Radio Testing of a Universal Remote Control

Model(s): 5000E

In accordance with
47 CFR FCC Part 15C

PSB Singapore

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Prepared for:
PCI Limited
35 Pioneer Road North
Singapore 628475

COMMERCIAL-IN-CONFIDENCE

Date: 28 Mar 2018
Document Number: 7191181956-EEC18/01 | Version Number: 01

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Approved By	Foo Kai Maun	28 Mar 2018	
Prepared By	Quek Keng Huat	26 Mar 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 in compliance with the mentioned standard(s).

TÜV SÜD PSB

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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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Contents

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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	28 Mar 2018

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1.2 Introduction

Applicant	:	Select Comfort Corp 9800 59th Avenue North Minneapolis, MN 55442 United States
Manufacturer	:	PCI Limited 35 Pioneer Road North Singapore 628475
Factory	:	PCI Kunshan Electronics Co., Ltd Kunshan Economic & Technological Development Zone Zhang Ji Road 100, Kunshan 215334, People's Republic of China
Model Number(s)	:	5000E (Tested) 5000C (Declared) 5000D (Declared) 5000F (Declared) 5000G (Declared) 5000H (Declared) 5000I (Declared)
Serial Number(s)	:	Nil
Number of Samples Tested	:	1
Quotation Reference	:	2191079934
Test Specification/Issue/Date	:	FCC 47 CFR Part 15C
Start of Test	:	19 Mar 2018
Finish of Test	:	20 Mar 2018

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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
47 CFR FCC Part 15			
15.107(a), 15.207	Conducted Emissions	Not Applicable *See Note 4	ANSI C63.4: 2014 ANSI C63.10: 2013 KDB 558074 D01 DTS Measurement Guidance V04: 2017
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 V04: 2017
15.247(a)(2)	Spectrum Bandwidth (6dB Bandwidth Measurement)	Pass	ANSI C63.10: 2013 KDB 558074 D01 DTS Measurement Guidance V04: 2017
15.247(b)(3)	Maximum Peak Power	Pass	ANSI C63.10: 2013 KDB 558074 D01 DTS Measurement Guidance V04: 2017
15.247(d)	RF Conducted Spurious Emissions (Non-Restricted Bands)	Pass	ANSI C63.10: 2013 KDB 558074 D01 DTS Measurement Guidance V04: 2017
15.247(d)	RF Conducted Spurious Emissions (Restricted Bands)	Pass	ANSI C63.10: 2013 KDB 558074 D01 DTS Measurement Guidance V04: 2017
15.247(d)	Band Edge Compliance (Conducted)	Pass	ANSI C63.10: 2013 KDB 558074 D01 DTS Measurement Guidance V04: 2017
15.247(d)	Band Edge Compliance (Radiated)	Pass	ANSI C63.10: 2013 KDB 558074 D01 DTS Measurement Guidance V04: 2017
15.247(e)	Peak Power Spectral Density	Pass	ANSI C63.10: 2013 KDB 558074 D01 DTS Measurement Guidance V04: 2017
2.1093	RF Exposure Evaluation - Specific Absorption Rate (SAR)	Not Applicable *See Note 5	KDB 447498 D01 General RF Exposure Guidance V06: 2015

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Notes

1. Three channels as listed below, which respectively represent the lower, middle and upper channels of the Equipment Under Test (EUT) were chosen and tested. For each channel, the EUT was configured to operate in the test mode.

Transmit Channel	Frequency (GHz)
Channel 11 (Lower Channel)	2.405
Channel 18 (Middle Channel)	2.440
Channel 26 (Upper Channel)	2.480

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 -2.218dBm.

4. The Equipment Under Test (EUT) is a battery operated device and contains no provision for public utility connections.

5. The Equipment Under Test (EUT) meets the SAR exclusion criterion for 10-g extremity SAR evaluation for general population exposure conditions as stated in KDB 447498 D01 General RF Exposure Guidance V06. Refer to page 60 for SAR Test Exclusion Computation.

6. The EUT was tested using fully charged batteries with DC voltage of 3.0V.

7. PCI Limited declares that Universal Remote Control models **5000C, 5000D & 5000E;** Remote 360 models **5000F, 5000G** and **5000H** and Dual Temp Remote Control model **5000I** are similar in terms of circuit design and PCB layout. All 7 models differ only in their mechanical structure, enclosure material, key features and the number of keys.

    - Universal Remote models **5000C, 5000D & 5000E** corresponds to 5 keys, 9 keys & 12 keys respectively.

    - Remote 360 models **5000F, 5000G & 5000H** corresponds to 5 keys, 10 keys & 12 keys respectively.

    - Dual Temp Remote Control model **5000I** and Remote 360 model **5000F** differs only in the software and key icons. Software change does not affect any RF parameters or settings. RF power is same with other models.

    The full EMC tests were applied on **5000H.** The declared models, **5000C, 5000D, 5000E, 5000F, 5000G & 5000I** are deemed to fulfill the same EMC requirements.

8. All the measurements in section 15.247 were done based on conducted measurements except Band Edge Compliance (Radiated) test.

9. The EUT was operated in continuous transmission, ie 100% duty cycle.

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1.4 Product Information

1.4.1 Technical Description

Description	:	The Equipment Under Test(s) (EUT(s)) is a **Universal Remote Control.**
Microprocessor	:	FREESCALE MK10DX256VLK7 – main controller FREESCALE MC13202RCR2 – RF transceiver
Operating Frequency	:	2.405GHz - 2.480GHz
Clock / Oscillator Frequency	:	48MHz – internal clock of the main controller 16MHz – RF transceiver oscillator
Modulation	:	PSM (Phase Shift Modulation)
Antenna Gain	:	Max gain of 5.3dBi (Please refer to manufacturer's antenna information for more details)
Port / Connectors	:	Refer to manufacturer's user manual / operating manual
Rated Power	:	2 x 1.5Vdc AA Batteries
Accessories	:	Batteries

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1.4.2 Test Configuration and Modes of Operation

<table>
<tr><th>Mode(s)</th><th>Description</th></tr>
<tr><td>Maximum RF power transmission</td><td>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.
<table>
<tr><th>Transmit Channel</th><th>Frequency (GHz)</th></tr>
<tr><td>Channel 11 (Lower Channel)</td><td>2.405</td></tr>
<tr><td>Channel 18 (Middle Channel)</td><td>2.440</td></tr>
<tr><td>Channel 26 (upper Channel)</td><td>2.480</td></tr>
</table>
</td></tr>
</table>

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1.5 Test Facilities Registrations

Requirements	Registration Numbers
FCC	994109 (Test Firm Registration Number) SG0002 (Designation Number)
ISED	Science Park 2932I-1 (3m and 10m Semi-Anechoic Chamber) International Business Park 2932N-1 (10m Semi-Anechoic Chamber)
VCCI	Science Park R-1335 (10m ANC), G-29 (10m ANC) C-2306 (C.E @ Lab 3) T-1471 (Telecom Ports @ Lab 3) International Business Park 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)]*

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1.6 Supporting Equipment

The EUT was tested as a stand-alone unit without any supporting equipment.

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2 Test Details

2.1 Radiated Emissions (Spurious Emissions Inclusive Restricted Bands Requirement)

2.1.1 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									

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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 filtered power supply for the EUT and supporting equipment were tapped from the appropriate power sockets located on the turntable.

2.1.2.3 The relevant broadband antenna was set at the required test distance away from the EUT and supporting equipment boundary.

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 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.

2.1.3.3 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

2.1.3.4 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 – 49k0kHz and above 1GHz, both Peak and Average measurements were carried out.

2.1.3.5 The measurements were repeated for the next frequency point, until all selected frequency points were measured.

2.1.3.6 The frequency range covered was from the lowest radio frequency signal generated from the EUT, without going below 9kHz to 10th 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 dBμV/m
Log-periodic antenna factor & cable loss at 300 MHz = 18.5 dB Q-P reading obtained directly from EMI Receiver = 40.0 dBμV/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

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2.2.5 Test Results

Test Input Power	3Vdc	Temperature	24°C
Test Distance	3m (<30MHz) 3m (≥30MHz – 25GHz)	Relative Humidity	60%
Mode	Continuous Transmission	Atmospheric Pressure	1030mbar
		Tested By	Li Chelmin

Spurious Emissions ranging from 9kHz – 30MHz (for 9kHz – 90kHz, 110kHz – 490kHz) *See Note 4 & 5

Freq (GHz)	Peak Value (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	AV Value (dBµV/m)	AV Limit (dBµV/m)	AV Margin (dB)	Height (cm)	Azimuth (Degrees)	Pol (H/V)	Ch
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Spurious Emissions ranging from 9kHz – 30MHz *See Note 4 & 5

Frequency (MHz)	Q-P Value (dBµV/m)	Q-P Limit (dBµV/m)	Q-P Margin (dB)	Height (cm)	Azimuth (Degrees)	Pol (H/V)	Channel
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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 (Worst)
115.8310	38.4	43.5	5.1	169	355	H	11
115.8510	30.8	43.5	12.7	100	214	V	11
133.7820	36.8	43.5	6.7	187	160	H	11
133.8380	33.7	43.5	9.8	100	345	V	11
213.8090	24.3	43.5	19.2	107	251	H	11
305.3970	33.9	46.0	12.1	100	263	H	11

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Spurious Emissions above 1GHz – 25GHz

Freq (GHz)	Peak Value (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	AV Value (dBµV/m) *See Note 2	AV Limit (dBµV/m)	AV Margin (dB) *See Note 3	Height (cm)	Azimuth (Degrees)	Pol (H/V)	Ch
1.2631	35.6	74.0	38.4	--	54.0	18.4	101	15	V	11
1.6882	33.0	74.0	41.0	--	54.0	21.0	200	50	V	11
2.1537	43.1	74.0	30.9	--	54.0	10.9	200	167	H	11
4.8153	48.2	74.0	25.8	--	54.0	5.8	200	115	V	11
7.2144	52.3	74.0	20.9	--	54.0	1.7	101	200	V	11
9.6190	49.9	74.0	24.1	--	54.0	4.1	200	84	H	11

Spurious Emissions above 1GHz – 25GHz

Freq (GHz)	Peak Value (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	AV Value (dBµV/m) *See Note 2	AV Limit (dBµV/m)	AV Margin (dB) *See Note 3	Height (cm)	Azimuth (Degrees)	Pol (H/V)	Ch
1.2631	31.2	74.0	42.8	--	54.0	22.8	200	44	H	18
2.0525	41.8	74.0	32.2	--	54.0	12.2	200	214	H	18
2.1537	36.2	74.0	37.8	--	54.0	17.8	200	135	V	18
4.8862	47.2	74.0	26.8	--	54.0	6.8	101	311	H	18
7.3116	49.6	74.0	24.4	--	54.0	4.4	200	38	V	18
9.7647	49.9	74.0	24.1	--	54.0	4.1	101	272	H	18

Spurious Emissions above 1GHz – 25GHz

Freq (GHz)	Peak Value (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	AV Value (dBµV/m) *See Note 2	AV Limit (dBµV/m)	AV Margin (dB) *See Note 3	Height (cm)	Azimuth (Degrees)	Pol (H/V)	Ch
1.6882	38.8	74.0	35.2	--	54.0	15.2	200	167	H	26
2.0525	38.4	74.0	35.6	--	54.0	15.6	200	195	V	26
3.3681	43.2	74.0	30.8	--	54.0	10.8	200	65	V	26
4.9671	47.4	74.0	26.6	--	54.0	6.6	101	241	H	26
7.4330	46.4	74.0	27.6	--	54.0	7.6	200	342	H	26
9.9226	49.7	74.0	24.3	--	54.0	4.3	101	285	V	26

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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.	As the measured peak shows compliance to the average limit, as such no average measurement was required.
3.	The average margin indicates the margin of the measured peak value below the average limit.
4.	"--" indicates no emissions were found and shows compliance to the limits
5.	The measurement was done at 3m. The measured results were extrapolated to the specified test limits as specified in § 15.209 (a) based on 40dB/decade.
6.	Quasi-peak measurement was used for frequency measurement up to 1GHz. Average and peak measurements were used for emissions above 1GHz. The average measurement was done by averaging over a complete cycle of the pulse train, including the blanking interval as the pulse train duration does not exceed 0.1 second.
7.	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.
8.	EMI receiver Resolution Bandwidth (RBW) and Video Bandwidth (VBW) settings: 30MHz - 1GHz RBW: 120kHz VBW: 1MHz >1GHz RBW: 1MHz VBW: 3MHz
9.	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.
10.	The channel in the table refers to the transmit channel of the EUT.

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2.2 Spectrum Bandwidth (6db Bandwidth Measurement)

2.2.1 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.

2.2.2 Test Setup

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

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

2.2.2.3 The RF antenna connector was connected to the spectrum analyser via a low-loss coaxial cable.

2.2.2.4 The resolution bandwidth (RBW) and the video bandwidth (VBW) of the spectrum analyser were respectively set to 100kHz and 3 times of RBW.

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

2.2.3 Test Method

2.2.3.1 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.

2.2.3.2 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.

2.2.3.3 The spectrum analyser was set to max hold to capture the transmitting frequency. The signal capturing was continuous until no further changes were observed.

2.2.3.4 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.

2.2.3.5 The 6dB bandwidth of the transmitting frequency is the frequency difference between the marked lower and upper frequencies, $| f_H - f_L |$.

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

2.2.3.7 The measurements were repeated with the transmitting frequency was set to middle and upper channel respectively.

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2.2.4 Test Results

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

Channel	Channel Frequency (GHz)	6dB Bandwidth (MHz) *See Note 1	Limit (MHz)
Lower	2.405	1.581	≥ 500
Middle	2.440	1.596	≥ 500
Upper	2.480	1.535	≥ 500

Notes

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

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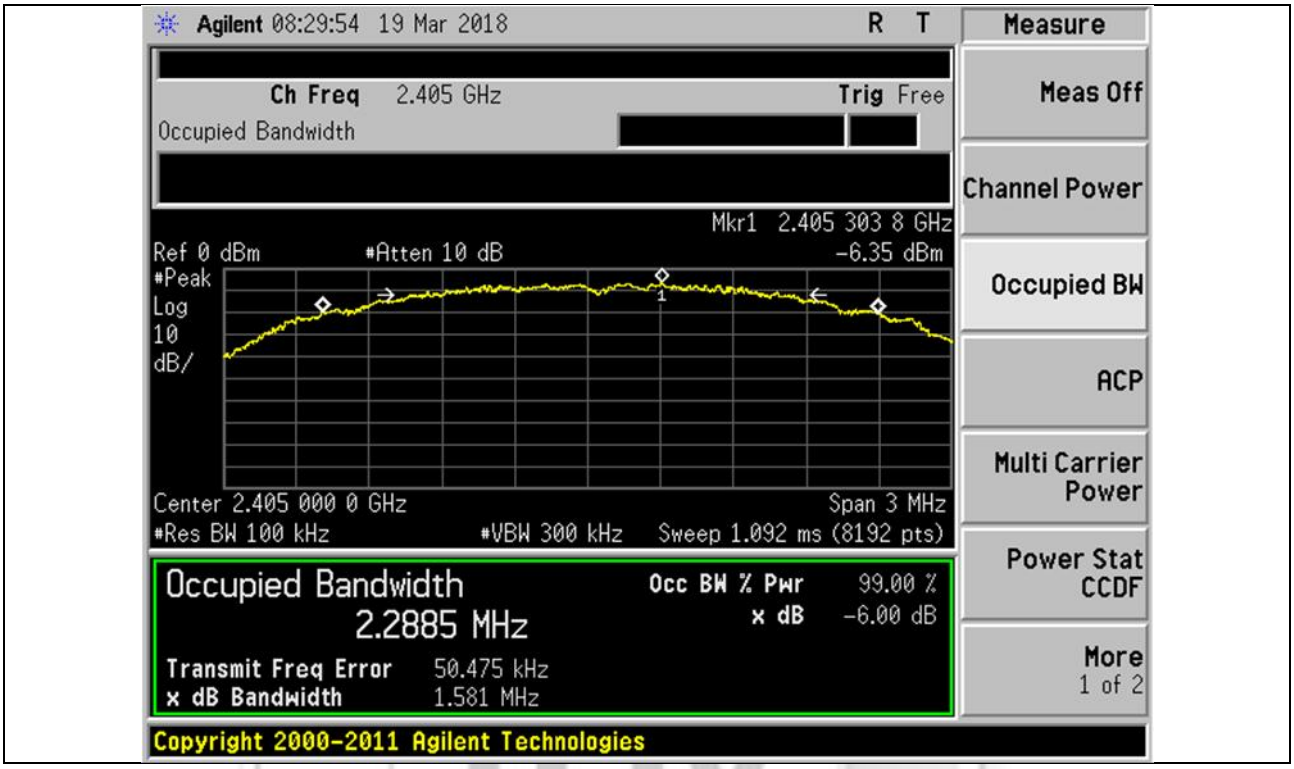
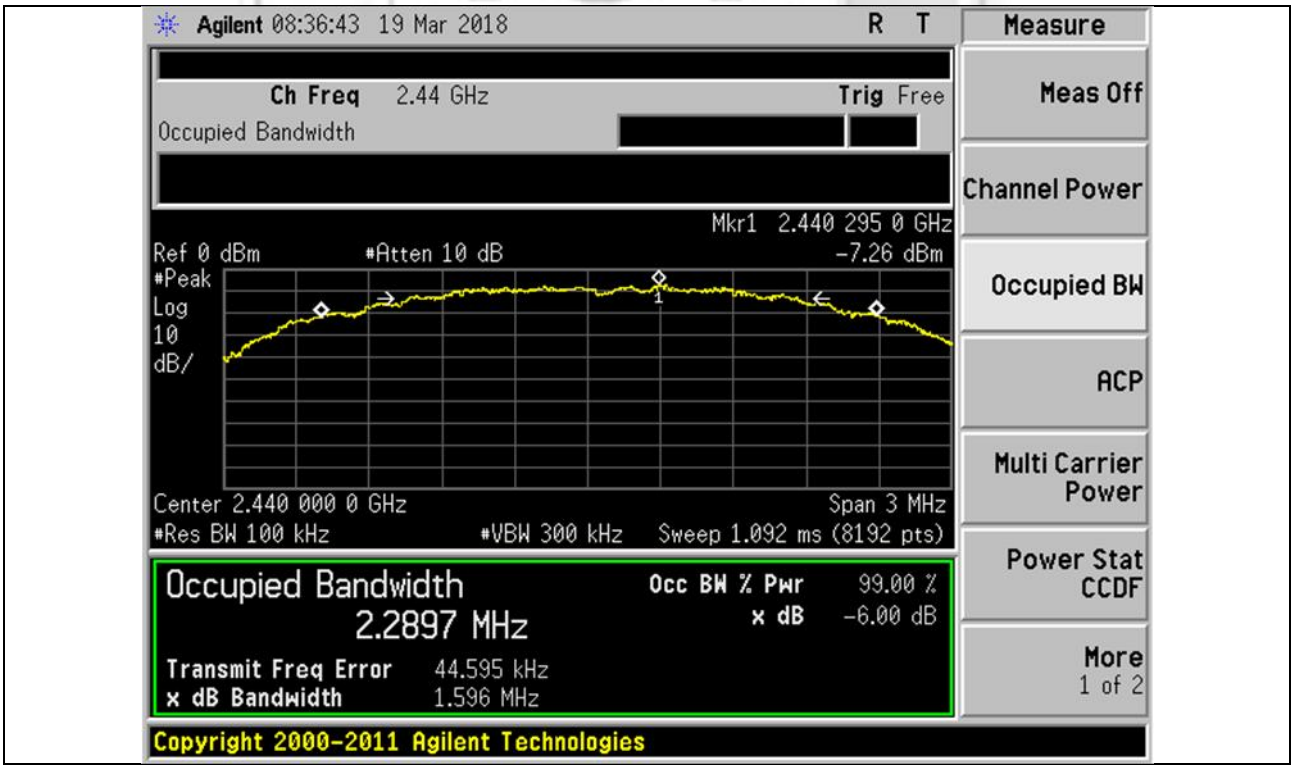
Spectrum Bandwidth (6dB Bandwidth Measurement) Plots



Plot 1 – Lower Channel



Plot 2 – Middle Channel

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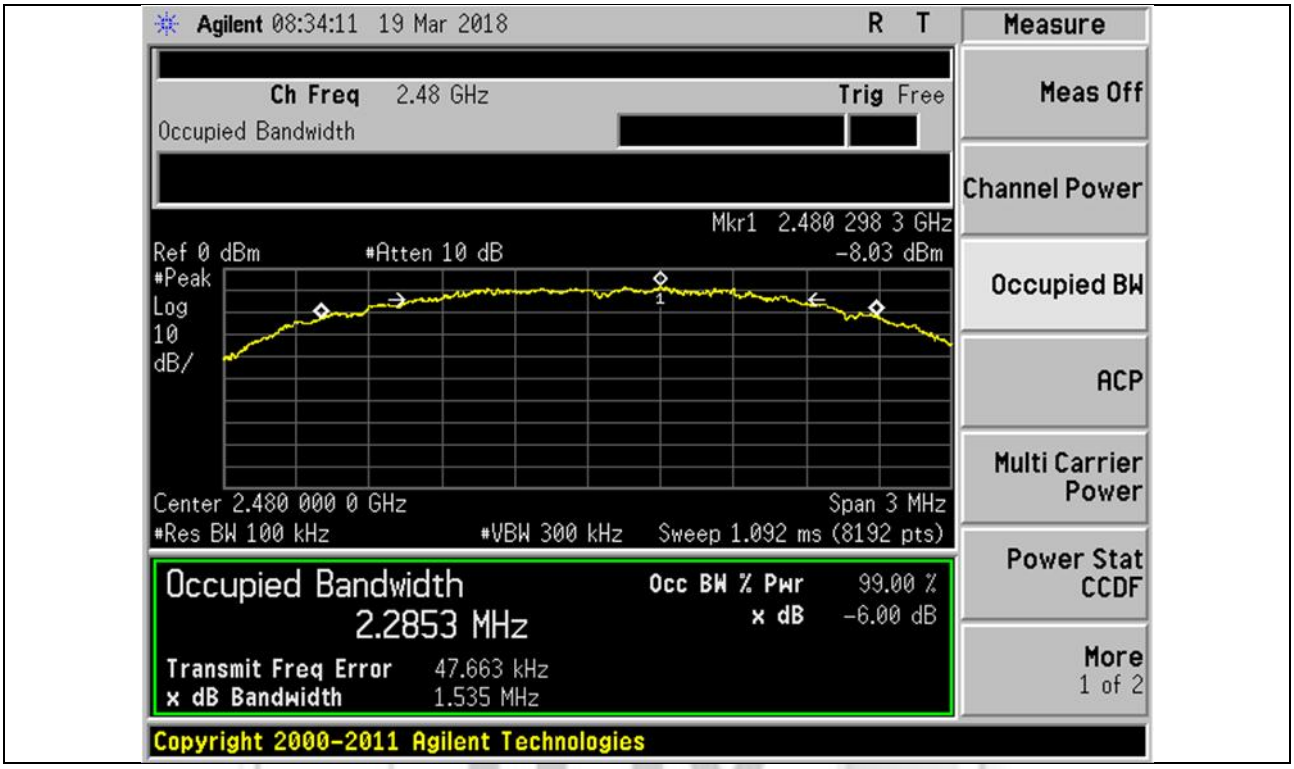
Spectrum Bandwidth (6dB Bandwidth Measurement) Plots



Plot 3 – Upper Channel

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2.3 Maximum Peak Power

2.3.1 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).

2.3.2 Test Setup

2.3.2.1 The EUT and supporting equipment were set up as shown in the setup 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 a power meter.

2.3.2.4 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 maximum peak power of the transmitting frequency was detected and recorded.

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

2.3.3.4 The measurement was repeated with the transmitting frequency was set to middle channel and upper channel respectively.

