



TEST REPORT

Applicant:	Ugreen Group Limited				
Address:	URGEEN Building, Longcheng Industrial Park, Longguanxi Road, Longhua, ShenZhen, China				
Equipment Type:	UGREEN HiTune P3 True Wireless Earbuds				
Model Name:	WS207 (refer to section 2.3)				
Brand Name:	UGREEN				
FCC ID:	2AQI5-WS207R				
Test Standard:	47 CFR Part 15 Subpart C (refer to section 3.1)				
Sample Arrival Date:	Apr. 02, 2024				
Test Date:	Apr. 09, 2024 - Apr. 14, 2024				
Date of Issue:	May 28, 2024				

ISSUED BY:

Shenzhen BALUN Technology Co., Ltd.

Tested by: Julie Zhu

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Hanson Lin



	Revision History				
		Version	Issue Date	Revisions	
		<u>Rev. 01</u>	<u>May 28, 2024</u>	Initial Issue	
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1 GENERAL INFORMATION

1.1 Test Laboratory

Name Shenzhen BALUN Technology Co., Ltd.	
Address	Block B, 1/F, Baisha Science and Technology Park, Shahe Xi Road,
Address	Nanshan District, Shenzhen, Guangdong Province, P. R. China
Phone Number	+86 755 6685 0100

1.2 Test Location

Name	Shenzhen BALUN Technology Co., Ltd.		
	☑ Block B, 1/F, Baisha Science and Technology Park, Shahe Xi		
	Road, Nanshan District, Shenzhen, Guangdong Province, P. R. China		
Location	1/F, Building B, Ganghongji High-tech Intelligent Industrial Park,		
	No. 1008, Songbai Road, Yangguang Community, Xili Sub-district,		
	Nanshan District, Shenzhen, Guangdong Province, P. R. China		
Accorditation Cartificate	The laboratory is a testing organization accredited by FCC as a		
Accreditation Certificate	accredited testing laboratory. The designation number is CN1196.		



2 **PRODUCT INFORMATION**

2.1 Applicant Information

Applicant Ugreen Group Limited	
Address	UGREEN Building, Longcheng Industrial Park Longguanxi Road,
Address	Longhua, ShenZhen, China

2.2 Manufacturer Information

Manufacturer Ugreen Group Limited	
Addross	UGREEN Building, Longcheng Industrial Park Longguanxi Road,
Address	Longhua, ShenZhen, China

2.3 General Description for Equipment under Test (EUT)

EUT Name	UGREEN HiTune P3 True Wireless Earbuds
Model Name Under Test	WS207
Series Model Name	45110
Description of Model name differentiation	All models are same with electrical parameters and internal circuit structure, but only differ in model name. (this information provided by the applicant)
Hardware Version	N/A
Software Version	N/A
Dimensions (Approx.)	N/A
Weight (Approx.)	N/A



2.4 Technical Information

	Network and Wireless connectivity	Bluetooth (BR+EDR+BLE)	
The	requirement for the followi	ng technical information of the EUT was tested in this report:	
	Modulation Technology	FHSS	
	Modulation Type	GFSK, π/4-DQPSK, 8-DPSK	
		Mobile	
	Product Type	⊠ Portable	
		Fix Location	
		DH5: 1 Mbps	
	Transfer Rate	2DH5: 2 Mbps	
		3DH5: 3 Mbps	
	Frequency Range	The frequency range used is 2400 MHz to 2483.5 MHz.	
	Number of Channel	79 (at intervals of 1 MHz)	
	Tested Channel	0 (2402 MHz), 39 (2441 MHz), 78 (2480 MHz)	
	Antenna Type	PCB Antenna	
	Antenna Gain	-1.9 dBi	
	Antenna Impedance	50Ω	
	Antenna System (MIMO Smart Antenna)	N/A	
	(MIMO Smart Antenna)	N/A	



All channel was listed on the following table:

Channel	Freq.	Channel	Freq.	Channel	Freq.	Channel	Freq.
number	(MHz)	number	(MHz)	number	(MHz)	number	(MHz)
0	2402	21	2423	42	2444	63	2465
1	2403	22	2424	43	2445	64	2466
2	2404	23	2425	44	2446	65	2467
3	2405	24	2426	45	2447	66	2468
4	2406	25	2427	46	2448	67	2469
5	2407	26	2428	47	2449	68	2470
6	2408	27	2429	48	2450	69	2471
7	2409	28	2430	49	2451	70	2472
8	2410	29	2431	50	2452	71	2473
9	2411	30	2432	51	2453	72	2474
10	2412	31	2433	52	2454	73	2475
11	2413	32	2434	53	2455	74	2476
12	2414	33	2435	54	2456	75	2477
13	2415	34	2436	55	2457	76	2478
14	2416	35	2437	56	2458	77	2479
15	2417	36	2438	57	2459	78	2480
16	2418	37	2439	58	2460	-	-
17	2419	38	2440	59	2461	-	-
18	2420	39	2441	60	2462	-	-
19	2421	40	2442	61	2463	-	-
20	2422	41	2443	62	2464	-	-



3 SUMMARY OF TEST RESULTS

3.1 Test Standards

No.	Identity	Document Title
1	47 CFR Part 15, Subpart C	Intentional radiators of radio frequency equipment
2	ANSI C63.10-2013	American National Standard for Testing Unlicensed Wireless Devices
3 ☆	KDB 558074 D01 15.247 Meas Guidance v05r02	Guidance for compliance measurements on digital transmission system, frequency hopping spread spectrum system, and hybrid system devices operating under section 15.247 of the FCC rules

3.2 Test Verdict

No.	Description	FCC Part No.	Channel	Test Result	Verdict	Remark
1	Antenna Requirement	15.203	N/A		Pass	Note ¹
2	Number of Hopping Frequencies	15.247(a)	Hopping Mode	5.3.4	Pass	Note ²
3	Peak Output Power	15.247(b)	Low/Middle/High	5.4.4	Pass	
4	Occupied Bandwidth	15.247(a)	Low/Middle/High	5.5.4	Pass	
5	Carrier Frequency Separation	15.247(a)	Hopping Mode	5.6.4	Pass	Note ²
6	Time of Occupancy (Dwell time)	15.247(a)	Hopping Mode	5.7.4	Pass	Note ²
7	Conducted Spurious Emission & Authorized-band band-edge	15.247(d)	Hopping Mode; Low/Middle/High	5.8.4	Pass	Note ²
8	Conducted Emission	15.207	Low/Middle/High	5.9.4	Pass	Note ²
9	Radiated Spurious Emission	15.209 15.247(d)	Low/Middle/High	5.10.4	Pass	Note ²
10	Band Edge(Restricted-band band-edge)	15.209 15.247(d)	Low/High	5.11.4	Pass	Note ²

Note ¹: The EUT has a permanently and irreplaceable attached antenna, which complies with the requirement FCC 15.203.

