ilac-MRA DAkkS Deutsche Akkreditierungsstelle D-PL-21375-01-03 D-PL-21375-01-04

INGENIEURBÜRO LENHARDT

Bundesnetzagentur BNetzA-CAB-21/21-21

Test Report

Test report no.: 21065785-20823-0
Date of issue: 2021-09-10

Test result: The test item **- passed -** and complies with the listed standards.

Applicant
Mitsubishi Electric Corporation Sanda Works

Manufacturer
Mitsubishi Electric Corporation

Test Item
R1LOW-R-SBM

RF-Spectrum Testing according to:

FCC 47 CFR Part 15
Radio Frequency Devices (Subpart C)

RSS-247, Issue 2 (2017-02)
Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

RSS-Gen, Issue 5 (2018-04)
General Requirements for Compliance of Radio Apparatus

Tested by (name, function, signature)	*Karsten Geraldy* *Head of Laboratory RF*	Geraldy signature
Approved by (name, function, signature)	*Andreas Bender* *Head of Laboratory*	A. Bender signature

Applicant and Test item details	
Applicant	Mitsubishi Electric Corporation Sanda Works 2-3-33, Miwa, Sanda-City, Hyogo 669-1513 Japan DESIGN-A SECTION, CAR MULTIMEDIA DESIGN DEPT. Fon: +81 79 559 4813 E-Mail: Yoshinaga.Ryuji@db.MitsubishiElectric.co.jp
Manufacturer	Mitsubishi Electric Corporation 2-3-33, Miwa, Sanda-City, Hyogo 669-1513 Japan DESIGN-A SECTION, CAR MULTIMEDIA DESIGN DEPT. Fon: +81 79 559 4813 E-Mail: Yoshinaga.Ryuji@db.MitsubishiElectric.co.jp
Test item description	Automotive Display Audio
Model/Type reference	R1LOW-R-SBM
Standard specific information	
FCC ID	UJH-R1LOW-R-SBM
IC	662K-R1LOWRSB
PMN	R1LOW-R-SBM
HVIN	NR-0C-R-DV
FVIN	N/A
HMN	N/A
Frequency	2.4 GHz ISM band (2400 – 2483.5 MHz)
Technology	Bluetooth Basic Data Rate (BDR), Enhanced Data Rate (EDR)
Antenna	external PCB antenna
Power supply	9 – 16.5 V DC Battery
Temperature range	-40 °C to +75 °C

Disclaimer and Notes

The content of this rest report relates to the mentioned test sample(s) only.
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The last valid version is available at TAMSys®.

Within this test report, a ☒ point / ☐ comma is used as a decimal separator.
If otherwise, a detailed note is added adjected to its use.

IBL-Lab GmbH does not take test samples. The sample used for testing is provided by the applicant.

Decision rule: Binary Statement for Simple Acceptance Rule according ILAC-G8:09/2019

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2 GENERAL INFORMATION

2.1 Administrative details

Testing laboratory	**IBL-Lab GmbH** Heinrich-Hertz-Allee 7 66386 Sankt Ingbert / Germany Fon: +49 6894 38938-0 Fax: +49 6894 38938-99 URL: www.ib-lenhardt.de E-Mail: info@ib-lenhardt.de
Accreditation	The testing laboratory is accredited by Deutsche Akkreditierungsstelle GmbH (DAkkS) in compliance with DIN EN ISO/IEC 17025:2018. Scope of testing and registration number: • Electronics D-PL-21375-01-01 • Electromagnetic Compatibility D-PL-21375-01-02 • Electromagnetic Compatibility and Telecommunication (FCC requirements) D-PL-21375-01-03 • Telecommunication (TC) and Electromagnetic Compatibility (EMC) for Canadian Standards D-PL-21375-01-04 • ISED Company Number 27156 • Testing Laboratory CAB Identifier DE0020 • Telekommunikation (TK) D-PL-21375-01-05 Website DAkkS: https://www.dakks.de/ The Deutsche Akkreditierungsstelle GmbH (DAkkS) is also a signatory to ILAC Mutual Recognition Arrangement
Testing location	**IBL-Lab GmbH** Heinrich-Hertz-Allee 7 66386 St. Ingbert / Germany
Date of receipt of test samples	2021-07-07
Start – End of tests	2021-07-08 – 2021-09-07

2.2 Possible test case verdicts

Test sample meets the requirements	P (PASS)
Test sample does not meet the requirements	F (FAIL)
Test case does not apply to the test sample	N/A (Not applicable)
Test case not performed	N/P (Not performed)

2.3 Observations

No additional observations other than the reported observations within this test report have been made.

2.4 Opinions and Interpretations

No appropriate opinions or interpretations according ISO/IEC 17025:2017 clause 7.8.7 are within this test report.

2.5 Revision History

-0 Initial Version

2.6 Further documents

List of further applicable documents belonging to the present test report:
- no additional documents -

3 ENVIRONMENTAL & TEST CONDITIONS

3.1 Environmental conditions

Temperature	20°C ± 5°C
Relative humidity	25-75 % r.H.
Barometric Pressure	860-1060 mbar
Power supply	230 V / 50 Hz

3.2 Normal and extreme test conditions

	minimum	nominal	maximum
Temperature	-/-	+25 °C	-/-
Relative humidity	-/-	50 % r.h.	-/-
Power supply	-/-	12.6 V DC	-/-

4 TEST STANDARDS AND REFERENCES

Test standard (accredited)	Description
FCC 47 CFR Part 15	Radio Frequency Devices (Subpart C)
RSS-247, Issue 2 (2017-02)	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
RSS-Gen, Issue 5 (2018-04)	General Requirements for Compliance of Radio Apparatus

Test standard (not accredited)	Description
none	---

Reference	Description
ANSI C63.4-2014	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
ANSI C63.10-2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
558074 D01 15.247 Meas Guide v05r02	Guidance for compliance measurements on digital transmission systems, frequency hopping spread spectrum systems and hybrid system devices operating under section 15.247 of the FCC rules

5 EQUIPMENT UNDER TEST (EUT)

5.1 Product Description

Automotive Display Audio

*: as declared by applicant

5.2 Test Item Description

Model name*	R1LOW-R-SBM
Serial numbers R1LOW-R-SBM test samples*	radiated EUT: 61314 conducted EUT: 61313
Serial numbers R1LOW-R test samples*	conducted EUT: 60337
PCB identifier*	NJ00193611
Hardware status*	NR-0C-R-DV
Software status*	Android 10

*: as declared by applicant; please see Annex A, B for EUT photographs.

5.3 Technical Data of Equipment

Operational frequency band*	2.4 GHz ISM band (2400 – 2483.5 MHz)
Transmitter*	Chip QCA6574AU with 48 MHz TCXO (Module UGKZ5A3006A)
Technology*	Bluetooth Basic Data Rate (BDR), Enhanced Data Rate (EDR)
Modulation type*	GFSK, π/4-DQPSK, 8DPSK
Data rate*	1 Mbps, 2 Mbps, 3 Mbps
Number of channels*	79
Channel bandwidth*	1 MHz
Channel spacing*	1 MHz
Rated RF Output Power*	< 2.5 mW (+4 dBm); Power Class: Class2
Antenna R1LOW-R-SBM model* Part name Antenna 0	external PCB antenna P68306857AA/00534042660 #0
Antenna gain R1LOW-R-SBM model *	Antenna 0: 1.85 dBi
Antenna R1LOW-R model* Part name Antenna 0	Sheet metal antenna, 2342059-2
Antenna gain R1LOW-R model*	Antenna 0: -3.55 dBi
Power supply*	9 – 16.5 V DC Battery
Temperature range*	-40 °C to +75 °C

*: as declared by applicant

5.4 Additional Information

Model differences	• R1LOW-R-SBM model with external antenna and disassociated display • R1LOW-R model with integrated sheet metal antenna and associated display **Applicant declares that transmitter modul and PCB are identical in both models** Conducted R1LOW-R test sample is used for following test cases: • Carrier Frequency Separation • Number of Frequency Hopping Channels • Time of channel occupancy • Minimum emission bandwidth 6dB • Emission bandwidth 20dB • Occupied Channel Bandwidth (99%) • Band edge compliance (BEC), conducted • Conducted spurious emissions (CSE) Conducted R1LOW-R-SBM test sample is used for following test cases: • RF output power (conducted peak power) Radiated R1LOW-R-SBM test sample is used for following test cases: • Antenna gain (calculated) • Band edge compliance (BEC), radiated • Radiated spurious emissions (RSE)
Ancillaries tested with	None
Additional equipment used for testing	Notebook with test tool

5.5 Test modes

Mode 1	GFSK, 1 Mbps
Mode 2	π/4-DQPSK, 2 Mbps
Mode 3	8DPSK, 3 Mbps
Low Channel	2402 MHz
Mid Channel	2441 MHz
High Channel	2480 MHz

6 SUMMARY OF TEST RESULTS

Test specification
FCC 47 CFR Part 15 **RSS-247, Issue 2 (2017-02) / RSS-Gen, Issue 5 (2018-04)**

Clause	Requirement / Test Case	Result - Remark	Verdict
15.247(a)(1) RSS-247, 5.1 (b)	Carrier frequency separation	KDB 558074, clause: 9	- PASS -
15.247(a)(1)(iii), (g) RSS-247, 5.1 (d)	Number of frequency hopping channels	KDB 558074, clause: 9	- PASS -
15.247(a)(1)(iii) RSS-247, 5.1 (d)	Time of channel occupancy	KDB 558074, clause: 9	- PASS -
§15.247(a)(1) RSS-247,5.1 (a)	Minimum emission bandwidth 6dB, emission bandwidth 20 dB	KDB 558074, clause: 2.2	- PASS -
RSS Gen, 6.7	Occupied channel bandwidth (99%)	-/-	- PASS -
§15.247(b)(1) RSS-247, 5.4 (b)	RF output power (conducted peak power)	KDB 558074, clause: 9	- PASS -
§15.247(b)(4) RSS-247, 5.4 (b)	Antenna gain (calculated)	-/-	- PASS -
§15.247(d) RSS-247, 5.5	Band edge compliance (BEC), conducted	KDB 558074, clause: 9	- PASS -
§15.247(d) RSS-247, 5.5	Band edge compliance (BEC), radiated	KDB 558074, clause: 9	- PASS -
§15.247(d) RSS-247, 5.5	Conducted spurious emissions (CSE)	KDB 558074, clause: 9	- PASS -
15.247(d) / §15.209 RSS-247, 5.5 / RSS-Gen, 8.9	Radiated spurious emissions (RSE)	-/-	- PASS -
§15.207 RSS-Gen, 8.8	AC conducted emissions	EUT is battery powered	- N/A -

Comments and observations
Following pages show requirements and references of FCC Part 15.247, ANSI C63.10 and KDB 558074 only. Same tests are also applicable and valid for RSS-247, with clauses given in table above.

7 TEST RESULTS

7.1 Carrier frequency separation

Applicability
This requirement applies to all types of FHS equipment operating in the 2400 – 2483.5 MHz band.

Description
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum frequency value.

Limit
§15.247 (a)(1)
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, 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, provided the systems operate with an output power no greater than 125 mW.

Test procedure
ANSI C63.10, 7.8.2
The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:
a) Span: Wide enough to capture the peaks of two adjacent channels.
b) 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.
c) Video (or average) bandwidth (VBW) ≥ RBW.
d) Sweep: No faster than coupled (auto) time.
e) Detector function: Peak.
f) Trace: Max-hold.
g) Allow the trace to stabilize.
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 spectral plot of the data shall be included in the test report.
Where the device shares the same channel plan (carrier frequencies and number of channels) across multiple data rates or modulation schemes then the carrier separation need only be measured for one of those modulation schemes or data rates.

Test setup: 8.4 with conducted test sample 60337 (see section 5.2)

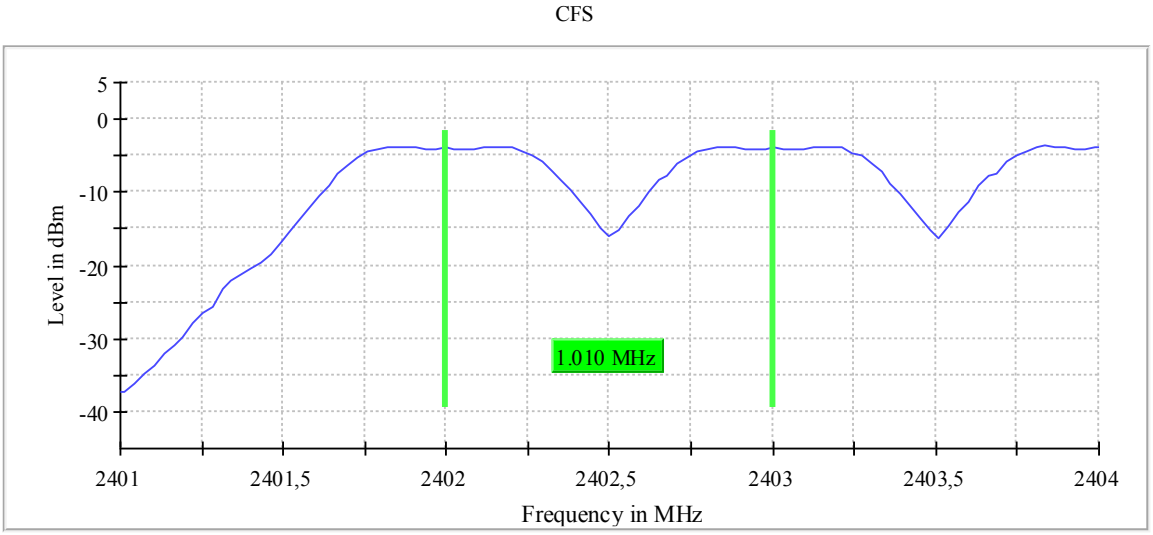
Test Results

EUT Mode	Carrier frequency separation			Limit [MHz]
	low channel [MHz]	mid channel [MHz]	high channel [MHz]	
Mode 1	1.010	1.010	1.010	≥ 0.620
Mode 2	1.010	0.999	0.980	≥ 0.877
Mode 3	1.010	0.999	0.980	≥ 0.847

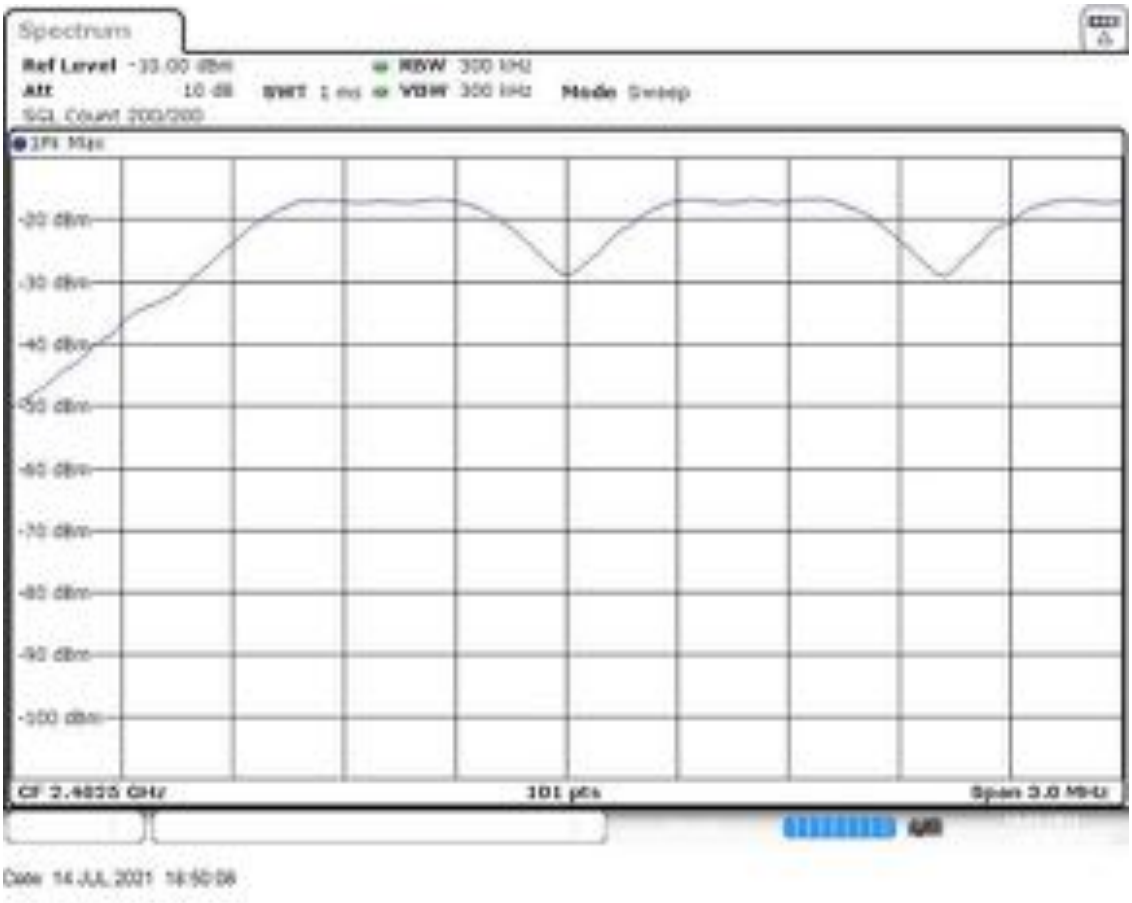
Comment:	---

Verdict	**- PASS -**	*see next plots*

Plot 1: Carrier Frequency Separation, Mode 1, low channel



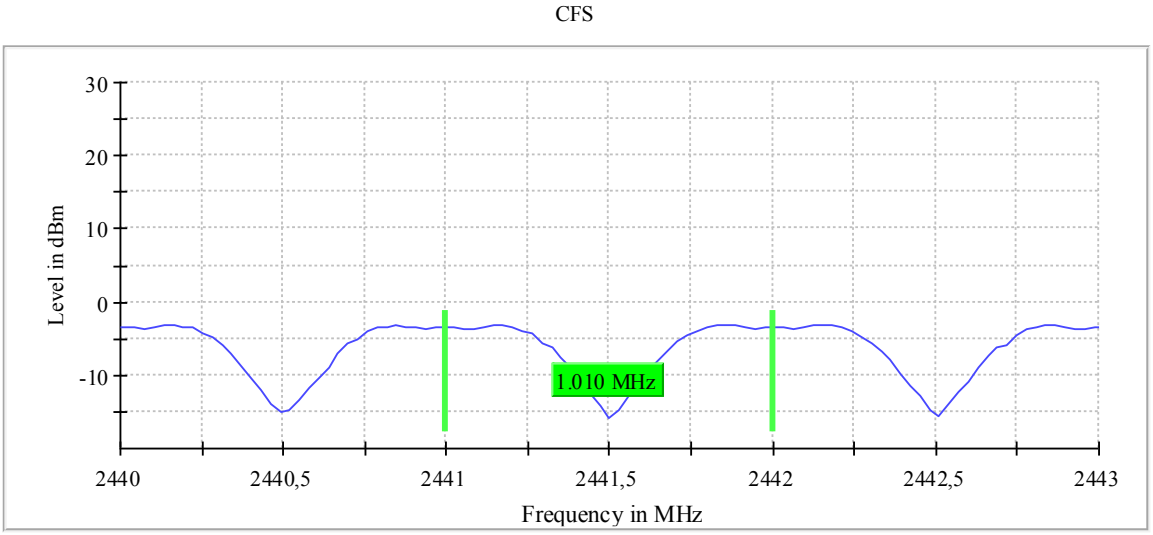
DUT Frequency (MHz)	Frequency Separation (MHz)	Limit Min (MHz)	Limit Max (MHz)	Center Frequency low Channel (MHz)	Center Frequency high Channel (MHz)
2402.000000	**1.009900**	**0.613333**	**---**	**2401.995050**	**2403.004950**