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2.3.4 Test Results

Test Input Power	3Vdc	Temperature	24°C
Antenna Gain	5.3 dBi	Relative Humidity	60%
Attached Plots	4 – 6	Atmospheric Pressure	1030mbar
		Tested By	Chang Wai Kit

Channel	Channel Frequency (GHz)	Maximum Peak Power (W) *See Note 1	Limit (W)
Lower	2.405	0.0006	1.0
Middle	2.440	0.0005	1.0
Upper	2.480	0.0004	1.0

Notes

1.	Only the highest measured peak power were reported.

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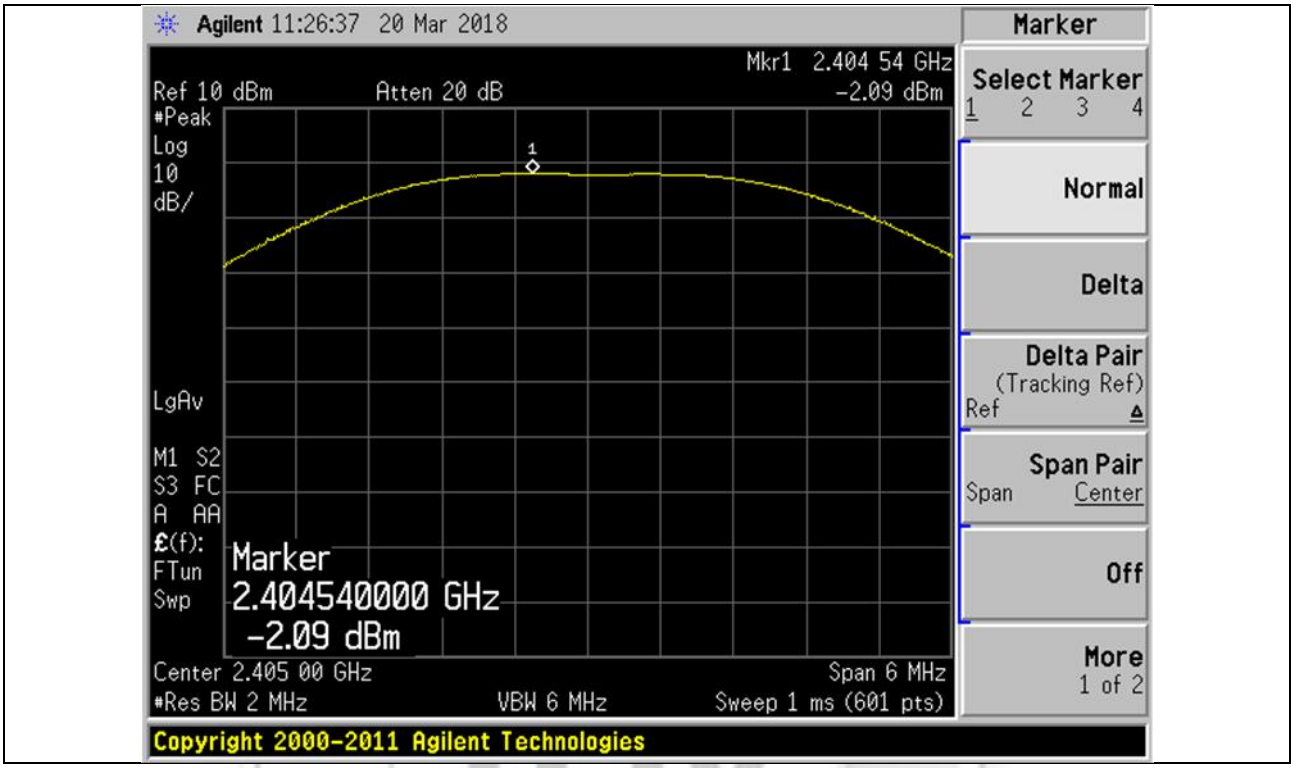
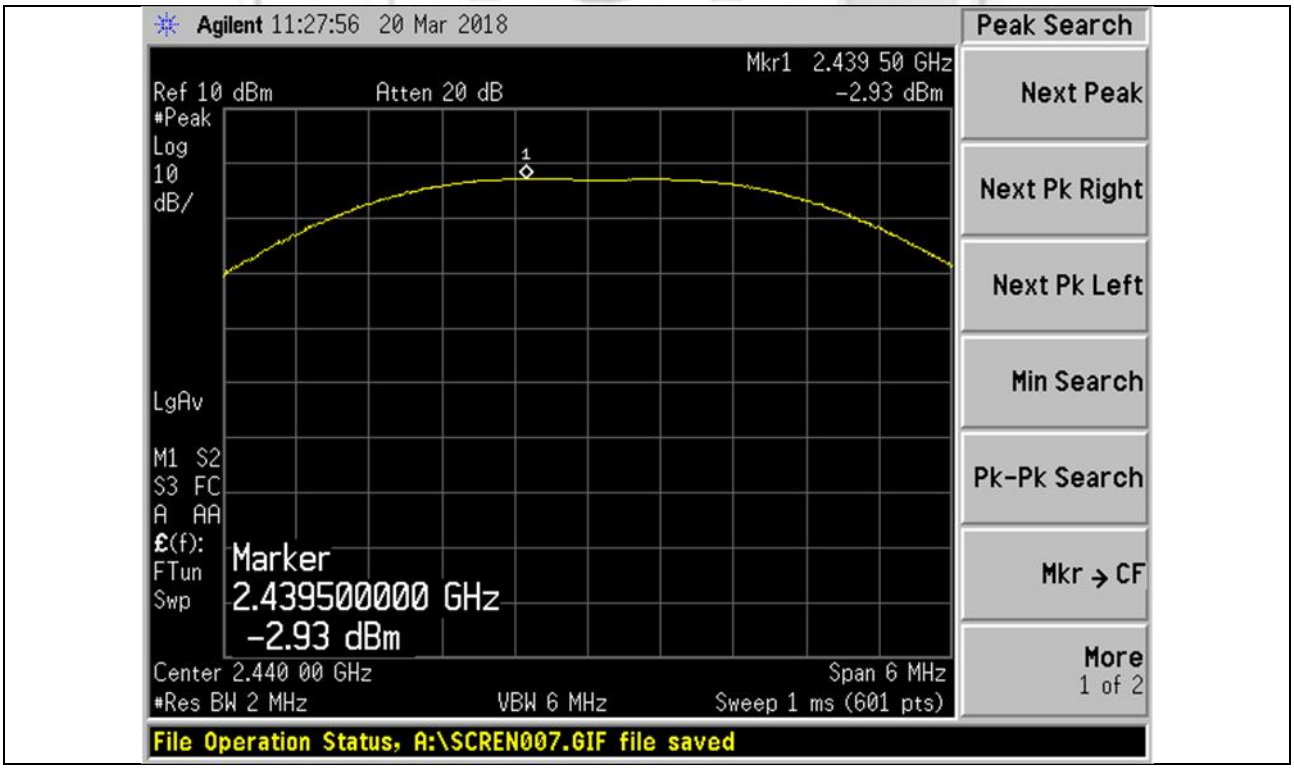
Maximum Peak Power Plots



Plot 4 – Lower Channel



Plot 5 – Middle Channel

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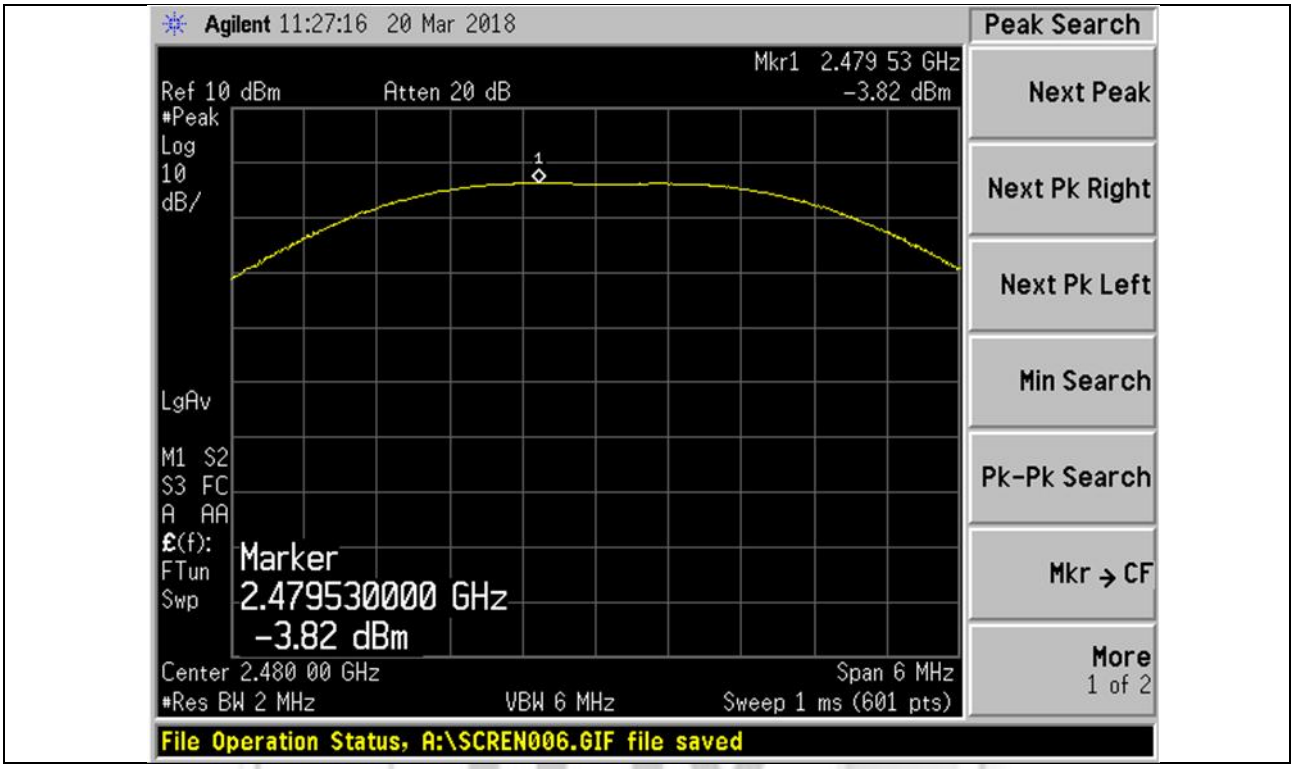
Maximum Peak Power Plots



Plot 6 – Upper Channel

PSB Singapore

2.4 RF Conducted Spurious Emissions (Non-Restricted Bands)

2.4.1 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.

2.4.2 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 the spectrum analyser via a low-loss coaxial cable.

2.4.2.4 The resolution bandwidth (RBW) and the video bandwidth (VBW) of the spectrum analyser were respectively set to 100kHz and 3 times of RBW.

2.4.2.5 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, with transmitting frequency at lower channel.

2.4.3.2 The start and stop frequencies of the spectrum analyser were set to 30MHz and 10GHz.

2.4.3.3 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.

2.4.3.4 The measurements were repeated with frequency span was set from 10GHz to 25GHz.

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

2.4.3.6 The measurements were repeated with the transmitting frequency was set to middle channel and upper channel respectively.

PSB Singapore

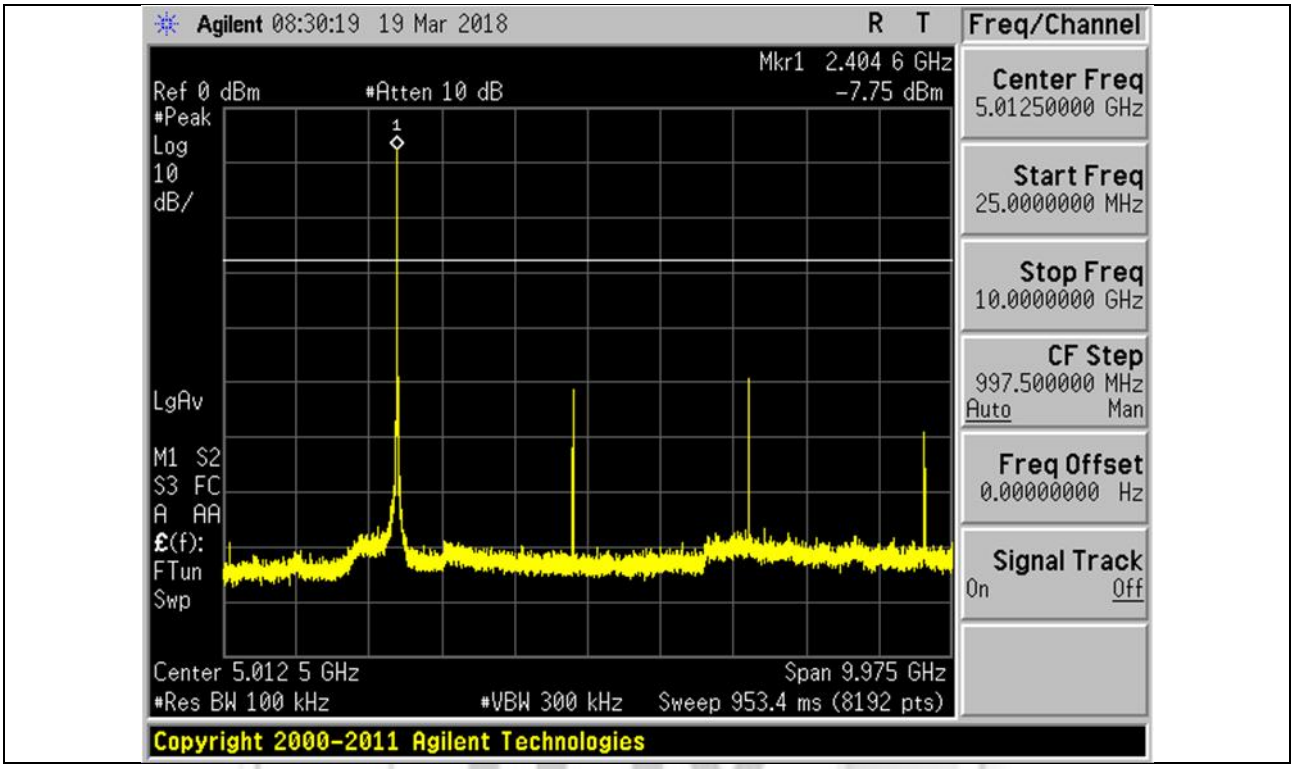
2.4.4 Test Results

Test Input Power	3Vdc	Temperature	24°C
Attached Plots	7 – 12	Relative Humidity	60%
		Atmospheric Pressure	1030mbar
		Tested By	Chang Wai Kit

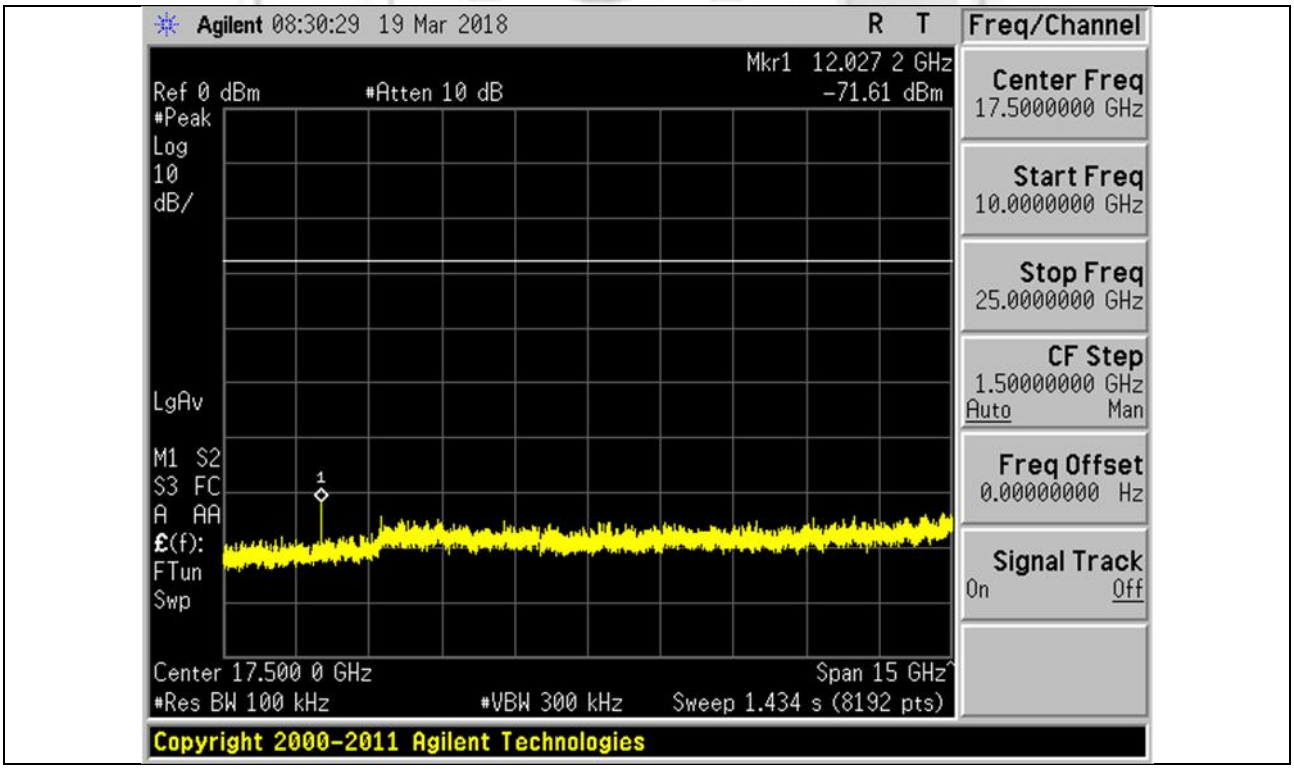
All spurious signals found were below the specified limit. Please refer to the attached plots.

PSB Singapore

RF Conducted Spurious Emissions (Non-Restricted Bands) Plots

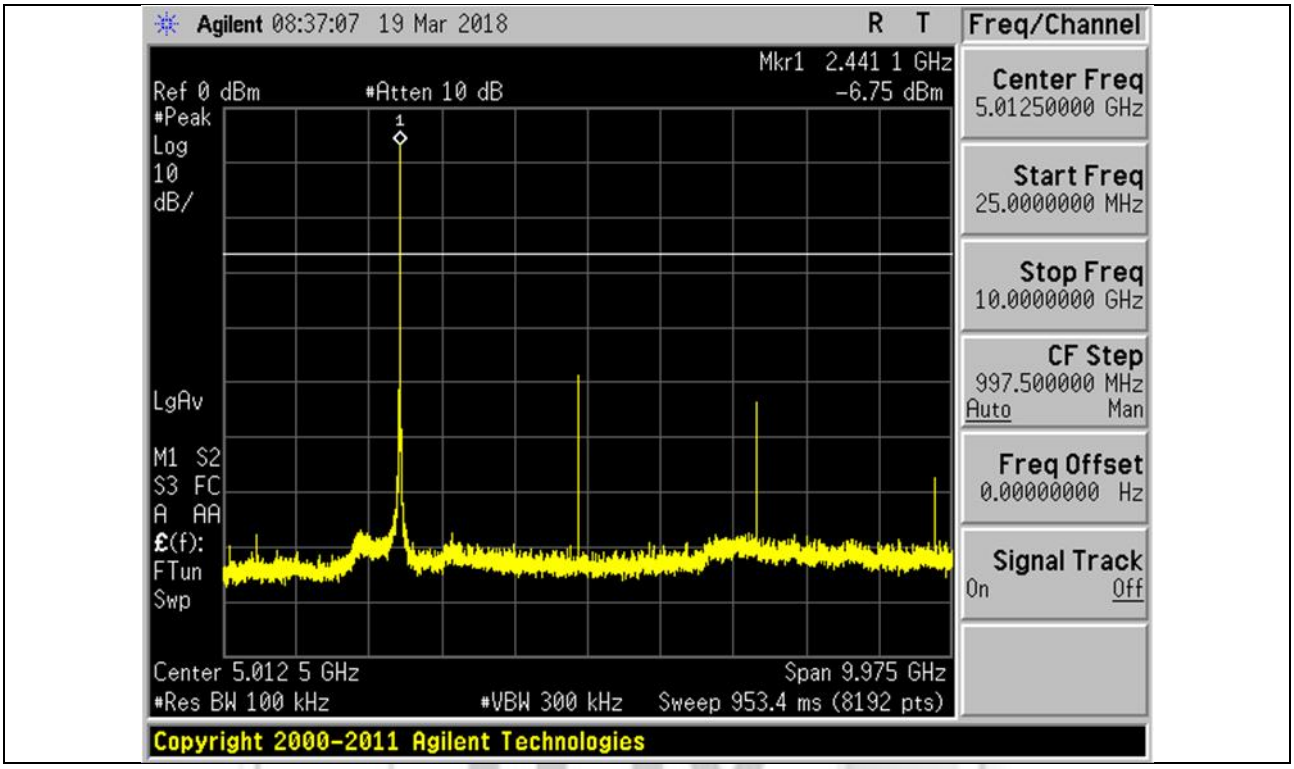


Plot 7 – Lower Channel

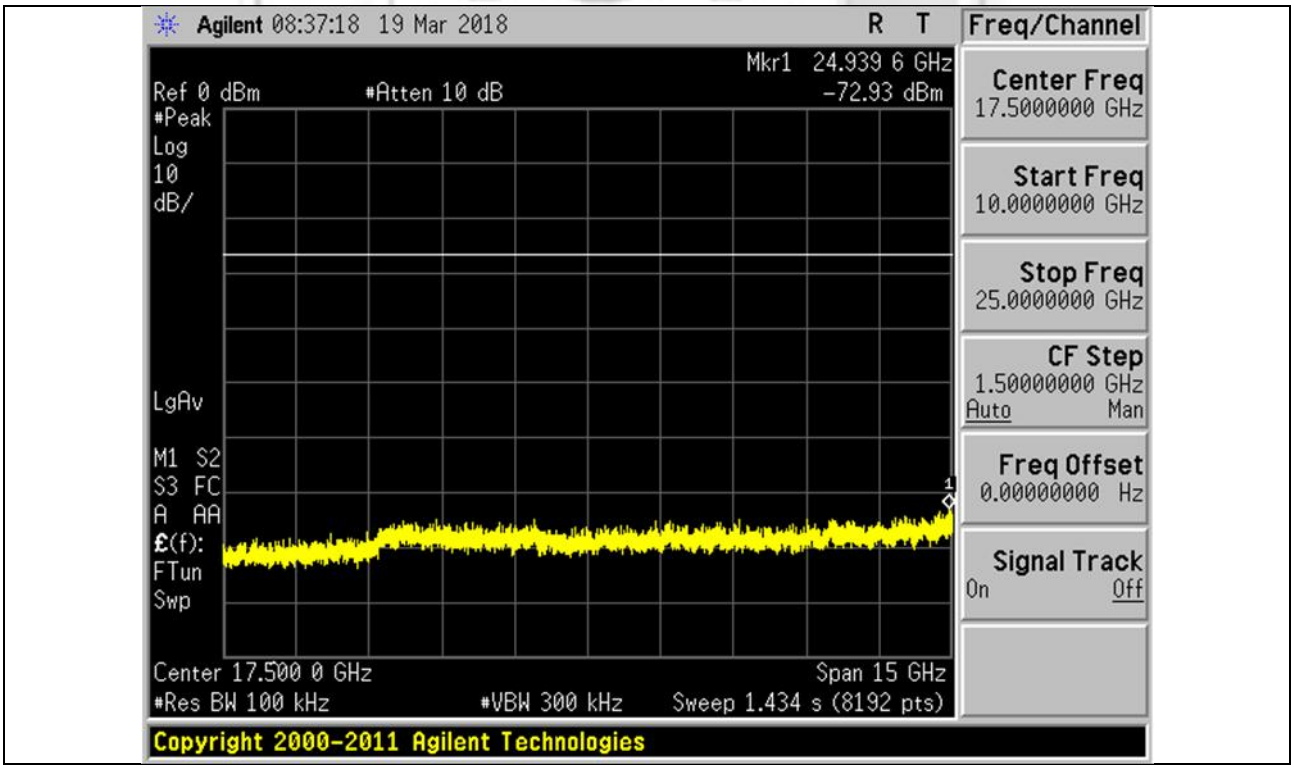


Plot 8 – Lower Channel

RF Conducted Spurious Emissions (Non-Restricted Bands) Plots



Plot 9 – Middle Channel



Plot 10 – Middle Channel

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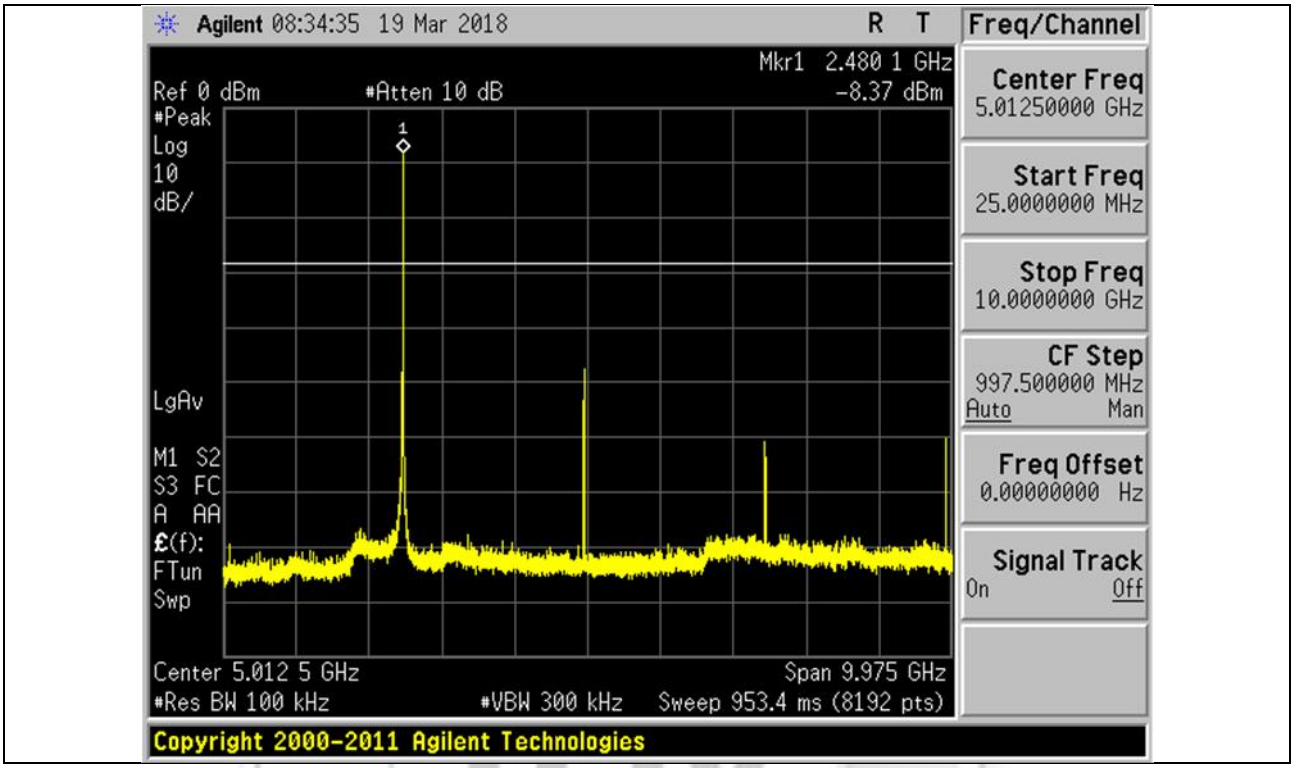
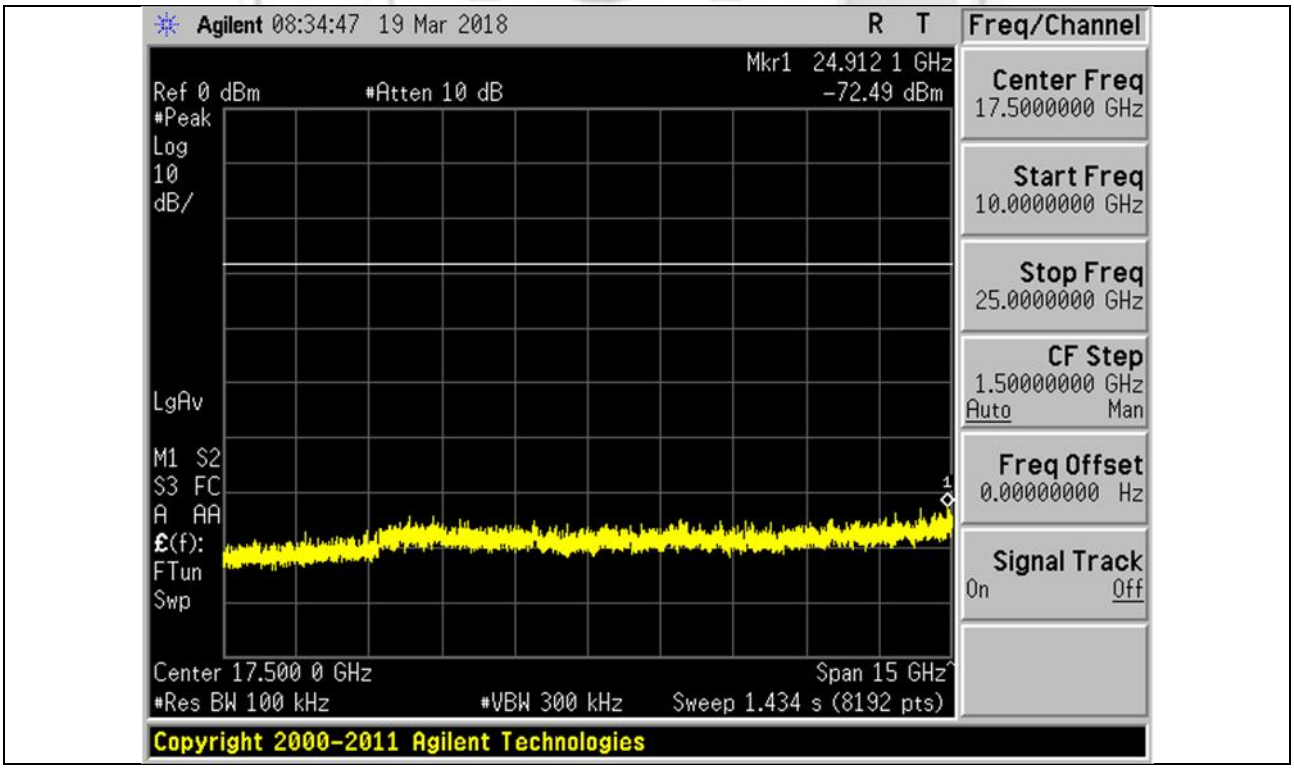
RF Conducted Spurious Emissions (Non-Restricted Bands) Plots