Note ²: π /4-DQPSK is the EDR 2M rate mode, 8-DPSK is the EDR 3M rate mode. The consistency of test results in π /4-DQPSK and 8-DPSK is very high. So we chose 8-DPSK as a typical representative to appear on the report. Another we will show all the modes on the RF output power test item.



4 GENERAL TEST CONFIGURATIONS

4.1 Test Environments

During the measurement, the normal environmental conditions were within the listed ranges:

Relative Humidity	47% to 64%	
Atmospheric Pressure	100 kPa to 102 kPa	
Temperature	NT (Normal Temperature)	+22.1℃ to +24.7℃
Working Voltage of the EUT	NV (Normal Voltage)	3.7 V

4.2 Test Equipment List

Description	Manufacturer	Model	Serial No.	Cal. Date	Cal. Due	
Spectrum Analyzer	KEYSIGHT	N9020A	MY50330200	2023.05.16	2024.05.15	
Spectrum Analyzer	KEYSIGHT	N9020A	MY52510065	2023.09.05	2024.09.04	
Test Antenna-Horn	SCHWARZBECK	BBHA 9120D	01631	2022.02.23	2025.02.22	
Test Antenna-Horn	A-INFO	LB-180400KF	J211060273	2021.07.02	2024.07.01	
Anechoic Chamber	RAINFORD	9m*6m*6m	144	2022.02.19	2024.09.03	
A novelifier		LSCX_LNA1-	100000	2022 00 05	2024 00 04	
Amplifier	COM-MV	12G-01	180602	2023.09.05	2024.09.04	
A mana lifi a m		XKu_LNA7-	100001	2022 00 05	2024 00 04	
Amplifier	COM-MV	18G-01	180601	2023.09.05	2024.09.04	
EMI Receiver	ROHDE&SCHWARZ	ESRP	101036	2023.09.05	2024.09.04	
Test Antenna-Loop	SCHWARZBECK	FMZB 1519	1519-037	2021.04.16	2024.04.15	
Amplifier	COM-MV	ZT30-1000M	B2018054558	2023.12.05	2024.12.04	
Anechoic Chamber	EMC Electronic Co.,	20.10*11.60*7	120	2021.08.15	2024 09 14	
Anechoic Chamber	Ltd	.35m	130	2021.06.15	2024.08.14	
EMI Receiver	KEYSIGHT	N9038A	MY53220118	2023.09.05	2024.09.04	
Test Antenna-Bi-Log	SCHWARZBECK	VULB 9163	9163-624	2021.08.20	2024.08.19	
Amplifier	COM-MV	ZT30-1000M	B2017119082	2023.12.05	2024.12.04	
Anechoic Chamber	RAINFORD	9m*6m*6m	101	2023.03.04	2026.03.03	
EMI Receiver	KEYSIGHT	N9010B	MY57110309	2023.09.05	2024.09.04	
LISN	SCHWARZBECK	NSLK 8127	8127-687	2023.05.16	2024.05.15	
	YiHeng Electronic	3.5m*3.1m*2.	440	2022 02 42	2025 02 42	
Shielded Enclosure	Co., Ltd	8m	112	2022.02.19	2025.02.18	

4.3 Test Software List

Description	Manufacturer	Software Version	Serial No.	Applicable test Setup
BL410R	BALUN	V2.1.1.488	N/A	The section 4.5.1
BL410E	BALUN	V22.930	N/A	The section 4.5.2&4.5.3&4.5.4&4.5.5



4.4 Measurement Uncertainty

The following measurement uncertainty levels have been estimated for tests performed on the EUT as specified in CISPR 16-4-2.

This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.

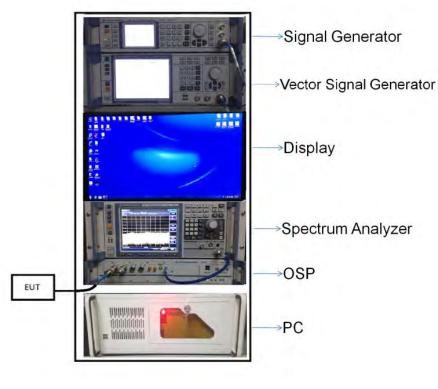
Parameters	Uncertainty
Occupied Channel Bandwidth	2.8%
RF output power, conducted	1.28 dB
Power Spectral Density, conducted	1.30 dB
Unwanted Emissions, conducted	1.84 dB
All emissions, radiated	5.36 dB
Temperature	3 8.0
Humidity	4%

4.5 Description of Test Setup

4.5.1 For Antenna Port Test

Conducted value (dBm) = Measurement value (dBm) + cable loss (dB)

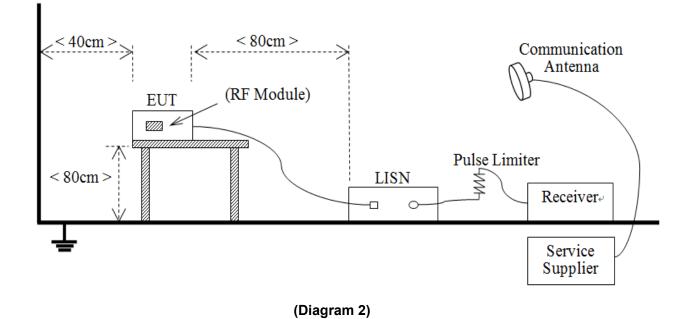
For example: the measurement value is 10 dBm and the cable 0.5dBm used, then the final result of EUT: Conducted value (dBm) = 10 dBm + 0.5 dB = 10.5 dBm



