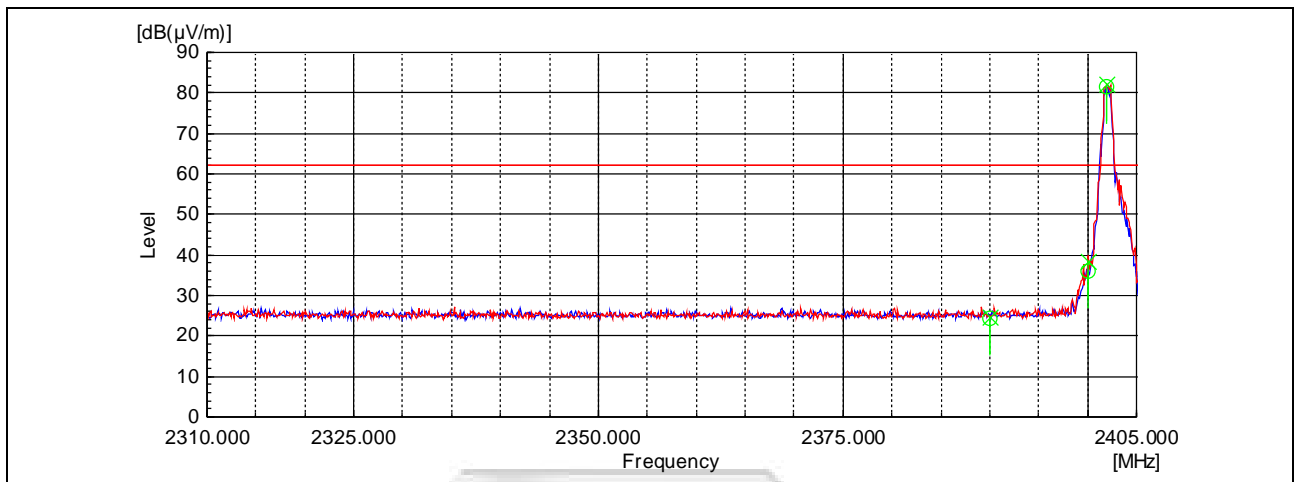
#### 2.8.4 Test Results

Test Input Power	3.7Vdc Battery	Temperature	23°C
Attached Plots	30 – 35	Relative Humidity	60%
		Atmospheric Pressure	1010mbar
		Tested By	Lim Kay Tak
		Test Date	19 Sep 2018

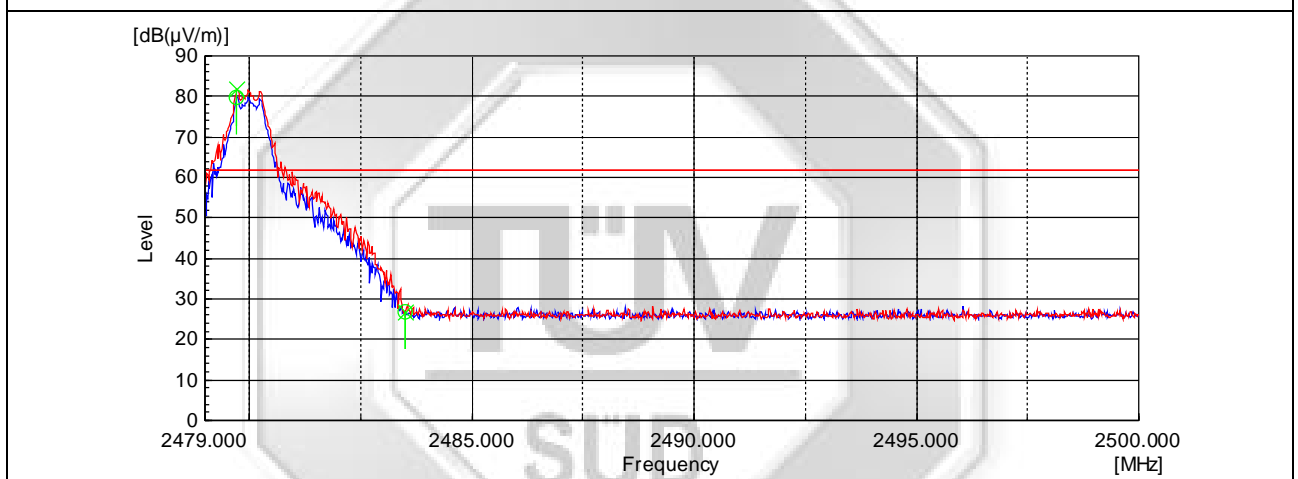
No significant signal was found and they were below the specified limit.



