Prüfbericht - Produkte
Test Report - Products

TÜVRheinland®

Prüfbericht-Nr.: *Test report no.:*	**CN213PL4 001**	**Auftrags-Nr.:** *Order no.:*	168338434	Seite 1 von 29 *Page 1 of 29*
Kunden-Referenz-Nr.: *Client reference no.:*	N/A	**Auftragsdatum:** *Order date:*	2021-10-08	
Auftraggeber: *Client:*	**Shenzhen RAKwireless Technology Co.,Ltd.** Room 506, Bldg B, New Compark, Pingshan First Road, Taoyuan Street, XiLi Town Nanshan District, Shenzhen, Guangdong, China			
Prüfgegenstand: *Test item:*	WisDuo LoRa Module			
Bezeichnung / Typ-Nr.: *Identification / Type no.:*	RAK4200(H) (Trademark: RAK)			
Auftrags-Inhalt: *Order content:*	FCC and IC approval			
Prüfgrundlage: *Test specification:*	CFR47 FCC Part 15: Subpart C Section 15.247 CFR47 FCC Part 15: Subpart C Section 15.207 CFR47 FCC Part 15: Subpart C Section 15.209 CFR47 FCC Part 2: Section 2.1093		RSS-247 Issue 2 February 2017 RSS-Gen Issue 5 February 2021 RSS-102 Issue 5 February 2021	

Wareneingangsdatum: *Date of sample receipt:*	2021-10-13	Please refer to photo documents
Prüfmuster-Nr.: *Test sample no.:*	A003143961-001 to 007	
Prüfzeitraum: *Testing period:*	2021-11-04 - 2021-11-11	
Ort der Prüfung: *Place of testing:*	TÜV Rheinland (Shenzhen) Co., Ltd.	
Prüflaboratorium: *Testing laboratory:*	TÜV Rheinland (Shenzhen) Co., Ltd.	
Prüfergebnis*: *Test result*:*	Pass	

geprüft von: *tested by:*	X Alex Lan	**genehmigt von:** *authorized by:*	X Winnie Hou
Datum: *Date:* 2021-11-23	Signed by: Alex Lan	**Ausstellungsdatum:** *Issue date:* 2021-11-23	Signed by: Winnie Hou
Stellung / Position	Senior Project Engineer	**Stellung** / Position	Department Manager

Sonstiges / *Other:* FCC ID: 2AF6B-RAK4200HX
IC: 25908-RAK4200H, HVIN: RAK4200(H)

Zustand des Prüfgegenstandes bei Anlieferung: Prüfmuster vollständig und unbeschädigt
Condition of the test item at delivery: *Test item complete and undamaged:*

* Legende:	1 = sehr gut	2 = gut	3 = befriedigend	4 = ausreichend	5 = mangelhalt
	P(ass) = entspricht o.g. Prüfgrundlage(n)		F(ail) = entspricht nicht o.g. Prüfgrundlage(n)	N/A = nicht anwendbar	N/T = nicht getestet
Legend:	1 = very good	2 = good	3 = satisfactory	4 = sufficient	5 = poor
	P(ass) = passed a.m. test specifications(s)		F(ail) = failed a.m. test specifications(s)	N/A = not applicable	N/T = not tested

TUV Rheinland (Shenzhen) Co., Ltd. 1601 R&D Room, 1602-1604, 17-18F, Building 7 Site C, Vanke Cloud City Phase I, Xingke First Street, Xili Street, Xili Community, Nanshan District, Shenzhen 518052, P.R. China
Mail: service@de.tuv.com http://www.tuv.com

Test Summary

5.1.1 ANTENNA REQUIREMENT
RESULT: *Pass*

5.1.2 MAXIMUM CONDUCTED OUTPUT POWER
RESULT: *Pass*

5.1.3 CONDUCTED POWER SPECTRAL DENSITY
RESULT: *Pass*

5.1.4 6DB BANDWIDTH
RESULT: *Pass*

5.1.5 20DB BANDWIDTH
RESULT: *Pass*

5.1.6 99% BANDWIDTH
RESULT: *Pass*

5.1.7 CONDUCTED SPURIOUS EMISSIONS MEASURED IN 100 KHZ BANDWIDTH
RESULT: *Pass*

5.1.8 RADIATED SPURIOUS EMISSION
RESULT: *Pass*

5.1.9 CARRIER FREQUENCY SEPARATION
RESULT: *Pass*

5.1.10 NUMBER OF HOPPING FREQUENCY
RESULT: *Pass*

5.1.11 TIME OF OCCUPANCY
RESULT: *Pass*

5.1.12 CONDUCTED EMISSION ON AC MAINS
RESULT: *Pass*

6.1.1 ELECTROMAGNETIC FIELDS
RESULT: *Pass*

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1 General Remarks

1.1 Complementary Materials

All attachments are integral parts of this test report. This applies especially to the following appendix:

Appendix A: Photographs of the Test Set-up

Appendix B: Test Results.

2 Test Sites

2.1 Test Facilities

TÜV Rheinland (Shenzhen) Co., Ltd.

362 Huanguan Road Middle Longhua District, Shenzhen 518110 People's Republic of China

FCC Registration No.: 694916

ISED wireless device testing laboratory: 25069, CAB identifier: CN0078

2.2 List of Test and Measurement Instruments

Table 1: List of Test and Measurement Equipment

TÜV Rheinland (Shenzhen) Co., Ltd.

Radio Spectrum Testing				
Equipment	**Manufacturer**	**Model**	**Serial No.**	**Cal. until**
EXA Signal Analyzer, Multi-touch	Keysight	N9010B	MY60241175	2022-09-28
MXG X-Series RF Vector Signal Generator	Keysight	N5182B	MY61250137	2022-09-28
EXG X-Series Microwave Analog Signal Generator	Keysight	N5173B	MY61250141	2022-09-28
DC Power Supply	Keysight	E3642A	MY61276100	2022-09-28
Power Control Unit	Tonscend	JS0806-4ADC	N/A	2022-09-28
Automation Control Unit	Tonscend	JS0806-2	21C8060396	2022-09-28
Test Software	Tonscend	JS1120-3	N/A	N/A
Control PC	Lenovo	TianYi510S-071MB	YLX23JMF	N/A
Unwanted Emission Testing				
Equipment	**Manufacturer**	**Model**	**Serial No.**	**Cal. until**
EMI Test Receiver	R&S	ESR 7	102021	2022-08-10
Signal Analyzer	R&S	FSV 40	101439	2022-08-09
System Controller Interface	R&S	SCI-100	S10010038	N/A
Filterbank	R&S	Wlan	100759	2022-08-09
OSP	R&S	OSP 120	102040	N/A
Pre-amplifier	R&S	SCU08F1	08320031	2022-08-09
Amplifier	R&S	SCU-18F	180070	2022-08-09
Amplifier	R&S	SCU40A	100475	2022-08-09
Trilog Broadband Antenna (30 MHz - 7 GHz)	Schwarzbeck	VULB 9162	193	2022-08-08

Double-Ridged Antenna (1 -18 GHz)	ETS-LINDGREN	3117	00218717	2022-08-08
Wideband Ridged Horn Antenna (18-40 GHz)	Steatite	QMS-00880	19067	2022-08-08
Active Loop Antenna	Schwarzbeck	FMZB 1513	302	2022-09-13
Test software	R&S	EMC32 (V10.60.10)	N/A	N/A
Control PC	Dell	OptiPlex 7050	36NV9P2	N/A
3m Semi-Anechoic Chamber	Albatross	SAC-3m	APC17151-SAC	2024-06-22
Conducted Emission on AC Mains				
Equipment	**Manufacturer**	**Model No.**	**Serial No.**	**Cali. until**
EMI Test Receiver	R&S	ESR3	102680	2022-04-25
Artificial Mains Network	R&S	ENV216	101445	2022-04-25
EMC32 test software	R&S	EMC32(Ver.10.50.00)	N/A	N/A

2.3 Traceability

All measurement equipment calibrations are traceable to NIM (National Institute of Metrology) or where calibration is performed in other countries, to equivalent nationally recognized standards organizations.

2.4 Calibration

Equipment requiring calibration is calibrated periodically by the manufacturer or according to manufacturer's specifications. Additionally all equipment is verified for proper performance on a regular basics using in house standards or comparisons.

2.5 Measurement Uncertainty

The estimated combined standard uncertainty for radiated emissions and conducted emissions measurements as below table.

Parameter	Uncertainty
Radio Frequency	±1 x 10-7
RF Power (conducted)	±2.5 dB
Radiated Emission of Transmitter, valid up to 26.5 GHz	±6 dB
Radiated Emission of Receiver, valid up to 26.5 GHz	±6 dB
Conducted Emission, (9kHz to 150kHz)/(150kHz to 30MHz)	± 3.70 dB / ± 3.30 dB
Radiated Emission (3m SAC), 30MHz to 1000MHz	± 4.52 dB
Radiated Emission (3m SAC), above 1000MHz	± 4.37 dB

2.6 Location of Original Data

The original copies of all test data taken during actual testing were attached at Appendix A & B of this report and delivered to the applicant. A copy has been retained in the TÜV Rheinland (Shenzhen) Co., Ltd. file for certification follow-up purposes.

2.7 Status of Facility Used for Testing

The TÜV Rheinland (Shenzhen) Co., Ltd. Test facility located at 362 Huanguan Road Middle Longhua District, Shenzhen 518110 People's Republic of China is listed on the US Federal Communications Commission list of facilities approved to perform measurements.

3 General Product Information

3.1 Product Function and Intended Use

The EUT is a WisDuo LoRa Module which supports Lora technology.

This module has two different antennas, the details specifications for these antennas as below:

Antenna #	Model	Antenna Gain	Antenna Type	Connector Type
1#	RAKARG19	5.1dBi	Fiber Glass Antenna	N-type male connector
2#	KRAKBJ2701C01C	2.3 dBi	Dipole Antenna	RPSMA connector

When connecting to the module, the antenna need to transfer to an IPEX connector

Data Rate	Configuration	Indicative physical bit rate [bit/sec]
0	LoRa Modulation: SF10 / Bandwidth 125 kHz	980
1	LoRa Modulation: SF9 / Bandwidth 125 kHz	1760
2	LoRa Modulation: SF8 / Bandwidth 125 kHz	3125
3	LoRa Modulation: SF7 / Bandwidth 125 kHz	5470
4	LoRa Modulation: SF8 / Bandwidth 500 kHz	12500

For details refer to the User Manual, Technical Description and Circuit Diagram.