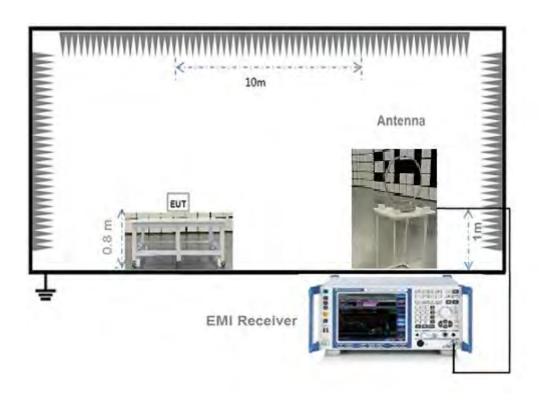
(Diagram 1)



4.5.2 For AC Power Supply Port Test



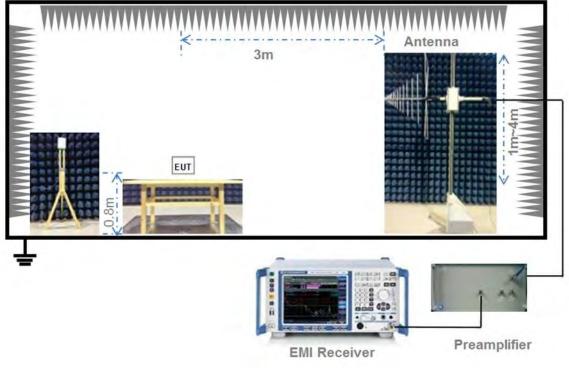
4.5.3For Radiated Test (Below 30 MHz)



(Diagram 3)

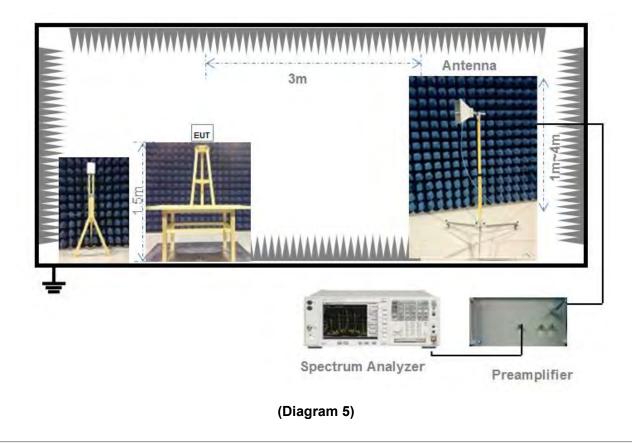


4.5.4 For Radiated Test (30 MHz-1 GHz)



(Diagram 4)

4.5.5 For Radiated Test (Above 1 GHz)





4.6 Measurement Results Explanation Example

4.6.1 For conducted test items:

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

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

Offset = RF cable loss + attenuator factor.



5 TEST ITEMS

5.1 Antenna Requirements

5.1.1 Relevant Standards

FCC §15.203 & 15.247(b)

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall 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 manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of § 15.211, § 15.213, § 15.217, § 15.219, or § 15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with § 15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

If directional gain of transmitting antennas is greater than 6 dBi, the power shall be reduced by the same level in dB comparing to gain minus 6 dBi. For the fixed point-to-point operation, the power shall be reduced by one dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi. 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 FCC rule.

5.1.2 Antenna Anti-Replacement Construction

The Antenna Anti-Replacement as following method:

Protected Method	Description
The antenna is embedded in the	An embedded-in antenna design is used.
product.	

Reference Documents	Item
Photo	Please refer to the EUT Photo documents.

5.1.3Antenna Gain

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



5.2 Frequency Hopping Systems

5.2.1 Relevant Standards

FCC §15.247(a) (1) (i) (ii) (iii) (iv); FCC §15.247(g); FCC §15.247(h)

Describe how the hopping sequence is generated. Provide an example of the hopping sequence channels, to demonstrate that the sequence meets the requirement specified in the definition of an FHSS system. Per the definition in Section 2.1(c), the hop set shall appear as random in the near term, shall appear as evenly distributed in the long term, and sequential hops shall be randomly distributed in both direction and magnitude of change.

Describe how each individual EUT meets the requirement that each of its hopping channels is used equally on average (e.g., that each new transmission event begins on the next channel in the hopping sequence after the final channel used in the previous transmission event).

Describe how the associated receiver(s) complies with the requirement that the input bandwidth (either RF or IF) matches the bandwidth of the transmitted signal.

Describe how the associated receiver(s) has the ability to shift frequencies in synchronization with the transmitted signals.

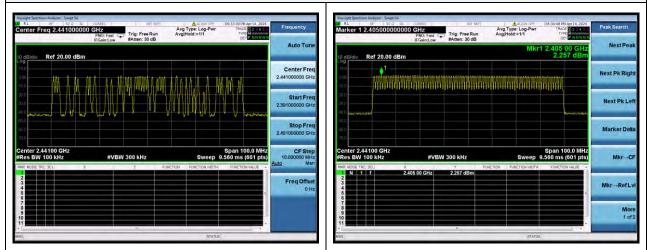
For short burst systems, describe how the EUT complies with the requirement that it be designed to be capable of operating as a true frequency hopping system. Specifically, the device shall comply with the equal frequency use and pseudorandom hopping sequence requirement when transmitting in short bursts, and shall be designed to comply when presented with continuous data (or information) stream. Describe how the EUT complies with the requirement that it not have the ability to be coordinated with other FHSS systems in an effort to avoid the simultaneous occupancy of individual hopping frequencies by multiple transmitters.



5.2.2 Description of the systems

- According to the preset procedure of the whole network, all the stations in the automatic control network synchronously change the frequency multiple times within one second, and temporarily stay on each frequency hopping channel. Periodic synchronization signaling is sent from the primary station, instructing all slaves to simultaneously change the operating frequency, then the hopping sequence is generated.
- 2. The hop set shall appear as random in the near term, shall appear as evenly distributed in the long term, and sequential hops shall be randomly distributed in both direction and magnitude of change.





- 3. Channels are classified into two categories, used and unused, where used channels are part of the hopping sequence and unused channels are replaced in the hopping sequence by used channels in a pseudo-random way. Make each individual EUT meets the requirement that each of its hopping channels is used equally on average.
- 4. The input bandwith and transmitted bandwith are both 1MHz, the associated receiver(s) complies with the requirement that the input bandwidth matches the bandwidth of the transmitted signal.
- 5. Connected devices communicate on the same physical channel by synchronizing with a common clock and hopping sequence.
- 6. EUT isn't short burst systems.
- 7. EUT can't have the ability to be coordinated with other FHSS systems in an effort.