Plot 11 – Upper Channel



Plot 12 – Upper Channel

PSB Singapore

2.5 RF Conducted Spurious Emissions (Restricted Bands)

2.5.1 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.		

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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									

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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) 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

2.5.2.5 The detector of the spectrum analyser was set to peak detection mode.

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

2.5.3 Test Method

Measurement in the range 9kHz – 1000MHz

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 the transmitting frequency was set to lower channel.

2.5.3.2 The start and stop frequencies of the spectrum analyser were set according to the supported RBW.

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. The antenna gain of the EUT was added to the captured spurious emissions.

2.5.3.4 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.

2.5.3.5 The measurements were repeated until all the captured emissions which exceeding the limits were measured.

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

2.5.3.7 The measurements were repeated with the transmitting frequency was set to middle and upper channel respectively

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Measurement above 1000MHz

2.5.3.8 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.

2.5.3.9 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.

2.5.3.10 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.

2.5.3.11 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.

2.5.3.12 The measurements were repeated until all the required frequency bands were measured.

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

2.5.3.14 The measurements were repeated with the transmitting frequency was set to middle and upper channel respectively.

2.5.3.15 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.

PSB Singapore

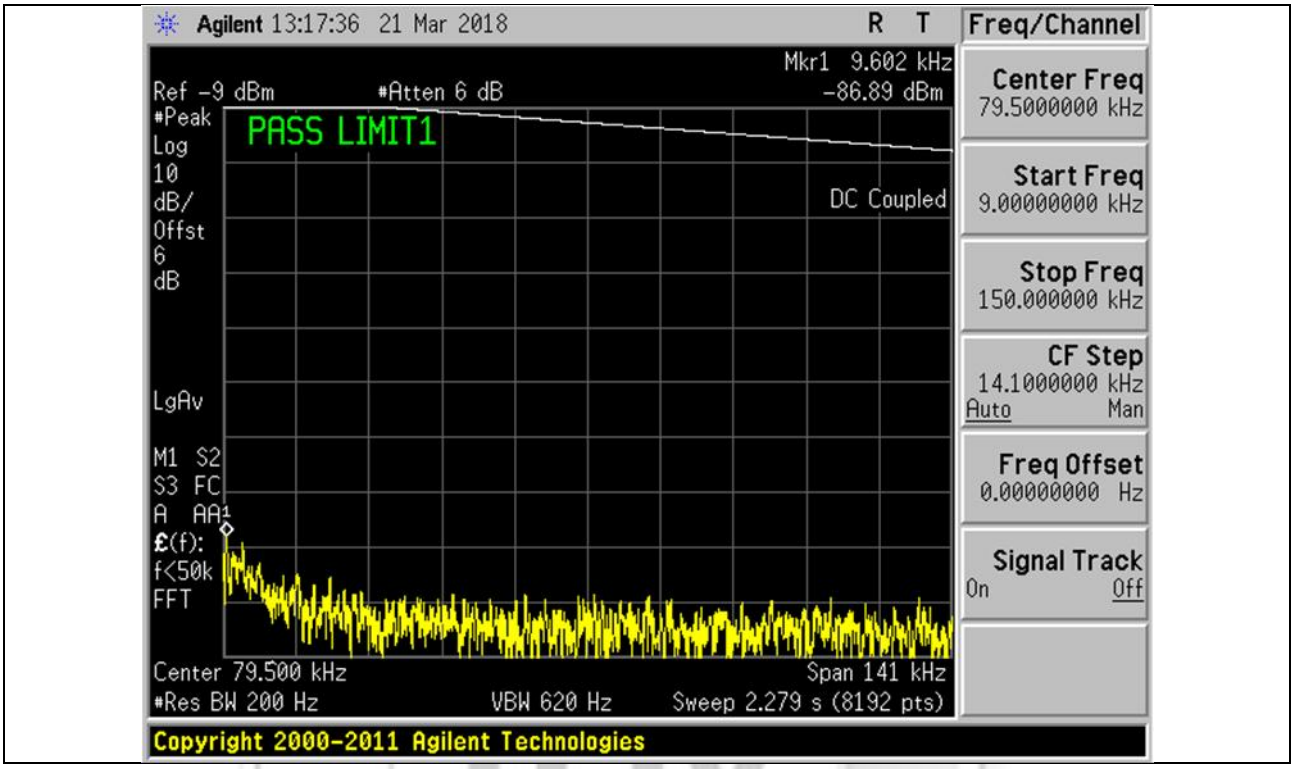
2.5.4 Test Results

Test Input Power	3Vdc	Temperature	24°C
Attached Plots	13 – 30 (Peak)	Relative Humidity	60%
	31 – 39 (Average)	Atmospheric Pressure	1030mbar
		Tested By	Chang Wai Kit

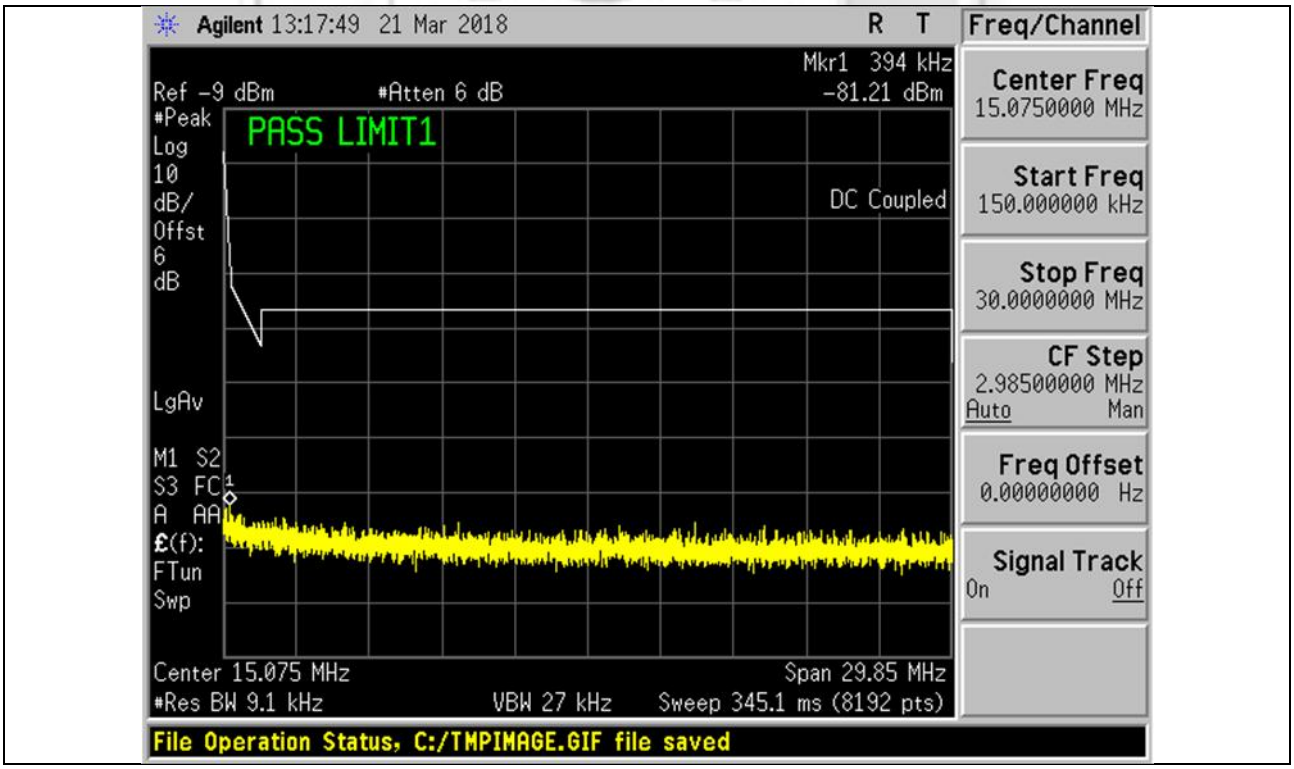
All spurious signals found were below the specified limit. Please refer to the attached plots.

