TEST REPORT

KOSTEC Co., Ltd. 28(175-20, Annyeong-dong) 406-gil sejaro, Hwaseong-si, Gyeonggi-do, Korea Tel:031-222-4251, Fax:031-222-4252	Report No.: KST-FCR-240004	KOSTEC

1. Applicant

- Name : Umain Inc.
- Address : 504, FIFTH FLOOR, 59, ONCHEON-RO, YUSEONG-GU Yuseong-gu, Daejeon, South Korea

2. Test Item

- Product Name: UWB Radar Sensor Module
- Model Name: UWB THUNDER 80M
- Brand: None
- FCC ID: 2AN8QUM80M

3. Manufacturer

- Name : UMAIN Inc.
- Address : 504, FIFTH FLOOR, 59, ONCHEON-RO, YUSEONG-GU Yuseong-gu, Daejeon, South Korea

4. Date of Test : 2024. 04. 24. ~ 2024. 04. 25.

5. Test Method Used : FCC CFR 47, Part 15. Subpart F-15.517
ANSI C 63.10-2013

6. Test Result : Compliance

7. Note: None

Supplementary Information

The device bearing the brand name and FCC ID specified above has been shown to comply with the applicable technical standards as indicated in the measurement report and was tested in accordance with measurement procedures specified in ANSI C 63.10-2013.

We attest to the accuracy of data and all measurements reported herein were performed by KOSTEC Co., Ltd. and were made under Chief Engineer's supervision. We assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

The results shown in this test report refer only to the sample(s) tested unless otherwise stated.
This test report is not related to KOLAS accreditation.

Affirmation	Tested by Name : Choo, Kwang-Yeol (Signature)	Technical Manager Name : Lee, Mi-Young (Signature)

2024. 04. 29.

KOSTEC Co., Ltd.

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1. GENERAL INFORMATION

1.1 Test Facility

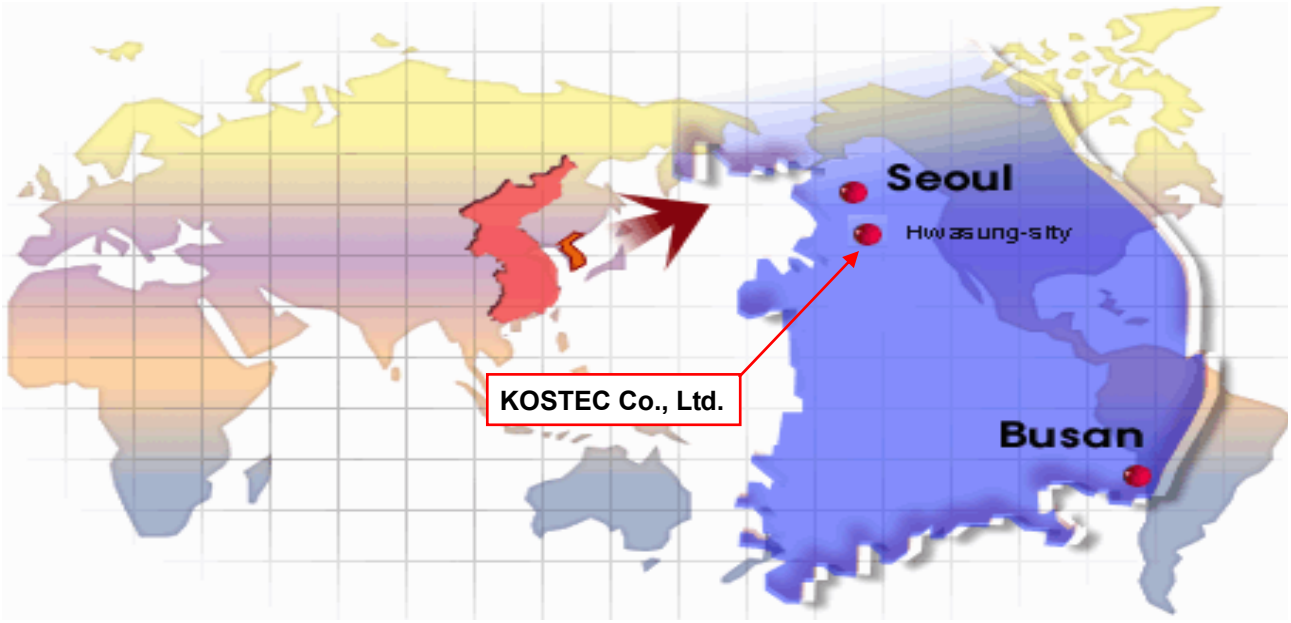
Test laboratory and address

KOSTEC Co., Ltd.
28(175-20,Annyeong-dong)406-gil sejaro, Hwaseong-si Gyeonggi-do, Korea
Telephone Number: 82-31-222-4251
Facsimile Number: 82-31-222-4252

Registration information

KOLAS No.: KT232
RRA (National Radio Research Agency): KR0041
FCC Designation No.: KR0041
IC Designation No.: KR0041
VCCI Membership No.: 2005

1.2 Location



1.3 Revision History of test report

Rev.	Revisions	Effect page	Reviewed	Date
-	Initial issue	All	Gyeong Hyeon, Park	2024. 04. 29.

2. EQUIPMENT DESCRIPTION

The product specification described herein was declared by manufacturer. And refer to user's manual for the details.

Equipment Name	UWB Radar Sensor Module
Model No	UWB THUNDER 80M
Usage	Harmless UWB Radar Sensor Module
Use Environment	Indoor
Serial Number	Proto type
Modulation type	BPSK/BPM
Emission Type	IEEE 802.15.4-2011 UWB
Maximum Output Power	88.57 dBμV/m
Operated Frequency	7 987.2 MHz
Channel Number	1
Operation temperature	-10 ℃ ~ 50 ℃
Power Source	DC 5.0 V
Antenna Description	Internal U-Slot antenna, max gain : 5.36 dBi
Remark	1. The device was operating at its maximum output power for all measurements. 2. The radiation measurements are performed in X, Y, Z axis positioning. Only the worst case (Y) is shown in the report. 3. The above DUT's information was declared by manufacturer. Please refer to the specifications or user manual for more detailed description.
FCC ID	2AN8QUM80M

3. SYSTEM CONFIGURATION FOR TEST

3.1 Characteristics of equipment

Harmless UWB Radar Sensor Module.

3.2 Used peripherals list

Description	Model No.	Serial No.	Manufacture	Remark
Adapter	MCS-V01KP	PA8X0000013	WEIHAI PNTELECOM CO., LTD.	For AC Conducted emission

3.3 Product Modification

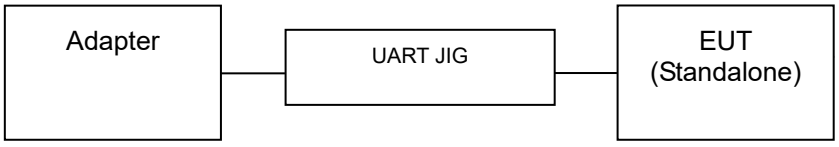
N/A

3.4 Operating Mode

The EUT was Operated in the engineering mode to fix the TX frequency that was for the purpose of the measurements.

3.5 Test Setup of EUT

The measurements were taken in continuous transmit mode using the test mode. The test Jig and cables were provided by the applicant.