5.3 Number of Hopping Frequencies

5.3.1Limit

FCC §15.247(a) (1) (iii)

Frequency hopping systems operating in the 2400 MHz to 2483.5 MHz bands shall use at least 15 hopping frequencies.

5.3.2 Test Setup

See section 4.5.1 for test setup description for the antenna port. The photo of test setup please refer to ANNEX A.

5.3.3 Test Procedure

The EUT must have its hopping function enabled. Use the following spectrum analyzer settings:

Span = The frequency band of operation 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. $VBW \ge RBW$ Sweep = auto Detector function = peak Trace = max hold Allow the trace to stabilize



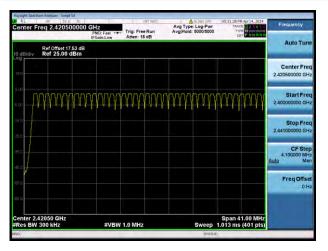
5.3.4 Test Result

<u>Test Data</u>

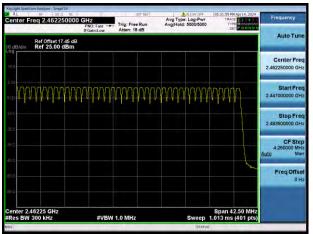
Test Mode	Frequency Block (MHz)	Min. Limit		Verdict
GFSK	2400 - 2483.5	79	15	Pass
8-DPSK	2400 - 2483.5	79	15	Pass

Test Plots

GFSK 2.4 GHz ~ 2.4415 GHz



GFSK 2.4415 GHz ~ 2.4835 GHz



8-DPSK 2.4 GHz ~ 2.4415 GHz

PNO: Fast +++ Trig: Free Run	Avg Type: Log-Pwr Avg Hold: 5000/5000	TYPE MUSACANA	Frequency
IFGain:Low Atten: 18 dB			Auto Tune
			Center Fred 20500000 GH
minnon	wwwwww	1 1 1 1 1 1 1 2.4	Start Free
		2.4	Stop Free 41000000 GH
		Auto	CF Step 4.100000 MH Ma
			Freq Offse 0 H
#7/PW 1 0 MU-	Swaar 10	pan 41.00 MHz	
	IFGainLow Atten: 18 dB	Picalinitary Arten: 18 dB	FGaintow Atten: 18 dB Cel Difference 2.4 AMMAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

8-DPSK 2.4415 GHz ~ 2.4835 GHz

RL RF 50 G 40 Center Freq 2,462250000	PNO: Cast -t- Trig	p Free Run en: 18 dB	Avg Type: Log-Pwr Avg Hold: 5000/5000	05:42:16 PM Apr 14, 2924 TRACE 2 2 4 5 TYPE DET P MINISTRE	Frequency
Ref Offset 17.45 dB 0 dB/div Ref 25.00 dBm					Auto Tune
5D					Center Free 2.462250000 GH
	vonannov	www	huntyt	www	Start Free 2:441000000 GH
50					Stop Fre 2.483500000 GH
so					CF Stej 4.250000 MH Auto Ma
δq				ł	Freq Offse 0 H
enter 2.46225 GHz				Span 42.50 MHz	
Res BW 300 kHz	#VBW 1.0	MHz	Sweep	1.013 ms (401 pts)	



5.4 Peak Output Power

5.4.1 Test Limit

FCC § 15.247(b)

For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 nonoverlapping hopping channels band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

5.4.2 Test Setup

See section 4.5.1 for test setup description for the antenna port. The photo of test setup please refer to ANNEX A.

5.4.3 Test Procedure

The Module operates at hopping-off test mode. The lowest, middle and highest channels are selected to perform testing to verify the conducted RF output peak power of the Module.

Use the following spectrum analyzer settings:

Span = approximately 5 times the 20 dB bandwidth, centered on a hopping channel

RBW > the 20 dB bandwidth of the emission being measured

VBW ≥ RBW

Sweep = auto

Detector function = peak

Trace = max hold

Allow the trace to stabilize.

5.4.4 Test Result

Peak Power Test Data

		Mea	sured Outp	out Peak Po	ower		Lir		
Channel	GFSK		π/4-DQPSK		8-DPSK		d Dura	mW	Verdict
	dBm	mW	dBm	mW	dBm	mW	dBm	IIIVV	
Low	3.11	2.05	3.36	2.17	3.81	2.40			Pass
Middle	2.97	1.98	3.32	2.15	3.74	2.37	21	125	Pass
High	2.09	1.62	2.38	1.73	2.75	1.88			Pass



Test Plots

GFSK LOW CHANNEL



GFSK MIDDLE CHANNEL



GFSK HIGH CHANNEL

CORREC INT REF O GHz PNO: Fast IFGain:Low #Atten: 30 dB	Avg Type: Log-Pwr Avg[Hold:>1/1	10;57:17 AM Apr 09, 2024 TRACE 2 2 3 4 5 TYPE Mysel 4000 DET P M N N N	Frequency
	Mkr	2.479 88 GHz 2.086 dBm	Auto Tuni
			Center Fre 2.480000000 GH
			Start Fre 2,477000000 GH
			Stop Fre 2,483000000 GH
			CF Ste 600.000 kH Auto Ma
			Freq Offse 0 F
#VBW 8.0 MHz	#Sween	Span 6.000 MHz	
	PNO: Fast C Trig: Free Run	Avg Type: Log-Pur PRO: Tear PRO: Tear Pro: Tear Avg Type: Log-Pur Avg Type: Log-Pur	10 OHz PRO: Fac PRO: Fac

