



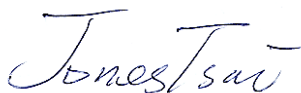
NCC RADIO TEST REPORT

Equipment : 無線音箱
Brand Name : Marshall
Model Name : WOBURN MULTI-ROOM
Applicant : 百滋國際股份有限公司
台北市松山區寶清街 17 號 5 樓之 1
Manufacturer : Zound Industries International AB
Room 411-412, 4th Floor, Main Building, No. 99 Qiao
Cheng East Road, Nanshan District, Shenzhen City, China
Standard : NCC LP0002 (2018-01-10)

The product was received on May 09, 2018, and testing was started from Jun. 05, 2018 and completed on Jul. 03, 2018. We, SPORTON INTERTIONAL INC. EMC & Wireless Communications Laboratory, would like to declare that the tested sample has been evaluated in accordance with the procedures given in NCC LP0002 (2018-01-10) and shown compliance with the applicable technical standards.

The report must not be used by the client to claim product certification, approval, or endorsement by TAF or any agency of government.

The test results in this report apply exclusively to the tested model / sample. Without written approval of SPORTON INTERTIONAL INC. EMC & Wireless Communications Laboratory, the test report shall not be reproduced except in full.



Approved by: Jones Tsai

SPORTON INTERTIONAL INC. EMC & Wireless Communications Laboratory

No. 52, Huaya 1st Rd., Guishan Dist., Taoyuan City, Taiwan (R.O.C.)



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History of this test report

Report No.	Version	Description	Issue Date
TR850937A	01	Initial issue of report	Jul. 13, 2018

Summary of Test Result

Report Clause	Ref Std. Clause	Test Items	Result (PASS/FAIL)	Remark
3.1	3.10.1.6(1)(A)	Number of Channels	Pass	-
3.2	3.10.1.6(1)(A)	Hopping Channel Separation	Pass	-
3.3	3.10.1.6(1)(A)	Dwell Time of Each Channel	Pass	-
3.4	3.10.1.6(1)(A)	20dB Bandwidth	Pass	-
3.4	-	99% Bandwidth	Pass	-
3.5	3.10.1.6(1)(A)	Peak Output Power	Pass	-
3.6	LP0002 3.10.1.5	Conducted Band Edges	Pass	-
3.7	LP0002 3.10.1.5	Conducted Spurious Emission	Pass	-
3.8	LP0002 3.10.1.5	Radiated Band Edges and Radiated Spurious Emission	Pass	Under limit 7.85 dB at 32.160 MHz
3.9	LP0002 2.11	Receiver Radiated Emission	Pass	Under limit 6.49 dB at 34.860 MHz
3.10	LP0002 2.3	AC Conducted Emission	Pass	Under limit 13.83 dB at 0.191 MHz
3.11	LP0002 2.2 3.10.1.3 3.10.1.4	Antenna Requirement	Pass	-

Reviewed by: Joseph Lin

Report Producer: Polly Tsai

1 General Description

1.1 Product Feature of Equipment Under Test

Bluetooth, Wi-Fi 2.4GHz 802.11b/g/n, and Wi-Fi 5GHz 802.11a/n/ac.

Product Specification subjective to this standard	
Antenna Type	WLAN: FPCB Antenna Bluetooth: FPCB Antenna

1.2 Modification of EUT

No modifications are made to the EUT during all test items.

1.3 Testing Location

Sporton Lab is accredited to ISO 17025 by Taiwan Accreditation Foundation (TAF code : 1190) and the FCC designation No. TW1190 and TW0007 under the FCC 2.948(e) by Mutual Recognition Agreement (MRA) in FCC Test.

Test Site	SPORTON INTERNATIONAL INC.	
Test Site Location	No. 52, Hwa Ya 1 st Rd., Hwa Ya Technology Park, Kwei-Shan District, Tao Yuan City, Taiwan, R.O.C. TEL: +886-3-327-3456 FAX: +886-3-328-4978	
Test Site No.	Sporton Site No.	
	TH05-HY	CO05-HY

Note: The test site complies with ANSI C63.4 2014 requirement.

Test Site	SPORTON INTERNATIONAL INC.	
Test Site Location	No.58, Aly. 75, Ln. 564, Wenhua 3rd Rd. Guishan Dist, Taoyuan City, Taiwan (R.O.C.) TEL: +886-3-327-0868 FAX: +886-3-327-0855	
Test Site No.	Sporton Site No.	
	03CH11-HY	

Note: The test site complies with ANSI C63.4 2014 requirement.



1.4 Applicable Standards

According to the specifications of the manufacturer, the EUT must comply with the requirements of the following standards:

- ♦ NCC LP0002 (2018-01-10)
- ♦ ANSI C63.10-2013

Remark: All test items were verified and recorded according to the standards and without any deviation during the test.

2 Test Configuration of Equipment Under Test

2.1 Test Mode

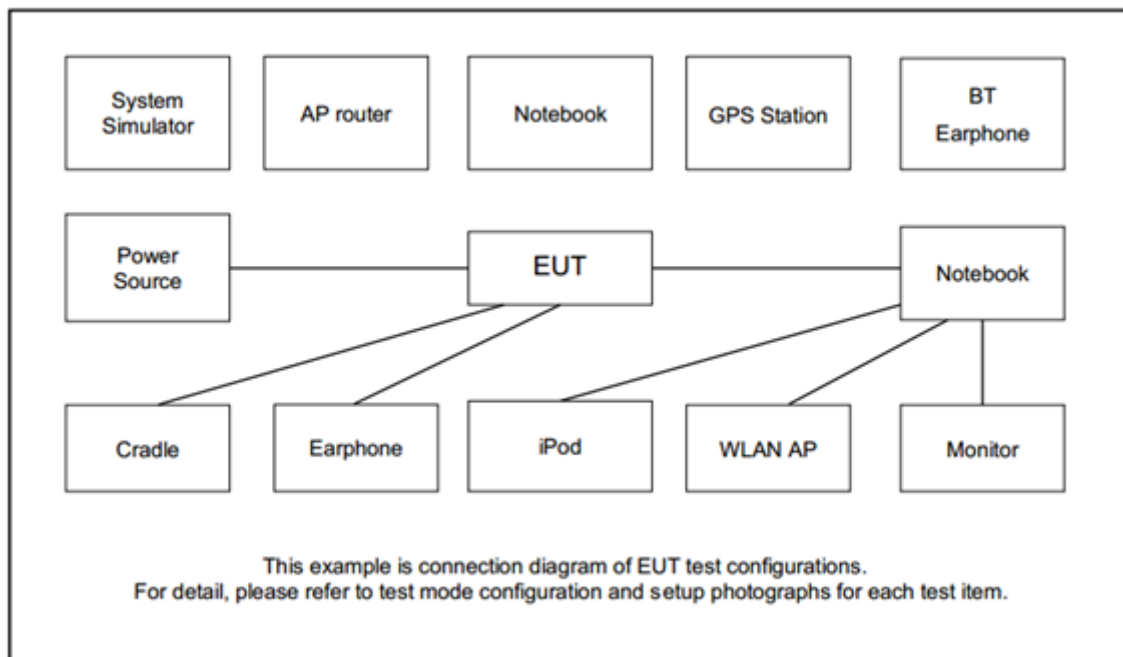
- a. The EUT has been associated with peripherals and configuration operated in a manner tended to maximize its emission characteristics in a typical application. Frequency range investigated: conduction emission (150 kHz to 30 MHz), radiation emission (9 kHz to the 10th harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower). The worst mode of radiated spurious emissions is Bluetooth 3Mbps mode, and recorded in this report.
- b. AC power line Conducted Emission was tested under maximum output power.

The following summary table is showing all test modes to demonstrate in compliance with the standard.

Summary table of Test Cases			
Test Item	Data Rate / Modulation		
	Bluetooth BR 1Mbps GFSK	Bluetooth EDR 2Mbps $\pi/4$ -DQPSK	Bluetooth EDR 3Mbps 8-DPSK
Conducted Test Cases	Mode 1: CH00_2402 MHz	Mode 4: CH00_2402 MHz	Mode 7: CH00_2402 MHz
	Mode 2: CH39_2441 MHz	Mode 5: CH39_2441 MHz	Mode 8: CH39_2441 MHz
	Mode 3: CH78_2480 MHz	Mode 6: CH78_2480 MHz	Mode 9: CH78_2480 MHz
Radiated Test Cases	Bluetooth EDR 3Mbps 8-DPSK		
	Mode 1: CH00_2402 MHz		
	Mode 2: CH39_2441 MHz		
AC Conducted Emission	Mode 3: CH78_2480 MHz		
	Mode 1: Bluetooth Link + AUX In (Load with iPod) + RCA In (Load with iPod) + Phone Play MP3 via Bluetooth Function + Power Cord		
	Mode 2: WLAN (2.4GHz) Link + AUX In (Load with iPod) + RCA In (Load with iPod) + Phone Play MP3 via WLAN (2.4GHz) Function + Power Cord		
	Mode 3: WLAN (5GHz) Link + AUX In (Load with iPod) + RCA In (Load with iPod) + Phone Play MP3 via WLAN (5GHz) Function + Power Cord		
	Mode 4: Bluetooth Idle + AUX In (Load with iPod) + RCA In (Load with iPod) + Power Cord		
	Mode 5: WLAN (2.4GHz) Idle + AUX In (Load with iPod) + RCA In (Load with iPod) + Power Cord		
	Mode 6: WLAN (5GHz) Idle + AUX In (Load with iPod) + RCA In (Load with iPod) + Power Cord		

Summary table of Test Cases	
Receiver Radiated Emission	Mode 1 :Bluetooth Idle + Power Cord
Remark: - For radiated test cases, the worst mode data rate 3Mbps was reported only, because this data rate has the highest RF output power at preliminary tests, and the conducted spurious emissions and conducted band edge measurement for each data rate are no worse than 3Mbps, and no other significantly frequencies found in conducted spurious emission. - The worst case of conducted emission is mode 2; only the test data of it was reported.	

2.2 Connection Diagram of Test System



2.3 Support Unit used in test configuration and system

Item	Equipment	Trade Name	Model Name	FCC ID	Data Cable	Power Cord
1.	Bluetooth Base Station	R&S	CBT32	N/A	N/A	Unshielded, 1.8 m
2.	WLAN AP	ASUS	RT-AC66U	MSQ-RTAC66U	N/A	Unshielded, 1.8 m
3.	iPhone	Apple	A1687	BCG-E2944A	N/A	N/A
4.	iPod	Apple	A1285	FCC DoC	Shielded, 1.0 m	N/A



2.4 EUT Operation Test Setup

The RF test items, utility “Putty” was installed in Notebook which was programmed in order to make the EUT get into the engineering modes to contact with base station to provide channel selection, power level, data rate and the application type and for continuous transmitting signals.

2.5 Measurement Results Explanation Example

For all conducted test items:

The offset level is set in the spectrum analyzer to compensate the RF cable loss and attenuator factor between EUT conducted output port and spectrum analyzer. With the offset compensation, the spectrum analyzer reading level is exactly the EUT RF output level.

Example:

The spectrum analyzer offset is derived from RF cable loss and attenuator factor.

Offset = RF cable loss + attenuator factor.

Following shows an offset computation example with cable loss 4.2 dB and 10dB attenuator.

$$\begin{aligned}\text{Offset(dB)} &= \text{RF cable loss(dB)} + \text{attenuator factor(dB)} \\ &= 4.2 + 10 = 14.2 \text{ (dB)}\end{aligned}$$

3 Test Result

3.1 Number of Channel Measurement

3.1.1 Limits of Number of Hopping Frequency

Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels.

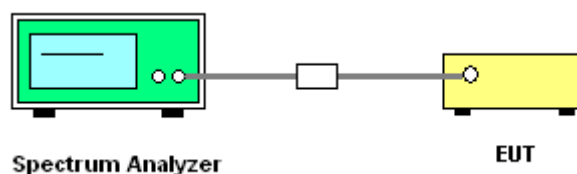
3.1.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.1.3 Test Procedure

1. The testing follows ANSI C63.10-2013 clause 7.8.3.
2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Enable the EUT hopping function.
5. Use the following spectrum analyzer settings: Span = the frequency band of operation;
RBW = 300kHz; VBW $\geq$ RBW; Sweep = auto; Detector function = peak; Trace = max hold.
6. The number of hopping frequency used is defined as the number of total channel.
7. Record the measurement data derived from spectrum analyzer.

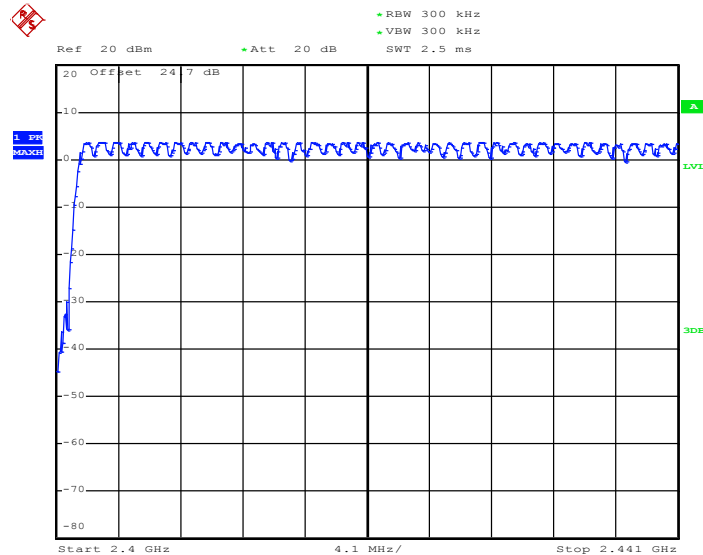
3.1.4 Test Setup



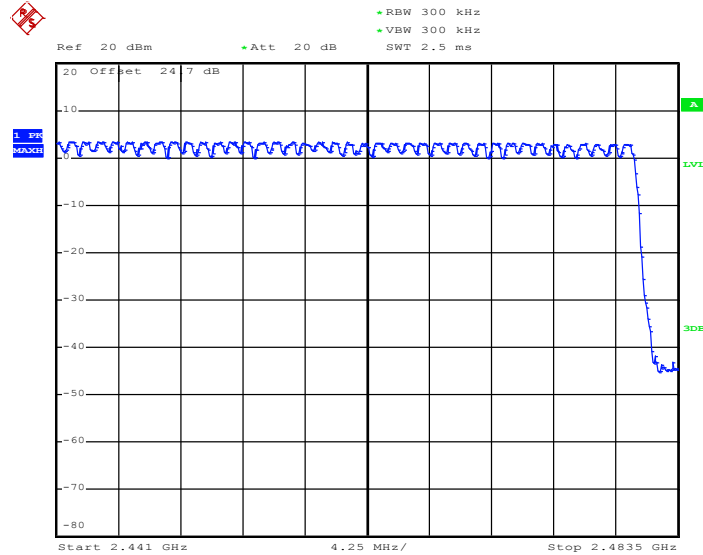
3.1.5 Test Result of Number of Hopping Frequency

Please refer to Appendix A.

Number of Hopping Channel Plot on Channel 00 - 78



Date: 3.JUL.2018 08:00:04



Date: 3.JUL.2018 08:01:33

3.2 Hopping Channel Separation Measurement

3.2.1 Limit of Hopping Channel Separation

Frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater.

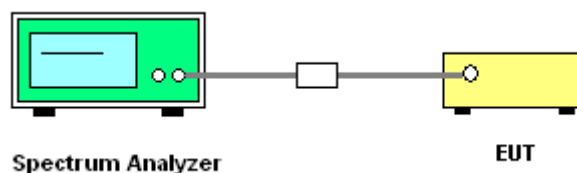
3.2.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.2.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 7.8.2.
2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Enable the EUT hopping function.
5. Use the following spectrum analyzer settings:
Span = wide enough to capture the peaks of two adjacent channels;
RBW = 300kHz; VBW $\geq$ RBW; Sweep = auto; Detector function = peak; Trace = max hold.
6. Measure and record the results in the test report.

3.2.4 Test Setup

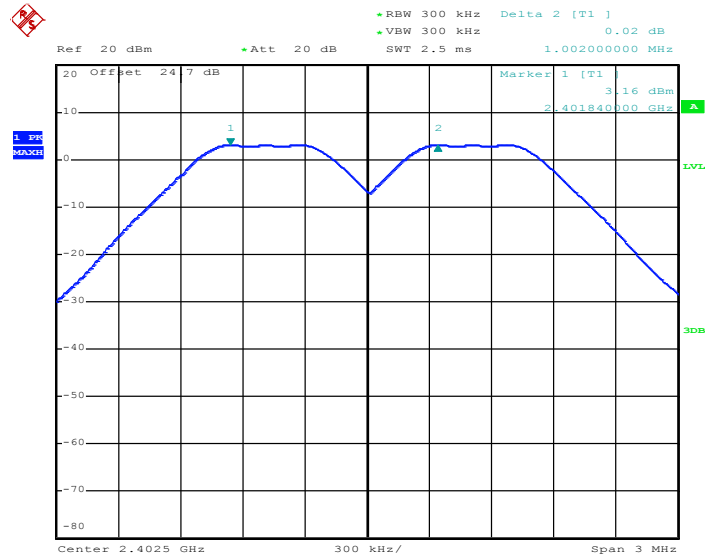


3.2.5 Test Result of Hopping Channel Separation

Please refer to Appendix A.

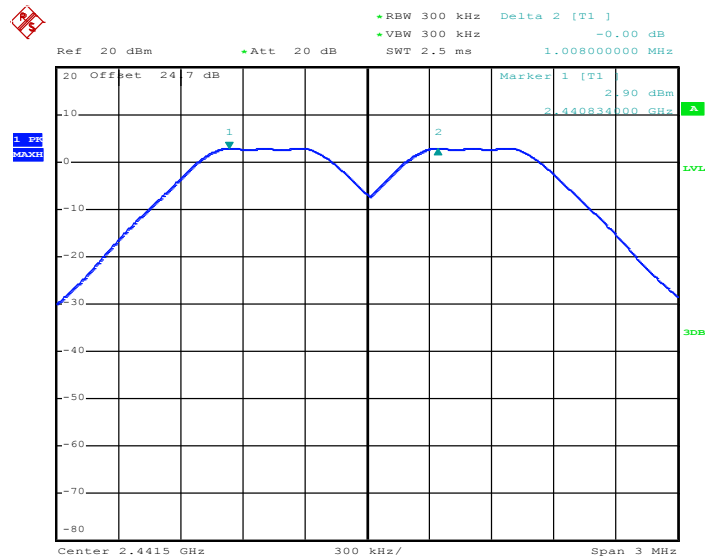
<1Mbps>

Channel Separation Plot on Channel 00 - 01

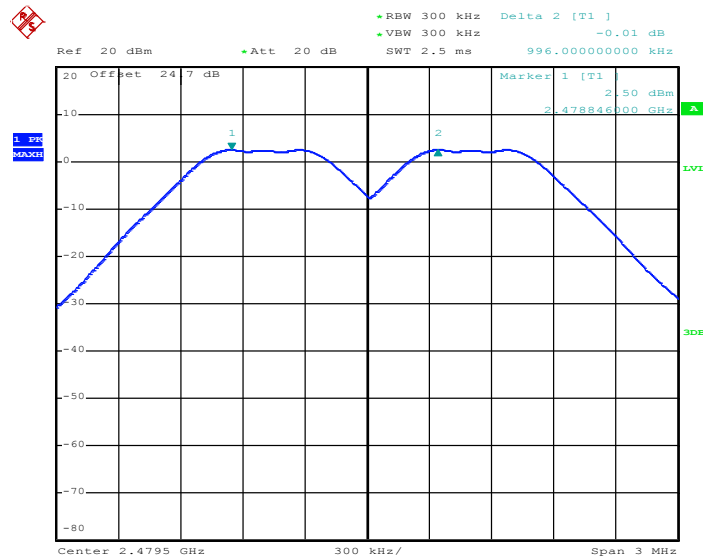


Date: 3.JUL.2018 08:10:59

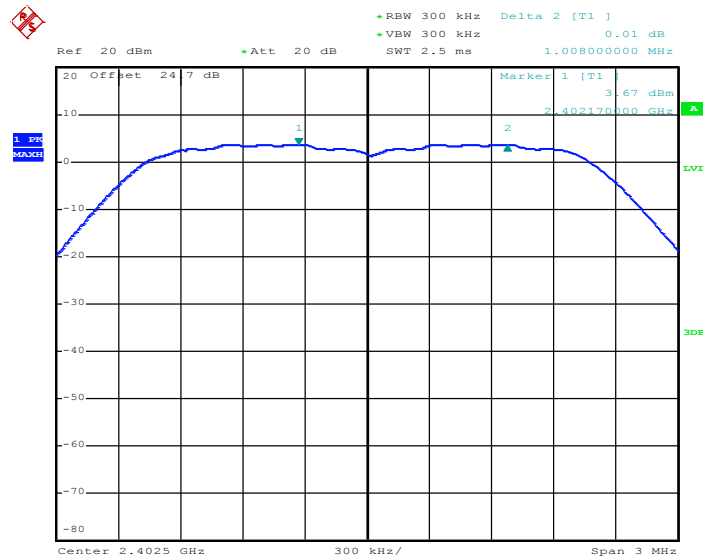
Channel Separation Plot on Channel 39 - 40



