

# FCC BT REPORT

# Certification

Applicant Name: SAMSUNG Electronics Co., Ltd.	Date of Issue: March 13, 2019 Location: HCT CO., LTD.,	
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Suwon-si, Gyeonggi-do, 16677, Rep. of Korea	<b>Report No.:</b> HCT-RF-1903-FC010	

# FCC ID: A3LSMA6060

# APPLICANT: SAMSUNG Electronics Co., Ltd.

Model:	SM-A6060
EUT Type:	Mobile Phone
Max. RF Output Power:	12.260 dBm (16.827 mW)
Frequency Range:	2402 MHz - 2480 MHz (Bluetooth)
Modulation type	GFSK(Normal), $\pi/4DQPSK$ and $8DPSK(EDR)$
FCC Classification:	FCC Part 15 Spread Spectrum Transmitter
FCC Rule Part(s):	Part 15 subpart C 15.247

The measurements shown in this report were made in accordance with the procedures specified in §2.947. I assume full responsibility for the accuracy and completeness of these measurements, and for the qualifications of all persons taking them. HCT CO., LTD. Certifies that no party to this application has subject to a denial of Federal benefits that includes FCC benefits pursuant to section 5301 of the Anti-Drug Abuse Act of 1998,21 U.S. C.853(a)

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# **Version**

TEST REPORT NO.	DATE	DESCRIPTION
HCT-RF-1903-FC010	March 13, 2019	- First Approval Report



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# 1. EUT DESCRIPTION

Model	SM-A6060	
ЕИТ Туре	Mobile Phone	
Power Supply	DC 3.85 V	
Battery Information	Model: EB-BA606ABU	
Dattery mornation	Type: Li-ion battery	
Travel Adapter Information	Model : EP-TA200	
	Manufacture: DYREL	
Frequency Range	2402 MHz - 2480 MHz	
Max. RF Output Power	12.260 dBm (16.827 mW)	
BT Operating Mode	Normal, EDR, AFH	
Modulation Type	GFSK(Normal), $\pi$ /4DQPSK and 8DPSK(EDR)	
Modulation Technique	FHSS	
Number of Channels	79Channels, Minimum 20 Channels(AFH)	
Antonno Specification	Antenna type: FPCB	
Antenna Specification	Peak Gain : -0.35 dBi	
Date(s) of Tests	January 31, 2019 ~ March 11, 2019	

# 2. Requirements for Bluetooth transmitter(15.247)

This Bluetooth module has been tested by a Bluetooth Qualification Lab, and we confirm the following:

- 1) This system is hopping pseudo-randomly.
- 2) Each frequency is used equally on the average by each transmitter.
- 3) The receiver input bandwidths that match the hopping channel bandwidths of their corresponding transmitters
- 4) The receiver shifts frequencies in synchronization with the transmitted signals.

• 15.247(g): The system, consisting of both the transmitter and the receiver, must be designed to comply with all of the regulations in this Section 15.247 should the transmitter be presented with a continuous data (or information) stream.

• 15.247(h): The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.



# 3. TEST METHODOLOGY

FCC KDB 558074 D01 15.247 Meas Guidance v05r01 dated February 11, 2019 entitled "guidance for compliance measurements on digital transmission system, frequency hopping spread spectrum system, and hybrid system devices and the measurement procedure described in ANSI C63.10(Version : 2013) 'the American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices'.

# **EUT CONFIGURATION**

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

# EUT EXERCISE

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

# **GENERAL TEST PROCEDURES**

### **Conducted Emissions**

The EUT is placed on the turntable, which is 0.8 m above ground plane. According to the requirements in Section 6.2 of ANSI C63.10. (Version :2013) Conducted emissions from the EUT measured in the frequency range between 0.15 MHz and 30MHz using CISPR Quasi-peak and average detector modes.

### Radiated Emissions

The EUT is placed on a turn table, which is 0.8 m above ground plane below 1GHz. Above 1GHz with 1.5m using absorbers between the EUT and receive antenna. The turntable shall rotate 360 degrees to determine the position of maximum emission level. EUT is set 3.75 m away from the receiving antenna, which varied from 1 m to 4 m to find out the highest emission. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical. In order to find out the max. emission, the relative positions of this hand-held transmitter (EUT) was rotated through three orthogonal axes according to the requirements in Section 6.6.5 of ANSI C63.10. (Version: 2013). To record the final measurements, the analyzer detector function was set to CISPR quasi-peak mode and the bandwidth of the spectrum analyzer was set to 120 kHz for frequencies below 1 GHz or 1 MHz for frequencies above 1 GHz. For average measurements above 1 GHz, the analyzer was set to peak detector with a reduced VBW setting(RBW = 1 MHz, VBW = 1/T Hz, where T = Pulse width).

# **DESCRIPTION OF TEST MODES**

The EUT has been tested under operating condition. Test program used to control the EUT for staying in continuous transmitting and receiving mode is programmed.



# 4. INSTRUMENT CALIBRATION

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

Espectially, all antenna for measurement is calibrated in accordance with the requirements of C63.5 (Version : 2017).

# 5. FACILITIES AND ACCREDITATIONS FACILITIES

The SAC(Semi-Anechoic Chamber) and conducted measurement facility used to collect the radiated data are located at the 74, Seoicheon-ro 578beon-gil, Majang-myeon, Icheon-si, Gyeonggi-do, 17383, Rep. of KOREA. The site is constructed in conformance with the requirements of ANSI C63.4. (Version :2014) and CISPR Publication 22.

Detailed description of test facility was submitted to the Commission and accepted dated April 02, 2018 (Registration Number: KR0032 ).

# EQUIPMENT

Radiated emissions are measured with one or more of the following types of Linearly polarized antennas: tuned dipole, bi-conical, log periodic, bi-log, and/or ridged waveguide, horn. Spectrum analyzers with pre-selectors and quasi-peak detectors are used to perform radiated measurements.

Conducted emissions are measured with Line Impedance Stabilization Networks and EMI Test Receivers.

Calibrated wideband preamplifiers, coaxial cables, and coaxial attenuators are also used for making measurements.

All receiving equipment conforms to CISPR Publication 16-1, "Radio Interference Measuring Apparatus and Measurement Methods."

# 6. ANTENNA REQUIREMENTS

### According to FCC 47 CFR §15.203:

"An intentional radiator antenna shall be designed to ensure that no antenna other than that furnished by the responsible party can be used with the device. 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 provisions of this section."

\* The antennas of this E.U.T are permanently attached.

\* The E.U.T Complies with the requirement of §15.203



# 7. MEASUREMENT UNCERTAINTY

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI C63.10-2013.

All measurement uncertainty values are shown with a coverage factor of k = 2 to indicate a 95 % level of confidence.

The measurement data shown herein meets or exceeds the  $U_{CISPR}$  measurement uncertainty values specified in CISPR 16-4-2 and, thus, can be compared directly to specified limits to determine compliance.

