Prüfbericht-Nr.: *Test report no.:*	**CN24V7P1 001**	**Auftrags-Nr.:** *Order no.:*	168478328	Seite 1 von 31 *Page 1 of 31*
Kunden-Referenz-Nr.: *Client reference no.:*	N/A	**Auftragsdatum:** *Order date:*	2024-04-11	
Auftraggeber: *Client:*	**Shenzhen RAKwireless Technology Co.,Ltd.** Room 506, Building B, New Compark, Pingshan First Road, Taoyuan Street, Nanshan District, Shenzhen, Guangdong, P.R. China			
Prüfgegenstand: *Test item:*	WisDuo LPWAN+BLE Module			
Bezeichnung / Typ-Nr.: *Identification / Type no.:*	RAK11720 (Trademark: RAK)			
Auftrags-Inhalt: *Order content:*	FCC CIIPC and IC CIIIPC			
Prüfgrundlage: *Test specification:*	CFR47 FCC Part 15: Subpart C Section 15.247 RSS-247 Issue 3 August 2023 RSS-Gen Issue 5 February 2021			
Wareneingangsdatum: *Date of sample receipt:*	2024-04-11	Please refer to photo documents		
Prüfmuster-Nr.: *Test sample no.:*	A003697710-004~006			
Prüfzeitraum: *Testing period:*	2024-04-11 - 2024-05-17			
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 Hardy Suo	**genehmigt von:** *authorized by:*	X Lin Lin	
Datum: *Date:* 2024-05-27		**Ausstellungsdatum:** *Issue date:* 2024-05-27		
Stellung / Position	Sachverständige(r)/Expert	**Stellung** / Position	Sachverständige(r)/Expert	
Sonstiges / *Other:*	FCC ID: 2AF6B-RAK11720 IC: 25908-RAK11720, HVIN: RAK11720, FVIN: RUI_3.5.2+user_final.hex This report is a FCC CIIPC and IC CIIIPC report for adding additional LoRa operating bands, refer to section 3.1 for details.			
Zustand des Prüfgegenstandes bei Anlieferung: *Condition of the test item at delivery:*	Prüfmuster vollständig und unbeschädigt *Test item complete and undamaged:*			

* Legende:	P(ass) = entspricht o.g. Prüfgrundlage(n)	F(ail) = entspricht nicht o.g. Prüfgrundlage(n)	N/A = nicht anwendbar	N/T = nicht getestet
** Legend:*	*P(ass) = passed a.m. test specification(s)*	*F(ail) = failed a.m. test specification(s)*	*N/A = not applicable*	*N/T = not tested*

Dieser Prüfbericht bezieht sich nur auf das o.g. Prüfmuster und darf ohne Genehmigung der Prüfstelle nicht auszugsweise vervielfältigt werden. Dieser Bericht berechtigt nicht zur Verwendung eines Prüfzeichens.

This test report only relates to the a. m. test sample. Without permission of the test center this test report is not permitted to be duplicated in extracts. This test report does not entitle to carry any test mark.

V05

Anmerkungen
Remarks

1	Alle eingesetzten Prüfmittel waren zum angegebenen Prüfzeitraum gemäß eines festgelegten Kalibrierungsprogramms unseres Prüfhauses kalibriert. Sie entsprechen den in den Prüfprogrammen hinterlegten Anforderungen. Die Rückverfolgbarkeit der eingesetzten Prüfmittel ist durch die Einhaltung der Regelungen unseres Managementsystems gegeben. Detaillierte Informationen bezüglich Prüfkonditionen, Prüfequipment und Messunsicherheiten sind im Prüflabor vorhanden und können auf Wunsch bereitgestellt werden. *The equipment used during the specified testing period was calibrated according to our test laboratory calibration program. The equipment fulfils the requirements included in the relevant standards. The traceability of the test equipment used is ensured by compliance with the regulations of our management system.* *Detailed information regarding test conditions, equipment and measurement uncertainty is available in the test laboratory and could be provided on request.*
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4	Die Entscheidungsregel für Konformitätserklärungen basierend auf numerischen Messergebnisen in diesem Prüfbericht basiert auf der "Null-Grenzwert-Regel" und der "Einfachen Akzeptanz" gemäß ILAC G8:2019 und IEC Guide 115:2021, es sei denn, in der auf Seite 1 dieses Berichts genannten angewandten Norm ist etwas anderes festgelegt oder vom Kunden gewünscht. Dies bedeutet, dass die Messunsicherheit nicht berücksichtigt wird und daher auch nicht im Prüfbericht angegeben wird. Zu weiteren Informationen bezueglich des Risikos durch diese Entscheidungsregel siehe ILAC G8:2019. The decision rule for statements of conformity, based on numerical measurement results, in this test report is based on the “Zero Guard Band Rule” and “Simple Acceptance” in accordance with ILAC G8:2019 and IEC Guide 115:2021, unless otherwise specified in the applied standard mentioned on Page 1 of this report or requested by the customer. This means that measurement uncertainty is not taken in account and hence also not declared in the test report. For additional information to the resulting risk based of this decision rule please refer to ILAC G8:2019.

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

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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 (TS8997-R&S)						
Equip. No.	**Description**	**Manufacturer**	**Model**	**Serial No.**	**Calibrated Date (DD.MM.YYYY)**	**Calibrated until (DD.MM.YYYY)**
G1825795	Signal Analyzer	R&S	FSV 40	101441	26.07.2023	25.07.2024
G1825798	OSP	R&S	OSP 150	101017	14.11.2023	13.11.2024
G1825799	Control PC	DELL	OptiPlex 7050	FTJZ9P2	N/A	N/A
G1825800	Test Software	R&S	WMS32 (V11.00.00)	N/A	N/A	N/A
G1825801	Power Meter	R&S	NRP2	107105	14.11.2023	13.11.2024
G1829620	Power Sensor	R&S	NRP-Z81	105677	26.07.2023	25.07.2024
G1826483	Humid & Temp Programmable Tester	BOST	NTH090-60	19040801	01.03.2024	28.02.2025
G1826431	Shielding Room 8#	Albatross	SR8	APC1715 1-SR8	22.06.2021	22.06.2024
Unwanted Emission Testing (TS9975)						
Equip. No.	**Description**	**Manufacturer**	**Model**	**Serial No.**	**Calibrated Date (DD.MM.YYYY)**	**Calibrated until (DD.MM.YYYY)**
G1826021	EMI Test Receiver	R&S	ESR 7	102021	26.07.2023	25.07.2024
G1826023	Signal Analyzer	R&S	FSV 40	101439	26.07.2023	25.07.2024
G1826024	System Controller Interface	R&S	SCI-100	S1001003 8	N/A	N/A
G1826025	Filterbank	R&S	Wlan	100759	26.07.2023	25.07.2024
G1826026	OSP	R&S	OSP 120	102040	N/A	N/A
G1826028	Pre-amplifier	R&S	SCU08F1	08320031	26.07.2023	25.07.2024
G1826029	Amplifier	R&S	SCU-18F	180070	26.07.2023	25.07.2024
G1826030	Amplifier	R&S	SCU40A	100475	26.07.2023	25.07.2024
G1826031	Trilog Broadband Antenna (30 MHz - 7 GHz)	Schwarzbeck	VULB 9162	193	07.08.2022	06.08.2024
G1826032	Double-Ridged Antenna (1 -18 GHz)	ETS-LINDGREN	3117	00218717	07.08.2022	06.08.2024
G1826033	Wideband Ridged Horn Antenna (18-40 GHz)	Steatite	QMS-00880	19067	28.08.2022	27.08.2024
G1826034	Active Loop Antenna	Schwarzbeck	FMZB 1513	302	07.08.2022	06.08.2024
G1826036	Test software	R&S	EMC32 (V10.60.10)	N/A	N/A	N/A
G1826037	Control PC	Dell	OptiPlex 7050	36NV9P2	N/A	N/A
G1826433	3m Semi-Anechoic Chamber	Albatross	SAC-3m	APC1715 1-SAC	22.06.2021	22.06.2024

Terminal Disturbance Voltage at Mains Terminals					
Equip. No.	**Equipment**	**Manufacturer**	**M/N**	**S/N**	**Calibrated until**
GC-SZ 001009	EMI Test Receiver	R&S	ESR3	102428	2024-09-13
GC-SZ 001010	Artificial Mains Network	R&S	ENV216	102333	2024-07-31
GC-SZ 001011	Artificial Mains Network	R&S	ENV432	101411	2024-07-31
G1825090	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 WisBlock LPWAN Module which supports Lora and Bluetooth Low Energy technologies. This module has two different antennas for Lora and one antenna for BLE, the details specifications for these antennas as below:

For Lora:

Antenna #	Model	Antenna Gain	Antenna Type	Connector Type
1#	RAKARJ14	2.3 dBi	Dipole Antenna	RP-SMA connector
2#	RAKARJ16	2.3 dBi	Dipole Antenna	RP-SMA connector

Note:
1. When connecting to the module, all antennas listed above need to transfer to an **IPEX connector**.
2. Antennas 1# and 2# have the same type and similar in-band and out-of-band characteristics and only the color of enclosure differnet, they are considered as equivalent antennas. Thus, the antenna 1# was selected to be tested.

For BLE:

Antenna #	Model	Antenna Gain	Antenna Type	Connector Type
1#	S2B1BH2A1B01000	3.12 dBi	PCB Layout Antenna	IPEX connector

This report is a FCC CIIPC and IC CIIIPC report for adding additional LoRa operating bands. New added LoRa has two different independent configurations and they cannot work simultaneously, details as below:

Configuration 1:

Data Rate	SF (Spreading factor)	Operating Frequency
0	LoRa Modulation: SF10 / Bandwidth 125 kHz	Original: 902.3 – 914.9 MHz **New: 915.1 – 927.7 MHz**
1	LoRa Modulation: SF9 / Bandwidth 125 kHz	
2	LoRa Modulation: SF8 / Bandwidth 125 kHz	
3	LoRa Modulation: SF7 / Bandwidth 125 kHz	
4	LoRa Modulation: SF8 / Bandwidth 500 kHz	Original: 903 – 914.2 MHz **New: 915.8 – 927.0 MHz**

Configuration 2:

Data Rate	SF (Spreading factor)	Operating Frequency
0	LoRa Modulation: SF12 / Bandwidth 500 kHz	Original: n/a **New: 902.5 – 927.1 MHz**
1	LoRa Modulation: SF11 / Bandwidth 500 kHz	
2	LoRa Modulation: SF10 / Bandwidth 500 kHz	
3	LoRa Modulation: SF9 / Bandwidth 500 kHz	
4	LoRa Modulation: SF8 / Bandwidth 500 kHz	
5	LoRa Modulation: SF7 / Bandwidth 500 kHz	

This report only includes test data for new operating frequency for both config1&2.

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 LPWAN+BLE Module
Type Designation	RAK11720
Trademark	RAK
FCC ID	2AF6B-RAK11720
IC	25908-RAK11720
HVIN	RAK11720
Operating Voltage	DC 3.6V Max. (Supplied by socket of PCB borad)
Testing Voltage	DC 5V Via USB port
Technical Specification of Lora DTS	
Operating Frequency	903 – 914.2 MHz and 915.8 – 927.0 MHz 902.5 – 927.1 MHz
Type of Modulation	Lora
Data Rate	SF8 / DR4 for 903 – 914.2 MHz and 915.8 – 927.0 MHz SF7-SF12 / DR0 to DR5 for 902.5 – 927.1 MHz
Channel Number	16 channels (Upstream)
Channel Separation	1.6 MHz
Occupied Bandwidth	500 kHz
Technical Specification of Lora FHSS	
Frequency Range	902.3 – 914.9MHz and 915.1 – 927.7 MHz
Type of Modulation	Lora
Data Rate	SF7 to SF10 / DR0 to DR3
Channel Number	127 channels (Upstream)
Channel Separation	200 kHz
Occupied Bandwidth	125 kHz
Technical Specification of BLE	
Operating Frequency	2402 - 2480 MHz
Type of modulation	GFSK
Channel Number	40 channels
Channel Separation	2 MHz
Data Rate	1Mbps

Table 3: RF Channel and Frequency of Lora FHSS (902.3 – 914.9MHz and 915.1 – 927.7 MHz)