π/4-DQPSK LOW CHANNEL



π /4-DQPSK MIDDLE CHANNEL





π/4-DQPSK HIGH CHANNEL



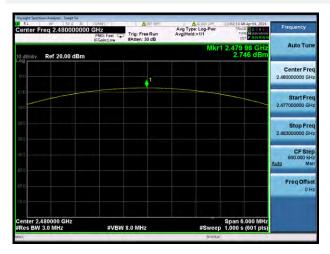
8-DPSK LOW CHANNEL

RL RE 560 AC Marker 1 2.402020000000		Run AvgiHo	pe: Log-Pwr	TRACE 2 3 4 5 TYPE NUMBER OF THE	Peak Search
0 dB/div Ref 20.00 dBm			Mkr1 2	.402 02 GHz 3.811 dBm	NextPeak
10.0		4			Next Pk Righ
6 D					Next Pk Lef
800					Marker Delta
10 0					Mkr→C
0.0					MkrRef Lv
Center 2.402000 GHz Res BW 3.0 MHz	#VBW 8.0 MHz		S #Sween 1	pan 6.000 MHz .000 s (601 pts)	More 1 of 3

8-DPSK MIDDLE CHANNEL

RL RF 50 g 4c Center Freq 2.441000000	PNO: Fast Trig: Free Run	Avg Type: Log-Pwr Avg[Hold:>1/1	11:01:33 AM Apr 09, 2024 TRACE	Frequency		
Mkr1 2.440 89 GHz 10 dB/div Ref 20.00 dBm 3.743 dBm						
100	•			Center Fre 2.441000000 GH		
10.0				Start Fre 2.438000000 GH		
309				Stop Fre 2.444000000 GH		
400				CF Ste 600.000 kH Auto Ma		
£0.0				Freq Offs 01		
Center 2.441000 GHz #Res BW 3.0 MHz	#VBW 8.0 MHz	#Sweep	Span 6.000 MHz 5 1.000 s (601 pts)			

8-DPSK HIGH CHANNEL





5.5 Occupied Bandwidth

5.5.1 Limit

FCC §15.247(a)

Measurement of the 20dB bandwidth of the modulated signal.

5.5.2 Test Setup

See section 4.5.1 for test setup description for the antenna port. The photo of test setup please refer to ANNEX A.

5.5.3 Test Procedure

Use the following spectrum analyzer settings:

Span = approximately 2 to 5 times the 20 dB bandwidth, centered on a hopping channel

RBW = in the range of 1% to 5% of the OBW

VBW ≥ RBW

Sweep = auto

Detector function = peak

Trace = max hold

The EUT should be transmitting at its maximum data rate, Allow the trace to stabilize.

5.5.4 Test Result

Test Data

	GFSK							
Channel	20 dB Bandwidth (MHz)	99% Bandwidth (MHz)						
Low	0.960000	0.852100						
Middle	0.960000	0.851290						
High	0.960000	0.851780						
	π/4-DQPSK							
Channel	20 dB Bandwidth (MHz)	99% Bandwidth (MHz)						
Low	1.290000	1.153700						
Middle	1.297600	1.154600						
High	1.290000	1.153800						
	8-DPSK							
Channel	20 dB Bandwidth (MHz)	99% Bandwidth (MHz)						
Low	1.290000	1.159900						
Middle	1.290000	1.159900						
High	1.290000	1.159800						



Test Plots

20 dB Bandwidth

GFSK LOW CHANNEL



GFSK MIDDLE CHANNEL



GFSK HIGH CHANNEL



$\pi/4$ -DQPSK LOW CHANNEL



π/4-DQPSK MIDDLE CHANNEL





π/4-DQPSK HIGH CHANNEL



8-DPSK LOW CHANNEL



8-DPSK MIDDLE CHANNEL



8-DPSK HIGH CHANNEL



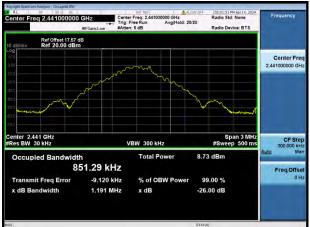


99% Bandwidth

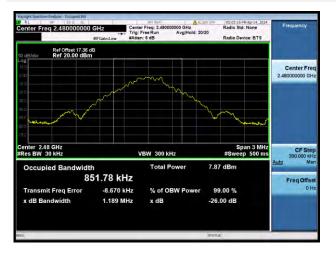
GFSK LOW CHANNEL



GFSK MIDDLE CHANNEL



GFSK HIGH CHANNEL



π/4-DQPSK LOW CHANNEL



π /4-DQPSK MIDDLE CHANNEL





π/4-DQPSK HIGH CHANNEL



8-DPSK LOW CHANNEL



8-DPSK MIDDLE CHANNEL



8-DPSK HIGH CHANNEL





5.6 Carrier Frequency Separation

5.6.1 Limit

FCC §15.247(a)

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 2/3 of the 20 dB bandwidth of the hopping channel, whichever is greater.

5.6.2 Test Setup

See section 4.5.1 for test setup description for the antenna port. The photo of test setup please refer to ANNEX A.

5.6.3 Test Procedure

The EUT must have its hopping function enabled. Use the following spectrum analyzer settings:

Span = wide enough to capture the peaks of two adjacent channels

Resolution (or IF) Bandwidth (RBW) ≥ 1% of the span

Video (or Average) Bandwidth (VBW) \geq RBW

Sweep = auto

Detector function = peak

Trace = max hold

Allow the trace to stabilize. Use the marker-delta function to determine the separation between the peaks of the adjacent channels.



5.6.4 Test Result

<u>Test Data</u>

Mode	Mode Frequency separation (MHz)		Verdict	
GFSK	1.000	0.640	Pass	
8-DPSK	1.000	0.860	Pass	

Test Plots

GFSK

8-DPSK

INT REF 05:33:36 PM Apr 14, 2024	Marker
AMkr1 1.000 MHz	Select Marker
-0.055 dB	Norma
	Delta
	Fixed
Span 3.000 MHz W 300 kHz Sweep 1.000 ms (601 pts)	or
Y FUNCTION FUNCTION NUTL, FUNCTION NULLE →	Properties
	Mon 1 of 3
STATUS	

Marker	05:44:54 PM Apr 14, 2024 TRACE 2 2 4 5 0 TVPE M	Type: Log-Pwr Hold:>1/1	Avg	Trig: Free Run #Atten: 30 dB	PNO: Wide	00000 MH	1.00000		RL rker
Select Marker	dB/div Ref 15.00 dBm								
Norma	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	142	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~		-Xe_	m		
Delt									0 D 10 D
Fixed									1)
0	Span 3.000 MHz 1.000 ms (601 pts)			300 kHz	#VBW		000 GH 0 kHz	W 10	es B
Properties	FUNCTION VALUE	FUNCTION WIDTH	FUNCTION	-0.130 dB 1.710 dBm	000 MHz (Δ) 160 GHz	× 2.440 1	(A)	TRC S	
Mor 1 of									



5.7 Time of Occupancy (Dwell time)

5.7.1Limit

FCC §15.247(a)

Frequency hopping systems in the 2400 MHz - 2483.5 MHz band shall use at least 15 non-overlapping channels. 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. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

5.7.2 Test Setup

See section 4.5.1 for test setup description for the antenna port. The photo of test setup please refer to ANNEX A.