Parameter	Expanded Uncertainty (±dB)
Conducted Disturbance (150 kHz ~ 30 MHz)	1.82
Radiated Disturbance (9 kHz ~ 30 MHz)	3.40
Radiated Disturbance (30 MHz ~ 1 GHz)	4.80
Radiated Disturbance (1 GHz ~ 18 GHz)	5.70
Radiated Disturbance (18 GHz ~ 40 GHz)	5.71



# 8. DESCRIPTION OF TESTS

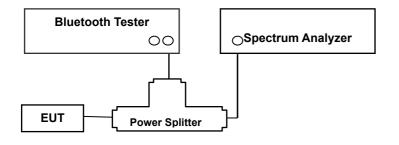
#### 8.1. Conducted Maximum Peak Output Power

### <u>Limit</u>

The maximum peak output power of the intentional radiator shall not exceed the following:

- 1. For frequency hopping systems operating in the 2400–2483.5 MHz band employing at least 75 nonoverlapping hopping channels, and all frequency hopping systems in the 5725–5850 MHz band: 1 W. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 W.
- 2. The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi.

#### **Test Configuration**



#### **Test Procedure**

The transmitter output is connected to the Spectrum Analyzer. The Spectrum Analyzer is set to the peak detector mode. This test is performed with hopping off.

The Spectrum Analyzer is set to (7.8.5 in ANSI 63.10-2013)

- 1) Span: approximately 5 times the 20 dB bandwidth, centered on a hopping channel
- 2) RBW > the 20 dB bandwidth of the emission being measured
- 3) VBW ≥ RBW
- 4) Sweep = Auto
- 5) Detector = Peak
- 6) Trace = Max hold

#### **Sample Calculation**

Output Power = Spectrum Reading Power + Power Splitter loss + Cable loss(2 ea)

= 10 dBm + 6 dB + 1.5 dB = 17.5 dBm

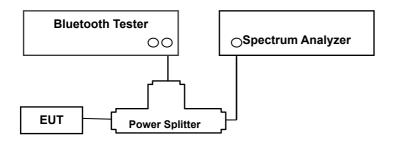


#### 8.2. Conducted Band Edge(Out of Band Emissions)

#### <u>Limit</u>

According to §15.247(d), in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits.

#### **Test Configuration**



#### **Test Procedure**

This test is performed with hopping off and hopping on.

The Spectrum Analyzer is set to (6.10.4 in ANSI 63.10-2013)

- 1) Span: Wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products which fall outside of the authorized band of operation
- Reference level: As required to keep the signal from exceeding the maximum instrument input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (OBW/RBW)] below the reference level.
- 3) Attenuation: Auto (at least 10 dB preferred).
- 4) Sweep time: Coupled.
- 5) RBW: 100 kHz
- 6) VBW: 300 kHz
- 7) Detector: Peak
- 8) Trace: Max hold

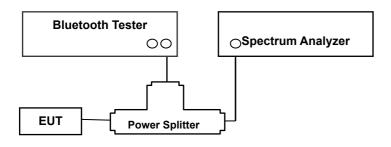


#### 8.3. Frequency Separation & 20 dB Bandwidth

#### <u>Limit</u>

According to §15.247(a)(1), 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.

#### **Test Configuration**



#### **Test Procedure**

The Channel Separation test is performed with hopping on. And the 20 dB Bandwidth test is performed with hopping off.

The Spectrum Analyzer is set to (7.8.2 in ANSI 63.10-2013)

- 1) Span: Wide enough to capture the peaks of two adjacent channels
- 2) RBW: Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
- 3) VBW ≥ RBW
- 4) Sweep: Auto
- 5) Detector: Peak
- 6) Trace: Max hold
- 7) All the trace to stabilize.
- 8) Use the marker-delta function to determine the separation between the peaks of the adjacent channels. Compliance of an EUT with the appropriate regulatory limit shall be determined. A plot of the data shall be included in the test report.

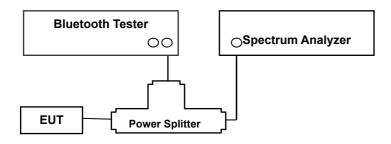


#### 8.4. Number of Hopping Frequencies

#### <u>Limit</u>

According to \$15.247(a)(1)(iii), Frequency hopping systems operating in the 2400 MHz ~ 2483.5 MHz bands shall use at least 15 hopping frequencies.

#### **Test Configuration**



#### Test Procedure

The Bluetooth frequency hopping function of the EUT was enabled.

The Spectrum Analyzer is set to (7.8.3 in ANSI 63.10-2013)

- 1) Span: the frequency band of operation
- 2) RBW: To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.
- 3) VBW ≥ RBW
- 4) Sweep: Auto
- 5) Detector: Peak
- 6) Trace: Max hold
- 7) Allow the trace to stabilize.

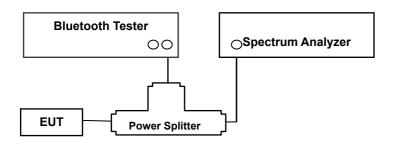


#### 8.5. Time of Occupancy

#### <u>Limit</u>

According to \$15.247(a)(1)(iii), Frequency hopping systems operating in the 2400 MHz ~ 2483.5 MHz bands. The average time of occupancy on any channels shall not greater than 0.4 s within a period 0.4 s multiplied by the number of hopping channels employed.

#### Test Configuration



#### Test Procedure

This test is performed with hopping off.

The Spectrum Analyzer is set to (7.8.4 in ANSI 63.10-2013)

- 1) Span: Zero span, centered on a hopping channel
- RBW shall be ≤ channel spacing and where possible RBW should be set >> 1 / T, where T is the expected dwell time per channel.
- 3) Sweep = as necessary to capture the entire dwell time per hopping channel
- 4) Detector: Peak
- 5) Trace: Max hold

The marker-delta function was used to determine the dwell time.



#### Sample Calculation

The following calculation process is not relevant to our measurement results. It is just an example.

\* Non-AFH Mode

- DH 5 (GFSK) : 2.890 \* (1600/6)/79 \* 31.6 = 308.27 (ms)
- 2-DH 5 (π/4DQPSK) : 2.890 \* (1600/6)/79 \* 31.6 = 308.27 (ms)
- 3-DH 5 (8DPSK) : 2.890 \* (1600/6)/79 \* 31.6 = 308.27 (ms)

\* AFH Mode

- DH 5 (GFSK) : 2.890 \* (800/6)/20 \* 8.0 = 154.13 (ms)
- 2-DH 5 (π/4DQPSK) : 2.890 \* (800/6)/20 \* 8.0 = 154.13 (ms)
- 3-DH 5 (8DPSK) : 2.890 \* (800/6)/20 \* 8.0 = 154.13 (ms)

Note :

DH5 Packet need 5 time slot for transmitting and 1 time slot for receiving.