3.2 Ratings and System Details

Table 2: Technical Specification of EUT

General Information of EUT	**Value**
Kind of Equipment	WisDuo LoRa Module
Type Designation	RAK4200(H)
Trademark	RAK
FCC ID	2AF6B-RAK4200HX
IC	25908-RAK4200H
HVIN	RAK4200(H)
Operating Voltage	2.0VDC to 3.6VDC (Supplied by socket of PCB board)
Testing Voltage	DC 5V Via USB port
Technical Specification of Lora DTS	
Operating Frequency	903 – 914.2MHz
Type of Modulation	Lora
Data Rate	SF8 / DR4
Channel Number	8 channels (Upstream)
Channel Separation	1.6 MHz
Occupied Bandwidth	500 KHz

Technical Specification of Lora FHSS	
Frequency Range	902.3 – 914.9MHz
Type of Modulation	Lora
Data Rate	SF7 to SF10 / DR0 to DR3
Channel Number	64 channels (Upstream)
Channel Separation	200 KHz
Occupied Bandwidth	125 KHz

Table 3: RF Channel and Frequency of Lora FHSS

RF Channel	Frequency (MHz)	RF Channel	Frequency (MHz)	RF Channel	Frequency (MHz)	RF Channel	Frequency (MHz)
0	**902.3**	16	905.5	**32**	**908.7**	48	911.9
1	902.5	17	905.7	33	908.9	49	912.1
2	902.7	18	905.9	34	909.1	50	912.3
3	902.9	19	906.1	35	909.3	51	912.5
4	903.1	20	906.3	36	909.5	52	912.7
5	903.3	21	906.5	37	909.7	53	912.9
6	903.5	22	906.7	38	909.9	54	913.1
7	903.7	23	906.9	39	910.1	55	913.3
8	903.9	24	907.1	40	910.3	56	913.5
9	904.1	25	907.3	41	910.5	57	913.7
10	904.3	26	907.5	42	910.7	58	913.9
11	904.5	27	907.7	43	910.9	59	914.1
12	904.7	28	907.9	44	911.1	60	914.3
13	904.9	29	908.1	45	911.3	61	914.5
14	905.1	30	908.3	46	911.5	62	914.7
15	905.3	31	908.5	47	911.7	**63**	**914.9**

Table 4: RF Channel and Frequency of Lora DTS

RF Channel	Frequency (MHz)	RF Channel	Frequency (MHz)	RF Channel	Frequency (MHz)	RF Channel	Frequency (MHz)
64	**903.0**	66	906.2	68	909.4	70	912.6
65	904.6	**67**	**907.8**	69	911.0	**71**	**914.2**

3.3 Independent Operation Modes

The basic operation modes are:

A. On, Lora transmitting mode (FHSS)
    1) Low Channel
    2) Middle Channel
    3) High Channel

B. On, Lora transmitting mode (DTS)
    1) Low Channel
    2) Middle Channel
    3) High Channel

C. On, Transmitting on Hopping channel

D. Off

3.4 Noise Generating and Noise Suppressing Parts

Refer to Circuit Diagram for further details.

3.5 Submitted Documents

- ID Label and Location Info
- User Manual

4 Test Set-up and Operation Modes

4.1 Principle of Configuration Selection

Radio Spectrum: The equipment under test (EUT) was configured at its highest power output in order to measure its highest possible radiation and conducted level. The test modes were adapted accordingly in reference to the instructions for use.

Emission: The equipment under test (EUT) was configured to measure its highest possible radiation level. The test modes were adapted accordingly in reference to the instructions for use.

4.2 Test Operation and Test Software

Test operation refers to test setup in chapter 5. All tests were performed according to the procedures in ANSI C63.10: 2013 and ANSI C63.4: 2014.
According to clause 3.1, all tests were performed on model RAK4200(H) for KRAKBJ2701C01C & RAKARG19 antennas in this report.

4.3 Special Accessories and Auxiliary Equipment

Table 5: Auxiliary Equipment Used during Test

Description	Manufacturer	Model	S/N	Rating
PC	Lenovo	ThinkPad T480	N/A	PC
PC adapter	Lenovo	ADLX65YDC3A	01FR030	PC adapter

4.4 Countermeasures to Achieve EMC Compliance

The test sample which has been tested contained the noise suppression parts as described in the Technical Construction File (TCF).

No additional measures were employed to achieve compliance.

4.5 Test Setup Diagram

Diagram of Measurement Configuration for Radiation Test (Below 30MHz)

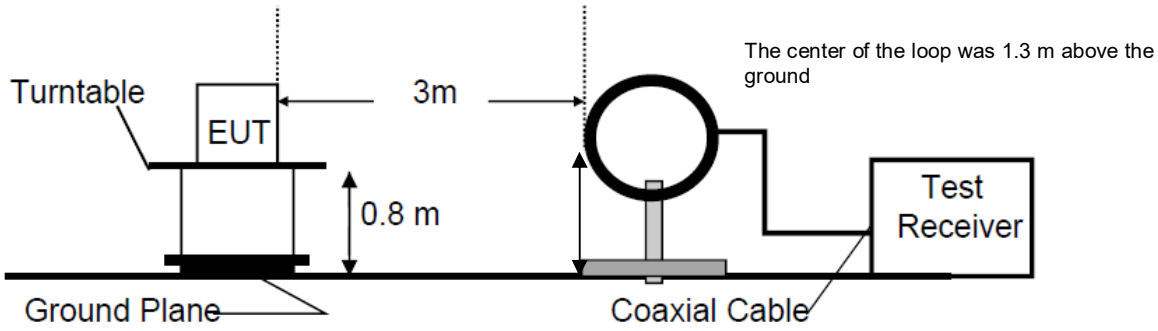


Diagram of Measurement Configuration for Radiation Test (Below 1GHz)

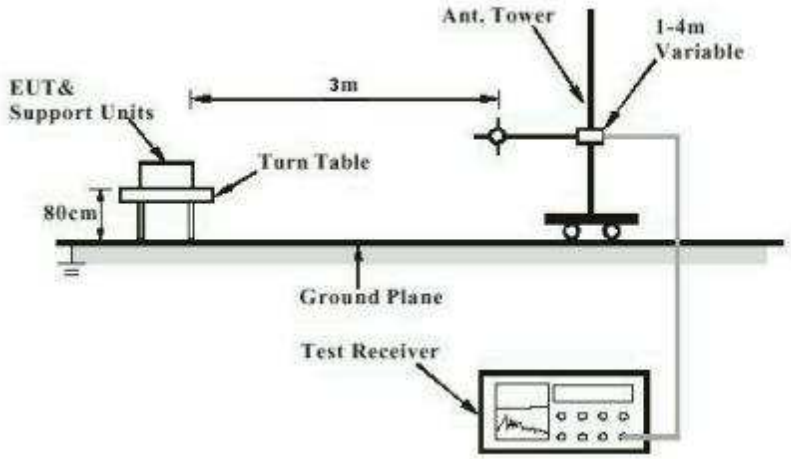


Diagram of Measurement Configuration for Radiation Test (Above 1GHz)

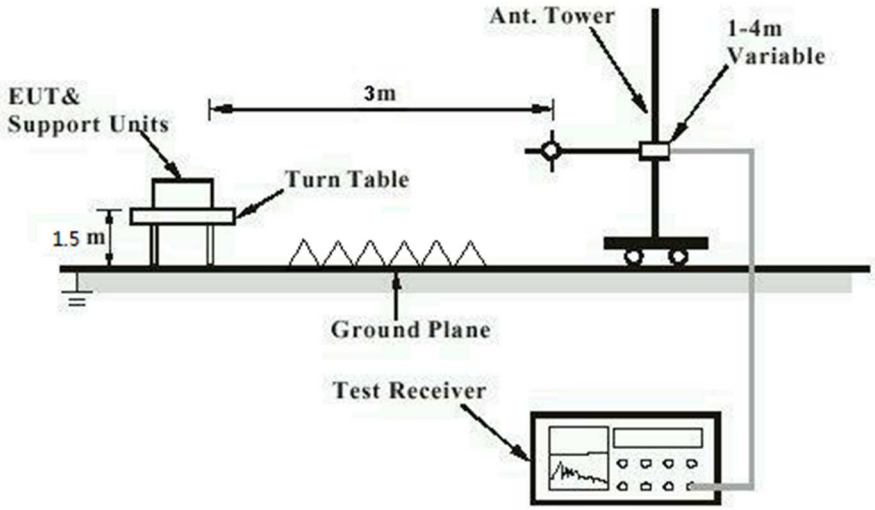


Diagram of Measurement Configuration for Mains Conduction Measurement

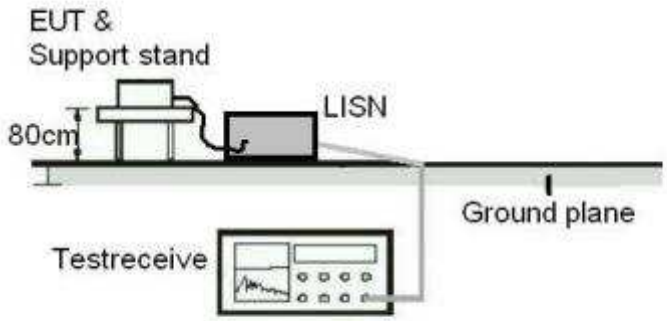
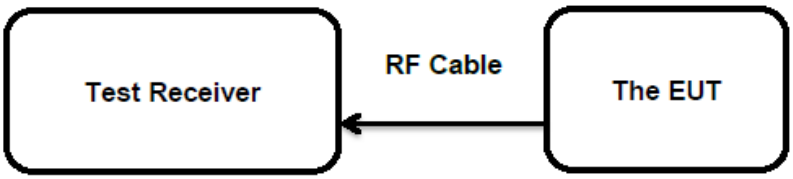


Diagram of Measurement Configuration for Conducted Transmitter Measurement



5 Test Results

5.1 Transmitter Requirement & Test Suites

5.1.1 Antenna Requirement

RESULT: **Pass**

Test Specification

Test standard : FCC Part 15.247(b)(4) and Part 15.203
RSS-Gen Clause 6.8

According to the manufacturer declared, the EUT has two IPEX Antenna, the directional gain of antenna are 2.3dBi & 5.1 dBi, and the antenna connector is designed with permanent attachment and no consideration of replacement. Therefore the EUT is considered sufficient to comply with the provision.

Refer to EUT Photo for further details.

5.1.2 Maximum Conducted Output Power

RESULT: **Pass**

Test Specification

Test standard	:	FCC Part 15.247(b)(2)&(3) RSS-247 Clause 5.4(a)&(d)
Basic standard	:	ANSI C63.10: 2013
Limits	:	Not more than 1Watt(30dBm) for DTS in the band 902-928MHz Not more than 1Watt(30dBm) for FHSS with at least 50 hopping channels in the band 902-928MHz
Kind of test site	:	Shielded Room

Test Setup

Date of testing	:	2021-11-04
Input voltage	:	DC 5V Via USB port
Operation mode	:	A, B
Test channel	:	Low / Middle / High
Ambient temperature	:	25 ℃
Relative humidity	:	56 %
Atmospheric pressure	:	101 kPa

Table 6: Test Result of Maximum Conducted Output Power, Lora FHSS

Test Mode	Test Channel (MHz)	Maximum Conducted Power		Limit (W)
		(dBm)	(W)	
Lora FHSS	902.3	19.50	0.0891	< 0.125
	908.7	19.48	0.0887	
	914.9	19.51	0.0893	
Max. Measured Value		19.51	0.0893	

Table 7: Test Result of Maximum Conducted Output Power, Lora DTS

Test Mode	Test Channel (MHz)	Maximum Conducted Power		Limit (W)
		(dBm)	(W)	
Lora DTS	903.0	19.55	0.0902	< 1.0
	907.8	19.54	0.0899	
	914.2	19.55	0.0902	
Max. Measured Value		19.55	0.0902	

Note:
1) The cable loss is taken into account in results.
2) The maximum Antenna gain(G) : 5.1 dBi,
e.i.r.p.=24.65dBm = 0.292W, which is far below the 4 W

5.1.3 Conducted Power Spectral Density

RESULT: **Pass**

Test Specification

Test standard	:	FCC Part 15.247(e) RSS-247 Clause 5.2(b)
Basic standard	:	ANSI C63.10: 2013
Limits	:	< 8 dBm / 3kHz
Kind of test site	:	Shielded Room

Test Setup

Date of testing	:	2021-11-04
Input voltage	:	DC 5V Via USB port
Operation mode	:	B
Test channel	:	Low / Middle / High
Ambient temperature	:	25 ℃
Relative humidity	:	56 %
Atmospheric pressure	:	101 kPa

For the measurement records, refer to the appendix B.

Table 8: Test Result of Maximum Peak Power Spectral Density, Lora DTS

Test Mode	Test Channel (MHz)	Measured Peak Power Spectral Density (dBm/3KHz)
Lora DTS	903.0	1.492
	907.8	0.606
	914.2	0.577
Maximum Measured Value		1.492

5.1.4 6dB Bandwidth

RESULT: **Pass**

Test Specification

Test standard	:	FCC Part 15.247(a)(2) RSS-247 Clause 5.2(a)
Basic standard	:	ANSI C63.10: 2013
Limits	:	At least 500kHz for bandwidth(DTS)
Kind of test site	:	Shielded Room

Test Setup

Date of testing	:	2021-11-04
Input voltage	:	DC 5V Via USB port
Operation mode	:	B
Test channel	:	Low / Middle / High
Ambient temperature	:	25 ℃
Relative humidity	:	56 %
Atmospheric pressure	:	101 kPa

For the measurement records, refer to the appendix B.