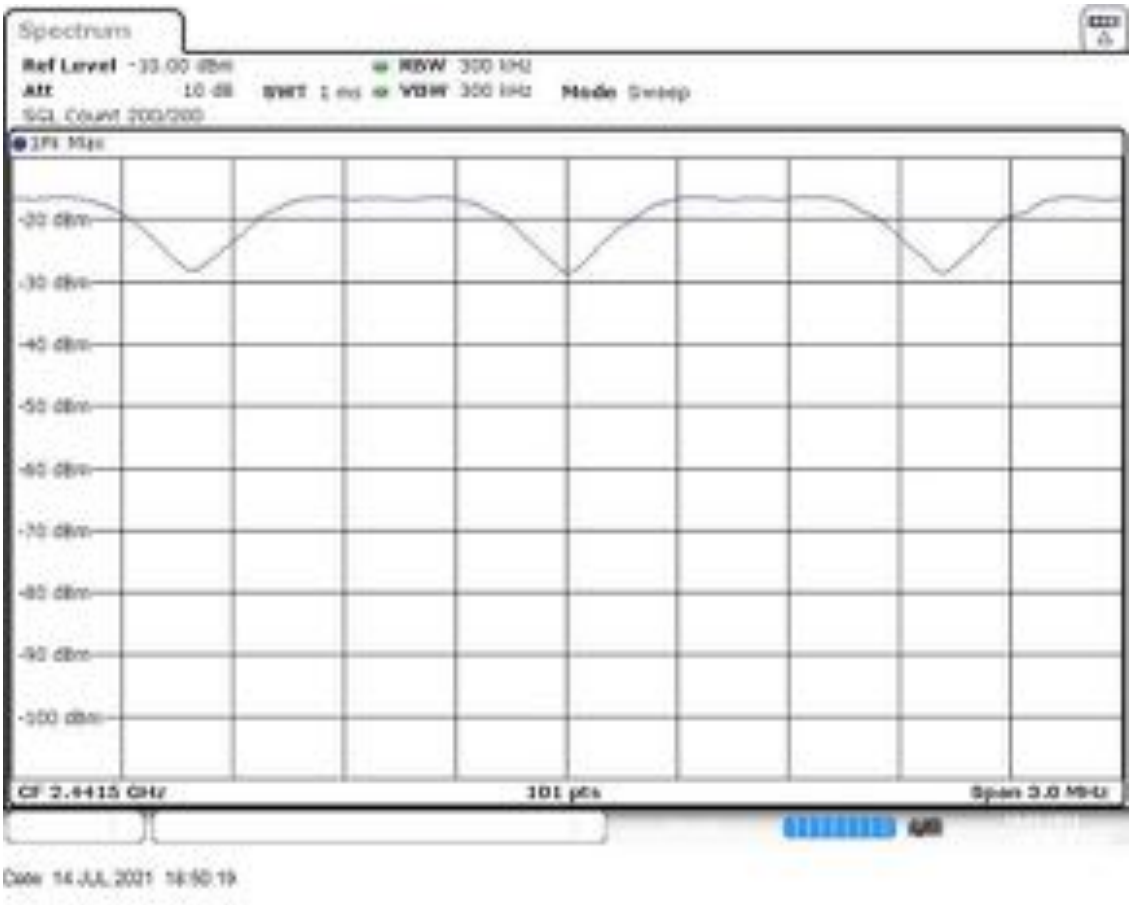
Measurement

Setting	Instrument Value	Target Value
Start Frequency	2.40100 GHz	2.40100 GHz
Stop Frequency	2.40400 GHz	2.40400 GHz
Span	3.000 MHz	3.000 MHz
RBW	300.000 kHz	<= 300.000 kHz
VBW	300.000 kHz	>= 300.000 kHz
SweepPoints	101	~ 10
Sweeptime	1.000 ms	AUTO
Reference Level	-10.000 dBm	-10.000 dBm
Attenuation	10.000 dB	AUTO
Detector	MaxPeak	MaxPeak
SweepCount	200	200
Filter	3 dB	3 dB
Trace Mode	Max Hold	Max Hold
Sweeptype	Sweep	Sweep
Preamp	off	off
Stablemode	Trace	Trace
Stablevalue	0.50 dB	0.50 dB
Run	21 / max. 150	max. 150
Stable	10 / 10	10
Max Stable Difference	0.06 dB	0.50 dB

Plot 2: Carrier Frequency Separation, Mode 1, mid channel



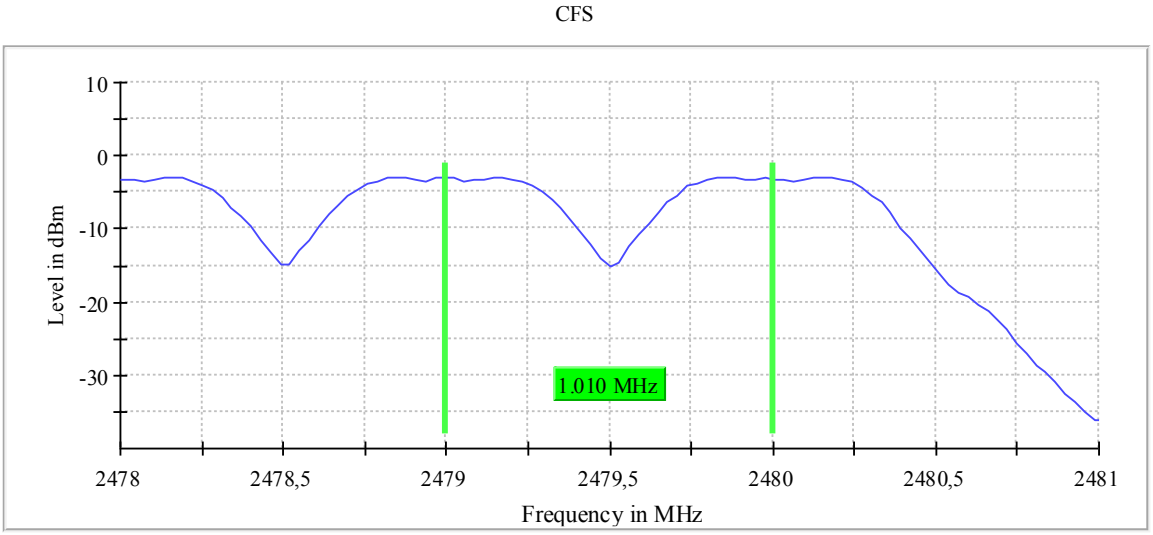
DUT Frequency (MHz)	Frequency Separation (MHz)	Limit Min (MHz)	Limit Max (MHz)	Center Frequency low Channel (MHz)	Center Frequency high Channel (MHz)
2441.000000	**1.009900**	**0.620000**	**---**	**2440.995050**	**2442.004950**



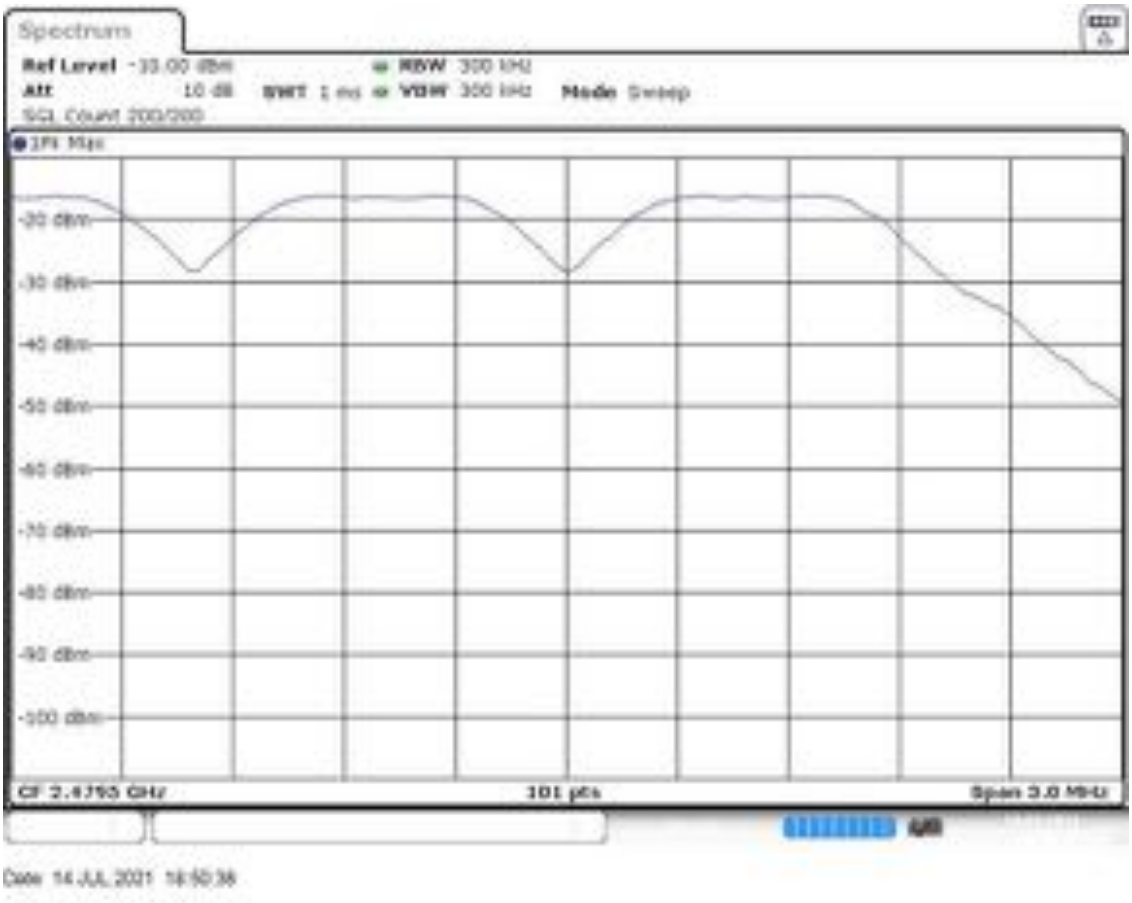
Measurement

Setting	Instrument Value	Target Value
Start Frequency	2.44000 GHz	2.44000 GHz
Stop Frequency	2.44300 GHz	2.44300 GHz
Span	3.000 MHz	3.000 MHz
RBW	300.000 kHz	<= 300.000 kHz
VBW	300.000 kHz	>= 300.000 kHz
SweepPoints	101	~ 10
Sweeptime	1.000 ms	AUTO
Reference Level	-10.000 dBm	-10.000 dBm
Attenuation	10.000 dB	AUTO
Detector	MaxPeak	MaxPeak
SweepCount	200	200
Filter	3 dB	3 dB
Trace Mode	Max Hold	Max Hold
Sweeptype	Sweep	Sweep
Preamp	off	off
Stablemode	Trace	Trace
Stablevalue	0.50 dB	0.50 dB
Run	12 / max. 150	max. 150
Stable	10 / 10	10
Max Stable Difference	0.00 dB	0.50 dB

Plot 3: Carrier Frequency Separation, Mode 1, high channel



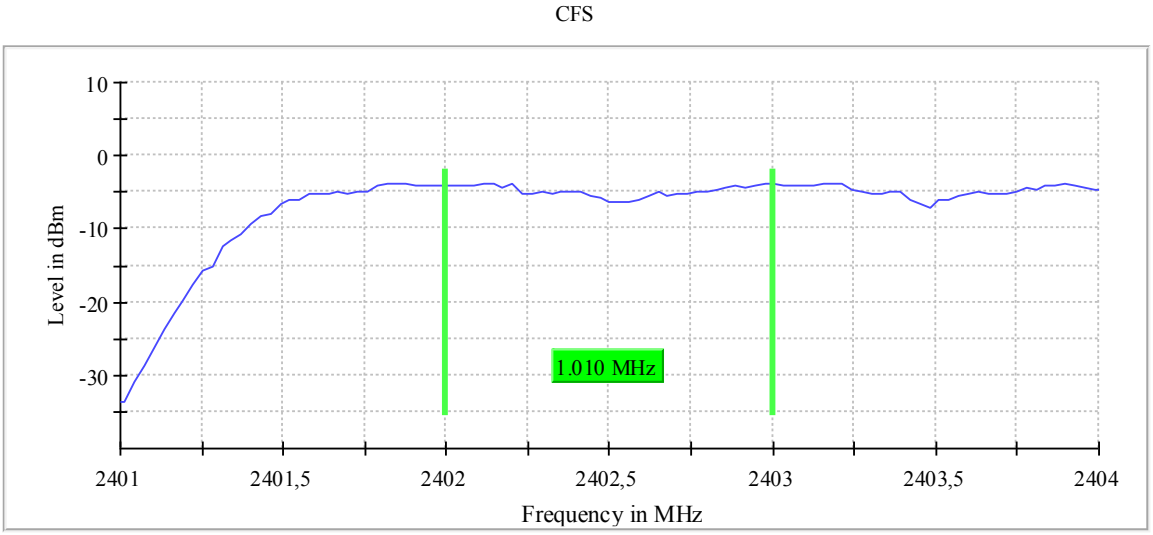
DUT Frequency (MHz)	Frequency Separation (MHz)	Limit Min (MHz)	Limit Max (MHz)	Center Frequency low Channel (MHz)	Center Frequency high Channel (MHz)
2480.000000	**1.009900**	**0.620000**	**---**	**2478.995050**	**2480.004950**



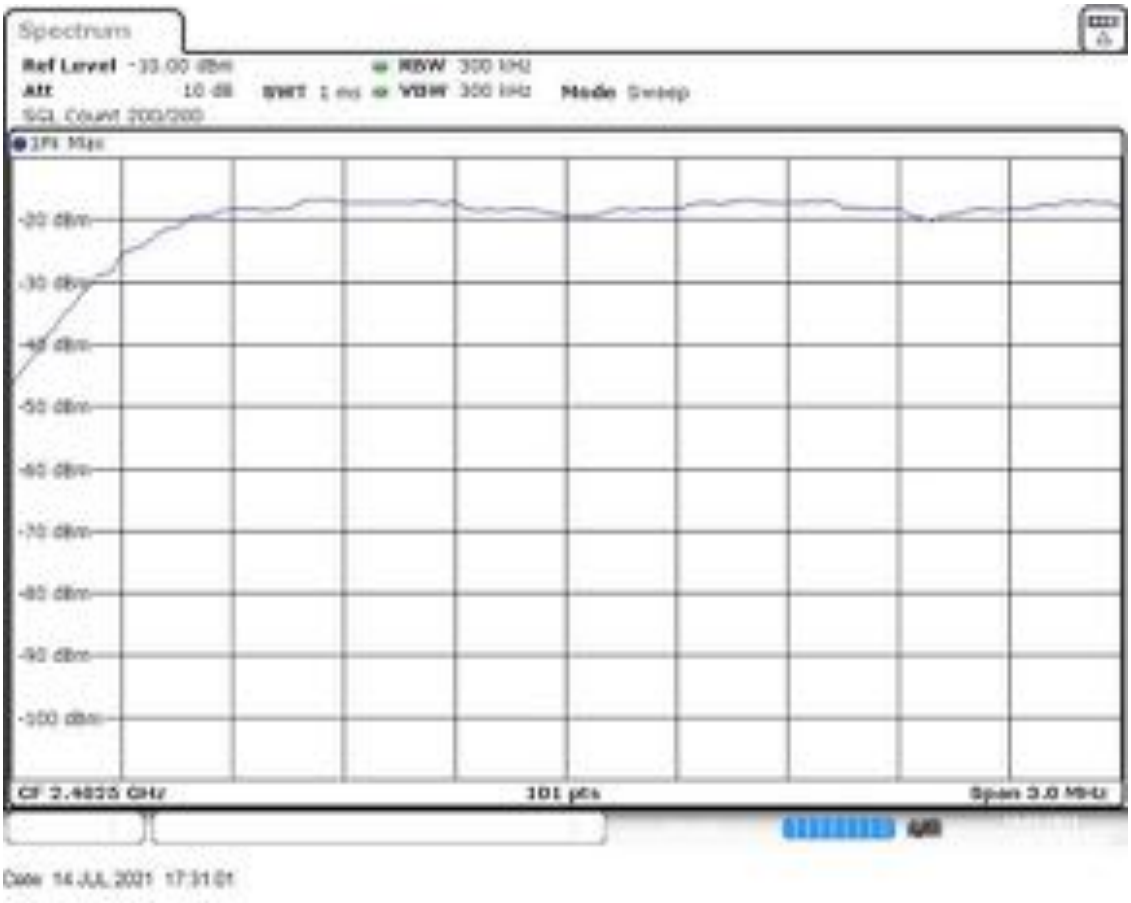
Measurement

Setting	Instrument Value	Target Value
Start Frequency	2.47800 GHz	2.47800 GHz
Stop Frequency	2.48100 GHz	2.48100 GHz
Span	3.000 MHz	3.000 MHz
RBW	300.000 kHz	<= 300.000 kHz
VBW	300.000 kHz	>= 300.000 kHz
SweepPoints	101	~ 10
Sweeptime	1.000 ms	AUTO
Reference Level	-10.000 dBm	-10.000 dBm
Attenuation	10.000 dB	AUTO
Detector	MaxPeak	MaxPeak
SweepCount	200	200
Filter	3 dB	3 dB
Trace Mode	Max Hold	Max Hold
Sweeptype	Sweep	Sweep
Preamp	off	off
Stablemode	Trace	Trace
Stablevalue	0.50 dB	0.50 dB
Run	27 / max. 150	max. 150
Stable	10 / 10	10
Max Stable Difference	0.11 dB	0.50 dB