Then the system makes worst case 1600/6 hops per second with 79 channels. So the system have each channel 3.3755 times per second and so for 31.6 seconds the system have 106.667 times of appearance. Each tx-time per appearance of DH5 is 2.890 ms.

Dwell time = Tx-time \* 106.667 = 308.27 (ms)

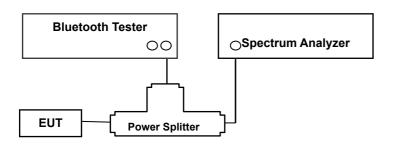


#### 8.6. Conducted Spurious Emissions

#### <u>Limit</u>

Conducted > 20 dBc

#### Test Configuration



#### **Test Procedure**

Conducted RF measurements of the transmitter output were made to confirm that the EUT antenna port conducted emissions meet the specified limit and to identify any spurious signals that require further investigation or measurements on the radiated emissions site.

The transmitter output is connected to the spectrum analyzer.

The Spectrum Analyzer is set to (7.8.8 in ANSI 63.10-2013)

- 1) Span: 30 MHz to 10 times the operating frequency in GHz.
- 2) RBW: 100 kHz
- 3) VBW: 300 kHz
- 4) Sweep: Coupled
- 5) Detector: Peak

Measurements are made over the 30 MHz to 25 GHz range with the transmitter set to the lowest, middle, and highest channels.

This test is performed with hopping off.



#### Factors for frequency

Freq(MHz)	Factor(dB)
30	7.18
100	6.35
200	7.04
300	6.58
400	6.26
500	5.95
600	6.17
700	6.34
800	6.72
900	7.08
1000	7.38
2000	7.21
2400*	7.40
2500*	7.44
3000	7.88
4000	8.95
5000	9.57
6000	6.68
7000	9.99
8000	8.34
9000	9.61
10000	10.47
11000	8.96
12000	9.73
13000	8.84
14000	9.50
15000	11.54
16000	8.14
17000	11.73
18000	9.71
19000	10.40
20000	11.69
21000	10.72
22000	12.31
23000	9.85
24000	12.52
25000	11.07
26000	10.50

Note : 1. '\*' is fundamental frequency range.

2. Factor = Cable loss + Splitter loss



#### FCC ID: A3LSMA6060

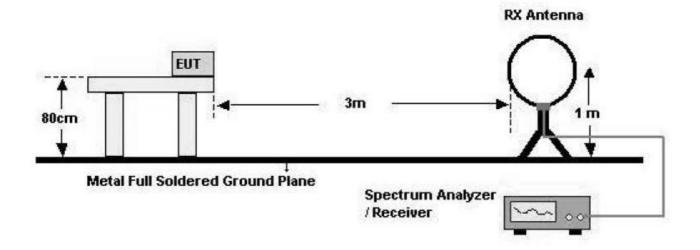
### 8.7. Radiated Test

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		-

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

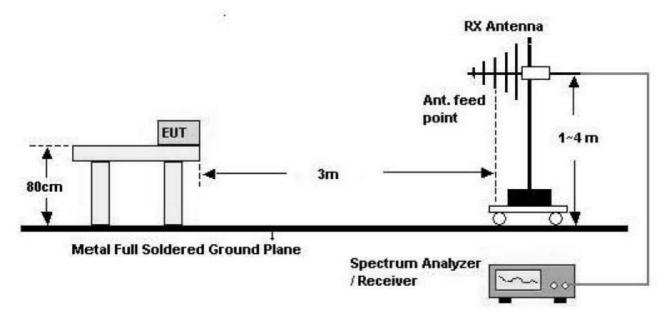
#### **Test Configuration**

Below 30 MHz

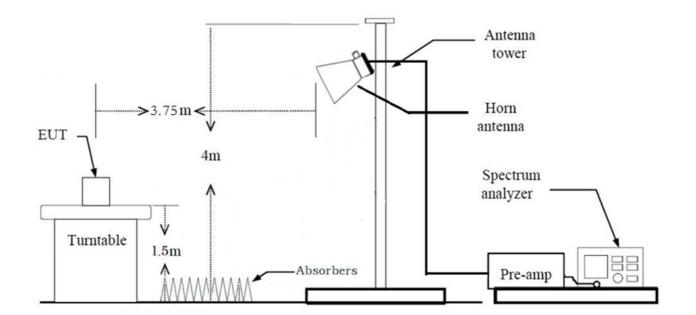




30 MHz - 1 GHz



Above 1 GHz





#### Test Procedure of Radiated spurious emissions(Below 30 MHz)

- 1. The EUT was placed on a non-conductive table located on semi-anechoic chamber.
- 2. The loop antenna was placed at a location 3m from the EUT
- 3. The EUT is placed on a turntable, which is 0.8m above ground plane.
- 4. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
- 5. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
- 6. Distance Correction Factor(0.009 MHz 0.490 MHz) =  $40*\log(3 \text{ m}/300 \text{ m}) = -80 \text{ dB}$ 
  - Measurement Distance : 3 m
- 7. Distance Correction Factor(0.490 MHz 30 MHz) = 40\*log(3 m/30 m) = -40 dB
  - Measurement Distance : 3 m
- 8. Spectrum Setting
  - Frequency Range = 9 kHz ~ 30 MHz
  - Detector = Peak
  - Trace = Maxhold
  - RBW = 9 kHz
  - VBW ≥ 3\*RBW
- 9. Total = Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) + Distance Factor(D.F)
- 10. The test results for below 30 MHz is correlated to an open site.

The result on OFS is about 2 dB higher than semi-anechoic chamber(10 m chamber)

#### Test Procedure of Radiated spurious emissions(Below 1GHz)

- 1. The EUT was placed on a non-conductive table located on semi-anechoic chamber.
- 2. The EUT is placed on a turntable, which is 0.8m above ground plane.
- 3. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
- 4. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
- 5. Spectrum Setting
  - (1) Measurement Type(Peak):
    - Measured Frequency Range : 30 MHz 1 GHz
    - Detector = Peak
    - Trace = Maxhold
    - RBW = 100 kHz
    - VBW ≥ 3\*RBW
  - (2) Measurement Type(Quasi-peak):
    - Measured Frequency Range : 30 MHz 1 GHz
    - Detector = Quasi-Peak
    - RBW = 120 kHz
  - \*In general, (1) is used mainly
- 6. Total = Reading Value + Antenna Factor(A.F) + Cable Loss(C.L)