Table 9: Test Result of 6dB Bandwidth

Test Mode	Test Channel (MHz)	6dB Bandwidth (KHz)	Limit (KHz)
Lora DTS	903.0	715	>500KHz
	907.8	714	
	914.2	713	
Minimum Measured Value		715	

5.1.5 20dB Bandwidth

RESULT: **Pass**

Test Specification

Test standard	:	FCC Part 15.247(a)(1) (i) RSS-247 Clause 5.1(a)
Basic standard	:	ANSI C63.10: 2013
Limits	:	Not more than 500kHz and < 250KHz for at least 50 hopping frequencies >=250KHz for at least 25 hooping frequencies
Kind of test site	:	Shielded Room

Test Setup

Date of testing	:	2021-11-04
Input voltage	:	DC 5V Via USB port
Operation mode	:	A
Test channel	:	Low / Middle / High
Ambient temperature	:	25 ℃
Relative humidity	:	56 %
Atmospheric pressure	:	101 kPa

For the measurement records, refer to the appendix B.

Table 10: Test Result of 20dB Bandwidth

Test Mode	Channel Frequency (MHz)	20dB Bandwidth (kHz)	Limit (KHz)
Lora FHSS	902.3	136.910	<500KHz
	908.7	136.991	
	914.9	137.210	

5.1.6 99% Bandwidth

RESULT: **Pass**

Test Specification

Test standard	:	RSS-Gen Clause 6.7
Basic standard	:	ANSI C63.10: 2013
Kind of test site	:	Shielded Room

Test Setup

Date of testing	:	2021-11-04
Input voltage	:	DC 5V Via USB port
Operation mode	:	A, B
Test channel	:	Low / Middle / High
Ambient temperature	:	25 ℃
Relative humidity	:	56 %
Atmospheric pressure	:	101 kPa

For the measurement records, refer to the appendix B.

Table 11: Test Result of 99% Bandwidth

Test Mode	Test Channel (MHz)	99% Bandwidth (KHz)	Limit (KHz)
Lora FHSS	902.3	126.29	/
	908.7	130.86	
	914.9	127.06	
Lora DTS	903.0	511.81	
	907.8	513.05	
	914.2	514.26	
Minimum Measured Value		126.29	

5.1.7 Conducted Spurious Emissions Measured in 100 kHz Bandwidth

RESULT: **Pass**

Test Specification

Test standard	:	FCC Part 15.247(d) RSS-247 Clause 5.5
Basic standard	:	ANSI C63.10: 2013
Limits	:	20dB (below that in the 100kHz bandwidth within the band that contains the highest level of the desired power); In addition, radiated emissions which fall in the restricted bands, must also comply with the radiated emission limits specified in 15.209(a)
Kind of test site	:	Shielded Room

Test Setup

Date of testing	:	Refer to test result
Input voltage	:	DC 5V Via USB port
Operation mode	:	A, B
Test channel	:	Low / Middle / High
Ambient temperature	:	25 ℃
Relative humidity	:	56 %
Atmospheric pressure	:	101 kPa

Test results of 100kHz Bandwidth of Frequency Band Edge by Conducted method refer to test plots, and compliance is achieved as well.

For the measurement records, refer to the appendix B.

5.1.8 Radiated Spurious Emission

RESULT: **Pass**

Test Specification

Test standard	:	FCC Part 15.247(d) & FCC Part 15.205 RSS-247 Clause 3.3
Basic standard	:	ANSI C63.10: 2013
Limits	:	Refer to 15.209(a) of FCC part 15.247(d)
Kind of test site	:	3m Semi-anechoic Chamber

Test Setup

Date of testing	:	2021-11-05
Input voltage	:	DC 5V Via USB port
Operation mode	:	A, B
Test channel	:	Low / Middle / High
Ambient temperature	:	Refer to test result
Relative humidity	:	Refer to test result
Atmospheric pressure	:	101 kPa

Remark:
Testing was carried out within frequency range 9kHz to the tenth harmonics with all data rate and three channels (Lowest, middle and highest). Only the worst case spurious emissions configuration of the each mode were reported.

Radiated spurious emissions were performed on the EUT with antenna in three orthogonal orientations and only the worst (antenna vertical) orientations was recorded.

For the measurement records, refer to the appendix B.

5.1.9 Carrier Frequency Separation

RESULT: **Pass**

Test Specification

Test standard	:	FCC Part 15.247(a)(1) RSS-247 Clause 5.1(b)
Basic standard	:	ANSI C63.10: 2013
Limits	:	≥ 20dB bandwidth, whichever is greater
Kind of test site	:	Shielded Room

Test Setup

Date of testing	:	2021-11-04
Input voltage	:	DC 5V Via USB port
Operation mode	:	C
Test channel	:	Low / Middle / High
Ambient temperature	:	25 ℃
Relative humidity	:	56 %
Atmospheric pressure	:	101 kPa

For the measurement records, refer to the appendix B.

Table 12: Test Result of Carrier Frequency Separation

Test Mode	Channel	Measured Channel Separation (KHz)	Limit (kHz)	Result
Lora FHSS	Low Channel	254.029	≥ 20dB bandwidth	Pass
	Adjacency Channel			
	Middle Channel	271.502		Pass
	Adjacency Channel			
	High Channel	254.935		Pass
	Adjacency Channel			

Note:

The limit is maximum 20 dB bandwidth: 136.7 KHz.

5.1.10 Number of Hopping Frequency

RESULT: **Pass**

Test Specification

Test standard	:	FCC part 15.247(a)(1)(iii) RSS-247 Clause 5.1(d)
Basic standard	:	ANSI C63.10: 2013
Limits	:	≥ 15 non-overlapping channels
Kind of test site	:	Shielded Room

Test Setup

Date of testing	:	2021-11-04
Input voltage	:	DC 5V Via USB port
Operation mode	:	C
Ambient temperature	:	25 ℃
Relative humidity	:	56 %
Atmospheric pressure	:	101 kPa

Table 13: Test result of hopping channel number

Test Mode	20dB Bandwidth(kHz)	Hopping frequencies	Limit
Lora FHSS	20dB Bandwidth < 250	64	≥50

5.1.11 Time of Occupancy

RESULT: **Pass**

Test Specification

Test standard	:	FCC part 15.247(a)(1)(iii) RSS-247 Clause 5.1(d)
Basic standard	:	ANSI C63.10: 2013
Limits	:	< 0.4s
Kind of test site	:	Shielded Room

Test Setup

Date of testing	:	2021-11-11
Input voltage	:	DC 5V Via USB port
Operation mode	:	C
Test channel	:	Low / Middle / High
Ambient temperature	:	25 ℃
Relative humidity	:	56 %
Atmospheric pressure	:	101 kPa

For the measurement records, refer to the appendix B.

Table 14: Test result of Channel Occupancy

Test Mode	20dB Bandwidth(kHz)	Period (s)	Channel Occupancy Time (ms)	Limit (ms)
Lora FHSS	20dB Bandwidth < 250	20	60	400

5.1.12 Conducted Emission on AC Mains

RESULT: **Pass**

Test Specification

Test standard	:	FCC Part 15.207(a) RSS-Gen Clause 8.8
Basic standard	:	ANSI C63.10: 2013
Frequency range	:	0.15 – 30MHz
Limits	:	FCC Part 15.207(a) RSS-Gen Table 3
Kind of test site	:	Shielded Room

Test Setup

Date of testing	:	2021-11-11
Input voltage	:	Powered by PC Adapter
Operation mode	:	A, B
Earthing	:	Not connected
Ambient temperature	:	22 ℃
Relative humidity	:	64 %
Atmospheric pressure	:	101 kPa

For the measurement records, refer to the appendix B.

6 Safety Human Exposure

6.1 Radio Frequency Exposure Compliance

6.1.1 Electromagnetic Fields

RESULT: **Pass**

Test Specification

Test standard	:	CFR47 FCC Part 2: Section 2.1091
		CFR47 FCC Part 1: Section 1.1310
		FCC KDB Publication 447498 v06
		FCC KDB Publication 865664 D02 v01r02
		OET Bulletin 65 (Edition 97-01)
		RSS-102 Issue 5 March 2019

This module has two different antennas, and the maximum e.r.i.p. configuration be evaluated as below:
FCC requirement: Systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy level in excess limit for maximum permissible exposure. In accordance with 47 CFR FCC Part 2 Subpart J, section 2.1091 this device has been defined as a mobile device whereby a distance of 20cm normally can be maintained between the user and the device.

MPE Calculation Method according to OET Bulletin 65

Power Density: $S_{(mW/cm^2)}= PG/4\pi R^2$ or $EIRP/4\pi R^2$

Where:

S = power density (mW/cm^2)

P = power input to the antenna (mW)

G = power gain of the antenna in the direction of interest relative to an isotropic radiator

R = distance to the center of radiation of the antenna (cm)

The worst-case mode (the configuration having highest EIRP) specified:

Lora DTS: 19.55 dBm with 5.1 dBi antenna gain

From the RF output power, the minimum mobile separation distance, d=20 cm, as well as the antenna gain, the RF power density can be calculated as below:

For Lora DTS: $\mathbf{S_{(mW/cm^2)}= PG/4\pi R^2 =}$ 0.058 mW/cm^2

Limits for Maximum Permissible Exposure (MPE) according to FCC Part 1.1310: 1.0 mW/cm2

- **IC requirements:** The EUT shall comply with the requirement of RSS-102 section 2.5.2.

Exemption from Routine Evaluation Limits – RF Exposure Evaluation

RF exposure evaluation is required if the separation distance between the user and/or bystander and the device's radiating element is greater than 20 cm, except when the device operates as follows:

at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $1.31 \times 10^{-2} f^{0.6834}$ W (adjusted for tune-up tolerance), where f is in MHz;

- RF exposure evaluation exempted power for Lora FHSS & DTS: 1.37 W

The worst-case mode (the configuration having highest EIRP) specified:

Lora DTS: 19.55 dBm

Antenna Gain: 5.1 dBi

The Max. e.i.r.p. for Lora DTS: 24.65dBm = 0.292 W

Both e.i.r.p. for the Lora FHSS and Lora DTS are less than the RF exposure evaluation exempted power. So RF exposure evaluation is not required.

"RF Radiation Exposure Statement Caution: This Transmitter must be installed to provide a separation distance of at least 20 cm from all persons."

7 Photographs of the Test Set-Up

For photographs of the test set-up, refer to the appendix A.

