

Prüfbericht-Nr.: <i>Test report no.:</i>	CN22DK0H 002	Auftrags-Nr.: <i>Order no.:</i>	168399706	Seite 1 von 23 <i>Page 1 of 23</i>	
Kunden-Referenz-Nr.: <i>Client reference no.:</i>	N/A	Auftragsdatum: <i>Order date:</i>	2022-11-09		
Auftraggeber: <i>Client:</i>	Shenzhen RAKwireless Technology Co., Ltd. Room 506, Bldg B, New Compark, Pingshan First Road, Taoyuan Street, XiLi Town Nanshan District, Shenzhen, Guangdong, P.R. China				
Prüfgegenstand: <i>Test item:</i>	WisDuo LPWAN Module				
Bezeichnung / Typ-Nr.: <i>Identification / Type no.:</i>	RAK11720				
Auftrags-Inhalt: <i>Order content:</i>	FCC and IC approval				
Prüfgrundlage: <i>Test specification:</i>	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 RSS-247 Issue 2 February 2017 RSS-Gen Issue 5 February 2021				
Wareneingangsdatum: <i>Date of sample receipt:</i>	2022-12-09	Please refer to photo documents			
Prüfmuster-Nr.: <i>Test sample no.:</i>	A003386865-001 to 005				
Prüfzeitraum: <i>Testing period:</i>	2022-12-09 - 2023-01-04				
Ort der Prüfung: <i>Place of testing:</i>	TÜV Rheinland (Shenzhen) Co., Ltd.				
Prüflaboratorium: <i>Testing laboratory:</i>	TÜV Rheinland (Shenzhen) Co., Ltd.				
Prüfergebnis*: <i>Test result*:</i>	Pass				
geprüft von: <i>tested by:</i>	genehmigt von: <i>authorized by:</i>				
Datum: <i>Date:</i> 2023-01-13					
	Signed by: Alex Lan		Signed by: Winnie Hou		
Stellung / Position	Assistant Project Manager	Ausstellungsdatum: <i>Issue date:</i> 2023-01-16	Stellung / Position Department Manager		
Sonstiges / Other:	FCC ID: 2AF6B-RAK11720 IC: 25908-RAK11720, HVIN: RAK11720				
Zustand des Prüfgegenstandes bei Anlieferung: <i>Condition of the test item at delivery:</i>	Prüfmuster vollständig und unbeschädigt <i>Test item complete and undamaged:</i>				
Legend:	1 = sehr gut P(ass) = entspricht o.g. Prüfgrundlage(n) 1 = very good P(ass) = passed a.m. test specifications(s)	2 = gut 2 = good 2 = satisfactory F(ail) = failed a.m. test specifications(s)	3 = befriedigend F(ail) = entspricht nicht o.g. Prüfgrundlage(n) 3 = satisfactory F(ail) = failed a.m. test specifications(s)	4 = ausreichend N/A = nicht anwendbar 4 = sufficient N/A = not applicable	5 = mangelhaft N/T = nicht getestet 5 = poor 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. <i>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.</i>					

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 99%dB BANDWIDTH

RESULT: Pass

5.1.5 6dB BANDWIDTH

RESULT: Pass

5.1.6 CONDUCTED SPURIOUS EMISSIONS MEASURED IN 100 KHz BANDWIDTH

RESULT: Pass

5.1.7 RADIATED SPURIOUS EMISSION

RESULT: Pass

5.1.8 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 of Conducted & Radiated Testing

2 Test Sites

2.1 Test Facilities

TÜV Rheinland (Shenzhen) Co., Ltd.

No. 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

Radio Spectrum Testing				
Equipment	Manufacturer	Model	Serial No.	Cal. until
EXA Signal Analyzer, Multi-touch	Keysight	N9010B	MY60241175	2023-10-10
MXG X-Series RF Vector Signal Generator	Keysight	N5182B	MY61250137	2023-10-10
EXG X-Series Microwave Analog Signal Generator	Keysight	N5173B	MY61250141	2023-10-10
DC Power Supply	Keysight	E3642A	MY61276100	2023-10-10
Wireless Connectivity Tester	R&S	CMW270	102505	2023-10-10
Power Control Unit	Tonscend	JS0806-4ADC	N/A	2023-10-10
Automation Control Unit	Tonscend	JS0806-2	21C8060396	2023-10-10
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	2024-08-02
Signal Analyzer	R&S	FSV 40	101439	2024-08-01
System Controller Interface	R&S	SCI-100	S10010038	N/A
Filterbank	R&S	Wlan	100759	2024-08-01
OSP	R&S	OSP 120	102040	N/A
Pre-amplifier	R&S	SCU08F1	08320031	2024-08-02
Amplifier	R&S	SCU-18F	180070	2024-08-02
Amplifier	R&S	SCU40A	100475	2024-08-02
Trilog Broadband Antenna (30 MHz - 7 GHz)	Schwarzbeck	VULB 9162	193	2024-08-06
Double-Ridged Antenna (1 -18 GHz)	ETS-LINDGREN	3117	00218717	2024-08-06
Wideband Ridged Horn Antenna (18-40 GHz)	Steatite	QMS-00880	19067	2024-08-07
Active Loop Antenna	Schwarzbeck	FMZB 1513	302	2024-08-06
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

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Conducted Emission on AC Mains				
Equipment	Manufacturer	Model No.	Serial No.	Cali. until
EMI Test Receiver	R&S	ESR3	102680	2023-02-27
Artificial Mains Network	R&S	ENV216	101445	2023-02-27
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 basis 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	$\pm 1 \times 10^{-7}$
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) file for certification follow-up purposes.

2.7 Status of Facility Used for Testing

The TÜV Rheinland (Shenzhen) Co., Ltd. Test facility located at No. 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#	KRAKBJ2701C01A	2.3 dBi	Dipole Antenna	RPSMA connector
2#	KRAKBJ2701C01C	2.3 dBi	Dipole Antenna	RPSMA 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# with highest gain 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

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 LPWAN 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 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
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

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

Table 5: 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, transmitting mode (BLE)
 - 1. Low channel
 - 2. Middle channel
 - 3. High channel
- B. On, Operating
- C. Off

3.4 Noise Generating and Noise Suppressing Parts

Refer to Circuit Diagram for further details.

3.5 Submitted Documents

- | | |
|----------------------------------|------------------|
| - Application Form | - Photo Document |
| - Block Diagram | - Schematics |
| - FCC/IC Label and Location Info | - User Manual |
| - Operation Description | |

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 testing were performed according to the procedures in ANSI C63.10: 2013.

According to clause 3.1, all tests were performed on model RAK11720

4.3 Special Accessories and Auxiliary Equipment

Table 6: List of Accessories and Auxiliary Equipment

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)

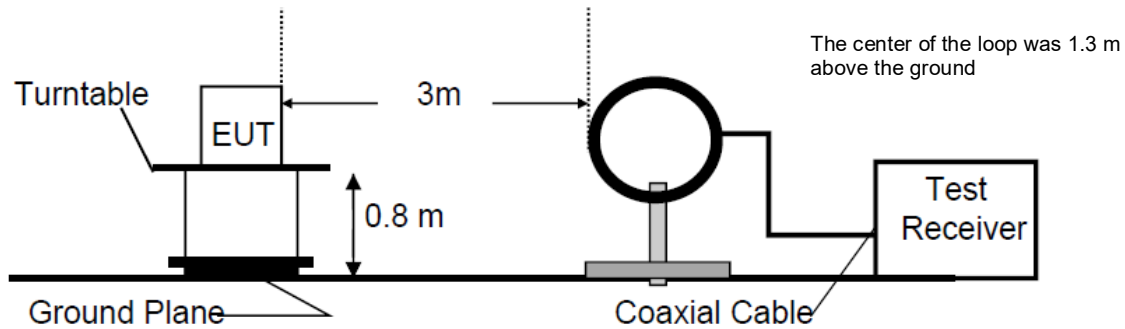


Diagram of Measurement Configuration for Radiation Test (Below 1GHz)

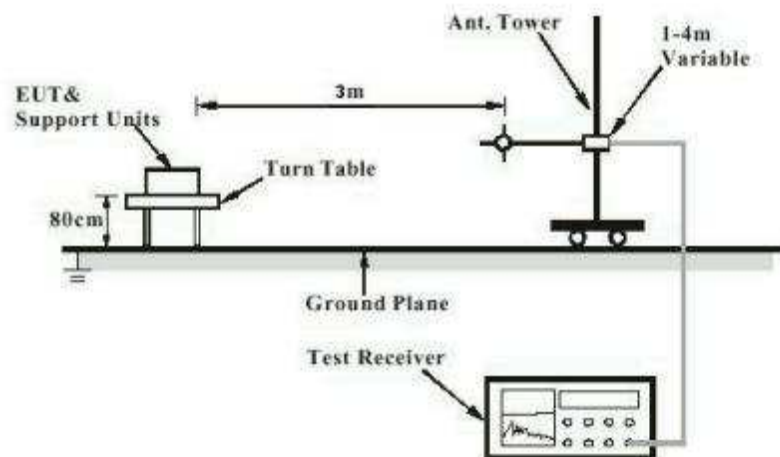


Diagram of Measurement Configuration for Radiation Test (Above 1GHz)

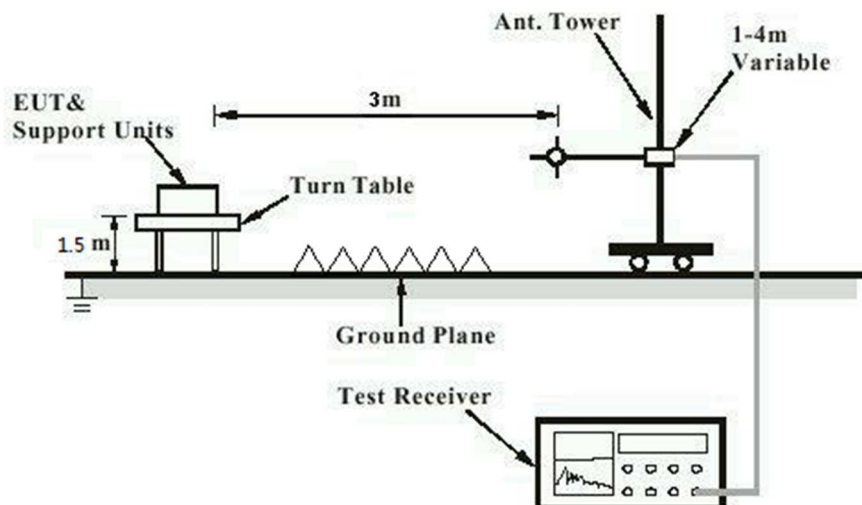


Diagram of Measurement Configuration for Mains Conduction Measurement

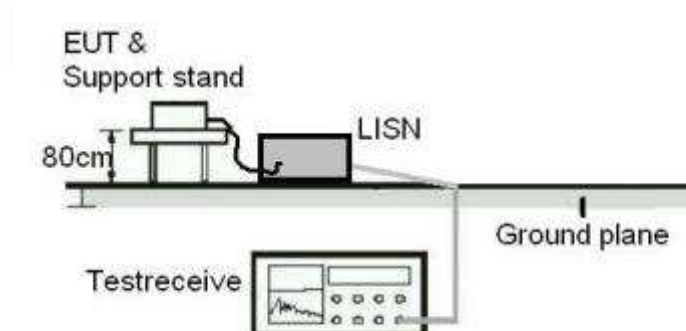
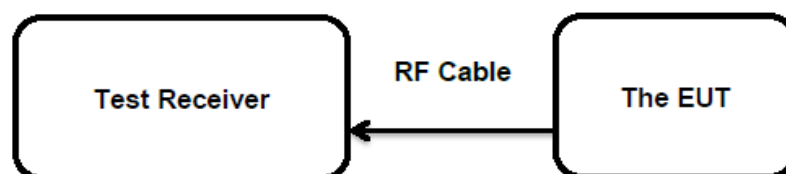


Diagram of Measurement Configuration for Conducted Transmitter Measurement



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 6.7
Limit	:	the use of antennas with directional gains that do not exceed 6 dBi

According to the manufacturer declared, the EUT has two IPEX Antenna, the directional gain of antenna are 2.3dBi & 3.12 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)(3)
	:	RSS-247 Clause 5.4(d)
Basic standard	:	ANSI C63.10: 2013
Limits	:	< 1 Watt (Maximum Conducted Peak Power)
	:	e.i.r.p. <4W
Kind of test site	:	Shielded Room

Test Setup

Date of testing	:	2022-12-09 to 2023-01-04
Input voltage	:	DC 5V
Operation mode	:	A
Test channel	:	Low / Middle / High
Ambient temperature	:	25 °C
Relative humidity	:	56 %
Atmospheric pressure	:	101 kPa

For details refer to following test result.

Table 7: Test Result of Maximum Conducted Output Power, 1Mbps

Channel	Channel Frequency (MHz)	Conducted Peak Output Power		Limit
		(dBm)	(W)	(W)
Low Channel	2402	2.8	0.00191	1
Middle Channel	2440	2.7	0.00186	1
High Channel	2480	2.3	0.00170	1

Channel	Channel Frequency (MHz)	Conducted Average Output Power		Limit
		(dBm)	(W)	(W)
Low Channel	2402	2.2	0.00166	1
Middle Channel	2440	2.2	0.00166	1
High Channel	2480	1.7	0.00148	1

Note: The cable loss is taken into account in results and the e.i.r.p. is 5.92 dBm less than 4W (36 dBm).

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	:	2022-12-09 to 2023-01-04
Input voltage	:	DC 5V
Operation mode	:	A
Test channel	:	Low / Middle / High
Ambient temperature	:	25 °C
Relative humidity	:	56 %
Atmospheric pressure	:	101 kPa

For details refer to following test result.