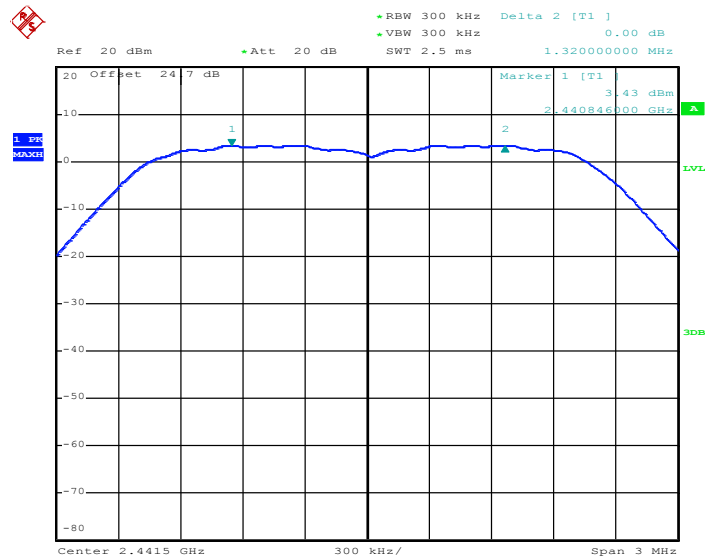
Date: 3.JUL.2018 08:18:37

Channel Separation Plot on Channel 77 - 78


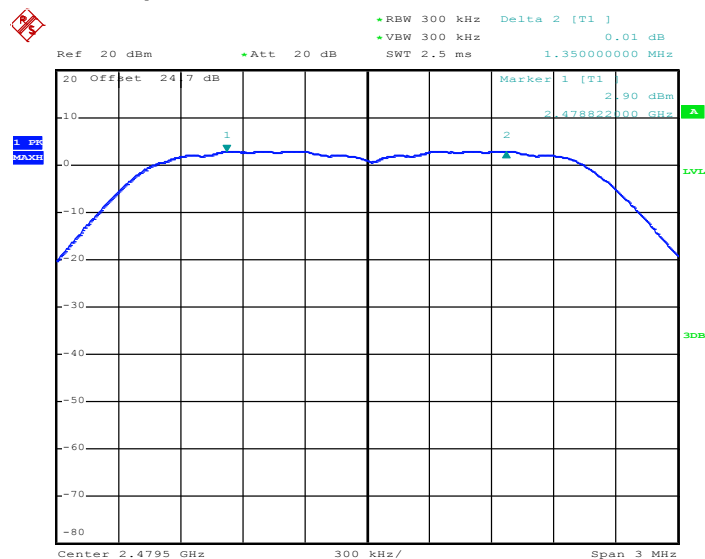
Date: 3.JUL.2018 08:23:03

<2Mbps>
Channel Separation Plot on Channel 00 - 01


Date: 3.JUL.2018 08:30:57

Channel Separation Plot on Channel 39 - 40


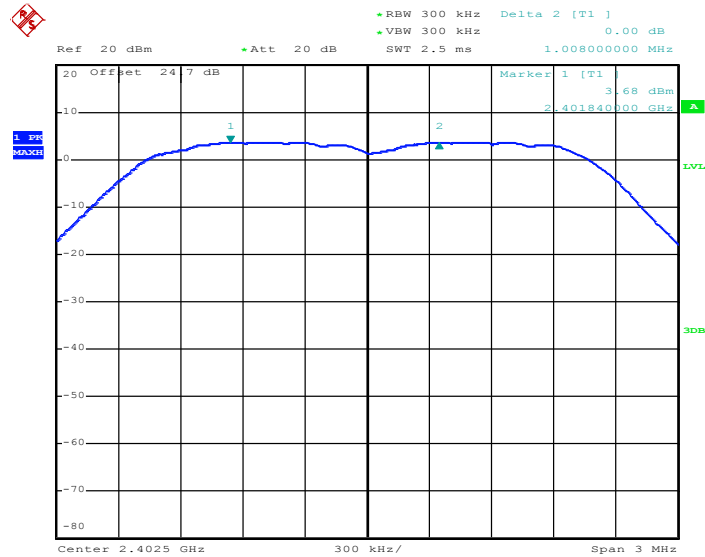
Date: 3.JUL.2018 08:39:39

Channel Separation Plot on Channel 77 - 78


Date: 3.JUL.2018 08:47:45

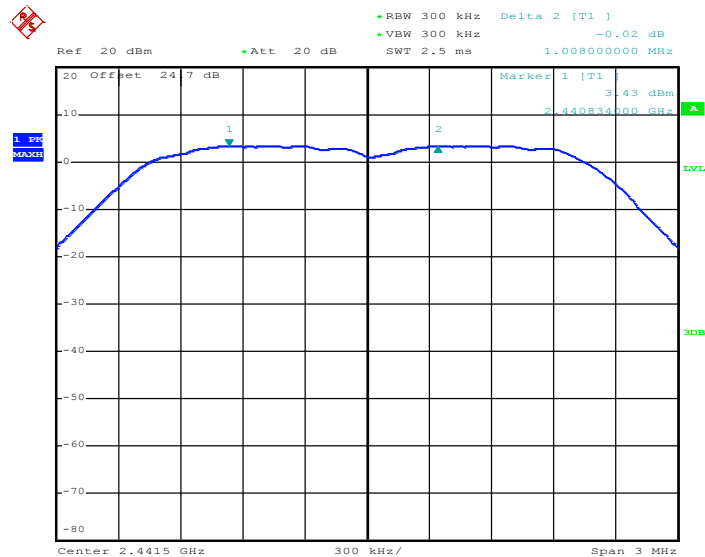
<3Mbps>

Channel Separation Plot on Channel 00 - 01



Date: 3.JUL.2018 08:55:01

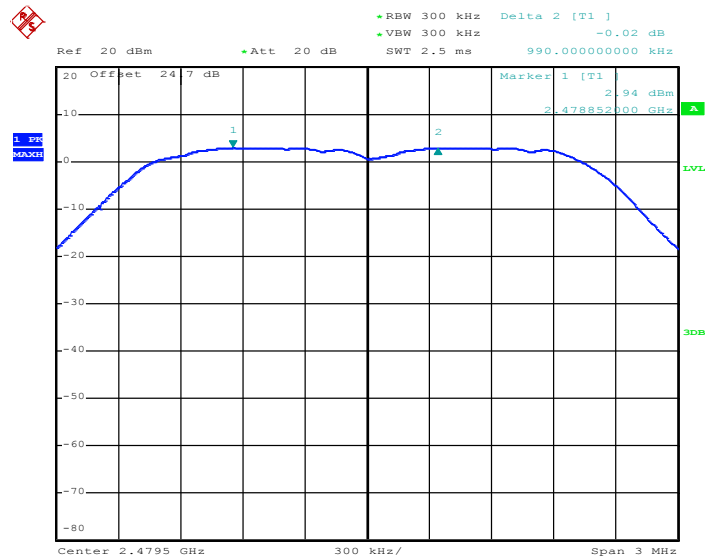
Channel Separation Plot on Channel 39 - 40



Date: 3.JUL.2018 09:01:36



Channel Separation Plot on Channel 77 - 78



Date: 3.JUL.2018 09:06:58

3.3 Dwell Time Measurement

3.3.1 Limit of Dwell Time

The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed.

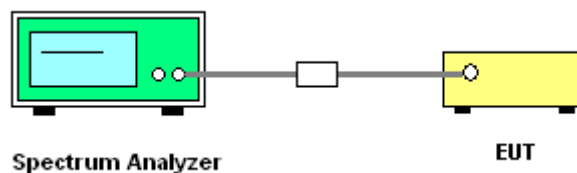
3.3.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.3.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 7.8.4.
2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Enable the EUT hopping function.
5. Use the following spectrum analyzer settings: Span = zero span, centered on a hopping channel; RBW = 1 MHz; VBW $\geq$ RBW; Sweep = as necessary to capture the entire dwell time per hopping channel; Detector function = peak; Trace = max hold.
6. Measure and record the results in the test report.

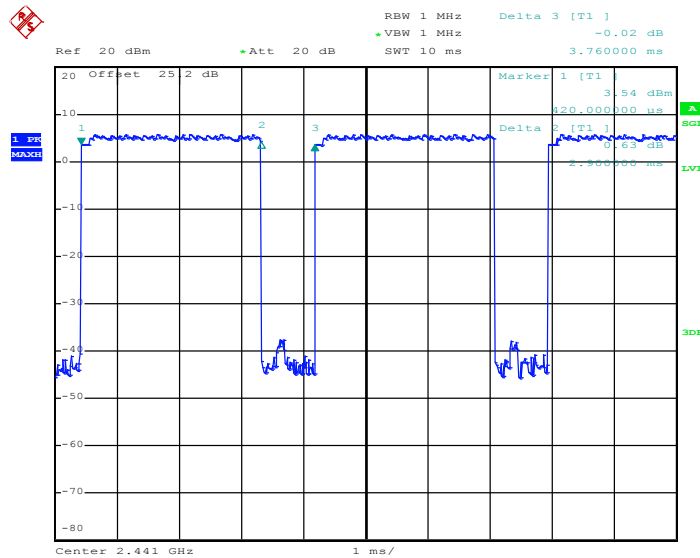
3.3.4 Test Setup



3.3.5 Test Result of Dwell Time

Please refer to Appendix A.

Package Transfer Time Plot



Date: 1.MAY.2018 16:15:23

Remark:

1. In normal mode, hopping rate is 1600 hops/s with 6 slots in 79 hopping channels.
 With channel hopping rate (1600 / 6 / 79) in Occupancy Time Limit (0.4 x 79) (s), Hops Over Occupancy Time comes to (1600 / 6 / 79) x (0.4 x 79) = 106.67 hops.
2. In AFH mode, hopping rate is 800 hops/s with 6 slots in 20 hopping channels. With channel hopping rate (800 / 6 / 20) in Occupancy Time Limit (0.4 x 20) (s), Hops Over Occupancy Time comes to (800 / 6 / 20) x (0.4 x 20) = 53.33 hops.
3. Dwell Time(s) = Hops Over Occupancy Time (hops) x Package Transfer Time

3.4 20dB and 99% Bandwidth Measurement

3.4.1 Limit of 20dB and 99% Bandwidth

Reporting only

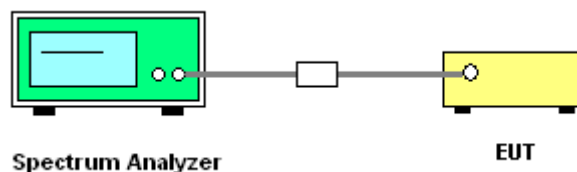
3.4.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.4.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 6.9.2 and 6.9.3.
2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Use the following spectrum analyzer settings for 20dB Bandwidth measurement.
Span = approximately 2 to 5 times the 20 dB bandwidth, centered on a hopping channel;
RBW $\geq$ 1% of the 20 dB bandwidth; VBW $\geq$ RBW; Sweep = auto; Detector function = peak;
Trace = max hold.
5. Use the following spectrum analyzer settings for 99 % Bandwidth measurement.
Span = approximately 1.5 to 5 times the 99% bandwidth, centered on a hopping channel;
RBW $\geq$ 1% of the 99% bandwidth; VBW $\geq$ RBW; Sweep = auto; Detector function = peak;
Trace = max hold.
6. Measure and record the results in the test report.

3.4.4 Test Setup

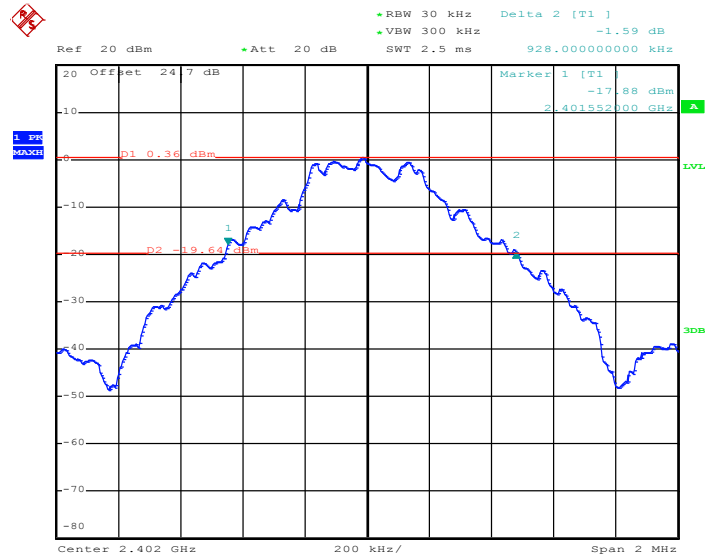


3.4.5 Test Result of 20dB Bandwidth

Please refer to Appendix A.