5.7.3 Test Procedure

The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings: Span: Zero span, centered on a hopping channel

RBW shall be \leq channel spacing and where possible RBW should be set >> 1 / T, where T is the expected dwell time per channel

Sweep: As necessary to capture the entire dwell time per hopping channel; where possible use a video trigger and trigger delay so that the transmitted signal starts a little to the right of the start of the plot. The trigger level might need slight adjustment to prevent triggering when the system hops on an adjacent channel; a second plot might be needed with a longer sweep time to show two successive hops on a channel

Detector function: Peak

Trace: Max hold

Use the marker-delta function to determine the transmit time per hop. If this value varies with different modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this test for each variation in transmit time.

The average time of occupancy on any channel within the Period can be calculated with formulas: For GFSK and 8-DPSK:

For DH1 package type {Total of Dwell} = {Pulse Time} * (1600 / 2) / {Number of Hopping Frequency} * {Period} {Period} = 0.4 s * {Number of Hopping Frequency} For DH3 package type {Total of Dwell} = {Pulse Time} * (1600 / 4) / {Number of Hopping Frequency} * {Period} {Period} = 0.4 s * {Number of Hopping Frequency} For DH5 package type {Total of Dwell} = {Pulse Time} * (1600 / 6) / {Number of Hopping Frequency} * {Period} {Period} = 0.4 s * {Number of Hopping Frequency} For AFH Mode: For DH1 package type {Total of Dwell} = {Pulse Time} * (800 / 2) / {Number of Hopping Frequency} * {Period} $\{Period\} =$ 0.4 s * {Number of Hopping Frequency} For DH3 package type {Total of Dwell} = {Pulse Time} * (800 / 4) / {Number of Hopping Frequency} * {Period} $\{Period\} =$ 0.4 s * {Number of Hopping Frequency} For DH5 package type {Total of Dwell} = {Pulse Time} * (800 / 6) / {Number of Hopping Frequency} * {Period} $\{Period\} =$ 0.4 s * {Number of Hopping Frequency}

The lowest, middle and highest channels are selected to perform testing to record the dwell time of each occupation measured in this channel, which is called Pulse Time here.

5.7.4 Test Result

Test Data

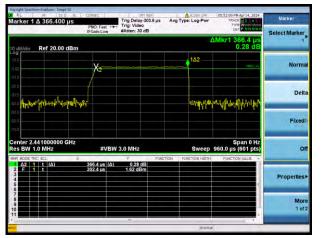
	GFSK							
DH Packet	Pulse Width (ms)	Total of Dwell (ms)	Limit (sec)	Verdict				
DH 1	0.36640	117.248	0.4	Pass				
DH 3	1.62400	259.840	0.4	Pass				
DH 5	2.88000	307.200	0.4	Pass				
		8-DPSK						
DH Packet	Pulse Width (ms)	Total of Dwell (ms)	Limit (sec)	Verdict				
3DH 1	0.37600	120.320	0.4	Pass				
3DH 3	1.63100	260.960	0.4	Pass				
3DH 5	2.88000	307.200	0.4	Pass				
	AFH Mode							
DH Packet	Pulse Width (ms)	Total of Dwell (ms)	Limit (sec)	Verdict				
DH 1	0.36640	58.624	0.4	Pass				
DH 3	1.62400	129.920	0.4	Pass				
DH 5	2.86800	152.960	0.4	Pass				



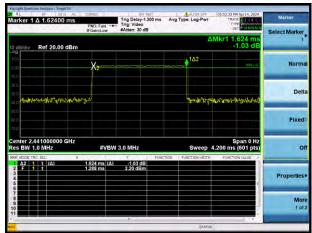


Test Plots





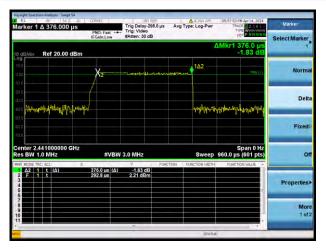
GFSK DH3



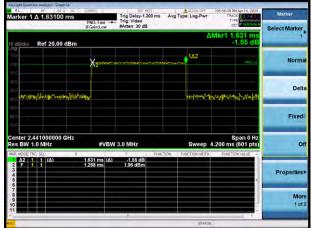
GFSK DH5

Marker 1 ∆ 2.88000 ms	PNO: Fast	Trig Delay-2.210 ms Trig: Video	Avg Type: Log-Pwr	05:53:03 PM Apr 14, 2024 TRACE 2 3 4 5 TYPE	Marker
	IFGain:Low	#Atten: 30 dB		DET PRINNIN	Select Marker
O dB/div Ref 20.00 dBm			Δ	Mkr1 2.880 ms -0.04 dB	1
-og run 0.uu	X ₂		142	mişuvu	Norma
10.0 20.0 30:0 41.0 หรือเริ่มชาติเมืองเป็นเป็นเป็นเป็นเป็นเป็นเป็นเป็นเป็นเป็น	priline		1.000 Days	Man Than Mapan duran	Delta
80.0					Fixed
Center 2.441000000 GHz Res BW 1.0 MHz	#VBW	3.0 MHz	Sweep	Span 0 Hz 7.200 ms (601 pts)	or
1 A2 1 t (Δ) 2 F 1 t 3 4	2.880 ms (Δ) 2.184 ms	-0.04 dB 2.01 dBm		PORCHONINEDE	Properties
6 7 8 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9					More 1 of 3