PSB Singapore

RF Conducted Spurious Emissions (Restricted Bands) Plots – Peak



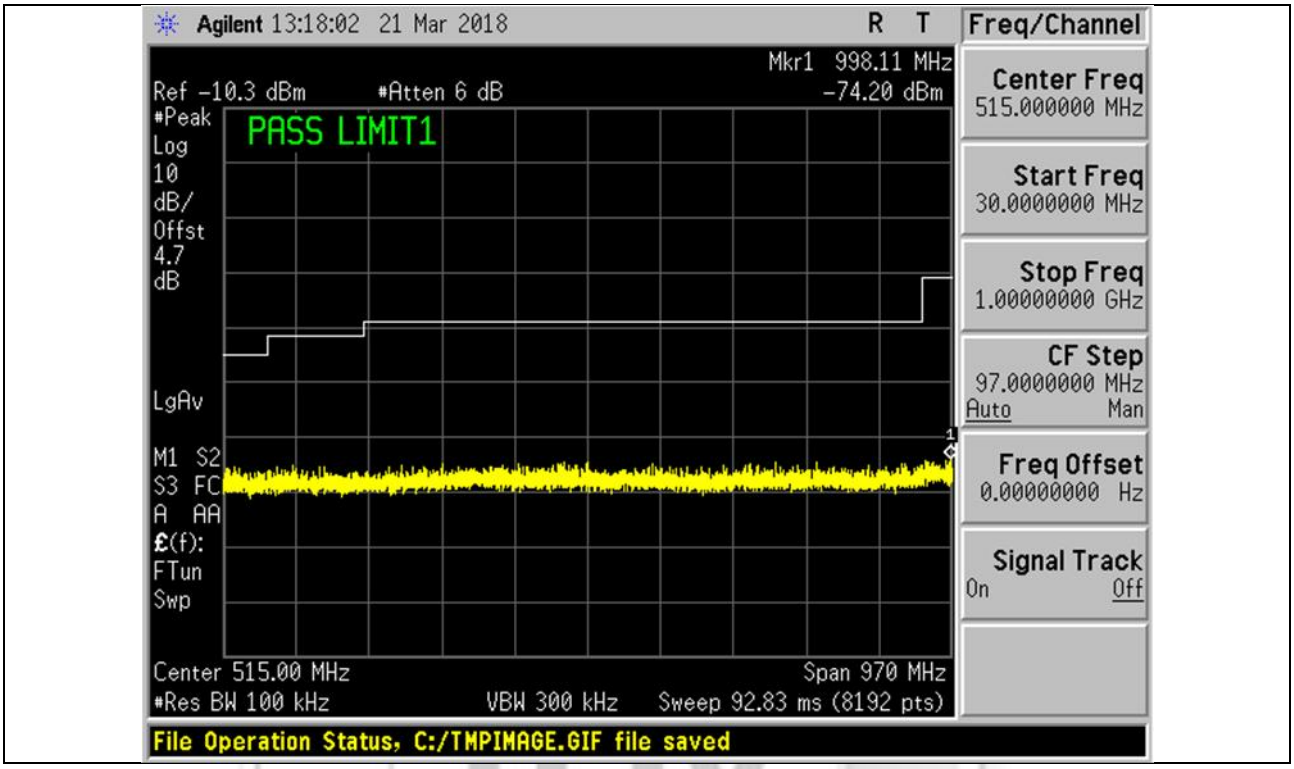
Plot 13 – Lower Channel



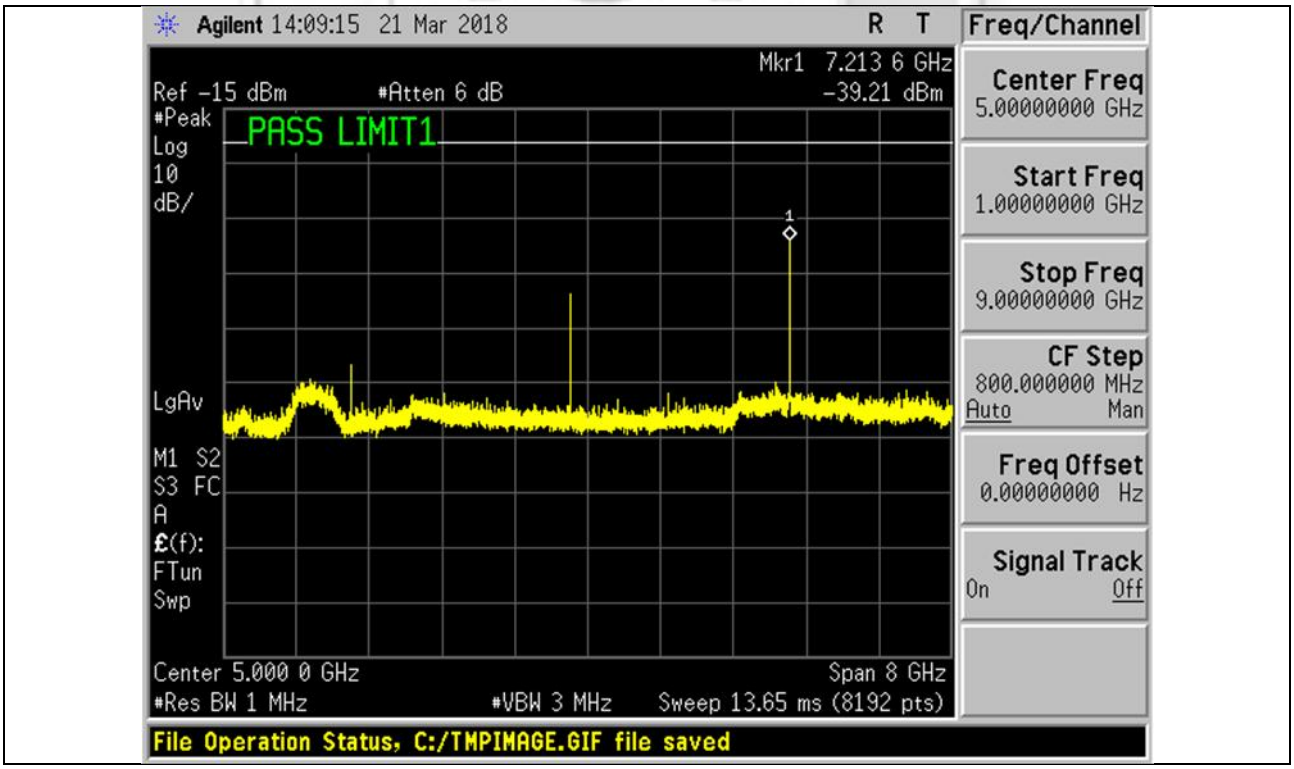
Plot 14 – Lower Channel

PSB Singapore

RF Conducted Spurious Emissions (Restricted Bands) Plots – Peak



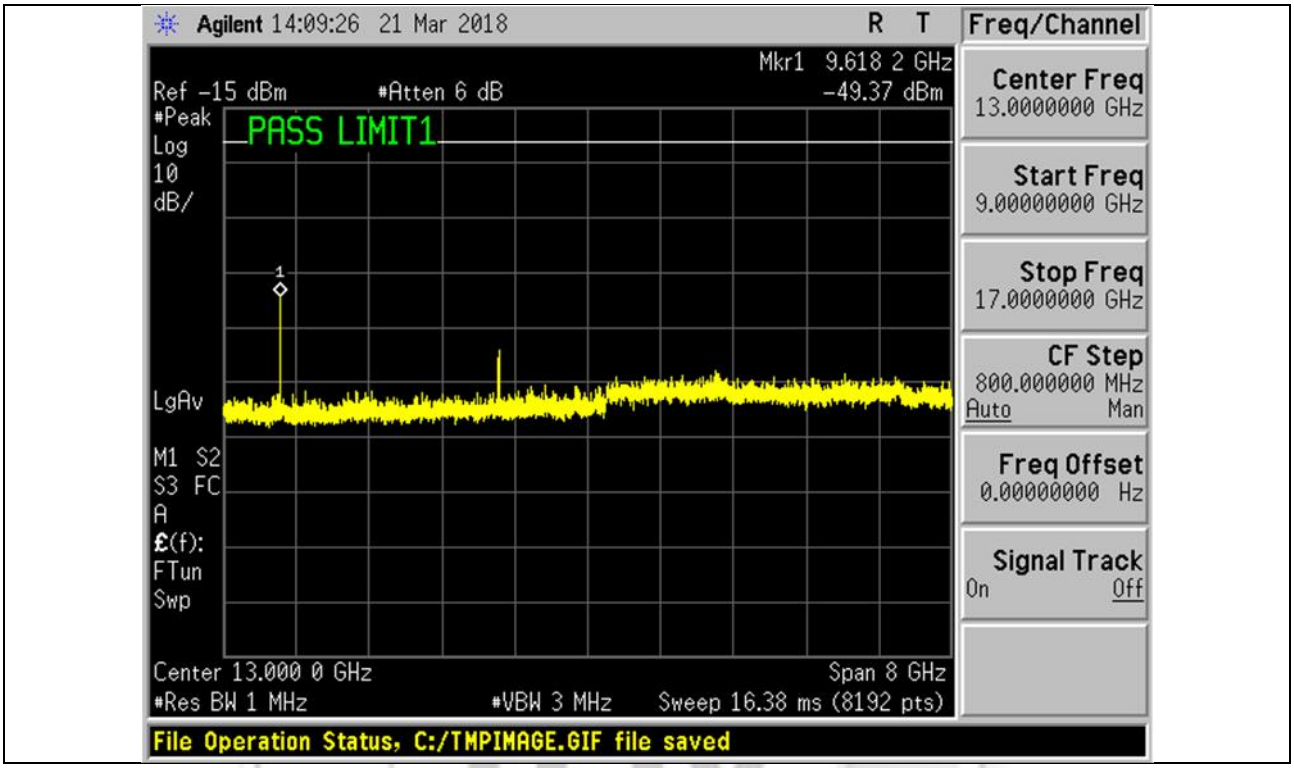
Plot 15 – Lower Channel



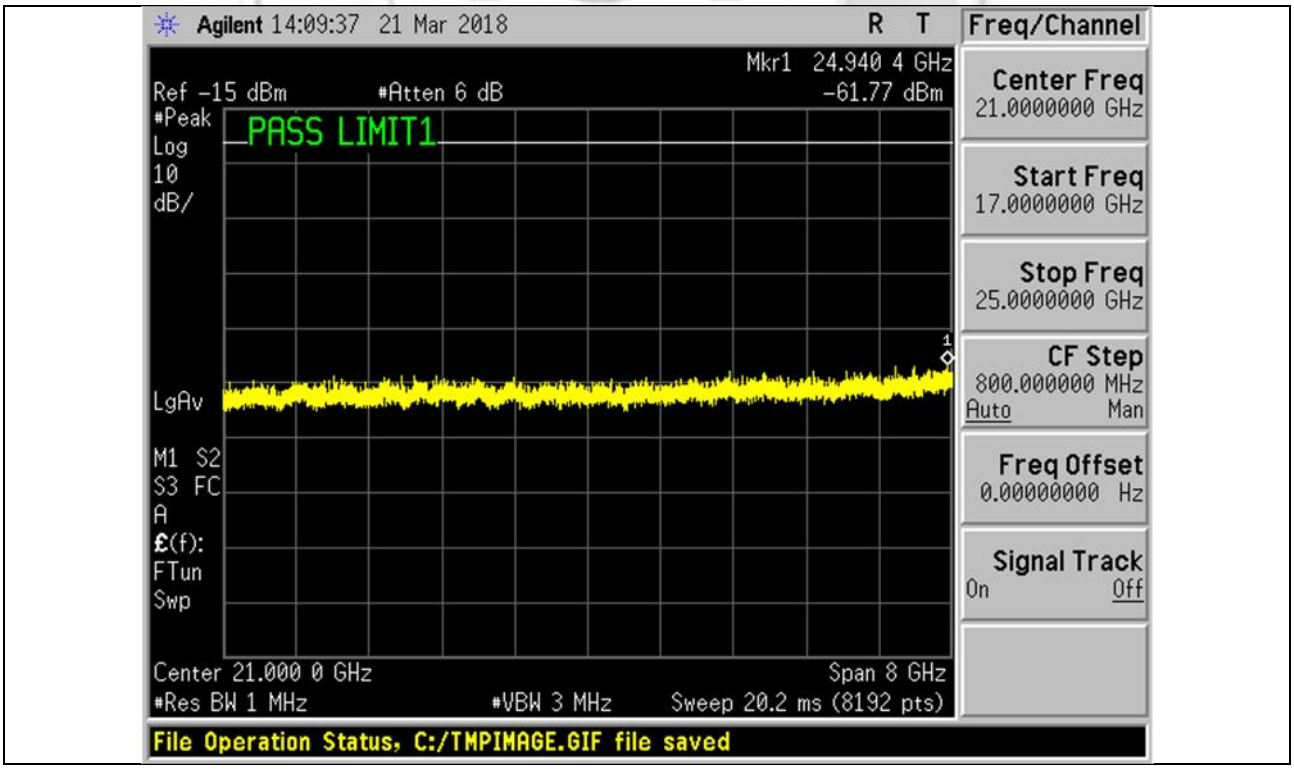
Plot 16 – Lower Channel

PSB Singapore

RF Conducted Spurious Emissions (Restricted Bands) Plots – Peak



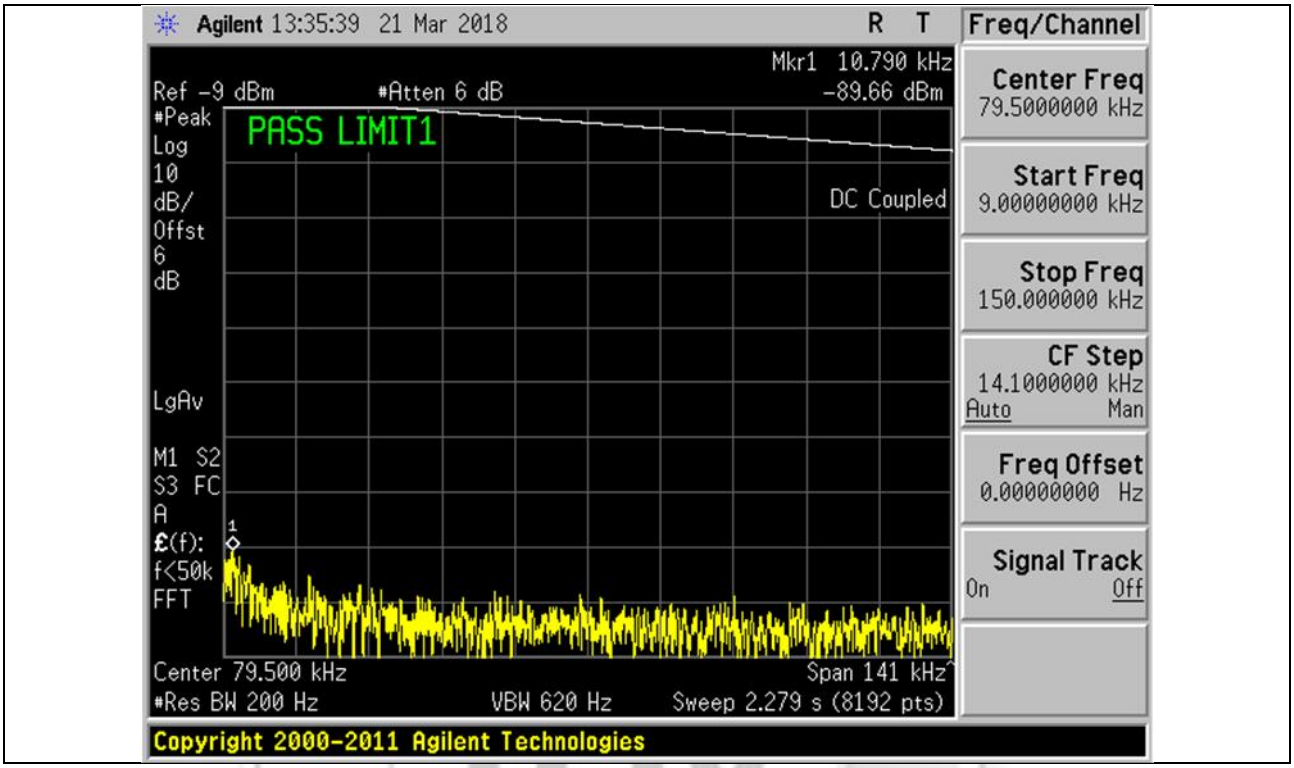
Plot 17 – Lower Channel



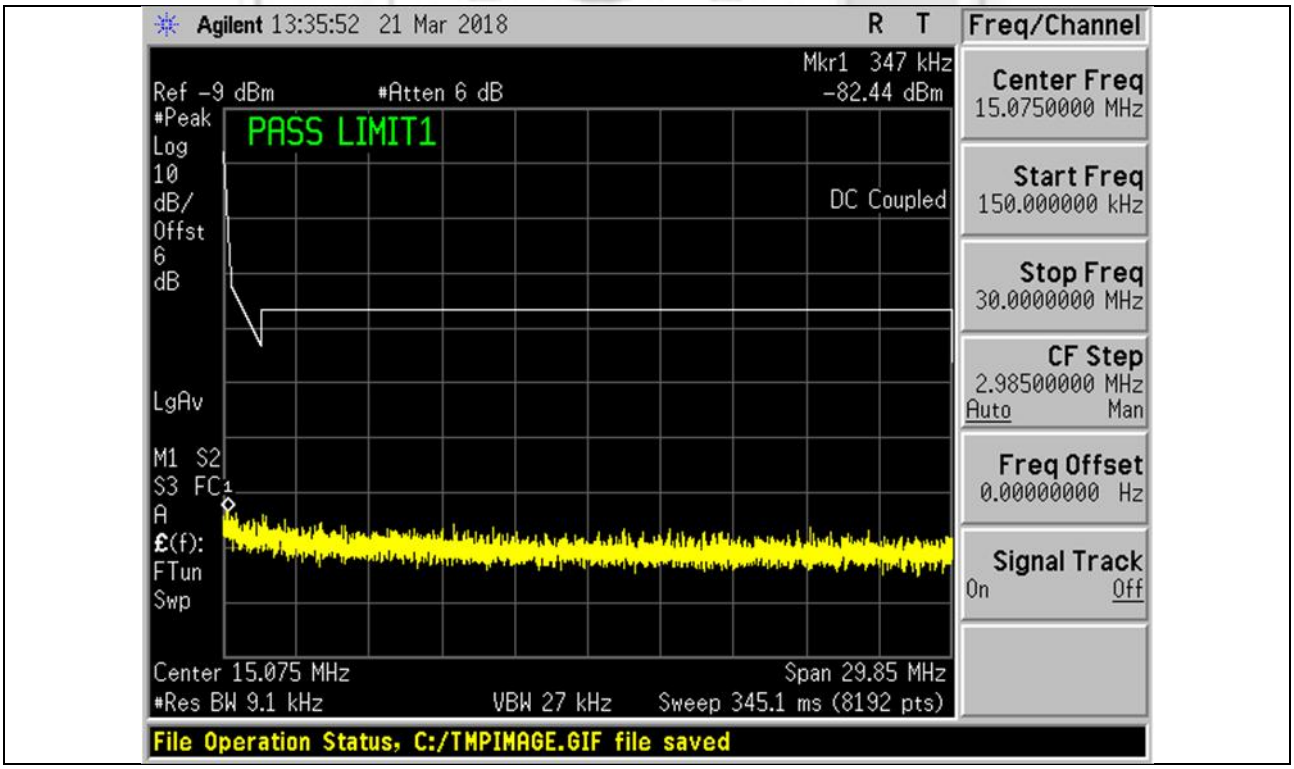
Plot 18 – Lower Channel

PSB Singapore

RF Conducted Spurious Emissions (Restricted Bands) Plots – Peak



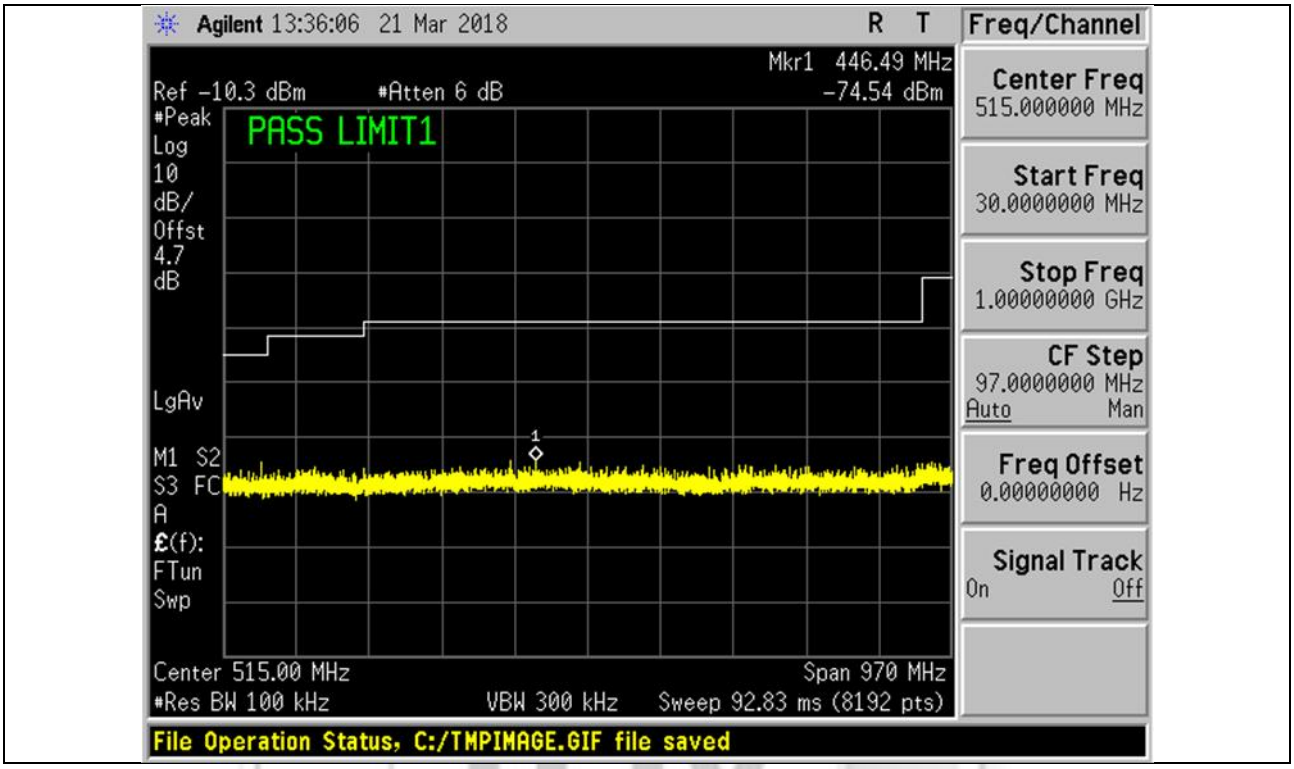
Plot 19 – Middle Channel



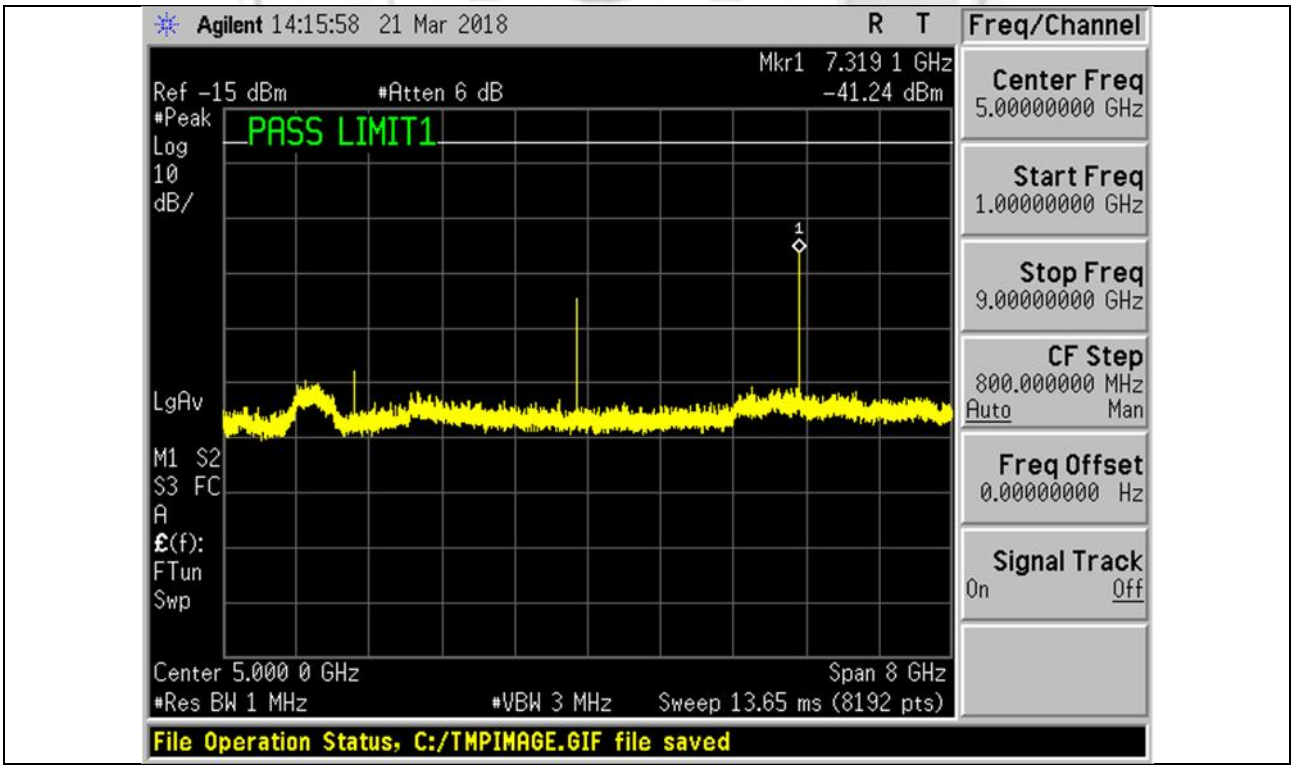
Plot 20 – Middle Channel

PSB Singapore

RF Conducted Spurious Emissions (Restricted Bands) Plots – Peak



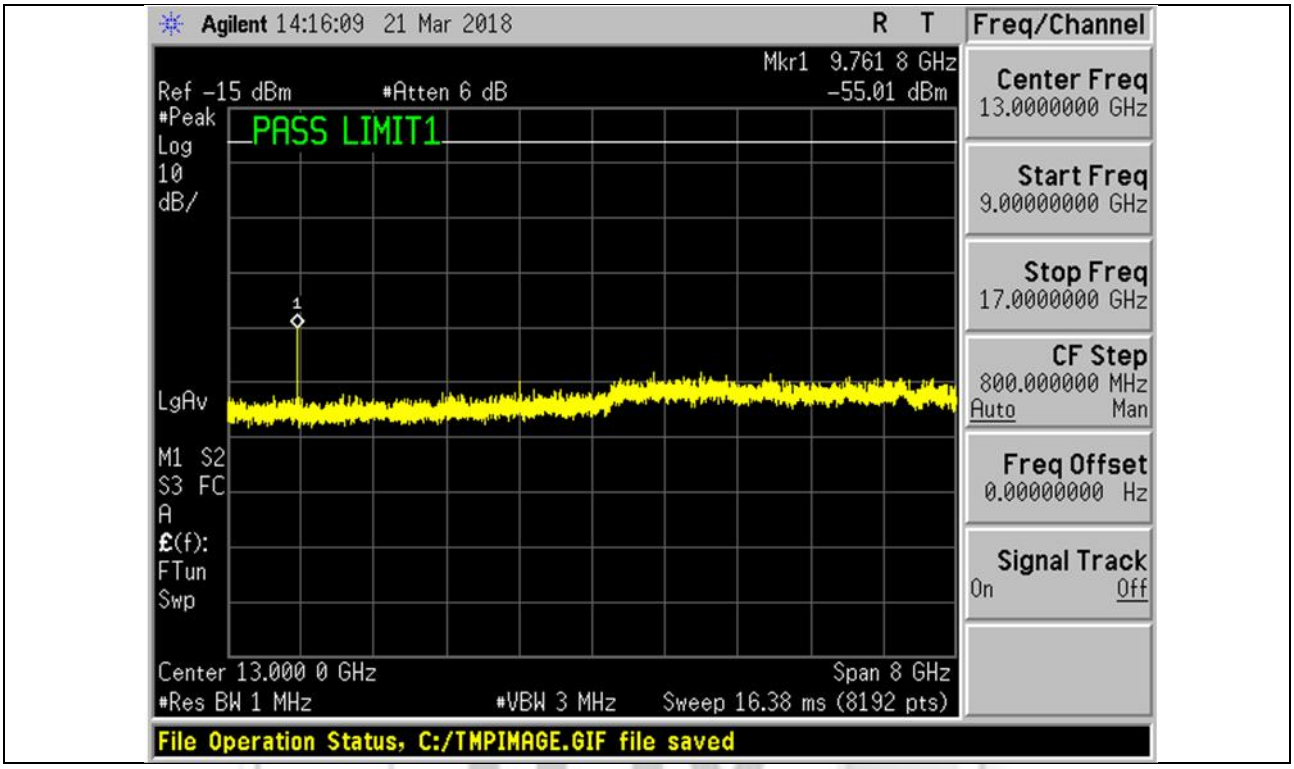
Plot 21 – Middle Channel



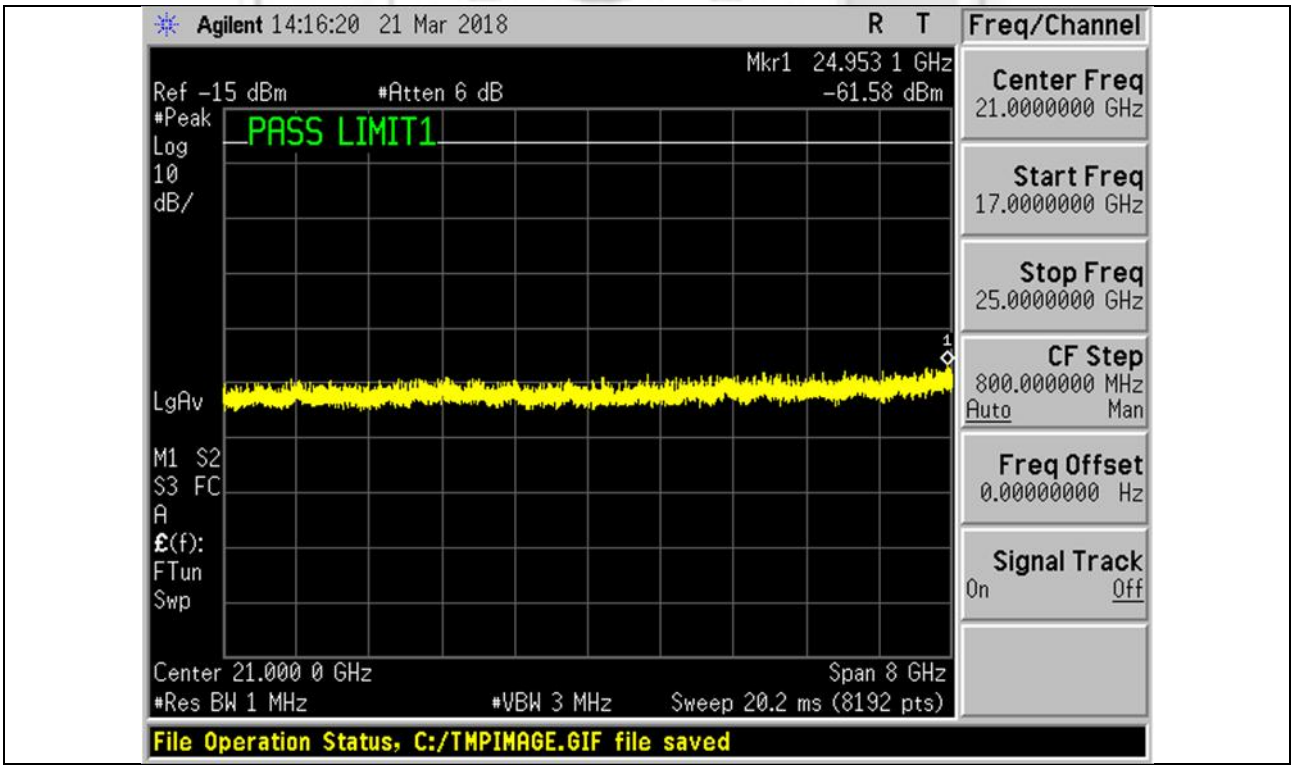
Plot 22 – Middle Channel

PSB Singapore