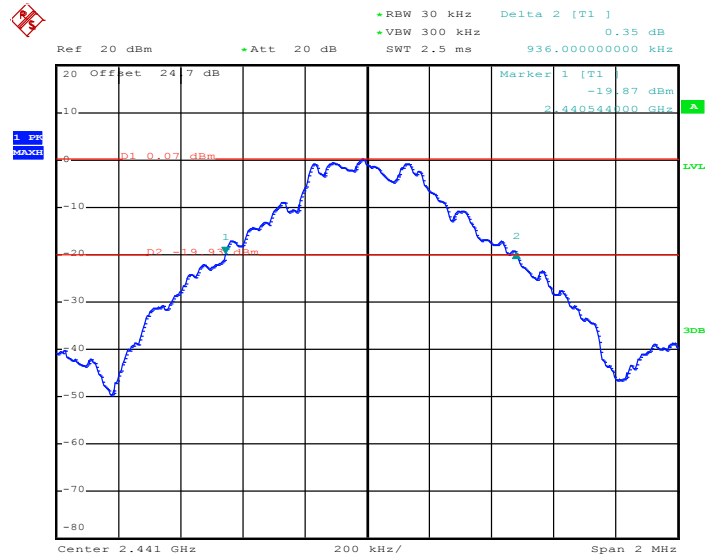
<1Mbps>

20 dB Bandwidth Plot on Channel 00

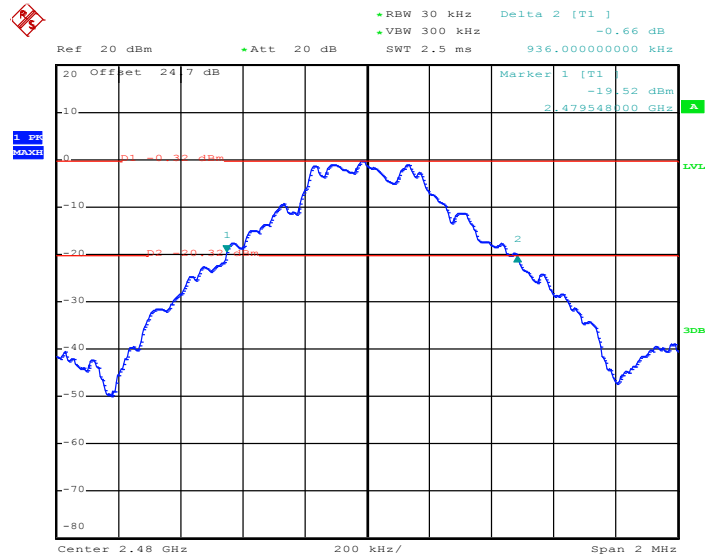


Date: 3.JUL.2018 08:11:49

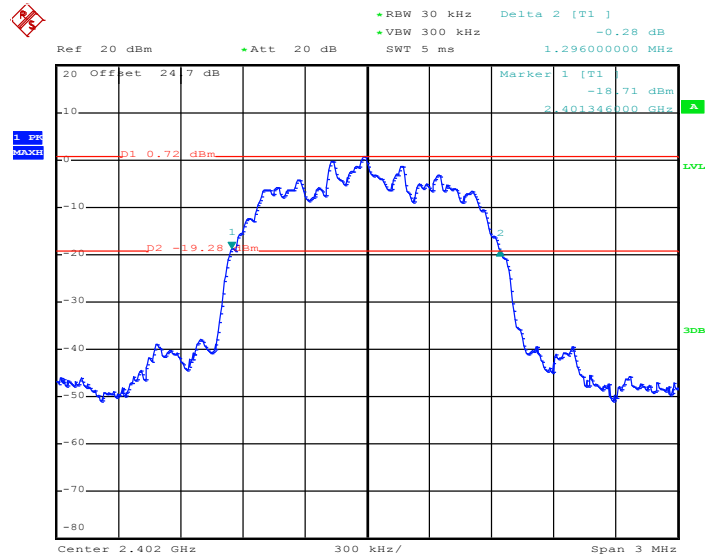
20 dB Bandwidth Plot on Channel 39



Date: 3.JUL.2018 08:19:32

20 dB Bandwidth Plot on Channel 78


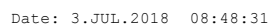
Date: 3.JUL.2018 08:23:52

<2Mbps>
20 dB Bandwidth Plot on Channel 00


Date: 3.JUL.2018 08:32:05

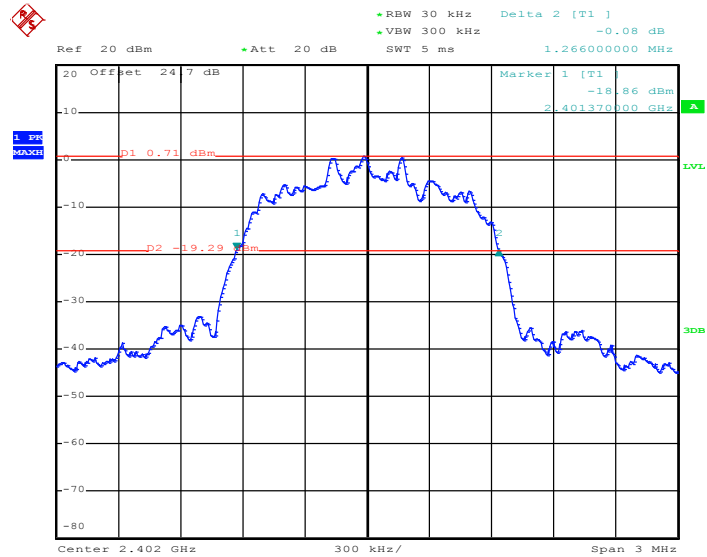


20 dB Bandwidth Plot on Channel 78



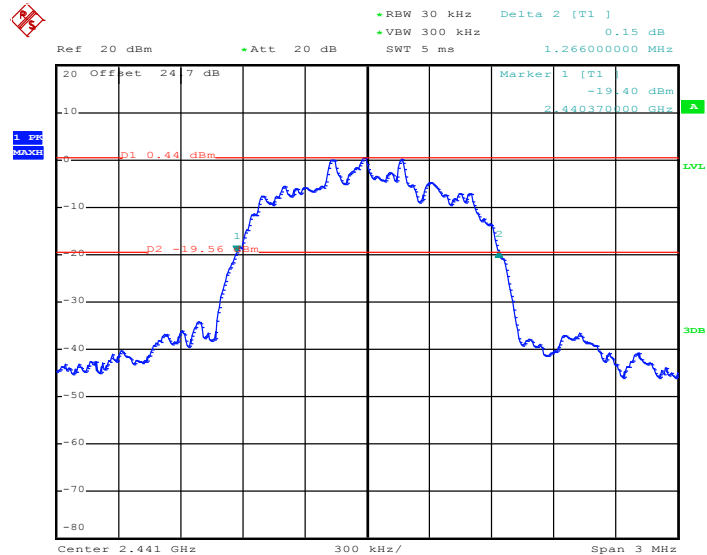
<3Mbps>

20 dB Bandwidth Plot on Channel 00

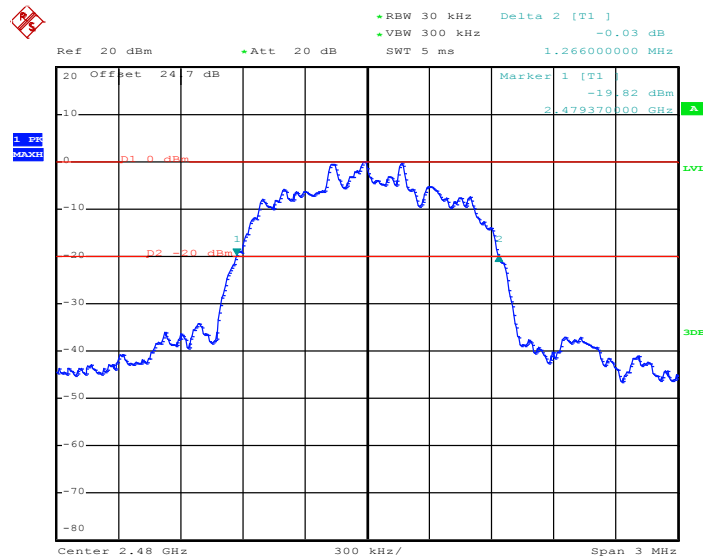


Date: 3.JUL.2018 08:56:24

20 dB Bandwidth Plot on Channel 39



Date: 3.JUL.2018 09:02:40

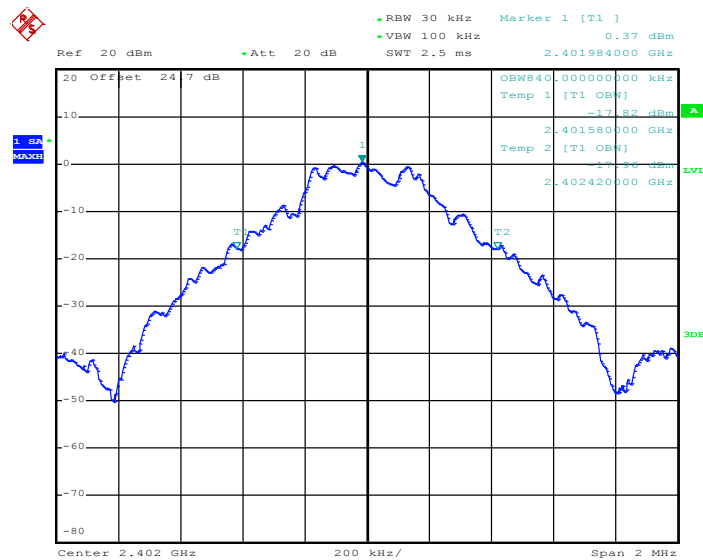
20 dB Bandwidth Plot on Channel 78


Date: 3.JUL.2018 09:07:48

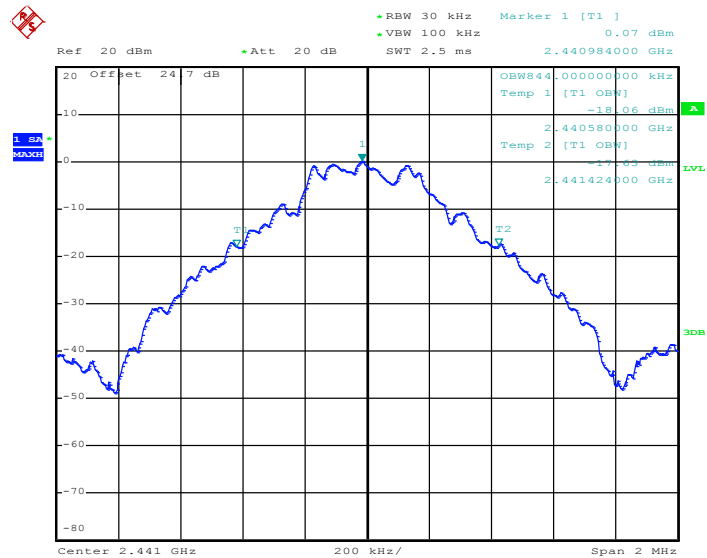
3.4.6 Test Result of 99% Occupied Bandwidth

Please refer to Appendix A.

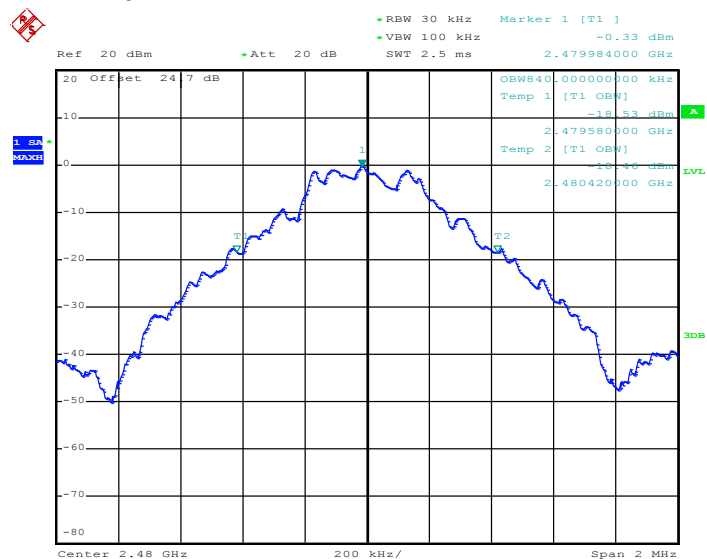
<1Mbps>

99% Occupied Bandwidth Plot on Channel 00


Date: 3.JUL.2018 08:14:27

99% Occupied Bandwidth Plot on Channel 39


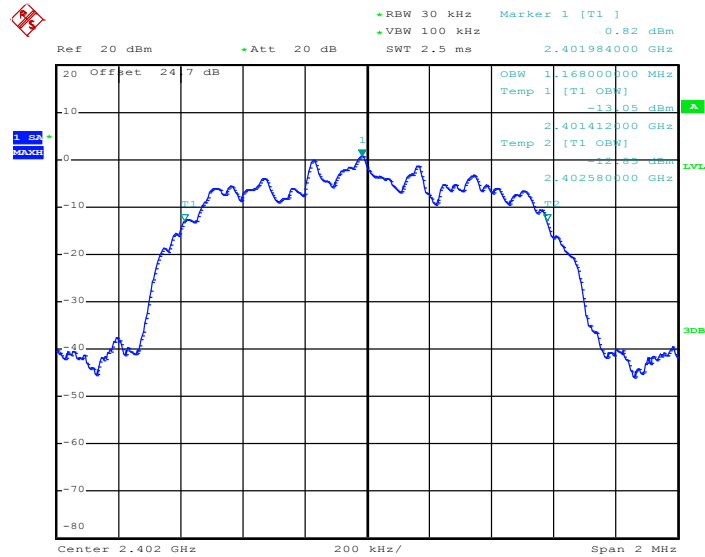
Date: 3.JUL.2018 08:20:29

99% Occupied Bandwidth Plot on Channel 78


Date: 3.JUL.2018 08:25:07

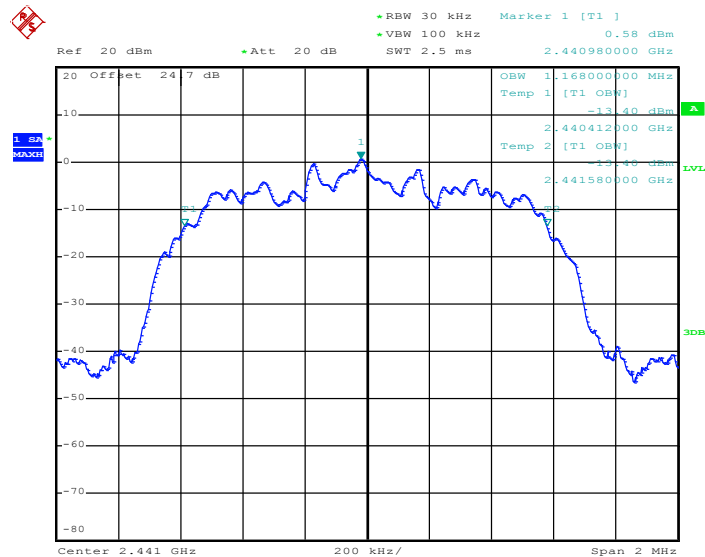
<2Mbps>

99% Occupied Bandwidth Plot on Channel 00



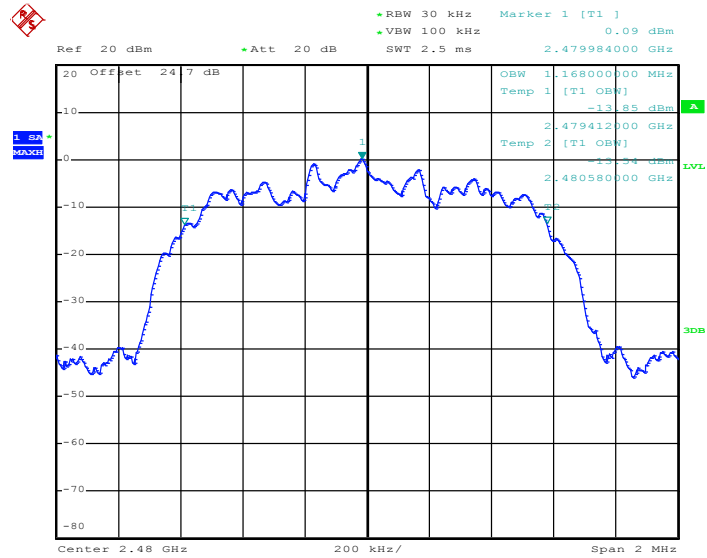
Date: 3.JUL.2018 08:33:39

99% Occupied Bandwidth Plot on Channel 39



Date: 3.JUL.2018 08:44:12

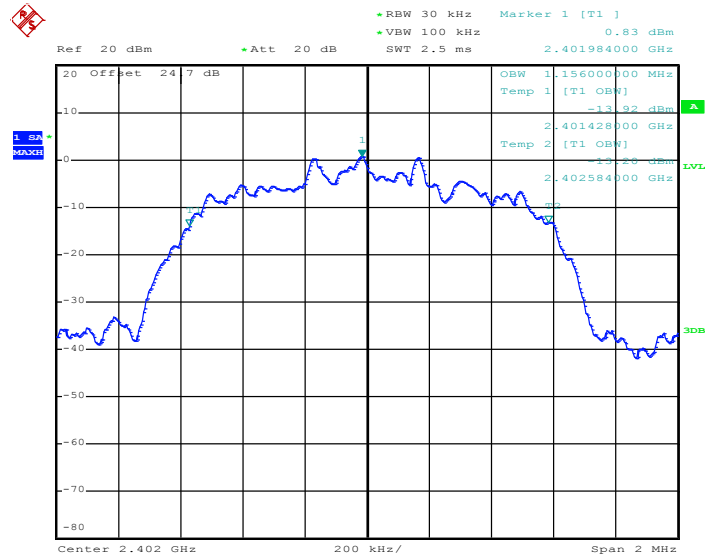
99% Occupied Bandwidth Plot on Channel 78



Date: 3.JUL.2018 08:49:59

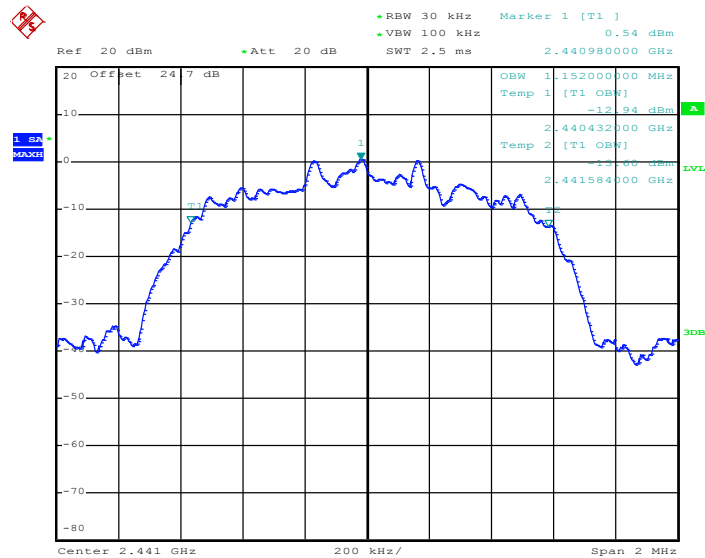
<3Mbps>

99% Occupied Bandwidth Plot on Channel 00



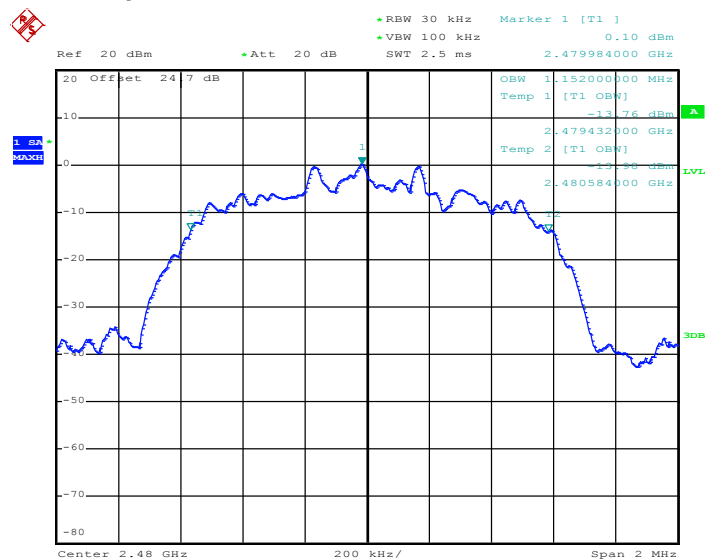
Date: 3.JUL.2018 08:57:36

99% Occupied Bandwidth Plot on Channel 39



Date: 3.JUL.2018 09:03:18

99% Occupied Bandwidth Plot on Channel 78



Date: 3.JUL.2018 09:08:44

Note: The occupied channel bandwidth is maintained within the band of operation for all of the modulations.

3.5 Output Power Measurement

3.5.1 Limit of Output Power

The maximum peak conducted output power of the intentional radiator shall not exceed the following:
For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band 0.125 watts. The power limit for 1Mbps, 2Mbps, 3Mbps and AFH modes are 0.125 watts.

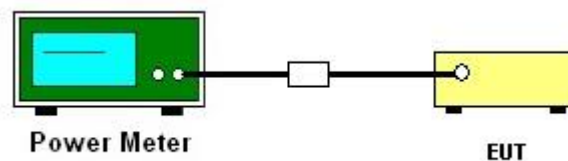
3.5.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.5.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 7.8.5.
2. The RF output of EUT was connected to the power meter by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Measure the conducted output power with cable loss and record the results in the test report.
5. Measure and record the results in the test report.

3.5.4 Test Setup



3.5.5 Test Result of Peak Output Power

Please refer to Appendix A.

3.5.6 Test Result of Average Output Power (Reporting Only)

Please refer to Appendix A.

3.6 Conducted Band Edges Measurement

3.6.1 Limit of Band Edges

In any 100 kHz bandwidth outside the intentional radiation frequency band, the radio frequency power shall be at least 20 dB below the highest level of the radiated power. In addition, radiated emissions which fall in the restricted bands must also comply with the radiated emission limits.

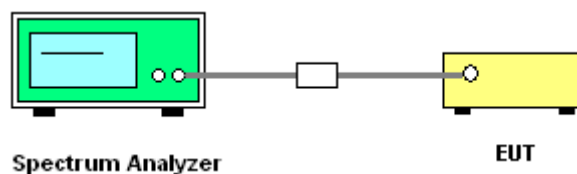
3.6.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.6.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 7.8.6.
2. Set to the maximum power setting and enable the EUT transmit continuously.
3. Set RBW = 100kHz, VBW = 300kHz. Band edge emissions must be at least 20 dB down from the highest emission level within the authorized band as measured with a 100kHz RBW. The attenuation shall be 30 dB instead of 20 dB when RMS conducted output power procedure is used.
4. Enable hopping function of the EUT and then repeat step 2. and 3.
5. Measure and record the results in the test report.