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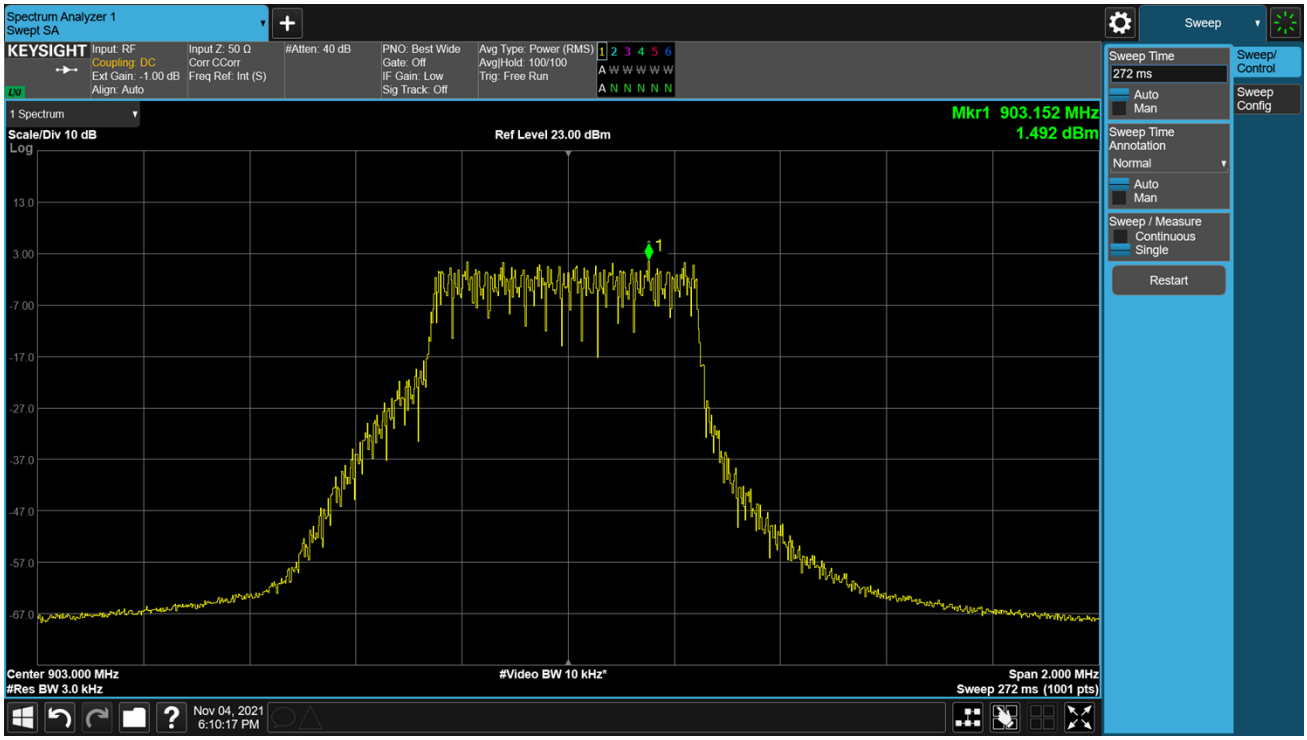
Appendix B.1: Conducted Power Spectral Density

Lora DTS

Low Channel



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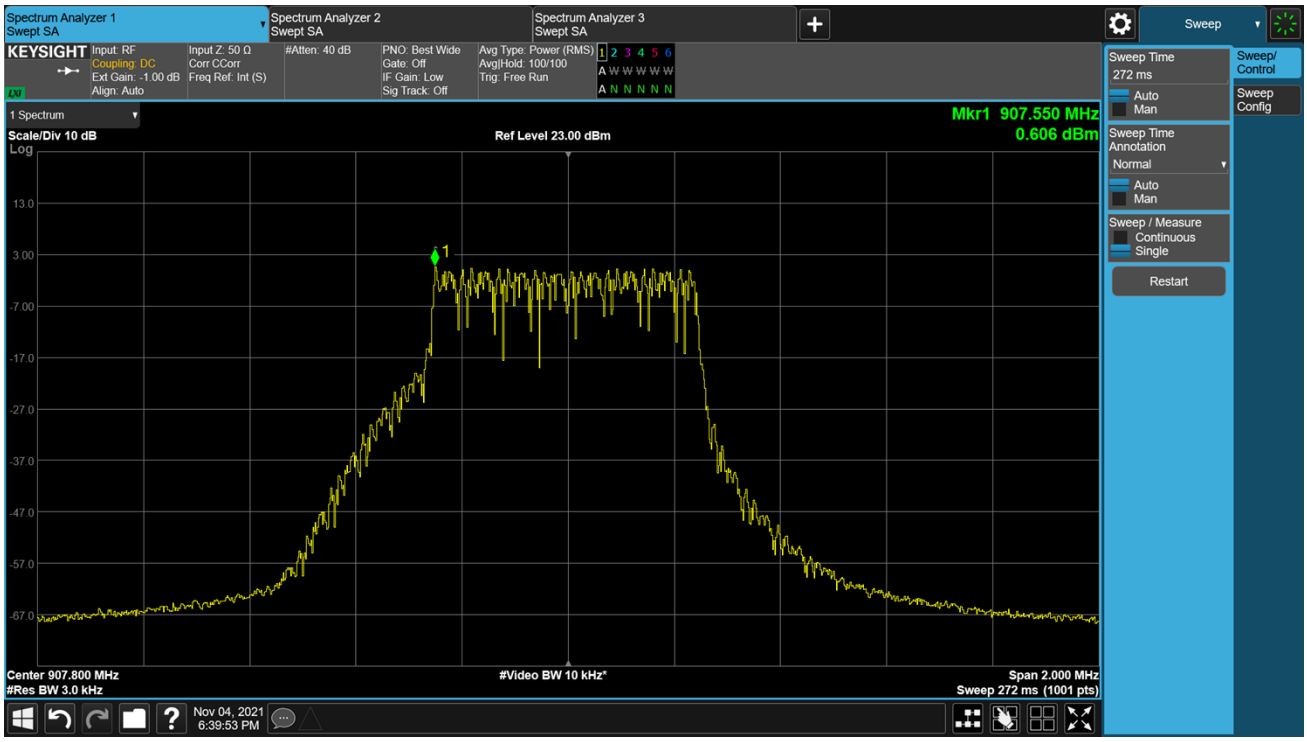
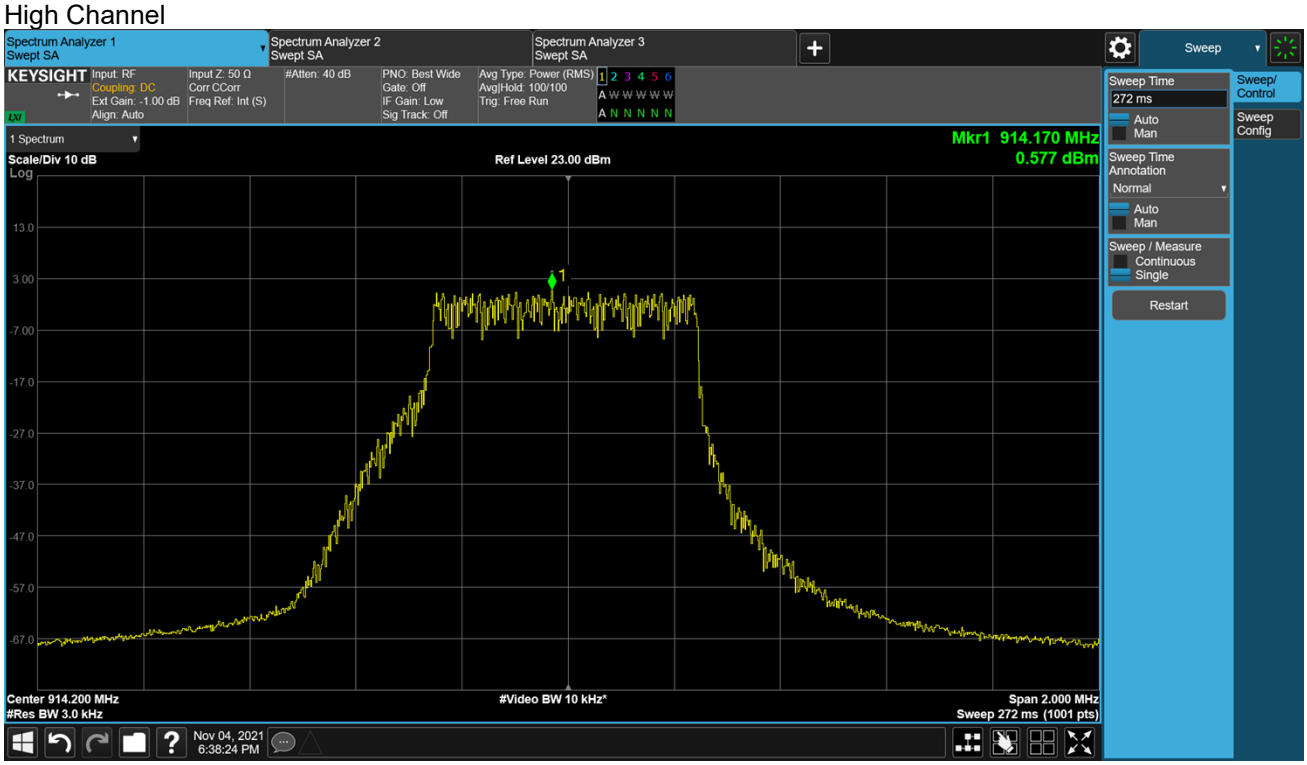
Middle Channel