Plot 4: Carrier Frequency Separation, Mode 2, low channel



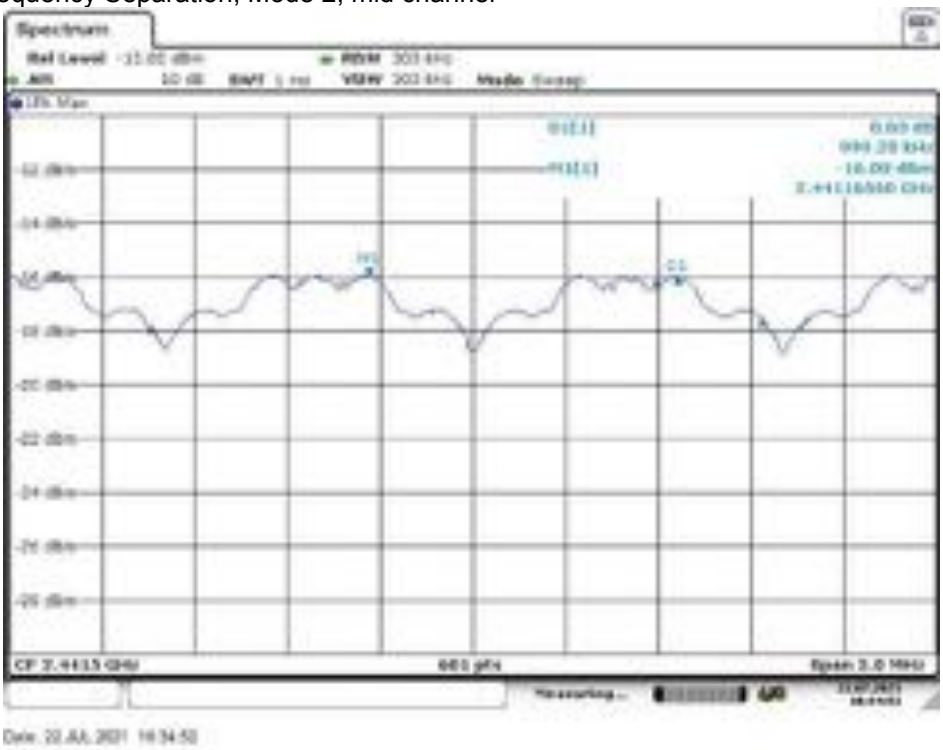
DUT Frequency (MHz)	Frequency Separation (MHz)	Limit Min (MHz)	Limit Max (MHz)	Center Frequency low Channel (MHz)	Center Frequency high Channel (MHz)
2402.000000	**1.009900**	**0.613333**	**---**	**2401.995050**	**2403.004950**



Measurement

Setting	Instrument Value	Target Value
Start Frequency	2.40100 GHz	2.40100 GHz
Stop Frequency	2.40400 GHz	2.40400 GHz
Span	3.000 MHz	3.000 MHz
RBW	300.000 kHz	<= 300.000 kHz
VBW	300.000 kHz	>= 300.000 kHz
SweepPoints	101	~ 10
Sweeptime	1.000 ms	AUTO
Reference Level	-10.000 dBm	-10.000 dBm
Attenuation	10.000 dB	AUTO
Detector	MaxPeak	MaxPeak
SweepCount	200	200
Filter	3 dB	3 dB
Trace Mode	Max Hold	Max Hold
Sweeptype	Sweep	Sweep
Preamp	off	off
Stablemode	Trace	Trace
Stablevalue	0.50 dB	0.50 dB
Run	31 / max. 150	max. 150
Stable	10 / 10	10
Max Stable Difference	0.20 dB	0.50 dB

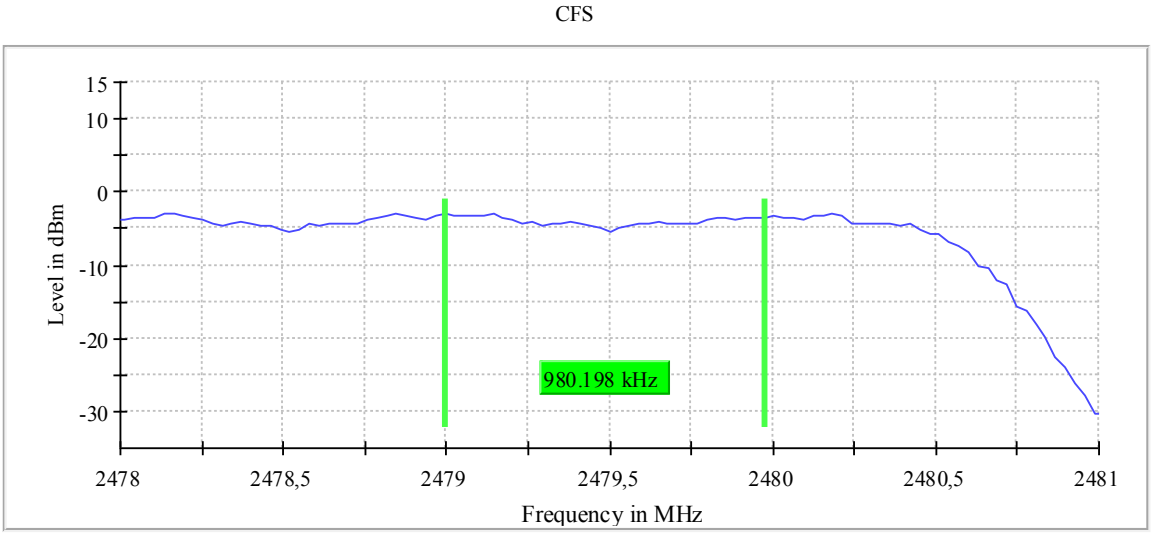
Plot 5: Carrier Frequency Separation, Mode 2, mid channel*



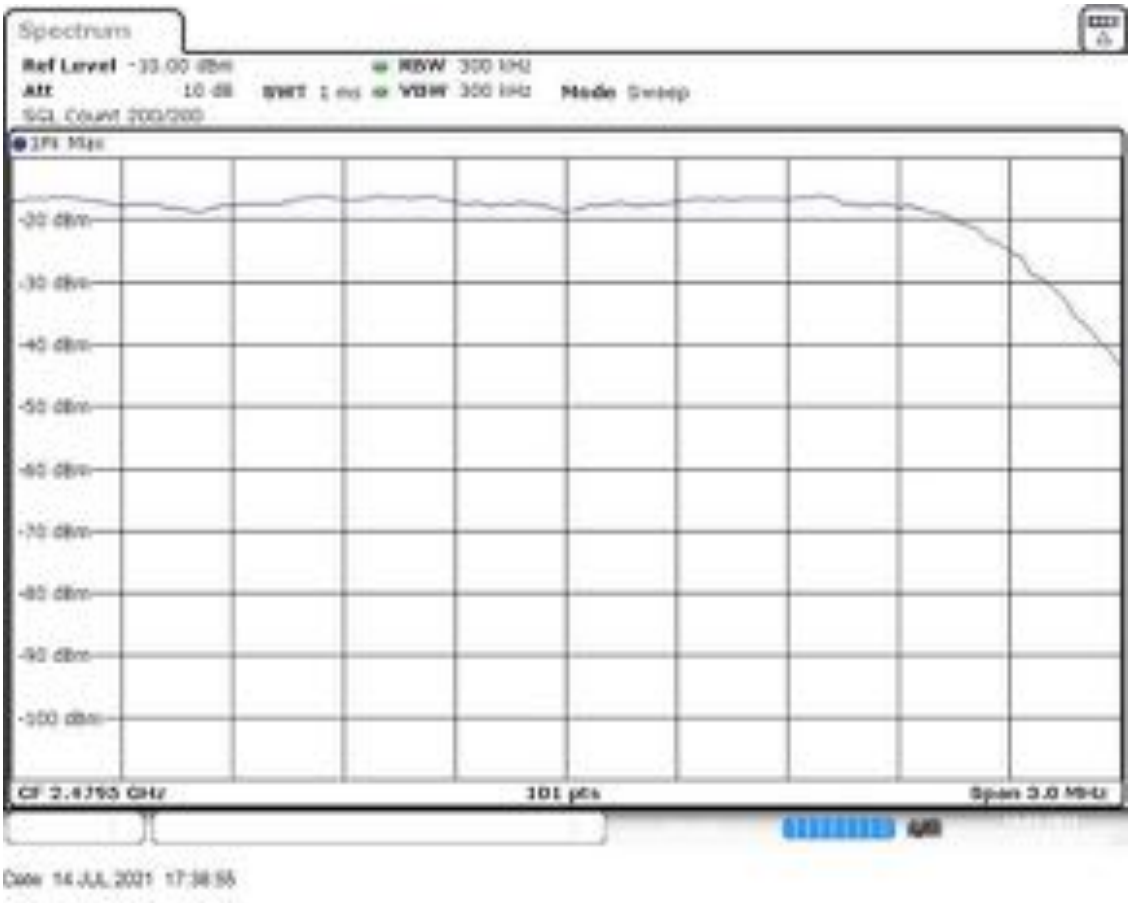
DUT Frequency (MHz)	Frequency Separation (MHz)	Limit Min (MHz)	Limit Max (MHz)	Center Frequency low Channel (MHz)	Center Frequency high Channel (MHz)
2441.000000	**0.99920**	**0.876667**	**---**	**2441.16560**	**2442.08560**

*) test has been done manually, because automated recognition not possible

Plot 6: Carrier Frequency Separation, Mode 2, high channel



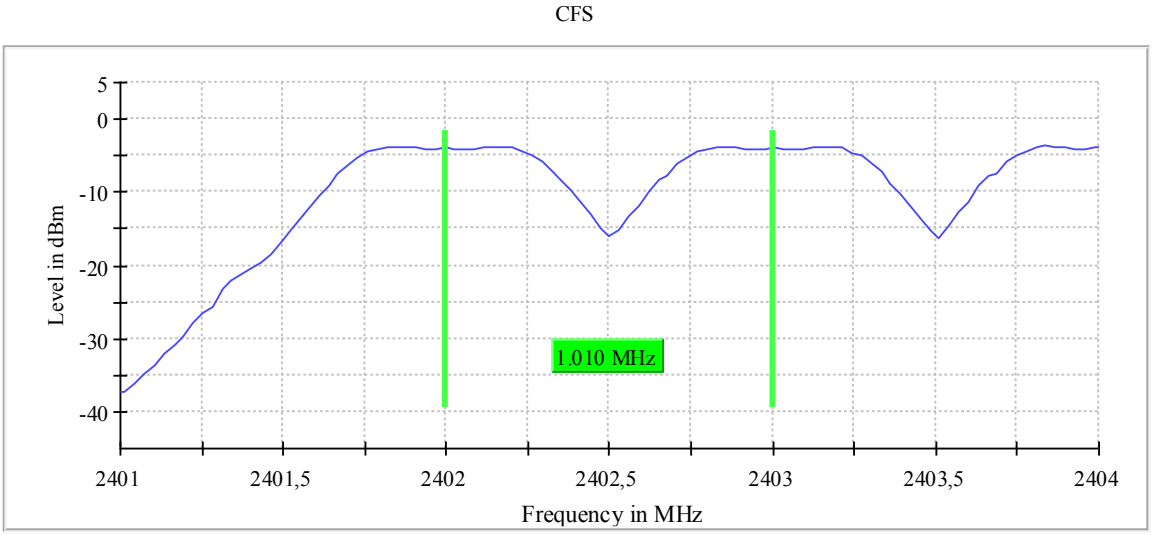
DUT Frequency (MHz)	Frequency Separation (MHz)	Limit Min (MHz)	Limit Max (MHz)	Center Frequency low Channel (MHz)	Center Frequency high Channel (MHz)
2480.000000	0.980198	0.876667	---	2478.995050	2479.975248



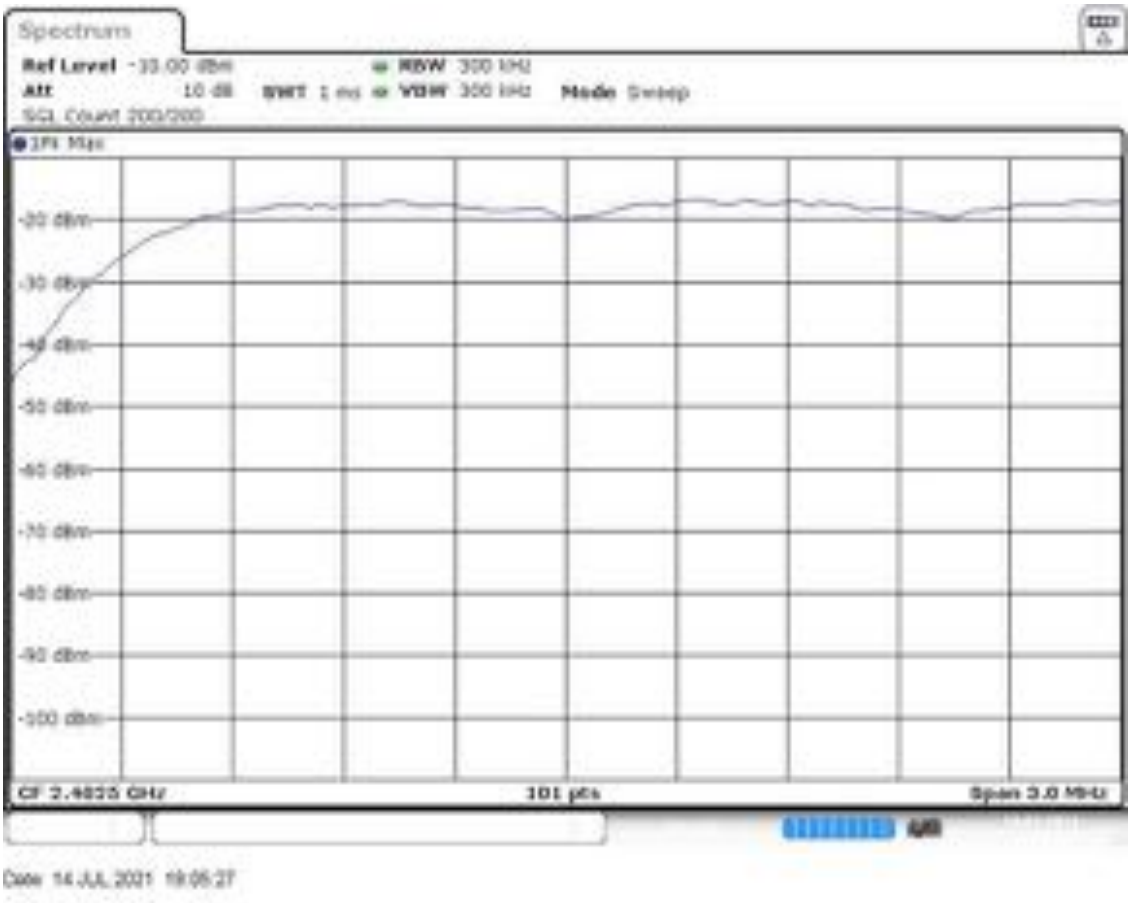
Measurement

Setting	Instrument Value	Target Value
Start Frequency	2.47800 GHz	2.47800 GHz
Stop Frequency	2.48100 GHz	2.48100 GHz
Span	3.000 MHz	3.000 MHz
RBW	300.000 kHz	<= 300.000 kHz
VBW	300.000 kHz	>= 300.000 kHz
SweepPoints	101	~ 10
Sweeptime	1.000 ms	AUTO
Reference Level	-10.000 dBm	-10.000 dBm
Attenuation	10.000 dB	AUTO
Detector	MaxPeak	MaxPeak
SweepCount	200	200
Filter	3 dB	3 dB
Trace Mode	Max Hold	Max Hold
Sweeptype	Sweep	Sweep
Preamp	off	off
Stablemode	Trace	Trace
Stablevalue	0.50 dB	0.50 dB
Run	43 / max. 150	max. 150
Stable	10 / 10	10
Max Stable Difference	0.04 dB	0.50 dB

Plot 7: Carrier Frequency Separation, Mode 3, low channel



DUT Frequency (MHz)	Frequency Separation (MHz)	Limit Min (MHz)	Limit Max (MHz)	Center Frequency low Channel (MHz)	Center Frequency high Channel (MHz)
2402.000000	**1.009900**	**0.613333**	**---**	**2401.995050**	**2403.004950**



