Test Report No. 7191163690-EEC17/04
dated 29 Jun 2017

PSB Singapore

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FORMAL REPORT ON TESTING IN ACCORDANCE WITH
47 CFR FCC Parts 15B & C
(BLUETOOH CLASSIC)
OF A
WIRELESS STEREO HEADSET
[Model : WH-H700]
[FCC ID : AK8WIH700]

TEST FACILITY	TÜV SÜD PSB Pte Ltd Electrical & Electronics Centre (EEC), Product Services, No. 1 Science Park Drive, Singapore 118221
FCC REG. NO.	99142 (3m and 10m Semi-Anechoic Chamber, Science Park)
IND. CANADA REG. NO.	2932I-1 (3m and 10m Semi-Anechoic Chamber, Science Park)
PREPARED FOR	Sony EMCS (Malaysia) Sdn. Bhd. Prai Free Industrial Zone Prai Industrial Estate 13600 Prai, Penang, Malaysia Tel : +60 4 383 6649 Fax : +60 4 399 0703
QUOTATION NUMBER	2191062017
JOB NUMBER	7191163690
TEST PERIOD	29 May 2017 – 22 Jun 2017

PREPARED BY	**APPROVED BY**
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Higher Associate Engineer	Executive Engineer

TÜV SÜD PSB

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The product was tested in accordance with the customer's specifications.

Test Results Summary

Test Standard	Description	Pass / Fail
47 CFR FCC Part 15		
15.107(a), 15.207	Conducted Emissions	Pass
15.109(a), 15.205, 15.209	Radiated Emissions (Spurious Emissions inclusive Restricted Bands Requirement)	Pass
15.247(a)(1)	Carrier Frequency Separation	Pass
	Spectrum Bandwidth (20dB Bandwidth Measurement)	Pass
15.247(a)(1)(iii)	Number of Hopping Frequencies	Pass
	Average Frequency Dwell Time	Pass
15.247(b)(1)	Maximum Peak Power	Pass
15.247(d)	RF Conducted Spurious Emissions	Pass
15.247(d)	Band Edge Compliance (Conducted)	Pass
15.247(d)	Band Edge Compliance (Radiated)	Pass
15.247(e)	Peak Power Spectral Density	Pass
2.1093	RF Exposure Evaluation	Pass

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 0	2.402
Channel 39	2.441
Channel 78	2.480

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

3. The EUT is a Class B device when in non-transmitting state and meets the 47 CFR FCC Part15B Class B requirements.

4. All test measurement procedures are according to ANSI C63.4: 2014 and ANSI C63.10: 2013.

5. The maximum measured RF power of the Equipment Under Test is 0.0dBm.

6. The Equipment Under Test (EUT) does not allow Bluetooth transmission during charging mode. It will enter charging mode when it is connected to a 5Vdc USB charger.

7. The EUT was tested using fully charged batteries with DC voltage of 3.7V.

Modifications

No modifications were made.

PRODUCT DESCRIPTION

Description	:	The Equipment Under Test (EUT) is a **Wireless Stereo Headset.**
Applicant	:	Sony EMCS (Malaysia) Sdn. Bhd. Prai Free Industrial Zone Prai Industrial Estate 13600 Prai, Penang, Malaysia
Manufacturer	:	Sony Corporation 1-7-1 Konan Minato-ku Tokyo, 108-0075, Japan
Factory (ies)	:	Sony EMCS (Malaysia) Sdn. Bhd. Prai Free Industrial Zone Prai Industrial Estate 13600 Prai, Penang, Malaysia
Model Number(s)	:	WH-H700
FCC ID	:	AK8WIH700
Serial Number(s)	:	Nil
Microprocessor(s)	:	CSR8675 (Bluetooth) RC-S967 (NFC)
Operating Frequency	:	i. 2402MHz-2480MHz (Bluetooth) ii. 13.56MHz (Passive NFC tag)
Clock / Oscillator Frequency	:	122.88MHz
Modulation	:	<u>Bluetooth</u> i. Gaussian Frequency Shift Keying (GFSK) ii. π/4-Differential Quadrature Phase-Shift Keying (DQPSK) iii. 8 Differential Phase Shift Keying (DPSK) <u>NFC (Passive NFC tag, receiver only)</u> i. Amplitude Shift Keying (ASK)
Antenna Gain	:	2.94 dBi
Port / Connectors	:	i. USB ii. NFC Reader iii. Bluetooth V4.1
Rated Input Power	:	3.7Vdc (Built-in lithium-ion rechargeable battery) 5Vdc (Charging via USB)
Accessories	:	i. 1 x 0.5m micro-USB cable ii. 1 x 1.0m headphone cable

SUPPORTING EQUIPMENT DESCRIPTION

Equipment Description (Including Brand Name)	Model, Serial & FCC ID Number	Cable Description (List Length, Type & Purpose)
Fujitsu S Series Lifebook Laptop	M/N: S6410 S/N: R7Y00054 FCC ID: DoC	0.8m unshielded USB cable
Fujitsu AC Adapter	M/N: CP311808-01 S/N: 08903690B FCC ID: DoC	1.80m unshielded power cable
Sony Digital Media Player	M/N: NW-ZX2 S/N: 2000643 FCC ID: DoC	Nil
Sony AC Adapter	M/N: AC-UD20 S/N: 12016000083 FCC ID: DoC	0.5m unshielded USB cable

EUT OPERATING CONDITIONS

47 CFR FCC Part 15
1. Conducted Emissions **2. Radiated Emissions (Spurious Emissions inclusive Restricted Bands Requirement)** **3. Spectrum Bandwidth (20dB Bandwidth Measurement)** **4. Maximum Peak Power** **5. RF Conducted Spurious Emissions** **6. Band Edge Compliance (Conducted)** **7. Band Edge Compliance (Radiated)** **8. Peak Power Spectral Density** **9. RF Exposure Evaluation**
The EUT was exercised by operating in maximum continuous transmission with frequency hopping off, i.e transmitting at lower, middle and upper channels respectively at one time. For Band Edge Compliance, only lower and upper channels were evaluated.
10. Carrier Frequency Separation **11. Number of Hopping Frequencies** **12. Average Frequency Dwell Time** **13. Band Edge Compliance (Conducted)**
The EUT was exercised by operating in maximum continuous transmission with frequency hopping on.

47 CFR FCC Parts 15.107(a) and 15.207 Conducted Emission Limits

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

47 CFR FCC Parts 15.107(a) and 15.207 Conducted Emission Test Instrumentation

Instrument	Model	S/No	Cal Due Date
Schaffner EMI Receiver	SMR4503	040	22 Mar 2018
Agilent EMC Analyzer-SA7	E7403A	US41160167	24 Aug 2017
Schaffner LISN –LISN7 (Ref)	NNB42	00008	11 Jan 2018
EMCO LISN (for supporting) – LISN6	3825/2	9309-2127	04 Oct 2017

47 CFR FCC Parts 15.107(a) and 15.207 Conducted Emission Test Setup

1. The EUT and supporting equipment were set up in accordance with the requirements of the standard on top of a 1.5m x 1m x 0.8m high, non-metallic table.
2. The power supply for the EUT was fed through a 50Ω/50μH EUT LISN, connected to filtered mains.
3. The RF OUT of the EUT LISN was connected to the EMI test receiver via a low-loss coaxial cable.
4. All other supporting equipment were powered separately from another LISN.

47 CFR FCC Parts 15.107(a) and 15.207 Conducted Emission Test Method

1. The EUT was switched on and allowed to warm up to its normal operating condition.
2. A scan was made on the NEUTRAL line over the required frequency range using an EMI test receiver.
3. High peaks, relative to the limit line, were then selected.
4. The EMI test receiver was then tuned to the selected frequencies and the necessary measurements made with a receiver bandwidth setting of 9kHz. Both Quasi-peak and Average measurements were made.
5. Steps 2 to 4 were then repeated for the LIVE line.

Sample Calculation Example

At 20 MHz	Q-P limit = 60.0 dBμV
Transducer factor of LISN, pulse limiter & cable loss at 20 MHz = 11.2 dB	
Q-P reading obtained directly from EMI Receiver = 40.0 dBμV (Calibrated for system losses)	
Therefore, Q-P margin = 60.0 - 40.0 = 20.0	i.e. 20.0 dB below Q-P limit

47 CFR FCC Parts 15.107(a) and 15.207 Conducted Emission Results

Operating Mode	Charging Mode	Temperature	22ºC
Test Input Power	120V 60Hz	Relative Humidity	55%
Line Under Test	AC Mains	Atmospheric Pressure	1030mbar
		Tested By	Dylan Lin

Frequency (MHz)	Q-P Value (dBµV)	Q-P Limit (dBµV)	Q-P Margin (dB)	AV Value (dBµV)	AV Limit (dBµV)	AV Margin (dB)	Line	Channel
0.1981	32.4	63.7	31.3	9.4	53.7	44.3	Neutral	-
0.2003	31.8	63.6	31.8	10.8	53.6	42.8	Live	-
0.3096	26.7	60.0	33.3	2.4	50.0	47.6	Live	-
0.3181	27.0	59.8	32.8	4.3	49.8	45.5	Neutral	-
0.4007	21.0	57.8	36.8	-3.3	47.8	51.1	Live	-
0.5100	18.2	56.0	37.8	-0.5	46.0	46.5	Neutral	-

Notes

1. All possible modes of operation were investigated from 150kHz to 30MHz. Only the worst case emissions measured, using the correct CISPR detectors, are reported. All other emissions were relatively insignificant.
2. A "positive" margin indicates a PASS as it refers to the margin present below the limit line at the particular frequency. Conversely, a “negative” margin indicates a FAIL.
3. EMI receiver Resolution Bandwidth (RBW) and Video Bandwidth (VBW) settings:
   9kHz - 30MHz
   RBW: 9kHz VBW: 30kHz
4. Conducted Emissions 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, in the range 9kHz – 30MHz is ±2.2dB.

47 CFR FCC Part 15.205 Restricted Bands

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

47 CFR FCC Parts 15.109(a) and 15.209 Radiated Emission 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.	

47 CFR FCC Parts 15.109(a) and 15.209 Radiated Emission Test Instrumentation

Instrument	Model	S/No	Cal Due Date
R&S Test Receiver – ESI1	ESI40	100010	11 Oct 2017
Schaffner Bilog Antenna –(30MHz-2GHz) BL4	CBL6112B	2593	18 Jan 2018
Com-Power Preamplifier (1MHz-1GHz)	PAM-103	441056	22 Jul 2017
TDK-RF Horn Antenna	HRN-0118	130256	18 Oct 2017
R&S Preamplifier (1GHz -18GHz)	SCU18	102191	10 Mar 2018
Agilent Preamplifier(1GHz-26.5GHz) (PA18)	8449D	3008A02305	12 Oct 2017
ETS Horn Antenna(18GHz-40GHz) (Ref)	3116	0004-2474	18 Oct 2017
EMCO Loop Ant (ext)_red_00134413	6502	134413	28 Oct 2017
Micro-Tronics Bandstop Filter (2.4-2.5 GHz)	BRM50701	17	27 Nov 2017

47 CFR FCC Parts 15.109(a) and 15.209 Radiated Emission Test Setup

1. The EUT and supporting equipment were set up in accordance with the requirements of the standard on top of a 1.5m X 1.0m X 0.8m high, non-metallic table for measurement up to 1GHz. For measurement above 1GHz, 1.5m height table was used.
2. The filtered power supply for the EUT and supporting equipment were tapped from the appropriate power sockets located on the turntable.
3. The relevant broadband antenna was set at the required test distance away from the EUT and supporting equipment boundary.