3.6 Used Test Equipment List

No.	Instrument	Model	S/N	Manufacturer	Next Cal Date	Cal interval	used
1	T & H Chamber	PL-3J	15003623	ESPEC CORP	2024.11.02	1 year	☐
2	T & H Chamber	SH-662	93000067	ESPEC CORP	2024.08.16	1 year	☐
3	T & H Chamber	SH-642	93011406	ESPEC CORP	2024.08.17	1 year	☐
4	Spectrum Analyzer	8563EC	3046A00527	Agilent Technology	2025.01.09	1 year	☐
5	Spectrum Analyzer	FSV30	104029	Rohde & Schwarz	2024.08.16	1 year	☐
6	Spectrum Analyzer	FSV30	20-353063	Rohde & Schwarz	2025.01.09	1 year	☐
7	Spectrum Analyzer	FSV40	101727	Rohde & Schwarz	2024.08.16	1 year	☐
8	Signal Analyzer	FSW43	101294	Rohde & Schwarz	2025.01.15	1 year	☒
9	Signal Analyzer	FSW85	101602	Rohde & Schwarz	2024.06.27	1 year	☐
10	EMI Test Receiver	ESCI7	100823	Rohde & Schwarz	2025.01.09	1 year	☐
11	EMI Test Receiver	ESPI	100488	Rohde & Schwarz	2025.01.08	1 year	☐
12	EMI Test Receiver	ESI	837514/004	Rohde & Schwarz	2024.08.16	1 year	☒
13	Vector Signal Analyzer	89441A	3416A02620	Agilent Technology	2025.01.11	1 year	☐
14	Network Analyzer	8753ES	US39170869	AGILENT	2024.08.16	1 year	☐
15	EPM Series Power meter	E4418B	GB39512547	Agilent Technology	2025.01.10	1 year	☐
16	RF Power Sensor	E9300A	MY41496631	Agilent Technology	2025.01.10	1 year	☐
17	Microwave Frequency Counter	5352B	2908A00480	Agilent Technology	2025.01.10	1 year	☐
18	Audio Analyzer	8903B	3514A16919	Agilent Technology	2025.01.10	1 year	☐
19	Audio Telephone Analyzer	DD-5601CID	520010281	CREDIX	2025.01.08	1 year	☐
20	Modulation Analyzer	8901A	3041A05716	H.P	2025.01.10	1 year	☐
21	Digital storage Oscilloscope	TDS3052	B015962	Tektronix	2024.08.17	1 year	☐
22	ESG-D Series Signal Generator	E4436B	US39260458	Agilent Technology	2025.01.10	1 year	☐
23	Vector Signal Generator	SMBV100A	257557	Rohde & Schwarz	2025.01.10	1 year	☐
24	GNSS Signal Generator	TC-2800A	2800A000494	TESCOM CO., LTD.	2025.01.10	1 year	☐
25	Signal Generator	SMB100A	179628	Rohde & Schwarz	2025.01.10	1 year	☐
26	Signal Generator	N5173B	MY57280148	KEYSIGHT	2024.05.31	1 year	☐
27	SLIDAC	None	0207-4	Myoung sung Ele.	2025.01.09	1 year	☐
28	DC Power supply	DDPS-3K	U03-109	Digitech Power	2025.01.10	1 year	☐
29	DC Power supply	E3610A	KR24104505	Agilent Technology	2025.01.09	1 year	☐
30	DC Power supply	UP-3005T	68	Unicon Co.,Ltd	2025.01.09	1 year	☐
31	DC Power Supply	SM 3400-D	114701000117	DELTA ELEKTRONIKA	2025.01.08	1 year	☐
32	DC Power supply	6632B	MY43004005	Agilent Technology	2025.01.09	1 year	☐
33	DC Power Supply	6632B	MY43004137	Agilent Technology	2025.01.09	1 year	☐
34	Termination	1433-3	LM718	WEINSCHEL	2025.01.10	1 year	☐
35	Termination	1432-3	QR946	AEROFLEX/WEINSCHEL	2025.01.10	1 year	☐
36	Attenuator	8498A	3318A09485	HP	2025.01.10	1 year	☐
37	Step Attenuator	8494B	3308A32809	HP	2025.01.10	1 year	☐
38	RF Step Attenuator	RSP	100091	Rohde & Schwarz	2025.01.11	1 year	☐
39	Attenuator	18B50W-20F	64671	INMET	2025.01.10	1 year	☐
40	Attenuator	10 dB	1	Rohde & Schwarz	2025.01.10	1 year	☐
41	Attenuator	54A-10	74564	WEINSCHEL	2024.08.16	1 year	☒
42	Attenuator	56-10	66920	WEINSCHEL	2025.01.12	1 year	☐
43	Attenuator	SA18N100-20	001	FAIRVIEW MICROWAVE	2024.08.16	1 year	☐
44	Attenuator	SA26B-10	33464/2134	FAIRVIEW MICROWAVE	2024.08.18	1 year	☐
45	Attenuator	SA4018-10	DC 2126	FAIRVIEW MICROWAVE	2024.08.18	1 year	☒
46	Power divider	11636B	51212	HP	2025.01.12	1 year	☐
47	3Way Power divider	KPDSU3W	00070365	KMW	2024.08.16	1 year	☐
48	4Way Power divider	70052651	173834	KRYTAR	2025.01.12	1 year	☐
49	3Way Power divider	1580	SQ361	WEINSCHEL	2025.01.12	1 year	☐
50	OSP	OSP120	101577	Rohde & Schwarz	2025.01.11	1 year	☐
51	White noise audio filter	ST31EQ	101902	SoundTech	2024.08.16	1 year	☐

No.	Instrument	Model	S/N	Manufacturer	Next Cal Date	Cal interval	used
52	Dual directional coupler	778D	17693	HEWLETT PACKARD	2025.01.10	1 year	☐
53	Dual directional coupler	772D	2839A00924	HEWLETT PACKARD	2025.01.10	1 year	☐
54	Band rejection filter	3TNF-0006	26	DOVER Tech	2025.01.11	1 year	☐
55	Band rejection filter	3TNF-0007	311	DOVER Tech	2025.01.11	1 year	☐
56	Band rejection filter	WTR-BRF2442-84NN	09020001	WAVE TECH Co.,LTD	2025.01.10	1 year	☐
57	Band rejection filter	WRCJV12-5695-5725-5825-5855-50SS	1	Wainwright Instruments GmbH	2025.01.11	1 year	☐
58	Band rejection filter	WRCJV12-5120-5150-5350-5380-40SS	4	Wainwright Instruments GmbH	2025.01.11	1 year	☐
59	Band rejection filter	WRCGV10-2360-2400-2500-2540-50SS	2	Wainwright Instruments GmbH	2025.01.11	1 year	☐
60	Band rejection filter	CTF-155M-S1	001	RF One Electronics	2024.08.16	1 year	☐
61	Band rejection filter	CTF-435M-S1	001	RF One Electronics	2024.08.16	1 year	☐
62	Band rejection filter	CTF-5890M-70MS1	1	RF One Electronics	2025.01.11	1 year	☐
63	Highpass Filter	WHJS1100-10EF	1	WAINWRIGHT	2025.01.10	1 year	☐
64	Highpass Filter	WHJS3000-10EF	1	WAINWRIGHT	2025.01.10	1 year	☐
65	Highpass Filter	WHNX6-5530-7000-26500-40CC	2	Wainwright Instruments GmbH	2025.01.12	1 year	☐
66	Highpass Filter	WHNX6-2370-3000-26500-40CC	4	Wainwright Instruments GmbH	2025.01.12	1 year	☐
67	WideBand Radio Communication Tester	CMW500	102276	Rohde & Schwarz	2025.01.10	1 year	☐
68	WideBand Radio Communication Tester	CMW500	117235	Rohde & Schwarz	2025.01.10	1 year	☐
69	WideBand Radio Communication Tester	MT8000A	6261987920	Anritsu	2025.01.15	1 year	☐
70	WideBand Radio Communication Tester	MT8821C	6262287695	Anritsu	2025.01.09	1 year	☐
71	Bluetooth Tester	TC-3000B	3000B6A0166	TESCOM CO., LTD.	2025.01.10	1 year	☐
72	Loop Antenna	6502	9203-0493	EMCO	2025.05.23	2 year	☐
73	Loop Antenna	FMZB1513	#374	Schwarzbeck	2025.02.21	2 year	☒
74	BiconiLog Antenna(R)	3142C	35880	ETS-LINDGREN	2024.10.13	2 year	☒
75	Trilog-Broadband Antenna(R)	VULB 9168	9168-606	SCHWARZBECK	2024.11.30	2 year	☐
76	Biconical Antenna(T)	VUBA9117	9117-342	Schwarz beck	2026.01.16	2 year	☐
77	Horn Antenna	3115	9605-4834	EMCO	2025.02.29	1 year	☐
78	Horn Antenna	QMS-00208	21909	STEATITE ANTENNA	2025.04.22	1 year	☐
79	Horn Antenna(R)	3117	00135191	ETS-LINDGREN	2025.03.26	1 year	☒
80	Horn Antenna(T)	3115	2996	EMCO	2025.01.11	1 year	☐
81	Horn Antenna(R)	BBHA 9170	9170-722	SCHWARZBECK	2025.01.11	1 year	☒
82	Horn Antenna(T)	BBHA 9170	743	SCHWARZBECK	2025.01.16	1 year	☐
83	AMPLIFIER(A_10)	TK-PA01S	220109-L	TESTEK	2025.01.09	1 year	☐
84	AMPLIFIER(C_3)	TK-PA01S	200141-L	TESTEK	2024.08.16	1 year	☒
85	PREAMPLIFIER(C_3)	8449B	3008A02577	Agilent	2025.01.09	1 year	☐
86	RF PRE AMPLIFIER	SCU08F2	100762	Rohde & Schwarz	2024.11.28	1 year	☐
87	AMPLIFIER	TK-PA18	150003	TESTEK	2025.01.09	1 year	☒
88	AMPLIFIER	TK-PA1840H	160010-L	TESTEK	2025.01.12	1 year	☒
89	Horn Antenna	M19RH	T01	OML, Inc.	2025.04.03	1 year	☐
90	Horn Antenna	M12RH	T02	OML, Inc.	2025.04.03	1 year	☐
91	Horn Antenna	M08RH	T03	OML, Inc.	2025.04.03	1 year	☐
92	Horn Antenna	M05RH	T04	OML, Inc.	2025.04.03	1 year	☐
93	Horn Antenna	M03RH	T05	OML, Inc.	2025.04.03	1 year	☐
94	Harmonic Mixer	M12HWD	200529-1	OML, Inc.	2025.04.08	1 year	☐
95	Harmonic Mixer	M08HWD	200529-1	OML, Inc.	2025.04.08	1 year	☐
96	Harmonic Mixer	M05HWD	200529-1	OML, Inc.	2025.04.08	1 year	☐
97	Harmonic Mixer	M03HWD	200529-1	OML, Inc.	2025.04.08	1 year	☐
98	Source Module	S19MS-A	200529-1	OML, Inc.	2025.04.08	1 year	☐
99	Source Module	S12MS-A	200529-1	OML, Inc.	2025.04.08	1 year	☐
100	Source Module	S08MS-A	200529-1	OML, Inc.	2025.04.08	1 year	☐
101	Source Module	S05MS-A	200529-1	OML, Inc.	2025.04.08	1 year	☐
102	Source Module	S03MS-A	200529-1	OML, Inc.	2025.04.08	1 year	☐