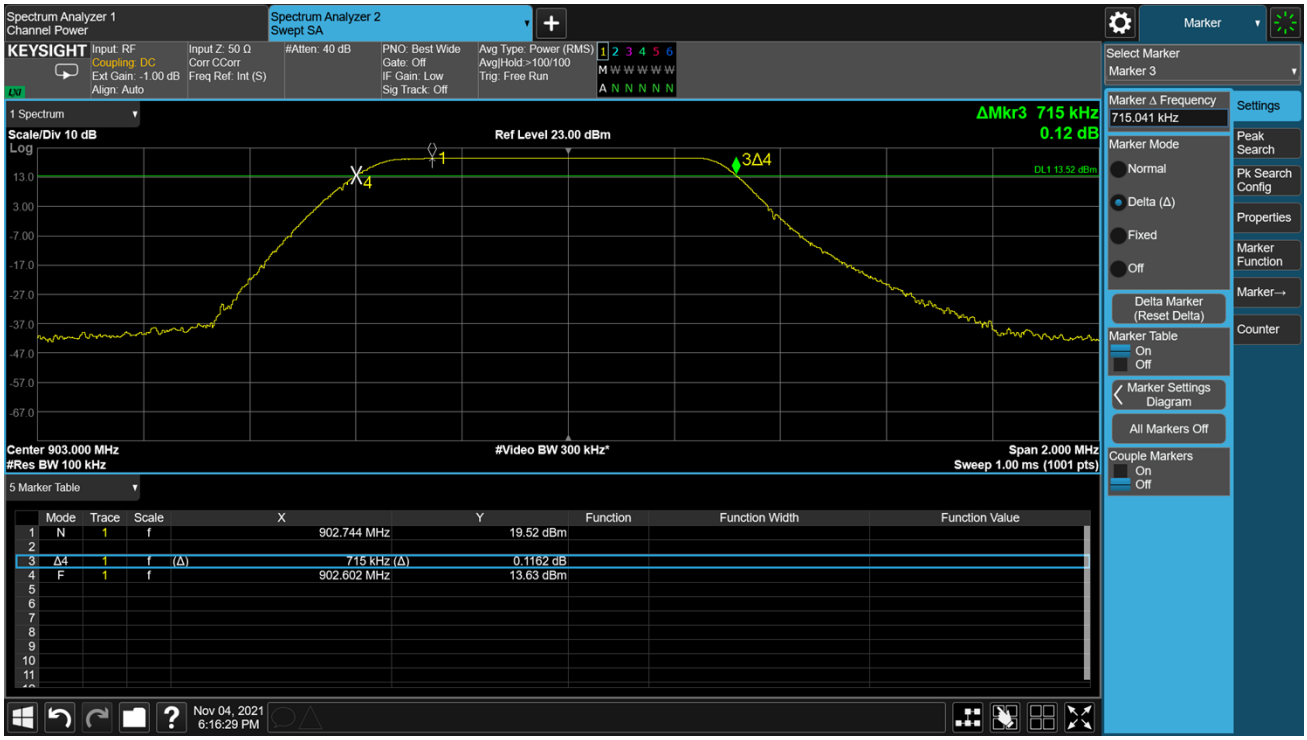
High Channel



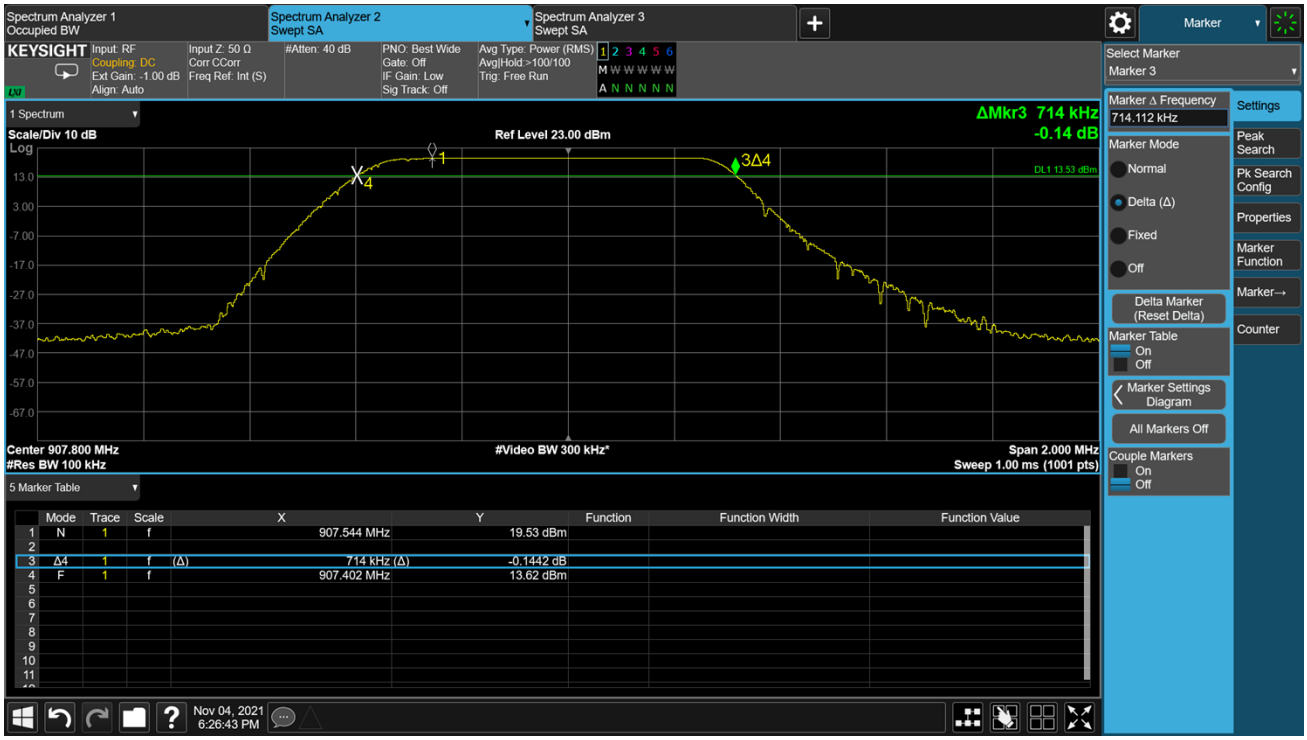
Appendix B.2: 6dB Bandwidth

Lora DTS

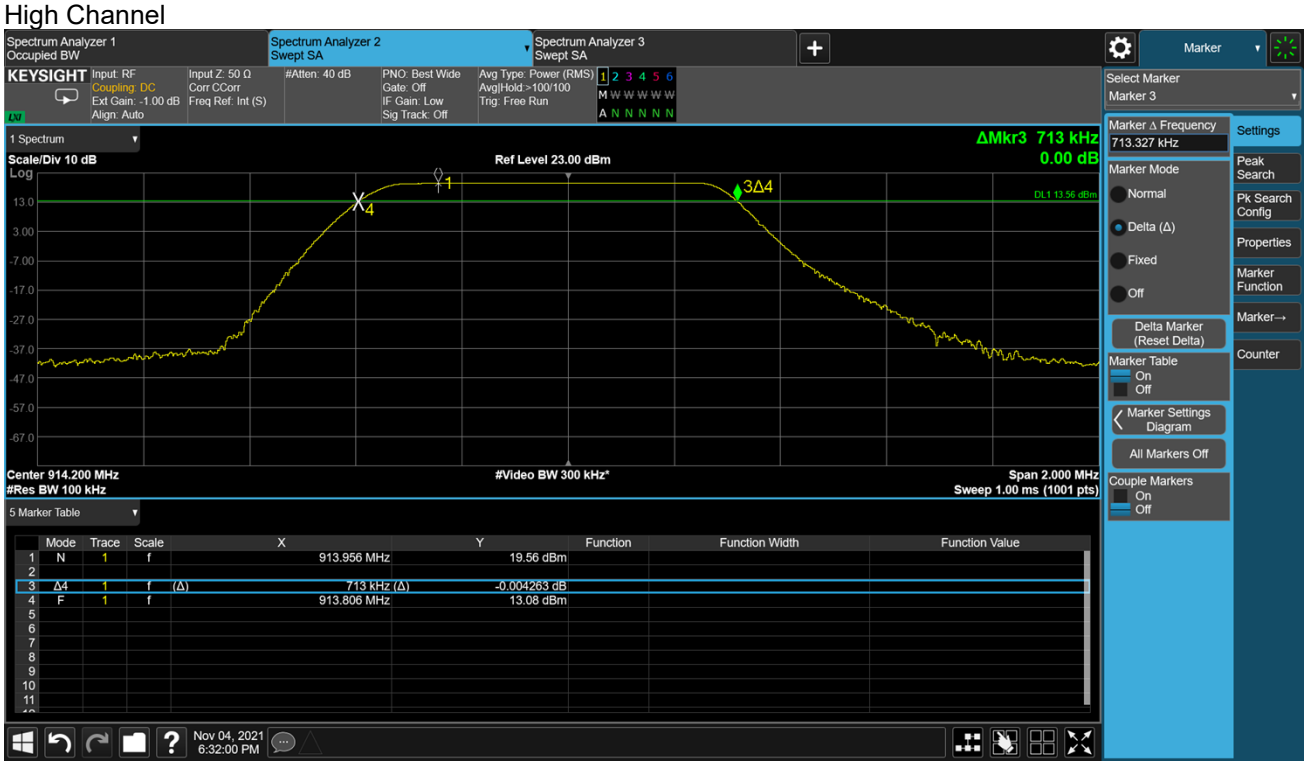
Low Channel



Middle Channel



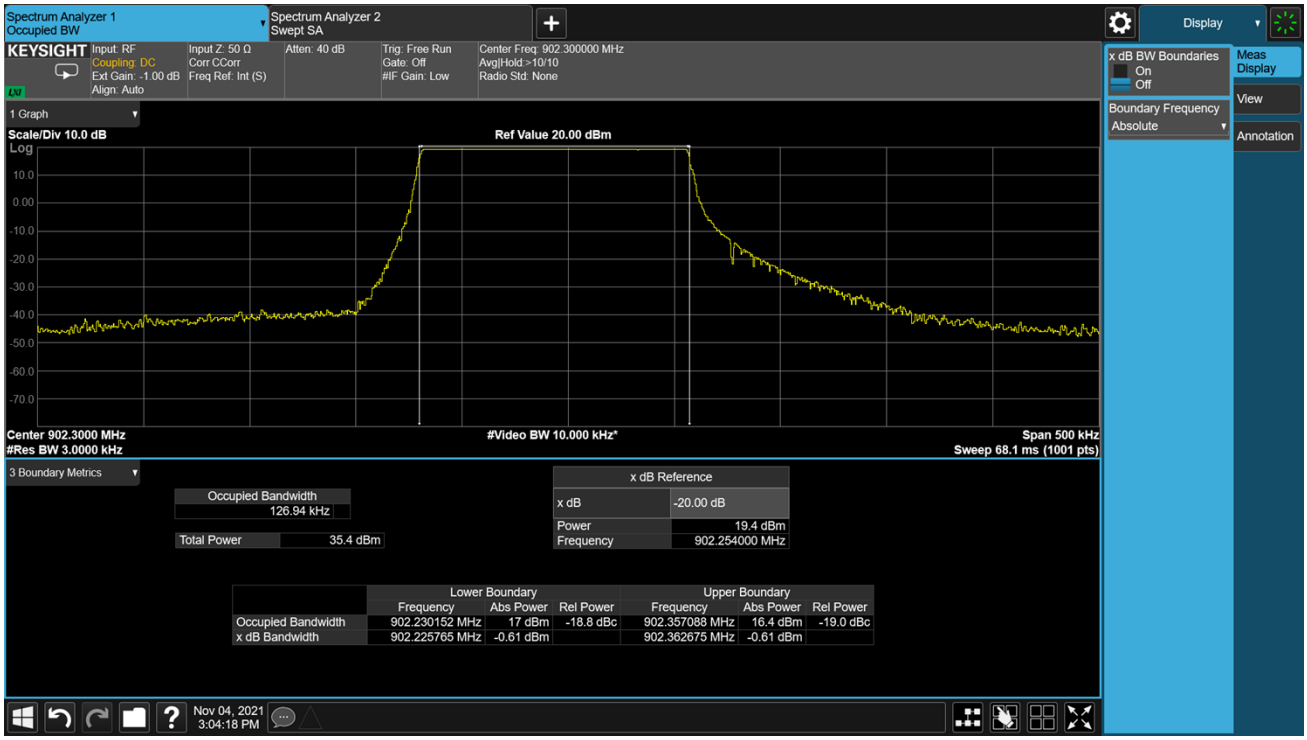
High Channel



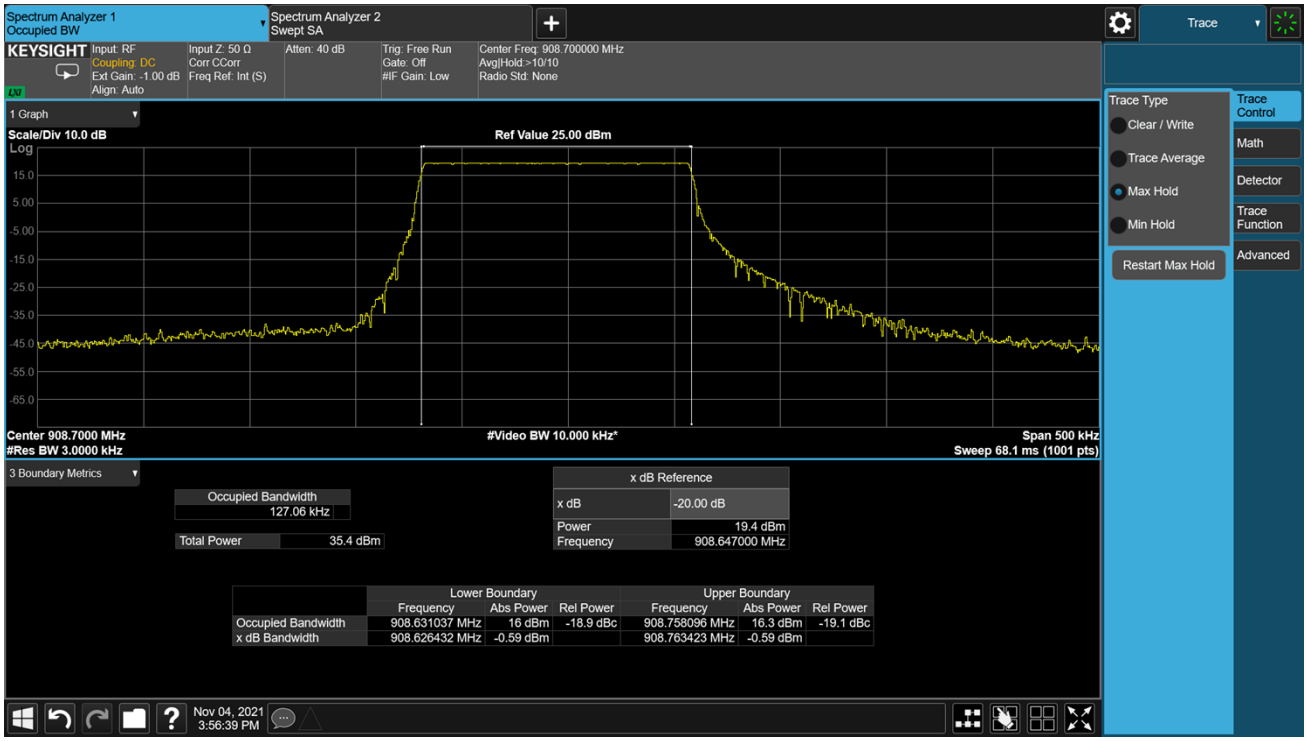
Appendix B.3: 20dB Bandwidth