47 CFR FCC Parts 15.109(a) and 15.209 Radiated Emission Test Method

1. The EUT was switched on and allowed to warm up to its normal operating condition.
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.
3. The test was carried out at the selected frequency points obtained from the prescan in step 2. 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.
4. A Quasi-peak measurement was made for that frequency point if it was less than or equal to 1GHz. For frequency point in the range of 9kHz – 90kHz, 110kHz – 490kHz and above 1GHz, both Peak and Average measurements were carried out.
5. Steps 3 and 4 were repeated for the next frequency point, until all selected frequency points were measured.
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

47 CFR FCC Parts 15.109(a), 15.205 and 15.209 Radiated Emission Results

Operating Mode	Bluetooth Transmit	Temperature	27°C
Test Input Power	Battery Powered	Relative Humidity	59%
Test Distance	3m (≥30MHz – 25GHz)	Atmospheric Pressure	1030mbar
		Tested By	Dylan Lin Lim Kay Tak

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

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

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)
63.3770	16.7	40.0	23.3	100	248	V	39
92.8260	20.8	43.5	22.7	100	29	H	39
151.7260	20.7	43.5	22.8	202	15	H	39
404.9950	22.9	46.0	23.1	100	272	H	39
793.7340	29.5	46.0	16.5	100	315	H	39
805.5140	29.0	46.0	17.0	100	315	H	39

47 CFR FCC Parts 15.109(a), 15.205 and 15.209 Radiated Emission Results

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
4.0766	39.6	74.0	34.4	--	54.0	14.1	300	15	V	0
5.3719	41.7	74.0	32.3	--	54.0	12.3	100	150	V	0
9.4368	46.8	74.0	27.2	--	54.0	7.2	400	225	H	0
11.2342	48.4	74.0	25.6	--	54.0	5.6	300	88	V	0
16.5177	48.6	74.0	25.4	--	54.0	5.4	200	93	V	0
17.3192	51.0	74.0	23.0	--	54.0	3.0	100	299	V	0

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
4.2284	40.4	74.0	33.6	--	54.0	13.3	100	37	H	39
5.4630	41.9	74.0	32.1	--	54.0	12.1	300	51	H	39
8.9389	46.2	74.0	27.8	--	54.0	7.8	400	75	H	39
10.5055	47.2	74.0	26.8	--	54.0	6.8	400	137	V	39
14.7203	49.9	74.0	24.1	--	54.0	4.1	200	66	V	39
15.5704	48.2	74.0	25.8	--	54.0	5.8	200	305	H	39

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
4.7242	39.8	74.0	34.2	--	54.0	13.3	300	232	V	78
6.1943	43.6	74.0	30.4	--	54.0	12.1	100	288	H	78
9.6311	46.9	74.0	27.1	--	54.0	7.8	100	149	V	78
10.3355	47.2	74.0	26.8	--	54.0	6.8	300	193	H	78
15.8133	48.6	74.0	25.4	--	54.0	4.1	200	142	V	78
16.2141	49.0	74.0	25.0	--	54.0	5.8	300	192	H	78

47 CFR FCC Parts 15.109(a), 15.205 and 15.209 Radiated Emission Results

Operating Mode	Charging Mode	Temperature	27°C
Test Input Power	120V 60Hz	Relative Humidity	59%
Test Distance	3m (≥30MHz – 13GHz)	Atmospheric Pressure	1030mbar
		Tested By	Dylan Lin Lim Kay Tak

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)
30.0000	20.5	40.0	19.5	100	265	V
51.5970	16.4	40.0	23.6	100	265	V
359.8390	23.3	46.0	22.7	100	79	H
391.2520	24.7	46.0	21.3	100	264	H
548.3180	24.0	46.0	22.0	100	149	V
779.9910	29.2	46.0	16.8	100	315	H

Spurious Emissions above 1GHz – 13GHz

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)
3.3580	37.9	74.0	36.1	--	54.0	15.8	100	204	H
6.9473	45.0	74.0	29.0	--	54.0	9.0	100	62	H
7.2994	45.5	74.0	28.5	--	54.0	8.5	300	59	H
8.1131	46.0	74.0	28.0	--	54.0	8.0	200	133	V
12.1579	50.1	74.0	23.9	--	54.0	3.9	300	192	H
12.8622	51.2	74.0	22.8	--	54.0	2.8	100	314	H

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. 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.
5. 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.
6. A "positive" margin indicates a PASS as it refers to the margin present below the limit line at the particular frequency. Conversely, a “negative” margin indicates a FAIL.
7. EMI receiver Resolution Bandwidth (RBW) and Video Bandwidth (VBW) settings:
   30MHz - 1GHz
   RBW: 120kHz VBW: 1MHz
   >1GHz
   RBW: 1MHz VBW: 3MHz
8. The upper frequency of radiated emission investigations was according to requirements stated in Section 15.33(a) for intentional radiators & Section 15.33(b) for unintentional radiators.
9. The channel in the table refers to the transmit channel of the EUT.
10. Radiated Emissions 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, in the range 30MHz – 25GHz is ±4.0dB.

47 CFR FCC Part 15.247(a)(1) Carrier Frequency Separation Limits

The EUT shows compliance to the requirements of this section, which states the adjacent carrier frequencies must be separated by a minimum of 25kHz or the 20dB bandwidth of the hopping channel, whichever is greater. Alternatively, the EUT may have hopping channel carrier frequencies that are separated by 25kHz or two-thirds of the 20dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125mW (21dBm).

47 CFR FCC Part 15.247(a)(1) Carrier Frequency Separation Test Instrumentation

Instrument	Model	S/No	Cal Due Date
Agilent Spectrum Analyzer	E4440A	MY45304764	04 Jan 2018

47 CFR FCC Part 15.247(a)(1) Carrier Frequency Separation Test Setup

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

47 CFR FCC Part 15.247(a)(1) Carrier Frequency Separation Test Method

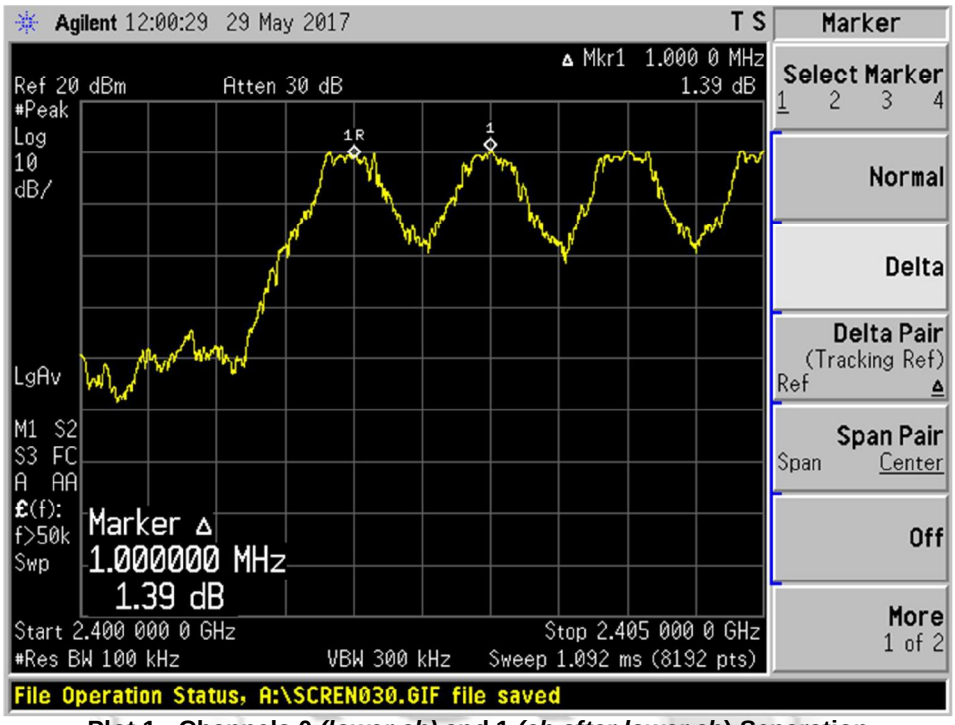
1. The EUT was switched on and allowed to warm up to its normal operating condition. The EUT was then configured to operate in the test mode with frequency hopping sequence on.
2. The start and stop frequencies of the spectrum analyser were set to 2.400GHz and 2.405GHz.
3. The spectrum analyser was set to max hold to capture the two adjacent transmitting frequencies within the span. The signal capturing was continuous until no further signals were detected.
4. The carrier frequency separation of the two adjacent transmitting / operating frequency was measured by finding the carrier frequency difference between the two adjacent channels.
5. The steps 2 to 4 were repeated with the following start and stop frequencies settings:
   a. 2.4385GHz to 2.4435GHz
   b. 2.478GHz to 2.4835GHz

47 CFR FCC Part 15.247(a)(1) Carrier Frequency Separation Results

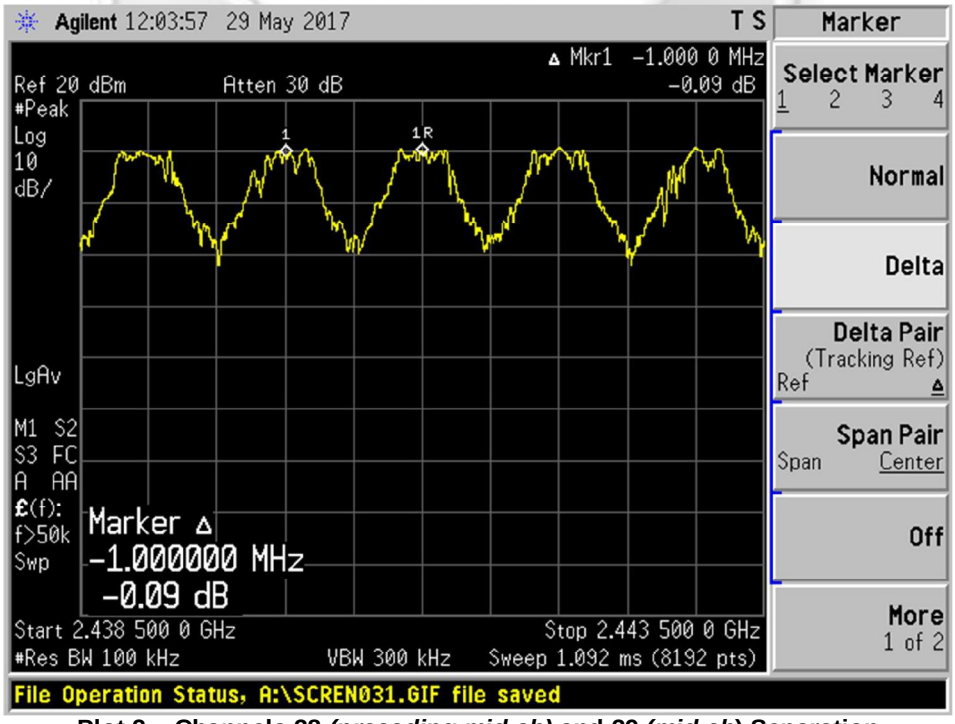
Test Input Power	3.7Vdc	Temperature	24ºC
Attached Plots	1 – 4	Relative Humidity	60%
		Atmospheric Pressure	1030mbar
		Tested By	Liau Lee Yin