4. SUMMARY TEST RESULTS

Description of Test	FCC Rule	Reference Clause	Used	Test Result
Transmission time	§ 15.517(a)	Clause 5.1	☐	N/A
UWB Bandwidth	§ 15.517(b)	Clause 5.2	☒	Compliance
Radiated Emissions	§ 15.517(c)/15.209	Clause 5.3	☒	Compliance
Radiated Emissions in GPS Bands	§ 15.517(d)	Clause 5.4	☒	Compliance
Peak Emissions within a 50MHz Bandwidth	§ 15.517(e)/15.521(g)	Clause 5.5	☒	Compliance
Antenna Requirement	§ 15.203	Clause 5.6	☒	Compliance
AC Power Conducted emissions	§ 15.207	Clause 5.7	☒	Compliance
Compliance: The EUT complies with the essential requirements in the standard. Not Compliance : The EUT does not comply with the essential requirements in the standard. N/A : The test was not applicable in the standard.				

Procedure Reference

FCC CFR 47, Part 15. Subpart F-15.517

ANSI C 63.10-2013

KDB 393764 D01 UWB FAQ v02r01

5. MEASUREMENT RESULTS

5.1 Transmission time

5.1.1 Standard Applicable [FCC §15.517(a)(5)]

A communications system shall transmit only when the intentional radiator is sending information to an associated receiver.

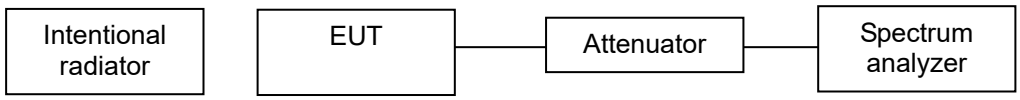
5.1.2 Test Environment conditions

• Ambient temperature : (22 ~ 23) ℃ • Relative Humidity : (43 ~ 45) % R.H.

5.1.3 Measurement Procedure

For test purpose the UWB port of the EUT is connected with the spectrum analyzer through a RF cable. The intentional radiator is located close by EUT. In this measurement intentional radiator is RTLS Smart Tag.
The measurement is made in time domain by the central frequency of the channel. Measurement duration 30 s. RBW = 50 MHz.
The first measurement is made without turning on intentional radiator. It will be checked, that the EUT doesn't transmit.
Shortly before the second measurement an intentional radiator is switched on. Then the measurement is started by the spectrum analyzer. It is checked, whether the EUT transmits, when the intentional radiator is switched on. After 15 s the intentional radiator is switched off. And it will be checked, whether the EUT continues to transmit and if so then how long.

5.1.4 Test setup



5.1.5 Measurement Result

Not applicable: The device is not intended to communicate with an associated receiver, therefore the requirements of Part 15.517(a)(5) do not apply.

5.2 UWB Bandwidth Measurement

5.2.1 Standard Applicable [FCC §15.503(a), 15.517(b)]

Ultra-wideband (UWB) transmitter. An intentional radiator that, at any point in time, has a fractional bandwidth equal to or greater than 0.20 or has a UWB bandwidth equal to or greater than 500 MHz, regardless of the fractional bandwidth. The UWB bandwidth of a device operating under the provisions of this section must be contained between 3100 MHz and 10,600 MHz.

5.2.2 Test Environment conditions

• Ambient temperature : (21 ~ 22) ℃ • Relative Humidity : (42 ~ 43) % R.H.

5.2.3 Measurement Procedure

The frequency at which the maximum power level is measured with the peak detector is designated f_M (RBW=1 MHz, VBW= 3 MHz, peak detection, maxhold). The outermost 1 MHz segments above and below f_M, where the peak power falls by 10 dB relative to the level at f_M, are designated as f_H and f_L. The UWB transmission, and the -10 dB bandwidth (B - 10), is defined as (f_H - f_L). -10 dB bandwidth should be ≥500 MHz and must be contained between 3100 MHz and 10.600 MHz.

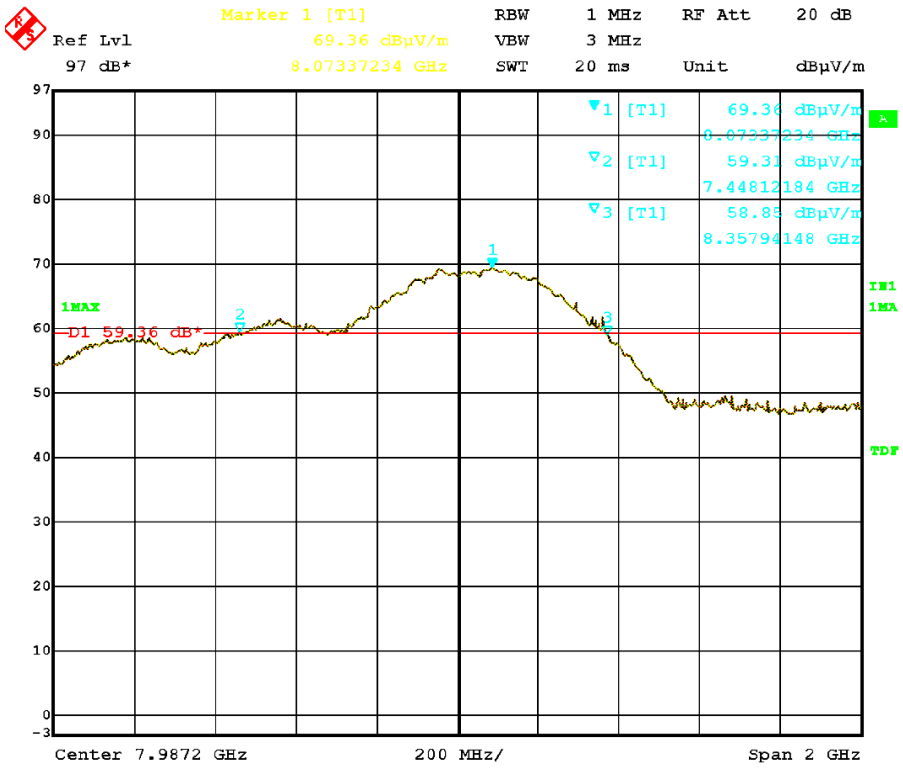
5.2.4 Measurement Result

The frequency at which the maximum power f_M [MHz]	Power of the frequency f_M [dBuV]	f_L [MHz]	f_H [MHz]	-10 dB bandwidth [MHz]
8 073	69.36	7 448	8 358	910

For a UWB device emission spectrum, the entire fundamental bandwidth (that portion of the spectrum between the outermost -10 dB points) must be fully contained within the authorized frequency band (3 100 MHz and 10 600 MHz). As stated Q3 of KDB 393764 D01 UWB FAQ v02r01

5.2.6 Test Plot

UWB Bandwidth



5.3 Spurious RF Radiated emissions

5.3.1 Standard Applicable [FCC §15.517(c), 15.209]

The radiated emissions at or below 960 MHz from a device operating under the provisions of this section shall not exceed the emission levels in § 15.209.

§15.209 limits for radiated emissions measurements (distance at 3 m)

Frequency Band [MHz]	DISTANCE [Meters]	Limit [㎶/m]	Limit [dB㎶/m]
0.009 ~ 0.490	300	2400/F(kHz)	67.6-20log(F)
0.490 ~ 1.705	30	24000/F(kHz)	87.6-20log(F)
1.705 ~ 30.0	30	30	29.54
30 - 88	3	100 **	40.00
88 - 216	3	150 **	43.52
216 - 960	3	200 **	46.02
Above 960	3	500	54.00
** fundamental emissions from intentional radiators operation under this Section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz, or 470-806 MHz. However, operation within these Frequency bands is permitted under other sections of this Part Section 15.231 and 15.241			

The radiated emissions above 960 MHz from a device operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of 1 MHz:

§15.517(c)

Frequency Band [MHz]	EIRP[dBm]	E-Field[dBuV/m] at 3 m	E-Field[dBuV/m] at 1 m
960-1 610	−75.3	19.9	29.5
1 610-1 990	−53.3	41.9	51.5
1 990-3 100	−51.3	43.9	53.5
3 100-10 600	−41.3	53.9	63.5
Above 10 600	−51.3	43.9	53.5

Note 1: This may be converted to a peak field strength level at 3 meters using E(dBuV/m) = P(dBm EIRP) + 95.2
Note 2: Above 960 MHz shall be extrapolated to the specified distance suing an extrapolation factor of 20 dB/decade from 3m to 1m. Distance extrapolation factor = 20 log (specific distance [3m] / test distance [1m]) (dB); Limit line = specific limits (dBuV) + distance extrapolation factor [9.54 dB]
From 47 CFR Section 15.517(c): Emissions from digital circuitry used to enable the operation fo the UWB transmitter shall comply with the limits in Section 15.209 of this chapter, rather than the limits specified in this subpart, provided it can be clearly demonstrated that those emissions from the UWB device are due solely to emissions from digital circuitry contained within the transmitter and that the emissions are not intended to be radiated from the transmitter's antenna. Emissions from associated digital devices, as defined in Section 15.3(k) of this chapter, e.g., emissions from digital circuitry used to control additional functions or capabilities other than the UWB transmission, are subject to the limits contained in Subpart B of Part 15 of this chapter.