RF Channel	Center Frequency (MHz)	Occupied Bandwidth (kHz)	Channel Separation (kHz)	Modulation
0	902.30	125(SF7~SF10)	200	LoRa:CSS
1	902.50	125(SF7~SF10)	200	LoRa:CSS
2	902.70	125(SF7~SF10)	200	LoRa:CSS
3	902.90	125(SF7~SF10)	200	LoRa:CSS
4	903.10	125(SF7~SF10)	200	LoRa:CSS
5	903.30	125(SF7~SF10)	200	LoRa:CSS
6	903.50	125(SF7~SF10)	200	LoRa:CSS
7	903.70	125(SF7~SF10)	200	LoRa:CSS
8	903.90	125(SF7~SF10)	200	LoRa:CSS
9	904.10	125(SF7~SF10)	200	LoRa:CSS
10	904.30	125(SF7~SF10)	200	LoRa:CSS
11	904.50	125(SF7~SF10)	200	LoRa:CSS
12	904.70	125(SF7~SF10)	200	LoRa:CSS
13	904.90	125(SF7~SF10)	200	LoRa:CSS
14	905.10	125(SF7~SF10)	200	LoRa:CSS
15	905.30	125(SF7~SF10)	200	LoRa:CSS
16	905.50	125(SF7~SF10)	200	LoRa:CSS
17	905.70	125(SF7~SF10)	200	LoRa:CSS
18	905.90	125(SF7~SF10)	200	LoRa:CSS
19	906.10	125(SF7~SF10)	200	LoRa:CSS
20	906.30	125(SF7~SF10)	200	LoRa:CSS
21	906.50	125(SF7~SF10)	200	LoRa:CSS
22	906.70	125(SF7~SF10)	200	LoRa:CSS
23	906.90	125(SF7~SF10)	200	LoRa:CSS
24	907.10	125(SF7~SF10)	200	LoRa:CSS
25	907.30	125(SF7~SF10)	200	LoRa:CSS
26	907.50	125(SF7~SF10)	200	LoRa:CSS
27	907.70	125(SF7~SF10)	200	LoRa:CSS
28	907.90	125(SF7~SF10)	200	LoRa:CSS
29	908.10	125(SF7~SF10)	200	LoRa:CSS
30	908.30	125(SF7~SF10)	200	LoRa:CSS
31	908.50	125(SF7~SF10)	200	LoRa:CSS
32	908.70	125(SF7~SF10)	200	LoRa:CSS
33	908.90	125(SF7~SF10)	200	LoRa:CSS
34	909.10	125(SF7~SF10)	200	LoRa:CSS
35	909.30	125(SF7~SF10)	200	LoRa:CSS
36	909.50	125(SF7~SF10)	200	LoRa:CSS
37	909.70	125(SF7~SF10)	200	LoRa:CSS
38	909.90	125(SF7~SF10)	200	LoRa:CSS
39	910.10	125(SF7~SF10)	200	LoRa:CSS
40	910.30	125(SF7~SF10)	200	LoRa:CSS
41	910.50	125(SF7~SF10)	200	LoRa:CSS
42	910.70	125(SF7~SF10)	200	LoRa:CSS
43	910.90	125(SF7~SF10)	200	LoRa:CSS
44	911.10	125(SF7~SF10)	200	LoRa:CSS
45	911.30	125(SF7~SF10)	200	LoRa:CSS
46	911.50	125(SF7~SF10)	200	LoRa:CSS
47	911.70	125(SF7~SF10)	200	LoRa:CSS
48	911.90	125(SF7~SF10)	200	LoRa:CSS
49	912.10	125(SF7~SF10)	200	LoRa:CSS
50	912.30	125(SF7~SF10)	200	LoRa:CSS
51	912.50	125(SF7~SF10)	200	LoRa:CSS
52	912.70	125(SF7~SF10)	200	LoRa:CSS
53	912.90	125(SF7~SF10)	200	LoRa:CSS
54	913.10	125(SF7~SF10)	200	LoRa:CSS
55	913.30	125(SF7~SF10)	200	LoRa:CSS
56	913.50	125(SF7~SF10)	200	LoRa:CSS
57	913.70	125(SF7~SF10)	200	LoRa:CSS
58	913.90	125(SF7~SF10)	200	LoRa:CSS
59	914.10	125(SF7~SF10)	200	LoRa:CSS

60	914.30	125(SF7~SF10)	200	LoRa:CSS
61	914.50	125(SF7~SF10)	200	LoRa:CSS
62	914.70	125(SF7~SF10)	200	LoRa:CSS
63	914.90	125(SF7~SF10)	200	LoRa:CSS
64	915.10	125(SF7~SF10)	200	LoRa:CSS
65	915.30	125(SF7~SF10)	200	LoRa:CSS
66	915.50	125(SF7~SF10)	200	LoRa:CSS
67	915.70	125(SF7~SF10)	200	LoRa:CSS
68	915.90	125(SF7~SF10)	200	LoRa:CSS
69	916.10	125(SF7~SF10)	200	LoRa:CSS
70	916.30	125(SF7~SF10)	200	LoRa:CSS
71	916.50	125(SF7~SF10)	200	LoRa:CSS
72	916.70	125(SF7~SF10)	200	LoRa:CSS
73	916.90	125(SF7~SF10)	200	LoRa:CSS
74	917.10	125(SF7~SF10)	200	LoRa:CSS
75	917.30	125(SF7~SF10)	200	LoRa:CSS
76	917.50	125(SF7~SF10)	200	LoRa:CSS
77	917.70	125(SF7~SF10)	200	LoRa:CSS
78	917.90	125(SF7~SF10)	200	LoRa:CSS
79	918.10	125(SF7~SF10)	200	LoRa:CSS
80	918.30	125(SF7~SF10)	200	LoRa:CSS
81	918.50	125(SF7~SF10)	200	LoRa:CSS
82	918.70	125(SF7~SF10)	200	LoRa:CSS
83	918.90	125(SF7~SF10)	200	LoRa:CSS
84	919.10	125(SF7~SF10)	200	LoRa:CSS
85	919.30	125(SF7~SF10)	200	LoRa:CSS
86	919.50	125(SF7~SF10)	200	LoRa:CSS
87	919.70	125(SF7~SF10)	200	LoRa:CSS
88	919.90	125(SF7~SF10)	200	LoRa:CSS
89	920.10	125(SF7~SF10)	200	LoRa:CSS
90	920.30	125(SF7~SF10)	200	LoRa:CSS
91	920.50	125(SF7~SF10)	200	LoRa:CSS
92	920.70	125(SF7~SF10)	200	LoRa:CSS
93	920.90	125(SF7~SF10)	200	LoRa:CSS
94	921.10	125(SF7~SF10)	200	LoRa:CSS
95	921.30	125(SF7~SF10)	200	LoRa:CSS
96	921.50	125(SF7~SF10)	200	LoRa:CSS
97	921.70	125(SF7~SF10)	200	LoRa:CSS
98	921.90	125(SF7~SF10)	200	LoRa:CSS
99	922.10	125(SF7~SF10)	200	LoRa:CSS
100	922.30	125(SF7~SF10)	200	LoRa:CSS
101	922.50	125(SF7~SF10)	200	LoRa:CSS
102	922.70	125(SF7~SF10)	200	LoRa:CSS
103	922.90	125(SF7~SF10)	200	LoRa:CSS
104	923.10	125(SF7~SF10)	200	LoRa:CSS
105	923.30	125(SF7~SF10)	200	LoRa:CSS
106	923.50	125(SF7~SF10)	200	LoRa:CSS
107	923.70	125(SF7~SF10)	200	LoRa:CSS
108	923.90	125(SF7~SF10)	200	LoRa:CSS
109	924.10	125(SF7~SF10)	200	LoRa:CSS
110	924.30	125(SF7~SF10)	200	LoRa:CSS
111	924.50	125(SF7~SF10)	200	LoRa:CSS
112	924.70	125(SF7~SF10)	200	LoRa:CSS
113	924.90	125(SF7~SF10)	200	LoRa:CSS
114	925.10	125(SF7~SF10)	200	LoRa:CSS
115	925.30	125(SF7~SF10)	200	LoRa:CSS
116	925.50	125(SF7~SF10)	200	LoRa:CSS
117	925.70	125(SF7~SF10)	200	LoRa:CSS
118	925.90	125(SF7~SF10)	200	LoRa:CSS
119	926.10	125(SF7~SF10)	200	LoRa:CSS
120	926.30	125(SF7~SF10)	200	LoRa:CSS
121	926.50	125(SF7~SF10)	200	LoRa:CSS

122	926.70	125(SF7~SF10)	200	LoRa:CSS
123	926.90	125(SF7~SF10)	200	LoRa:CSS
124	927.10	125(SF7~SF10)	200	LoRa:CSS
125	927.30	125(SF7~SF10)	200	LoRa:CSS
126	927.50	125(SF7~SF10)	200	LoRa:CSS
127	927.70	125(SF7~SF10)	200	LoRa:CSS

Table 4: RF Channel and Frequency of Lora DTS (903 – 914.2 MHz and 915.8 – 927.0 MHz)

RF Channel	Center Frequency (MHz)	Occupied Bandwidth (kHz)	Channel Separation (kHz)	Modulation
1	903.00	500(SF8)	1600	LoRa:CSS
2	904.60	500(SF8)	1600	LoRa:CSS
3	906.20	500(SF8)	1600	LoRa:CSS
4	907.80	500(SF8)	1600	LoRa:CSS
5	909.40	500(SF8)	1600	LoRa:CSS
6	911.00	500(SF8)	1600	LoRa:CSS
7	912.60	500(SF8)	1600	LoRa:CSS
8	914.20	500(SF8)	1600	LoRa:CSS
9	915.80	500(SF8)	1600	LoRa:CSS
10	917.40	500(SF8)	1600	LoRa:CSS
11	919.00	500(SF8)	1600	LoRa:CSS
12	920.60	500(SF8)	1600	LoRa:CSS
13	922.20	500(SF8)	1600	LoRa:CSS
14	923.80	500(SF8)	1600	LoRa:CSS
15	925.40	500(SF8)	1600	LoRa:CSS
16	927.00	500(SF8)	1600	LoRa:CSS

Table 5: RF Channel and Frequency of Lora DTS (902.5 – 927.1 MHz)

RF Channel	Center Frequency (MHz)	Occupied Bandwidth (kHz)	Channel Separation (kHz)	Modulation
0	902.50	500	600	LoRa:CSS
1	903.10	500	600	LoRa:CSS
2	903.70	500	600	LoRa:CSS
3	904.30	500	600	LoRa:CSS
4	904.90	500	600	LoRa:CSS
5	905.50	500	600	LoRa:CSS
6	906.10	500	600	LoRa:CSS
7	906.70	500	600	LoRa:CSS
8	907.30	500	600	LoRa:CSS
9	907.90	500	600	LoRa:CSS
10	908.50	500	600	LoRa:CSS
11	909.10	500	600	LoRa:CSS
12	909.70	500	600	LoRa:CSS
13	910.30	500	600	LoRa:CSS
14	910.90	500	600	LoRa:CSS
15	911.50	500	600	LoRa:CSS
16	912.10	500	600	LoRa:CSS
17	912.70	500	600	LoRa:CSS
18	913.30	500	600	LoRa:CSS
19	913.90	500	600	LoRa:CSS
20	914.50	500	600	LoRa:CSS
21	915.10	500	600	LoRa:CSS
22	915.70	500	600	LoRa:CSS
23	916.30	500	600	LoRa:CSS
24	916.90	500	600	LoRa:CSS
25	917.50	500	600	LoRa:CSS
26	918.10	500	600	LoRa:CSS
27	918.70	500	600	LoRa:CSS
28	919.30	500	600	LoRa:CSS
29	919.90	500	600	LoRa:CSS
30	920.50	500	600	LoRa:CSS
31	921.10	500	600	LoRa:CSS

32	921.70	500	600	LoRa:CSS
33	922.30	500	600	LoRa:CSS
34	922.90	500	600	LoRa:CSS
35	923.50	500	600	LoRa:CSS
36	924.10	500	600	LoRa:CSS
37	924.70	500	600	LoRa:CSS
38	925.30	500	600	LoRa:CSS
39	925.90	500	600	LoRa:CSS
40	926.50	500	600	LoRa:CSS
41	927.10	500	600	LoRa:CSS

Table 6: RF Channel and Frequency of Bluetooth Low Energy

RF Channel	Frequency (MHz)	RF Channel	Frequency (MHz)	RF Channel	Frequency (MHz)	RF Channel	Frequency (MHz)
00	**2402.00**	10	2422.00	20	2442.00	30	2462.00
01	2404.00	11	2424.00	21	2444.00	31	2464.00
02	2406.00	12	2426.00	22	2446.00	32	2466.00
03	2408.00	13	2428.00	23	2448.00	33	2468.00
04	2410.00	14	2430.00	24	2450.00	34	2470.00
05	2412.00	15	2432.00	25	2452.00	35	2472.00
06	2414.00	16	2434.00	26	2454.00	36	2474.00
07	2416.00	17	2436.00	27	2456.00	37	2476.00
08	2418.00	18	2438.00	28	2458.00	38	2478.00
09	2420.00	**19**	**2440.00**	29	2460.00	**39**	**2480.00**

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 (Lora FHSS)

D. On, Simultaneous Transmission operation mode (Lora +BLE)

E. 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 RAK11720.

4.3 Special Accessories and Auxiliary Equipment

Table 7: Auxiliary Equipment Used during Test

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

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)

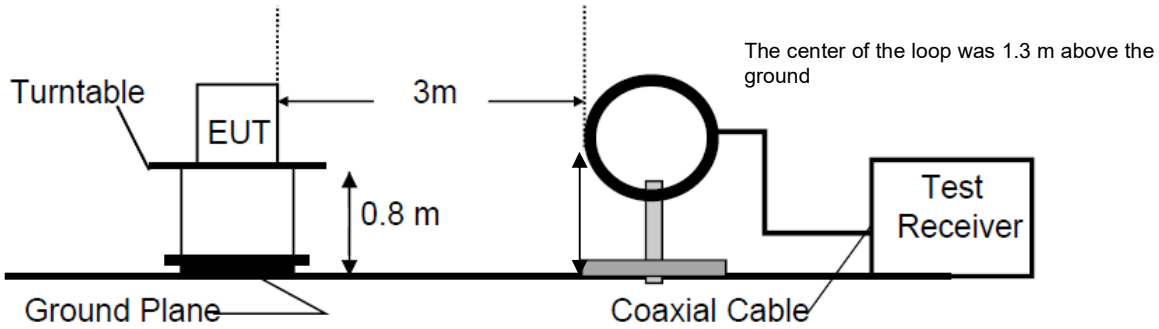


Diagram of Measurement Configuration for Radiation Test (Below 1GHz)