### Band Edge Compliance (Radiated) Plots (20dB Delta from Carrier at Band Edge)

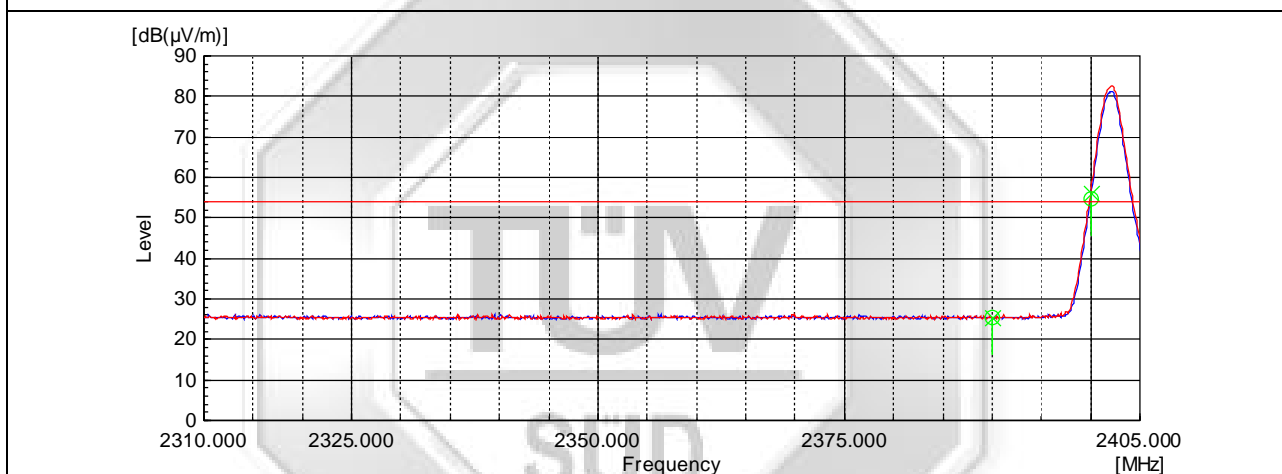
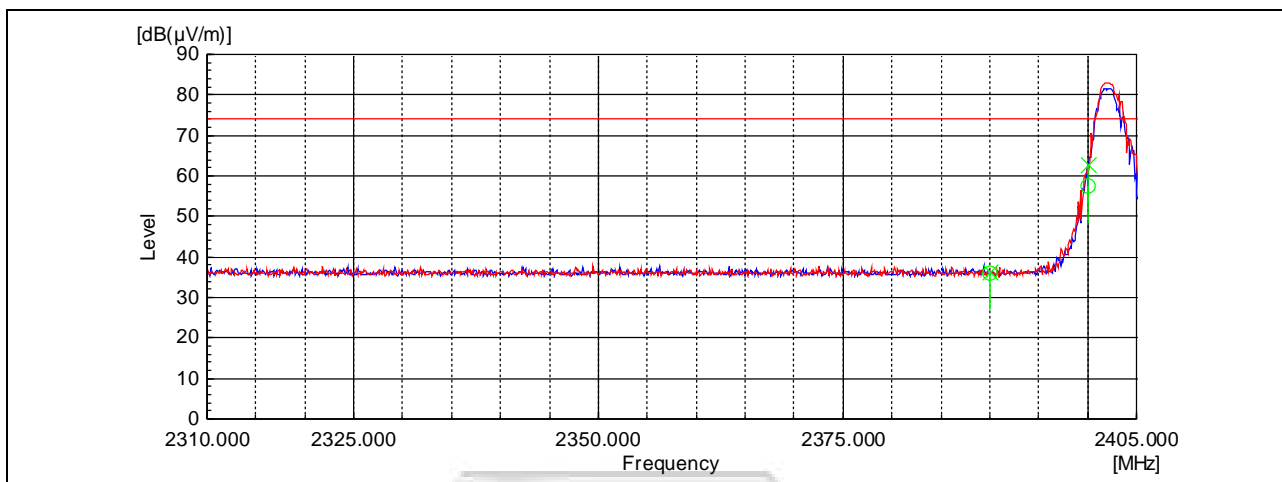