Lora FHSS

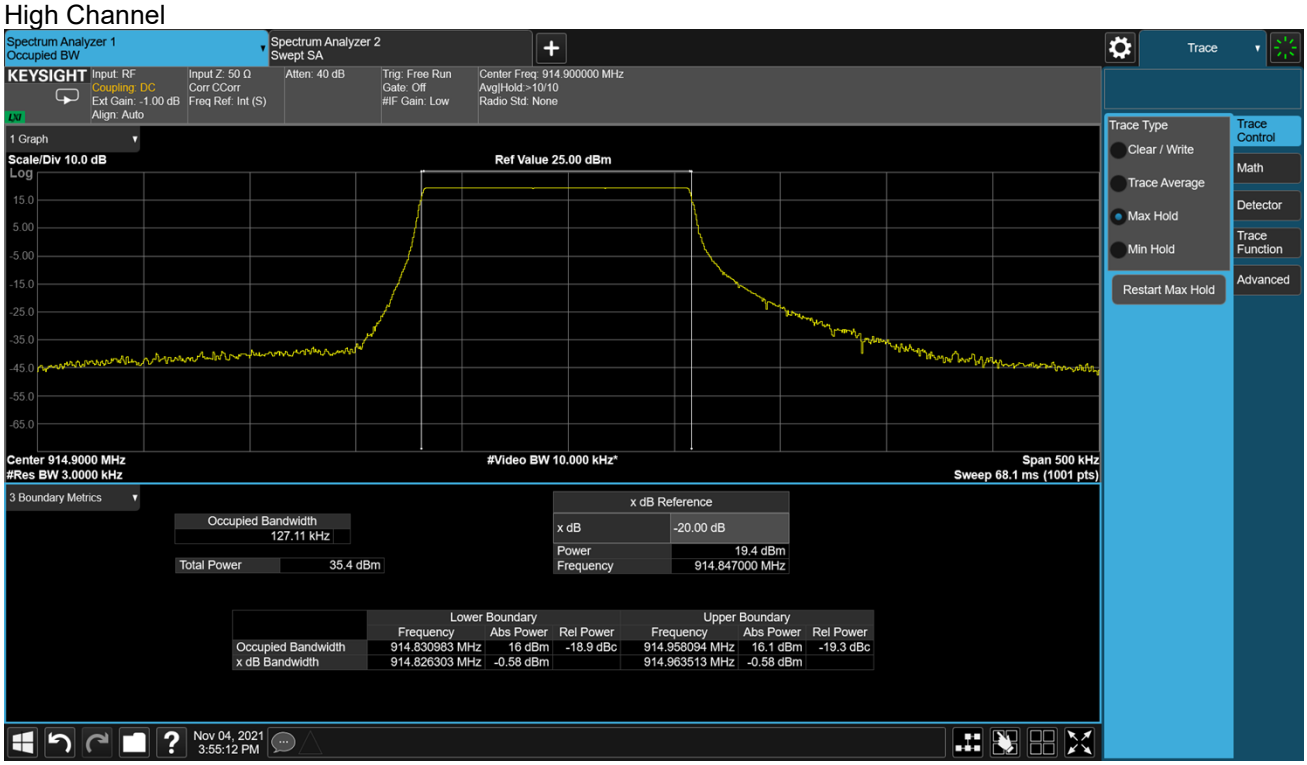
Low Channel



Middle Channel



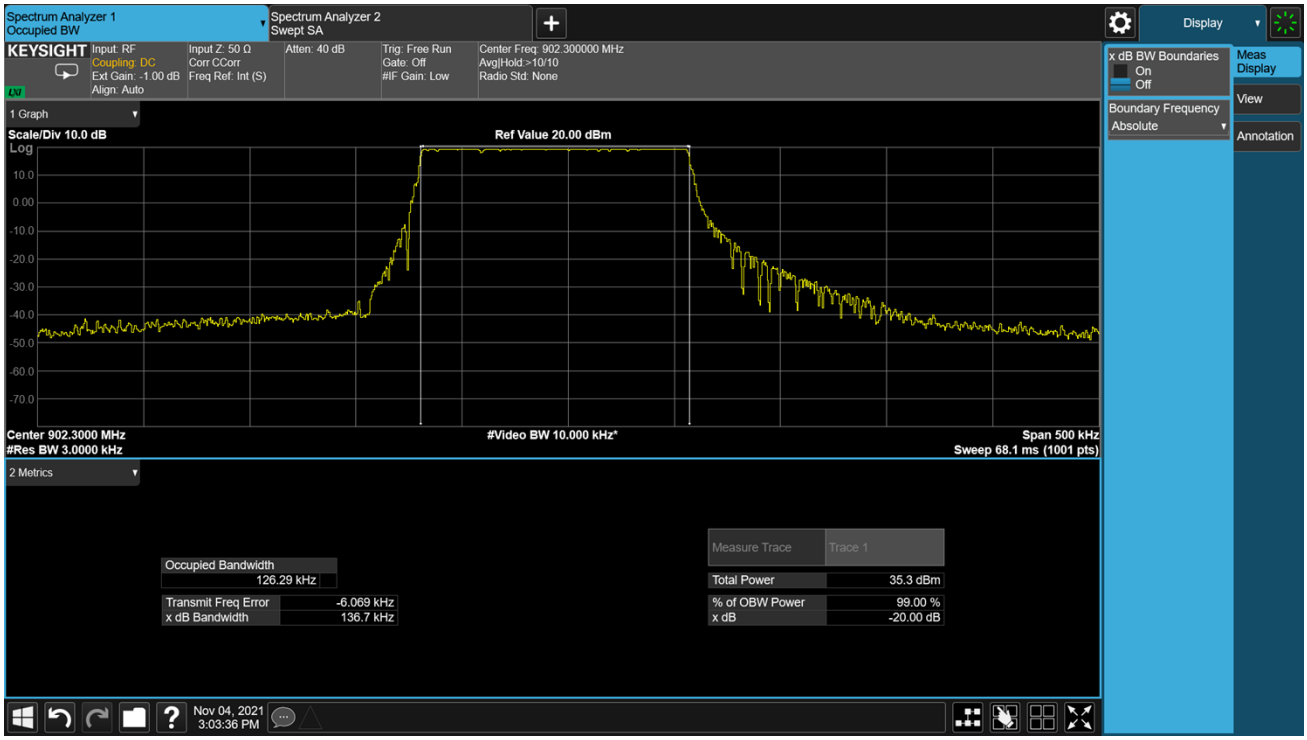
High Channel



Appendix B.4: 99% Bandwidth

Lora FHSS

Low Channel



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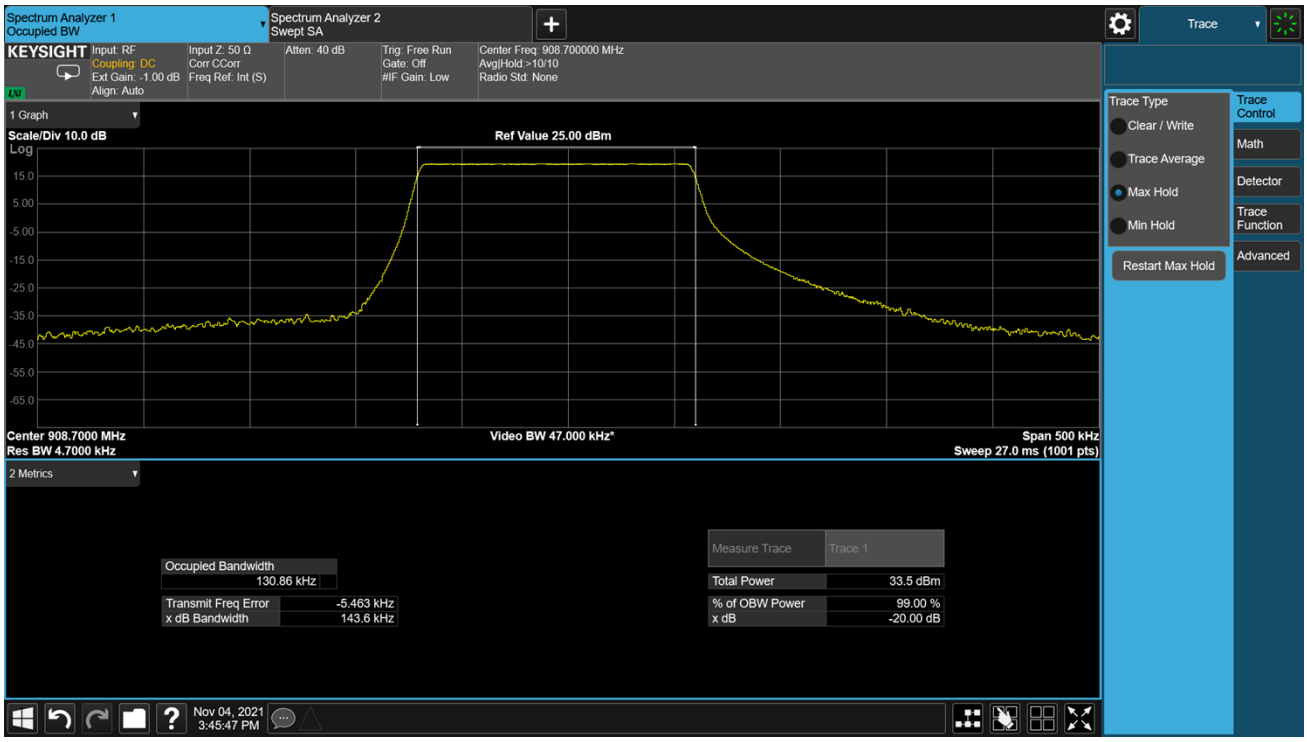
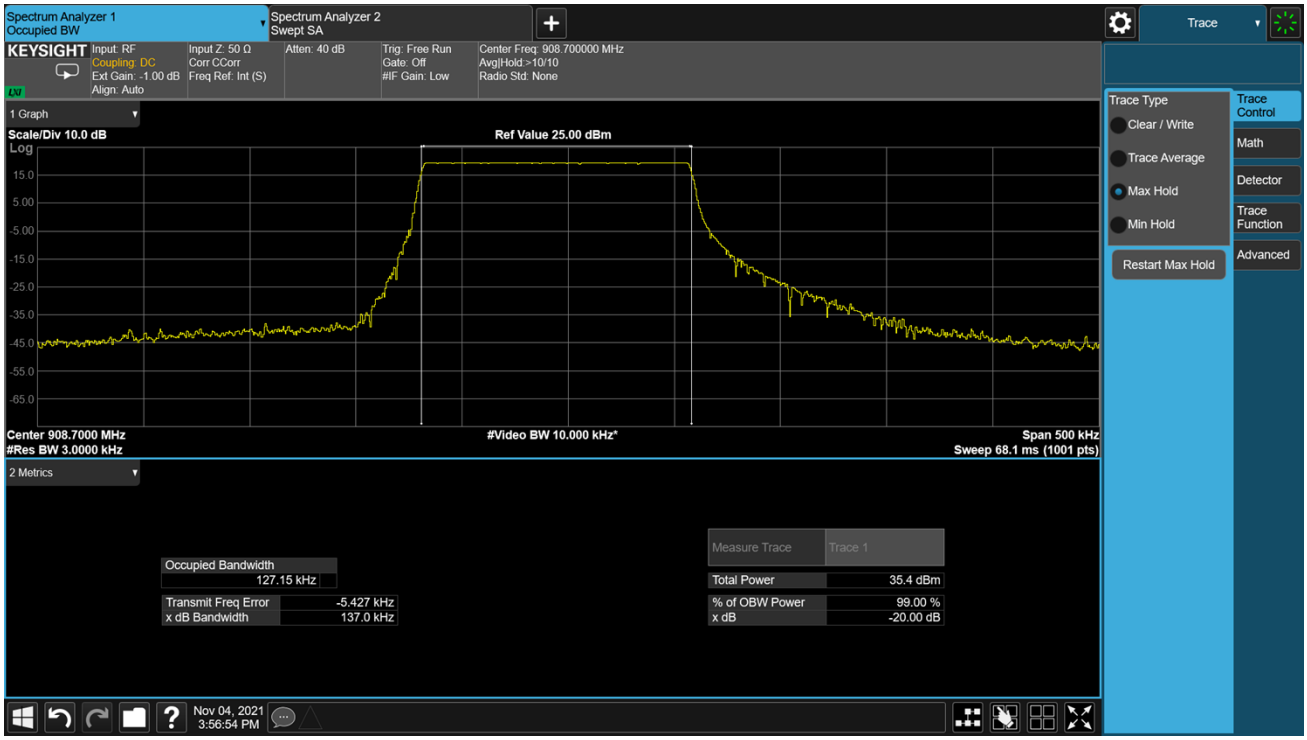
Middle Channel