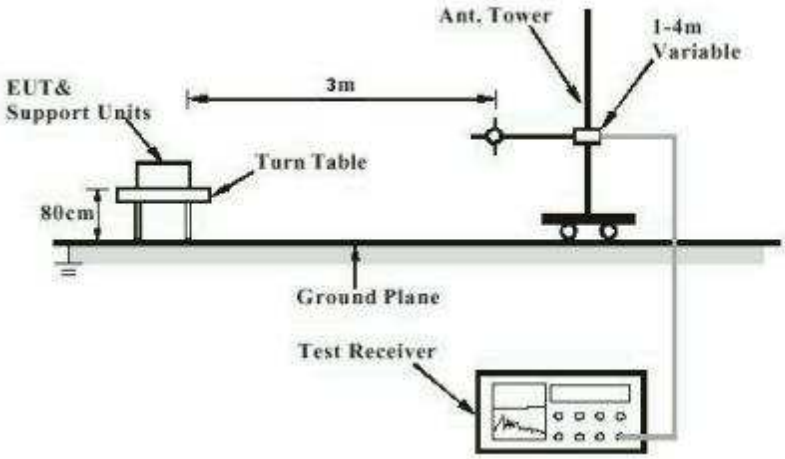


Diagram of Measurement Configuration for Radiation Test (Above 1GHz)

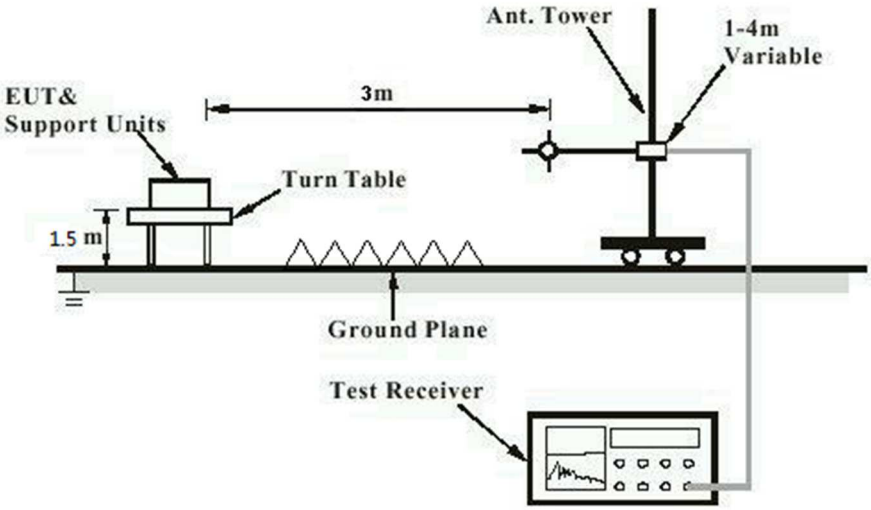


Diagram of Measurement Configuration for Mains Conduction Measurement

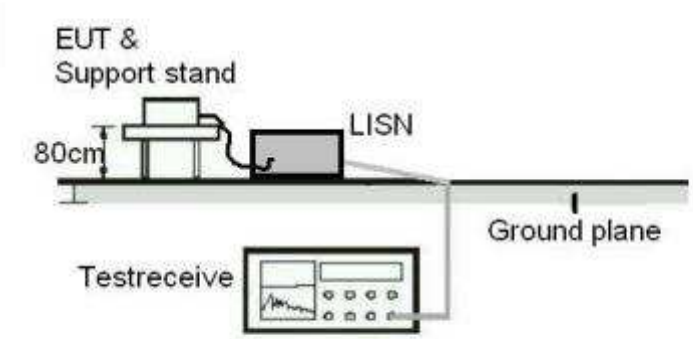
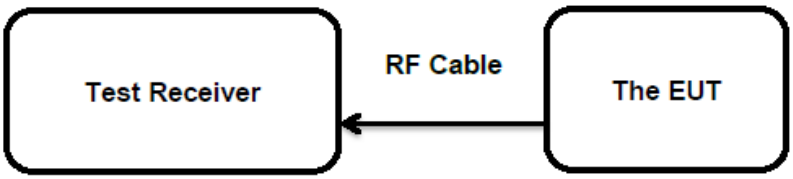


Diagram of Measurement Configuration for Conducted Transmitter Measurement



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 is 2.3dBi, 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	:	2024-04-11 - 2024-05-17
Input voltage	:	DC 5V Via USB port
Operation mode	:	A, B
Test channel	:	Low / Middle / High
Ambient temperature	:	23 ℃
Relative humidity	:	55 %
Atmospheric pressure	:	101 kPa

Antenna gain 2.3dBi

Table 8: Test Result of Maximum Conducted Output Power, Configuration 1:

Test Mode	Test Channel (MHz)	Maximum Conducted Power		Limit (W)
		(dBm)	(W)	
Lora DTS	915.8	**21.31**	**0.1352**	< 1.0
	920.6	21.26	0.1337	
	927.0	21.03	0.1268	
Lora FHSS SF7	915.1	20.56	0.1138	< 1.0
	921.5	20.38	0.1091	
	927.7	**21.25**	**0.1334**	
Lora FHSS SF10	915.1	20.83	0.1211	< 1.0
	921.5	20.43	0.1104	
	927.7	20.12	0.1028	
Max. Measured Value		**21.31**	**0.1352**	

Note:
1) The cable loss is taken into account in results.
2) The maximum Antenna gain(G) : 2.3 dBi

e.i.r.p.=21.31dBm + 2.3dBi = 23.61dBm = 229.61mW, which is far below the 4 W

Table 9: Test Result of Maximum Conducted Output Power, Configuration 2:

Test Mode	Test Channel (MHz)	Maximum Conducted Average Power		Limit (W)
		(dBm)	(W)	
Lora DTS/SF7	902.5	20.77	0.1194	< 1.0
	914.5	**21.36**	**0.1368**	
	927.1	21.21	0.1321	
Lora DTS/SF12	902.5	21.32	0.1355	
	914.5	21.35	0.1365	
	927.1	21.33	0.1358	
Max. Measured Value		**21.36**	**0.1368**	

Note:

3) The cable loss is taken into account in results.

4) The maximum Antenna gain(G) : 2.3 dBi

e.i.r.p.=21.36dBm + 2.3dBi = 23.66dBm = 232.27mW, 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	:	2024-04-11 - 2024-05-17
Input voltage	:	DC 5V Via USB port
Operation mode	:	B
Test channel	:	Low / Middle / High
Ambient temperature	:	23 ℃
Relative humidity	:	55 %
Atmospheric pressure	:	101 kPa

For the measurement records, refer to the appendix B.

Table 10: Test Result of Maximum Peak Power Spectral Density, Lora DTS, Configuration 1

Antenna Gain	Test Mode	Test Channel (MHz)	Measured Peak Power Spectral Density (dBm/3kHz)
2.3 dBi	Lora DTS	915.8	0.96
		920.6	0.61
		927.0	1.02
Maximum Measured Value			1.02

Table 11: Test Result of Maximum Peak Power Spectral Density, Lora DTS, Configuration 2

Antenna Gain	Test Mode	Test Channel (MHz)	Measured Peak Power Spectral Density (dBm/3kHz)
2.3 dBi	Lora DTS/SF7	902.5	1.20
		914.5	1.23
		927.1	0.83
	Lora DTS/SF12	902.5	1.22
		914.5	1.46
		927.1	2.04
Maximum Measured Value			2.04

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	:	2024-04-11 - 2024-05-17
Input voltage	:	DC 5V Via USB port
Operation mode	:	B
Test channel	:	Low / Middle / High
Ambient temperature	:	23 ℃
Relative humidity	:	55 %
Atmospheric pressure	:	101 kPa

For the measurement records, refer to the appendix B.

Table 12: Test Result of 6dB Bandwidth, Lora DTS, Configuration 1

Test Mode	Test Channel (MHz)	6dB Bandwidth (kHz)	Limit (kHz)
Lora DTS	915.8	628.1	>500kHz
	920.6	628.1	
	927.0	628.1	
Minimum Measured Value		628.1	

Table 13: Test Result of 6dB Bandwidth, Lora DTS, Configuration 2

Test Mode	Test Channel (MHz)	6dB Bandwidth (kHz)	Limit (kHz)
Lora DTS	902.5	642.5	>500kHz
	914.5	639.7	
	927.1	512.3	
Minimum Measured Value		642.5	

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	:	2024-04-11 - 2024-05-17
Input voltage	:	DC 5V Via USB port
Operation mode	:	A
Test channel	:	Low / Middle / High
Ambient temperature	:	23 ℃
Relative humidity	:	55 %
Atmospheric pressure	:	101 kPa

For the measurement records, refer to the appendix B.

Table 14: Test Result of 20dB Bandwidth, Lora FHSS, Configuration 1

Test Mode	Test Channel (MHz)	20dB Bandwidth (kHz)	Limit (kHz)
Lora FHSS SF7	915.1	144.70	n/a
	921.5	144.70	
	927.7	145.90	
Maximum Measured Value		145.90	

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	:	2024-04-11 - 2024-05-17
Input voltage	:	DC 5V Via USB port
Operation mode	:	A, B
Test channel	:	Low / Middle / High
Ambient temperature	:	23 ℃
Relative humidity	:	55 %
Atmospheric pressure	:	101 kPa

For the measurement records, refer to the appendix B.

Table 15: Test Result of 99% Bandwidth, Configuration 1:

Test Mode	Test Channel (MHz)	99% Bandwidth (kHz)	Limit
Lora DTS	915.8	500.62	Within assigned band
	920.6	503.62	
	927.0	500.72	
Lora FHSS SF7	915.1	127.35	
	921.5	127.35	
	927.7	127.35	
Maximum Measured Value		503.62	

Table 16: Test Result of 99% Bandwidth, Configuration 2:

Test Mode	Test Channel (MHz)	99% Bandwidth (kHz)	Limit
Lora DTS	902.5	506.51	Within assigned band
	914.5	503.62	
	927.1	506.51	
Maximum Measured Value		506.51	

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	:	2024-04-11 - 2024-05-17
Input voltage	:	DC 5V Via USB port
Operation mode	:	A, B
Test channel	:	Low / Middle / High
Ambient temperature	:	23 ℃
Relative humidity	:	55 %
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	:	2024-04-11 - 2024-05-17
Input voltage	:	DC 5V Via USB port
Operation mode	:	A, B, D
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	:	2024-04-11 - 2024-05-17
Input voltage	:	DC 5V Via USB port
Operation mode	:	C
Test channel	:	Low / Middle / High
Ambient temperature	:	23 ℃
Relative humidity	:	55 %
Atmospheric pressure	:	101 kPa

For the measurement records, refer to the appendix B.

Table 17: Test Result of Carrier Frequency Separation, Lora FHSS, Configuration 1

Test Mode	Channel	Measured Channel Separation (kHz)	Limit (kHz)	Result
Lora FHSS	Low Channel	200.72	≥ 20dB bandwidth	Pass
	Adjacency Channel			
	Middle Channel	200.72		Pass
	Adjacency Channel			
	High Channel	200.72		Pass
	Adjacency Channel			

Note:

The limit is maximum 20 dB bandwidth: 144.90 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	:	2024-04-11 - 2024-05-17
Input voltage	:	DC 5V Via USB port
Operation mode	:	C
Ambient temperature	:	23 ℃
Relative humidity	:	55 %
Atmospheric pressure	:	101 kPa

Table 18: Test result of hopping channel number, Lora FHSS, Configuration 1

Test Mode	20dB Bandwidth(kHz)	Hopping frequencies	Limit
Lora FHSS	20dB Bandwidth < 250	63	≥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	:	2024-04-11 - 2024-05-17
Input voltage	:	DC 5V Via USB port
Operation mode	:	C
Test channel	:	Low / Middle / High
Ambient temperature	:	23 ℃
Relative humidity	:	55 %
Atmospheric pressure	:	101 kPa

Table 19: Test result of Channel Occupancy, Lora FHSS, Configuration 1

Test Mode	20dB Bandwidth(kHz)	Period (s)	Channel Occupancy Time (ms)	Limit (ms)
Lora FHSS	20dB Bandwidth < 250	20	60.87	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	:	2024-04-25
Input voltage	:	Powered by PC Adapter
Operation mode	:	A, B
Earthing	:	Not connected
Ambient temperature	:	22 ℃
Relative humidity	:	56 %
Atmospheric pressure	:	101 kPa

For the measurement records, refer to the appendix B.