Table 8: Test Result of Power Spectral Density, 1Mbps

Channel	Channel Frequency (MHz)	Power Spectral Density (dBm/3kHz)	Limit (dBm/3kHz)
Low Channel	2402	-13.63	8
Middle Channel	2440	-13.98	8
High Channel	2480	-14.33	8

Note: The cable loss is taken into account in results.

For the measurement records, refer to the appendix B.

5.1.4 99%dB 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 : 2022-12-09 to 2023-01-04
Input voltage : DC 5V
Operation mode : A
Test channel : Low / Middle / High
Ambient temperature : 25 °C
Relative humidity : 56 %
Atmospheric pressure : 101 kPa

Table 9: Test Result of 99% Bandwidth, 1Mbps

Channel	Channel Frequency (MHz)	99% Bandwidth (MHz)	Limit (MHz)	Result
Low Channel	2402	1.045	/	Pass
Mid Channel	2440	1.060	/	Pass
High Channel	2480	1.090	/	Pass

For the measurement records, refer to the appendix B.

5.1.5 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
Kind of test site : Shielded Room

Test Setup

Date of testing : 2022-12-09 to 2023-01-04
Input voltage : DC 5V
Operation mode : A
Test channel : Low / Middle / High
Ambient temperature : 25 °C
Relative humidity : 56 %
Atmospheric pressure : 101 kPa

Table 10: Test Result of 6dB Bandwidth, 1Mbps

Channel	Channel Frequency (MHz)	-6dB Bandwidth (kHz)	Limit (kHz)	Result
Low Channel	2402	712.872	500	Pass
Mid Channel	2440	732.674	500	Pass
High Channel	2480	752.476	500	Pass

For the measurement records, refer to the appendix B.

5.1.6 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	: 2022-12-09 to 2023-01-04
Input voltage	: DC 5V
Operation mode	: A
Test channel	: Low / Middle / High
Ambient temperature	: 25 °C
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.

5.1.7 Radiated Spurious Emission

RESULT:**Pass****Test Specification**

Test standard	:	FCC Part 15.247(d) & FCC Part 15.205 RSS-247 Clause 3.3 & 5.5
Basic standard	:	ANSI C63.10: 2013
Limits	:	Refer to 15.209(a) of FCC part 15.247(d) RSS-Gen Table 4 & Table 5
Kind of test site	:	3m Semi-anechoic Chamber

Test Setup

Date of testing	:	2022-12-09 to 2023-01-04
Input voltage	:	DC 5V
Operation mode	:	A
Test channel	:	Low / Middle / High
Ambient temperature	:	23 °C
Relative humidity	:	56 %
Atmospheric pressure	:	101 kPa

Remark:

Testing was carried out within frequency range 9kHz to the tenth harmonics. Only the worst case spurious emissions configuration of the each mode were reported.

For the measurement records, refer to the appendix B.

5.1.8 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 4
Kind of test site	: Shielded Room

Test Setup

Date of testing	: 2022-12-09 to 2023-01-04
Input voltage	: DC 5V (via PC)
Operation mode	: B
Earthing	: Not connected
Ambient temperature	: 25 °C
Relative humidity	: 56 %
Atmospheric pressure	: 101 kPa

For the measurement records, refer to the appendix B.

6 Photographs of the Test Set-Up

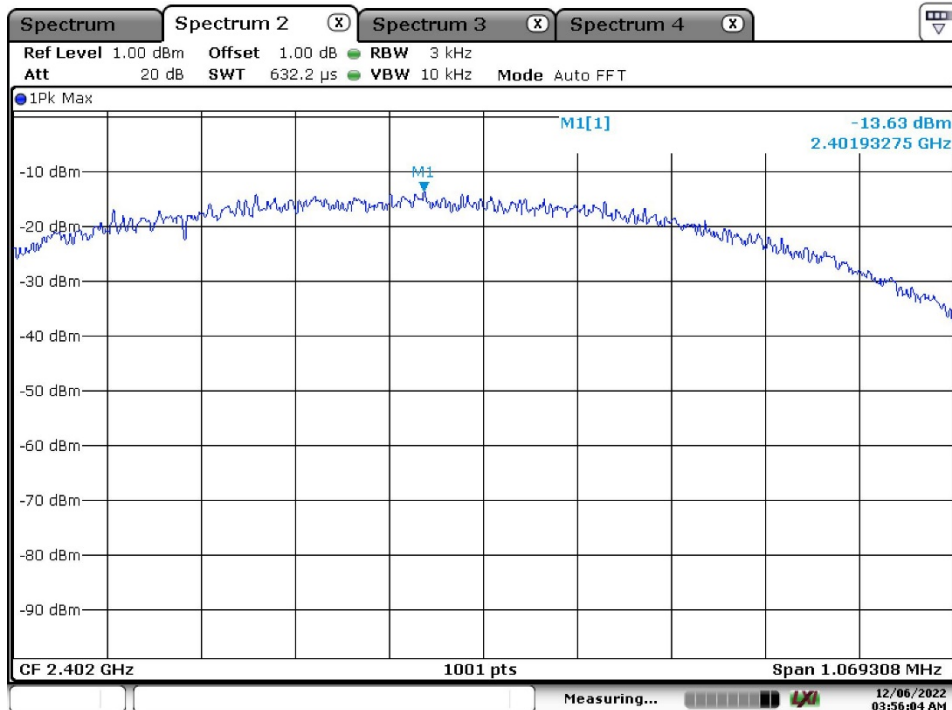
For photographs of the test set-up, refer to the appendix A.

7 List of Tables

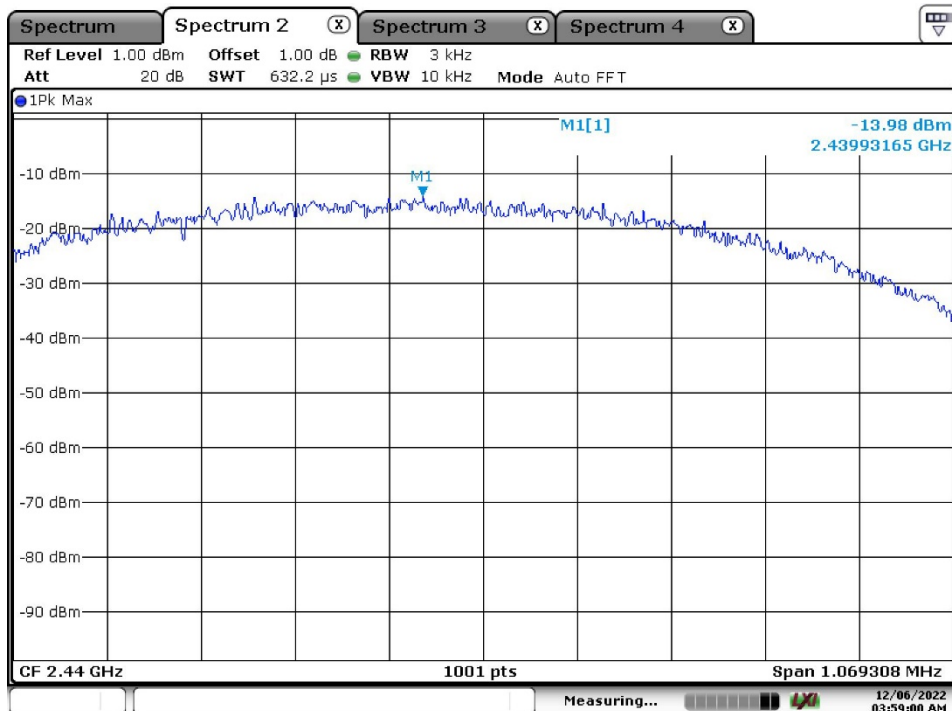
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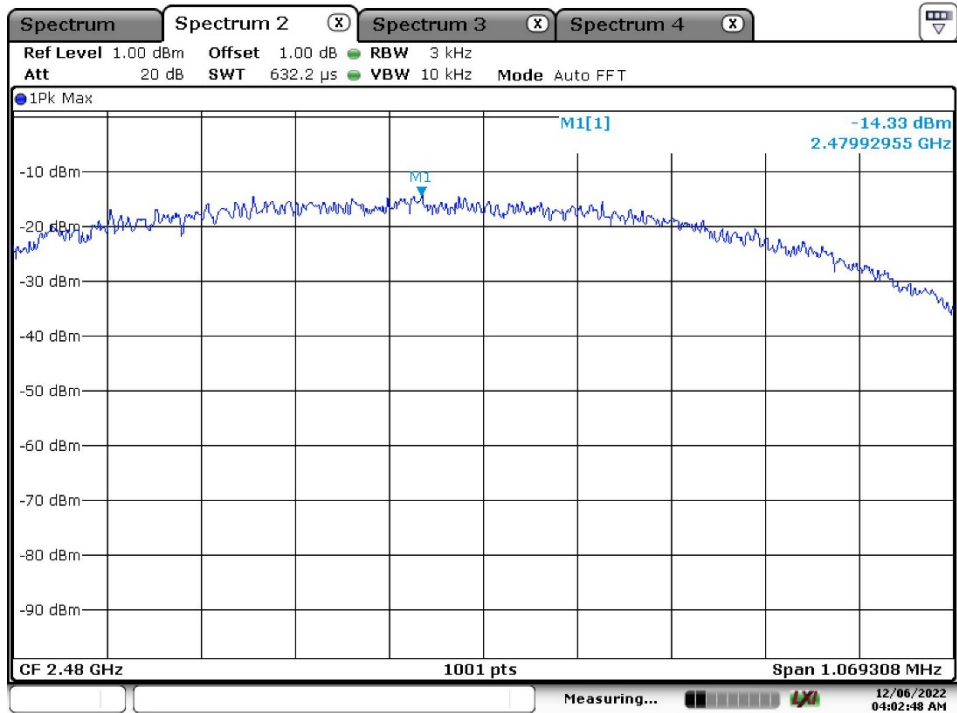
Appendix B.1: Conducted Power Spectral Density**BLE, 1Mbps
Low Channel**

Date: 6.DEC.2022 03:56:04

Middle Channel

Date: 6.DEC.2022 03:59:00

High Channel



Date: 6.DEC.2022 04:02:48

Appendix B.2: 6dB Bandwidth

BLE, 1Mbps
Low Channel

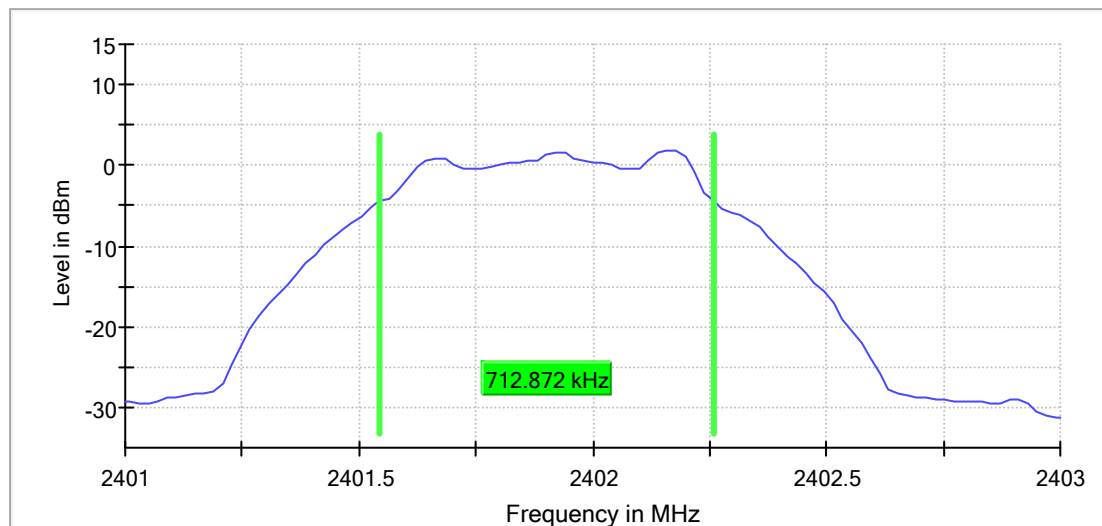
6 dB Bandwidth

DUT Frequency (MHz)	Bandwidth (MHz)	Limit Min (MHz)	Limit Max (MHz)	Band Edge Left (MHz)	Band Edge Right (MHz)
2402.000000	0.712872	0.500000	---	2401.544554	2402.257426

(continuation of the "6 dB Bandwidth" table from column 6 ...)

DUT Frequency (MHz)	Max Level (dBm)	Result
2402.000000	1.9	PASS

6 dB Bandwidth



RBW=100kHz, VBW=300kHz

Middle Channel

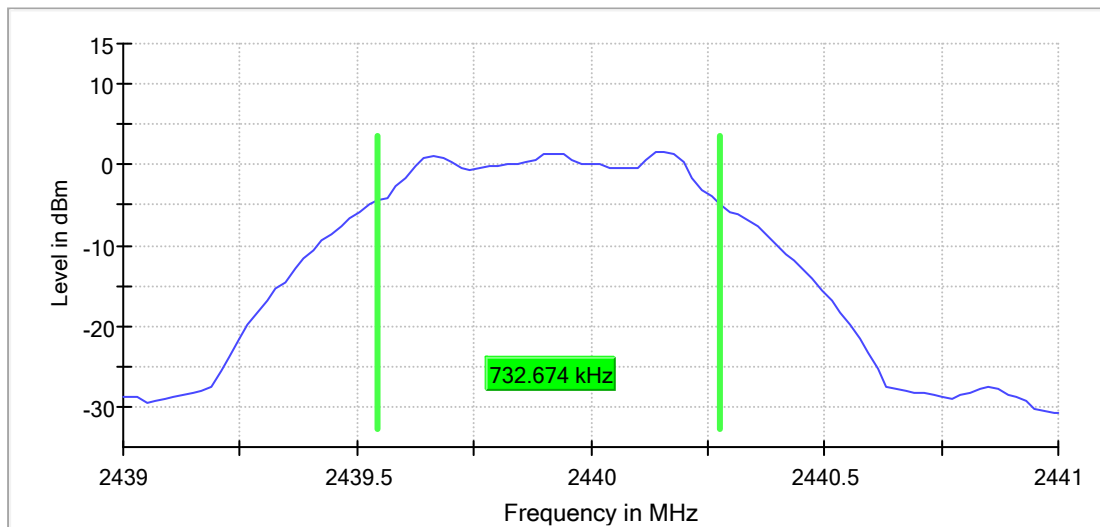
6 dB Bandwidth

DUT Frequency (MHz)	Bandwidth (MHz)	Limit Min (MHz)	Limit Max (MHz)	Band Edge Left (MHz)	Band Edge Right (MHz)
2440.000000	0.732674	0.500000	---	2439.544554	2440.277228

(continuation of the "6 dB Bandwidth" table from column 6 ...)