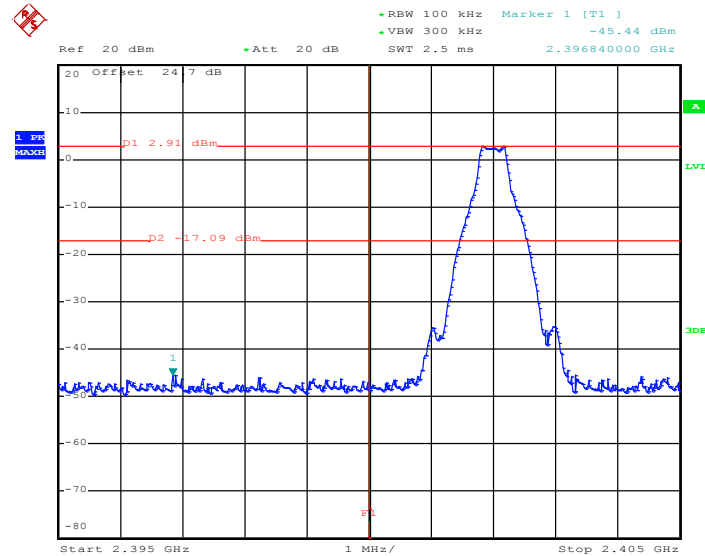
3.6.4 Test Setup



3.6.5 Test Result of Conducted Band Edges

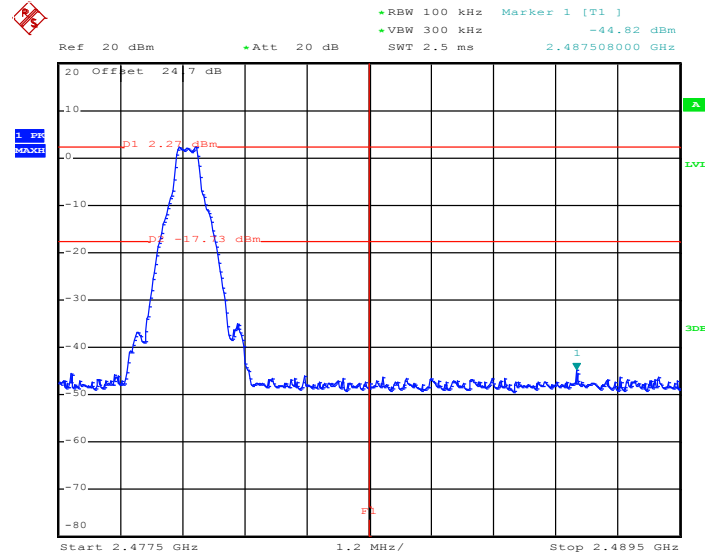
<1Mbps>

Low Band Edge Plot on Channel 00



Date: 3.JUL.2018 08:13:21

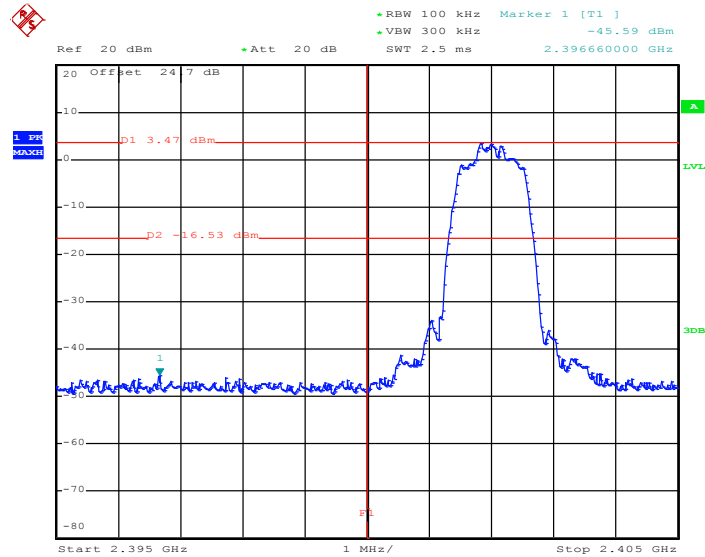
High Band Edge Plot on Channel 78



Date: 3.JUL.2018 08:24:31

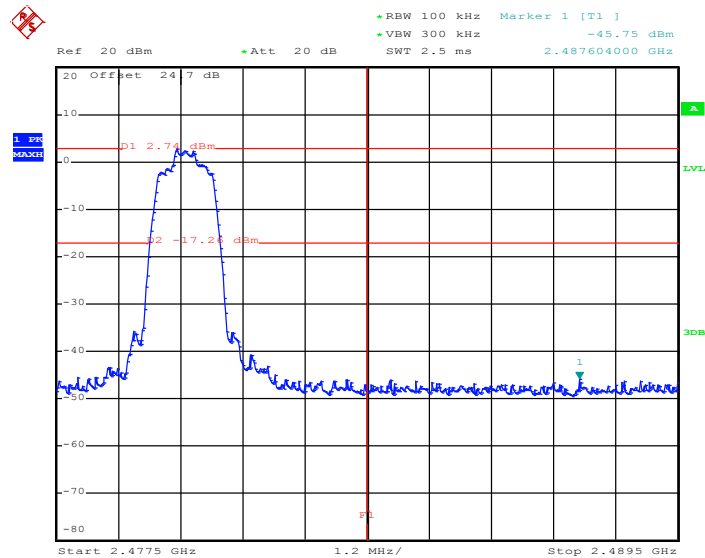
<2Mbps>

Low Band Edge Plot on Channel 00



Date: 3.JUL.2018 08:32:53

High Band Edge Plot on Channel 78

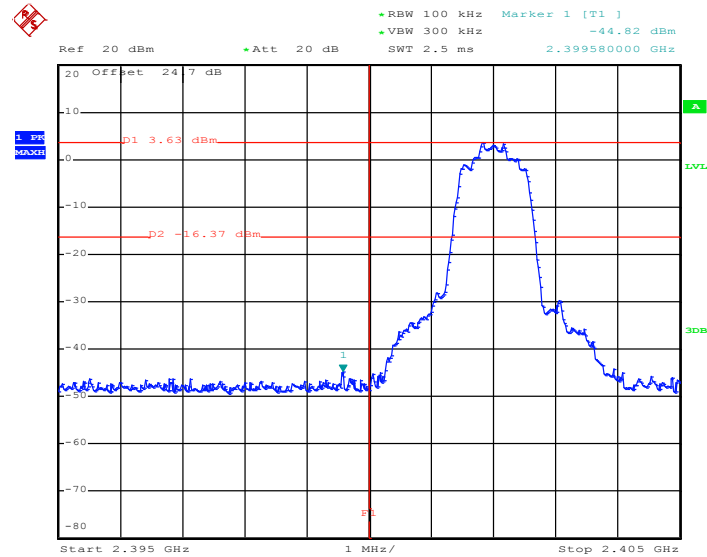


Date: 3.JUL.2018 08:49:22



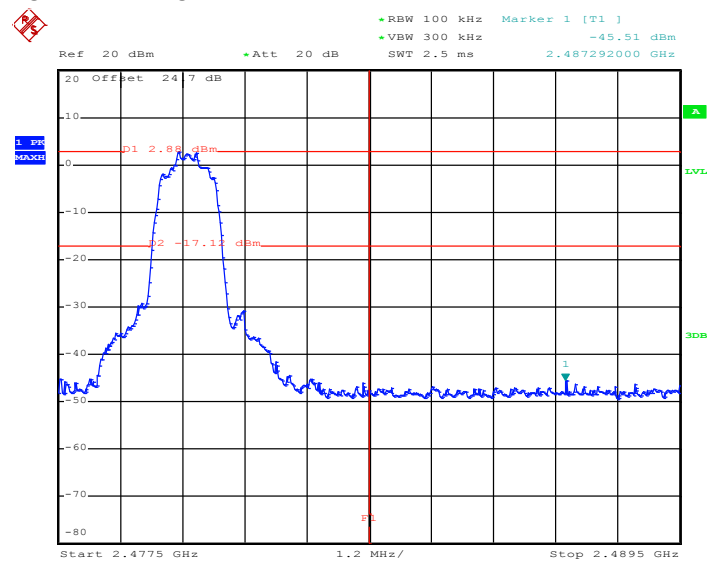
<3Mbps>

Low Band Edge Plot on Channel 00



Date: 3.JUL.2018 08:57:00

High Band Edge Plot on Channel 78

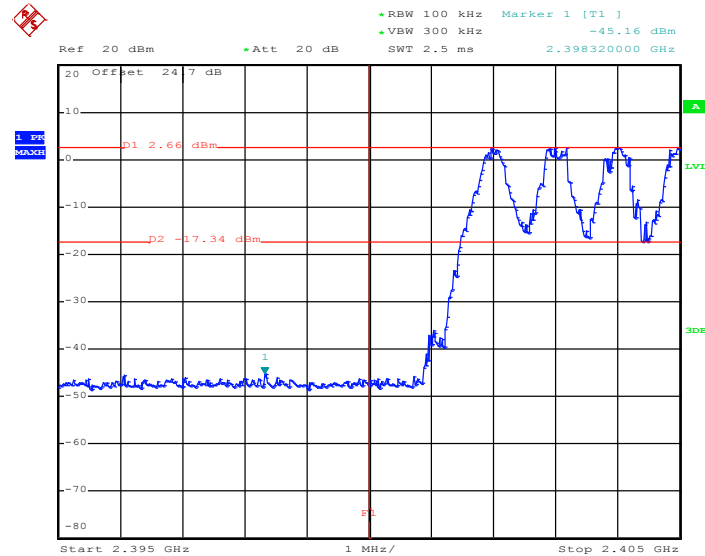


Date: 3.JUL.2018 09:08:06

3.6.6 Test Result of Conducted Hopping Mode Band Edges

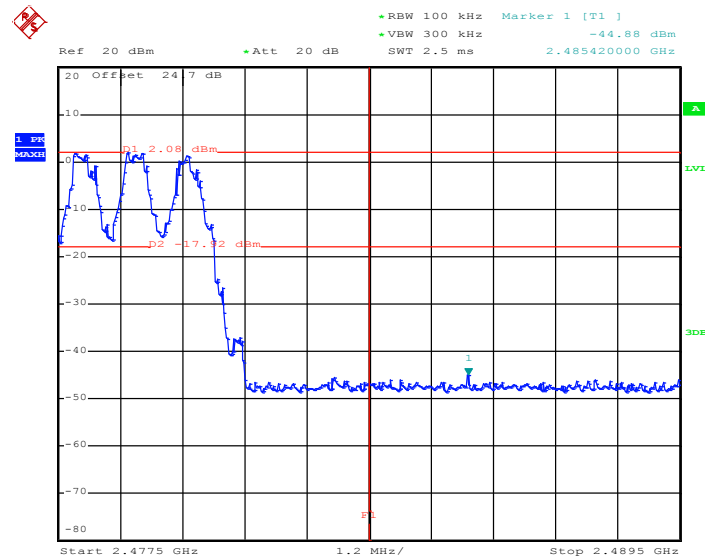
<1Mbps>

Hopping Mode Low Band Edge Plot

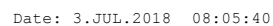


Date: 3.JUL.2018 08:07:42

Hopping Mode High Band Edge Plot

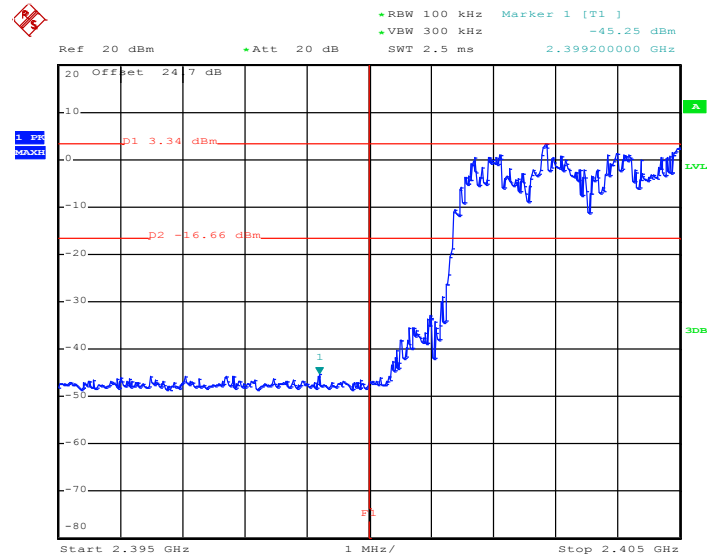


Date: 3.JUL.2018 08:08:33



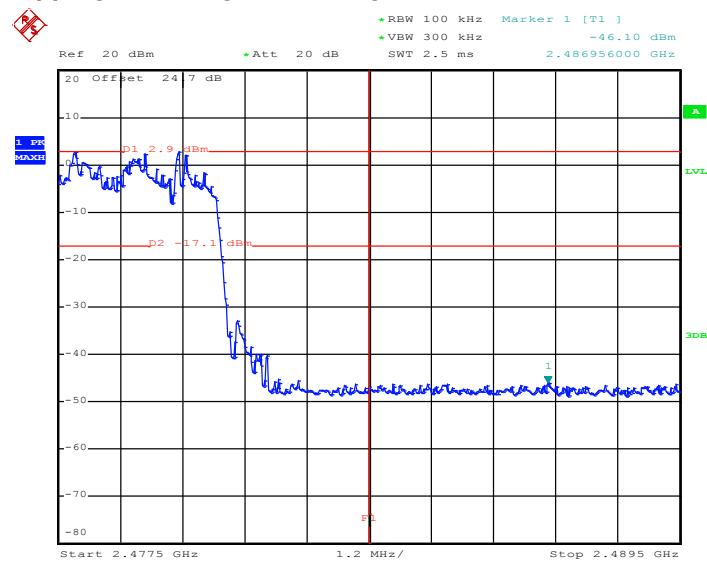
<3Mbps>

Hopping Mode Low Band Edge Plot



Date: 3.JUL.2018 08:02:48

Hopping Mode High Band Edge Plot



Date: 3.JUL.2018 08:03:32

3.7 Conducted Spurious Emission Measurement

3.7.1 Limit of Spurious Emission Measurement

In any 100 kHz bandwidth outside the intentional radiation frequency band, the radio frequency power shall be at least 20 dB below the highest level of the radiated power. In addition, radiated emissions which fall in the restricted bands must also comply with the radiated emission limits.

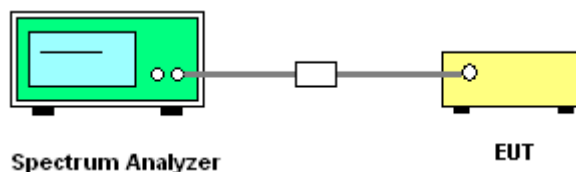
3.7.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.7.3 Test Procedure

1. The testing follows ANSI C63.10-2013 clause 7.8.8.
2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Set RBW = 100 kHz, VBW = 300kHz, scan up through 10th harmonic. All harmonics / spurs must be at least 20 dB down from the highest emission level within the authorized band as measured with a 100 kHz RBW.
5. Measure and record the results in the test report.
6. The RF fundamental frequency should be excluded against the limit line in the operating frequency band.

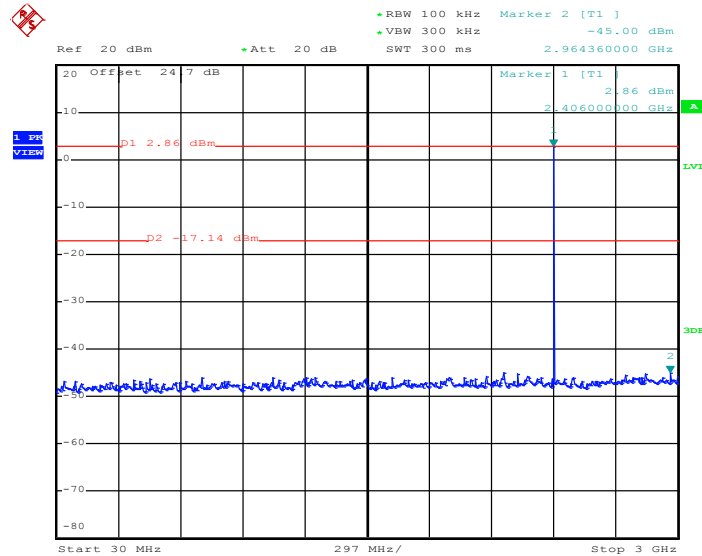
3.7.4 Test Setup



3.7.5 Test Result of Conducted Spurious Emission

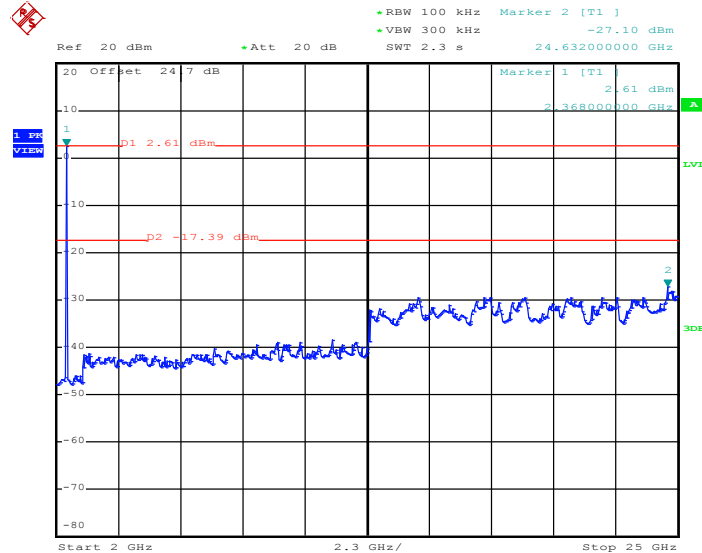
<1Mbps>

CSE Plot on Ch 00 between 30MHz ~ 3 GHz

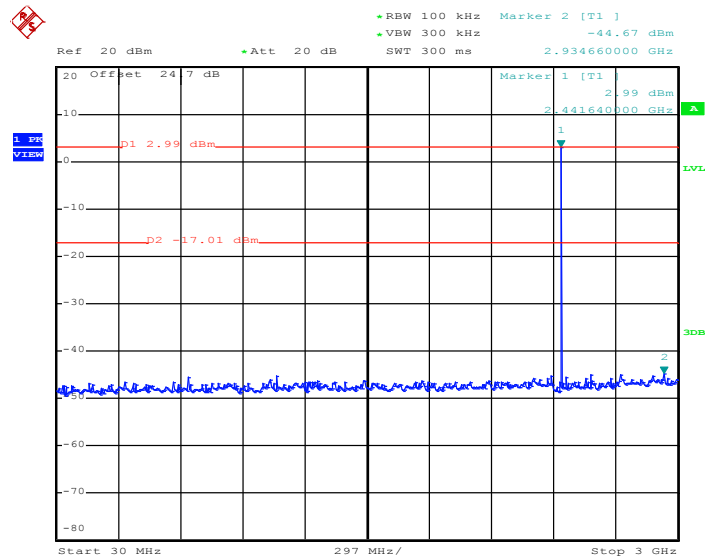


Date: 3.JUL.2018 08:15:48

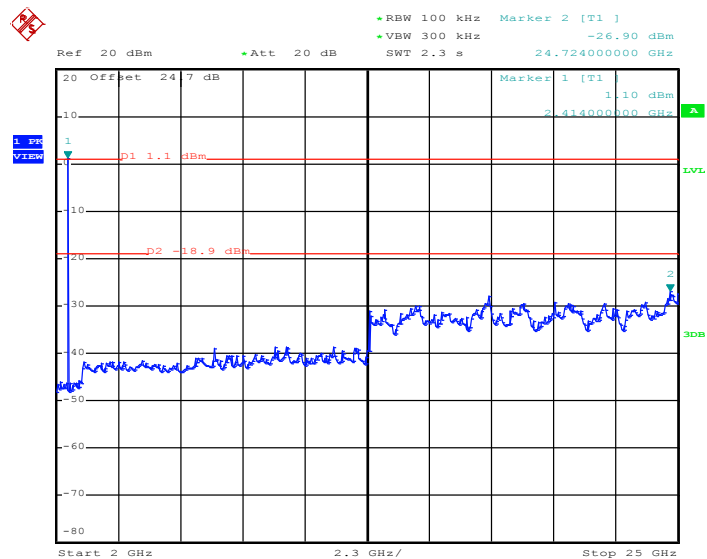
CSE Plot on Ch 00 between 2 GHz ~ 25 GHz



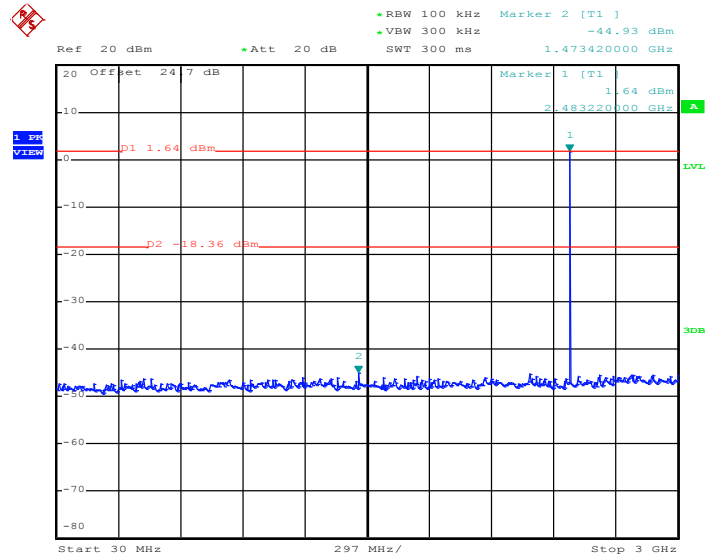
Date: 3.JUL.2018 08:16:15

CSE Plot on Ch 39 between 30MHz ~ 3 GHz


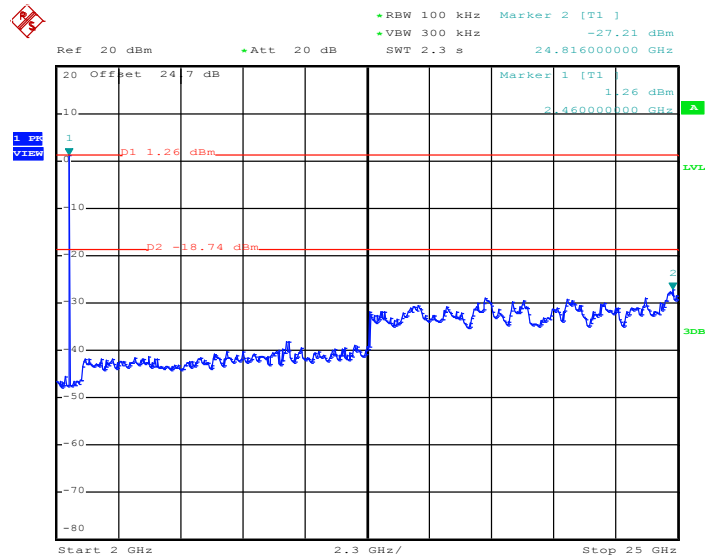
Date: 3.JUL.2018 08:21:21

CSE Plot on Ch 39 between 2 GHz ~ 25 GHz


Date: 3.JUL.2018 08:21:54

CSE Plot on Ch 78 between 30MHz ~ 3 GHz


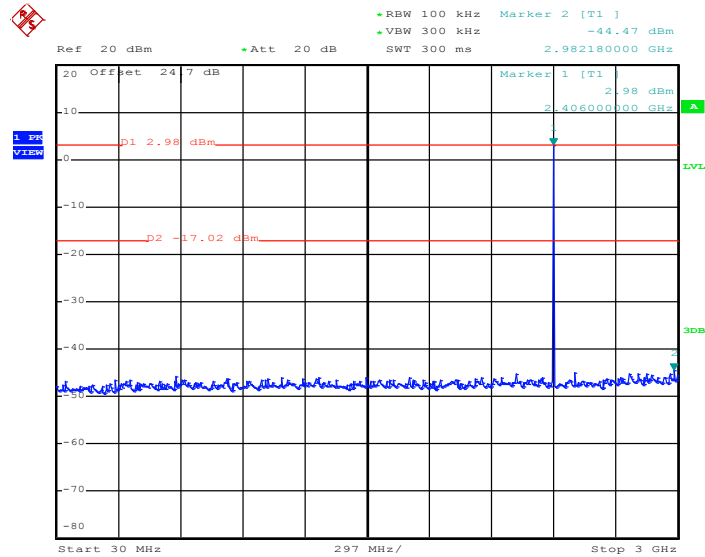
Date: 3.JUL.2018 08:25:44

CSE Plot on Ch 78 between 2 GHz ~ 25 GHz


Date: 3.JUL.2018 08:26:11

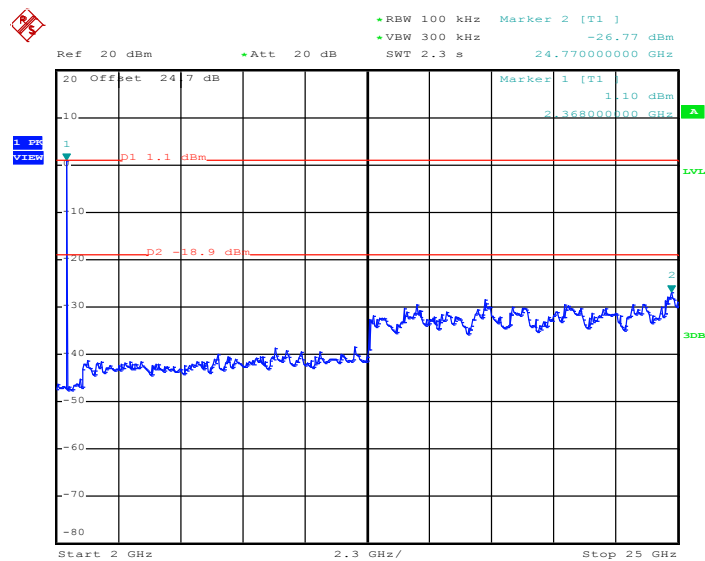
<2Mbps>

CSE Plot on Ch 00 between 30MHz ~ 3 GHz

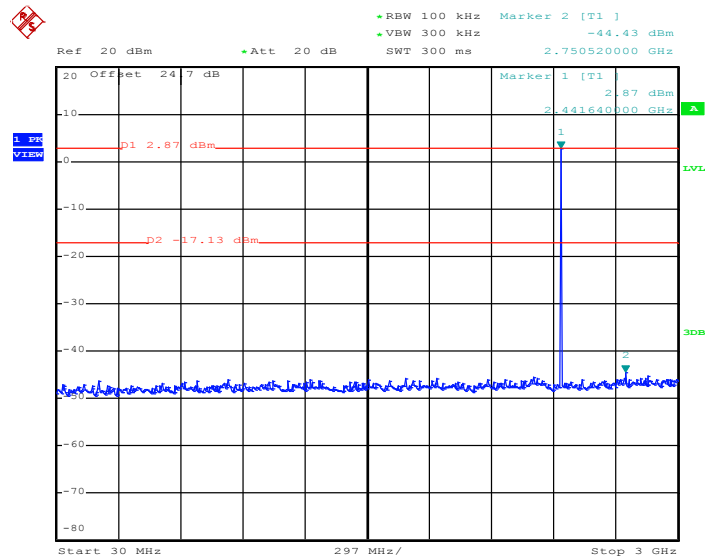


Date: 3.JUL.2018 08:36:54

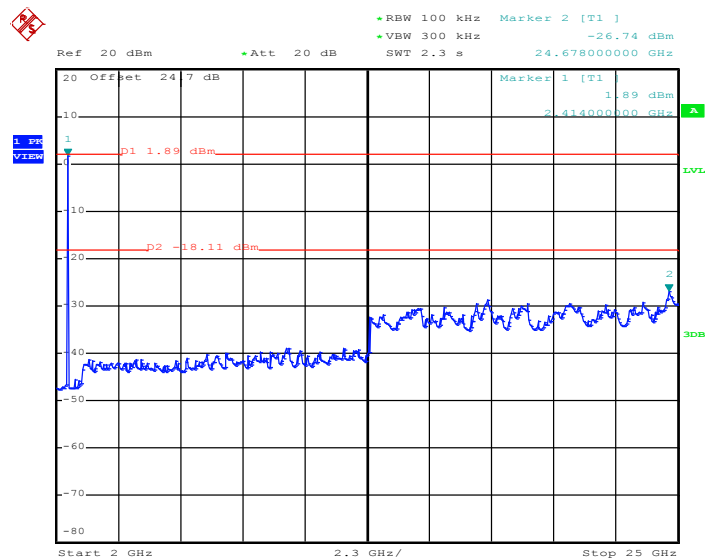
CSE Plot on Ch 00 between 2 GHz ~ 25 GHz