5.3.2 Test Environment conditions

• Ambient temperature : (21 ~ 22) ℃ • Relative Humidity : (42 ~ 43) % R.H.

5.3.3 Measurement Procedure

1. Configure the EUT according to ANSI C63.4. The EUT was placed on the top of the turntable 0.8 meter above ground. The phase center of the receiving antenna mounted on the top of a height-variable antenna tower was placed 3 meters far away from the turntable for measured the frequency range below 960 MHz and antenna tower was placed below 1 meters far away from the turntable for measured the frequency range above 960 MHz.

2. Power on the EUT and all the supporting units. The turntable was rotated by 360 degrees to determine the position of the highest radiation.

3. The height of the broadband receiving antenna was varied between one meter and four meters above ground to find the maximum emissions field strength of both horizontal and vertical polarization.

4. For each suspected emissions, the antenna tower was scan (from 1 M to 4 M) and then the turntable was rotated (from 0 degree to 360 degrees) to find the maximum reading.

5. The measurements made over the frequency range from 9 kHz to 960 MHz were maximized using an EMI receiver with peak detector capabilities. Measurements of the radiated field from 9 kHz to 960 MHz were made with the measurement antenna located a distance of 3 meters from the EUT. If the emissions level of the EUT in peak mode was 3 dB lower than the limit specified, then testing will be stopped and peak values of EUT will be reported, otherwise, the emissions which do not have 3 dB margin will be repeated one by one using the quasi-peak method for below 1GHz.

6. Measurements above 960 MHz were maximized using a spectrum analyzer with RMS detector capabilities. A spectrum analyzer was used for the final measurements utilizing an RMS detector at the frequencies with the largest amplitudes. The prescribed RBW of 1 MHz and VBW of 3 MHz, and a1 msec averaging time were used for these measurements. Measurements of the radiated field at frequencies above 960 MHz were made with the measurement antenna located a distance of below 1 meter from the EUT.

7. The spectrum between 9 kHz and 960 MHz contained no intentional radiation and lies below the limits. The spectrum from 960MHz to18GHz contained intentional UWB signals between 3100 MHz and 10600 MHz and lie below the limits. No other emissions above 10600 MHz were detected. The maximum frequency tested was 40 GHz.

8. Per 47 CFR, Part 15, Subpart F, §15.521(c) (§15.209) all digital emissions from the transmitter not intended to be radiated from the antenna port meet the 15.209 subpart C limits.

9. Additional measurements in the 960 MHz to 40 GHz range were performed to determine the nature of all unintentional emissions in this span. Conducted antenna port measurement and terminated antenna port measurement were done in the 960 MHz to 8 GHz range show that all noise peaks have the same frequency and polarization and are determined to be emission from the digital circuit and are not radiated from the antenna.

10. All radiated tests for above 1GHz utilized a one-meter separation distance between the DUT and the measurement antenna. This enabled an improved signal-to-noise ratio (S/N) for the radiated tests. Although these types of measurements are typically performed at a distance of three-meters, it was necessary to reduce the measurement distance to enable discrimination between the emissions radiating from the DUT and the measurement system noise floor.

5.3.4 Measurement Uncertainty

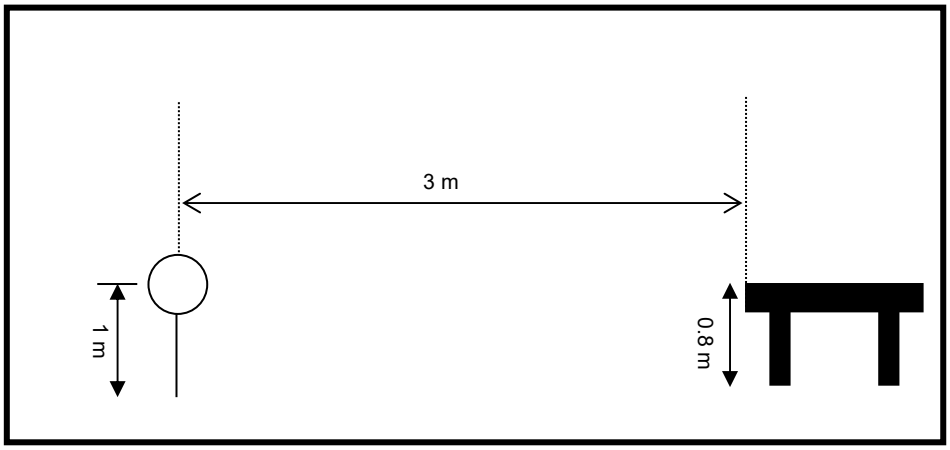
The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI C63.10-2013. All measurement uncertainty values are shown with a coverage factor of k = 2 to indicate a 95% level of confidence. The measurement uncertainty shown below meets or exceeds the UCISPR measurement uncertainty values specified in CISPR 16-4-2 and, thus, can be compared directly to specified limits to determine compliance.

Radiated Emission measurement: Below 1 GHz: 3.80 dB (CL: Approx 95 %, k=2)

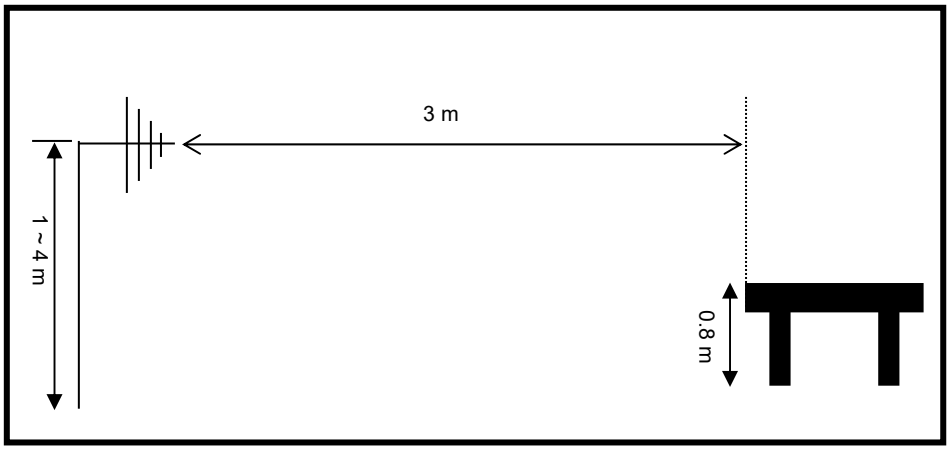
Above 1 GHz: 3.42 dB (CL: Approx 95 %, k=2)

5.3.5 Test Configuration

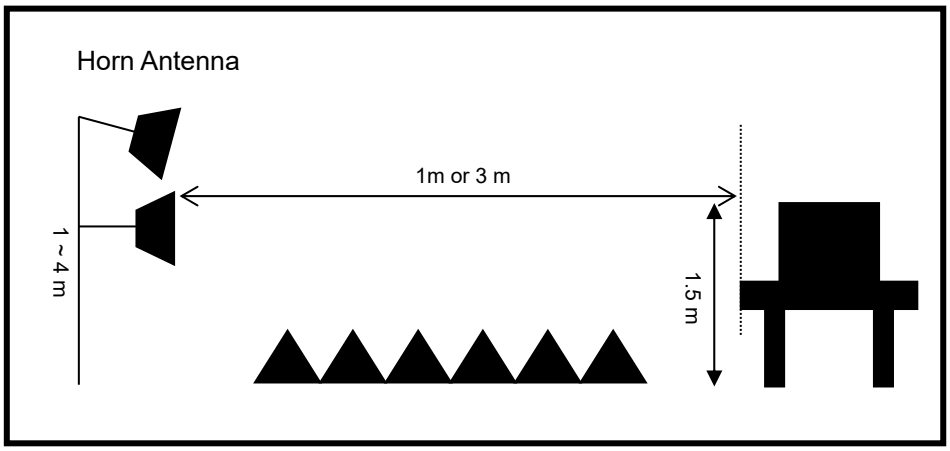
Radiated emission setup, below 30 MHz



Radiated emission setup, below 1 000 MHz



Radiated emission setup, above 1 GHz



5.3.6 Measurement Result

Above 1 GHz

Measurement distance: 1m

Freq. (MHz)	Reading (dBμV/m)	Detector Mode	Antenna			CL (dB)	AMP (dB)	Meas Result (dBμV/m)	Limit (dBμV/m)	Mgn. (dB)	Result
			Height (m)	Pol. (H/V)	Fctr. (dB/m)						
1 523.21	27.07	Average	1.5	H	26.93	0.74	-45.86	27.07	29.5	2.43	Compliance
1 490.20	27.36	Average	1.5	V	26.80	0.73	-45.86	27.36	29.5	2.14	Compliance
1 848.36	29.01	Average	1.5	H	30.05	0.83	-45.86	29.01	51.5	22.49	Compliance
1 846.83	29.13	Average	1.5	V	30.04	0.83	-45.86	29.13	51.5	22.37	Compliance
2 692.93	29.82	Average	1.5	H	31.79	0.99	-45.79	29.82	53.5	23.68	Compliance
2 701.82	29.35	Average	1.5	V	31.80	0.95	-45.78	29.35	53.5	24.15	Compliance
7 368.54	40.35	Average	1.5	H	35.44	2.08	-44.95	40.35	63.5	23.15	Compliance
10 554.91	35.28	Average	1.5	V	37.33	2.81	-44.44	35.28	63.5	28.22	Compliance
17 169.54	41.42	Average	1.5	H	41.62	3.93	-44.47	41.42	53.5	12.08	Compliance
17 288.18	41.37	Average	1.5	V	41.56	3.90	-44.25	41.37	53.5	12.13	Compliance