8-DPSK 3DH1

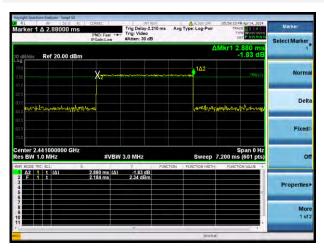


8-DPSK 3DH3





8-DPSK 3DH5



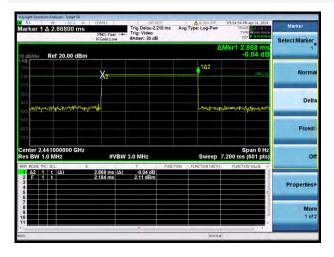
AFH Mode DH1

RL 18 360 4c larker 1 Δ 366,400 μs	CORREC	Trig Delay-304.6 µs Trig: Video	Avg Type: Log-Pwr	05:53:50 PM Apr14, 2024	Marker
0 dBidiv Ref 20.00 dBm	IFGain:Low	#Atten: 30 dB	۵	Mkr1 366.4 µs -0.19 dB	Select Marker
	X ₂		162	mişuvu	Norma
0.0 20.0 20.0 20.0	N.		mulari	sa ia i ulaha tihia	Delta
				ash dhhi e utu d	Fixed
Center 2.441000000 GHz tes BW 1.0 MHz	#VBW	(3.0 MHz	Sweep	Span 0 Hz 960.0 µs (601 pts)	or
1 Δ2 1 t (Δ) 2 F 1 t 4 5	366.4 μs (Δ) 302.4 μs	-0,19 dB 2.09 dBm		FORCHOR PLOT	Properties
6 7 9 9					Mon 1 of:
		-	STATUS		1 of 2

AFH Mode DH3

RL RF 50 G ACT arker 1 Δ 1.62400 ms	CORREC	Trig Delay-1.300 ms Trig: Video	Avg Type: Log-Pwr	05:54:21 PM Apr 14, 2024 TRACE 2 2 4 9 0	Marker
	PNO: Fast ++- IFGain:Low	#Atten: 30 dB		DET P MUNICIPATI	Select Marker
dB/div Ref 20.00 dBm			Δ	Mkr1 1.624 ms -0.86 dB	
29 0.0	X2		162	THE LVI.	Norma
an talmushayaytrayyyayi	W/04		the state of the s	mappingually	Delta
10 10 10					Fixed
enter 2.441000000 GHz es BW 1.0 MHz	#VBW	3.0 MHz		Span 0 Hz 4.200 ms (601 pts)	or
R MDDE TRC SCL X A 2 1 t (Δ) 2 F 1 t	1.624 ms (Δ) 1.288 ms	-0.86 dB 2.16 dBm	TION FUNCTION WOTH	FUNCTION VALUE	
					Properties
					Mor
				-	1 of S
a			STATU		

AFH Mode DH5





5.8 Conducted Spurious Emission & Authorized-band band-edge

5.8.1 Limit

FCC §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.

5.8.2 Test Setup

See section 4.5.1 for test setup description for the antenna port. The photo of test setup please refer to ANNEX A.

5.8.3 Test Procedure

Use the following spectrum analyzer settings:

Span = wide enough to capture the peak level of the in-band emission and all spurious emissions (e.g., harmonics) from the lowest frequency generated in the EUT up through the 10th harmonic. Typically, several plots are required to cover this entire span.

RBW = 100 kHz VBW = 300 kHz Sweep = auto Detector function = peak Trace = max hold Allow the trace to stabilize



5.8.4 Test Result

<u>Test Data</u>

GFSK							
	Measured Max.	Limit	(dBm)				
Channel	Out of Band	Carrier Level	Calculated	Verdict			
	Emission (dBm)		20 dBc Limit				
Low	-24.17	2.20	-17.80	Pass			
Middle	-23.48	2.03	-17.97	Pass			
High	-24.39	1.17	-18.83	Pass			
		8-DPSK					
	Measured Max.	Limit	(dBm)				
Channel	Out of Band	Carrier Level	Calculated	Verdict			
	Emission (dBm)		20 dBc Limit				
Low	-23.95	2.21	-17.79	Pass			
Middle	-23.52	1.58	-18.43	Pass			
High	-24.11	1.11	-18.89	Pass			

Hopping Mode						
	Measured Max.	Limit (dBm)				
Mode	Out of Band	Carrier Level	Calculated	Verdict		
	Emission (dBm)	Carrier Level	20 dBc Limit			
GFSK	-23.61	2.26	-17.74	Pass		
8-DPSK	-23.53	2.40	-17.60	Pass		



Test Plots

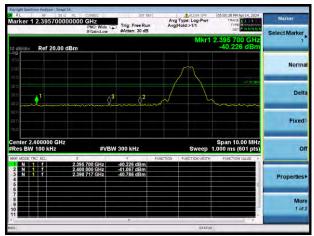
GFSK LOW CHANNEL, CARRIER LEVEL



GFSK LOW CHANNEL, SPURIOUS 30 MHz ~ 3 GHz

RL RF 30.0 AC Marker 1 2.730285000000	ORREC GHZ PNO: Fast	Trig: Free Run	Avg Type: Log-Pwr Avg Hold:>1/1	04:59:46 PM Apr 14, 2024 TRACE 12, 14, 5 TYPE	Marker
	IFGain:Low	#Atten: 30 dB		DET P NINNN	Select Marker
O dB/div Ref 20.00 dBm			Mk	r1 2.730 3 GHz -38.202 dBm	1
-og (0)) 					Norma
10.0				-17.00-dBm	-
30:0 40 b				î	Delta
ອບກ ແກລ ການ					Fixed
Start 0.030 GHz #Res BW 100 kHz	#VB	W 300 kHz	Sweep 2	Stop 3.000 GHz 84.0 ms (4001 pts)	01
MKR MODE TRC SCL X	730 3 GHz	-38.202 dBm	UNCTION FUNCTION WIDTH	FUNCTION VALUE	
2 N 1 f 2. 3 4 5	673 3 GHz	-38.358 dBm			Properties
6 7 8 9 10					Mon 1 of
11		-			-