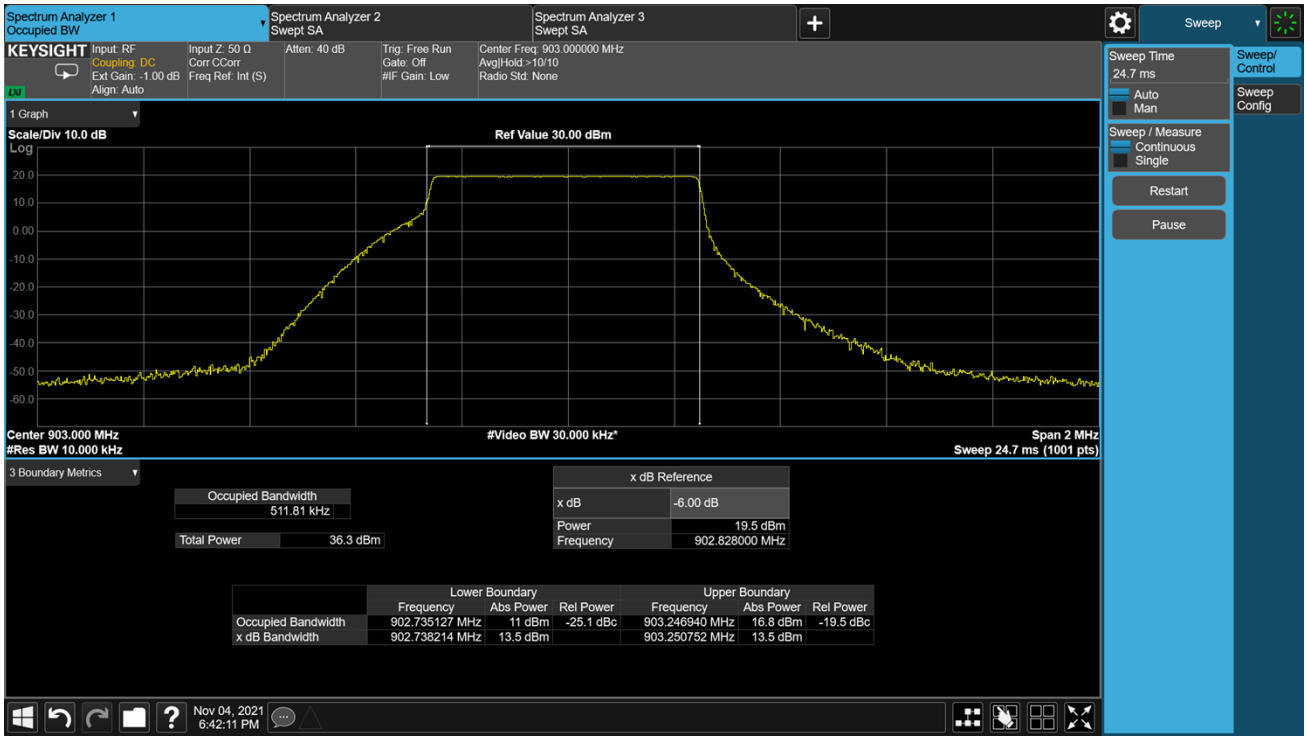


High Channel

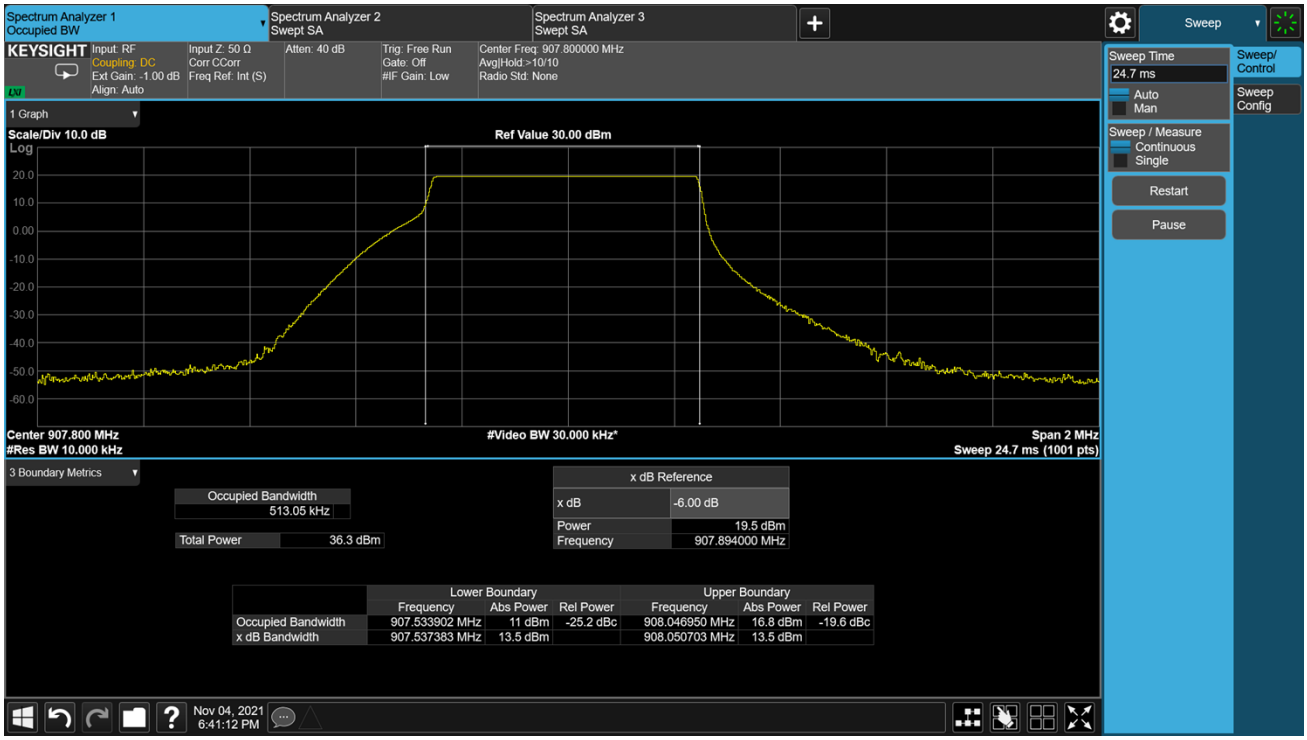


Lora DTS

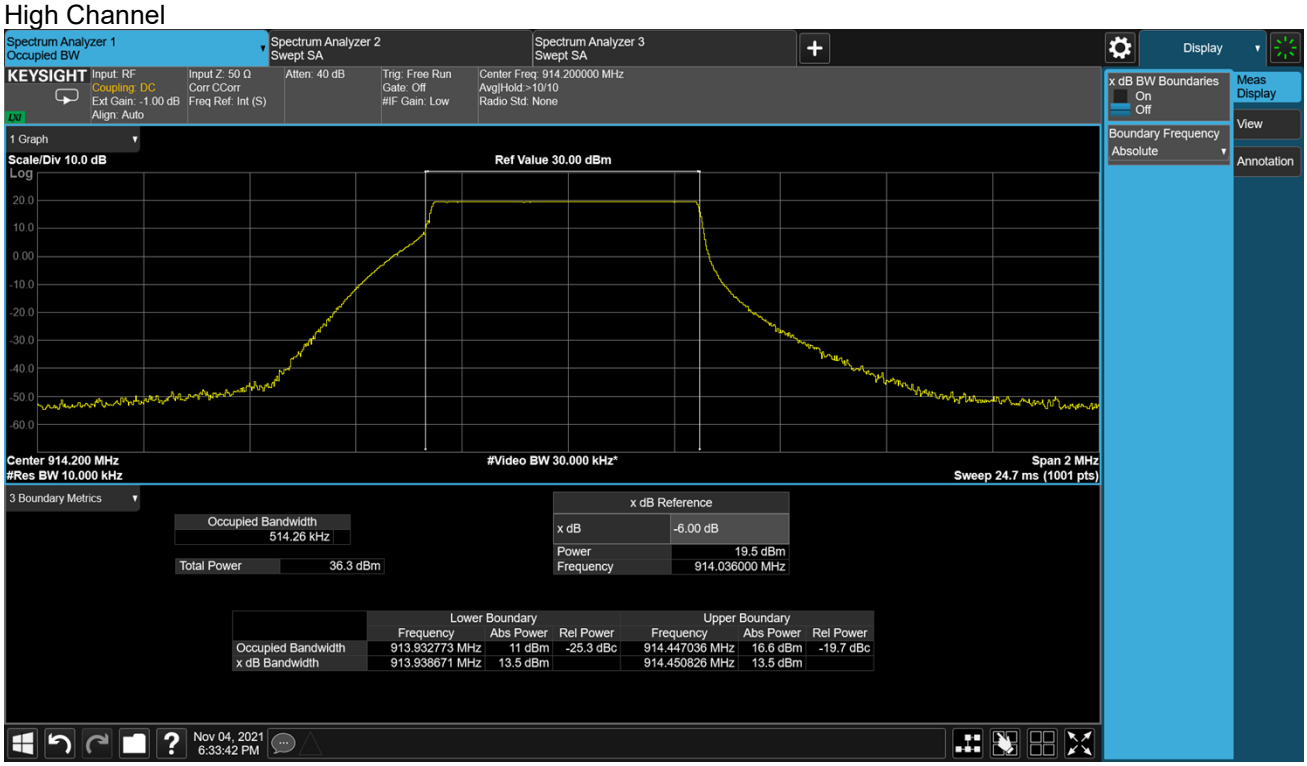
Low Channel



Middle Channel



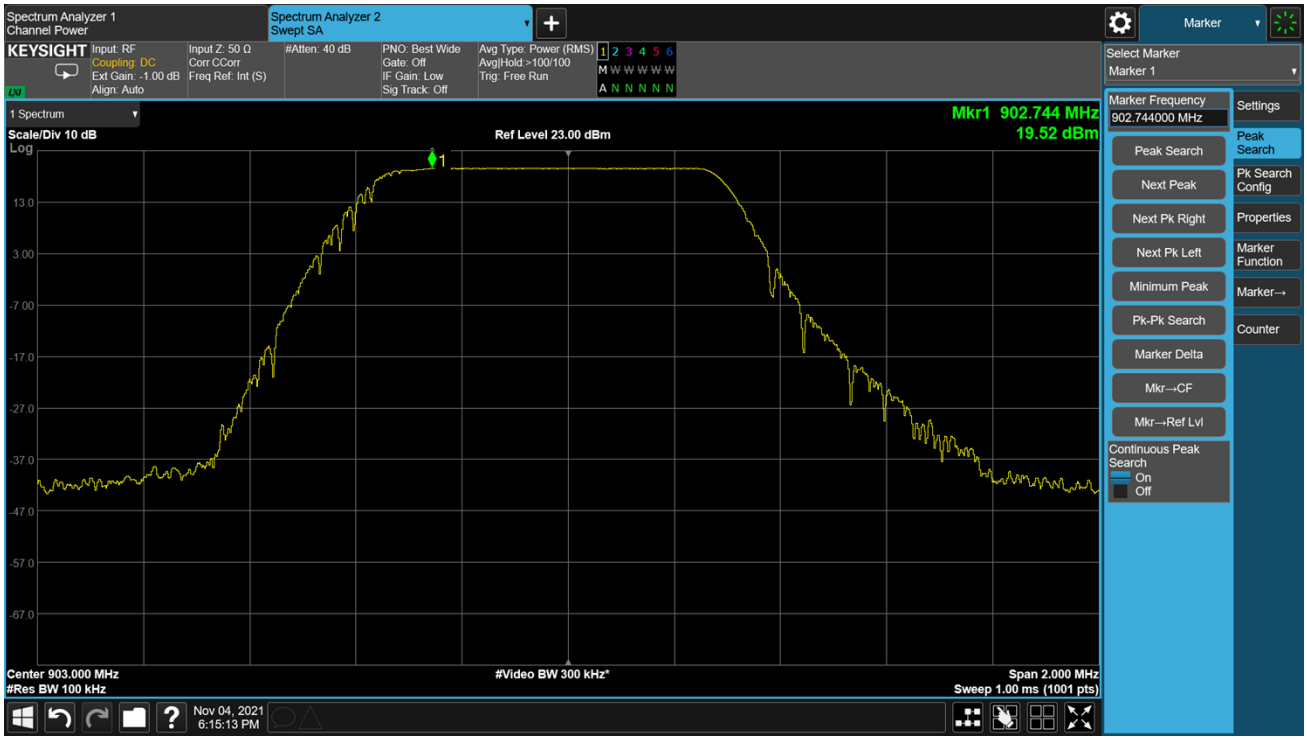
High Channel