※Note

- It is not recorded on the report that the reading of emissions are attenuated more than 20 dB below the permissible limits or the field strength is too small to measured.
- The transmitter radiated spectrum was investigated from 9 kHz to 40 GHz.
- Meas Result & Reading (dBμV/m) : Test receiver reading value(Included Antenna factor.(dB/m), CL(dB), AMP(dB) Factor)

Below 1 GHz

Measurement distance: 3m

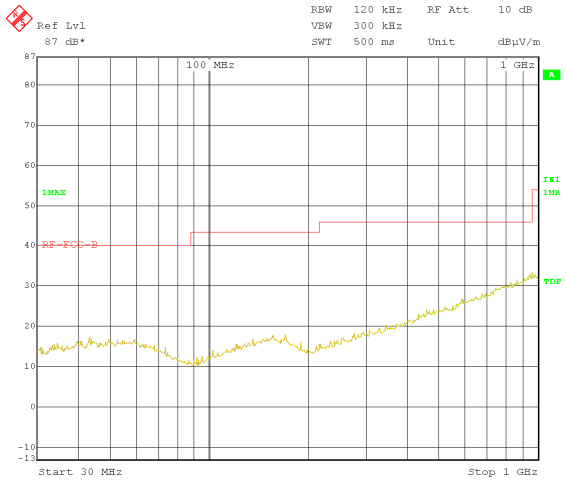
Freq. (MHz)	Reading (dBμV/m)	Antenna			CL (dB)	AMP (dB)	Meas Result (dBμV/m)	Limit (dBμV/m)	Mgn (dB)	Result
		Height (m)	Pol. (H/V)	Fctr. (dB/m)						
43.23	17.02	1.5	H	16.32	0.97	46.33	17.02	40.00	22.98	Compliance
60.58	32.48	1.0	V	12.96	1.14	46.46	32.48	40.00	7.52	Compliance
94.98	31.05	1.0	V	13.46	1.42	46.61	31.05	43.50	12.45	Compliance
156.43	17.64	1.5	H	14.77	1.85	46.69	17.64	43.50	25.86	Compliance
190.44	24.89	1.5	H	15.69	2.01	46.60	24.89	43.50	18.61	Compliance
361.23	26.09	1.0	V	21.04	2.75	46.09	26.09	46.00	19.91	Compliance
958.71	33.07	1.5	H	29.69	4.51	45.38	33.07	46.00	12.93	Compliance

Freq.(Mhz): Measurement frequency, Antenna(Height, Pol, Fctr): Antenna Height, Polarization and Factor, CL(dB): Cable loss, AMP(dB): Preamplifier gain(dB), Limit(dBμV/m): Limit value specified with FCC Rule, Mgn(dB): FCC Limit (dBμV/m) - Meas Result(dBμV/m),
Meas Result & Reading (dBμV/m) : Test receiver reading value(Included Antenna factor.(dB/m), CL(dB), AMP(dB) Factor)

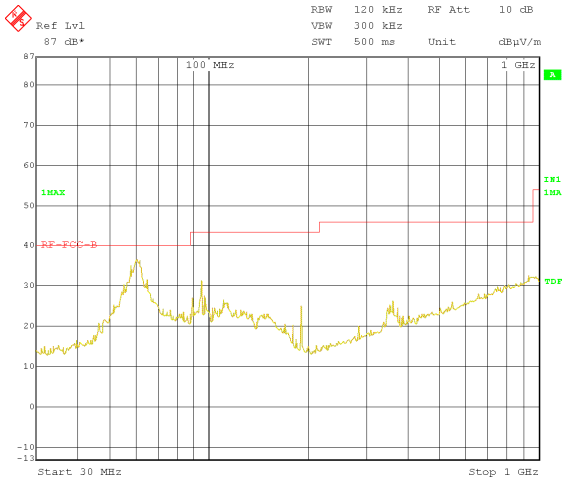
5.3.7 Plots
*The worst case only.

▪ Below 1 GHz

Horizontal

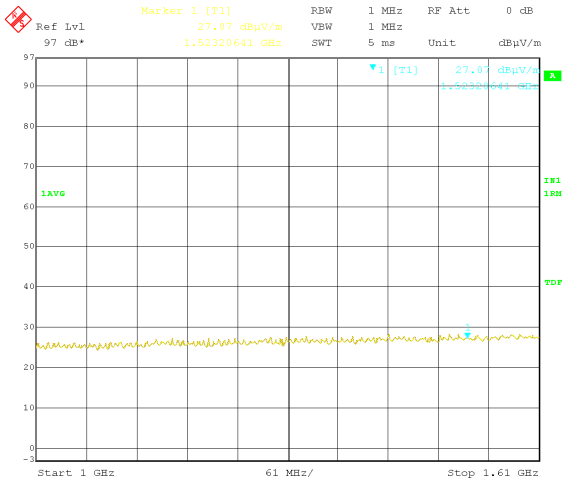


Vertical

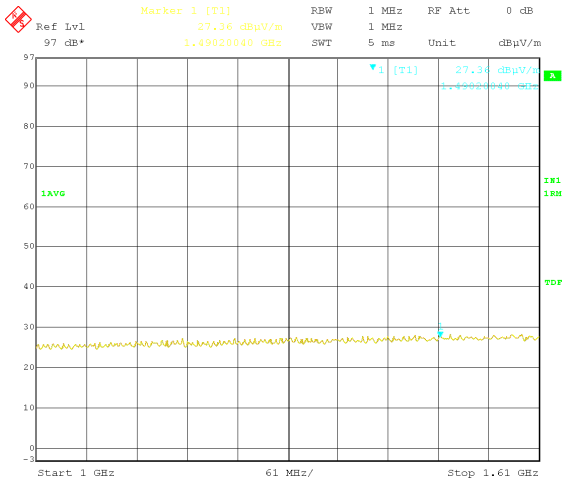


▪ Above 1 GHz

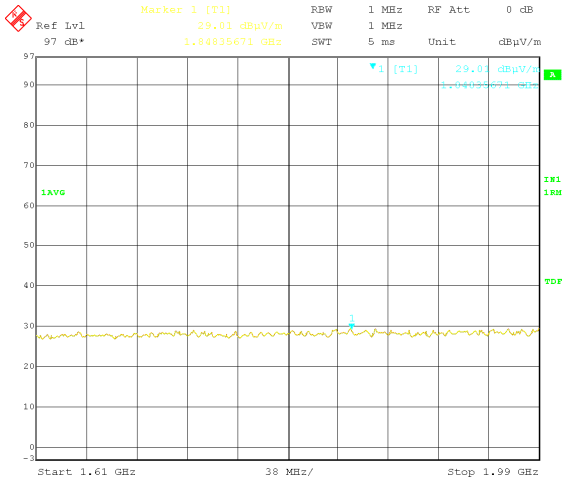
Horizontal(960-1 610 MHz)



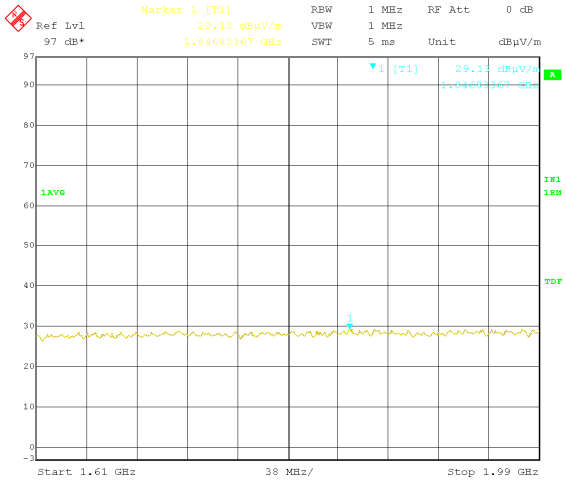
Vertical(960-1 610 MHz)