6 Photographs of the Test Set-Up

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

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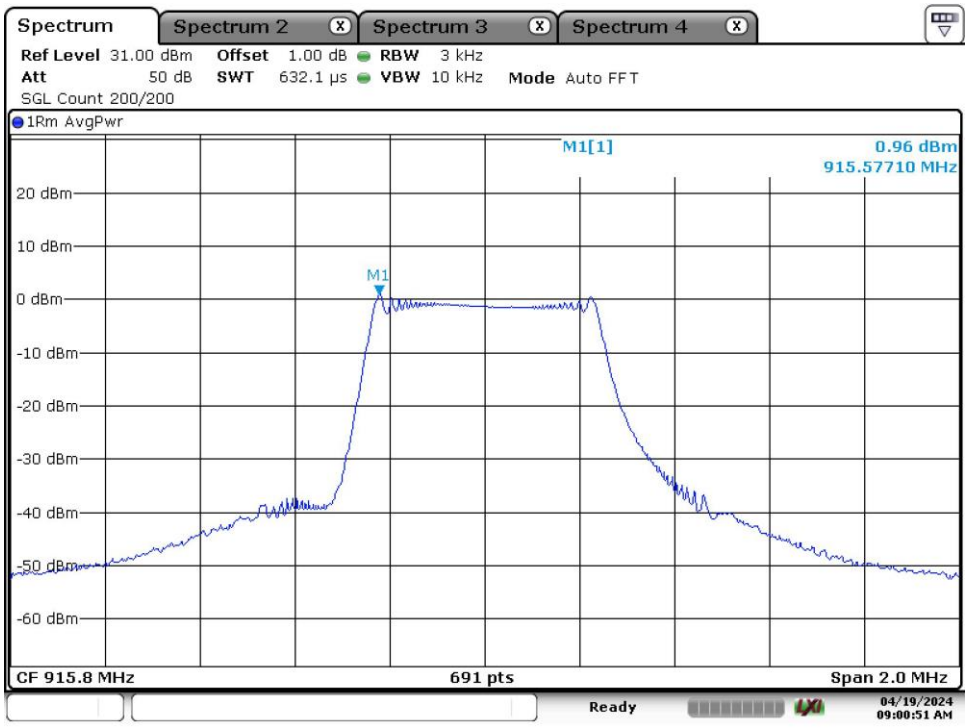
Appendix B.1: Conducted Power Spectral Density