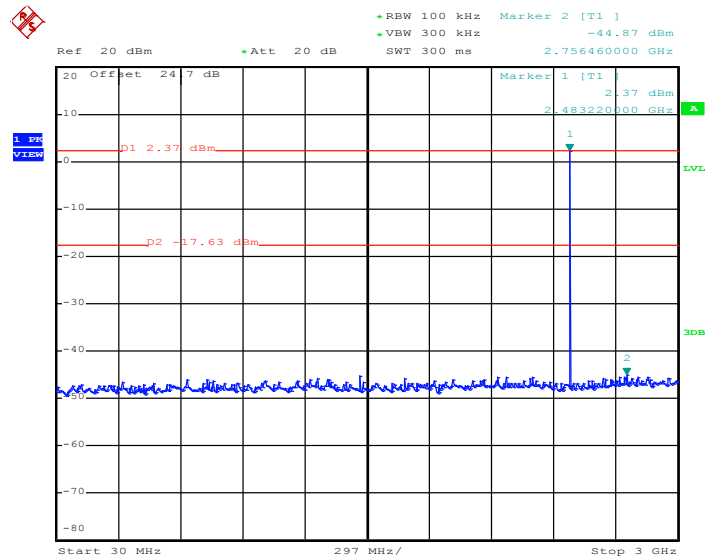
Date: 3.JUL.2018 08:37:22

CSE Plot on Ch 39 between 30MHz ~ 3 GHz


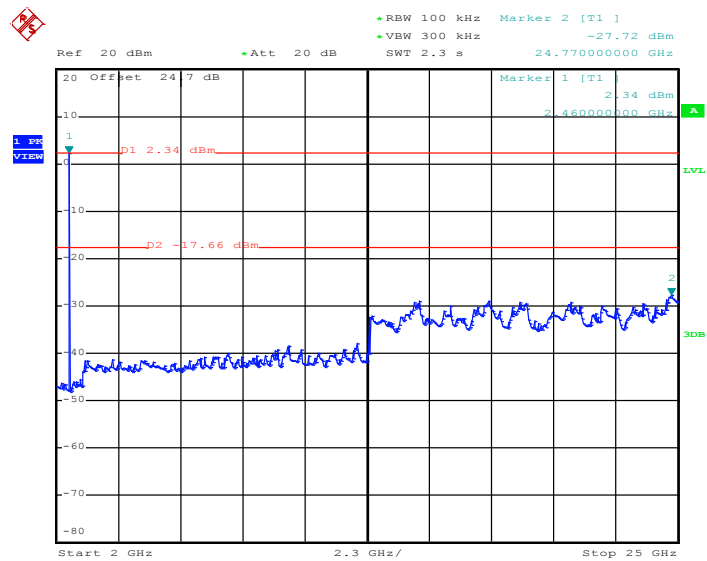
Date: 3.JUL.2018 08:44:49

CSE Plot on Ch 39 between 2 GHz ~ 25 GHz


Date: 3.JUL.2018 08:45:17

CSE Plot on Ch 78 between 30MHz ~ 3 GHz


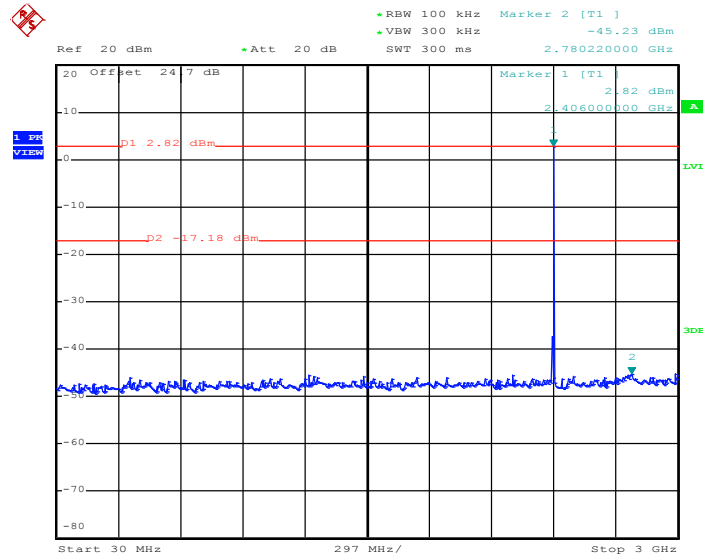
Date: 3.JUL.2018 08:51:22

CSE Plot on Ch 78 between 2 GHz ~ 25 GHz


Date: 3.JUL.2018 08:51:49

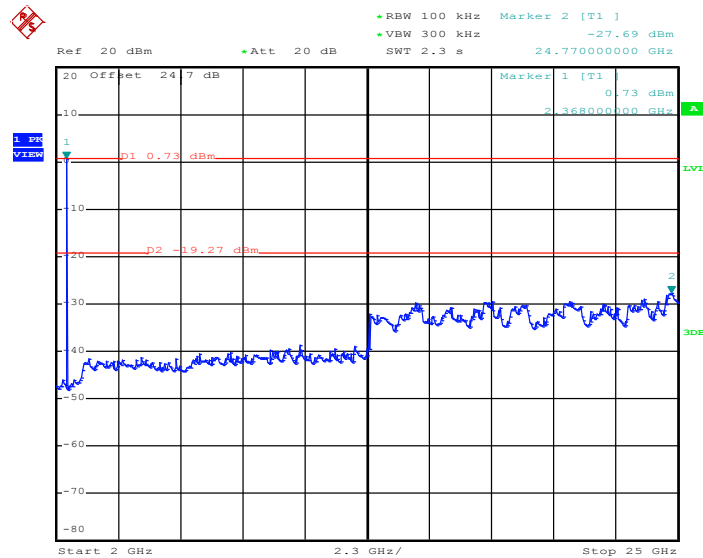
<3Mbps>

CSE Plot on Ch 00 between 30MHz ~ 3 GHz

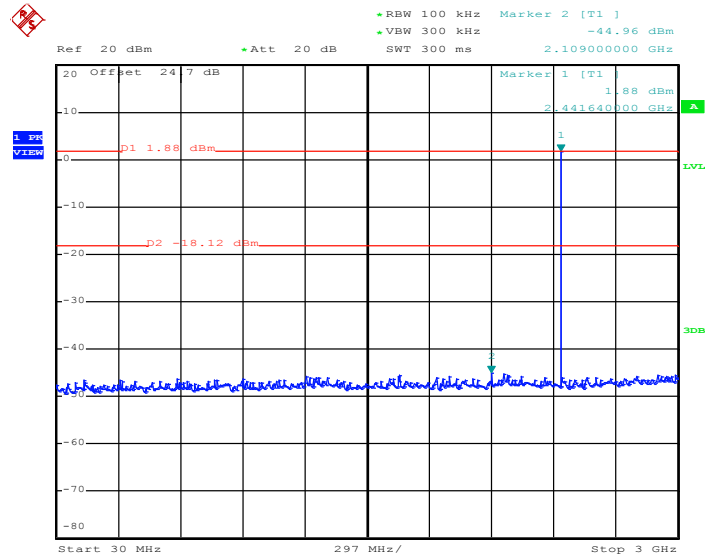


Date: 3.JUL.2018 08:58:26

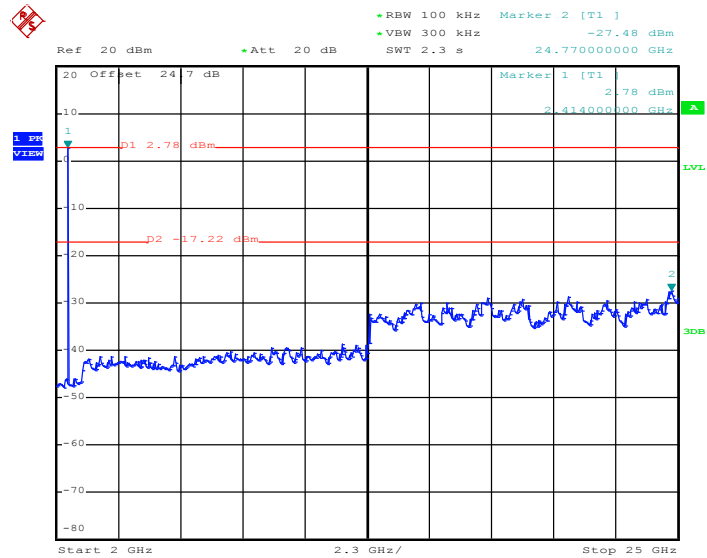
CSE Plot on Ch 00 between 2 GHz ~ 25 GHz



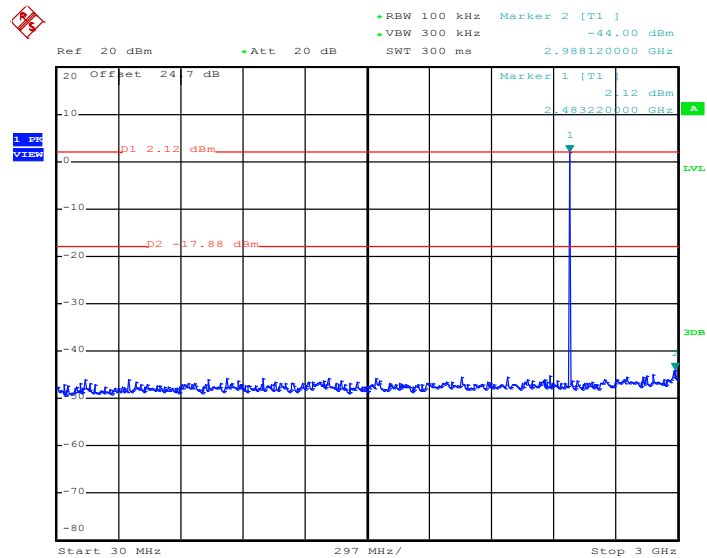
Date: 3.JUL.2018 08:59:19

CSE Plot on Ch 39 between 30MHz ~ 3 GHz


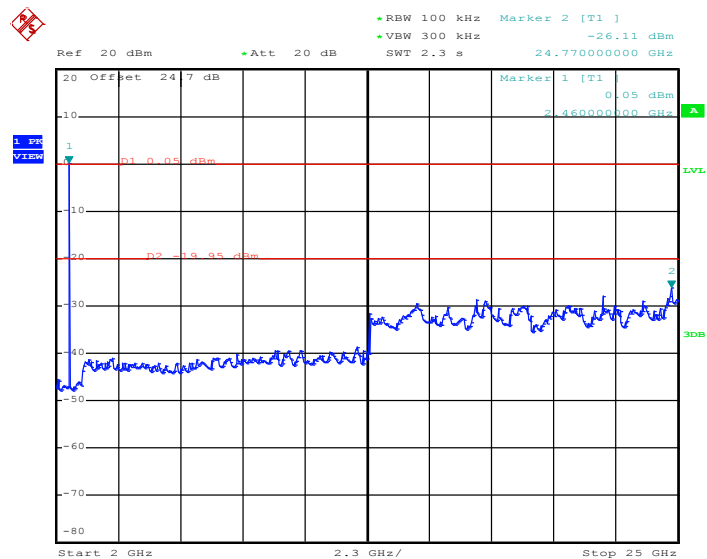
Date: 3.JUL.2018 09:05:12

CSE Plot on Ch 39 between 2 GHz ~ 25 GHz


Date: 3.JUL.2018 09:05:41

CSE Plot on Ch 78 between 30MHz ~ 3 GHz


Date: 3.JUL.2018 09:10:20

CSE Plot on Ch 78 between 2 GHz ~ 25 GHz


Date: 3.JUL.2018 09:10:48

3.8 Radiated Band Edges and Spurious Emission Measurement

3.8.1 Limit of Radiated Band Edges and Spurious Emission

In any 100 kHz bandwidth outside the intentional radiator frequency band, all harmonics/spurious must be at least 20 dB below the highest emission level within the authorized band. In addition, radiated emissions which fall in the restricted bands must also comply with the NCC LP0002 section 2.8 limits as below.

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

3.8.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

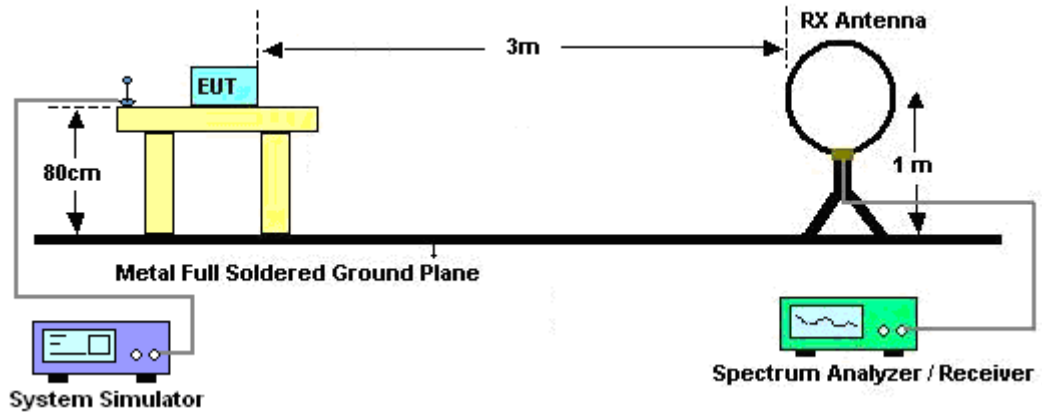
3.8.3 Test Procedures

1. The EUT was placed on a turntable with 0.8 meter for frequency below 1GHz and 1.5 meter for frequency above 1GHz respectively above ground.
2. The EUT was set 3 meters from the interference receiving antenna, which was mounted on the top of a variable height antenna tower.
3. For each suspected emission, the EUT was arranged to its worst case and then tune the Antenna tower (from 1 m to 4 m) and turntable (from 0 degree to 360 degrees) to find the maximum reading. A pre-amp and a high pass filter are used for the test in order to get better signal level to comply with the guidelines.
4. Set to the maximum power setting and enable the EUT transmit continuously.
5. Use the following spectrum analyzer settings:
 - (1) Span shall wide enough to fully capture the emission being measured;
 - (2) Set RBW=100 kHz for $f < 1$ GHz, RBW=1MHz for $f > 1$ GHz ; VBW $\geq$ RBW; Sweep = auto; Detector function = peak; Trace = max hold for peak
 - (3) For average measurement: use duty cycle correction factor method per 15.35(c).
Duty cycle = On time/100 milliseconds
On time = $N_1 * L_1 + N_2 * L_2 + \dots + N_{n-1} * L_{n-1} + N_n * L_n$
Where N_1 is number of type 1 pulses, L_1 is length of type 1 pulses, etc.
Average Emission Level = Peak Emission Level + $20 * \log(\text{Duty cycle})$
6. Corrected Reading: Antenna Factor + Cable Loss + Read Level - Preamp Factor = Level.
7. For testing below 1GHz, if the emission level of the EUT in peak mode was 3 dB lower than the limit specified, then peak values of EUT will be reported, otherwise, the emissions will be repeated one by one using the CISPR quasi-peak method and reported.
8. For testing above 1GHz, the emission level of the EUT in peak mode was 20dB lower than average limit (that means the emission level in average mode also complies with the limit in average mode), then peak values of EUT will be reported, otherwise, the emissions will be measured in average mode again and reported.

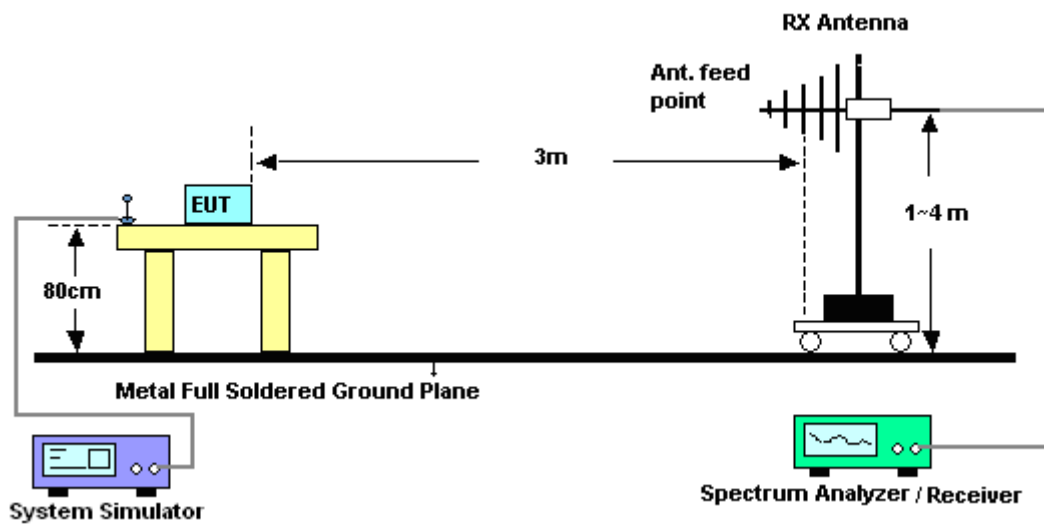
Note: The average levels were calculated from the peak level corrected with duty cycle correction factor (-24.75dB) derived from $20 \log(\text{dwell time}/100\text{ms})$. This correction is only for signals that hop with the fundamental signal, such as band-edge and harmonic. Other spurious signals that are independent of the hopping signal would not use this correction.