Measurement

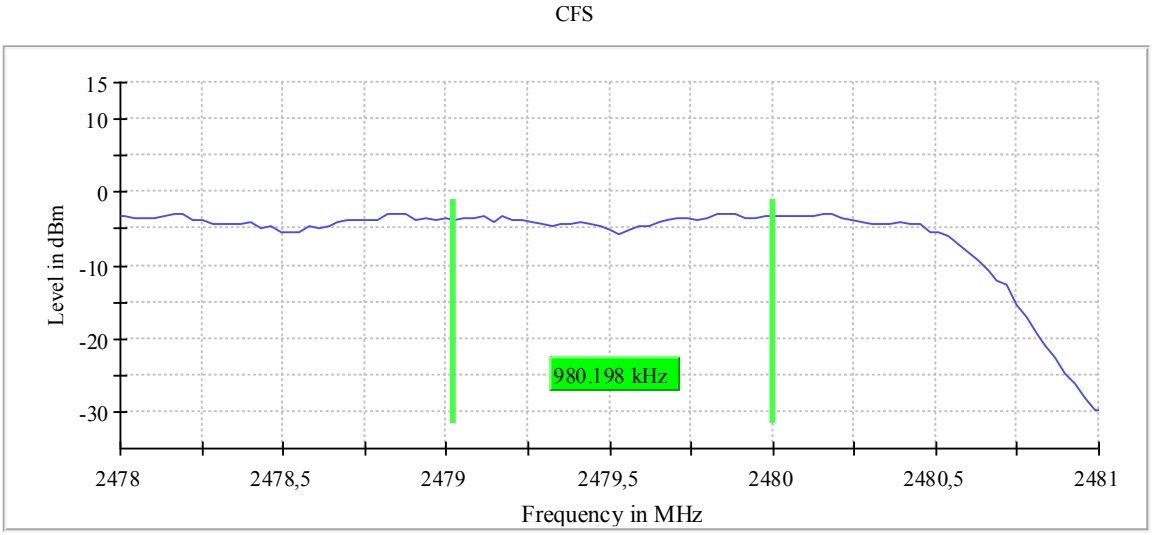
Setting	Instrument Value	Target Value
Start Frequency	2.40100 GHz	2.40100 GHz
Stop Frequency	2.40400 GHz	2.40400 GHz
Span	3.000 MHz	3.000 MHz
RBW	300.000 kHz	<= 300.000 kHz
VBW	300.000 kHz	>= 300.000 kHz
SweepPoints	101	~ 10
Sweeptime	1.000 ms	AUTO
Reference Level	-10.000 dBm	-10.000 dBm
Attenuation	10.000 dB	AUTO
Detector	MaxPeak	MaxPeak
SweepCount	200	200
Filter	3 dB	3 dB
Trace Mode	Max Hold	Max Hold
Sweeptype	Sweep	Sweep
Preamp	off	off
Stablemode	Trace	Trace
Stablevalue	0.50 dB	0.50 dB
Run	34 / max. 150	max. 150
Stable	10 / 10	10
Max Stable Difference	0.00 dB	0.50 dB

Plot 8: Carrier Frequency Separation, Mode 3, mid channel*

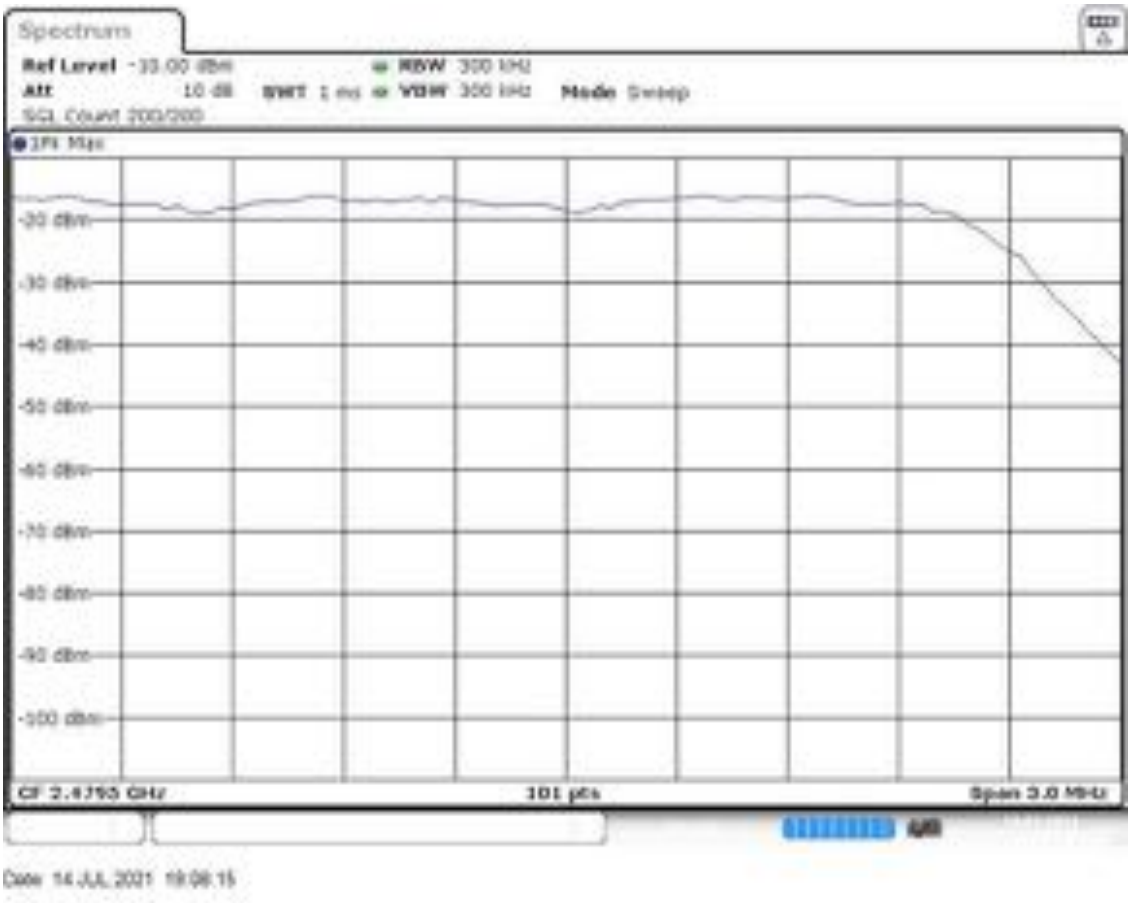
DUT Frequency (MHz)	Frequency Separation (MHz)	Limit Min (MHz)	Limit Max (MHz)	Center Frequency low Channel (MHz)	Center Frequency high Channel (MHz)
2441.000000	0.99920	0.846667	---	2441.16560	2442.08560

*) test has been done manually, because automated recognition not possible

Plot 9: Carrier Frequency Separation, Mode 3, high channel



DUT Frequency (MHz)	Frequency Separation (MHz)	Limit Min (MHz)	Limit Max (MHz)	Center Frequency low Channel (MHz)	Center Frequency high Channel (MHz)
2480.000000	**0.980198**	**0.846667**	**---**	**2479.024752**	**2480.004950**



Measurement

Setting	Instrument Value	Target Value
Start Frequency	2.47800 GHz	2.47800 GHz
Stop Frequency	2.48100 GHz	2.48100 GHz
Span	3.000 MHz	3.000 MHz
RBW	300.000 kHz	<= 300.000 kHz
VBW	300.000 kHz	>= 300.000 kHz
SweepPoints	101	~ 10
Sweeptime	1.000 ms	AUTO
Reference Level	-10.000 dBm	-10.000 dBm
Attenuation	10.000 dB	AUTO
Detector	MaxPeak	MaxPeak
SweepCount	200	200
Filter	3 dB	3 dB
Trace Mode	Max Hold	Max Hold
Sweeptype	Sweep	Sweep
Preamp	off	off
Stablemode	Trace	Trace
Stablevalue	0.50 dB	0.50 dB
Run	56 / max. 150	max. 150
Stable	10 / 10	10
Max Stable Difference	0.23 dB	0.50 dB

7.2 Number of frequency hopping channels

Applicability
This requirement applies to all types of FHS equipment operating in the 2400 – 2483.5 MHz band.

Description
Frequency hopping systems shall have a minimum number of hopping channels.

Limit
§15.247 (a)(1)(iii)
Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels.

Test procedure
ANSI C63.10, 7.8.3
The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:
a) Span: The frequency band of operation. Depending on the number of channels the device supports, it could be necessary to divide the frequency range of operation across multiple spans, to allow the individual channels to be clearly seen.
b) 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.
c) VBW ≥ RBW.
d) Sweep: No faster than coupled (auto) time.
e) Detector function: Peak.
f) Trace: Max-hold.
g) Allow the trace to stabilize.
It might prove necessary to break the span up into subranges to show clearly all of the hopping frequencies. Compliance of an EUT with the appropriate regulatory limit shall be determined for the number of hopping channels. A spectral plot of the data shall be included in the test report.
Where the device shares the same channel plan (carrier frequencies and number of channels) across multiple data rates or modulation schemes then the number of channels need only be measured for one of those modulation schemes or data rates.

Test setup: 8.4 with conducted test sample 60337 (see section 5.2)

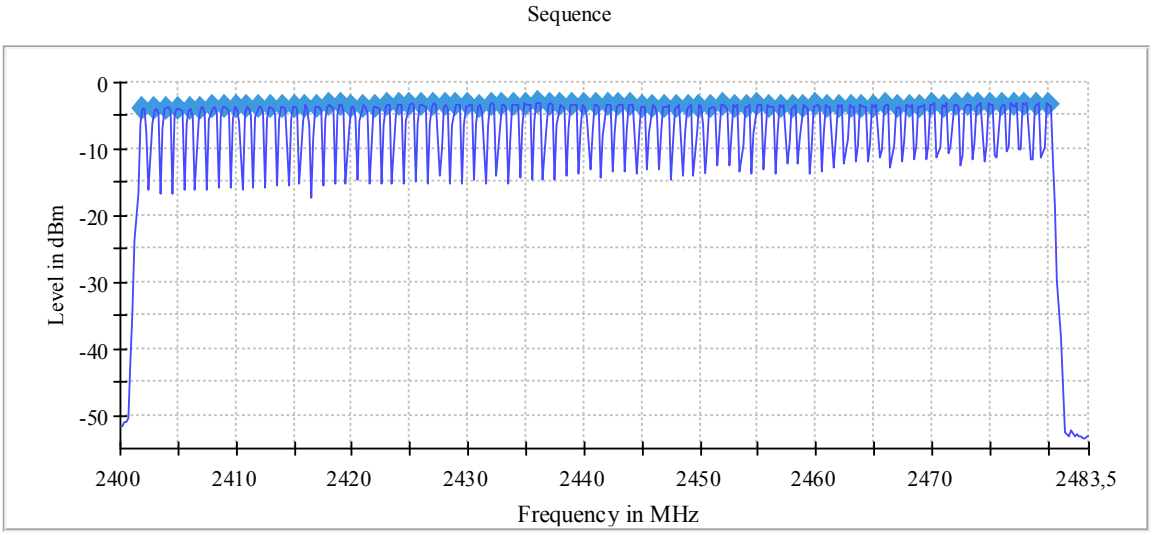
Test Results

EUT Mode	Number of frequency hopping channels			Result
	Channels	Limit min	Limit max	
Mode 1	79	15	-	≥ 15
Mode 2	80	15	-	≥ 15
Mode 3	80	15	-	≥ 15

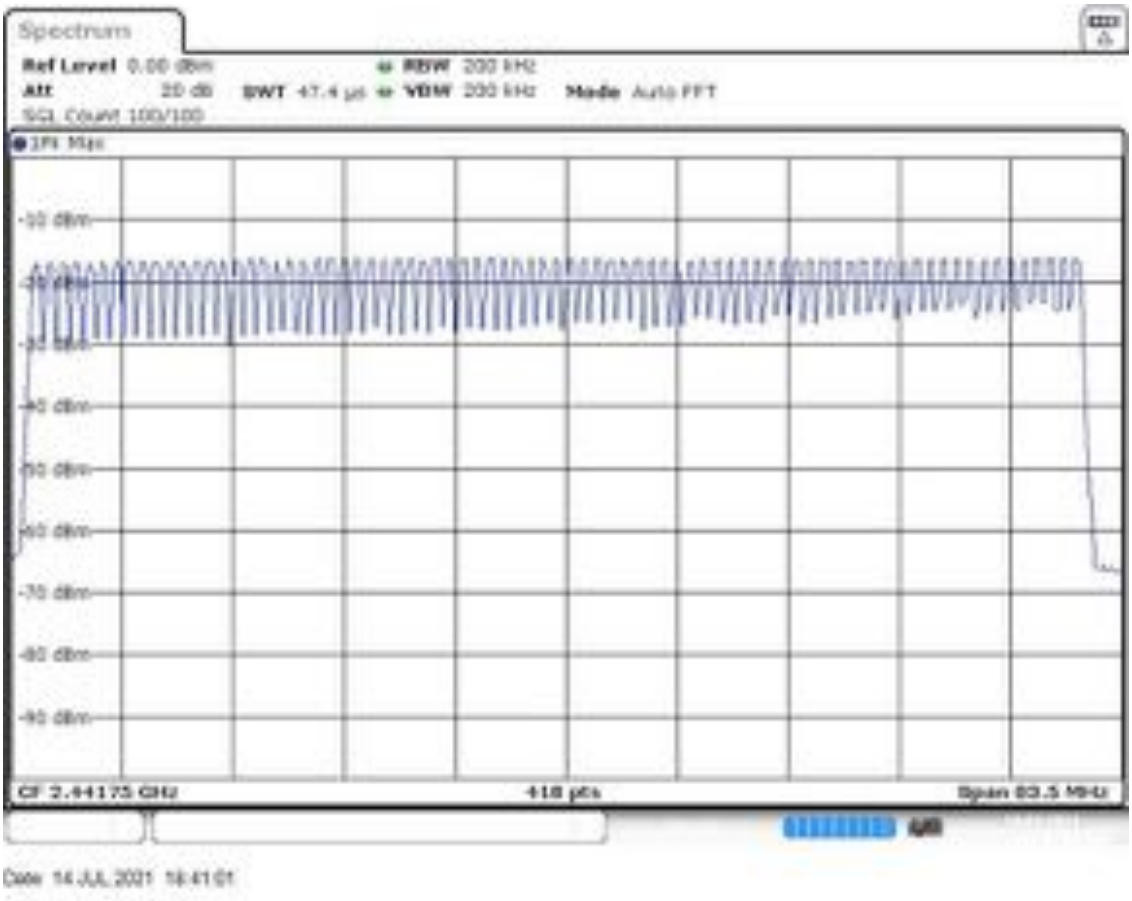
Comment:	---

Verdict	- PASS -	*see next plots*

Plot 10: Mode 1, Hopping Frequencies



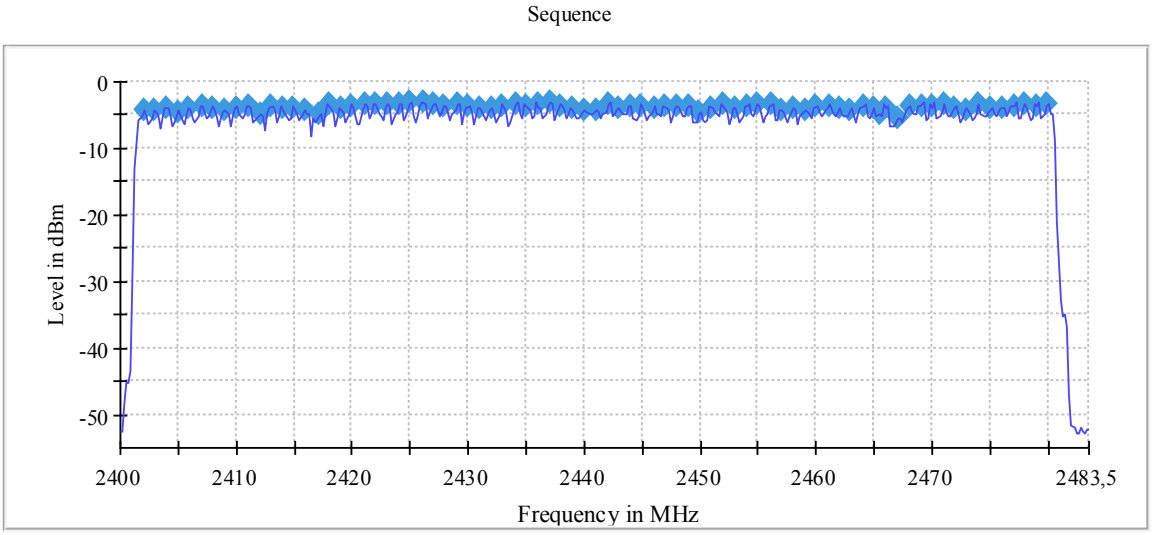
Channels	Limit Min	Limit Max	Result
79	15	---	PASS