Plot 30 – Lower Band Edge at 2.4000GHz

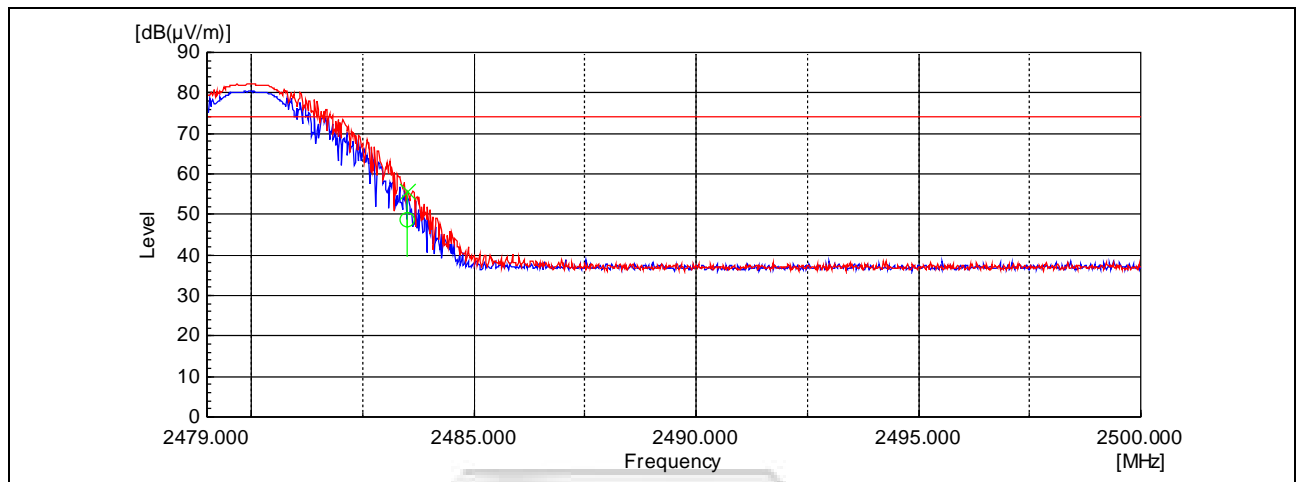


Plot 31 – Upper Band Edge at 2.4835GHz

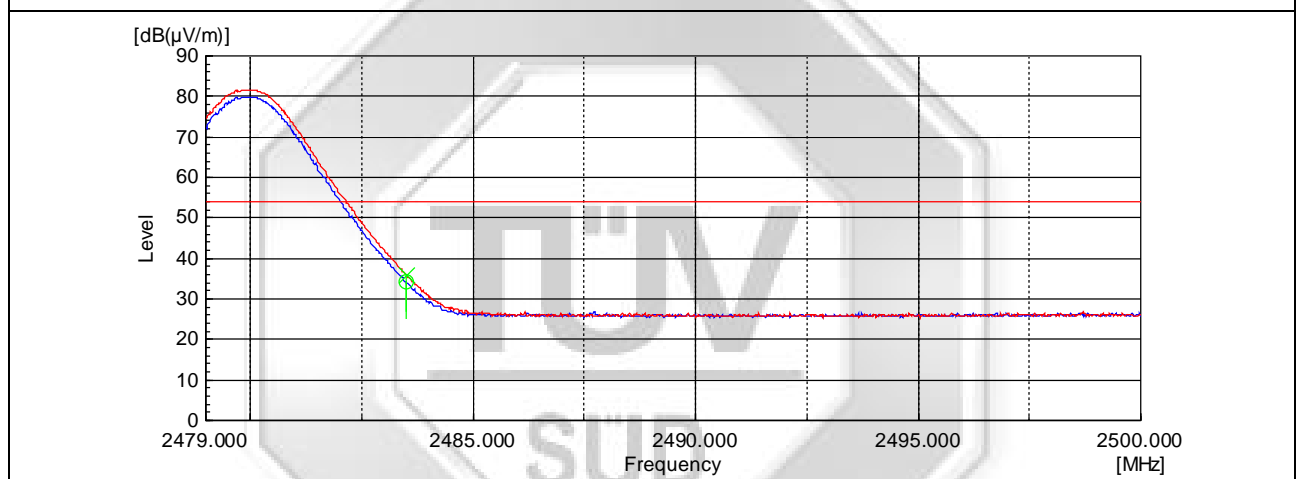
### Band Edge Compliance (Radiated) Plots (Restricted Band)



### Band Edge Compliance (Radiated) Plots (Restricted Band)



**Plot 34 – Peak Plot at Upper Band Edge at 2.4835GHz**



**Plot 35 – Average Plot at Upper Band Edge at 2.4835GHz**



## **2.9 Peak Power Spectral Density**

### **2.9.1 Test Limits**

The EUT shows compliance to the requirements of this section, which states the peak power spectral density conducted from the intentional radiator (EUT) to the antenna shall not be greater than 8dBm (6.3mW) in any 3kHz band during any time interval of continuous transmission.