3.8.4 Test Setup

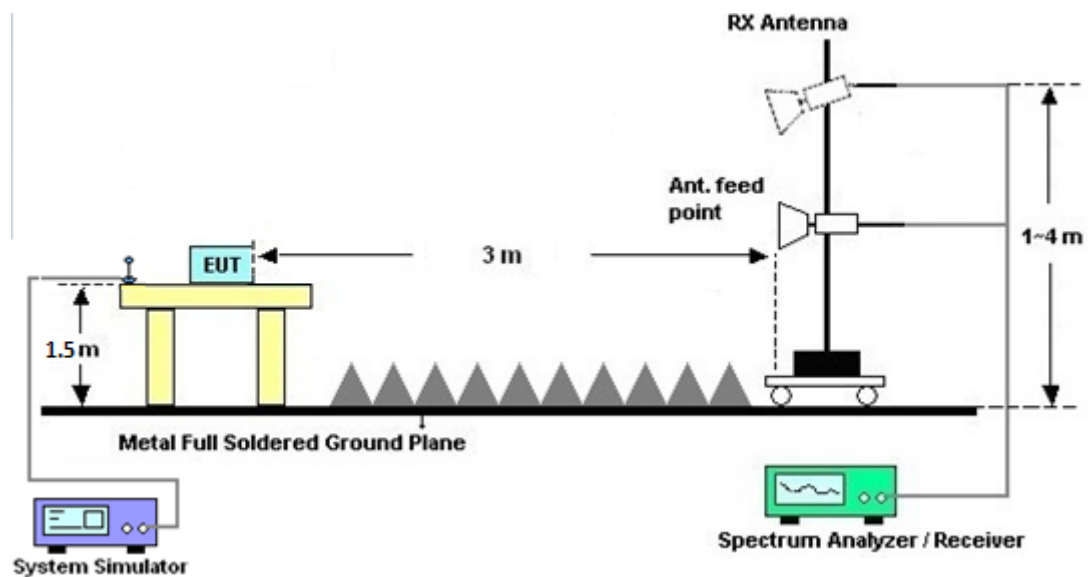
For radiated emissions below 30MHz



For radiated emissions from 30MHz to 1GHz



For radiated emissions above 1GHz



3.8.5 Test Results of Radiated Spurious Emissions (9 kHz ~ 30 MHz)

The low frequency, which started from 9 kHz to 30MHz, was pre-scanned and the result which was 20dB lower than the limit line per NCC LP0002 section 5.13 was not reported.

There is a comparison data of both open-field test site and semi-Anechoic chamber, and the result came out very similar.

3.8.6 Test Result of Radiated Spurious at Band Edges

Please refer to Appendix C and D.

3.8.7 Duty Cycle

Please refer to Appendix E.

3.8.8 Test Result of Radiated Spurious Emission (30MHz ~ 10th Harmonic)

Please refer to Appendix C and D.

3.9 Test of Receiver Radiated Emission Measurement

3.9.1 Limit of Receiver Radiated Emission

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

3.9.2 Measuring Instruments

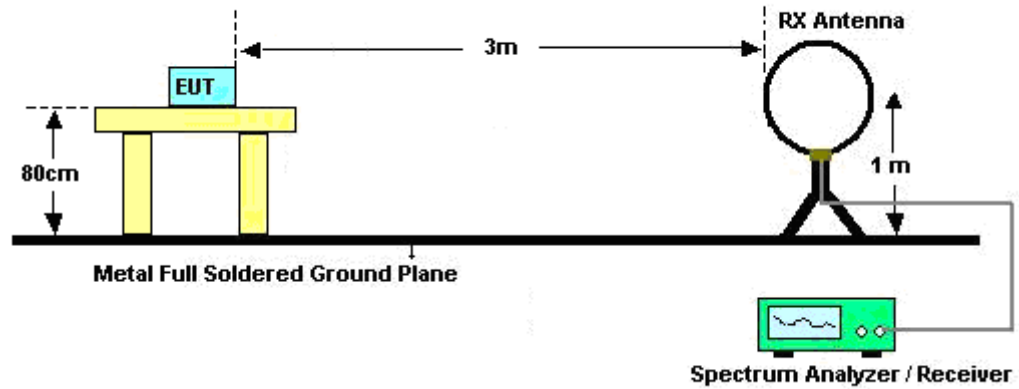
The measuring equipment is listed in the section 4 of this test report.

3.9.3 Test Procedures

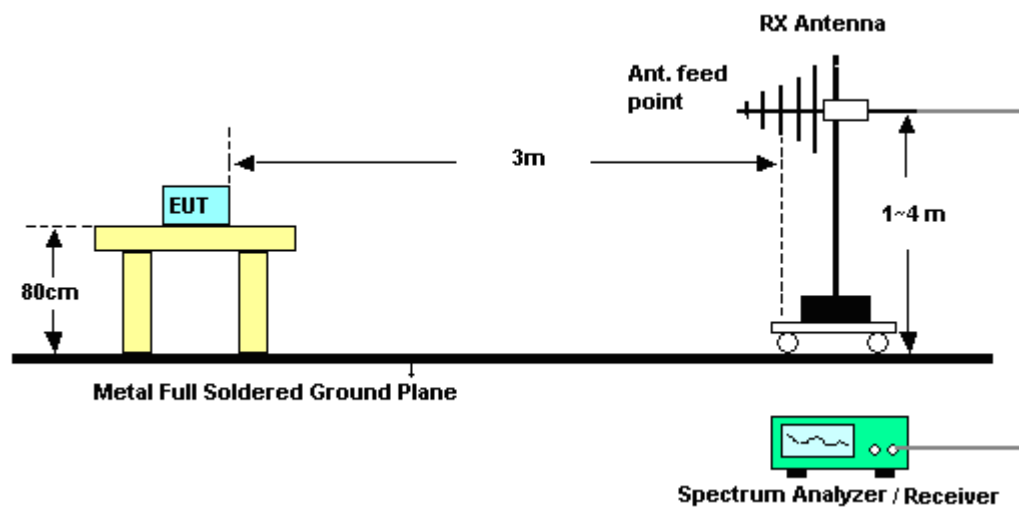
1. The EUT was placed on a turntable with 0.8 meter above ground.
2. The EUT was set 3 meters from the interference receiving antenna, which was mounted on the top of a variable height antenna tower.
3. The table was rotated 360 degrees to determine the position of the highest radiation.
4. The antenna is a Bi-Log antenna and its height is adjusted between one to four meters above ground to find the maximum value of the field strength for both horizontal polarization and vertical polarization of the antenna.
5. For each suspected emission, the EUT was arranged to its worst case and then tune the antenna tower (from 1 m to 4 m) and turntable (from 0 degree to 360 degrees) to find the maximum reading.
6. Set the test-receiver system to Peak Detect Function and specified bandwidth with Maximum Hold Mode (RBW=120kHz/VBW=300kHz for frequency below 1GHz; RBW=1MHz VBW=3MHz (Peak), RBW=1MHz/VBW=10Hz (Average) for frequency above 1GHz).
7. If the emission level of the EUT in peak mode was 3 dB lower than the limit specified, peak values of EUT will be reported. Otherwise, the emission will be repeated by using the quasi-peak method and reported.
8. Emission level (dBμV/m) = 20 log Emission level (μV/m)
9. Corrected Reading: Antenna Factor + Cable Loss + Read Level - Preamp Factor = Level

3.9.4 Test Setup

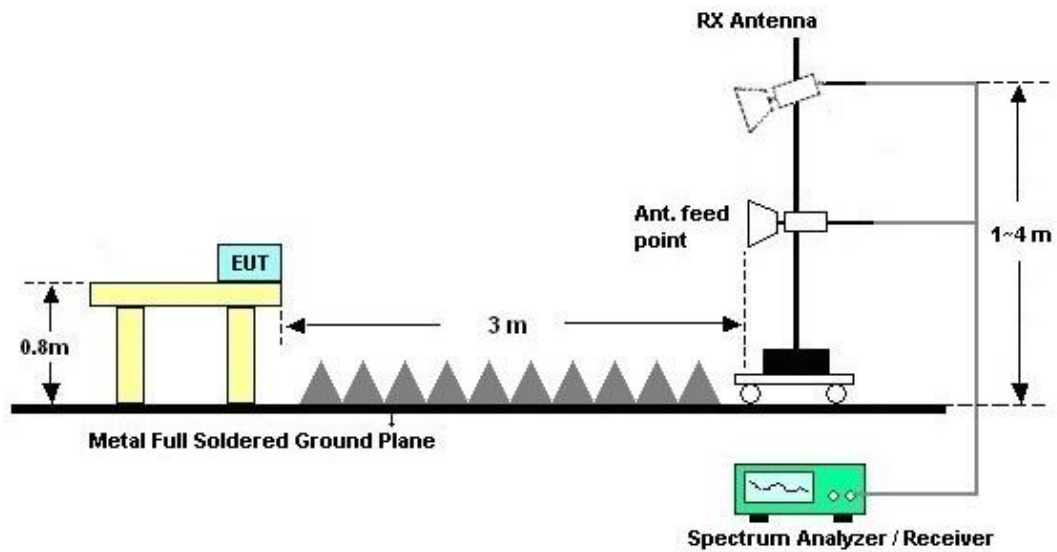
For radiated emissions below 30MHz



For radiated emissions from 30MHz to 1GHz



For radiated emissions above 1GHz



3.9.5 Test Result of Receiver Radiated Spurious Emissions (9kHz ~ 30MHz)

The low frequency, which started from 9 kHz to 30MHz, was pre-scanned and the result which was 20dB lower than the limit line per NCC LP0002 clause 5.13 was not reported.

There is a comparison data of both open-field test site and semi-Anechoic chamber, and the result came out very similar.

3.9.6 Test Result of Receiver Radiated Spurious Emission (30MHz ~ 5th Harmonic)

Please refer to Appendix D.

3.10 AC Conducted Emission Measurement

3.10.1 Limit of AC Conducted Emission

For equipment that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in the following table.

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

*Decreases with the logarithm of the frequency.

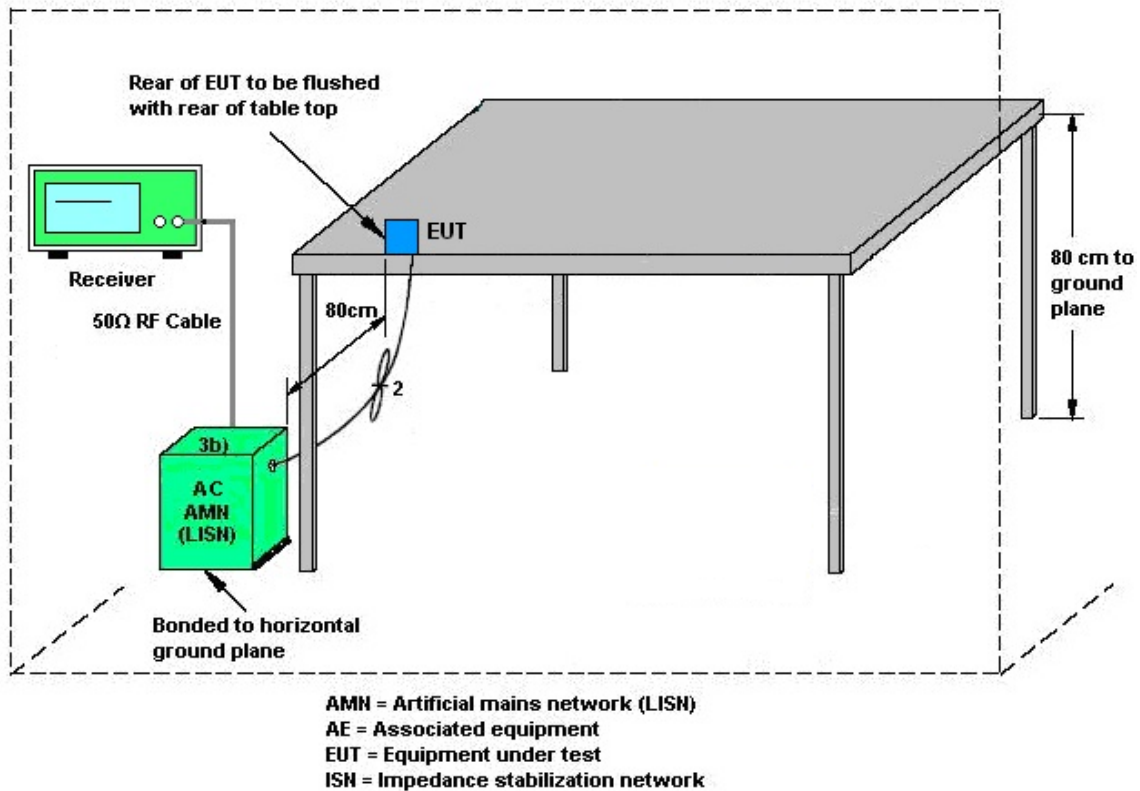
3.10.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.10.3 Test Procedures

1. The EUT was placed 0.4 meter from the conducting wall of the shielding room was kept at least 80 centimeters from any other grounded conducting surface.
2. Connect EUT to the power mains through a line impedance stabilization network (LISN).
3. All the support units are connecting to the other LISN.
4. The LISN provides 50 ohm coupling impedance for the measuring instrument.
5. The FCC states that a 50 ohm, 50 microhenry LISN should be used.
6. Both sides of AC line were checked for maximum conducted interference.
7. The frequency range from 150 kHz to 30 MHz was searched.
8. Set the test-receiver system to Peak Detect Function and specified bandwidth (IF Bandwidth = 9kHz) with Maximum Hold Mode.

3.10.4 Test Setup



3.10.5 Test Result of AC Conducted Emission

Please refer to Appendix B.

3.11 Antenna Requirements

3.11.1 Standard Applicable

If directional gain of transmitting antennas is greater than 6dBi, the power shall be reduced by the same level in dB comparing to gain minus 6dBi. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the LP0002 Section 2.2, Section 3.10.1.3, and Section 3.10.1.4.

3.11.2 Antenna Anti-Replacement Construction

An embedded-in antenna design is used.

3.11.3 Antenna Gain

The antenna peak gain of EUT is less than 6 dBi. Therefore, it is not necessary to reduce maximum peak output power limit.



4 List of Measuring Equipment

Instrument	Manufacturer	Model No.	Serial No.	Characteristics	Calibration Date	Test Date	Due Date	Remark
Power Meter	Agilent	E4416A	GB41292344	N/A	Dec. 20, 2017	Jun. 05, 2018~Jul. 03, 2018	Dec. 19, 2018	Conducted (TH05-HY)
Power Sensor	Agilent	E9327A	US40441548	50MHz~18GHz	Dec. 20, 2017	Jun. 05, 2018~Jul. 03, 2018	Dec. 19, 2018	Conducted (TH05-HY)
Spectrum Analyzer	Rohde & Schwarz	FSP30	101067	9kHz ~ 30GHz	Nov. 13, 2017	Jun. 05, 2018~Jul. 03, 2018	Nov. 12, 2018	Conducted (TH05-HY)
BT Base Station (Measure)	Rohde & Schwarz	CBT	101136	BT 3.0	Sep. 20, 2017	Jun. 05, 2018~Jul. 03, 2018	Sep. 19, 2018	Conducted (TH05-HY)
Switch Box & RF Cable	Burgeon	ETF-058	EC1300484	N/A	Mar. 01, 2018	Jun. 05, 2018~Jul. 03, 2018	Feb. 28, 2019	Conducted (TH05-HY)
AC Power Source	ChainTek	APC-1000W	N/A	N/A	N/A	Jun. 12, 2018	N/A	Conduction (CO05-HY)
EMI Test Receiver	Rohde & Schwarz	ESR3	102388	3.6GHz	Dec. 08, 2017	Jun. 12, 2018	Dec. 07, 2018	Conduction (CO05-HY)
LISN	Rohde & Schwarz	ENV216	100080	9kHz~30MHz	Nov. 30, 2017	Jun. 12, 2018	Nov. 29, 2018	Conduction (CO05-HY)
Software	Rohde & Schwarz	EMC32 V10.30	N/A	N/A	N/A	Jun. 12, 2018	N/A	Conduction (CO05-HY)
LF Cable	HUBER + SUHNER	RG-214/U	LF01	N/A	Jan. 03, 2018	Jun. 12, 2018	Jan. 02, 2019	Conduction (CO05-HY)
Pulse Limiter	Rohde & Schwarz	ESH3-Z2	100851	N/A	Jan. 03, 2018	Jun. 12, 2018	Jan. 02, 2019	Conduction (CO05-HY)
Loop Antenna	Rohde & Schwarz	HFH2-Z2	100488	9 kHz~30 MHz	Nov. 23, 2017	Jun. 16, 2018~Jun. 22, 2018	Nov. 22, 2018	Radiation (03CH11-HY)
Bilog Antenna	TESEQ	CBL 6111D&N-6-06	35414&AT-N0602	30MHz~1GHz	Oct. 14, 2017	Jun. 16, 2018~Jun. 22, 2018	Oct. 13, 2018	Radiation (03CH11-HY)
Horn Antenna	SCHWARZBECK	BBHA 9120 D	9120D-1326	1GHz ~ 18GHz	Oct. 16, 2017	Jun. 16, 2018~Jun. 22, 2018	Oct. 15, 2018	Radiation (03CH11-HY)
SHF-EHF Horn Antenna	SCHWARZBECK	BBHA 9170	BBHA9170584	18GHz- 40GHz	Nov. 27, 2017	Jun. 16, 2018~Jun. 22, 2018	Nov. 26, 2018	Radiation (03CH11-HY)
Amplifier	SONOMA	310N	187312	9kHz~1GHz	Jan. 16, 2018	Jun. 16, 2018~Jun. 22, 2018	Jan. 15, 2019	Radiation (03CH11-HY)
Preamplifier	Jet-Power	JPA0118-55-303K	1710001800054002	1GHz~18GHz	Apr. 17, 2018	Jun. 16, 2018~Jun. 22, 2018	Apr. 16, 2019	Radiation (03CH11-HY)
Preamplifier	Keysight	83017A	MY53270080	1GHz~26.5GHz	Jan. 16, 2018	Jun. 16, 2018~Jun. 22, 2018	Jan. 15, 2020	Radiation (03CH11-HY)
Amplifier	MITEQ	TTA1840-35-HG	1871923	18GHz~40GHz, VSWR : 2.5:1 max	Jul. 18, 2017	Jun. 16, 2018~Jun. 22, 2018	Jul. 17, 2018	Radiation (03CH11-HY)
Spectrum Analyzer	Keysight	N9010A	MY54200486	10Hz ~ 44GHz	Oct. 19, 2017	Jun. 16, 2018~Jun. 22, 2018	Oct. 18, 2018	Radiation (03CH11-HY)
Antenna Mast	EMEC	AM-BS-4500-B	N/A	1~4m	N/A	Jun. 16, 2018~Jun. 22, 2018	N/A	Radiation (03CH11-HY)
Turn Table	EMEC	TT 2000	N/A	0~360 Degree	N/A	Jun. 16, 2018~Jun. 22, 2018	N/A	Radiation (03CH11-HY)



Instrument	Manufacturer	Model No.	Serial No.	Characteristics	Calibration Date	Test Date	Due Date	Remark
RF Cable	HUBER + SUHNER	SUCOFLEX 104	MY9837/4	9K-30M	Mar. 20, 2018	Jun. 16, 2018~ Jun. 22, 2018	Mar. 19, 2019	Radiation (03CH11-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 104	MY9837/4	30M-18G	Mar. 15, 2018	Jun. 16, 2018~ Jun. 22, 2018	Mar. 14, 2019	Radiation (03CH11-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 102	MY2589/2	30M-18G	Mar. 15, 2018	Jun. 16, 2018~ Jun. 22, 2018	Mar. 14, 2019	Radiation (03CH11-HY)
Filter	Wainwright	WHKX12-270 0-3000-18000 -60SS	SN3	2.7G High Pass	Sep. 18, 2017	Jun. 16, 2018~ Jun. 22, 2018	Sep. 17, 2018	Radiation (03CH11-HY)
Filter	Wainwright	WLK4-1000-1 530-8000-40S S	SN11	1G Low Pass	Sep. 18, 2017	Jun. 16, 2018~ Jun. 22, 2018	Sep. 17, 2018	Radiation (03CH11-HY)
Software	Audix	E3 6.2009-8-24	RK-00104 2	N/A	N/A	Jun. 16, 2018~ Jun. 22, 2018	N/A	Radiation (03CH11-HY)

5 Uncertainty of Evaluation

Uncertainty of Conducted Emission Measurement (150 kHz ~ 30 MHz)

Measuring Uncertainty for a Level of Confidence of 95% ($U = 2Uc(y)$)	2.7
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Uncertainty of Radiated Emission Measurement (30 MHz ~ 1000 MHz)

Measuring Uncertainty for a Level of Confidence of 95% ($U = 2Uc(y)$)	5.2
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Uncertainty of Radiated Emission Measurement (1000 MHz ~ 18000 MHz)

Measuring Uncertainty for a Level of Confidence of 95% ($U = 2Uc(y)$)	5.5
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Uncertainty of Radiated Emission Measurement (18000 MHz ~ 40000 MHz)