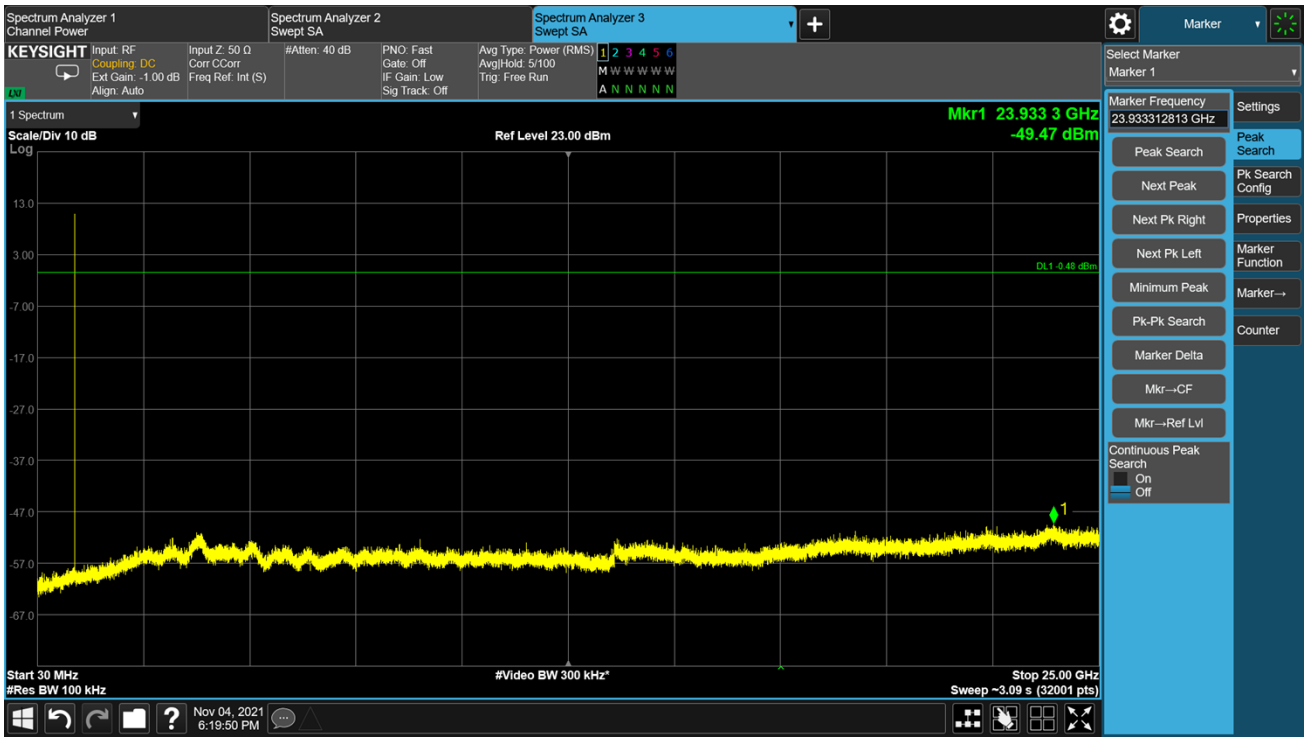


Appendix B.5: Conducted Spurious Emissions Measured in 100 kHz Bandwidth

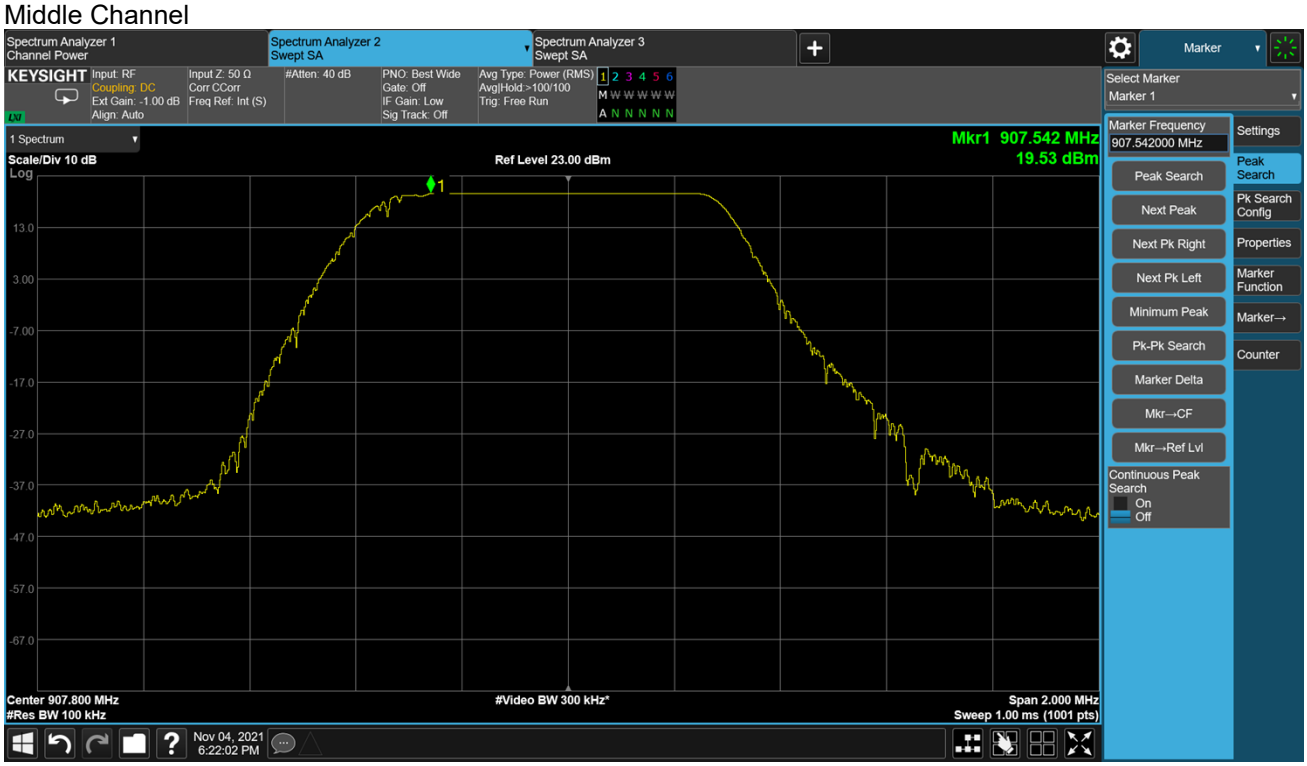
Lora DTS

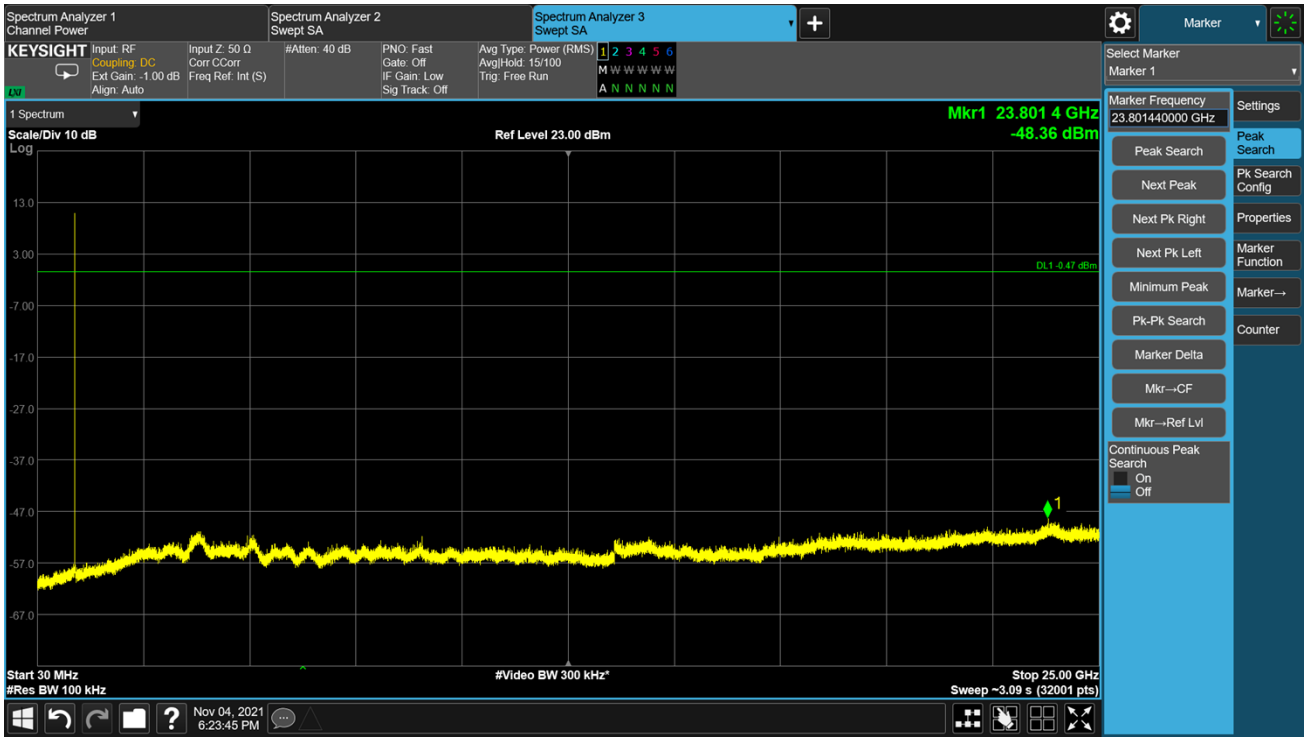
Low Channel





Middle Channel





High Channel