### **2.9.2 Test Setup**

- 2.9.2.1 The EUT and supporting equipment were set up as shown in the setup photo.
- 2.9.2.2 The power supply for the EUT was connected to a filtered mains.
- 2.9.2.3 The RF antenna connector was connected to the spectrum via a low-loss coaxial cable.
- 2.9.2.4 The resolution bandwidth (RBW) and the video bandwidth (VBW) of the spectrum analyser were set to the following:  
RBW = 3kHz  
VBW = 3RBW  
Span = 1.5 times the channel bandwidth (6dB Bandwidth)  
Sweep time = auto couple
- 2.9.2.5 All other supporting equipment were powered separately from another filtered mains.

### **2.9.3 Test Method**

- 2.9.3.1 The EUT was switched on and allowed to warm up to its normal operating condition. The EUT was then configured to operate in the test mode at lower channel.
- 2.9.3.2 The peak of the transmitting frequency was detected with the marker peak function of the spectrum analyser.
- 2.9.3.3 The peak power density of the transmitting frequency was plotted and recorded.
- 2.9.3.4 The measurements were repeated if the EUT supports more than one modulation and data rate.
- 2.9.3.5 The measurement was repeated with the transmitting frequency was set to middle channel and upper channel respectively.

## 2.9.4 Test Results

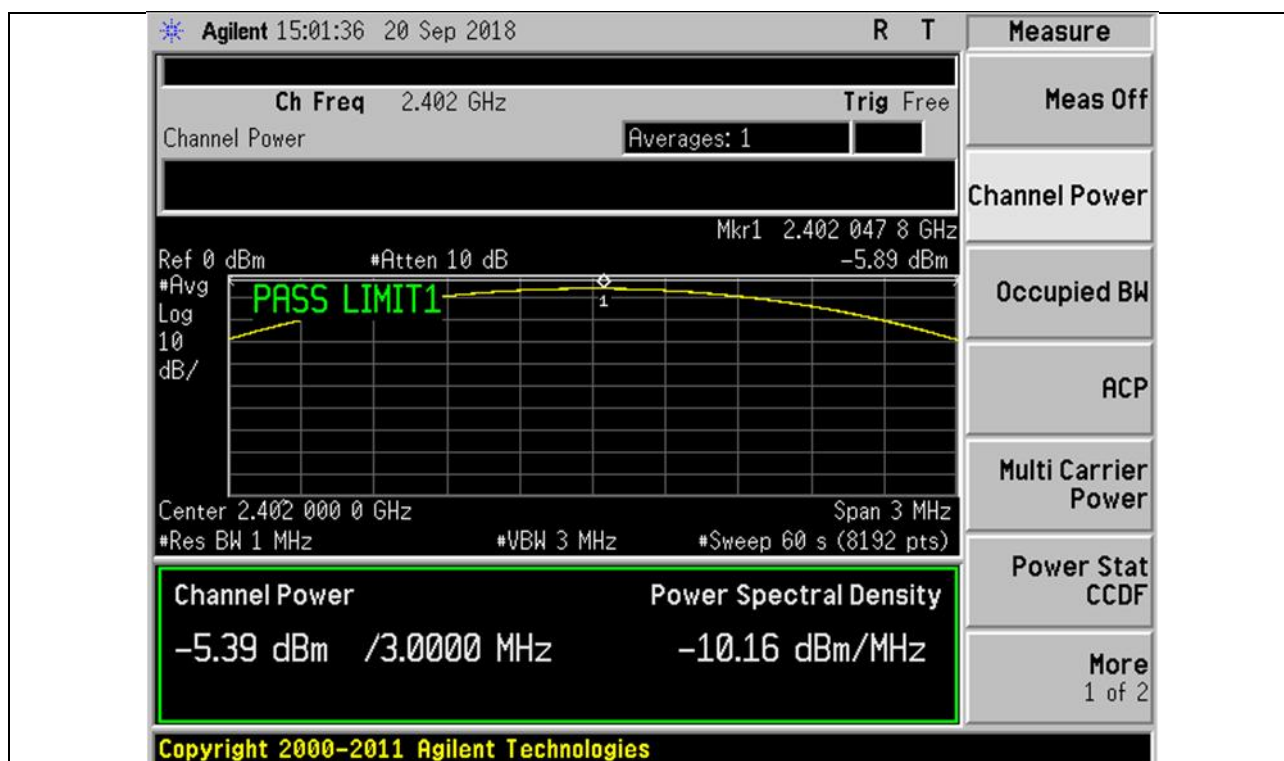
Test Input Power	3.7Vdc Battery	Temperature	24°C
Attached Plots	36 – 38	Relative Humidity	60%
		Atmospheric Pressure	1030mbar
		Tested By	Chang Wai Kit
		Test Date	20 Sep 2018