Measuring Uncertainty for a Level of Confidence of 95% ($U = 2Uc(y)$)	5.2
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Appendix A. Test Result of Conducted Test Items

Test Engineer:	Rebecca Li/Shiming Liu	Temperature:	21~25	°C
Test Date:	2018/6/5~2018/7/3	Relative Humidity:	51~54	%

TEST RESULTS DATA**20dB and 99% Occupied Bandwidth and Hopping Channel Separation**

Mod.	Data Rate	NTX	CH.	Freq. (MHz)	20db BW (MHz)	99% Bandwidth (MHz)	Hopping Channel Separation Measurement (MHz)	Hopping Channel Separation Measurement Limit (MHz)	Pass/Fail
DH	1Mbps	1	0	2402	0.928	0.840	1.002	0.6187	Pass
DH	1Mbps	1	39	2441	0.936	0.844	1.008	0.6240	Pass
DH	1Mbps	1	78	2480	0.936	0.840	0.996	0.6240	Pass
2DH	2Mbps	1	0	2402	1.296	1.168	1.008	0.8640	Pass
2DH	2Mbps	1	39	2441	1.296	1.168	1.320	0.8640	Pass
2DH	2Mbps	1	78	2480	1.296	1.168	1.350	0.8640	Pass
3DH	3Mbps	1	0	2402	1.266	1.156	1.008	0.8440	Pass
3DH	3Mbps	1	39	2441	1.266	1.152	1.008	0.8440	Pass
3DH	3Mbps	1	78	2480	1.266	1.152	0.990	0.8440	Pass

TEST RESULTS DATA**Dwell Time**

Mod.	Hopping Channel Number Rate	Hops Over Occupancy Time(hops)	Package Transfer Time (msec)	Dwell Time (sec)	Limits (sec)	Pass/Fail
Nomal	79	106.67	2.90	0.31	0.4	Pass
AFH	20	53.33	2.90	0.15	0.4	Pass

TEST RESULTS DATA**Peak Power Table**

DH	CH.	NTX	Peak Power (dBm)	Power Limit (dBm)	Test Result
DH1	0	1	3.75	20.97	Pass
	39	1	3.51	20.97	Pass
	78	1	3.06	20.97	Pass
2DH1	0	1	6.44	20.97	Pass
	39	1	6.18	20.97	Pass
	78	1	5.67	20.97	Pass
3DH1	0	1	6.75	20.97	Pass
	39	1	6.47	20.97	Pass
	78	1	5.99	20.97	Pass

TEST RESULTS DATA**Average Power Table****(Reporting Only)**

DH	CH.	NTX	Average Power (dBm)	Duty Factor (dB)
DH1	0	1	3.36	5.14
	39	1	3.12	5.14
	78	1	2.58	5.14
2DH1	0	1	3.81	5.07
	39	1	3.52	5.07
	78	1	2.91	5.07
3DH1	0	1	3.84	5.14
	39	1	3.53	5.14
	78	1	2.95	5.14

TEST RESULTS DATA**Number of Hopping Frequency**

Number of Hopping (Channel)	Adaptive Frequency Hopping (Channel)	Limits (Channel)	Pass/Fail
79	20	> 15	Pass



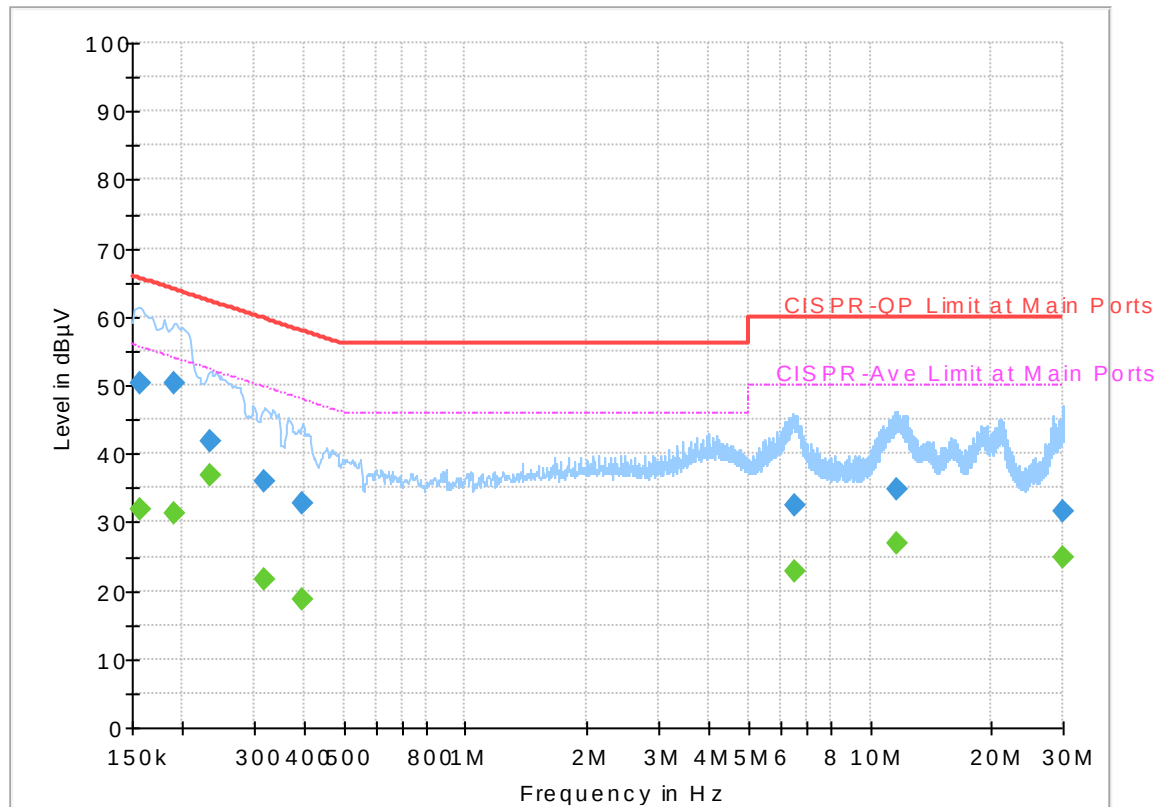
Appendix B. AC Conducted Emission Test Results

Test Engineer :	Kai-Chun Chu	Temperature :	25~27°C
		Relative Humidity :	50~52%

EUT Information

Report NO : 850937
 Test Mode : Mode 2
 Test Voltage : 110Vac/60Hz
 Phase : Line

Full Spectrum



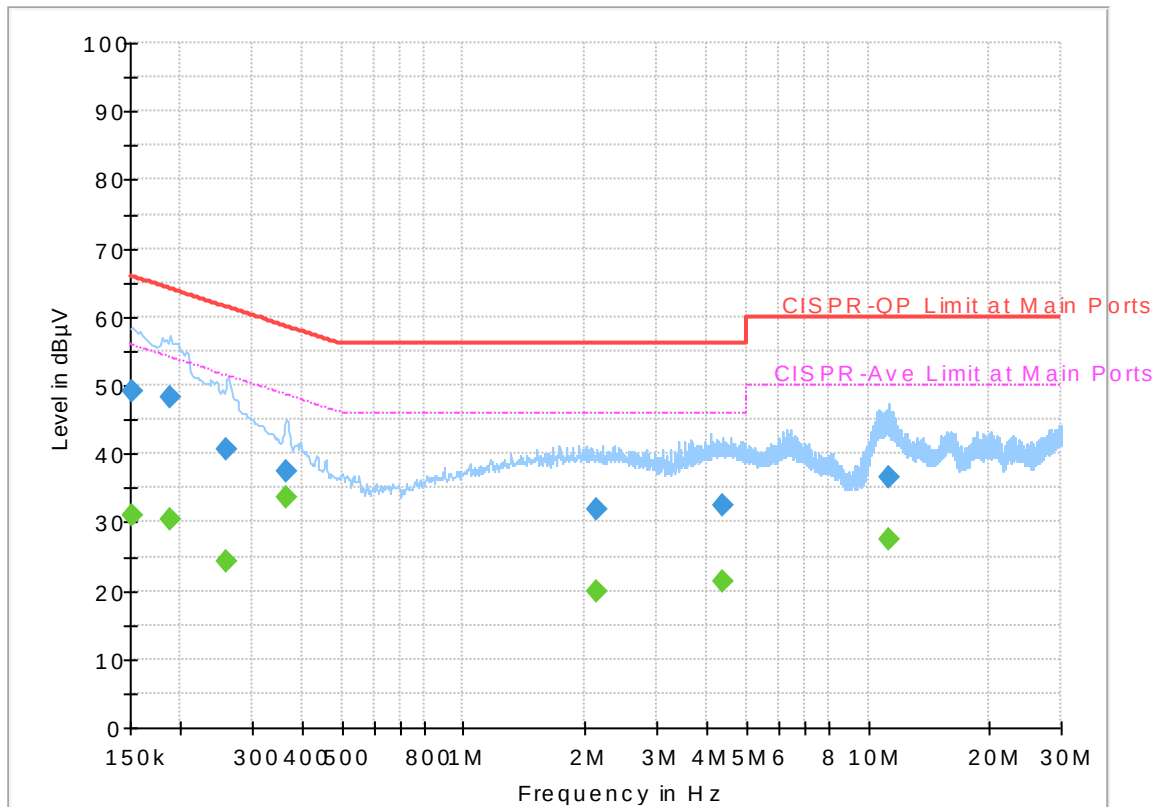
Final Result

Frequency (MHz)	QuasiPeak (dBμV)	CAverage (dBμV)	Limit (dBμV)	Margin (dB)	Line	Filter	Corr. (dB)
0.156750	---	31.87	55.63	23.76	L1	OFF	19.5
0.156750	50.44	---	65.63	15.19	L1	OFF	19.5
0.190500	---	31.35	54.02	22.67	L1	OFF	19.5
0.190500	50.19	---	64.02	13.83	L1	OFF	19.5
0.233250	---	36.71	52.33	15.62	L1	OFF	19.5
0.233250	41.91	---	62.33	20.42	L1	OFF	19.5
0.318750	---	21.50	49.74	28.24	L1	OFF	19.5
0.318750	35.97	---	59.74	23.77	L1	OFF	19.5
0.395250	---	18.58	47.95	29.37	L1	OFF	19.5
0.395250	32.72	---	57.95	25.23	L1	OFF	19.5
6.481500	---	22.89	50.00	27.11	L1	OFF	19.6
6.481500	32.59	---	60.00	27.41	L1	OFF	19.6
11.625000	---	26.82	50.00	23.18	L1	OFF	19.7
11.625000	34.84	---	60.00	25.16	L1	OFF	19.7
29.971500	---	24.85	50.00	25.15	L1	OFF	19.8
29.971500	31.54	---	60.00	28.46	L1	OFF	19.8

EUT Information

Report NO : 850937
 Test Mode : Mode 2
 Test Voltage : 110Vac/60Hz
 Phase : Neutral

Full Spectrum



Final Result

Frequency (MHz)	QuasiPeak (dBμV)	CAverage (dBμV)	Limit (dBμV)	Margin (dB)	Line	Filter	Corr. (dB)
0.152250	---	30.92	55.88	24.96	N	OFF	19.5
0.152250	49.18	---	65.88	16.70	N	OFF	19.5
0.188250	---	30.47	54.11	23.64	N	OFF	19.5
0.188250	48.18	---	64.11	15.93	N	OFF	19.5
0.260250	---	24.29	51.42	27.13	N	OFF	19.5
0.260250	40.70	---	61.42	20.72	N	OFF	19.5
0.366000	---	33.50	48.59	15.09	N	OFF	19.5
0.366000	37.56	---	58.59	21.03	N	OFF	19.5
2.141250	---	19.78	46.00	26.22	N	OFF	19.4
2.141250	31.89	---	56.00	24.11	N	OFF	19.4
4.353000	---	21.49	46.00	24.51	N	OFF	19.6
4.353000	32.35	---	56.00	23.65	N	OFF	19.6
11.235750	---	27.63	50.00	22.37	N	OFF	19.7
11.235750	36.47	---	60.00	23.53	N	OFF	19.7



Appendix C. Radiated Spurious Emission

Test Engineer :	Hao Hsu and Ken Wu	Temperature :	22~25°C
		Relative Humidity :	50~55%

2.4GHz 2400~2483.5MHz

BT (Band Edge @ 3m)

BT	Note	Frequency	Level	Over	Limit	Read	Antenna	Path	Preamp	Ant	Table	Peak	Pol.
				Limit	Line	Level	Factor	Loss	Factor	Pos	Pos	Avg.	
		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
BT CH00 2402MHz		2349.69	42.18	-31.82	74	42.56	27	6.22	33.6	300	141	P	H
		2349.69	17.43	-36.57	54	-	-	-	-	-	-	A	H
	*	2402	94.3	-	-	94.4	27.13	6.36	33.59	300	141	P	H
	*	2402	69.55	-	-	-	-	-	-	-	-	A	H
													H
													H
		2337.195	48.02	-25.98	74	48.41	27	6.22	33.61	225	176	P	V
		2337.195	23.27	-30.73	54	-	-	-	-	-	-	A	V
	*	2402	103.19	-	-	103.29	27.13	6.36	33.59	225	176	P	V
	*	2402	78.44	-	-	-	-	-	-	-	-	A	V
													V
													V
BT CH 39 2441MHz		2386.58	41.97	-32.03	74	42.08	27.13	6.36	33.6	297	136	P	H
		2386.58	17.22	-36.78	54	-	-	-	-	-	-	A	H
	*	2441	94.16	-	-	94.09	27.27	6.38	33.58	297	136	P	H
	*	2441	69.41	-	-	-	-	-	-	-	-	A	H
		2489.64	41.86	-32.14	74	41.65	27.4	6.39	33.58	297	136	P	H
		2489.64	17.11	-36.89	54	-	-	-	-	-	-	A	H
		2373	45.94	-28.06	74	46.16	27.09	6.29	33.6	293	194	P	V
		2373	21.19	-32.81	54	-	-	-	-	-	-	A	V
	*	2441	102.02	-	-	101.95	27.27	6.38	33.58	293	194	P	V
	*	2441	77.27	-	-	-	-	-	-	-	-	A	V
		2498.53	44.14	-29.86	74	43.92	27.4	6.39	33.57	293	194	P	V
		2498.53	19.39	-34.61	54	-	-	-	-	-	-	A	V



BT CH 78 2480MHz	*	2480	93.6	-	-	93.44	27.36	6.38	33.58	289	132	P	H
	*	2480	68.85	-	-	-	-	-	-	-	-	A	H
		2484.08	42.67	-31.33	74	42.51	27.36	6.38	33.58	289	132	P	H
		2484.08	17.92	-36.08	54	-	-	-	-	-	-	A	H
													H
													H
	*	2480	101.79	-	-	101.63	27.36	6.38	33.58	291	188	P	V
	*	2480	77.04	-	-	-	-	-	-	-	-	A	V
		2483.72	47.71	-26.29	74	47.55	27.36	6.38	33.58	291	188	P	V
		2483.72	22.96	-31.04	54	-	-	-	-	-	-	A	V
													V
													V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												



2.4GHz 2400~2483.5MHz

BT (Harmonic @ 3m)

BT	Note	Frequency (MHz)	Level (dBμV/m)	Over Limit (dB)	Limit Line (dBμV/m)	Read Level (dBμV)	Antenna Factor (dB/m)	Path Loss (dB)	Preamp Factor (dB)	Ant Pos (cm)	Table Pos (deg)	Peak Avg. (P/A)	Pol. (H/V)
BT CH 00 2402MHz		4804	42.82	-31.18	74	58.11	31.26	10.03	56.58	100	0	P	H
		4804	18.07	-35.93	54	-	-	-	-	-	-	A	H
													H
													H
		4804	39.45	-34.55	74	54.74	31.26	10.03	56.58	100	0	P	V
		4804	14.7	-39.3	54	-	-	-	-	-	-	A	V
													V
													V
BT CH 39 2441MHz		4882	39.91	-34.09	74	55.09	31.38	9.99	56.55	100	0	P	H
		4882	15.16	-38.84	54	-	-	-	-	-	-	A	H
		7323	41.5	-32.5	74	49.64	36.32	11.75	56.21	100	0	P	H
		7323	16.75	-37.25	54	-	-	-	-	-	-	A	H
		4882	39.6	-34.4	74	54.78	31.38	9.99	56.55	100	0	P	V
		4882	14.85	-39.15	54	-	-	-	-	-	-	A	V
		7323	42.46	-31.54	74	50.6	36.32	11.75	56.21	100	0	P	V
		7323	17.71	-36.29	54	-	-	-	-	-	-	A	V
BT CH 78 2480MHz		4960	39.45	-34.55	74	54.45	31.54	9.97	56.51	100	0	P	H
		4960	14.7	-39.3	54	-	-	-	-	-	-	A	H
		7440	42.67	-31.33	74	50.42	36.59	11.72	56.06	100	0	P	H
		7440	17.92	-36.08	54	-	-	-	-	-	-	A	H
		4960	39.78	-34.22	74	54.78	31.54	9.97	56.51	100	0	P	V
		4960	15.03	-38.97	54	-	-	-	-	-	-	A	V
		7440	43.75	-30.25	74	51.5	36.59	11.72	56.06	100	0	P	V
		7440	19	-35	54	-	-	-	-	-	-	A	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

Emission below 1GHz

2.4GHz BT (LF)

BT	Note	Frequency	Level	Over	Limit	Read	Antenna	Path	Preamp	Ant	Table	Peak	Pol.
				Limit	Line	Level	Factor	Loss	Factor	Pos	Pos	Avg.	
		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
2.4GHz BT LF		122.88	30.93	-12.57	43.5	44.58	17.26	1.55	32.46	-	-	P	H
		221.16	36.28	-9.72	46	51.71	15.18	1.78	32.39	100	0	P	H
		270.3	32.57	-13.43	46	43.59	19.19	2.17	32.38	-	-	P	H
		319.6	32.64	-13.36	46	43.38	19.23	2.39	32.36	-	-	P	H
		417.6	33.96	-12.04	46	41.19	22.43	2.68	32.34	-	-	P	H
		786.5	31.3	-14.7	46	31.84	28.04	3.64	32.22	-	-	P	H
													H
													H
													H
													H
													H
													H
													H
		32.16	32.15	-7.85	40	40.56	23.24	0.84	32.49	100	0	P	V
		122.88	32.33	-11.17	43.5	45.98	17.26	1.55	32.46	-	-	P	V
		221.16	32.42	-13.58	46	47.85	15.18	1.78	32.39	-	-	P	V
		319.6	29.37	-16.63	46	40.11	19.23	2.39	32.36	-	-	P	V
		800.5	31.42	-14.58	46	31.78	28.13	3.69	32.18	-	-	P	V
		945.4	32.54	-13.46	46	29.44	30.36	3.99	31.25	-	-	P	V
													V
													V
													V
													V
													V
												V	
												V	
Remark	1. No other spurious found. 2. All results are PASS against limit line.												



Note symbol

*	Fundamental Frequency which can be ignored. However, the level of any unwanted emissions shall not exceed the level of the fundamental frequency.
!	Test result is over limit line.
P/A	Peak or Average
H/V	Horizontal or Vertical

A calculation example for radiated spurious emission is shown as below:

BT	Note	Frequency	Level	Over	Limit	Read	Antenna	Path	Preamp	Ant	Table	Peak	Pol.
				Limit	Line	Level	Factor	Loss	Factor	Pos	Pos	Avg.	
		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
BT CH 00 2402MHz		2390	55.45	-18.55	74	54.51	32.22	4.58	35.86	103	308	P	H
		2390	43.54	-10.46	54	42.6	32.22	4.58	35.86	103	308	A	H

1. Path Loss(dB) = Cable loss(dB) + Filter loss(dB) + Attenuator loss(dB)
2. Level(dBμV/m) =
Antenna Factor(dB/m) + Path Loss(dB) + Read Level(dBμV) - Preamp Factor(dB)
3. Over Limit(dB) = Level(dBμV/m) – Limit Line(dBμV/m)

For Peak Limit @ 2390MHz:

1. Level(dBμV/m)
= Antenna Factor(dB/m) + Path Loss(dB) + Read Level(dBμV) - Preamp Factor(dB)
= 32.22(dB/m) + 4.58(dB) + 54.51(dBμV) – 35.86 (dB)
= 55.45 (dBμV/m)
2. Over Limit(dB)
= Level(dBμV/m) – Limit Line(dBμV/m)
= 55.45(dBμV/m) – 74(dBμV/m)
= -18.55(dB)

For Average Limit @ 2390MHz:

1. Level(dBμV/m)
= Antenna Factor(dB/m) + Path Loss(dB) + Read Level(dBμV) - Preamp Factor(dB)
= 32.22(dB/m) + 4.58(dB) + 42.6(dBμV) – 35.86 (dB)
= 43.54 (dBμV/m)
2. Over Limit(dB)
= Level(dBμV/m) – Limit Line(dBμV/m)
= 43.54(dBμV/m) – 54(dBμV/m)
= -10.46(dB)

Both peak and average measured complies with the limit line, so test result is “PASS”.