Adjacent Channels	Channel Separation (MHz)
0 and 1 (2.402GHz and 2.403GHz)	1.000
38 and 39 (2.440GHz and 2.441GHz)	1.000
39 and 40 (2.441GHz and 2.442GHz)	1.000
77 and 78 (2.479GHz and 2.480GHz)	1.000

Carrier Frequency Separation Plots

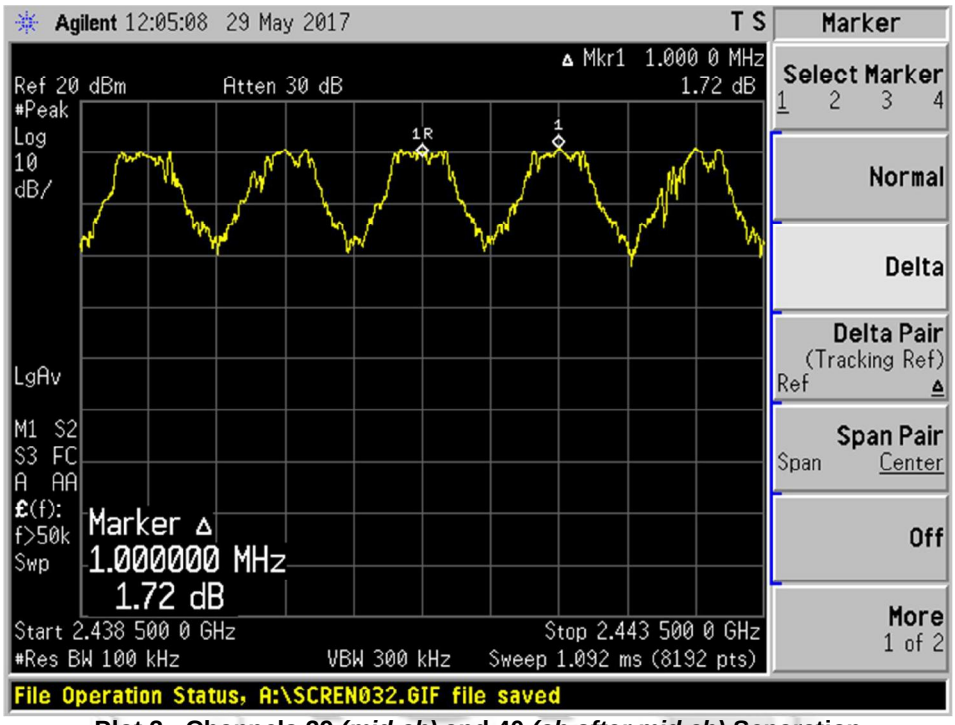


Plot 1 - Channels 0 *(lower ch)* and 1 *(ch after lower ch)* Separation

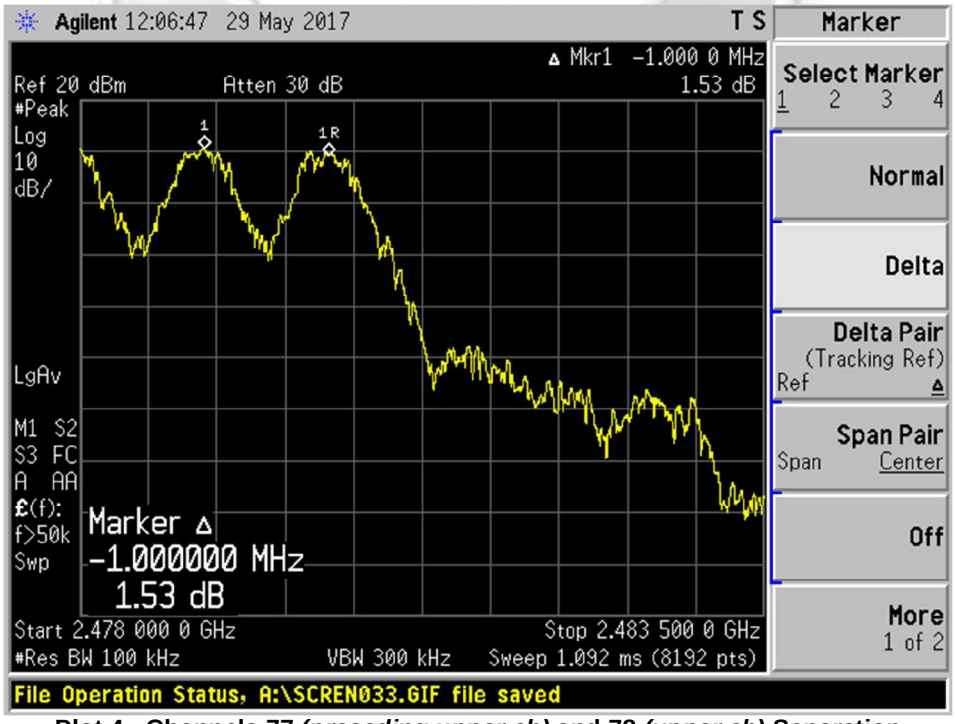


Plot 2 – Channels 38 *(preceding mid ch)* and 39 *(mid ch)* Separation

Carrier Frequency Separation Plots



Plot 3 - Channels 39 *(mid ch)* and 40 *(ch after mid ch)* Separation



Plot 4 - Channels 77 *(preceding upper ch)* and 78 *(upper ch)* Separation

SPECTRUM BANDWIDTH (20dB BANDWIDTH MEASUREMENT) TEST

47 CFR FCC Part 15.247(a)(1) Spectrum Bandwidth (20dB Bandwidth Measurement) Limits

The EUT shows compliance to the requirements of this section, which states that the 20dB bandwidth of the hopping channel shall be the channel frequency separation by a minimum of 25kHz or the 20dB bandwidth of the hopping channel, whichever is greater.

47 CFR FCC Part 15.247(a)(1) Spectrum Bandwidth (20dB Bandwidth Measurement) Test Instrumentation

Instrument	Model	S/No	Cal Due Date
Agilent Spectrum Analyzer	E4440A	MY45304764	04 Jan 2018

47 CFR FCC Part 15.247(a)(1) Spectrum Bandwidth (20dB Bandwidth Measurement) Test Setup

1. The EUT and supporting equipment were set up as shown in the setup photo.
2. The power supply for the EUT was connected to a filtered mains.
3. The RF antenna connector was connected to the spectrum analyser via a low-loss coaxial cable.
4. The resolution bandwidth (RBW) and the video bandwidth (VBW) of the spectrum analyser were respectively set to 10kHz and 30kHz.
5. All other supporting equipment were powered separately from another filtered mains.

47 CFR FCC Part 15.247(a)(1) Spectrum Bandwidth (20dB Bandwidth Measurement) Test Method

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, non-hopping with transmitting frequency at Channel 0 (2.402GHz) *(lower ch)*.
2. The center frequency of the spectrum analyser was set to the transmitting frequency with the frequency span was set in between two to five times of the captured 20dB bandwidth of the transmitting frequency.
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.
4. The peak of the transmitting frequency was detected with the marker peak function of the spectrum analyser. The frequencies below the 20dB 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.
5. The 20dB bandwidth of the transmitting frequency is the frequency difference between the marked lower and upper frequencies, $| f_H - f_L |$.
6. The steps 2 to 5 were repeated with the transmitting frequency was set to Channel 39 (2.441GHz) *(mid ch)* and Channel 78 (2.480GHz) *(upper ch)* respectively.

SPECTRUM BANDWIDTH (20dB BANDWIDTH MEASUREMENT) TEST

47 CFR FCC Part 15.247(a)(1) Spectrum Bandwidth (20dB Bandwidth Measurement) Results

Test Input Power	3.7Vdc	Temperature	24ºC
Attached Plots	5 – 7	Relative Humidity	60%
Modulation	GFSK	Atmospheric Pressure	1030mbar
		Tested By	Liau Lee Yin

Channel	Channel Frequency (GHz)	20dB Bandwidth (MHz)
0 *(lower ch)*	2.402	0.913
39 *(mid ch)*	2.441	0.933
78 *(upper ch)*	2.480	0.933

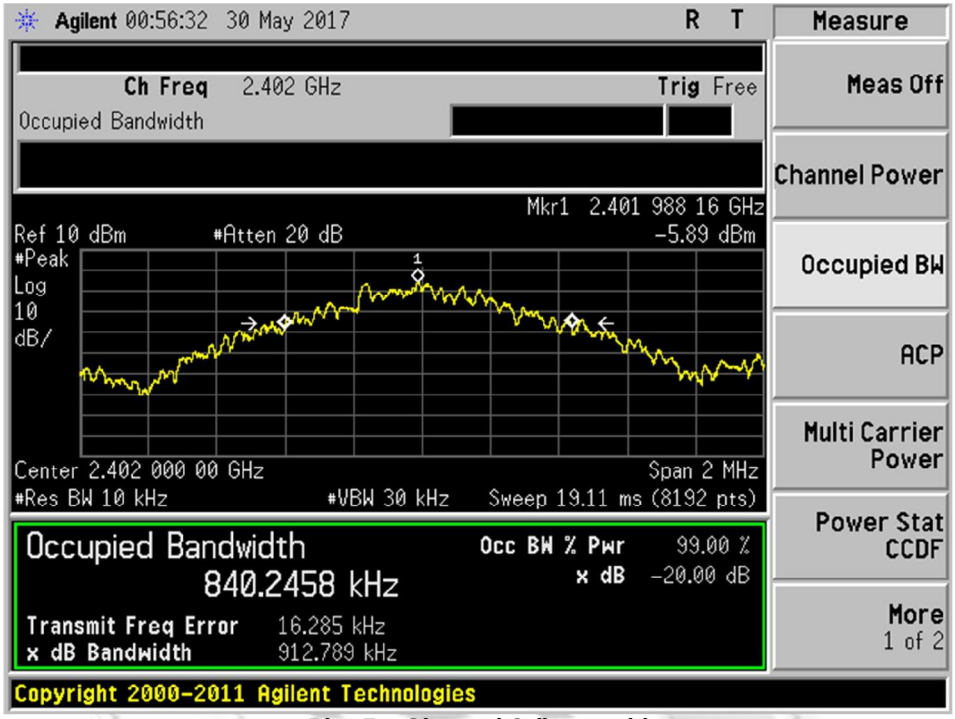
Test Input Power	3.7Vdc	Temperature	24ºC
Attached Plots	8 – 10	Relative Humidity	60%
Modulation	(π/4) DQPSK	Atmospheric Pressure	1030mbar
		Tested By	Liau Lee Yin