#### Test Procedure of Radiated spurious emissions (Above 1 GHz)

- 1. Radiated test is performed with hopping off.
- 2. The EUT is placed on a turntable, which is 1.5 m above ground plane.
- 3. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
- 4. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
- 5. EUT is set 3.75 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
- 6. According to SVSWR requirement in ANSI 63.4-2014, We performed the radiated test at 3.75 m distance from center of turn table. So, we applied the distance factor( reference distance : 3 m).
  \*Distance extrapolation factor = 20\*log (test distance / specific distance) (dB)
- 7. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
- 8. Each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
- 9. The unit was tested with its standard battery.
- 10. Spectrum Setting
  - (1) Measurement Type(Peak):
    - Measured Frequency Range : 1 GHz 25 GHz
    - Detector = Peak
    - Trace = Maxhold
    - RBW = 1 MHz
    - VBW ≥ 3\*RBW
  - (2) Measurement Type(Average):
    - We performed using a reduced video BW method was done with the analyzer in linear mode
    - Measured Frequency Range : 1 GHz 25 GHz
    - Detector = Peak
    - Trace = Maxhold
    - RBW = 1 MHz
    - VBW  $\ge$  1/T Hz, where T = pulse width in seconds
      - The actual setting value of VBW = 1 kHz
- 11. Measurement value only up to 6 maximum emissions noted, or would be lesser if no specific emissions from the EUT are recorded (ie: margin > 20 dB from the applicable limit) and considered that's already beyond the background noise floor.
- 12. Total = Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) Amp Gain(G) + Distance Factor(D.F)



#### Test Procedure of Radiated Restricted Band Edge

- 1. Radiated test is performed with hopping off.
- 2. The EUT is placed on a turntable, which is 1.5 m above ground plane.
- 3. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
- 4. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
- 5. EUT is set 3.75 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
- 6. According to SVSWR requirement in ANSI 63.4-2014, We performed the radiated test at 3.75 m distance from center of turn table. So, we applied the distance factor( reference distance : 3 m).
  \*Distance extrapolation factor = 20\*log (test distance / specific distance) (dB)
- 7. Each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
- 8. The unit was tested with its standard battery.
- 9. Spectrum Setting
  - (1) Measurement Type(Peak):
    - Detector = Peak
    - Trace = Maxhold
    - RBW = 1 MHz
    - VBW ≥ 3\*RBW
  - (2) Measurement Type(Average):
    - We performed using a reduced video BW method was done with the analyzer in linear mode
    - Detector = Peak
    - Trace = Maxhold
    - RBW = 1 MHz
    - VBW  $\ge$  1/T Hz, where T = pulse width in seconds

The actual setting value of VBW = 1 kHz

- 10. Total(Measurement Type : Peak)
  - = Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) + Distance Factor(D.F)

Total(Measurement Type : Average)

= Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) + Distance Factor(D.F)



#### 8.8. AC Power line Conducted Emissions

#### <u>Limit</u>

For an intentional radiator 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, as measured using a 50  $\mu$ H/50 ohms line impedance stabilization network (LISN).

	Limits (dBµV)		
Frequency Range (MHz)	Quasi-peak	Average	
0.15 to 0.50	66 to 56*	56 to 46*	
0.50 to 5	56	46	
5 to 30	60	50	

\*Decreases with the logarithm of the frequency.

Compliance with this provision shall be based on the measurement of the radio frequency voltage between each power line (LINE and NEUTRAL) and ground at the power terminals.

#### **Test Configuration**

See test photographs attached in Annex A for the actual connections between EUT and support equipment.

#### **Test Procedure**

- 1. The EUT is placed on a wooden table 80 cm above the reference ground plane.
- 2. The EUT is connected via LISN to a test power supply.
- 3. The measurement results are obtained as described below:
- 4. Detectors : Quasi Peak and Average Detector.

#### Sample Calculation

Quasi-peak(Final Result) = Reading Value + Correction Factor



#### 8.9. Worst case configuration and mode

#### Radiated test

- 1. All modes of operation were investigated and the worst case configuration results are reported.
  - Mode : Stand alone, Stand alone + external accessories(earphone, etc)
  - Worstcase : Stand alone
- 2. EUT Axis
  - Radiated Spurious Emissions : Y
  - Radiated Restricted Band Edge : Z
- 3. We applied DCCF in the test result which hopping channel number is 20.
- 4. All data rate of operation were investigated and the test results are worst case in highest datarate of each mode.
  - GFSK : DH5
  - π/4DQPSK : 2-DH5
  - 8DPSK : 3-DH5

#### AC Power line Conducted Emissions

- 1. All modes of operation were investigated and the worst case configuration results are reported.
  - Mode : Stand alone+Earphone+Travel Adapter, Stand alone+Travel Adapter
  - Worstcase : Stand alone+Travel Adapter

#### **Conducted test**

- 1. The EUT was configured with data rate of highest power.
  - GFSK : DH5
  - $\pi/4DQPSK$  : 2-DH5
  - 8DPSK : 3-DH5
- 2. AFH & Non-AFH were tested and the worst case results are reported.

(Worst case : Non-AFH)



# 9. SUMMARY OF TEST RESULTS

Test Description	FCC Part Section(s)	Test Limit	Test Condition	Test Result
20 dB Bandwidth	§15.247(a)(1)	N/A		PASS
Occupied Bandwidth	§2.1049	N/A		PASS
Conducted Maximum Peak Output Power	§15.247(b)(1)	< 0.125 W		PASS
Carrier Frequency Separation	§15.247(a)(1)	> 25 kHz or >2/3 of the 20dB BW		PASS
Number of Hopping Frequencies	§15.247(a)(1)(iii)	≥ 15	Conducted	PASS
Time of Occupancy	§15.247(a)(1)(iii)	< 400 ms		PASS
Conducted Spurious Emissions	§15.247(d)	> 20 dB for all out-of band emissions		PASS
Band Edge (Out of Band Emissions)	§15.247(d)	> 20 dB for all out-of band emissions		PASS
AC Power line Conducted Emissions	§15.207(a)	cf. Section 8.8		PASS
Radiated Spurious Emissions	§15.247(d), 15.205, 15.209	cf. Section 8.7		PASS
Radiated Restricted Band Edge	§15.247(d), 15.205, 15.209	cf. Section 8.7	Radiated	PASS



# **10. TEST RESULT**

## 10.1 PEAK POWER

Channel Frequency		Output Power (GFSK)		Limit
(MHz)	(dBm)	(mW)	(mW)	
Low	2402	10.660	11.64	
Mid	2441	10.218	10.51	125
High	2480	10.233	10.55	

Channel	Frequency (MHz)	Outpu (8D	Limit (mW)	
		(dBm)	(mW)	(11100)
Low	2402	12.260	16.83	
Mid	2441	12.098	16.21	125
High	2480	11.832	15.25	

Channel	Frequency (MHz)	Outpu (π/4D	Limit (mW)	
		(MH2) (dBm) (mW)		(11177)
Low	2402	12.059	16.07	
Mid	2441	11.856	15.33	125
High	2480	11.608	14.48	

#### Note:

1. Spectrum reading values are not plot data.

The power results in plot is already including the actual values of loss for the splitter and cable combination.

2. We apply to the offset in the 2.4 GHz range that was rounded off to the closest tenth dB. Actual value of loss for the splitter and cable combination is 7.36 dB at 2402 MHz and is 7.44 dB at 2480 MHz.