Appendix D. Radiated Spurious Emission Plots

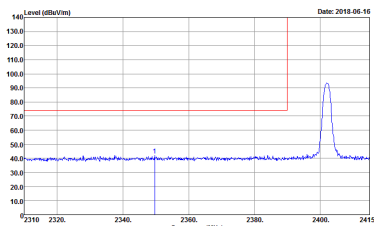
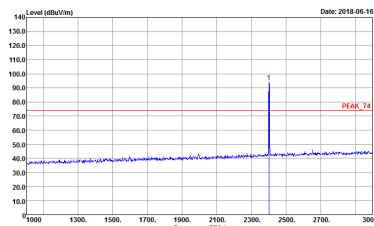
Test Engineer :	Hao Hsu and Ken Wu	Temperature :	22~25°C
		Relative Humidity :	50~55%

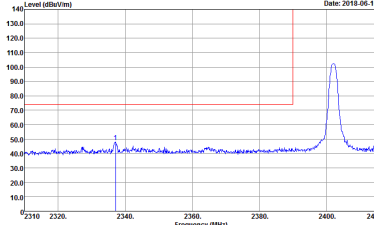
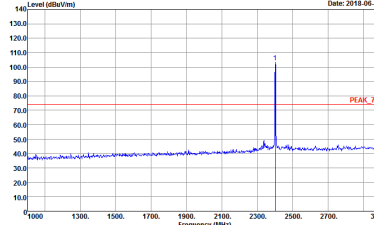
Note symbol

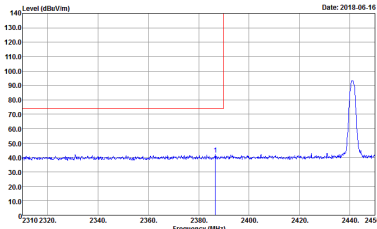
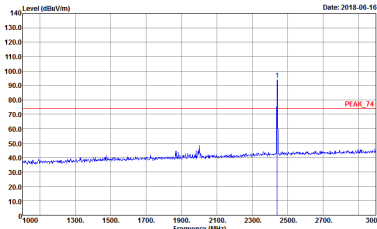
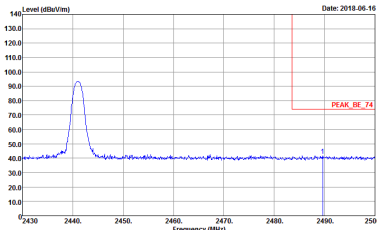
-L	Low channel location
-R	High channel location

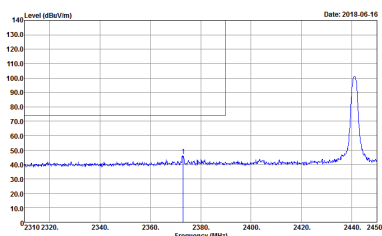
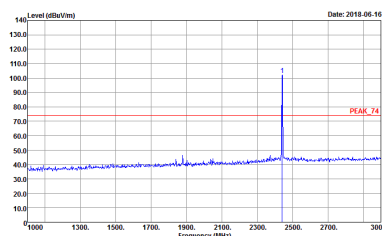
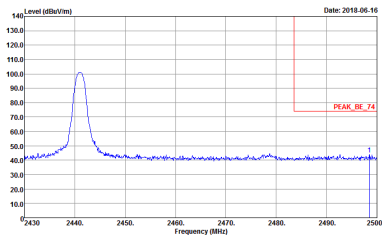
2.4GHz 2400~2483.5MHz

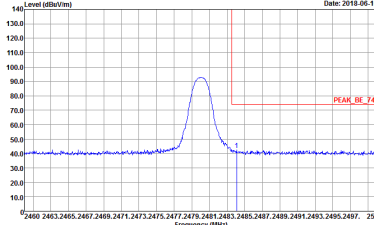
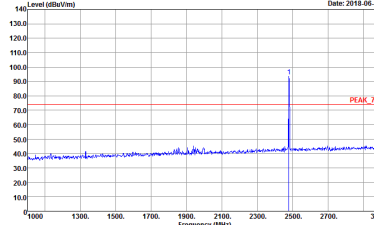
BT (Band Edge @ 3m)

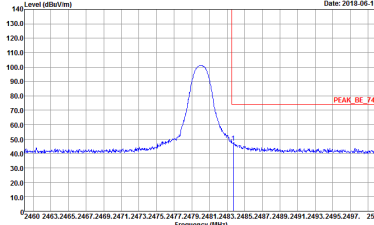
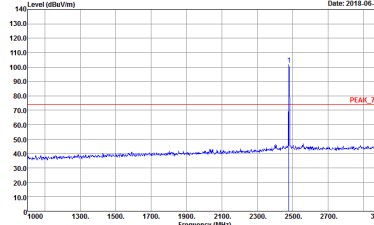
BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
ANT	BT CH00 2402MHz	
1	Horizontal	Fundamental
Peak	 Site : 03CH11-HY Condition : PEAK_BE_74 3m HORN 9120D-HF HORIZONTAL Detector : RBW:1000.000KHz VBW:3000.000KHz SW1:Auto Project : 850937	 Site : 03CH11-HY Condition : PEAK_74 3m HORN 9120D-HF HORIZONTAL Detector : RBW:1000.000KHz VBW:3000.000KHz SW1:Auto Project : 850937

BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
ANT	BT CH00 2402MHz	
1	Vertical	Fundamental
Peak	 Site : 03CH11-HY Condition : PEAK_BE_74 3m HORN 91200-HF VERTICAL RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 850937	 Site : 03CH11-HY Condition : PEAK_74 3m HORN 91200-HF VERTICAL RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 850937

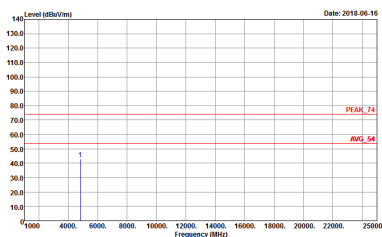
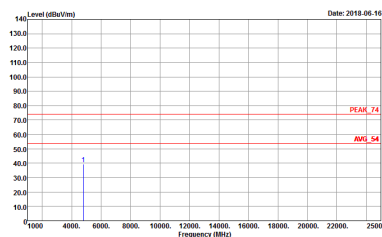
BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
ANT	BT CH39 2441MHz	
1	Horizontal	Fundamental
Peak	 Site : 03CH11-HY Condition : PEAK_BE_74 3m HORN 91200-HF HORIZONTAL RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 850937	 Site : 03CH11-HY Condition : PEAK_74 3m HORN 91200-HF HORIZONTAL RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 850937
	 Site : 03CH11-HY Condition : PEAK_BE_74 3m HORN 91200-HF HORIZONTAL RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 850937	Left blank

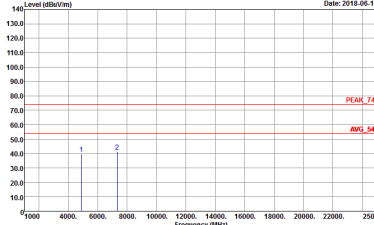
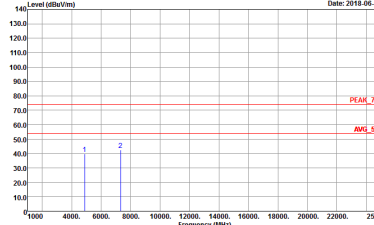
BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
ANT	BT CH39 2441MHz	
1	Vertical	Fundamental
Peak	 Site : 03CH11-HY Condition : PEAK_BE_74 3m HORN 91200-HF VERTICAL RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 850937	 Site : 03CH11-HY Condition : PEAK_74 3m HORN 91200-HF VERTICAL RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 850937
Peak	 Site : 03CH11-HY Condition : PEAK_BE_74 3m HORN 91200-HF VERTICAL RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 850937	Left blank

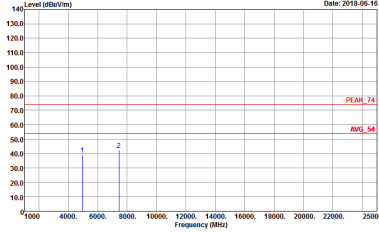
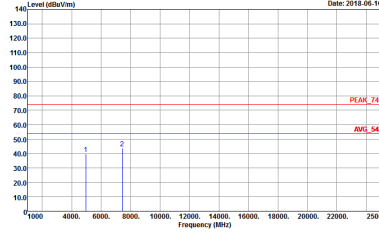
BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
ANT	BT CH78 2480MHz	
1	Horizontal	Fundamental
Peak	 Site : 03CH11-HY Condition : PEAK_BE_74 3m HORN 91200-HF HORIZONTAL RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 850937	 Site : 03CH11-HY Condition : PEAK_74 3m HORN 91200-HF HORIZONTAL RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 850937

BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
ANT	BT CH78 2480MHz	
1	Vertical	Fundamental
Peak	 Site : 03CH11-HY Condition : PEAK_BE_74 3m HORN 91200-HF VERTICAL RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 850937	 Site : 03CH11-HY Condition : PEAK_74 3m HORN 91200-HF VERTICAL RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 850937

2.4GHz 2400~2483.5MHz
BT (Harmonic @ 3m)

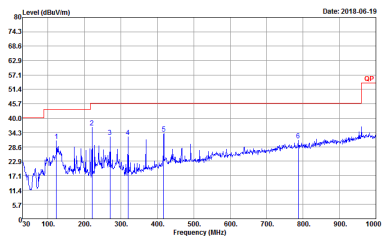
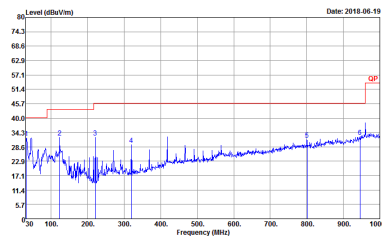
BT	2.4GHz 2400~2483.5MHz Harmonic @ 3m	
ANT	BT CH00 2402MHz	
1	Horizontal	Vertical
Peak Avg.	 Site : 03CH11-4FY Condition : PEAK_74 3m HORN 91200-HF HORIZONTAL Detector : Peak Project : 850937	 Site : 03CH11-4FY Condition : PEAK_74 3m HORN 91200-HF VERTICAL Detector : Peak Project : 850937

BT	2.4GHz 2400~2483.5MHz Harmonic @ 3m	
ANT	BT CH39 2441MHz	
1	Horizontal	Vertical
Peak Avg.	 Site : 03CH11-HY Condition : PEAK_74 3m HORN 91200-HF HORIZONTAL Detector : Peak Project : 850937	 Site : 03CH11-HY Condition : PEAK_74 3m HORN 91200-HF VERTICAL Detector : Peak Project : 850937

BT	2.4GHz 2400~2483.5MHz Harmonic @ 3m	
ANT	BT CH78 2480MHz	
1	Horizontal	Vertical
Peak Avg.	 Site : 03CH11-HY Condition : PEAK_74 3m HORN 91200-HF HORIZONTAL Detector : Peak Project : 850937	 Site : 03CH11-HY Condition : PEAK_74 3m HORN 91200-HF VERTICAL Detector : Peak Project : 850937

Emission below 1GHz

2.4GHz BT (LF)

BT	2.4GHz 2400~2483.5MHz	
ANT	BT LF	
1	Horizontal	Vertical
QP / Peak	 Site : 03CH11-4F Condition : QP 3m BT-LOG 6111D-LF_ETC HORIZONTAL Detector : Peak Project : 850937	 Site : 03CH11-4F Condition : QP 3m BT-LOG 6111D-LF_ETC VERTICAL Detector : Peak Project : 850937



Bluetooth Idle

Horizontal

Level (dBuV/m)

Date: 2018-06-19

140

130.0

120.0

110.0

100.0

90.0

80.0

70.0

60.0

50.0

40.0

30.0

20.0

10.0

0.0

0.0

3000

5000

7000

9000

11000

13000

15000

17000

19000

21000

23000

25000

7

8

9

10

11

12

PEAK_74

AVG_54

Site : 03CH11-HY
Condition : PEAK_74 3m HORN 9120D-HF HORIZONTAL
Detector : Peak
Project : 850937

Freq	Level	Over	Limit	ReadAntenna	Cable	Preamp	A/Pos	T/Pos	Remark		
MHz	dBuV/m	dB	dBuV/m	dBuV	dB/m	dB	dB	cm	deg		
1	122.88	36.03	-7.47	43.50	49.68	17.26	1.51	32.46	100	0 Peak	
2	221.16	35.74	-10.26	46.00	51.17	15.18	1.72	32.39	---	---	Peak
3	279.30	32.14	-13.86	46.00	43.16	19.19	2.09	32.38	---	---	Peak
4	319.60	31.08	-14.92	46.00	41.82	19.23	2.31	32.36	---	---	Peak
5	638.00	28.60	-17.40	46.00	31.51	26.30	3.15	32.46	---	---	Peak
6	884.50	31.89	-14.11	46.00	30.66	29.08	3.73	31.74	---	---	Peak
7	1460.00	41.29	-32.71	74.00	45.79	25.22	4.81	34.53	---	---	Peak
8	2998.00	47.90	-26.10	74.00	45.94	28.60	6.88	33.52	---	---	Peak
9	5965.00	40.39	-33.61	74.00	53.26	32.75	10.62	56.63	---	---	Peak
10	8985.00	44.56	-29.44	74.00	50.57	37.67	12.98	56.88	---	---	Peak
11	18485.00	47.53	-26.47	74.00	53.09	39.68	14.72	60.26	---	---	Peak
12	14940.00	49.37	-24.63	74.00	49.19	40.67	17.47	58.49	100	0 Peak	

Vertical

Level (dBuV/m)

Date: 2018-06-19

140

130.0

120.0

110.0

100.0

90.0

80.0

70.0

60.0

50.0

40.0

30.0

20.0

10.0

0.0

0.0

3000

5000

7000

9000

11000

13000

15000

17000

19000

21000

23000

25000

7

8

9

10

11

12

PEAK_74

AVG_54

Site : 03CH11-HY
Condition : PEAK_74 3m HORN 9120D-HF VERTICAL
Detector : Peak
Project : 850937

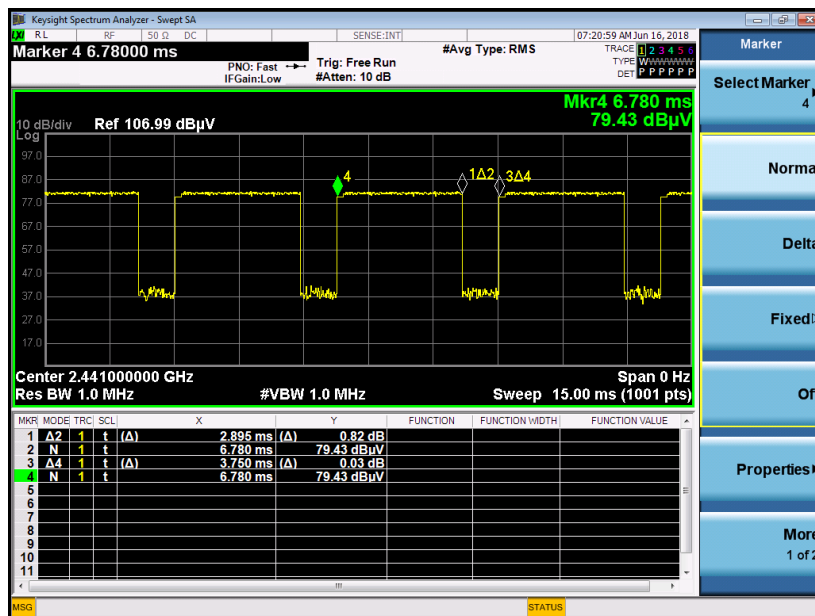
Freq	Level	Over	Limit	ReadAntenna	Cable	Preamp	A/Pos	T/Pos	Remark		
MHz	dBuV/m	dB	dBuV/m	dBuV	dB/m	dB	dB	cm	deg		
1	34.86	33.51	-6.49	40.00	43.34	21.84	0.82	32.49	100	0 Peak	
2	61.32	33.01	-6.99	40.00	52.91	11.55	1.02	32.49	---	---	Peak
3	221.36	33.38	-12.62	46.00	40.01	15.18	1.72	32.39	---	---	Peak
4	417.60	31.22	-14.78	46.00	38.45	22.43	2.63	32.34	---	---	Peak
5	565.30	29.54	-16.46	46.00	32.96	25.89	3.03	32.43	---	---	Peak
6	855.10	31.43	-14.57	46.00	30.58	28.92	3.67	31.89	---	---	Peak
7	1482.00	41.09	-32.91	74.00	45.40	25.26	4.86	34.43	---	---	Peak
8	2488.00	46.39	-27.61	74.00	46.18	27.40	6.39	33.58	---	---	Peak
9	5880.00	39.72	-34.28	74.00	52.93	32.78	10.63	56.62	---	---	Peak
10	8970.00	44.21	-29.79	74.00	50.49	37.64	12.94	56.86	---	---	Peak
11	11520.00	47.07	-26.93	74.00	53.29	39.97	15.45	61.64	---	---	Peak
12	14460.00	48.13	-25.87	74.00	48.34	41.77	17.21	59.19	100	0 Peak	

Peak

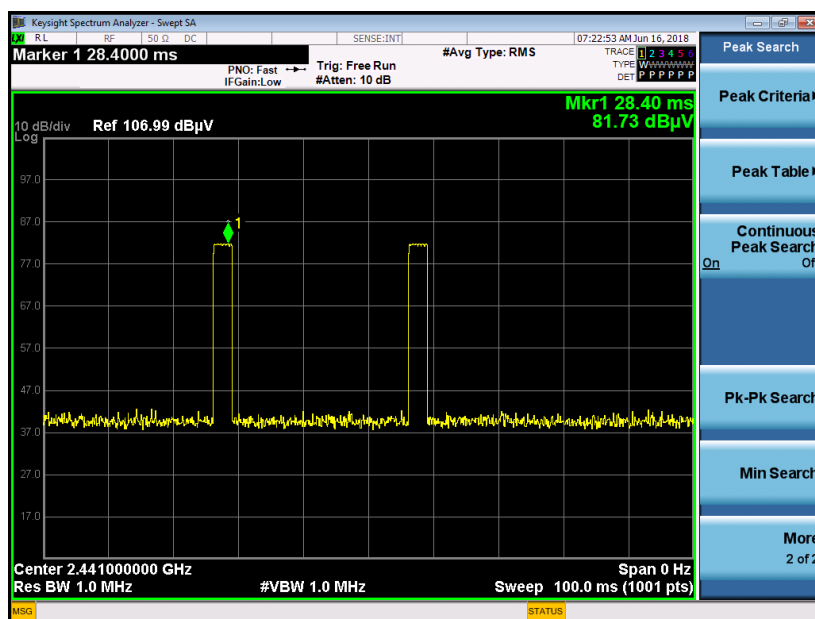
Avg.

Appendix E. Duty Cycle Plots

3DH5 on time (One Pulse) Plot on Channel 39



on time (Count Pulses) Plot on Channel 39



Note:

1. Worst case Duty cycle = on time/100 milliseconds = $2 * 2.895 / 100 = 5.79 \%$
2. Worst case Duty cycle correction factor = $20 * \log(\text{Duty cycle}) = -24.75 \text{ dB}$
3. 3DH5 has the highest duty cycle worst case and is reported.

Duty Cycle Correction Factor Consideration for AFH mode:

Bluetooth normal hopping rate is 1600Hz and reduced to 800Hz in AFH mode; due to the reduced number of hopping frequencies, with the same packet configuration the dwell time in each channel frequency within 100msec period is longer in AFH mode than normal mode.

In AFH mode, the minimum hopping frequencies are 20, to get the longest dwell time DH5 packet is observed; the period to have DH5 packet completing one hopping sequence is

$$2.895 \text{ ms} \times 20 \text{ channels} = 57.9 \text{ ms}$$

There cannot be 2 complete hopping sequences within 100ms period, considering the random hopping behavior, maximum 2 hops can be possibly observed within the period. $[100\text{ms} / 57.6\text{ms}] = 2 \text{ hops}$

Thus, the maximum possible ON time:

$$2.895 \text{ ms} \times 2 = 5.79 \text{ ms}$$

Worst case Duty Cycle Correction factor, which is derived from the maximum possible ON time,

$$20 \times \log(5.79 \text{ ms}/100\text{ms}) = -24.75 \text{ dB}$$