Channel	Channel Frequency (GHz)	20dB Bandwidth (MHz)
0 *(lower ch)*	2.402	1.300
39 *(mid ch)*	2.441	1.199
78 *(upper ch)*	2.480	1.225

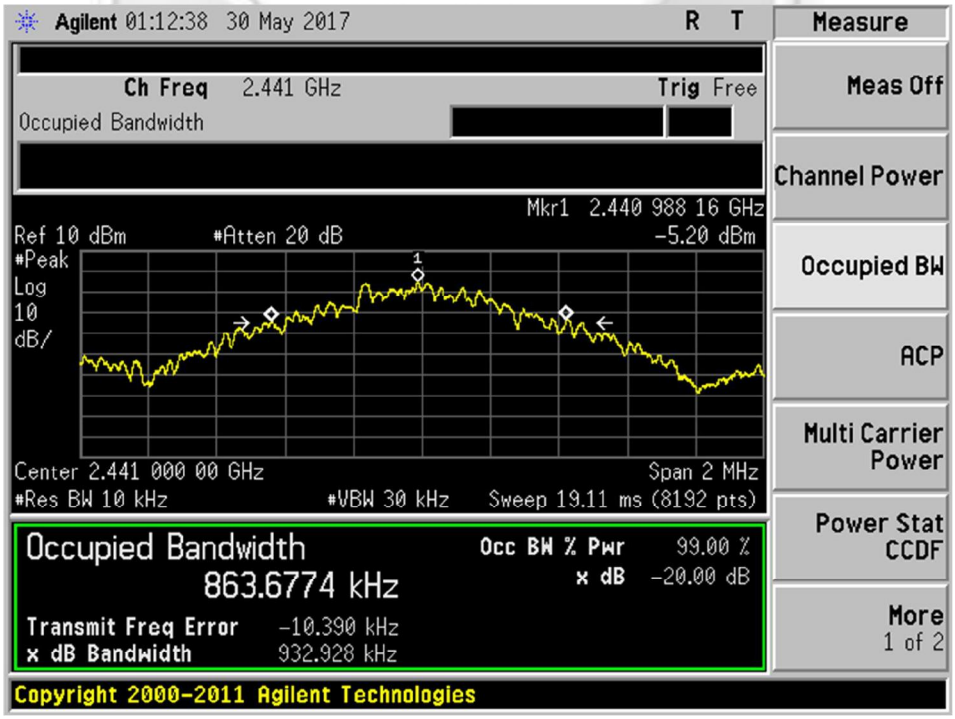
Test Input Power	3.7Vdc	Temperature	24ºC
Attached Plots	11 – 13	Relative Humidity	60%
Modulation	8DPSK	Atmospheric Pressure	1030mbar
		Tested By	Liau Lee Yin

Channel	Channel Frequency (GHz)	20dB Bandwidth (MHz)
0 *(lower ch)*	2.402	1.235
39 *(mid ch)*	2.441	1.251
78 *(upper ch)*	2.480	1.254