RF Conducted Spurious Emissions (Restricted Bands) Plots – Peak



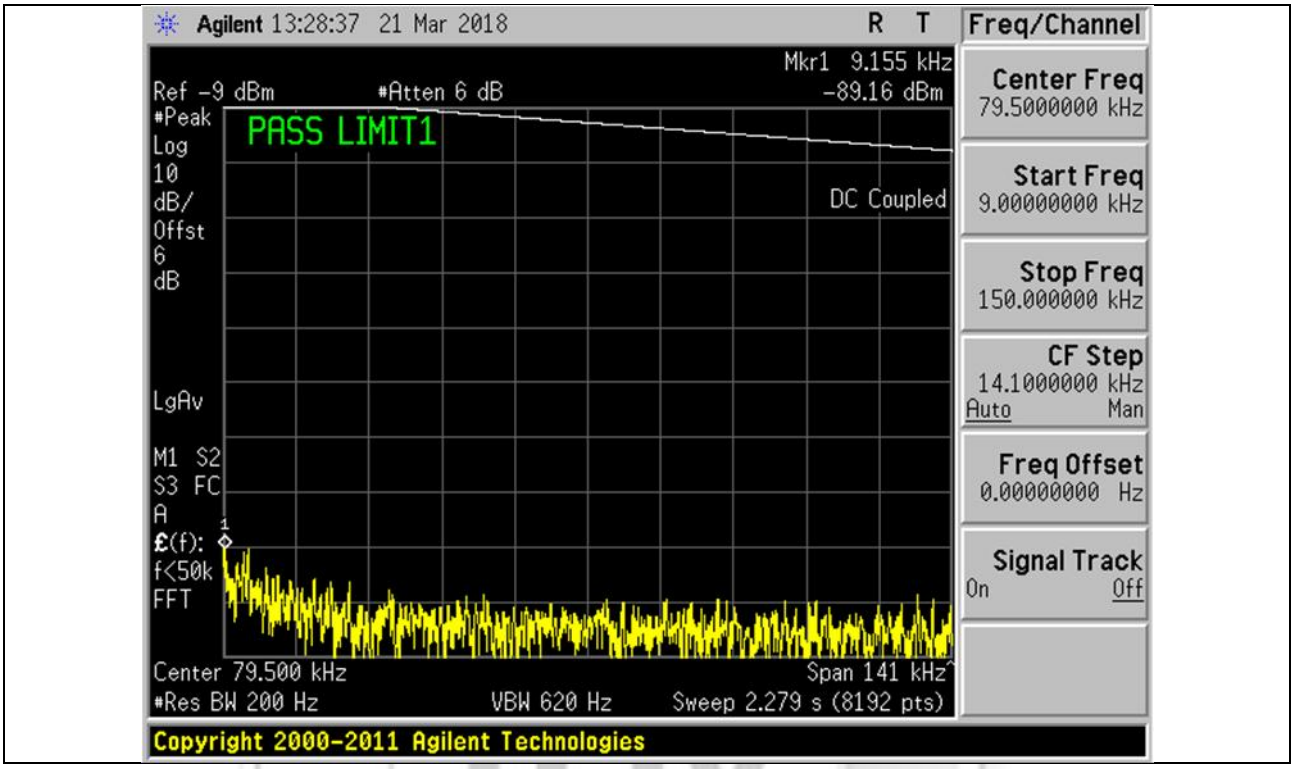
Plot 23 – Middle Channel



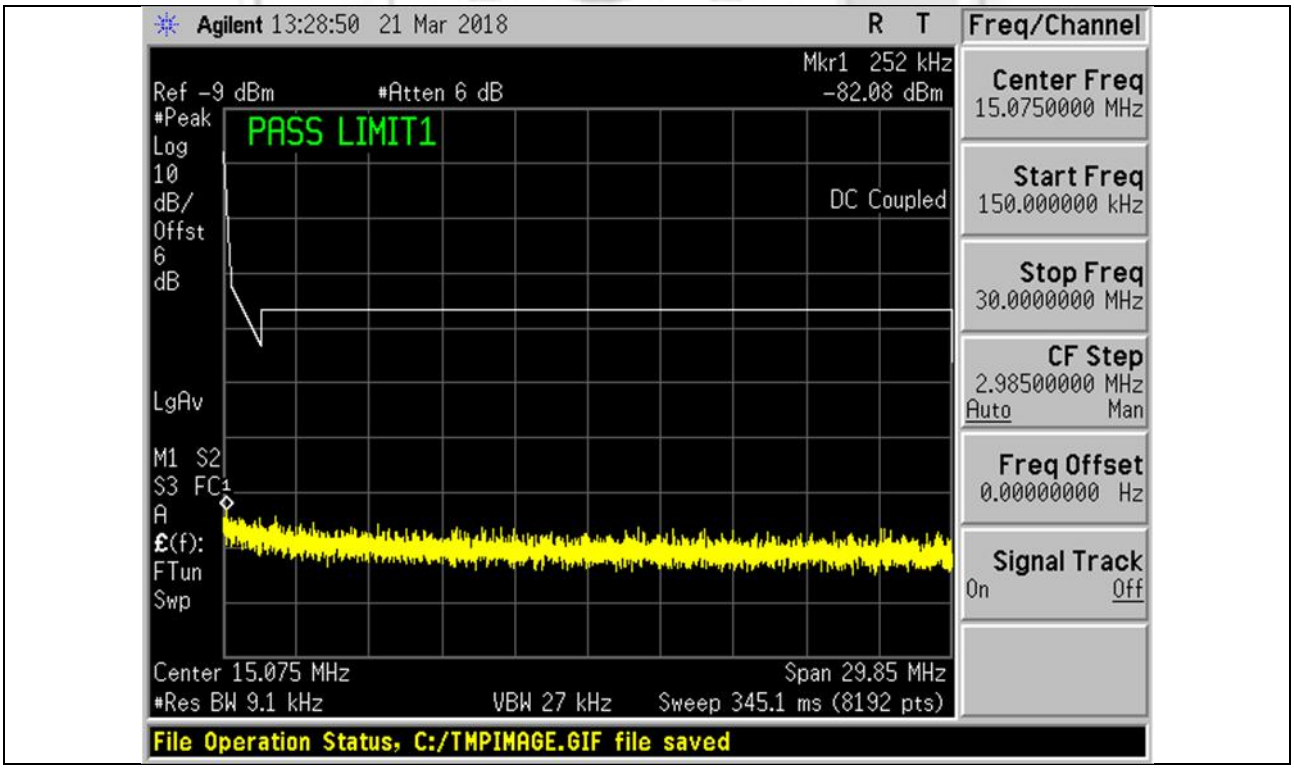
Plot 24 – Middle Channel

PSB Singapore

RF Conducted Spurious Emissions (Restricted Bands) Plots – Peak



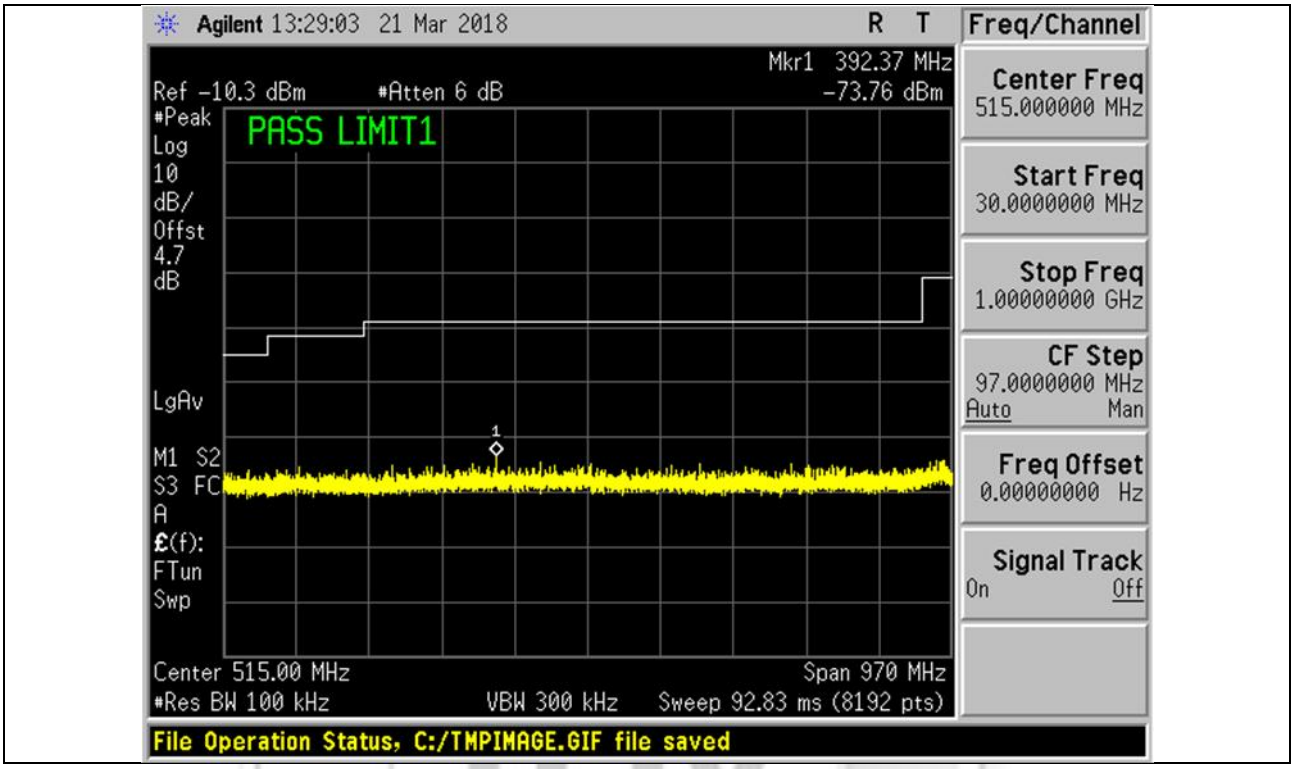
Plot 25 – Upper Channel



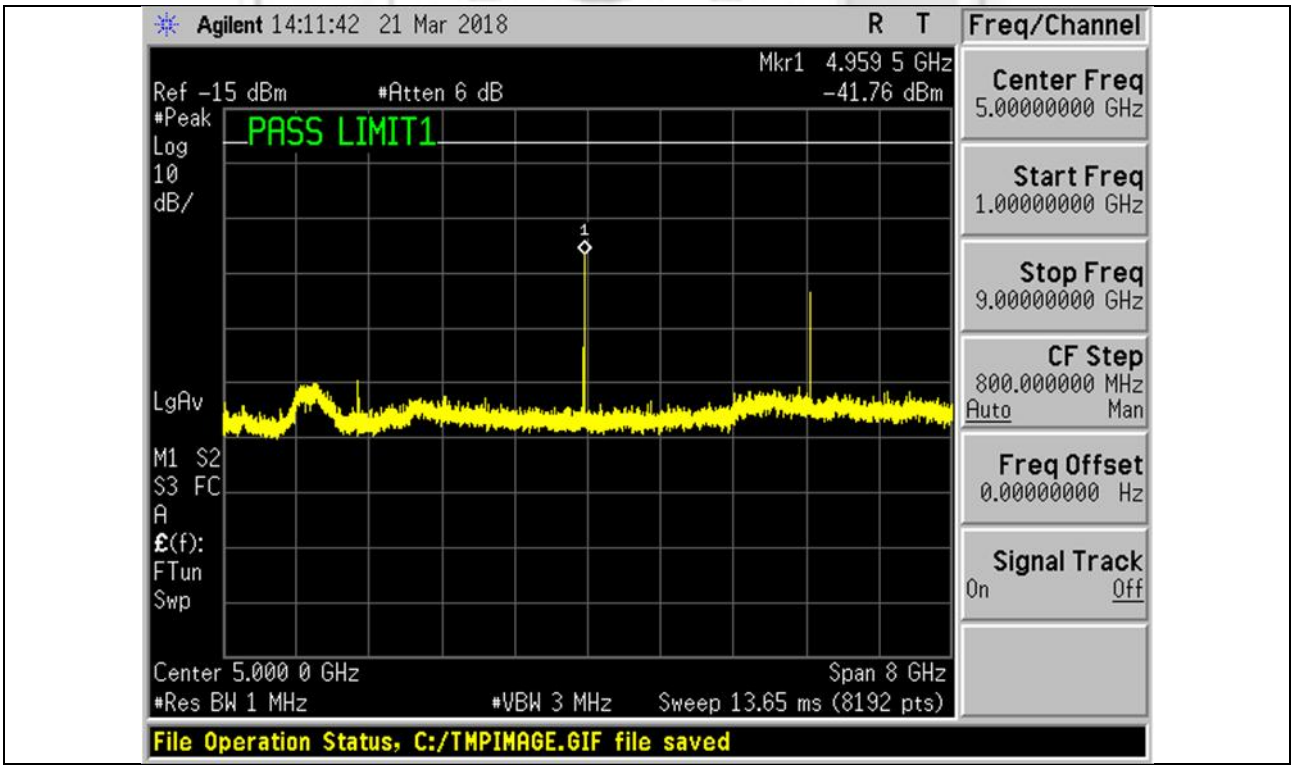
Plot 26 – Upper Channel

PSB Singapore

RF Conducted Spurious Emissions (Restricted Bands) Plots – Peak



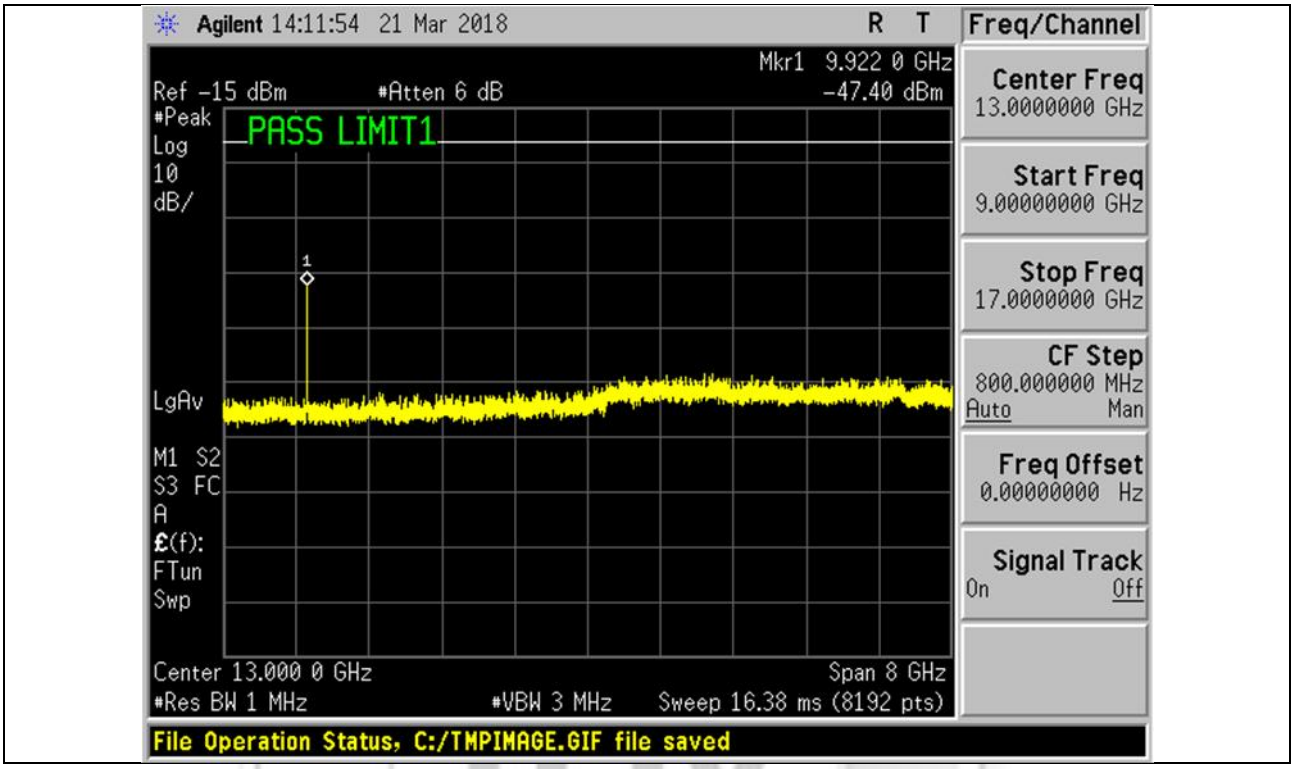
Plot 27 – Upper Channel



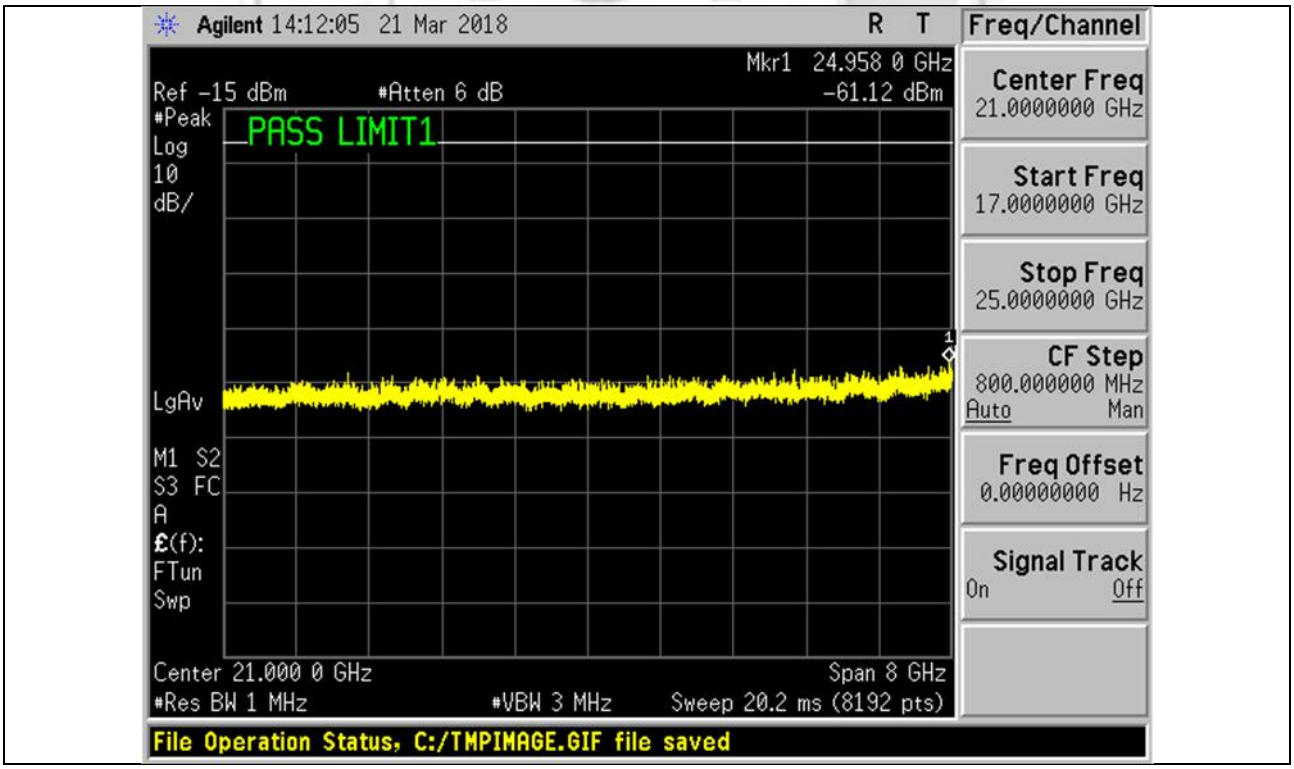
Plot 28 – Upper Channel

PSB Singapore

RF Conducted Spurious Emissions (Restricted Bands) Plots – Peak



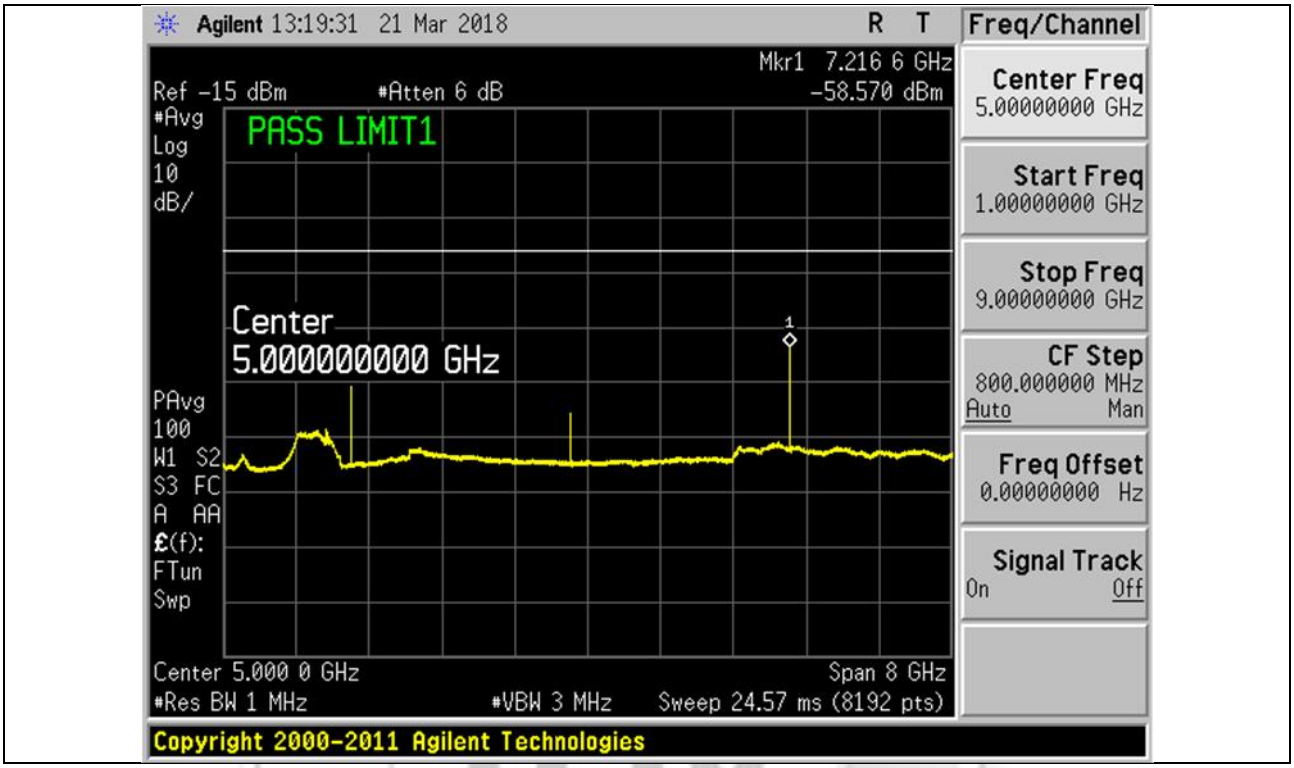
Plot 29 – Upper Channel



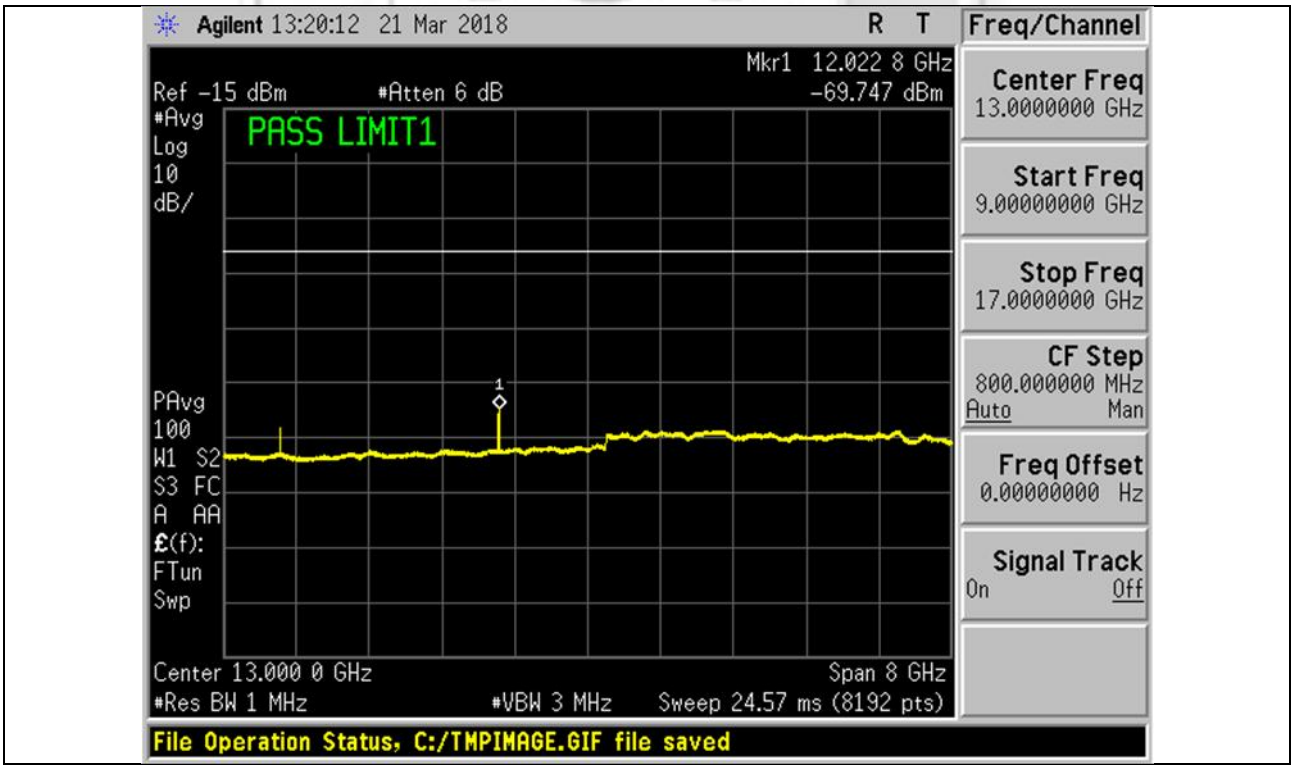
Plot 30 – Upper Channel

PSB Singapore

RF Conducted Spurious Emissions (Restricted Bands) Plots – Average



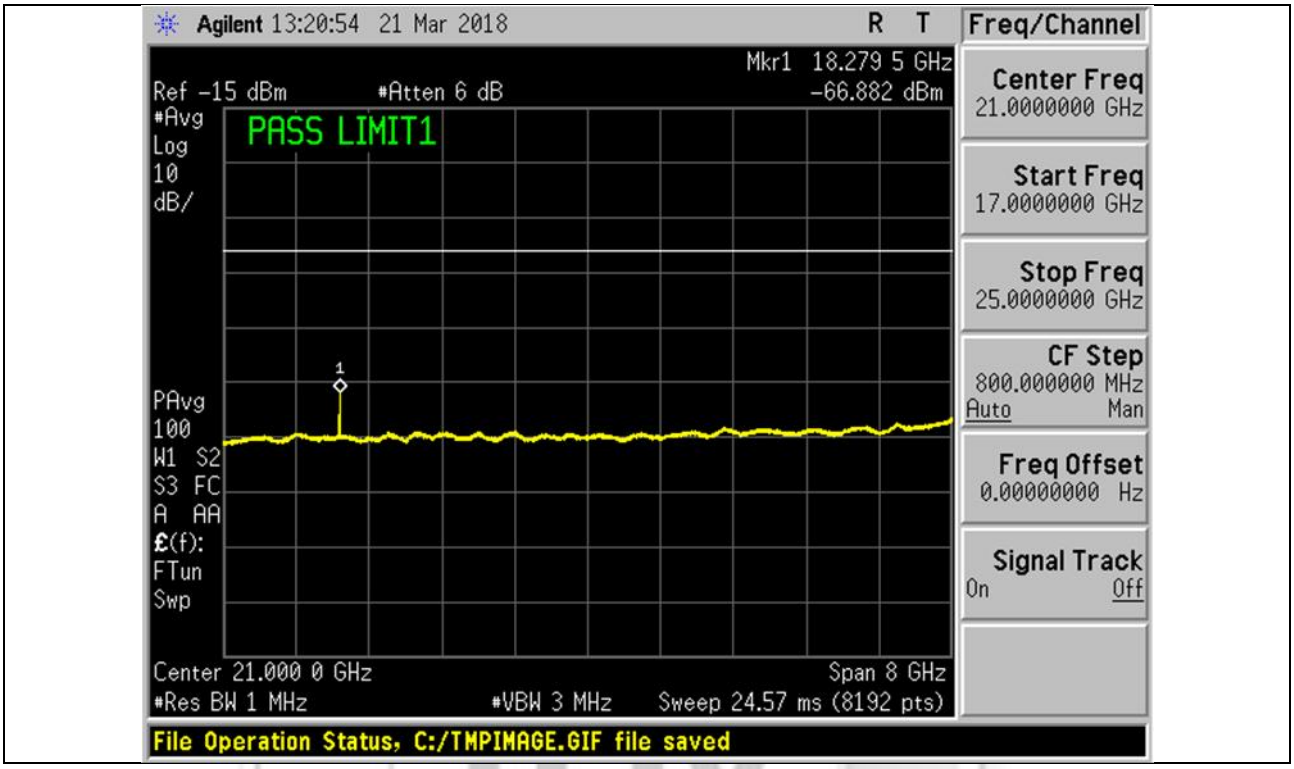
Plot 31 – Lower Channel



Plot 32 – Lower Channel

PSB Singapore

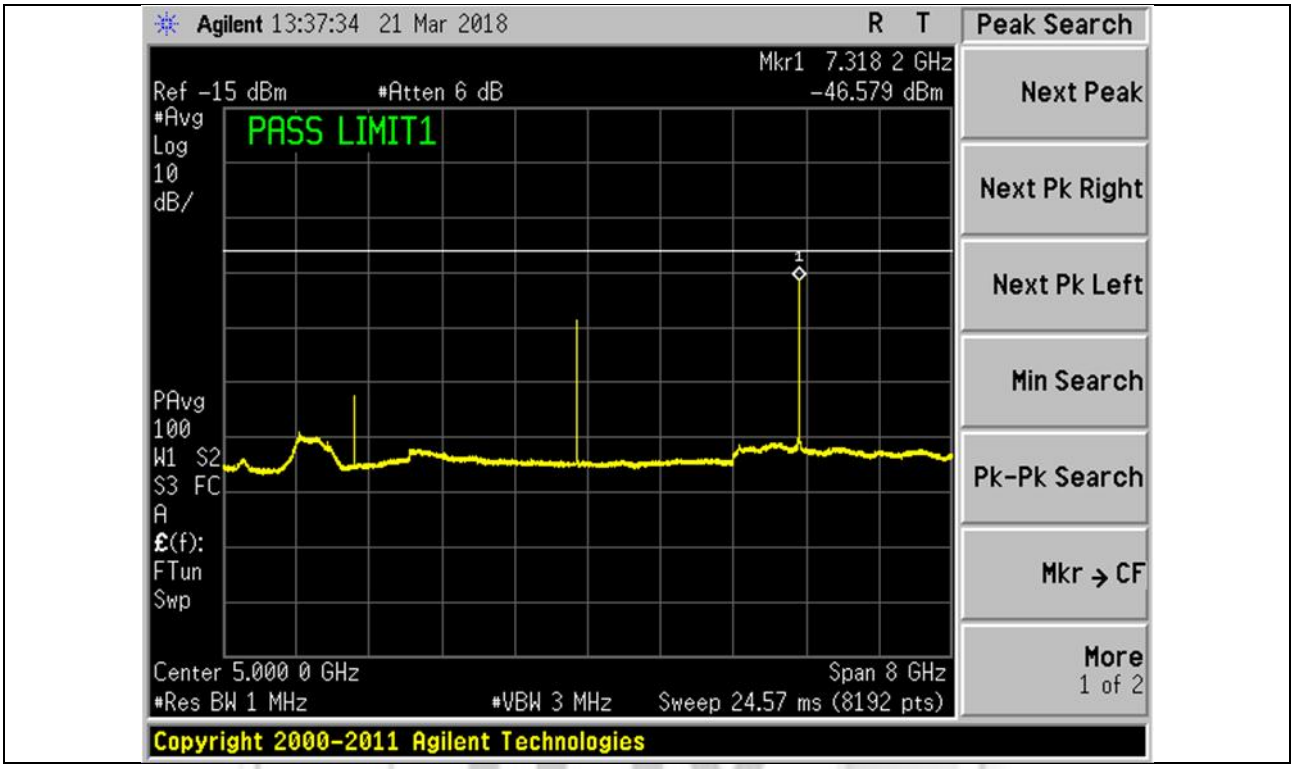
RF Conducted Spurious Emissions (Restricted Bands) Plots – Average