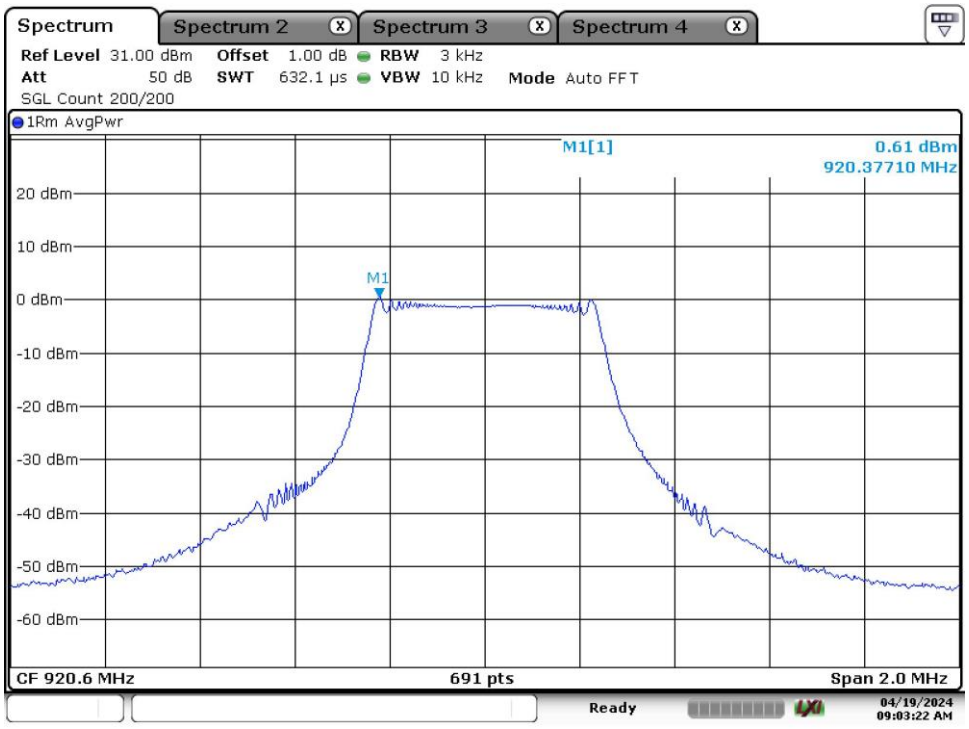
Lora DTS, Lora DTS, Configuration 1

Low Channel



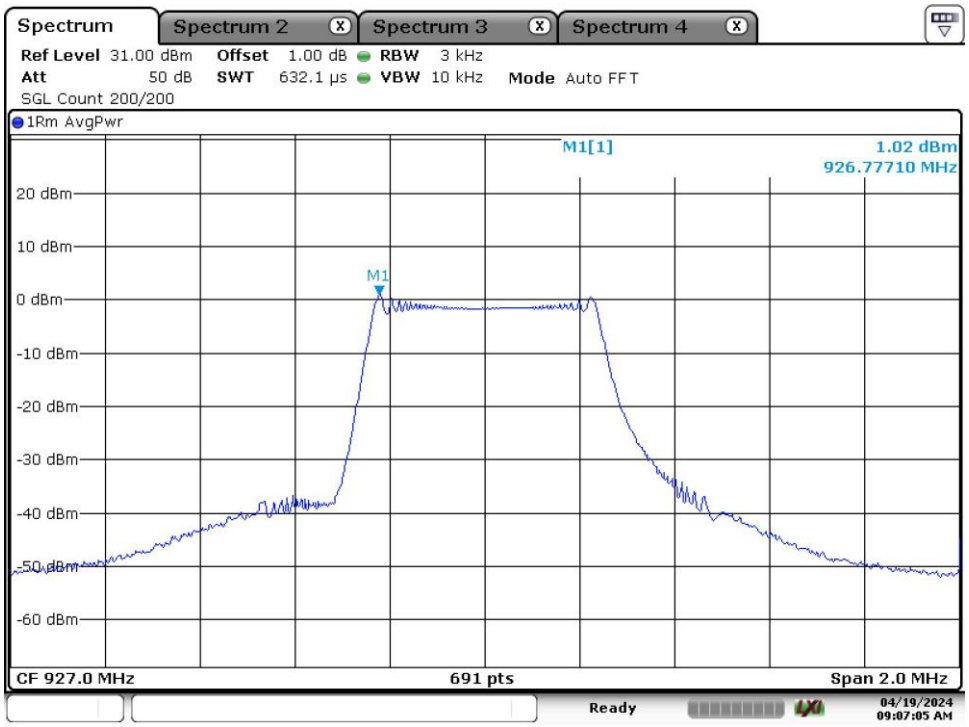
Date: 19.APR.2024 09:00:51

Middle Channel



Date: 19.APR.2024 09:03:22

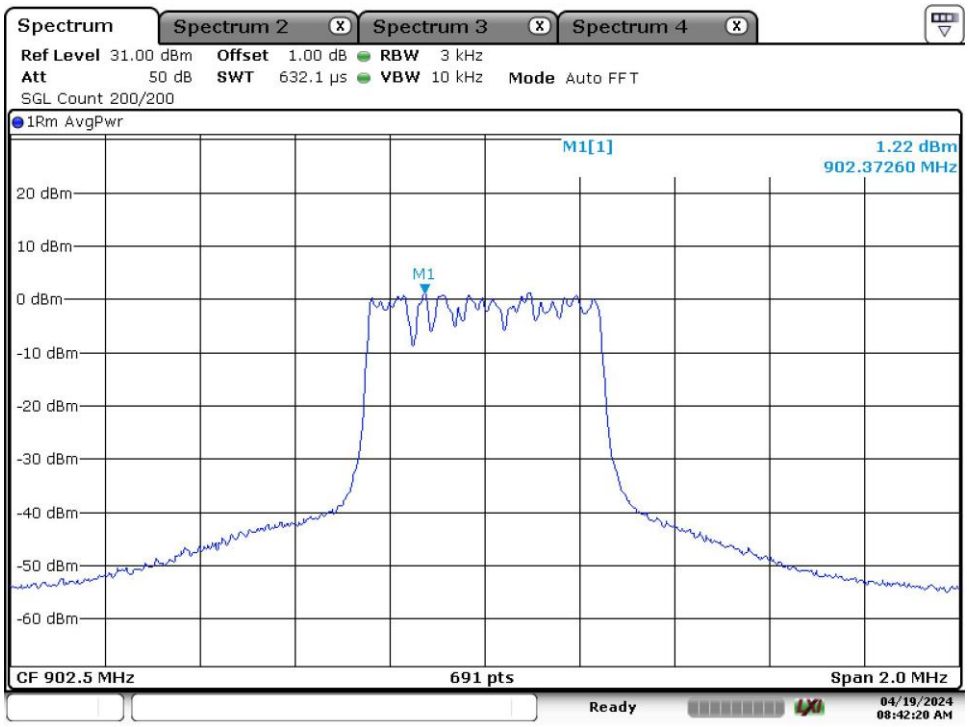
High Channel



Date: 19.APR.2024 09:07:05

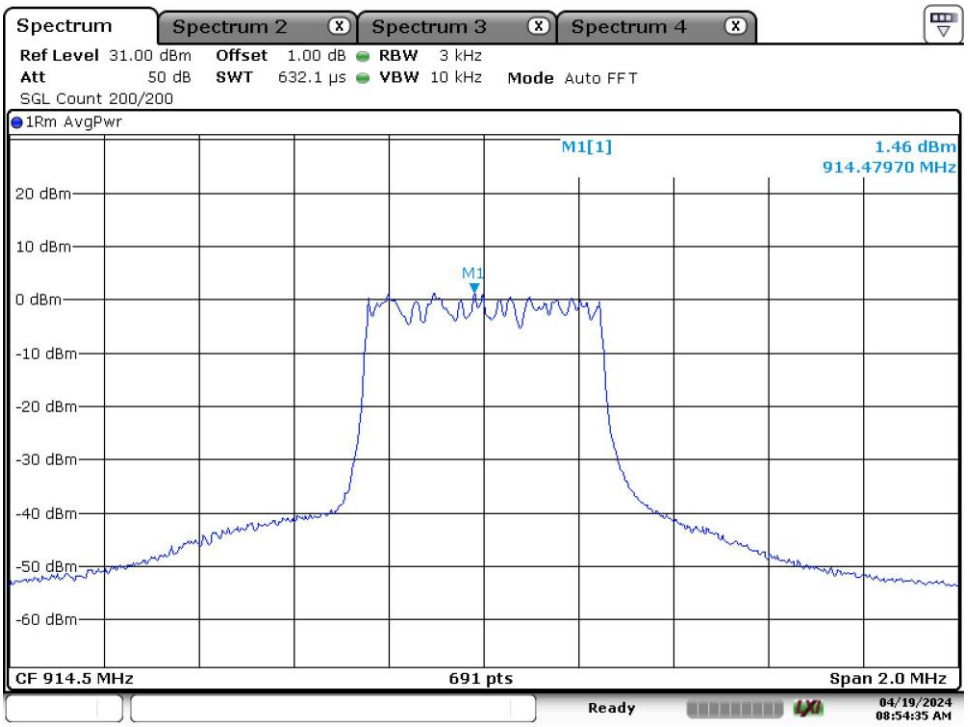
Lora DTS, Lora DTS, Configuration 2

Low Channel



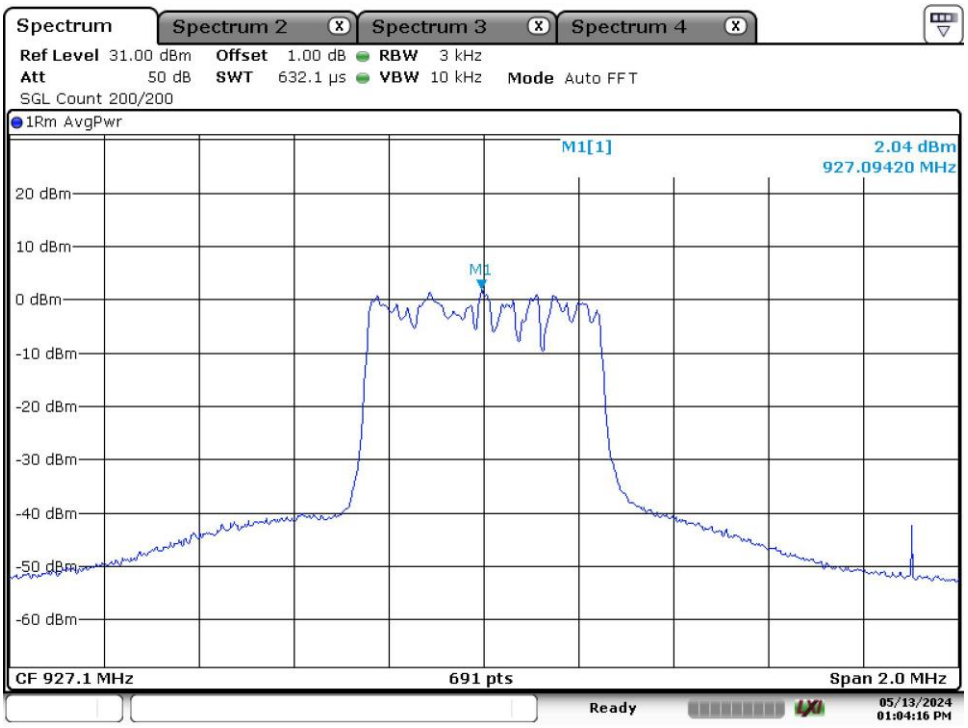
Date: 19.APR.2024 08:42:20

Middle Channel



Date: 19.APR.2024 08:54:35

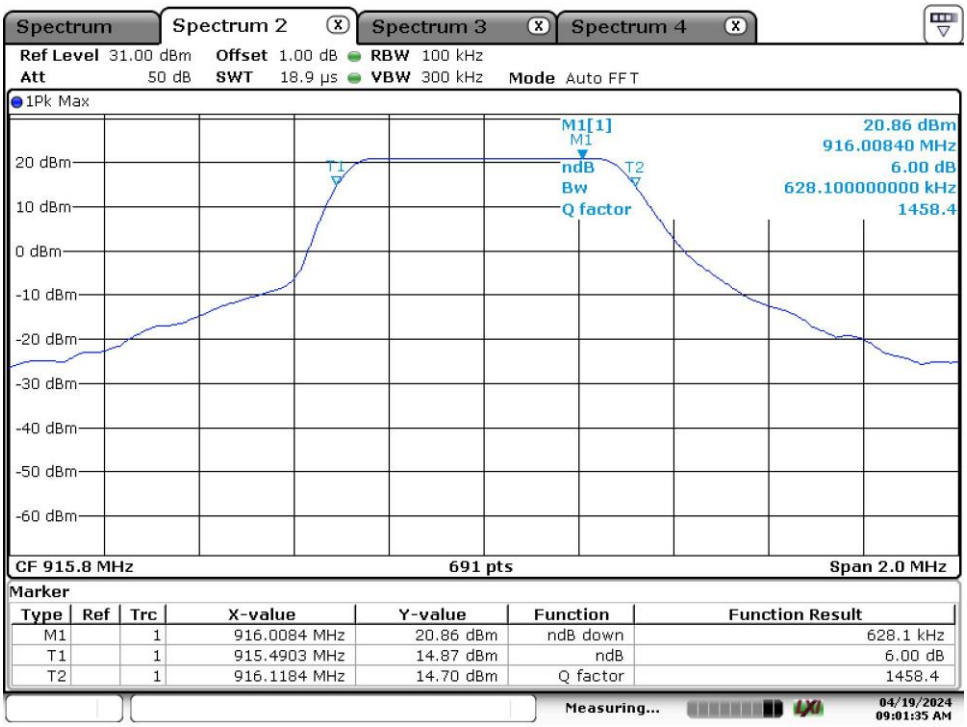
High Channel



Date: 13.MAY.2024 13:04:17

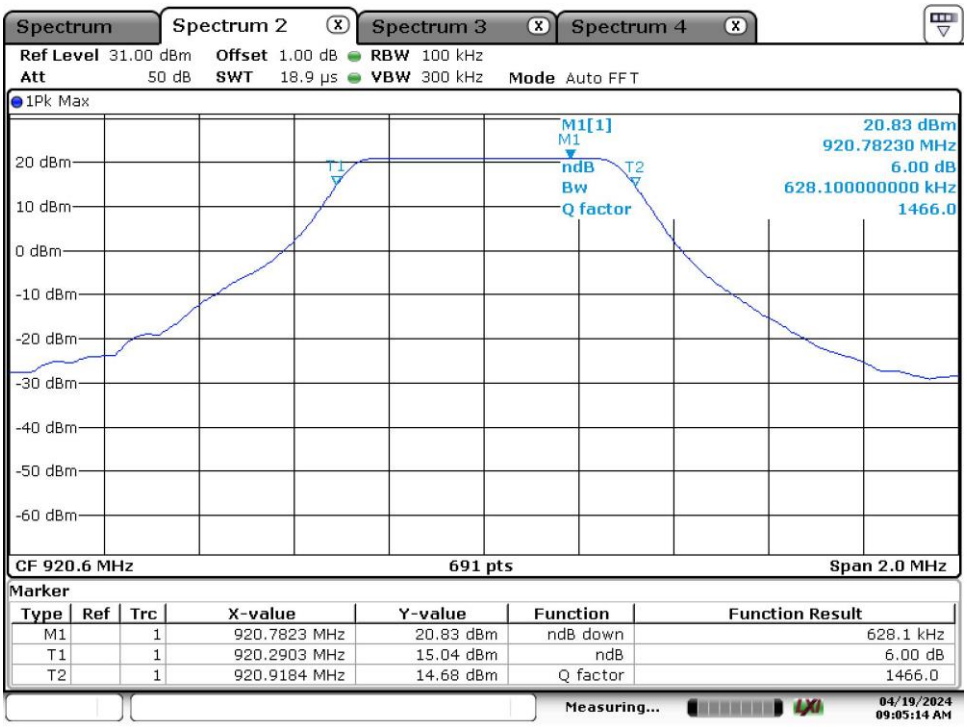
Appendix B.2: 6dB Bandwidth

Lora DTS, Configuration 1
Low Channel



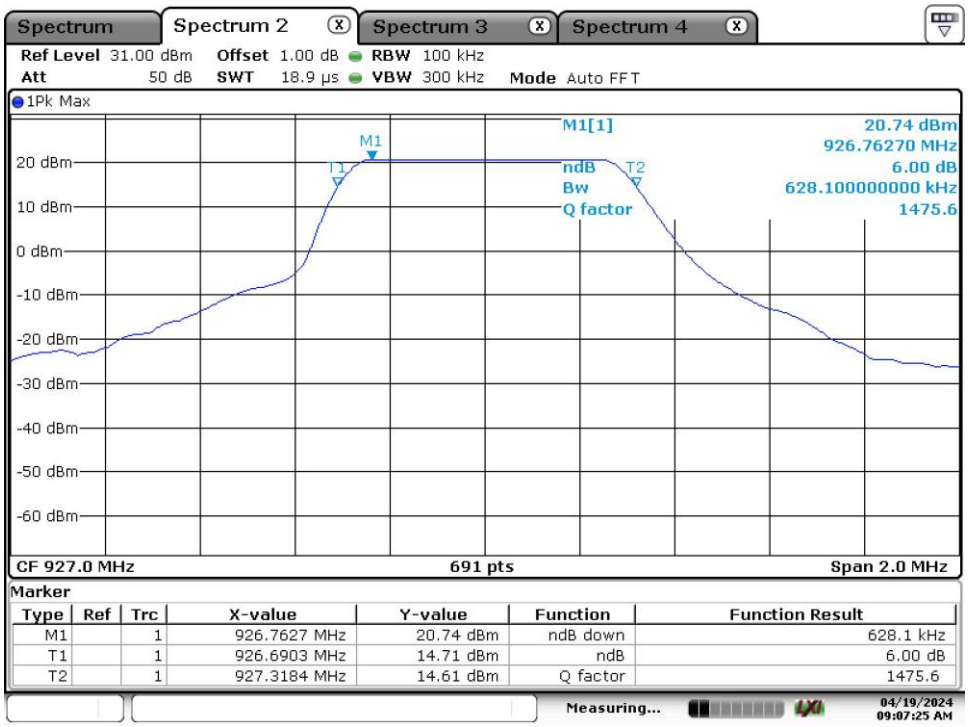
Date: 19.APR.2024 09:01:35

Middle Channel