DUT Frequency (MHz)	Max Level (dBm)	Result
2440.000000	1.7	PASS

6 dB Bandwidth



RBW=100kHz, VBW=300kHz

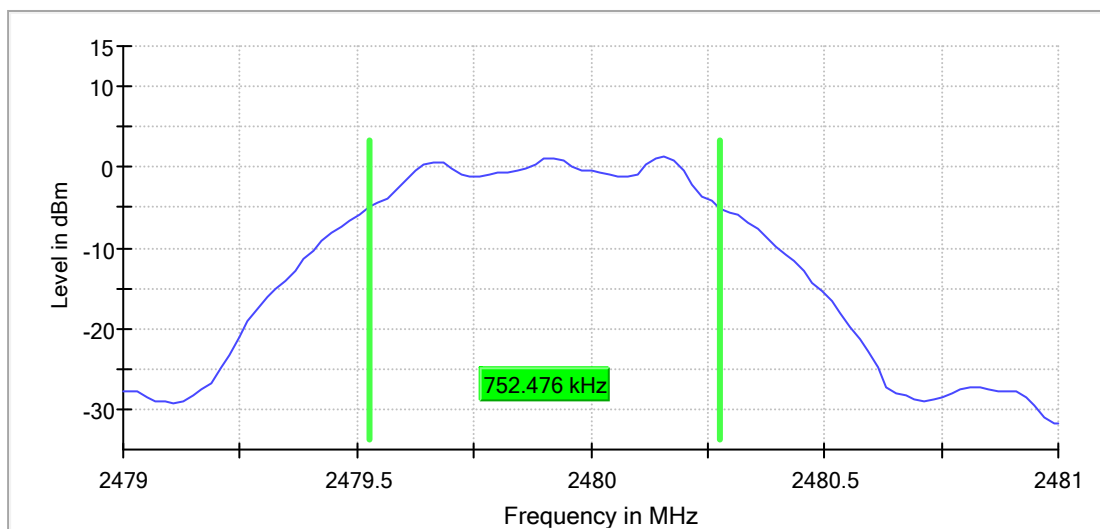
High Channel**6 dB Bandwidth**

DUT Frequency (MHz)	Bandwidth (MHz)	Limit Min (MHz)	Limit Max (MHz)	Band Edge Left (MHz)	Band Edge Right (MHz)
2480.000000	0.752476	0.500000	---	2479.524752	2480.277228

(continuation of the "6 dB Bandwidth" table from column 6 ...)

DUT Frequency (MHz)	Max Level (dBm)	Result
2480.000000	1.3	PASS

6 dB Bandwidth



RBW=100kHz, VBW=300kHz

Appendix B.3: 99% Bandwidth

BLE, 1Mbps
Low Channel

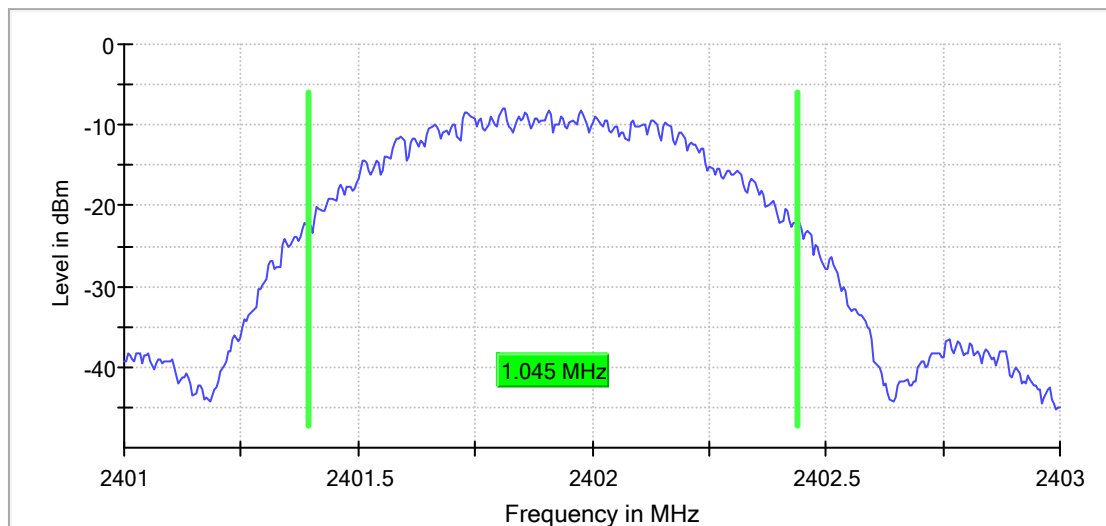
99 % Bandwidth

DUT Frequency (MHz)	Bandwidth (MHz)	Limit Min (MHz)	Limit Max (MHz)	Band Edge Left (MHz)	Band Edge Right (MHz)
2402.000000	1.045000	---	---	2401.392500	2402.437500

(continuation of the "99 % Bandwidth" table from column 6 ...)

DUT Frequency (MHz)	Result
2402.000000	PASS

99 % Bandwidth



RBW=30kHz, VBW=100kHz

Middle Channel

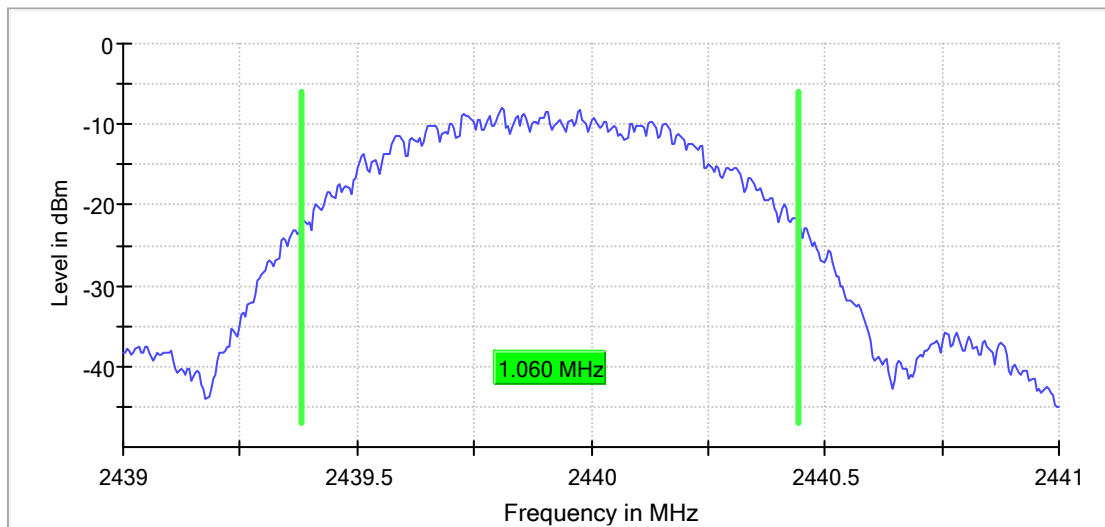
99 % Bandwidth

DUT Frequency (MHz)	Bandwidth (MHz)	Limit Min (MHz)	Limit Max (MHz)	Band Edge Left (MHz)	Band Edge Right (MHz)
2440.000000	1.060000	---	---	2439.382500	2440.442500

(continuation of the "99 % Bandwidth" table from column 6 ...)

DUT Frequency (MHz)	Result
2440.000000	PASS

99 % Bandwidth



RBW=30kHz, VBW=100kHz

High Channel

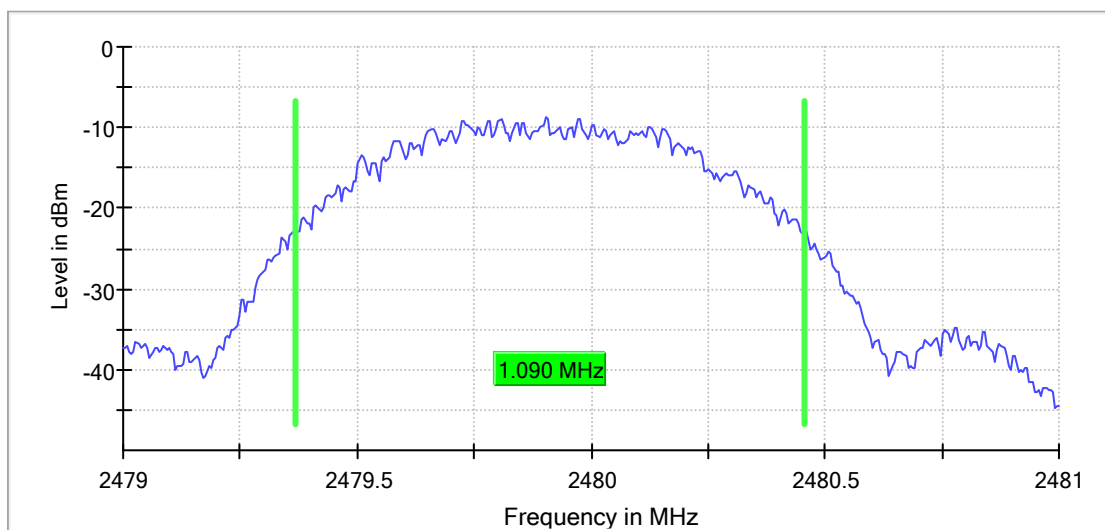
99 % Bandwidth

DUT Frequency (MHz)	Bandwidth (MHz)	Limit Min (MHz)	Limit Max (MHz)	Band Edge Left (MHz)	Band Edge Right (MHz)
2480.000000	1.090000	---	---	2479.367500	2480.457500

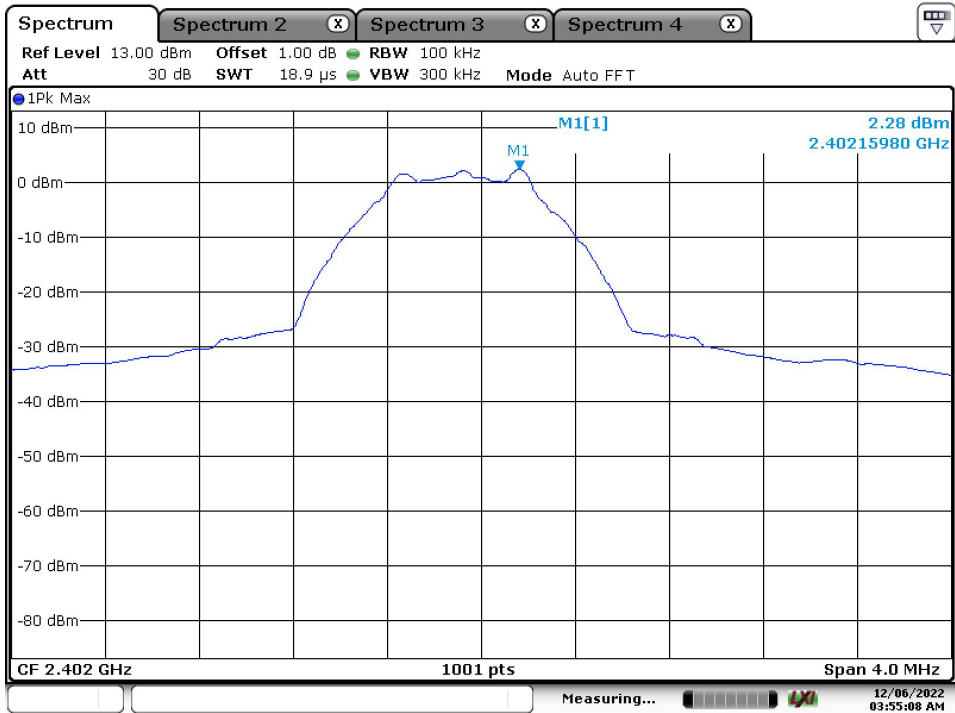
(continuation of the "99 % Bandwidth" table from column 6 ...)