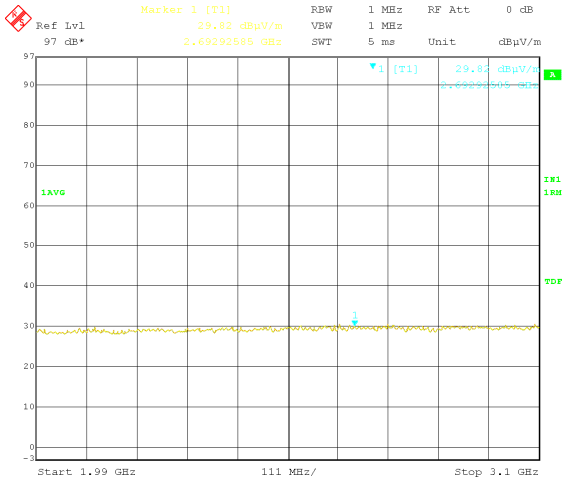
Horizontal(1 610-1 990 MHz)



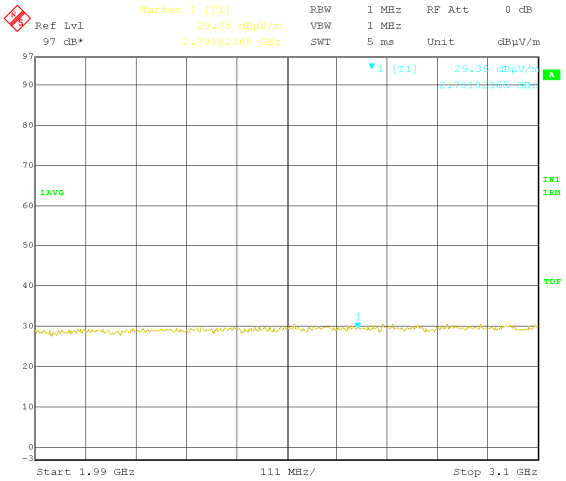
Vertical(1 610-1 990 MHz)



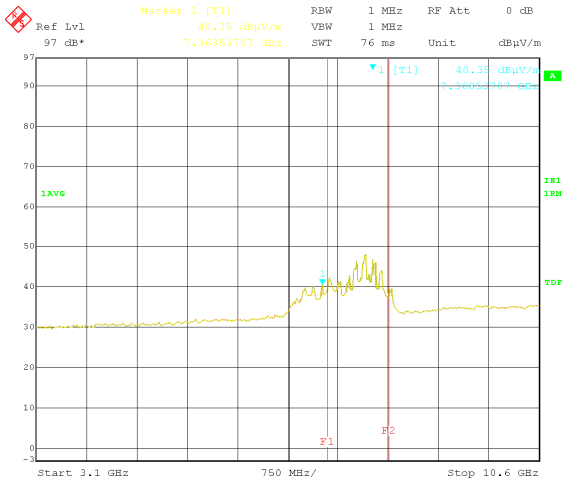
Horizontal(1 990-3 100 MHz)



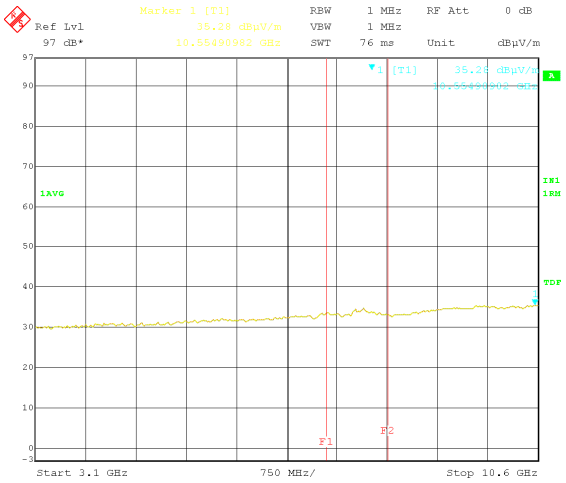
Vertical(1 990-3 100 MHz)



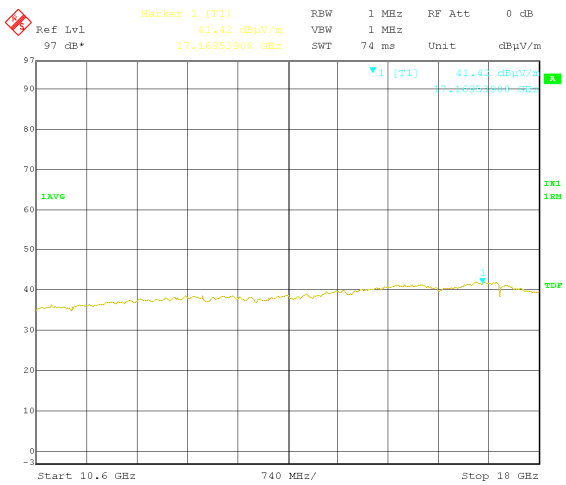
Horizontal(3 100-10 600 MHz)



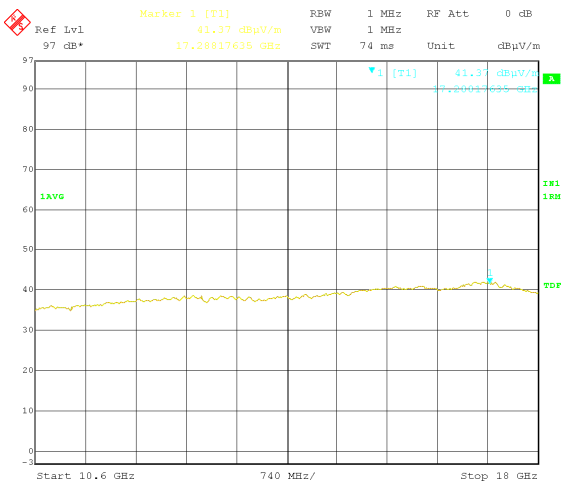
Vertical(3 100-10 600 MHz)



Horizontal(Above 10 600 MHz)



Vertical(Above 10 600 MHz)



5.4 Radiated Emissions in GPS Bands Measurement

5.4.1 Standard Applicable [FCC §15.517(d)]

In addition to the radiated emission limits specified in the table in paragraph (c) of this section, UWB transmitters operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of no less than 1 kHz:

Frequency Band [MHz]	EIRP[dBm]	E-Field[dBuV/m] at 3 m	E-Field[dBuV/m] at 1 m
1 164-1 240	-85.3	9.9	19.44
1 559-1 610	-85.3	9.9	19.44

Note 1: This may be converted to a peak field strength level at 3 meters using E(dBuV/m) = P(dBm EIRP) + 95.2 dB.

Note 2: Above 960MHz shall be extrapolated to the specified distance using an extrapolation factor of 20 dB/decade form 3m to 1m. Distance extrapolation factor = 20 log (specific distance [3m] / test distance [1m]) (dB); Limit line = specific limits (dBuV) + distance extrapolation factor [9.54 dB].

Note 3: Above 960MHz shall be extrapolated to the specified distance using an extrapolation factor of 20 dB/decade form 3m to 1m. Distance extrapolation factor = 20 log (specific distance [3m] / test distance [1m]) (dB); Limit line = specific limits (dBuV) + distance extrapolation factor [9.54 dB]. from 3m to 0.5m. Distance extrapolation factor = 20 log (specific distance [3m] / test distance [0.5m]) (dB); Limit line = specific limits (dBuV) + distance extrapolation factor [15.56 dB]

5.4.2 Test Environment conditions

• Ambient temperature : (21 ~ 22) ℃ • Relative Humidity : (42 ~ 43) % R.H.

5.4.3 Measurement Procedure

1. Configure the EUT according to ANSI C63.4. The EUT was placed on the top of the turntable 0.8 meter above ground. The phase center of the receiving antenna mounted on the top of a height-variable antenna tower was placed 1 meters far away from the turntable.
2. Power on the EUT and all the supporting units. The turntable was rotated by 360 degrees to determine the position of the highest radiation.
3. The height of the broadband receiving antenna was varied between one meter and four meters above ground to find the maximum emissions field strength of both horizontal and vertical polarization.
4. For each suspected emissions, the antenna tower was scan (from 1 M to 4 M) and then the turntable was rotated (from 0 degree to 360 degrees) to find the maximum reading.
5. Measurements frequencies were maximized using a spectrum analyzer with RMS detector capabilities. A spectrum analyzer was used for the final measurements utilizing an RMS detector at the frequencies with the largest amplitudes. The prescribed RBW of 1 kHz and VBW of 1 kHz, and a 1 msec averaging time were used for these measurements.
6. Per 47 CFR, Part 15, Subpart F, §15.521© (§15.209) all digital emissions from the transmitter not intended to be radiated from the antenna port meet the 15.209 subpart C limits.
7. All radiated tests for above 1GHz utilized a one-meter separation distance between the DUT and the measurement antenna. This enabled an improved signal-to-noise ratio (S/N) for the radiated tests. Although these types of measurements are typically performed at a distance of three-meters, it was necessary to reduce the measurement distance to enable discrimination between the emissions radiating from the DUT and the measurement system noise floor.