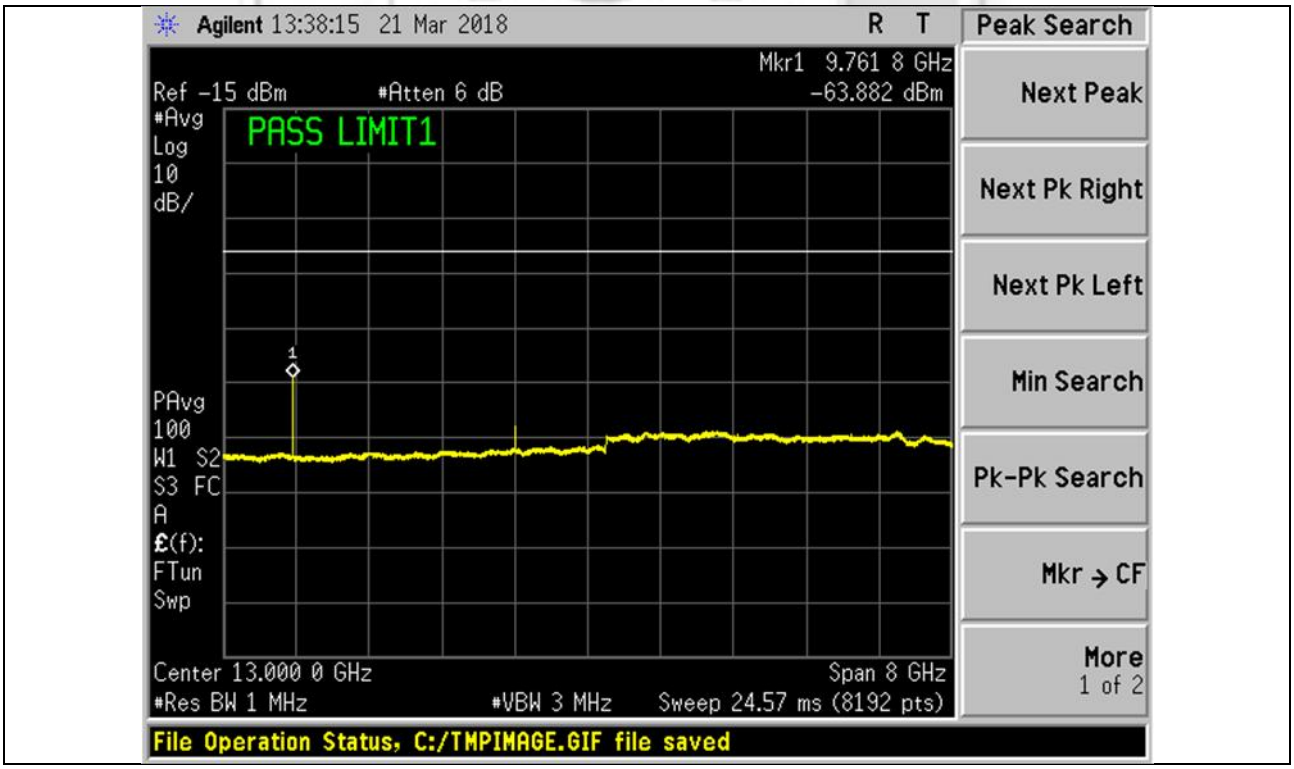
Plot 33 – Lower Channel

PSB Singapore

RF Conducted Spurious Emissions (Restricted Bands) Plots – Average



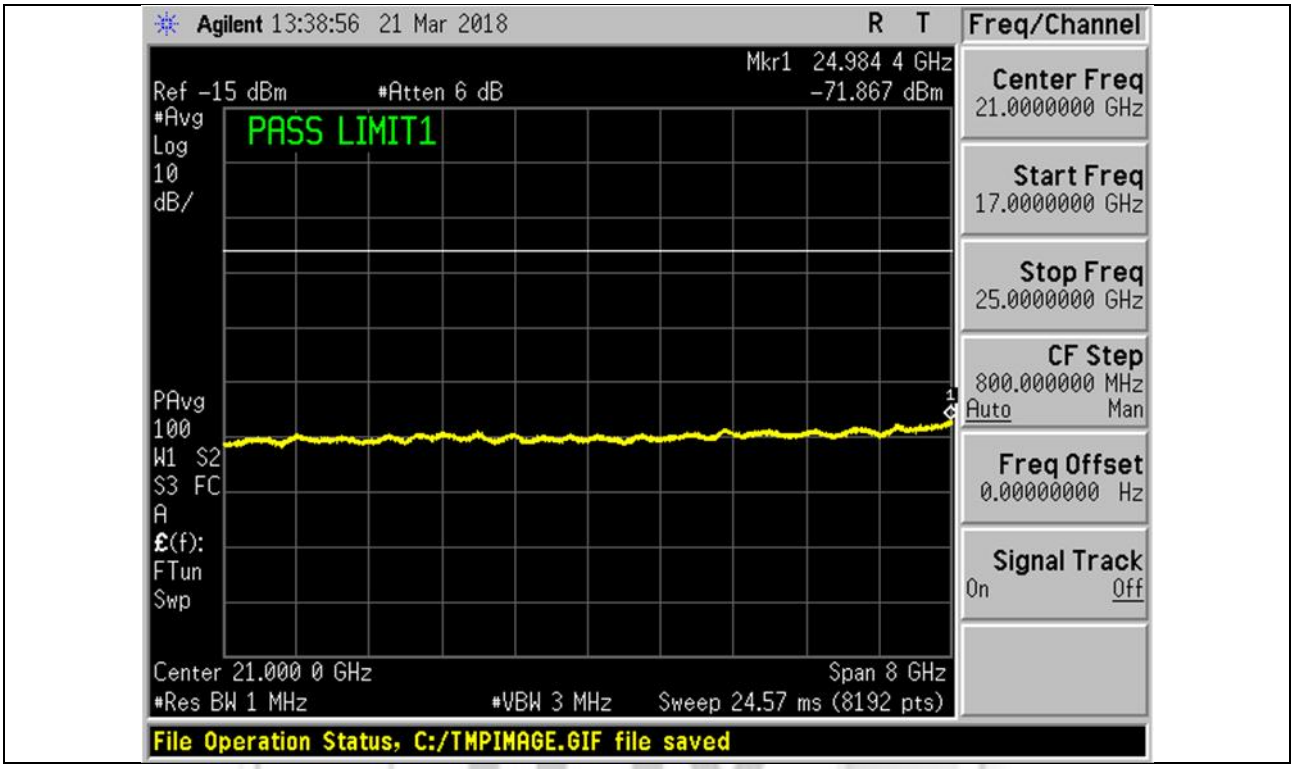
Plot 34 – Middle Channel



Plot 35 – Middle Channel

PSB Singapore

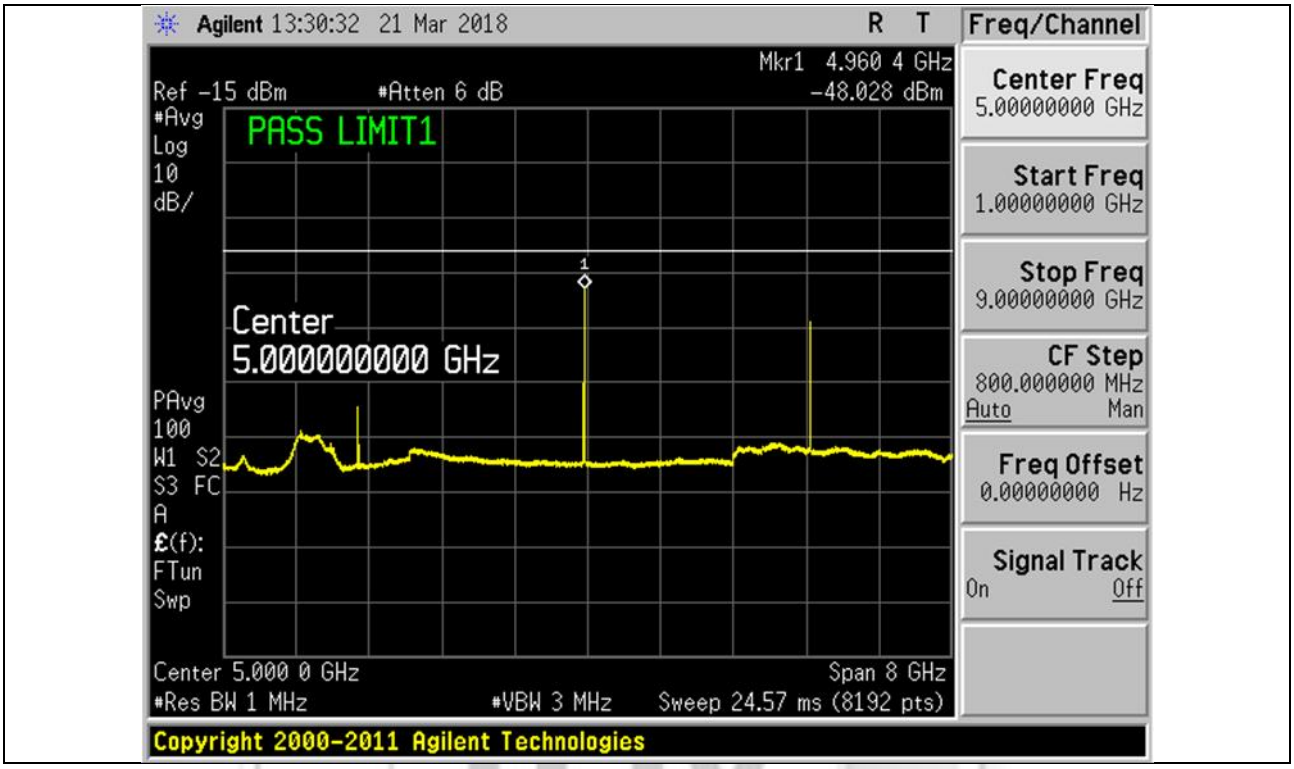
RF Conducted Spurious Emissions (Restricted Bands) Plots – Average



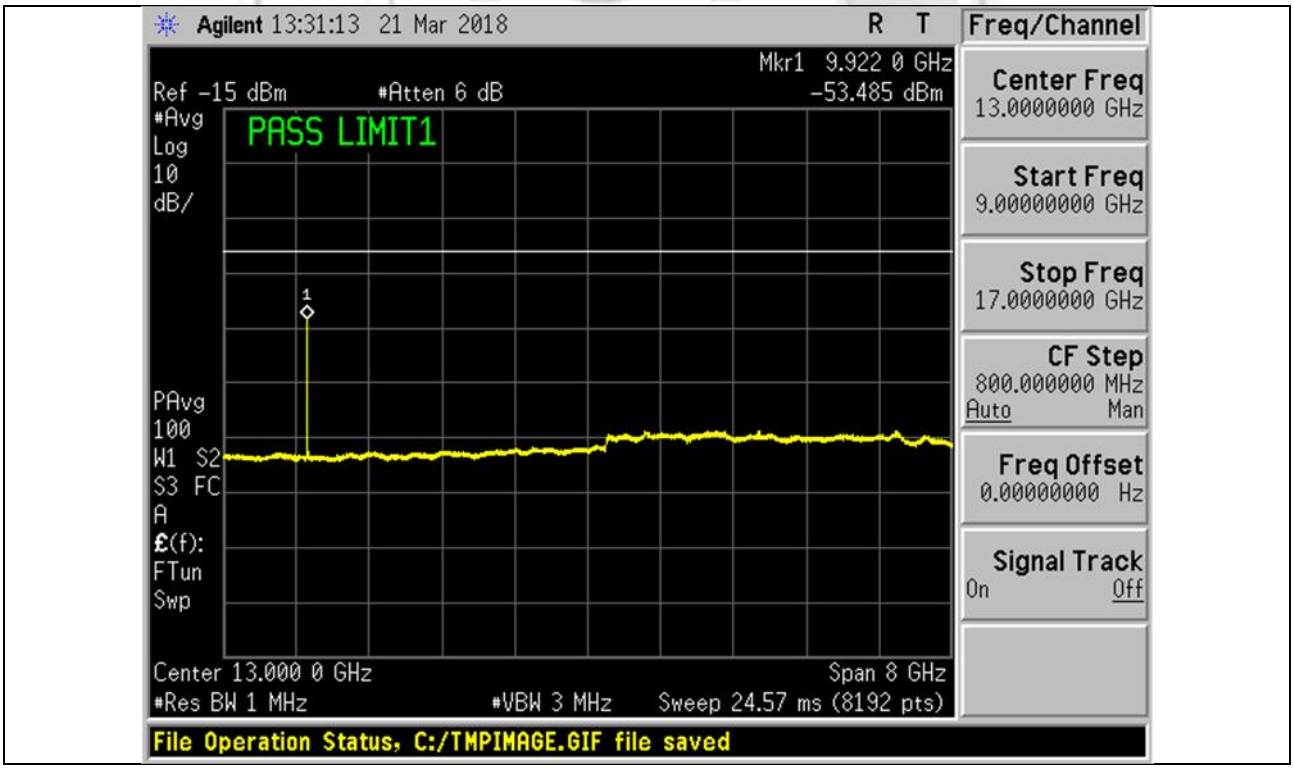
Plot 36 – Middle Channel

PSB Singapore

RF Conducted Spurious Emissions (Restricted Bands) Plots – Average



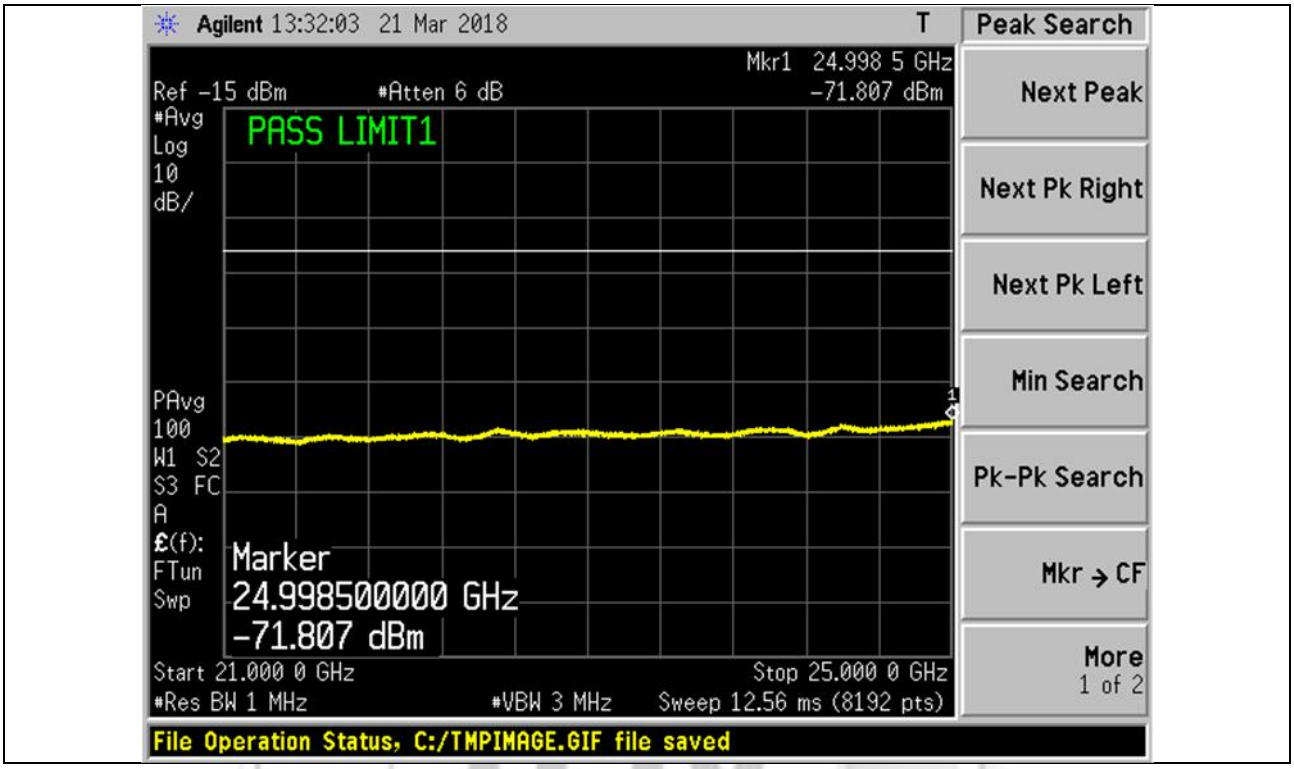
Plot 37 – Upper Channel



Plot 38 – Upper Channel

PSB Singapore

RF Conducted Spurious Emissions (Restricted Bands) Plots – Average



Plot 39 – Upper Channel

PSB Singapore

2.6 Band Edge Compliance (Conducted)

2.6.1 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.

2.6.2 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) and the video bandwidth (VBW) of the spectrum analyser were respectively set to 100kHz and 300kHz.

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

2.6.3 Test Method

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.

2.6.3.2 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).

2.6.3.3 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.

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

2.6.3.5 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.

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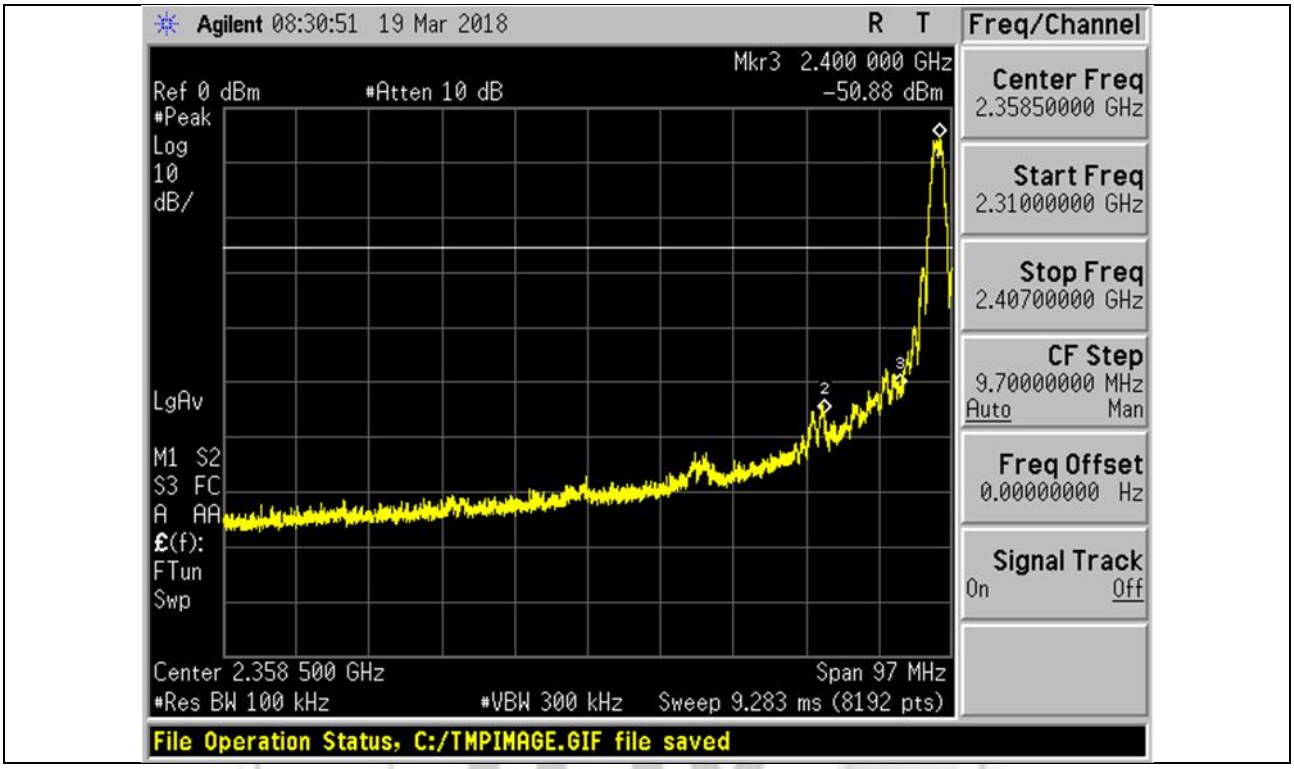
2.6.4 Test Results

Test Input Power	3Vdc	Temperature	24°C
Attached Plots	40 – 41	Relative Humidity	60%
		Atmospheric Pressure	1030mbar
		Tested By	Chang Wai Kit

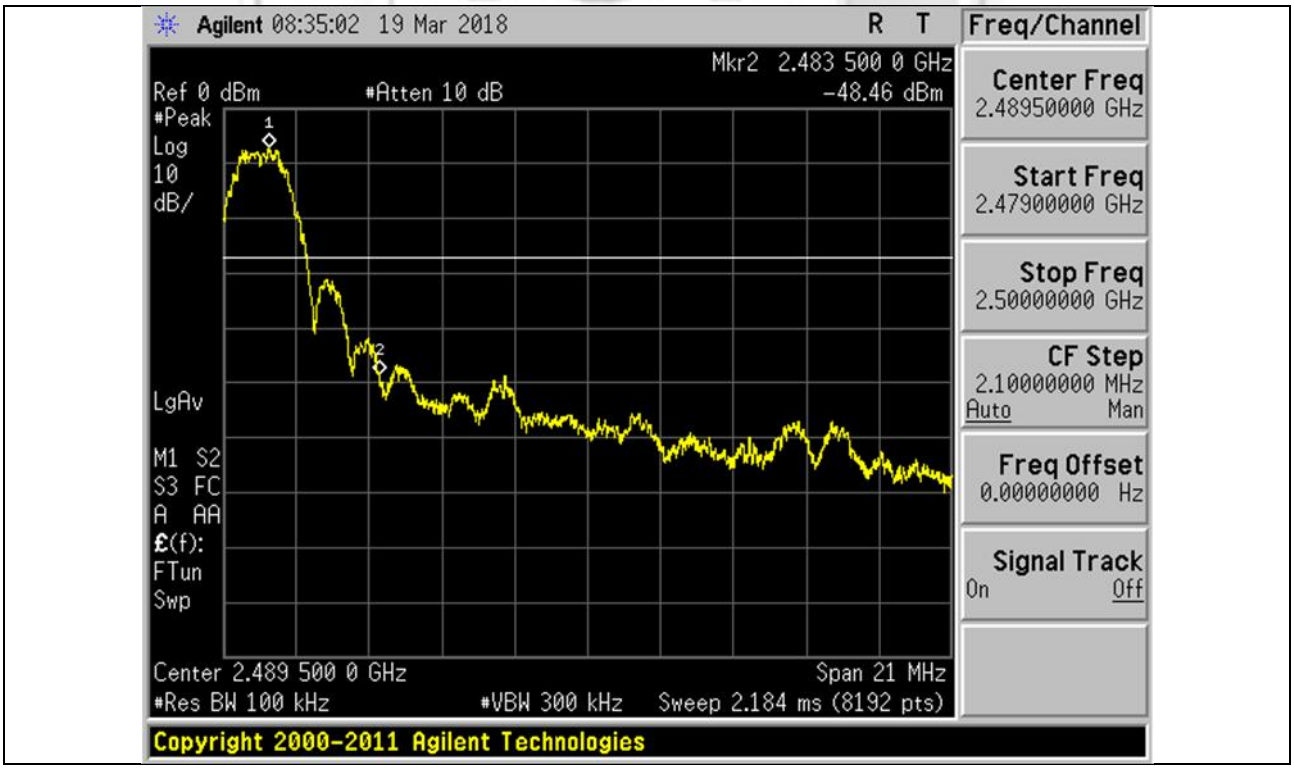
No significant signal was found and they were below the specified limit.

PSB Singapore

Band Edge Compliance (Conducted) Plots



Plot 40 – Lower Band Edge at 2.4000GHz



Plot 41 – Upper Band Edge at 2.4835GHz

PSB Singapore

2.7 Band Edge Compliance (Radiated)

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 the desired power. In addition, radiated emissions which fall in the restricted bands shall comply to the radiated emission limits specified in 15.209.

2.7.2 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 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

2.7.2.4 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.

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.