DUT Frequency (MHz)	Result
2480.000000	PASS

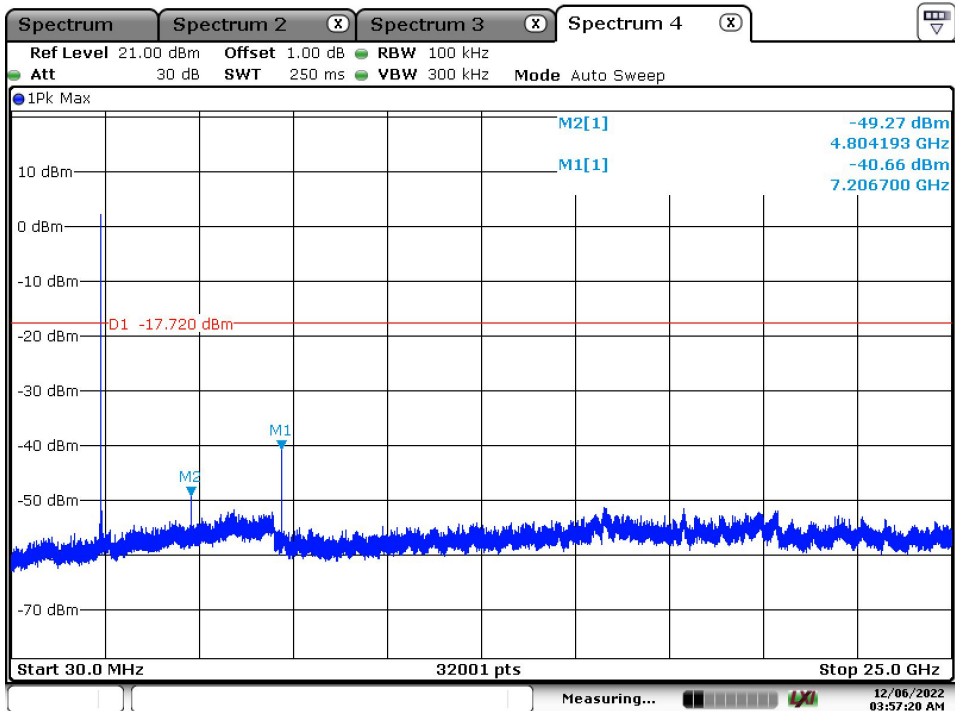
99 % Bandwidth



RBW=30kHz, VBW=100kHz

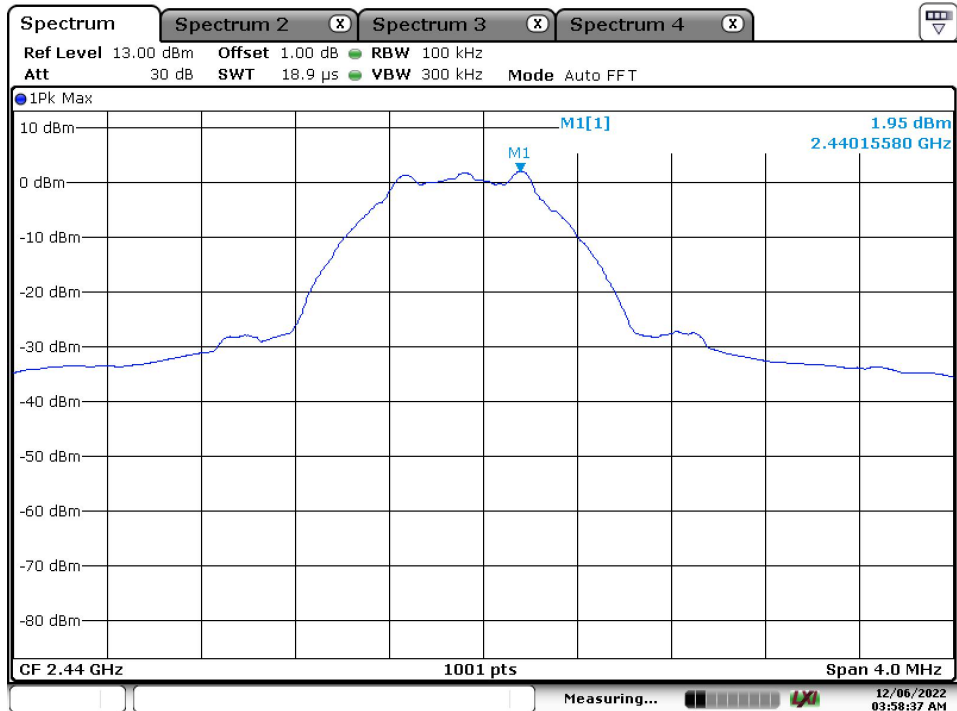
Appendix B.4: Conducted Spurious Emissions Measured in 100 kHz Bandwidth**BLE, 1Mbps
Low Channel**