So, 7.4 dB is offset. And the offset gap in the 2.4 GHz range do not affect the conducted peak power final result.



# Test Plots (GFSK)

Peak Power (CH.0)

B m	Atten: 24 dB		Mkr	1 2.402	10 GHz 60 dBm	Auto Tun Center Free 2.40200000 GH Start Free 2.39700000 GH
						2.40200000 GH Start Free 2.397000000 GH Stop Free
						2.397000000 GH Stop Free
					X	2.407000000 GH
						CF Ste 1.000000 MH Auto Ma
						Freq Offs 0 F
40.15	W 50 MHz		Sweep 1			
	#VB	#VBW 50 MHz	#VBW 50 MHz	#VBW 50 MHz Sweep 1.		Span 10.00 MHz #VBW 50 MHz Sweep 1.000 ms (1001 pts)

### Test Plots (GFSK) Peak Power (CH.39)

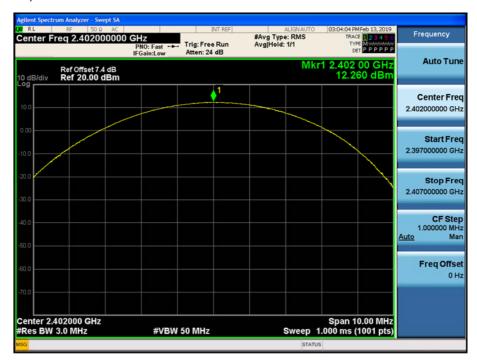




### Test Plots (GFSK) Peak Power (CH.78)

Agilent Spectr	rum Analyzer - Swept				NT REF		ALIGN AUTO	02:02:16.0	4Feb 13, 2019	-
	req 2.480000	000 GHz	Fast +++	Trig: Free	Run	#Avg Typ Avg Hold:	e: RMS	TRAC		Frequency
		IFGai	n:Low	Atten: 24	dB		Mkr		03 GHz	Auto Tune
10 dB/div Log	Ref Offset 7.4 d Ref 20.00 dE							10.2	33 dBm	
					1					Center Fred
10.0										2.48000000 GHz
0.00										
-10.0										Start Fred 2.475000000 GH:
									$\setminus$	
-20.0										Stop Free 2.485000000 GH
-30.0										2.485000000 GH2
-40.0										CF Step
										1.000000 MH Auto Mar
-50.0										
-60.0										Freq Offse 0 H
-70,0										
Center 2.4 #Res BW	480000 GHz		#VBW	50 MHz			Sween_1	Span 1	0.00 MHz 1001 pts)	
MSG				0.01111/2			STATUS	110	100 ( pt3)	

### Test Plots (8DPSK) Peak Power (CH.0)



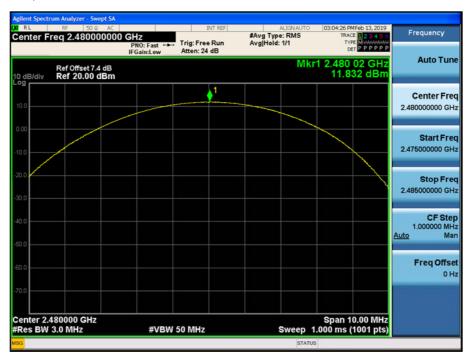


### Test Plots (8DPSK)

Peak Power (CH.39)

enter Freq 2.4410	PN	2 D: Fast ++-	INT REF Trig: Free Run Atten: 24 dB	#Avg Type Avg Hold:		TRA TY	MFeb 13, 2019 CE 1 2 3 4 5 6 PE MULLION ET P P P P P P P	Frequency
Ref Offset 7. 0 dB/div Ref 20.00	4 dB				Mkr	1 2.440 12.0	97 GHz 98 dBm	Auto Tun
10.0			1					Center Fre 2.441000000 GF
10.0								Start Fre 2.436000000 GF
								Stop Fro 2.446000000 Gi
00								CF Sto 1.000000 M Auto M
0.0								Freq Offs 0
center 2.441000 GHz Res BW 3.0 MHz		#VBW	50 MHz		Sweep 1	Span 1	0.00 MHz (1001 pts)	

#### Test Plots (8DPSK) Peak Power (CH.78)

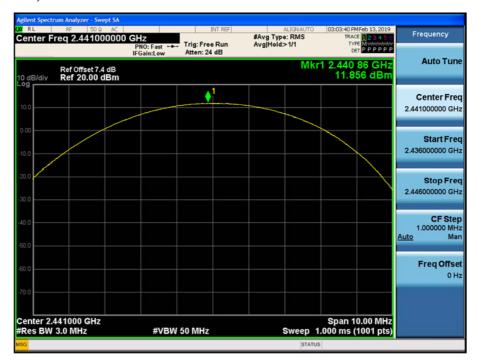




### Test Plots (π/4DQPSK) Peak Power (CH.0)

Center Freq 2.4020		st 🛶 Trig: Free		#Avg Type Avg Hold:		TRAC	1Feb 13, 2019 E <b>1 2 3 4 5 6</b> E MUNICIPAL P P P P P P P P P P P P P P P P P P	Frequency
Ref Offset 7. 0 dB/div Ref 20.00	4 dB	W Atten: 24			Mkr	1 2.402	15 GHz 59 dBm	Auto Tu
10.0			<b>∮</b> <sup>1</sup>					Center Fr 2.402000000 G
0.00								Start Fr 2.397000000 G
20.0								Stop Fr 2.407000000 G
40.0								CF SI 1.000000 M Auto M
0.0								Freq Off 0
70.0								
enter 2.402000 GHz Res BW 3.0 MHz		VBW 50 MHz			Sweep 1.	Span 1 000 ms (	0.00 MHz 1001 pts)	

Test Plots (π/4DQPSK) Peak Power (CH.39)





# Test Plots ( $\pi$ /4DQPSK)

Peak Power (CH.78)

gilent Spectrum Analyzer - Swept SA				
RL RF 50Ω AC Center Freq 2.480000000		ALIGNAUTO #Avg Type: RMS Avg Hold: 1/1	03:03:51 PMFeb 13, 2019 TRACE 2 3 4 5 6	Frequency
Ref Offset 7.4 dB 0 dB/div Ref 20.00 dBm	PNO: Fast +++ Trig: Free Run IFGain:Low Atten: 24 dB		2.480 17 GHz 11.608 dBm	Auto Tun
10.0	<b>↓</b> 1			Center Fre 2.480000000 GH
0.00				Start Fre 2.475000000 G⊦
20.0				Stop Fre 2.485000000 GH
0.0				CF Ste 1.000000 Mi <u>Auto</u> M
0.0				Freq Offs 01
enter 2.480000 GHz Res BW 3.0 MHz	#VBW 50 MHz	Sweep 1.	Span 10.00 MHz 000 ms (1001 pts)	
SG SG		STATUS		



# 10.2 BAND EDGES

#### Without hopping

Outside Frequency Pand	GFSK	8DPSK	π/4DQPSK	Limit
Outside Frequency Band	(dB)	(dB)	(dB)	(dBc)
Lower	55.739	55.919	57.628	00
Upper	67.341	65.901	66.418	20

#### With hopping

Outside Frequency Dand	GFSK	8DPSK	π/4DQPSK	Limit
Outside Frequency Band	(dB)	(dB)	(dB)	(dBc)
Lower	59.395	58.734	56.971	20
Upper	68.353	66.485	66.862	20

#### Note :

1. Spectrum reading values are not plot data.

The power results in plot is already including the actual values of loss for the splitter and cable combination.