Spectrum Bandwidth (20dB Bandwidth Measurement) Plots – GFSK

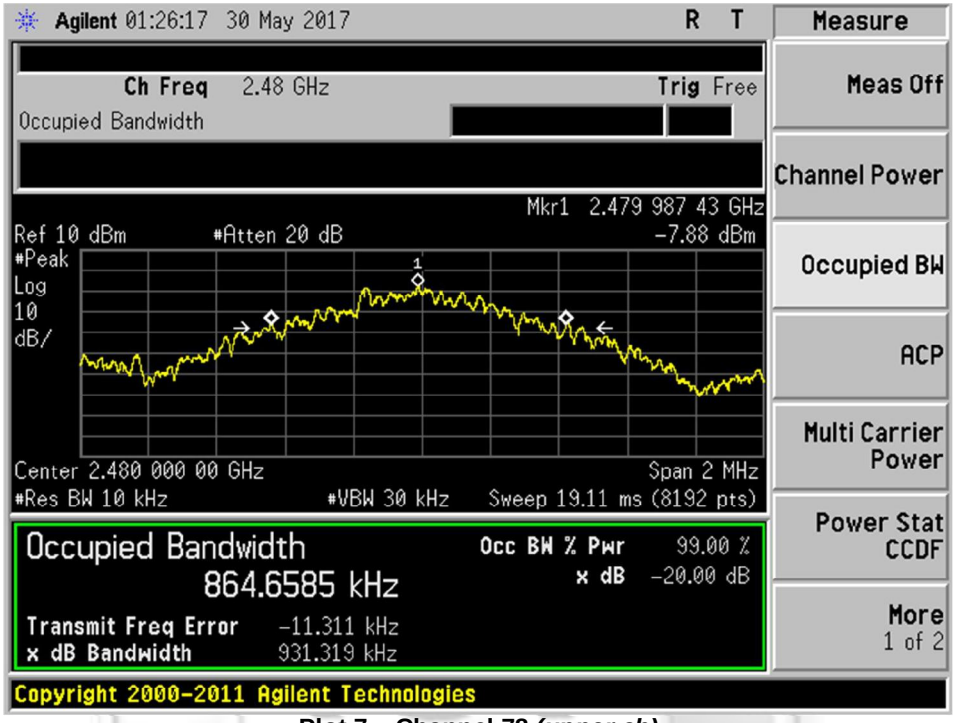


Plot 5 – Channel 0 *(lower ch)*



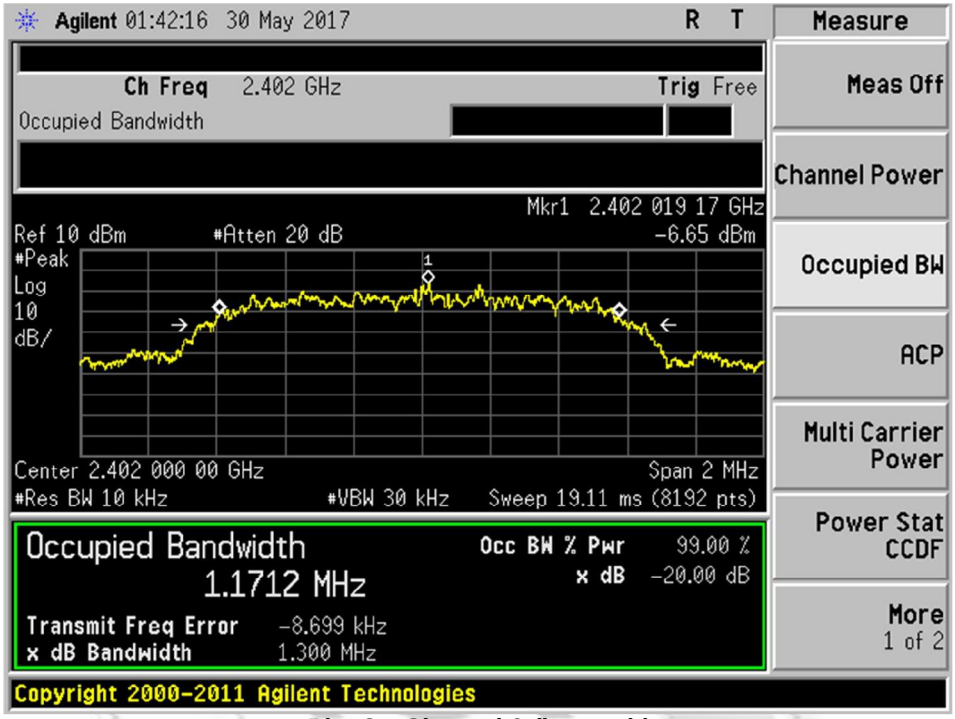
Plot 6 – Channel 39 *(mid ch)*

Spectrum Bandwidth (20dB Bandwidth Measurement) Plots – GFSK

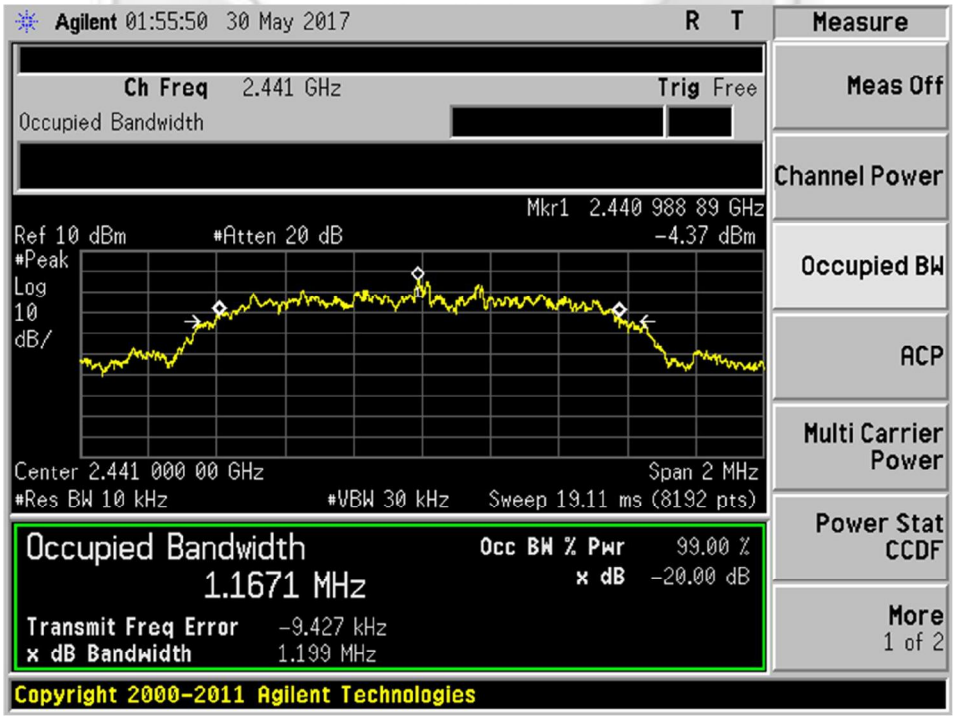


Plot 7 – Channel 78 *(upper ch)*

Spectrum Bandwidth (20dB Bandwidth Measurement) Plots – (π/4) DQPSK

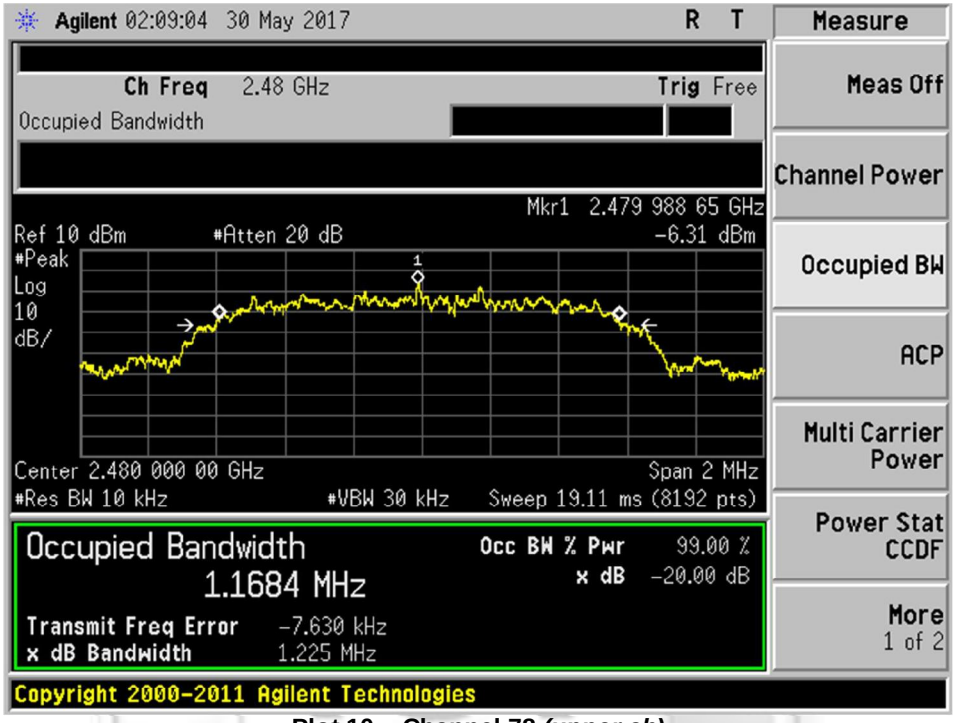


Plot 8 – Channel 0 *(lower ch)*



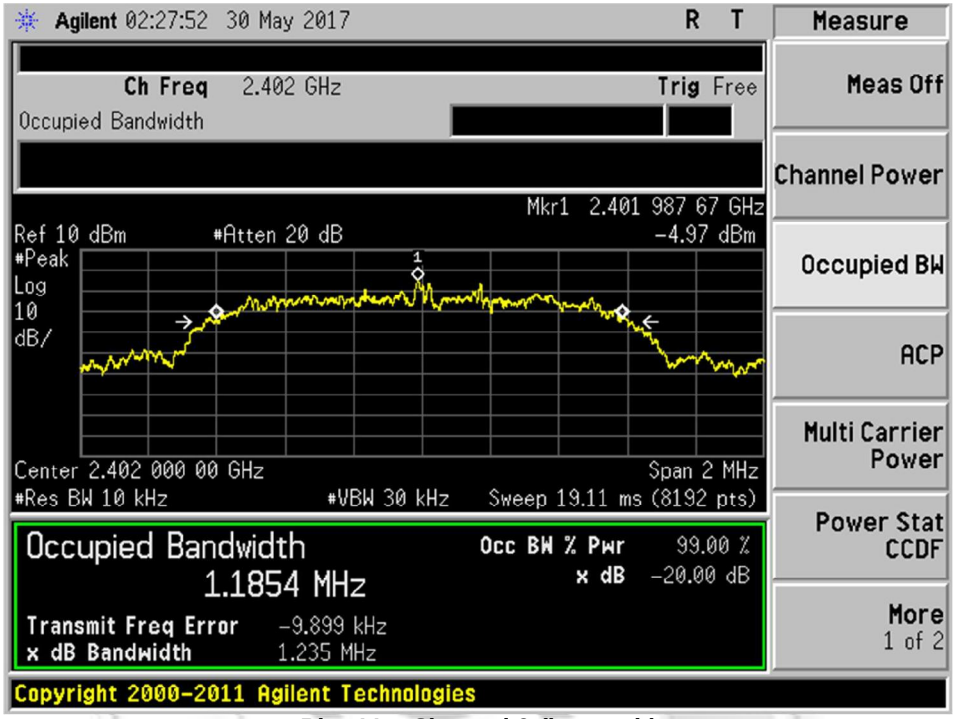
Plot 9 – Channel 39 *(mid ch)*

Spectrum Bandwidth (20dB Bandwidth Measurement) Plots – (π/4) DQPSK

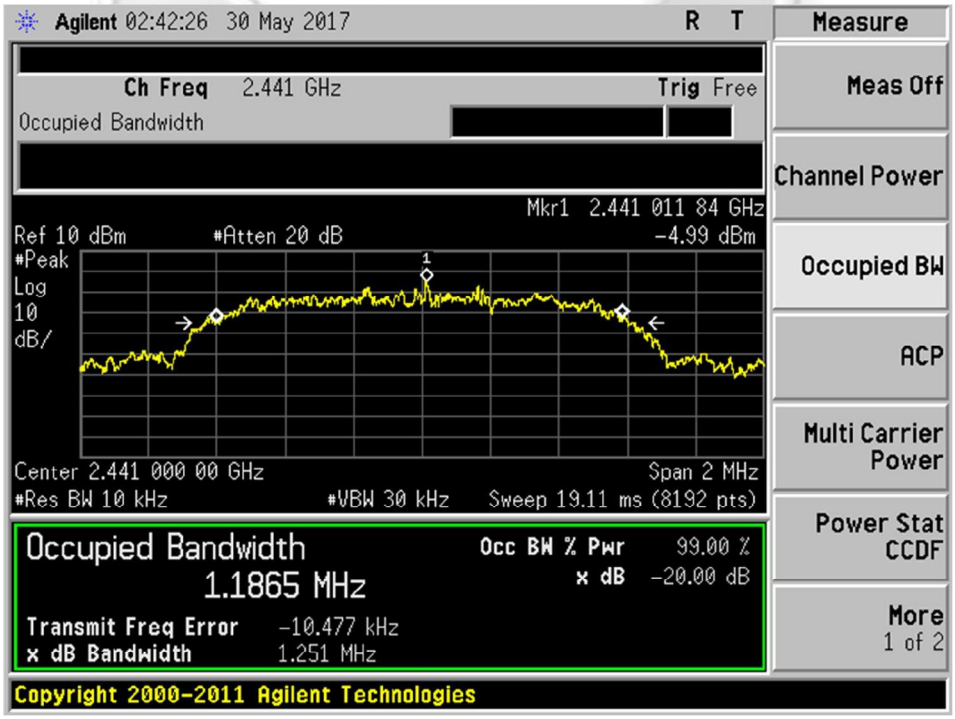


Plot 10 – Channel 78 *(upper ch)*

Spectrum Bandwidth (20dB Bandwidth Measurement) Plots – 8DPSK

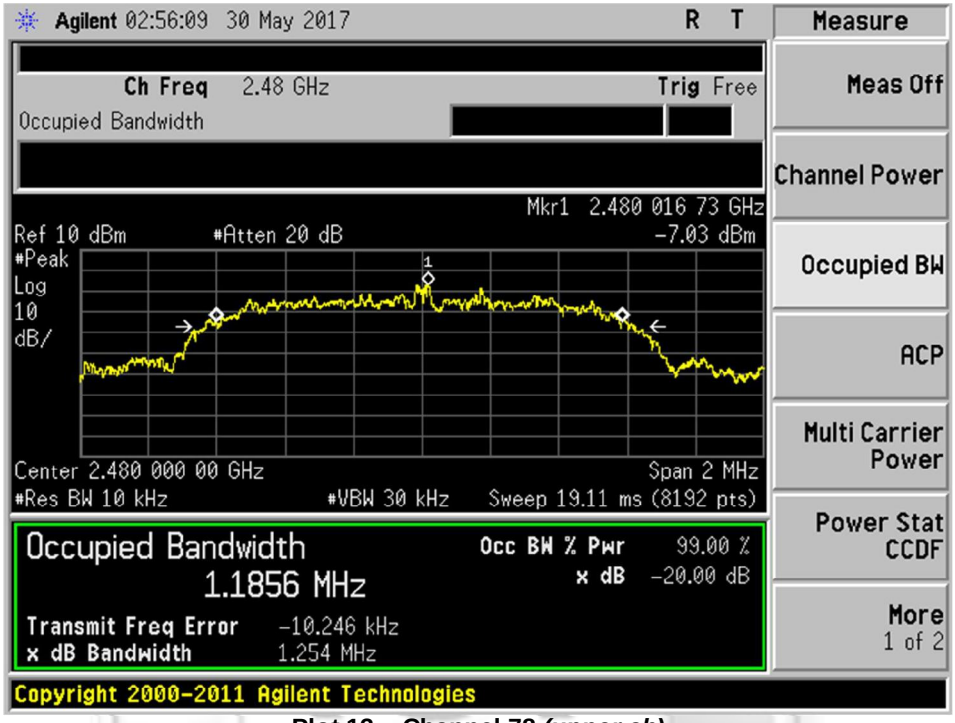


Plot 11 – Channel 0 *(lower ch)*



Plot 12 – Channel 39 *(mid ch)*

Spectrum Bandwidth (20dB Bandwidth Measurement) Plots – 8DPSK



Plot 13 – Channel 78 *(upper ch)*

47 CFR FCC Part 15.247(a)(1)(iii) Number of Hopping Frequencies Limits

The EUT shows compliance to the requirements of this section, which states the EUT shall use at least 15 channels.

47 CFR FCC Part 15.247(a)(1)(iii) Number of Hopping Frequencies Test Instrumentation

Instrument	Model	S/No	Cal Due Date
Agilent Spectrum Analyzer	E4440A	MY45304764	04 Jan 2018

47 CFR FCC Part 15.247(a)(1)(iii) Number of Hopping Frequencies Test Setup

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

47 CFR FCC Part 15.247(a)(1)(iii) Number of Hopping Frequencies Test Method

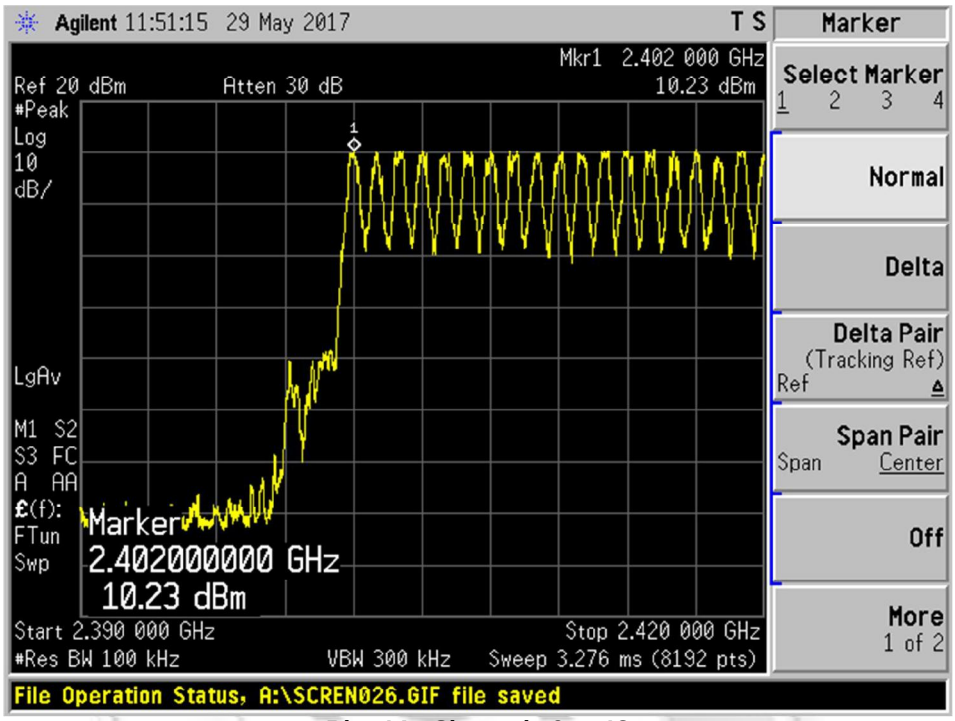
1. The EUT was switched on and allowed to warm up to its normal operating condition. The EUT was then configured to operate in the test mode with frequency hopping sequence on.
2. The start and stop frequencies of the spectrum analyser were set to 2.39GHz and 2.420GHz.
3. The spectrum analyser was set to max hold to capture all the transmitting frequencies within the span. The signal capturing was continuous until all the transmitting frequencies were captured and no further signals were detected.
4. The numbers of transmitting frequencies were counted and recorded.
5. The steps 2 to 4 were repeated with the following start and stop frequencies settings:
   a. 2.420GHz to 2.441GHz
   b. 2.441GHz to 2.461GHz
   c. 2.461GHz to 2.4835GHz
6. The total number of hopping frequencies is the sum of the number of the hopping frequencies found for each span.