Date: 6.DEC.2022 03:55:09

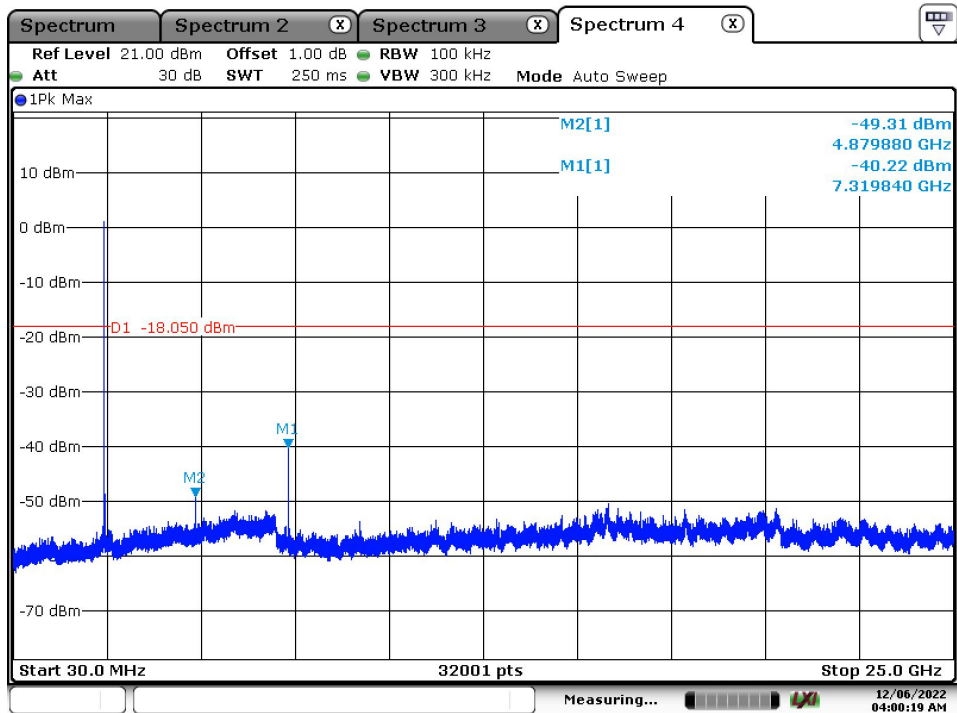


Date: 6.DEC.2022 03:57:21

Middle Channel

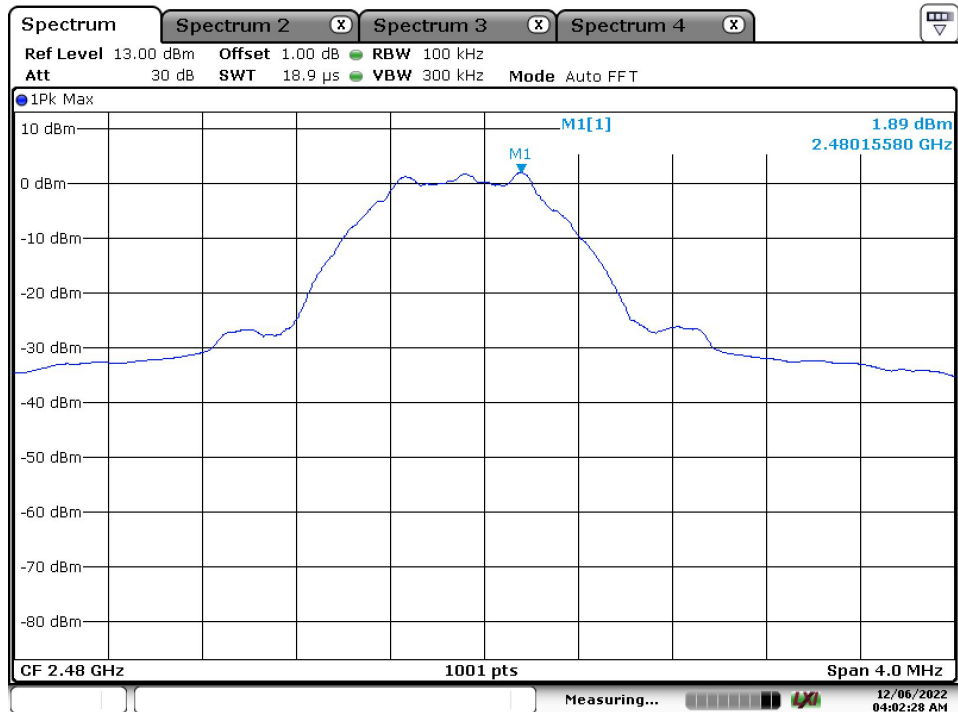


Date: 6.DEC.2022 03:58:38

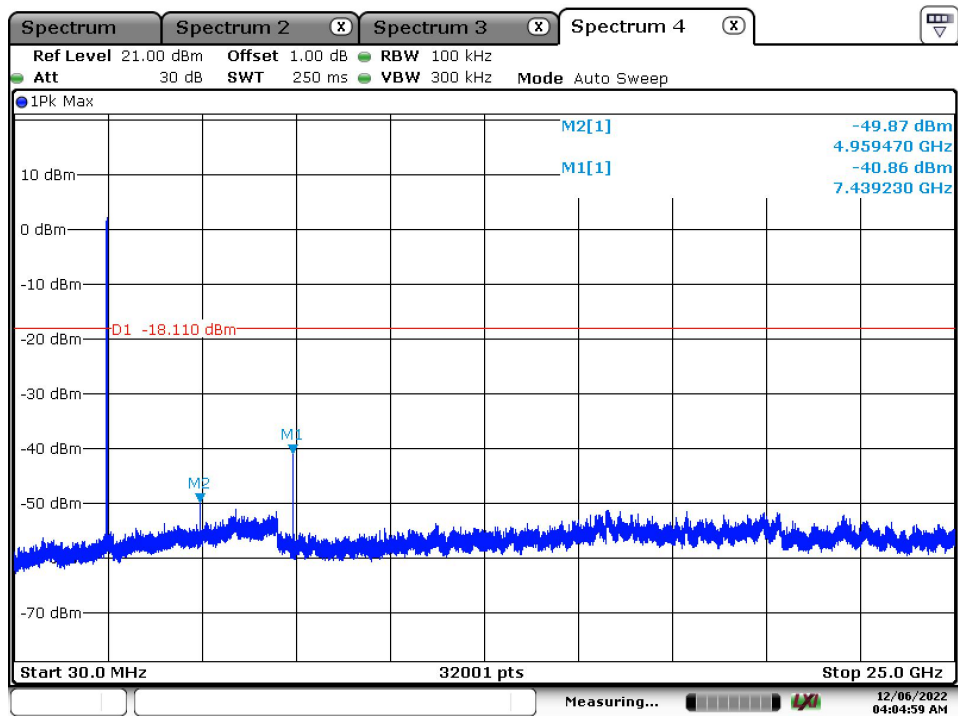


Date: 6.DEC.2022 04:00:19

High Channel

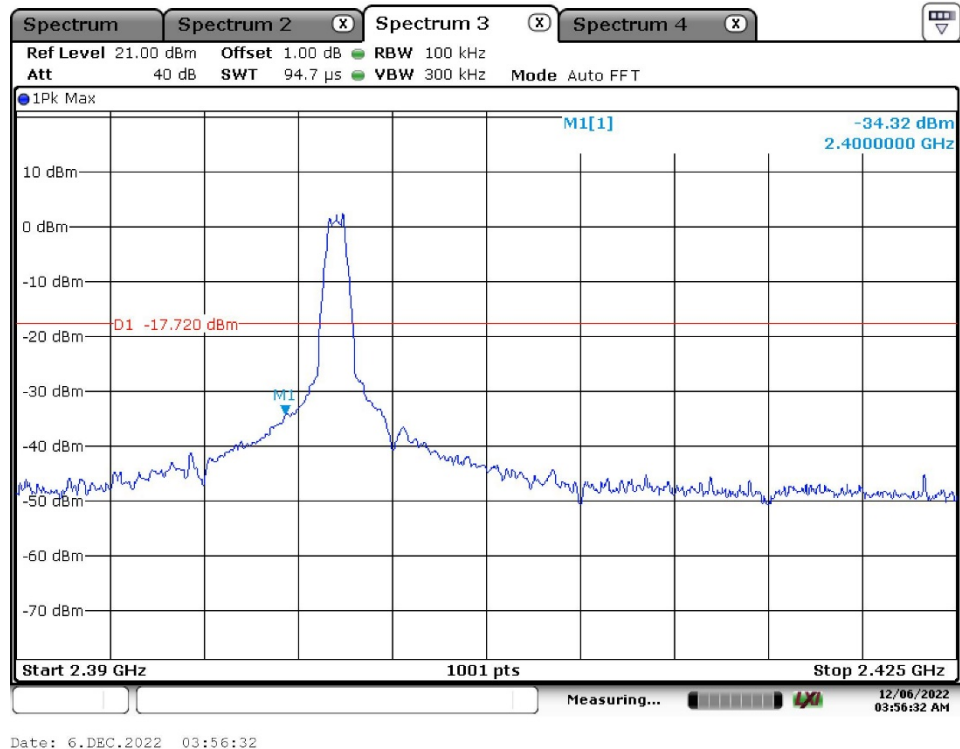


Date: 6.DEC.2022 04:02:29

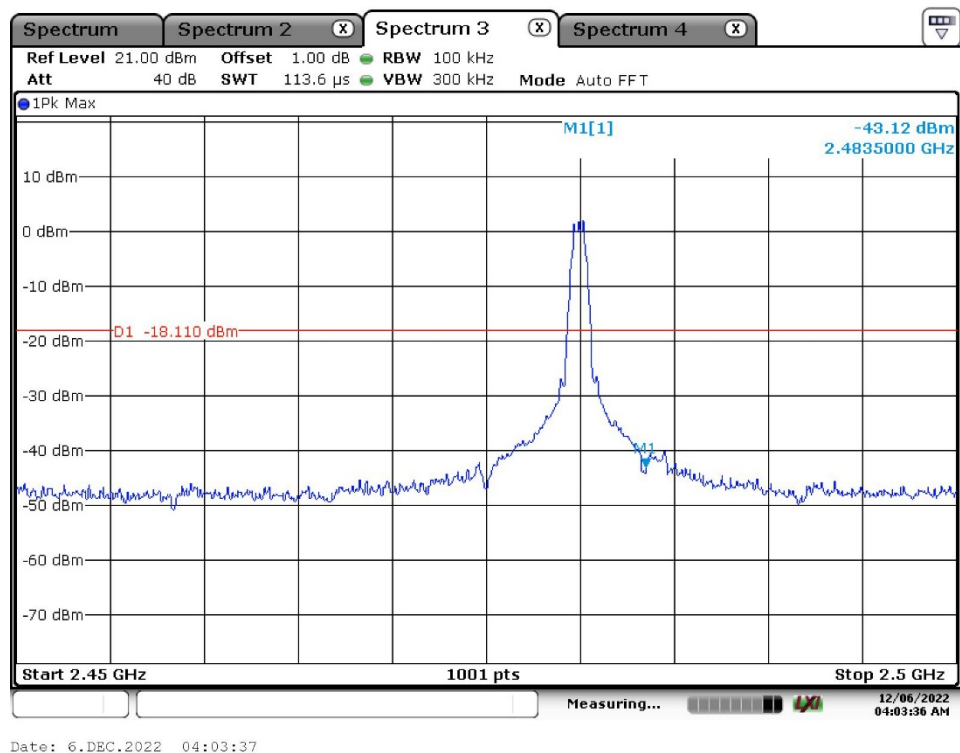


Date: 6.DEC.2022 04:05:00

Low Channel_Band Edge



High Channel_Band Edge



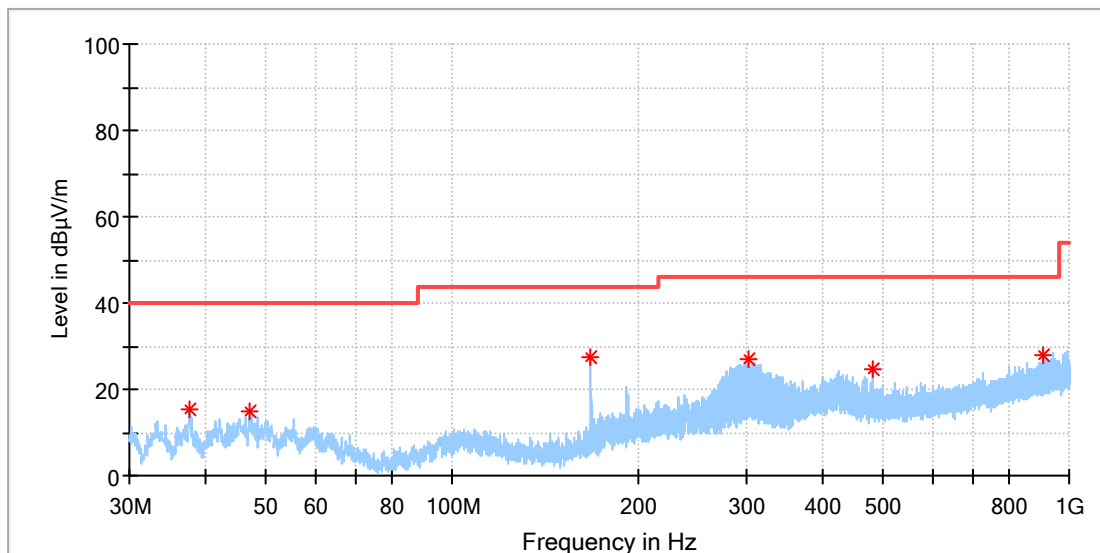
Appendix B.5: Test Results of Radiated Spurious Emissions

Note 1: Testing was carried out within frequency range 9 kHz to the tenth harmonics. The measurement results below 30MHz and above 18GHz were greater than 20dB below the limit, so only the radiated spurious emissions from 30MHz to 18GHz were reported.

BLE, 1Mbps

EUT Information

EUT Name:	WisDuo LPWAN Module
Model:	RAK11720
Test Mode:	BLE 1M_Mid channel
Order No/Sample No:	168399706/A003386865-004
Test Voltage::	DC 5V From USB
Remark:	Temp 23 Humi:56%
Test Standard:	FCC 15.247
Tested By:	Kei Zhang
Reviewed By:	Terry Yin

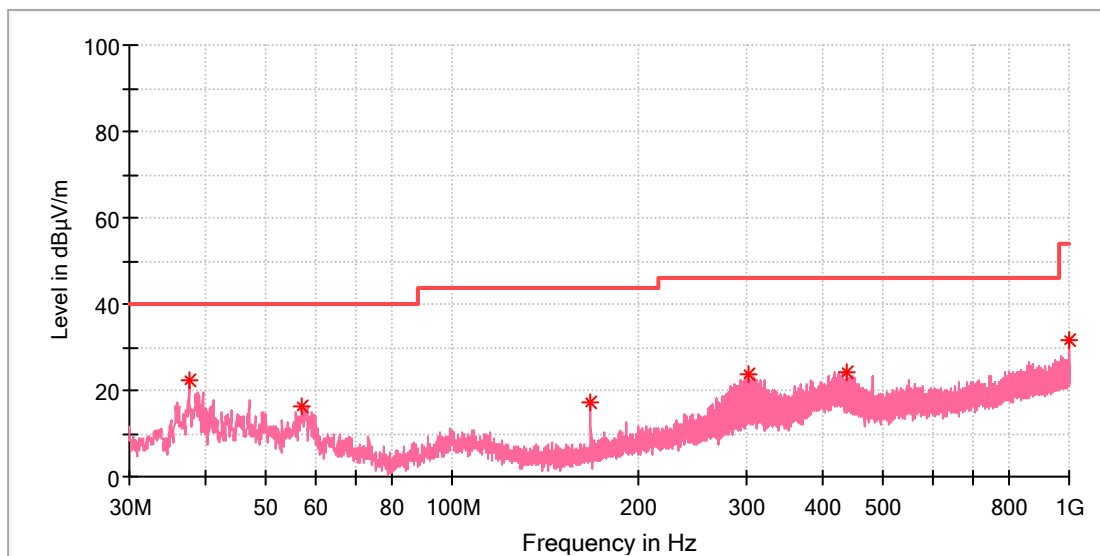


Critical_Freqs

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
37.461539	15.45	40.00	24.55	100.0	H	0.0	-21.3
46.900385	14.88	40.00	25.12	100.0	H	128.0	-18.8
168.001154	27.37	43.50	16.13	100.0	H	279.0	-21.7
303.353462	26.92	46.00	19.08	100.0	H	204.0	-16.6
480.005385	24.84	46.00	21.16	100.0	H	238.0	-12.6
910.760000	28.05	46.00	17.95	100.0	H	18.0	-5.3

EUT Information

EUT Name:	WisDuo LPWAN Module
Model:	RAK11720
Test Mode:	BLE 1M_Mid channel
Order No/Sample No:	168399706/A003386865-004
Test Voltage::	DC 5V From USB
Remark:	Temp 23 Humi:56%
Test Standard:	FCC 15.247
Tested By:	Kei Zhang
Reviewed By:	Terry Yin

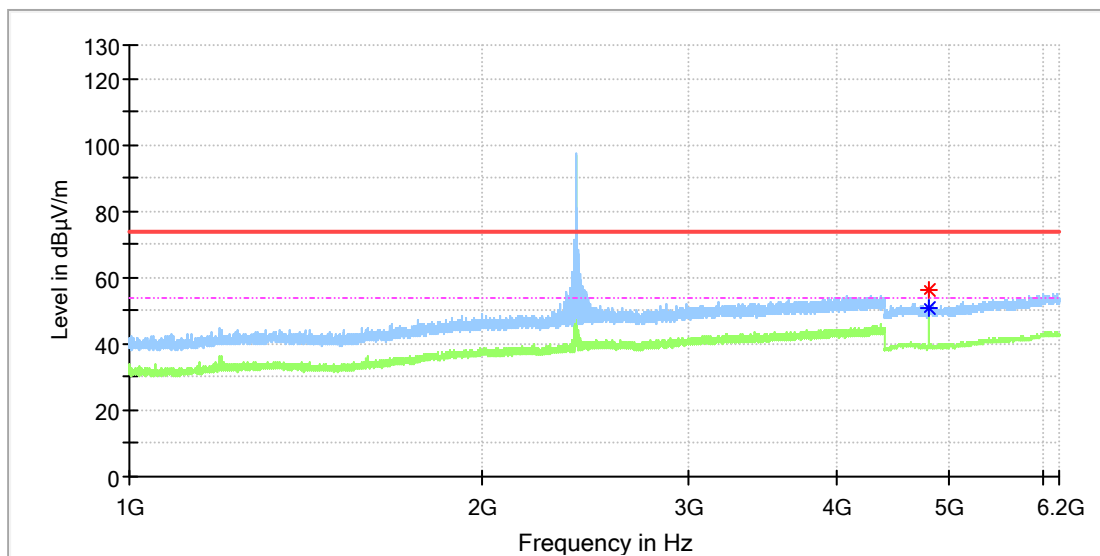


Critical_Freqs

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
37.498846	22.14	40.00	17.86	100.0	V	166.0	-21.2
57.160000	16.25	40.00	23.75	100.0	V	37.0	-19.0
168.001154	17.06	43.50	26.44	100.0	V	22.0	-21.7
303.390769	23.68	46.00	22.32	100.0	V	116.0	-16.5
436.355385	24.32	46.00	21.68	100.0	V	93.0	-13.5
996.605000	31.66	54.00	22.34	100.0	V	231.0	-4.1

EUT Information

EUT Name:	WisDuo LPWAN Module
Model:	RAK11720
Test Mode:	BLE 1M_Low channel
Order No/Sample No:	168399706/A003386865-004
Test Voltage::	DC 5V From USB
Remark:	Temp 23 Humi:56%
Test Standard:	FCC 15.247
Tested By:	Kei Zhang
Reviewed By:	Terry Yin

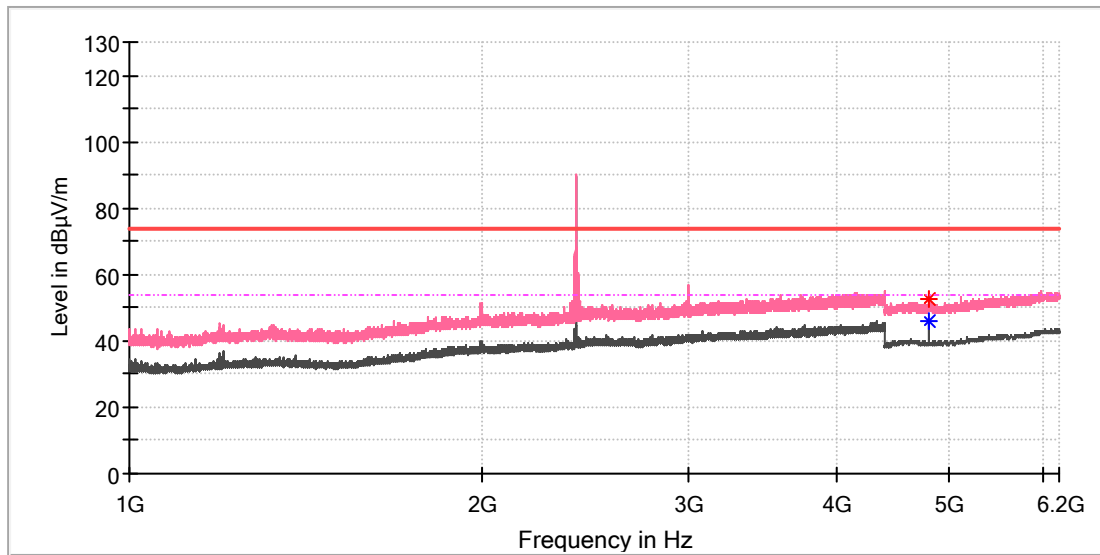


Critical_Freqs

Frequency (MHz)	MaxPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
4804.000000	56.30	---	74.00	17.70	100.0	H	184.0	11.8
4804.000000	---	50.59	54.00	3.41	100.0	H	184.0	11.8

EUT Information

EUT Name:	WisDuo LPWAN Module
Model:	RAK11720
Test Mode:	BLE 1M_Low channel
Order No/Sample No:	168399706/A003386865-004
Test Voltage::	DC 5V From USB
Remark:	Temp 23 Humi:56%
Test Standard:	FCC 15.247
Tested By:	Kei Zhang
Reviewed By:	Terry Yin

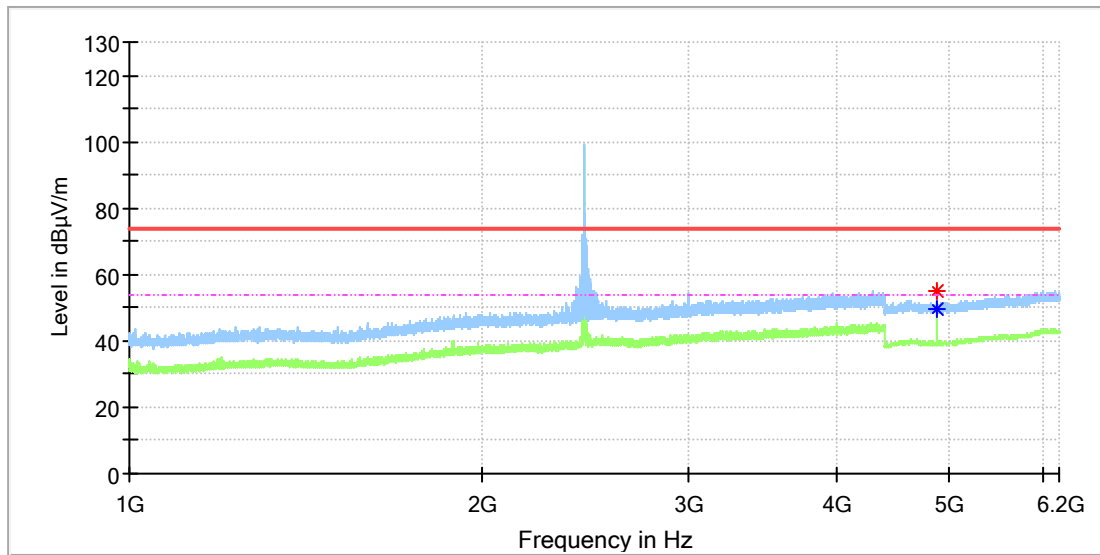


Critical_Freqs

Frequency (MHz)	MaxPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
4803.500000	52.67	---	74.00	21.33	100.0	V	86.0	11.8
4803.500000	---	45.80	54.00	8.20	100.0	V	86.0	11.8