GFSK LOW CHANNEL, BAND EDGE



GFSK LOW CHANNEL, SPURIOUS 3 GHz ~ 25 GHz

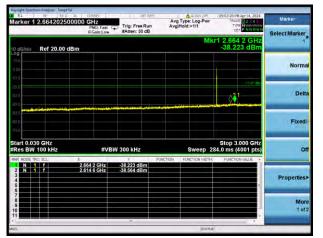


GFSK MIDDLE CHANNEL, CARRIER LEVEL





GFSK MIDDLE CHANNEL, SPURIOUS 30 MHz ~ 3 GHz



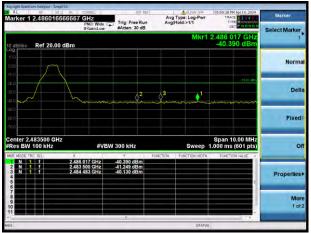
GFSK HIGH CHANNEL, CARRIER LEVEL



GFSK MIDDLE CHANNEL, SPURIOUS 3 GHz ~ 25 GHz



GFSK HIGH CHANNEL, BAND EDGE



GFSK HIGH CHANNEL, SPURIOUS 30 MHz ~ 3 GHz



GFSK HIGH CHANNEL, SPURIOUS 3 GHz ~ 25 GHz





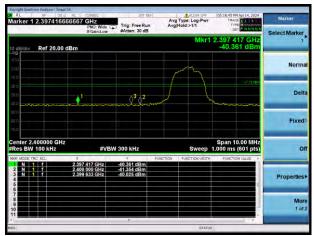
8-DPSK LOW CHANNEL, CARRIER LEVEL



8-DPSK LOW CHANNEL, SPURIOUS 30 MHz ~ 3 GHz

larker 2 2.66216250000		Trig: Free Run	Avg Type: Log-Pwr AvgIHold:>1/1	05:17:02 PM Apr 14, 2024 TRACE 2 2 3 4 5 TYPE NUMBER	Marker	
PNO: Fast Trig: Free Run Avg/Hold:>1/1 7/76 IFGain:Low #Atten: 30 dB Det Control of Cont						
10 dB/div Ref 20.00 dBm38.538 dBm						
00					Norma	
10.0				-17.79 dbm		
30.0 40 D				¢12	Delt	
ຍແມ ຍາ ກ					Fixed	
Tart 0.030 GHz Stop 3.000 GHz Res BW 100 kHz #VBW 300 kHz Sweep 284.0 ms (4001 pts)						
NR MODE TRC SCL X 1 N 1 1 2 2 N 1 7 2	610 7 GHz	-37.994 dBm -38.538 dBm	UNCTION FUNCTION WIDTH	FUNCTION VALUE		
3	662 2 GHZ	-38.538 GBM			Properties	
6 7 8 9 9					Mon	

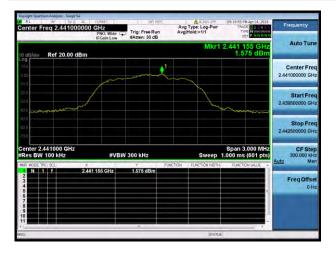
8-DPSK LOW CHANNEL, BAND EDGE



8-DPSK LOW CHANNEL, SPURIOUS 3 GHz ~ 25 GHz



8-DPSK MIDDLE CHANNEL, CARRIER LEVEL





8-DPSK MIDDLE CHANNEL, SPURIOUS 30 MHz ~ 3 GHz



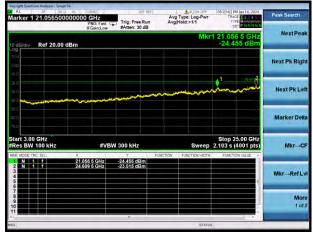
8-DPSK HIGH CHANNEL, CARRIER LEVEL



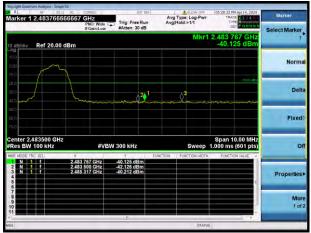
8-DPSK HIGH CHANNEL, SPURIOUS 30 MHz ~ 3 GHz



8-DPSK MIDDLE CHANNEL, SPURIOUS 3 GHz ~ 25 GHz



8-DPSK HIGH CHANNEL, BAND EDGE

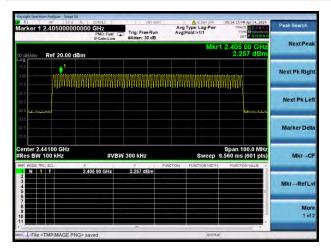


8-DPSK HIGH CHANNEL, SPURIOUS 3 GHz ~ 25 GHz





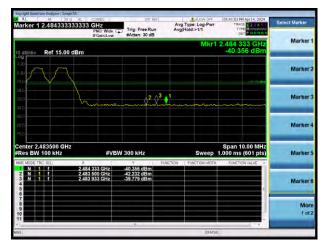
GFSK HOPPING, CARRIER LEVEL



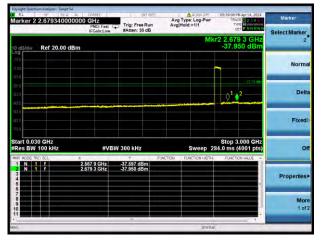
GFSK HOPPING BAND EDGE (LOW)

RL 12.39748	30 g AC CORREC 33333333 GHz PNO: Wide IEGain Low	Trig: Free Run	Avg Type: Log-Pwr Avg Hold:>1/1	105:40:06 PM Apr14, 2024 TRACE 2014 5 TYPE MUSEUM CONTRACT DET P R N 2014 5	Select Marker	
10 dB/div Ref 20.00 dBm -40.402 dBm						
-og min 0.00			m	n.m.r	Marker 2	
20.0 30.0 40.0	● ¹ Ø ³	Q ²			Marker 3	
ธมาว์ ธภาภ กา.ว					Marker 4	
Center 2.400000 C Res BW 100 kHz		3W 300 kHz		Span 10.00 MHz 1.000 ms (601 pts)	Marker 5	
MKR MODE TRC SCL 1 N 1 F 2 N 1 F 3 N 1 F 4 5	2 397 483 GHz 2 400 000 GHz 2 397 933 GHz	-40.402 dBm -42.926 dBm -40.638 dBm	NCTION FUNCTION INIDTH	FUNCTION VALUE	Marker	
6 7 8 9 10 11					More 1 of 2	
10			STATU	8	_	

GFSK HOPPING BAND EDGE (HIGH)



GFSK Hopping Mode, SPURIOUS 30 MHz ~ 3 GHz



GFSK Hopping Mode, SPURIOUS 3GHz ~ 25 GHz