2. We apply to the offset in the 2.4 GHz range that was rounded off to the closest tenth dB.

Actual value of loss for the splitter and cable combination is 7.36 dB at 2402 MHz

and is 7.44 dB at 2480 MHz.

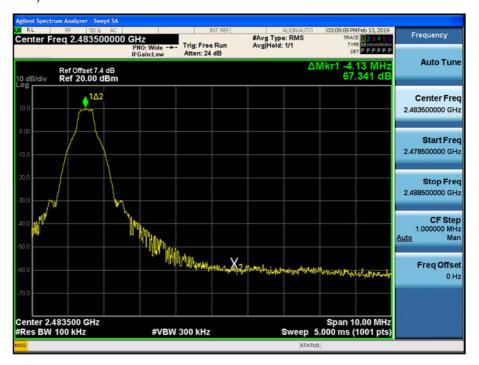
So, 7.4 dB is offset. And the offset gap in the 2.4 GHz range do not affect the conducted peak power final result.



Test Plots without hopping (GFSK) Band Edges (CH.0)



Test Plots without hopping (GFSK) Band Edges (CH.78)



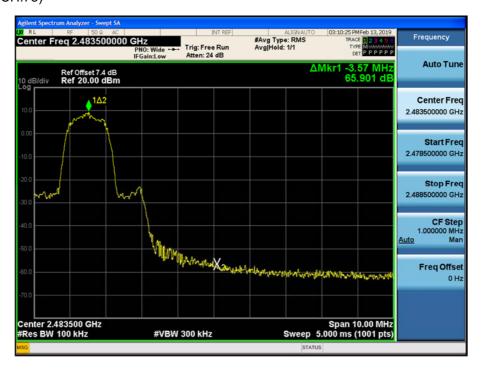


# Test Plots without hopping (8DPSK)

Band Edges (CH.0)



Test Plots without hopping (8DPSK) Band Edges (CH.78)





### Test Plots without hopping ( $\pi$ /4DQPSK)

Band Edges (CH.0)



### Test Plots without hopping ( $\pi$ /4DQPSK) Band Edges (CH.78)

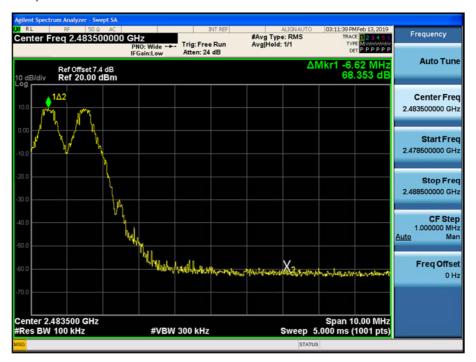




### Test Plots with hopping (GFSK) Band Edges (CH.0)

Frequency #Avg Type: RMS Avg|Hold: 1/1 Freq 2.400000000 GHz PNO: Wide +++ IFGain:Low Atten: 24 dB Cent PPPPPP Auto Tune ΔMkr1 4.31 MHz 59.395 dB Ref Offset 7.4 dB Ref 20.00 dBm 1Δ2 **Center Freq** 2.40000000 GHz Start Freq 2.395000000 GHz Stop Freq 2.40500000 GHz CF Step 1.000000 MHz Man lin X2 uto **Freq Offset** 0 Hz Center 2.400000 GHz #Res BW 100 kHz Span 10.00 MHz Sweep 5.000 ms (1001 pts) #VBW 300 kHz

Test Plots with hopping (GFSK) Band Edges (CH.78)



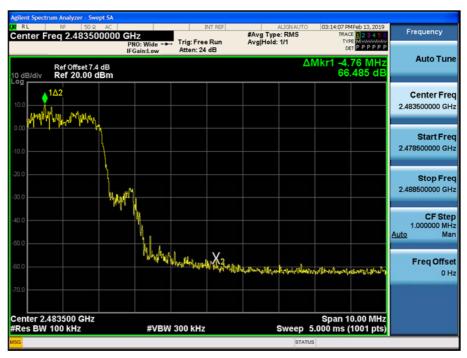


### Test Plots with hopping (8DPSK)

Band Edges (CH.0)



## Test Plots with hopping (8DPSK) Band Edges (CH.78)





# Test Plots with hopping ( $\pi$ /4DQPSK)

### Band Edges (CH.0)



### Test Plots with hopping ( $\pi$ /4DQPSK) Band Edges (CH.78)





# 10.3 FREQUENCY SEPARATION / OCCUPIED BANDWIDTH (99% BW)

99% BW (kHz)										
Channel	GFSK	8DPSK	π/4DQPSK							
CH.0	846.45	1184.1	1174.6							
CH.39	849.84	1179.7	1174.3							
CH.78	845.67	1188.6	1173.3							

20dB BW (kHz)										
Channel	GFSK	8DPSK	π/4DQPSK							
CH.0	951.5	1307	1289							
CH.39	950.8	1304	1288							
CH.78	950.7	1309	1288							

	Limit		
GFSK	8DPSK	(kHz)	
			>25 kHz
971	988	1008	or
			>2/3 of the 20dB BW



### Test Plots (GFSK)

### **Channel Separation**

LXI RL	RF	lyzer - Swept SA 50 Ω AC		I	NT REF		ALIGNAUTO	03:14:50 PM	4Feb 13, 2019	
Center Fr	req 2	2.441000000	PNO: Wide	Trig: Free		#Avg Typ Avg Hold		TYP	E 1 2 3 4 5 6 E Mulaiana T P P P P P P	Frequency
10 dB/div		Offset 7.4 dB 17.40 dBm	IFGain:Low	#Atten: 20	) dB			ΔMkr3 s		Auto Tune
-2.60 -12.6	لمهر	~X2	~~~~	and the second	1Δ2 Φ~η	~~~~	مرمر	304	سررر	Center Freq 2.441000000 GHz
-22.6 -32.6 -42.6										Start Fred 2.439500000 GH2
-52.6 -62.6 -72.6										Stop Fred 2.442500000 GH2
Center 2.4 #Res BW			#VE	3W 100 kHz			Sweep	Span 3 3.176 ms	.000 MHz (900 pts)	CF Step 300.000 kH: Auto Mar
MKR MODE TF		×	971 kHz (	γ Δ) 0.000	FUNCT	ION FUI	NCTION WIDTH	FUNCTIO	IN VALUE	Auto Mar
2 F 1	f		0 014 GHz 988 kHz (	7.805 dE	3m					Freq Offset
4 F 1 5 6 7			0 985 GHz	7.804 dE	3m					0 Hz
8 9 10 11									-	
K MSG				1.01			STATUS	1	>	