EUT Information

EUT Name:	WisDuo LPWAN Module
Model:	RAK11720
Test Mode:	BLE 1M_Mid channel
Order No/Sample No:	168399706/A003386865-004
Test Voltage::	DC 5V From USB
Remark:	Temp 23 Humi:56%
Test Standard:	FCC 15.247
Tested By:	Kei Zhang
Reviewed By:	Terry Yin

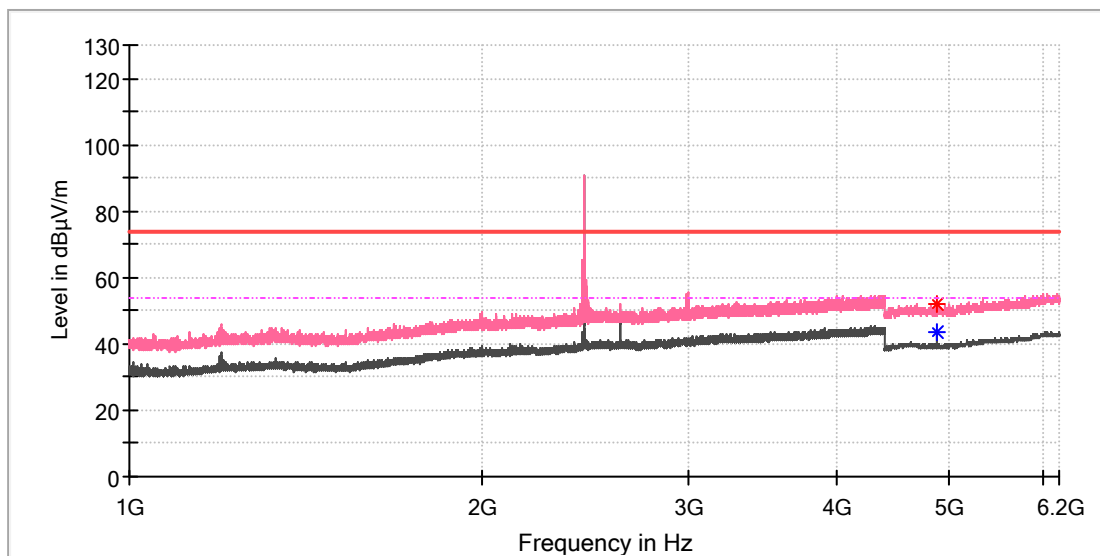


Critical_Freqs

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
4879.500000	---	49.37	54.00	4.63	100.0	H	176.0	11.8
4880.000000	55.18	---	74.00	18.82	100.0	H	176.0	11.8

EUT Information

EUT Name:	WisDuo LPWAN Module
Model:	RAK11720
Test Mode:	BLE 1M_Mid channel
Order No/Sample No:	168399706/A003386865-004
Test Voltage::	DC 5V From USB
Remark:	Temp 23 Humi:56%
Test Standard:	FCC 15.247
Tested By:	Kei Zhang
Reviewed By:	Terry Yin

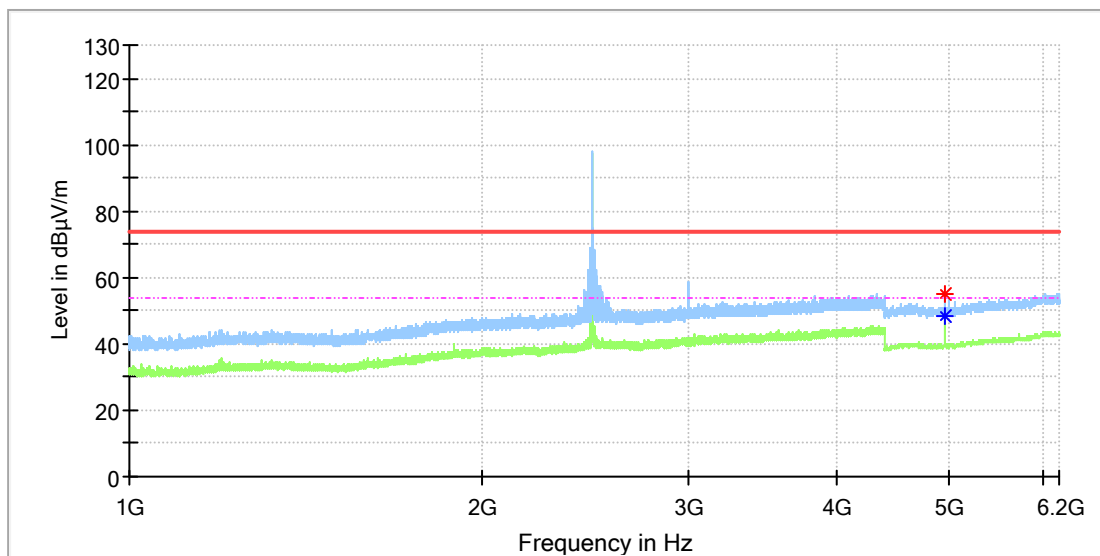


Critical_Freqs

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
4879.500000	51.76	---	74.00	22.24	100.0	V	314.0	11.8
4879.500000	---	43.54	54.00	10.46	100.0	V	314.0	11.8

EUT Information

EUT Name:	WisDuo LPWAN Module
Model:	RAK11720
Test Mode:	BLE 1M_High channel
Order No/Sample No:	168399706/A003386865-004
Test Voltage::	DC 5V From USB
Remark:	Temp 23 Humi:56%
Test Standard:	FCC 15.247
Tested By:	Kei Zhang
Reviewed By:	Terry Yin

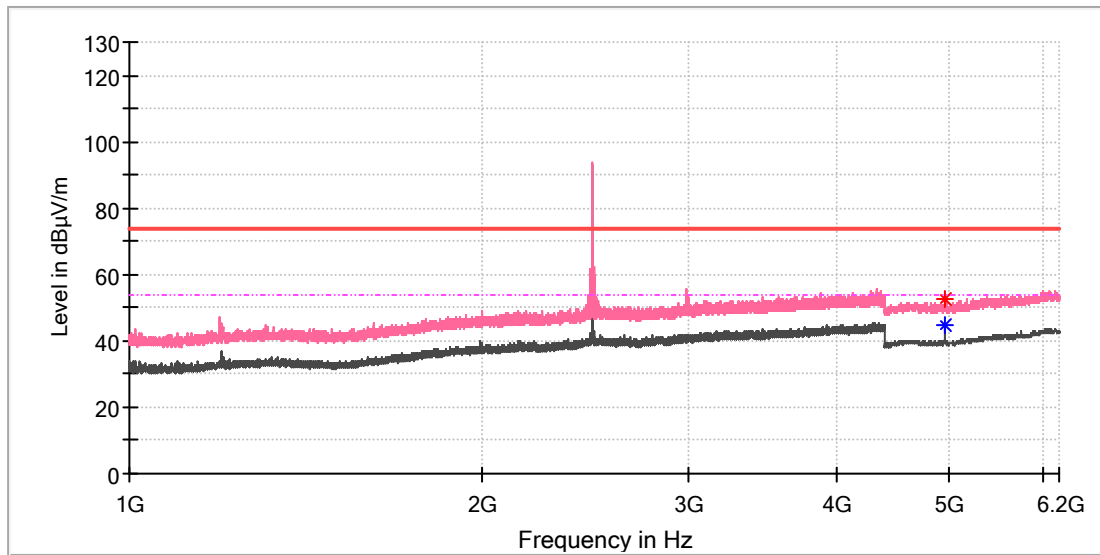


Critical_Freqs

Frequency (MHz)	MaxPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
4959.500000	55.20	---	74.00	18.80	100.0	H	297.0	11.8
4960.000000	---	48.64	54.00	5.36	100.0	H	297.0	11.8

EUT Information

EUT Name:	WisDuo LPWAN Module
Model:	RAK11720
Test Mode:	BLE 1M_High channel
Order No/Sample No:	168399706/A003386865-004
Test Voltage::	DC 5V From USB
Remark:	Temp 23 Humi:56%
Test Standard:	FCC 15.247
Tested By:	Kei Zhang
Reviewed By:	Terry Yin

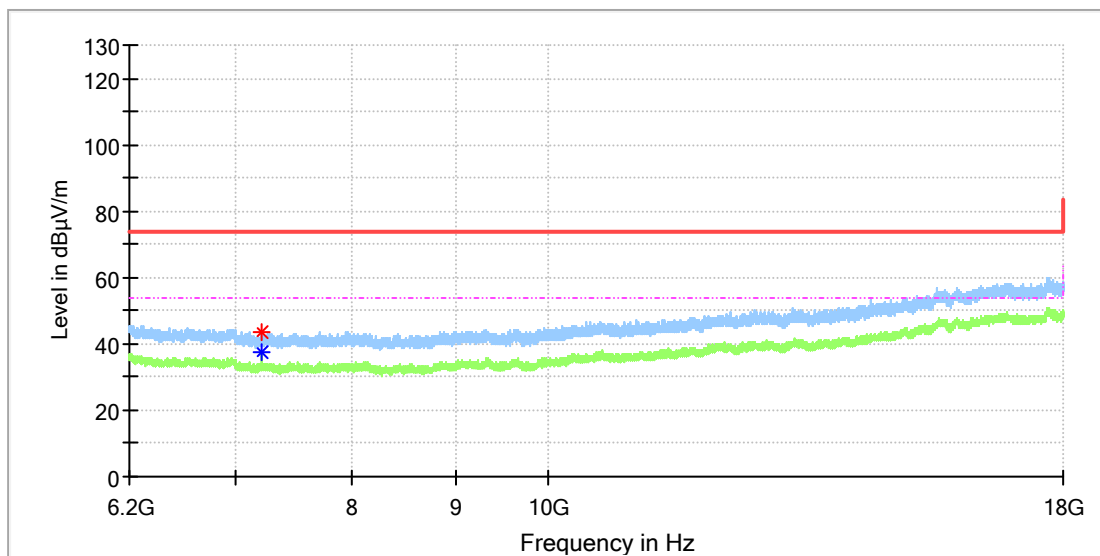


Critical_Freqs

Frequency (MHz)	MaxPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
4960.000000	---	44.50	54.00	9.50	100.0	V	188.0	11.8
4960.500000	52.35	---	74.00	21.65	100.0	V	307.0	11.8

EUT Information

EUT Name:	WisDuo LPWAN Module
Model:	RAK11720
Test Mode:	BLE 1M_Low channel
Order No/Sample No:	168399706/A003386865-004
Test Voltage::	DC 5V From USB
Remark:	Temp 23 Humi:56%
Test Standard:	FCC 15.247
Tested By:	Kei Zhang
Reviewed By:	Terry Yin

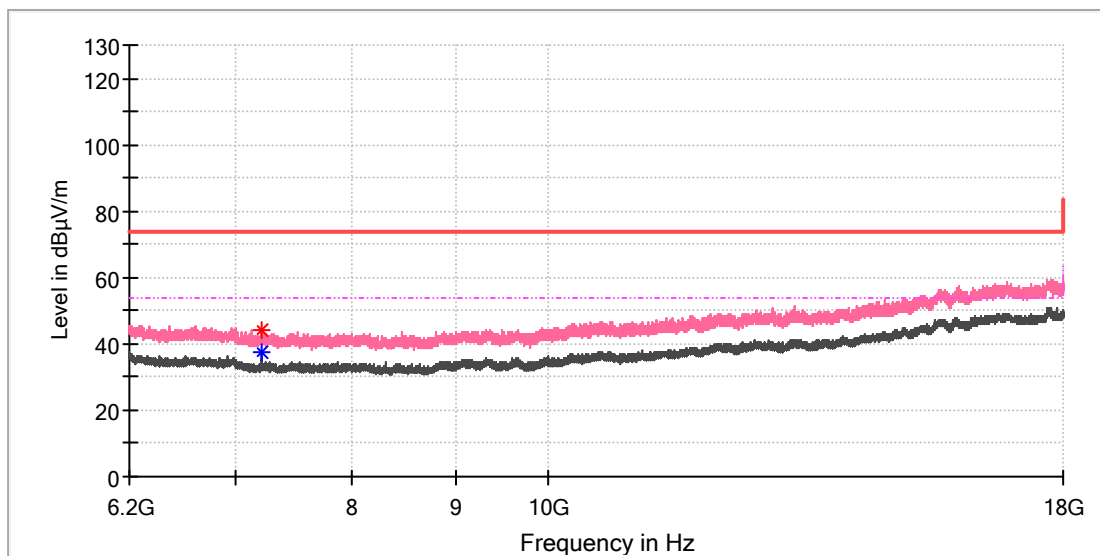


Critical_Freqs

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
7204.966667	43.52	---	74.00	30.48	100.0	H	61.0	8.8
7206.441667	---	37.65	54.00	16.35	100.0	H	150.0	8.8