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2.7.4 Test Results

Test Input Power	3Vdc	Temperature	24ºC
Attached Plots	42 – 47	Relative Humidity	60%
		Atmospheric Pressure	1030mbar
		Tested By	Li Chelmin

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

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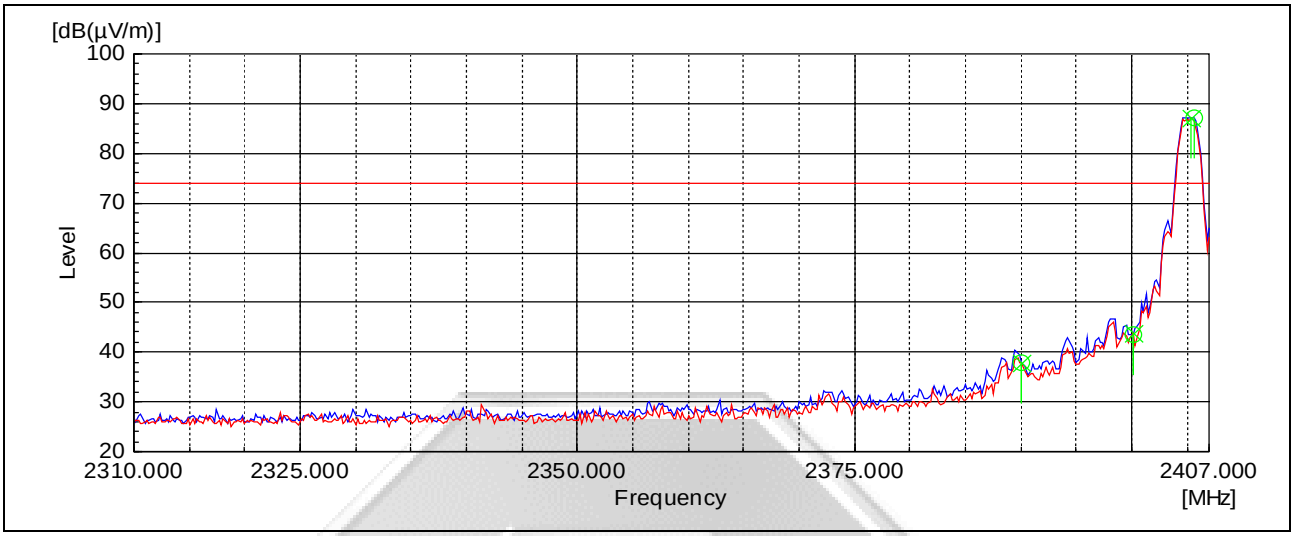
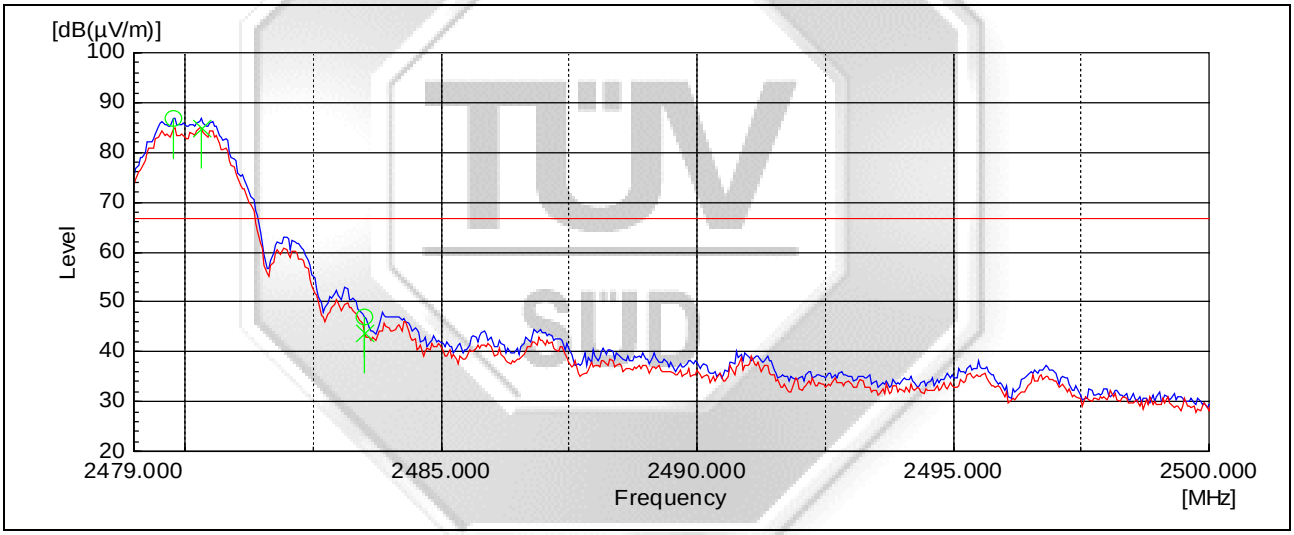
Band Edge Compliance (Radiated) Plots (20dB Delta from Carrier at Band Edge)



Plot 42 – Lower Band Edge at 2.4000GHz



Plot 43 – Upper Band Edge at 2.4835GHz

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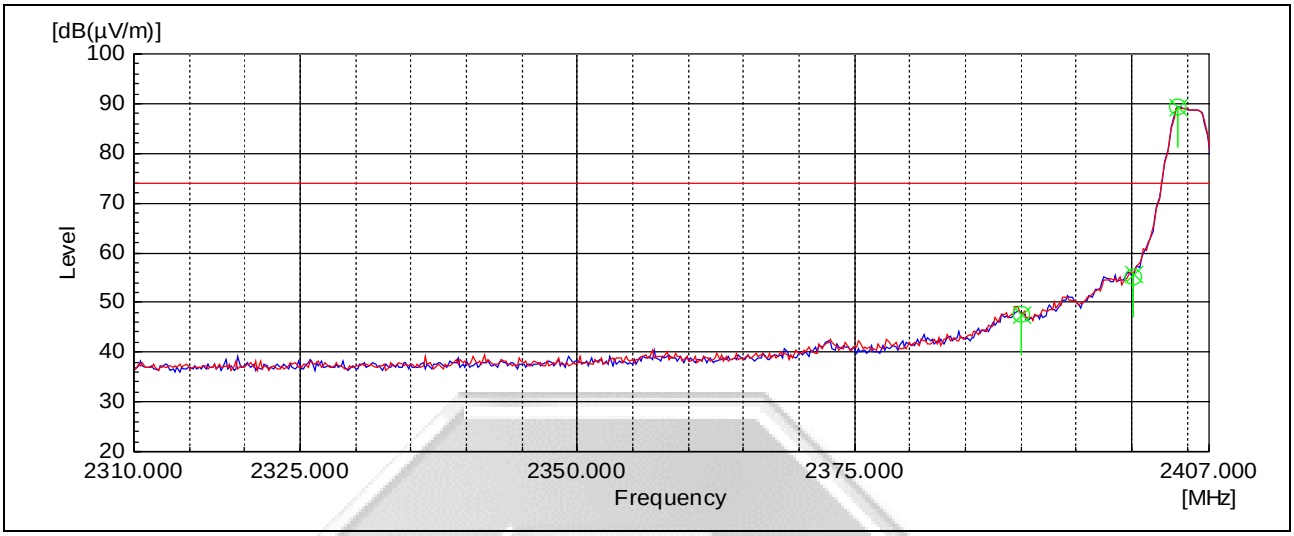
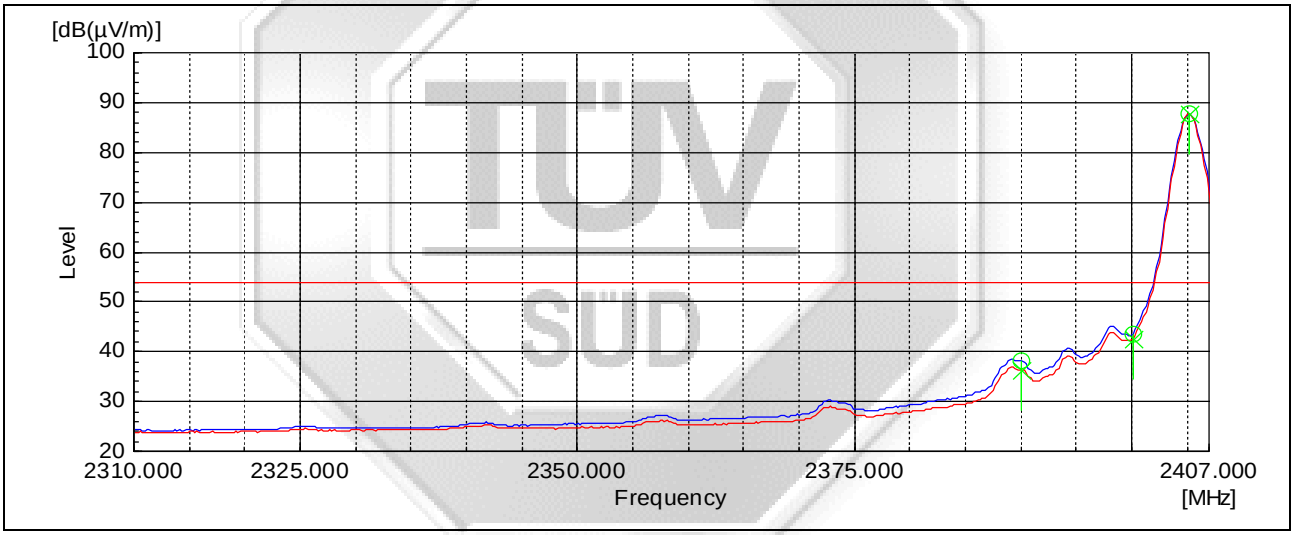
Band Edge Compliance (Radiated) Plots (Restricted Band)



Plot 44 – Peak Plot at Lower Band Edge at 2.4000GHz



Plot 45 – Average Plot at Lower Band Edge at 2.4000GHz

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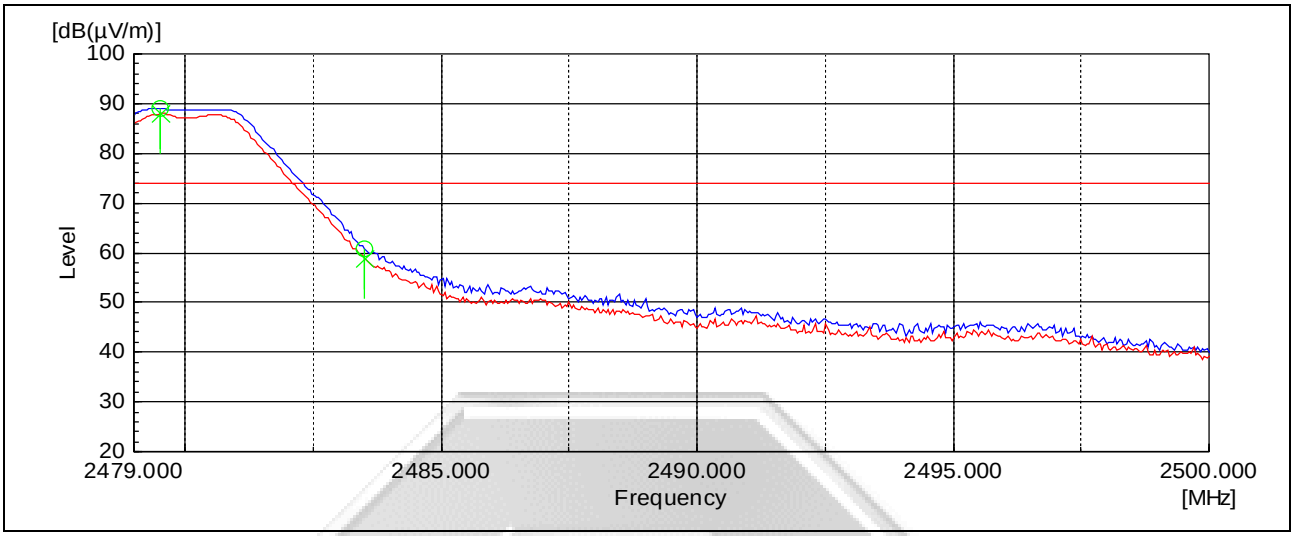
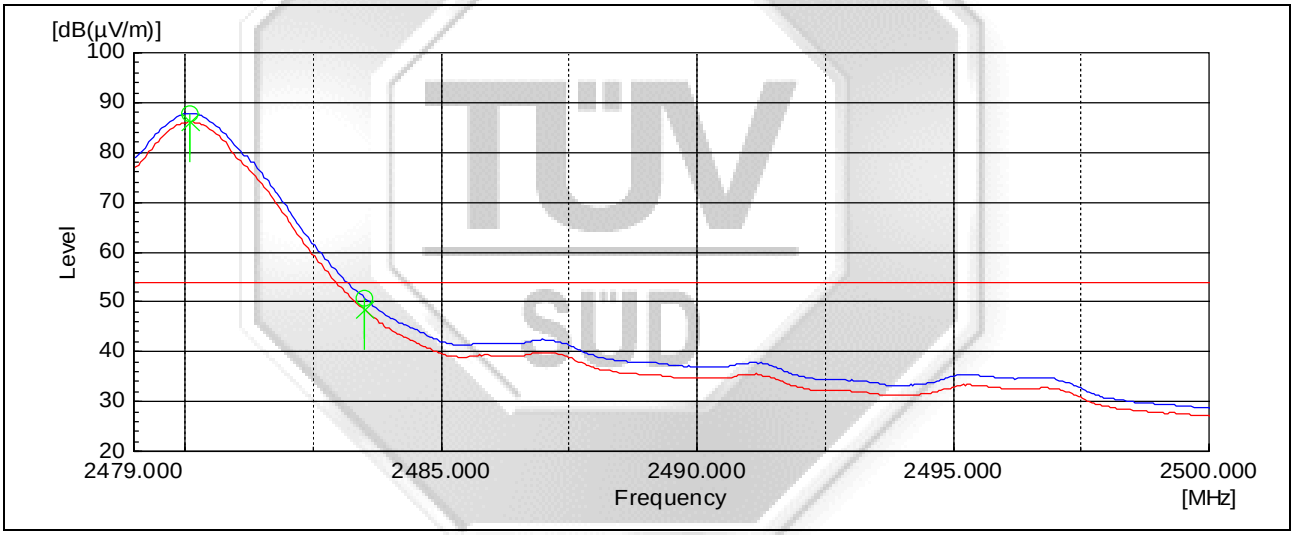
Band Edge Compliance (Radiated) Plots (Restricted Band)



Plot 46 – Peak Plot at Upper Band Edge at 2.4835GHz



Plot 47 – Average Plot at Upper Band Edge at 2.4835GHz

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2.8 Peak Power Spectral Density

2.8.1 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.

2.8.2 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 RF antenna connector was connected to the spectrum via a low-loss coaxial cable.

2.8.2.4 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

2.8.2.5 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 at lower channel.

2.8.3.2 The peak of the transmitting frequency was detected with the marker peak function of the spectrum analyser.

2.8.3.3 The peak power density of the transmitting frequency was plotted and recorded.

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

2.8.3.5 The measurement was repeated with the transmitting frequency was set to middle channel and upper channel respectively.

2.8.4 Test Results

Test Input Power	3Vdc	Temperature	24ºC
Attached Plots	48 – 50	Relative Humidity	60%
		Atmospheric Pressure	1030mbar
		Tested By	Chang Wai Kit

Channel	Channel Frequency (GHz)	Peak Power Spectral Density (mW) *See Note 1	Limit (mW)
Lower	2.405	0.017	6.3
Middle	2.440	0.013	6.3
Upper	2.480	0.013	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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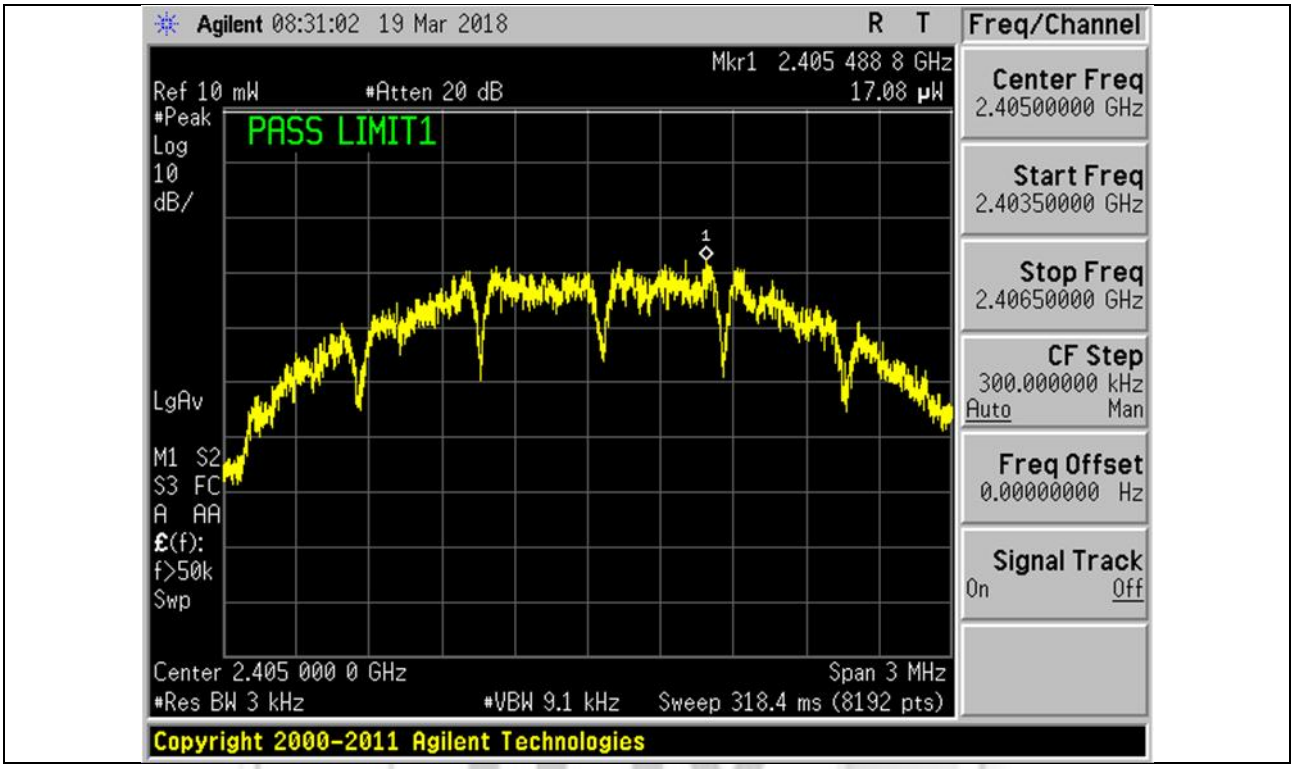
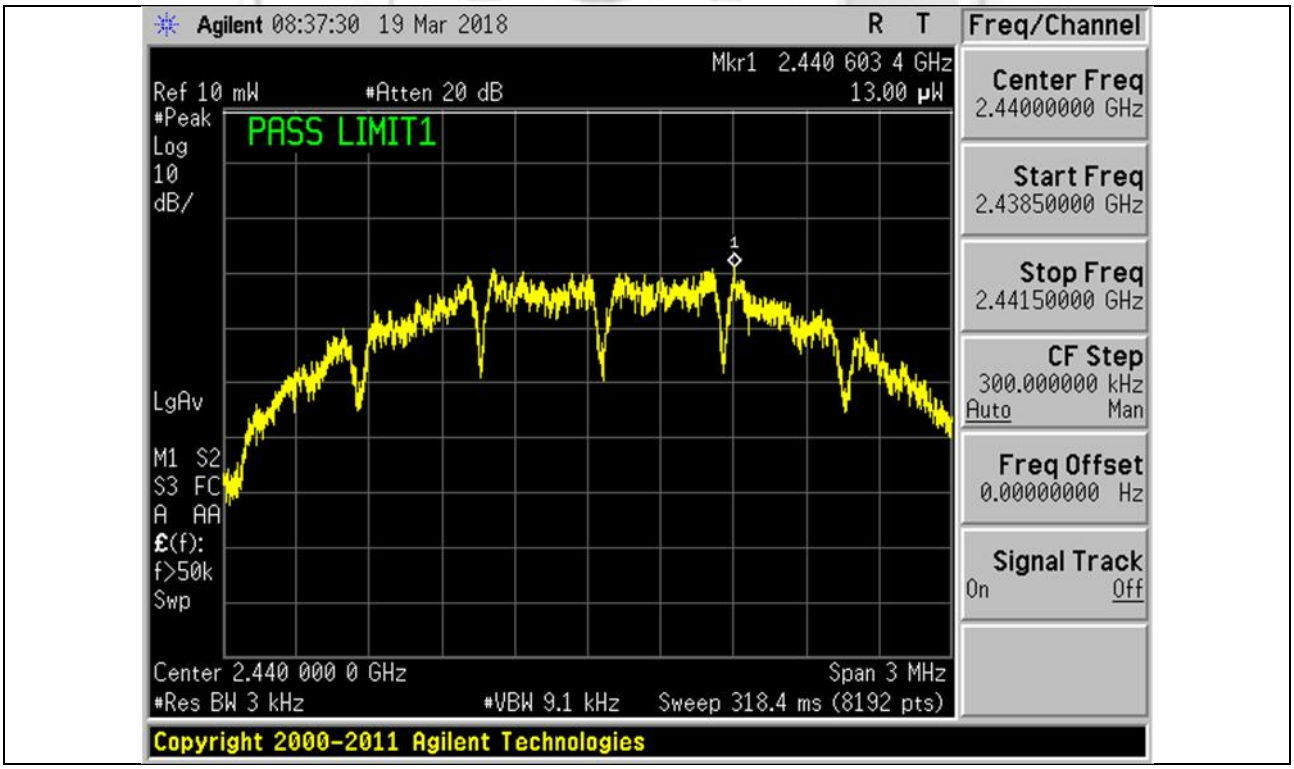
Peak Power Spectral Density Plots



Plot 48 – Lower Channel



Plot 49 – Middle Channel

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Peak Power Spectral Density Plots

Plot 50 – Upper Channel

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2.9 SAR Test Exclusion Computation

SAR test exclusion computation threshold, SAR_{thres} for 10-g extremity for test distance separation of ≤ 50mm is shown below. The computed value shall not more than 7.5 to meet the criterion for SAR test exclusion.

SAR_{thres}		=	(P / d) x f
		=	(0.6 / 5) x 2.405
		=	0.3
where	P	=	Maximum power of channel in mW (0.6mW)
	f	=	RF channel transmit frequency in GHz
	d	=	Minimum test separation in mm, in this case 5mm

From the computation, the computed value, ie 0.3 is < 7.5, as such, the EUT is meeting the criterion for SAR test exclusion.