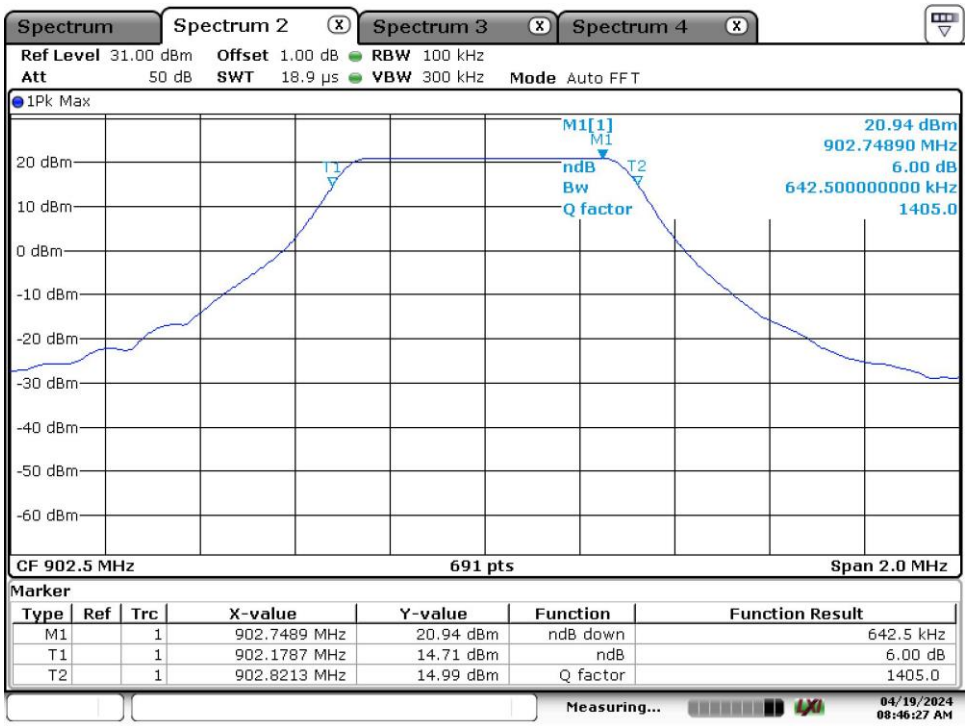
Date: 19.APR.2024 09:05:14

High Channel



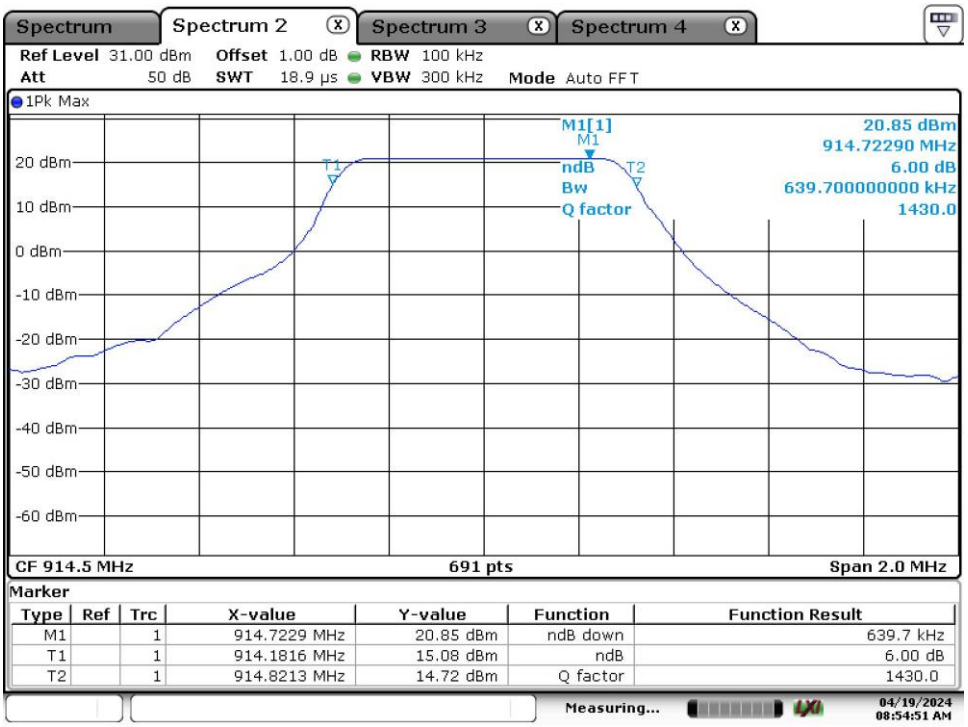
Date: 19.APR.2024 09:07:25

Lora DTS, Configuration 2
Low Channel



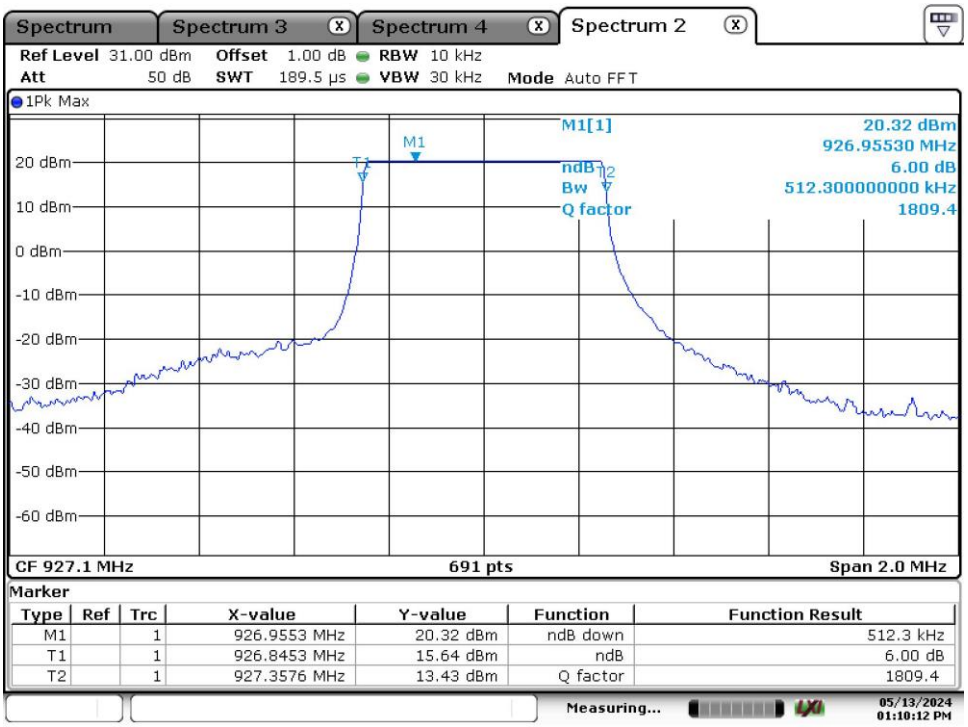
Date: 19.APR.2024 08:46:27

Middle Channel



Date: 19.APR.2024 08:54:51

High Channel

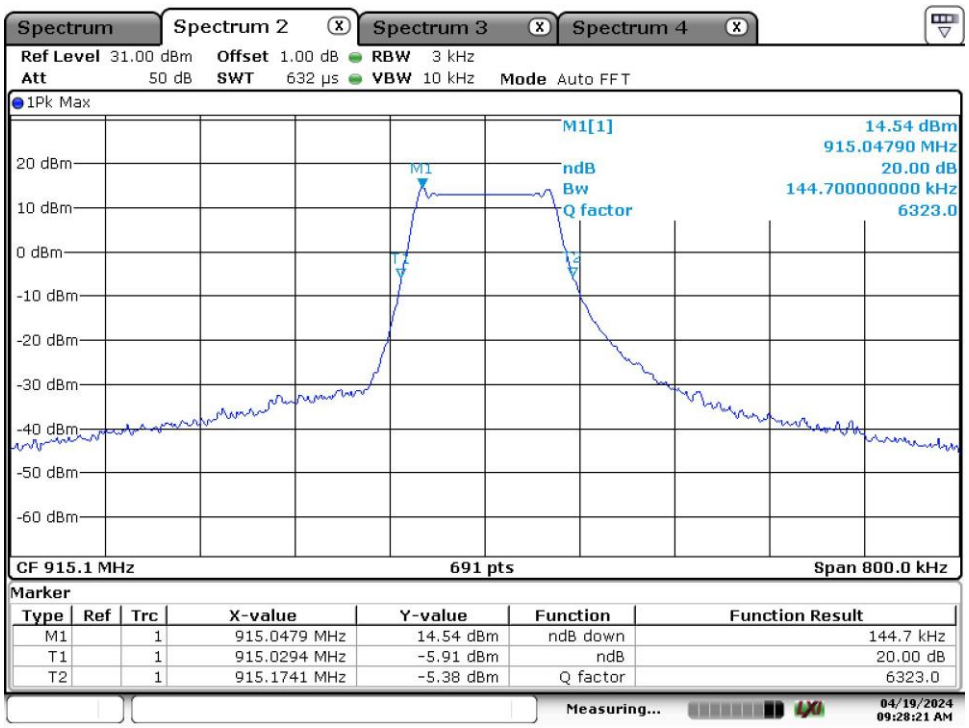


Date: 13.MAY.2024 13:10:12

Appendix B.3: 20dB Bandwidth

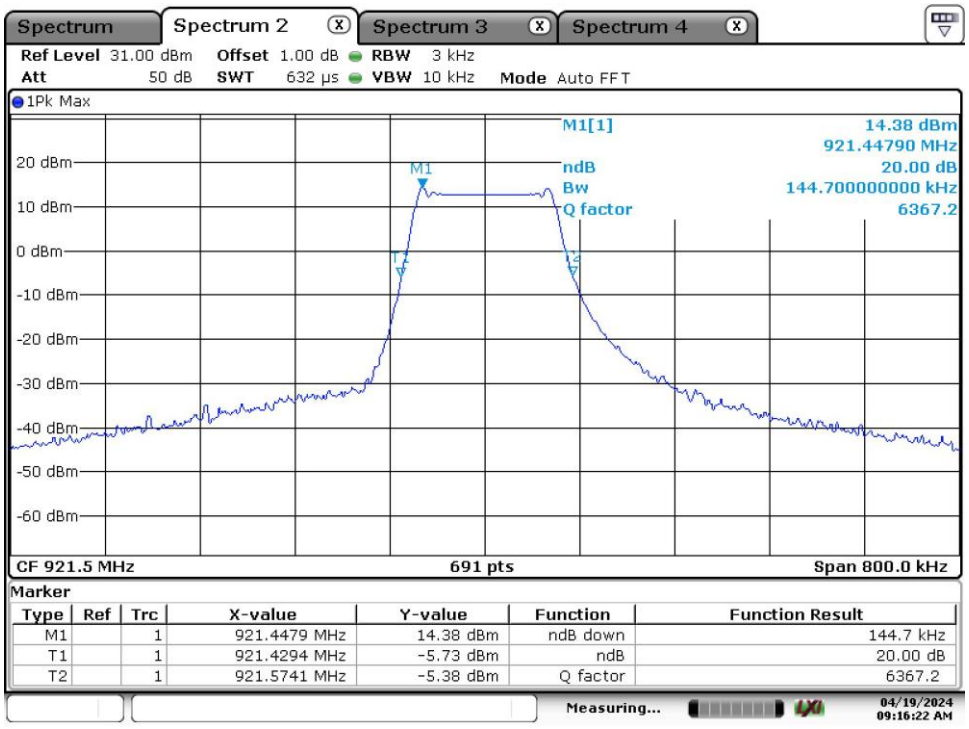
Lora FHSS, Configuration 1

Low Channel



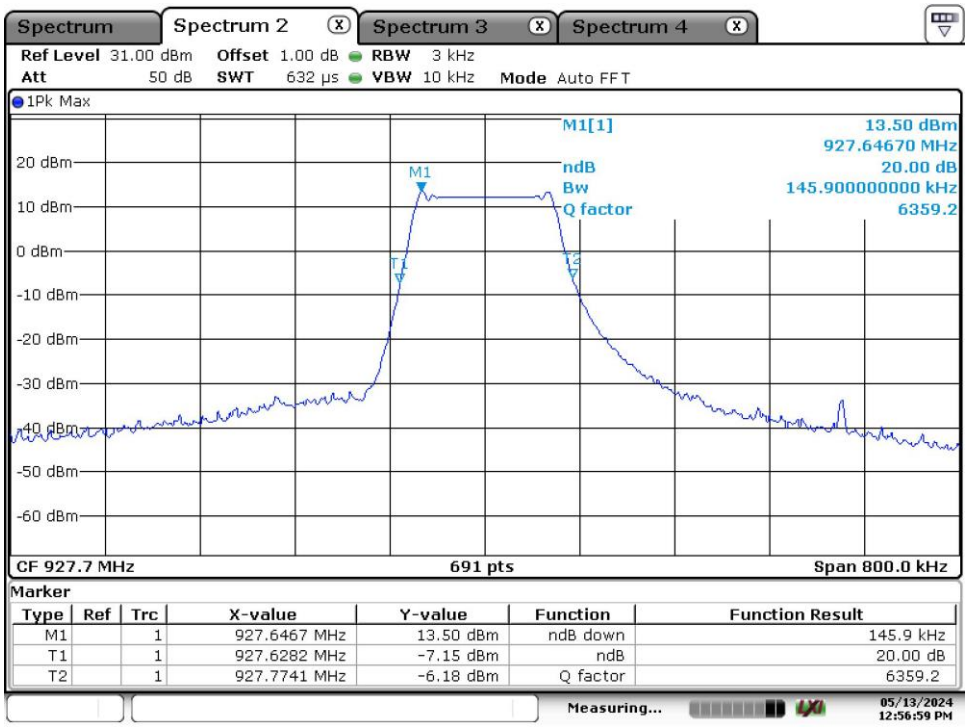
Date: 19.APR.2024 09:28:21

Middle Channel



Date: 19.APR.2024 09:16:22

High Channel

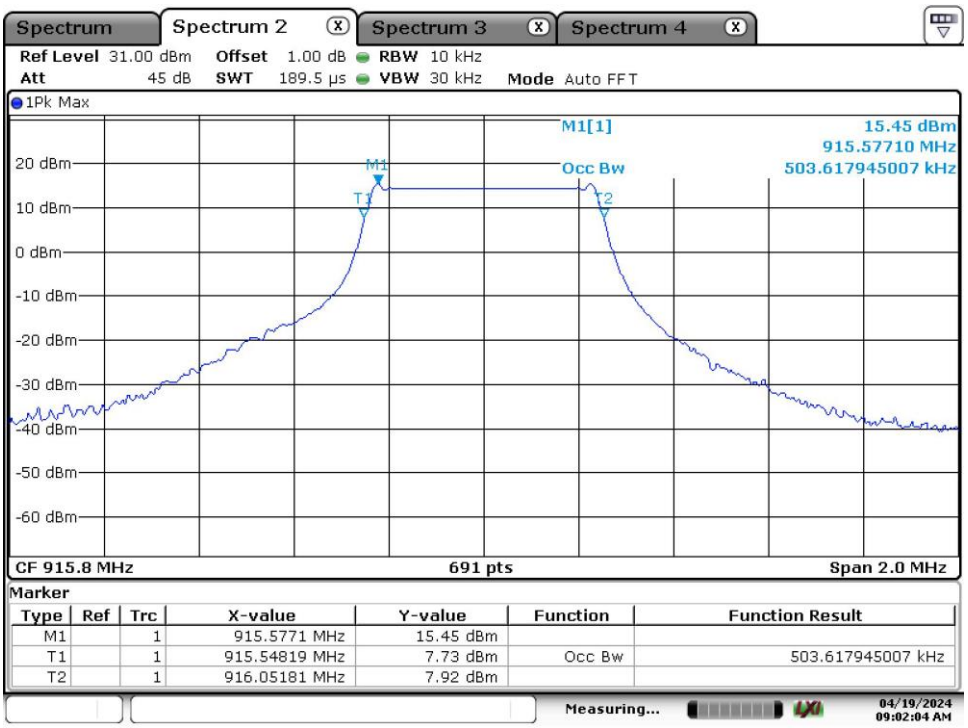


Date: 13.MAY.2024 12:57:00

Appendix B.4: 99% Bandwidth

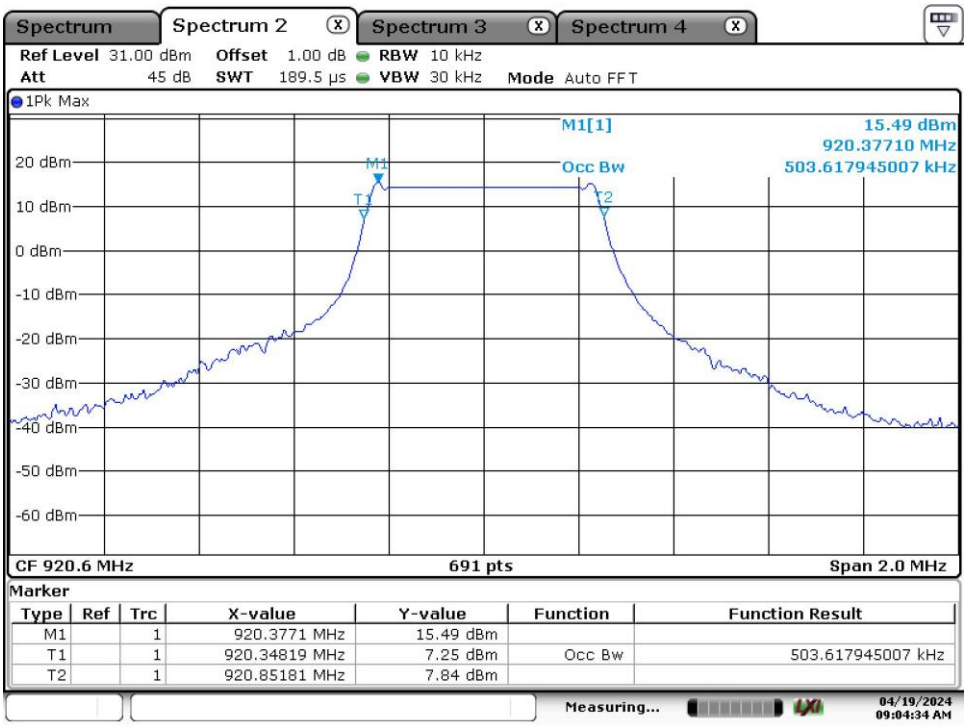
Lora DTS, Configuration 1:

Low Channel



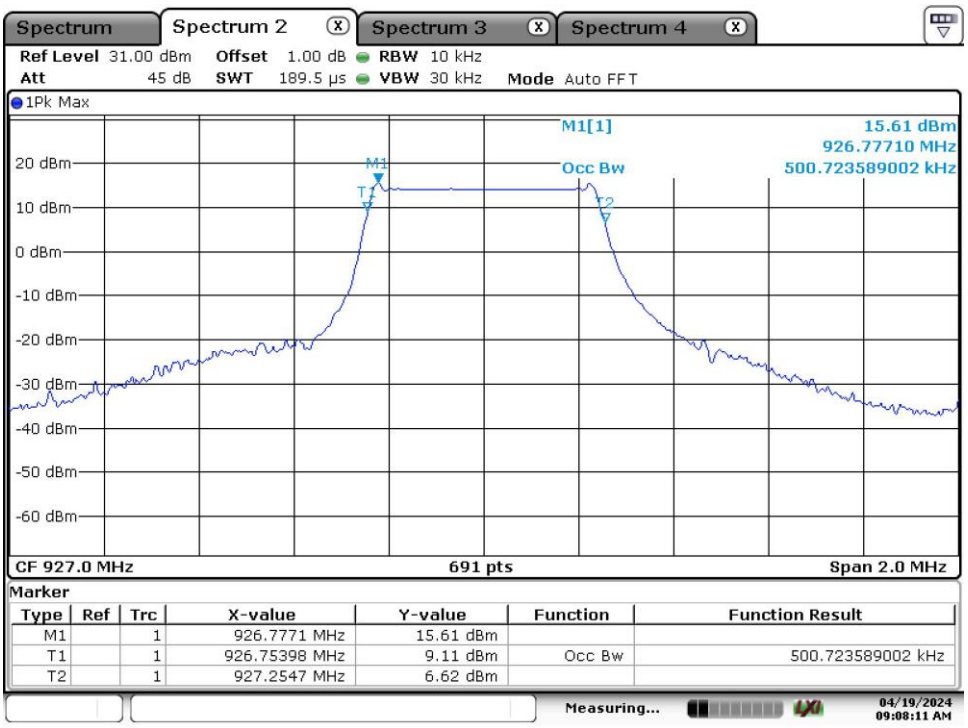
Date: 19.APR.2024 09:02:04

Middle Channel



Date: 19.APR.2024 09:04:34

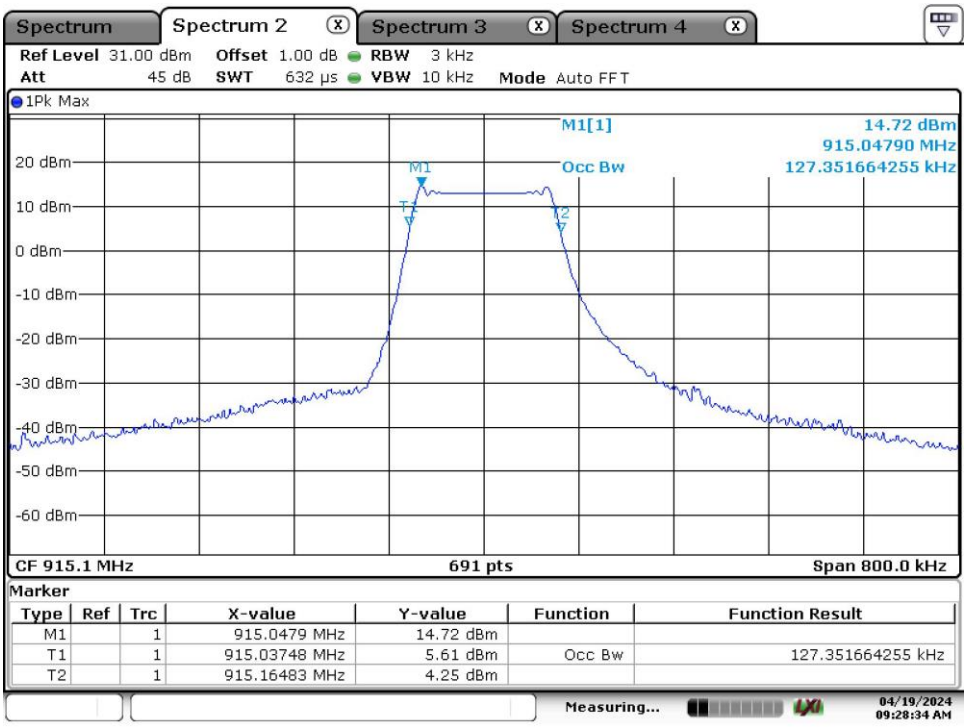
High Channel



Date: 19.APR.2024 09:08:11

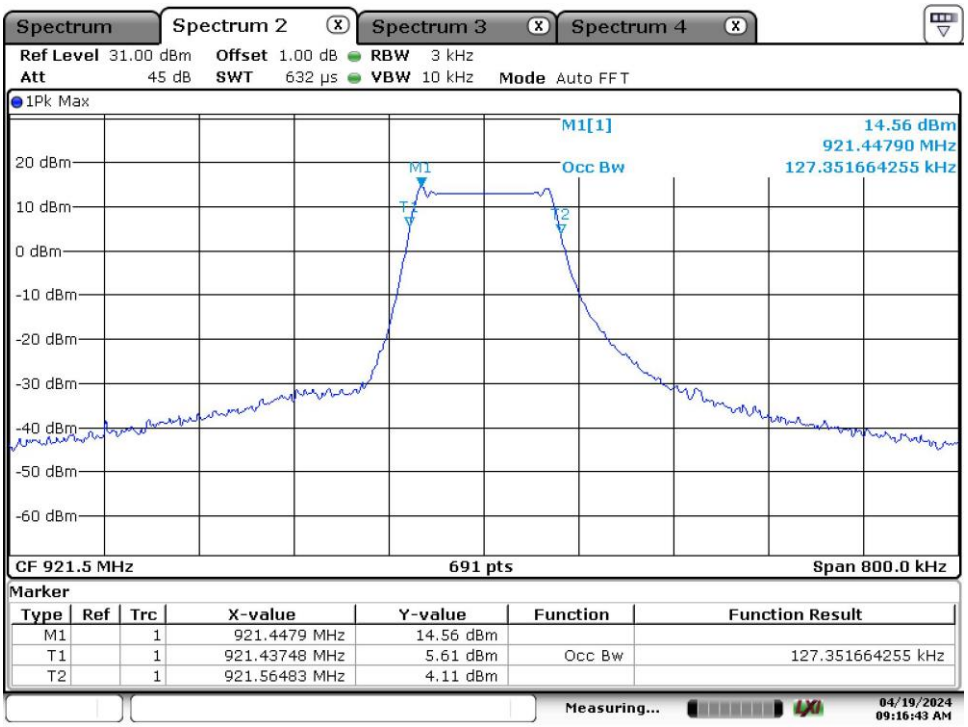
Lora FHSS, Configuration 1:

Low Channel



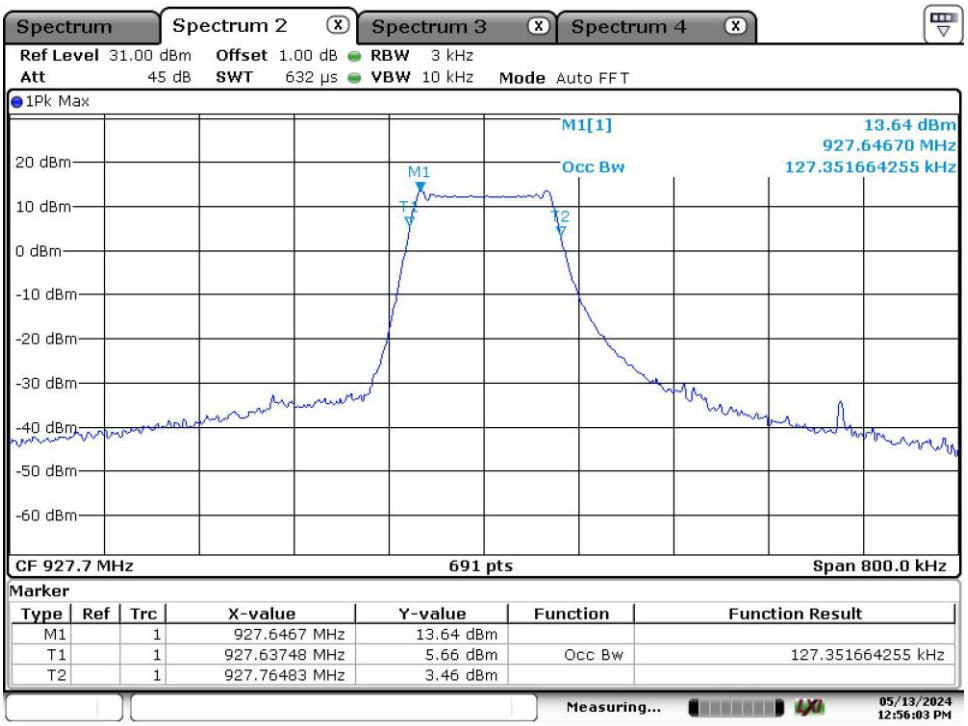
Date: 19.APR.2024 09:28:34

Middle Channel



Date: 19.APR.2024 09:16:43

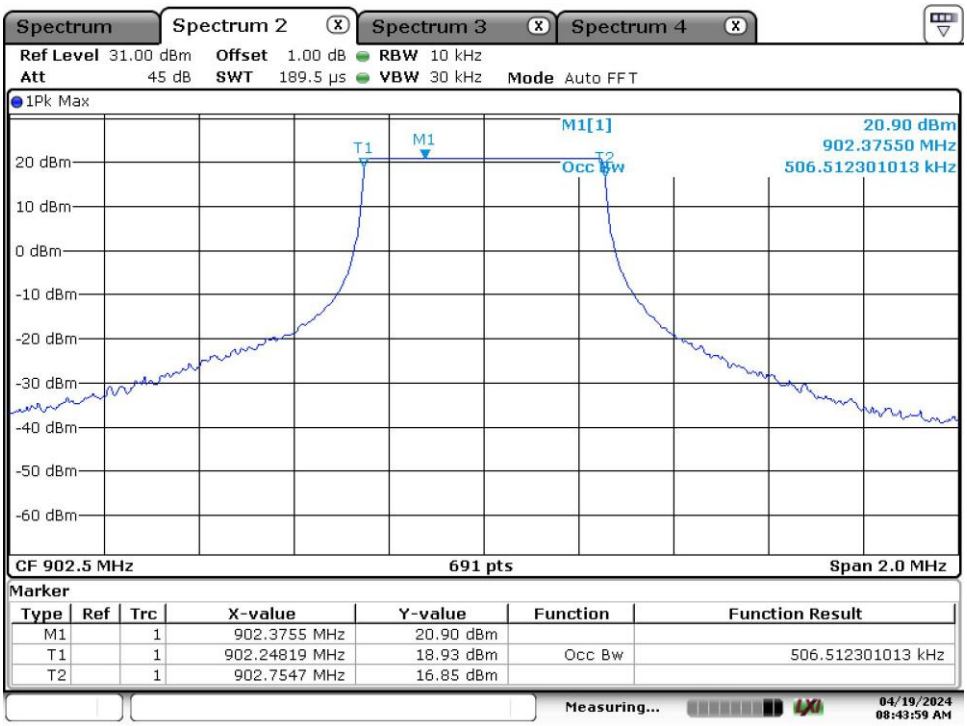
High Channel



Date: 13.MAY.2024 12:56:04

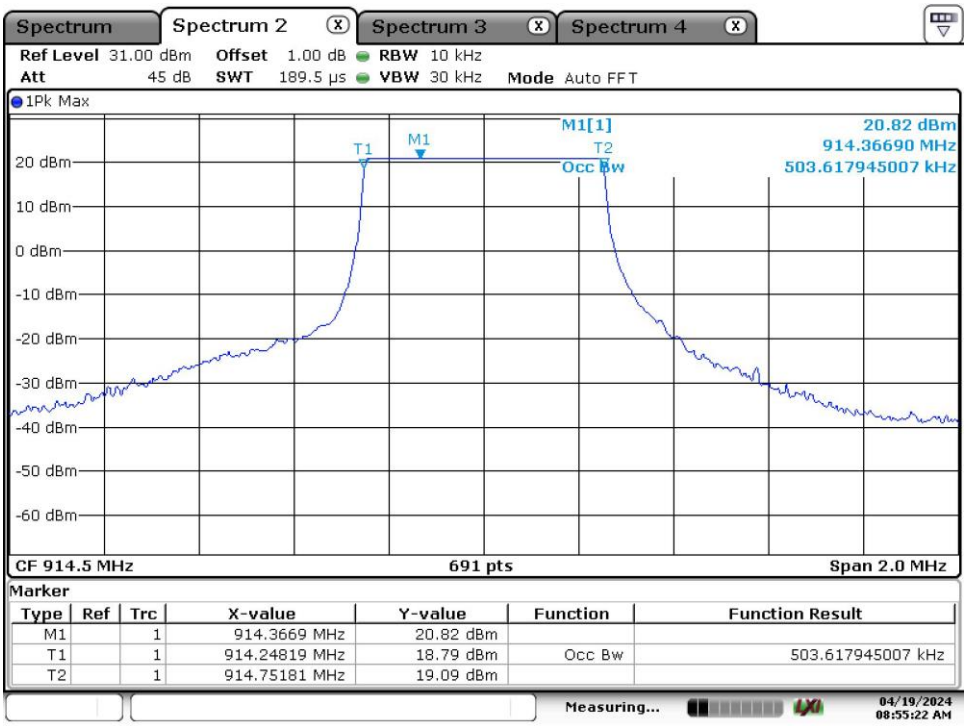
Lora DTS, Configuration 2:

Low Channel



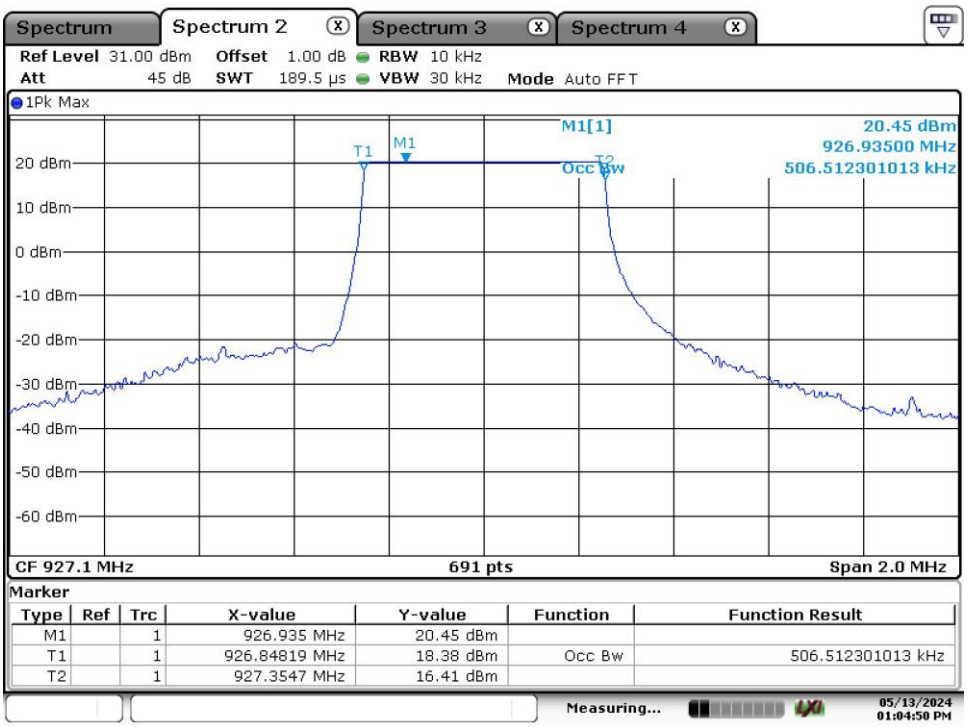
Date: 19.APR.2024 08:43:59

Middle Channel



Date: 19.APR.2024 08:55:21

High Channel



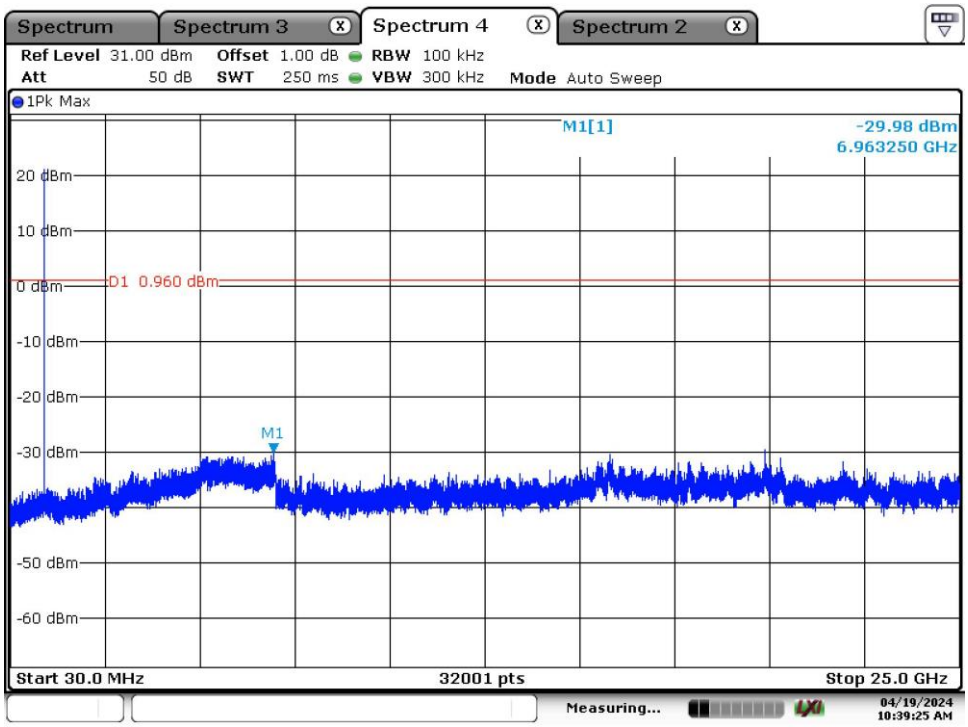
Date: 13.MAY.2024 13:04:50

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

Lora DTS, Configuration 1:

Low Channel

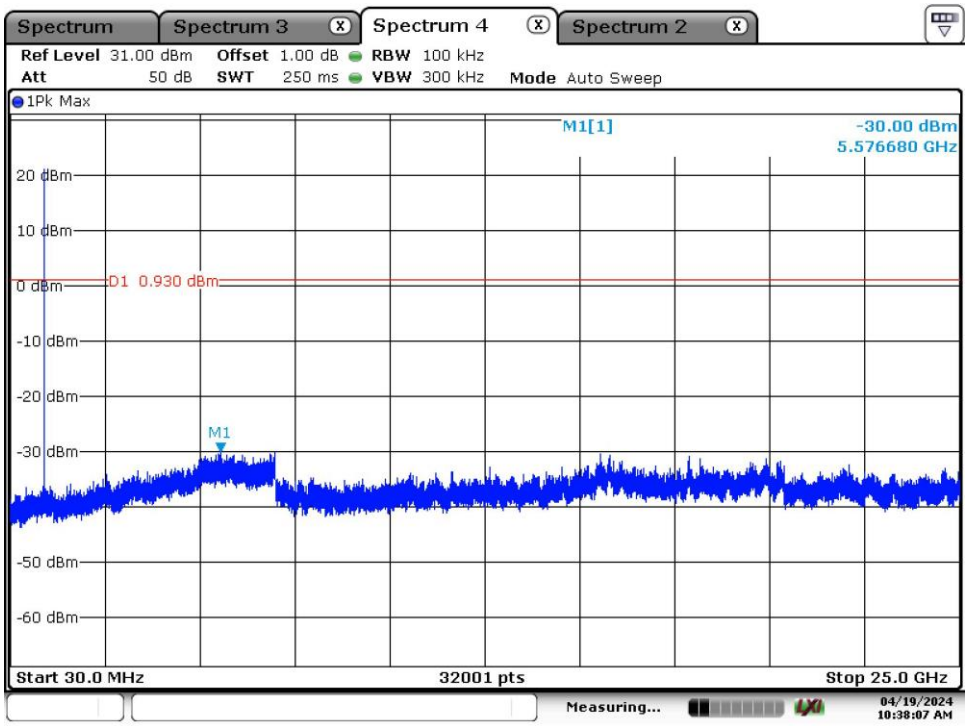
Date: 19.APR.2024 09:02:26



Date: 19.APR.2024 10:39:25

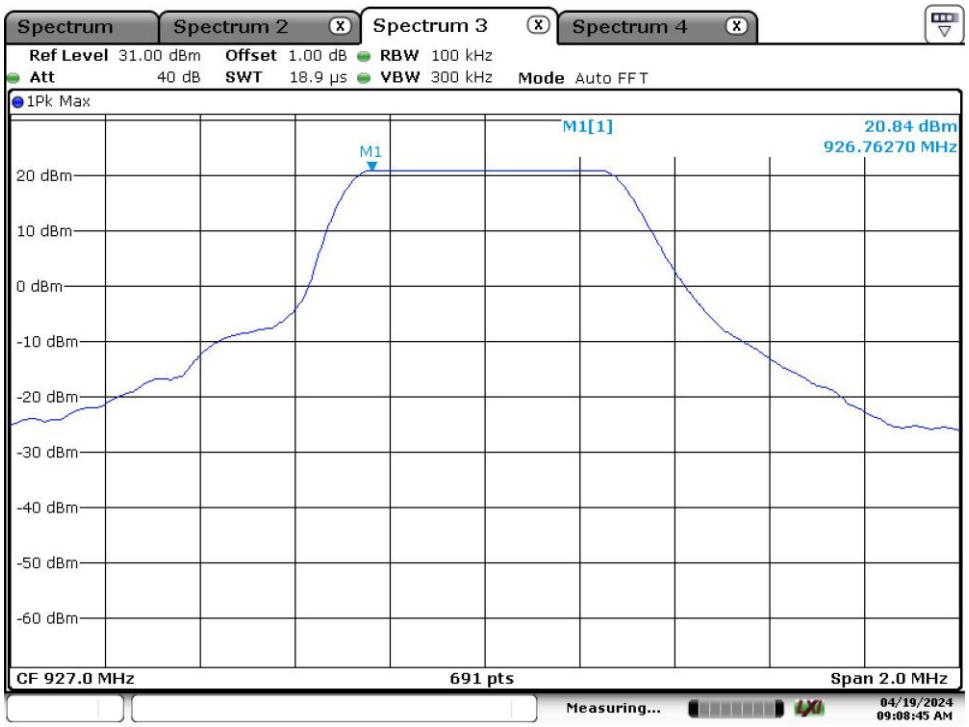
Middle Channel

Date: 19.APR.2024 09:05:46

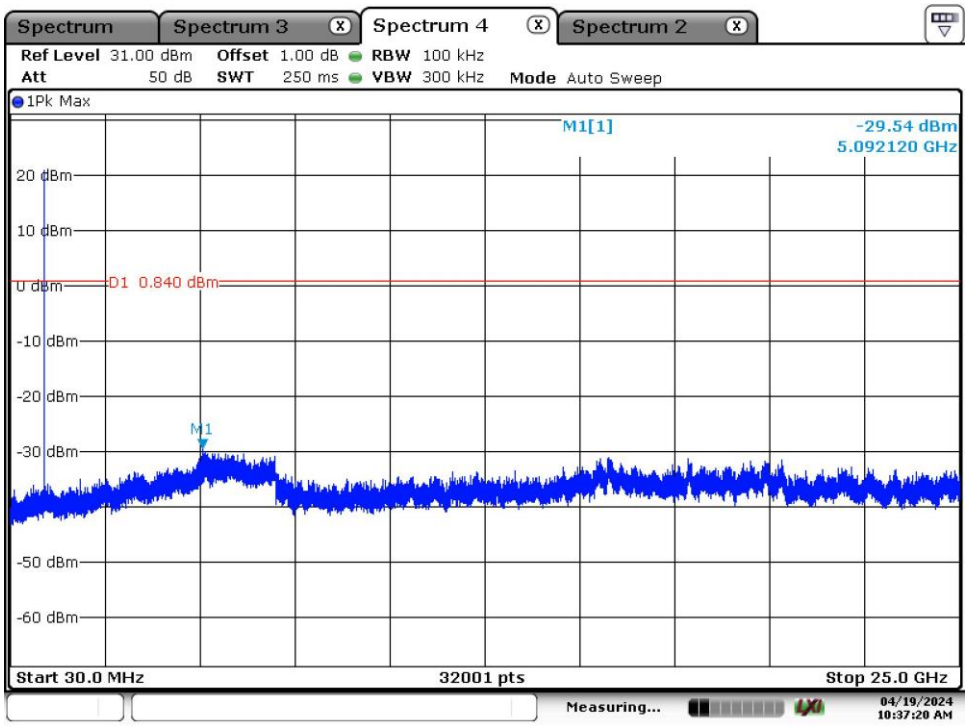


Date: 19.APR.2024 10:38:07

High Channel

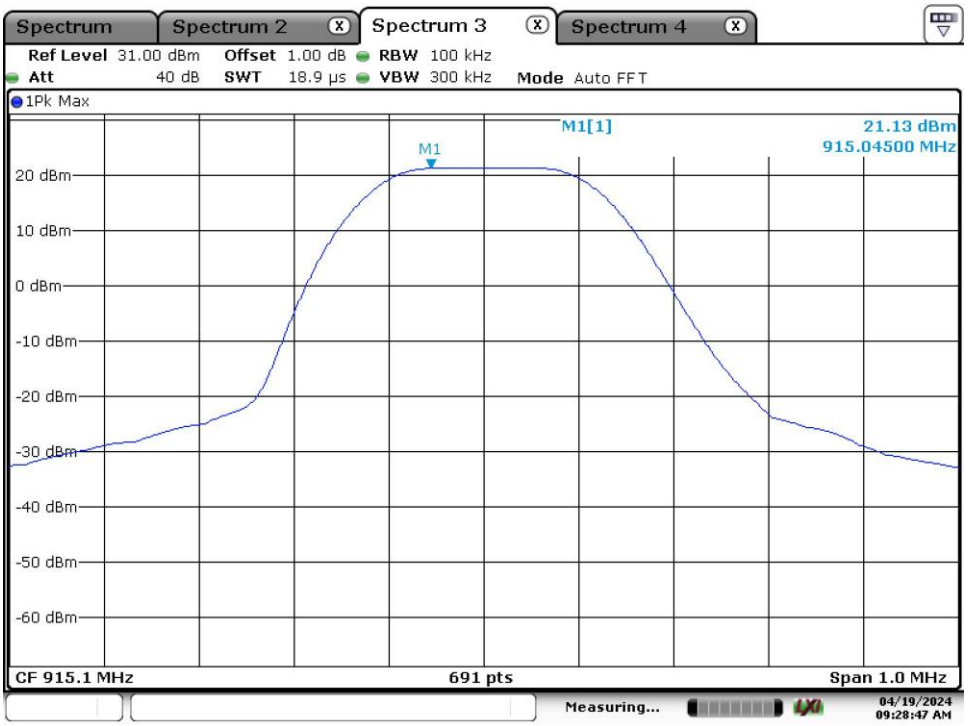


Date: 19.APR.2024 09:08:45

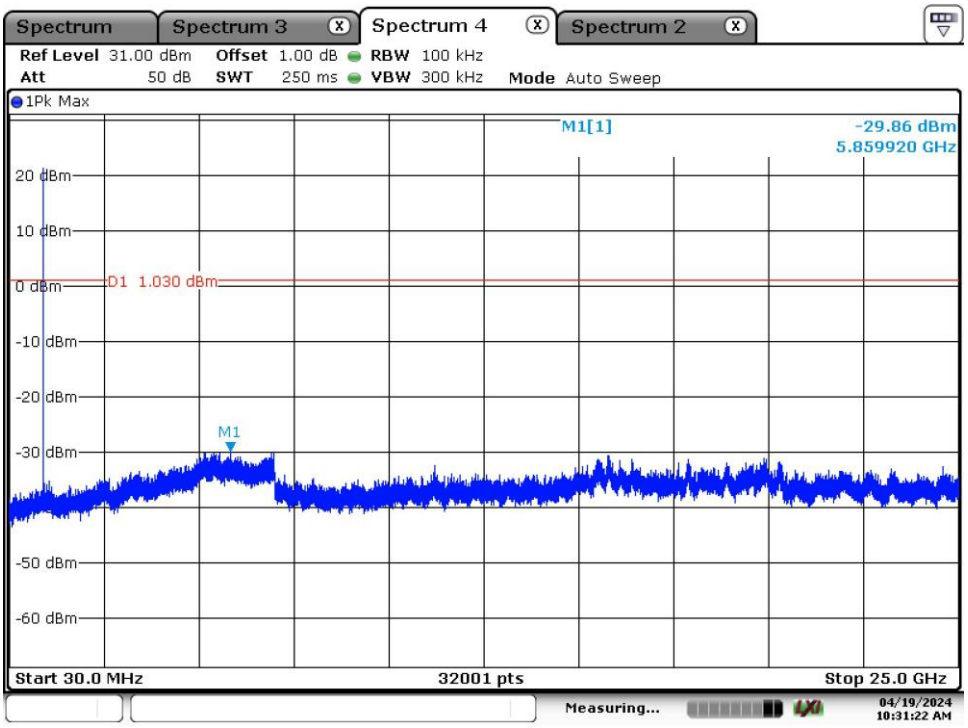


Date: 19.APR.2024 10:37:20

Lora FHSS, Configuration 1:
Low Channel



Date: 19.APR.2024 09:28:47



Date: 19.APR.2024 10:31:22