Channel	Channel Frequency (GHz)	Peak Power Spectral Density (mW) *See Note 1	Limit (mW)
Lower	2.402	0.0960	6.3
Middle	2.440	0.3732	6.3
Upper	2.480	0.3508	6.3

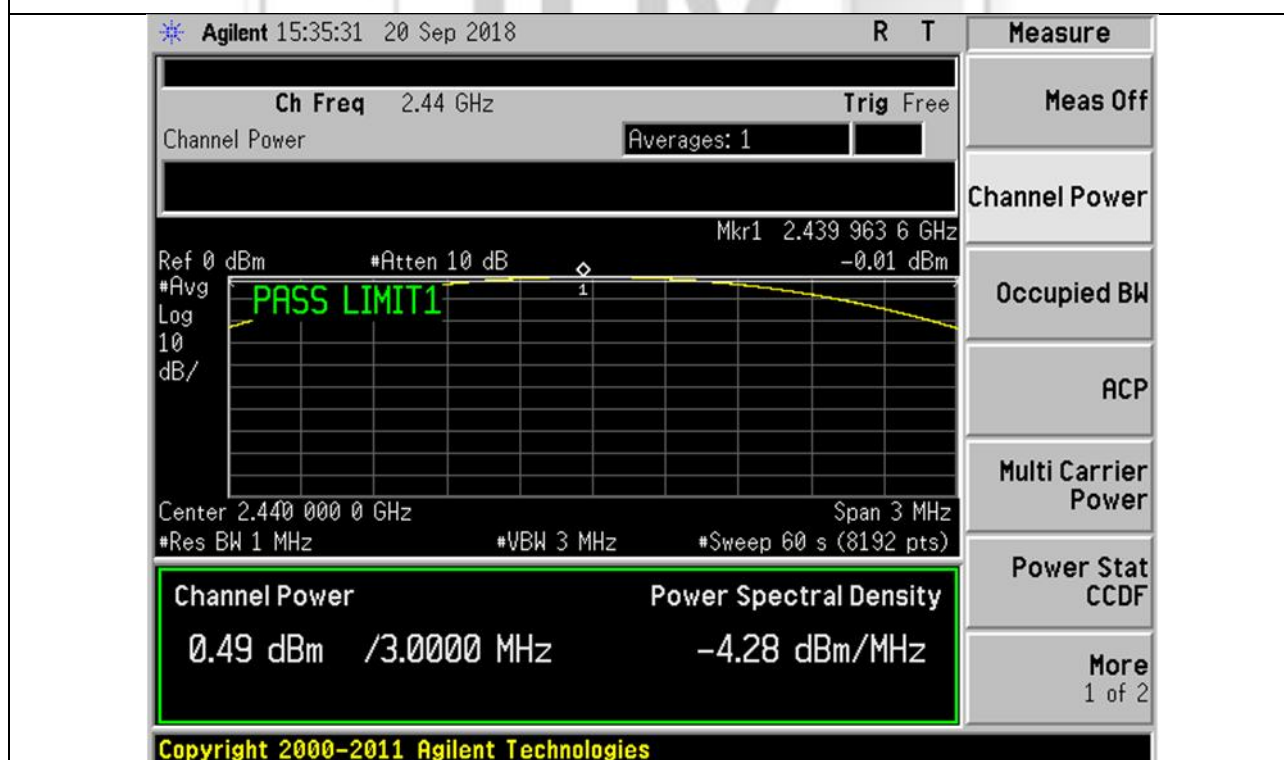
### Notes

1.	Only the highest measured peak power spectral density was reported. Refer to plots for all measured peak power spectral density.
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## Peak Power Spectral Density Plots



Plot 36 – Lower Channel



Plot 37 – Middle Channel

## Peak Power Spectral Density Plots