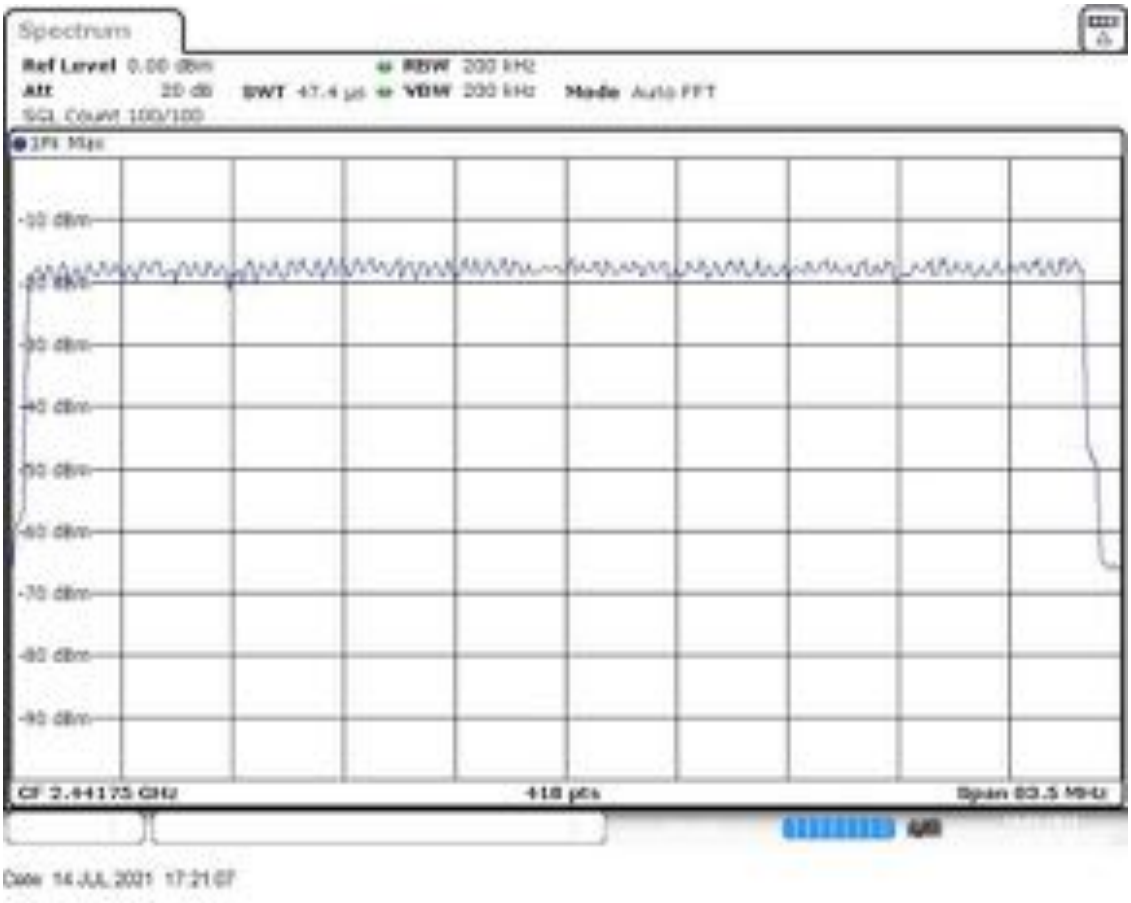
Measurement

Setting	Instrument Value	Target Value
Start Frequency	2.40000 GHz	2.40000 GHz
Stop Frequency	2.48350 GHz	2.48350 GHz
Span	83.500 MHz	83.500 MHz
RBW	200.000 kHz	<= 299.000 kHz
VBW	200.000 kHz	>= 200.000 kHz
SweepPoints	418	~ 418
Sweeptime	47.405 µs	AUTO
Reference Level	0.000 dBm	0.000 dBm
Attenuation	20.000 dB	AUTO
Detector	MaxPeak	MaxPeak
SweepCount	100	100
Filter	3 dB	3 dB
Trace Mode	Max Hold	Max Hold
Sweeptype	FFT	AUTO
Preamp	off	off
Stablemode	Trace	Trace
Stablevalue	0.50 dB	0.50 dB
Run	59 / max. 150	max. 150
Stable	3 / 3	3
Max Stable Difference	0.18 dB	0.50 dB

Plot 11: Mode 2, Hopping Frequencies



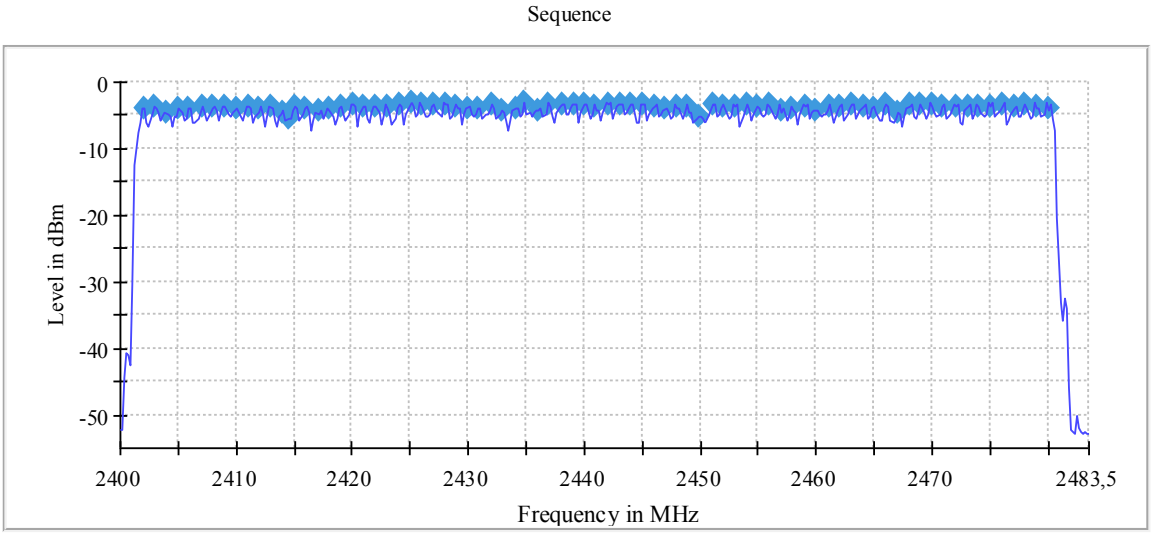
Channels	Limit Min	Limit Max	Result
80	15	---	PASS



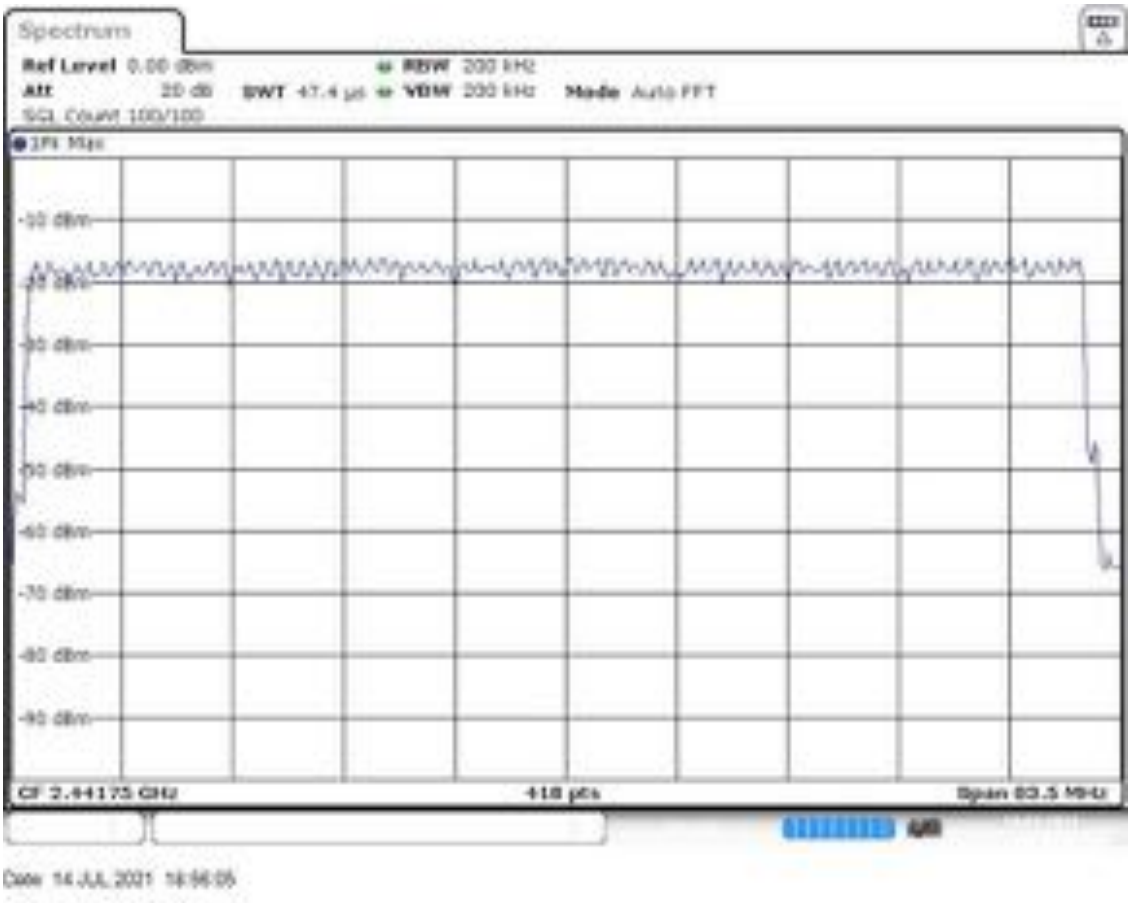
Measurement

Setting	Instrument Value	Target Value
Start Frequency	2.40000 GHz	2.40000 GHz
Stop Frequency	2.48350 GHz	2.48350 GHz
Span	83.500 MHz	83.500 MHz
RBW	200.000 kHz	<= 299.000 kHz
VBW	200.000 kHz	>= 200.000 kHz
SweepPoints	418	~ 418
Sweeptime	47.405 µs	AUTO
Reference Level	0.000 dBm	0.000 dBm
Attenuation	20.000 dB	AUTO
Detector	MaxPeak	MaxPeak
SweepCount	100	100
Filter	3 dB	3 dB
Trace Mode	Max Hold	Max Hold
Sweeptype	FFT	AUTO
Preamp	off	off
Stablemode	Trace	Trace
Stablevalue	0.50 dB	0.50 dB
Run	121 / max. 150	max. 150
Stable	3 / 3	3
Max Stable Difference	0.30 dB	0.50 dB

Plot 12: Mode 3, Hopping Frequencies



Channels	Limit Min	Limit Max	Result
80	15	---	PASS



Measurement

Setting	Instrument Value	Target Value
Start Frequency	2.40000 GHz	2.40000 GHz
Stop Frequency	2.48350 GHz	2.48350 GHz
Span	83.500 MHz	83.500 MHz
RBW	200.000 kHz	<= 299.000 kHz
VBW	200.000 kHz	>= 200.000 kHz
SweepPoints	418	~ 418
Sweeptime	47.405 µs	AUTO
Reference Level	0.000 dBm	0.000 dBm
Attenuation	20.000 dB	AUTO
Detector	MaxPeak	MaxPeak
SweepCount	100	100
Filter	3 dB	3 dB
Trace Mode	Max Hold	Max Hold
Sweeptype	FFT	AUTO
Preamp	off	off
Stablemode	Trace	Trace
Stablevalue	0.50 dB	0.50 dB
Run	142 / max. 150	max. 150
Stable	3 / 3	3
Max Stable Difference	0.00 dB	0.50 dB

7.3 Time of channel occupancy

Applicability

This requirement applies to all types of FHS equipment operating in the 2400 – 2483.5 MHz band.

Description

The dwell time per hop on a channel is the time from the start of the first transmission to the end of the last transmission for that hop. If the device has a single transmission per hop then the dwell time is the duration of that transmission. If the device has a multiple transmissions per hop then the dwell time is measured from the start of the first transmission to the end of the last transmission.
The time of occupancy is the total time that the device dwells on a channel over an observation period specified in the regulatory requirement. To determine the time of occupancy the spectrum analyzer will be configured to measure both the dwell time per hop and the number of times the device transmits on a specific channel in a given period.

Limit

§15.247 (a)(1)(iii)
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.

Test procedure

ANSI C63.10, 7.8.4
The EUT shall have its hopping function enabled. Compliance with the requirements shall be made with the minimum and with the maximum number of channels enabled. If the dwell time per channel does not vary with the number of channels than compliance with the requirements may be based on the minimum number of channels. If the device supports different dwell times per channel (example Bluetooth devices can dwell on a channel for 1, 3 or 5 time slots) then measurements can be limited to the longest dwell time with the minimum number of channels.
Use the following spectrum analyzer settings to determine the dwell time per hop:

a) Span: Zero span, centered on a hopping channel.
b) RBW shall be ≤ channel spacing and where possible RBW should be set >> 1 / T, where T is the expected transmission time per hop.
c) Sweep time: Set so that the start of the first transmission and end of the last transmission for the hop are clearly captured. Setting the sweep time to be slightly longer than the hopping period per channel (hopping period = 1/hopping rate) should achieve this.
d) Use a video trigger, where possible with a trigger delay, so that the start of the transmission is clearly observed. The trigger level might need adjustment to reduce the chance of triggering when the system hops on an adjacent channel.
e) Detector function: Peak.
f) Trace: Clear-write, single sweep.
g) Place markers at the start of the first transmission on the channel and at the end of the last transmission. The dwell time per hop is the time between these two markers.

To determine the number of hops on a channel in the regulatory observation period repeat the measurement using a longer sweep time. When the device uses a single hopping sequence the period of measurement should be sufficient to capture at least 2 hops. When the device uses a dynamic hopping sequence, or the sequence varies, the period of measurement may need to capture multiple hops to better determine the average time of occupancy. Count the number of hops on the channel across the sweep time.
The average number of hops on the same channel within the regulatory observation period is calculated from the number of hops on the channel divided by the spectrum analyzer sweep time multiplied by the regulatory observation period. For example, if three hops are counted with an analyzer sweep time of 500 ms and the regulatory observation period is 10 s, then the number of hops in that ten seconds is 3 / 0.5 × 10, or 60 hops.
The average time of occupancy is calculated by multiplying the dwell time per hop by the number of hops in the observation period.

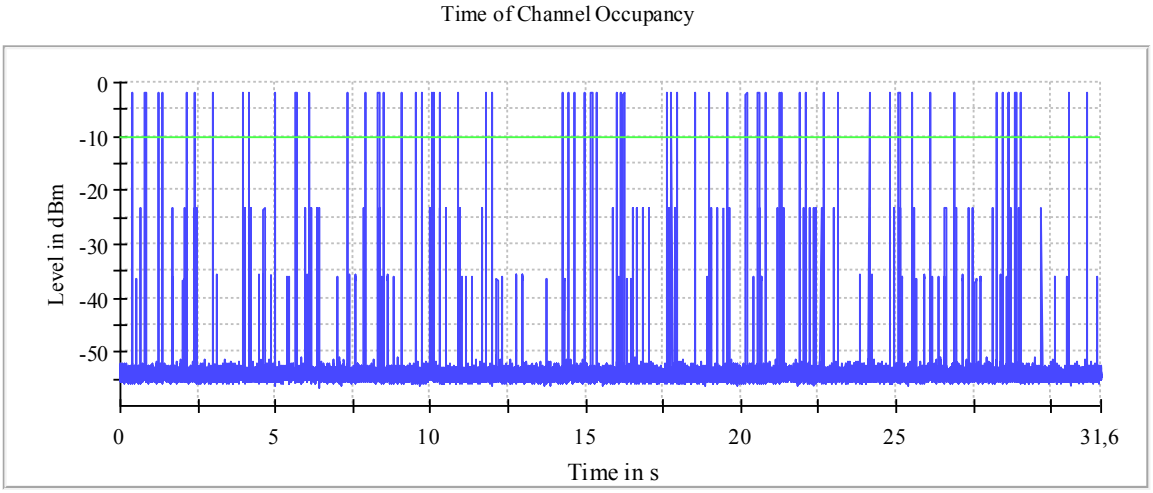
Where the device shares the same hopping algorithms (dwell time, channel selection) across multiple data rates or modulation schemes then the time of occupancy need only be measured for one of those modulation schemes or data rates. If the dwell time value varies with different modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this test for each variation in dwell time.
Test setup: 8.4 with conducted test sample 60337 (see section 5.2)
Test Results

EUT Mode	Average time of occupancy			Limit [ms]
	low channel [ms]	mid channel [ms]	high channel [ms]	
Mode 1	182.42	159.19	185.27	≤ 400
Mode 2	130.46	173.35	156.21	≤ 400
Mode 3	160.72	158.74	164.49	≤ 400