### Test Plots (8DPSK) Channel Separation

IFGain:Low	#Atten: 20 dB			DET P P P	P P P	
n			ΔN	lkr3 1.168 M -0.881 (		Auto Tune
~~~~~	10: 	2	~~~~~	<u>3∆4</u>		Center Fre 41000000 GH
					2.4	<b>Start Fre</b> 39500000 GH
					2.4	Stop Fre 42500000 GH
#VB	W 100 kHz		Sweep		ots)	CF Ste 300.000 kH Ma
× 988 kHz (/	Y 2,298 dB	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE	Auto	Ma
440 001 GHz	5.534 dBm					Freq Offse
					>	
	× 988 kHz (/ 440 001 GHz 1.168 MHz (/	988 kHz (Δ) 2.298 dB 440 001 GHz 5.534 dBm 1.168 MHz (Δ) -0.881 dB	Y         FUNCTION           988 kHz         (Δ)         2.298 dB           440 001 GHz         5.534 dBm           1.168 MHz         (Δ)         -0.881 dB	X         Function         Function width           988 kHz         (Δ)         2.298 dB         440 001 GHz         5.534 dBm           1.168 MHzI         (Δ)         9.881 dB         640	Span 3.000 N           #VBW 100 kHz         Span 3.000 N           \$\$983 kHz (\Delta)         2.298 dB           \$\$440 001 GHz         5.534 dBm           \$\$1168 kHz (\Delta)         2.783 dB           \$\$440 001 GHz         7.831 dBm	#VBW 100 kHz         Span 3.000 MHz         2.4           #VBW 100 kHz         Span 3.000 MHz         2.4           #VBW 100 kHz         Sweep 3.176 ms (900 pts)         4.40 001 GHz         5.53 dBm           1.168 MHz (Δ)         2.28 dB         4.40 001 GHz         5.53 dBm         4.40 001 GHz



### Test Plots (π/4DQPSK)

### **Channel Separation**

Agilent Sp	ectrun	RE	l <mark>iyzer - Swep</mark> 50 Ω				IN	IT REF		ALIGN AUT(	02:15:29	PMFeb 13, 2019	_	
	Fre		2.441000	0000 GI	NO: Wide		Trig: Free	Run		Type: RMS Hold: 1/1	TRA			requency
10 dB/di			Offset 7.4 17.40 dl	dB	Gain:Low	r	#Atten: 20	dB		Δ	Mkr3 1.			Auto Tune
Log 7.40 -2.60 ← -12.6	$\sim$	~^	X2m	<u>^</u>	~~~~		Å	1∆2 •~~~	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	~~~~	<b>€3∆4</b>	h		Center Freq 1000000 GHz
-22.6 — -32.6 — -42.6 —													2.43	Start Freq 9500000 GHz
-52.6 -62.6 -72.6													2.44	Stop Freq 2500000 GHz
#Res B	W 3	0 k	00 GHz Hz		#V	BW	100 kHz				3.176 m		Auto	CF Step 300.000 kHz Man
MKR MODE			(A)	×	1 MHz	(Δ)	Y 0.822 d	в	FUNCTION	FUNCTION WID	TH FUNCT	ION VALUE		
2 F 3 Δ4	1		(Δ)	2.439 85	0 GHz 8 MHz		6.716 dB 0.510 d 7.538 dB	m IB						Freq Offset
5 6 7 8 9				2.440.00										0 Hz
10 11 ¢												~		
ISG										STA	TUS			

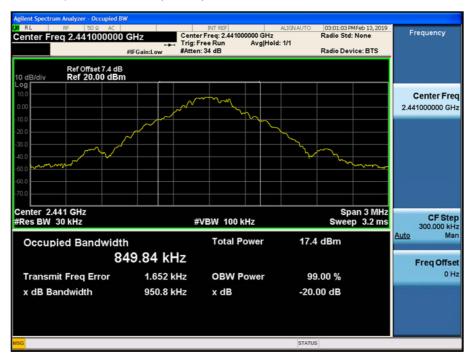


### Test Plots (GFSK)

20 dB Bandwidth & Occupied Bandwidth (CH.0)



### Test Plots (GFSK) 20 dB Bandwidth & Occupied Bandwidth (CH.39)



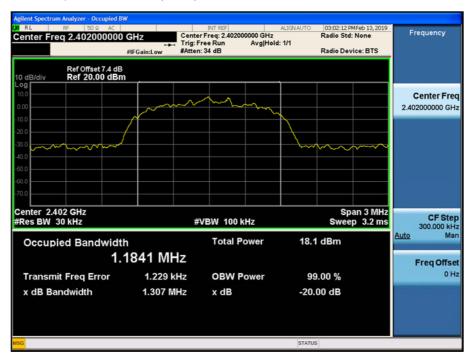


### Test Plots (GFSK)

20 dB Bandwidth & Occupied Bandwidth (CH.78)



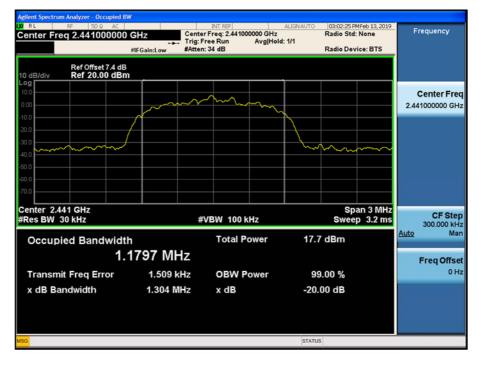
### Test Plots (8DPSK) 20 dB Bandwidth & Occupied Bandwidth (CH.0)





### Test Plots (8DPSK)

20 dB Bandwidth & Occupied Bandwidth (CH.39)



### Test Plots (8DPSK)

20 dB Bandwidth & Occupied Bandwidth (CH.78)





### Test Plots ( $\pi$ /4DQPSK)

20 dB Bandwidth & Occupied Bandwidth (CH.0)



### Test Plots (π/4DQPSK)

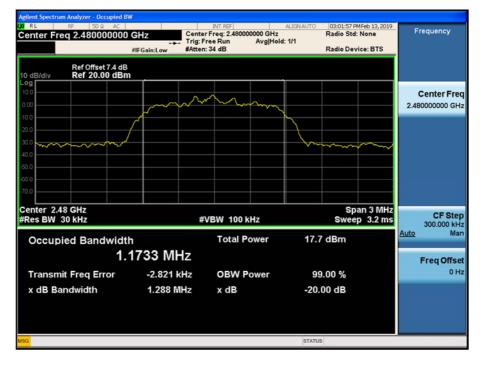
20 dB Bandwidth & Occupied Bandwidth (CH.39)





### Test Plots (π/4DQPSK)

20 dB Bandwidth & Occupied Bandwidth (CH.78)





# 10.4 NUMBER OF HOPPING FREQUENCY

	Result (No. of CH)							
GFSK	GFSK 8DPSK π/4DQPSK							
79	79	79	>15					

### Note :

In case of AFH mode, minimum number of hopping channels is 20.