47 CFR FCC Part 15.247(a)(1)(iii) Number of Hopping Frequencies Results

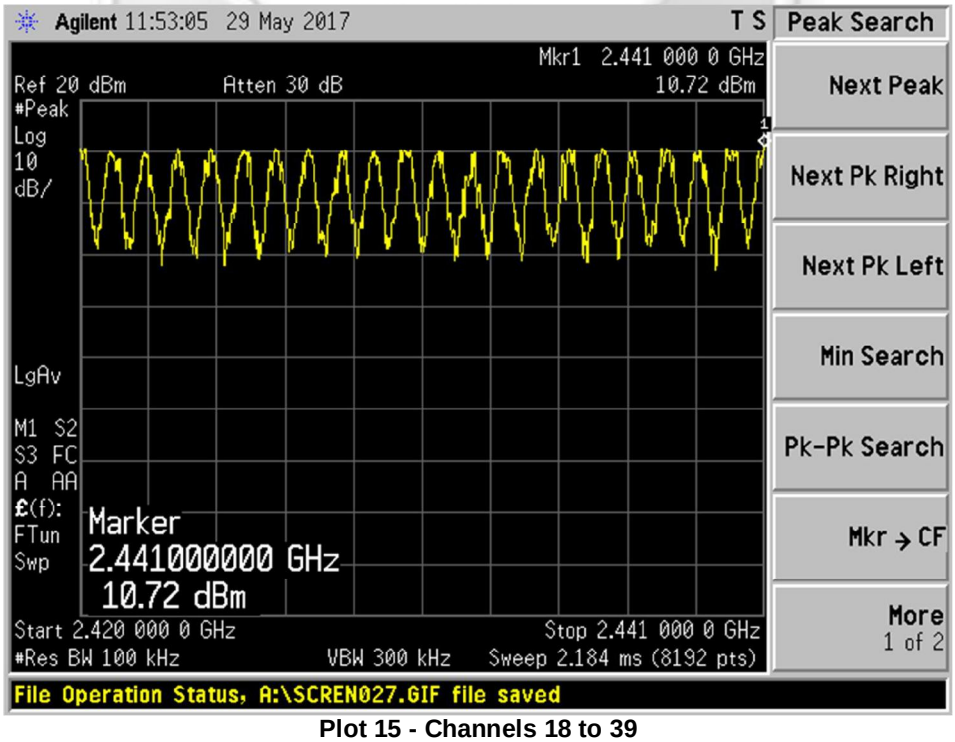
Test Input Power	3.7Vdc	Temperature	24ºC
Attached Plots	14 – 17	Relative Humidity	60%
		Atmospheric Pressure	1030mbar
		Tested By	Liau Lee Yin

The EUT was found to have 79 *(total number of ch)* hopping frequencies. Please refer to the attached plots.

Number Of Hopping Frequencies Plots

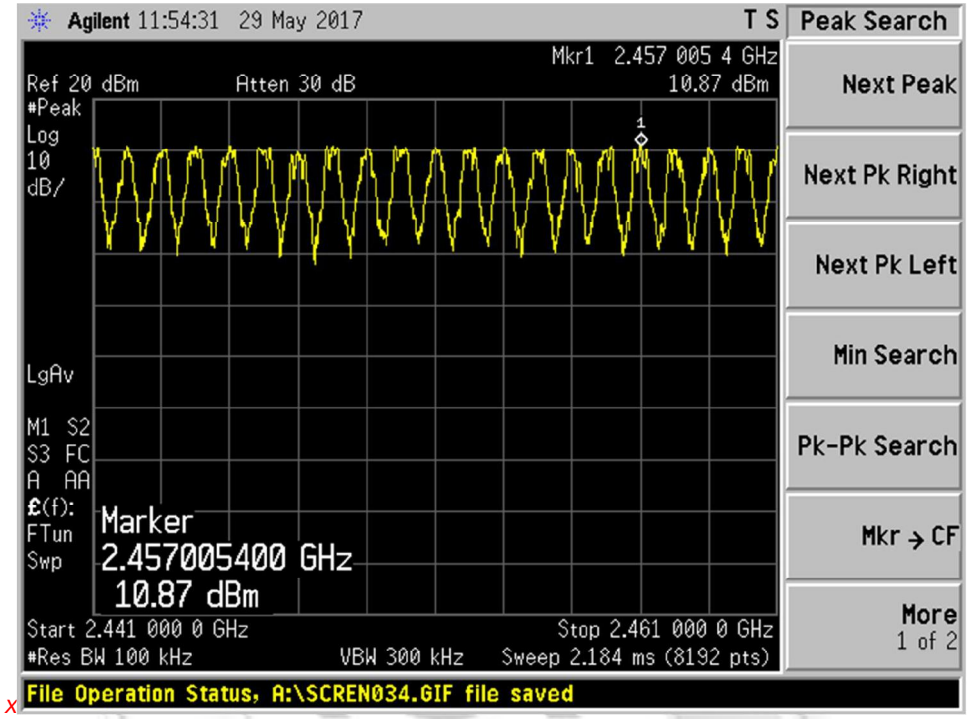


Plot 14 - Channels 0 to 18

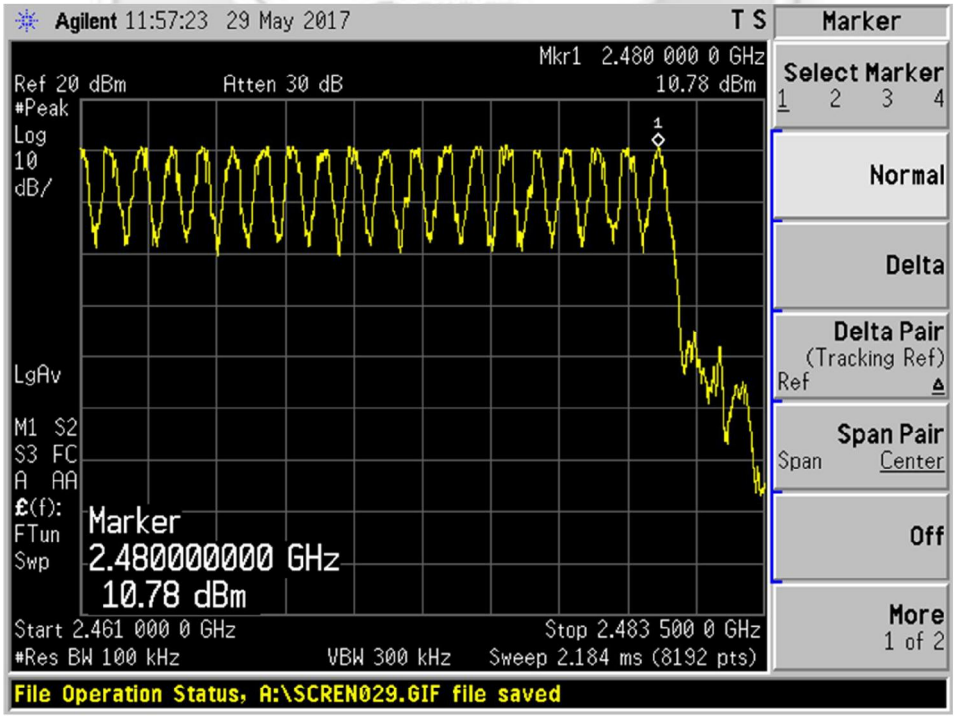


Plot 15 - Channels 18 to 39

Number Of Hopping Frequencies Plots



Plot 16 - Channels 39 to 59



Plot 17 - Channels 59 to 78

47 CFR FCC Part 15.247(a)(1)(iii) Average Frequency Dwell Time Limits

The EUT shows compliance to the requirements of this section, which states the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed.

47 CFR FCC Part 15.247(a)(1)(iii) Average Frequency Dwell Time Test Instrumentation

Instrument	Model	S/No	Cal Due Date
Agilent Spectrum Analyzer	E4440A	MY45304764	04 Jan 2018

47 CFR FCC Part 15.247(a)(1)(iii) Average Frequency Dwell Test Setup

1. The EUT and supporting equipment were set up as shown in the setup photo.
2. The power supply for the EUT was connected to a filtered mains.
3. The RF antenna connector was connected to the spectrum analyser via a low-loss coaxial cable.
4. The resolution bandwidth (RBW) and the video bandwidth (VBW) of the spectrum analyser were respectively set to 1MHz and 3MHz.
5. All other supporting equipment were powered separately from another filtered mains.

47 CFR FCC Part 15.247(a)(1)(iii) Average Frequency Dwell Test Method

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 frequency hopping sequence on.
2. The center frequency of the spectrum analyser was set to 2.402GHz *(lower ch)* with zero frequency span (spectrum analyser acts as an oscilloscope).
3. The sweep time of the spectrum analyser was adjusted until a stable signal can be seen on the spectrum analyser.
4. The duration (dwell time) of a packet (transmit time per hop) was measured using the marker-delta function of the spectrum analyser.
5. The measurement was repeated with the sweep time was set to equal to period specified in the requirement.
6. The number of hops in the period specified in the requirement, N was computed as below:
   N = [number of hops on spectrum analyser] x [period specified in the requirement / spectrum analyser sweep time]
7. The average time of occupancy is calculated from the transmit time per hop multiplied by the number of hops in the period specified in the requirement, N.
8. The steps 2 to 7 were repeated with the center frequency of the spectrum analyser were set to 2.441GHz *(mid ch)* and 2.480GHz *(upper ch)* respectively.