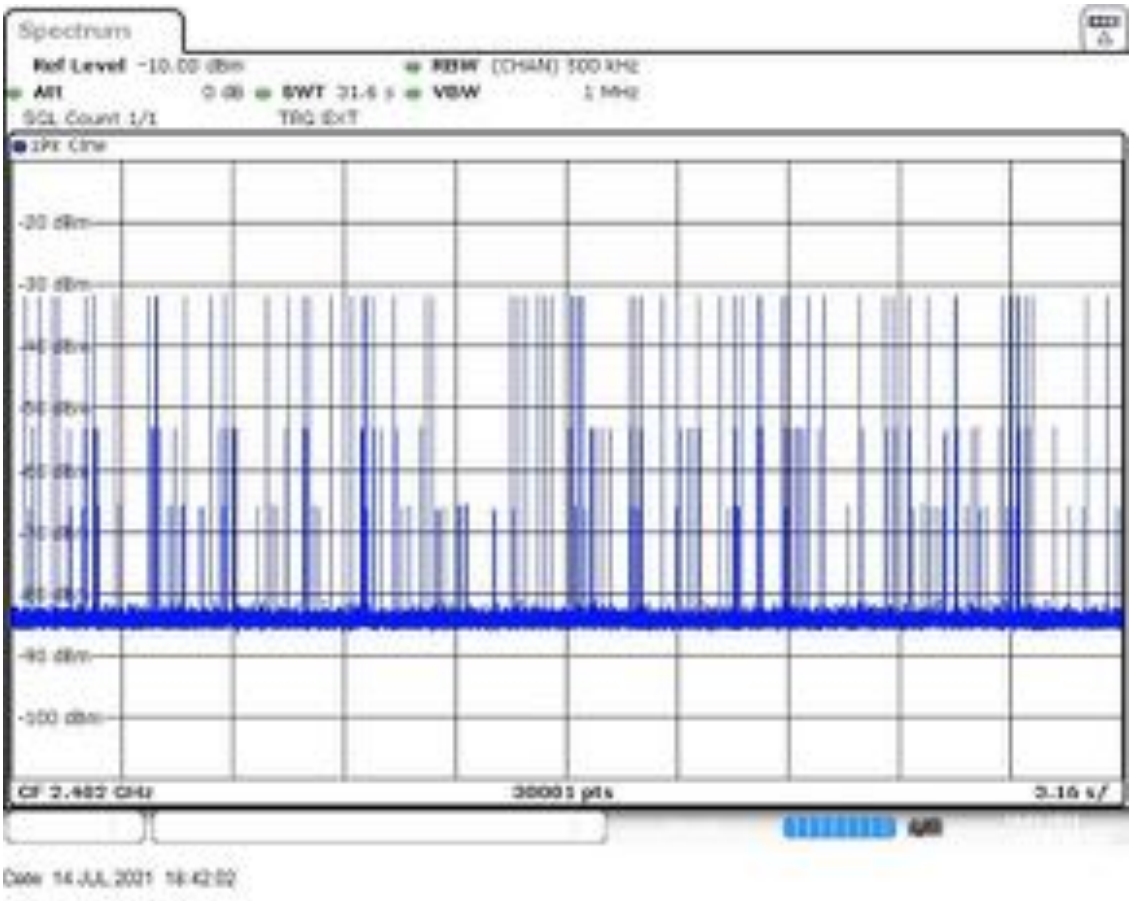
Comment:	---

Verdict	**- PASS -**	*see next plots*

Plot 13: Mode 1, Time of Channel Occupancy, low channel



DUT Frequency (MHz)	Result	Number of Hops	Average time of occupancy (ms)	Threshold (dBm)
2402.000000	PASS	62	182.420	-10.0



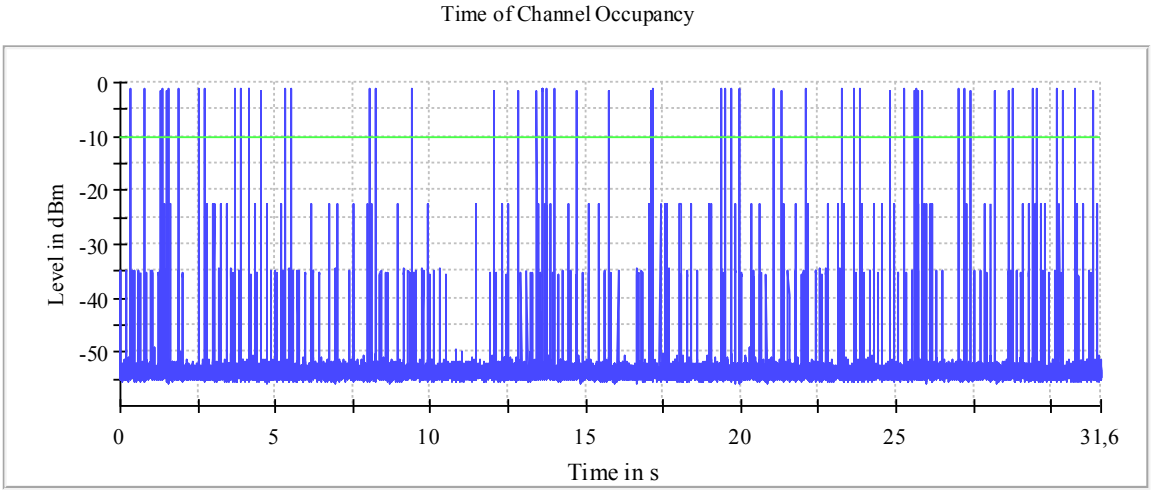
Measurement

Setting	Instrument Value	Target Value
Center Frequency	2.40200 GHz	2.40200 GHz
Span	ZeroSpan	ZeroSpan
RBW	500.000 kHz	~ 500.000 kHz
VBW	1.000 MHz	~ 1.500 MHz
SweepPoints	30001	~ 30001
Sweeptime	31.600 s	31.600 s
Reference Level	-10.000 dBm	-10.000 dBm
Attenuation	0.000 dB	0.000 dB
Detector	MaxPeak	MaxPeak
SweepCount	1	1
Filter	Channel	Channel
Trace Mode	Clear Write	Clear Write
Sweeptype	Sweep	AUTO
Preamp	off	off
Trigger	External	External
Trigger Offset	0.000 s	0.000 s

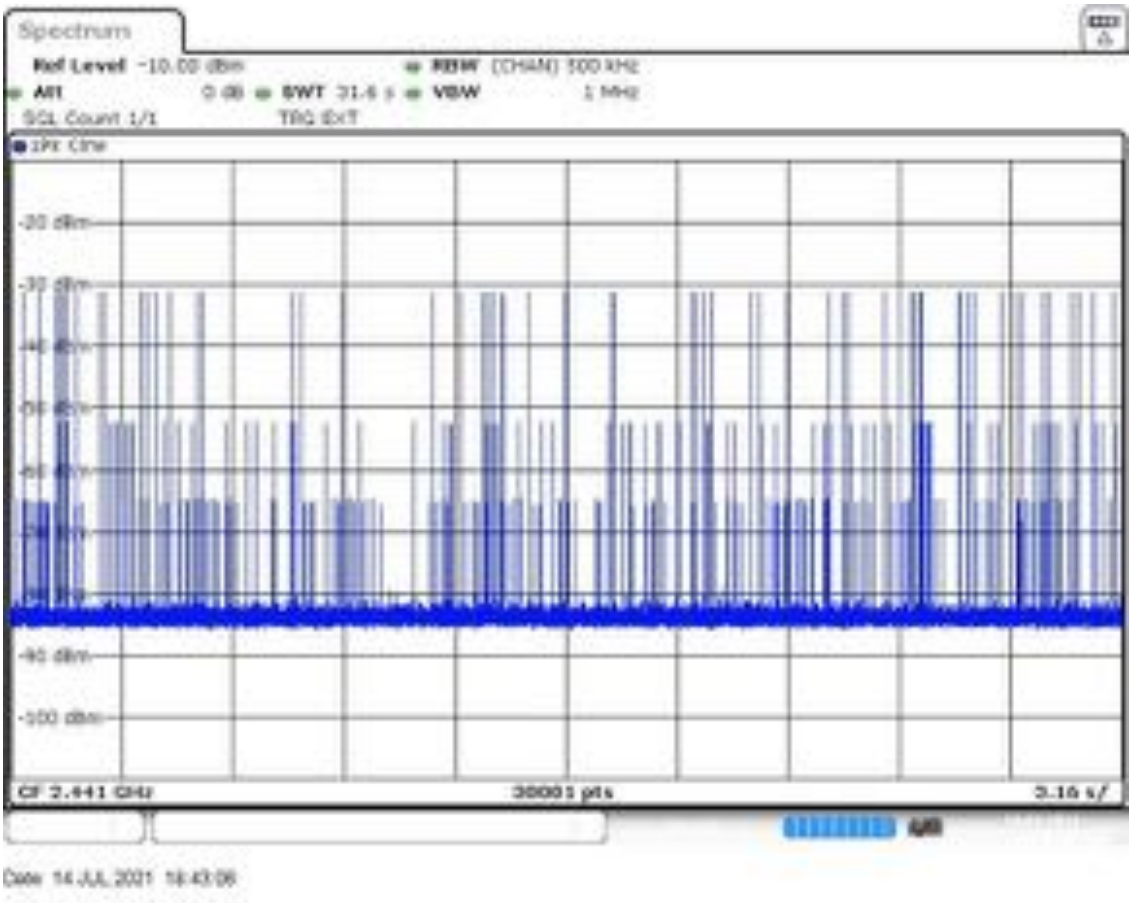
OSP

Setting	Instrument Value	Target Value
Measurement Time	31.600 s	31.600 s
Tracepoints	31600000	31600000
Time resolution	1.000 µs	1.000 µs
Detector	RMS	RMS

Plot 14: Mode 1, Time of Channel Occupancy, mid channel



DUT Frequency (MHz)	Result	Number of Hops	Average time of occupancy (ms)	Threshold (dBm)
2441.000000	PASS	54	159.190	-10.0



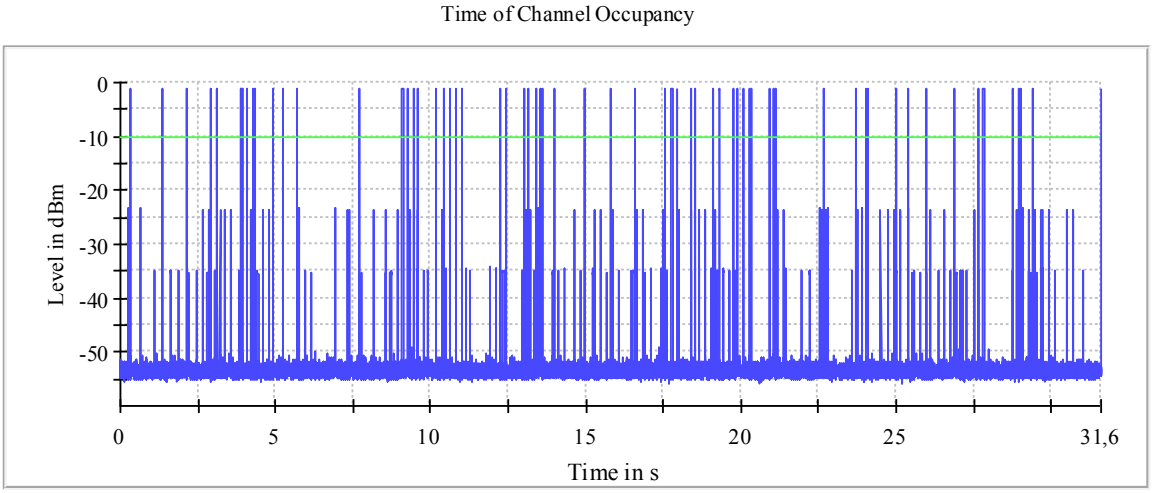
Measurement

Setting	Instrument Value	Target Value
Center Frequency	2.44100 GHz	2.44100 GHz
Span	ZeroSpan	ZeroSpan
RBW	500.000 kHz	~ 500.000 kHz
VBW	1.000 MHz	~ 1.500 MHz
SweepPoints	30001	~ 30001
Sweeptime	31.600 s	31.600 s
Reference Level	-10.000 dBm	-10.000 dBm
Attenuation	0.000 dB	0.000 dB
Detector	MaxPeak	MaxPeak
SweepCount	1	1
Filter	Channel	Channel
Trace Mode	Clear Write	Clear Write
Sweeptype	Sweep	AUTO
Preamp	off	off
Trigger	External	External
Trigger Offset	0.000 s	0.000 s

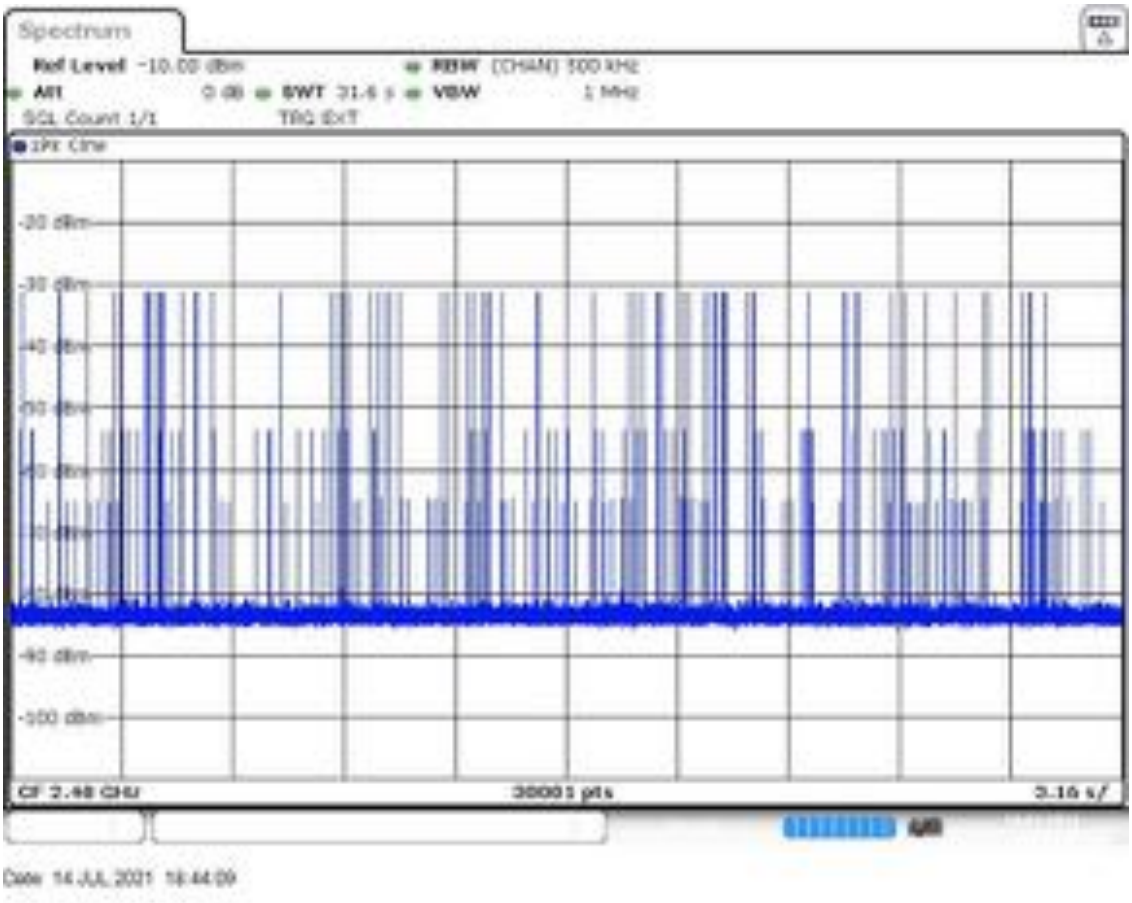
OSP

Setting	Instrument Value	Target Value
Measurement Time	31.600 s	31.600 s
Tracepoints	31600000	31600000
Time resolution	1.000 µs	1.000 µs
Detector	RMS	RMS

Plot 15: Mode 1, Time of Channel Occupancy, high channel



DUT Frequency (MHz)	Result	Number of Hops	Average time of occupancy (ms)	Threshold (dBm)
2480.000000	PASS	63	185.270	-10.0



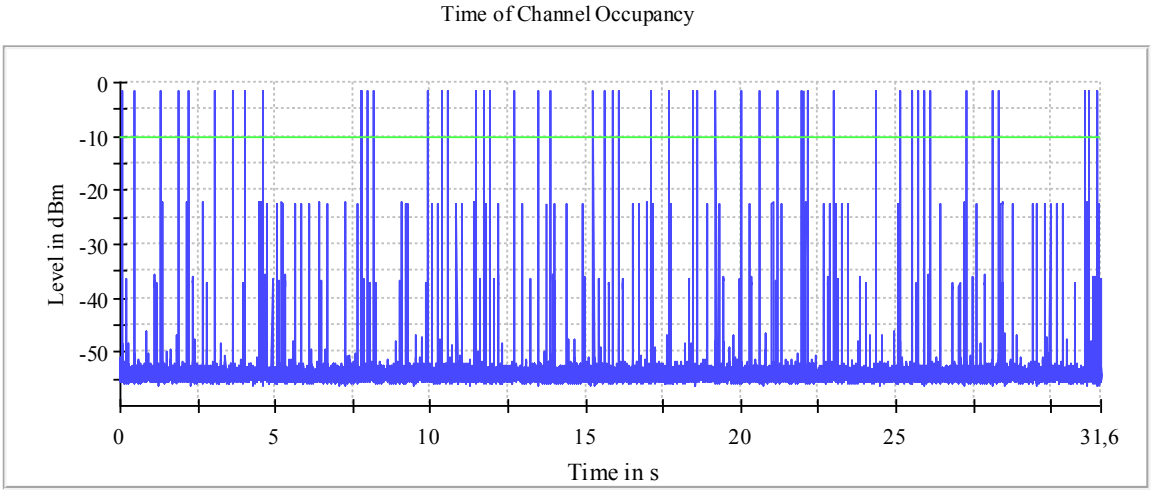
Measurement

Setting	Instrument Value	Target Value
Center Frequency	2.48000 GHz	2.48000 GHz
Span	ZeroSpan	ZeroSpan
RBW	500.000 kHz	~ 500.000 kHz
VBW	1.000 MHz	~ 1.500 MHz
SweepPoints	30001	~ 30001
Sweeptime	31.600 s	31.600 s
Reference Level	-10.000 dBm	-10.000 dBm
Attenuation	0.000 dB	0.000 dB
Detector	MaxPeak	MaxPeak
SweepCount	1	1
Filter	Channel	Channel
Trace Mode	Clear Write	Clear Write
Sweeptype	Sweep	AUTO
Preamp	off	off
Trigger	External	External
Trigger Offset	0.000 s	0.000 s