Test Plots (GFSK)

Number of Channels (2.4 GHz - 2.441 GHz)



### Test Plots (GFSK)

Number of Channels (2.441 GHz - 2.4835 GHz)





### Test Plots (8DPSK)

Number of Channels (2.4 GHz - 2.441 GHz)

RL RF 50 Q AC Start Freq 2.400000000 G	PNO: Wide 🛶 Trig: Free Run	#Avg Type: RMS Avg Hold: 1/1	03:19:05 PMFeb 13, 2019 TRACE 1 2 3 4 5 6 TYPE MUMANANANANANANANANANANANANANANANANANANA	Frequency
Ref Offset 7.4 dB 0 dB/div Ref 17.40 dBm	IFGain:Low #Atten: 20 dB		Der <b>Franz</b>	Auto Tune
<b>og</b> 7.40			᠋ᠯ᠕ᡔᡒᡃᡇᡗᠵᡐᠬᢦᢊ	Center Fre 2.420500000 GH
2.60				<b>Start Fre</b> 2.400000000 GH
32.6				Stop Fre 2.441000000 GH
52.6				CF Ste 4.100000 MH Auto Ma
				Freq Offs 0 F
r226 itart 2.40000 GHz Res BW 240 kHz	#VBW 240 kHz		Stop 2.44100 GHz .000 ms (1001 pts)	

### Test Plots (8DPSK)

Number of Channels (2.441 GHz - 2.4835 GHz)

gilent Spectrum Analyzer - Swept SA RL RF 50 Ω AC		NT REF ALIGN AUT	0 03:19:40 PMFeb 13, 2019	
tart Freq 2.441000000		#Avg Type: RMS Run Avg Hold: 1/1	TRACE 123456 TYPE MUMUUUU DET PPPPP	Frequency
Ref Offset 7.4 dB 0 dB/div Ref 17.40 dBm	IFGall:LUW Protein 20			Auto Tun
•g 7.40 <b>~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~</b>	mm	ᠰᡊᠰᠬ᠈ᠬᢇᠬᡢᠬ	mmm	Center Fre 2.461500000 GH
2.60				<b>Start Fre</b> 2.441000000 GH
32.6				Stop Fre 2.482000000 GH
26				CF Ste 4.100000 MI <u>Auto</u> M
2.6				Freq Offs 0
r2.6 tart 2.44100 GHz			Stop 2.48200 GHz	
Res BW 240 kHz	#VBW 50 MHz	Sweep	1.000 ms (1001 pts)	



### Test Plots (π/4DQPSK)

Number of Channels (2.4 GHz - 2.441 GHz)

Agilent Spectrum Analyzer - Swept SA RL RF 50 Ω AC Start Freq 2.400000000 G		#Avg Type	RMS TRAC	MFeb 13, 2019 E 1 2 3 4 5 6 Frequency
Ref Offset 7.4 dB	IFGain:Low #Atten: 20		De	Auto Tune
Log	<b>1</b>	ᢉᡧᡘ᠋᠆ᠬ᠆ᠰᡢᡎᠰᢇᡝ	waterbuck	Center Free 2.420500000 GH:
-2.60				Start Free 2.400000000 GH
32.6				Stop Fre 2.441000000 GH
42.6				CF Ste 4.100000 MH <u>Auto</u> Ma
-62.6				Freq Offse 0 H
-72.6 Start 2.40000 GHz	#VBW 240 kHz			100 GHz
#Res BW 240 kHz <mark>Iso</mark>	#VBW 240 KH2		Sweep 1.000 ms (	

### Test Plots (π/4DQPSK)

Number of Channels (2.441 GHz - 2.4835 GHz)

RL RF 50 Q AC		INT REF	ALIGN AUTO	03:18:29 PMFeb 13, 2019	Frequency
tart Freq 2.441000000	PNO: Wide Trig	Free Run en: 20 dB	#Avg Type: RMS Avg Hold: 1/1	TRACE 123456 TYPE MUMUUUUU DET PPPPP	Frequency
Ref Offset 7.4 dB dB/div Ref 17.40 dBn	1				Auto Tur
9 .40 <mark>עייץייאראריאריאריאריאריאריאריאריאריאריאריארי</mark>	᠕ᢆ᠆᠉᠕	ᡙᠬᢩ᠆᠆᠆᠆	᠕ᡧ᠕ᡔᢧᡗᡇᢧ᠊ᠬ	many	Center Fre 2.461500000 Gi
2.6					<b>Start Fr</b> 2.441000000 G
2.6					Stop Fr 2.482000000 G
2.6					CF St 4.100000 M <u>Auto</u> M
26					Freq Offs 0
2.6 tart 2.44100 GHz				Stop 2.48200 GHz	
Res BW 240 kHz	#VBW 50 N	IHz	Sweep	1.000 ms (1001 pts)	



## 10.5 TIME OF OCCUPANCY (DWELL TIME)

	Channel	GFSK	8DPSK	π/4DQPSK
Pulse Time	Low	2.890	2.890	2.885
(ms)	Mid	2.885	2.890	2.885
	High	2.890	2.890	2.890

### Non-AFH Mode

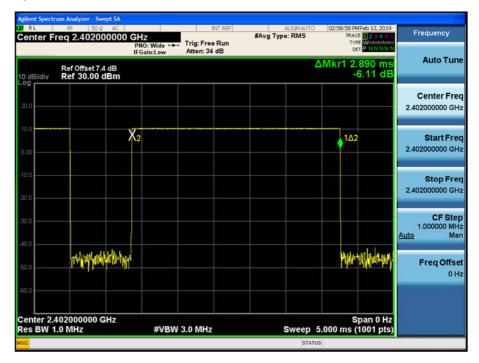
	Channel	GFSK	8DPSK	π/4DQPSK	Period Time (s)	Limit (ms)
Total of Dwell	Low	308.27	308.27	307.73	31.6	
(ms)	Mid	307.73	308.27	307.73	31.6	400
	High	308.27	308.27	308.27	31.6	

#### AFH Mode

	Channel	GFSK	8DPSK	π/4DQPSK	Period Time (s)	Limit (ms)
Total of Dwell	Low	154.13	154.13	153.86	8.0	
(ms)	Mid	153.86	154.13	153.86	8.0	400
	High	154.13	154.13	154.13	8.0	



### Test Plots (GFSK) Dwell Time (CH.0)



### Test Plots (GFSK) Dwell Time (CH.39)