47 CFR FCC Part 15.247(a)(1)(iii) Average Frequency Dwell Time Results

Test Input Power	3.7Vdc	Temperature	24ºC
Attached Plots	18 – 26	Relative Humidity	60%
Hopping Rate	1600 hops / s	Atmospheric Pressure	1030mbar
Number of Hopping Channels	79 channels	Tested By	Liau Lee Yin

DH1

Channel	Channel Frequency (GHz)	Measured Time Slot Length (µs)	Average Frequency Dwell Time (s)	Average Occupancy Limit (s)
0 *(lower ch)*	2.402	384.874	0.1232	0.4
39 *(mid ch)*	2.441	386.265	0.1236	0.4
78 *(upper ch)*	2.480	383.357	0.1227	0.4

DH3

Channel	Channel Frequency (GHz)	Measured Time Slot Length (ms)	Average Frequency Dwell Time (s)	Average Occupancy Limit (s)
0 *(lower ch)*	2.402	1.6419	0.2627	0.4
39 *(mid ch)*	2.441	1.6405	0.2625	0.4
78 *(upper ch)*	2.480	1.6419	0.2627	0.4

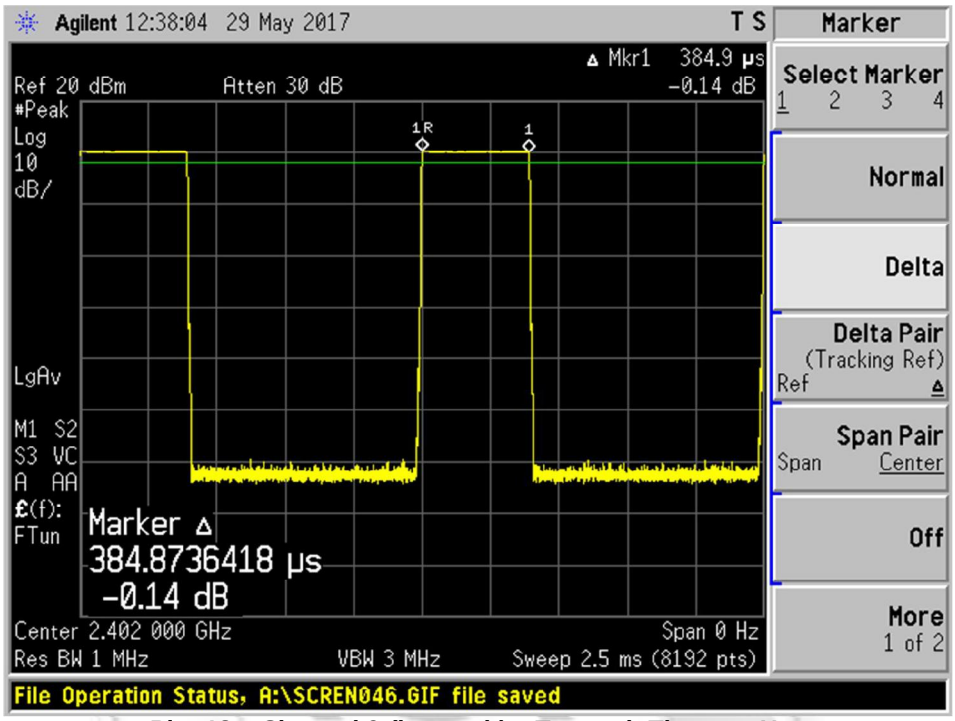
DH5

Channel	Channel Frequency (GHz)	Measured Time Slot Length (ms)	Average Frequency Dwell Time (s)	Average Occupancy Limit (s)
0 *(lower ch)*	2.402	2.8867	0.3121	0.4
39 *(mid ch)*	2.441	2.8880	0.3093	0.4
78 *(upper ch)*	2.480	2.8855	0.3121	0.4

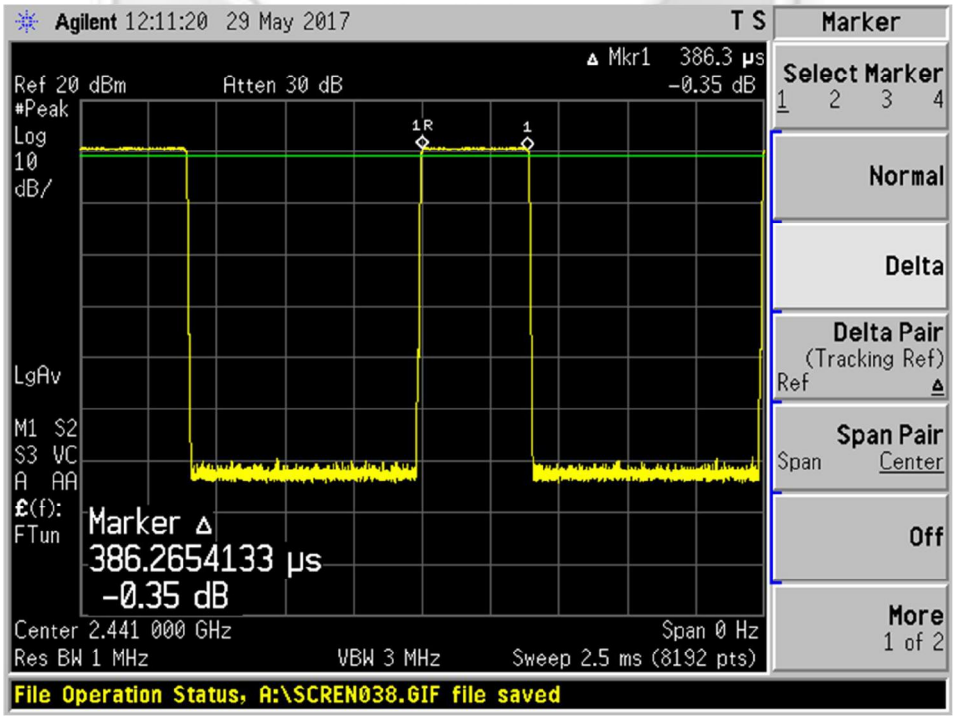
Notes

1. DH1 Dwell time = Measured Time Slot Length *(1600/2/79) *31.6
   DH3 Dwell time = Measured Time Slot Length *(1600/4/79) *31.6
   DH5 Dwell time = Measured Time Slot Length *(1600/6/79) *31.6

Average Frequency Dwell Time Plots – DH1

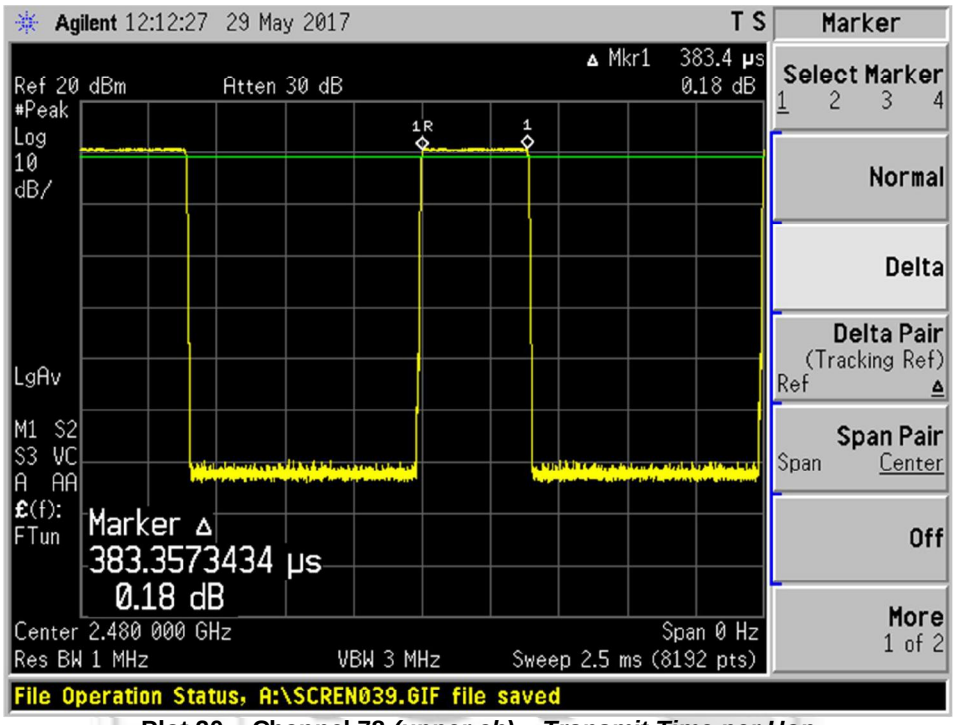


Plot 18 – Channel 0 *(lower ch) – Transmit Time per Hop*



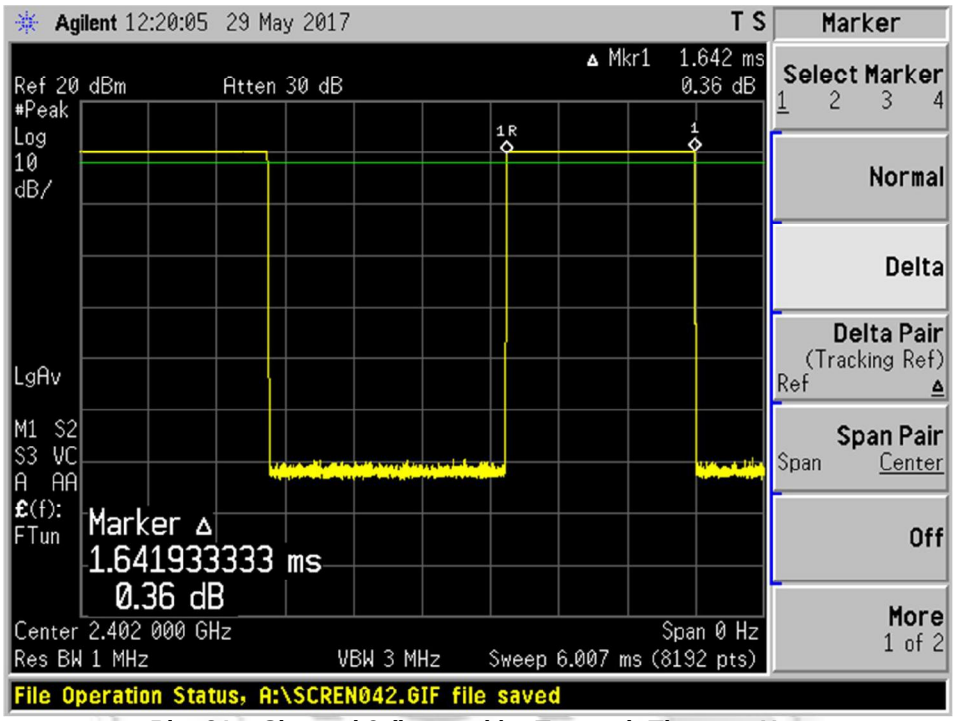
Plot 19 – Channel 39 *(mid ch) – Transmit Time per Hop*