EUT Information

EUT Name:	WisDuo LPWAN Module
Model:	RAK11720
Test Mode:	BLE 1M_Low channel
Order No/Sample No:	168399706/A003386865-004
Test Voltage::	DC 5V From USB
Remark:	Temp 23 Humi:56%
Test Standard:	FCC 15.247
Tested By:	Kei Zhang
Reviewed By:	Terry Yin

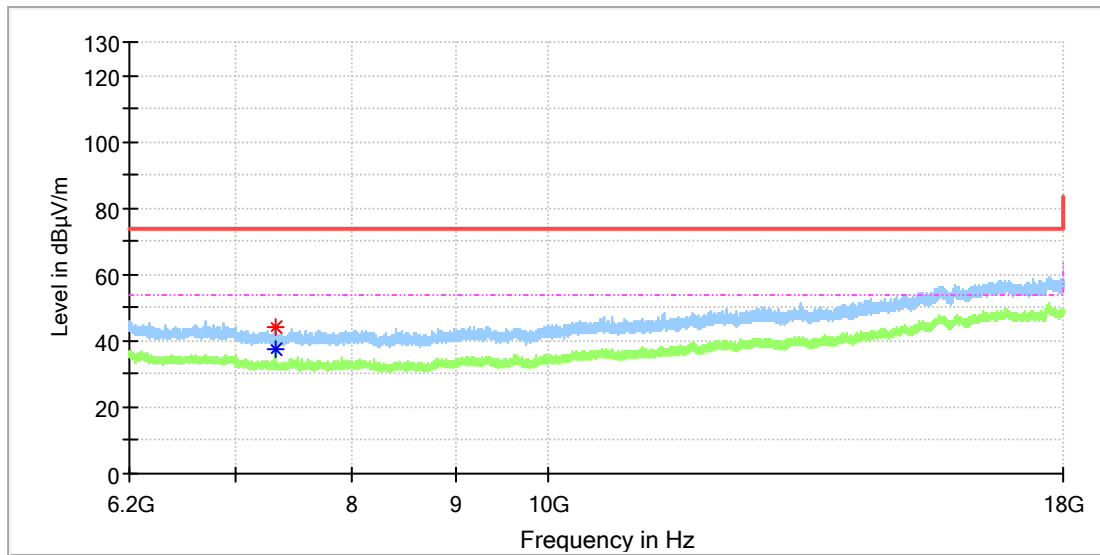


Critical_Freqs

Frequency (MHz)	MaxPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
7205.950000	---	37.32	54.00	16.68	100.0	V	272.0	8.8
7206.441667	44.10	---	74.00	29.90	100.0	V	105.0	8.8

EUT Information

EUT Name:	WisDuo LPWAN Module
Model:	RAK11720
Test Mode:	BLE 1M_Mid channel
Order No/Sample No:	168399706/A003386865-004
Test Voltage::	DC 5V From USB
Remark:	Temp 23 Humi:56%
Test Standard:	FCC 15.247
Tested By:	Kei Zhang
Reviewed By:	Terry Yin

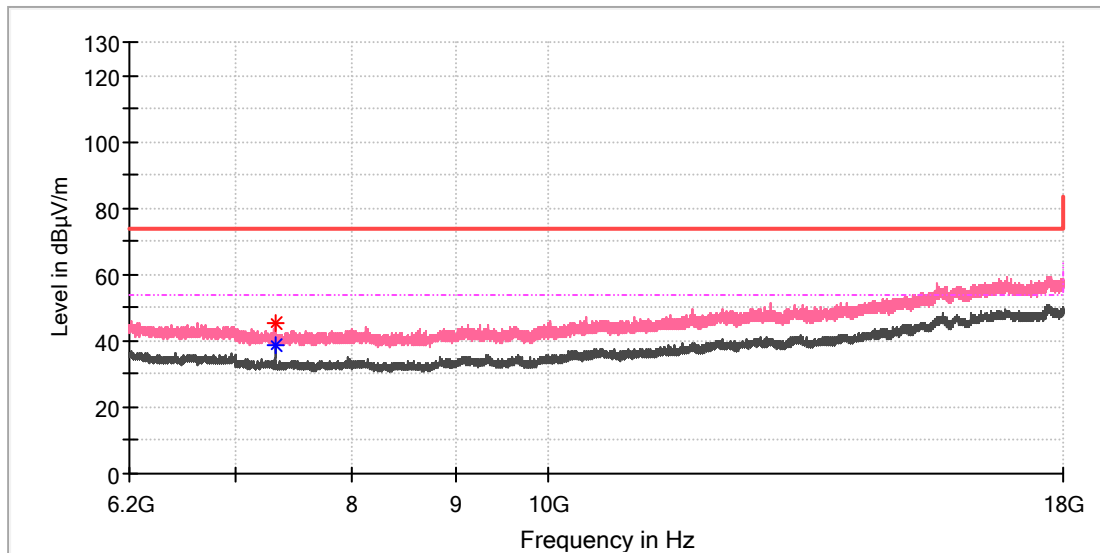


Critical_Freqs

Frequency (MHz)	MaxPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
7320.016667	44.03	---	74.00	29.97	100.0	H	152.0	8.2
7320.508333	---	37.71	54.00	16.29	100.0	H	320.0	8.2

EUT Information

EUT Name:	WisDuo LPWAN Module
Model:	RAK11720
Test Mode:	BLE 1M_Mid channel
Order No/Sample No:	168399706/A003386865-004
Test Voltage::	DC 5V From USB
Remark:	Temp 23 Humi:56%
Test Standard:	FCC 15.247
Tested By:	Kei Zhang
Reviewed By:	Terry Yin

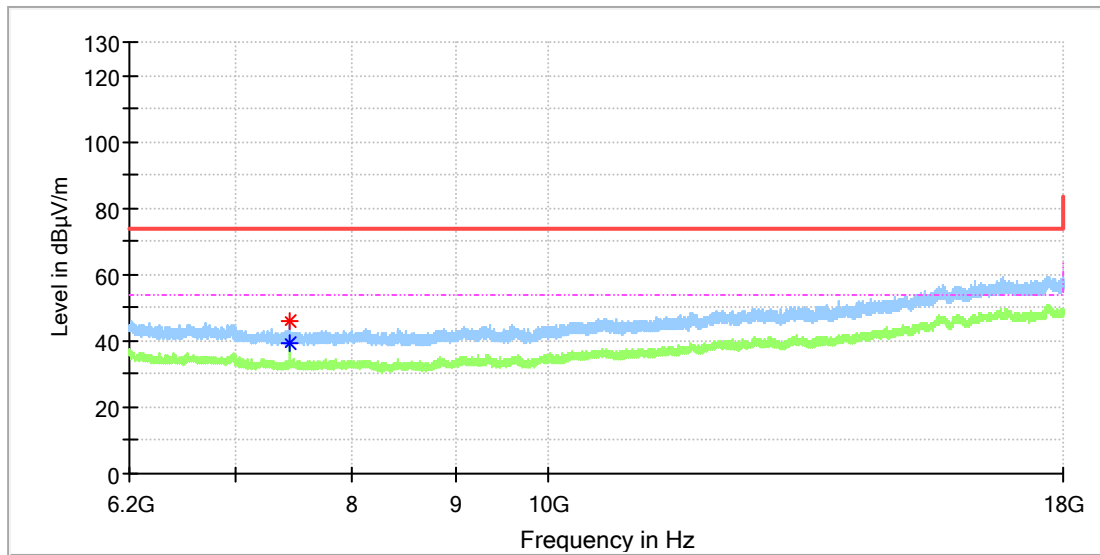


Critical_Freqs

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
7319.525000	---	38.61	54.00	15.39	100.0	V	51.0	8.2
7320.016667	45.53	---	74.00	28.47	100.0	V	63.0	8.2

EUT Information

EUT Name:	WisDuo LPWAN Module
Model:	RAK11720
Test Mode:	BLE 1M_High channel
Order No/Sample No:	168399706/A003386865-004
Test Voltage::	DC 5V From USB
Remark:	Temp 23 Humi:56%
Test Standard:	FCC 15.247
Tested By:	Kei Zhang
Reviewed By:	Terry Yin

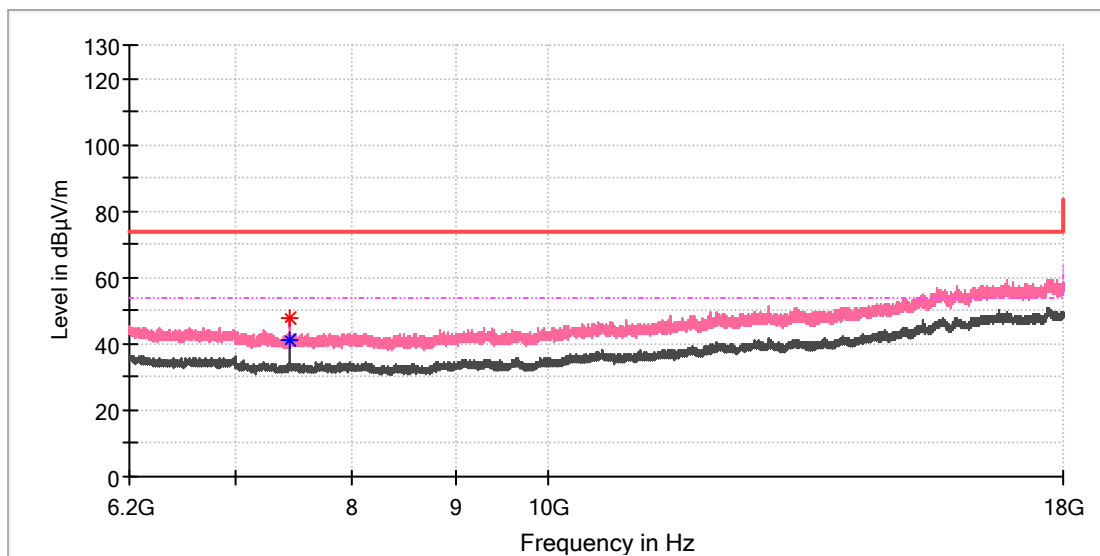


Critical_Freqs

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
7439.983333	46.11	---	74.00	27.89	100.0	H	46.0	8.4
7440.475000	---	39.37	54.00	14.63	100.0	H	60.0	8.4

EUT Information

EUT Name:	WisDuo LPWAN Module
Model:	RAK11720
Test Mode:	BLE 1M_High channel
Order No/Sample No:	168399706/A003386865-004
Test Voltage::	DC 5V From USB
Remark:	Temp 23 Humi:56%
Test Standard:	FCC 15.247
Tested By:	Kei Zhang
Reviewed By:	Terry Yin



Critical_Freqs

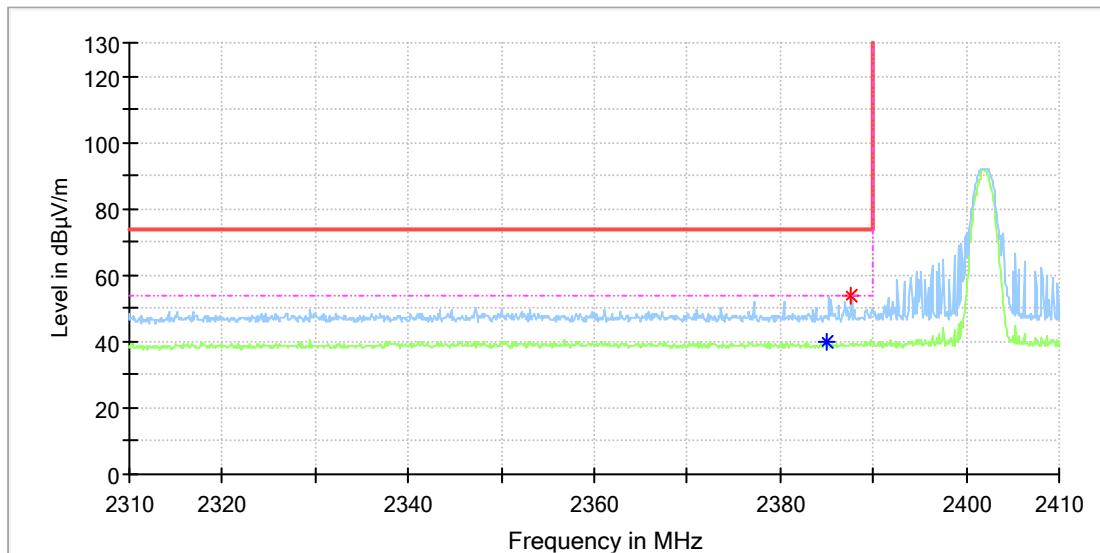
Frequency (MHz)	MaxPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
7439.000000	47.60	---	74.00	26.40	100.0	V	288.0	8.4
7440.475000	---	41.07	54.00	12.93	100.0	V	61.0	8.4

Appendix B.6: Test Results of Radiated Emissions in Restricted Bands

BLE, 1Mbps

EUT Information

EUT Name:	WisDuo LPWAN Module
Model:	RAK11720
Test Mode:	BLE 1M_Low channel
Order No/Sample No:	168399706/A003386865-004
Test Voltage::	DC 5V From USB
Remark:	Temp 23 Humi:56%
Test Standard:	FCC 15.247
Tested By:	Kei Zhang
Reviewed By:	Terry Yin