5.4.5 Measurement Result

1 164 MHz ~ 1 240 MHz

Freq. (MHz)	Reading (dBμV/m)	Detector Mode	Antenna			CL (dB)	AMP (dB)	Meas Result (dBμV/m)	Limit (dBμV/m)	Mgn. (dB)	Result
			Height (m)	Pol. (H/V)	Fctr. (dB/m)						
1 233.76	14.10	Average	1.5	H	28.40	0.68	-45.79	14.10	19.44	5.34	Compliance
1 227.97	14.05	Average	1.5	H	28.42	0.68	-45.79	14.05	19.44	5.39	Compliance

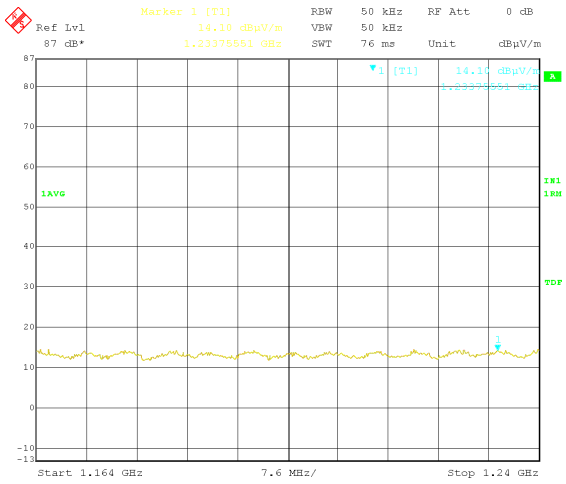
1 559 MHz ~ 1 610 MHz

Freq. (MHz)	Reading (dBμV/m)	Detector Mode	Antenna			CL (dB)	AMP (dB)	Meas Result (dBμV/m)	Limit (dBμV/m)	Mgn. (dB)	Result
			Height (m)	Pol. (H/V)	Fctr. (dB/m)						
1 586.08	15.09	Average	1.5	H	27.56	0.77	-45.86	15.09	19.44	4.35	Compliance
1 587.41	15.43	Average	1.5	V	27.57	0.77	-45.86	15.43	19.44	4.01	Compliance

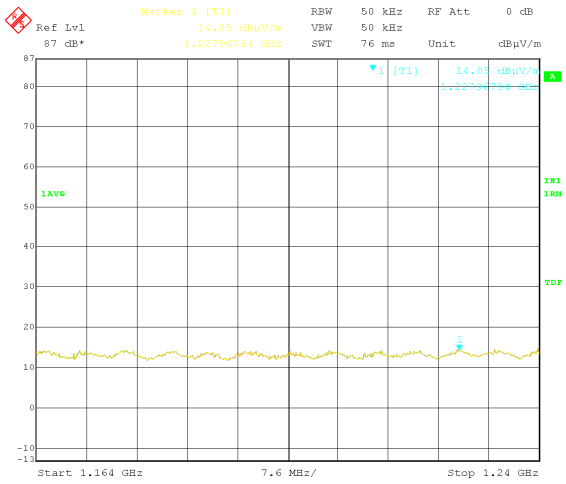
5.4.6 Test plot

▣ 1 164 MHz ~ 1 240 MHz

Horizontal

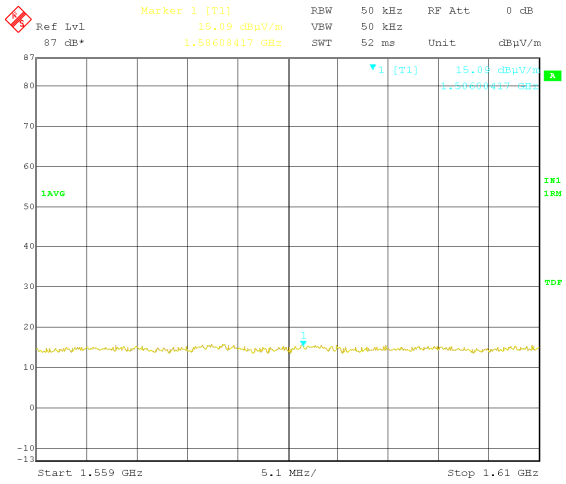


Vertical

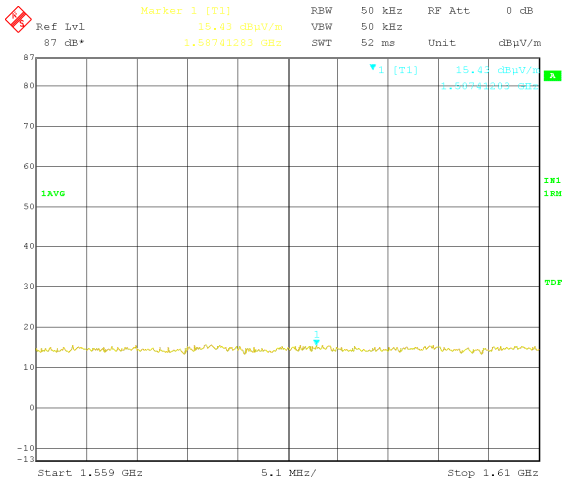


▣ 1 559 MHz ~ 1 240 MHz

Horizontal



Vertical



5.5 Peak Emissions within a 50 MHz Bandwidth Measurement

5.4.1 Standard Applicable [FCC §15.517(e)/15.521(g)]

15.517(e) There is a limit on the peak level of the emissions contained within a 50 MHz bandwidth centered on the frequency at which the highest radiated emission occurs, fM. That limit is 0 dBm EIRP. It is acceptable to employ a different resolution bandwidth, and a correspondingly different peak emission limit.

15.521(g) When a peak measurement is required, it is acceptable to use a resolution bandwidth other than the 50 MHz specified in this subpart. This resolution bandwidth shall not be lower than 1 MHz or greater than 50 MHz, and the measurement shall be centered on the frequency at which the highest radiated emission occurs, f_M. If a resolution bandwidth other than 50 MHz is employed, the peak EIRP limit shall be 20 log (RBW/50) dBm where RBW is the resolution bandwidth in megahertz that is employed. This may be converted to a peak field strength level at 3 meters using E(dBuV/m) = P(dBm EIRP) + 95.2. If RBW is greater than 3 MHz, the application for certification filed with the Commission must contain a detailed description of the test procedure, calibration of the test setup, and the instrumentation employed in the testing.

Peak EIRP Limit [dBm] (RBW: 50 MHz)	Peak EIRP Limit [dBm] (RBW: 10 MHz)	E-Field [dBuV/m] at 3 m (RBW: 10 MHz)	E-Field [dBuV/m] at 1 m (RBW: 10 MHz)
0	-13.98	81.22	90.76

EIRP limit has to be adjusted by the resolution bandwidth ratio of 20log(RBW/50) dB, where RBW is the resolution bandwidth used for the measurement expressed in MHz. In addition, This may be converted to a peak field strength level at 3 meters using E(dBuV/m) = P(dBm EIRP) + 95.2 dB. And Peak emission shall be extrapolated to the specified distance using an extrapolation factor of 20 dB/decade form 3m to 1m. Distance extrapolation factor = 20 log (specific distance [3m] / test distance [1m]) (dB); Limit line = specific limits (dBuV) + distance extrapolation factor [9.54 dB]

5.4.2 Test Environment conditions

• Ambient temperature : (21 ~ 22) ℃ • Relative Humidity : (42 ~ 43) % R.H.

5.4.3 Measurement Procedure

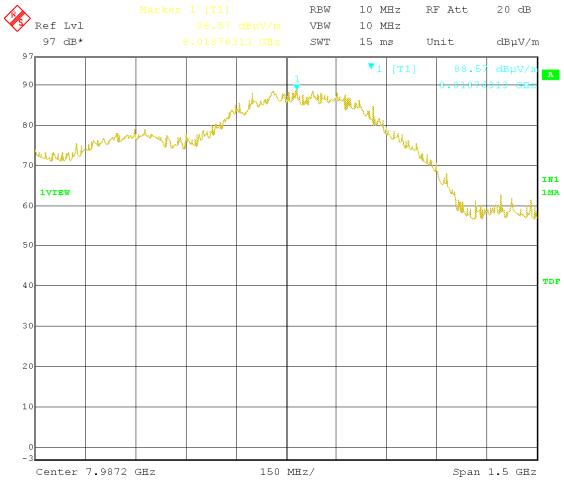
1. The EUT was placed on the top of the turntable 0.8 meter above ground. The phase center of the receiving antenna mounted on the top of a height-variable antenna tower was placed 1 meters far away from the turntable.
2. The horn receiving antenna was varied between one meter and four meters above ground to find the maximum emissions field strength of both horizontal and vertical polarization.
3. For maximum peak emission amplitude, the antenna tower was scan (from 1 M to 4 M) and then the turntable was rotated (from 0 degree to 360 degrees) to find the maximum reading and was used to determine the frequency at which the highest radiated emission occurs, f_M.
4. The individual UWB bandwidths were measured for each BAND_ID (nb) of the UWB spectrum. Both horizontal and vertical polarizations were taken into account to determine the full UWB BW on the maximized (in azimuth and elevation) signals.
5. A spectrum analyzer was used for the final measurement utilizing a peak detector at the frequency with the largest amplitude. The prescribed resolution bandwidth of 50 MHz was not supported by the spectrum analyzer. However, when a peak measurement is required, The resolution bandwidth for this measurement was set to 8 MHz, and the measurement was centered on the frequency at which the highest radiated emission occurred, f_M. The video bandwidth was 10 MHz.
6. All radiated tests for above 1GHz utilized a one-meter separation distance between the DUT and the measurement antenna. This enabled an improved signal-to-noise ratio (S/N) for the radiated tests. Although these types of measurements are typically performed at a distance of three-meters, it was necessary to reduce the measurement distance to enable discrimination between the emissions radiating from the DUT and the measurement system noise floor.