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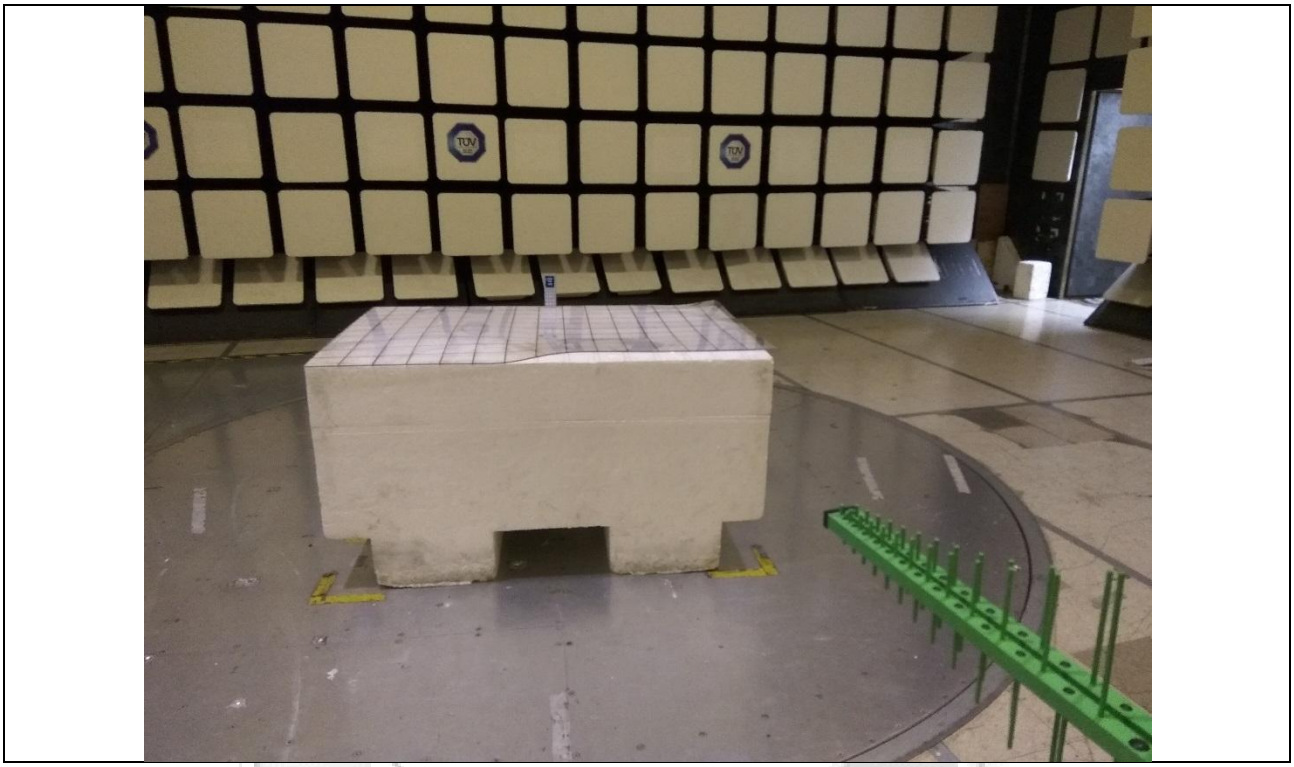
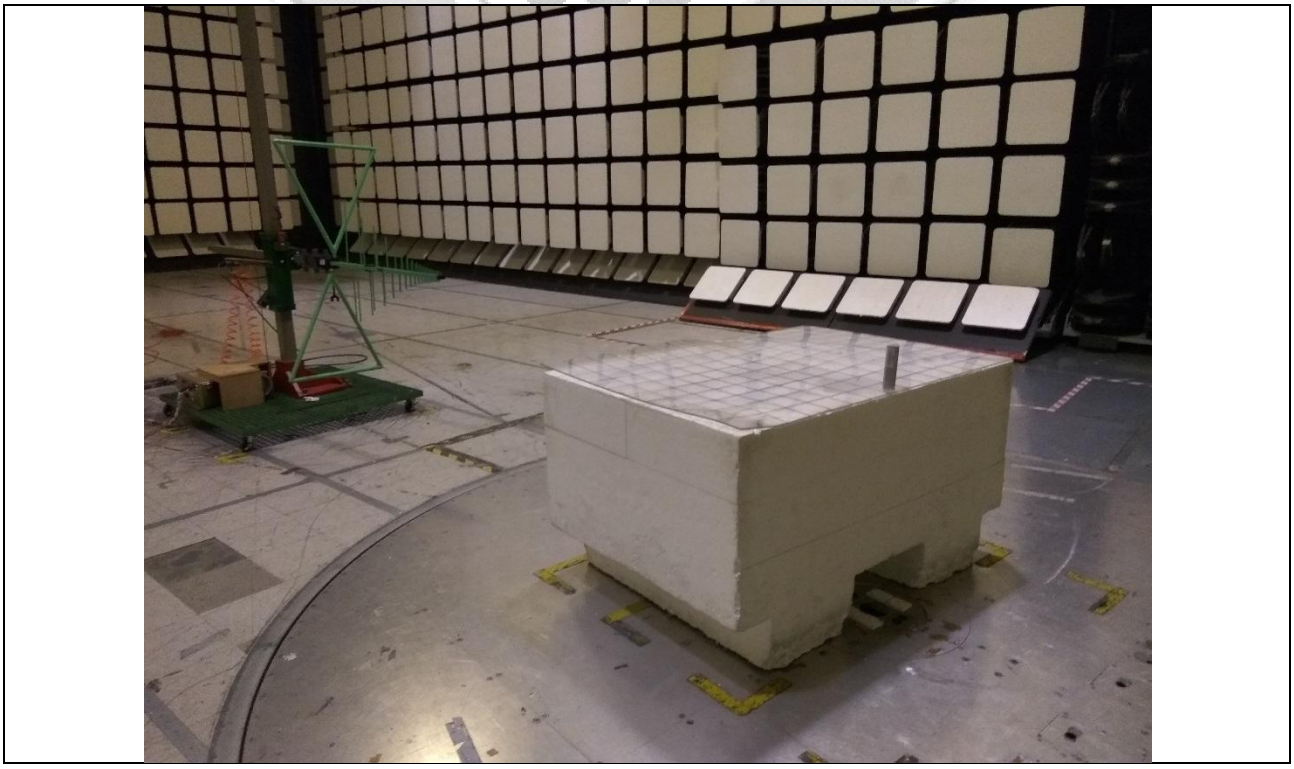
3 Photographs

TEST SETUP (30MHz to 1GHz)



Radiated Emissions (Spurious Emissions Inclusive Restricted Bands Requirement) Test Setup (Front View)



Radiated Emissions (Spurious Emissions Inclusive Restricted Bands Requirement) Test Setup (Rear View)

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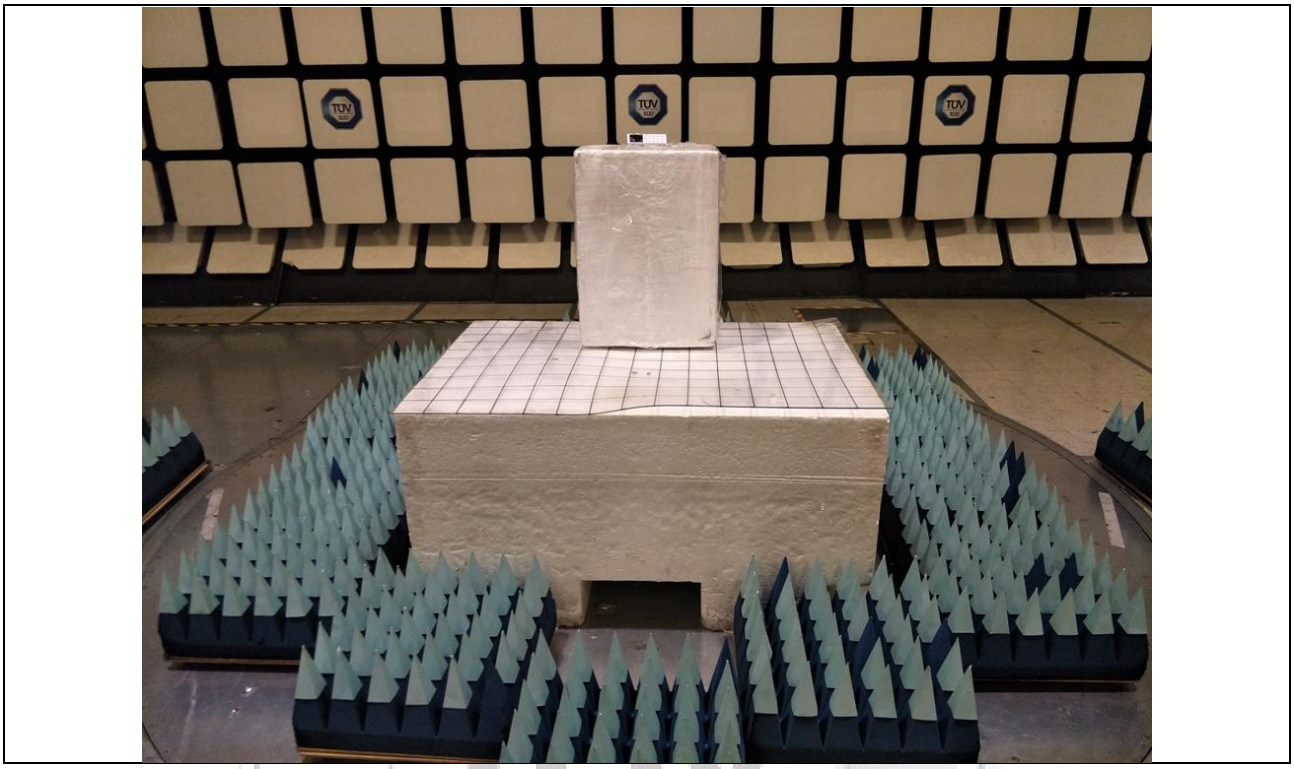
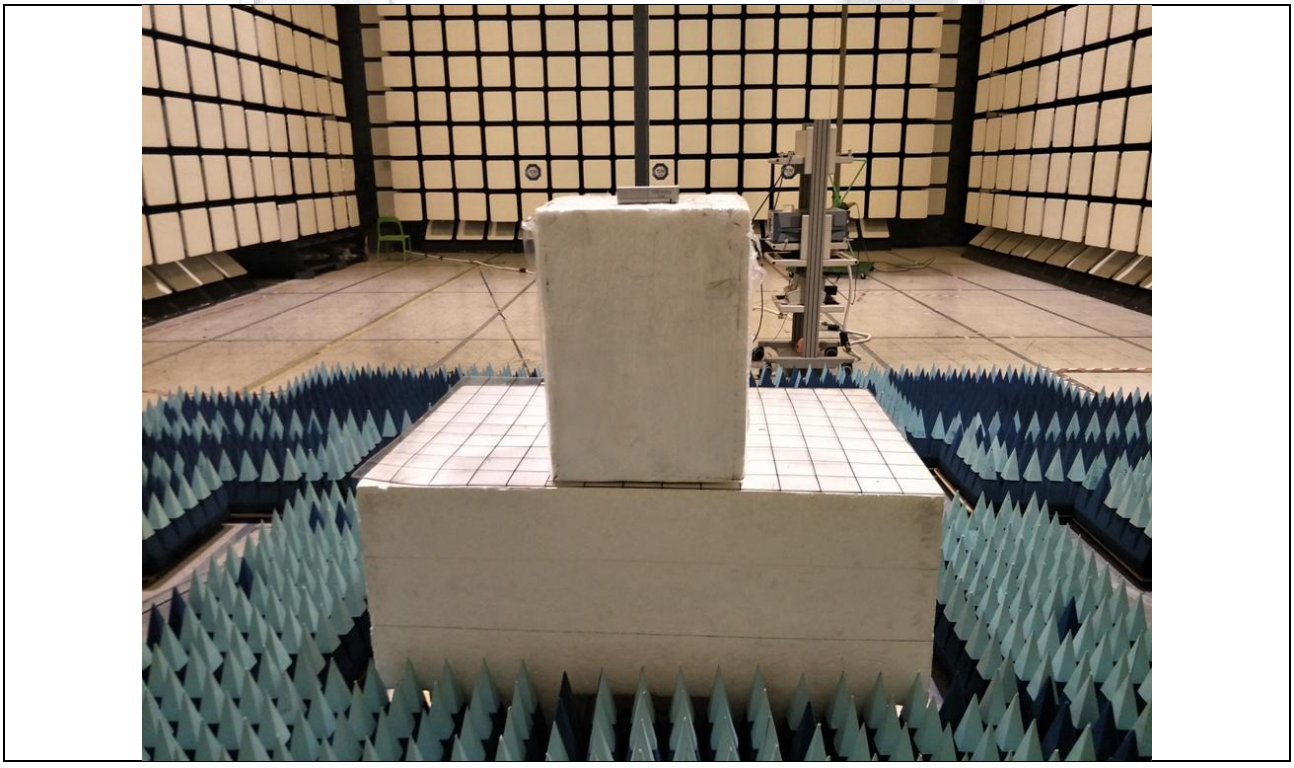
TEST SETUP (Above 1GHz)



Radiated Emissions (Spurious Emissions Inclusive Restricted Bands Requirement) Test Setup (Front View)



Radiated Emissions (Spurious Emissions Inclusive Restricted Bands Requirement) Test Setup (Rear View)

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TEST SETUP

Spectrum Bandwidth (6db Bandwidth Measurement) Test Setup

Maximum Peak Power Test Setup

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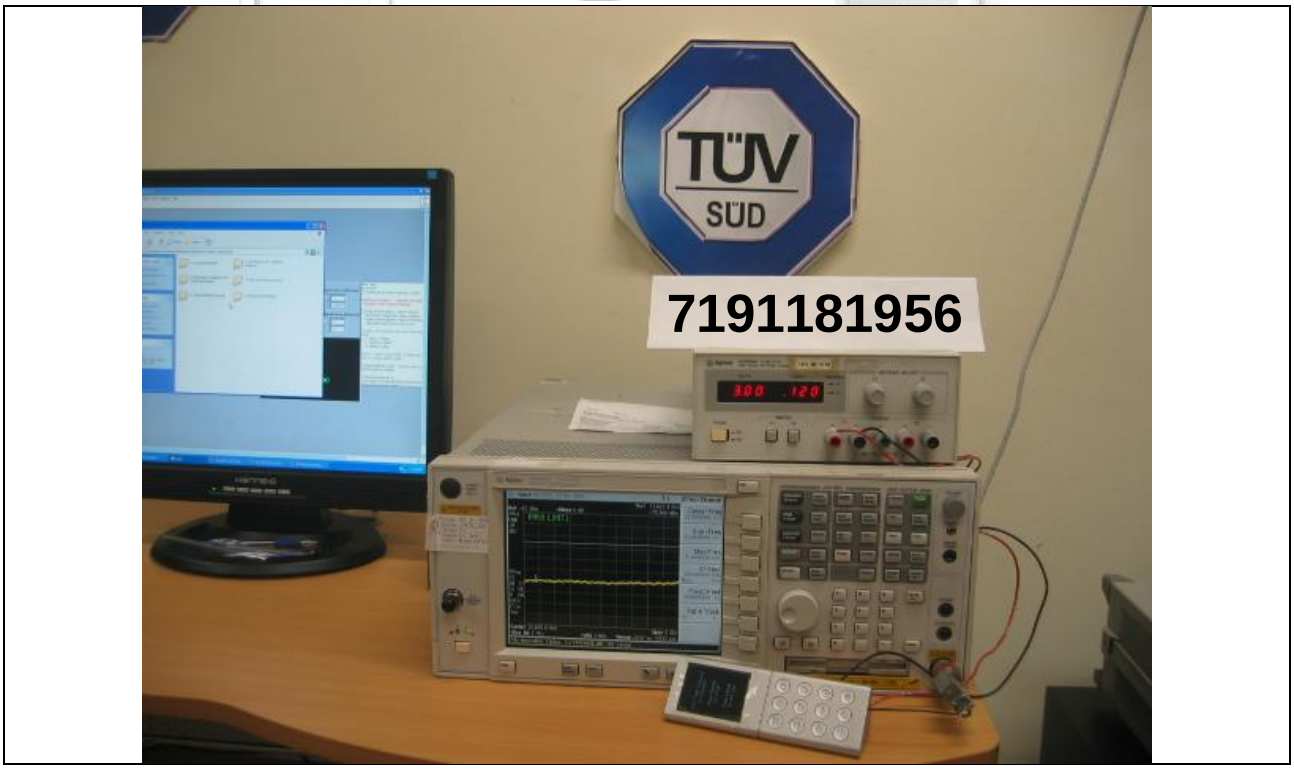
TEST SETUP

RF Conducted Spurious Emissions (Non-Restricted Bands) Test Setup



RF Conducted Spurious Emissions (Restricted Bands) Test Setup

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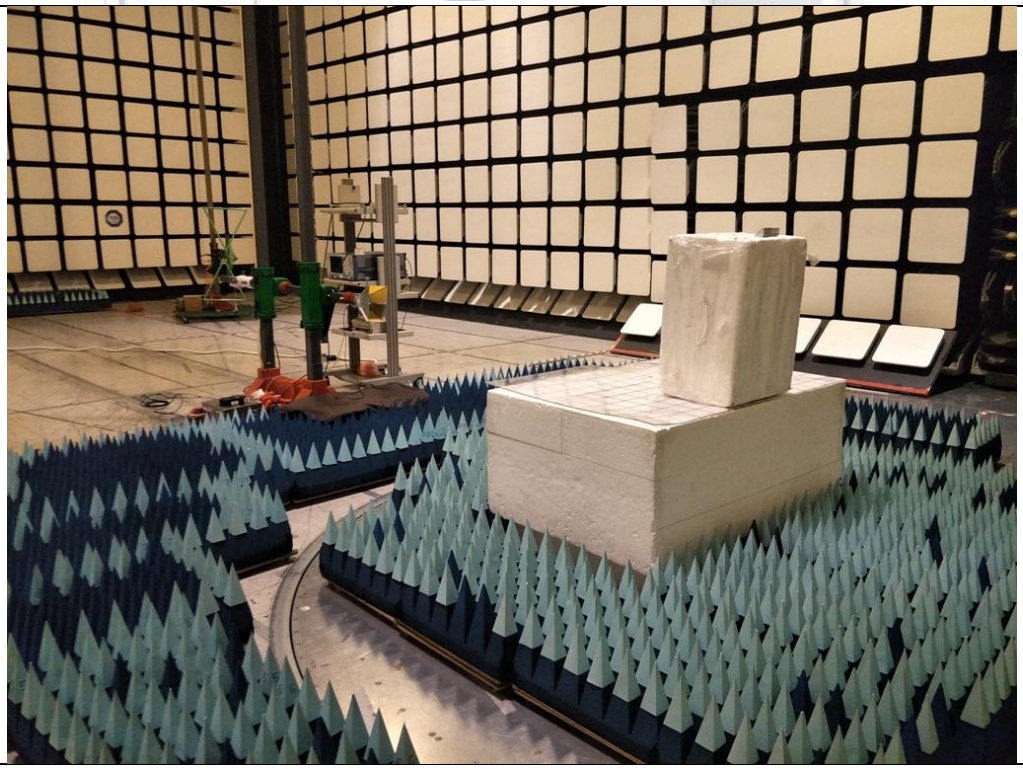
TEST SETUP

Band Edge Compliance (Conducted) Test Setup



Band Edge Compliance (Radiated) Test Setup

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TEST SETUP

Peak Power Spectral Density Test Setup

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EUT PHOTOGRAPHS

View 1

View 2

PSB Singapore

EUT PHOTOGRAPHS

EUT Internal View 1

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EUT PHOTOGRAPHS

Main-Board PCB Component Side

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Main-Board PCB Trace Side

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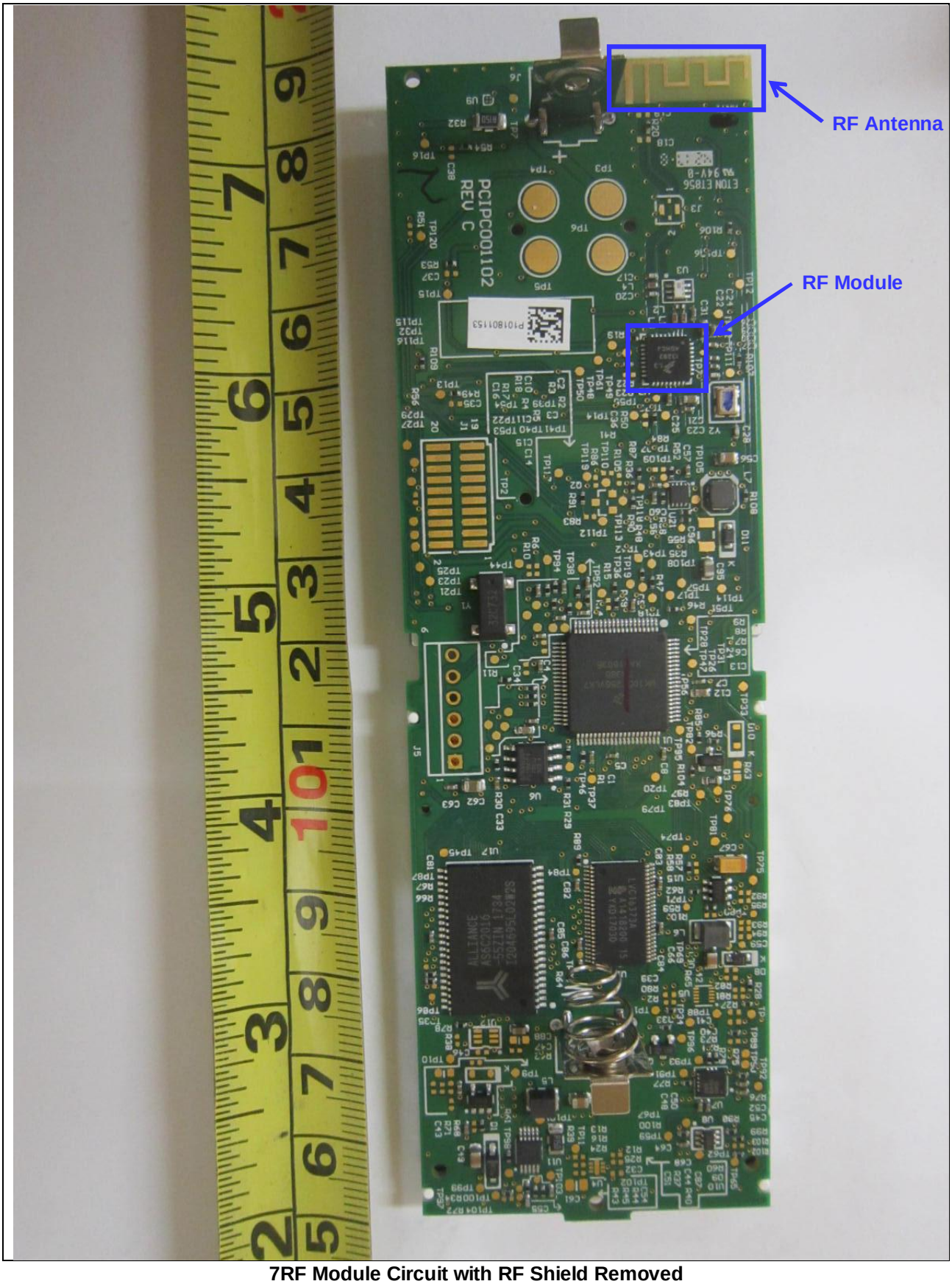
EUT PHOTOGRAPHS



7RF Module Circuit with RF Shield Removed

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4 Test Equipment

Instrument	Model	S/No	Cal Due Date
Radiated Emissions (Spurious Emissions Inclusive Restricted Bands Requirement)			
R&S Test Receiver – ESI1	ESI40	100010	25 Oct 2018
EMCO Loop Ant (ext)_red_00134413	6502	134413	28 Oct 2018
Schaffner Bilog Antenna –(30MHz-2GHz) BL4	CBL6112B	2593	18 Jul 2018
EMCO Horn Antenna(1GHz-18GHz)	3115	0003-6088	24 Sep 2018
ETS Horn Antenna(18GHz-40GHz) (Ref)	3116	0004-2474	15 Nov 2018
Com-Power Preamplifier (1MHz-1GHz)	PAM-103	441096	25 Sep 2018
R&S Preamplifier (1GHz -18GHz)	SCU18	102191	10 Sep 2018
Agilent Preamplifier(1GHz-26.5GHz) (PA18)	8449D	3008A02305	02 Oct 2018
Toyo Preamplifier (26.5GHz-40GHz)	HAP26-40W	00000005	18 Apr 2018
Micro-tronics Bandstop Filter (2.4GHz)	BRM50701-02	007	12 Jul 2018
Spectrum Bandwidth (6dB Bandwidth Measurement)			
Agilent Spectrum Analyzer	E4440A	MY45304764	09 Jan 2019
Agilent DC Power Supply	E3620A	MY40000448	Output Monitor
Maximum Peak Power			
Agilent Spectrum Analyzer	E4440A	MY45304764	09 Jan 2019
Agilent DC Power Supply	E3620A	MY40000448	Output Monitor
RF Conducted Spurious Emissions (Non-Restricted Bands)			
Agilent Spectrum Analyzer	E4440A	MY45304764	09 Jan 2019
Agilent DC Power Supply	E3620A	MY40000448	Output Monitor
RF Conducted Spurious Emissions (Restricted Bands)			
Agilent Spectrum Analyzer	E4440A	MY45304764	09 Jan 2019
Agilent DC Power Supply	E3620A	MY40000448	Output Monitor
Micro-tronics Bandstop Filter (2.4GHz)	BRM50701-02	007	12 Jul 2018
Band Edge Compliance (Conducted)			
Agilent Spectrum Analyzer	E4440A	MY45304764	09 Jan 2019
Agilent DC Power Supply	E3620A	MY40000448	Output Monitor

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Instrument	Model	S/No	Cal Due Date
Band Edge Compliance (Radiated)			
R&S Test Receiver – ESI1	ESI40	100010	25 Oct 2018
EMCO Horn Antenna(1GHz-18GHz)	3115	0003-6088	24 Sep 2018
R&S Preamplifier (1GHz -18GHz)	SCU18	102191	10 Sep 2018
Peak Power Spectral Density			
Agilent Spectrum Analyzer	E4440A	MY45304764	09 Jan 2019
Agilent DC Power Supply	E3620A	MY40000448	Output Monitor

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5 Measurement Uncertainty

All test measurements carried out are traceable to national standards. The uncertainty of the measurement at a confidence level of approximately 95%, with a coverage factor of 2.

Test Name	Measurement Uncertainty
Conducted Emissions	9kHz to 30MHz, ±2.2dB
Radiated Emissions	30MHz to 1GHz, ±3.8dB >1GHz to 40GHz, ±4.5dB
Maximum Permissible Exposure	0.1MHz – 3GHz is ±15.0%

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5. Unless otherwise stated, the tests were carried out in TÜV SÜD PSB Pte Ltd, No.1 Science Park Drive Singapore 118221.

July 2011

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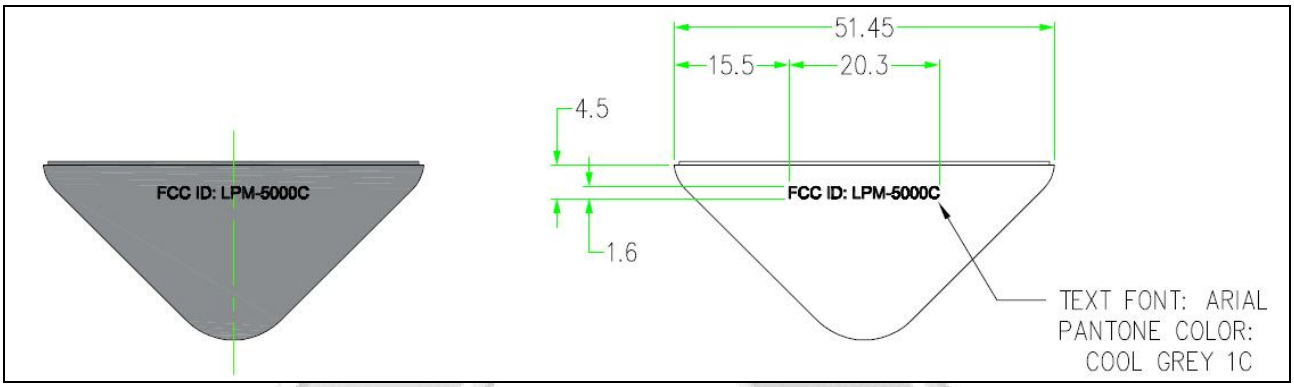
6 Annex A – FCC Label and Position

Labelling requirements per Section 2.925 & 15.19

The label shown will be permanently affixed at a conspicuous location on the device and be readily visible to the user at the time of purchase.



Sample Label

Physical Location of FCC Label on EUT