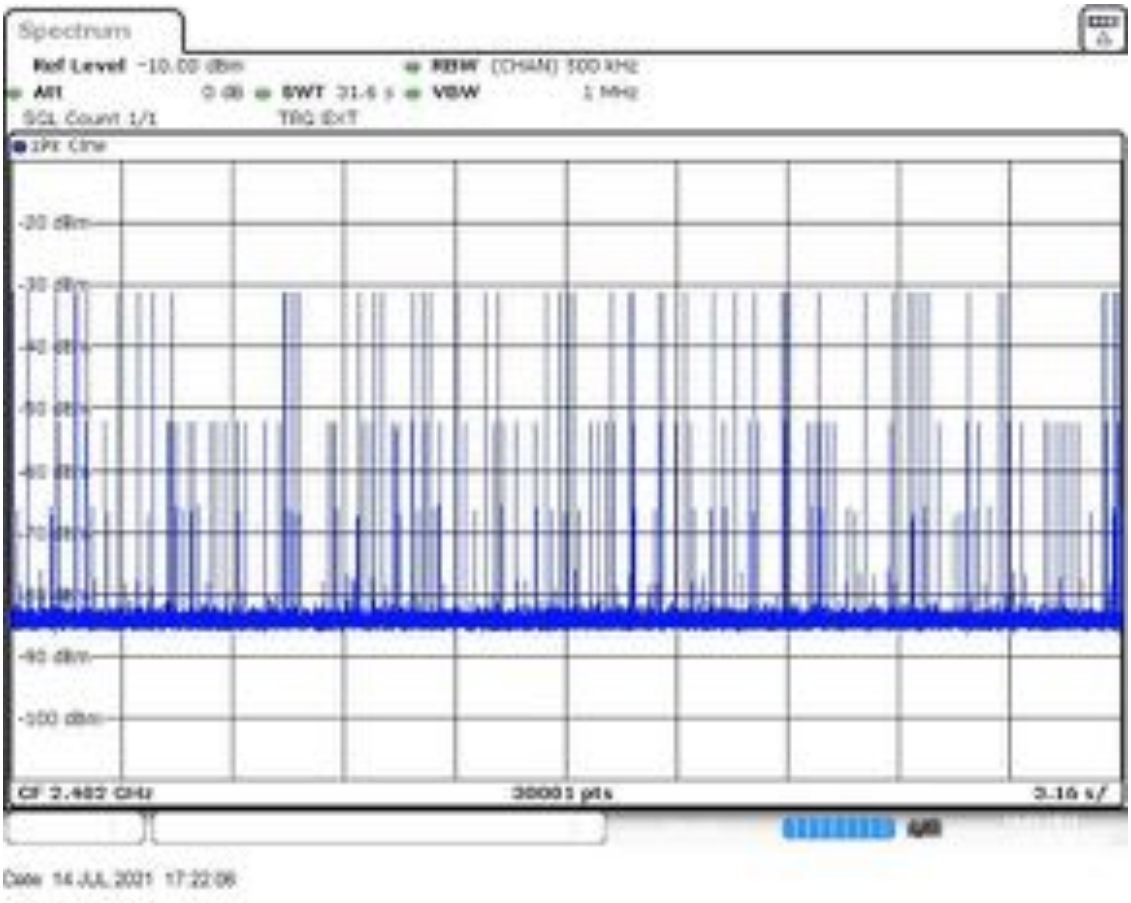
OSP

Setting	Instrument Value	Target Value
Measurement Time	31.600 s	31.600 s
Tracepoints	31600000	31600000
Time resolution	1.000 µs	1.000 µs
Detector	RMS	RMS

Plot 16: Mode 2, Time of Channel Occupancy, low channel



DUT Frequency (MHz)	Result	Number of Hops	Average time of occupancy (ms)	Threshold (dBm)
2402.000000	PASS	50	130.460	-10.0



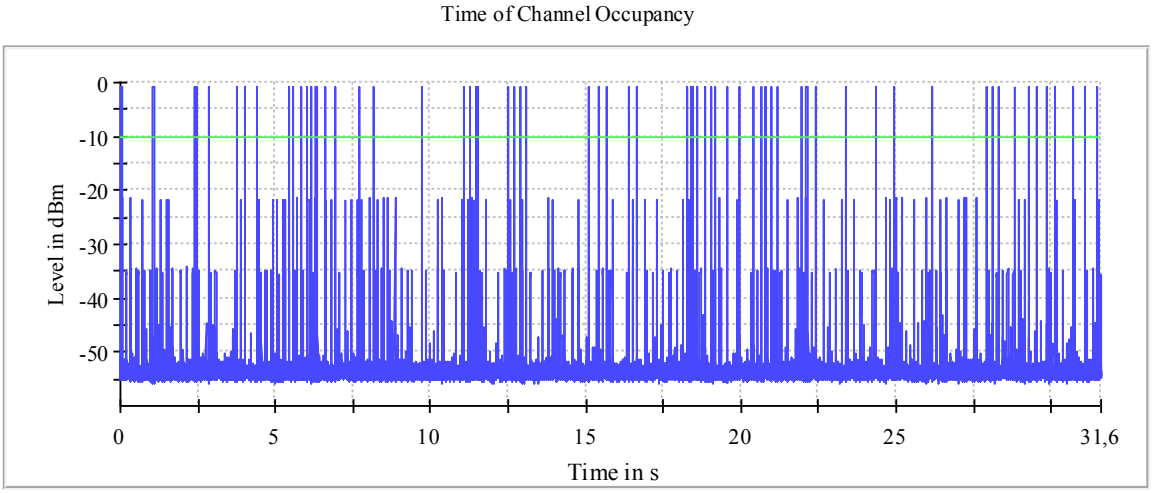
Measurement

Setting	Instrument Value	Target Value
Center Frequency	2.40200 GHz	2.40200 GHz
Span	ZeroSpan	ZeroSpan
RBW	500.000 kHz	~ 500.000 kHz
VBW	1.000 MHz	~ 1.500 MHz
SweepPoints	30001	~ 30001
Sweeptime	31.600 s	31.600 s
Reference Level	-10.000 dBm	-10.000 dBm
Attenuation	0.000 dB	0.000 dB
Detector	MaxPeak	MaxPeak
SweepCount	1	1
Filter	Channel	Channel
Trace Mode	Clear Write	Clear Write
Sweeptype	Sweep	AUTO
Preamp	off	off
Trigger	External	External
Trigger Offset	0.000 s	0.000 s

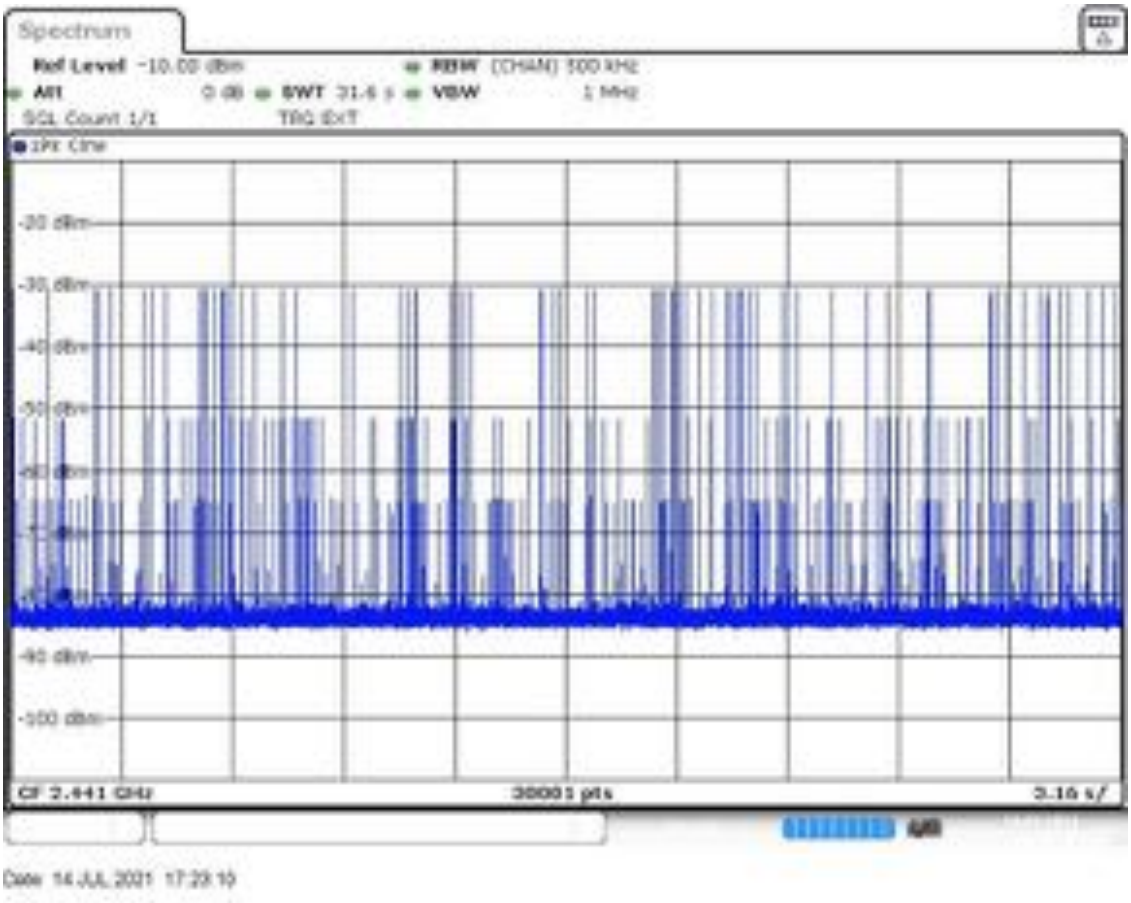
OSP

Setting	Instrument Value	Target Value
Measurement Time	31.600 s	31.600 s
Tracepoints	31600000	31600000
Time resolution	1.000 µs	1.000 µs
Detector	RMS	RMS

Plot 17: Mode 2, Time of Channel Occupancy, mid channel



DUT Frequency (MHz)	Result	Number of Hops	Average time of occupancy (ms)	Threshold (dBm)
2441.000000	PASS	64	173.350	-10.0



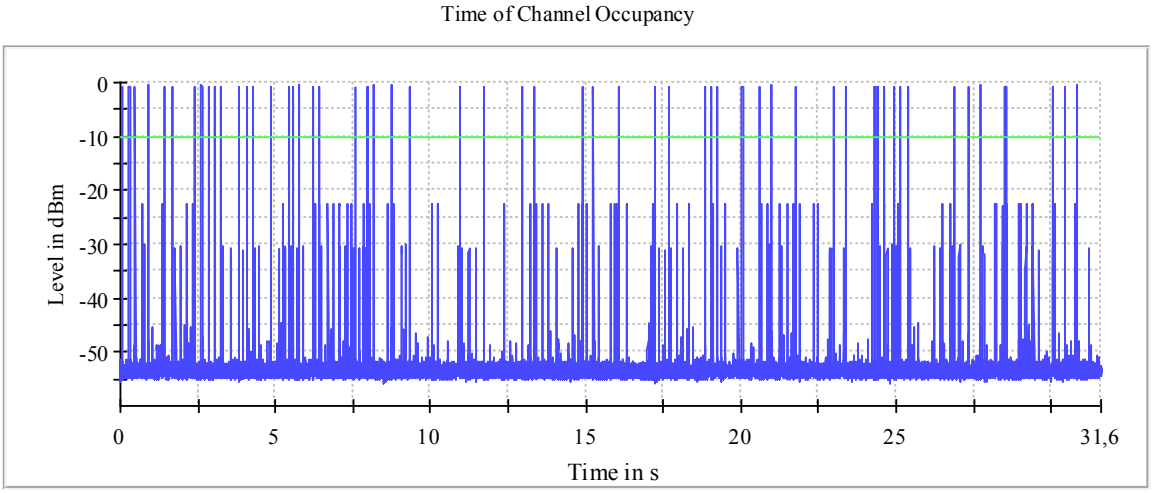
Measurement

Setting	Instrument Value	Target Value
Center Frequency	2.44100 GHz	2.44100 GHz
Span	ZeroSpan	ZeroSpan
RBW	500.000 kHz	~ 500.000 kHz
VBW	1.000 MHz	~ 1.500 MHz
SweepPoints	30001	~ 30001
Sweeptime	31.600 s	31.600 s
Reference Level	-10.000 dBm	-10.000 dBm
Attenuation	0.000 dB	0.000 dB
Detector	MaxPeak	MaxPeak
SweepCount	1	1
Filter	Channel	Channel
Trace Mode	Clear Write	Clear Write
Sweeptype	Sweep	AUTO
Preamp	off	off
Trigger	External	External
Trigger Offset	0.000 s	0.000 s

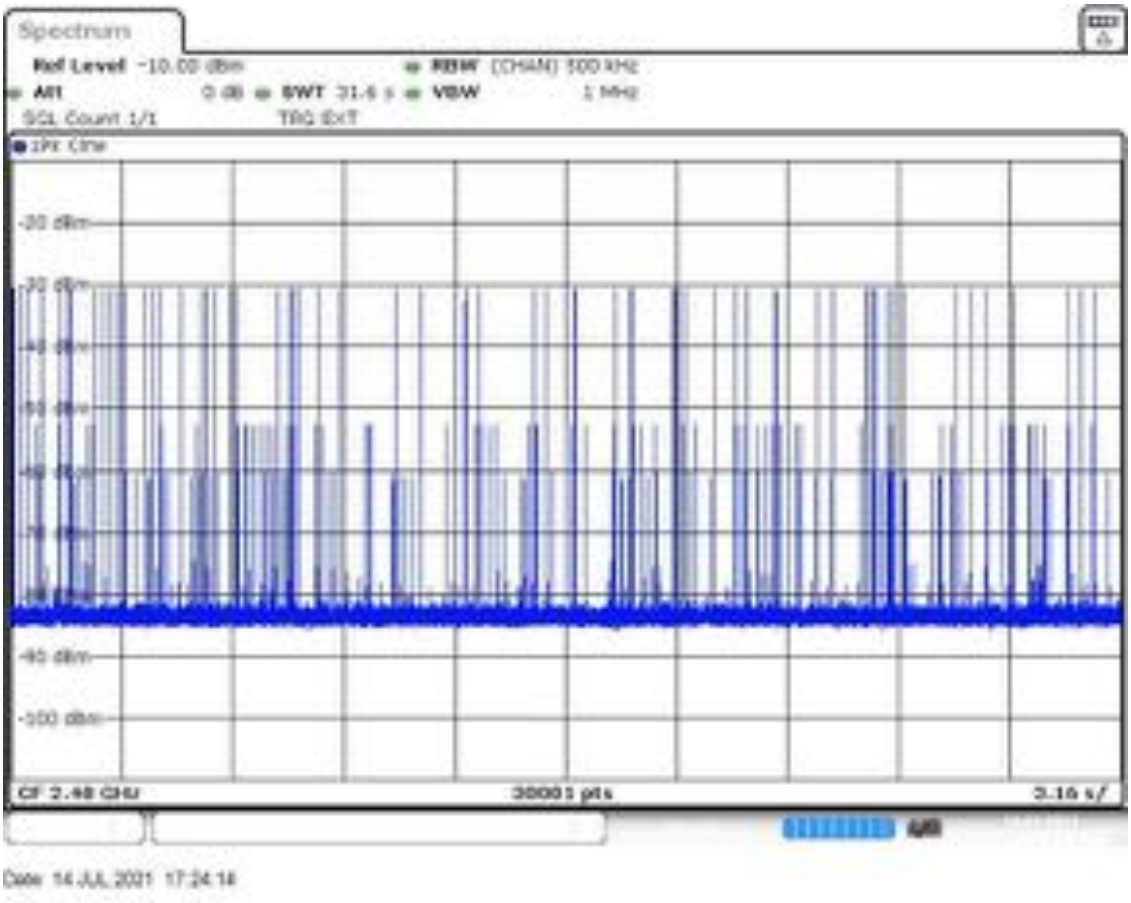
OSP

Setting	Instrument Value	Target Value
Measurement Time	31.600 s	31.600 s
Tracepoints	31600000	31600000
Time resolution	1.000 µs	1.000 µs
Detector	RMS	RMS

Plot 18: Mode 2, Time of Channel Occupancy, high channel



DUT Frequency (MHz)	Result	Number of Hops	Average time of occupancy (ms)	Threshold (dBm)
2480.000000	PASS	57	156.210	-10.0



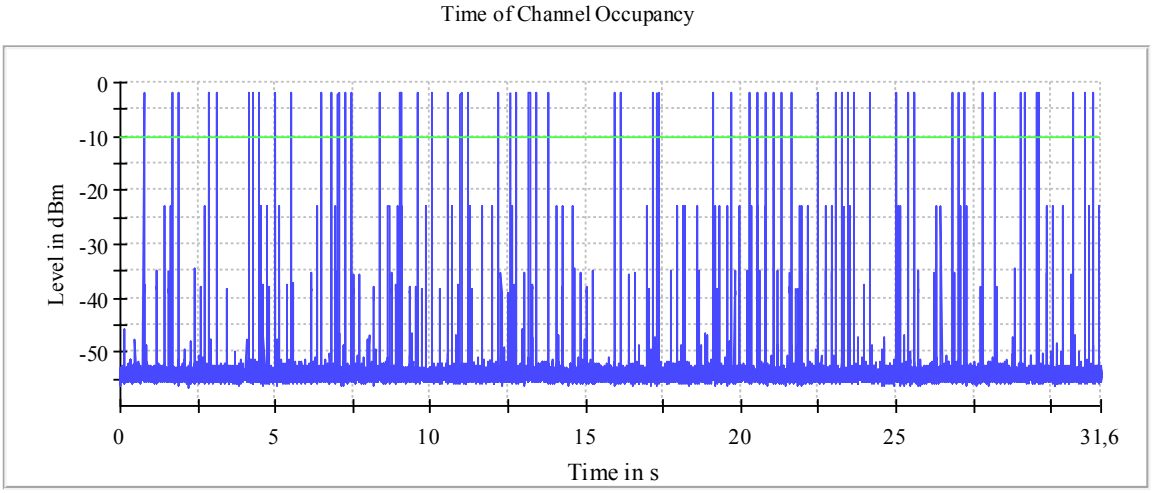
Measurement

Setting	Instrument Value	Target Value
Center Frequency	2.48000 GHz	2.48000 GHz
Span	ZeroSpan	ZeroSpan
RBW	500.000 kHz	~ 500.000 kHz
VBW	1.000 MHz	~ 1.500 MHz
SweepPoints	30001	~ 30001
Sweeptime	31.600 s	31.600 s
Reference Level	-10.000 dBm	-10.000 dBm
Attenuation	0.000 dB	0.000 dB
Detector	MaxPeak	MaxPeak
SweepCount	1	1
Filter	Channel	Channel
Trace Mode	Clear Write	Clear Write
Sweeptype	Sweep	AUTO
Preamp	off	off
Trigger	External	External
Trigger Offset	0.000 s	0.000 s