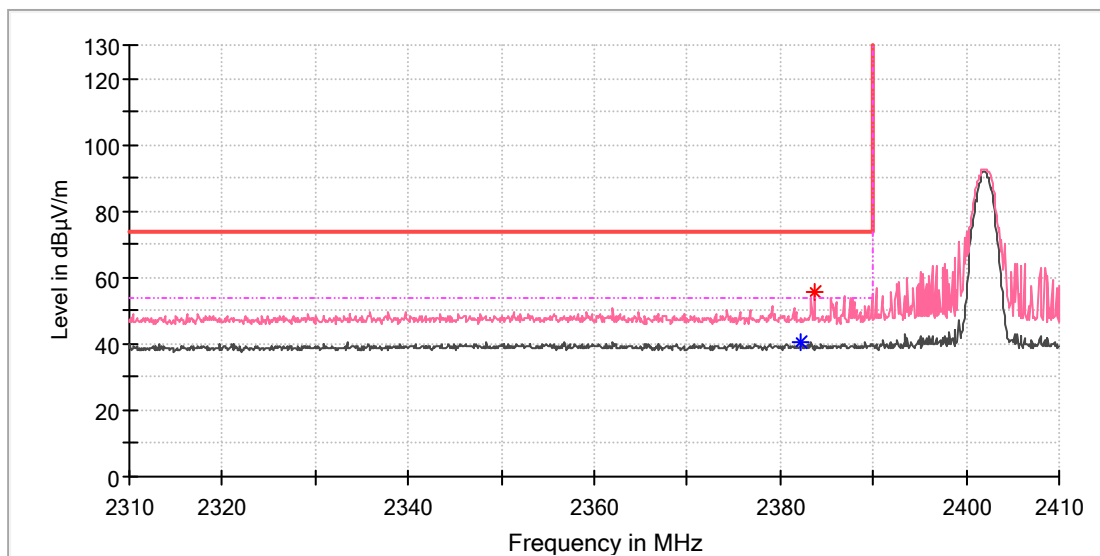


Critical Freqs

Frequency (MHz)	MaxPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
2384.900000	---	39.89	54.00	14.11	100.0	H	201.0	7.0
2387.600000	53.54	---	74.00	20.46	100.0	H	276.0	7.0

EUT Information

EUT Name:	WisDuo LPWAN Module
Model:	RAK11720
Test Mode:	BLE 1M_Low channel
Order No/Sample No:	168399706/A003386865-004
Test Voltage::	DC 5V From USB
Remark:	Temp 23 Humi:56%
Test Standard:	FCC 15.247
Tested By:	Kei Zhang
Reviewed By:	Terry Yin

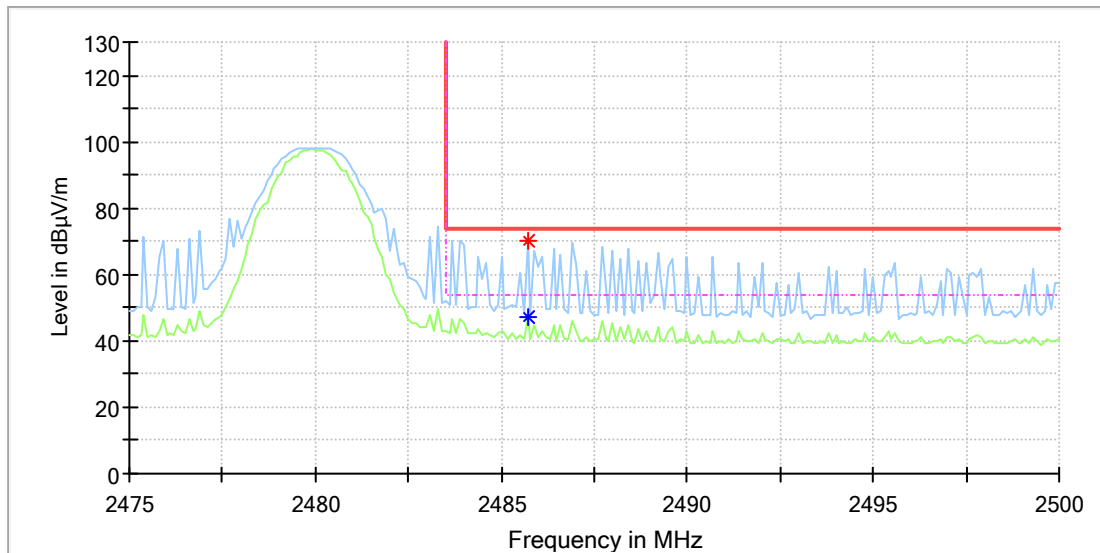


Critical_Freqs

Frequency (MHz)	MaxPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
2382.300000	---	40.60	54.00	13.40	100.0	V	103.0	7.0
2383.700000	55.43	---	74.00	18.57	100.0	V	26.0	7.0

EUT Information

EUT Name:	WisDuo LPWAN Module
Model:	RAK11720
Test Mode:	BLE 1M_High channel
Order No/Sample No:	168399706/A003386865-004
Test Voltage::	DC 5V From USB
Remark:	Temp 23 Humi:56%
Test Standard:	FCC 15.247
Tested By:	Kei Zhang
Reviewed By:	Terry Yin

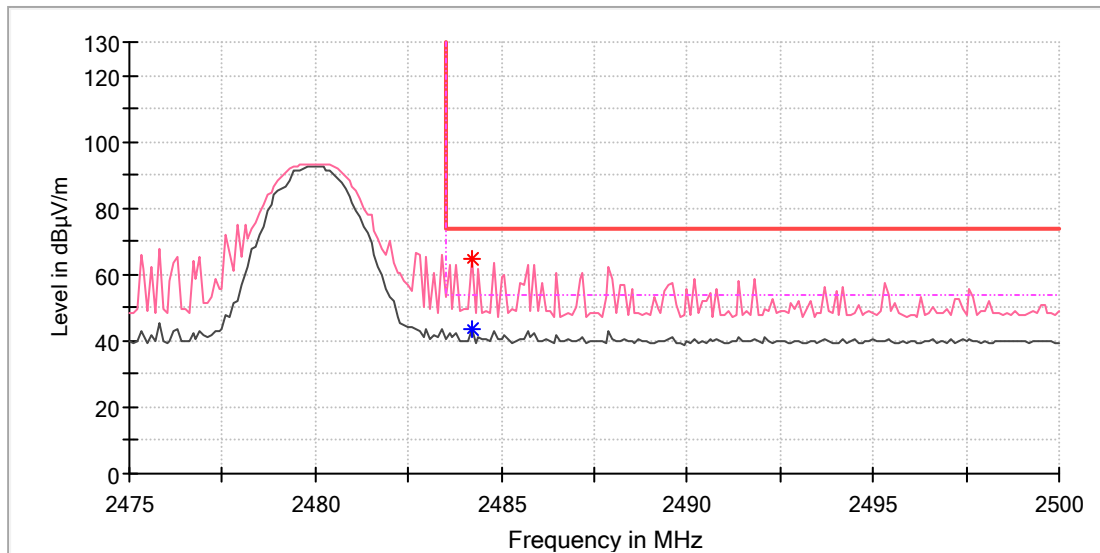


Critical_Freqs

Frequency (MHz)	MaxPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
2485.700000	70.40	---	74.00	3.60	100.0	H	0.0	7.4
2485.700000	---	46.93	54.00	7.07	100.0	H	0.0	7.4

EUT Information

EUT Name:	WisDuo LPWAN Module
Model:	RAK11720
Test Mode:	BLE 1M_High channel
Order No/Sample No:	168399706/A003386865-004
Test Voltage::	DC 5V From USB
Remark:	Temp 23 Humi:56%
Test Standard:	FCC 15.247
Tested By:	Kei Zhang
Reviewed By:	Terry Yin



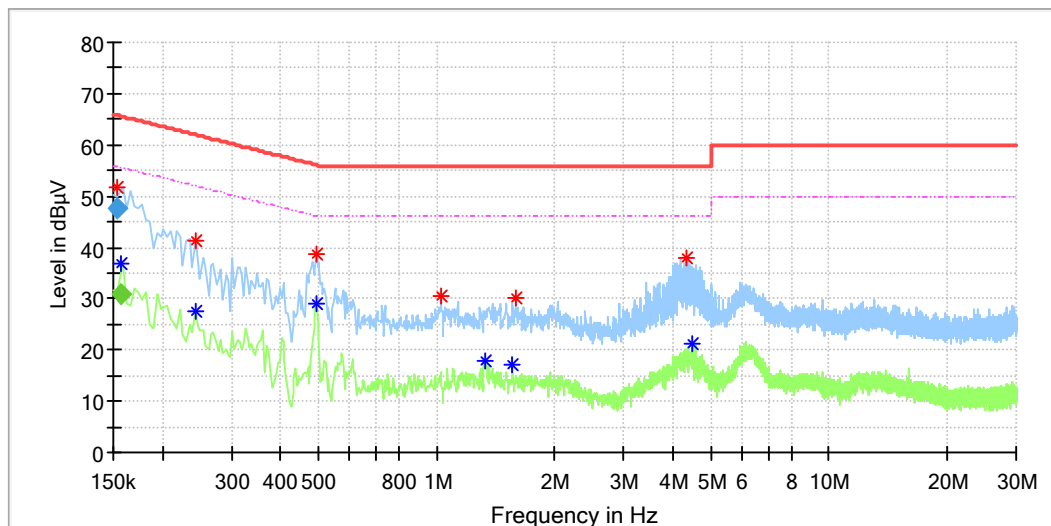
Critical_Freqs

Frequency (MHz)	MaxPeak (dBμV/m)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
2484.200000	---	43.47	54.00	10.53	100.0	V	31.0	7.4
2484.200000	64.67	---	74.00	9.33	100.0	V	31.0	7.4

Appendix B.7: Test Results of Conducted Emissions on AC Mains

EUT Information

EUT Name:	WisDuo LPWAN Module
Order Number:	168399706
Model:	RAK11720
Test Mode:	Lora & BLE connect
Test Voltage:	AC 120V 60Hz
Test By:/Review By:	Kevin Zhou/Gary Chen
Standard:	FCC Part 15
Tem./Hum./Pressure:	25.0°C/50.2%/101kPa
Remark:	SR2



Critical Freqs

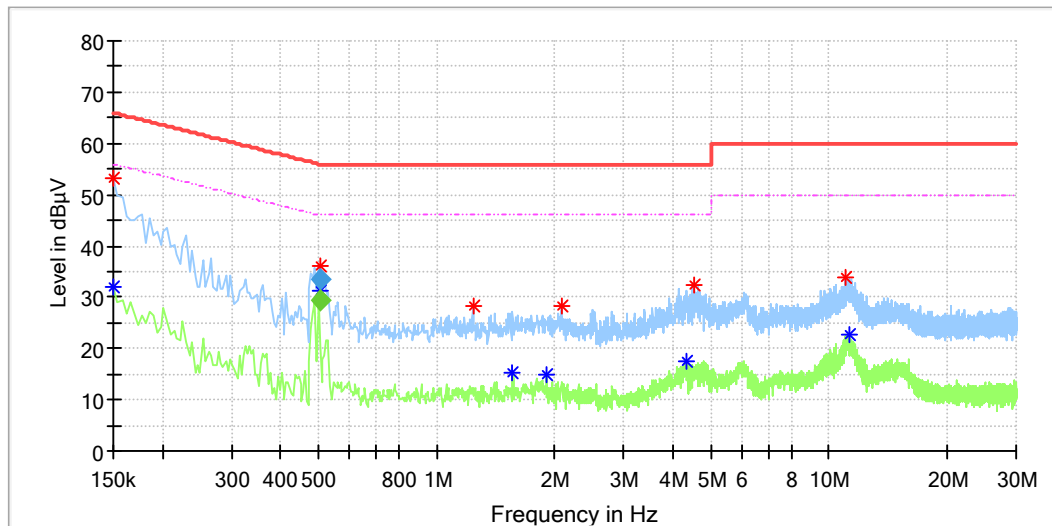
Frequency (MHz)	MaxPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Line	Corr. (dB)
0.153500	51.71	---	65.57	13.85	L1	9.9
0.157500	---	36.67	55.57	18.90	L1	9.9
0.242000	---	27.46	52.03	24.56	L1	9.9
0.242000	41.46	---	62.03	20.56	L1	9.9
0.494000	---	29.03	46.10	17.07	L1	10.0
0.494000	38.62	---	56.10	17.48	L1	10.0
1.026000	30.36	---	56.00	25.64	L1	10.0
1.326000	---	17.87	46.00	28.13	L1	10.1
1.562000	---	17.16	46.00	28.84	L1	10.1
1.590000	30.25	---	56.00	25.75	L1	10.1
4.326000	37.77	---	56.00	18.23	L1	10.2
4.502000	---	21.17	46.00	24.83	L1	10.2

Final Result

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.153500	47.63	---	65.81	18.18	1000.0	9.000	L1	9.9
0.157500	---	30.84	55.60	24.76	1000.0	9.000	L1	9.9

EUT Information

EUT Name:	WisDuo LPWAN Module
Order Number:	168399706
Model:	RAK11720
Test Mode:	Lora & BLE connect
Test Voltage:	AC 120V 60Hz
Test By./Review By:	Kevin Zhou/Gary Chen
Standard:	FCC Part 15
Tem./Hum./Pressure:	25.0°C/50.2%/101kPa
Remark:	SR2



Critical Freqs

Frequency (MHz)	MaxPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Line	Corr. (dB)
0.150000	53.25	---	66.00	12.75	N	9.8
0.150000	---	32.16	56.00	23.84	N	9.8
0.505500	---	31.07	46.00	14.93	N	9.8
0.506500	36.04	---	56.00	19.96	N	9.8
1.238000	28.14	---	56.00	27.86	N	9.8
1.562000	---	15.41	46.00	30.59	N	9.8
1.906000	---	14.84	46.00	31.16	N	9.8
2.078000	28.34	---	56.00	27.66	N	9.9
4.326000	---	17.59	46.00	28.41	N	9.9
4.546000	32.27	---	56.00	23.73	N	9.9
11.078000	34.03	---	60.00	25.97	N	10.0
11.234000	---	22.79	50.00	27.21	N	10.0

Final Result

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.505500	---	29.50	46.00	16.50	1000.0	9.000	N	9.8
0.506500	33.65	---	56.00	22.35	1000.0	9.000	N	9.8