5.4.5 Measurement Result

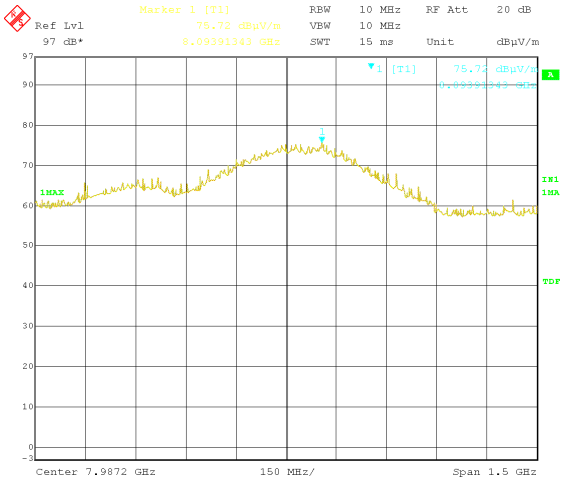
Freq. (MHz)	Reading (dBμV/m)	Detector Mode	Antenna			CL (dB)	AMP (dB)	Meas Result (dBμV/m)	Limit (dBμV/m)	Mgn. (dB)	Result
			Height (m)	Pol. (H/V)	Fctr. (dB/m)						
8 018.76	88.57	Average	1.5	H	35.51	2.42	-45.23	88.57	90.76	2.19	Compliance
8 093.91	75.72	Average	1.5	V	35.55	2.42	-45.13	75.72	90.76	15.04	Compliance

5.4.6 Test plot

▣ Horizontal at 1 m



▣ Vertical at 1 m



5.6 Antenna requirement

5.6.1 Standard applicable [FCC §15.203]

For intentional device, according to §15.203, an intentional radiator shall be designed to ensure that no antenna other than furnished by responsible party shall be used with the device.

The use of a permanently attached antenna or of an antenna that user a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section.

The manufacturer may design the unit so that broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

5.6.2 Antenna details

Frequency Band	Antenna Type	Gain [dBi]	Results
7.9 GHz	Internal U-Slot Antenna	5.36	Compliance

5.7 AC Power Conducted emissions

5.7.1 Standard Applicable [FCC §15.207(a)]

For intentional radiator that is designed to be connected to the public utility(AC)power line, the radio frequency. Voltage that is conducted back onto the AC power line on any frequencies hopping mode within the band 150 kHz to 30 MHz shall not exceed the limits in the following table, as measured using a 50 μH/50 ohms line Impedance stabilization network(LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

§15.207 limits for AC line conducted emissions;

Frequency of Emission(㎒)	Conducted Limit (dBμV)	
	Quasi-peak	Average
0.15 ~ 0.5	66 to 56 *	56 to 46 *
0.5 ~ 5	56	46
5 ~ 30	60	50

* Decreases with the logarithm of the frequency

5.7.2 Test Environment conditions

• Ambient temperature : (19 ~ 20) ℃ • Relative Humidity : (43 ~ 45) % R.H.

5.7.3 Measurement Procedure

EUT was placed on a non- metallic table height of 0.8 m above the reference ground plane. Cables connected to EUT were fixed to cause maximum emission. Test was made with the antenna positioned in both the horizontal and vertical planes of polarization. The measurement antenna was varied in height above the conducting ground plane to obtain the Maximum signal strength.

5.7.4 Used equipment

Equipment	Model No.	Serial No.	Manufacturer	Next cal date	Cal interval	Used
Test receiver	ESCS30	100111	Rohde & Schwarz	2025. 01. 09.	1 year	☒
Pulse Limiter	EMZ10-200M	514158	Emzer	2025. 02. 22.	1 year	☒
LISN	ESH2-Z5	100044	R&S	2025. 01. 09.	1 year	☐
	ESH3-Z5	100147	R&S	2025. 01. 09.	1 year	☒

*Test Program: " ESxS-K1 V2.2"

Measurement uncertainty

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI C63.10-2013. All measurement uncertainty values are shown with a coverage factor of k = 2 to indicate a 95% level of confidence. The measurement uncertainty shown below meets or exceeds the UCISPR measurement uncertainty values specified in CISPR 16-4-2 and, thus, can be compared directly to specified limits to determine compliance.

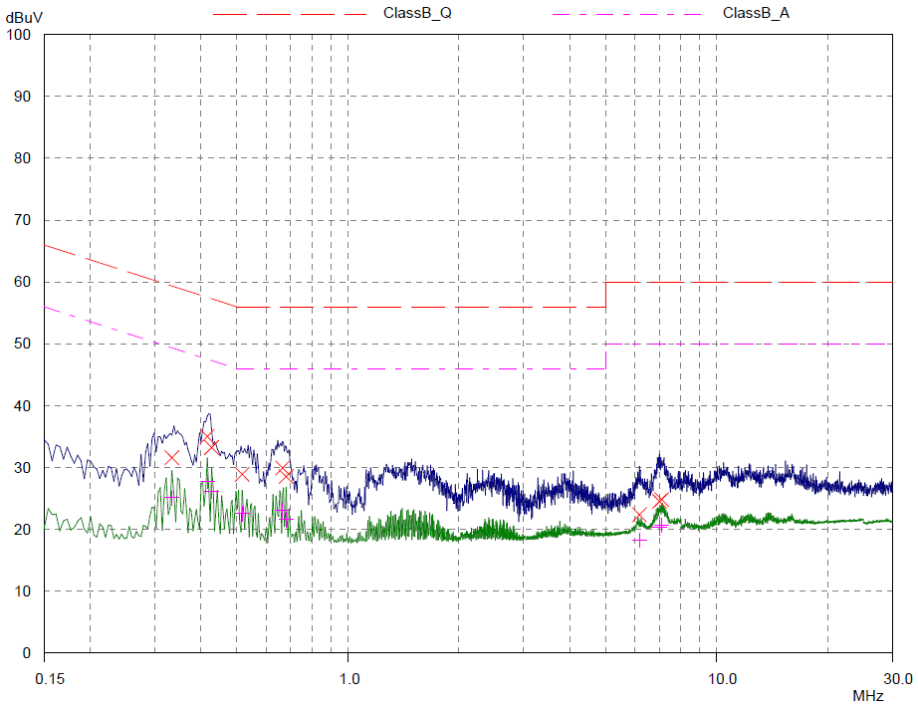
0.009 kHz ~ 30 MHz(L) : 3.94 dB(CL: Approx 95 %, *k*=2)
0.009 kHz ~ 30 MHz(N) : 3.32 dB(CL: Approx 95 %, *k*=2)

5.7.5 Measurement Result

Freq.	Factor [dB]		POL	QP			CISPR AV		
				Limit	Reading	Result	Limit	Reading	Result
[㎒]	LISN	CABLE +P/L		[dB㎶]	[dB㎶]	[dB㎶]	[dB㎶]	[dB㎶]	[dB㎶]
0.334	0.15	10.08	L	59.36	31.60	31.75	49.36	24.63	24.78
0.416	0.15	10.08	L	57.54	35.02	35.17	47.54	27.24	27.39
0.427	0.15	10.08	L	57.30	33.22	33.37	47.30	25.63	25.78
0.517	0.15	10.08	L	56.00	28.89	29.04	46.00	22.02	22.17
0.666	0.16	10.10	L	56.00	29.93	30.09	46.00	22.59	22.75
0.681	0.16	10.11	L	56.00	28.55	28.71	46.00	21.04	21.20
6.177	0.34	10.31	L	60.00	22.37	22.71	50.00	17.78	18.12
7.005	0.37	10.33	L	60.00	24.54	24.91	50.00	19.81	20.18
7.111	0.37	10.34	L	60.00	24.82	25.19	50.00	20.23	20.60
0.158	0.12	10.07	N	65.58	27.33	27.45	55.58	17.43	17.55
0.349	0.13	10.08	N	58.98	26.12	26.25	48.98	17.80	17.93
0.416	0.13	10.08	N	57.54	29.09	29.22	47.54	19.57	19.70
0.642	0.14	10.10	N	56.00	24.36	24.50	46.00	15.43	15.57
0.681	0.14	10.11	N	56.00	23.28	23.42	46.00	14.82	14.96
3.908	0.24	10.26	N	56.00	25.08	25.32	46.00	17.31	17.55
6.185	0.31	10.31	N	60.00	24.54	24.85	50.00	19.12	19.43
7.064	0.34	10.33	N	60.00	25.12	25.46	50.00	20.52	20.86

* LISN: LISN insertion Loss, Cable: Cable Loss, P/L:pulse limiter factor
* L: Line. Live, N: Line. Neutral
* Reading: test receiver reading value (with cable loss & pulse limiter factor)
* Result = LISN + Reading

Line. Live



Line. Neutral