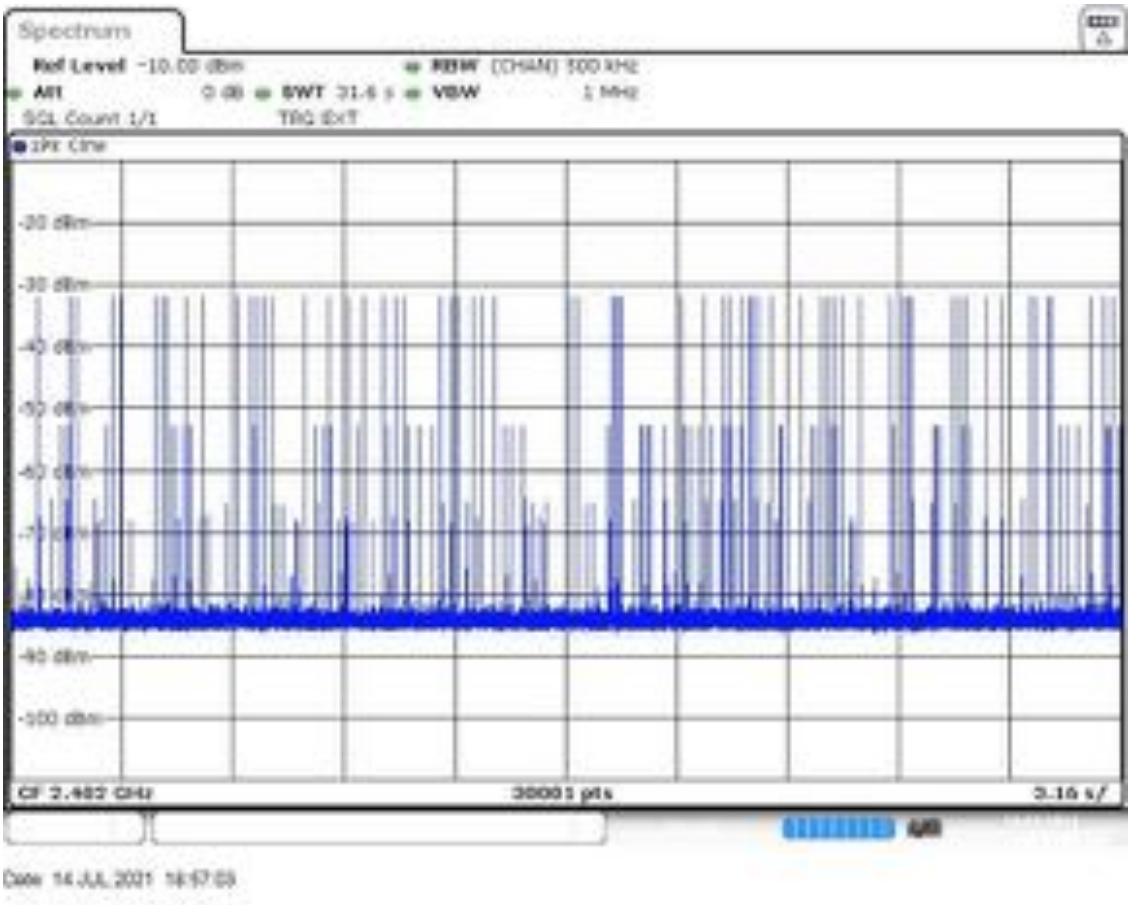
OSP

Setting	Instrument Value	Target Value
Measurement Time	31.600 s	31.600 s
Tracepoints	31600000	31600000
Time resolution	1.000 µs	1.000 µs
Detector	RMS	RMS

Plot 19: Mode 3, Time of Channel Occupancy, low channel



DUT Frequency (MHz)	Result	Number of Hops	Average time of occupancy (ms)	Threshold (dBm)
2402.000000	PASS	63	160.720	-10.0



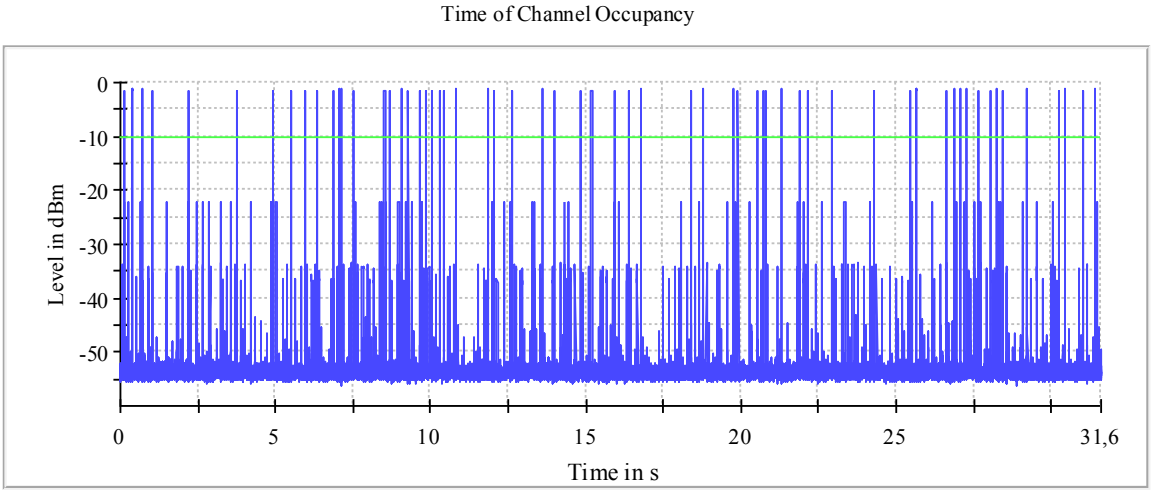
Measurement

Setting	Instrument Value	Target Value
Center Frequency	2.40200 GHz	2.40200 GHz
Span	ZeroSpan	ZeroSpan
RBW	500.000 kHz	~ 500.000 kHz
VBW	1.000 MHz	~ 1.500 MHz
SweepPoints	30001	~ 30001
Sweeptime	31.600 s	31.600 s
Reference Level	-10.000 dBm	-10.000 dBm
Attenuation	0.000 dB	0.000 dB
Detector	MaxPeak	MaxPeak
SweepCount	1	1
Filter	Channel	Channel
Trace Mode	Clear Write	Clear Write
Sweeptype	Sweep	AUTO
Preamp	off	off
Trigger	External	External
Trigger Offset	0.000 s	0.000 s

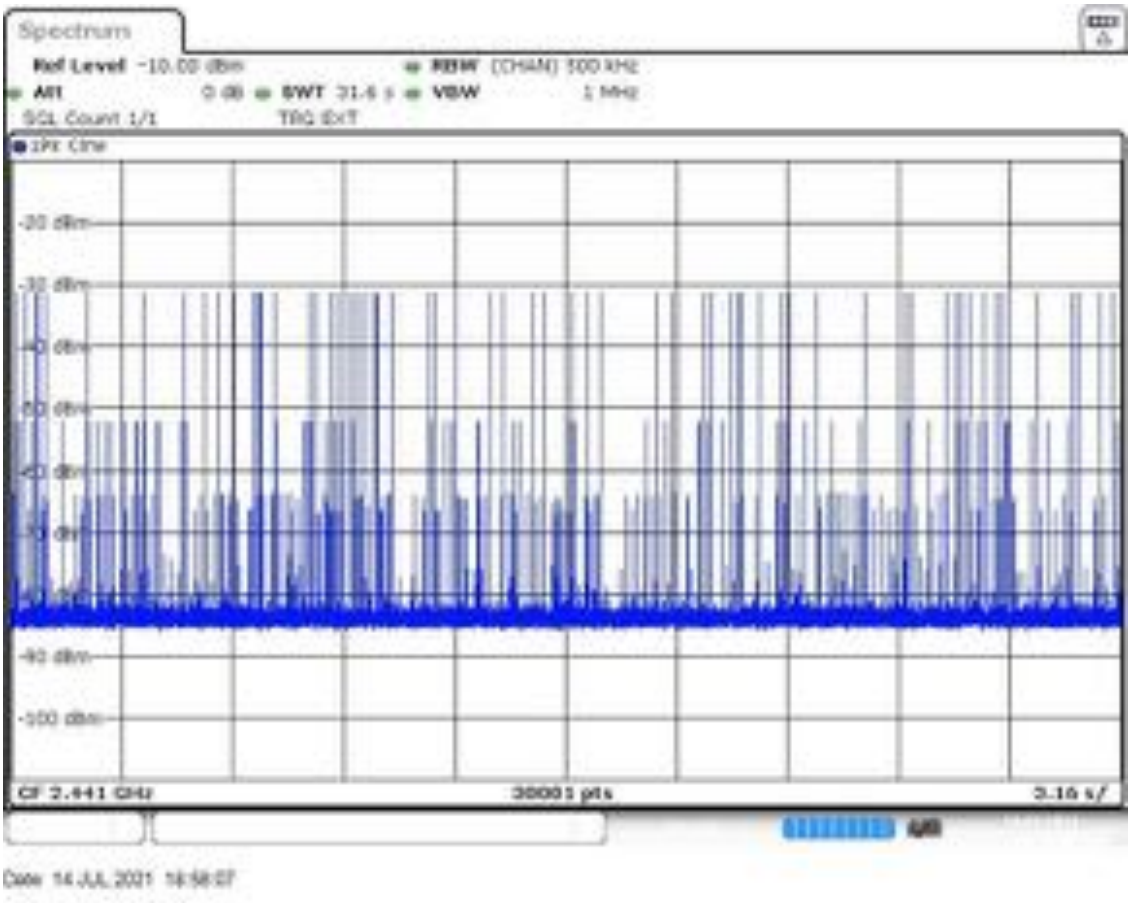
OSP

Setting	Instrument Value	Target Value
Measurement Time	31.600 s	31.600 s
Tracepoints	31600000	31600000
Time resolution	1.000 µs	1.000 µs
Detector	RMS	RMS

Plot 20: Mode 3, Time of Channel Occupancy, mid channel



DUT Frequency (MHz)	Result	Number of Hops	Average time of occupancy (ms)	Threshold (dBm)
2441.000000	PASS	60	158.740	-10.0



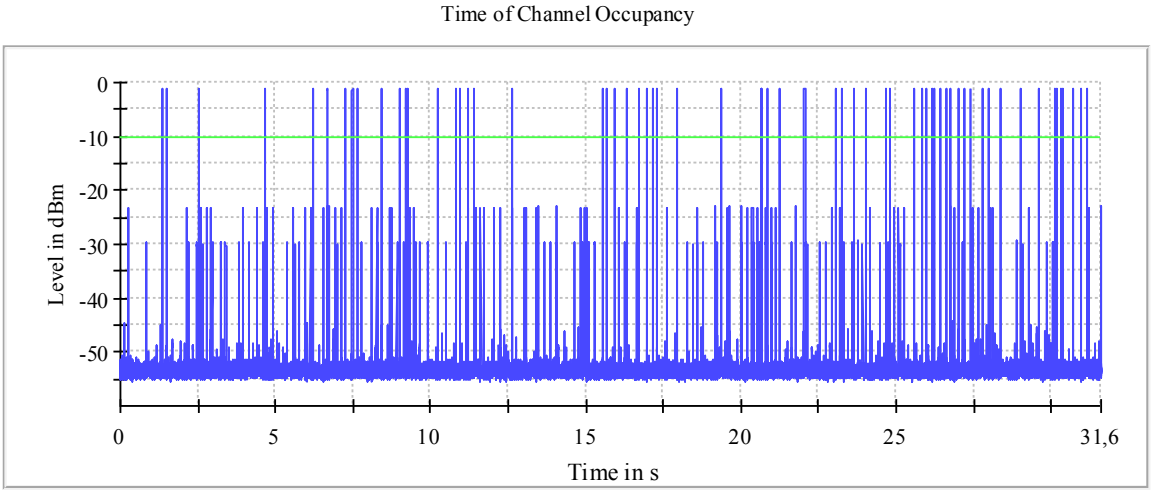
Measurement

Setting	Instrument Value	Target Value
Center Frequency	2.44100 GHz	2.44100 GHz
Span	ZeroSpan	ZeroSpan
RBW	500.000 kHz	~ 500.000 kHz
VBW	1.000 MHz	~ 1.500 MHz
SweepPoints	30001	~ 30001
Sweeptime	31.600 s	31.600 s
Reference Level	-10.000 dBm	-10.000 dBm
Attenuation	0.000 dB	0.000 dB
Detector	MaxPeak	MaxPeak
SweepCount	1	1
Filter	Channel	Channel
Trace Mode	Clear Write	Clear Write
Sweeptype	Sweep	AUTO
Preamp	off	off
Trigger	External	External
Trigger Offset	0.000 s	0.000 s

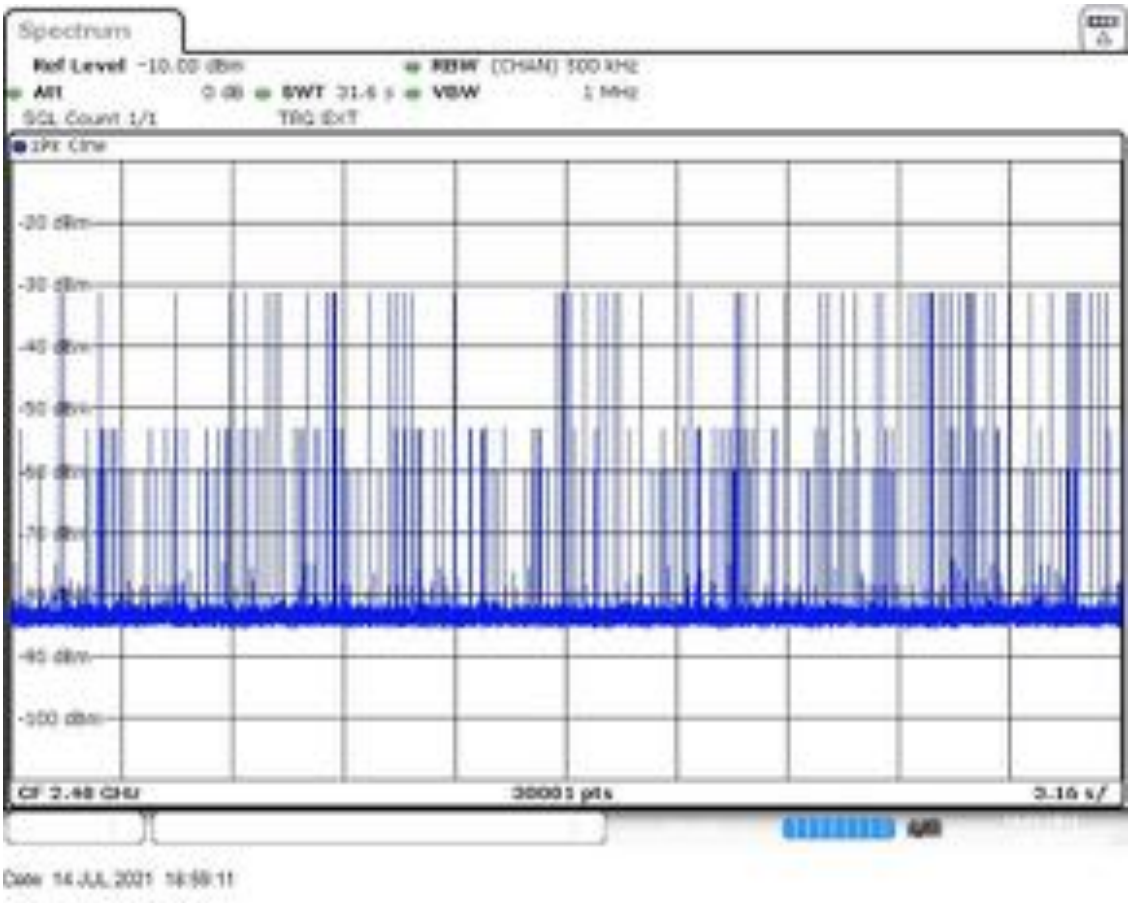
OSP

Setting	Instrument Value	Target Value
Measurement Time	31.600 s	31.600 s
Tracepoints	31600000	31600000
Time resolution	1.000 µs	1.000 µs
Detector	RMS	RMS

Plot 21: Mode 3, Time of Channel Occupancy, high channel



DUT Frequency (MHz)	Result	Number of Hops	Average time of occupancy (ms)	Threshold (dBm)
2480.000000	PASS	62	164.490	-10.0



Measurement

Setting	Instrument Value	Target Value
Center Frequency	2.48000 GHz	2.48000 GHz
Span	ZeroSpan	ZeroSpan
RBW	500.000 kHz	~ 500.000 kHz
VBW	1.000 MHz	~ 1.500 MHz
SweepPoints	30001	~ 30001
Sweeptime	31.600 s	31.600 s
Reference Level	-10.000 dBm	-10.000 dBm
Attenuation	0.000 dB	0.000 dB
Detector	MaxPeak	MaxPeak
SweepCount	1	1
Filter	Channel	Channel
Trace Mode	Clear Write	Clear Write
Sweeptype	Sweep	AUTO
Preamp	off	off
Trigger	External	External
Trigger Offset	0.000 s	0.000 s

OSP

Setting	Instrument Value	Target Value
Measurement Time	31.600 s	31.600 s
Tracepoints	31600000	31600000
Time resolution	1.000 µs	1.000 µs
Detector	RMS	RMS