Average Frequency Dwell Time Plots – DH1

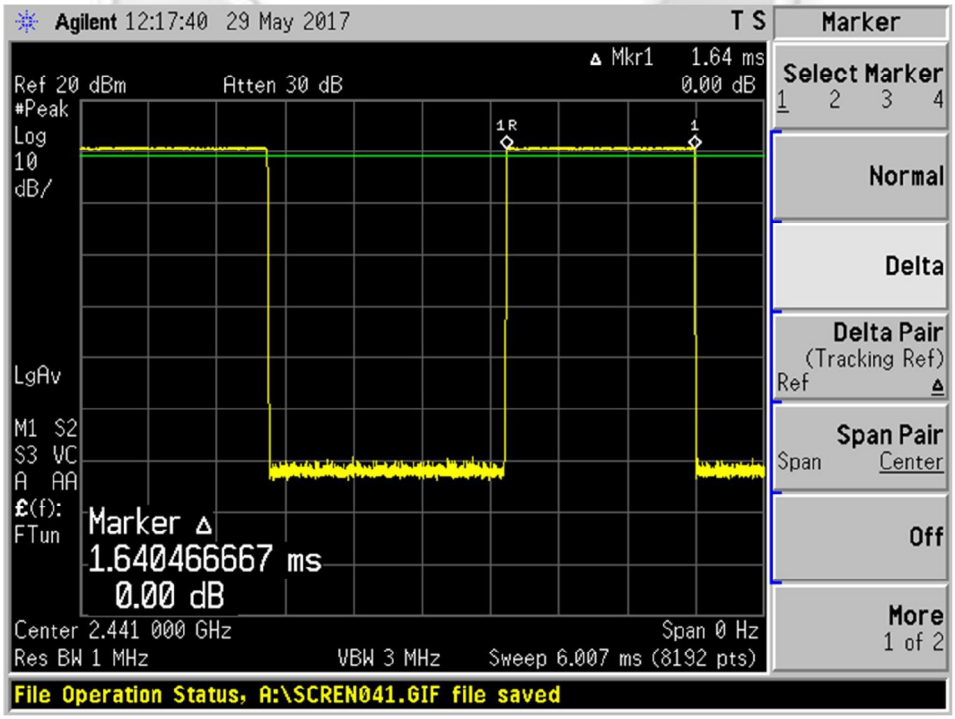


Plot 20 – Channel 78 *(upper ch) – Transmit Time per Hop*

Average Frequency Dwell Time Plots – DH3

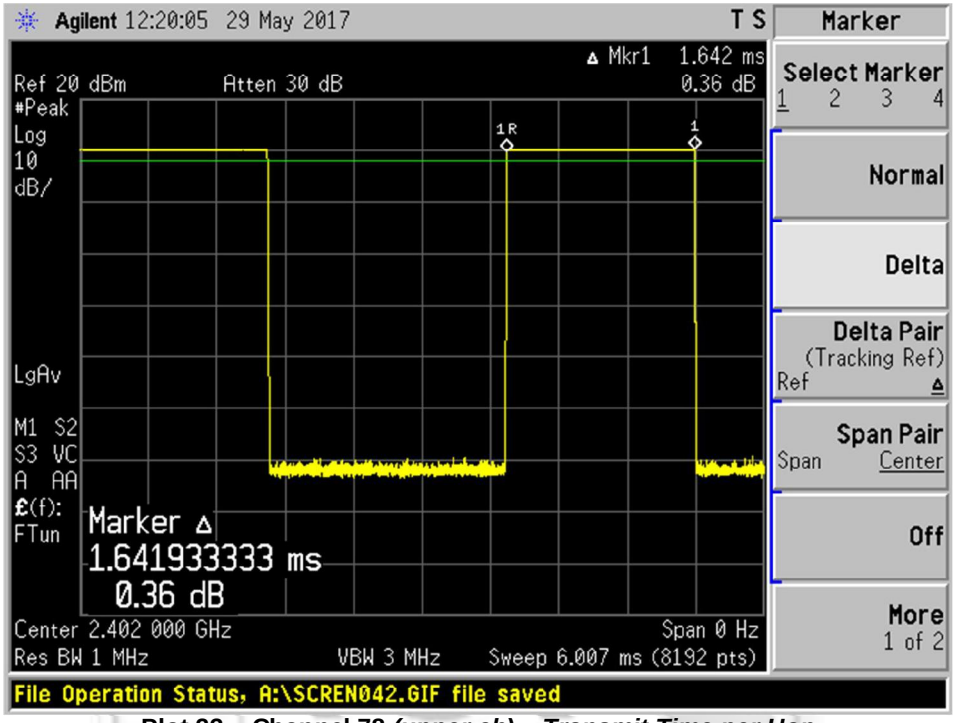


Plot 21 – Channel 0 *(lower ch) – Transmit Time per Hop*



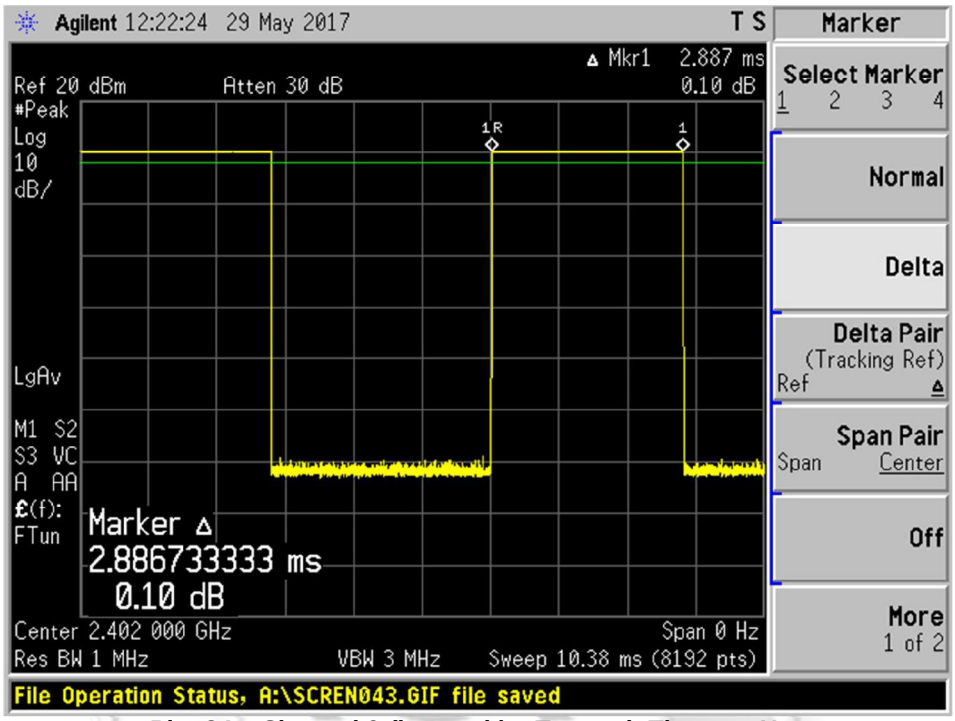
Plot 22 – Channel 39 *(mid ch) – Transmit Time per Hop*

Average Frequency Dwell Time Plots – DH3

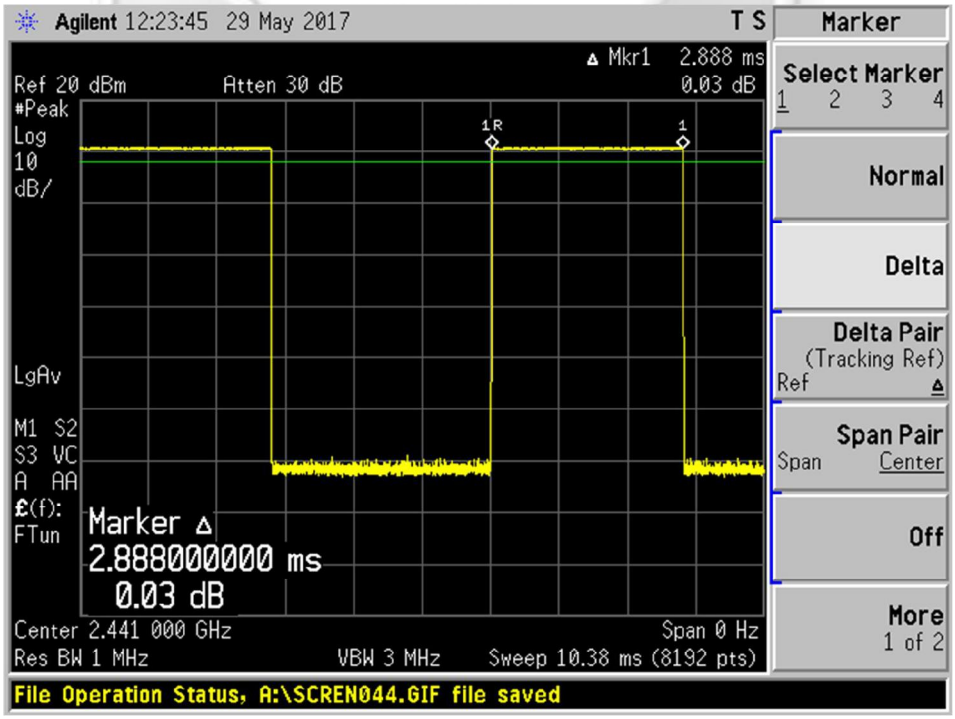


Plot 23 – Channel 78 *(upper ch) – Transmit Time per Hop*

Average Frequency Dwell Time Plots – DH5

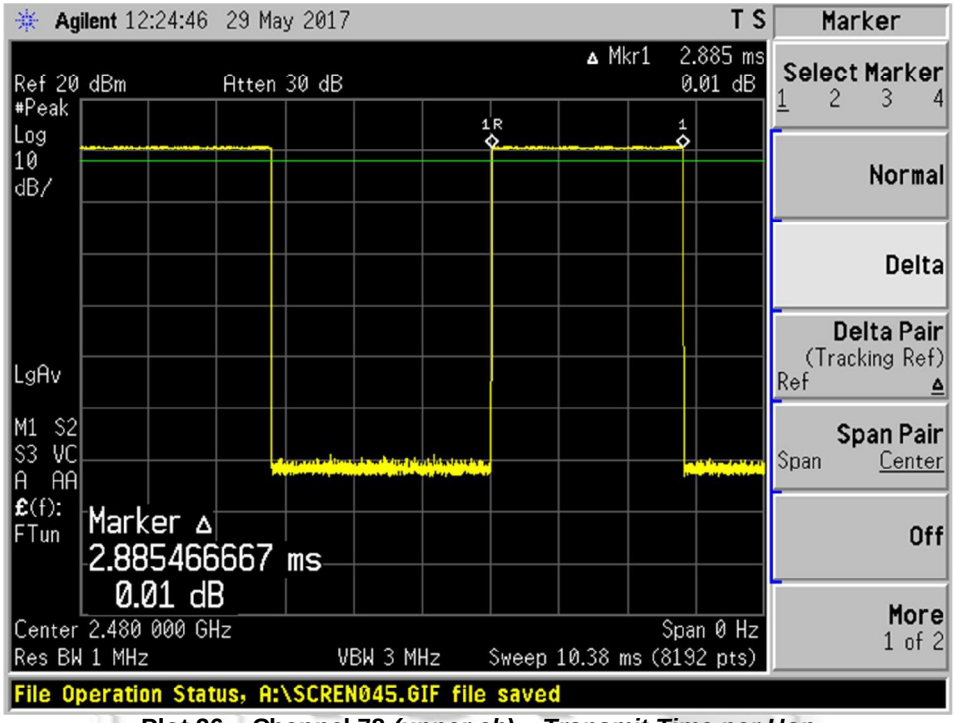


Plot 24 – Channel 0 *(lower ch) – Transmit Time per Hop*



Plot 25 – Channel 39 *(mid ch) – Transmit Time per Hop*

Average Frequency Dwell Time Plots – DH5



Plot 26 – Channel 78 *(upper ch) – Transmit Time per Hop*